Chapter 5.
PROJECT MANAGEMENT
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1 Introduction to Project Management

in the previous chapters we have seen an introduction to engineering projects, largely focused on the design or creative stages. In all projects, however, to be considered successful, the time comes when it is necessary to manufacture that designed product or build the installation of interest. In this topic, we are going to broaden the scope of our vision of projects through a tool that is used during all phases of projects but that acquires critical importance in the construction or execution phase: project management.

As we said in the first topic, project management is the definition, organization, planning and scheduling of activities, as well as the control of technical, economic and human capital put together to achieve the objectives set in a project.

Project management is a discipline whose use has undergone exponential growth in recent decades. It is common to consider the enormously complex projects developed in the United States during the Cold War as the beginnings of techniques typical of project management. The development of intercontinental missiles or some NASA projects were the only places where their use seemed justified. However, the increasing complexity of organizations, their products and facilities, as well as the globalization of production systems, led to a constant increase in the use of tools associated with project management.

The last two decades (1990-2010) have seen a real boom in project management, with the popularization of numerous methodologies, standardization organizations or certifications. Today, few engineering-related organizations can afford not to use project management to a greater or lesser extent. shows, by way of example, the sharp growth in the number of members and professionals certified from Project Management Institute (PMI)
There are a good number of methodologies and standardization institutes in the world related to project management. In this text, we will largely follow the structure and nomenclature that the Project Management Institute (PMI) disseminates through its Project Management Fundamentals Guide (better known as the Project Management Body of Knowledge or simply PMBOK). There are many other standardizations and organizations, such as the Spanish association of integrated project management (AEDIP), the International Project Management Association (IPMA, with headquarters in Switzerland), or the British Association for Project Management (APM). Despite this profusion of organizations, it should be noted that the principles of project management are the same in all cases with very slight differences between them. In Topic 1, in particular, and throughout this text, we have talked about the phases of projects, differentiating the design, execution (or construction) and exploitation phases. Like what we have seen so far, project management is usually limited to the design and construction phases (often including commissioning in the case of installations) and not including the operation phase. From the point of view of project management, it is convenient to know the processes that are going to be developed over time. There are five groups of processes, which are (see also Fig. 1.2):

- The **start-up process group** consists of those processes carried out to define a new project (or phase) and obtain the necessary authorizations. Examples of activities include defining the scope, initial resources or users of the project, choosing a person responsible for the project (or phase), etc.

- The **group of planning processes** consists of those processes carried out to fully define the scope of the project (or phase) and its objectives, as well as establishing the necessary actions to achieve those objectives. Examples of these processes include the planning and scheduling of activities, planning of human, economic or other resources (facilities, laboratories, etc.)

- The **execution process group** includes the performance of all those activities defined during planning and necessary to achieve the objectives of the project (or phase). Most of the technical activities that we have described in the previous topics (such as analysis of user needs, realization of conceptual designs or use of prototypes) would fall into this group of processes. Execution processes are also considered some of management and coordination such as the distribution of information, supplies or team-building activities.

- The **group of supervision and control processes** has to do with reviewing whether the development of the project is correct, identifying conflictive points and establishing corrective measures if necessary.

- Finally, the **group of closure processes** includes all those activities necessary to formally complete the project. Examples of closing processes are obtaining customer acceptance, if required, documenting lessons learned, or closing supply contracts.
As seen in **Fig. 1.1**, the process groups overlap throughout the entire project (or phase). It is important to understand that these groups of processes are not comparable to the phases (conceptual design, detail design, construction, etc.). In fact, in large enough projects, in addition to overall project management, each phase can be considered to consist of the 5 groups of processes described above. Thus, for example, after the preliminary design phase, in the detailed design phase, the start-up and planning processes would begin, the design itself and its supervision (execution and control processes) would continue, and it would be completed with the closing processes. Subsequently, the construction phase would begin with the start-up and planning processes, etc. In simple projects, however, a breakdown of processes is not necessary for each phase and, for example, a single planning can be carried out that includes the entire project and is updated at each phase change. This feature, in which the tools must be adapted to the type and size of the project, is general for all project management. Using levels too much scarce or excessive management can ruin projects due to chaos and lack of control or bureaucratic drowning, respectively.

![Fig. 1.2. Grupos de procesos que tienen lugar durante un proyecto o fase](image)

In addition to the five groups of processes described above, the PMI Project Management Body of Knowledge describes nine areas of knowledge related to project management. These knowledge areas are added to the particular technical areas of each project and summarize those topics that must be taken into account for the project to have guarantees of success. The areas of knowledge of project management will be used throughout all phases of the project and are:
• Project integration management
• Project scope management
• Time management in projects
• Project cost management
• Quality management in projects
• Human resources management in projects
• Communication management in projects
• Risk management in projects
• Procurement management in projects

In the next three sections we will see methods and tools for these areas of knowledge during the planning phase (in the next section) and those of execution, supervision and control (in the next) and closure (in the third). We will not include communication management in projects, as this is covered in the next topic. Human resource management, on the other hand, we consider of special importance and that is why we reserve the last section. We should note that there are other areas of knowledge for specific projects (for example, security or claims on construction projects).

As throughout the rest of the topics, we must remember that this is an introductory text on a very broad topic and that the interested reader should refer to more specialized texts. The titles referenced at the end of the topic are a good starting point.

2. Project “reason to be”

The first step must be taken to be properly organized, is "know" what to do, and that happens to know the "reason to be" of the project. The "reason to be" of the project is understood as the reason for the existence of the organization created to be a beneficiary of the project. And probably the best known methods for this purpose is to undertake projects which are defined as "analysis of the client's wishes," the first user and the project applicant.

2.1 Analysis of wishes

The most useful methodology to get to know which is the reason why the customer "wants" to get the AU (Activity Unit or project group) (information necessary for a correct interpretation) is now to try to get a set of responses, without being very precise, if that one can assert that, behind them, the project manager (PM) and get three substantial progress: 1) helping your customer focus to better define their own haunts, 2) know the "tuned" by the move to be the project team and 3) near- equality in terms of knowledge, which the client has their own desires.

The answers must be obtained from the questions: What and Why, Who, Why, Where, When, How, many times, how long and at what cost.
- **What and Why:** It is a teleological analysis of the nature of the characteristics of what we are trying to achieve.

- **Who and Why:** This is an analysis of users who are recipients or are involved in the service to be provided by the object. As you can guess at the question, the user ID (we speak, regardless of user, customer, or client-user), includes a causality is a condition in many cases, indispensable.

- **Where and when:** It is a description and analysis of the "environs" with all the consequences of urban conditions, technological, etc.. We also are beginning to talk about deadlines and their implications first.

- **How:** We analyze the function that is capable of providing the service the user wants. It is likely that the function is fairly predetermined by the customer's own will, but this does not prevent an initial analysis is made, which will be phased later confronted with the deepening of defining the composition of the function.

- **How often:** This refers primarily to AUs that exercise the function with repetitiveness. In any case, one can interpret here the existence of some constants, or values to get that condition in a decision-making technological features or use.

- **At what cost** commitment is gained here is the acceptance condition of satisfactory service. It must therefore lay the foundation for its evaluation in order to carry out reasonable development of value engineering.

### 2.2 Project Objectives

Known that is what "to do", the PM should be put through a definition of objectives. The success of a project depends largely on the objectives given by the PM are well marked, which means they should be: clear, specific and measurable.

**Clear** so as not to be confused with others and easily understood and displayed throughout the development of the whole design process (eg, that the budget of the structure to oscillate between a +/- 10%).

**Specific time**, space or given environment as to permit individualized treatment (eg, to form an engineer in monitoring a particular planning system).
**Measurable**, if possible, so that they can be susceptible to subjectivity and allow a reasonable size of the level of achievement (e.g., ensuring profitability of 15% or that the ceiling be increased costs for administration of 2 %.)

### 2.3 External objectives the project team

Are marked primarily by the customer and it is he who must be must be sought to be as explicit as possible to cover them vigorously. But I must say that is not always easy. In any case it is likely that the customer is explicit in cost or time targets, for example, but in others there will be serious difficulties in obtaining consistent definition and delimitation.

In any case would be classified as: a) Objectives of the AU-own-device (design, quality or cost), b) Goal setting (time, environment, licensing or security) and c) Millennium perception of management / leadership.

**Targets outside the project team and the AU's own Design:** We focus primarily on:

- **Aesthetic:** What shape the forms and their relationship to the environment: landscape, trends, fashion, ...
- **Functional:** Relative to their use for what you want and adaptation to the objective needs.
- **Construction:** Impact on the property of an AU to be more or less easily realizable of the three, the first is the most affordable in the primordial stage of the project life cycle (previous studies, master plan, etc.). The other two will have their peak in the next phases of project implementation including (read also construction or embodiment).
- **Quality:** This is getting to undertake a project with the minimum possible errors. But to say that they have to get zero errors in all proceedings, it is seen that does not solve the problem. Probably if the customer has a quality system approved, it will help focus the action of DP (remember, the project manager) because some of his performances come governed by the quality system procedures.

