Project Controls: Value Enhancement Practice

European Construction Institute

ECI Benchmarking Steering Committee

Project Controls

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April 2002

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Preface

Measurement is the precursor to enhancement. Thus, an important aspect of the work of both the ECI and its American counterpart, the Construction Industry Institute (CII), is the benchmarking of the effect on project performance of a number of Value Enhancing Practices (VEPs). The VEPs selected are those which offer the greatest opportunity for performance enhancement on project execution. To date, the following VEPs are being measured: -

- Team Building
- Pre-Project Planning
- Design/Information Technology
- Constructability
- Project Change Management
- Safety
- Cost Estimating

As part of the process of continuous improvement, the ECI Benchmarking Steering Committee regularly review VEP development and identify additional practices which can have a significant impact on project outcome. Project Controls was identified as one such practice.

The VEP was developed by a Working Group which drew together participants from the Engineering Construction Industry with specialist knowledge of Project Controls. The objectives of the Working Group were to:-

- distill the key practices used in Project Controls,
- determine elements which can be benchmarked,

- develop a source document providing guidance as to what is considered to be current best practice in Project Controls,
- distill this guidance into a VEP Summary document, providing the essential core elements of Project Controls in guideline form,
- weight the constituent elements relative to their impact on project performance and develop a questionnaire to objectively measure the VEP.

Acknowledgements

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Tony Reid	-	Washington Group International
Shane Forth	-	AMEC
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John Hughes	-	ECI
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Summary of Value Enhancement Practice

Project Controls

1 Definition

Project Control is a planned and systematic process for:

- the setting and monitoring of targets,
- analysis of performance,
- identification and anticipation of inefficiencies, and
- implementation of preventative and remedial actions.

2 Characteristics of Effective Project Control

2.1 Project Control is an essential element of executing a project. It should be recognised that strength in one or more elements of project control is not sufficient; it is a comprehensive subject which needs to be utilised in depth, across all its elements.

2.2 One of the keys to an effective project control system is the quality of the information it uses, and how that information flows. Good information is wasted if it is not communicated quickly, correctly and consistently.

2.3 The extent of project control, the level at which it should be applied, and the frequency of reporting should take account of :

- project size and complexity
- level of project definition
- level of risks associated with the project
- the number of internal and external interfaces
- the number of work faces
- the clients requirements and expectations

2.4 Project Controls should be established to meet the following requirements:

- setting expectations by establishing monitoring baselines, i.e. the control estimate and budget, planned progress
- monitoring performance and intervention by regular progress and cost measurement reports and determining corrective action when deviations are identified
- identifying and capitalising on opportunities
- retrospective review, identifying successes and failures and determining lessons to be learned. Maximising the benefits of retrospective review requires:
  - a process for mapping of out-turn costs against the original estimate,
  - an open and honest culture,
  - access to relevant project personnel, and
  - a robust change control procedure.

2.5 To further enhance continuous improvement, projects should be benchmarked, whereby project performance is measured, compared with other projects and opportunities to improve identified and implemented.

2.6 It is important that project controllers should have the confidence of the remainder of the team, such that the team takes on responsibility for the report content and potential corrective action. Despite the title, project controls do not control at all; control remains in the hands of those who do the work.

2.7 To perform the task effectively a project controller should have practical, hands-on experience, be an effective communicator; have helicopter vision, and be a team player. Consequently, adequate training and succession planning should be provided to ensure the appropriate skills are recruited and retained.

3 Recommendations

3.1 Clear minimum conditions of satisfaction should be agreed by all stakeholders, underpinned, where appropriate, by a life-cycle business case.

3.2 At start of Project Execution an outline Project Execution Plan should be in place, containing:

- project status
- project objectives, minimum conditions of satisfaction, scope of work

- project strategy for each phase
- organisational roles, responsibilities and interfaces
- procedures
- work instructions

3.3 "Stages" and "gates" should be clearly defined, i.e. subdivision of the project into distinct phases which can be quantified in cost and time, and points identified between those phases with a defined set of criteria to be achieved before further progress can be made.

3.4 The contract should clearly reflect responsibility for project controls.

3.5 The level of project control to be adopted must be determined, taking account of:

- project size and complexity
- level of project definition
- level of risks associated with the project
- the number of internal and external interfaces
- the number of work faces
- clients requirements and expectations

3.6 In order to effectively control the project, the data to be controlled should be based on a hierarchical structure, which should be subjected to ongoing review, and refinement, if necessary.

Three representations of the project are recommended, each subjected to ongoing review and, if necessary, refinement:

- Work Breakdown Structure (WBS)
- Cost Breakdown Structure (CBS)
- Organisational Breakdown Structure (OBS)

3.7 Baselines against which cost and time will be monitored must be established and clearly communicated.

3.8 The frequency of project reporting must be established, and reviewed if appropriate. Information should be communicated quickly, correctly and consistently.

3.9 An agreed, and verifiable, means of progress measurement must be in place. Input on the level of progress should be provided by relevant members of the project team. Total and free float usage should be monitored as an early warning of potential problems.

3.10 A verifiable method of cost commitment and expenditure must be established. The input on these levels should be provided by relevant members of the project team.

3.11 Deviations which occur from the cost and time baselines must be identified, their causes examined and action agreed to limit the deviation.

3.12 A trend analysis, i.e. the perceived sequence of deviations from the baseline, should be used for forecasting cost and time. The basis for forecasting must be verifiable and consistently applied.

3.13 It should be ensured that relevant members of the project team buy-in to the forecast and commit to its achievement.

3.14 A formal method of performance measurements, e.g. budget value for work completed, should be applied.

3.15 An agreed method of cash flow management must be applied along with a plan for management of contingency.

3.16 An appropriate change management process must be in place; this must be clearly understood and followed by all members of the project team.

3.17 Projects should be subjected to retrospective review and, preferably, benchmarked against an independent database.

ECI Benchmarking Steering Committee

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VEP Index

1 INTRODUCTION

The practice of good Project Controls is vital to the overall success (time, cost and quality) of any enterprise which executes projects of any description. In this context, projects comprise any piece of work which can be defined, cost estimated, programmed and executed to a point at which it can be considered to be complete, within the required standards of quality.

All too often we hear of projects which suffer from escalating cost and time overruns and are eventually completed at many times the original estimate. This can be due to many factors but one of the most common is inadequate or incomplete Project Controls, including the necessary project accounting processes. Very often, the problem is that this field is not perceived as a part of the ultimate deliverable and is, therefore, an extra which is unnecessary. **Nothing could be further from the truth!**

Project Controls is perhaps, the most effective piece of added value to the whole process of executing a project, and simply cannot be omitted from the process, particularly since different stakeholders quite often have different success criteria, e.g. client, contractor and sub contractor. It should also be recognised that strength in one or more elements of project control is not sufficient; it is a comprehensive subject which needs to be utilised in depth across all its elements.

This Value Enhancement Practice sets out to define the best practice of good and effective Project Controls, and is intended to generate an awareness of the value of the techniques to the success of projects. The practices contained have been distilled from a wide spectrum of the heavy engineering industry in Europe and are based on experience gained from executing projects all over the world.

2. PROJECT CONTROL APPROACHES

2.1 Project Execution Plan

2.1.1 The Business Case

Before any project is undertaken there should be a clear statement of the business case comprising the project's functional requirements, a statement of the minimum conditions of satisfaction, and an economic assessment of the expenditure and income profile, including risks and opportunities. This will be used to justify the investment of funds to achieve a pre-determined, or expected, level of return.

On occasions, projects are undertaken which do not provide an obvious economic return, for example legislation-driven environmental or safety improvements. In these cases, the business case would be predicated on the basis of continuing operation of an asset, rather than the legislation causing operations to cease and abandonment of that asset.

Whatever the justification, it is important that all of the stakeholders understand the project's objectives, that they are aligned and encouraged towards achieving them and that they have clear roles and responsibilities.

Stakeholders comprise all of those who have an interest in the project and would include shareholders, clients, consultants, contractors, suppliers, local communities, customers, Government and non-Governmental organisations and the project team.

Sometimes different terminology is used for describing the manner in which a project will be delivered and how the roles and responsibilities of the stakeholders vary; here this will be referred to as the Project Execution Plan or PEP. Whilst there are a number of different styles, the following structure is typical: -

1. Vision/mission statement
2. Current project status
3. Objectives, minimum conditions of satisfaction, scope of work
4. Strategy for management, design, procure, construct, commission, operation and maintenance, project controls and compliance
5. Organisation roles, responsibilities and interfaces
6. Procedures
7. Work instructions

At the start of Project Execution an outline of the full PEP should be in place covering all of the above elements. Detail for each section of the PEP should be developed as a rolling process as each stage of the project is approached. This provides clarity for all of the stakeholders as to their scope of work as well as their roles and responsibilities in achieving this and describes how change will be scrutinised, managed and, only where absolutely necessary, incorporated into the project.

A description of how the project will be controlled would be included within the Strategy section, leading to a Quality Plan, procedures and detailed work instructions. It is often the case that these procedures will be provided to potential contractors as part of the invitation to tender administration instructions.

2.1.2 Project Approval

It is common practice in the engineering and infrastructure industries to adopt a phased approach to investment or commitment to a project. This is here described as 'stages' and 'gates' with defined development periods culminating in project review and business case re-validation, prior to authorisation to proceed further.

The 'stages' and 'gates' adopted will depend on whether being developed by Clients or Contractors. The degree of compartmentalising and the number of 'stages' will depend on the scope of the projects; for major construction projects it will cover all phases from concept to abandonment. The principles of 'stages' and 'gates' development are covered more fully in Appendix 1.

In property and building works this exaggerated compartmentalisation is less common; building projects, however, usually undergo concept approval prior to client commitment to the entire scheme.

Where this phased approach is adopted, the completion of each phase provides a snapshot of the project at which time the scope is frozen and change control is implemented. This provides the baseline for the subsequent project controls, repeated for each of the following phases in an iterative process until the project is complete. Detailed development of the 'stages' and 'gates' process is outside the remit of this VEP.

2.2 Impact of Life Cycle Costing

The business case supporting a project should address the full life cycle of the asset from concept, through implementation, operation and maintenance including shutting down and abandonment. Consideration therefore needs to be given to the cost of the asset in terms of operational expenditure (OPEX) as well as the initial capital expenditure outlay (CAPEX).

