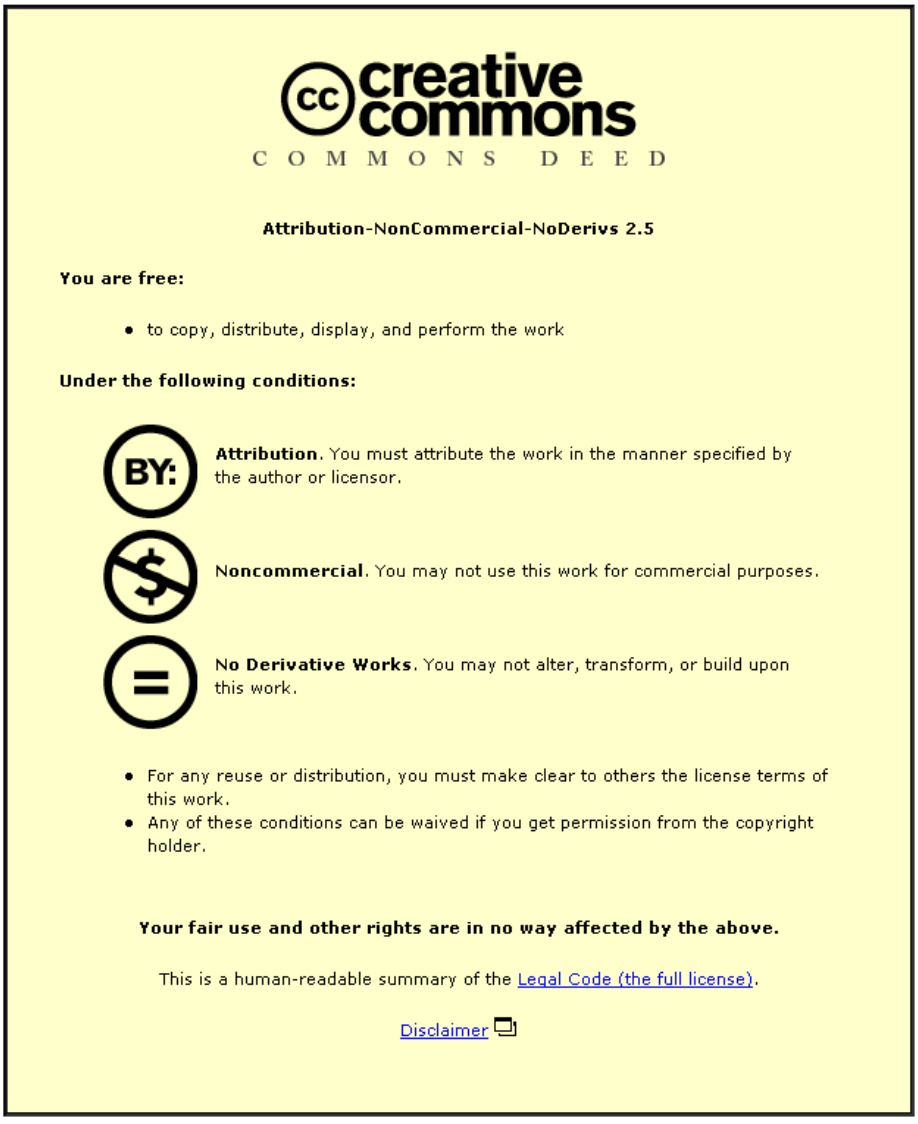
View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Loughborough University Institutional Repository

This item was submitted to Loughborough's Institutional Repository (https://dspace.lboro.ac.uk/) by the author and is made available under the following Creative Commons Licence conditions.



creative commons

COMMONS DEED

Attribution-NonCommercial-NoDerivs 2.5

You are free:

- to copy, distribute, display, and perform the work

Under the following conditions:

Attribution. You must attribute the work in the manner specified by the author or licensor.

Noncommercial. You may not use this work for commercial purposes.

No Derivative Works. You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

Your fair use and other rights are in no way affected by the above.

This is a human-readable summary of the Legal Code (the full license).

