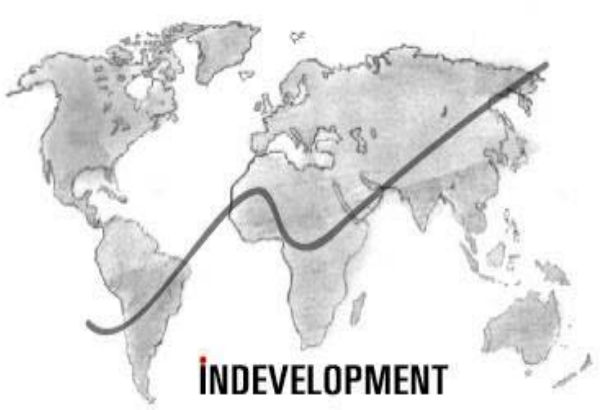

PROJECT MANAGEMENT FOR CIVIL ENGINEERS

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INDEVELOPMENT

PROJECT MANAGEMENT FOR CIVIL ENGINEERS

Edition 2004.

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1 STRUCTURING PROJECTS

Routine versus project approach

In most industrial sectors (including agricultural) the production of the goods is more or less a routine process. Production of infrastructure is on the other hand usually not a routine. The construction output is a prototype and usually addresses specific needs and demands. The design of each piece of infrastructure is unique and purpose specific. Therefore the project approach is widely considered to be more appropriate in the construction industry. A big difference between routine and project production is that routine production uses one design to produce hundreds, thousands, or even millions of exactly the same goods, whereas the project approach usually result in one unique product. Although an existing design may be modified over and over again, the final product is always different. This implies that final characteristics of the product are uncertain at the start of the project.

Project characteristics

Projects have the following characteristics:

- A project is carried out only once for an exceptional case
- A project has a fixed deadline and start- and finish dates
- Every project has a clearly formulated purpose, usually solving a unique problem or the development of a unique idea.

Unique

A traffic congestion problem and the development of a water distribution system are typical examples of such unique problems and ideas.

Managing projects

To deal with the higher uncertainties, projects require different management technologies than routine operations.

Project activities

In each project three kinds of activities will take place:

1. Decisions, about the project results, impacts and resources
2. Work on substance (outputs, activities, tasks)
3. Managing resources (time, budget, information and project staff) and controlling quality

Clients' involvement

Because only one design in the end can be implemented and to avoid unnecessary work, the project manager and the client should agree upon at what moment the decisions have to be taken to direct the project. The choice of moments depends on the wish of the client to be involved in the decision taking process. Many private clients are not familiar with the processes in the construction industry. The project manager obliged to assist the clients to develop an understanding of the building process and its risks to make decisions.

The procurement of constructions is costly to most clients and easily exceeds the cost of expensive mass produced items, like refrigerators, washing machines and cars. While purchasing expensive mass produce items most costumers spend a lot of type comparing different and competing products on basis of their quality and costs. It is

therefore not more than logical that the client should be involved in judging and comparing alternative designs of the construction it intends to procure.

Phasing

However it is not in the client's and project's interest that the client is available to take every single decision. The project manager has to develop decision moments, moments in which the client is given time to take decisions about the project. Several decisions are possible, among which are:

- Stop the project
- Eliminate design alternatives
- Choosing one alternative to be implemented
- Redirect the project and redo the previous phase
- Other options

The period between two decision moments are called phases.

Decision indicators

In all cases the number of decisions and the decisions themselves are based on the performance assessments. Businesses will use profit as their main indicator. Profit includes all (future) expenditures, which are always one element in the performance assessments (the cost element). Other elements (the benefit elements) vary from infrastructure to infrastructure. The Highway department may use indicators like, congestion and accidents, where a provincial or district road agency will also include the number of households (villages) connected. Water supply- and electricity agencies often consider the profitability but also the number of household served as their performance indicators.

Number of decision moments

The numbers of decision moments do not only depend on the needs of the client, but also on the chance that new information will come forward. Usually it is possible to provide more accurate cost estimates when more details about risky elements like ground works becomes available. It is not always possible to provide more accurate benefit or impact assessments on basis of more detailed designs.

Basically projects can be phased in three ways:

1. Linear
2. Cyclic
3. Parallel

Linear phasing

Linear phasing is common on most infrastructure projects. These projects are concrete and the share of expected unknown information with regard to the end result is relatively low. It is therefore possible to define the project results from the start. A typical linear phased project would distinguish five phase:

1. Initiating phase; in which the project manager and the principle agree on the result (idea/problem) and the project plan
2. Defining phase: Basically defining the performance of the end result; producing a schedule of requirements
3. Design phase: resulting in a detailed design
4. Preparation phase; resulting in signed contracts with a contractor or a detailed implementation plan for force account works
5. Implementation.

In most infrastructure projects the defining phase is used to gather information from other stakeholders, like the communities involved or addressed with this project. Usually the performance requirements of the organisation is known and standardised. The design phase may be divided in three different phases, resulting in the following products:

1. Rough draft/sketch plan
2. Preliminary design
3. Detailed design

Each of these stages starts with detailing/modifying the existing schedule of requirements.

During the preparation phase, the tender documents (specifications, drawings and contract documents) are prepared and the bidding process is completed.

Parallel phasing

The second next common phasing structure of infrastructure projects is the parallel phasing. In particular big foreign funded projects are phased in this way. The project is divided in many sub-projects. Before the sub-projects start, an overall schedule of requirements is defined, basically presenting the performance indicators. From that point onwards each of the subprojects starts designing the specific outputs. At some point the subprojects are grouped back into the mother project. This could for example be done during the preparation phase when the works are contracted out to one big contractor or when the assets are created and handed over to principle government.

Development phasing

Cyclic phasing is more appropriate for product development projects (R+D). However it is possible to apply one of the sub-Cyclic phasing approaches on complex infrastructure projects: development phasing. Development phasing is usually more common in building/architecture projects, where the client is not capable to define all his/her wishes and requirements. After a design is completed, based on a certain schedule of requirements, that schedule of requirements is redefined and the output has to be redesigned as well. This iterative process may occur several times till design and schedule of requirements are actually meeting the demands of the client.

Version Phasing

The other form of Cyclic phasing, version phasing could also be applied on infrastructure projects. Although it usually not intended. Normally it relates to problems for which many possible solutions exist and it is very difficult to predict the impacts of these solutions. In these situations, one idea is worked out, implemented and its impacts are monitored. When that idea does not result in the wanted impacts the project may modify or revise completely the idea (read construction). Projects addressing traffic accidents are often phased this way.