It is common for issues arising from reliability and maintenance to impact on the design and specification, especially in the areas of ergonomics, access/egress, equipment and materials selection, control systems and automation. Whilst there is often an apparent conflict between minimising CAPEX and maximising operational reliability and flexibility (including

OPEX), to appreciate the true value of a project, proper consideration should be given to whole life-cycle costing.

In order to construct the economics over the whole life cycle of an asset, the CAPEX and OPEX costs are estimated for the design life, offset by the projected income. All figures are normalised through the application of escalation and discounting rates to arrive at the net present value. This is of particular importance as the reduction in impact of expenditure and income when discounted from the future back to today's value is significant; in times of high inflation especially so.

Combining these expenditure and income projections provides a rate of return for the asset, which is an indicator of its true value to the client.

This VEP is aimed at identification of improvements through the concept and implementation phases such that a review can be held at the completion of construction before the team is disbanded. This is not to say that opportunities do not exist for increasing value during operations, maintenance and shutdowns.

2.3 Information Flow In and Out

One of the keys to an effective project control system is the quality of the information it uses, and how that information flows. Good information is wasted if it is not communicated quickly, correctly and consistently.

2.3.1 The importance of scope of work definition

The quality of project information often depends upon the extent of the definition of the scope of work. If the scope of work is loosely defined, every piece of information derived from it is likely to be suspect. This merely serves as a warning that all subsequent information needs to be verified and, of course, the more that this has to happen, the more inefficient the whole execution process will be.

The message here is that good quality input will clearly provide a higher probability of achieving good quality output which is succinct and accurate – and the converse also applies.

2.3.2 The significance of timely production of output

In the pressurised environment in which many projects are executed, time is of the essence. It is often a temptation to release work before it is complete. This may be driven to achieve a scheduled date, or to make a progress percentage point, before the work has reached the correct level of quality.

To do this is detrimental to the effectiveness of subsequent work because it inevitably leads to re-work, extra effort, delays to the schedule and a resultant cost increase.

The lesson here is that it is better to issue the information once, but correctly, rather than having to correct it later on.

2.4 Level of Control

When considering to what level (i.e. Level I – IV, where I is summary level and IV is detailed level) and extent control should be applied, a number of factors should be considered. These include project size and complexity; level of definition; level of risk associated with project; the number of internal and external interfaces, the number of workfaces and also the stakeholder's expectations and requirements.

It is desirable to specify and define to what level control should be applied at the earliest opportunity in order to ensure that the systems used to plan, monitor and control are flexible enough for the task and satisfy all stakeholders. It is essential that the PEP details the level of control to be applied and this may also be specified in contractual agreements. This must then be adequately reflected in the project estimate with sufficient budget provision to cover resources needed to identify and deliver the required level of control. Extended time and effort expended at project initiation should be considered as an investment, with ongoing payback through the project lifecycle.

A general principle is that the responsibility for control should be with those best able to control the project. The shift in that responsibility for differing types of contract is illustrated in Figure 1.

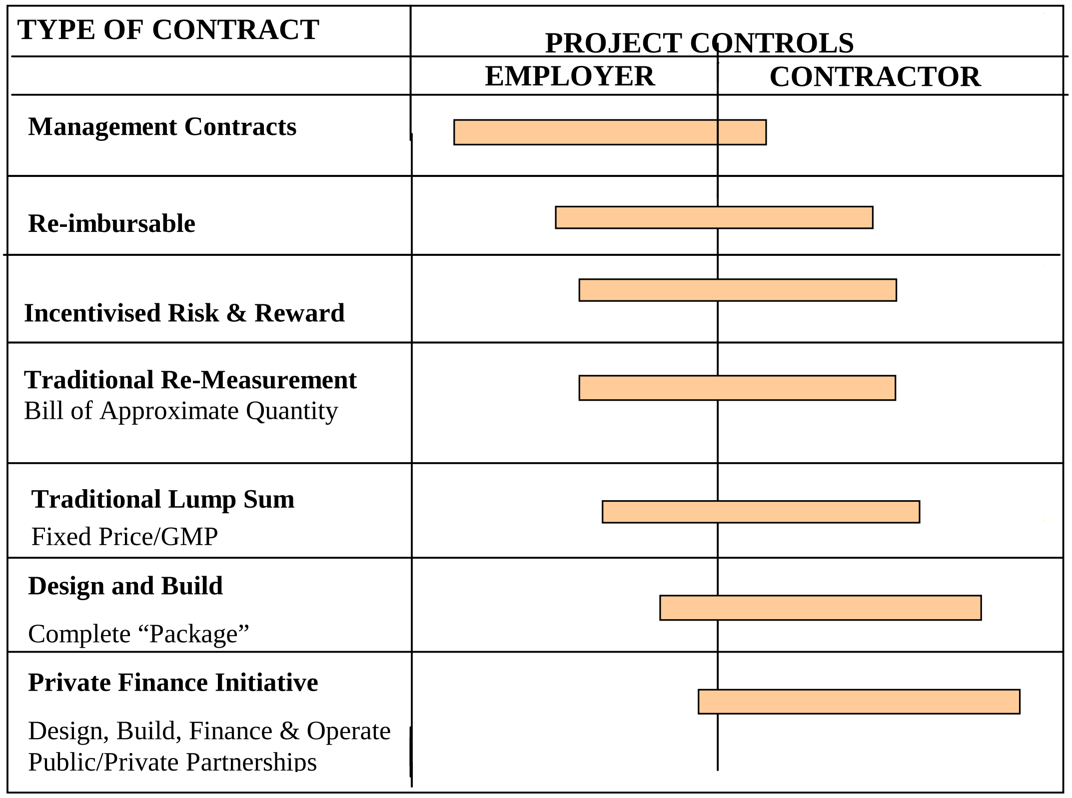


Figure 1 – Shift in responsibility for Project Controls

Where a project forms part of a wider programme of work then consistency is needed to ensure that each project's structure is compatible with the overall programme or company requirements. Where compatibility is achieved this enables the production of invaluable information such as a forecast of key skills resource requirements, overall resource requirements and expected plant purchasing requirements. Indeed, in resource limited markets this type of information is of paramount importance in the development of implementation strategies and may even influence the release of further work.

Consideration should be given to the management of data, where the complexity of the project will determine whether an integrated system is needed or whether simple spreadsheets will suffice. This is particularly relevant where data is to be handled in a partnering environment. Whichever option is used, double entry of data and duplication of effort should be avoided; consistency should be the keynote.

2.5 Integrity of the Project Control Data

Mention has been made above of the integrity of the information used for project controls. This can be described as follows: -

- the quality of historical data
- the extent of input from experts

2.5.1 Quality of historical data

Much use should be made of historical data since the cost of recovering it for project use is generally considerably less than that of creating it from new. The key issues are: -

- how old it is
- does the data reflect current working practices/market conditions
- has the technical content been superseded
- is the content of the data absolutely clear
- are there any problems associated with scaling factors
- if so, is it relevant to the specific task?

Review of these will dictate whether historical data can be used or whether market research should be initiated.

2.5.2 Gaining specialist input

It is important that those who are required to execute the work can buy-in to the data which has been presented to them and are committed to the particular project, utilising, where necessary, specialist input.

Further, the difficulty must be recognised for those who have not been party to the development of the budget having to buy-in to what may well be a very challenging budget, requiring a clear process of explanation and encouragement to take up the challenge. This can be achieved by means of the Project Manager, the Cost Estimator and the Cost Engineer presenting the budgets which have been developed from the estimate and explaining the rationale, and specific areas which have given cause for concern or which are subject to greatest risk.

2.5.3 Credibility and reliability of information presented and the confidence level in the data

An area where errors can be introduced into project control data can occur with the over-extensive use of spreadsheets and, to a lesser extent, databases. Although of significant value, if used as an integral element of a complex control system, there is always the risk of a simple error in a formula having a compounding effect, with adverse consequences.

2.6 Integration of Project Controls

The integrity of a project control system is enhanced greatly by sound data, used in a timely manner. This can be achieved in many ways but not the least of these, of course, is consistency and clarity of the information. This comes from a system which integrates: -

- a Work Breakdown Structure (WBS), with the scope of each element of work clearly indicated – either in the element description, or as an explanatory attachment to the WBS
- an Organisation Breakdown Structure (OBS)
- a Cost Breakdown Structure (Code of Accounts) (CBS)
- a clear definition of the planned resources – both human and otherwise – to be utilised
- a hierarchical approach to cost and planning elements
- a definition of the detail at each level of the hierarchy

All of the above have to be developed within the requirements of the project stakeholders. The above integration implies single point entry of data (which provides consistency across the board), the need for clear ownership of each element of the data, and the requirement for computing systems which are appropriate to the job.

In each case the level of details and applications used should be fit for purpose and professional judgement should be applied to any output to ensure a satisfactory level of quality is maintained.

The benefits of an integrated system such as above will only be realised to the full if the users and operators (i.e. the customers and the Project Controllers) maintain a reasonable level of scepticism and carry out "sanity checks" at various points in the control process.

3 PROJECT CONTROL PROCESSES

3.1 Organisation of the Project

3.1.1 Introduction

The PEP will contain a section describing how the project will be monitored to ensure that the objectives are achieved. However before the project can be controlled it has to be arranged in a format which will facilitate its management. This takes the form of sub-division of the project into three aspects: -

- physical, referred to as the Work Breakdown Structure (WBS)
- financial, referred to as the Cost Breakdown Structure (CBS)
- functional, referred to as the Organisational Breakdown Structure (OBS)

3.1.2 Work Breakdown Structure

This is the subdivision of the project into its constituent elements, e.g. geographical areas, items of equipment or process systems, that make up the functional units of the project. Whilst the development of each project's WBS can be created from a standard template, each WBS will be specific to a project. It is common practice to design by system, procure by package, commence erection using geographical areas, then transfer to completion by process systems to assist in commissioning and ramp-up to operational throughput.

The highest level would be the project (or programme, if a portfolio of projects is under consideration), followed by the main physical areas, reflecting the geographical arrangement of the site, for example on-plot and off-plot. Below this would be the constituent parts within each area, for example the buildings, equipment items etc., and at the lowest level would be individual components, e.g. foundations, pieces of steel, individual valves and pipe lines etc.