**Cost:** This is probably the main objective pursued by the client, perhaps because very often, the PM does not pay outstanding interest and therefore the client is led to the use of an intermediate form, manager or project manager, which has the main objective. However the DP should organize the

**quality objectives** have more or less rapidly. In the last one gives answers to problems that appear, putting in projective propositions, the appearance of a smaller number of errors, accuracy of results, etc ...
project for maximum control over the cost. The logic is that the cost target be set from a previous study is justified by the goodness of the investment.

The PM should know, however, that market pressures, technological changes, the constructability or reliability, financial implications, competition, bureaucratic and legislative problems of termination of contracts, etc. are factors that work against the maintenance cost in the desired range goal.

**Targets outside the project team and environment of the UA**

They relate mainly to those objectives proposed by the Client, largely involving collateral aspects of the AU but that can influence both their attributes and in their functions and thus projecting well in development or in its final contents. In this section we discuss the term referred to, the environment, licensing and security.

The term, together with the cost, are most commonly set goals, not only because they are perceived with the greatest need, but because they also are more clear to define and easier to evaluate. These two goals on time and cost traditionally has been joined, as inseparable, the quality is less concrete but no less essential to attend. This triangle has formed over many years the strategic theory of project management because their balance has always been as basic as difficult to maintain, because the pressure on one of them causes a tendency for some of the other two see suffering in their completion. Today, there are other objectives such as safety or the environment that have taken enough prominence.

The a priori definition of the term depends among other factors: the needs of the client and the historical memory that sets many times inescapably about runtimes of some items or activities. This is also one of the goals that are among the most characteristic of a manager / project manager when a figure than that of the PM. Note, however, that, as we have said on many occasions PM manager and merge in the same person or team of people, but we must also clarify that the DP, above all, should be given in conflict resolution, that is designing and managing the implementation of the AU so that it meets the desired functions with sufficient quality assurance.

**The environment** is also one of the aims of calls from environment that are fixed to the DP and depends basically on existing legislation, the responsibility of the actors themselves and the image you want to record. The law often determines the definition of objectives, particularly in AUs associated with chemical companies, pharmaceutical or food. AUs but also high social or representation in which an image is intended to make such a permit, or establish a sound example for other actors or entities, or simply make a difference.
We must say that with increasing frequency this objective becomes consubstantial with the AU itself, so it is integrated as an objective "own" more.

**Licenses and / or patents** could be another objective of environment and not usually marked by the event itself to get them, and that should be obtained to make and put into service any U, but get them at one time or a given period. And I must say that many projects do not pass it because not achieved this goal, it motivates expose it as very important. The licensing has prompted often stories of confusion, broken promises, corrupt, obscure procedures, treatment "between corridors, but has also assumed the existence of profound ignorance and lack of realism of many people who believe that" all "can be obtained and only need to put the right price. A good case management can save many of those stories and even save you the hassle of having to think about any price "transfer". PM often declines to perform these tasks to perform services other professionals, mostly managers of projects or the client.

**The security** is a goal in the last decade has begun to acquire great importance and refers to the express wishes of clients and designers who want above all: a) safety in the design and b) safe conduct (especially when must be embodied / build). The first objective justification that taken during the design assumptions and projective systems safest possible level of reliability in operation as well as a review or audit of the actions that are carried out. The second objective is achieved with more care in selecting who "made" or "builds", and greater efforts in monitoring construction processes, including specific technical hiring managers that work to prevent physical collapse, functional or humans.
3. Starting and project planning

Start-up processes are those that are carried out to officially start the project or any of its phases. In many cases, these processes require the participation of external project people. For example, to start a project for a new product in a company, the company management must formally authorize the project. In the case of a phase change, for example, for the transition from the design phase to the construction phase, there is generally also a complete revision where the company management authorizes the project to continue or rejects it because it does not see a future interesting.

The two main activities of project initiation (or phase) are the development of the articles of incorporation and the preliminary scope statement of the project. These are documents that formally authorize the start of a project (or phase) and define the initial requirements. Through these documents, the project team (usually in the figure of its person in charge, the project manager) is transferred the necessary authority to have sufficient resources to carry out the project (or phase). Identifying so-called stakeholders (people affected during the project life cycle) is also an activity that can be considered within this group.

The planning processes are usually already completely carried out by the project team, although some external approval is sometimes necessary in some actions. In general, it is about defining in detail the scope of the project (or phase) and the activities necessary to achieve it. The main milestone is the preparation of the project management plan, which is a compendium that integrates the planning of all areas (scope, time, cost, risk, etc.). We will now look at the planning of each of those areas.

3.1 Project scope planning

Planning the scope of a project (or phase) is one of the critical activities in any project. Even so, in many cases it is not carried out, due to lack of good practices in project management, thus dragging the problems during the rest of the processes. Scope planning includes activities to identify user needs and define technical specifications that we saw in previous topics. It will be necessary to clearly and in writing identify the objectives of the project (or phase) with respect to the product or installation that we are dealing with. A good number of projects fail because its members (or even the director) do not have the same vision of the scope of the project with each other or with respect to the direction of the company or other users. Clearly defining the deliverables that a project or phase should produce helps to avoid problems and is something that every project must do.

An especially useful tool in outreach planning is the Task Breakdown Structure (TBS), also known as the Project Breakdown Structure (PBS) or its English term Work Breakdown Structure (WBS). WBS is developed by
dividing and subdividing the deliverables and the work necessary to meet the project (or phase) objectives into smaller, more manageable components.

WBS is organized into levels, each of which is subdivided into the lower level to represent a more detailed structure. The breakdown into levels is carried out until there are elements that are easily programmable in time, whose costs are easily estimated and whose supervision and control is simple. Each of the elements in this last level is called a work package.

A correct WBS is essential for the success of a project, since the rest of the planning and control tools are developed from it, such as programming, budgets, etc. Although there are some common practices in certain industries (for example, regarding the number of levels and the detail of each one), there is no correct or unique way that works for all projects and all organizations. Each project could develop different valid WBSs, as long as it met the goal of breaking down the tasks into manageable packages.

**Fig. 3.1** shows an WBS structure for a design and construction project of a facility (a car wash). For small projects, WBS can be represented as a tree diagram. In most real engineering projects, the number of work packages is so high that such a representation is not practical, so a tiered listing is used. In these cases, correctly defining naming codes for each level is extremely important to avoid mistakes.

![Fig. 3.1. WBS example for a car wash project. Note that this is only one example of possible decomposition, and that there are many others that are equally valid.](image)
In some organizations, there is a trend towards the standardization of WBSs, in order to facilitate subsequent supervision and control. This is possible in organizations with a high number of similar projects (e.g., a company that carries out several car wash projects), but not advisable in other cases.

### 3.2 Time planning and scheduling

Time planning and scheduling includes the processes necessary to ensure that the project (or phase) is completed correctly in the target time. It is convenient to distinguish between the two concepts (planning and programming), because although they are often used as synonyms, they are not. Planning has to do with estimating the individual activities to be carried out, as well as their durations and relationships between them. Programming, on the other hand, is the specification of start and end dates in order to optimize resources and time necessary for the entire project. Here we will see several planning and programming tools used in practically all projects.

![Fig. 3.1. Time planning and scheduling processes](image)

The first task to be performed is to define all the activities that are necessary to produce the project deliverables. If a correct WBS has been carried out, this will only involve dividing each work package into the activities that are necessary to comply with that particular work package.

Knowledge refers not only to subsequent course of events leading to the completion of objectives, but also constraints, relationships or problems in general they support. That is, the context in which they occur. It is synthesized in what we call restrictions and dependencies.

- **Restrictions**: These are constraints that are designers and directors who are generally affluent external function that determine when they can or should start or stop certain activities, not giving options to the analysis of different ways. This could be the case, for example, the possibility of using...
recyclable materials, restrictions on air pollution, the granting of planning permission or the need for completion of certain milestones by political and technical problems of supplies of certain parts of equipment, etc. ... Many restrictions arise from the very objectives of the mission and other customer needs, information from government or limitations of any other technical considerations unrelated to the project or the project team action.

**Dependencies:** These are conditions that arise as events required to initiate others. Unlike constraints, dependencies sideways support for different policy options on that if you have management capacity, and therefore do not limit its resolution, a single proposal.

The units can come from the same interior design process from the creation or outside (nearby). Let us quote for example: the inability to make a contest without having the design and technical specifications, not to start without having to install a pipe supports, etc. In any case, the approach is to be produced for one or more events that may befall the other representation techniques to manage activities. To use them, they are part of the knowledge that the activities have precedence in terms of execution time and the dependencies and constraints involved. With these assumptions the most used are the activities at the nodes, the activities in the arrows and the network diagram.

