The Fast Track Manual

European Construction Institute

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A guide to schedule reduction for clients and contractors on engineering and construction projects

Fast Track Projects Study Task Force

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dti
Department of Trade and Industry

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The information given in this handbook, which has been based on research into practical experience reported by third parties, is given in good faith and belief in its accuracy. While every effort has been made to ensure that the advice contained in the handbook provides suitable guidance for experienced business and project managers and other project professionals, such advice and guidance requires careful application to take account of specific project circumstances. No legal liability or responsibility whatsoever is accepted, by the DTI, Davis Langdon Consultancy, the ECI, the Project Partner companies and their representatives, the publishers or by the author, for the consequences of use or misuse of this handbook in any particular circumstances.

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Foreword

The research that has resulted in the production of this handbook was initiated by the members of the European Construction Institute. They comprise clients of the engineering and construction industries and the management, design and construction contractors who support them in the creation of new assets and the development and maintenance of existing assets.

The projects executed by these organisations include infrastructure and industrial installations, power stations and process plant for the oil, gas , chemical, pharmaceutical and other industries which typically embrace elements of building, civil engineering and engineering construction. All of these sectors are increasingly driven by a competitive requirement to reduce project schedules and the time taken to get products to market.

The overall objective of this handbook is to provide advice and guidance to clients and contractors which will help them to succeed in:

- reducing the duration of their projects through the application of a wide range of techniques
- identifying the business and project environment in which these techniques can succeed and
- managing the risks which can arise from schedule reduction

This is a comprehensive document which has been prepared by a task force of experts drawn from ECI member and associated companies directed by a manager with experience of all stages of the project process. I strongly recommend it to all who have an interest in or a responsibility for the creation of new capital assets.

Sir Michael Latham
President, European Construction Institute.

Section 1 Introduction

1.1 The ECI Fast Track Projects Study

Much has been published on the subjects of project management, construction, building, contracting and associated topics and there is a great deal of accumulated experience and wisdom for those with the time to read it all. The intention of this handbook is not to repeat what has already been published, although that is to a degree inevitable, but to present the best ideas, advice and guidance on the reduction of the schedule for delivery of a project to the practical minimum, in one easily accessible document. All the information contained in the following pages has been gathered together from the current experience of individual managers and companies, directly or from literature.

This work is the result of a study carried out by a Task Force of European Construction Institute Members and other interested companies, supported by the UK Government Department of Trade and Industry. It is not an academic treatise but a reservoir of practical ideas and suggestions that need to be considered and interpreted before they can be successfully applied to any specific project. All stages of a project have been covered from formation of the initial concept through to beneficial use of the completed asset. Decommissioning and demolition have not been specifically included because they are usually separated from the original asset creation process by many years, but the guidance which follows is equally applicable to these activities which are projects in their own right.

The research on which this handbook is based has drawn on both general company experience and specific projects which ranged from 4 to 36 months in duration and achieved an average reduction in schedule duration of 29% when compared to previous similar projects, benchmarked industry averages or initial estimates.

An attempt was made in the interviews to distinguish between "Schedule Reduction Techniques", defined as normal project management practices for shortening the duration of the project without the introduction of significant additional risk, and "Fast Track Techniques" which involve unusual and innovative practices that are likely to introduce significant additional risk. This distinction was not recognised by many of the interviewees who took the view that, as one person put it, " there is no boundary between a normal project and a fast track project; both are part of the same continuum and it is a matter of degree rather than doing anything differently." There is thus a high degree of commonality between the good practices recommended for delivering projects to a tight schedule and those for delivering a project to an exceptionally short schedule.

The reasons given for utilising a fast track strategy varied with industry but the most common theme was an urgent requirement by the client to take commercial advantage of an opportunity either to maximise profit or limit loss. In some cases a fast track strategy had been adopted because of an imposed deadline such as the start of an academic year, end of a current lease or new legislation. Other reasons given included the need to minimise disruption of services, to improve the commercial standing of a company, especially a contractor, and to improve product quality.

The views expressed on penalties for the project arising from the adoption of a fast track strategy varied considerably through the sample taken and depended on the individual's personal experience. One third of interviewees stated flatly that they had identified no project

penalties from adopting a fast track strategy and that, on the contrary, there were many advantages since the effective project management needed to deliver the schedule also resulted in tight control of safety, cost and quality. A further third of the sample responded that the main penalty was an increase in project risk which had to be managed, but that in practice, given effective risk management processes, those risks only rarely turned into penalties. It is worth noting that only two thirds of the sample actually had an established risk management process. The final third of the sample reported that there were increased project costs due principally to additional design, redesign and site rework although it was not possible to identify how much this extra work cost in practice, nor was not possible to establish whether this was more than off-set by the business benefits of early completion.

It is not the role of the Task Force to persuade anyone to adopt a fast track strategy for their projects. From the practical experience gathered, both from the members of the Task Force and other companies, it is clearly a difficult and often stressful route to follow. The intention in producing this handbook is to assist those who are considering a fast track strategy to make the right decisions, and to help those who have already decided, or on whom the decision has already been imposed, to implement the strategy successfully.

A very broad definition of "fast track" has been used in the hope that all those involved in fixed asset creation, whether it be domestic or commercial building, civil works or engineering construction, can see that this could be applied to their projects. The terminology used is that of the contributors to this handbook and is not intended to be exclude any group or industry. On the contrary, discussions have been held with those responsible for projects in many industries with the specific intention of spreading ideas from one area to others in which it may not yet be common practice.

1.2 Handbook Layout & Use

The handbook has been structured to enable individuals to access the information that is of most relevance to themselves without the need to read the whole document and to be constantly referring to other sections. This has resulted in a small amount of information appearing in more than one section, as will become apparent to those who use the whole manual. Readers, whatever their role in the management of projects, are recommended to look at Sections 1 to 5 in addition to the sections which address their particular area of interest.

Check lists of any size have been taken out of the text and included at the end of the most relevant section, with cross references in other sections. They are designed to be copied for use on specific projects.

A short glossary of terms has been provided and words that are defined in the glossary appear in italics in the text. The author relies on the reader interpreting any unfamiliar phrases within the context of the text.

The amount of information in this handbook may appear daunting at first sight. However, all the aspects of new asset creation mentioned in the following pages are there because they are considered to be important by one or more of the people whose experience formed the research on which this manual is based. Some things are inevitably more important than others and the diagram which follows provides a scale of relative importance (red = greatest

relevance to yellow = least relevance) that will, in the view of the Task Force, be appropriate for many projects. The page numbers provide a ready reference to the location of the information on that subject.

Significance Diagram and page reference

	People	Scope	Strategy	Project Systems and Procedures	Project Risk Management	*Logistics*
Concept	Page	Page	Page	Page	Page	Page
Development	Page	Page	Page	Page	Page	Page
Definition	Page	Page	Page	Page	Page	Page
Design	Page	Page	Page	Page	Page	Page
Procurement	Page	Page	Page	Page	Page	Page
Construction	Page	Page	Page	Page	Page	Page
Commissioning	Page	Page	Page	Page	Page	Page
Operation	Page	Page	Page	Page	Page	Page

From this it can be seen that the calibre of the individuals involved and their working relationships, together with the adequacy of the definition of the project, are fundamental to the success of the venture, closely followed by the strategy adopted and the systems for its implementation. Not evident from this diagram, but of great importance in the view of the Task Force, is the passion to succeed on the part of the key participants in the project.

The risks associated with the increased overlap of each of the phases of a fast track project have been addressed in Sections 6 to 12 inclusive, along with the mitigation opportunities that have been identified by the Task Force or during the research. The management of risk in general has been covered in Section 15.

Section 2 Definition of a "Fast Track" Project

The term "fast track" is in general use to describe something that takes place more quickly than normal, and that is indeed the essence of a fast track project. There are however a variety of ways in which this reduced project duration can be achieved and it has been normal in the construction / building industry to limit the definition to exceptional ways of executing the activities involved in the creation of a new asset. These exceptional strategies invariably introduce additional risks, which is why they are not more commonly practiced. These risks need to be actively managed to limit their impact on the other aspects of the project, such as safety, cost or quality.

On this basis, simply doing all the normal things involved in the creation of a new facility more quickly than normal would not constitute a fast track project. However, there is unlikely to be any benefit gained by adopting a fast track (as opposed to the most efficient or cost effective) strategy, with its attendant risks, if the most time-effective procedures are not being followed in the execution of all project activities.

Thus the successful delivery of a fast track project is dependent not only on adopting a different and more innovative strategy but also on the time-effective execution of all the normal, mundane project activities.

Kwakye in the CIOB Occasional Paper No. 46, 1991, which is aimed specifically at the building industry, defines it as "a managerial approach to the achievement of early project delivery, involving the application of innovations in the management of construction procurement and recent advances in the industrialisation of the construction process, bringing into play:

- The integration of design and construction phases
- The involvement of the contractor in both the design and construction phases
- Work packaging
- Overlapping of work packages to enable construction of sections of the project to proceed while the design for other sections is being considered or progressed
- The employment of the expertise of works contractors and the recognition of their active participation in both design and construction."

Turner in The Handbook of Project-based Management, 1996, distinguishes between three approaches to shortening the duration of a project based principally on the level of additional risk that is introduced:

- "fast build" in the building industry in which design and construction of the different stages of the building process are overlapped with little additional risk since later design elements are unlikely seriously to affect earlier elements

- "fast track" in the oil, gas and chemical industry in which design and construction are overlapped and different sections of the plant are designed and built in parallel, but where there is significant additional risk due to the links between the design of different parts of the plant

- "concurrency" in which the overlapping of design and construction introduces significant additional risks due to the inter-relationship between the various parts of the design.

For the purpose of this study a very broad definition incorporating all three of the above has been used in which a project is considered to be "fast track" when the **reduction of the schedule to the minimum practicable is the principal driving force** for one or more stages of the project.

Evidence that the project is "fast track" will be that, in addition to the good business and project management practices normally used to ensure timely delivery, exceptional practices are deployed to achieve the shortest possible time, probably involving higher levels of risk and a trade-off with other requirements.

This fits with the common understanding and dictionary definition "Fast Track – the quickest route to achieve a particular goal or position".

References and Further Reading

Title	The Handbook of Project-based Management, Second Edition, 1996
Publisher	McGraw-Hill
Subject	Projects and project management
Author	J R Turner
ISBN	0-07-709161-2
Review	This is a very comprehensive book which provides the general manager with a structured approach to project management. There are several references to fast track projects, but more importantly, there is thorough coverage of all those aspects of project management which are of significance for a fast track project. Recommended reading and reference work for all project managers.

Title	The Management of Projects
Publisher	Thomas Telford, 1994
Subject	General guidance on the management of projects
Author	Peter W G Morris
ISBN	0 7277 1693 X
Review	A tour de force of project management development up to the early 1990s with numerous references (250 at the end of chapter 7 alone). Sound general guidance covering the full range of industries served by construction but little specifically on fast track projects except pages 180 and 241.

Section 3 General Principles of the Fast Track Approach

This section gives a brief catalogue of the main techniques that can be applied to speed up the delivery of a project. None of them is unique to fast track projects. The only real difference between a fast track project and a normal project is the extent to which these techniques are applied.

3.1 Project Stage Overlap

The project process adopted by both clients and contractors normally consists of a number of sequential stages, and there may be *gates* between the stages which can only be opened to permit progress to the next stage by satisfying a set of pre-defined conditions. These conditions have usually been developed as a result of bad experiences on past projects and are intended to reduce risk and increase the certainty of outcome, whether of cost, time, quality or safety.

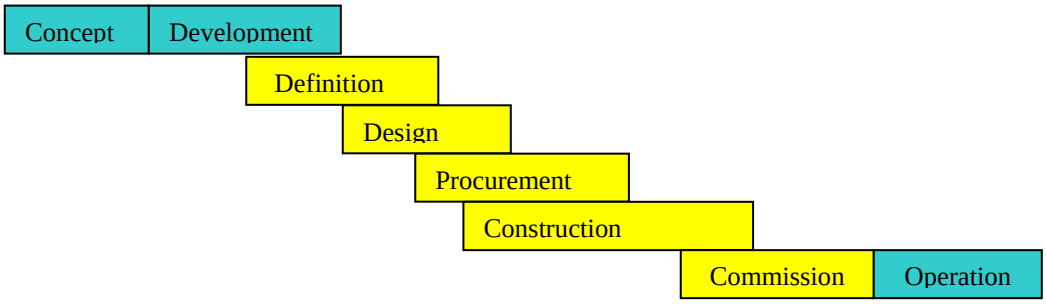
While there can be a wide variety of variations on the theme, a typical conventional project process might be represented by the simple diagram below.

In this it is assumed that the client, assisted by consultants, architects or others as appropriate, manages the project through to the point of having a definition on which a contract can be based. During the Concept, Development and Definition Stages the project will have passed a number of *stage gate*s at which approval will have been given for the work to continue and funding will have been sanctioned, at least for the following stage. Each of these *stage gates* may have resulted in a delay while approval is sought.

The design would normally be executed by a design contractor or architect following a lengthy selection process, during which there is unlikely to be any significant progress on the project. A further delay would ensue while the construction contractor / builder is selected, possibly based on a lump sum bid against the firm design. Procurement could be carried out by the design or construction contractor, but may not start until design has been completed. Once the work has been completed it would be handed over to the original client for commissioning and ultimate operation.

This arrangement would be different if a management contractor were to be involved, or if the contract were to be of the Design and Build or EPC (Engineer, Procure, Construct) type. Never-the-less, many of the delays would still occur between the project stages.

By contrast, on a fast track project there may be a significant degree of overlap between adjacent stages resulting in a shorter overall programme as represented below:



Most commonly there is overlap of the design, procurement, construction and commissioning stages of the project since these often come under the management of a contractor who has been awarded the contract by a client based on a defined scope. The maximum reduction in overall schedule will be achieved when there is overlap of all stages of the project from concept through to beneficial operation. That can only occur when an integrated team is involved in the project from the start, see Section 3.4 below.

3.2 Work Package Overlap

It is common practice to break down a project into a number of sub-units or work packages to assist with general management and cost control.

In the case of the fast track project this is also done:

(a) to shorten the schedule by enabling some or all of the work packages to be progressed in parallel with other work packages and

(b) to enable the stages of the project process, as it is applied to each of the work packages, to be overlapped (as described in Section 3.1 above) to minimise the schedule for completing each work package.

3.3 Early Decisions

The purpose of overlapping project stages and splitting the project into work packages is to create a situation in which it is possible to make decisions and progress work earlier than would otherwise be the case, e.g. to commence design before the project scope has been completely defined. These opportunities must be grasped or the schedule will revert to a conventional one and there will be no significant saving in overall time to complete the project.

Some decisions will need to be made with only limited information available. This will require experienced judgement to ensure the correct outcome. It will be necessary to authorise and empower the team members to behave in this way, which may be contrary to their training and previous experience. The organisation must make it clear that it is prepared to accept that some decisions will be wrong or sub-optimum and that it is prepared to carry the risk that some decisions will need to be changed when the full information becomes available.

3.4 Integrated project team

The *conventional project process* may result in delays at several stages where responsibility for progressing the project transfers from one party to another, e.g. from client responsibility for definition to contractor responsibility for design; from contractor responsibility for construction to client responsibility for commissioning.

A number of significant benefits to the schedule can be achieved by developing an *integrated project team* as early as possible in the project process, e.g. development or definition stage, and continuing with the same team through to beneficial operation of the asset. An *integrated project team* in this context is one in which the main parties to the project are combined into a single organisation and participate to the limit of their capability in achieving the project objectives.

This will require the identification, selection and appointment of many of the parties to the project at an earlier stage than would normally be the case and will limit the contractual terms available, e.g. when contracts are let before the project scope has been defined. It will be easier to establish the *integrated team* where relationships between the parties have already been established, perhaps where there are partnerships, *alliance*s, term contracts and supply agreements.

The benefits of this approach include:

- Additional expertise available for the development and definition stages
- Continuity of involvement, avoiding "learning curve" errors
- Reduction in the overall workload
- Commitment to the project definition
- Design and construction process can be developed together
- Optimisation of the project schedule
- Commitment to achieve the project schedule
- Avoidance of contractor and supplier selection delays during the course of the project
- Reduction in the need for in line approvals
- Removal of dual roles and man to man marking

It has been pointed out that these benefits may be partly offset by increased costs resulting from the input of some of the parties, especially if they are not committed to the proper achievement of the project *CSFs*.

3.5 Additional Staff

A consequence of scheduling activities in parallel rather than in series is that more staff will be needed at peak periods if each of the parallel paths is to make the optimum rate of progress. It is therefore necessary to provide resource levels to deliver the plan rather than levelling the plan according to the resources available. The flexible provision of these additional staff should be taken into account when deciding the resource strategy.

The parallel path approach will create a higher than normal peak demand for staff to manage and execute the project. While the resources required to execute the work can be estimated as for any other project with due allowance for productivity / efficiency, experience suggests that the management workload that is likely to be generated in the co-ordination of work packages

will be higher than expected based on conventional projects. Without this additional management resource the interface and progress issues arising from the inter-dependencies between disciplines and between design, procurement and construction will not be addressed at the required rate when each work package is being driven at the maximum rate.

3.6 Schedule Reduction Techniques

The benefits to be obtained from a combination of the techniques listed above will all be wasted unless the project is managed in an efficient manner making full use of all the normal schedule reduction / compression techniques as listed in Sections 9.8.2 and 11.8.2.

3.7 Additional Risks

The conventional project approach utilising a *stage gate* process has evolved to minimise risks and increase certainty of outcome. The highly commendable objective is to "get it right first time, every time". But this frequently requires that a decision is delayed until all the information is available so that the risk that the decision will be wrong is minimised. Early decisions, based on limited information, cannot always be right first time and a system will need to be put in place to ensure that decisions are reviewed and corrected where necessary as soon as possible in the project programme.

A structured and thorough risk management process is therefore even more important on a fast track project than on a conventional project. It will need to address not only the normal project risks but also the additional risks that are introduced as a result of decisions based on experience and judgement in advance of the facts becoming available.

3.8 Case Studies

3.8.1 Retail Store

An example of a new supermarket built by an international contractor which clearly demonstrated that significant improvements in schedule can be achieved through an innovative approach to a conventional project process without the need for excessive project stage overlap.

The building was designed, constructed and commissioned in half the time typically taken for previous similar stores, a total of 16 weeks. This was achieved with a reduction in cost and building waste and zero defects at handover – an industry leading efficiency as measured using *CALIBRE*. The project had the advantage of being the latest in a series of similar projects and the building was of very simple design.

Keys to this success included:

- Top management commitment from client and all contractors and sub-contractors
- Teamwork based on selection of the right people and using team and relationship building exercises to create the right team dynamics
- Motivation of the team members, empowerment to achieve tough but realistic objectives within a no blame culture

- Design and construction process improvement initiatives focussing on the transformation process
- Technical improvements to simplify the building and reduce the work or time taken, e.g. by the reduction of wet trade work, using *value engineering*
- Effective detailed planning commencing with the required end point
- Desensitisation of the programme by taking things off the critical path, adding value off site by fabrication of building and equipment components, and de-skilling the site processes
- Good systems and control procedures
- Using the latest IT systems for communication, collaboration and approval of design
- Effective risk management which addresses most risks in terms of cost

3.8.2 Chemical Plant

An example in which the degree of overlap between project stages was deliberately pushed to the perceived limit, resulting in considerable additional risk, and innovative approaches were used to minimise the project schedule.

The project consisted of a 30% extension of a much modified, 35 year old chemical plant and an adjacent, totally new, chemical plant which is the largest of its type in the world, together with associated off-sites and utilities and a new office building which also contains amenities, workshop and store. It was designed, constructed and commissioned in 19 months, independently benchmarked as 10 months ahead of a typical comparable plant, while saving 14% on cost, having no lost time accidents and achieving design output shortly after start-up. This was achieved in spite of neither client nor contractor having previous experience of this unique project which involved novel technology and most of the project team not having worked together before.

The keys to success included:

- Top management commitment from client, contractors and sub-contractors
- Clear strategy and objectives, including parallel (concurrent) engineering
- Forceful and innovative project leadership / management
- Client / contractor team based on selection of the best available people / contractors
- Highly incentivised, mainly reimbursable, contracts to enable early start without adequate definition
- Motivation of the team members, empowerment to achieve tough but realistic objectives within a *no blame culture* requiring early decision making based on limited information
- Partnership, trust and close co-operation between client and main contractor, reinforced by team building and joint accommodation on site
- Size and complexity of the process plant reduced through technical improvements to simplify the chemical process and strictly limiting scope to that required to meet current objectives
- Best possible planning (based on inadequate definition until late in the project)
- Management focus on long delivery / critical path activities
- Good systems and control procedures
- Using IT systems for communication, collaboration and approval of design
- Managed and shared risk and reward

- Experience, expertise, dedication and shear hard work (quote Project Manager)

Section 4 Benefits and Penalties

During the course of the study companies were asked to list the potential benefits which they had used to justify a fast track strategy for their projects, and the potential penalties associated with such a course of action.

4.1 Client Benefits

From the client point of view there have to be significant benefits from early completion if the risks associated with the fast track approach are to be justified. These benefits naturally vary with the industry and the circumstances of the company. They are usually financial benefits, of exceptional increased profit or reduced loss from early use of the asset, as a result of one or more of the following:

- Earlier income generation from the new asset - rent or manufactured goods
- Ability to deliver against commitments / contractual obligations
- Earlier completion of urgent works of restoration following accident or incident e.g. flood damage, bridge collapse, train crash
- Reduced cost of providing alternative facilities
- Earlier availability of cheaper production from up-dated assets
- Earlier closure of old and less efficient plants
- Alignment to fixed date of plant shut-down
- Earlier investment payback
- Shorter investment payback time, especially in times of high inflation
- New product to market ahead of competition
- Increased market share
- Compliance with inviolable regulatory requirements which would otherwise result in closure of the facility
- Benefiting from changes in the tax regime
- Earlier start to other projects following release of resources
- The shorter the time between investment decision and the asset being in beneficial use:
    - the less likelihood there is of changes in market conditions on which the investment was justified and
    - the more likely it is that the investment decision will be proved to have been correct.

The client may have other reasons for the achievement of a reduced project programme, such as:

- To improve the financial standing of the company
- Reduced period of risk exposure, although at a higher level of risk in the short term
- Minimised disruption to customers
- Reduced period of adverse publicity where new or modified equipment is needed to solve a problem
- Completion in time for a special occasion which has to be booked long in advance, e.g. public opening by royalty

It has been reported by more than one company that fast track schedules save money in spite of the risks of additional costs which are introduced by adopting a fast track strategy. In

practice there are threats of cost increases and opportunities for cost reduction. The balance at the end of the project will depend on the astuteness with which the project manager and his team has dealt with both threats and opportunities.

Cost saving opportunities can arise from the strategies that are embedded in a fast track approach such as:

- "Lean" design, optimising the process and minimising number/size of equipment
- Standard or reusable design
- Reduced development costs through focused evaluation of options
- Restricting changes to prevent disruption of schedule
- Purchase of standard or off-the-shelf equipment
- Economy of optimum construction period
- Reduced establishment costs resulting from shorter time
- Reduced duration for which overheads need to be covered

4.2 Contractor Benefits

From the contractor's point of view there are fewer reasons to embrace a fast track strategy unless the relationship is such that they are able to share in the benefits which caused the client to commit to such a strategy in the first place. It is more usual for the client to propose the use of a fast track strategy, or to set such a tight completion date that the only way to achieve it is to adopt a fast track strategy. It is still the case that many contractors only become involved following receipt of tender documents so that they are unable to influence the earlier stages of the project during which decisions may have been made which determine the success or failure of the strategy.

Potential benefits to the contractor include:

- Earlier income from the job due to the shorter overall duration
- Earlier deployment of resources to other jobs
- Ability to tackle more jobs with the same level of resources
- Possible opportunity to earn incentives, although it seems that these are rarely focused on early completion even for fast track projects
- Possible opportunity for longer term relationship with client through an *alliance*
- Enhanced reputation leading to opportunities with other clients
- Reduction in risk of late completion against contractual target by working to even tighter schedule.

4.3 Penalties

It is far less easy to summarise the penalties that can arise as a result of adopting a fast track strategy. As described in the Introduction, Section 1.1, the contributors to the research results can be divided into three equal groups:

(a) those who had found there to be no penalties but a number of advantages
(b) those who recognised that there are additional risks that could lead to penalties, but had managed those risks so as to avoid them becoming penalties
(c) those who had incurred additional costs in delivering the fast track strategy that were not wholly offset by savings within the budget for the project.

The risks that could lead to penalties have been addressed under each of the project stages, Sections 6 to 13, to which reference should be made.

One penalty that is most likely to be incurred is an increase in the amount of project management, planning and control effort for the successful delivery of a fast track project compared to a conventional project, resulting in these costs being a greater percentage of total project cost.

Section 5 The Influence of Business and Project Environment

5.1 Characteristics which Support a Fast Track Strategy

This section is intended to assist business and project managers to recognise the characteristics of their staff and organisations which will support the achievement of the *critical success factor*s for all projects. It can be used in two ways:
(a) to identify whether a project is suitable for a fast track strategy or
(b) to identify areas for improvement when required to implement a fast track strategy

There is no difference in the culture and behaviours required for the successful achievement of different *CSF*s so that the right culture and behaviours will lead to equally high levels of success in all the project parameters; safety, cost, quality and time. However, the research suggests that the success of innovative, fast track projects is more dependent on the presence of supporting factors within the businesses involved than is the case for more conventional projects. It is also apparent that a passion to succeed with the fast track strategy on the part of the key players is an essential requirement in ensuring success.

5.1.1 Ownership

An essential pre-requisite for success is strong ownership of the project and its objectives by the client, and the appointment of a single project *sponsor* or *champion* at an appropriate level within the organisation. This appointment is required whether or not there is a *steering group* for the project since the *steering group* usually consists of representatives of a number of *stakeholder*s and meets only infrequently. A *steering group* must not be allowed to take over any parts of the role of the project manager since to do so would inhibit rapid decision making.

The individual who fulfils the role of client project *champion* needs to be at a senior enough level to be able to:

- Promote the client's will to succeed with a fast track strategy
- Ensure that benefit to the client rather than cost of asset drives the client's thinking
- Make decisions speedily which commit the client business to actions
- Deliver client business actions in support of the project
- Ensure that the client business management fit in with the demands of the project schedule e.g. for approving funds
- Provide support to the project manager / project director on request
- Protect the project team from client business pressures and interference

In addition to the client, all other *stakeholder*s also need to recognise, accept and support the project *CSF*s, particularly the fast track strategy which is aimed at achieving the principal success factor of the shortest practicable schedule. If any one of the parties to the project is not committed to the fast track strategy then it is likely to undermine the determination of the rest and limit the rate of progress which is possible. Architectural and engineering design which incorporates fast build features will clearly contribute to earlier completion than would be the case if the build process were to be left to the site contractor alone.

It is very beneficial if the concept of project *champion* is carried forward into the other organisations involved in the delivery of the project, e.g. management / main contractor, sub-

contractors, although in this case the role relates to the contractor business rather than the client business.

5.1.2 Organisation

The client and contractor organisations which will be most successful at (fast track) project delivery are those that enable people with the characteristics described in Section 5.1.3 below to flourish. Regardless of the complexity of the business structure, the project team needs to be simple, clear and devoid of rigid hierarchy. **If the parent organisation has a *functional matrix structure*, the functional line must be subordinate to the project management (task) line for the duration of the project team.**

There is no single organisational structure which has been identified as being more likely to be successful in running a fast track project. Structures which are appropriate for normal projects are also capable of delivering fast track projects. Some client companies have found that on larger projects the appointment of a project director is helpful in removing external pressures from the project manager and allowing the project team to concentrate on speedy delivery of the project objectives. For optimum performance the project manager must have control of all the component parts of the project so that the ability of the project team to achieve the *CSF*s is not restricted by the performance of others outside the project team.

The culture of the client's and contractors' parent organisations, together with the personal / leadership characteristics of the project manager, will greatly influence the culture that is established within the project team.

Desirable project team characteristics include:

- Honesty
- Openness
- Trust
- Anticipation and avoidance of issues rather than waiting for them to turn into problems that have to be solved
- Mutual Support – willing to take time out to resolve Human Relations / Personnel and other issues, coaching, mentoring, development of members within the team
- *No blame culture* – essential for decisiveness when information limited
- Access to all parties, no communications barriers
- Lean organisation, which aids communication and speeds decision taking
- Full time members, avoiding whenever possible part-time members with other responsibilities and priorities
- Permanency of membership for duration of the project
- Authorised, empowered and enabled members of the team
- Approved risk taking so that people will make bolder decisions
- Decision making delegated to lowest competent level
- Decision making on the spot, without reference to higher authority
- Discipline to work to *fit for purpose* rather than customising and fine tuning
- Flexibility to use / bend company systems to the benefit of the project
- Tolerant of staff who think differently / creatively and challenge convention / the obvious
- No alternative agendas

The project team should be formed as early as possible in the life of the project and should preferably continue until the completed and operating asset is handed over to the customer organisation. It may be that, if the project team is formed at the concept or development stage rather than following definition / at the bid stage, then there will need to be a change of leadership as the project evolves from a business idea through to design and construction. However, there are considerable benefits from the appointment of a single project manager for the life of the project e.g. the application of project process discipline to limit the time utilised during the development and definition stages.

The fast track project organisation will need to include all the functions normally seen within a project team but the following are likely to be particularly beneficial:

- Experienced, competent and innovative planners with leadership characteristics
- Individuals who can be dedicated to dealing with issues which would otherwise delay the progress of the whole team
- Responsive administration supporting the project team and working with a sense of urgency, e.g. prompt equipment provision, travel arrangements arranged quickly, and providing easily accessible documentation
- Works representatives and commissioning staff (two separate roles) who need to give early consideration to:
    - Systems definition – process, instrument, electrical
    - Handover philosophy, methodology, standards, documentation
    - Planning of systems preparation and commissioning in order to drive the construction plan which in turn will drive design and procurement plans
    - Writing commissioning procedures and operations / maintenance procedures
    - Identifying and recruiting resources
    - Training staff
    - Testing plant and equipment, e.g. hydro tests, elect and instrument circuit and loop tests, trip and alarms, etc.
    - Writing plant performance test procedures

An essential characteristic of successful fast track project organisations is that they are able to make resources availability to meet the needs of the project so that the progress of the project is not limited by the staff available. Fast track projects are very demanding of resources. There is a limit to the number of truly stretching fast track projects that any organisation can accommodate at one time and usually a limit to the number of normal projects that the organisation is prepared to have disrupted in order to service the demands of the fast track projects.

5.1.3 People and Relationships

People and their working relationships are the factors most critical to project success.

Fast track projects require a higher than normal proportion of those involved to have the following characteristics:

- Technical competence, based on skills, knowledge and relevant experience
- Decisiveness, willing to make decisions based on judgement in the absence of facts
- "Self starter" who will get on with the job without waiting for instructions
- "Can do" attitude and willingness to tackle seemingly impossible tasks
- Flexibility, constrained only by limits of personal competence

- Ability to forecast the outcome and decide / act accordingly
- Ability to take the broad project picture into account
- Cooperativeness, willing to collaborate to achieve team objectives
- Enthusiasm, relishing the challenge of achieving difficult objectives
- Strong leadership capability to build team spirit and inspire the project team
- Managerial competence to ensure that essential systems and procedures are followed
- Openness, willing to share problems and contribute to solutions

Project team selection should, whenever possible, take into account the desired characteristics of the individuals who are to make up the team so as to get the team dynamics right as well as ensuring the necessary compliment of skills, knowledge and experience. In practice these options are only rarely open to the project manager who may have to populate his core team from the staff available when the vacancy occurs.

