Major Projects Association

Is the secret of successful projects in the management of design and engineering?

Seminar 134 held at the Institution of Engineering and Technology, London
1st May 2007

Summary

Key conclusions

- Unrealistic budgets for engineering design continue to haunt major projects. Is this the result of mistimed value engineering or value for money processes causing options to diverge at a time in the project when they should be converging?
- Realistic estimates go with a mature understanding of the allocation and management of contingency.
- There is no substitute for upfront investment in concept, feasibility designs and testing.
- In space industry projects, 'zero design defects' are achieved by careful planning, a ban on non-essential functionality and late changes, and a structured approach to technology readiness – such as the NASA scheme of technology readiness levels (TRLs).
- System engineering is probably greatly underutilised in major projects. Focus on what is left to do rather than what has been done.
- Do not rely too much on quality management systems to protect engineers from their mistakes – engineers themselves have the responsibility for quality in their designs.
- Ensure construction (and/or manufacturing) experience exists in design teams.
- Make arrangements to measure design maturity. Use the measures in managing the project.
- Good design management demands attention to every detail.
- Domain knowledge in the hands of the project manager increases the chance of success.
- 'Intelligent client' understanding, acceptance and approval of designs is the key to success.
- Freeze design progressively on a 'late as possible' basis to reduce the risk of rework. After this, safety should be the only reason to justify a change.
- Invest in risk mitigation as a principle rather than risk assessment as an exercise.
- Have design reviews that assess design maturity rather than using them to approve milestone payments.

Introduction

Major projects face many hazards that can jeopardise success if not managed skilfully. Some of the risks facing project managers are foreseeable, others come as nasty surprises. One of the most critical determinants of project outcome lies in the management of design and engineering, which should clearly be controlled by the project manager. However, this is an area where problems can be expected to afflict every major project.

With contributions from various industry sectors, including highways, space, oil and gas, nuclear submarines and construction, the seminar looked at factors involved in the management of design from the viewpoint of the different stakeholders involved in a project. There were presentations on the ways in which design teams are drawn together, organised and managed, the influence of contractual relationships, and the importance of early and effective investment in design briefs and front-end engineering.

The highways sector

The management of major highways project design within an early contractor involvement (ECI) model was described. ECI means that the client employs the contractor as project manager, who then engages the designers; design is delivered by an integrated team consisting of the contractor, the designer and supply chain partners.

The cost of rectifying problems experienced with the design process was examined, and examples of the sort of design management issues that can impact on project outcomes outlined. For instance, the client may have an expectation regarding the budget, and if value engineering is used to improve the ratio of function to cost it becomes difficult to ‘freeze’ the design. The aim is to set a more realistic budget in the first place.

ECI is often started with new teams of client/contractor/designer who do not have historic project knowledge, and project managers who may have very different views on how a project should be run. Collaboration between the parties is therefore beneficial, and to achieve this culture of trust the co-location of designers under competent leadership is essential. Tensions between the contractor’s planners and designers may arise and must be managed: for example the planners will tend to link the scope of the work to the output, resources and constraints, whilst the designers wish to achieve maximum design from the resources before the project end date.

Some of the lessons learned were considered, for instance the importance of committing resources and solving buildability issues at an early stage, understanding the impact of late changes on the designers’ workload and the need to introduce productivity measurement into highways design management.

The space sector

Some of the managerial issues involved in developing novel and complex instrumentation in the space industry were explored, including effective risk mitigation through up front investment and the creation of credible ‘roadmaps’; retaining a consistent development philosophy in the face of programmatic pressures; monitoring real progress (rather than false metrics); and retaining focus on the key project objectives and stakeholder needs.

Space research is a competitive, time consuming and expensive environment, and since it is allocated relatively little money, projects have to provide good value. This means there is a tension between producing the best piece of technology, which does everything that it is designed to do, and producing equipment that might not do anything useful when it reaches space: that requires some very effective risk management. In the space industry risk mitigation is achieved through, for example, endless studies, technology readiness levels, serious risk assessment and a pervasive risk adverse culture.

The life cycle of a project begins with establishing visions, envisaging functions, creating roadmaps and developing the relevant underpinning technologies, a process that may take 5–20 years. Early involvement of contractors is key, working with the scientific community to develop relevant leading-edge technologies that will provide a competitive edge.