1.1 WORK PLAN

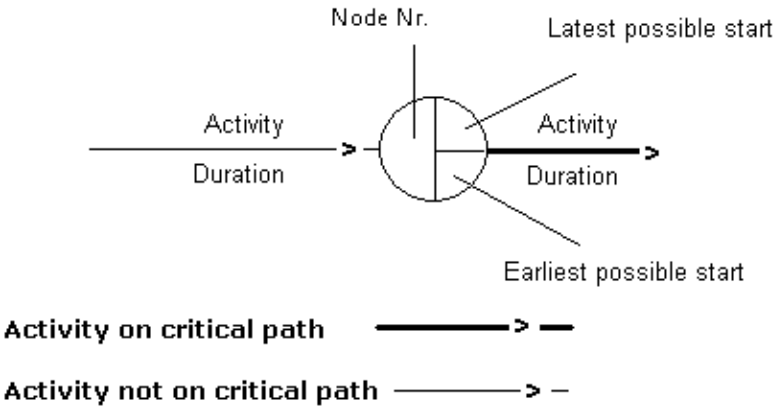
Work plan

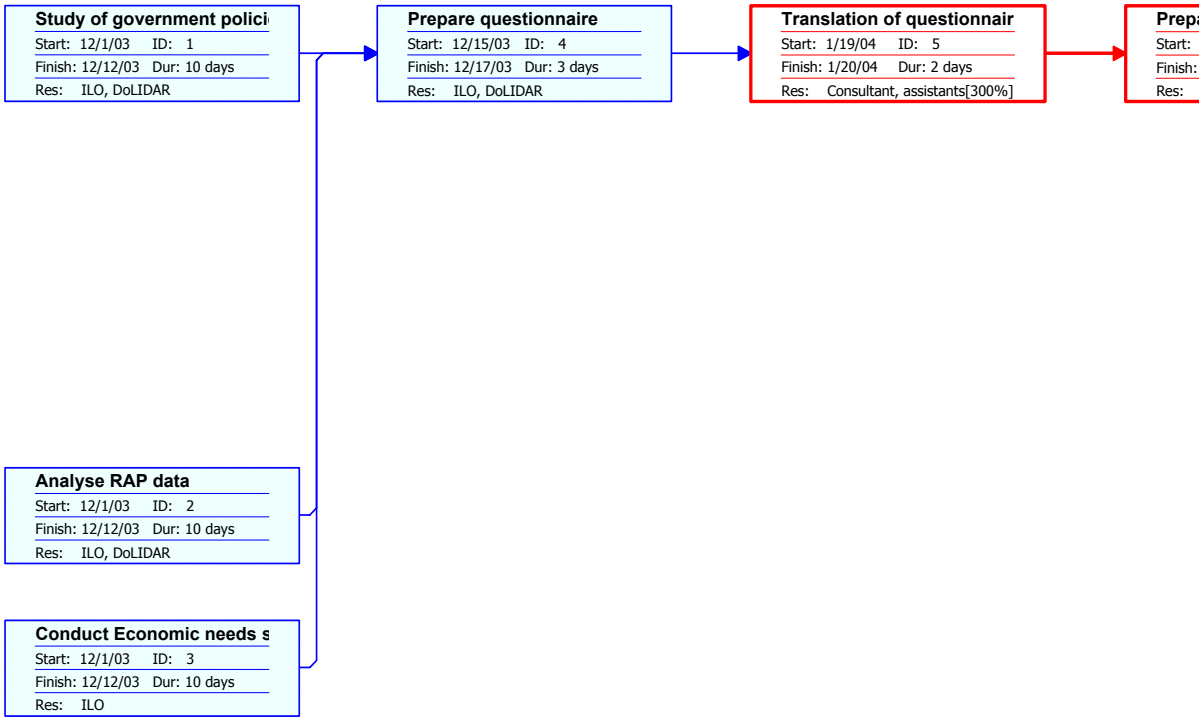
After the project is structured in phases, the project manager has to develop a work plan for the project. For the first coming phase this work plan has be very detailed. Later phases require fewer details. A work plan shows all tasks that have to be carried out to produce all necessary outputs/services. It describes who are involved in these activities and when the activity takes place. A good work plan also presents the relationships between the different tasks (successors and predecessors).

Typical ways of presenting work plans are network plans and chant charts.

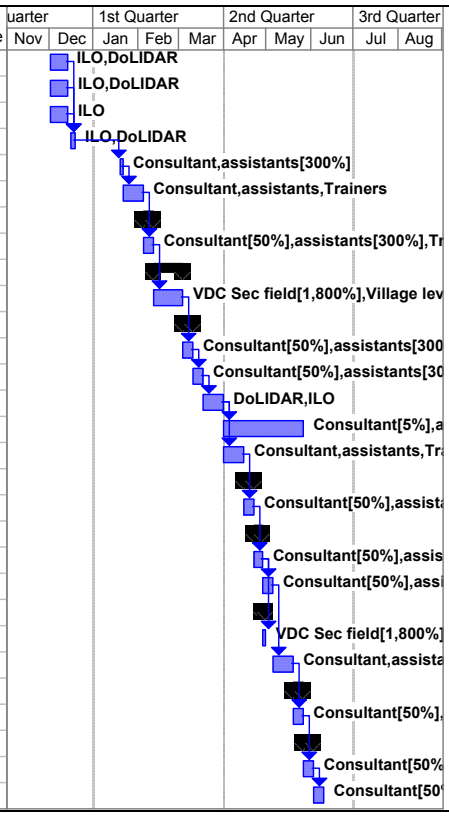
Network plans can be presented in two ways:
1. Activity on the Arrow (critical path method)
2. Activity in the node (PERT chart)

The figures below respectively present the legend for the Activity on the Arrow chart, an example of a PERT chart and an example of a Gant chart.




Study of government polici
Start: 12/1/03 ID: 1
Finish: 12/12/03 Dur: 10 days
Res: ILO, DoLIDAR
Prepare questionnaire
Start: 12/15/03 ID: 4
Finish: 12/17/03 Dur: 3 days
Res: ILO, DoLIDAR
Translation of questionnair
Start: 1/19/04 ID: 5
Finish: 1/20/04 Dur: 2 days
Res: Consultant, assistants[300%]
Prep
Start:
Finish:
Res:
Analyse RAP data
Start: 12/1/03 ID: 2
Finish: 12/12/03 Dur: 10 days
Res: ILO, DoLIDAR
Conduct Economic needs s
Start: 12/1/03 ID: 3
Finish: 12/12/03 Dur: 10 days
Res: ILO