All parties to the project should be located together so that there is the greatest chance of creating one team from the disparate individuals. It is better still if that group can be forged into a dedicated project team which is based in the most appropriate location for the stage of the project, e.g. initially at design office, at site during construction and commissioning. This will greatly increase awareness of project progress and issues, ease communication and make it easier to build and maintain team spirit.

The relationships between the project team members will be tested on numerous occasions during the course of a fast track project. It is therefore important that relationships are sufficiently robust to withstand these pressures and that there is a willingness to confront and resolve relationship issues. This requires a respect for and understanding of other people's roles, and a willingness to compromise in the interests of the project.

Existing relationships should be taken into account when addressing the contractual arrangements. Good experience of working together on previous projects should greatly speed up the process of forming the project team.

5.1.4 Motivation

Motivation of all parties to the project to maintain a high personal work rate and to drive the project to a rapid conclusion is essential if the potential of the individuals and organisation are to be realised. In many cases the requirement is to avoid the de-motivation of individuals who are only too keen to succeed, but who are prevented by the organisation, procedures, etc., from doing as well as they would wish. The greatest contribution to staff motivation will be the creation of a team culture as described above.

Committed and inspired staff who are passionate about achieving their objectives have been known to form themselves into a motivated team, but this is far too important a matter to be left to chance. People will only accept the stretch and challenge of difficult targets if they see that they are part of a team, all working equally hard and supporting each other in the achievement of the objectives. The appointment of individuals who are known to be good motivators to key positions will help to develop the team in the right way and ensure that problems are identified and addressed promptly.

Early identification and removal of under-performing individuals is essential to prevent them from undermining the work ethic of the rest of the team. To this end it is essential to distinguish between the true under-performers and those who fail to achieve targets in spite of personal commitment and hard work who should receive management support, assistance and encouragement (assuming that they have the necessary core competence).

Team building events can help to settle a new team down and form a foundation for the development of appropriate relationships. This is probably the one opportunity for the most senior managers (Managing Director or Chief Executive) of the companies involved to spell out their own commitment to the project and their expectation of the project team. Finding time for such an event at any stage of a fast track project can be a problem and it is suggested that some aspects of the project work should be the basis for team building activities. *Interactive planning*, see Section 7.8, has been used successfully for this purpose.

The make-up of project teams change over the life of the project and it is important to recognise that newcomers can feel very excluded if a strong team culture and personal relationships are established before they arrive. Thus it may be useful to hold a number of w*orkshops* at change points in the project when there is an influx of new team members so that professional contributions can be assessed and effective working partnerships developed.

Team maintenance events are as important as the initial team building and these should, ideally, be built around project orientated *workshops* although social events and celebrations e.g. *milestone* achievements, safety performance, all have their place. Recognition of performance and contribution, for the project team as a whole and on a one-to-one basis by senior managers, should be the norm in any well run organisation which seeks to get the best from its staff and provide them with personal satisfaction as part of the reward for their efforts.

The inclusion of incentive / penalty clauses and bonuses are recognised as valid ways of aligning the contractor's interests with those of the client. They need to be very carefully considered when negotiating contracts and should be targeted on those *CSF*s which are of greatest value to the client. For short duration projects the use of incentives to achieve *milestones* is not recommended since the objective is to get to focus all attention on the true end point. On larger, longer duration projects, consideration should be given to the use of incentives for the achievement of significant intermediate milestones that clearly move the project forward. Such successes, when achieved, can be used to re-motivate, re-focus and re-launch participants on to the next phase of the project. Early *milestone*s should be lightly weighted in comparison to later *milestones* so as to reward the cumulative effort and recovery / maintenance of the schedule. Failure to meet milestone dates gives the managing organisation a clear message that something needs to be done.

Special attention should be given to the motivation of sub-contractors within the context of the project contractual arrangements since this currently appears to be more difficult than motivation of management and main contractors who are more likely to have a long term working relationship with the client.

Personal incentive schemes are in limited use, but many companies recognise that they can become a source of dissatisfaction and hence a de-motivator if they are not earned at any stage. When used it is essential that they are available to all members of the project team, not just selected individuals.

5.1.5 Contractual Arrangements

Contract arrangements are required that bring together the client's objectives with the interests of all the parties who need to co-operate so as to achieve the client's objectives. The intention must be to achieve a win - win situation so that everyone can concentrate on delivering the project *critical success factor*s, confident in the knowledge that their best interests are being served by doing so. This requires that the project risks are fully understood and placed with the parties best able to manage them.

The fast track schedule is most likely to be achieved if the maximum possible contribution is made by all parties from the earliest practicable date. This suggests that the client should be able to call on contractor and specialist supplier skills and knowledge at a time when there is insufficient definition to support competitive tendering and good cost estimation. Support services are therefore likely to be engaged on a reimbursable basis, perhaps with incentives, from a list of pre-selected, preferred suppliers and contractors.

The basis for contractor selection for a fast track project should include the organisational and personal capabilities as described in Sections 5.1.2 and 5.1.3 above covering:

- Resources, capacity and capability available (vendors and sub-contractors)
- Calibre / personal characteristics of staff available at the time
- Technical skills and knowledge
- Project management skills.

It is assumed that the process of pre-selection will have ensured

- Financial integrity
- Competitive rates
- Cultural compatibility between contractor / supplier and client
- Good corporate systems – especially Safety, Project Management and Quality Assurance
- Clear and open arrangements between the parties
- Willingness of the contractor to share some of the risks with the client

*Alliance*s, *term agreement*s and *framework agreement*s help to ensure stability of working arrangements, so avoiding time lost while new staff become familiar with the required standards and procedures. If a client's forward investment plans have been shared with the contractors involved in an *alliance* or *framework agreement* then it is more likely that the necessary levels of resources will be available when required.

*Alliance*s with foreign national companies can greatly speed up the introduction to new countries by overcoming the lack of local knowledge.

Cash flow problems must not be allowed to inhibit the progress of the project. Where early procurement of materials and equipment is required this should be to the client's account and if the client company does not place the order directly then the contractor should do so as agent for the client. *Alliance*s and other long term relationships may also have the advantage for the client that, where trust has been built up, the contractor may be willing to commence work in support of the client without an order and before funds have been approved.

The majority of fast track projects to date appear to have been executed on a reimbursable basis, with incentives for achievement of the *CSF*s, for the primary contracts. However, this

is not universally the case and most forms of contract have been used successfully, right up to fixed price, lump sum. Whatever the form of contract, it is very important that those executing the project have a full understanding of the "rules of the road" so that everyone can go off and apply them without constant reference to contract documents or higher authority. Sub-contracts appear to be most frequently let on a fixed price basis, even on fast track projects.

Arrangements for the payment of additional costs resulting from extra work or changed work conditions should be agreed up front so that settlement can be effected quickly, thus maintaining motivation and avoiding diverting the focus away from the project objectives. **Claims of the "delay and disruption" type are incompatible with an incentive based contract.**

There is general agreement that, whatever the terms, conditions and form of contract between the parties involved in the project, it is important to get the money out of the way and let the project team concentrate on achieving the schedule, safely and at the right quality.

5.1.6 Communications

Communications within the project team and between project staff and other *stakeholder*s need to be accelerated in line with the overall level of activity on the project. There must also be more informal communication at the expense of formal communications which should be kept to a minimum commensurate with maintaining appropriate records.

Barriers to communication should be removed so that information flows directly between all affected parties regardless of parent organisation and level in the hierarchy. The shorter the lines of communication the better. Discussion should be face-to-face if at all possible. Where it is not possible to meet then electronic media is to be preferred for speed. In an empowered project team, the responsibility for communication lies with the individual who has made the decision or has obtained information that is of interest to the rest of the team.

Frequency of communication should be such that all members of the project team are aware of the current situation and able to take decisions secure in the knowledge that they are up to date. Progress meetings might need to be weekly, 2-daily or even daily. Early warning of potential problems is essential if mitigating action is to be taken. Tight deadlines should be set on the issue of essential written information e.g. notes within 2 days of a meeting taking place. Significant decisions which are required to influence the actions of the project team should be communicated immediately.

Frequent and concise reporting should be possible within the "lean" organisation envisaged and the physical proximity provided by open plan accommodation should encourage communication and general awareness within the project team.

5.2 Characteristics which Undermine a Fast Track Strategy

Business and project environments which do not have the characteristics listed in Section 5.1 above will prevent or limit the success of a fast track strategy. Projects with just some of these characteristics can benefit from the ideas in this handbook, since many ideas can be

used for the expeditious delivery of any project without the risks associated with the "full" fast track approach.

5.2.1 Cost Driven Projects

A fast track approach can be justified only where:
(a) reduction of the schedule to the practicable minimum has significant benefits for the client who is therefore prepared to accept the risks that are introduced, or
(b) the contractor will benefit under the terms of the contract.

This will rule out the majority of projects which tend to be principally driven by cost considerations for the creation of the new asset rather than the maximum benefit to the client business. The introduction of cost cutting exercises are a clear indication that, even if schedule was the principal driver initially, the situation has changed and schedule has ceased to be the principal driver. A requirement for absolute security of cost out-turn, e.g. by insisting on a lump sum contract, is strong evidence that the shortest practicable schedule is not the principal *critical success factor* for the project.

5.2.2 Risk Aversion

A fast track strategy, by definition, results in the introduction of greater risks, which then have to be managed to prevent them from damaging the project outcome. Risk averse companies, especially clients who demand certainty of outcome, will seek to limit their risk exposure and in so doing will constrain the project team that is attempting to deliver the new asset to a fast track schedule. The presence of individuals within the project team or among the *stakeholder*s who are mesmerised by risk and unwilling to make decisions which involve risk exposure will restrict the rate of progress to one which is within their personal comfort zone.

Organisations must accept that staff will occasionally not make the right decisions when they are required to work with limited information. Without this acceptance of failure the decisive behaviour that is at the heart of a fast track project will be inhibited. The inappropriate allocation of risk, i.e. those best able to deal with it are not given responsibility for its management, will inhibit the successful management of that risk.

A frequent cause of difficulty is the project that is initially intended to be delivered on a low risk basis to a conventional schedule but which is left "no option" but to take a fast track approach due to an extended front end definition stage or reduced completion time that leaves insufficient time for conventional delivery. Project managers are warned against accepting such a brief. The slow decision making at the front end of the project is most likely to continue throughout the life of the project and will inevitably result in the schedule being exceeded.

5.2.3 Lack of Ownership

The following issues have been recorded as having a particularly adverse effect on the performance of a fast track project:

- Lack of buy-in by any of the *stakeholder*s to project *critical success factor*s and fast track strategy for achievement of schedule objective

- Political constraints (indicating lack of ownership by some *stakeholder*s)
- Large number of *stakeholder*s, regulators and others who want to influence the project
- Multiple and / or extended approval processes
- Lack of a robust client *sponsor* / *champion*
- Failure of client management to become fully involved
- Slow decision making by client staff at the front end and unwillingness to work to a tight plan for commissioning and handover
- Unwillingness to be first with a new idea or accept an innovative approach
- Obstructive local regulations and approval procedures
- Extended statutory lead times for approvals and notifications

5.2.4 Organisation Issues

Any organisation which fails to provide an environment in which individuals can flourish and make their maximum contribution will limit their ability to achieve the project objectives.

There is a particular problem with big projects which exceed the span of control of one individual but which cannot be broken down into smaller independent work packages since this prevents the application of one of the techniques for achieving a fast track schedule. However, there are other ways of speeding up the schedule which are still applicable even on a project of this nature.

The following organisational features have been noted as being particularly unhelpful:

- Lack of experienced and knowledgeable resources to support action in parallel on all phases of the project
- Too many levels in a hierarchical structure, e.g. consultant between client and contractor, resulting in filtering or misinterpretation of client requirements
- Inflexible, over-complex or inconsistent procedures
- Rigidity in the application of company procedures
- Lack of delegation - approvals based on hierarchical level rather than competence
- Widely distributed decision making leading to multiple approvals
- Absence of arrangements to prevent recycling of decisions
- Lack of sound design information on which to base decisions
- Lack of procedures to limit / control design changes
- Lack of flexibility within the company manufacturing programme to accommodate project scheduling requirements.
- Matrix organisations in which function and task clash for control with infighting and compartmentalisation
- Failure to resolve personality issues
- Existence of "area barons" or "fiefdoms" within the parent organisations
- Presence of "not invented here" syndrome within client or contractors

5.2.5 Lack of People and Inappropriate Relationships

As noted earlier, people and their working relationships are one of the main keys to successful project performance. Competent and experienced personnel must be made available to meet the needs of the schedule. Particular problems have been recorded with:

- Absence of end users when decisions are being made during development and definition
- Technical staff who may be needed for only a limited period
- Project management and engineering staff to meet the short-term peak demands of a fast track schedule
- Operating staff to commission and operate in accordance with the project schedule

Anything which distracts the project team members from devoting their full-time energies to delivering the project objectives will undermine the fast track strategy. A particular problem is the negotiating / competitive approach which exists within some organisations, e.g. between the business and project over cost estimates, between project manager and construction manager over control of the project at the construction stage.

5.2.6 Inappropriate Contractual Arrangements

Contractual arrangements which fail to achieve the fundamental requirement of aligning the objectives of all parties with the *critical success factor*s for the project are the most commonly quoted cause for failure to meet those *CSF*s. The normal consequence (for any project) is an adversarial relationship between the parties as each seeks to gain maximum advantage for their own company. It is in recognition of the short-comings of these arrangements that companies have sought better forms of contract and in some cases formed a*lliance*s between client and contractor. However, this is far from universally the case even within Europe, so that contracts which are intended to ensure certainty of outcome for the parties are still the basis on which much construction work is executed.

Cash flow problems are the second most common inhibitor of progress, either as a result of lack of funding from the client to enable work to proceed at maximum pace or because of funds which have been made available being held up by one party, usually main or management contractor, rather than being passed on to the ultimate provider of services or goods. This second problem can be readily overcome by the client paying all suppliers and sub-contractors direct, limiting the up-front funding to the minimum essential to ensure rapid progress. This arrangement would probably not be acceptable to those contractors who seek to make a turn on the purchase of equipment and materials and are therefore not prepared to be open with the client about the true cost of these items.

5.2.7 New Technology

The inclusion of new and unproven technology and innovative design does not automatically rule out the possibility of executing a project to a fast track schedule. However, it is likely to increase the number of uncertainties and thus make planning and execution more difficult. It is recommended that the new technology and innovative design content be kept to a minimum and realistic allowances make in both time and cost for dealing with the issues introduced.

Section 6 Concept Stage

6.1 Introduction

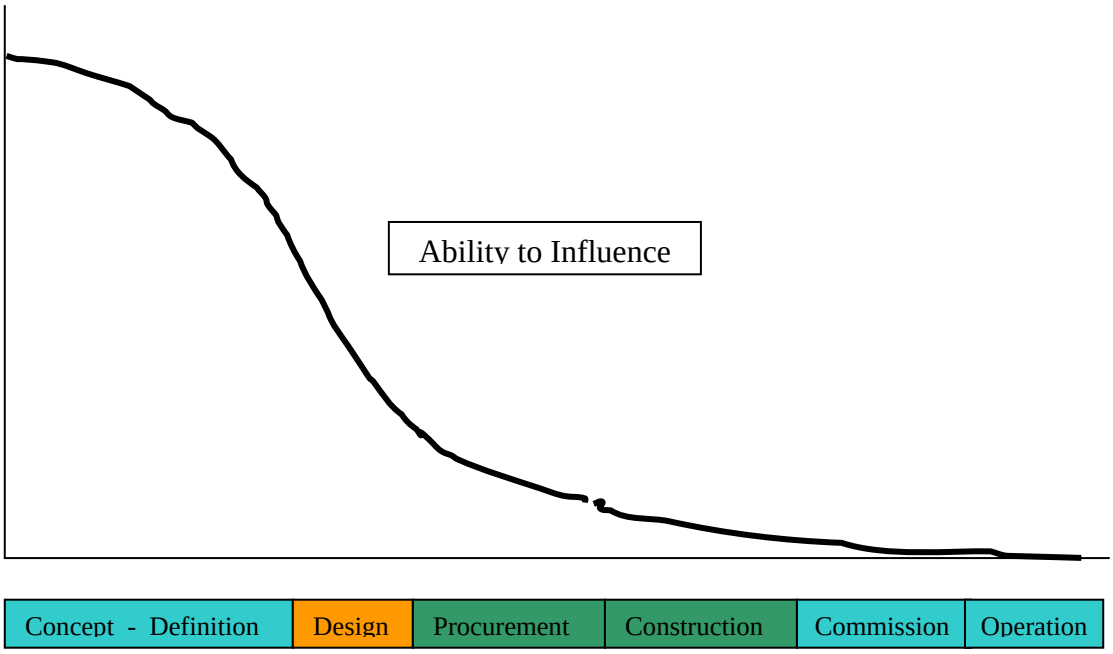
This is considered to be the first stage of the project process, although it can only loosely be described as a stage and is often more a part of the business process than the project process. It can exist for many months or years as an idea or general opportunity before becoming formalised as a specific intent to create new assets.

At this early stage the concept is likely to be developed as part of a business project perhaps involving sales and marketing; product, process and market research; commercial "make or buy" decisions; warehousing; transportation; company restructuring; build new or buy existing assets, and many other considerations. It is entirely possible that the project manager who will eventually be asked to deliver the new assets safely, to time and cost and of the appropriate quality, is not involved at this stage.

It is therefore vital that those who are responsible for the project at this stage are aware that

(a) time being used to establish the concept will not be recoverable during later project delivery stages

(b) the opportunity to influence the outcome of the project falls off rapidly over the project stages as illustrated so that the greatest opportunity to ensure that the project is completed in the minimum time exists at the beginning of the project.



6.2 People

***Stakeholder*s**

All significant *stakeholder*s should be identified from the earliest practical stage and their interests considered in formulating the concept. Consultation and involvement should follow once the concept has been sufficiently well developed to make discussion worthwhile.

See 6. 8.1 List of Potential S*takeholder*s.

Ideally, resolution of conflicting interests between *stakeholder*s will take place at this early stage so that there will be a sound basis on which to proceed with the development of the project. However, achievement of full consensus is not always possible and it will be necessary for the senior client manager with responsibility for the concept stage to identify any outstanding issues and manage / influence the *stakeholder*s to prevent residual dissatisfactions from undermining later stages of the project.

The objective must be to achieve full buy-in to the concept by the key *stakeholder*s, the support of whom will be needed for the rapid and successful completion of later project stages.

Integrated Team
The concept stage is usually too soon for a full-time team to be assembled although there will be many people involved, most probably from different parts of the client organisation but also possibly from architects, consultants, contractors and service providers. Where it is possible for a team to be formed consideration should be given to accommodating them in one location to aid communication and focus.

The concept stage is not too soon for the appointment of:

- *Champion* / *Sponsor* at an appropriately senior level within the client organisation who will oversee the project through to completion
- Client Project Manager, with appropriate skills / approach / seniority to drive the concept stage, who will introduce project management disciplines and procedures from the earliest appropriate stage and have continuity of responsibility throughout project
- Senior managers within architects, consultants, contractors and service providers who will have overall responsibility for the support provided to the client in establishing the concept.

Whatever the structure may be for a specific project, it is important that those senior managers involved establish the project culture that will promote speedy decision making through the life of the project, including:

- Co-operation
- Mutual trust
- Delegation
- Empowerment

While the responsibility for decisions affecting the client business will naturally need to be taken at an appropriate level, the process by which such decisions are taken should be carefully structured to prevent undue delay while still ensuring that all relevant aspects are taken into account.

Suitably Qualified and Experienced Personnel
The requirement for competent staff to be involved is just as important at this early stage to ensure that the project is based on the right concept as it will be in later stages to ensure that the project's objectives are achieved. Corporate procedures normally require that decisions are taken at an appropriate level of seniority which should not be confused with an appropriate level of competence to address the technical and other issues involved. It is important to ensure that suitably qualified and experienced personnel are involved in the

decision making process, and this will be particularly valuable where the same staff will be responsible for subsequent stages of the project.

Motivation
It is important to identify as early as possible in the development of the concept that there will be significant additional benefits to the client from the earliest practicable completion of the project, and to use this information to obtain buy-in by all parties to the fast track strategy. The fast track approach will place additional demands on the organisations and individuals involved who must be motivated to deliver the strategy if it is to be successful.

6. 3 Scope

At the heart of any successful project lies a full understanding of the real objectives of the client business and the requirements for the delivery of the project. This will enable the *critical success factor*s (*CSF*s) to be defined in a permanent and meaningful way for the life of the project. These *CSF*s should cover how the client wants the project delivered as well as what it is, where it is to be sited and when it should be completed. At this early stage it is likely that some *CSF*s will be defined in terms of a range of values or upper limits, quantities which will need to be refined during the development and definition stages. These should be measurable and re-measured throughout the project.

In addition to the client business there are likely to be a number of *stakeholder*s whose requirements need to be taken into account. The client's aspirations may need to be modified in light of the positions adopted by influential *stakeholder*s and it may pay to seek simultaneous input from key *stakeholder*s to multiple aspects of project scope where it is already apparent that time is of the essence.

Only when the potential benefits of the project in relation to the likely range of costs and possible beneficial operation / use dates are known can the decision be taken to adopt a fast track strategy to minimise the project duration and maximise the benefits of the investment.

Whether time or cost is the key driver for a particular project there are considerable advantages to be gained from minimising / simplifying the scope - adopting a lean thinking approach, see Section 14 - while still achieving client business and *stakeholder* requirements. Consideration should also be given to the possibility of repeat and modular design as part of the concept with the specific intention of shortening the project duration.

6. 4 Strategy

The project strategy must align with the client business strategy and objectives, as modified by *stakeholder* requirements, and expressed as *CSFs* for the project. In cases where early use is the key value driver it might be assumed that the project should adopt an innovative, higher risk, fast track strategy. This is not necessarily the case. It may be that a lower risk, conventional approach is more suitable and will deliver the new asset sufficiently early to meet the business needs.

A fast track strategy should be avoided unless the client business benefits from early completion significantly outweigh any financial or other risks involved.

The options selected for providing the new asset / capability, e.g. high tech vs. low tech approach, together with such factors as design life, equipment quality, *stage gate* process and contract strategy will have a significant impact on the project duration:

- New build
- Extension of existing asset
- Revamp of old asset
- Repeat design of existing asset
- Use of standard / on-the-shelf design
- Pre-existing / off-the-shelf equipment
- Modularisation
- Prefabrication

Where a *stage gate* project process is in use the fast track project strategy will need to address the way in which compliance will be achieved while not hindering progress. This may need agreement that *stage gate* information and approvals will lag behind the development of the project and that the additional risks resulting from this change to company procedure will be handled in the risk management process. Where company financial and other procedures exist with which the project has to comply, these should be identified and addressed from the beginning rather than being introduced part way through.

Contract strategy will need to be addressed, at least in outline, with recognition that the supply chain will need to be driven by time rather than cost, assuming safety and quality are given requirements. Support may be required by the client in the early stages of the project from consultants, architects, contractors or suppliers for work which cannot be quantified from the beginning and this will need to be paid using some form of measurement and reimbursement without certainty of cost outcome. The risks associated with reimbursable contracts will need to be managed by the client.

As part of the contract strategy, consideration should be given to decoupling funding for the project from the stages of the project so as to ensure that funds are always available for the work which is being carried out even though the project as a whole has not been sanctioned. Only in this way will front end definition work be carried out at the right pace and delays to subsequent work avoided i.e. design, procurement (against cancellation charges) and construction.

The project strategy for the considered introduction and management of risk associated with the fast track strategy should be explicit and clearly led by the most senior managers involved in the project.

6. 5 Business and Project Management Systems & Procedures

Business Planning

The risk to the client business funds that are needed to support the fast track project strategy will be much reduced if there are good business processes for weeding out poor projects during the concept stage.

A smooth transition from client business process to project management process will help to ensure that there are no discontinuities and delays at this stage

A conceptual planning process involving *stage gate*s should help to limit the recycle of ideas and ensure there is an agreed, firm basis on which to proceed to the next stage.

Communications
Communications need to be managed to ensure the rapid transmission of appropriate levels of information to all participating and interested parties. The availability of IT systems, e.g. video conferencing, intranet, internet, for information management, sharing and reuse to speed up the communications process and overcome geographical separation of *stakeholder*s should be considered.

Publicity will need to be controlled and carefully targeted to minimise the possibility of extensive delays arising from an adverse public reaction to the project proposal, e.g. as a result of a public enquiry.

Risk Management
Risk management processes should be introduced at the concept stage and utilised throughout the life of the project both in support of the investment decision and in the achievement of the project *CSF*s. Risk should be placed where it can be most effectively managed.

6. 6 Cost & Risk

Determination of cost at the concept stage is fraught with difficulties unless the project is a repeat of one that has previously been completed, and even then the changes of circumstances and the passage of time are likely to result in significant differences between the two projects. There is only very limited industry information on fast track projects, as opposed to conventional projects for which there are large commercial databases. The use of corporate conceptual estimating tools / information to provide early cost estimates is strongly recommended, especially since the processes of concept determination and development are iterative ones requiring estimates of alternatives, and repeatedly of the selected option as the level of detail is increased.

It is important to achieve a cost estimate that is as accurate as possible at this stage since:
(a) this is an essential component of the decision to adopt a fast track strategy. Unless benefit to the client is significantly greater than the estimated cost, with due allowance for the normal and fast track risks, then a conventional project strategy should be followed and
(b) once a figure has been declared, however uncertain the basis of the estimate, it has often proved difficult to persuade the organisation that an alternative figure is justified as the scope is clarified and more detail uncovered.

The following risks are the result of overlapping of concept and development stages to a greater extent than would be normal on a conventionally run project.

Concept / Development

The following table lists the risks that are principally associated with the increased level of overlap between the concept and development stages of a project.

Risk	Mitigation Opportunities

Wrong concept or strategy resulting in time and effort being wasted on inappropriate development activities	• Ensure that requirements of all *stakeholder*s are addressed in the formation of the concept and strategy for its delivery • Employ thorough evaluation processes for options, including costs and benefits, and record basis of decisions, alternatives considered, risk assessments • Ensure ownership by key *stakeholder*s of proposed concept and the strategy • Establish clear policy and methodology for change control • Where change is essential, effect change as soon as practicable • Communicate details of change and consequences to all parties as soon as possible
Recycling of ideas resulting from the overlap of stages and options not being closed off at the end of each stage, causing confusion and delay	• Ensure that requirements of all *stakeholder*s are addressed in formation of concept • Ensure ownership by key *stakeholder*s as concept evolves • Record option evaluation rationale, including rejected options • Establish clear policy and methodology for change control to prevent e.g. recycling of options, as alternative to or in addition to a *stage gate* process
Delays due to lack of approved funds	• Client to ensure that there is continuous availability of funds to support project activity based on a series of concept papers from which the project proposal is eventually developed.

6. 7 *Logistics*

At the concept stage the greatest consideration is likely to be given to the location of the new asset in relation to:

- Location of customers
- Source and availability of feedstocks, component parts, etc.
- Supply routes
- Transport security and cost for supplies and products
- Existing assets
- Workforce skills and numbers

However, the *logistics* of managing, designing and constructing the new asset will have a significant bearing not only on the cost but also on the time it takes to get from the concept stage to beneficial use. Among the things which should be considered are:

- Locations of parties involved:
  - client site
  - design office
  - contractors, sub-contractors
  - suppliers
- Sources of construction plant
- Sources of materials
- Labour – competence, numbers and source
- Supply routes and methods

- Site access and controls
- Availability of permanent facilities, offices, stores, etc.

6. 8 Checklists

Checklist 6.8.1	**List of Potential Stakeholders**	
Project No.	**Title**	
Revision	**Date**	**Author**
Client Upstream Customer Business Management Commercial / Marketing / Sales Research Technical Engineering - Projects Functions Production - Management Operatives Maintenance - Engineers Trades QA **Local Authorities** Planning Councillors **Emergency Services** Police Fire Health **Regulatory Authorities** H&SE (Health & Safety Executive) Environment Agency Building Inspectorate FDA (Federal Drug Authority) NII (Nuclear Installations Inspectorate) HMRI (HM Rail Inspectorate) **Public** Locally / Nationally Those immediately affected Those potentially affected **Pressure Groups** **Contractors/Subcontractors** Management Design Construction **Suppliers/Vendors** **Neighbouring Companies** **Unions**		

6. 9 Case Studies

6.10 References & Further Reading

ACTIVE Workbook: AP 1 Effective Project Concept and Definition
VEP 1.1 Project Process

7 Development

7.1 Introduction

Development is the stage of the project at which all the options for delivering the basic concept are identified and evaluated (the divergent phase) before a decision is made on the preferred option (the convergent phase) which will be defined in detail during the definition stage, Section 8.

Depending on the nature of the project, this stage can use up an unacceptable proportion of the total time available for the whole project. The effective project management of the development stage is therefore essential to avoid being forced into completing the project to a compressed schedule whether or not that is justified by the business benefits from early completion.

7.2 People

Clarity of Objectives
A clear focus on the objectives as agreed with the *stakeholder*s at the concept stage must be maintained as the options for the delivery of the concept are explored. Failure to do so is likely to result in a broadening of the concept and the introduction of side issues which will take up valuable time and divert the project (development) team from coming to a speedy conclusion as to the scope of the preferred option.

***Stakeholder*s**
The significant *stakeholder*s identified at the concept stage should continue to be involved, i.e. consulted or advised as appropriate, as the development progresses to ensure that best use is made of their expertise and that they remain committed to the proposal. While this will undoubtedly take both time and effort, and may be seen as delaying the project at this stage, it is essential to ensure there are no subsequent hold-ups. Of particular significance is the funding authority from whom financial support for the project will be needed at every stage.

The list of *stakeholder*s will need to be reviewed as development progresses, especially if the development goes in a different direction from that originally anticipated, and as new parties are brought into the project. The initial focus will most probably have been on the needs of customers for the new asset production, the client for the project and the regulatory authorities. However, the potential introduction of consultants, contractors and suppliers to the development process will broaden the *stakeholder* base considerably. The appointment of a construction manager who can contribute to the *constructability* considerations should take place at this stage. Care should be taken to ensure that the core decision making team remains clear in spite of the increased number of *stakeholders*.

Integrated Team
Depending on the nature of the project, the development stage may still be too soon for the full-time project team to be formed and the work of option exploration may be going ahead under a development manager who will not be the project execution manager. Whoever leads the development effort, they need to possess both management and leadership skills, along with the ability to manage development with focus and energy, to ensure that the work is organised and executed in a timely manner whether or not the disparate parties involved are under their direct control.

The earliest possible introduction of *interactive planning* involving all parties to achieve team alignment, commitment and the optimum plan has been recommended. See Section 7.8.1 below.