Reviews are another key feature within the industry: there are specific points beyond which the design is frozen, after which the work is about focusing on the concept and minimising change, followed by controlling how the equipment interfaces with the rest of the spacecraft. One of the lessons learned from space research is that last minute changes which are not properly controlled and thoroughly thought through can be disastrous – some 50% of last minute changes lead to failure.

The oil and gas industry

In delivering major projects in the oil and gas industry the project manager must manage a business, with all the attendant risks and challenges. High risks are embodied in the forms of contract, schedules, costs, technology and current market conditions, often working in countries with a low or non-existent safety culture.

Some of the design and engineering management issues facing the industry were outlined.

The industry’s top priority is to deliver a safe plant, safely. Thus safety is one of the key factors driving and managing the design process, for example by designing so that as much as possible can be fabricated in the controlled environment of a factory.

The project team is likely to be spread around the world with much of the detailed engineering being executed in low cost centres. The various locations and specialist companies must work to common methodologies and goals, with the interfaces understood and managed.

Construction and supplier input at the early stages of engineering and throughout the duration pays dividends for the project, but it was pointed out that to keep the project under control it is essential to manage individual expectations at the design stage.

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Robust conceptual and front end engineering packages are the key to defining project scope, budget and risk profile. By making sure the front end design is detailed and thorough helps to reduce scope creep.

The project manager must create a climate in which all participants understand and commit to the project goals, and avoid the dangers of over-engineering and change. The only criteria for design change should be factors such as safety and external circumstances. However, change will occur, and the systems and culture to manage it are important.

Large urban regeneration projects

Realising the potential of large urban development sites, where there are a great number of interested parties, often creates conflicts of interests between developers, landowners, local authorities and designers.

Managing the challenges faced by designers in satisfying the demands of these stakeholders was discussed, with reference to the regeneration of the 1960s Feltham Town Centre, a new build development of supermarket, retail space, library, medical centre, hotel and residential units on the edge of West London.

The engineering design involved a number of different organisations. The importance of the relevant expertise of individuals involved in the construction process was noted: the building of different structures is no longer just about defying gravity, but about coordinating user requirements into a structural form which is cost-effective.

One recommendation put forward to delegates was to involve engineers with the lawyers as early on as possible in a project, to make sure that the terms used in an agreement are fully understood. In the case of Feltham Town Centre development plan, interpreting the interface requirements and responsibilities between the various participants was not easy, and led to some loose definitions. This in turn meant that different stakeholders had different interpretations as the project moved forward, making implementation more difficult.

Some of the current sustainability issues that designers and developers now have to tackle were outlined, for example reducing the energy consumption of buildings; using recycled and reclaimed construction materials; using natural ventilation via underground ducting to channel cooled air into public places; and looking at ways of reusing heat generated by combined heat and power (CHP) plants.

The nuclear submarine industry

Nuclear submarines are one of the most complex products in the world today and present a challenge to design and build.

In the case of the new Astute class submarine the design programme entailed fitting what is essentially a nuclear power station plus a hotel and a large amount of weapons and supporting equipment, into a relatively small space. The challenge was further complicated by the first time use of 3D CAD modelling technology and an almost 20-year gap since the last submarine design programme.

The programme slipped three years, with engineering design being the critical phase where most of the slippage occurred. The business in general and the project management in particular did not have the appropriate experience, controls and infrastructure to recognise and respond to the problems.

The management problems and some of the measures introduced to improve the control of the engineering process were considered. For example, the political and contractual environment in which the Astute programme operates is complicated. Started in 1996, the early years of the programme saw significant changes of staff, two changes of ownership and ten name changes. Key people in the prime contract organisation were located in different parts of the country, some in Farnborough but most in Barrow in Furness. By 2003 the problems had come to a head, and this precipitated a change of leadership and contract.

Following a high level ‘red team’ review involving key UK and US Defence Departments and Navy personnel, there is now a single organisation, clear roles, common objectives and expectations. A number of lessons learned, for instance making sure that engineering solutions are ‘demonstrably mature’ before release to production, and that project management is specific and appropriate to the product.

Operational improvements include using the correct project management tools, appropriate project planning, phase reviews (using industry experts), earned value management (EVM) to provide reliable management information and use of key engineering design metrics. Underpinning all of the measures is investment in improving people relationships, behaviours and communications between the teams.

Managing creative design on major construction projects

Successful management of design engineering requires clear reporting on progress and expected outturn; it requires regular communication, simple reporting and tracking of key issues, attention to the designer’s health and safety log and its interaction with construction safety, trend management of deliverables and risk management.