Disclaimer

For the full text of this licence, please go to:
http://creativecommons.org/licenses/by-nc-nd/2.5/

The Analytical Design Planning Technique (ADePT) experience

by

David Scott, FCIOB, *Laing Limited*

Simon Austin, BSc PhD CEng MICE, *Department of Civil and Building Engineering, Loughborough University*

Paul Waskett, BEng, PhD, *AMEC Capital Projects*

1 Background

The Analytical Design Planning Technique (ADePT) project has its roots in the early 1990's when research at Loughborough University developed a possible solution to the problem of inadequate planning and management of the design process in construction projects (Austin, Baldwin & Newton, 1994, 1996). This led, in 1996, to the successful application for grant funding under the Department of the Environment, Transport and the Regions (DETR) and Engineering and Physical Sciences Research Council (EPSRC) Integration in Design and Construction (IDAC) programme and further grant funding under the EPSRC Technology Transfer programme. Both of these projects involved significant industrial collaboration from AMEC, ARUP, BAA, Boots, Laing, and Sheppard Robson.

These grant funded projects closed at the end of 1999 (re Austin et al, 2000) with the ADePT project already winning a number of awards and plaudits, including: winning the Quality in Construction Innovation and Supreme awards in 1999; and an EPSRC research project top alpha 5 grading.

The ADePT project team (Loughborough University, AMEC Capital Projects, Laing Limited and Ove Arup and Partners) recognised a need to capitalise on the success of the research projects and to secure deployment of ADePT into the construction industry. With this intent the ADePT project team have secured the collaboration of the Building Information Warehouse in development and provision of a web based industrial tool (portal) called PlanWeaver due for release during the third quarter of 2001.

2 Why ADePT?

From the early stages of the ADePT project it was recognised that design for construction was compromised due to:

i. an incomplete understanding of the design process;

ii. failure to account for the iterative nature of design;

iii. planning based on the production of deliverables;

iv. design co-ordination focused on individual disciplines;

v. assessment of the effects of change proving problematic;

vi. client's lack of understanding of the process; and

vii. procurement systems biased to suit construction.

In fact, the ADePT work was targeting a number of key challenges for the industry that were subsequently highlighted in the government's Rethinking Construction report (Egan, 1998).

Testing of the ADePT prototypes, both research and industrial, has demonstrated that it:

i. provides a new, coherent approach to design planning, management and control;

ii. can identify of the optimal design programme;

iii. assists the decision-making that must be made to integrate the optimal design process with the overall project programme (especially the construction stage);

iv. improves the understanding of the effects of these decisions on cost, risk and design flexibility;

v. enables the scheduling of management tasks to suit the design process; and

vi. can reduce abortive work through the timely undertaking and approval of interrelated loops of design.

3 How does ADePT work?

ADePT is currently applicable to the process of detail design programme production for building projects and is intended to be applied towards the end of what is typically defined as Scheme Design (RIBA Plan of Work stage D). At this stage the ADePT project modelling routine will benefit from the level of design development inherent in the scheme design and deliver the best possible programme solution for the detail design stage. The technique consists of four principal stages. These are shown in figure 1 and described below.