As for the concept stage, whatever the structure may be for a specific project, it is important that the senior managers involved maintain a project culture that will promote speedy decision making through the life of the project, including:

- Co-operation
- Mutual trust
- Delegation
- Empowerment

Suitably Qualified and Experienced Personnel
In addition to the normal requirement for managerial and technical competence, the development manager should ensure that the development team contains both conceptual and analytical thinking capability in order to reach both a speedy and appropriate conclusion on the preferred option which is to form the scope of the project.

7.3 Scope

It is stating the obvious to say that development work must be based on a clear understanding of the concept incorporating client business and *stakeholder* requirements. However, there is some evidence that the project (development) manager and the, sometimes disparate, parties involved are not always as clear as they might be at this stage and that valuable time has been wasted in exploring inappropriate, over-complicated or non-viable options.

If it is possible at this stage, the division of the work into separate packages using a *work breakdown structure* may enable the packages to be developed in parallel by different teams, which may included architects, consultants, contractors and suppliers. The correct definition of the *work breakdown structure*, either at this stage or the definition stage, is likely to have a determining influence on the success of the fast track strategy.

The development of the scope should take into account the following options which will have a bearing on the speed with which the project can be executed:

- *fit for purpose* but not ideal
- fastest rather than best
- project specific (rather than generic) standards and specifications
- reuse of design from existing assets
- potential for modular design
- potential for pre-fabrication of components
- reduction in the number of processing steps in a manufacturing plant
- reduction in the size of the asset
- elimination of non-essential elements of the design
- standardisation of layout or repeated units
- incorporation of standard / off-the-shelf components
- simplification of design dependencies
- simplification of the build / construct / assemble process

- avoidance of innovation / new / untried elements
- alternatives to avoid the use of long delivery items

Good control of the development stage is required to ensure that there is no unnecessary recycle of options once decisions have been made, while still accepting positive rework which might arise from *value management* (*value analysis, value engineering*) and other evaluation and improvement processes. It has been noted that *value management* is a useful tool for identifying ways to shorten the schedule as well as improve quality and reduce costs.

A process should be established for getting interested parties to sign off the conclusions reached during the development stage to ensure that there is a firm basis on which to proceed. It has been found to be helpful if signatures cover the current agreement on the features that will not be included as well as those that will be included, since the former tend to resurface at later stages of the project.

It may not be possible to come to a firm conclusion within the time available on some aspects of the project. It may therefore be necessary to pursue more than one option and to continue development work while moving on to the definition stage for those aspects of the project on which a decision has been reached. For example, in the case of a new pharmaceutical product, the clinical trials may well continue in parallel with other project activities which remain at risk until the trials have been successfully completed.

7.4 Strategy

The first questions that needs to be addressed before making any decisions about strategy are
(a) does the project really need to adopt a fast track strategy to achieve a client or contractor objective?
(b) does the commercial benefit to the client or contractor from early completion justify a fast track strategy?

If the answer to either of these questions is an unqualified "yes" then a fast track strategy for the whole project is justified and the development work should be carried out on the basis of minimising the overall duration while still achieving the client's objectives and the *stakeholder*s' requirements. Time lost in the development stage cannot be recovered during later stages of the project.

The strategy for the development stage of a fast track project should take into account the following aspects which have been noted as being of particular significance in achieving time effective development:

- *Work breakdown structure* and ability to delegate work packages to different groups, consultants, suppliers, etc.
- Willingness to take early decisions and accept competent solutions, i.e. *fit for purpose* in meeting the project *CSF*s, based on limited information so as not to delay the project in a search for optimum solutions.
- Ability to keep options open until the *last responsible moment*.
- Agreement that the project will accept the best decision in light of the information available at the time the decision has to be made, so that some adjustments and rework are likely and a process will be needed to manage this effectively.

- Acceptance of risk taking, the impact of which will be limited by a comprehensive approach to management of risk.
- Delegation and empowerment of staff to promote decision taking.
- Early application for authorisations and approvals, e.g. planning, building regulations, based on outline proposals or options under consideration. This will enable the views of these *stakeholder*s to be identified / incorporated and avoid delays when formal applications are submitted in parallel with design / construction.
- Availability of benefits / incentives to all parties vs. time to achieve beneficial use of the asset.
- Opportunity to allocate risk & reward between the parties in a way which is seen to be reasonable.

7.5 Project Management Systems & Procedures

Planning
Planning, using schedules, target dates, *milestone*s, etc., and co-ordination of actions in line with the plan, are as essential in the development stage as in any other if a fast track schedule is to be achieved. It has often proved difficult to get this accepted by those involved in what is initially an open-ended, divergent process, especially where this includes research. However, the project (development) manager should insist on formulating a plan, however rough it may be initially, and assessing it from the client's required beneficial operation dated backwards through the project stages to obtain a realistic view of the amount of time available for the development stage. This plan will need to be revised frequently as development progresses and the scope becomes more clearly defined.

Interactive planning, which involves all members of the project team (development team) in problem solving and plan optimisation has been suggested by some companies as a useful technique, especially for fast track projects where innovative approaches are being sought to shortening the schedule. See 7.8.1 for an explanation.

Project Control
The process of decision making is naturally an iterative one and the opportunity for confusion and delay is probably greater during the development stage than any other stage. It is therefore essential that the normal project control processes i.e. plan, measure progress, evaluate deviations from plan, take corrective action, are fully used by the project (development) manager to drive decision making during the development stage. As noted in Section 7.3 above, there will need to be an efficient process for recording decisions and agreements reached to avoid recycling of ideas at this or later stages of the project.

Communications
The system for rapid communication of appropriate information to all participating and interested parties which should have been established at the concept stage, Section 6.5, needs to be maintained throughout the development stage. It is essential that *stakeholder*s are kept on board with the development as it progresses to minimise recycling of issues and subsequent delays.

Publicity which was most likely controlled by the client alone in the beginning now needs to be effectively managed across all participants and suitable arrangements need to be incorporated in contracts which are let during the development stage.

7.6 Cost & Risk

Development / Definition

The following table lists the risks that are principally associated with the increased level of overlap between the development and definition stages of a project.

Risk	Mitigation Opportunities
Wrong options selected during the development process	• Institute independent or peer review of proposed option selection • Keep options open until the *last responsible moment*
Recycling of ideas resulting from the overlap of stages and options not being closed off at the end of each stage causing confusion and delay	• Ensure that requirements of all *stakeholder*s continue to be addressed during the development process • Ensure ownership by key *stakeholder*s as definition evolves • Record option evaluation rationale, including rejected options • Establish a clear policy and methodology for the control of changes to prevent recycling of options, as alternative to or in addition to a *stage gate* process
Wrong definition produced	• Proceed with detailed definition of more than one option, at additional cost, up to the earliest of either: o the point at which a preferred option can be selected on a sound basis or o the *last responsible moment* beyond which the project will be delayed
Wrong project cost figures are used as basis for investment decision	• Develop estimate in parallel with project definition • Incorporate allowances and contingencies based on experience, preferably of similar projects • Get acceptance that cost ideas based on early guesswork are not maximum cost figures for the project

7.7 *Logistics*

The comments in Section 6.7 regarding *Logistics* at the concept stage also apply to the development stage and are repeated here for convenience.

The greatest consideration during project development is likely to be given to the location of the new asset in relation to:

- Location of customers
- Source and availability of feedstocks, component parts, etc.
- Supply routes
- Transport security and cost for supplies and products

- Existing assets
- Workforce skills and numbers

However, the *Logistics* of managing, designing and constructing the new asset will have a significant bearing not only on the cost but also on the time it takes to get from the concept stage to beneficial use. Among the things that should be considered are:

- Locations of parties involved
  - client site
  - design office
  - contractors, sub-contractors
  - suppliers
- Sources of construction plant
- Sources of materials
- Labour – competence, numbers and source
- Supply routes and methods
- Site access and controls
- Availability of permanent facilities, offices, stores, etc.

7. 8 Checklists

7.8.1 Interactive Planning

The process involves getting all interested parties, e.g. *stakeholder*s, clients, key suppliers, usually amounting to 20+ people, together in a (one day) session overseen by trained facilitators. The objective is to gain understanding and agreement about how the project is to be run including any changes to standard company procedures. The group needs to address in particular the interdependencies between various disciplines involved in the project, and between the work packages if these are to be progressed in parallel. People work together to share out the available time and undertake to co-operate to deliver against the tight overall timescale. The output is tidied up by the project planner.

A generic programme for an interactive planning session would include:

1 Presentation ($^1/_2$ hour) of proposed fast track project programme by Project Manager to assembled group of senior people with responsibility for all aspects of the project, including planning, safety, quality, cost, project engineering, functional engineering, procurement, construction, commissioning, production.

2 Interactive review (4 hours) during which members of the team challenge the programme for assumptions, risks, interfaces, etc., looking at:

- project scope
- programme logic
- allowed times
- resource requirements and availability
- costs and funding available
- risk management

Issues are logged by the meeting secretary on a spreadsheet, identifying major / critical issues in red. The project manager leaves the meeting once the list of issues has been completed.

3 The remaining members of the meeting conduct a (Red Team) review (2+ hours) of the major / critical issues and come up with a list of actions / recommendations / suggested ways forward.

4 The Red Team review findings and conclusions are presented to the Project Manager and are then used to modify the programme.

5 Follow up meetings take place to check on actions and progress.

6 The process continues until the schedule is recognised as being acceptable, robust and the best way forward in meeting the project objectives.

7.9 Case Studies

7.9.1 Chemical Plant

Pre-engineered, prefabricated Pilot/Manufacturing Plant (www.manrochem.co.uk)

An example of an innovative approach which should be considered at the Development Stage of a chemical or pharmaceutical plant project.

A modular process plant / pilot plant / research facility has been developed that is fully integrated and self contained and intended for the manufacture of small scale fine chemicals and pharmaceuticals. It consists of a series of flexible operations modules, linked to a separate services module, a control room and an office facility. The whole installation can be factory manufactured, tested and validated before transport as 6 modules that can be assembled and ready to run within days of arrival at site. A simple concrete raft foundation and power, water and effluent disposal are all that are required on site.

Equipment within the manufacturing modules is mounted on standard frames so that individual sub-modules can be manufactured in parallel and assembled in the order in which they become available.

This has the advantages of:

- Off-the-shelf design for a standard process plant capable of a wide range of products
- Capable of rapid customisation
- Minimum site work
- Can be used on small sites with limited access as long as transport and crane can get there
- Pre-tested and validated
- Operable within a few days of arriving on site

7.9. 2 Fast food retail outlets

Factory manufactured buildings (www.Yorkon.com)

An example of the way in which modularisation and pre-fabrication can be taken to the limit such that the entire building and contents can be manufactured, assembled and tested as a number of modules on a factory production line prior to transportation and final erection on site. In this example of a standard design, drive through, fast food outlet, manufacture takes 20 weeks but on site erection and testing can be achieved in only 7 days after completion of the foundation raft. Module size and weight are normally restricted only by transportation limitations.

The principal drivers for this approach are speed to beneficial use and reduced disruption of existing operations, but there are a number of other benefits:

- Factory levels of productivity, quality control and safety
- Production planning rather than construction planning of the work
- Work can take place under cover, avoiding delays and imperfections due to weather
- Can be used on limited site areas as long as crane and module transport have access
- Units can be replaced, e.g. after a fire, or dismantled and reused elsewhere

While this approach is most beneficial for the manufacture of a standard design, it has also been used very successfully for one-off designs, especially where they can be split into a series of standard modules, e.g.

42 bedroom extension to a hotel completed in 16 weeks with only 6 weeks on site
500 pupil school completed in 25 weeks from order to opening
Hospital extension in which the programme was halved from 1 year to 6 months

7.10 References & Further Reading

ACTIVE Workbook: AP 1 Effective Project Concept and Definition
VEP 1.4 *Value analysis*

Section 8 Definition

8.1 Introduction

The lack of an adequate definition has arguably been responsible for more project failures than any other cause. The benefit of getting the definition right as early as possible, and not changing it during the life of the project, cannot be over emphasised. Without the right definition the project will be seen as a failure, however well it has been executed, since it will not satisfy the client's true objectives.

Ideally the project would be sufficiently well defined before sanction that approval can be given on the basis of a secure estimate (normally considered to be within plus or minus 10%), a tight schedule with little float and detailed performance criteria for the asset. Achieving this ideal position may require expenditure of as much as 25% of the total design effort.

On a fast track project, the overlap of detailed definition with the design stage may be similar to that on a conventional project, but not for the purpose of obtaining an estimate to decide if the project should go ahead. That decision may already have been taken on far more tentative information. In the case of the fast track project, design will need to be progressed on those elements of the definition that are judged to be sufficiently secure in order to feed information to construction at the earliest practicable time. Thus the quality of project definition is very often a casualty in fast-track projects, with the potential for the usual consequences of overrun of cost and time.

8.2 People

Clarity of Objectives
A clear focus on the objectives as agreed with the *stakeholder*s at the concept stage must be maintained as the selected option for the delivery of the concept is defined in detail. Failure to do so may result in incorrect judgements being made about those aspects of the project which have not completed the development stage while the team is forging ahead on the aspects for which the preferred options have been clearly selected.

***Stakeholder*s**
The significant *stakeholder*s identified at the concept and development stages should continue to be involved, i.e. consulted or advised as appropriate, as the definition progresses to ensure that best use is made of their expertise and that they remain committed to the proposal.

A key to successful fast track projects has been the early involvement of all the parties which can contribute to, or obstruct, the progress of the project, e.g. planning and environmental authorities. If the management, design and works contractors, and suppliers of significant items of equipment have not been involved during the development stage, then they should become involved as soon as possible during the definition stage if they are to make the maximum contribution to the speedy delivery of the project. This is contrary to the normal, sequential approach in which the work contractors and suppliers would be invited to tender for a clearly defined and fully funded scope of work. It has serious implications for the choice of viable contractual relationships for a fast track project.

Integrated Team

The importance of having senior managers within the client and major contractor organisations as *champion*s / *sponsor*s of the project, to smooth the way by ensuring full commitment and support for the project team, has already been emphasised in the concept and development stages. The fast track project will benefit if *champion*s / *sponsor*s are appointed in companies at all levels in the supply chain and it is suggested that agreement should be reached on the appointment of these individuals during contract negotiations.

If the project has not so far been led by the project manager who will be responsible for seeing it through to beneficial use, that individual should be appointed at the beginning of the definition Stage. Continuity of key personnel is highly desirable in any project but is considered to be an essential requirement for a successful fast track project. The project manager will need the full range of managerial and leadership competencies along with boundless energy, enthusiasm, flexibility, willingness to work hard and determination to succeed. Where transfer of responsibility occurs from a development manager to the project manager it should be effected carefully to avoid any loss of focus on the part of the team or loss of control over the project activities.

Suitably Qualified and Experienced Personnel
Selection of individuals who are to work in the fast track project team should be based not only on their technical and managerial competence but also on their personal characteristics, including:

- Will to overcome the obstacles and succeed in achieving the project *CSFs*
- Willingness to work with high levels of uncertainty and manage risks
- Willingness to work flexibly outside the normal work boundaries and practices
- Willingness to cooperate with others for the benefit of the project

When the opportunity to select team members does occur the project manager is advised to consider the characteristics of individuals as identified by Meredith Belbin in his book "Management Teams: why they succeed or fail" – see Section 8.10.

See 8.8.1 for a list of potential team members.
See 8.8.5 for table of Belbin's team types

8.3 Scope

It is essential that the members of the project team have a clear understanding of what has been agreed by the *stakeholder*s to be in the scope, and what has been similarly agreed to be excluded from the scope, as a firm basis on which to proceed. However, in the case of the fast track project in which the development stage and the definition stage may overlap to a greater than normal extent, this clear understanding will only emerge over a period of time and the project team will have to make informed assumptions about the outcome of development issues until they are finally resolved.

In determining the technical definition of a fast track project the team should take into account the following options which can have a significant bearing on the schedule:

- *Fit for purpose* (which may not be ideal) project specific standards and specifications, not generic documents that are difficult to interpret
- Fastest to manufacture / construct rather than cheapest
- Reuse of design from existing assets

- Modular design
- Pre-fabrication of components
- Minimisation of scope – Lean Construction approach
- Reduction in the number of processing steps in a manufacturing plant
- Reduction in the size of the asset
- Elimination of non-essential elements of the design
- Standardisation of layout or repeated units
- Standard / off-the-shelf components
- Simplification of design dependencies
- Simplification of the build / construct / assemble process
- Avoidance of innovation / new / untried elements in general but not overlooking technical developments that have been proved to reduce construction times
- Early identification and ordering of long delivery items and alternatives to avoid the use of long delivery items
- *Constructability* / *Buildability* / Operability

In determining the overall project scope the fast track project team should be careful to include all the normally required aspects including the following which have been specifically mentioned in the research:

- Achievement of the overall project objectives, both what is to be done and how it is to be achieved
- Whether the client requires the whole of the new asset to be completed as soon as possible or whether phased completion would be acceptable or advantageous
- Arrangements for handover and commissioning
- Proving and warranty tests to be carried out
- Definition of beneficial operation / use as the end point of the project
- Project specific *critical success factor*s

As soon as practical the project scope should be divided into separate work packages using a *work breakdown structure*. Extra care is needed in developing this structure for a fast track project to take into account the interdependencies between functions and project stages when work is taking place in parallel on separate work packages. Safety, cost and quality also need to be taken into account while ensuring that the work packages form a sound basis for the structure of the organisation, cost control, etc.

An issue which needs to be generally addressed, but is particularly significant for the fast track project, is the apparent lack of understanding by client business management of the amount of time and resource required to provide a good quality project definition and the quality and extent of data required from the business to produce a given quality of estimate.

Fast track projects have been completed successfully even though there has been a far lower level of definition at the commencement of the design stage than would normally be considered prudent. Where this is the case it is recommended that some form of independent evaluation should be carried out to ensure that the risks arising from the lack of definition are fully understood and appropriate allowances made in the cost and time estimates.

8.4 Strategy

As in the development stage, the first questions that needs to be addressed before making any decisions about strategy are:
(a) does the project really need to adopt a fast track strategy to achieve a client or contractor objective?
(b) does the commercial benefit to the client or contractor from early completion justify a fast track strategy?

A generic list of items to be addressed in the project strategy has been included as in Section 8.8.2.

The strategy for the definition stage of a fast track project should take into account the same aspects which were listed at the development stage as being of particular significance in achieving time effective development. These are repeated here for ease of access:

- *Work breakdown structure* and ability to split the project into relatively independent parts and delegate work packages to different groups, consultants, suppliers, etc.
- Willingness to take early decisions and accept competent solutions, i.e. *fit for purpose* in meeting the project *CSF*s, based on limited information so as not to delay the project in a search for optimum solutions
- Ability to keep options open until the *last responsible moment*
- Elimination of *hold points* for the approval of design through use of an *integrated project team*
- Agreement that the project will accept the best decision in light of the information available at the time that the decision has to be made, so that some adjustments and rework are likely and a process will be needed to manage this effectively
- Acceptance of risk taking, the impact of which will be limited by a comprehensive approach to management of risk
- Delegation and empowerment of staff to promote decision taking
- Early application for authorisations and approvals, e.g. planning, building regulations, based on outline proposals or options under consideration. This will enable the views of these *stakeholder*s to be identified / incorporated and avoid delays when formal applications are submitted in parallel with design / construction
- Availability of benefits / incentives to all parties vs. time to achieve beneficial use of the asset
- Opportunity to allocate risk & reward between the parties in a way that is seen to be reasonable

8.5 Project Management Systems & Procedures

Planning
It is essential that, as the definition evolves, work is scheduled on the basis of achieving the earliest beneficial use of the finished asset. This will not require the earliest possible start on all subsequent activities, but the probable critical path and the longest lead items should certainly receive priority attention and be started as soon as possible.

The *interactive planning* process advocated as a team building activity, see 7.8.1, is also recommended for ensuring that all members of the team contribute to optimising the plan to achieve the shortest possible schedule.

Project Process
Depending on the project organisation, the project processes may be those of the client, the management contractor or one of the other parties to the project. Whatever the starting point, it is likely to be necessary to modify the process to some extent to meet the needs of all the parties to the specific project. It will also be necessary for the standard processes to be modified to accommodate the degree of overlap between the various stages of the project in order to optimise the balance of risk and benefit, e.g. continuing beyond *stage gate*s without signing off all requirements. Authority for modification of the project processes should be sought at the earliest stage at which the requirements can be defined and it will greatly speed up subsequent changes if the authority can be delegated to the project manager.

A project risk management system must be set up as part of the project process to handle the additional risks introduced by the fast track schedule, whether or not this is a normal part of the project management process for the companies involved.

Documentation becomes even more of an issue for a fast track project than for a conventionally run project and an effective system of document control is an essential requirement if delays are to be avoided at later stages of the project.

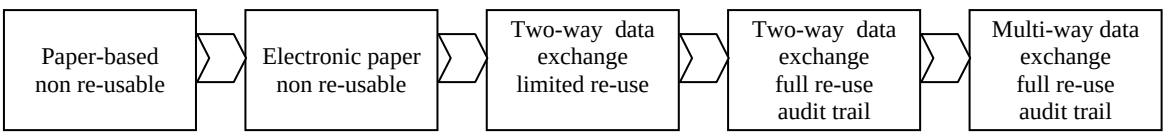
Project Control
Care is needed to ensure that previously rejected ideas are not reintroduced at the definition stage and that "nice to have" features are not added to the scope of the project by those with a minority interest in the project outcome. This is a particular risk where *value engineering*, design simplification and similar exercises have taken out features on which particular individuals are especially keen but which have been agreed by the majority to be unnecessary.

Communications
Communications systems that have been established during earlier stages of the project will need to be expanded to include the new organisations and individuals joining the project team.

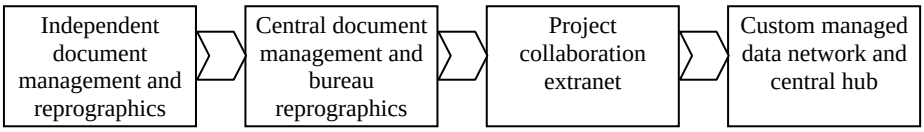
Full use should be made of IT systems for the storage and communication of all information to overcome geographical separation of the parties involved and ensure that they are kept up to speed with the progress of the project, including:

- Company Intranet
- Extranet
- Internet
- Project chat rooms
- Bulletin boards
- Event calendars
- Data bases
- Secure lines for confidential information transfer

The greater the level of integration in the sharing and re-use of information the more that the communication system will support a fast track project. Companies should consider where they currently lie along the following path and seek to move further to the right of the diagram.



The way in which information is managed will need to be developed alongside the communication mechanisms and again it would be highly beneficial for companies to move their information management processes to the right of the diagram:



See diagram in 8.8.3 for consideration at this and later stages of the project which has been take with permission from the report "Effective Integration of IT in Construction" published by the Building Centre Trust.

8.6 Cost & Risk

Cost
It is likely that a cost estimate to within plus or minus 10% on which project funding would normally be approved will not be obtained until well into the design stage of a fast track project, and this will be some time after the procurement and construction stages have commenced. Approval will therefore have to be given on a lower level of definition and with a wider tolerance on the estimate if the project is to proceed unhindered by the supply of funds. This is contrary to most client business procedures and it may be necessary to convince them that the requirement for so called 10% estimates before authorisation is totally unrealistic for fast-track projects.

It is recommended that a *control estimate* should be produced once all the necessary details are known, quotations received, etc., against which the performance of the project can be managed. An independent review of the estimate can be arranged if assurances are needed, most probably by the client, that the estimate has not been inflated unreasonably to pay for the fast track approach.

Whether or not the fast track approach results in increased costs depends entirely on the nature of the project and the effectiveness with which it is delivered. The research indicates that additional costs were incurred on some projects, but that this was more than off-set by the additional benefits to the client, the contractor, or both. There is equally valid evidence from other projects that the strategies used to deliver a fast track schedule can result in a lower cost project so that the client gets a double benefit – a lower cost asset and earlier use of that asset.

During the definition stage it will be necessary to address the potential causes of increased cost which may arise as a result of adopting a fast track strategy, tabulated below, in order to ensure that they have minimum impact on the overall project costs. It has been calculated by Kwakye, see Section 8.10, that the extra cost of a fast track building project could be 7.5%, based on it being run by a management contractor and managed by a project manager, and in which the architect's role is confined essentially to that of the building designer. This is the normal organisation for many industrial projects which would therefore not recognise such an increase.

Opportunities should be sought during the project definition stage to ensure that maximum advantage is taken of the cost saving opportunities that arise as a result of supporting the fast track strategy. See check list 8.8.4.

Definition / Design

The following table lists the risks that are principally associated with the increased level of overlap between the definition and design stages of a project.

Risk	**Mitigation Opportunities**
Design (and construction) rework arising from lack of firm definition	• Leave decisions until the *last responsible moment* • Sign off work packages, sub-units, etc., progressively to release firm information to the design organisation in a phased manner
Additional management effort at peak to control the project	• Identify and plan resources for peaks • Modify package size and number for efficient management • Use resources of appropriate calibre
Use of additional resources arising from repeat work and parallel working requiring more than the optimal number of people	• Mitigation not always possible – this is a penalty which may result from the fast track strategy • Minimise rework o work on approved packages / sub-units o leave until *last responsible moment* • Plan work for best available efficiency while supporting fast track schedule
Essential additional items to achieve the *CSF*s which creep into the scope through lack of firm definition	• Establish effective change control process • Identify additional items as early as possible
Procurement against best / guaranteed delivery rather than lowest price	• Ensure that cost penalty vs. delivery benefit is justified • Seek local suppliers to minimise transport time and cost • Select from client and contractor preferred supplier lists • Use corporate contracts with agreed prices
Additions to equipment orders as details evolve	• Anticipate additions and include in original contract • Negotiate schedule of prices for typical additions if details not known at time of contract
Additional expediting	• Use of consolidated suppliers
Air freighting to speed delivery	• Seek local / national suppliers to avoid air freight • Ensure that improved delivery justifies additional costs
Incorrect initial material quantities which may give	• Negotiate return of surplus and small quantity top up within the original contract

rise to surpluses, or shortages which will need to be topped up at premium cost	• Seek local suppliers for small quantities • Use corporate contracts / call off orders • Works contractors to supply small quantities, consumables
Additional contingencies being included in quotations to cover unknown elements where there is no firm scope	• Client to retain risks of unknown elements • Use reimbursable contracts with appropriate levels of management, including incentives and penalties
High allowances in tender prices to cover penalties for defaults	• Client to retain risks of unknown elements • Include incentives rather than penalties
Overtime and shift working resulting in higher cost and loss of productivity	• Minimise use of premium time working • Only use premium time when benefit in time saved is greater than cost incurred
Over design vs. waiting for detailed information	• Minimise additional costs involved • Commit only to relatively low cost items • Consider knock on effects to costs of related items

8.7 *Logistics*

The project team should be housed in a single location to enable frequent face-to-face communications and simplify the transmission of documentation, etc. Where this is not possible then special arrangements will be needed to ensure that delays do not occur simply due to the time taken for movement of documentation.

In developing the project definition, due consideration should be given to the following items which can have a significant impact on the time taken to design, procure and build the asset:

- Locations of parties involved
  - client site
  - design office
  - contractors, sub-contractors
  - suppliers
- Sources of construction plant
- Sources of materials
- Labour – competence, numbers and source
- Supply routes and methods
- Site access and controls
- Availability of permanent facilities, offices, stores, etc.

8. 8 Checklists

Checklist 8.8.1	**Project Team Members at Definition Stage**	
Project No.	**Title**	
Revision	**Date**	**Author**
Project management **Project engineering** **Planning** **Project Control – cost and time** **Research** **Development** **Design** Process Civil Architectural Building Structural Mechanical (machinery, piping) Electrical Control Instrumentation **Functional specialists** Safety Quality **Specialist material suppliers** **Equipment vendors** **Procurement** **Fabricators** Equipment Components Modules **Construction** Management Civil Building Structural Mechanical Electrical / Instrumentation Specialists e.g. heavy lift **Commissioning** **Operating Works** Operations Maintenance		

Checklist 8.8.2	**Project Strategy Considerations – Sheet 1 of 2**	
Project No.	**Title**	
Revision	**Date**	**Author**

Project Management Strategy
Organisation, personnel, responsibilities
Approvals and authorisations
Project plan and fast track schedule
Risk management
Project control, progress measurement, reviews
Payment, accounting and invoicing
Technical query resolution
Change control
Communications (nature, frequency, language)
Secrecy and security
Document control
Quality control

Contract Strategy (Services)
Management
Design
Procurement
Construction
Commissioning
Forms of contracts

Design Strategy
Contributions from:
- client business
- client operating Works
- project team
- functional consultants
- contractors
- suppliers / vendors

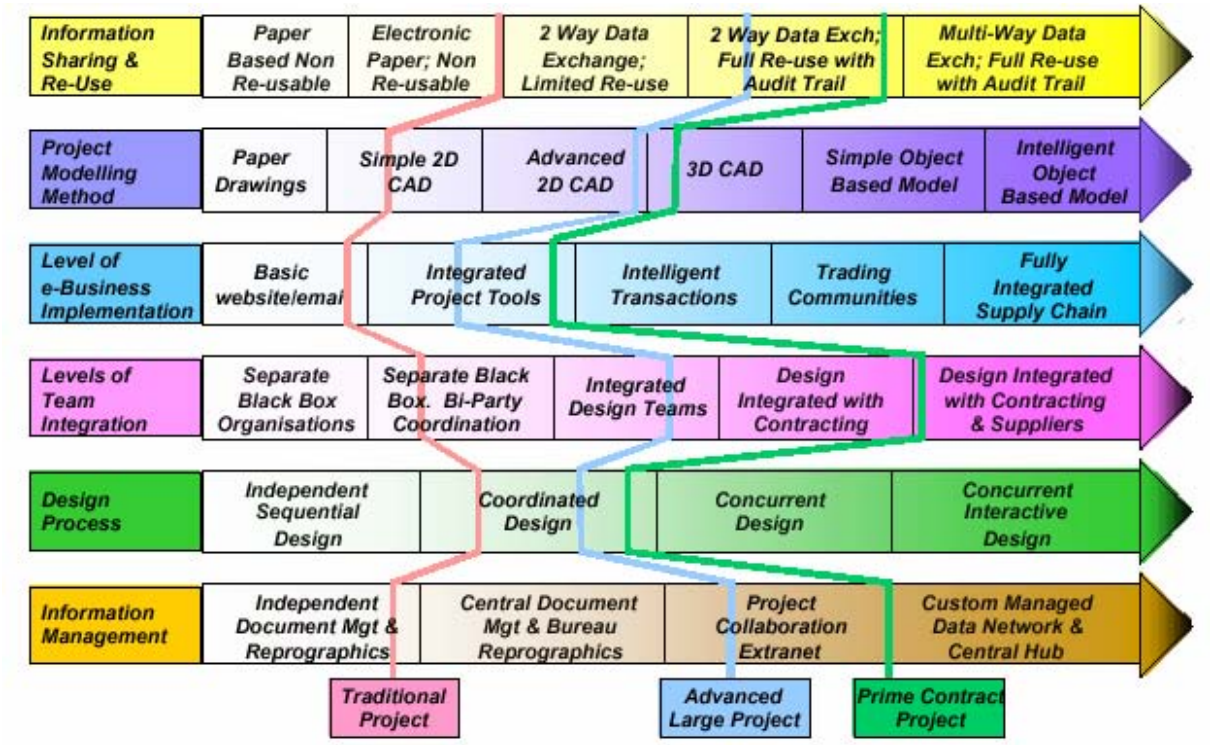
Work breakdown structure
Execution of detailed design
Design authorities

Procurement Strategy (materials and equipment)
Who will procure materials and equipment?
As principal or as agent for client?
Preferred suppliers and client required suppliers
Progressing, inspection and expediting
Receipt, storage and management
Importation of overseas supply items
Spares (construction, commissioning and operating)
Documentation
Foreign currency
Bank guarantees
Stage payments
Warranties and retention

Checklist 8.8.2	**Project Strategy Considerations – Sheet 2 of 2**	
Project No.	**Title**	
Revision	**Date**	**Author**
Construction Strategy Site management and organisation Site ownership and control Site layout including access, amenities, offices, car parks, lay down and fabrication areas Power, utilities and drainage *Work breakdown structure* Construction methodology Off-site prefabrication and assembly Schedule and *milestone*s Work sub-contractors Operating Works liaison (on an operating site) Industrial relations Preparation (cleaning), testing and calibration, pre-commissioning (safe fluids) **Commissioning Strategy** Responsibilities Schedule and integration with Construction Resources Safe working Training and validation Engineering and trade support Provision of operating materials Disposal of products and waste **Handover Strategy** Acceptance authority Acceptance conditions performance tests reservations / incomplete items Financial provisions for outstanding items **Auditing Strategy** Safety Financial Technical Project control Quality		

Checklist 8.8.3 Use of IT by the Project Team

The following diagram covering all aspects of the use of IT by the project team has been reproduced by permission of The Building Centre Trust from their report "Effective Integration of IT in Construction". It shows increasing levels of integration from left to right of the diagram.