The WBS uses a hierarchical coding structure to enable traceability and aggregation to view varying levels of summation to suit the review and reporting requirements of each of the stakeholders. It also enables reporting by exception, where increased levels of detail can be examined only where problems or deviations from expectations become evident.

The following figures reflect the geographical sub-division of the project into its main areas, followed by equipment items, then by a systems example covering construction works.

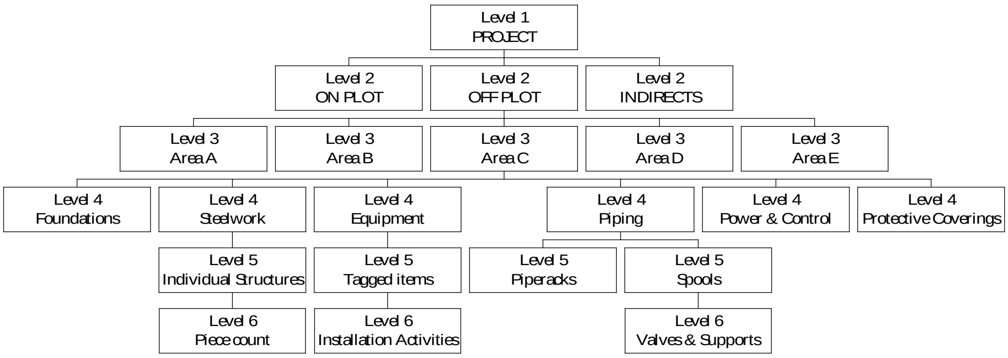


Figure 2 – Typical Geographical sub-division of the project

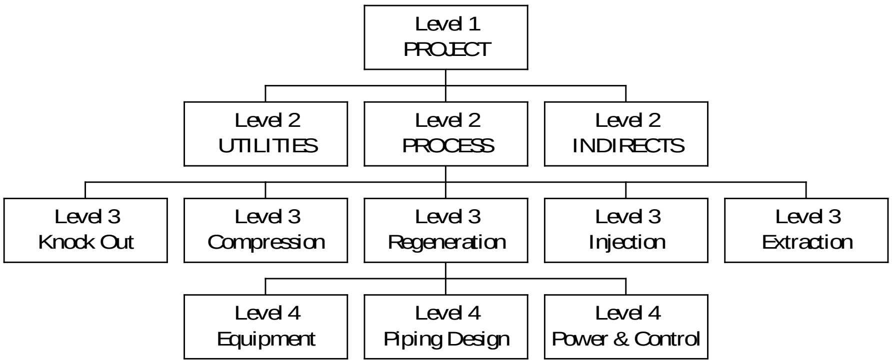


Figure 3 – Typical Systems sub-division

All parties concerned with the project should adopt the WBS for consistency and reporting purposes. It should also be capable of supporting the reconciliation of the final costs back to the cost estimate to report on the accuracy of the estimate.

3.1.3 Cost Breakdown Structure

This is otherwise referred to as a code of accounts and is usually divided into disciplines, either trade or technical.

At the lowest level will be labour outputs, plant and material costs augmented by specialist suppliers quotations. This is then rolled up into composite unit rates which are typical of a measured bill of quantities or schedule of rates. This can then be rolled up into key quantities, all-in costs for m^3 of concrete or tonne of steel, and ultimately into a functional level, e.g. all-up cost per barrel of oil for an oil refinery processing unit.

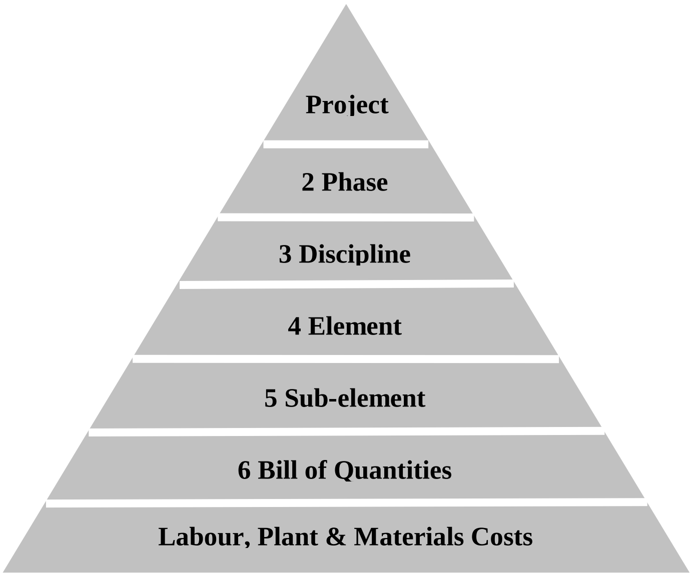


Figure 4 – Typical Cost Breakdown Structure

It is common practice to use a hierarchical coding structure for the CBS for the same reasons as outlined for the WBS. The CBS coding also allows the mapping of actual costs from completed projects against the estimate to improve the quality of the cost estimating database.

3.1.4 Organisational Breakdown Structure

This represents the organisation of the various parties who are going to undertake or have an impact on the project, including the client, contractors, consultants, suppliers and community. The OBS matrix also enables interfaces to be identified where one party hands over to another.

The first step in development of the OBS is mapping the stakeholders to establish the requirements to keep the stakeholders informed, involved, satisfied (or ignored). From this analysis priorities can be determined where conflicts exist and alignment issues can be identified.

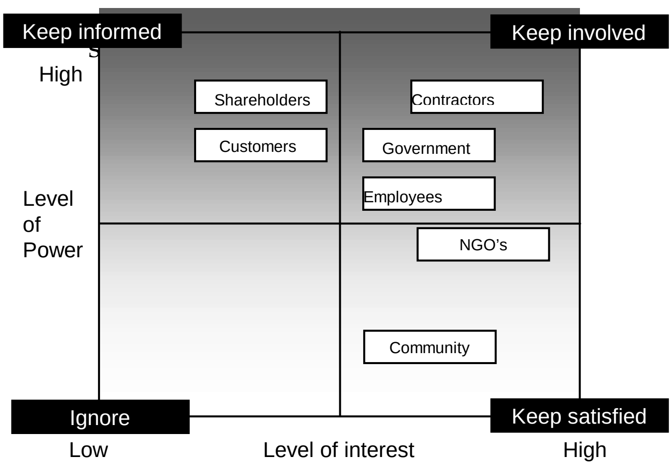


Figure 5 – Typical Mapping of Stakeholders

The next step is to develop a matrix relating the work and cost breakdown structures, and demonstrating within the project organisation the responsibilities for each work and cost element, i.e. who does what.

	Civils	Steelwork	Equipment	Pipewrok	Electrical	Instruments	Painting & Insulation	Fireproofing	Pipelines
Process Unit									
Storage									
Common Facilities									
Utilities									
Buildings									
Support Facilities									

Figure 6 – Work and Cost Breakdown Matrix
(N.B. represents only the construction phase of the CBS for clarity)

This matrix of “pigeon holes” can then be used to allocate the attributes of each element of the project, e.g. cost, time, resources, risks and opportunities. The individual packages of work are then amalgamated according to the analysis and investigations that are undertaken as part of the contract plan development. The resultant contract packaging can then be reflected as an overlay on the OBS to identify the interfaces that need to be managed; a typical example is shown in Figure 7.

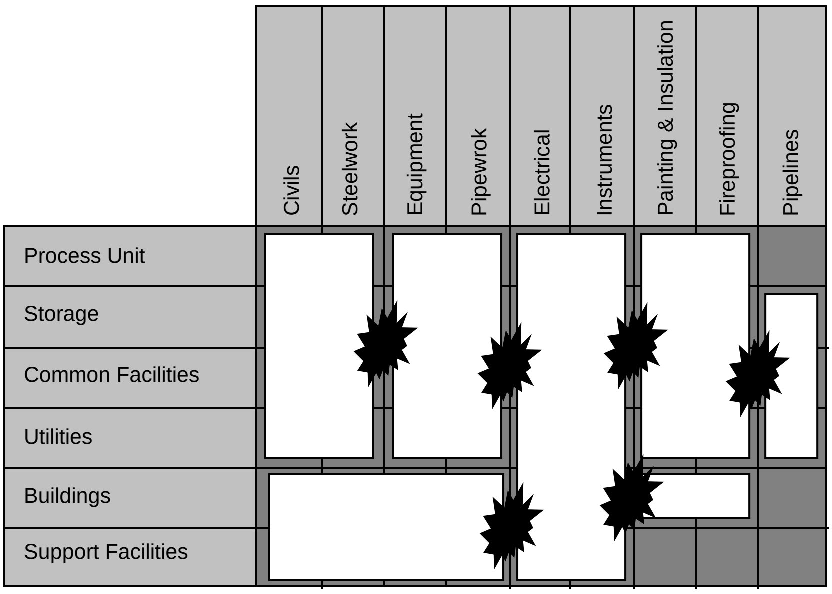


Figure 7 – Contract Packaging and Interfaces

3.1.5 General

It is unrealistic to expect a complete detailed WBS, CBS and OBS at the outset of the project, rather they are subject to ongoing review and possible refinement as each stage of the project is approached. However, it is important to start with an outline in place which uses a hierarchically coded structure capable of subsequent expansion and development.

The WBS and CBS reporting facilities provide project information tailored to each of the stakeholders requirements. Invariably these are different, from one page summaries for the more senior representatives down to the most detailed lists for those closest to the 'coalface'.

In addition to project reporting there will also be a requirement for business or finance cost reporting. This would look at how a company is performing against its finance targets, the balance sheet or shareholders reports. The basic data required for these reports is the same as for project reporting, it is simply output in a dissimilar format which can be accounted for through the CBS coding.

3.2 Setting Expectations

3.2.1 Introduction

Once the project is organised against a WBS/CBS/OBS, project controls can be established according to the following cycle:

Setting expectations	establishing the monitoring baselines for the project, i.e. the control estimate and budget (cost estimating), planned progress (planning)
Monitoring performance and intervention	daily, weekly, monthly progress and cost measurement to see whether the project remains on track and, when deviations are identified, examining their cause(s) and determining action which best suits the project.
Retrospective review	comparing planned and actual outputs, looking back at what happened, identifying the successes and failures and determining learning points to improve future performance.

Each of these stages is described more fully below. Using the 'stages' and 'gates' approach to implementing a project provides the opportunity at each gate to refresh the baseline for each new stage to be undertaken.