ID	Task Name	Duration	Start	Finish	Prede
1	Study of government policies	10 days	Mon 12/1/03	Fri 12/12/03	
2	Analyse RAP data	10 days	Mon 12/1/03	Fri 12/12/03	
3	Conduct Economic needs study	10 days	Mon 12/1/03	Fri 12/12/03	
4	Prepare questionnaire	3 days	Mon 12/15/03	Wed 12/17/03	1,2,3
5	Translation of questionnaire	2 days	Mon 1/19/04	Tue 1/20/04	4
6	Preparation of data collection training	10 days	Wed 1/21/04	Tue 2/3/04	5
7	**Data collection training**	**5 days**	**Wed 2/4/04**	**Tue 2/10/04**	
8	District 1, batch 1	5 days	Wed 2/4/04	Tue 2/10/04	6
9	**Data collection**	**15 days**	**Wed 2/11/04**	**Tue 3/2/04**	
10	District 1, batch 1	15 days	Wed 2/11/04	Tue 3/2/04	8
11	**Data verification and gap filling**	**5 days**	**Wed 3/3/04**	**Tue 3/9/04**	
12	District 1, batch 1	5 days	Wed 3/3/04	Tue 3/9/04	10
13	Data analysis and storing	5 days	Wed 3/10/04	Tue 3/16/04	12
14	Updating manual + training materials	10 days	Wed 3/17/04	Tue 3/30/04	13
15	Translation of updated Manual	40 days	Wed 3/31/04	Tue 5/25/04	14
16	Preparing t2 workshop	10 days	Wed 3/31/04	Tue 4/13/04	14
17	**T2 workshops**	**5 days**	**Wed 4/14/04**	**Tue 4/20/04**	
18	District 1, batch 1	5 days	Wed 4/14/04	Tue 4/20/04	16
19	**Data verification and gap filling**	**5 days**	**Wed 4/21/04**	**Tue 4/27/04**	
20	District 1, batch 1	5 days	Wed 4/21/04	Tue 4/27/04	18
21	Data analysis and storing	5 days	Wed 4/28/04	Tue 5/4/04	20
22	**Project identification meetings**	**1.67 days**	**Wed 4/28/04**	**Thu 4/29/04**	
23	District 1, batch 1	1.67 days	Wed 4/28/04	Thu 4/29/04	20
24	Preparing t3 workshop	10 days	Wed 5/5/04	Tue 5/18/04	21
25	**T3 workshops**	**5 days**	**Wed 5/19/04**	**Tue 5/25/04**	
26	District 1, batch 1	5 days	Wed 5/19/04	Tue 5/25/04	24
27	**Data verification and gap filling**	**5 days**	**Wed 5/26/04**	**Tue 6/1/04**	
28	District 1, batch 1	5 days	Wed 5/26/04	Tue 6/1/04	26
29	Data analysis and storing	5 days	Wed 6/2/04	Tue 6/8/04	28



First draft

Preparing work plans is an iterative process. It is almost impossible to provide immediately accurate answers on every questions, like for example, when key resources are needed, are available, how much time an activity will need etc. The planner will usually start with rough estimates to prepare a first version and modify this when more accurate information becomes available. Planners will have to make notes on their assumptions, which influences the plan. Important considerations during the planning exercise are:

- Relationships with other projects or departments: If the project depends on the work of others, do the others understand the project's dependency and agree to the hand-off dates?
- Resources[1] availability and usage (including people, materials, and equipment): Who manages the resources?
- Activity duration's: What is the base of Activity duration estimates?
- Project costs: What is the base of the project/activity costs? Who approves the budget?
- Available time: Is the deadline for the task fixed or flexible?
- Deliverables

Schedule a project

Projects are scheduled from the start date when the project finish date is not yet determined. This is usually the situation for most infrastructure projects. However some infrastructure projects, for

[1] Resources Material, facilities, equipment, and people, and the costs associated with them.

example school buildings, have to be completed before a certain deadline and are therefore scheduled from the finish date. Scheduling from the finish date means that the project will be scheduled backwards from a particular date, with each activity finishing as late as possible while still making the end date.

Activity duration and dependencies

The project manager determines which activities are necessary, and makes an estimate about the duration of these activities, the amount of resources needed and relationship between these activities. The number of labourers and type of equipment often determine the duration of an activity. However the duration of some activities depends also on other factors, like for example of curing of concrete or ordering of materials. These activities have so-called lead-times.

Activity dependencies

The nature of the relationship between two linked activities defines a dependency between their finish and start dates. For example, the "Preparation of Contract document" activity must finish before the start of the "Signing contract" activity. There are four kinds of activity dependencies:

Act. Dependency	Description
Finish-to-start (FS)	Activity (B) cannot start until Activity (A) finishes.
Start-to-start (SS)	Activity (B) cannot start until activity (A) starts.
Finish-to-finish (FF)	Activity (B) cannot finish until activity (A) finishes.
Start-to-finish (SF)	Activity (B) cannot finish until activity (A) starts.

Activities can also be related to specific dates. For example production of asphalt concrete should not take place during the rainy season or the blasting of an old viaduct should be done on Sunday October 13, etc.

Sequence of activities

Sometimes a succeeding activity cannot immediately start after the completion of the preceding activity, like for example casting of concrete and removing of formwork. The minimum time between the finish date of the preceding and the earliest possible start date of succeeding activity is called lag time.

1.2 PLAN FOR AND PROCURE RESOURCES

Estimate resources needed

After all activities and tasks have been determined, the project manager may start allocating resources to activities and specific tasks.

Historical data

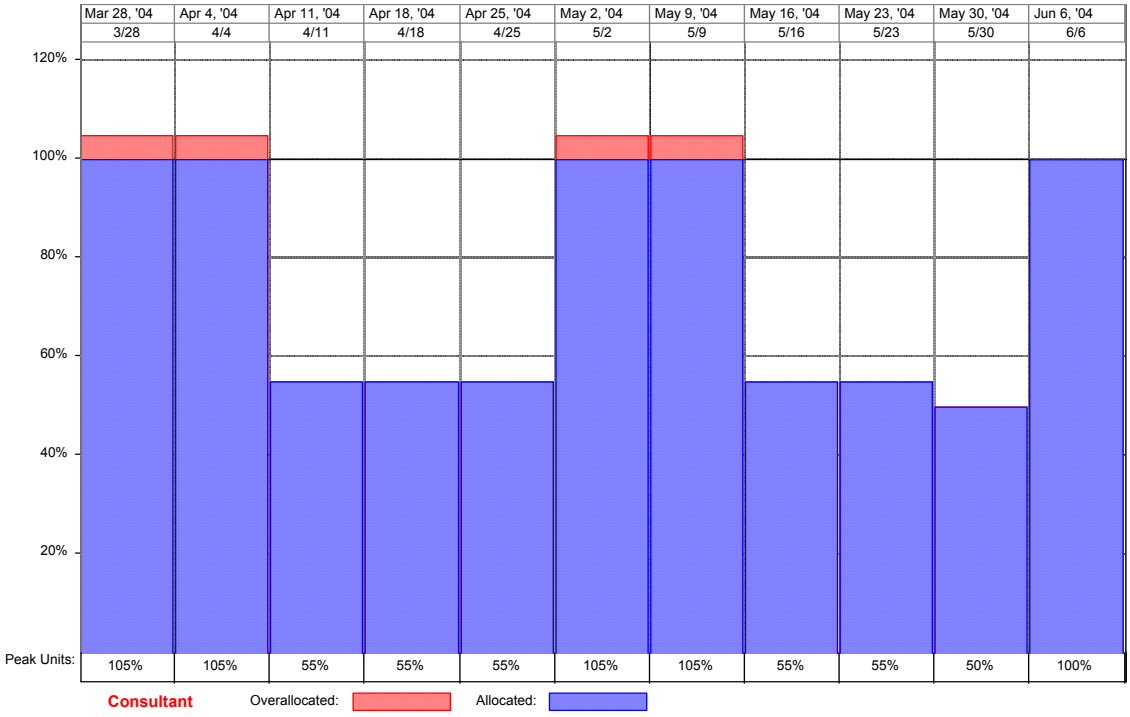
(S) he may obtain the data from a manual, but an update from other historical resources is always highly recommended to adjust the duration information to the specific circumstances. Professional organisations collect historical information from old project files, databases, and from people who have worked on similar projects on regular intervals. Smaller, more pioneering organisations may try to review any available post-mortem information from previous projects. Project managers should in particular search for information on the types and numbers of resources used.