Checklist 8.8.4	**Cost Saving Opportunities**	
Project No.	**Title**	
Revision	**Date**	**Author**
Items included in Section 7.3 Development • *fit for purpose* but not ideal • fastest rather than best • project specific (not generic) standards and specifications • reuse of design from existing assets • modular design • pre-fabrication of components • reduction in the number of processing steps in a manufacturing plant • reduction in the size of the asset • elimination of non-essential elements of the design • standardisation of layout or repeated units • standard / off-the-shelf components • simplification of design dependencies • simplification of the build / construct / assemble process • *Constructability* / *Buildability* / Operability • avoidance of innovation / new / untried elements • alternatives to avoid the use of long delivery items **Reduced project duration** • project management effort • on-costs and overheads • site establishment **Reduced enquiry and tendering** • use of existing a*lliances, framework agreements* and term contracts • single source supply **Integrated team working** • reduced formal meetings • reduced correspondence • avoidance of "man for man marking" • avoidance of multiple measurements, inspections, testing		

Checklist 8.8.5 Belbin Team Types (Courtesy of Butterworth Heinemann)

Type	Typical Features	Positive Qualities	Allowable Weaknesses
Company Worker	Conservative, dutiful, predictable	Organising ability, practical common sense, hard-working, self-discipline	Lack of flexibility, unresponsiveness to unproven ideas
Chairman	Calm, self-confident, controlled	Capacity for treating and welcoming all potential contributors on their merits and without prejudice; strong sense of objectives	No more than ordinary in terms of intellect or creative ability
Shaper	Highly strung, outgoing, dynamic	Drive and a readiness to challenge inertia, ineffectiveness, complacency or self-deception	Proneness to provocation, irritation and impatience
Plant	Individualistic, serious-minded, unorthodox	Genius, imagination, intellect, knowledge	Up in the clouds, inclined to disregard practical details or protocol
Resource Investigator	Extroverted, enthusiastic, curious, communicative	Capacity for contacting people and exploring anything new; ability to respond to challenge	Liable to lose interest once the initial fascination has passed
Monitor – Evaluator	Sober, unemotional, prudent	Judgement, discretion, hard-headedness	Lacks inspiration or the ability to motivate others
Team Worker	Socially orientated, rather mild, sensitive	Ability to respond to people and to situations, and to promote team spirit	Indecisiveness at moments of crisis
Completer - Finisher	Painstaking, orderly, conscientious, anxious	Capacity for follow-through; perfectionist	Tendency to worry about small things; reluctant to let go

8.9 Case Studies

8.9.1 Design Simplification (also relevant for Section 9.9 - Design)

An example of an innovative approach to batch chemical plant design which should be considered at both definition and design stages.

"Britest" Process Design: a set of design tools which aim to improve the design of batch chemical plant so as to use the most effective chemical process, not one constrained by the historic approach to the manufacture of fine chemicals and pharmaceuticals. This has the following added advantages which all have a significance for fast track construction:

- Main plant items of smaller size
- Standard "bits of kit" which could be off-the-shelf items
- Modular design capable of modular construction
- Reduction in piping due to small size and proximity of modules
- Reduced infrastructure
- Reduced services
- Plug and change approach to modifications
- Process control is inherent in the process, and therefore does not require the normal level of instrumentation

8.10 References & Further Reading

ACTIVE Workbook:	AP 1	Effective Project Concept and Definition
	VEP 1.2	Project Definition and Objectives
	VEP 1.3	Project Planning
	VEP 1.6	Information Management Strategy
	VEP 1.7	Procurement Strategy
	AP 2	Effective Project Team Management
	VEP 2.1	Project Team Organisation
	AP 4	Effective Information Management and Communication
	VEP 4.1	Information Management

Title	Schedule Reduction
Published	CII, 1995, Reference 41-1
Pages	32
Availability	Available through ECI
Review Comment	A very useful primer on the subject. The 5 pages covering concurrent engineering are especially useful and should be read by every project manager whether or not they are involved in a fast track project.

Title	Fast track construction
Published	CIOB, 1991.
Subject	Building / Construction industry / Construction contracts.
Name	Kwake AA.
ISBN	1853800228
Review	This is a practical paper that addresses a fast track approach specifically

aimed at the building industry, advocating a project management model rather than a traditional, architect led, model.

Title	Effective Integration of IT in Construction
Publisher	The Building Centre Trust 26 Store Street, London. WC1E 7BT
Availability	www.buildingcentretrust.org – free copy of full report

A wide range of information on the application of IT in projects is available from the IT Construction Best Practice Programme – www.itcbp.org.uk.

Title	Partnering in Europe
Publisher	Thomas Telford
ISBN	0727729659

Title	Partnering in the Public Sector
Publisher	ECI (1997)
ISBN	1 873844 34 4

Section 9 Design

9.1 Introduction

The opportunities that are available to the design organisation and individual designer will depend crucially on their involvement in the preceding stages and the decisions that have already been taken when detailed design commences.

Successful fast track projects are successful not only because they challenge the conventional approach to project management and manage the additional risks introduced, but also because they do all the normal things well, including achieving high productivity during the design stage. This requires a good understanding of the options for compressing the schedule as described in the CII Publication 6-7, November 1988, "Concepts and Methods of Schedule Compression". See checklist 9.8.2.

A fully integrated design team is an essential requirement if a fast track schedule is to be achieved. The importance of progressing the design smoothly and rapidly will be greatly assisted if all parties are able to work together to avoid disruptive *holds*, delays pending approvals and recycling of decisions once taken. Design should be stopped when it is good enough to communicate the information to other parties, and not continued to the point of perfection. The contribution and ownership of construction, commissioning and operations staff to this stage cannot be over-emphasised. The members of the design team need to be empowered to make the design decisions which are within their combined capability, avoiding the delays which occur when the Project Manager of Chief Engineer have to sign off all design output.

The use of the most up-to-date, proven, computer aided design tools should be considered since in appropriate circumstances they can speed up the design process and to ensure that the minimum number of errors are included, by e.g. clash checking. The value of these design tools to construction, commissioning and operations with familiarisation and training to speed subsequent stages should be fully explored.

9.2 People

Clarity of Objectives
An essential pre-requisite for the achievement of the project *critical success factor*s is a clear understanding and acceptance of these objectives by the members of the design team. While it is now recognised that the best outcome will be achieved if the asset and its construction method are designed at the same time, this has not always been the case. The most elegant design is useless unless it is capable of being built safely and to time and budget.

***Stakeholder*s**
The interests of all *stakeholder*s should be kept under review as the design progresses so that interested parties can be kept up to date and involved at the earliest appropriate stage. The progressive involvement of e.g. the regulatory authorities will help to ensure their commitment and speedy approval when formal applications are ultimately submitted. See *stakeholder* checklist 6.8.1

Alliances

Establishment of a longer-term relationship between the companies involved, and between the employees of those companies, helps to ensure a rapid start-up of the team involved on a new project. There is more chance of this happening under an *alliance* arrangement, *framework agreement* or *term agreement* since this can enable the contractor to plan for the servicing of future projects if he is made aware of the client's future investment intentions.

Integrated Team
The use of single design team incorporating the expertise of all disciplines and involving those responsible for the subsequent phases of the project i.e. building, commissioning, operating, should enable the design to be "right first time" and thus minimise the number and duration of design reviews and the number of changes /amount of rework which results from those reviews. The contractual relationships between the parties involved need to be set up to promote such integration and to enable contractors, including specialist sub-contractors to be available to client, architect and design staff from the earliest stages of the project.

The further to the right that the project team is in the diagram below, the more likely it is to be successful in delivering a fast track project.

A handbook describing the key principles and practices for the application of integrated collaborative design has recently been published, see 9.10 "Design Chains".

The integrated team needs to be supported with appropriate collaboration and communication systems, see Section 8.5. This is a rapidly developing area and several systems are currently available from a number of competing suppliers. A new user would be well advised to research the latest situation before selecting the most appropriate system.

Team members should have clearly defined roles and responsibilities to eliminate duplication and inefficiencies while ensuring that there are no gaps in the overall team capability. Team workshops should be used to help sort out interface problems between the various parties involved in the project.

Management effort must be deployed to ensure that the design team become committed to the objectives of the project and understand how they can make the maximum contribution to the *critical success factor*s. Alignment and team building / team maintenance exercises must include all those involved in the design. Project induction packs and "welcome" arrangements can help to ensure that new members joining the team are brought on board.

See checklist 9.8.1 for list of possible members of an integrated project team at the design stage.

Delegation / Empowerment
The requirement to authorise and empower members of the project team to promote rapid and effective decision taking applies to the design team as much as to any others.

***Suitably Qualified and Experienced Personnel* (SQEP)**

While the employment of people who are both qualified and experienced is always desirable, it becomes even more important that the individuals who are making decisions on the basis of personal judgement have the necessary experience to support those decisions. Inexperienced staff can be employed on fast track projects but their freedom to make decisions must be restricted within the limits of their competence. The integrated team structure helps to overcome any shortfall in experience of the individual members of the team.

9.3 Scope

Clarity of Definition
A clear definition is the foundation on which the success of any project is based. It has often been said that there are three things that are important in project management – definition, definition and definition – and the problem with some fast track projects is that detailed design has to proceed without total clarity of definition. There are limits to what is possible and it is a matter of judgement as to which areas are sufficiently well defined to proceed with detailed design without incurring too great a risk, and which areas need to be held back until greater clarity of definition has been achieved. In some cases a *black box* approach has to be taken in which the contents of the box remain to be clarified later but the boundary conditions can be specified to enable design to progress external to the box. The assumed boundary conditions become a constraint on the what is possible within the box and need to be chosen with good judgement and suitable tolerances.

Extent of Design
The extent of design to be carried out by the design organisation needs to be defined from the beginning. Some element of design has always been left for the site contractor to complete but in the case of fast track projects the extent of this design tends to increase. However, it is very important that difficult details should not be left to be sorted out on site but should be detailed on the drawings even if this results in the issue of design information being delayed until a later date. There will be no benefit if the easy 95% is fully detailed and the site contractor is left to struggle with sorting out on site the difficult 5%. There is also an argument that it is helpful to keep the responsibility for both design and construction within the same organisation, "design and build", allowing key team members to follow through the design into construction, in order to minimise interfaces and the confusion and delay that can occur at them.

Design can only be based on the best option at the time given the information available and it should be recognised that in the case of a fast track project this is often less than the complete information. Similarly procurement sometimes has to proceed on insecure information and early production by the design organisation of "worst case" data sheets for long delivery items of equipment.

Getting design data from equipment vendors at the time it is required by the schedule can be a major problem on any project and lack of information is often a constraint on general design progress. The need for early information on a fast track project makes this a more critical issue that must be vigorously addressed. The costs and resources required for expediting vendor information should be considered at an early stage in the project planning.

Design should be carried out to the appropriate level of detail for the site and the construction contractors involved. Where possible *holds* on design should be avoided. The inclusion of

provisional information, clearly identified as such, to show what is likely to be the final design, will be helpful to the planners and to site contractors in organising work on site.

Over-design

Where judgement has been applied in the design process in the absence of hard information it is necessary to make more generous allowances than would normally be the case, especially where e.g. the structural integrity of the asset is concerned. The level of this over-design will depend on the extent of the unknowns, the significance and perhaps the cost of the item. The design can be based on the maximum expected values e.g. weight of superstructure, pressure in system, together with an appropriate safety factor, rather than waiting until precise values can be calculated. For example there may be little cost difference for the project as a whole if piling is 30% over-designed or 50% over-designed, but one may allow site work to proceed well ahead of the other and long before accurate details of the superstructure can be determined.

Design Process

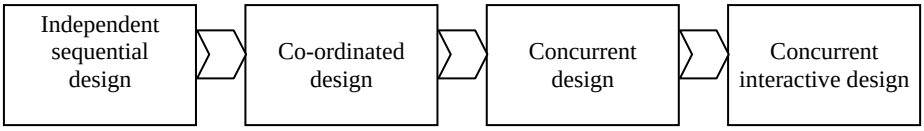
The design process must address all the usual project requirements of the client and contractors involved. There are no shortcuts that can be justified simply because the project is running to a fast track schedule.

The things that are likely to differ include:

- The design sequence must be planned to ensure that the schedule needs of construction drive the design process for the production at the right time of:
  - design information
  - drawings
  - documents
  - materials
  - equipment
- Long lead item data sheets and specifications will need to be produced out of sequence with the rest of the design
- Visual appearance and structural design may need to be compromised to achieve the fastest completion e.g. by acceptance of roof mounted, prefabricated plant rooms installed towards the end of the construction process
- Design option selection may be based on fastest to manufacture or build / construct rather than lowest cost
- The design will overlap with procurement and construction
- The design of work packages, modules or units will be in parallel with other work packages, modules or units and great care will be needed to recognise and deal with the interconnections between them
- It will be necessary to by-pass those design areas for which there is insufficient information and work to assumptions, then put experienced team members to work resolving the issues within the *black box* area
- The design of the construction process must be an integral part of the asset design process, incorporating *buildability* and *constructability*, to ensure the optimum construction duration. The design may need to accommodate the use of specific construction techniques and equipment through e.g. modification of the layout, provision of clear access ways for mobile rather than fixed scaffolds, foundations for large radius cranes.
- Design *holds* must be minimised and every attempt made to avoid them being a cause of delay

- Design reviews must be carried out as thoroughly on fast track projects as on any others. However, they should be simplified and fewer problems are likely to be identified if an integrated team involving all *stakeholder*s is used to carry out the design. Reviews must not be allowed to cause delay but may result in later rework if problems are subsequently identified.

Consideration needs to be given to the design process and to the IT systems that support it. The further the design organisation(s) are to the right of the diagram below, the more likely they are to be successful in the delivery of a fast track project.



Design freeze

The application of a *design freeze* as part of an overall change control process is even more important (if that is possible) for a fast track project as it is for a conventional project, but it is much more difficult to apply. The overlap between definition, design and construction means that the number of unknowns remains higher than in a normal project while work is proceeding on the following stage. It is therefore possible only to freeze parts of the design which then have to be accepted as constraints on the rest of the design. All the design team have to be kept up to speed with progress of the design to ensure that they are aware of these constraints. Long lead and critical items need to be identified as early as possible in the design process so that firm information can be issued for purchase of the items. Again these will become constraints on the rest of the design once their specification has been determined.

9.4 Strategy

Simplicity and Repetition

Simplification of the final asset and repetition of the design elements are all desirable aids to fast track since the less there is to do, the shorter the time it should take:

- Reduction in the number of processing steps in a manufacturing plant
- Reduction in the size of the asset
- Elimination of non-essential elements of the design – de-scoping
- Standardisation of layout or repeated units
- Simplification of the build / construct / assemble process

See "Britest" case study 8.9.1 for an example of design simplification.

The application of lean thinking principles, see Section 14, may help to reduce to the minimum the amount of work which has to be done while still achieving the project objectives.

Standard / Reusable / Off-the-shelf design

Where a design exists for a comparable asset, consideration should be given to reuse in order to shorten the design time and, perhaps more importantly, to provide early information for procurement, construction and commissioning. An existing asset can be used to train both the constructors and users of the new asset. Even if the whole design cannot be reused it may still

be possible to base the design of the long delivery items on those that already exist so that material procurement and fabrication can be started at the earliest possible time.

In many cases, standard, off-the-shelf components will be available which can be incorporated in the design thus eliminating lead time for manufacture.

Modularisation

If the overall design can be structured as a series of units or modules then there is the potential to introduce a number of schedule reduction approaches.

It may be possible to progress separate modules / units in parallel using separate design teams, suppliers, construction contractors, etc., as appropriate through all the succeeding stages of the project. In the extreme this could reduce the overall schedule to that required for the longest duration module / unit. However, great care should be taken to identify all the interdependencies between the separate modules /units and to ensure that these are taken into account as the design progresses.

If a number of the modules can be of identical / similar design then, even if it is not possible to progress them in parallel, it should be possible to utilise the experience gained on early modules to improve the efficiency and shorten the duration of later modules.

In the case of process plant, designing as a number of parallel streams, rather than a single large stream, may enable smaller, off-the-shelf items to be procured and installed more quickly even if this arrangement is not required for technical or operational reasons.

Consideration should be given to the concept of sub-modules mounted within plant or building units. If the sub-modules can be of identical overall dimensions, or be multiples of the smallest sub-module, then they may be interchangeable within the overall structure. Under these circumstances it may be possible to install late running sub-modules without affecting the overall schedule.

Prefabrication / Pre-assembly

Where the design can be broken down into units / modules / pre-assemblies then the opportunity will exist to manufacture these components off the construction site and possibly under factory controlled conditions. This is normal project practice. The fast track approach challenges the extent to which this is normally done and seeks to extend the practice as far as is practicable in the circumstances of the particular project. In the extreme case the entire asset can be prefabricated, furnished and tested in the factory before being transported, to a site which has been prepared while the units were being manufactured, for final assembly and site testing.

Fast track projects tend to push pre-fabrication to new limits including:

- Preformed timber cladding
- Cladding panels complete with windows, external fittings, internal finishes
- Fully finished air handling units
- Complete, pre-tested plant rooms
- Skid mounted plant
- Fully finished bathrooms
- Standardised internal partitioning

- Complete, tested, validated pilot / process plant

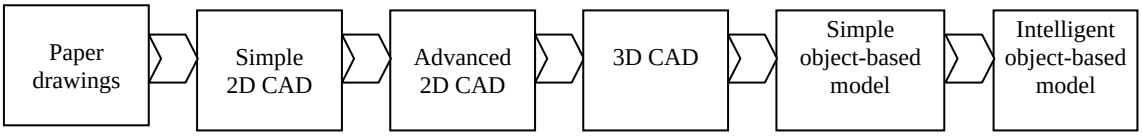
Piping design has been a particular problem, especially on retrofit projects, due to the difficult trade-off between quality of information and time. One of the frequent outcomes is incorrect ordering of materials and significant rework of piping spools.

Design Tools
Technology is providing the designer with ever more sophisticated tools but it is important to select the most appropriate tool for the job. A "high touch – low tech." approach is to be recommended for many projects. The low technology approach will often be found to be the quickest to produce results, e.g. in response to site technical queries, when the high tech. route would take much longer.

Consideration should be given to the use of the latest, proven, design (*CAD*) and communication systems (IT) since in appropriate circumstances they can:

- Speed up the design process
- Assist in understanding of the asset being designed through 3D modelling etc.
- Avoid the need for physical mock-ups and testing of innovative design features
- Ensure that the design is capable of being built without modification through use of clash resolution, etc.
- Speed communication between remote locations, e.g. India and UK
- Enable *fab to fit* through the use of photogrammetry input to *CAD*, avoiding field work and greatly increasing accuracy

The further that the project design methods are to the right of the diagram below, the greater the level of integration and the easier it will be to accommodate the complex interdependencies between the elements of the project and the stages of the project.



It is important to note that all parties must be operating to common standards to enable the direct interchange of information and agreement of the standards to be used on a particular project can be a very time consuming activity for which due allowance must be made.

9.5 Project Management Systems & Procedures

Planning
As described under the Design Process Section above, planning of design must be driven by the requirements of later stages, most notably construction (which itself is driven by commissioning), and, in support of construction, procurement.

Interactive planning, which involves all members of the project team in problem solving and plan optimisation has been suggested by some companies as a useful technique, especially for fast track projects where innovative approaches are being sought to shortening the schedule. See Section 7.8.1 for a typical interactive planning process.

"Critical Chain" project planning methodology has been credited with a significant reduction in project duration by companies that have used it. The theory is well described in E M Goldratt's book of the same title, see Section 9.10. The methodology results in the schedule contingency, which is normally hidden in the planned duration of each activity, being removed from the critical chain of activities and being replaced by a number of buffers of project contingency that are provided to protect blocks of activities and are visible to the project team. This helps to ensures that the contingency is not wasted as a result of late starts to activities, and makes it easier to recover schedule contingency from any activities that are completed earlier than planned. Software is available to support the methodology e.g. ProChain Plus which is an add-on to Microsoft Project.

The Analytical Design Planning Technique, ADePT, developed by Loughborough University together with a number of industrial partners, is now commercially available under the title "Planweaver" from BIW Technologies, see Section 9.10. This is web-based software that can be fully integrated with other planning systems. It addresses a number of the key aspects of fast track projects:

- Integration of design and construction programmes
- Concurrent programming of interdependent design tasks
- Prediction of the effect of single and multiple design changes
- Risk management

Project Control

Effective project control is one of the keys to a successful fast track strategy, following closely on effective planning of the project activities. Control **must** be a dynamic process with a very short cycle time so that deviations from plan are recognised and corrected in a time scale which ensures that the overall schedule is maintained. Consideration should be given to both recovery of any slippage against the schedule and opportunities to shorten the schedule.

The following have been mentioned as being particularly helpful in focussing management attention on areas requiring corrective actions:

- Design progress measurements and trend data at the simplest level that is essential to maintain control
- Frequent up-dates of measurements / information
- Progress information / reports that are simple, concise, easily available to relevant people
- Monitoring of key trends – flagging adverse trends and forecast out-turns that are not in accordance with the schedule – including schedule float
- Exception reporting of items not completed to scheduled
- Progress against deliverables, *milestone*s, *CSF*s and forecast out-turns
- *Earned value* measurement

Design document control must support the project document control system by ensuring that documentation is completed to meet the needs of procurement, construction, commissioning and handover.

Design Approval

To ensure that the client fully understands the detail of the assets being created by the project and does not come up with additional or alternative requirements during the procurement, construction or commissioning phases, it is necessary to have a design approval system which

includes sign-off by the ultimate client. The aim should be for this system to be so responsive that approval can be obtained before design is issued for construction but this may not be achieved and construction may have to commence at risk on the basis of provisional approval from within the project team.

Approval of the design of sub-units that are the responsibility of specialist vendors may need to take place on their premises to avoid delays if approval of electronic documents is not acceptable.

Verification
Verification of design should commence as soon as possible in the design sequence to limit the amount of rework that may be required and prevent verification being a cause of delay as the plant approaches commissioning.

Change control
An effective change control procedure is essential for any well run project. In the case of a fast track project control it is needed even more, but it is more difficult to enforce due to the increased risk of rework arising from the overlap of design and construction. Speedy completion depends on limiting scope changes and restricting design development to that which is essential to meet the project objectives, and even then approval should be required at a senior level in the client / project organisation.

Where change is proposed, rapid rejection or approval will help to limit rework and minimise the impact of changes. Any change which is approved should be clearly indicated on the documentation to ensure that the result can be quickly understood by all who have to implement the change.

Where the scale of the project justifies it and project staff have both the skills and willingness to use the latest electronic systems, consideration should be given to employing them to speed up the change control process. Some of these systems will require the involvement of IT specialists.

Communications
Good verbal communications need to be established between the parties to the design so that decisions which affect the work of others are known quickly and the design can progress rapidly and securely. This is especially important where parallel design teams have been set up to address separate work packages or sub-units which are interconnected.

Meetings should be kept to a minimum and focused on decision taking rather than communication of matters purely for interest. Communications within the team should take place as needed and not be restricted to a meetings timetable.

Communications with other parties outside the integrated design team who may be dealing with other aspects of the project, such as planning applications, need to be kept up to speed with design details as they evolve and it is recommended that a system be put in place to ensure that this happens.

Full use should be made of IT systems for the storage and communication of all information as described in Section 8.5. See also Section 8.8.3.

Access controlled web sites can now be rented which enable a project team to have a secure location for their database, etc.

***Constructability* / *Buildability* Reviews**
The integrated team is best placed to address the issues which arise from *Constructability* and *Buildability* considerations as the asset structure and detailed design are evolving.

9.6 Cost & Risk Considerations

The main risks associated with the design phase of a fast track project are of increased cost and delay due to sub-optimum design or incorrect design resulting in rework. The root cause can be either commencing detailed design before a comprehensive and firm definition has been agreed or from the concurrent engineering /early decision approach which underlies the fast track strategy, especially where there are interdependencies between the elements on which parallel working is taking place. Some of the cost and delay consequences of the design risks only become apparent during the procurement and construction stages, but the mitigation opportunity exists mainly within the design process.

Design / Construction

The following table lists the risks that are principally associated with the increased level of overlap between the design and construction stages of a project.

Risks	Mitigation Opportunities
Product which is to be manufactured on the plant fails its trials, e.g. clinical trials, so that the plant is no longer needed for that product	• Design plant with alternative uses in mind so that, with modifications, the investment in the asset will not be totally wasted. However, beware of investing "foresight capital" against unspecified future needs since this is contrary to the concept of simplification and minimisation in the interests of speed.
Failures of innovative designs as a result of putting them into practice without sufficient development.	• Innovative design should be avoided if possible on fast track projects • Where innovative design is unavoidable, the maximum possible time should be made available for development
Failures of innovative methodologies as a result of hasty and insufficiently considered application.	• Carry out pilot or proving trials before full implementation if possible • Plan alternative, fall-back methodologies which can be implemented quickly in the event that the preferred choice fails
Increased levels of rework to accommodate changes as a result of (a) lack of firm definition (b) errors e.g. failure to recognise interdependencies between separate modules (c) omissions that are primarily the consequence	• Establish effective change control procedures • Employ an experienced Project Engineering Manager to co-ordinate and control rework • Use 3D Computer Aided Design where appropriate • Carry out independent / peer group design reviews and independent verification • Use an integrated design team • Adopt a pro-active and pre-emptive approach • Commit time and resources at the design stage to avoid

of out-of-sequence design (d) Changes to design of fabricated items after delivery to site	rework later • Modify on site, after installation
Increased capital cost arising from (a) modularisation e.g. extra structural steel, extra joints/connections, greater precision (b) over-design due to judgements based on limited information (c) sub-optimum design through the use of standard designs or reuse of existing designs.	• All of these are potentially the cost premium that has to be paid for the strategy adopted to achieve the fast track schedule. The additional costs should be off-set against savings elsewhere, e.g. (a) less site labour. It is important to aim for reasonable estimates in the earliest stages of the project so that the right trade-offs can be made. • Ensure that over-design (b) is limited on expensive construction elements, allowing more freedom on cheaper items • Ensure that sub-optimum design does not result in shortfall of performance of finished asset
Increased whole of life cost due to sub-optimum design.	• Utilise a 2-phase approach by designing for an upgrade or revamp at a later date, e.g. first shut-down, to eliminate the sub-optimum element of the design
Problems at design and construction discipline interfaces.	• Ensure that an integrated team is used from the start • Provide design support for construction at site to respond immediately to technical queries as construction progresses • Where *CAD* has been used as a design tool, install *CAD* stations on site with good communications to design office
Conflict	• Ensure that there is a strong Project Manager providing a clear focus and sound priorities for the team, with first class communications • Promote good working relationships through leadership and team building • Ensure a "can do – will do" attitude throughout the team and get rid of anyone who is unwilling to accept the team consensus

Design / Procurement

The following table lists the risks that are principally associated with the increased level of overlap between the design and procurement stages of a project.

Risk	**Mitigation Opportunities**
Lack of understanding of scope	• Involve contractors and suppliers in scope definition and design • Involve contractors and suppliers in team building exercises

	• Ensure that areas of uncertainty are understood by procurement staff and the contractors and suppliers with whom they are dealing • Communicate scope clarification as soon as it is available
Design changes requiring revised contracts and purchase orders leading to delays or cost increases.	• Design team to advise procurement staff of assumptions and risk assessments with indications of areas of potential change • Allow contingencies for growth in quantities • Procurement to negotiate flexible terms regarding re-measurement and changes at pre-established rates prior to signing contracts • Ensure speedy and open communications with suppliers and contractors to minimise delay when changes are identified
Errors or omissions in purchase of materials or equipment.	• Employ dedicated equipment / material controller as a member of the team • Ensure good inter-disciplinary co-ordination based on standard discipline specifications and guidelines • Negotiate material call-off (and surplus return) arrangements with suppliers • Make generous scrap, cutting, wastage allowances • Consider especially pre-fabricated piping spools which are frequently ordered on preliminary information with the result that high levels of rework are required • Negotiate use of equipment and materials in maintenance stores • Base design on standard items whenever possible
Reduced certainty of outcome for all project parameters: cost, time, quality, safety.	• Establish sound baseline position and consider the minimum / most likely / maximum values for *work breakdown structure* element cost and schedule activity durations • Establish standards for Quality Assurance and Health, Safety and Environment • Use Monte Carlo tools to assess range of potential cost and time outcomes • Agree appropriate "levels of confidence" in the outcomes and acceptable contingencies
Interdisciplinary design conflicts arising from out-of-sequence working.	• Ensure that there is a fully integrated design team approach • Ensure good communications between disciplines • Use experienced designers who have a broad understanding of the design process • Use multi-disciplinary designers when available • Use *interactive planning*, see Section 7.8.1 for joint problem resolution across discipline interfaces

Problems with systems integration.	• Appoint co-ordinator with specific responsibility for integration of systems across module and other boundaries • Model systems to identify specific interface / conflict issues • Use 3D CAD as a minimum design tool
Inappropriate form of contract for those contracts which are let on the basis of inadequate or incorrect design information.	• Project strategy to include early definition of contracting strategy • Use reimbursable contract where the definition of project scope is inadequate to justify other forms of contract and accept that this will require greater levels of project management input from client and / or management contractor • Incorporate incentive, bonus and penalty clauses to encourage focus on the project *CSF*s
Selection of inappropriate contractors, due to lack of clear contract scope, from the point of view of : • Resource capacity • Skills • Finance • Culture	• Procurement strategy to include criteria for pre-qualification and bid evaluation with focus on culture, capability and competence in depth rather than cost, since resource demand is likely to increase over initial expectations • Use multiple contractors to spread the load and risk and encourage competition so that work can be reallocated in favour of best performers • Client to finance purchase of materials and equipment by contractor as agent so that client retains secure ownership
Inappropriate allocation of risk, i.e. not allocated to the organisation best able to deal with it.	• Project strategy to include early definition of risk sharing criteria and approach • Client to consider greater level of risk retention than is normal, but must also commit to a greater level of risk management • Contracts to include provision to allow removal of work from a non-performing organisation and allocation to others which can deliver

9.7 *Logistics*

Design Team Location

The design team will be the centre of the project team activities for a significant part of the total project programme. If the whole of the project team cannot be located together for the duration of the project then consideration should be given to basing the project team on the design team when design is in the lead. It will greatly help to unify the project team and maintain focus on the project *CSF*s if all design team members can be housed in separate accommodation away from other project teams. This will also make it easier to maintain secrecy where that is a requirement of the project.