Unfortunately, a common feature of many organisations is the tendency to finish a project and immediately move on to the next one thus avoiding the third of these stages. Learning from success and failure is crucial to improving performance. Investing time and effort on proper close out should not be seen as delaying the onset of a new and more exciting challenge, rather as an opportunity to improve the quality of future project realisation.

3.2.2 Cost

Referring to the 'stages' and 'gates' approach to authorisation, the cost estimate prepared on completion of one stage becomes the control tool for the subsequent phase. Care is required therefore to ensure that the estimate is prepared in a form that can be translated, electronically to ensure accuracy, into the subsequent budgets for each of the WBS/CBS/OBS elements.

Uncertainty in the estimate arising from the accuracy of the scope definition, quantification and rates used needs to be captured in a form that can be incorporated in the risk analysis process.

Once the control budget has been agreed there is a need to implement stringent change control. This should challenge the need for change as this is disruptive and causes inefficiency; if change becomes inevitable, the procedure should capture the full impact of the change including cost, time, risk and opportunity.

Finally, when the cost estimate has been agreed and has been re-aligned into the control estimate, a cost monitoring system is required that captures commitments, value of work performed, payments due and payments made, such that variances can be identified and corrective actions taken.

A separate VEP has been produced for Cost Estimating (1).

3.2.3 Planning

The WBS, CBS and OBS provide three views of the sub-division of the project and all need to be reflected in how, in time, the project will be undertaken. Therefore the plan should include activities linked together in a logical pattern such that the progress of the work can be forecast and tracked.

It is usual to develop the plan in a hierarchical format, normally referred to as levels 1,2 3 and 4 which reflect the level of detail displayed and provides project information tailored to each of the stakeholders requirements. These vary from one page summaries for the more senior representatives down to the most detailed outputs for those at the working level. The lower levels of detail are best developed towards the start of each phase, in effect a rolling, or emerging, plan as definition becomes available.

In the following example the lowest level comprises the key dates for the individual steps in the procurement cycle. These would be monitored to ensure that they remain on target for delivering the items to site when required by the construction team. However, this level of detail is not necessary for more senior management, who wish to view whether progress is being achieved at a higher level. In this instance, rolled-up summary activities would be generated using the higher level WBS codes.

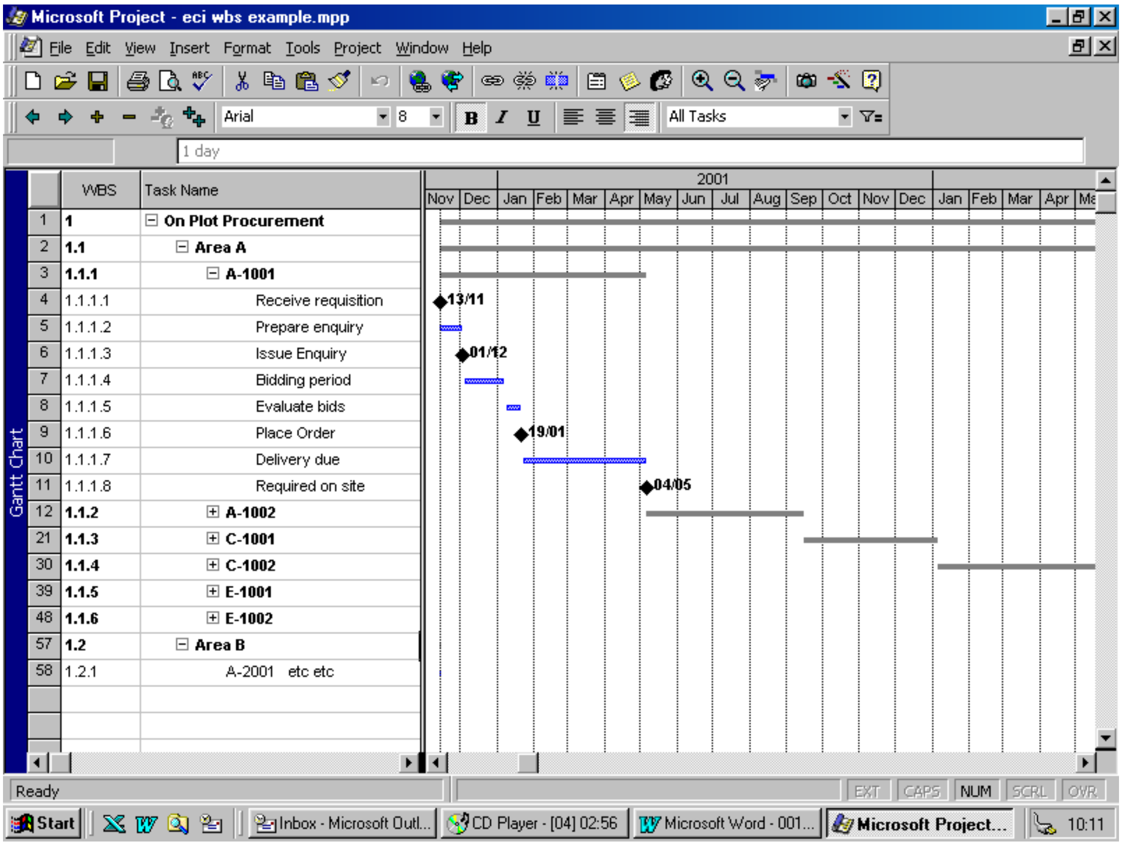


Figure 8 – Activity Planning

The duration of the activities in the plan should be supported by the resource estimates used in the cost estimate. The manhours to be consumed, when linked to a working shift pattern, can be reflected as resource histograms and, through study of the working environment and effective resource saturation levels, the durations can be derived. Also the cost rates for each of the resources can be accessed to provide information on over or under-run costs when progress fails to match expectations.

Each activity should be allocated in the organisational structure so that plans can be generated and progress monitored for each of the companies involved in the project. This is particularly relevant when the achievement of milestones has financial implications under the contract payment terms.

Having the planned cost of the activities associated with their anticipated start and completion dates and spend profile enables the calculation of the cash flow for the project. Measurement of the actual, physical progress and applying this to the estimated cost provides the earned value. This can be used as an indicator of whether the project will be over or under-spent at completion.

Each activity should be linked logically to those activities that are effected by either it's start, progress or completion. This enables the identification of the critical path through the project, i.e. the chain of activities that control the minimum duration of the project from start to finish. This is of value when examining ways of saving time as well as considering where and how much contingency to use if things go astray.

Critical path analysis also looks at a range of sub-critical paths through the plan and allows the identification of total and free float. Total float is defined as the time that an activity can be delayed before it impacts on the completion date of the project. Free float is defined as the amount of time an activity can be delayed before it impacts upon the downstream (succeeding) activity. As the project progresses, monitoring float erosion provides a useful early warning tool to anticipate problems which are emerging before they become critical.

When the plan is agreed it should be approved by all senior members of the project team, including the client. It is important that all key members of the Project team buy in to the programme and version control should be implemented. The programme planned dates, resources, costs etc should be frozen. This is referred to as the baseline, such that it can be used to measure physical progress and track whether the project is progressing according to plan.

3.2.4 Risk

Uncertainty can be categorised as arising from two sources – internal and external. Internal is the uncertainty which is self created through the uncertainty of the business drivers and inherent inaccuracy in the cost estimate and the plan; external arises from the interaction of the project with the environment in which it is constructed.

Both are dealt with in detail in a separate VEP (2) dealing with risk analysis and risk management, such that it is not intended to go into detail here. Rather, this text describes the process for capturing the uncertainty in the cost estimate and the plan for inclusion in the overall project risk analysis and risk management process. The identification, evaluation and management of uncertainty arising from the external environment is excluded.

Cost Estimating

Since the cost estimate is a forecast of the expected cost of work in the future there is uncertainty included which comes from three sources – scope, quantities and rates.

The uncertainty in the scope arises either from a lack of scope definition or proper change control. This is not to say that the scope of what is to be constructed needs to be fixed. However, when the scope is described, any uncertainty should be declared and it's impact on the estimate calculated. Uncertainty could lead to scope changes which would be reflected in new line items being required in the cost estimate.

Quantity uncertainty arises from inaccuracy when taking off quantities which results in changes in the quantity against line items that are already in the cost estimate.

Rates uncertainty arises from either imprecise description of the scope of work which results in using the wrong rate, inaccuracies in the database where labour or plant and material components are priced incorrectly or are out of date.

Another cause for prices (not costs) varying is the state of the market – whether suppliers and contractors are busy or have spare capacity they wish to fill. The potential impact of cost inflation over time also needs to be considered, identifying and isolating those items within the estimate that will be subject to inflation.

Planning

Uncertainty in the plan primarily arises from a lack of scope definition and/or novel processes or techniques. These are likely to impact upon start and completion dates, activity durations and the accuracy of the logic links.

Start and completion dates, along with intermediate milestones, should be incorporated into a plan to reflect key decision dates and the impact of missing those dates.

Change in durations arises mainly from errors or mis-assumptions in the resource estimates, or delays in obtaining required approvals from stakeholders. Uncertainty can also arise from either too much or too little inter-dependence between the activities. Change in one area needs to be transferred, through logic links, to reflect it's impact in other affected areas.

Another source of uncertainty is that associated with approval cycles by other stakeholders, e.g. Government, over which the project team has little or no control. It is important to ensure that the effects of time uncertainty are captured in the cost risk analysis, i.e. where time related changes are incurred.

Contingency

If it is assumed that none of the risk issues mentioned above occur, the estimate and plan should represent a reasonably accurate estimate of the cost and time required to complete the project. However, this is most unlikely and adopting this attitude has led to some notable projects over-running.

It is more likely that some of these risks and opportunities will occur and that they will require management action for which time and money will be required. The extent of that requirement is gauged by Risk Assessment where, through statistical sampling, a distribution of possible project outcomes can be developed.

An important aspect of this process is deciding how much certainty is required on the final cost and completion date; the greater the degree of certainty required, the greater will be the contingency needed to be allocated to cover for a large proportion of the possible events and their consequences.

It should be remembered that the risk management process continues throughout the duration of the project, it is not a one-off study to be completed at the beginning of the project then filed away. As time passes, previously identified risks and opportunities will become redundant and new ones will emerge which require to be tracked and, if they occur, the project team will be called on to manage them to best effect.