Refine duration estimates

It goes without saying that the duration estimates should be upgraded, when more accurate information comes forward or when the allocation of resources is changed.

Resource graphs

Resource graphs shows what resources are needed and when. It is aso shows when certain resources are overallocated. Typical resource graphs are labour schedules, plant and transport schedules and materials schedules. A typical resource graph is presented below.



Labour schedules

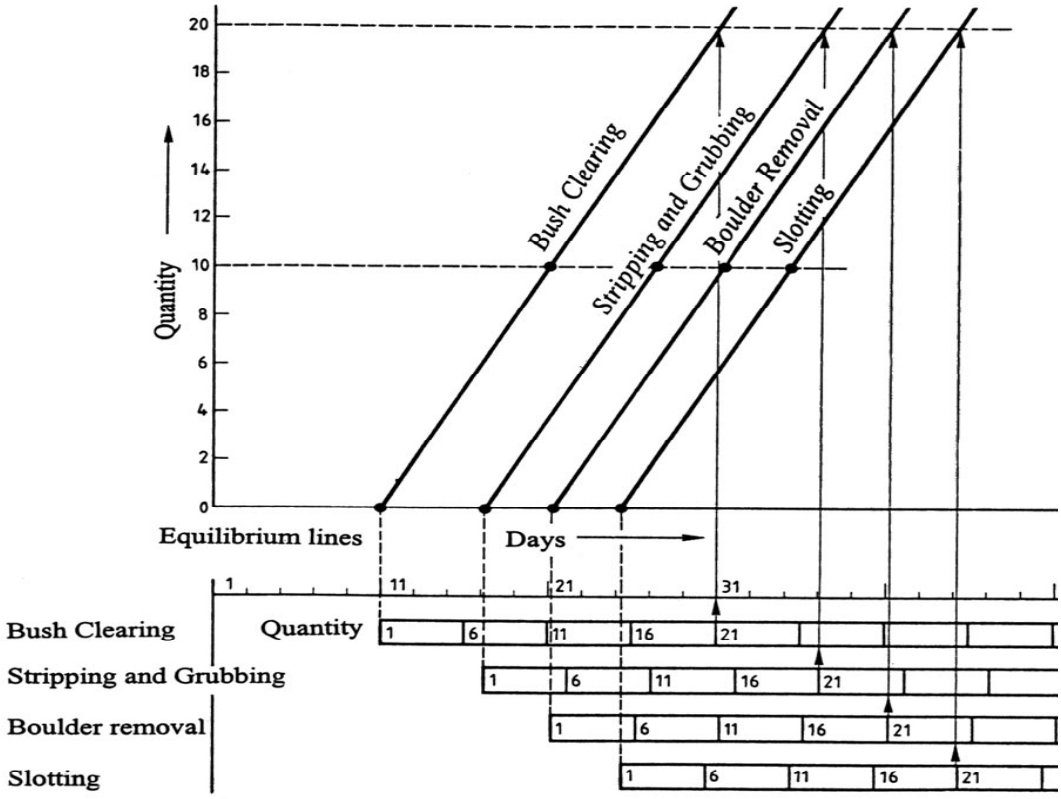
The construction of infrastructure requires besides flexible unskilled labourers also many specialised labourers. Those labourers with the same qualifications are positioned in the same so-called labour pool. To avoid reduction in productivity due to reduced motivation and start and finish periods it is advisable to aim for an even workload for each of the labour-pools. This is even more of interest for those organisations, which have employed the labour-force on a permanent basis.
This is achieved by a continuing exchange between the labour schedule and the chant chart or network plan. The labour schedules are drawn up using the chant charts already prepared. For each activity the number of workers from each labour pool is recorded.

Plant and transport schedules

Expensive plant and transport vehicles are generally planned to be 100% utilised. Cheaper plant and transport vehicles are generally planned to fit in with the prepared plan.

Besides for aiming at constant utilisation of the different resource pools, the project manager (in particular during the implementation phase) wants to avoid that a succeeding activity will overtake a preceding

activity. The project manager prefers therefore that all activities will run at the same speed.



Material schedule

Material schedules act as a guide for ordering materials, but also serves as a checklist of materials needed. It is usually minor items that get forgotten and cause temporarily delays.

Meeting deadlines

Changing the duration is one method to help meeting deadlines, resolve resource over-allocations, and budget cuts.
Another option to meet the deadlines is the creation of sub-projects. If a big project contains a number of outputs or an output, which can be segmented, it may be advisable to use this technique. Segmenting of road works will result in many production gangs undertaking the same activity at the same time.

Specify resource availability:

Availability of resources refers to the availability of resources to work on the project, that is, whether the resource is working half time or full time on the project, whether there are two or three of the same resource, and whether the resource's availability changes at any point.
Infrastructure projects may compete with the agricultural sector to attract workers during the harvest seasons.
The more familiar, project managers are with resource capabilities, the more efficiently and effectively these resources can be assigned to the

different tasks. Project managers should also be familiar with equipment preventive maintenance schedules, especially when equipment is not rented. A special plan should be developed to present the rate of consumption for materials, their costs and specifically when they need to be purchased. If the project does not purchase from regular suppliers, time should be allocated for the selection of these suppliers.

1.3 MORE INFORMATION

Web-sites

There are a number of web-sites discussing development of work plans in more detail, like:

- http://www.pmi.org/publictn/pmboktoc.htm
- http://www.4pm.com/books/mecp.html
- http://www.netmba.com/operations/project/cpm/

2 RISK MANAGEMENT PLAN

A complete and detailed project plan provides guidance through the expected events of the project. But what will provide guidance for the unexpected events, especially those events that pose a risk to the project? A risk management plan enables project managers to deal swiftly and effectively with most risks that might arise. It is a strategy that is well thought out prior action, to eliminate risks when they occur.

Risk management doesn't remove all the risks. It identifies the consequences of individual risks. Like the work plan, the risk management plan is an evolving plan. It needs to be updated on regular intervals. Usually the same interval for updating the work plan is chosen. It is also updated when new information comes forward. Sometimes it is necessary to actively look for new information to identify the most appropriate action.

The risk management plan is often presented in the form of Risk Registers. The contents of the register can be very simple:

1. Description of the Risk
2. Action plan to mitigate or reduce risk

It is possible to add information to the register like:

- Description of the causes of the risk
- Description of likelihood and consequences of risk
- Relative importance of the risk compared to other risks
- Triggers, or indicators, that a risk has occurred or is about to occur

And per action:

- Required capacity
- Required timing of action
- An assessment of the residual risk after action
- Estimated cost
- Cost-benefit analysis
- Suggested actor to control risk

It is however not always possible to select the measure immediately and sometimes it is necessary to carry out some investigations. Risk management plans may therefore include flow charts with information about:

- Activators
- Checkpoints
- Point plotter
- Terminators

Activators
Checkpoints

The activators define the conditions when the plan has to be used. Once the plan is activated, the next step is often to investigate assignable causes. The checkpoints instruct what needs to be

investigated.