The conventional approach to major construction projects has been one in which the client, the designer and the contractor have clearly distinguishable roles. That is becoming less common and some new ‘joined up’ thinking is needed to decide the best way in which the parties can be integrated

The numerous factors and processes involved in successfully developing and managing design in a major infrastructure project were examined in detail, with particular reference to the £5 billion Channel Tunnel Rail Link (CTRL) project.

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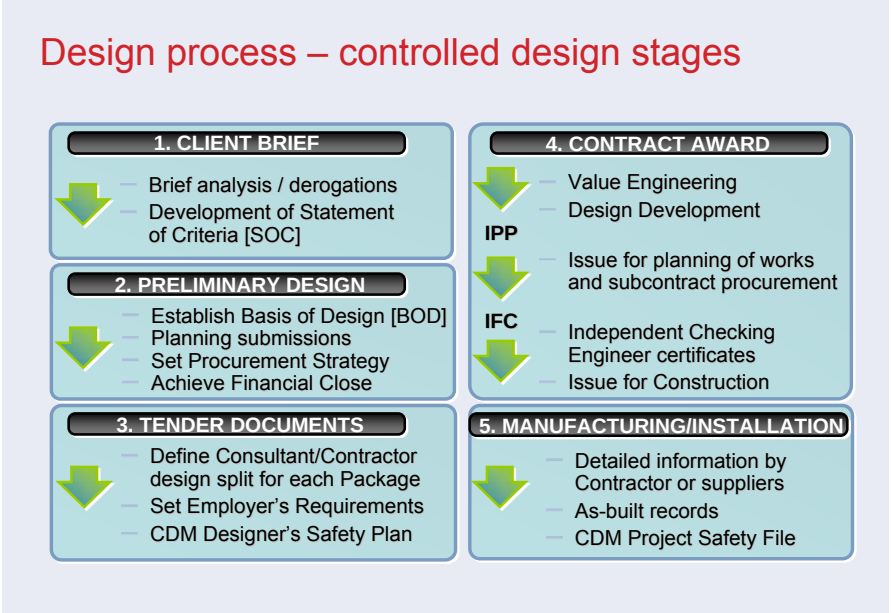
For example, the advantages of early contractor involvement were questioned. It is better to have client control of the design development before making commitments to the major costs of construction. Thus the need is not for early contractor involvement, but for construction planning skills which enable the development of a procurement strategy, and an understanding of how complex phasing issues will influence the final design. On the CTRL project a conscious decision was made to ensure that project definition, approvals and consents, construction planning, sequencing and particularly packaging were established before engaging the contractors.

Alignment of the project objectives between the client and the design team is absolutely crucial, with clear, controlled design stages from the client brief to the manufacturing or installation phase. These stages are fundamental to the success of a complex project. The illustration below shows the stages used on the CTRL project.



CDM: Construction and Design Management (Health & Safety Executive regulations)

IPP: Issue for Planning and Procurement

IFC: Issue for Construction

Other factors looked at included the role of value engineering, the reporting of key issues, measuring design progress project controls and the management of the design process: on CTRL there was a classic matrix management scheme, which monitored and matched design quality with design delivery. Co-location with the client was crucial, particularly in the early stages.

Conclusion

The question asked in the seminar was whether the secret of successful projects depended on the management of design and engineering.

The Chairman concluded that if the design is really understood, it is clear what the client wants delivered and change can be managed, then delivery of a successful project is likely.

Participating organisations

Advance Consultancy Ltd
Amey
Atkins plc
BAA plc
BAE SYSTEMS, Submarines
Balfour Beatty plc
BMCE Bank
Bovis Lend Lease
BP International Ltd
BP Oil International
British Energy
British Telecommunications plc
CJ Associates
Cross London Rail Links Ltd
Costain Ltd
CSE International Ltd
EDF Energy
Electronic Data Systems Ltd
Emcor Rail Ltd
Henley Management College
Imperial College London
Integrated Systems & Strategy
John Laing plc
KBR
London Development Agency
Major Projects Association
May Gurney Integrated Services
Metronet Rail
Mott MacDonald Group Ltd
Mullard Space Science Laboratory
Mustang Engineering
National Air Traffic Services Ltd
NUKEM Ltd
Ove Arup & Partners
QinetiQ
Risk Solutions
Scott Wilson Kirkpatrick & Co, Ltd
Sir Robert McAlpine
University College London