3.3 Performance & Intervention

During the life of any project there is the need to monitor progress and to generate reports at regular intervals. The function of the monitoring process is not merely to produce a report for filing or to provide a basis for penalising or rewarding project members. The object is to be able to review the information generated by the reports and to be able to recognise any potential problem areas then to recommend/take timely, corrective action to meet the project goals, whether they are problems pertaining to time, cost or quality. This monitoring process is continuous or cyclic; hence we get the progress control loop illustrated below.

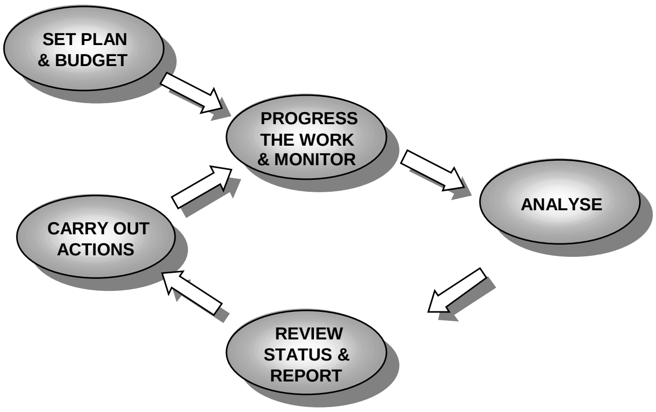


Figure 9 – Progress and Control Loop

3.3.1 Measurement

The benefits of an integrated system will only be realised to the full if the users and operators (i.e. the customers and the Project Controllers) maintain a reasonable level of scepticism and carry out "sanity checks" at various points in the control process.

Measurement and the preparation of progress reports of any project must be carried out at regular intervals of time as agreed with senior management and/or clients at the project outset. However, problem areas may well require increased scrutiny. The time intervals must be sufficiently frequent to enable the project management team to maintain control and to avoid shocks when it is too late for remedial action. Generally, reporting can take place on a daily, weekly or monthly basis.

- Daily is restricted to major projects; e.g. in the construction phase or the hook-up and commissioning phase of an offshore project usually taking the form of a meeting to discuss urgent/important problems.

- Weekly reporting may necessitate a high level report dwelling on critical items which need attention; project team and project phase interface co-ordination providing early warning of problems.

- Monthly progress and narrative reporting provides management with the ability to overview the whole project. It is essential that reporting is brief and concise and the use of exception reports is advised, thus avoiding great volumes of data.

The main feature of measurement is to compare both cost and schedule progress data with actual (achieved) data; to review any deviations which may have occurred from the plan; to ascertain and understand why these deviations have happened and finally if any deviations are causing adverse trends towards achieving the ultimate goal, to make recommendations on what actions need to be taken to rectify the situation.

It is important that the current and frozen scope is used for both schedule and cost progress measurement, thus avoiding reporting against a moving target which precludes the identification of trends. If authorised changes to the scope make reports unrealistic, the estimate and plan will need to be re-baselined – updated to reflect the latest scope.

At each progress cut-off, both planning and cost functions will consolidate the progress and expenditure information respectively from all phases of the project, producing a set of management reports which will provide information on status, trends and forecasts for the project.

Planning and Scheduling

At each pre-determined progress cut-off, schedule progress of all phases of the scope (engineering, procurement, construction or fabrication and commissioning) are measured at the lowest level of detail (usually level 4 depending upon the project complexity) and "rolled-up" through the various levels to provide the overall project progress figure. The physical progress is captured and evaluated based upon an objective assessment of the work completed and takes no account of time taken at this stage. The most common expression of progress is percentage complete. See Figure 8.

A more subjective method is by assessing the remaining or duration for each activity (Rdu). Time and resource taken to achieve the stated progress only comes into play for the calculation of productivity factors.

Progress measurement and forecast completion must involve all relevant members of the project team, in order to obtain the highest confidence in the analysed results. The importance of accurate, realistic progress measurement cannot be over emphasised especially where project progress is directly linked to the payment terms.

Having gathered all the progress data, reports can be generated which will provide information on status, trends and forecast of the project. Progress achieved must be communicated widely within the project team so that all members are aware if any corrective action needs to be taken to maintain the project objectives and completion date. Various methods of illustrating achieved progress against the plan are used, including: -

- Tabular reports at summary and detail level.
- Marked up bar charts at summary and detail level.
- Milestone charts for key events.

- Progress ‘S’ curves, based on percentage complete, achieved man-hours or in some instances quantities e.g. Pipework installed and tested.
- Histograms showing planned and actual manpower.

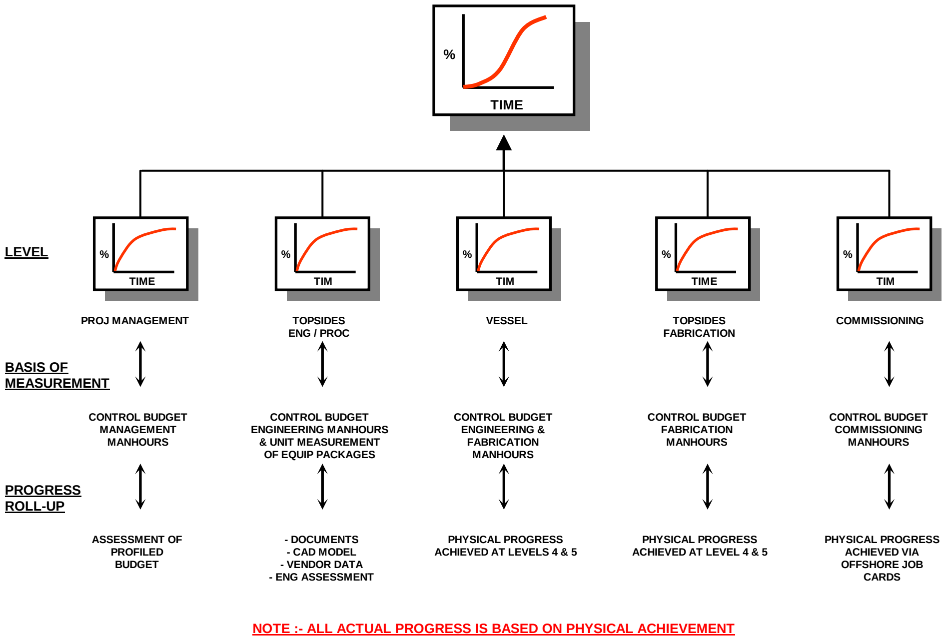


Figure 10 – Typical Progress Measurement Scheme

Cost

Cost measurement involves monitoring expenditure, commitment and forecasts of costs against a control estimate (all in accordance with the project WBS, CBS and OBS), providing early warning of any possible overspend and initiation of corrective action. Adherence to the change control process and subsequent approval of changes in scope together with any effect on cost or schedule are the mechanisms by which the original budget is changed to current budget.

It is important to involve all relevant members of the project team in owning and committing to the budget estimate and to promote continuous cost awareness throughout the life of the project. The original budget becomes the project reference with respect to cost.

Cost measurement systems differ from company to company with some using packages available on the open market, whilst others develop their own internal systems to suit their own requirements. In any event the general requirements of a cost measurement method/system is to be able to: -

- Use cost estimate data to generate a control estimate.
- Link with procurement (equipment, materials and contract placement) capturing commitments as they are made and feeding them into the cost management system.
- Link with any engineering applications, which may provide bills of quantity information.
- Link with man-hour reporting system. (Actual man-hours recorded against the project)
- Receive data from sub-contractors for total project cost reporting.
- Store historical data for trending/forecasting.
- Link to accounts payable for invoice processing status.
- Perform cost phasing for cash and commitment profiles.

3.3.2 Deviation from plan

Having performed all the stages of updating both schedule and cost, there is a need prior to issue to consider the results carefully to see if there is any adverse deviation from the plan. If there are problems, it is at this point that remedial/corrective action must be considered. There are three main courses of action which can help: -

- either re-arranging the logic of the schedule,
- increasing the resources, bearing in mind this can adversely affect cost
- changing the work pattern or calendar

In reconsidering the logic it is essential to be realistic, not hopeful and not to give in to pressure to compromise.

If the option to rearrange logic is taken, it is imperative that all the involved parties (both “shop floor” and management) buy into the logic changes as being practical and achievable without affecting any other downstream activities.

Whatever solution is applied it is important that cognisance of the problem is noted and benchmark data or estimates are recorded to ensure the same problem does not happen again on future projects.

Obviously in the worst instance, often when a project is in its latter stages, it may be that there are no ways to rectify the situation and the only solution is to extend a milestone or the project completion date and to advise the client accordingly.

3.3.3 Trend analysis

Analysing trends is all part of the progress measurement process in providing timely information and early warnings of problem areas. Having the ability to realistically understand trends, draw conclusions and analyse solutions requires certain skills but more importantly requires relevant experience.