Access

Arrangements should be made for design staff to gain access to the site of the new asset as early in the process as possible and with the minimum of essential restrictions. It is essential that firm information is made available as soon as possible in the design process and this becomes especially important where the asset is to be built on old / contaminated sites and those with difficult ground conditions, or as an extension to an operating asset, such as a process plant, where the tie-in arrangements need to be determined with precision. Late discovery of site conditions which are significantly worse than had been assumed has been the cause of delay on many projects.

9. 8 Checklists

Checklist 9.8.1: Design Team Members	
Project No. **Title** **Revision** **Date**	**Author**
Project management **Design management** **Architect** **Designers:** Process Civil Architectural Building Structural Mechanical (machinery, piping) Electrical Control Instrumentation **Functional specialists** Safety Quality **Specialist material suppliers** **Equipment vendors** **Management contractor** **Procurement** **Fabricators** Equipment Components Modules **Construction contractors** Construction management Civil Building Structural Mechanical Electrical / Instrumentation **Specialist construction sub-contractors** **Commissioning manager** **Works representative** Operations Maintenance	

9.8.2 Schedule Compression

The author is indebted to CII for permission to publish the following list that has been extracted from the CII Publication 6-7, November 1988, "Concepts and Methods of Schedule Compression" to which reference should be made for explanation of each of the headings.

Checklist 9.8.2 Schedule Compression	
Project No. **Title** **Revision** **Date**	**Author**
1 Ideas Applicable to All Phases of a Project 1.01 Avoidance of Interruptions 1.02 Efficient Staffing 1.03 Incentives 1.04 Modern Management Systems 1.05 *Pareto's Law* Management 1.06 Participative Management 1.07 Partnering & Team Building 1.08 Personnel Management Practices – General 1.09 Planning 1.10 Reduction of Task Scope 1.11 Safety/Loss Control Programme 1.12 Well-defined Organisational Structure **2 Engineering Phase** 2.01 Change Management System during Engineering 2.02 Computer Aided Design & Drafting 2.03 Consolidation of Permanent Components or Functions 2.04 *Constructability* Analysis During Engineering 2.05 Dual-purpose Design 2.06 Efficient Packaging for Transportation 2.07 Engineering Approvals 2.08 Freezing of Project Scope 2.09 Interstitial Design 2.10 Materials, Equipment and Systems Standards 2.11 Non-Traditional Drawing Release 2.12 Off-the-Shelf Components 2.13 Parametric Estimating 2.14 Permanent Facilities used for Construction Purposes 2.15 Physical Modelling 2.16 Productive Working Environment 2.17 Specification Review 2.18 Standard or On-the-Shelf Designs 2.19 Vendor/Engineer early Information Exchange	
Reference CII Publication6-7, November 1988	

See Checklist 11.8.2 for remainder of this list which is relevant to subsequent stages of the project.

9.9 Case Studies

9.9.1 Multi-storey Housing

Murray Grove Apartments is an architect designed, factory made, housing development of architectural merit manufactured by Yorkon and erected on a brownfield site in London for the Peabody Trust. The 5 Storey, high specification, apartments were manufactured as steel framed modules and craned into place in just a few days with all fixtures and fittings in place, down to and including carpets. The £2.89m project has collected numerous awards since completion in 1999 and has led to a high level of client and end-user satisfaction.

The scheme was completed in 39 weeks compared to 62 weeks for a comparable, traditionally built development for the same client. The project was a success in spite of the obstacles to team working which resulted from the design and build contract with tight budgetary constraints.

Keys to success include:

- Buy-in and commitment from senior managers in all parties who had a shared vision and drive to succeed
- Technical innovation of design
- Prefabrication, turning the process from construction into manufacturing (NB the link to Lean Manufacture – see Section 14)
- Client risk taking
- Passion to make it happen on the part of key players

9.9.2 Design Simplification

See case study 8.9.1

9.9.2 University Campus

See case study 11.9.1

9.10 References & Further Reading

ACTIVE Workbook:	AP7	Effective Project Execution
	VEP 7.1	Project Control
	VEP 7.2	Design Effectiveness
	VEP 7.3	*Constructability*
	VEP 7.4	Standards and Specifications

Title	Faster Building for Industry
Published	NEDO 1983
Pages	107
Subject	Speeding up the process of designing and constructing industrial buildings
Name	Building Economic Development Committee
ISBN	0 11 701183 5

Comments This is a useful document that contains some very pertinent comments although it is primarily concerned with the scope for improving the overall pace in normal circumstances and is not concerned to find the recipe for

maximum speed regardless of other factors. Section 1, Report of the *Steering group*, pages 2 – 20, is especially recommended for the common sense advice it contains.

Title	Critical Chain
Publisher	North River Press
Author	Eliyahu M Goldratt
ISBN	0-88427-153-6

Title	Design Chains
Publisher	Thomas Telford
ISBN	0 7277 3039 8
	See also www.designchains.com

Title	Planweaver planning software
Supplier	BIW Technologies
	www.biwtech.com

Section 10 Procurement

10.1 Introduction

The procurement staff have a key role in any project, working at the interfaces between client, design, construction, suppliers, contractors, transport, shipping agents, etc. to ensure that the project *CSFs* are achieved. In the case of the fast track project they are expected to handle the flow down of risk from the client / main contractor to the supply chain.

Procurement activities normally overlap both design and construction stages in a conventional project. The key differences with a fast track project are:

(a) the increased extent of this overlap with the design stage and the provisional nature of the information on which the procurement activity has to be initiated

(b) the increased extent of the overlap with the construction stage and the need for equipment and materials to be delivered at the time required by the construction schedule.

Contractual arrangements have been addressed in Section 5.1.5. The research indicates that there are no forms of contract that are specific to fast track projects. Because of the greater need for early involvement, in advance of a firm definition being available, a higher proportion of fast track project contracts appear to be let on a reimbursable basis in the first instance than is the case for conventional projects. Many fast track project contracts include targets and an agreement to convert to a fixed price on an defined basis for some or all parts of the project once the information becomes available. Sub-contracts are frequently let on a lump sum basis even on fast track projects.

10.2 People

Clarity of Objectives

The project *critical success factors*, and what is expected of procurement staff in achieving these *CSFs*, should be clearly and unambiguously communicated to all staff involved in the letting of contracts and the purchase of materials and equipment. The *key performance indicators* against which procurement performance is to be measured should be:

- Schedule orientated, i.e. related to progress of critical path items
- Explained in ways which will enable procurement staff to recognise how their contribution will affect the achievement of the *CSFs*
- Displayed and regularly updated in the procurement offices

The end point for the procurement stage should be the beneficial use of the completed asset by the client, as it is for the project as a whole. Intermediate milestones, important as they may be for triggering contract payments, should not be allowed to diminish the responsibility of the procurement organisation for supporting the project until it is handed over and in full operation.

***Stakeholder*s**

Engagement of *stakeholder*s should continue through the procurement phase according to their level of responsibility, influence and interest. Of particular significance is the knowledge and position of the client with respect to potential contractors and suppliers. This should be established from the start of procurement so as to take into account all market and

other intelligence, and to ensure that the client's wider interests are not damaged while still achieving the fast track schedule. Procurement responsibility should be clearly divided between client and (main) contractor, and where a contractor is carrying out the purchasing function it should be clear as to whether this is as principal or as agent.

By agreement it may be possible to reduce the procurement duration by:

- Simplifying the approvals procedures for pre-qualifications, tenders, etc.
- Simplifying the competitive tendering procedure
- Going to a single source
- Combining (bundling) work packages / elements
- Utilising existing *alliance*, term or other contracts
- Using pre-qualified contractors and suppliers
- Working from preferred supplier lists

Integrated Team

Procurement staff should be members of the project team in the same way as all other parties to the project, ideally on a full time basis. In practice many purchasing departments are organised along discipline lines so that individuals can be serving several projects in parallel. This will require greater effort on the part of the fast track project manager to ensure that the procurement staff serving his project are included in team building and other exercises. Where possible a single, full-time purchasing manager should head up the project procurement team to provide clear leadership and drive and to ensure that the supply chain is properly integrated with other project activities.

The purchasing organisation on a fast track project needs to be proactive in seeking ways to meet the needs of the project and to recognise that this is not "business as usual". This may necessitate modifying the standard procurement procedures and / or authorising waivers and dispensations to avoid the delays that normally occur. It is helpful in creating the "one team – one culture" approach if purchasing staff are located with other project support function staff and receive project progress and other information along with all other members of the project team.

Design engineers, *responsible* / *accountable* engineers and functional specialists will all need to be involved alongside procurement professionals in the purchasing process in defining and specifying requirements, technically evaluating tenders, selecting suppliers, inspecting and witnessing factory and site acceptance tests. This is best done by a flexible, integrated team and at least one management contractor has found it beneficial to have the equipment engineers respond directly to the purchasing manager while they carry out purchasing activities.

Higher than normal levels of expediting may be required to ensure that equipment and materials arrive in time to meet the fabrication / construction schedule. In many cases expediting is best performed by the functional engineer who specified the equipment since that individual is in the best position to work with the supplier to overcome any difficulties that threaten delivery to schedule. However, as an expediter the functional engineer should be competent to perform a multi-functional role to avoid the cost and delay associated with multiple visits.

The presence of a materials controller with responsibility for fixing any problems which arise in the supply of materials or equipment has been found to be very helpful. This is normally a

site based individual who has responsibility for receiving, inspecting, marking, storing, conserving, marshalling documentation and issuing materials and equipment to the work location. Where materials are issued "just in time" to the work face direct from the vendors / suppliers, then the materials controller should also work with these organisations to ensure that deliveries to site arrive at the right location and on time.

Delegation / Empowerment
Delegation and empowerment of staff to promote decision taking at the lowest competent level is as important for the procurement organisation as for any of the other parties to the project.

Suitably Qualified and Experienced Personnel
Fast track projects tend to place a high demand on resources, the supply of which must not be allowed to limit the rate of progress on the project. The necessary numbers and skills must be made available to meet the demands of the schedule on a short-term, dedicated basis even if this results in less efficient working.

The chances of success are greatly increased if skilled and experienced staff are employed on the fast track project at all levels and the "top team" should be used whenever possible. This can have implications for other projects and is likely to limit the number of fast track projects that it is possible to implement at any one time.

Motivation
It is essential that the procurement staff are motivated along with other members of the team to achieve the project objectives, see Section 5.1.4. A "can do - will do" attitude should be one of the key criteria for selection of staff to work on the project.

10.3 Scope

A clear definition of project scope is highly desirable but in the case of a fast track project it is likely that procurement will need to commence long before there is full clarification of the scope. The best available overall picture should be obtained from the *work breakdown structure*, risk register, etc., so that the likely extent of equipment and materials procurement can be taken into account in determining the procurement strategy.

Procurement staff should advise project management and functional engineers of any opportunities to reduce the procurement duration through:

- Changes to scope of supply
- Minimising scope of supply e.g. resulting from lean thinking
- Clear and simple standards and specifications that avoid ambiguous and all-embracing terminology such as "supplier will comply with all local codes and regulations"
- Alternative standards or specifications
  - national rather than company
  - *fit for purpose*
- Alternative suppliers
- *Value engineering*
- Standard or off-the-shelf alternative materials or equipment

Standards and specifications should be simplified as far as possible and every effort should be made to ensure that they are unambiguous and as easy as possible to understand and apply. The optimum result may be produced by utilising standard designs available from the supply chain rather than seeking a bespoke solution.

While attempts may be made to avoid project and supplier scope changes, the probability of scope changes should be recognised when negotiating procurement contracts and flexibility built in whenever possible to allow for changes in specification and quantities once definition has been finalised. To this end call-off orders and buy-back arrangements for surplus materials should be incorporated whenever possible. The adoption of a "no shortage" strategy to ensure that critical activities can proceed at maximum rate will dictate the need for early delivery, supplier warehousing and similar arrangements.

An alternative approach, based on lean thinking that requires the delivery of materials and equipment to the work face just in time is likely to be appropriate only for some projects or some elements of a project. The most relevant approach will depend entirely on the project circumstances.

An effective design change control system will need to be agreed with suppliers.

Key, long lead and critical procurement items will need special attention and orders may need to be based on the early production by the design organisation of "worst case" data sheets. Where complex items need to be manufactured, supplier selection may need to be based on general information with specific information being released in stages as detailed design progresses and this will need to be taken into account in the terms of the contract. In the case of a pressure vessel the sequential steps might include: production space booked - shell material and dished ends ordered - nozzles ordered when size has been decided – nozzle attachment specified when precise orientation has been determined.

The levels of expediting, inspection and testing specified within company engineering and procurement procedures based on standard equipment and material classifications are unlikely to be adequate to support a fast track project and should be revised accordingly.

Deliveries of materials and equipment and the availability of contractors should be scheduled so as to satisfy the requirements of the construction process. The construction stage could be regarded as "pulling" through its requirements as advocated in the lean approach – see Section 14. In particular the critical path / bottleneck activities should be fed with materials and resources, to ensure that they proceed at the maximum possible rate. This may eliminate "best value" procurement but should result in maximum benefit through the achievement of the project *CSF* of shortest duration.

10.4 Strategy

The procurement strategy must be based on a good understanding of the reasons for adopting a fast track approach and must fit within the overall project strategy.

The strategy will need to address the following aspects that have been identified as being of specific significance to a fast track project:

- No shortage of materials or equipment on the scheduled date for construction use

    - Bulk ordering of non-specialist items
    - Advance order and arrange early delivery of initial quantities to get work started
    - Supplier warehousing and delivery to job site / work front on JIT basis
- Potential for construction to fall back on to contingency plans and work out of sequence
- Flexible / progressive ordering to match progressive definition and material take-offs
- Where necessary, client funding of contractors and suppliers to eliminate financial causes of delay
- Procurement of standard materials, equipment, packages and repeat designs wherever possible
- Avoidance of unnecessarily onerous standards and specifications
- Contracts which reward achievement of the project schedule objective and other *critical success factor*s by all parties. In particular opportunities should be sought to cascade incentives down the contract structure
- Early ordering of long lead items against provisional data sheets
- Progressive detailing of orders as design information becomes available
- Maximise works testing of specialist / novel plant to prove it works before delivery / installation
- Evaluation of manufacturing / fabrication / transportation processes with a view to minimising times to deliver materials and equipment
- Effective inspection and expediting of equipment, materials and paperwork to ensure that construction always work on good materials and defects are eliminated ahead of each stage
- Equipment orders include:
    - training requirements for commissioning, operations and maintenance staff
    - commissioning support by vendor representatives
    - buy-back of surplus materials
    - documentation
    - construction overage and spares
    - commissioning spares
    - initial (2 year?) operations and maintenance spares
    - Factory Acceptance Tests
- Utilising all market knowledge to ascertain the ability of contractors and suppliers to meet the requirements of the schedule with adequate resources, workshop facilities, etc.
- Building on existing relationships, *alliance*s, pre-qualified contractors and approved supplier lists, where trust has already been established
- Timing of issue of tenders and subsequent start date for construction contractors which are likely to be the subject of a trade off between proceeding with incomplete information and starting so late that fast track schedule achievement is impossible

Consideration should be given to the extent to which the project is capable of conducting its business using electronic media. The further to the right that the purchasing system lies on the following diagram, the more likely it is to be able to support a complex, fast track project.

See Section 8.8.3 for an view as to how this fits in to the overall level of IT usage within the project team processes.

E-commerce can considerably increase the speed of business transactions but care is needed to ensure security and electronic systems need to be compatible with industry software standards. It may be advisable to resort to encryption software and digital certificates to confirm authorisation and identity in an electronic transaction. See Section 10.10 for contacts that can assist with e-commerce.

10.5 Project Management Systems & Procedures

Planning
Effective planning and progress measurement is even more important on a fast track project but is more difficult to achieve due to the lack of firm information resulting from the overlap of activities. Effective linkages are required between the project critical path planning system and the supporting procurement systems (procurement schedule database and procurement document database).

The procurement element of the project plan should take into account the following aspects that have been recognised as being particularly helpful in the achievement of a fast track schedule:

- Material and equipment deliveries aligned to *constructable* work packages based on the pull-through demand from the succeeding construction activity in the schedule
- Sound logic links to and from preceding design/specification activities. The lead time for procurement of materials and equipment to meet the construction schedule should drive the design sequence
- Flexible procurement resource plans which ensure that procurement workload peaks are effectively serviced
- Completion is achieved only with beneficial use of the asset, not the arrival of purchased items on site
- Design data from vendors is required even earlier on a fast track project and this will require unusual levels of attention

Project Control
Effective project control is one of the keys to a successful fast track strategy, following closely on effective planning of the project activities. Control **must** be a dynamic process with a very short cycle time so that deviations from plan are recognised and corrected in a time scale which ensures that the overall schedule is maintained. Consideration should be given to both recovery of any slippage against the schedule and opportunities to shorten the schedule. This will require a very close working relationship with equipment manufacturers, pre-fabricators and material suppliers to ensure that their work is progressing in line with the very tight schedule and that effective corrective action is taken by them as soon as any deviations from plan are identified. Where the supplier does not take action to correct adverse trends / recover the schedule, the buyer will need to be in a position to take control of the situation and must reserve the right to do so within the contract.

The following have been mentioned as being particularly helpful in focussing management attention on areas requiring corrective actions:

- Measurements and trend data at the simplest level that is essential to maintain control

- Effective links between the procurement data base and project schedule
- Frequent up-dates of measurements / information
- Progress information / reports that are simple, concise, easily available to relevant people
- Monitoring of key trends – flagging adverse trends and forecast out-turns that are not in accordance with the schedule – including schedule float
- Exception reporting of items not completed to scheduled
- Progress against deliverables, *milestone*s, *CSF*s and forecast out-turns
- *Earned value* measurement

Procurement document control must support the project document control system by ensuring that documentation is completed by suppliers to meet the needs of design, construction, commissioning and operations through:

- Identification of documentation requirements for all project phases
- Agreement of required document delivery dates
- Inclusion as contractual requirements in purchase orders and contracts with appropriate incentives and penalties

Change Control

An effective change control system should be in place for any project but it has been stated to be vital on a fast track project since there is a strong probability that there will be more changes to purchase orders resulting from:
(a) scope changes, since design may proceed without a signed off definition
(b) the development of design, which normally takes place before purchase orders are raised
(c) the shorter time available in which to communicate the changes to other suppliers and downstream sub-contractors

Authorisation of change should take place only after the impact of the proposed change on the schedule has been determined.

Particular care is needed on a fast track project when there are interdependencies between separate suppliers within the supply chain since an apparently simple change for one supplier could result in a far more complex, expensive and time consuming change for another supplier.

Procedures need to be agreed with suppliers and contractors, at the time that contracts are let, for the effective management of changes within their respective organisations. The desire for rapid implementation of changes to maintain or recover the schedule should not be allowed to result in lack of control. Verbal authorisation at an appropriate level, promptly followed by documented confirmation, should be acceptable within an integrated team that has good communications.

Communications

In keeping with the dynamic nature of a fast track project, communications should be:

- Simple – limited to that which is necessary from the point of view of the recipient but ensuring that people have the big picture and understand their part in it
- Pertinent
- Timely
- Using best available mechanism: face-to-face if possible

See Section 8.5 for information on project collaboration and communication systems.

Purchasing Procedures
An early understanding of client and contractor corporate issues should be established to ensure compliance with appropriate company policies and requirements, e.g. purchasing procedures, corporate supply contracts, financial audits. Acceptable opportunities should be identified to streamline procedures and eliminate stages of the process, e.g. competitive tendering. Authority should be delegated to the lowest competent level so as to avoid delays for paperwork and signatures. Regardless of the time saving available, control must be maintained and an audit trail created where it is required for Quality Assurance or financial control purposes.

Experience indicates that the early involvement of contractors and suppliers, perhaps as early as the definition stage, is one of the keys to a successful fast track project. However, it should be recognised that it has generally been difficult to change from the companies with early involvement to others at a later stage without significant delays to the project. Selection of these early contractors and suppliers should therefore be made in the knowledge that they need the capability of finishing the project as well as starting it. An alternative model is that the professional advice required in the early stages is secured through one or more consultancy services contracts, keeping open the supply options until a greater degree of definition has been achieved.

The procurement document management system will need to be set up to deal with early and provisional documents and progressive updating of documents as the project progresses and draft information is replaced by final information.

10.6 Cost & Risk

By definition, a fast track project is principally driven by early completion in comparison to a conventionally run project which is likely to be driven by cost. That is not to say that cost is unimportant on a fast track project. The client certainly wants the tight schedule to be achieved and may accept that there will be additional costs which have to be off-set against the benefit of early completion. However, it is doubtful if there are any projects for which early completion "at any cost" would be acceptable. Therefore, cost effective procurement of materials, equipment and services is still required on the fast track project and the skills and knowledge of the procurement staff will be needed in order to achieve all of the *critical success factor*s for the project.

In considering the cost of purchased goods and services it is important to see them in the context of the project as a whole. There is evidence from some projects that pursuing a fast track schedule does incur extra costs, while from others the additional costs of some elements are more than off-set by the savings on other elements. Where potentially higher cost routes are selected, e.g. reimbursable vs. fixed price contracts, then the risk of higher costs must be addressed through close management of the contract. Incentives and penalties can be incorporated in the contract to motivate the contractor / supplier to achieve all the project *CSF*s.

Contracts will need to be set up with an appropriate balance of risk and reward. In the situation where the financial risk cannot be adequately defined it will be necessary for the

client to carry the risk and not try to pass it down a chain of unsuspecting contractors and suppliers. The increased risk of a fast track project needs to be effectively managed and this will only happen if the risk is identified and allocated to the organisation or person most able to deal with it.

Procurement / Construction – Materials and Equipment

The following table lists the risks that are principally associated with the increased level of overlap between the procurement and construction stages for supply contracts of a project.

Risk	Mitigation Opportunities
Late delivery of materials or equipment resulting from: (a) Failure to manufacture in time (b) Transportation	• Agree manufacturing programme • Monitor progress and agree corrective actions when progress deviates from plan • Build incentives into the contract • Inspection of work in progress • Expedite • Split orders over several suppliers • Use specialist transport companies, especially for overseas
Equipment delivery exceeds schedule requirement	• Book time in manufacturing programme e.g. foundry, machine shop. • Purchase raw materials e.g. billet • Release design details progressively as equipment definition evolves, e.g. vessel shell, trays, nozzles, ladders / platforms, painting, insulation. • Minimise transportation problems / duration
Material shortages (a) Insufficient ordered (b) Incomplete delivery (c) Construction fall back on to contingency plans resulting in out of sequence working	• Call–off orders • Alternative suppliers • Expediting of orders • Equipment orders to include: o construction overage and spares o commissioning spares o specified initial operations and maintenance spares
Damaged equipment due to: (a) Inadequate packing (b) Inadequate conservation in transit	• Ensure that packing, environmental protection, storage and conservation are all specified or agreed at time of order • Ensure time in schedule for proper packing and conservation of equipment • Increased inspection and expediting
Wrong materials / equipment or not to specification	• Multi-disciplinary engineering check on purchase orders • Ensure that equipment and materials are correctly classified • Inspection during manufacture and on completion • Change control procedure

Equipment not working	• Inspection during manufacture • Witnessed factory acceptance tests before despatch • Vendor to fix on site after installation • Ensure commissioning covered by warranty period – extended if necessary beyond manufacturer's standard
Inadequate documentation (a) shipping / customs (b) installation instructions (c) operations manuals (d) maintenance manuals	• Ensure documentation requirements adequately defined in contract • Ensure schedule for issue of documents agreed along with schedule for delivery of materials and equipment • Monitor / inspect production of documentation along with materials and equipment • Consider incentives / liquidated damages for delivery of documentation
Surplus materials at end of construction	• Negotiate buy-back of surplus materials at time supply contract is let

Procurement / Construction – Services Contracts

The following table lists the risks that are principally associated with the increased level of overlap between the procurement and construction stages for services contracts of a project.

Excessive costs of reimbursable contracts	• Provide incentives in the contract to achieve cost targets as well as other *CSF*s while avoiding the problem of mixed messages when achievement of schedule is the top priority, i.e. a fast track project by definition
Insufficient resources to meet peak demands of fast track schedule	• Select companies that have "strength in depth" • Avoid companies that are already (over) committed on other contracts • Select contractors with a track record of successful completion of similar schedule driven projects
Contractors fail to deliver in accordance with the schedule	• Retain right to direct contractor to take specific actions to get back on schedule or to reallocate work to other, more effective, contractors
Site contractors working to unacceptable safety, health or environment standards to achieve the schedule	• Include safety track record in contractor selection criteria • Clearly communicate requirements • Retain right to direct contractor to take specific actions to improve performance • Include incentives in contracts to motivate site contractors to achieve safety, health and environment *CSFs* – see Section 11.6 for safety mitigation list on which contract incentives could be based, along with HSE and other statistics

Site contractors working to unacceptable quality standards to achieve the schedule	• Include quality track record in contractor selection criteria • Clearly communicate requirements • Retain right to direct contractor to take specific actions to improve performance • Include (loss of) incentives in contracts to motivate site contractors to achieve quality *CSFs* and ensure that cost of rework is carried by the party responsible for causing the problem
Changes due to e.g.: unforeseen site conditions, design development growth, externally imposed costs	• Ensure an effective change control system to (a) limit and (b) authorise essential change rapidly • Include change management arrangements within the contract

10.7 *Logistics*

Purchasing staff should ideally be located along with the rest of the project team. Where this is not possible then the best available arrangement should be sought – purchasing staff alongside designers during the design stage and along with construction staff when the centre of gravity moves to site.

Where location alongside design and / or construction is not possible then an effective IT system should be used to improve communications and enable information to be transmitted rapidly and accurately. The whole objective is to maintain the momentum of the project, e.g. avoid the need to move site labour on to less urgent work due to hold ups in the supply of materials and equipment required for critical activities. Regardless of location, the planning, design, procurement, construction and commissioning databases all need to be effectively linked for the proper integration of activity schedules, document control and material control.

Transportation is a non-value adding activity and should be eliminated / minimised whenever possible. Supplier location and the implications for time (and cost) of delivery should be taken into account at the selection stage. Minimising the number of steps between the supplier and the user will reduce the opportunity for delay and error. This will be of particular importance for overseas projects or overseas suppliers when there may need to be a trade-off between speed and security of delivery. The employment of single international and local agents by the project under a direct agreement may be found to be more effective than relying on numerous agents working for suppliers. The tracking of critical materials and equipment movements should be tied in to procurement and construction databases.

Special arrangements will be needed to streamline customs clearance procedures where these are involved. This may justify an advance visit to establish a working relationship, agree joint working procedures and negotiate any special dispensations or support facilities.

Arrangement for inspection prior to despatch should be aimed at ensuring that the construction site receives:

- Specified materials or equipment

- In the right quantities
- In the right place
- At the right time
- Properly packaged / suitably protected and in a known orientation
- Undamaged
- Clearly identified
- Properly documented
- With clearly defined off-loading arrangements

Consideration should be given to bar coding and electronic data tagging of materials and equipment to enable them to be speedily and accurately identified on receipt at site and during the building / erection process. Data tagging has been credited with dramatically reducing the time spent locating materials on site and reducing the wastage caused by incorrect use of materials. It also helps to eliminate the delay and disruption which can arise while incorrectly used materials are being replaced.

Arrangements for inspection on receipt at the construction site, involving appropriate engineering specialists and construction personnel, should ensure that the materials and equipment are in a fit state to be erected without fear that work is being needlessly expended on incorrect or damaged items.

Storage and conservation of materials and equipment prior to installation on site, and care and maintenance after installation but prior to commissioning, all need to be arranged to ensure that unnecessarily damaged materials and equipment are not the cause of delay at a later stage.

10. 8 Checklists

10.9 Case Studies

10.9.1 Commercial Building

Repair, restoration and refurbishment of a 28 storey bomb damaged office block in 20 months, saving approximately 6 months as a result of the application of schedule reduction techniques.

This example shows that significant schedule time savings are possible under a fixed price contract where there is sufficient information to enable that price to be estimated. The time saving on this project was achieved under a guaranteed maximum price, design, procure and construct contract containing penalty clauses, in which the contractor carried all the financial risk. A total of 40 sub-contract packages, valued at £48 million, were designed and procured in 10 months and delivered as part of a complete building approximately one year later.

Factors which contributed to this success included:

- Team working by the client, consultant team and contractors
- High levels of motivation to complete the contract
- Plant relocated to the roof (where it was enclosed by a glazed screen) enabling it to be fabricated in parallel with the building work and installed as one of the last items

- High site productivity
- Maximum off-site pre-fabrication including 2-storey mechanical pipework risers and full storey height cladding panels
- High speed rack and pinion hoists were used for transportation up the building
- Decentralised welfare facilities for the site workforce

10.10 References & Further Reading

ACTIVE Workbook:	AP 3	Effective Supply Chain Relationships
	VEP 3.1	Procurement Cycle Management
	VEP 3.2	Supplier Selection
	VEP 3.3	Contract Disputes Resolution
	VEP 8.2	Contract Monitoring and Measurement

Title	The Handbook of Supply Chain Management
Publisher	CIRIA ref: C546 www.ciria.org.uk
Authors	R Holti, D Nicolini, M Smalley
ISBN	086017 546 4

E-commerce advice contacts

IT Construction Best Practice (ITCBP)
www.itcbp.org.uk

Construction Industry Trading Electronically (CITE)
www.cite.org.uk

Construct IT
www.construct-it.Salford.ac.uk

Section 11 Construction

11.1 Introduction

Successful fast track projects are successful not only because they challenge the conventional approach to project management and manage the additional risks introduced, but also because they do all the normal things well, including achieving high productivity from the construction workforce. This requires a good understanding of the options for compressing the schedule as described in the CII Publication 6-7, November 1988, "Concepts and Methods of Schedule Compression", and the way in which site time is used as described by Prof. Andrew Price in his 1992 paper "Factors Influencing Construction Productivity", which also contains a number of useful references on construction productivity.
See checklists 11.8.1 and 11.8.2.

Depending on the nature of the asset being created and the contractual terms between the construction company and the eventual user of the asset, the construction period may include the following:

- Plant cleaning and preparation, e.g. the removal of manufacturing and construction debris by blowing and flushing, and if required the subsequent drying of the lines and equipment.
- Site testing (mechanical, instrument, electrical, IT) and calibration of completed systems.
- Pre-commissioning, using "safe" fluids, e.g. air and water.