Point plotter — The point plotter determines whether the item is indeed the assignable cause or the investigation has to continue.

Terminator — Terminators are the actions to eliminate causes of the risks.

Definition — A risk is the combination of the likelihood that an adverse event will take place and the consequences of the adverse event. The consequences or damages are often expressed in monetary terms (costs).

Risks are often expressed in a formula:

Risk= Likelihood * Consequences

The likelihood is the probability or frequency of occurrence of a defined hazard often expressed in the number of occurrences per year.

In this formula, risks are expressed in costs per year.

Besides difficulties of determining realistic figures for the consequences and likelihood, the formula poses another problem. It has difficulties to deal with potential catastrophic events with a near to zero probability. According to the formula the risk can be neglected. However because the damages are catastrophic it is best to avoid the risk and to insure against it.

Scale points — It may be extremely difficult and costly to determine the probability and consequences of a particular event. Alternatively the project manager and his/her team may use scale points to describe the importance of the risks.
The team estimates and values the occurrence of the risk with a mark. Similarly the team estimates and values the consequences of the risk with a mark. The marks are presented on a scale from 1 to 10 (where 1 is the minimum and 10 is the maximum). The marks are multiplied with each other. The highest possible value of a risk is 100 and the minimum is 1.

Typical risks — Typical risks in the construction industry are:

- Cost, time overruns
- Unacceptable quality
- Weather
- Health and safety
- Environment
- Soil conditions

Project managers should be in particular cautious about the soil and environmental conditions. The project site may be located on an old dump yard and therefore its soil may be heavily contaminated. In many countries the project has to treat the soil prior construction or dispose the soil at certain facilities. These facilities store or clean the polluted

soil. It often results in additional costs to the project.

Note that only a small portion of the soil is investigated. A ratio of 1/10,000 is already a very high proportion. This means that a large part of the soil is to some extend unknown. The location of the samples influences the reliability of the information. If the sample is taken at the exact location of the pile foundation, it becomes more likely that the correct length of the pile can be determined prior drilling. When the soil characteristics changes between neighbouring samples it is often necessary to take some more samples between these two samples. Besides sampling the soil, it is advisable to study aerial pictures, interview the people in the neighbourhood of the project to obtain information about the history of the soil.

The client of the project is not only affected by the construction related risks but bears another set of risks to his/her business due to the project, e.g.:

- Financial and economic risks
- Social risks
- Environmental risks
- Operation and Maintenance consequences

Depending on his/her job description, the project manager looks beyond the risks to the construction project and has to take into account the risks to the client's business.

For example the project manager should not only provide the most realistic cost estimate. It is also necessary to develop several pessimistic scenarios.

Risk identification

The first and most important step for the preparation of the risk management plan is to identify everything that can go wrong with regard to achieving a certain objective.

During the design stage, it is necessary to identify the risks that are caused by the design features of the product (construction, infrastructure). Most of these risks are relevant to clients and the regulators.

During the preparation phase and the implementation phase of the project, the project management has to identify the risks caused by uncertainties in the production process. Thus the project management needs to have insight to what degree the result of the production process can be statistically and technically controlled.

During these phases the project management would develop a task force that is responsible for assessing the risks. The task force can be composed of operators, maintenance engineer, construction engineers and design engineers. The main questions this task force has to answer:

- What are potential causes that the product does not meet its specifications?
- How can the production process influence the product characteristics and result in a failure?

The work plan presents the sequence of activities and is therefore a good guideline to identify the risks during the construction process. For every activity the things that can go wrong and their causes are identified. Typical causes are related to:

- Human inputs
- Equipment
- Production method
- Raw materials and semi-finished products
- Site (soil conditions, weather, etc)
- Measurement techniques

It is important to describe the risk and the causes as concise and specific possible. Some risk may arise from a combination of events.

Revise plan to reduce risks

As the project progresses, more accurate and realistic data will be available about the duration, used resources and budget, project managers will have to adjust the plans already prepared.

Allow for some buffers

Every project should have buffers with regard time, resources and budget deadlines. These buffers give projects flexibility. The buffers ideally are based on the probability of expected variances in the estimates of costs, duration and resources for each activity.

Some rules of the thumb:

- Projects should do all their thinking first, before going anywhere near the site. Allow the contractor to prepare technical designs and construction plans prior start of the construction activities.
- Plan from a month before the deadline.
- Never allocate resource inputs of people and equipment for 100%. This will result in constraints. A more realistic figure is 80% allocation for professionals and equipment, 50% for middle management and 20% for senior management.
- Present the accuracy of cost and time estimate per activity. (The more detailed an estimate the more accurate the estimate is.)
- Progress reports without proposals for changes, are indications that something is seriously wrong!

Time management

Certain activities can be considered more risky than others. For example activities for which the estimated duration is a pure guess are a potential risk. Activities with long duration or those depending of uncontrollable resources are also potential risks. But the most potential risks have those activities, which immediately result in a delay of the whole project if they are delayed. These activities are on the so-called critical path.

Critical path method

The critical path method can help the project manager to establish the

margins/buffers within the project. The critical path method is presented as an activity on the arrow network plan. The network is composed of path or links. Each path presents an activity. The longest path is the critical path. Delaying any activity on the critical path will immediately result in a delay of the total project. The first and last activities are always on this critical path.

The critical path can be identified by determining the following five parameters for each activity:

Duration.

ES – earliest start time: the earliest time at which the activity can start given that its precedent activities must be completed first.

EF – earliest finish time, equal to the earliest start time for the activity plus the time required to complete the activity.

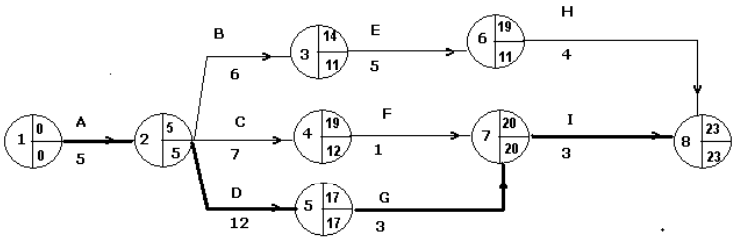
LF – latest finish time: the latest time at which the activity can be completed without delaying the project.

LS – latest start time, equal to the latest finish time minus the time required to complete the activity.

Slack time

The slack time for an activity is the time between its earliest and latest start time, or between its earliest and latest finish time. Slack is the amount of time that an activity can be delayed past its earliest start or earliest finish without delaying the project. Thus, the activities on the critical path do not have any slack time.

To calculate the slack time, it is necessary to calculate the project in two directions. First the earliest start of all activities is calculated through scheduling the project from the starting date, where all activities take place as soon as possible. Subsequently the project is scheduled from the latest finish date. Now all activities are scheduled to take place as late as possible and the respective latest possible starting dates are registered.