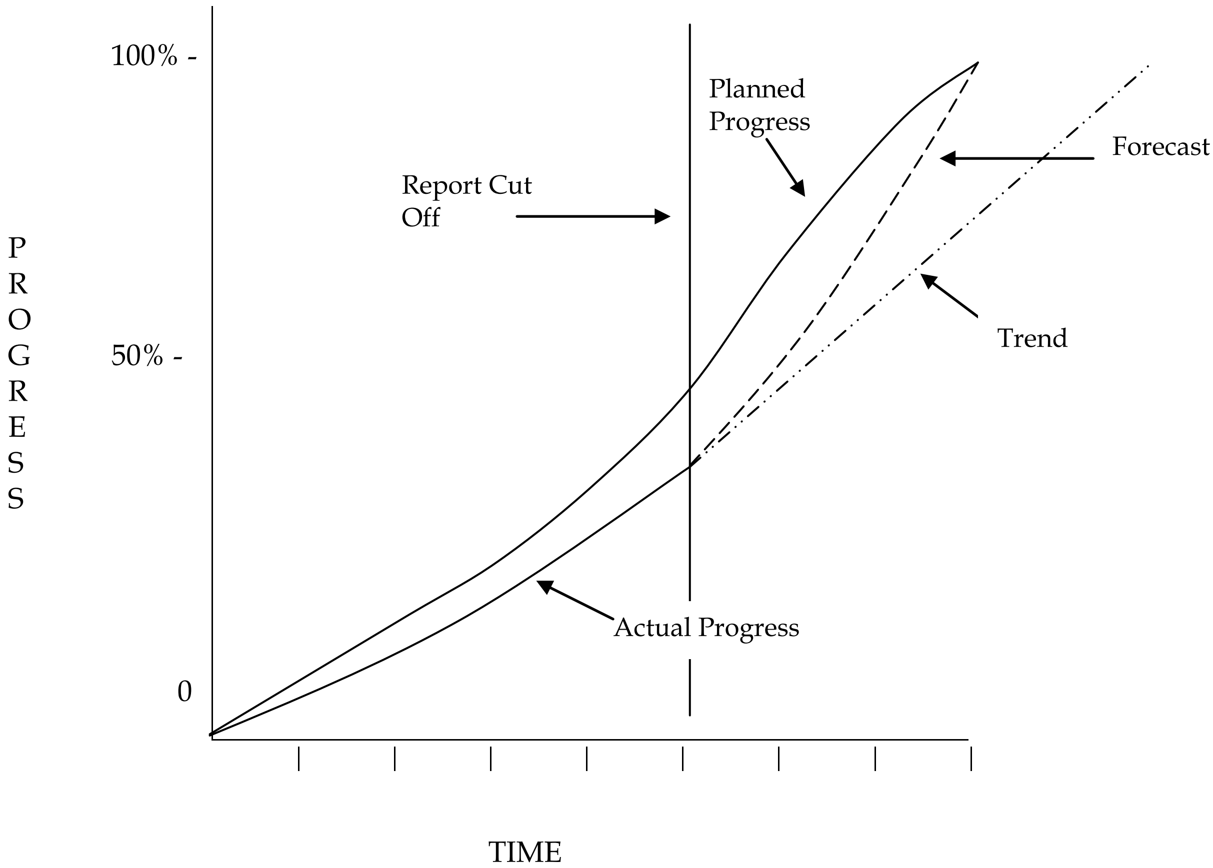


Figure 11 – Typical Adverse Trend Curve

The progress curve illustrates an adverse trend which clearly requires urgent attention. First it must be understood what has caused the situation, then there is a need to impose corrective action (as described in 3.3.2) to endeavour to get back on schedule.

It is important here to distinguish between “trends” and “forecasts”. “Trends” refer to the course of the deviations from the established base if corrective action is not taken. "Forecasts" reflect the predicted outcome once corrective action has been implemented.

Trend analysis is the recognition of deviations between planned and actual and is the mechanism used by management to decide the appropriate time(s) for a re-schedule or a re-estimate. It may be that the project is on schedule from a time viewpoint but resultant efforts to maintain the programme often have an adverse effect on cost which at some point must lead to a re-estimate. On the other hand whenever a re-schedule becomes necessary, for whatever reason, it almost always leads to the need for a re-estimate by distributing the budgetary data based upon the revised schedule.

Whenever a trend away from the planned is evident the first consideration is to establish the cause. A variety of reasons have to be considered before any meaningful remedial action can be recommended. The main considerations in establishing the cause are: -

- Has the wayward trend been caused by "change", if so what are the reasons for the changes, are they being properly managed and are there more changes likely to be imposed on the project?
- How efficiently is the work being carried out?
- Was the original (or current) estimate correct?
- Is there a specific resource which is causing the problem?
- Are the resources being properly directed?

Whatever the outcome, and should the decision be taken to re-schedule, then two golden rules apply. Firstly all incomplete scope must be re-forecast ahead of the "time now" line. Secondly, planned and actual values for both cost and progress must be equal at the time of re-estimate and re-schedule respectively.

Above all it is important to reflect on the causes, whatever they turn out to be, to ensure that lessons are learnt with a view to getting it right next time. Management must also ensure that any re-scheduling or re-estimate does not lead to complacency among the workforce and further ensure that, whatever the cause of the adverse trend might have been, it is not repeated.

3.3.4 Earned Value and Forecasting

Earned Value

When assessing the effectiveness of Project Controls for any project it is important to ensure that sufficient attention is paid to trend forecasting in order to provide early warning of overspend and / or under- performance. One of the most useful methods of performance tracking is Earned Value Analysis (EVA).

In order to apply EVA to any size project it is necessary to establish a budget for the scope of work to be executed. The budget values are normally sourced from the control estimate for the identified scope of work and may be broken down at the appropriate level. Since the lowest common denominator of all phases of a project is money, this is normally expressed in monetary terms.

In order to provide a time base for a given scope of work it is best practice to develop a logic linked detailed programme or schedule. This provides a vehicle to allocate budget values to specific tasks and when rolled up (summarised) gives a graphical profile for the identified scope of work (most project control software packages are configured such that budget values can be entered at task level and graphical reports produced). When graphed, the budget profile typically follows an S-curve profile. In some instances, where low level detail control is not required, (see 2.4) it may be acceptable to profile the total budget value between the project start and finish dates or with increasing detail across, phase, contract, discipline, system, or sub system, rather than allocate budget values at task/deliverable level.

The earned value is calculated as the product of the % complete and the current budget. It should be noted that: -

- Current budget is often known as Budgeted Cost of Work Scheduled (BCWS)
- Earned value is often known as Budgeted Cost of Work Performed (BCWP)
- Actual expenditure is often known as Actual Cost of Work Performed (ACWP)

Having established values for BCWS, BCWP and ACWP it is possible to establish a series of performance indices to enable forecasting and trend analysis to take place. The basic calculations are as follows:

Cost Performance Index (CPI) $= \frac{\text{Earned Value}}{\text{Actual Expenditure}}$ i.e. BCWP/ACWP

(A CPI >1.0 is good)

The Cost Performance Index provides a measure of the amount expended relative to the amount Budgeted. This provides an indicator to cost under/ overspend.

Schedule Performance Index (SPI) $= \frac{\text{Earned Value}}{\text{Work Scheduled}}$ i.e. BCWP/BCWS

(An SPI >1.0 is good)

The Schedule Performance Index provides a measure of the amount Earned relative to the amount Budgeted. This provides an indicator to time under/ overrun.

Forecasting

Forecasting is the process of establishing the following information at the project cut off points, once the project is underway: -

- Manhours required to complete each unfinished activity
- Cost required to complete each unfinished activity
- Duration required to complete each unfinished activity
- Reassessment of network logic for uncompleted/unstarted activities in the light of actual achieved progress.
- Continual reassessment of the above data for unstarted activities, and adjustment where necessary, but only in line with agreed change control procedures

The above data will enable the calculation of forecast end date, manhours at completion and cost to complete for the project. This action is very much linked to the previous entity of trending and the outcome of forecast together with the trend, further aids any re-scheduling/re-estimating decisions.

Forecast to complete is the amount outstanding of the known remaining scope, taking into account the agreed scope changes incorporated into the control budget, actual (achieved) progress to date, productivity to-date and any adjustment based on reassessment of planning (network logic and remaining durations) for unstarted/uncompleted activities.

For cost and manhours, the forecast to complete plus the value of work done provides the current forecast at completion. The accuracy will be dependent on the quality of scope definition, physical progress assessment, and trending at the activity level. Forecasts to complete can then be derived from the results of trending or, alternatively, earned value measurement.

Whenever forecasting takes place as a result of progress updating and/or re-scheduling there must be strict discipline to maintain the forecast having first ensured it is achievable and realistic. This must be the result of buy-in from those members of the project team who can best influence the result.

3.3.5 Cash flow management

Cash flow is the time-phased plan for the cash management, funding and expenditure requirements. Once the project is underway the spend profile is recalculated based on actual spend plus the forecast of outstanding commitments.

Input and assurance is required from all involved parties that the latest information is made available. Financial constraints may be imposed on the project by the client. Funding limits may be established by quarter, fiscal year, calendar year etc. Project Management is responsible for operating within these limits by monitoring and adjusting the work plan as required.

3.3.6 Contingency management

Contingency management is a method of dealing with the cost or schedule impact of unforeseen events. Although contingency management and estimate allowances share some basic similarities, they represent two distinct concepts.

Contingency is included to cover risks of occurrences which could not have been anticipated. It should only be used where it can significantly impact upon (or recover) a critical aspect of the project and improve the minimum conditions of satisfaction.

During the life of a project a more detailed review or re-estimate may be necessary.

3.3.7 Change Management

An inherent part of cost and schedule management is the ability to identify and control change. Figure 10, illustrates the concept of the change process and, in this example, a two step approval mechanism is employed. The first step allows for an initial assessment of the change based on order of magnitude estimates. Following internal approval/acceptance, the second step is invoked which requires more detailed review to provide the necessary details to obtain the client's approval. The two step process is particularly useful where the change is complex and management buy-in is required prior to spending too much time developing detail that may not be required.