The representation of the activities at the nodes, specifies that the nodes represent activities and arrows between them are the dependencies or restrictions that exists between them, and recorded the time that must elapse before they occur one after another or other (Fig.3.2).

![Fig. 3.2. Tasks in arrows or nodes](image)

The arrows, n1, n2, n3, and so on, Are plotted the units of time to wait between the completion of one or other activity.

Between any two events A and B, can be found delays (restrictions and / or units) that define the time between:

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Fig. 3.2. Tasks in arrows or nodes
From those four relationships the most common is: first order of A and B. This method can be equally done manually or through a computer program. The representation diagram of those activities with the arrows define the activity and the time it needs to be done. The nodes mean only milestones that mark the beginning and end of each. In fact in the representation only uses the relationship between the end of an activity and the beginning of another (Fig.3.2).

The complete development of the management of all activities indicating the restrictions and dependencies between them, generates a network diagram universally displayed throughout cycle activities, although as will be discussed when speaking of control, it is useful to split sub-cycles cycle in hosting part of the parties and allow for better control. Along the following pages is considered in more concrete the use of graphs, networks and different software among the most common.

**Duration**

Probably the hardest part of planning because it attempts to predict the time that each of the tasks needed for its total completeness without having direct control all the factors that may affect you. Just as the prediction of what the activities you can get reasonably good results, the prediction of the duration for each run is more complicated, because we are not talking of continuous processes, but only processes in which constraints and restrictions are often different due to human intervention and the uniqueness of each case. However, the PM must, once to specify the activities that are needed, venture a duration for each of them, using the means described below.

The next step is to establish sequential relationships or dependencies between activities. For this, the use of network diagrams is common through any of the numerous computer packages that exist in the market. The sequential relationship that two activities (activity A and activity B, for example) may have with each other, in general, will correspond to the following two types:

- B can only start when A is finished
- B can only end when A is finished

There are actually other types of dependencies (and even activities that require multiple iterations without linear dependency), but the previous two types represent the majority of cases in real projects. Some of these sequential relationships or dependencies will be mandatory and others will show preferable sequences. An example of the latter case would be the situation where doing Activity B after A reduces the risk of problems, although it is not strictly necessary. In some cases, in addition, there will be external constraints to the project for some of the activities, for
example, the granting of a government permit for the start of construction activities.

Once all the activities are listed and the dependencies between them are defined, it is time to assign an estimated duration. For this, in general, it will have been necessary to identify for each activity what resources are necessary (in terms of personnel, equipment or material) and what availability of them we will have. Of course, in some cases, the necessary resources will depend on the cost that we are willing to take over, so some time and cost planning iterations may be required. Activity duration estimation is a difficult process, sometimes closer to art than science. In general, it will be based on experience, as well as knowledge of the processes involved (eX, the setting time of the concrete).

The last step in the process is already time scheduling, for which a project (or phase) schedule is usually drawn up. A project schedule is an extremely useful tool, not only for planning, but for internal communication and organization. Developing a project (or phase) schedule is an iterative process in which resource estimates and durations are reviewed and corrected. Although a base schedule is defined at the start of the project or phase, as the project progresses, the schedule must be updated to incorporate the new information available.

**Establishing a project schedule** consists of defining the planned start and end dates for carrying out the activities, as well as defining the planned dates to meet the different milestones.

Within the planning and scheduling of times the concept of critical path is important. The critical path is the sequence of activities on the schedule that determines the total duration of the project. From the above definition, it follows that a delay in any of the critical path activities will lead to a delay in the entire project. It is important to note that most project activities are not on the critical path, hence the importance of knowing those that do deserve special attention from the project team.

There are several methods for developing schedules. In a simple project it will be possible to do it by hand, but in complicated projects, with thousands of activities, the use of support techniques is necessary. Although there are many tools, the best known and used are:

- **PERT or ROY diagrams**, where activities are analyzed with the use of network methods to determine the critical path. There are several methodologies (the two best known are activities on nodes and activities on arrows), although perhaps the most common is that in which each activity is assigned a node, where its name and duration are written, and the dependencies are represented by arrows. Both manually and through software programs it is easy to estimate the start and end dates of each activity, as well as the clearance (time that a non-critical activity can be delayed before affecting the total duration of the project) of those that are not critical.
• **Gantt charts (or bars),** which represent each task in the form of a horizontal bar based on its start and end date. Gantt charts are very useful for their simplicity and ease of interpretation, but do not allow all dependencies to be easily represented.

We have already said that there are many other tools, such as the PERT that allows the incorporation of iterations and ramifications, the critical chain method, which takes into account the limitation of resources, or the use of probabilistic techniques, in which each Activity is assigned not a discrete duration but a possible interval of durations or a probability density of durations. Also, there are numerous software packages that allow PERT, Gantt diagrams, etc. Two very common programs are Microsoft Project (for more or less simple projects) and Oracle Primavera (for more complex projects). **Fig. 3.3** shows an example of a PERT diagram in MS Project and **Fig. 3.4** a Gantt diagram (plus information in tabular form) in Primavera.

If once the complete schedule is developed, the duration of the project (or phase) is not acceptable, there are some ways in which the project team can try to decrease it. The basic options are to try to reduce the time of some of the critical activities or to try to carry out in parallel critical activities currently programmed in series. Reducing the time of some critical activity in many cases will be possible by increasing the cost (for example, by having more staff, better equipment, etc.). To do this, crashing is used to analyze in which activities it is better to include more resources from the global point of view of the project. On the other hand, fast tracking design and construction consists of overlapping activities that are normally carried out in series, such as starting to build a facility (e.g., foundation) even if the design is not completely finished. Both crashing and fast tracking are commonly used tools to shorten project deadlines, but they must be applied with care since they represent an increase in project risk.

![Fig. 3.3. Example of PERT diagram in MS Project (critical path is pink)](image)
At the beginning of the process of realization of the dates by putting them in the best moments that allow for the maximum of activities that can minimize the time and / or cost, will go into the detail and depth of the units and possibly in the possible margin of variability of the restrictions. This is done through a check of the total length and a review of the dates, ending with a consolidation of resources made available to the project. This allows us to determine the critical path of the cycle that marks the final deadline. Later, when discussing the media, seek technical and mathematically optimal circuits combined activities leading to the best results using minimum resources.

**Verification of the total duration**

It is the verification and confirmation of the compatibility of the total length, structured through the following criteria: customer, filmmakers, and other external actors (government, utility companies, etc.). In this regard it is noted that there are many possibilities for all stakeholders' views do not coincide. The method used for this test is to investigate each of them testing it in two ways:

- For separate activities (total time for construction of a steel tank of a building structure, calculation of gas network, etc.).
- In order of execution (already having specific dates and placing an activity behind or in parallel with others).

![Fig. 3.4. Example of a tabular list of activities and a Gantt chart generated with Primavera](image-url)
If at the time of the program has not yet appeared some of the actors (not yet hired the "filmmakers", designers, etc.), The PB or manager must use the means listed thereafter to supplement their contest. In any case, what is important is that exercise is done taking into account different views and thinking about what I would have said each of them, ie putting in place. In this way the restrictions are best detected, dependencies or relationships. Ultimately it gets closer to reality.

**Reconsideration of the dates and durations. Consolidation**

If verification of the total length to achieve the goal of the period, made earlier, it departs from the provisions, we must reconsider the program again under the points of view (**Fig. 3.5**):

![Diagram](attachment:image.png)

**Fig 3.5.** Total length verification

**Change order of activities.**

Edit the resources that supposedly would be used in each activity (different equipment, different techniques, different systems, etc.). Using more resources in the same or a longer working time (more teams, more people, etc.).

**Share resources.**

The change in the order of activities that might lead to positive change in dates for a better term, usually the result of advance knowledge or prediction of the number and characteristics of companies involved in the project and / or conduct. The same applies to the assumption of such technical means will be used and can alter the length. Here can be useful
using Load Curves as support for GANTT and/or PERT/ROY

They can also radically change the start and end of some activities has been increasing or decreasing the applied human resources, although not in proportion as might be supposed. In this regard it is noted, for example, that a group of workers in a second night shift and on a construction job, can not be effective beyond 70% on a day shift. Fundamentally, because the "staging" of the entire set of means and resources involved in the operation during the night is a specific weight is less than that during the day, resulting in the reduced effectiveness and probably in inefficiency. Do not enter any physical or psychological connotations that could be used and which also could impact on the job. Finally, it should perform an exercise to consolidate all resources to try to find synergies that favor the disappearance of points of conflict and the efficiency of resources invested to achieve, ultimately, a reduction in the durations of activities.