Perhaps a time-overrun risk can be avoided to replace an activity with a long duration with two or more overlapping activities with smaller outputs and smaller duration's.

2.1 TRANSFERING RESPONSIBILITIES

The construction industry is characterised by its procurement nature. Contract documents are tools for managing and transferring risks. Among others contract documents formulise the risk management responsibilities.

The contract has to make provisions for a range of “what if” scenarios. It describes the roles, tasks, authorities of the client and contractor in these situations. It also provides detailed information about the project and project conditions. This information reduces uncertainties. Not only about the construction project itself, but also about the practical and financial consequences when uncertainties eventuate into reality.

Contract frameworks are adaptable tools

There are many standard frameworks of contract, like FIDIC and ICE. Clients and their engineers should be careful to apply these documents without amending the risk transfer clauses. Risks may have consequences for the assets (the output of the project), the business of the client or it may be limited to difficulties during the construction process. It is very unlikely that a contractor will feel responsible for the risks to the assets after completion of his/her contract obligations. A client, who intends to occupy the building, has all the incentives to reduce risks to it. The contract should provide incentives to the responsible actor to manage the risks. The division of responsibilities depends also on the capacities of the different actors involved in the construction process. Contractors usually have more knowledge and skills with regard to technologies and therefore are more aware of their respective risks. The smaller contractors in low and middle-income countries may lack the financial capacity (cash flow) to advance the construction costs and bear the financial consequences of the risk. The risk transfer arrangements therefore should have consequences for the selection of the contractor. Smaller contractors may want to avoid to risky contract offers.

Clients are in particular concerned about the quality of the design. The last thing they want to happen is that the construction collapses or becomes a public treat.

In some countries, the law has formalised these responsibilities. For example in France the contractors carry this burden. The contractors operating in France, therefore have to assess the quality of the design.

In other countries, the designers and architects may have to provide the design warranties. But because most designs are based on an uncertainty and therefore may have to be modified during the construction phase, in most countries the contractors are held responsible.

Regardless who is responsible, there is always the problem that it is possible to identify several rivalling causes of the damage, which

insurance companies may want to exploit. For example according several reports claim that damaged spillways of the Pemba Small Scale Irrigation projects were caused by a severe typhoon. However my personal assessment was that the concrete structures lacked reinforcement, cut-off walls and its floor was simply to weak to carry the water pressure and the foundation of the floor was to porous.

3 SITE ORGANISATION & ADMINISTRATION

3.1 SITE LAYOUT

Good site layout is important to increase the productivity. The site layout can be judged on the efficiency of the production process. With a bad layout, time and materials are wasted through double handling. Transport and handling of materials always cost money. Every time a stack of bags of cement is transported over the site the actual cost increases. The layout of the site will depend upon two main factors: the methods and sequence of activities and the space available. Some basic principles for the design and evaluation of the site layouts are:

- Minimise handling and stacking time
- Reduce distances that materials and labourers have to travel
- Are the piles of stacks of materials located close to where they are to be used

Generally, the site will have to accommodate a variety of temporary buildings, materials, plant and equipment at different times. Schedules will be needed to present their respective times of arrival and departure from the site. Particular care should be taken to avoid items blocking access and interfering with the activities at the various stages of a project. It is essential to list all the items and storage area that will be needed on site, and to locate their position on a site plan.
Good layout is most important when the product or materials being used are very heavy or big. Without a precise site layout plan, neither the site manager nor other site staff will have a clear indication of where stores and offices, items of plant, work areas and stacks of materials should be located. On a cramped or complicated site, a series of plans will be needed covering the layout at each stage of the work.

3.2 SITE ADMINISTRATION

The administration of the construction works is very important. After all it is the basis for many management, organisational and accounting affairs. It is important to present the

- Physical progress
- Financial progress
- Final reporting

Diary

The site-foremen usually keep a diary of the progress of the work. The diary is the basis for a week report. It presents among others:

- Number of man-days used
- Clarification of the difference between the budget and real resources
- Usage of equipment
- And general information like, agreements, undertaken activities, constraints in progress and damages.

Both the contractor and client review and sign for acceptance of the diary on regular intervals, for example once per week.

Provisional items

The site foreman records data about provisional items, price fluctuations etc. separately. The contractor and the site foreman should keep records on test results, delivered and used materials (split in provided by contractor, and provided by client.)

Meetings

Minutes should be prepared of every meeting and the draft minutes should be distributed as soon as possible but certainly a week before the next meeting. The draft minutes should be discussed and formalised during the next meeting.

As built drawings

The construction and the project should not be regarded completed if the as-built drawings are not completed. During construction the client or its consultant and contractor negotiated about certain variations to the contract. These variations often are not yet presented on a drawing. The as-built drawings are crucial for the operations and maintenance of the infrastructure. Therefore the supervisor should either prepare these documents or provide detailed instructions to the contractor.

Practical completion

A certificate of Practical Completion is issued when the work is substantially finished. In such case the constructed asset is perfectly useable, although some minor corrections and/or additions may be required. Issuing of this certificate means that;

- The defects liability period starts
- Part of the retention money is released
- The contractor ceases to be liable for liquidated damages
- Client takes possession of the works

Retention money

Retention money is the money subtracted from the valuation of the work at interim and final payment stages, and will be kept by the client as a guarantee the work will properly completed and all defects rectified. The remaining part will be released after the maintenance period as specified in the contract.

3.3 SUPERVISION PLAN

Although the work is contracted out, it is still advisable for the supervising consultant to plan the supervision inputs. It should be noted that this plan has a high-risk element because it will have to follow the actual progress on site. If supervision inputs are scarce, these inputs should concentrate on risky activities. Risky activities are those activities of which the quality of the asset cannot be influenced after the activity is completed.
If it can be expected that the supervision input is extremely scarce, the specifications and contract documents may be adjusted. For example it can be specified that certain activities should take place within period X and that succeeding activities may only take place after inspection or accepted test results of the product of the preceding activities.

4 PROJECT ORGANISATION STRUCTURES

To ensure effectiveness and efficiency the project manager has to develop structures. Structures to communicate with the clients and the managers of resource pools and structures to communicate with the project members. These are respectively the external and internal structures.

4.1 EXTERNAL STRUCTURES

External structures are the relationships between the project team and the client and the resource pools. Resource pools are often permanent divisions within the same organisations, which provide (human, technical, financial) resources to the project.

Clients and stakeholders

Larger clients may have their own project managers and even employ the project staff permanently. Other clients hire consultants to provide the project management and substance related services.

It is often possible to identify other stakeholders and clients of infrastructure projects. As most infrastructure projects serve the public, the public will have an interest in the project results. In particular certain pressure groups may actively lobby in favour or against certain project outcomes. Projects may have direct beneficiaries, who can be identified, e.g. irrigation projects. Clearly these beneficiaries should be consulted about their specific demands.

Slum upgrading projects may have several clients, all contributing to finance the project results:

- Municipal government
- Utility companies
- The neighbourhood or slum dwellers
- Donors from external governments and the private sector

All these clients and stakeholders need to be involved in some form during the life of the project.