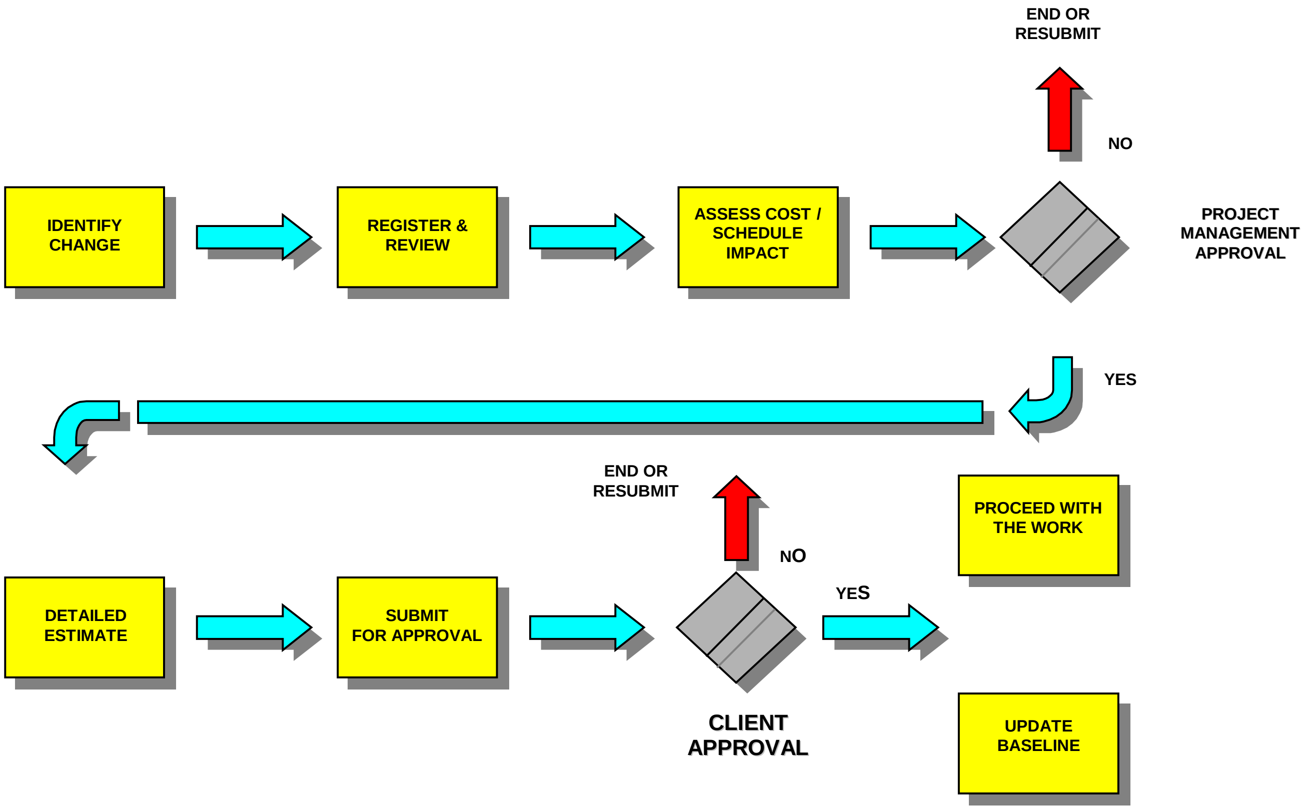


Figure 12 – A typical Change Control Process

The process can be "fine tuned" to suit individual projects; however, the main intent is that the system allows all members of the project team to be aware and comprehend the full impact of any change prior to the work taking place. This is paramount in maintaining control of the work-scope.

3.4 Retrospective Review

This section is intended to provide an introduction to the process of looking back at what has been achieved, internally or through comparison with external projects, to identify areas of above average performance from which future projects can benefit. Specifically this process should attempt to reduce the uncertainty in future estimates and plans and improve risk analysis.

3.4.1 Developing Actual Performance Metrics

Most projects and companies are being increasingly driven to demonstrate continual improvement and cost savings combined with improved performance. In order to provide a consistent and uniform measure of this it is necessary to establish a series of metrics or benchmarks.

When generating data for analysis these metrics or benchmarks need to be measured against agreed criteria, allowing for varying terminology between differing sectors of industry.

An important element of project control is the provision and subsequent re-use of outturn data in a format suitable to provide norms for use in new bids/proposals. As described in section 2.4, and in order to identify norms, it must be agreed at what level time and cost data is to be collected.

Each project phase from concept, design, procurement, construction, installation, testing, commissioning and operations requires a slightly different approach to capture the relevant outturn data.

Actual costs can be compared to estimated costs, using the CBS, to provide actual performance metrics.

In some instances it may be appropriate to capture outturn against the work breakdown structure (WBS). Data capture against key systems enables the generation of time and cost data for major generic systems. This can readily be used in comparative estimating of future projects systems.

3.4.2 Performance Review

To get the most from retrospective review requires:

- an automated process for mapping out-turn costs against the original estimate, using the WBS/CBS coding
- an open and honest culture where participants are prepared to discuss successes and failures without fear of 'finger-pointing'
- a record of significant events that impacted on the project completion
- access to those involved with the project and their availability
- a robust change control procedure

There are opportunities on completion of each stage in the delivery process for retrospective review to be undertaken, as well as at the completion of construction and after a suitable period of stable operation; each is discussed below.

Project Completion

The success of a project should be assessed against how well the minimum conditions of satisfaction were achieved. This is measured as described in the sections which addressed how to map actual costs and time to the budget and plan and the use of contingency. However a judgement is also required whether the out-turn represented good value-for-money.

It is generally accepted that in seeking to challenge complacency and improve results, projects and people have to take risks and on occasions unfavorable outcomes will occur. If the company culture allocates blame to all unfavorable outcomes there will be an inevitable move towards risk-averse estimates and in-built, hidden contingencies. In the longer term, routine over-estimation is inefficient and the business will be adversely effected. Therefore, a blame-free culture is an important pre-requisite for an open and frank debate on performance.

The most effective means of collecting the successes and failures and distilling learning points is the project close out report. This should be initiated at the start of the project and should be developed and filled out as the project progresses. Often the team that built the project will see the problems that they encountered as far more significant than the successes, hence the close out report will naturally dwell on the problems. This can be countered by using an external, independent facilitator to draw together their input and provide a balanced and objective perspective. The facilitator can also provide direction to the project team to examine areas that they have taken for granted, but from which others may learn.

Above each individual project close out there should be an oversight 'committee' whose responsibility is to review all of the reports to see whether trends can be identified and to cascade learning points to others in the organisation. This will help them to improve through adopting successful practices. It is good practice to adopt a consistent structure for all project close out reports.

The change control summary report should record all of the changes that were incorporated into the scope of work, including evaluation of the options, justification, cost, schedule, risk and opportunity and authorisation records. It is widely accepted that change is disruptive and disproportionately expensive; this suggests that the final change control register should be reviewed to determine the main cause(s) of changes to see whether this can be avoided in future.

Production Phase

The next opportunity for project review comes after a period of stable production or operation, when a view can be taken as to whether the assumptions and expectations included in the business case were accurate.

Primarily this involves a review of the performance of the plant, the inputs and outputs and the production economics and is usually undertaken by a combined team of engineers and project controls professionals. During this review there are opportunities to capture economic indicators e.g. how accurate were the forecast escalation index, currency fluctuations, raw materials prices, the product price, operational manning, etc.

Mapping actual prices against indices can lead to improvements in future investment considerations.

Benchmarking

Beyond scrutiny of the close out reports, performance can be measured in a more structured environment using benchmarking techniques. This can take many forms but consists of the following basic types: -

Process -v- Results	'process' is looking at the way that something is done, through the use of flow diagrams and decision tree analysis 'results' is a metric of what was built, for example the cost per barrel of oil processed or cost/m^3 concrete.
Functional -v- Generic	'functional' is the comparison of departments or sub-sets of the same organisation 'generic', between a number of companies

All have their place and all provide benefit through looking at what others do and investigating how it can be adopted, however the basic benchmarking steps apply in all cases, namely measurement, analysis, change and re-measurement, in an iterative process.

Corporate Memory

One aspect of corporate memory is building databases to hold statistics on performance metrics, but, more importantly, data capture should be augmented by the capture of ***knowledge*** in a consistent, retrievable format and it should be communicated throughout an organisation.

This provides the leverage to exploit the captured knowledge and can be encouraged in a number of ways, through: -

- focusing on measurement and analysis, as described in the earlier sections on metrics
- cultivating intellectual curiosity
- mentoring and staff development planning
- forming close-knit business groups rather than one, single, corporate-wide organisation
- measuring the quality of contributions not just their quantity
- promoting a diversity of views to encourage people to challenge the *status quo*

The importance of electronic data capture as an output from the cost and time monitoring software should be emphasised. If this is not possible, it imposes an extra burden for the project team at a time when other activities are pressing. The chances are that data capture will fall into disuse and the cost estimating database will soon become out of date.

4. PROJECT CONTROLS PEOPLE

4.1 Roles and Responsibilities

This section describes how the project controllers fit within the project management team and their roles and responsibilities, by answering two key questions: -

What are we here to do?

This can be summarised as follows: -

- to establish and publish realistic targets
- to supply the tools and information to the team to assist the meeting of these targets
- to ensure that current status is always known and published
- to ensure the required level of reporting is achieved
- to provide analysis of the current status and trends
- to identify – as early as possible – potential problems in meeting targets
- to recommend one or more possible solutions

It is not the purpose of this section to define how to do this, rather to emphasise the need to do it.

In fact, despite the title, project controls do not control at all; control remains in the hands of those who perform the work.

To whom is the project controls team responsible?

The direct line of responsibility and reporting is to the project manager. It is essential that accurate and unbiased reports on the performance of the project are made to the person who is charged with directing the project.

The project controllers should be able to gather data, make assessments of trends and advise the project manager when deviations occur, without distortion or inappropriate influence.

However, it is important that the project controllers should build and maintain the confidence of the remainder of the team, so that reports are supported with agreed facts. If it is bad news, the team must take responsibility and not "blame the messenger".

In some cases there may be a secondary reporting requirement, for example where the project forms part of a portfolio or departmental reports are made. In this instance it is important that data and conclusions are reported consistently.

There are occasions when the need for project controls is challenged – who is to say that a crime would have been committed if the policeman wasn't there? It is often difficult to prove the worth of advisors and, when costs are under pressure, the temptation can be to sacrifice the messenger. However this should be refused; projects are much more likely to succeed when properly monitored and controlled.

4.2 Attributes

In order to fulfil the roles and responsibilities as outlined above a project controller needs to be skilled in a number of areas: -

- **Experience**

There is no substitute for having seen it done. It is essential that project controllers have practical, hands-on experience of how things are designed and built. This should include time spent in a design office as well as on a construction site.

- **Communications**

The project controller needs to build up relationships with the project team so that they are frank and open in their discussions and reports are accepted and acted upon. Clarity, conciseness, organisation are all key skills, required for both verbal and written communications.

- **Self Confidence**

Very often, reporting by exception means that progress reports tell of failure, either in achieving the required rate of progress or over-spending on cost. Project controllers often are the first to tell the bad news and need the support of the project manager.

- **Helicopter Vision**

This is the ability to withdraw from the detail, whilst retaining perspective, and see the full implications of what is happening.

- **Team Player**

The project controller must build relationships within the team as an equal rather than as a subordinate. It enables building up status which lends credibility to the progress and cost reports and encourages the team to take notice and act.

- **Multi-tasking**

A project controller may be a specialist in either planning or costs or risk as opposed to being an all-rounder, capable of providing all of these services, albeit with a lesser degree of expertise. There is no absolute preference, rather there are occasions when the complexity or sensitivity of a project will require special skills, whereas on routine projects an all-rounder is appropriate.