The period from completion of construction to operating asset is one in which a great deal of time can be lost if the work is not meticulously planned and effectively coordinated to ensure maximum progress on each activity with minimum interference to adjacent activities.

Handover, being the formal transfer of ownership for the assets from one organisation to another, can take place at any stage by agreement of the parties involved. This could be before pre-commissioning if that is to be under the control of someone other than the construction contractor, or it could be after commissioning. The situation is further complicated if the asset is to be handed over in a series of packages, as is quite likely on a fast track project, rather than as a single entity. However, in the case of a fast track project the time or times selected should take into account the organisation most able to promote speedy action through to beneficial operation as well as being able to manage safety and control costs. Where necessary a temporary transfer of responsibility for a part of the asset can take place between parties, e.g. construction to commissioning, if this places control of site activities in the most appropriate hands.

11.2 People

Clarity of Objectives
The project *CSFs*, and what is expected of site staff in achieving these *CSFs*, should be communicated, in terms that can be clearly and unambiguously understood, to all the construction staff. The *key performance indicators* against which construction performance is to be measured should be explained in ways that will enable site staff to recognise how their contribution will affect the outcome, before being displayed and regularly updated on site.

KPIs should be based on the progress achieved against the plan, using earned value measures rather than the traditional percentages of material quantities installed or time elapsed.

The end point for construction should be the same as that for the project as a whole, i.e. beneficial use of the completed asset by the client. Intermediate *milestone*s, such as *mechanical completion,* should not be allowed to be seen as the end of the construction phase on a fast track project.

***Stakeholder*s**
Engagement of *stakeholder*s should continue through the construction phase according to their level of responsibility, influence and interest. Of particular significance are the health, safety, environment, planning and building authorities from whom approval is required for arrangements on the site. Failure to manage the approvals process effectively will inevitably result in delays and difficulties.

The interests of the site workforce should be identified before they arrive on site, through either the Unions that represent them or their employers, including their site supervisors. The plans for the delivery of the fast track strategy should take into account any local working practices and demarcations between trades, and establish site specific agreement on:

- Working arrangements
- Harmonisation of active working periods
- Flexibility for critical path activities

Integrated Team
On a conventional project in which design is largely complete before construction commences, leadership sometimes transfers from the project manager to the construction manager during the construction phase when the bulk of activity is on site. In the case of a fast track project the construction manager should still be responsible for site activity but, with parallel design and procurement at the front end and overlapping pre-commissioning and commissioning at the back end of construction, it is vital that the responsibility for overall integration of activities remains firmly with the project manager. Whether project manager or construction manager is in charge, there must be clear leadership and direction to the site activity so as to drive site work to the earliest practicable completion in line with the schedule.

There is general agreement that the single integrated team with one culture should be carried through to the construction site but it is recognised that can be extremely difficult to achieve when there are many suppliers and site work contractors involved as well as the client, management contractor, architect, design contractor, etc. As with previous stages, the contracts between the parties involved need to be set up to promote such integration and co-operation (even when no direct contractual relationship exists), and to enable contractors, including specialist sub-contractors / vendors, to be available as and when demanded by the fast track schedule.

The following elements of a proactive project / construction organisation have been noted as being particularly helpful for a fast track project:

- Effective management of the overall team effort, co-ordinating and controlling the working relationships of the team members
- Contractual obligations for all parties to work constructively and co-operatively with all other team members regardless of direct contractual relationship

- Engineering / discipline design staff based on the construction site to deal quickly with technical queries, "site run" design issues, etc., to coincide with the implementation of their functional design
- Rapid response from engineering staff who are retained but not site based during the construction period
- Vendors available to assist in the erection, site testing and commissioning of complex equipment
- Dedicated staff to co-ordinate and expedite permits, clearances, etc., from the issuing organisation
- Commissioning staff used as construction inspectors, which has the additional benefits of training the staff on the new equipment and reducing the number of items eventually put on the snag list
- Client and commissioning staff involved in snagging / punch listing of defects and omissions
- Project facilitator(s) to deal with any hold ups, interface problems, etc.
- Joint construction and commissioning snagging / punch-listing team which will combine two potentially sequential activities and minimise the end list
- A snag rectification squad which is separate from the normal construction squad to hit critical items while avoiding disruption to construction progress
- Testing as part of the installation process, not a subsequent activity

Delegation / Empowerment
The requirement to authorise and empower members of the project team to promote rapid and effective decision taking at the lowest competent level applies to the construction team as much as to any others.

Suitably Qualified and Experienced Personnel **(SQEP)**
Fast track projects tend to be resource hungry. Resources must not be allowed to limit the rate of progress of the construction work and the necessary numbers and skills must be made available to meet the demands of the schedule even if this results in less efficient working. Special arrangements may be needed to ensure a sufficient supply of appropriately skilled personnel, especially in some developing countries. Supervision ratios may need to be increased to achieve the required level of progress.

The chances of success are greatly increased if skilled and experienced staff are employed on the fast track project at all levels and the "top team" should be used whenever possible. This can have implications for other projects and is likely to limit the number of fast track projects that it is possible to implement at any one time. The maintenance of rapid progress will be greatly assisted if site operatives will work flexibly in the semi-skilled areas peripheral to main trades, and to this end dual-skilled or multi-skilled supervisors and operatives should be used when available.

Motivation
It is essential that the work contractors and their site staff are motivated to build the new asset in accordance with the schedule, without incurring excessive costs, taking safety or health risks or dropping below the required quality level. This applies whether the project is being constructed to a fast track or normal schedule. However, since it is more difficult to achieve the fast track schedule it becomes even more important that all concerned work flexibly, find ways round problems and delays, help each other to achieve the *milestone* targets and generally support each other in the drive to achieve the near impossible. It is essential to

establish good co-ordination and co-operation between contractors – the satisfaction of working together in a successful team can itself be a motivator.

When considering motivation it is as important to ensure the removal of disincentives as it is to provide incentives to ensure that staff remain motivated to achieving the project *CSFs*, including the schedule. See Section 11.8.3. As can be seen, there are numerous actions that can be taken to motivate the workforce, only one of which, and perhaps the last that should be considered, is to provide a financial incentive. Unless all the other factors are addressed as well, the provision of a financial incentive will not produce the required results. On the other hand, if all possible motivational factors are utilised the probability is that not only will a fast track schedule be achieved but it will be done safely, within budget and to a high quality.

Consideration should have been given to sharing some of the client's financial benefit from early completion with the construction contractors and suppliers at the procurement stage, whether within an *alliance* or individual contracts. Where incentivised contracts have been set up, consideration should be given to cascading some of this benefit down to individual employees. However, great care is needed to ensure that the incentives cover all the *CSF*s of the project or some features will be sacrificed in favour of those that result in the greatest financial reward to the employees.

11.3 Scope

A clear definition of scope in the form of drawings and specifications together with applicable codes, standards and approved codes of practice is essential for any project. Those responsible for the construction site need to know both what is required and how they are required to deliver it.

A project with a fast track schedule will benefit from reduction of the scope to the essential minimum that is needed to achieve the project *CSF*s. A *fit for purpose* approach which has not been over-specified or unnecessarily complicated, with unambiguously stated requirements, will greatly assist in speedy construction on site.

11.4 Strategy

The construction strategy must be based on a good understanding of the reasons for adopting a fast track approach and fit within the overall project strategy. It should address the following aspects which have been identified as being of particular significance to fast track projects as well as all the normal aspects e.g. safety, health and environment:

- Construction Plan
  - Satisfy conditions for plant preparation, commissioning and handover based on clear understanding of these requirements
  - Provision of agreed documentation to following phases of the project
  - Pull through of design, documentation, materials, equipment, resources
  - Inclusion of output from *Constructability* / *Buildability* reviews
  - Utilisation of latest proven methods and technical improvements
  - Detailed planning / control for critical path and special operations (e.g. major assembly, heavy lift) so as to maximise rate of site working on critical items (not necessarily optimum efficiency)

    - Modularisation
    - Off-site fabrication
    - Pre-dressing of main plant items
    - Locations of site facilities, workshops, lay-down areas
    - Complete weld preps prior to installation of steelwork / pipes
    - Pre-painting of pipe and steel
- Site Contracts
    - Number and arrangement of contractors / subcontractors which should be optimised for speed of construction taking plot area and disciplines involved into account
- Management and Resources
    - Numbers & skills supplied to meet demands of plan so as to ensure no delay through shortage
    - Competence in required project management and discipline skills
    - Workforce clocking / accommodation / messing facilities arranged as close as possible to the work faces
- Materials & Equipment
    - Materials, consumables, etc., including site and subcontractor procured items supplied to meet demands of the plan so as to ensure no delay through shortage
    - Materials management system which supplies materials and equipment safely and efficiently to the work face
    - Generous supply of construction plant, equipment, personal protective equipment and other safety requirements, tools and transport to support the schedule
    - Construction, commissioning and operational spares ordered with equipment to ensure they are available to cover any unexpected requirements
- Quality Assurance
    - Focus on the transformation process and build quality in by doing the job right first time (inspection does not improve quality)
    - Systems designed to minimise rework
    - Document management systems to ensure that the latest revision is in use and previous issues have been withdrawn
- Access
    - Good, safe site access for personnel and vehicles, separated where necessary
    - Generous lay-down, storage and work areas for pre-fabrication, assembly and inspection / testing
    - Safe and unobstructed access to the work face, e.g. scaffolding, designed for productive working
    - Maximum use of mobile access devices such as "cherry pickers" and scissor lifts
- Safety, Health & Environment
    - Safe systems of work (SSOW) that are also efficient, productive and motivating

11.5 Project Management Systems & Procedures

Planning
Construction requirements in terms of design, planning approvals, contracts, materials, equipment, services and documentation should be built into the project plan from the earliest practicable time. Only in this way will it be possible for the preceding stages (development, design, procurement) to organise their work so as to produce *constructable* design packages

and *constructable* procurement packages, allowing the construction activity to pull through its requirements as advocated in the lean approach, see Section 14.

Similarly, the construction plan should be based on the requirements for pre-commissioning and commissioning so that the downstream stage is pulling its requirements through the entire project.

Effective planning and progress measurement is even more important on a fast track project. Because of the tight schedule the plan has initially to be based on assumptions and judgements rather than hard information, so there is a greater likelihood that the plan will be incorrect. It is therefore necessary to keep the plan under review throughout the construction period, to change it when new information is to hand, and to make good use of any opportunities to get ahead of the plan. Contrary to the popular misconception that a fast track project requires work to start before it is ready, fast track actually requires better and more detailed planning, and the formation of fall-back plans for use in the event that the preferred plan cannot be achieved. As much uncertainty as possible should be removed from the construction stage so as to ensure a predictable, reliable and uninterrupted work schedule. Consideration should also be given to contingency plans for the effective use of labour on other jobs in the event that the current critical job is delayed.

The construction plan should take into account the following aspects which have been seen as being particularly helpful in the achievement of a fast track schedule:

- Desensitise the programme by ensuring that only the minimum number of essential activities are on the critical path
- Maximise benefit from prefabricated / pre-assembled elements so as to add value off site and reduce the numbers and skill levels required for the site processes
- Plan construction of repetitive units as a manufacturing process, developing experience of operatives on first unit so as to increase speed and efficiency of work on subsequent units, and progressively releasing usable units to client rather than all at the end
- Package work to allow multiple work fronts in parallel – each block may take longer but the overall programme will be shorter
- Plan the construction sequence so as to meet pre-commissioning and commissioning needs, e.g. availability of services systems for plant preparation and pre-commissioning
- Base the schedule on shorter than normal construction time intervals, e.g. days, hours for critical and complex items
- Site access arrangements
- Establishment of site infrastructure
- Work permit provision
- Resource demands of the schedule – recruitment, induction, training
- Move from area based to process system / building unit based management as soon as practicable e.g. when construction 60% complete
- *Constructable* work packages
- Commence construction based on early design information, part-approved drawings, etc., to achieve optimum overlap with design. This may require the drawing / document control system to be modified to enable release / approval for construction of parts of drawings
- Key long lead and critical items / activities to ensure that construction sequence is optimised, recognising that many more items will come into this category on a fast track project than on a conventional one
- Contingency planning for critical activities

- Deferment of non-essential items until late in the programme, possibly after commissioning of all essential items.
- Modifications to standard construction procedures aimed at reducing schedule while still maintaining safety, health, environment and quality standards

Project Control

Effective project control is one of the keys to a successful fast track strategy, following closely on effective planning of the project activities. In many conventional projects, "control" is little more than progress monitoring and recording. In the case of a fast track project, control **must** be a dynamic process with a very short cycle time so that deviations from plan are recognised and corrected in a time scale which ensures that the overall schedule is maintained. The research has not identified any techniques that are specific to fast track projects which will enable this to be achieved. The lesson is simply that the known project control techniques that are important for conventional projects are essential for the success of fast track projects.

It is recommended that the project team includes full time, professional, project control staff to ensure that not only are monitoring and reporting carried out effectively but that due consideration is given to both recovery of any slippage against the schedule and opportunities to shorten the schedule.

The following have been mentioned as being particularly helpful in focussing management attention on areas requiring corrective action during the construction stage:

- Frequent monitoring of all trends in work progress, e.g. rebar, concrete, using easily identifiable measures, e.g. courses of bricks laid, number of piping isometric drawings installed
- Frequent monitoring of changes in the remaining float available
- The use of simple S-curves (progress indicator graphs) on a daily basis to aid the early identification of any slippage
- Progress reports that are simple, concise and easily available to relevant people
- Exception reporting of items not completed to scheduled
- Progress against deliverables, *milestone*s, *CSF*s and forecast out-turns
- *Earned value* measurement

In addition to targeting recovery of slippage against the plan, project control should also seek to make maximum use of opportunities to improve on the plan, maximising productivity on critical jobs but maximising efficiency on jobs that are not on the critical path in order to control cost as well as achieving or beating the fast track schedule.

Construction document control must support the project document control system by ensuring that documentation is completed to meet the needs of commissioning and handover.

Change Control

Design changes, whether as a result of project scope change or design development, are to be avoided whenever possible on the fast track project since the original design may already have been turned into concrete or steel. However, design changes are normally not under the control of the construction organisation. Where change is essential it should be implemented on site only after being approved through the project change control system. This overall system must integrate the design, procurement and site change control systems where they exist as separate but linked entities. The temptation to implement changes on the basis of

verbal requests from other members of the project team, e.g. commissioning or operations staff, must be resisted at all costs.

Communications
In keeping with the dynamic nature of a fast track project, communications should be:

- Simple – limited to that which is necessary from the point of view of the recipient
- Pertinent
- Timely
- Using best available mechanism; face-to-face if possible

Consideration should be given as to the extent to which the schedule would benefit from the use of IT systems including information management, communication, procurement and design. See Section 8.5 for information on project collaboration and communication systems and diagram Section 8.8.3.

The value to the construction staff of the use of 3D design tools should not be overlooked since this is a very powerful tool that has been found to be a useful vehicle for bringing together the integrated project team, e.g. for reviews, to identify access routes and assembly sequence, and to have a clear understanding of the end product. By enabling all parties (designers, constructors, commissioners, operators, maintainers) to work together with an improved understanding of the design intent it can help to avoid the delays that might otherwise arise from misunderstandings and interdisciplinary conflicts and clashes.

11.6 Cost & Risk

The major decisions regarding cost will all have been taken before the construction stage has been reached and the main mechanisms for control of cost on site are through the efficient use of labour and materials and the avoidance of rework, including rectification and replacement of defective, damaged or inappropriate equipment and materials.

Actions taken to achieve high productivity in the interests of a shortened schedule will have the added benefit of reducing costs as well. Some strategies to shorten the critical path e.g. use of rolling shifts, will increase costs over a conventional programme and should to be used only where essential. It may be necessary to carry out activities on the night shift that would otherwise jeopardise the schedule and this will result in additional costs compared to doing the work during normal day hours. There will be few opportunities to reduce cost, although this should not be totally ignored, and the main focus of attention will be on avoiding unplanned expenditure. The contribution of good site supervision to the achievement of these objectives cannot be over-emphasised.

Depending on the terms of the construction services contracts, it may be necessary / desirable for the client to provide financial support in the form of up-front funding for the contractors and sub-contractors. This will enable the service providers to commit to materials and resources at the earliest time and so promote speedy action in support of the fast track schedule. Under these circumstances the buyer is at risk in the event that the contractor goes into administration / liquidation and will want to limit that risk by e.g. funding resources on a rolling monthly programme, having materials and equipment purchased as agent so that title immediately passes to the buyer, having construction plant hired in their name.

It is to be expected, if the advice in the Section 10 has been followed, that there is an appropriate balance between risk and reward defined in the site contracts. It is essential that this balance between risk and reward is maintained during the life of the contracts and that, where measurement is required to ascertain the apportionment of reward, this data is gathered at appropriate stages.

The risks associated with the overlap of the Design and Construction phases have been identified, together with the options for mitigation, in Section 9.6. The following table deals with the overlap of construction (including for the purpose of this table such activities as testing and calibration, cleaning of construction debris and preparation for live running, pre-commissioning on "safe" fluids) and commissioning on operating materials and performance testing.

Construction/Commissioning

The following table lists the risks that are principally associated with the increased level of overlap between the construction and commissioning stages of a project.

Risk	Mitigation
Safety	• Provide greater than normal levels of management attention and site supervision • Carry out risk assessments of specific tasks or situations, such as: o parallel working o increased number of interfaces between activities o higher concentrations of personnel • Carry out risk assessments of construction / commissioning materials including mixtures of these materials • Training / task familiarisation of the parties who are working alongside each other • Training in work *permit* / *clearance* issuing and receiving • Define clearly roles and responsibilities for work areas • Ensure that one organisation carries responsibility for safe working at any time and that they issue permits to work (by construction for commissioning or by commissioning for construction) • Communicate more frequently to keep people abreast of rapidly changing situations through briefing and co-ordination meetings • Provide temporary personnel protection for incomplete areas during testing and plant preparation and commissioning • Bring forward out of sequence the installation of permanent personnel protection to avoid the need for temporary protection • Identify live systems and equipment on the ground using signs, labels, tape • Provide high visibility personnel protective clothing and equipment with high profile enforcement of its use • Provide status identification charts, boards, posters • Prevent / restrict access to unsafe areas and equipment and prevent unauthorised operation using barriers, signs, lock-off • Pay special attention to site cleanliness – employ clean-up teams

Late Documentation	• Organise for on-time documentation: include in project plan, appoint document management staff and set up document management system • Include the completion of documentation in the contract incentives • Take action as necessary to pursue contractual obligations to produce, expedite, inspect, monitor progress, etc. • Direct suppliers or arranging alternative sources of supply if essential • Give special attention to documents needed for training of commissioning and operations staff • Agree where it is acceptable to work to provisional or part documentation in advance of final documentation • Ensure that documentation requirements are defined on a *fit for purpose* basis
Changes to completed work	• Operate an effective project change control system, integrating change control in design, procurement and construction • Locate design and procurement staff on site to minimise delay if changes are authorised
Reduced Efficiency	• Reduced efficiency may be a price that has to be paid for maximising progress against the schedule e.g. as a result of moving people more frequently to critical path items • Organise all preceding activities to support construction • Ensure that all the normal project management controls are in place to minimise the loss of efficiency, including planning with suitable float – see Section 9.5 for critical chain planning • Move resources that are held up on critical jobs to alternative work if this can be done efficiently (but note conflict with lean construction theory) • Ensure appropriate levels of resources are available within the site services companies and that there is the flexibility to deploy them to the most urgent work • Use completion crews to tidy up the last few percent of work leaving the main crews to progress bulk work at maximum efficiency • Minimise the amount of work and eliminate repeat work, e.g. use joint construction and commissioning snag (punch) listing teams • Ensure effective integration of construction and commissioning plans (same time intervals)
Extended activity times on the critical path	• Carry out detailed planning of critical path activities to ensure that all aspects of the work can be organised efficiently • Use modelling of critical path activities to develop optimum methods • Make optimum / additional / "top team" resource available • Ensure maximum work rate on critical items to minimise extension • Extend work time through shifts, overtime, etc. • Operate on multiple work fronts

	• Provide special logistical support at work front, e.g. pre-selected, boxed materials and consumables readily to hand at assembly site; mobile, rapid access equipment for personnel • Modify plan or procedures to remove activity from critical path • Ensure critical path does not include any activities that are not directly required to achieve beneficial operation on the specified date, i.e. postpone non-essential items even though they will still be required to complete the project • Combine items on critical path, e.g. pressure test and flush, do and inspect with same crew
Damage / rework / more spares required	• Increased training and awareness • Install equipment at the *last responsible moment* • Barrier off areas and equipment which have been completed • Set up quarantined areas to which all access is prohibited e.g. completed rooms • Provide protection for vulnerable and completed items using local barriers, covers • Use signs, tags, tapes to warn of e.g. final finishes, delicate items • Ensure spares are available – order construction, commissioning and operations spares for delivery with equipment
Lack of commissioning resource availability, vendor specialists, temporaries, etc.	• Define commissioning / operations resource requirements at design stage • Include resource provision in project plan: o displace experienced crew from existing teams with new recruits and / or temporaries o recruit additional staff o train existing and new staff o reserve resources with suppliers / vendors o reserve resources with client operations o pay retainers to keep staff on standby o contract in specialist staff from agencies • Agree special working arrangements, shift patterns, overtime • Purchase orders and sub-contract documents to include specific / extended vendor rep. attendance at pre-agreed rates
Shortage of commissioning materials / facilities / utilities	• As for resources: define requirements early, plan to provide materials, etc., purchase construction, commissioning and operating spares with equipment, reserve warehoused spares • Consider buying excess spares as insurance which can be sold on to client or returned by prior agreement to supplier if not used • Consider all utilities and services: o permanent o temporary o packaged units • Consider process materials, chemicals, catalysts, containers, packaging – buy forward for operation and replace if used for commissioning • Consider transport, including special arrangements for critical spares

	• Consider disposal of surplus spares and materials including off-specification and scrap / waste materials
Loss of control at interfaces due to increased complexity	• One manager responsible for all activities within clearly defined areas of the site at any time • Plan in detail • Use permitting systems to authorise work taking into account the hazards of the job and the effects from / to the adjacent activities • Employ full-time co-ordination staff to deal with interface issues on the site • Ensure good progress reporting and communications which may need daily meetings between the parties involved • Hand-over and hand-back to ensure most appropriate organisation is in charge at any time • Retain commissioning and operations activities under project control until final plant hand-over

11.7 *Logistics*

The planning and organising a complex enterprise such as a fast track construction site requires more thought and greater anticipation than is normally required for a conventional site because of the overlap of activities and the potential for a greater level of interference between trades and activities which arises from the use of multiple workforces and multiple work fronts.

Design support for construction should be located at site and preferably in the same building as construction management so that immediate assistance is available to answer technical queries. Where a site location is not possible then an effective IT system should be used to improve communications and enable marked up drawings and other information to be rapidly transmitted. See Sections 8.5, Communications, and checklist 8.8.3. The whole objective is to maintain the momentum of the construction site and avoid the need to move site labour on to less urgent work due to hold ups on the critical activities.

Procurement support for construction in equipment and materials management should also be provided on site to ensure a seamless transfer of responsibility between the two organisations including:

- Documentation – covering both the purchasing transaction and documentation to be supplied
- Goods receipt procedures
- Inspection requirements
- Quarantine of incorrect or defective goods
- Storage and conservation
- Handling and delivery to the work face
- Surpluses
- Returns of incorrect, defective or surplus materials and equipment

Where space allows it will usually pay to establish a good construction compound with generous site facilities, workshops, warehouse and working space although in the case of a

fast track project this must be balanced with the need for these facilities to be as close as possible to the work face.

Consideration should be given to the use of mobile platforms rather than fixed scaffolding, the provision and modification (to meet each trade's needs) of which is often a cause of delay. The intention to use mobile access platforms needs to be taken into account in the layout of the plant at the initial design stage as identified in Section 9.3, Scope of Design.

On some projects it will be appropriate to maximise the hours available for effective work, especially where there are limited access windows for particular trades, independent of the weather or time of day by providing:

- Environmental protection both for the work and work force
- Heating
- Ventilation
- Lighting
- Local welfare facilities

In all cases a high rate of progress is more likely to be maintained by the generous provision of construction support resources, e.g.:

- Personal protective equipment
- Plant
- Equipment (access, lifting)
- Tools
- Transport
- Communications systems (radios)

When progress is delayed consideration should be given to devising a work-around i.e. a temporary fix. Bypassing obstacles in this way can be justified only if it enables the rest of the work to be completed and tested since this is likely to be at the cost of having to do the work twice or of having to return to install to specification once the cause of the delay has be removed.

Consideration will need to be given to the protection of erected equipment, surface finishes, etc., as construction proceeds to ensure that out-of-sequence trade working, movement of access and lifting equipment, etc., does not result in damage with the consequent delay and cost of rework. If correctly specified, this temporary protection of the completed work can also be used as personnel protection for the construction staff as commissioning of systems proceeds to the point where steam and other systems are live.

11. 8 Checklists

11.8.1 Site Productivity

The following list has been taken from the 1992 paper "Factors Influencing Construction Productivity" by A D F Price of Loughborough University.

Time can be categorised as "effective" when it is spent on:

- Real Work Content i.e. the essential value added work which is needed to create the asset

Essential to the operation but not value adding is:

- Ancillary Work that is necessary in support of the real work content e.g. construction plant maintenance

Much of the time spent on site is "ineffective" because it is wasted on:

- Added Work Content resulting from errors in Design, Planning or job Method
- Additional work resulting from deviation from the standard method
- Delays resulting from the nature of the task
- Waiting time associated with the task
- Inadequate Work Rate
- Rework
- Official Breaks
- Unofficial Breaks

11.8.2 Catalogue of Schedule Compression Techniques

The author is indebted to CII for permission to publish the following list that has been extracted from the CII Publication 6-7, November 1988, "Concepts and Methods of Schedule Compression" to which reference should be made for explanation of each of the headings.

Checklist 11.8.2 Schedule Compression – Sheet 1 of 2		
Project No.	**Title**	
Revision	**Date**	**Author**
1	**Ideas Applicable to All Phases of a Project**	
1.01	Avoidance of Interruptions	
1.02	Efficient Staffing	
1.03	Incentives	
1.04	Modern Management Systems	
1.05	*Pareto's Law* Management	
1.06	Participative Management	
1.07	Partnering & Team Building	
1.08	Personnel Management Practices – General	
1.09	Planning	
1.10	Reduction of Task Scope	
1.11	Safety/Loss Control Programme	
1.12	Well-defined Organisational Structure	
2	**Engineering Phase**	
	See Design Section 9.8	
3	**Contractual Approach**	
3.01	Contract Document Review	
3.02	Evergreen Contract	
3.03	Fair Risk Assignment	
3.04	Fast Track Scheduling	
3.05	Improve Contractor Cash Flow	
3.06	Contractual Incentive Programmes	
3.07	Lump-sum Contracts	
3.08	Minimise Owner Involvement	
3.09	Multiple Prime Contracts	
3.10	Prequalification	
3.11	Reimbursable Contracts	
3.12	Shared Material Take-offs	
3.13	Work Subject to Owner Approval	
4	**Scheduling**	
4.01	Adaptation to Weather Conditions	
4.02	Realistic Scheduling	
4.03	Repetitive Tasks Scheduling	
4.04	Schedule Crashing	
4.05	Start-up Driven Scheduling	
4.06	Use of Float Flexibility	
Reference CII Publication6-7, November 1988		

Checklist 11.8.2 Schedule Compression – Sheet 2 of 2		
Project No.	**Title**	
Revision	**Date**	**Author**
5	**Materials Management**	
5.01	Vendor Chief Executive Officer Commitment	
5.02	Dedicated Truck Shipments	
5.03	Just-in-time Material Deliveries	
5.04	Laydown Area Assignment	
5.05	Materials Co-ordinator	
5.06	Material Identification on Purchase Document	
5.07	Owner-furnished Materials	
5.08	Prime-contract-furnished Materials	
5.09	Prioritise Procurement	
5.10	Product Identification	
5.11	Special Material Handling Crew	
5.12	Transportation System Review	
5.13	Vendor Submittal Control	
6	**Construction Work Management**	
6.01	Advanced Construction Equipment	
6.02	Area Co-ordinators	
6.03	Assistant Field Project Managers	
6.04	Change Management During Construction	
6.05	*Constructability* Analysis During Construction	
6.06	Critical Equipment Contingency Planning	
6.07	Field Models	
6.08	Job Site Pre-assembly	
6.09	Making Site a Good Place to Work	
6.10	On-ground Pre-assembly	
6.11	Site Layout	
6.12	Special Network Analyses	
6.13	Staged Pre-positioning	
6.14	Tool Management	
6.15	Work Sampling	
7	**Field Labour Management**	
7.01	Continuity of Work Responsibility	
7.02	Craft Worker Bonus/Award Programme	
7.03	Crew pre-work Briefings	
7.04	Crew Training and Rehearsals	
7.05	Cross-training	
7.06	Labour Minimisation	
7.07	Personnel Management Practices – Field	
7.08	Project Agreements	
7.09	Rolling Shifts	
7.10	Scheduled Overtime	
7.11	Specialty Shifts	
7.12	Spot Overtime	
7.13	Supervisor/Worker Ratio	
8	**Start-up Phase**	
8.01	Minimise Scope of Start-up	
8.02	Temporary Start-up Systems	
8.03	Start-up Planning	
Reference CII Publication 6-7, November 1988		

3 Motivation of site teams

Remove disincentives to achievement of schedule (and other *CSF*s)

- Ensure that the schedule is challenging but realistic so that people do not feel they are being asked to achieve the impossible
- Demonstrate management dedication and commitment to high work rate
- Remove under-performing staff from the team
- When delays occur, deploy staff on to other jobs to maintain momentum, even if lower priority work
- Design out unnecessary work
- Simplify work methods to avoid unnecessarily difficult work
- Avoid rework due to:
  - scope changes
  - design changes
  - errors by others
- Avoid the use of non-essential overtime leading to increased cost and reduced productivity

Make it harder to delay the schedule (and fail to achieve other *CSF*s)

- Provide competent, firm and fair site supervision
- Form multi-trade squads with whole task targets to drive flexibility and mutual support
- Supply design information, materials, equipment, support services, to the workface as required by the schedule

Make it easy to achieve the schedule (and other *CSF*s)

- Employ only suitably qualified and experienced people, or provide appropriate levels of supervision and training
- Provide safe and convenient access to suit the job
- Minimise manual effort required through use of lifts, hoists
- Minimise travelling time - amenities close to work place
- Ensure that everyone understands their role in achieving the clearly defined schedule
- Ensure that design & documentation is available when and where needed
- Ensure that materials and equipment are available when and where needed
- Ensure easy and accurate identification of materials, equipment, parts
- Ensure that preparatory work has been completed before each task start time
- Provide support trades and services when and where needed
- Make tools and equipment available when and where needed
- Provide suitable working environment including as required weather protection, heating, ventilation, air conditioning, lighting

Provide incentives to achieve the schedule (and other *CSF*s)

- Aim to make everyone feel proud of the project and their role in it
- Ensure a safe and healthy site:
- control of chemicals
  - good quality amenities
  - hygienic messing facilities
  - clean and tidy site
  - provide all necessary Personal Protective Equipment as and when needed

- Ensure prompt and effective response to all reported accidents, incidents, near misses and constructive suggestions / complaints
- Provide recognition for groups and individuals in the achievement of targets: thanks / praise / badges / posters / displays of progress / mention in company newsletters
- Inter - squad competitions
- Individual bonuses based on group achievements

11.9 Case Studies

11.9.1 University Campus (cross reference Section 9.9 Design)

Construction of a £30m, 250,00 sq ft university campus with student accommodation, teaching, library and catering facilities with an estimated time saving of 12 months resulting from the application of a number of schedule reduction techniques.