The risk you run when you run all these reviews, is to try to reduce lengths at any price, deceiving the client himself or through an alternative proposal, with the aim of resolving the situation. But it can no longer be realistic, again, to become proactive or purely speculative, if not, a simple "postponing the problem" later. In any case it is a danger that PE must overcome.

Determination of critical and noncritical activities. Clearance

The confirmation of the goodness of the periods and dates does not culminate in any way with programming. We need to know what activities are going directly affect the final deadline. This requires determining which activities are critical. It is defined as critical, that a delay in the start delay provided at the end of the whole operation. In contrast, a noncritical activity is one that delayed the start does not affect the deadline. He supplements his definition by adding that is the time elapsed between the date later in his possible start and end earlier, is of a length greater than its standard length.

The delay, in terms of time, which may affect a scheduled activity at the specified time without suffering the delay or deadline or other activity of that depends is called slack. In that sense it is appropriate clearances have some activities in order to have a turn, chance to correct deviations in perceptions of time from other activities on which it was not possible or is not appropriate, planning and programming with margins security It is precisely the critical activities, those which, especially, should pay attention to a PM.

3.3 Determining the critical path (CP)

The critical path (CP) is what defines the concatenation of activities classified as critical. (time margin=0 between finishing previous and starting next task)
The key features of determining the CP are:

- Define the final end of project life cycle.
- It is not immutable and therefore can move to another mode criticality.
- There may be more of one CP.
- When in doubt about its authenticity, is that there is another CP. In a tight planning, there is always a CP.
- The existence of a CP is the absence of any slack in it and therefore unable to accept any delay in it.

**Resources**

The resources used to program the term are primarily:

Similar past experiences and updated data, simultaneous engineering and architecture (IAS) and mathematical analysis and computer programs.

**Similar experiences and update of data**

Like to plan, we believe that the experiences in previous cases are the best weapon available to a manager or PM to know the time when the activities can be started and when can end. In fact the situations are repeated frequently, at least in the simplest and so do dependencies or restrictions: always exist, eg official constraints for implementation and will get to know an average time that it entails and what elements of the AU and thereby affect their interaction. The same goes for any of the "items". Experience, own and acquired, we understand that without doubt are the principal means. Moreover, the massive use of computer software can be meaningless for lack of realism due to ignorance of what "has always happened and will want to avoid.

We must also make clear that the experience can become outdated if not quite up to date, and one way of being is to have a good archive of experiences, his own and others, allowing constant updating. In this regard it should be mentioned that the provision of useful frankly a quality system in any of the procedures required to carry built a record of occurrences, dependencies, constraints and time of each project. The register shall be available to all, and the DP every time you start a project may have an unbeatable gun that lets you talk with authority and defend their proposed dates.

**The simultaneous engineering and architecture (IAS)**

This is another way to not become outdated in programming. In reality this is a system used by many managers and PM do not have the aforementioned record or lack of experience: The IAS is the use of the filmmakers' experience or knowledge of the tools they have to specify the term and the moments that can make the games and activities.
This means, however, errors can also feed from precisely the same defect reported previously, namely that the director has no reliable historical memory or does not have adequate technical resources, if not that, provided a positive approach to the project and its goals, makeup your information in order to exclusively own interests.

This will continue supporting the use of this medium by considering it extremely useful, but always linked to the other two.

**The design and construction accelerated (DYCA)/"fast track"**

It is a system design development, planning, programming and implementing the AU to meet the deadline premium over other objectives. The DYCA influences: a documentary of the project definition differently than usual, a different recruitment system and planning and scheduling also different. This term is used primarily when the AU is a product, even though conceptually it could be used normally when addressing service projects.

As for the goals that justify the use of DYCA, must not make the mistake thinking that the other two classic goals, the price or quality, are outside the control or are not sufficiently taken into account. In fact, the cost for example is referred to in the short to medium term. In this regard we must say that many investors prefer to invest more than normal in the initial cost of the AU with the assurance that the operation will begin early. This applies to shopping centers, suppliers of parts to car manufacturers and even some public works (political gain). When the developer has decided to take the investment and has the resources, both financial and human, and is draining and maintenance costs of such availability, it seems clear that the earlier you start to "produce" the AU, the sooner you start the recovery of investment and of course you bring that cost less impasse. However, it should be noted that this is not so evident in many cases and do not always need to go to DYCA.

Project documents in a DYCA / fast track. The project documentation is not a traditional DYCA. Based on the regular documentation, it is possible to summarize the most defining what is essential and decisive, leaving the rest to concrete for the construction phase, either by the designer or the constructor (here, embodies more than ever) as well to interpret the philosophy of the project and reflected in the executive project first and then construction.
4. Costs planning and programming

4.1 Cost Control

Control is more complicated than usually presented to DP, mostly because their best effort, creativity and the highest number of their hours are aimed at achieving good design, which limits your choice well in time and resources to always need to exercise a "tight" control on costs. Control to be put in mind that there are other actors who constantly try to just not exist, and in any event, if any, is to certify a final price increase. This situation is causing, in many cases, go to the introduction within the organizational structure of the leadership of a project, a manager / project manager whose primary mission is precisely that: the maintenance cost of AU from the beginning to the end of the process.

In any case, control of cost can be defined as:

The control must be done to keep the cost within the limits set by the mission objectives of a project. The stages of a general plan to control costs, considering all life cycle phases of a project-CVP-(design, development, implementation and final) are as follows:

- **Orientation and preparation.** It is performed during the phases of Design and Development. It is often undertaken Previous studies, sometimes a Master Plan, and ordinarily the Draft. It will be known, approximately, the cost of future AU. It is estimated that the assessment round between 20-35% □ real budget of the AU.

- **Review and confirmation.** It takes place during the implementation phase within the CVP. The planner may carry out the blueprint, the project executive and provisioning (hiring contractors and suppliers). The designer produces documents theoretically very complete and contractors are given a price for doing so in written form and explained them. There is therefore a compromise that is ordinarily supported by a contract between client and contractor or a customer order to the contractor with the same legal value. Here, the degree of approximation to reality may be in the range between 20% to +/- 5%.

- **Verification and control.** It also occurs in the implementation phase, while under construction / by the AU The PM will verify that / those contractor / s running / n the implementation of the AU, according to project documents, are obtained and expected results solving technical problems that occur and the economic consequences of changes, errors, additions, etc.. Logically, the end of this phase, which ends up making the AU, the price is real enough, provided that the final settlements with the conclusion of contracts for breach did not change or modification of contractual terms by some actor.
Cost planning and scheduling includes estimating the costs required for each activity, adding them up to a budget, and scheduling them to create a cost baseline for the project (or phase).

We understand **as budget** an estimate of the costs of a project, some component of the WBS, or an activity. A cost baseline is the scheduling or temporal breakdown of costs for the entire project (or base).

We have already discussed in Topic 4 on estimating project costs. We will only note here that said estimation will be much simpler if, previously, an WBS has been carried out and a correct breakdown of activities. In this case, we will only have to estimate for each element of the WBS or activity its cost, with which we will already have the structure of the global budget. A common type of cost that has not been mentioned before is so-called contingencies, reserve cost items that are added to the total budget to prevent uncertainty and risks. Contingencies can be a percentage of the total cost (usually 15-20%), a specific value or be calculated using some more sophisticated technique. Contingencies must be clearly identified as such and normally require specific management approval for their use. It is important not to introduce cascading contingencies that make the cost estimate completely unrealistic. The preparation of the cost baseline of a project (or phase) is direct, if the costs of each activity have been estimated and the project (or phase) schedule has been developed. The most usual form of representation consists of a graph of accumulated cost as a function of time. **Fig. 4.1** shows an example of a baseline for a typical project. There is software to help in the realization of this type of graph, although it is commonly used which will later be used to control costs throughout the project. A very common package is the SAP R / 3, which also allow integrating all the project information (not only in terms of costs, but also human resources, documentation, etc.) with the rest of the company.

From the integration of the cost baseline and the project's income forecast, we will obtain extremely critical information, which is the need for
financing, that is, to have money before the project has generated them. This integration of the cost baseline and the forecast of income is equivalent to the estimation of the temporary cash flow that we already discussed in the previous topic. **Fig. 4.2** shows an example graph of cash flow and financial needs for the same project as in **Fig. 4.1**.

![Cash flow and financial needs](image)

**Fig. 4.2.** Cash flow in front financial needs

### 4.2 Planning of other areas (quality, risk, supplies)

Although the scope, time and cost are the classic areas of project management, these are totally insufficient to ensure its success. Here we will briefly see how to plan other areas, such as quality, risks and supplies. We have already mentioned that communications will be seen in the next topic, while human resources, including the necessary planning, will be seen in the last section of this topic. Quality, risks or supplies are such broad topics that they would fill several volumes each. We will not do here but a brief introduction to each of them. The interested reader will find at the end of this topic some references to delve into the aspect they want.