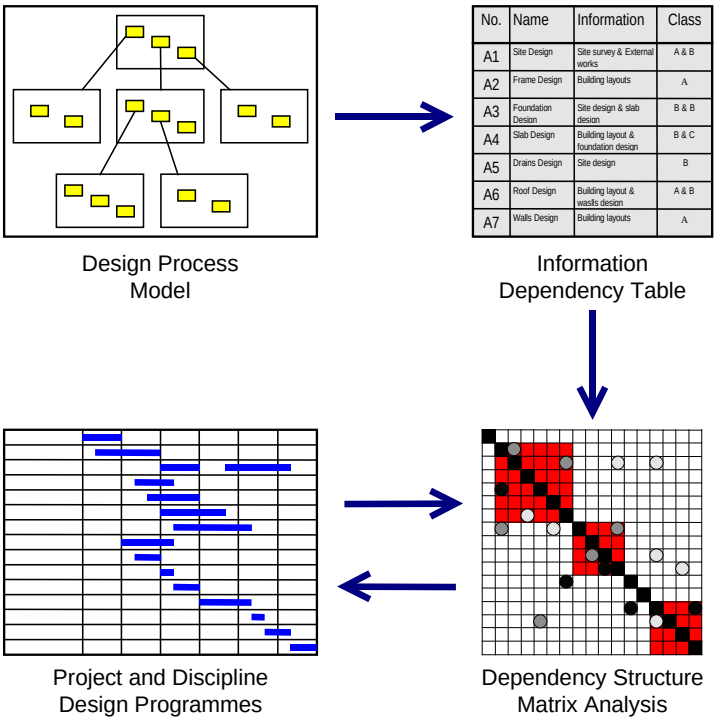


Figure 1 – the four stages of ADePT

3.1 Stage 1 – Generic Design Process Model

A significant proportion of the overall effort during the early stages of the ADePT project was expended in the development of a generic design process model. This displays (figure 2) a basic hierarchical structure of design disciplines (architect, structural, civil, mechanical and electrical engineers).

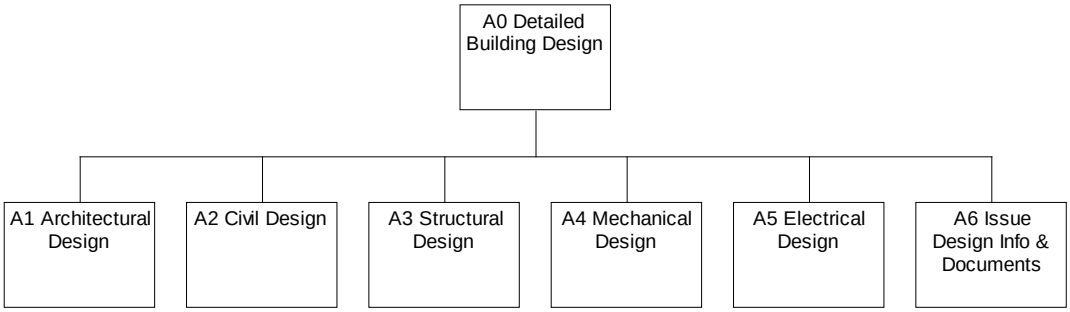


Figure 2 – Level 1 Hierarchy of ADePT Process Model

The resultant model contains over 500 native design tasks and 4,500 information flows between those tasks. There was significant concern within the project team that such a model should closely reflect industry norms and accepted practice. For this reason each part of the model was developed by one part of the collaborating organisations and peer reviewed by another in that discipline. It is noteworthy that it proved easy to get agreement on descriptions of the tasks and information flows, demonstrating a common understanding and their generic nature. Also, case studies were carried out on a number of projects to test how closely the task definition in the model matched the requirements of actual projects with the result that over 90% of the tasks in the project specific models were incorporated in the generic model.

3.2 Stage 2 – Information Dependency Table

It is not necessary for design managers and practitioners to understand the technicalities of process modelling. For this reason the generic model is presented in the form of an information dependency table, sorted and divided into disciplines as defined within the generic model (figure 3).

Activity		Information Required		
Number	Name	Name	Type	Source Activity
A 3 4 2 1	Lift Shaft Structure Calcs	Ground water levels	Cross-disciplinary	A 2 2 1 3
		Lift plans & elevations	Cross-disciplinary	A 5 7 1 3
		Lift shaft pit/head reqs	Cross-disciplinary	A 5 7 1 2
		Lift type	Cross-disciplinary	A 5 7 1 2
		Precast floor details	Cross-disciplinary	A 3 3 2 3 2 4
		Precast floor details	Cross-disciplinary	A 3 3 2 3 2 7
		Lifting beam details	Intra-disciplinary	A 3 4 1 4
		Plant floor details	Intra-disciplinary	A 3 3 2 3 1 4
		Plant floor details	Intra-disciplinary	A 3 3 2 3 2 4
A 3 4 2 2	Lift Shaft Structure Drawings	AC / vent layouts	Cross-disciplinary	A 4 2 3 5
		Lift control method	Cross-disciplinary	A 5 7 1 1
		Lift door opening details	Cross-disciplinary	A 5 7 1 1
		Lift levelling accuracy	Cross-disciplinary	A 5 7 1 1
		Lift motor room vent reqs	Cross-disciplinary	A 5 7 1 1
		Lift shaft pit/head reqs	Cross-disciplinary	A 5 7 1 2
		Precast floor details	Cross-disciplinary	A 3 3 2 3 2 4
		Precast floor details	Cross-disciplinary	A 3 3 2 3 2 7
		Lift shaft structure calcs	Intra-disciplinary	A 3 4 2 1
		Plant floor details	Intra-disciplinary	A 3 3 2 3 1 4
		Plant floor details	Intra-disciplinary	A 3 3 2 3 2 4
		Subcontractor's info.	External	
		Manufacturer's info.	External	
A 3 4 2 3	Lift Shaft Structure Specs	Lift shaft structure calcs	Intra-disciplinary	A 3 4 2 1
		Lift shaft structure details	Intra-disciplinary	A 3 4 2 2