The three-storey concrete frame buildings incorporate a number of innovative materials and technologies that are aimed at increasing by 60% the previous standard of energy efficiency on the campus while reducing the cost of future maintenance.

Design features aimed at reducing project duration included high levels of modularisation and pre-fabrication:

- Pre-formed timber cladding units
- Fully finished air handling units
- Energy plant located on permanent skids
- Fully finished, pre-fabricated bathrooms
- Standard width, pre-fabricated, internal partitions

The overall time saving was made possible through:

- Overlap of design, procurement and construction covering ground work, building design and sub-contract packages for manufacture and erection
- Early determination of end user requirements
- Early collaboration of the sub-contractors with the architects

The construction sequence was planned to enable lessons learned on one building to be applied on subsequent similar units.

11.10 References & Further Reading

Concepts and Methods of Schedule Compression
CII Publication 6-7, November 1988

Factors Influencing Construction Productivity
A D F Price, Loughborough University, 3.9.92

ACTIVE Workbook:	AP7	Effective Project Execution
	VEP 7.1	Project Control
	VEP 7.3	*Constructability*

Section 12 Commissioning

12.1 Introduction

Commissioning is usually considered to be the act of putting the new asset to use, in the case of a manufacturing plant using operating materials and making the products for which the plant has been designed. It includes testing the performance of the asset to ensure that the consumption of materials and utilities and the quantity and quality of outputs are in line with the scope of the project. In many cases, pre-commissioning using safer fluids, e.g. air or water, is included in the Commissioning Stage since the skills required are those of the asset operator rather than those of the constructor.

The powering up of electrical systems and the introduction of operating utilities and process materials to what has been a construction site up to this stage raises a number of safety and other issues which have to be addressed on every project. The fast track project is different only in degree. The extent of overlap of pre-commissioning and commissioning with construction is likely to be greater than in a conventional project, increasing the intensity of the problem to be overcome using the safety management systems.

Handover, being the formal transfer of ownership of the assets from one organisation to another, could take place at any stage by agreement of the parties involved, as described in Section 11.1, and this should have been established under the terms of the contract. In the case of the fast track project, responsibility should be held by the organisation most able to influence the earliest achievement of beneficial operation, while taking safety and cost control into account.

Responsibility for a part of the asset and for the activities on that part of the construction site can be temporarily transferred between parties, e.g. from construction to commissioning. It may be that the schedule is best served by temporary transfer so that part of the asset can be commissioned under the control of the future operator, before being returned to the construction contractor for e.g. completion of reservation works. It may then form a part of a larger, permanent hand-over of the overall asset.

12.2 People

Clarity of Objectives
The commissioning strategy should have been considered at the definition stage and the commissioning sequence should have been taken into account in planning all the preceding steps.

The requirements for commissioning by systems, plants, rooms, buildings, should all have been taken into account by the designers so that any special features required to enable commissioning to take place should already have been included in the design and project planning. This is essential to avoid the need for last minute changes to enable preparation, testing, pre-commissioning or commissioning to take place.

It is essential that the commissioning staff, many of whom will be joining the project for the first time at this stage, are given a very clear understanding of the overall (fast track) strategy for the project, the commissioning strategy and the arrangements that have been included to

enable commissioning to take place in accordance with the schedule. Failure to gain understanding and acceptance by commissioning staff as they join the project will inevitably result in a demand for changes and delays to the schedule.

Integrated Team

The benefits to a fast track project of continuity of personnel have been stressed throughout this manual and apply as much to the commissioning stage as to any other. Ideally commissioning will be under the overall control of the project manager who will ensure the effective integration with preceding stages of the project. It is likely that a commissioning manager will head up the commissioning activities, responding to the project manager, and he will need the full range of managerial and leadership competencies along with the energy, enthusiasm, flexibility, willingness to work hard and determination to succeed that have previously been ascribed to the project manager. The "can do" attitude must permeate the whole organisation, along with a willingness to listen to ideas and to take bold and innovative decisions. However, the project will not be best served if these innovative ideas only emerge at the commissioning stage and result in a demand for late changes. The times for innovation are at the development, definition and design Stages. The commissioning manager and experienced operating staff should join the project team and make their input at that time.

Every effort should be made to maintain the integrated team during the transition period from construction through to commissioning, regardless of whether construction or commissioning are responsible for the asset and whoever has the lead role. The situation will generally be improved if the commissioning staff have been brought on to the project at an earlier stage to help with inspection and testing as part of the construction team or for training on the new asset. Co-operation rather than rivalry between construction and commissioning is essential if a fast and efficient completion is to be achieved. The overall project manager may need to make special efforts to bring the commissioning staff into the team and to develop the required behaviour.

Support of the commissioning team may be needed from both designers and constructors of the assets and it is recommended that arrangements should be made to ensure that staff from these organisations are available on site so that no delays arise due to an inability to resolve a technical query or to carry out temporary works. Where necessary key design and construction staff should come under the control of the commissioning manager to ensure continuity and efficiency in implementing any work required.

Suitably Qualified and Experienced Personnel

A major problem is usually the inability of the client organisation to provide operating staff at an early enough stage in the schedule and in sufficient numbers to support the fast track schedule. Assuming that additional staff are needed to run the new asset, rather than a surplus of staff being transferred from elsewhere in the client organisation, then a lengthy sequence of activities may be needed in order to put suitably qualified and experienced people into their new roles. These activities should be included in the project plan since the success of the project is dependent on their completion at times required by the schedule, including:

- External recruitment – to fill new jobs
- External recruitment – to fill existing jobs to displace experienced staff on to the project
- Training of staff on the new asset
- Selection and appointment of vendor specialists

The numbers of staff required for commissioning are generally greater (in some cases by a factor of at least 2) than the numbers needed for subsequent operation of the asset and the source of these temporary staff will also need to be determined in sufficient time for them to be trained for the commissioning task. Possible sources include:

- Temporary transfer from other operating assets on the same or other sites
- Contractors
- Agencies
- Vendors

Arrangements for training commissioning staff may include

- Involvement in plant inspections, snag listing
- Involvement in factory acceptance tests
- Involvement in plant and equipment site acceptance tests
- Use of:
  - simulators
  - physical plant models
  - *CAD* 3D electronic models
  - vendors facilities
  - existing similar asset
  - existing dissimilar asset with top up training
  - plant specific training programmes
- Involvement in plant preparation and pre-commissioning

Motivation

Motivation of the project team needs to be sustained all the way to beneficial use of the asset and the comments in previous sections apply during the commissioning stage. Many of the ideas in checklist 11.8.3 are also relevant for commissioning staff.

Where commissioning takes place on a 24 hour basis additional effort will be needed to maintain motivation and momentum across all shifts, especially when difficulties arise and there is the option to leave it to be resolved by a subsequent shift. Careful consideration should be given to the seniority and experience of shift management and to the level of technical support available on shifts and by call-out from the day staff.

12.3 Scope

The scope of the project will have been defined during earlier stages and, regardless of the degree of overlap of the project stages, it will have been settled long before the commissioning stage. A commissioning input should have been made at the development and definition stages, ideally by the person or persons who will be responsible for the commissioning activity. Commissioning should be recognised as a separate activity from operations and it has been found to be advantageous if the project team includes both a commissioning manager and a works or operations representative who will provide operations and maintenance input.

The responsibility of commissioning staff at the commissioning stage is therefore to understand what the asset is supposed to do and to make it work.

The project system for change management should still be in place and under the control of the project manager and the only changes which should be accepted at this stage are those required to overcome real safety issues and to remove obstacles to progress which cannot be overcome in any other way.

12.4 Strategy

The commissioning strategy for any project should include the following aspects which are particularly important for a fast track project:

- Definition stage involvement of a commissioning manager
- Commissioning requirements specified as part of definition
- Design incorporating commissioning features
- Timely recruitment and training of commissioning staff
- Timely production of commissioning procedures
- Full use of an integrated client and contractor team for inspection, testing, preparation, pre-commissioning and commissioning
- Full application of safety procedures to safeguard construction and commissioning staff
- Progressive system / sub-unit commissioning in sequence determined by earliest beneficial use
- Identification, isolation and protection of commissioned systems / sub-units awaiting completion of rest of asset
- Progressive acceptance and hand-over of systems to avoid end of job delays

In order to allay any concerns that may exist that the fast track nature of the project has resulted in short cuts being taken resulting in residual safety, health or environmental problems with the asset, it is suggested that a safety audit should take place prior to commissioning. See check list 12.8.1.

12.5 Project Management Systems & Procedures

Planning

Commissioning plans will usually be based on services or process systems, rooms or similar units which may not align with the geographical basis on which the asset has been constructed. Early definition of commissioning systems, ideally at the definition stage, will help to ensure that the preceding stages are completed in the order required for commissioning. The earlier that system, or part-system, commissioning commences the greater the degree of overlap with construction and the greater the safety and other risks that are introduced. More detailed planning is generally required for this period of the project than for any other to ensure that all the activities in an area can proceed quickly, efficiently and above all, safely. Particular care should be taken when moving from construction planning, possibly at level 3, to commissioning planning at the more detailed level 4, to ensure that the logic linkages are maintained.

There is a tendency for commissioning, as the final stage of most projects, to be squeezed by the overrun of earlier activities so that there is insufficient time available for the activities to be carried out in a measured and controlled way. Adequate time should therefore be built into the schedule for the pre-commissioning and commissioning activities during the initial project

planning exercise when the overall time available can be shared between the various stages in an equitable manner.

Procedures
Procedures which generally need to be written by the lead commissioning staff include:

- Pre-commissioning
- Commissioning
- Training of commissioning staff
- Validation of commissioning staff to ensure competence
- Safety, health and environment, including e.g. permits to work, access restrictions, personal protective equipment, *COSHH*, process material disposal, alarm testing
- Proving tests for the asset

In the event that the commissioning and operations staff are one and the same group, then the procedures will also need to include:

- Safety
- Security
- Operations
- Maintenance
- Training
- Validation

Because of the complexity of the construction/commissioning interface it is recommended that a responsibility matrix should be drawn up so that all parties know who is responsible for which activities. This will help to ensure that nothing fails to be done on time due to assumptions that someone else would be doing it.

12.6 Cost & Risk

The potential for additional costs at the commissioning stage principally arise from:

- The additional, short-term resources required for the parallel commissioning of systems / units
- The additional signs, barriers, etc., needed to identify live systems and to isolate areas that have already been commissioned
- The additional precautions that have to be taken to safeguard construction and commissioning personnel when working in the same area, including additional work permits

Commissioning / Operation

The following table lists the risks that are principally associated with the increased level of overlap between the commissioning and operation stages of a project.

Risks	Mitigation Opportunities
Failure to get internal and external (regulatory) approvals at all, or failure to get it in time to support the	• Engage with and involve the approving body / individual so that they are aware of the importance of complying with the schedule dates • Establish a one to one relationship with the individuals

fast track schedule	concerned • Schedule the approving body's time as early as possible in the process to ensure that they are available to meet the needs of the fast track schedule
Failure of investment to achieve design intentions covering all parameters, e.g. product quality, plant capacity	• If this is the result of phased commissioning, initial batch or unit operations to achieve early production then the problem probably exists only for the interim phase and will be resolved when the whole plant has been commissioned • If the limitation results from work carried forward to a later opportunity, e.g. the first shut-down, then again it is a short duration problem • If it results from lack of adequate design this can only be resolved through use of competent designers, adequate supervision and review at the design stage
No opportunity to demonstrate that the investment is capable of delivering the design intentions	• If this results from a deliberated decision to remove proving trials from the programme then it must be recognised that there is no way of mitigating the risks involved
Resource shortages limit progress due to peak workload for critical staff	• The most likely problem is the lack of process operations staff who are required in far greater numbers when commissioning and operations overlap. This problem is further exaggerated if there is also a simultaneous overlap of construction. Operations staff can then be required to get involved in: o defects listing along with construction o testing of equipment preparatory to commissioning o production of commissioning instructions o commissioning o production of training materials o training o production of operations and maintenance manuals o operation of equipment already commissioned • Depending on the extent of overlap this requires several times as many people as are required for normal operations • Mitigation can include: o early identification of true needs and contracting for resources needed both inside and outside the client company o clarification of roles and responsibilities o redirection of resources from project to operations
Loss of focus due to wide range of disparate activities	• Good planning • Active management • Ensure that the current situation is highly visible through good feed-back / reporting systems • Reduce individual responsibilities to ensure that they are

	within capability of individuals involved • Increase numbers of resources
Restricted access for both commissioning staff and operations staff due to conflict with the other's activities	• Ensure that there is total clarity of responsibility for the site / area in which the 2 organisations are working • Hand over and hand back responsibility for areas / systems to ensure the most appropriate organisation is in control at any point in time • Issue work permits by the organisation with responsibility for the site as a whole, whether operations or construction • Maintain one plan for all the activities on the site so that all parties are aware of all the activities • Ensure that any delay to an activity is in the interests of the project as a whole • Provide barriers and signs to permit access wherever possible • Provide personnel protection where health or safety hazards exist • Use a standard marking system for live equipment
Safety, Health or Environment	• Carry out risk assessments of specific tasks or situations • Ensure that training / familiarisation takes place of the parties who are working alongside each other • Define roles and responsibilities clearly • Communicate more frequently to keep people abreast of rapidly changing situations – daily briefings • Provide temporary personnel protection for incomplete areas • Bring forward out of sequence the installation of permanent personnel protection • Clear mark live equipment
Interruption of activities resulting in delays and inefficiencies	• Plan for highest priority work to take precedence • Defer lower priority work • Categorise snags o Safety, Health of Environment – do now o Essential for production – plan into workload o Preference / cosmetic – do online or at first shutdown

12.7 *Logistics*

Among the things that will have a bearing on the speed with which the new asset can be commissioned are:

- Locations of parties involved who should ideally be housed together or local to one another at the asset site:
  - o operations & maintenance staff
  - o commissioning staff
  - o design staff in support of commissioning

    - contractors and sub-contractors supporting commissioning
    - suppliers / vendors assisting commissioning
- Availability of sufficient resources on 24 hour basis
- Availability of all necessary documentation covering
    - materials and equipment
    - construction
    - testing
    - commissioning procedures
    - operations procedures
    - maintenance, including vendors manuals
- Availability of services and utilities
- Availability of process materials, packaging, etc.
- Availability of commissioning and operating / maintenance spares
- Disposal routes for waste and contaminated / off-specification materials
- Disposal routes for products.

12. 8 Checklists

Checklist 12.8.1	**Pre-Commissioning Audit – Sheet 1 of 3**	
Project No.	**Title**	
Revision	**Date**	**Author**

Hazard Studies
(*HAZOP*) 1 To 5 - completed

Project documentation: completed and filed
- Master Engineering Line Diagrams
- As Built drawings
- Design verification certificates:
  - relief streams
  - critical machines
  - vessels

Operating and Emergency Procedures:
written, tested and approved

Training and validation:
- Operations staff
- Maintenance staff
- Permit issuers/acceptors
- Use of communications systems
- Induction training of contractors / others

Reservations / outstanding items:
All safety and essential for start-up completed
Remainder identified and implementation planned

Design Changes:
System in place to manage all changes throughout project
All essential for start-up completed
Remainder planned

Permit to Work system in operation:
Permit books designed, printed, in use

Communications systems:
Fixed / mobile systems tested, commissioned and in use

Emergency alarms:
Fire / gas detection / alarm systems tested and in use.
Audible in all areas when plant operational

Checklist 12.8.1	**Pre-Commissioning Audit – Sheet 2 of 3**	
Project No.	**Title**	
Revision	**Date**	**Author**

Operational alarms:
Tested and in use
No false or misleading indications
All over-rides removed
System for registering and approving over-rides in place

Alarm & Trip testing:
Routine methods defined and in use

Equipment Identification:
All equipment clearly and permanently labelled
Major equipment has manufacturer's nameplate data
Equipment controls and instruments clearly labelled

Laboratory Analysis:
Test methods developed and tested
Staff trained in methods and safe handling of materials
Laboratory systems fully commissioned
Equipment calibrated

Approvals received:
All required approvals and permits received
- Planning
- Building Regulations
- Fire Certificate
- Environment Agency
- Health & Safety Executive

Company and External Emergency Services:
Emergency Plan drawn up
Procedures written
Company & Police, Fire and Ambulance Staff trained
- location
- access routes
- materials
- procedures

Checklist 12.8.1	**Pre-Commissioning Audit – Sheet 3 of 3**	
Project No.	**Title**	
Revision	**Date**	**Author**
Safe Place of Work: Access routes level and clear of debris Stairs, handrails, etc., in place Escape routes clear of obstruction and clearly marked Scaffolds, etc., removed where possible Permanent lighting in place and working Temporary lights where permanent lights obstructed Emergency lighting tested and operational **Safety Equipment:** Fire extinguishers working, in-date, in place Showers, eyewash cabinets, tested and operational First aid kits installed and in-date Safety signs installed and clearly visible Personal Protective Equipment available as needed Contaminated clothing control system in place **Hose control:** Process, service and emergency hoses tested / available **Access Control:** Fencing installed Gates operational Security staff employed, trained, on site Induction training for visitors in place Visitor identification system in use PPE provided for visitors **Environmental controls in place:** Effluent analysers tested and in use Arrangements in place for disposal of contaminated materials	

12.9 Case Studies

12.10 References & Further Reading

ACTIVE Workbook: AP 7 Effective Project Execution
VEP 7.5 Project Handover and Commissioning

Section 13 Operation

13.1 Introduction

It has been argued throughout this manual that the end point of a project should be beneficial use of the asset which has been created, rather than some intermediate step along the way, and that this should be the target for all parties to the project. It has been assumed that use of the asset will be by the client of the project team, or by a tenant of that client.

This section has been written principally to cover the situation in which the final operator / user of the asset has not been responsible for the commissioning of the asset. In the case where the final operator / user has carried out the commissioning then on-going operations should be planned to evolve smoothly from commissioning with the minimum of interruption and delay.

In all of this there is little difference between the fast track project and a normal project except in the degree of urgency in achieving the design rate of production or level of occupancy.

Handover, if it has not occurred at an earlier stage, will need to take place with the asset in normal use.

13.2 People

Clarity of Objectives
The primary objective must be to achieve full beneficial use of the asset in accordance with the original scope and schedule of the project, and the current business plan of the asset operator. In this there is no difference between the fast track and conventional project, although it may be expected that the time scale for the fast track project will be shorter than that for the conventional project.

To ensure fast and effective action, the respective responsibilities of the project manager and the asset operations manager should be clear, especially as regards project responsibilities:

- Supplier warranties
- Contractor liabilities for defects rectification
- Release of retention monies

Integrated Team
The benefit of operations staff being a part of the *integrated project team* will only become fully apparent as commissioning moves into normal operation of the asset. The involvement of the operations staff in defining the scope of the project and in contributing to design should have ensured that the most appropriate asset has been built, and that the operations staff are committed to the design and to achieving the project objectives, including earliest practicable beneficial operation / use. Continuity of involvement of individuals is essential to achieve quick decisions and commitment to the outcome of those decisions.

Suitably Qualified and Experienced Personnel
Normal operation will require fewer staff than are needed for commissioning, so that where commissioning is carried out by the future operations team most of the work in recruitment and much of the training will already have been carried out. There may still be a need to

address any differences between the skills and knowledge needed for commissioning and those for normal operation.

Where commissioning is carried out by a separate commissioning team, perhaps provided by the management contractor, then the operator of the assets will need to recruit and train operations and maintenance staff to meet the fast track schedule. This may involve taking over and operating parts of the asset progressively as they are completed and commissioned during the main construction stage, so that a start may need to be made on recruitment and training very early in the life of the project, driven by the fast track schedule.

The activities required to provide suitably qualified and experienced operations and maintenance personnel should be included in the project programme, since the success of the project is dependent on these resources being available at the times required by the schedule, including:

- External recruitment – to fill new jobs directly
- External recruitment and training – to fill existing jobs to displace experienced staff on to the project
- Training of staff on the new asset
- Selection and appointment of suppliers and support contractors

Arrangements for training operations and maintenance staff may include all those for commissioning staff together with involvement in the commissioning process:

- Involvement in HAZOP, operability, maintainability and similar design reviews
- Involvement in plant inspections, snag listing
- Involvement in factory acceptance tests
- Involvement in plant and equipment site acceptance tests
- Use of:
  - simulators
  - physical plant models
  - *CAD* 3D electronic models
  - vendors facilities
  - existing similar asset
  - existing dissimilar asset with top up training
  - plant specific training programmes
- Involvement in plant preparation and pre-commissioning
- Involvement in commissioning

Motivation

Special efforts will be needed to ensure that the operations and maintenance staff who have not been involved throughout the project are motivated to maintain the level of momentum that has been achieved in the earlier stages of the project. In many cases they will be faced with an uncomfortable change of circumstances from a training situation during normal day work time to full operational responsibility on shifts.

It should be recognised that the late arriving operations staff will not have had the benefits of:

- Early involvement with scope decisions
- Being part of the *integrated project team*
- Contributing to the design
- Commitment to previous decisions, including design
- Acceptance of the asset through involvement in inspections and testing

- Knowledge gained during plant preparation, pre-commissioning and commissioning.

Special steps will need to be taken to bring the late arrivals on board with the project strategy and up to speed with their colleagues.

13.3 Scope

The scope of the project will have been determined during earlier stages, in particular development and definition, and every effort should have been made during the intervening stages of the fast track project to ensure that scope changes have been restricted to the essential minimum. As part of this process, experienced operations and maintenance personnel should have contributed to both the divergent and convergent stages of scope determination and their commitment to the agreed scope should have been obtained. Ideally these will be the same people who are responsible for the operation and maintenance of the completed asset.

In the event that use of the asset results in desirable changes being identified, whether as a result of shortcomings in the original scope or changes to commercial and other circumstances since the initial scope was determined, these should be subject to a change control or modification procedure that is no less rigorous than that which has been used throughout the project. Modifications other than those affecting safety are usually best left until the asset can be shut down to allow any outstanding defects and modifications to be carried out.

13.4 Strategy

The operations strategy for the asset will naturally depend on the nature of the asset and the business plan of the operator.

The strategy of the client organisation which will eventually have operational responsibility for the new asset should include:

- Appointment of an operations manager in time to be involved at the development stage
- Continuity of involvement of operations and maintenance staff throughout the project
- Support for the project with experienced personnel to ensure that operations and maintenance experience is fully utilised in the definition and design stages
- Due consideration being given at the design stage to:
  - repetition of design with which operations / maintenance staff are familiar
  - inclusion of equipment with which operations / maintenance staff are familiar
- Timely recruitment and training of additional resources
- The inclusion of plant models, simulators, etc., for operator training
- The inclusion of training facilities at vendor / supplier factories
- The production of operations and maintenance documentation as a project responsibility which is included in the resource plan and project schedule
- Involvement as part of the integrated team in:
  - site inspections
  - factory acceptance tests
  - site acceptance tests
  - snag listing
  - plant preparation
  - pre-commissioning

    - commissioning
- The purchase of operational spares along with original equipment

13.5 Project Management Systems & Procedures

Planning
There should be only one project plan, and that should include all the activities that are required to get the asset to beneficial operation and successfully handed over to the client. It should therefore include the activities of all parties to the project, including the client and, if different, the ultimate operator / user. The overall plan should be driven by the project manager to ensure that each activity is completed in accordance with the schedule so that subsequent activities are not unnecessarily delayed.

Care should be taken to ensure that a number of plans are not generated by the different parties to the project, e.g. construction, commissioning, operations, in such a way that the interaction of the various activities cannot be identified. It is often the case that different organisations use different planning tools and work to different time scales, again making it difficult to identify and manage the interfaces between the parties involved. The speedy completion of commissioning and ramp up to full production will only be achieved if there is a single, integrated and optimised plan and all parties are energetically following it.

The project plan should include the timely provision of all documentation that is necessary for completion, operation and hand over of the asset. This has been identified as being a particular problem on many projects.

Organisation
The operations organisation should be headed up by a manager of appropriate experience and seniority to drive the operation of the new asset. Ideally this will be the same person who has been a part of the project team from the beginning.

It is prudent to arrange for operations staff to have immediate access to design and construction resources so that any problems can be quickly solved, even though these should all have been taken care of during the previous stages of the project.

Procedures
Operations and maintenance procedures may need to be written specifically for the new asset incorporating information provided by a variety of parties including process licensors, designers, constructors, suppliers and vendors. It is essential that these are produced early enough in the project programme for them to be used as the basis for training operations staff, and that there is a system in place to enable them to be modified to incorporate early experience gained in the operation of the asset.

Operations staff should review plant preparation, pre-commissioning, commissioning and testing procedures so as to ensure that, wherever possible, there is a smooth transition from construction to normal operations without any missed or repeated activities, or unnecessary delays.

Operations staff should also review the construction quality control procedures and their application in practice to ensure that, as far as practicable, the asset is free of residual snags by the time it is in normal operation.

Operations staff should ensure that appropriate procedures are in place for the smooth, conflict free, hand-over of the asset and supporting documentation from project / construction management to the client.

Communications
The communications systems that have been in use throughout the project should continue to be available into the operations stage and for as long as the project management, design, procurement and construction are involved. Operations and maintenance may obtain considerable benefit from the earlier integration of advanced IT into the project systems, including information management and sharing, and asset modelling.

The normal operations communications systems will need to be established at the commissioning stage of the first system that is processing material and / or as soon as an operating team works on a shift pattern. These communications systems may need to include:

- Shift to shift (hand-overs, logs)
- Operations to Maintenance
  - work orders
  - permits to work
- On-plant: loud speaker systems, radios
- Production to
  - Marketing / Business
  - Purchasing
  - Feedstock suppliers
  - Utilities suppliers
  - Services suppliers
  - Transport
  - Warehousing
  - Customers

13.6 Cost & Risk

The client's representative / operations manager on the project team should ensure that:

- the search for a cost effective outcome does not compromise the ultimate profitability of the asset or extend the time taken to ramp up to full output
- financial incentives for all parties to the project are based on the asset achieving the real business requirements of the client

13.7 *Logistics*

Operations staff should ensure that the commissioning and operation of the new asset is not delayed by the operation and / or maintenance of pre-existing assets, or by the activities of suppliers of feedstocks, utilities and services.

13. 8 Checklists

13.9 Case Studies

13.10 References & Further Reading

Section 14 Lean Thinking

14.1 Introduction

The UK Government Department of Trade and Industry's Construction Task Force, chaired by Sir John Egan, produced the "Rethinking Construction" report in July 98 which is based upon lean thinking techniques, as implemented primarily by manufacturing companies. In it a number of improvement targets were set for the construction industry, including year on year reductions of 10% in both cost and time to complete projects, and 20% increase in predictability of completion within time and budget.

"Lean" is defined by Womack and Jones in their book entitled Lean Thinking as "a way to do more & more with less & less - less effort, less equipment, less time, & less space - whilst providing customers with exactly what they want" so it is hardly surprising that it is being seen as the way forward for many industries.

The extension of lean thinking from its origins in manufacturing to the engineering, procurement and construction processes is currently developing at a rapid rate. The advocates of applying lean thinking to project management are challenging the conventional wisdom and raising many of the same issues that have to be addressed on a fast track project. One of the principal issues that lean thinking seeks to address is that of interdependence between the design, procurement and construction activities. This interdependence is the main source of additional risk on a fast track project as the previously sequential stages are overlapped to progressively greater extents.

The parallel with the manufacture of multiple copies of the same unit is more obvious at first sight for some projects, such as domestic housing, than for others such as a single industrial plant. However, deeper consideration suggests that every project should be able to benefit to some extent from the lean concepts which are being developed out of manufacturing experience.

Lean construction may be considered as being at the convergence of the separate developments in manufacturing and project management. Even where lean thinking is resulting in similar ideas to those that already exist in one or more parts of the construction industry, it is evolving as a way of articulating those ideas as a logical and consistent approach. It has been included in this handbook in the expectation that it will be able to offer new insights into engineering, procurement and construction of fast track projects in the capital project business, and in due course, robust processes for the application of these ideas.

One of the best sources of information is the Lean Construction Institute, a US based, non-profit research organisation founded in 1997 with the purpose of reforming project management through design, engineering and construction of capital facilities. See the contact details 14.6 below.

14.2 Lean Production

Lean manufacture originated in the automobile industry about 50 years ago. Engineer Ohno, working for Toyota in Japan, recognised that the current mass production approach of operating the production line at maximum speed, with no allowance for interruption even if

the right information and parts were not available, was extremely wasteful. He set out to eliminate waste in all its forms with the ideal of making an individual product to the particular requirements of a specific customer and delivering it instantly, while maintaining no inventories or intermediate stores.

Ohno set out to eliminate the many sources of waste by:

- Identifying and delivering value to the customer
- Eliminating anything that doesn't contribute to that value
- Designing the production process at the same time as the product
- Organising the production process as a continuous and reliable flow of work
- Resisting the temptation to keep production going at any cost

The original lean ideas have evolved over the years and Toyota is still regarded by many as being the example that all other motor manufacturers should strive to match. Lean manufacture has spread to many other parts of the industrialised world and it is now recognised that the principals are applicable to manufacturing in general. From this have evolved lean theory, principles and techniques which are collectively described as the result of lean thinking and the organisations which come together to apply lean thinking form a lean enterprise.

The benefits in the manufacturing process have included:

- Shorter manufacturing time
- Greater flexibility to customise products
- Reduced costs
- Reduced resources
- Less work in progress
- Lower intermediate component stock levels (Just In Time deliveries)
- Less space required

Advocates of lean manufacture argue that making the production process "flow" in a lean way can result in the amount of effort, time, space, tools and inventories needed to design and provide services or goods being typically cut in half – with potential to achieve further reductions beyond that as experience develops. "Flow" implies that the process proceeds in a steady, planned, reliable and predictable way as a result of the equally steady, planned, reliable and predictable supply of the high quality information and materials needed for the process. As a result there should be no disruption or delay due to incomplete prior work, shortages of information, materials or support resources, changes, rework, temporary fixes or work-arounds. It has been argued that the "flow" manufacturing principles can be applied to any activity and that the result is always a dramatic improvement.

The objectives of a lean enterprise, according to Womack and Jones in their book "Lean Thinking", are very simple:

> "Correctly specify value for the customer, avoiding the normal tendency for each firm along the stream to define value differently to favour its own role in providing it. Then identify all the actions required to bring a product from concept to launch, from order to delivery and from raw material into the hands of the customer and on through its useful life. Next remove any actions which do not create value and make those actions which do create value proceed in continuous flow as pulled by the customer."