Although the word “quality” is commonly associated with the concept of luxury, within the context of engineering projects, we will understand the quality of a product or installation as the degree to which its set of inherent characteristics satisfies the requirements for which it has been designed. In general, quality is usually covered from two complementary points of view:

- **Quality Control (Quality Control or QC)** is the most specific approach and deals with the actions carried out throughout the design and construction / manufacturing processes of facilities or products to prevent deficiencies. It involves sampling and associated statistical analysis to ensure that there are no failures or problems in the product or installation.

- **Quality assurance (Quality Assurance or QA)** is a more comprehensive vision and consists of the application of planned and systematic activities related to quality, to ensure that the project uses all the processes necessary to comply with the requirements. It is about designing that all activities take quality into account so that there are no faults or defects. Quality assurance itself requires that the organization's quality system (procedures, processes, etc.) be audited against written standards. In this sense, the family of ISO 9000 quality standards (and in general ISO 9001) can be considered as the...
Over the last decades, methodologies such as total quality (TQM), the so-called 6 sigma (Six Sigma), read six sigma, etc. have been developed. The use of each of them will be conditioned by the environment and the particularities of each project. The quality of the projects is not the result of chance, but must be properly planned. The so-called quality plan is carried out within the planning process group, which will ensure the appropriate levels in this area throughout the project. The quality plan, broadly speaking, must clearly identify what are the applicable quality requirements and / or standards for the project, as well as how the project will demonstrate compliance. Quality planning must be carried out at the same time as the rest of the planning processes, since it will influence the cost and duration of the project.

We define the concept of project risk in Topic 3 as the probability of an adverse event, impact or consequence occurring, multiplied by the magnitude of said consequence. In the field of project management, we define more specifically the event or negative impact, as any event that affects one or more of the project's objectives. Examples include failing to obtain a permit from the administration to start construction of a facility (affects the project deadlines and possibly its economic profitability), the cost of raw materials for our product (affects the cost of our product and its economic profitability) or the catastrophic failure of our prototype during the tests (it affects the term, cost and profitability of our project, in addition to possibly our public image).

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECNICS</td>
<td>It is not possible to achieve the desired specifications, immature technology, obsolescence of the planned technology, etc.</td>
</tr>
<tr>
<td>COSTS</td>
<td>Material shortages or price increases, changes in macroeconomic variables (eg, currency exchange), lack of financing, etc.</td>
</tr>
<tr>
<td>TIME</td>
<td>Delay in milestones that depend on external (for example, government permits), slow work, strikes, etc.</td>
</tr>
<tr>
<td>COMPANY INTERNALS</td>
<td>Cancellation of company support mid-project, restructuring, etc.</td>
</tr>
<tr>
<td>MARKET</td>
<td>Changes in market or customer preferences, competitor actions, etc.</td>
</tr>
<tr>
<td>REGULATIONS</td>
<td>Breach of any patent, environmental regulation, environmental law, etc.</td>
</tr>
<tr>
<td>HUMAN FACTOR</td>
<td>Lack of some critical human resource, lack of motivation, lack of skills or experience, etc.</td>
</tr>
<tr>
<td>MANAGEMENT</td>
<td>Incorrect planning, excessive or non-existent control, etc.</td>
</tr>
<tr>
<td>PHYSICAL</td>
<td>Robo, sabotaje, terremoto, etc.</td>
</tr>
</tbody>
</table>

*Table 4.1. Examples of areas to identify risks in a project*

As in most aspects, correct planning is essential for the project to achieve its objectives. Risk management in a project includes, in the planning processes, the identification of risks, the qualitative and quantitative analyzes of the project and the planning of responses to those risks.
All this must be supported by a risk management plan that details the methodologies to be used in each case.

Risk identification is a key activity in risk management. We can hardly manage what we have not correctly identified. There are a number of techniques for identifying risks, from brainstorming by the project team, user interviews or expert panel discussions with more sophisticated methods (e.g., Delphi type) to the use of checklists or cause diagrams. Table 4.1 shows a series of factors, by way of example, that must be considered to identify possible risks. This activity must produce a list of risks, described by the possible associated event and its consequence in our project. In Topic 3, the identification of risks has already been discussed, as well as qualitative and quantitative analysis methods to estimate the probability of their occurrence. The analysis, however, cannot end there, but it is also necessary to estimate the damage we face if the adverse event turns out to be real. Only after knowing all this information will we be able to categorize the risks and be able to manage them properly. A very common method for this is the so-called probability-impact matrix. In this matrix we classify the risks according to their probability on one axis and according to the damage that would occur on the other axis. The most critical risks are those with high probability and large damage, while those with very low probability and small damage are those that least concern us. The use of this matrix allows to graphically visualize the different risks and helps a lot in making decisions about how to manage them.

![Figure 4.3](image.png)

**Fig. 4.3.** Example instructions for use of the probability-impact matrix at NASA
The last step in the planning processes associated with project risk is deciding how the risks identified and categorized in the previous activities will be faced. Broadly speaking, there are four ways to treat each risk:

- Eliminate the risk, through the necessary changes in design, program, etc. or even canceling the project.
- Transfer the risk to a third party, for example, through currency exchange insurance, the use of derivative contracts in raw materials, etc.
- Mitigate risk by taking measures that reduce the probability or damage in the event of occurrence. An example would be building additional prototypes of a product to check that they are working properly, or designing an installation with redundant systems.
- Accept the risk, normally monitoring and reassessing it periodically to see if it is convenient to change your decision.

The project's risk management plan must include the methodology that has been used for the identification and analysis of risk, the categorized list of risks, as well as the decided way to treat each risk. It is important to appoint a person responsible for each risk (so that nothing happens, because everyone thinks it is someone else's responsibility). Finally, it should indicate what risk management activities should be carried out throughout the project, in general, how to monitor risks and under what circumstances risk management decisions should be reassessed.

The last area that we are going to talk about in this section of other planning processes is that of supplies. Procurement activities include the processes of purchasing and acquiring materials, products, services or results outside the project team. In many cases this will include the use of contracts and other legal documentation. In many projects there will be one or more responsible for supplies (or purchases), in some cases transferred from the company's own purchasing organization. Procurement is of great importance in projects, and in some cases, can completely condition it. Such is the example of a key component of a product (ex., the chip of a laptop) or installation (ex., the turbine of a combined cycle plant). They need to be properly managed throughout the project so that they are available when needed and associated costs are minimized (ex., stock).

Supply planning begins with identifying what project needs need to be met through procurement. In some cases it will be clear (for example, the purchase of raw material), in other cases it will be necessary to make an analysis of what is more interesting, whether to buy it outside or to do it internally in the organization.
For example, a project may include its own personnel to carry out quality control activities, or it may outsource them, contracting the services to a company specialized in these tasks. The choice of one or the other alternative will depend on each particular case. After being clear about what is going to be bought or hired outside, it is necessary to define in great detail the scope of the material, product or services needed, the most appropriate type of contract (fixed price, with incentives, by administration, etc.) and what criteria must be used for the choice of the contractor or supplier (price, references, guarantees, geographic location, etc.). Finally, it will be necessary to review in the planning of times what are the moments to start carrying out the own purchasing activities (request offers from potential contractors, sign contracts, receive material) to ensure that they do not negatively influence any objective of the project. In many cases, a specific supply schedule is prepared for this.

5. Execution, control and supervision of Projects

You must respond to three lines of thought and action: 1) on the one hand, a "finding" of the reality at all times compared with original estimates (benchmarking), 2) the other a performance to hear and decide on changes in the project (change control), also comparing them on schedule, and 3) whether any of the two "findings" are suspicious of power previous result in lengthening the period, the manager and / or the PB should propose measures to prevent the negative prediction occurs (proposed remedial measures) (Fig. 5.1).

![Fig 5.1 Diagram of short-term actions regarding modifications](image)
El siguiente texto muestra una noticia extraída de reuters (www.reuters.com) el 12 de octubre de 2011 sobre los problemas existentes en la construcción de la central nuclear de Olkiluoto 3 (Finlandia). La central ha sido contratada por la compañía eléctrica TVO al gigante francés AREVA. De entre los factores responsables de las enormes pérdidas que se están produciendo en el proyecto se ha destacado la falta de buenas prácticas de gestión de proyectos.

UPDATE 2-Olkiluoto 3 nuke plant may be delayed further –TVO

TVO says Olkiluoto 3 may start in 2014 - Areva says plans fuel load by end 2012

Both blame each other for delays

HELSEINKI/ PARIS, Oct 12 (Reuters) - Finnish utility firm Teollisuuden Voima (TVO) blamed supplier Areva for further delays to the construction of its Olkiluoto 3 nuclear power plant which may further push back operations to 2014. The 1,800 megawatt plant Olkiluoto 3, Finland's fifth nuclear reactor, was originally scheduled to start operations in 2009 but delays and soaring costs meant TVO revised its start date to 2013.