Figure 3 – Information Dependency Table

Typically, a representative of each design discipline will modify the appropriate part of the generic model to better represent the specific requirements of the subject project. For example, the generic model contains tasks for three possible foundation solutions – piled, spread (pad) or raft – with the simple requirement that the inapplicable tasks be deleted. It may be necessary to add tasks to the generic model for tasks that are relatively exclusive to the subject project, however, it is also relatively easy to replicate groups of generic tasks and re-name according to the specific requirements. An example of the latter may be multiple HVAC extract systems where the generic model has provision for one.

During this process it is also necessary for the design manager(s) / practitioner(s) to estimate and allocate the strength of the relationship between the tasks. ADePT uses a three point scale ranging from A – the most critical and dependant – to class C – the least critical or easily estimable (figure 4).

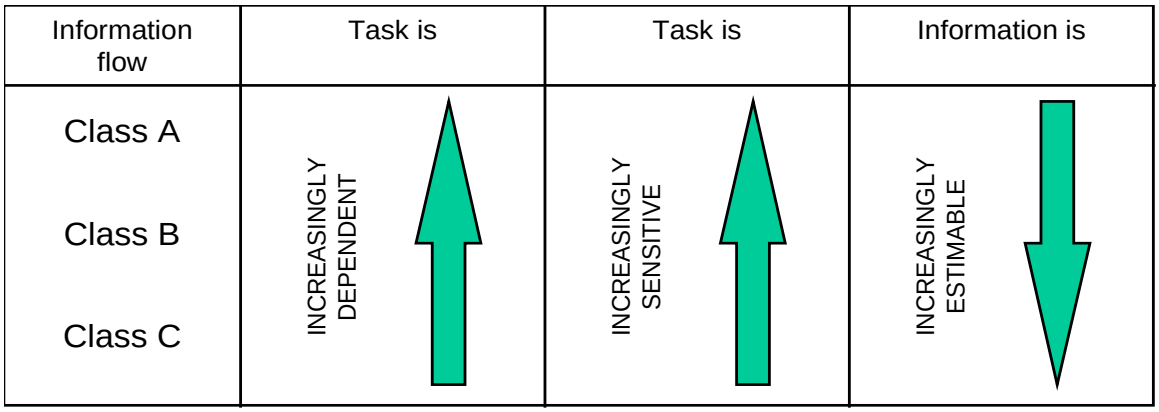


Figure 4 – Classification of Information Flow

When all data for the subject project has been collected a copy of the generic model is modified; through a simple user interface, e.g. spreadsheet; to create a project specific model.

3.3 Stage 3 – Dependency Structure Matrix Analysis

The ADePT software includes a matrix analysis tool to optimise the sequence of tasks in order to maximise the availability of information required and minimise the amount of unnecessary iteration and size of iterative loops within the process (some iteration is clearly desirable in designing an appropriate solution). The matrix analysis tool helps to sequence design tasks such that all dependant information flows are satisfied,

i.e. all tasks that output data to the subject task are sequenced to be executed prior to the subject task. Given that this is not possible in all instances the remaining 'blocks' of iteration are highlighted to the user.

An illustrative example of a design matrix is shown in figure 5.