14.3 Comparison of Construction & Production

There are clear differences between the manufacturing and construction processes. This may suggest that there are no transferable lessons, but construction differs from production in only a limited number of ways:

- It is site based, and sites are usually different one from another
- The product is unique, except in the case of some housing and retail developments
- The organisation normally exists only for the duration of a single project

There are clearly similarities between manufacturing and construction and these make it worth while exploring the lean approach and transferring those lessons that are relevant:

- Concept, development, definition, design and procurement together form the supply chain that precedes construction as they precede production
- The constructability process is intended to ensure that the construction process is designed at the same time as the asset, which is fundamental to lean production, but constructability is rarely used to its full extent
- Construction rarely flows smoothly and at maximum efficiency because of shortages of information, materials, equipment, resources, support resources, construction plant, etc., which are all problems that Ohno sought to address at the start of his work in Toyota
- When delays occur to critical path work, resources get diverted to lower priority tasks or short-term fixes or work-arounds are carried out, reducing efficiency and resulting in rework, which are basic problems of the production process
- The project / construction plan builds in "float" which then gets used (wasted time), just as existed in the early production plans
- Site area is wasted with excessive lay-down and material storage areas because materials and equipment do not flow to site as required by construction, just as factory floor space was wasted with excessive buffer stocks between processing stages
- Each of the parties to the project seeks to optimise duration, cost, etc. of their part which results in sub-optimisation of the project as a whole because the fundamental interdependencies are not taken into account. It took lean thinking to reveal these interdependencies in the production process

14.4 Lean Construction – Current Situation

The Lean Construction Institute offers a "Lean Project Delivery System" to its members and suggests the following key differences between lean construction and the current forms of project management:

> "Lean construction is a new way to design and build capital facilities. Lean theory, principles and techniques, taken together, provide the foundation for a new form of project management. From roots in production management, lean construction has produced significant improvements particularly on complex, uncertain and quick projects. Key differences between lean construction and other forms of project management include:
>
> - Control is redefined from “monitoring results” to “making things happen”. Planning system performance is measured and improved to assure reliable workflow and predictable project outcomes.

- Performance is maximizing value and minimizing waste at the project level. Current practice attempts to optimise each activity and thus reduces total performance.
- Project Delivery is the simultaneous design of the facility and its production process. This is concurrent engineering. Current practice, even with Constructability reviews is a sequential process unable to prevent wasteful iterations.
- Value to the customer is defined, created and delivered throughout the life of the project. In current practice, the owner is expected to completely define requirements at the outset for delivery at the end, despite changing markets, technology and business practices.
- Coordinating action through pulling and continuous flow as opposed to traditional schedule driven push with its over-reliance on central authority and project schedules to manage resources and coordinate work.
- Decentralizing decision making through transparency and empowerment. This means providing project participants with information on the state of the production systems and empowering them to take action."

Lean construction processes are still being developed and the fast track study research revealed no projects other than the case study, Section 14.7.1 below, that had been explicitly run on what were recognised by the interviewees to be lean lines and using lean processes.

The following aspects of lean construction have been extracted from a number of publications on the subject. They are written in project management terms and are recognisably part of the normal project management practices in one or more parts of the industry.

Project management

- Key organisational features include leadership and teamwork
- Project control is "controlling the project", not just retrospective monitoring, i.e. it involves driving delivery according to the plan and implementing corrective actions to get back on plan when deviations occur
- Project team members are empowered and decision making is pushed down to the lowest competent level
- All parties involved in the enterprise of creating the new asset form a voluntary *alliance* to achieve common objectives
- The construction requirement is the basis for planning the supply of design, documentation, materials, equipment and resources
- Good communications are needed to support local decision making
- Eliminate waste wherever possible including:
  - unnecessary processing steps
  - unnecessary inventory
  - surplus materials
  - unnecessary movement of people, e.g. site amenities close to work places, site stores close to building site
  - unnecessary transport of goods, e.g. avoid double handling of materials on site
  - organise multi-trade tasks to avoid waiting time pending arrival of a key trade or support service, e.g. crane
  - rework
- Form a lean enterprise (integrated project team) which ignores traditional job boundaries, functions and firms

Definition

- Identify the value stream – the irreducible minimum set of activities needed to design, order and make an item
- Providing the wrong goods or services the right way is waste i.e. "do the right project before you do the project right"
- Involve the fabricator in the project definition process

Design
- Simplification of design
- The delivery process is designed concurrently with the product rather than being the subject of post design reviews e.g. *Constructability* or *Buildability*.
- Computer based 3D modelling

Procurement
- Suppliers are selected who are close to the assembly site
- Suppliers are responsible for making materials available to meet the assembly schedule
- Suppliers are responsible for warehousing materials to minimise the amount on site
- Accelerate or eliminate submittals

Construction
- Consider construction as a manufacturing process, especially where the same activity has to be repeated, e.g. setting a row of pumps, bricklaying
- Get the job done in a steady continuous flow with no wasted motions, no interruptions, no batches and no queues.
- Eliminate buffer stocks of materials and equipment
- Eliminate ineffective time on site activities:

Commissioning
- Computer based 3D modelling to train operators in advance of start-up
- Beneficial operation is the end of the project, not some intermediate stage such as *mechanical completion*.

14.5 Lean Construction Developments

Lean construction is setting out to address some of the fundamental failings of the current project management / construction processes:
- Necessity for the client to decide requirements at the start of the process
- Failure of current planning methods to align design, procurement and construction so as to optimise the total process
- Failure to identify interdependencies / logic links between design disciplines resulting in greatly increased risks if concurrent engineering is attempted
- Shortage of cross-functional teams capable of carrying out concurrent engineering
- Inadequacy of electronic tools, and shortage of people trained to use those that do exist, to deal with the complexities of concurrent engineering
- Inefficiencies and time wasted by diverting from plan when supply shortcomings arise

The anticipated benefits from lean construction developments will come when robust and proven processes are available for the application of these ideas in ways that are easily assimilated in the construction industry.

14.6 Contacts

The **Lean Construction Institute** charges a sliding scale of membership fees according to the level of benefits. Papers over 12 months old are posted on the website.
www.leanconstruction.org

14.7 Checklists

14.8 Case Studies

14.8.1 Hospital M&E Installation

This is an example of the application of lean principles to the mechanical, electrical, telecommunications and IT installation on a new, state-of-the-art hospital consisting of 9 major operating theatres, large accident and emergency unit, specialist radiotherapy unit and 2 ward blocks together with all plant and services. The target was to reduce by 33% the time traditionally taken for such an installation.

Lean principles were wholeheartedly applied by the M&E sub-contractor, in conjunction with the main contractor, design team and suppliers, with the intention of addressing the 60% inefficiency that they consider to exist on a typical construction site. Among the actions taken were:

- Partnering workshops with main contractor, design team and suppliers
- Team working, involving team building, agreement and co-operation
- Analysis and rationalisation of the design and installation process involving a critical appraisal of every aspect of the work aiming for maximum efficiency and productivity
- Division of the work into a number of zones through which installation teams progressed, transferring experience between zones and moving from a construction process towards a manufacturing process
- Continuous development involving measurement of performance against agreed KPIs and lessons learned reviews on a weekly basis with the lessons being applied immediately
- Buildability reviews
- Careful component and tool selection, and use of battery operated tools to avoid power cable constraints
- Just in time delivery of materials direct to the workface as and when needed using purpose designed stillages, greatly reducing the need for site storage
- Purpose designed access incorporating stocks of minor components and consumables which were topped up on a regular basis

14.9 References & Further Reading

Title	The Machine that Changed the World
Published	1990

Name	Womack, Jones & Roos
Subject	Origins of lean manufacture
ISBN	0-89256-350-8
Review	One of the definitive books on the subject of the development of lean manufacture and fascinating for anyone with an interest in the history of the motor industry.

Title	Lean Thinking
Published	1996 Simon & Schuster
Pages	350
Subject	History and development of lean thinking in manufacturing companies
Name	James P Womack & Daniel T Jones
ISBN / Availability	
Review	This is a useful primer for those with the time and inclination to study the origins of lean thinking in a manufacturing setting with plenty of detailed examples, principally of engine or motor production. While there is only one page specifically on "construction", it is easy to see how the principles and action plans could be translated into a project situation.

Title	Rethinking Construction
Published	DETR 1998
Available	www.construction.detr.gov.uk/cis/rethink
Review	Essential reading for anyone wishing to understand government thinking on the construction industry in general and house building in particular.

Papers published on www.leanconstruction.org – see especially:

Title	Lean Construction and EPC Performance Improvement, Glenn Ballard
Title	Reforming Project Management: The Role of Lean Construction, Greg Howell & Lauri Koskela
Title	Towards Construction JIT, Glenn Ballard & Greg Howell
Title	What is lean Construction, Greg Howell
Title	Lean Project Delivery System, Glenn Ballard
Title	What Kind of Production is Construction, Glenn Ballard & Greg Howell

Section 15 Risk Management

15.1 Introduction

Risk is an integral and unavoidable part of any enterprise and the successful management of that risk is the prime responsibility of the manager of that enterprise. In this handbook risk management is taken to mean a formal process that identifies, assesses, plans and manages the uncertainty factors that can have positive or negative impacts on the project and / or the businesses involved.

Project risk management is a major subject in its own right and a considerable amount has already been written on the topic. It is not the intention here to repeat what is already available elsewhere, but rather to present an overview and to highlight the importance of utilising an effective risk management process when adopting a high risk strategy to reduce the project schedule.

The management of risks on fast track projects is no different in principal or process from that which should be used for any project. The significant difference in the case of a fast track project is that the normal project processes, which have been developed over time to minimise risk, are challenged and may in part be replaced by innovative processes aimed at greatly reducing the schedule. This can introduce increased levels of normal project risk and additional risks that are not normally encountered when using the established project processes.

The risks that may need special consideration as a result of using a fast track strategy for a project are covered in each of the project process sections. This section sets out some of the options for dealing with risk which can be applied on any project whether of not schedule reduction is the principal driver. However, it is suggested that the use of a relational database will increase the understanding of the impact that risks arising from individual work packages can have on the project as a whole, thus ensuring that the highest overall risks receive the greatest level of attention. This is particularly true when interdependent work packages are being progressed in parallel as part of the fast track strategy.

The type, magnitude and probability of risk will change with time from the early concept stage through to beneficial use of the asset. The processes of identification, analysis and management must therefore be in constant use over the life of the project. The people contributing to and utilising these processes will also change as the project evolves and there is the great potential that serious risks, and the actions that are required to manage them, become lost or overlooked. It is therefore recommended that one system should be in use from start to finish and that an experienced risk manager should be in place to support whoever has overall responsibility for the project, whether that is a business manager, architect, technical manager, project manager, construction manager or commissioning manager.

15.2 Risk Identification

Risk identification is the first step in the risk management process and needs to be carried out thoroughly to ensure that all significant risks are captured and addressed. The people involved need to cover all functions and to be able, between them, to address all aspects of the

project. The employment of a risk manager to facilitate the risk identification and analysis processes has been found to be very helpful.

There are generally recognised to be three processes for the identification of the risks associated with any particular project:

- Historic records and general checklists
- Interviews with *stakeholder*s and participants
- Group *workshops* and brainstorming sessions

None of these is specific to fast track projects and none of them on their own is likely to result in a complete list of all risks, so it is recommended that all three approaches should be used whenever possible, and preferably in the order listed.

The risks identified should be recorded in a risk register, usually in spreadsheet or database form. A generic example of a spreadsheet is shown in checklist 15.5.2. On more complex projects the use of a relational database will be beneficial in that it will allow the "many to many" links between risks on work packages and actions taken in their mitigation to be addressed.

Historic Records

Historic company records and generic checklists can be useful starting points for the identification of risks on a specific project. However, they do need careful interpretation and it will generally be found that they have been derived from conventional projects and so do not address the specific issues of a fast track project.

Interviews with *stakeholder*s and participants

One-to-one interviews with *stakeholder*s and project participants are likely to generate a great deal of information, much of which may be strongly biased in favour of the person being interviewed. The benefit of this approach is that it enables all parties to voice concerns which they may not be willing to debate in a more public meeting. The drawback is that these concerns may be exaggerated and intended to protect the individual's position should things go wrong in the future. The success of this approach is therefore largely dependant on the skills of the interviewer and the experience and integrity of the individuals being interviewed.

Workshops and Brainstorming Sessions

Facilitated group sessions are an effective way of exposing risks, especially if they commence with a true brainstorming session in which the ideas are accepted at face value and not evaluated or criticised. The facilitator will need to have prepared for the session so as to be able to direct the group to the aspects of the project that are known from the historic records and interviews to carry the greatest risk. Having listed the risks the same group can usefully go on to evaluate probability and impact for each of them, and to agree on the individual who is best able to manage the risk.

The processes described above are typically applied early in the project process and should result in the project team owning the list of risks, even though individuals have been charged with managing specific risks. However, the risk position will change as the project develops and it is important that the register is reviewed and modified on a regular basis. Some risks will be time expired and can be crossed off the list, the status of others will change and new ones will be identified.

The regular review and up-dating of the register is especially important in the case of the fast track project since the overlap of project stages and early decisions based on limited information automatically introduce additional risks which may be fully recognised only by the individuals making the decisions. Each member of the project team should therefore be committed to the risk management process and actively use it to help them handle the risks in their areas of responsibility.

15.3 Risk Assessment

Each of the risks that have been identified needs to be assessed to determine
(a) the probability of the risk occurring and
(b) the magnitude of the impact if it does occur.
Only when this has been done can a management judgement be made as to the significance of the risk and hence the priority and extent of efforts that can be justified in dealing with it.

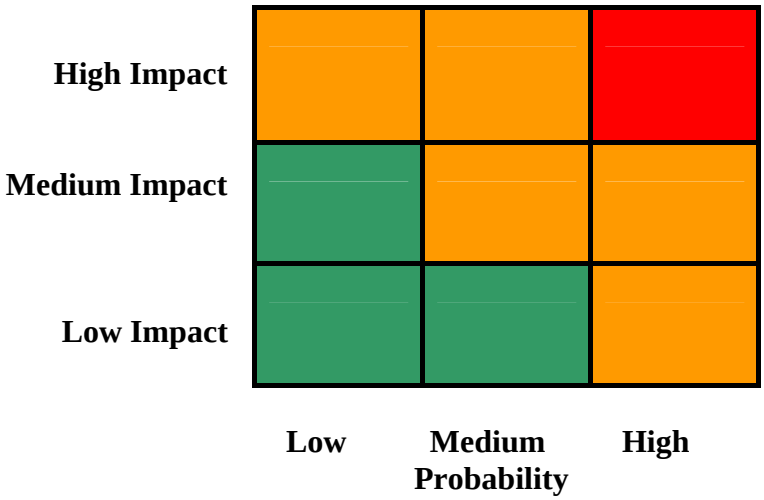
At the simplest level, subjective judgement of the project team can be used to evaluate both probability and impact on a scale of low (1), medium (2) and high (3). Once the initial assessments have been recorded, individual members of the fast track project team can use these as a framework against which to judge any risks which they personally add to the register between the regular reviews.

Probability
It is usual to determine indicative percentage probabilities for the project as a whole, based on the nature of the project, e.g. Low Probability (1) may be up to 10%, Medium Probability (2) may be from 10% to 25%, High Probability (3) may be anything in excess of 25%.

Impact
This is more complicated since there can be a number of consequences, which may be interlinked, e.g. delay to schedule and increase in cost, requiring subjective and / or objective judgements. The example below has been taken from a recent project in which great effort was made to quantify all impacts.

	Internal Rate of Return %	Capital cost £m	Production loss weeks	Schedule extension weeks	Capacity loss kte/yr	Production £/te increase
High (3) = greater than	2	5	4	12	10	5
Medium (2) = greater than	1	2.5	2	6	5	2.5
Low (1) = less than	1	2.5	2	6	5	2.5

The results of the probability and impact judgements are sometimes displayed in a "Boston Grid" which provides a simple picture of the risk situation.



The "traffic light" colours give an immediate indication of the seriousness of the individual risks:

- Critical risks with high probability and high impact appearing in the red area require urgent management attention
- Significant risks in the amber area with medium / high probability and medium / high impact require attention
- Lesser risks in the green area with low / medium probability and low / medium impact may be acceptable as normal levels of project risk.

The simple system described above will probably prove to be sufficient for a project team member who is introducing additional risks to the project as a direct result of their personal decisions within the fast track schedule. It is important to ensure that the impact is determined before the probability to avoid the analysis being skewed.

There are a number of more sophisticated tools that can be used for the quantitative evaluation of project risks, e.g. @risk, Crystal Ball, PREDICT. They are generally dependent on the quality of the data with which they are supplied and as a consequence the outcome can be misleading. Their use and interpretation generally requires experienced risk management assistance and their application is no different on fast track projects than it is on conventional projects.

15.4 Risk Management

The management of specific risks, once they have been identified and their significance assessed, should be allocated to the individual who is best able to achieve a satisfactory outcome. The individual may be within or outside the project team depending on whether the risks are internal or external. It is not the role of the Risk Manager, in spite of his job title, to manage the risks that lie firmly within the responsibilities of those managers who have executive authority for the mitigating actions.

While the options available for dealing with risks will critically depend on the nature of the project, there are usually considered to be five main ways in which a risk can be addressed. Examples are given in checklist 15.5.3.

Avoid / Eliminate

The greatest opportunity to influence the risks involved over the life of a project exist at the start of that project. Early on it may be possible to avoid the risks altogether by changing the concept and hence the objectives of the project. During the development of the scope it may be possible to eliminate those risks that have been created as a result of the basic concept by changing the way in which the concept is delivered.

Reduce

If the risk cannot be avoided altogether then the next best thing is to reduce either the probability that it will occur or the magnitude of the impact if it does occur. Opportunities should be considered for reduction ahead of transferring the risk to other parties or sharing with other parties.

Transfer

The act of transferring the risk to another party does not in any way improve the actual risk. If it is done properly it can make sure that the risk is managed by the party best able to control the risk or deal with the impact if the risk occurs. However, there is a danger that the practice of contracting, especially on a lump sum turn key basis with back to back sub-contracts, can result in the organisation least able to deal with the risk being left holding it at the end of the line. There is usually a price to be paid for the transfer of risk since risk and reward should be linked if the transfer is to be effective. It should be noted that transfer of risk may affect the assessment of probability.

Insurance is a particular form of risk transfer on which there will be a premium related to the assessed scale of the risk.

Share

Depending on the terms of the contracts involved, risk can be shared between the parties to the project. To be effective, each should carry the burden of risk proportionate to the value and scope of their work and their contribution to the outcome.

Retain and Accept

Retention and acceptance of residual risk does not mean doing nothing. Effective project management systems and procedures, e.g. QC, QA, should be employed to ensure that the probability of the event occurring is reduced as far as is practicable.

There are two circumstances under which the residual risk should be accepted by the party owning it:

(a) if the probability and / or magnitude are sufficiently low, i.e. the consequences are acceptable

(b) if it has not been possible to avoid, reduce, transfer or share it, but there is the proviso that if the owning party does not have the ability to absorb the consequences the results could be disastrous and under these circumstances further efforts should be made to avoid the risk by withdrawing from the project commitments.

15.5 Checklists

Checklist 15.5.1	**General List of Sources of Risk – Sheet 1 of 3** **Externally Imposed Risks**	
Project No.	**Title**	
Revision	**Date**	**Author**
Economic Availability of material Availability of skilled labour **Political/Regulatory** Changes in regulation, standards and/or law Local customs Work permits, visas Planning / building permit approval Host government requirements (overseas projects) Training requirements Licences and approvals Union actions Languages of project participants Stability of country Loss or damage by fire, flood, accident, landslide, hurricane **Customer Organisation** Timely availability of information, equipment, etc., provided by customer Dependencies on other projects Availability of sufficient funding to support project programme **Market** Competition for resources Product approval trials **Social and Cultural** Education Demographics Religion, religious holidays Cultural norms Languages of participants Standards of workmanship Project labour (quantity, quality, supervision, etc.) Terrorism Vandalism / Theft Sabotage		

Checklist 15.5.1	**General List of Sources of Risk – Sheet 2 of 3** **Risks Under Project Control**	
Project No.	**Title**	
Revision	**Date**	**Author**
Project Objectives Clarity, reasonableness and understanding of *CSF*s Strategic fit of *CSF*s with Business objectives Priority of objectives (is project schedule driven?) **Project Strategy** Reliability of data used for planning and scheduling. **Project Definition** Size and complexity of project *Critical success factor*s Changes in scope or *CSF*s Adequacy of scope definition Accuracy of site condition data Adequacy of agreed procedures for all project stages Documentation requirements Commitment of *stakeholder*s to scope, *CSF*s, etc. **Technical** Changes to process definition Need for process or product research or development Is this a new process? Is this a new product? Is new equipment included? Are there technology transfer issues? **Project Organisation** Strength/experience /skills of management team Authority of project manager Continuity of project manager and team Clarity of responsibilities of all project participants Interfaces with customer, associated projects. etc. Arbitrary interference from outside Likely effectiveness of project organisation Suppliers and sub-contractors Geographical spread of project team Communication problems **Project Staff** Availability of skills required Client and Contractor availability (competing projects?) Dedicated or part time staff Morale and team building Union representation Working terms and conditions Accommodation and subsistence requirements Personality clashes Resource build-up strategy	

Checklist 15.5.1	**General List of Sources of Risk – Sheet 3 of 3** **Risks Under Project Control (continued)**	
Project No.	**Title**	
Revision	**Date**	**Author**
Suppliers and Sub-Contractors Extent of competition Bankruptcy or receivership Experience and capability Motivation Management skills & disciplines Patents & licensing agreements Contractual arrangements **Project Design** Adequacy of design to meet need Appropriateness of design for operating environment Site and ground conditions, ground contamination Unusual aspects or areas of limited previous experience Accuracy of existing as-builts / reference drawings Planning permission/Operating Licence constraints Experience / competence of designers Co-ordination between designers, customer, developers and sub-contractors Novelty and complexity of solution Re-use of redundant equipment Security aspects Environmental testing Reliability of scheduling data Training for maintainers & operators User Involvement Design validation Prototyping Impact on current operations **Project Development and/or Production** Realism of timescale Timing and number of reviews Code and functionality testing User Involvement Factory / Site acceptance testing and design proving New techniques or technology in manufacturing / development *I* construction **Acceptance** Is the acceptance authority clearly defined for all aspects of system functionality? Is there more than one level of acceptance? Are the necessary facilities and supporting infrastructure available to achieve acceptance?		

15.5.2 Generic Risk Register

Project Title
Location

Register revision no.
Date of revision

Ref. No.	Source of Risk	Description of Risk	Phase affected	Description of Impact	Impact I	Probability P	Score IxP	Risk Management Actions	Action By	Required By Date

Checklist 15.5.3 Risk Response Options	
Project No. Title **Revision Date**	**Author**
Avoidance / Elimination Modify the concept by addressing the root causes of risk Change the project objectives Postpone all / part of the work Relocate the project Change the project methodology Change the technology Change the parties involved in the project **Reduction** Change strategies Change technology Change materials Change methods Relax constraints Use proven people, contractors, specialists, expertise Increase human resources for critical activities Increase supervision, inspection, expediting Train staff Test and prove methods, procedures, etc., in advance Revise plan / schedules to modify critical path Avoid poor weather conditions / provide protection Increase financial resources Hedge currencies **Transfer to:** Venture partner Main contractor Sub-contractor Supplier / Vendor Insurance company **Share with:** Finance company Main contractor Sub-contractor Supplier / Vendor **Retain / Accept** Make provision /provide contingencies for the event Ensure effective management systems and procedures, e.g. progress, cost and change control are in use	

15.6 References & Further Reading

Crystal Clear Management Ltd has developed a proprietary database using the risk matrix technique. The database is written in Access 2000 allowing for customer definable modifications and easy linkages into normal Microsoft office packages.
E-mail: kevinjl@tcp.co.uk

ACTIVE Workbook:	AP5	Effective Project Risk Management
	VEP 5.1	Project Risk Management
	VEP 5.2	Risk and benefit *framework agreement*s

ECI Value Enhancing Practice Review (draft)	Risk Management (due for publication in 2002) A short but comprehensive review of project risk management that contains some useful explanations, advice and check lists.

Title	The Handbook of Project-based Management, Second Edition, 1996
Publisher	McGraw-Hill
Subject	Projects and project management
Author	J R Turner
ISBN	0-07-709161-2
Review	Chapter 11 (26 pages) summarises and explains the management of risk.

Section 16 Glossary

Accountable Engineer
A professionally qualified engineer, e.g. electrical, who is responsible for ensuring the integrity of functional design, i.e. compliance with regulations, standards, specifications, procedures. Normally independent of the initial design process.

Alliance
Agreement committing 2 or more companies to work together, normally based on common interests, to achieve a set of objectives. The arrangement can last for one or more projects but is most effective when trust, relationships, etc., are allowed to develop over a period of time.

Black box
Generally used to describe something with unknown contents.

An area of a drawing, bounded by lines forming a box, the contents of which cannot be determined until a later date when more information becomes available.

Also used to describe an organisation the details of which are known only to the members of that organisation.

Buildability
A formal review process for evaluating the ease with which a particular design can be built. A Buildability review is normally carried out on an existing design and may result in the need to change that design to improve the safety, ease, cost or speed with which it can be built.

CAD
Computer Aided Design, which can be 2D or 3D.

CALIBRE
A series of tools that enables the companies in a supply chain to manage their project processes through performance measurement covering time utilisation, predictability of the delivery process, environmental impact and waste generation. Produced by the Centre for Performance Improvement in Construction at BRE (Building Research Establishment Ltd). Details can be found on www.CALIBRE2000.com

Champion
A member of either the client 's or the contractor's staff who is more senior than the project manager and is in a position to provide the project with support, especially finances or resources, and guidance when needed and to defend the project within the organisation.

Clearance
See Permit below

Constructability
A formal process for ensuring that any design is capable of safe, easy, cost effective or speedy construction through the consideration of construction aspects, usually involving experienced construction professionals, at the definition and design stages. Contrast with Buildability which is normally regarded as a post design review process.

Constructable
Literally "able to be constructed". Usually refers to a work package that is a complete entity and therefore able to be completed with the information and materials supplied.

Control estimate
Cost estimate based on a high level of detailed definition, usually produced some time after project sanction and representing the expected cost out-turn, against which the project performance is compared.

Conventional Project Process
See 3.1

COSHH
UK legislation: Abbreviation for Control of Substances Hazardous to Health Regulations.

CSF / Critical Success Factor
An important objective of the project against which performance will be measured at the end. If all CSFs are achieved then it will be regarded as a success by all parties; if one or more CSFs are not achieved then it will be seen as a failure by one or more of the stakeholders.

Design Freeze
The act of fixing the design with the intention that it will not be subjected to any further changes so that purchasing and construction can proceed with confidence.

Earned Value
The actual value of work done compared with the value of work planned at any point in time and used as a measure of progress (rather than time elapsed or hours spent on the activity which are not accurate measures of progress).

Fab to fit
Fabricate an item to accurate dimensions so that it can be assembled on site without further adjustment or the need site work, e.g. welding of closure pieces.

Fast Track Project
See Section 2 – Definition of a Fast Track Project

Fit for purpose
Complying with the standards and specification necessary for the intended use but not better than is actually needed for the current task. The implied risk is that it will not be good enough for some future, as yet unspecified, use.

Framework agreement
A formal agreement (contract) between two or more parties in a supply chain that is aimed at encouraging co-operation, innovation and the deployment of skills and knowledge to achieve excellence, usually through the sharing of risk and benefit associated with the achievement of project CSFs.

Functional Matrix Structure
An organisational structure in which engineering disciplines are separated into different departments or groups but come together to execute tasks, e.g. projects, under a project leader. The characteristics of this structure are high levels of engineering competence but the

principal loyalty of each engineer is to the functional department head and this can undermine the authority of the project manager and inhibit the success of the project.

Gate
See Stage gate.

HAZOP
A formal process for reviewing the HAZard and OPerability of a design, usually in a series of stages as the design develops, and most commonly used in the process industries.

Hold point / hold
A point in the design or construction process beyond which no further progress can be made until the work up to that point has been formally approved.

Integrated Project Team
A project team formed from employees of the participating companies that operates as a single entity and in which the members co-operate to achieve the project objectives. Relies on a supportive contract structure but should eliminate man for man marking and focus attention on achieving the project CSFs.

Interactive Planning
A process that involves getting all interested parties, e.g. clients, key suppliers, usually 20+ people, together in a (one day) session overseen by trained facilitators. The objective is to gain understanding and agreement about how the project is to be run including any changes to standard company procedures. People work together to share out the available time and undertake to co-operate to deliver against the tight overall timescale.

KPIs / Key Performance Indicators
Quantifiable measures of design, procurement or construction performance which are indicative of the overall performance of the project.

Last responsible moment
A lean manufacturing term implying that commitment is deferred, keeping as wide a set of options and range of values open as long as practicable, as determined by the lead time to realise that option or value.

Logistics
The heading in this manual is used to cover movement and supply issues only rather than the broader topic of planning and organising a complex enterprise.

Mechanical completion
The physical completion of all aspects of the asset. The use of the word "mechanical" is misleading since it includes civil, structural, electrical, etc. At this point the asset has not been made ready to be used, i.e. preparation, pre-commissioning, commissioning has not been carried out.

Milestone
A point in the programme indicating the end of a large and identifiable piece of work, completion of which is frequently used to justify a contract payment.

No blame culture

An organisation in which the members are not disposed to blame each other for errors resulting from honest endeavour to achieve the common objectives and will support each other in correcting any such errors that do occur.

Pareto's Law
Pareto was an Italian economist and sociologist who formulated a complicated mathematical "law" of income distribution. This has been greatly simplified and is now commonly called the 80:20 law, referring to the approximation that 80% of the output comes from 20% of the input.

Permit / Work Permit / Clearance
Part of a site safety system. Written authorisation to carry out work which is:
(a) hazardous to participants, e.g. entry to enclosed space and/or
(b) hazardous to adjacent staff, e.g. radiography and/or
(c) takes place in a hazardous environment, e.g. an operating chemical plant.
The permit or clearance would normally specify precautions to be taken, including personal protective equipment to be worn, be for a clearly defined time and may transfer responsibility between people or organisations.

Responsible engineer
See Accountable engineer above

Sponsor
See Champion above.

Stage Gate
A defined point in the project process at which a number of conditions are required to be satisfied before it is permissible to pass on to the next stage of the process.

Stakeholder
A person or organisation with an interest or involvement in the project, its outcome or impact. Strictly speaking the interest should be some form of financial stake but in practice the definition has been extended to include any form of interest, e.g. environmental campaigners. See Checklist 6.8.1 for examples

SQEP / Suitably Qualified and Experienced Personnel
Individuals who have the skills, knowledge and experience to perform the role competently.

Steering Group
A group of people with responsibility for "steering" the project to a successful conclusion, to which the project manager or project director would report. Normally client senior managers, e.g. finance, marketing, research, operations, but may also include contractor management when an alliance exists.

Term Agreement
A contract, normally between client and contractor, that initially exists for a fixed term, e.g. 3 years for the supply of goods or services. May include review and escalation clauses e.g. annually.

Value Management, Value Analysis, Value Engineering,

Formal processes for assessing and improving the value in terms of project CSFs, including the schedule, of a proposed design, piece of equipment or course of action.

Work Breakdown Structure
A formal process of dividing the scope of the project into a number of separate work packages in order to make the overall job more manageable and to provide suitable units against which to control costs and measure progress.

Workshop
A meeting, that could be a conference or symposium, at which the participants are expected to work by participating in a discussion, contributing their experience or being involved in the formulation of new ideas or the resolution of problems.

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17.1 Task Force Members

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