Project managers may be given different level of authority.
In one of the extreme cases the project team only contains a project coordinator. The main function of the project coordinator is coordination of the activities of existing units for a specific purpose (project result). Often the project coordinator does not have authority over the collaborating organisations and the project team. He or she only facilitates the project through meetings.

The other extreme is a situation in which the project management is in full control and have all the authorities to take decisions about project outputs and required inputs. Often the project management has at its disposal a project implementation unit. These organisation structures are very common on World Bank and other donor funded projects.

Steering committee

More and more governments choose for a laissez-faire approach towards certain infrastructure projects. It may feel that it should facilitate a certain development process rather than take the lead in that process. This process is more tempting in political risky projects. Outputs of political risky projects may result in resistance of communities, interest groups and the like. These groups may take government to court or even vandalise the output.
A major part of the project team is to organise these informal clients. Often the clients are grouped in committees on basis of common interest. The committees have to select their committee representative. The committee representatives together could form a steering or consultation committee. The government itself could fill one or more posts within the steering committee. Preferably the size of the steering committee should be limited to five members. It will otherwise be difficult to take quick and adequate decisions. Thus the committees have to give their representative the necessary authority to take decisions on their behalf.

4.2 INTERNAL STRUCTURES

Need for structure

Construction projects can be seen as temporarily firms. An organisation in which people co-operate to construct a certain piece of infrastructure. If the number of people becomes too big it becomes more difficult to arrange the work in an informal manner. As construction projects almost always have a temporarily character, it is even more difficult to achieve the required result without a proper organisation structure. Tasks need to be split up and combined in functions. Authorities and responsibilities should be divided and assigned to certain officers. Co-ordination mechanisms have to be established and all collaborators must be informed about these arrangements.

The division of labour results in a reduced coherence in activities and tasks and this requires co-ordination. The implementing organisation also co-ordinates with its environment, like suppliers, sub-contractors, client, media, government, labour unions and financing institutions. Thus it goes without saying that co-ordination is crucial.

Internal structures relates to the division of labour, tasks, functions, and authorities of the project members. Usually project managers have to compose a team.

Team composition

Of course the team should be able to deliver the requested outputs and carry out the necessary tasks. But the team should be complementary. Every individual has its stronger and weaker point. Project managers are no exception. The team would supplement rather than duplicate the project manager's qualifications. It is often easy to select team members on basis of their know-how, expertise or specialisation. It is also important that the team members are complementary on basis of their functioning in the team. Some persons behave as an aspirator, where others behave more like conservators. Other members are more

analytical and again others are more pragmatic. Some persons may act like entrepreneurs where others are supporters. Usually a team would benefit of all these characteristics. It is difficult to find all these characteristics in one person.

Acceptance

A major task of the project manager is to create acceptance among the team member about the project goals, planning and operations. Too many project managers only focus on the outputs and do not spent enough time on this more managerial orientated tasks. Only with sufficient acceptance the project members will deliver the outputs that meet set qualifications.

Team spirit

The project manager has to establish a team spirit. He or she should enable the team members to use and appreciate each other strengths and tolerate each other weaknesses. Again an important process, but often neglected by many project managers.

Substitutes

Every team need substitutes. It is very unlikely that the substitute is a duplicate of the predecessor. It is also very unlikely that the substitute knows the whole project history by heart if at all. Project managers have an important role to guide and integrate the substitutes into the team.

Implementation Phase

Construction projects require a specific organisation down to site level. Depending on the technology it is necessary to add additional site management. Projects using labour-intensive or complex technologies need more site management, planning and supervision. A technician usually manages labour-based road constructions. He or she can be in charge of a number of sites. The size of the work sites will vary, depending on the type of work being carried out and the expected level of output, but a trained supervisor should be able to manage 100 - 150 labourers. Gangs, formed for the different activities, normally range from 10 to 25 workers, depending on the nature and amount of work to be carried out. Among the workers in each gang, one person should be appointed as their leader, the *gang leader*. This person will receive the work instructions from the site supervisor and hand them on to the workers in his/her gang. Since each gang will become more and more skilled the longer they work together on specific activities, it is a good practice to let the gangs work on the same operation throughout the period they are employed.

A gang may specialise on one particular activity, such as clearing, earthworks or laterite surfacing, but there should be flexible working arrangements, where the size and work of the gang can be changed at short notice. If group task work is used, a gang may be assigned to carry out an entire operation, consisting of several activities from bush clearing up to camber formation. Equally, some works can be awarded to petty contractors on a piece or task work basis.

4.3 MANAGING PEOPLE

In addition to the need for financial and physical resources, every organisation requires people in order to function. Organisations have two behavioural requirements in this respect:

- People should be attracted not only to apply for the job but also to stay
- People must perform the tasks as required for which they are hired

In short (project)organisations have to motivate their (future) staff.

Herzberg

The theory of Herzberg states that some factors do not motivate in themselves, but their absence would be a strong demotivator (dissatisfiers). Other factors (satisfiers) have a stronger positive influence and can direct the energy of staff.

Dissatisfiers

Dissatisfies are prerequisites for proper functioning: terms of employment, working conditions, working relations, and employment policies.

Satisfiers

Satisfiers (motivators) are crucial to positive work attitude. They give pleasure, lead to commitment, and give people the feeling that they can develop, reach certain goals.

Equity theory

The equity theory or social comparison theory argues that a person compares his/her inputs (time, efforts, skills, etc) in relation to his/her outputs with a relevant other person. This other person could be the person himself in another job, or another person with the same skills in a comparable job. This theory indicates that people ask themselves: Am I being paid fairly in comparison to others?"
If (s)he feels that there is an imbalance (s)he will strive to reduce this imbalance by:

- Changing his/her inputs (spending less time/energy)
- Changing his/her outputs (producing less)

Expectancy-valence theory

Expectancy-valence theory states that there are three factors important in relation to performance:

- Motivation
- The abilities and traits necessary to perform a task
- A clear defined role in the organisation

The first factor, motivation of people in relation to a task at hand, is heavily based on people's expectations. The higher the value of the outcome (a bonus/salary increase/promotion), the higher the motivation. Also, the more likely it is that an incentive will be realised, the greater the motivation force will be.

Financial incentive schemes

There are two often used bonus targets schemes which are often applied to motivate workers on construction projects:

- Piece work, i.e. payment based on the amount of work done
- Task rate, i.e. a target time is set for completing a specific task. If the task is completed in less time, the bonus is paid in time save.

A huge advantage of task rate system above piecework is that the

	velocity of different gangs can be controlled.
Conditions	The incentive schemes can only be applied if the individual outputs are measurable and the labourer has the biggest influence on his/her pace. When equipment determines the pace of the production this system cannot be applied. The system can be considered unfair when the nature of the tasks or the materials to be worked with changes frequently or contingencies are likely.

5 COST ESTIMATES

Every project has to prepare feasibility studies, like cost-benefit analysis. Basics in Planning[2] describe these studies. The methods of assessing benefits are very specific for each type of infrastructure and to describe them would go beyond the scope of this document. On the other hand every construction project estimates the costs applying more or less the same method.