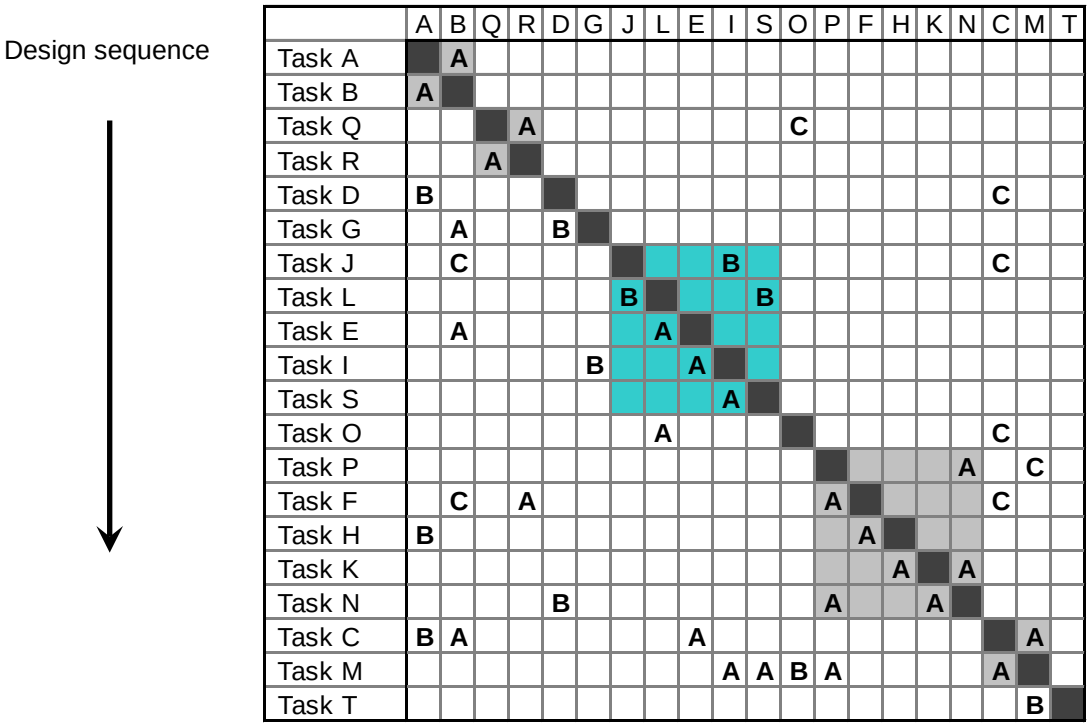


Figure 5 – Illustrative Design Dependency Matrix

In figure 5 it can be imagined that design tasks are initially listed alphabetically within disciplines in the rows of the matrix. The order is mirrored in the columns. A mark in the matrix represents a dependency of the task in the row upon the task in the column. The dependencies are weighted on a three point scale (A, B, C) on the basis of the strength of dependency, sensitivity of the receiving task to changes in the information and the ease with which the information can be estimated (figure 4). Dependencies

weighted A or B are considered critical, while C is not essential to the task and does not contribute to iteration in the process. If design is undertaken in the order on the matrix from top-left to bottom-right, a shaded block including marks above the diagonal indicates a need for iteration within the process. Figure 5(b shows a matrix following analysis to determine the optimal sequence of tasks such that iteration is reduced to a minimum.

This example, shown after optimisation, displays a number of desirable characteristics, including:

i. the classification of the dependency between each pair of tasks is clearly shown;
ii. dependencies of classifications A and B are clustered close to the topside of the diagonal (Note: any dependency below the diagonal is satisfied in respect of design sequence); and
iii. the remaining blocks of iteration are clearly highlighted for identification or further analysis.

This example is necessarily simplistic for the purpose of this paper. In the application of ADePT on construction projects the team have found an initially large iterative block encompassing 60% or more of all tasks in the matrix (which consists of several hundred tasks) necessitating a period of investigating the dependency logic to break down this block into a series of smaller, manageable groups of concurrent design activity. This process is addressed later in paper, but it should be noted here that this constitutes a process of declassification of key dependencies that aim to reduce

wasteful rework whilst retaining the useful, value-adding iteration necessary for good design.