TVO said its plant supplier, a consortium originally formed by France's Areva and Siemens AG (SIEGn.DE), had informed it of delays in building the reactor's automation system and in installing piping and electrical systems. TVO and Areva-Siemens disagree over who is responsible for the delays and have taken a dispute over payment to the International Chamber of Commerce. Siemens has withdrawn from the consortium. Areva on Wednesday denied the delay was its fault, saying it still plans to load nuclear fuel at Olkiluoto 3 by the end of next year and that the exact timing depends on authorisation from TVO and Finland's nuclear safety authority.

Areva Chief Executive Luc Oursel said he was surprised by TVO's announcement. "We are at this moment working with them on the details of the schedule," Oursel told reporters. "I am surprised by this premature statement that doesn't correspond to the spirit of the partnership and cooperation that I wish to see on this construction site." On Tuesday, Oursel said it was well positioned to build more nuclear reactors in Finland after learning lessons from delays and cost overruns on existing projects. TVO and Finnish nuclear consortium Fennovoima are planning to build Finland's sixth and the seventh reactors in the next decade and are expected to choose contractors in the next few years.

Areva blamed TVO's "inertia" in validating technical documents before passing them to the Finnish nuclear safety authority. But it has also encountered engineering issues. The reactor is the first of its kind, with a double containment building, a compartment isolating the molten core, six back-up diesel generators and four back-up cooling systems which Areva says would have withstood the earthquake and tsunami that struck Japan's Fukushima plant in March.

TVO said it wants an updated project schedule. "The plant supplier is responsible for the time schedule. TVO is continuing to provide support to the plant supplier to complete the project as soon as possible without compromising safety and quality," TVO's project director Jouko Silvennoinen said in a statement.
5.1 Comparative Analysis

It is the most practical system to verify the compliance deadline without waiting for the final deadline is met (Fig. 5.2). It is based on the definition of a reference model that is proposed at the beginning of the operation and to be compared with reality. The model is usually done in two ways:

- Predicting performance of items and activities that will enable the realization
- The prediction of turnover provided by each contractor during the process.

This will take into consideration the means of those who spoke at the following pages but ultimately what it is to periodically compare the forecast with what actually will occur. The result is usually given in percentage of one over the other, and this tool is taken as essentially subjective appreciation that experience brings. This is because normally you can not expect to compare when each game or activity is totally finished, but must be compared in semi-processing stages, so everything is subject to their own subjective perception. In any case the more disaggregate the project, the degree of certainty is taken into the assessment.
These tests offer them regularly and periodically throughout the cycle. As the duration is greater, we will also be testing more widely spaced. Usually for UAs with a cycle time of less than 4 or 5 months, the tests are usually done every two weeks. If the cycle time passes this value is more normal to be made monthly. And in any case, as the deadline approaches, the analysis is done with greater frequency.

**Comparative analysis of billings from contractors**

With the finalization of the contract between the contractor / s client, the contractor is normally required to commit to a forecast of billing based on the realization of the AU to be getting, billed periodically (usually every month) the cost of the achievements, works and installs. This estimate of turnover is necessary for proper planning of the expenditures that the client should do.

Projected billings is an excellent model of comparison that will reveal whether the contractor is complying with the contractual provision of project implementation and, where appropriate, of the AU on schedule. Of course the proportionality obviously keeps a check to the value of the developments and also with the efficient use of time in making, if not met, by default the billing, it is wise to suspect that the implementation is not progressing expected rate. In fact, if you cross this comparison with the previous one, is almost certain to match both in terms of diagnosis of the situation on time.

An important consideration to take into account is the billing capacity that is possible under the fingernails, which becomes the same as knowing the capacity to make an AU in a given time. This capacity
depends on:

- The physical space available for the implementation of the AU.
- The complexity is the implementation process and the interrelationship of the various elements of the AU.
- The extent of provision of existing standard elements.
- The technical capacity of the / s company / s director
- The situation of demand for equipment and labor at the time of execution.

**Comparative analysis on the provision of technical or human capital**

Also in the procurement phase and during contract negotiations between the client and / contractors, the contractor must ask what are the means that are arranged in the implementation of the AU and what technical and human resources made available. Typically, each contractor make a planning of these facilities and resources, demonstrating its suitability, with the completion, timeliness and quality required. The plan shall also indicate at what point are incorporated or subtracting means. Well, this will be the reference model, the manager and, if the project director (PM) used. And the monitoring of compliance with this commitment, it is also an excellent way to predict whether they meet deadlines for completion of activities or partial implementation of items and, therefore, whether they will be met deadlines.

One of the common situations when operations start aiming at designing and / or execute the AU, is the slowness in the provision of means and resources needed to reach the expected average. That delay also delayed the progress of work either as a construction project and has been shown that it is often very difficult to recover. This situation is fairly widespread for two main reasons:

**First**, because, indeed, when you start an operation is not needed immediately and 100%, all means and resources which are considered as the average of the necessary, but will remain strictly necessary as are being defined with further action frameworks.

**Second**, there is often begun to take seriously the inclusion of people and resources to a project when you have the assurance that begins "for real". And that happens when there have been some crucial milestones, including signing a contract, the full and expeditious clearance of "place" where the AU will be located, the inclusion of certain actors, the provision of certain services, etc..

All this causes when it begins operation, the inertia with which they move is huge and organizations often need more time than would be reasonable to begin to have the means to be truly productive. So finally, it is important the manager alarm signal and report the corresponding actor when you see that is beginning to produce one of those situations
provided for difference between means and those who are actually using.

And in general, PM must be attentive, knowing what is the bet of all players in their commitments to use certain number of resources. Monitor and control should, therefore, that additions have been made in the dates involved, and of course there are no defections (which is normal in certain situations inflationary talking constructively, which Contractors few resources are removed to others).

The execution and control (or supervision) process groups are those that are carried out once the project is already underway and until its completion. Execution processes include those activities necessary to complete the scope and meet the project objectives. Control and supervision tasks are those that aim to observe the execution of the project so that possible problems can be identified and corrective actions can be taken, if necessary, to control the execution of the project.

5.2 Supervision and control of scope, time and costs

The control of the scope of the project is in charge of reviewing the factors that can cause changes in the scope of the project and of channeling those that are really necessary, through the processes established for it. Despite what would be desirable, changes occur in all real projects, so it is necessary to have a system defined that allows them to occur without problems of organization or coordination.

The most widely used tool within this change control system (which must be, like the rest of the processes, duly documented) is the request for a change in scope. This is a document requesting (by the project team, the client or someone interested in the project) a change in scope, stating the reasons for it. This request, after being suitably approved by the competent persons (in general, those who approved the initial scope of the project) is incorporated as an attachment to the original scope to become an official part of the scope of the project. If necessary, the WBS, budget, or schedule will need to be reviewed to account for this new scope. For example, if a facility customer requests extra work not covered by the original contract, a scope change request would be made and attached to the initial contract explaining the details. This extra work would require adding some WBS work packages, some schedule activities, and possibly budget (and billing) increases. The control of time and costs of a project have many similarities. In both cases, it is necessary, as the project progresses, to determine what the current status is compared to the expected one, to identify possible non-compliance problems when they are still small, to determine when a revision of the budget or schedule is necessary and to carry out said revision when applicable.

To meet these objectives, it is usual for projects to periodically issue
project monitoring reports (for example, monthly), where the differences between the project schedule and the cost baseline are analyzed with the actual data to date. For this, an agile and efficient cost and deadline control system is necessary, almost always through the use of software programs. As we have already mentioned, an example of a widely used program is the SAP R3 modules, which allow the monitoring and control of budgets and the issuance of periodic reports, or the Primavera, which facilitates the monitoring of project deadlines and comparison with original schedules.

For the control of scope, deadlines and cost, it is quite common to use a technique that allows us to see the performance we are having of the project in a global way compared to what was originally planned. This measurement can be done, in some cases, by degree of progress in the scope of the project, but normally this will not be easy, since the degrees of achievement of objectives are not linear. For example, in the project of designing a product, the realization of a prototype or a calculation of mechanical resistance is not easy to quantify in terms of increasing the scope of the overall project. To solve this problem, several techniques are used such as the% of cost that we have used over the budget, the% of activities carried out over the total number of project activities (assuming activities of similar importance), or some more elaborate technique such as the so-called earned value. In the earned value technique, given an advance or work already carried out, the real cost that has been had is compared both with the budgeted cost for that work and with the expected cost depending on the schedule for the date we are. This technique is especially useful for cost control, resource management, and production. **Fig. 5.2** shows an example of a monthly report (extract) in three different periods.