4.3 Recruitment and Retention of SQEP (Suitably Qualified Experienced Persons) Resources

When considering the skills and competencies required for project control it is important to recognise that there are many different roles that may be presented to the Project Controller. These range from junior/assistant level in a small engineering company through to senior manager in a multi-national company responsible for several hundred people. Clearly this broad spectrum requires different skills and attributes.

In a complex engineering environment operating on major capital projects it is likely that cradle to grave (concept through to commissioning/operations on one project) experience may well take in the range of 7 - 10 years to complete. On the job training and real experience of each project phase is an essential requirement for a well-rounded Project Control Engineer.

There is no specific academic qualification in Project Control, however, there are some that provide a grounding in project control, these include project management and most aspects of engineering. These fields have many different professionally recognised qualifications which provide a measure of an individuals academic abilities however they do not necessarily provide a measure of competence in a specific field.

During the late 1990's a competence based measure has been developed through the National Vocational Qualification (NVQ) system. At present there are two levels identified in project controls – Project Control Level III which has a wider application to all those that have a responsible role in project control. The Project Control Level IV is aimed at individuals who have a more senior position in project control and are likely to have greater experience in some of the more sophisticated aspects of the discipline.

It is also possible to provide a measure of a candidates suitability and experience by selecting those who are members of an appropriate professional body, e.g. Association of Cost Engineers (ACostE) or Association of Project Management (APM).

Other routes to professional accreditation include Incorporated Engineer (IEng) and Chartered Engineer (CEng). Both of these are accredited by the International Cost Engineering Council or through registration with the Association of Cost Engineers who are affiliated to the Engineering Council or the Federation of National Engineering Associations. It is becoming increasingly common that individuals are required to keep a log of their training and development in order to demonstrate Continual Professional Development (CPD). The CPD system requires that on an annual basis a predetermined number of points are achieved through attending training courses, preparation and delivery of presentations, further qualifications, etc.

Some companies are now establishing training courses that are accredited with an appropriate professional institution; this provides a measure of the course content and also provides some recognition of such courses to other companies, i.e. the training is not company specific but follows approaches endorsed by impartial bodies.

4.4 Succession Planning

Given the difficulties in recruiting high calibre Project Controls Engineers it is becoming increasingly important that engineering/project management companies look inwardly to develop their own staff for future key roles and senior positions within project control.

In most major companies it is likely that all staff are routinely appraised to assess their potential. This would normally be in the form of an annual review of performance and development. Those staff selected for fast track long term development should be mentored by senior managers to provide a more effective learning environment with sharing of views and experiences. A programme of Mentoring may well span a period of several years and as such requires major commitment from all parties involved.

It is important that the basic skills and techniques are mentored at the working level. It should also be recognised that most project control computer software packages have the functionality to perform the necessary calculations. However, the Project Control Engineer should understand the approaches for themselves and recognise that the computer system is only a tool to enable delivery of an efficient and consistent service. All too often individuals assume that the computer output is always correct.

5. GLOSSARY OF TERMS

Actual Cost of Work Performed (ACWP): - Known cost of work actually completed or of services actually rendered.

Budget: - 1. Authorised target for project achievement, or part thereof, usually expressed in terms of quantities, man-hours or costs.
2. A financial and/or quantitative statement, prepared and approved prior to a defined period of time, of the policy to be pursued during that period for the purpose of attaining a given objective.

Budget Cost of Work Performed (BCWP): - Budget value of work actually completed or of services actually rendered.

Budget Cost of Work Scheduled (BCWS): - Budget value of work planned or scheduled to have been completed or of services planned or scheduled to have been rendered.

Business Case: - The recorded description of the financial and technical purposes of the investment and the required levels of achievement and return.

Capital Expenditure (CAPEX): - Expenditure attributable to the creation of a permanent or fixed asset or improvement of an existing asset.

Cash-flow: - Projected cash balance over a stated time period based on the net flow of actual or anticipated cash payments/receipts.

Commitment: - Gross commitment: Total value of all orders placed to date, including letters of intent.

Contingency: - Budget and/or schedule provision for unforeseeable occurrences within a defined project scope.

Cost Breakdown Structure (CBS): - Systematic breakdown of costs into pre-defined elements in order to summate cost of like items.

Cost Performance Index (CPI): - A measure of the amount expended (ACWP) relative to the amount budgeted (BCWP). Equivalent to: BCWP/ACWP

Critical Path: - A path through a network with least float, often zero float.

Earned Value: - Budget value for work completed.

Escalation: - Increase in cost due to inflationary movements, as measured from a defined base date.

Expenditure: - Value of all invoices and charges paid or approved for payment.

Forecast: - Estimate or prediction, usually expressed in terms of final quantities, man-hours, costs, or completion dates.

Free Float: - The time available on an activity before its delays impact on another activity.

Gates: - Points within or at the end of a project "Stage", with a defined set of criteria to be achieved before further progress can be made.

Hierarchical Structure: - The use of a coding system to identify elements of cost (i.e. labour, equipment, materials) at a number of discrete levels of detail, with the greatest level of detail at the lower end of the hierarchy.

Milestone: - Principal or critical event or occurrence within a project programme.

Minimum Conditions of Satisfaction: - A set of criteria covering safety, cost, time, and technical matters, which define the least requirements for success for the project.

Operations Expenditure (OPEX): - Expenditure attributable to the ongoing operations and maintenance of a permanent or fixed asset.

Organisational Breakdown Structure (OBS): - The way in which a project team may be organised for programming, cost planning and control purposes.

Performance: - Expression of productivity in respect of actual achievement compared to budget or plan.

Physical Progress/Completion: - Progress completion assessed from physical measurement.

Productivity: - Measure of efficiency of productive work relative to an established base or norm.

Project Accounting: - The management, during project execution, of the accounting process.

Project Control: - The pro-active setting and monitoring of targets, analysis of performance, identification and anticipation of inefficiencies and implementation of preventative and remedial actions.

Project Execution Plan (PEP): - The recorded description of the principles, strategies, policies and procedures established for the cost estimating and execution of the project.

Project Implementation Plan (PIP): - See Project Execution Plan (PEP).

Risk: - Assessed chance of exposure to adverse cost or schedule problems.

Schedule Performance Index (SPI): - A measure of the amount earned (BCWP) relative to the amount budgeted (BCWS). Equivalent to: BCWP/BCWS

Scope of Work: - Defined extent of work to be executed under contract.

Stages: - Defined phases of a project which can be quantified in terms of cost and time.

Stakeholders: - All those parties who have an interest and/or an involvement in the project.

Total Float: - The time by which an activity may be delayed or extended without affecting the total project duration.

Trend (analysis): - Perceived sequence of either adverse or favourable deviations from an established base.

Uncertainty: - See Risk

Whole Life Cycle Costing: - Analysis of cost to design, build, operate, maintain and de-commission.

Work Breakdown Structure (WBS): - The way in which a project may be divided into discrete groups of work for programming, cost planning and control purposes.

Note: The source of many of these definitions is the **"Glossary of Professional Terminology and Definitions"** published by The Association of Cost Engineers.
Copies can be obtained from The Association at:
Lea House, 5 Middlewich Road, Sandbach, Cheshire CW11 1XL,
or by e-mail at: enquiries@acoste.org.uk

6. REFERENCES

1. Cost Estimating Value Enhancement Practice, March 2000, European Construction Institute.

2. Risk Management Value Enhancement Practice, (to be issued), European Construction Institute.

APPENDIX 1 ‘Stages’ and ‘Gates’ Development

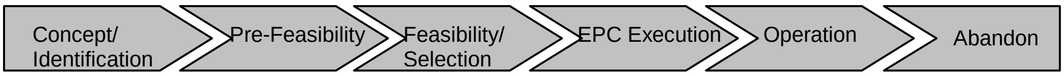
This appendix is provided to explain the principles of the asset investment control and management provided by the method referred to as ‘stages and gates’.

In simple terms this process reflects divide and control; the life of the asset is subdivided into a number of ‘stages’. These are separated by hold points where further development of the asset is considered in light of the improved definition provided by the completed ‘stage’.

Naturally, as this process describes the development of the asset, it is under the control of the asset owner, however all of the stakeholders in the development of the asset – including shareholders, clients, consultants, contractors, suppliers, local communities, customers, Government and non-Governmental organisations, will be managed within this process and their input will be sought at the appropriate time.

There are many different subdivisions or ‘stages’, dependant on the type of project – the one that is demonstrated here is commonly found in offshore oil and gas. There is also differing terminology for describing each of the ‘stages’. What is common, however, is the subdivision into discrete packages of work which can be subjected to project controls.

For the purpose of this appendix the following ‘stages’ and ‘gates’ are used: -



The first ‘stage’ is the concept or identification of a business opportunity which could be exploited. A paper would be drafted describing the idea, for submission to an authorising body for funds to develop the business opportunity and prepare further support for the business case.

The first ‘gate’ would be the authorising body considering the proposal and either providing funds for the next stage, or rejecting the proposal. The grounds for their decision would include technical as well as financial and commercial evaluation of the opportunities and threats provided.

If development is authorised, the idea can be developed through pre-feasibility to increase the engineering and design to a stage where the technical solutions or specifications available for the project can be narrowed down, estimated costs for capital and operations as well as income projections can be developed and a more accurate business case developed. The ‘gate’ at the conclusion of the pre-feasibility ‘stage’ would be consideration by an authorising body and, if successful, further funds provided for the development.

Typically the expenditure to complete these first two 'stages' would amount to between 1% and 3% of the capital cost. It is usual for these to be undertaken by owner operator's in-house staff as very high level economics are considered.

The next 'stage' (feasibility/selection) increases the level of specification of the project through engineering and design. This work is often contracted out to process engineering specialists and usually represents between 3% and 5% of the capital cost.

The next 'stage' is execution, i.e. EPC, engineering, procurement and construction. Whilst not always packaged together these activities are usually undertaken by one contractor or a consortium depending on the scale of the project, it's location or the technical difficulties associated with the specification.

Once complete the asset is put into operation; when its useful life is over and the economic operation is complete it is decommissioned, dismantled and the environment returned to it's original state.

Towards the conclusion of each of these 'stages' the scope of work for the following 'stage' is developed, estimated and planned. This provides the baseline for the project controls for that 'stage' until it is complete and the cycle is repeated in an iterative process until the asset is developed.

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