Basically there are three types of cost estimates, all with different level of accuracy.

1. Rough estimate
2. Indicative estimate
3. Detailed estimate

Every type of estimate should include optimistic, pessimistic and the most likely estimates. The ranges between these figures depend on the accuracy of the estimate and the accuracy of the information on which the estimate is based. Obviously the less accurate the estimate or information, the bigger the range between the optimistic, most likely and pessimistic figures. For example the level of soil investigation influences the accuracy of the estimate. Rough estimates for ground works are often based on desk studies and assumptions alone, While the detailed estimate may be based on soil investigations as good as 1:10,000 ratio.

The Most Likely Scenario is seldom enough for a client to make its judgement. The client needs to check if it can afford the pessimistic scenario. As construction budgets are large, unforeseen extreme high cost may result in bankruptcy of the project and perhaps the client. Large clients with many infrastructure projects, like the national road authority, develop alternative plans to utilise financial godsends. They may develop several small contracts that can be implemented within a few months before the end of the budget year, utilising the unspent cash prior the deadline to return it to the treasury.

The choice between the levels of estimate depends on the needs of the client and the available information. Most clients need the most accurate cost estimate possible, prior financially-committing themselves. However it may not always be possible to develop a detailed cost estimate for the construction at an early stage of the project.

Rough estimates

Rough estimates are usually used during the initial stage of the project and is based on unit rates for whole constructions.

[2] Downloadable from this website

The constructions are classified on basis of a few simple indicators, like

- Number of household connecting to a sewer pipe,
- Height of elevation, number of lanes and number of elevated crossings of elevated motorway
- Location, number of floors, volume of building and garden of the building

This type of unit rates often includes the costs to design, prepare and supervise the construction.

Indicative cost

Indicative cost estimates at least require a preliminary design, but preferably a detailed design. The design is broken down in specific semi-finished products, like walls, floors, roofs, foundations, windows, doors, etc. The amount of each semi-finished product, e.g. volume of foundation, is multiplied with a unit rate that includes the direct, indirect costs, profit and supervision costs. Alternatively the unit rates may only include the direct costs. The total direct cost to build the construction is subsequently multiplied with ratios for indirect costs, profit, and design and supervision inputs.

Detailed cost estimate

Consultants or contractors that bid for a certain contract usually develop the detailed cost estimate, but clients who aware of the financial risks may also prepare detailed cost estimates.
First of all the client need to add the cost of its supervision inputs to the cost estimate of the potential contractors.
Secondly the bidders may increase their demand for profit or willing to take a loss depending on their market situation. Loss making contractors may go bankrupt or may not be able advance the construction costs. The profit/loss is usually a percentage of total direct and indirect costs.
Thirdly bidders will base their cost price on their financial risk assessment. But because most civil engineering contracts are based on remeasurement payment arrangements, and have a certain degree of unknown in it, the client is interested in its financial risks. Information the client cannot obtain from the bidders' quotations.

The preparation of the detailed cost estimate separates the direct and the indirect costs and profit. The direct costs are the costs that can be assigned to construction of a certain semi-finished product, like a wall.

Indirect costs

The indirect costs are the project costs that cannot be assigned to a specific construction element. In a way the production unit of the specific construction elements (walls, floors, roofs etc) all share these resource covered under the indirect costs. Typical examples of indirect costs are:

1. Site management
2. Offices, sheds, storage
3. Access roads
4. Transport of workers
5. Water and sanitation service
6. Health and safety provisions
7. Insurance
8. Bonds
9. Tools, scaffolds
10. Company costs

Site management

The site management costs is based on the duration and number of site managers.

Offices, sheds and stores

The contractor may either hire the necessary offices, sheds and stores, usually for the whole project duration or may have purchased mobile buildings. In the latter case the cost depend on the utilisation degree, depreciation and the duration of the use of the buildings.
In formula:

Costs for buildings= duration* annual depreciation* 100/utilisation degree

Where:
Duration [years]
Utilisation degree [percentage of time building is in use]
Annual depreciation [local currency]

Access roads

Many construction sites are inaccessible for motorised transport and it is necessary to construct an access road. The access road may be a simple dirt road, but when heavy equipment is expected, concrete and metal slabs are more appropriate.

Transport of workers

It is very common that the project has to pick up workers from neighbouring villages. The transport of the workers costs fuel, wage of the drivers and depreciation of the vehicles.

The cost of the fuel is usually calculated by multiplying of the number of trips during project duration, average length of a trip [km], fuel consumption rate [l/km] and the fuel cost per litre [$/l] with each other.

The wage of the driver is calculated with the following equation:
No of Trips* average trip duration [hour] * wage per hour

And the depreciation of the vehicles is calculated with the formula:
No of Trips* average trip duration [year] * annual depreciation* 100/utilisation degree

Health and safety provisions

The cost of the health and safety provisions depends on the number of workers on site and the technology. Experienced contractors will have unit rates to calculate the costs of health and safety provisions.

Tools

Tools and plant will wear and tear. Its cost is estimated on basis of its depreciation rates and utilisation degree.

Bonds and insurances

Bonds and insurances are usually purchased per project and contractor will obtain quotations from their insurance companies.

Company costs

There are various company costs like;

- Staff salaries
- Office rent, or depreciation and O&M costs
- Vehicles
- Loan interests

The company costs are usually divided over the number of expected projects that are running at the same time.

Staff salaries

The staff salaries are the salaries paid to the office staff, like the director, secretary, bookkeepers and others. It also includes the additional benefits and allowances paid to the permanent staff of the company.

Direct costs

The direct costs are the costs of all the inputs that can be directly and solely linked to a certain activity or construction of a certain semi-finished product. It includes risk allowances. Typical inputs are;

- Human resources
- Equipment
- Materials

Direct cost calculation

To calculate the direct costs, the construction is divided in semi-finished products like: walls, floors, roofs, doors, foundations etc. Ideally the construction is broken down as detailed as possible.

The production of each semi-finished product is analysed. The quantities for the materials, human and equipment resources are estimated but also the risks of the production process of that particular semi-finished product are described. The quantities of materials are often expressed in volumes, weight or length units. The quantities of human resources are expressed in the number of work days, weeks or months. Because most workers receive different salaries, depending on their skills and responsibilities, it is necessary to differentiate the human resource inputs of the various salary scales, e.g. unskilled, semi-skilled and skilled activities. The quantity of equipment is described in consumption of time. The risk allowances are often expressed in a

percentage, for example 10% for groundwork and 2% for a mason wall.

The direct costs per semi-finished product are calculated with the following formula:

Direct costs= $(1+RA/100\%)*\sum Q_i * UR_i$

Where:
RA; Risk allowance [%]
Q_i; Quantity of (i)
i; Material, human resource or equipment
UR; Unit rate [local currency]

The quantities are multiplied with their respective unit rates. The unit rates of the human resources are based on the gross salaries, benefits and bonuses. The unit rates of the equipment are based on the lease rates or the depreciation and utilisation rates (when the equipment is owned). And the unit rates of the materials include delivery costs.