**Monitoring of the implementation (design, construction, quality , risks, supply-chain)**

The DP, in the case of construction projects, whether to assume the leadership optional, have the power and obligation to ensure proper implementation of the AU. For this, among others, to undertake the following tasks:

- Verifying key attributes, particularly in pre-construction stages.
- Supervision of construction / completion and verification of its proper implementation in accordance with the instructions to the builder / director.
- Testing and interpretation of the quality tests and suggestions for improvement, replacement, modification or correction in general if necessary.
- Supervision of procedures for delivering work or exercise. Analysis in anticipation.
- Analysis of problems arising both those detected by the PM as expressed by the builder / director. Technical Resolution
- Verifying that made it relates to the objectified.
- Final approval for the AU will be declared fit for legalization, commissioning and operation.

In the areas of quality, risk and provisioning, the tasks to be carried out within the project execution and control processes will basically be to follow the plan that has been carried out for each area.

In the case of quality, two types of activities stand out: those related to quality assurance and those related to quality control. Those related to quality assurance will be those planned and systematic activities whose objective is to ensure that the project uses the necessary processes to meet the established quality requirements. It is common for these tasks to be performed or supervised by an independent department (commonly, the quality department). The most widely used tool is quality audits, which review the policies, processes and procedures that the project is using to verify that they are in line with the quality plan. In case of finding any discrepancy, its correction begins. The quality control tasks, for their part, are those that supervise the specific results of the project to determine that they comply with the established standards. The tools of quality control are varied and generally have to do with statistics and sampling. An example of quality control in the project of an installation would be the performance of non-destructive tests (NDT) in the welds of the metal structures to ensure that they are free of defects.

Monitoring and controlling risk in the project requires verifying that the responses to the risks identified in the risk plan are being carried out correctly. On the other hand, it will also be necessary to periodically reevaluate the risks of the project to identify the appearance of new threats and manage them appropriately.

The numerous tasks of execution and control of the procurement area will include the performance of all project hires. For each supply, the bid

Fig. 5.4. Quality control tasks monitor specific project results
The request process will be necessary, reception and evaluation of the same, selection of contractor, negotiation and issuance of the contract, reception of merchandise or service, payment and closing of the contract. In most contracts, in addition, an evaluation of the quality of the supplier and a possible follow-up of claims or adjustments will be necessary. In many projects, these activities are carried out by personnel dedicated exclusively to this type of task.

**Fig. 5.5.** Example of monthly report (extract) of a project of a facility for scientific exploration in the South Pole (IceCube) in three different periods. Note that the vertical value corresponds to cost (monetary value) and that the earned value metric is used to show the progress of the project. The first report uses a different format than the others, a more common situation than is desirable in the projects.

JUNE 2005 (41%)
ABRIL 2007 (72%)
ENERO 2011 (98%)
Track Changes

In a design and implementation of an AU is almost impossible to think that they will not produce change. So we must start from the premise that exist and the challenge for a project management team is to have no effect on the project objectives.

It is likely that in many cases no changes are likely to affect the goals, but that's an unlikely circumstance and that it must know the PB. In any case, the manager, if any, and the PM have to try to avoid, as far as possible, there are changes, and when that happens, try to control through:

- Understanding and definition of change.
- Understanding the causes of their production.
- Knowledge of the anticipated effects.
- Analysis of alternatives.
- Proposals for Action.

This procedure allows the control action, leaving the decision to the appropriate parties. But you can have all the necessary information.

In design phase, changes are being proposed solely by the customer or by the designer and in both cases do not usually cause a conflict because they do not represent substantial changes in the final term of the PLC, unless there is a change on project radical, which would lead to another order of considerations. Problematic changes occur during the implementation phase especially if the AU is a product and therefore there is construction, and defendants are essentially three ways: the designer, client and / the contractor / s. They may come through other actors, but those are the ones that produce more regularly.

The designer generated projective changes affecting the term primarily as a result of:

- Improvements in the functional solution of the AU:
  - Corrigendum projective.
  - Improvements compositional.

- The client generates primarily by:
  - Changes to goals.
  - Improvements compositional.

- The contractor's request primarily by:
  - Reduced costs associated with construction.

Those who are for the designer and the client often have negative consequences in addition to the deadline in respect of the cost. Probably the only change that does not generate increases in period is the projective errors, if detected early. Those who promote the client if they relate to compositional improvements, lead to increases almost certainly cost and probably later.
Changes requested by the contractor, are generally aimed at reducing its own costs but also the reduction of time, which ultimately also leads to a reduced cost. Obviously, the designer also proposes changes to shorten time, but much greater concern is that the line will get what he planned to "work" best, so most of their efforts is aimed ordinarily in that direction.

Knowledge, definition and causes of the proposed changes will have to realize, through the formalization of a procedure requiring the submission of written, and adequately supported in their approach, the reason for the change. This will be able to think a certain method, on the likely impact affecting some goal. Knowing the impact, the analysis of alternatives should be made jointly by the manager, the PM and if the Contractor so that the proposed solutions to preclude the failure of the target having the largest possible consensus. In this regard, it must be said that the proposals for action in which all participate usually have a high degree of accuracy. Otherwise, ie unilateral proposals often fail, therefore it is recommended to go solely by way of consensus and not waste time on ideas that do not match will always find if not rejection, apathy in putting it into action, leading inevitably to the futility of the action.

Made a change, measures to correct the negative consequences that are generally more favorable are those which go by way of seeking the quickest ways to carry out the agreed changes: more time is lost at the beginning of the implementation of the amendment than anything else. Approval of a change must come backed, ultimately, by the DP and the manager, if any, representing the client.

6. Project closure

The project closure processes (or phases) are those necessary to formally finish them. This includes the procedures that verify and document the deliverables (or facilities), as well as coordinate and interact to formalize the delivery of those deliverables (or facilities). In the event that a project is canceled before achieving its objectives, it will be necessary to investigate and document the reasons for it.

Organizations generally have procedures for the administrative closure of projects (which usually includes verification, documentation and records archiving, lessons learned, etc.) and for the closing of related contracts (both with clients and contractors).

Project closure is sometimes conflicting. It is usual to gradually decrease the personnel involved in them, who join new projects and stop paying attention to the previous project. It is necessary to ensure a minimum of efforts so that the tasks necessary for the closure (which are often underestimated) are carried out correctly. Another typical case of closure problems is that of vegetative projects. Often times, a failed project (or one that is doomed, for example, due to a lack of budget) does not close, but remains latent for political reasons or for not wanting to admit failure. Such
practices should be avoided, as they only lead to diverting energy that could be channeled to active projects.

7. Human factor in projects

The human factor in projects is, if not the most important, one of the most critical in terms of success or failure. On the other hand, the project team is far from being an arithmetic sum of the skills of each individual member. The internal dynamics of the group can enhance the capacities of its members in an amazing way or, in the worst case, ruin them in a ruinous way.

![Fig. 7.1. In projects, as in most sports, the team needs to be more than the sum of its members to be successful](image)

7.1 Human resources planning and management

A factor that influences the performance of the personnel that carry out the different activities of the projects is the organizational structure of the company in which the project is included. This structure is formed by the relationships that exist between different individuals, such as supervisory relationships, membership in different departments, or even physical distribution. In general, 3 types of structure are usually distinguished within organizations with regard to projects:

- Function structures, in which each group or department of the company is specialized in a function. Examples of departments could be design, marketing, manufacturing, or finance. Personnel in each department interact relatively little with the rest of the company and report to their department or area manager.

- Project structures, in which company personnel are directly
integrated into the project in which they work, regardless of their role (e.g., engineering, commercial, financial). There is a project manager responsible for each project to which the members of the project report.

- Matrix or mixed structures, in which workers belong to a functional area at the same time and are temporarily assigned to specific projects. It is normally impossible to maintain neutrality and the structures end up being more project than functional (the project manager has more authority than the functional one) or vice versa.

Each of the types of organizational structure has its advantages and disadvantages. The choice of one or another type of structure will depend on the needs of each organization at each specific moment. **Fig. 7.2** shows an example of the structure of each type. Within the human resources planning and management processes we can distinguish four especially important ones. As an initial step, it will be necessary to develop a human resources plan for the project, detailing the necessary roles, the capacities that must exist in the project team, the internal organization and the responsibilities of each member. Normally, it includes the preparation of the project organization chart, a histogram of personnel involved, and the selection of dates of incorporation and planned departure from the project.

The next step is to effectively incorporate the members of the project team. This activity, obvious from a theoretical point of view, is usually critical and not easy, since in most organizations people (and, even more, the most competent) are a rare commodity. The need for negotiation and even haggling between the project manager and the person in charge of the staff to join is common to achieve a solution satisfactory to all parties. During the execution of the bulk of the project activities, the activities to be carried out will include the management and development of the project team. Management will involve supervising staff, providing feedback, and resolving conflicts that will inevitably occur to optimize team performance. The development of the team will seek, on the other hand, to develop the capacities of each individual (through training or promotion activities) and those of the team (through the so-called team-building techniques).

### 7.2 Project Manager

In every project there is a particularly relevant figure that is that of the project manager. The project manager is normally appointed by the management of the mother organization and will be responsible for carrying out the project entrusted to him. It is important to distinguish the differences between the responsibilities of the project manager as responsible for achieving their objectives versus the technical legal responsibilities that may have added. These legal responsibilities will be determined by the applicable jurisdiction (different in each country).
In the Spanish case, they will be associated if the project manager is also one of the following two figures:

- The person responsible for signing the project document (memory, design, technical calculations, budget, etc.) in the case of installations.

- The person in charge of the optional management of the work, in the case of construction of an installation.

**Fig. 7.2**. Examples of functional organizational structure (a), by projects (b) and matrix (c)

- D ENG Engineering director
- D PROD Production director
- D SALES Sales director
- D FIN Financial director
- D HR Human director
- PM Project manager project A
- PM Project manager project B
- PM Project manager project C
- CEO Chief Executive Officer
The project manager (or project manager) is the person appointed by the executing organization to achieve the objectives of the project. He is also known as an administrator or project manager.

In the two previous cases, in Spain, the person responsible (whether or not he is the project manager) will have technical, civil and criminal responsibility. It should be noted that the project manager need not assume any of the above responsibilities. As projects become larger and more complicated, the project manager's tasks shift more to direction and management than technique, so he will tend to no longer have such responsibilities.

Project management is a controversial task that is often halfway between general management, technical management, and the project team. With an authority often less than what is really necessary to fulfill the objectives under his responsibility, the project manager must have a series of capacities, not excessively common skills and attitudes. You will need to perform the classic management functions of any type of organization (planning, organizing, controlling, and leading) in a particularly complicated and dynamic environment.

There are literally hundreds (see Case 5.2, Tips for Project Managers at NASA) of descriptions of the skills that a good project manager should possess.

At a minimum, you must have skills for team-building (that is, creating the right working atmosphere for teamwork to flourish), leadership (as you will be the person the entire team will look to for inspiration), conflict resolution (which will surely occur) and negotiation. In general, an attitude of orientation towards the achievement of objectives and problem solving in contrast to that of monitoring processes will also be necessary. The project manager must, on the other hand, have extensive experience in all administrative tasks such as planning, budgeting, task scheduling, or activity control. Regarding the degree of knowledge and technical experience that you should have, there is no complete consensus. Despite the fact that it is fully accepted that the project manager must have a minimum of technical knowledge in the area in which his project is encompassed, some argue that an excess of technical capabilities can detract from his management functions and be an impediment to delegate them. This is frequent, especially if we bear in mind that in many organizations (following undesirable practices), technical functional managers are promoted to the position of project manager without any specific training for it. It is usual for the recently released project manager to find the plans and calculations of the project much more attractive than for him boring schedules or budgets, and neglect the latter to focus on the former.

Currently there is a wide variety of centers that provide training in project management, generally in the master's program. Despite the fact that this
training is very interesting, the experience of working on real projects is usually irreplaceable, which is why in many organizations, in the projects, together with the corresponding project manager, an assistant is appointed with the idea that it is a training period for him. Many of the organizations that we mentioned at the beginning of this topic (IPMA, PMI, etc.), have also developed certification processes so that project management professionals can accredit their capabilities.

Despite the professional attractiveness of the figure of project manager for many engineers, as a consequence of being a generally well-paid and challenging position, we must emphasize that it is not without problems. **There is the call dark side of project management** as personal cost that project managers (and their families) often pay as a result of generally very absorbing responsibilities. During especially intense projects, such as space projects in the United States, divorce rates for project managers were estimated by companies to be twice the national average. If you are a project manager, it is very important to be aware of and manage your time and personal work properly so as not to swell negative statistics. Table 5.2 shows, with a humorous tone, signs that can lead to meeting a project manager seduced by the dark side.

Table 7.1. Warning signs to recognize a project manager seduced by the dark side

- Every Friday, he thinks there are only two days left until next week.
- At 5 o'clock in the afternoon, you think you have already spent half the workday.
- Rest or relaxation is something that does not go with it.
- There is not a day when you don't take your laptop home. The mobile or blackberry is an extension of your body without which you feel extremely nervous.
Abajo se muestra un extracto de las famosas “100 reglas para directores de proyecto de la NASA”. El listado completo (que incluye más de 100 consejos) se puede encontrar fácilmente en internet. A fecha de la revisión de este texto, se encuentra en http://askmagazine.nasa.gov/issues/14/practices/ask14_lessons_madden.html

### One Hundred Rules for NASA Project Managers

**Lessons Learned as compiled by Jerry Madden, Associate Director of the Flight Projects Directorate at NASA’s Goddard Space Flight Center. Jerry collected these gems of wisdom over a number of years from various unidentified sources. They have been edited by Rod Stewart of Mobile Data Services in Huntsville, Alabama, January 1, 1995. Updated July 9, 1996. Re-edited by Oliver F. Lehmann, Ismaning, Germany (pmp.oliverlehmann.com).**

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### 1. The Project Manager

**Rule 1:** A project manager should visit everyone who is building anything for his project at least once, should know all the managers on his project (both government and contractor), and know the integration team members. People like to know that the project manager is interested in their work and the best proof is for the manager to visit them and see first hand what they are doing.

**Rule 2:** A project manager must know what motivates the project contractors (i.e., their award system, their fiscal system, their policies, and their company culture).

**Rule 3:** Management principles still are the same. It is just that the tools have changed. You still find the right people to do the work and get out of the way so they can do it.

**Rule 4:** Whoever you deal with, deal fairly. Space is a big playing field. You may be surprised how often you have to work with the same people. Better they respect you than carry a grudge.

**Rule 5:** Vicious, despicable, or thoroughly disliked persons, gentlemen, and ladies can be project managers. Lost souls, procrastinators, and wishy-washies can not.

**Rule 6:** A comfortable project manager is one waiting for his next assignment or one on the verge of failure. Security is not normal to project management.

**Rule 7:** One problem new managers face is that everyone wants to solve their problems. Old managers were told by senior management—“solve your own darn problems, that is what we hired you to do.”

**Rule 8:** Running fast does not take the place of thinking for yourself. You must take time to smell the roses. For your work, you must take time to understand the consequences of your actions.

**Rule 9:** The boss may not know how to do the work but he has to know what he wants. The boss had better find out what he expects and wants if he...
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<th>Rule 10:</th>
<th>Rule 12: Don't get too egoistical so that you can't change your position, especially if your personnel tell you that you are wrong. You should cultivate an attitude on the project where your personnel know they can tell you of wrong decisions.</th>
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<td>Rule 11: Never try to get even for some slight by anyone on the project. It is not good form and it puts you on the same level as the other person and, besides, probably ends up hurting the project getting done.</td>
<td>Rule 13: A manager who is his own systems engineer or financial manager is one who will probably try to do open heart surgery on himself.</td>
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<td>Rule 14: Most managers succeed on the strength and skill of their staff.</td>
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<td>Rule 15: The seeds of problems are laid down early. Initial planning is the most vital part of a project. The review of</td>
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<td>Rule 16: Cooperative efforts require good communications and early warning systems. A project manager should try to keep his partners aware of what is going on and should be the one who tells them first of any rumor or actual changes in plan. The partners should be consulted before things are put in final form, even if they only have a small piece of the action. A project manager who blindsides his partners will be treated in kind and will be considered a person of no integrity.</td>
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<td>Rule 18: Most international meetings are held in English. This is a foreign language to most participants such as Americans, Germans, Italians, etc. It is important to have adequate discussions so that there are no misinterpretations of what is said.</td>
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<td>Rule 19: You cannot be ignorant of the language of the area you manage or with that of areas with which you interface. Education is a must for the modern manager. There are simple courses available to learn computerese, communicationese and all the rest of the modern &quot;ese's&quot; of the world. You can't manage if you don't understand what is being said or written.</td>
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<td>Rule 20: You cannot watch everything. What you can watch is the people. They have to know you will not accept a poor job.</td>
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<td>Rule 21: We have developed a set of people whose self interest is more paramount than the work or at least it appears so to older managers. It appears to the older managers that the newer ones are more interested in form than in substance. The question is are old managers right or just old? Consider both viewpoints.</td>
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<td>Rule 22: A good technician, quality inspector, and straw boss are more important in obtaining a good product than all the paper and reviews.</td>
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Fig. 7.3. The dangers of project management certification have reached Dilbert's company.

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