The process of declassification introduces one of the major benefits of ADePT, that of informed decision making and risk management, which is addressed further in section 4.

3.4 Stage 4 – Project Design Programmes

In project planning terminology the result of the matrix analysis provides the task definition and logic or relationship data necessary to construct a network that can be analysed and managed in the chosen project management application. To date, this has been successfully achieved in three leading industrial applications and should prove capable of supporting any tool whose engine consists of an industrial standard database.

Further activity data can be collected at stage 2 – Information Dependency Table – such as activity duration and resources and this data made readily available for time and resource analysis within the chosen project management application. It is also feasible to populate the resultant programme with project management tasks and milestones, for example, the completion of a significant block of mutually interdependent tasks may signal an effective date for a review of design for that section of the works. Further milestones may be introduced to test compliance of the evolving design with the project cost parameters, particularly appertaining to sensitive elements.

Whilst the design programme has been allowed to evolve independently thus far it is necessary to test and integrate this with the intended programmes for procurement and construction. In doing so conflict will undoubtedly arise between the products of an optimised design programme and the demands of an often challenging construction programme. A typical example can be found in foundation design where the design programme may indicate a relatively late sequencing of activity to allow for accumulation of building loads whilst the construction programme naturally demands early release of such information.

These conflicts have to be rationalised, however; ADePT enables the timely identification of such conflicts (by moving activities in the matrix, which highlights critical dependencies above the diagonal) and the effective application of control measures. In the above example this may involve tendering on preliminary information, with the attendant risk of cost escalation, or making assumptions regarding certain building loads, entailing increased cost but reduced risk. These issues result in the possibility of further declassification of the design task interdependencies albeit with informed judgement and linkage to risk management. The net result is a fully integrated project programme consisting of what may be described as a sub-optimal design plan of work supporting an agreed procurement strategy and construction programme (figure 6).

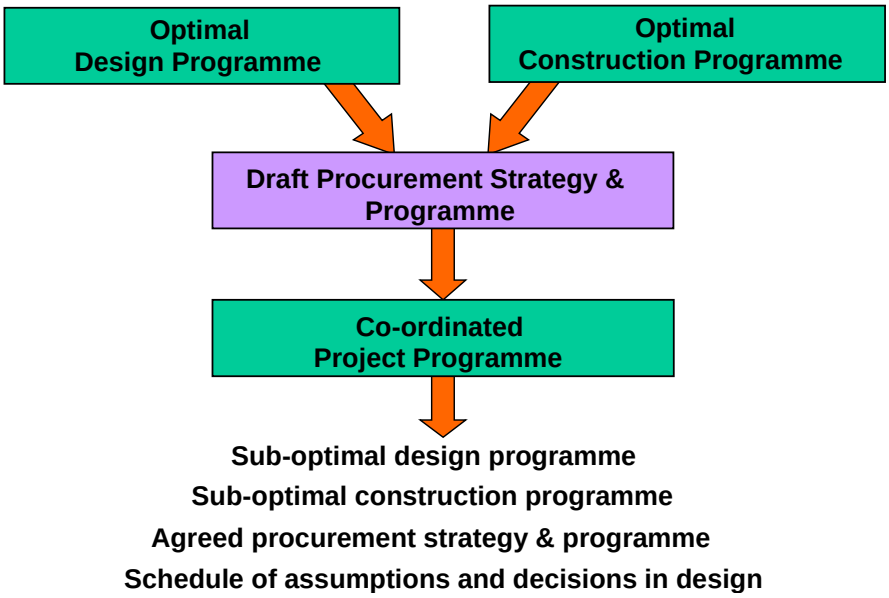


Figure 6 – Integration of Design and Construction Process

4 Project Experience and Lessons Learned

4.1 The issues

During the research project a number of case studies were undertaken in order to test the validity of the ADePT model and technique. This served to prove that the generic model contained design tasks that represented in excess of 90% of tasks encountered within the case studied projects. These projects, having fulfilled the purpose of proving the validity of the technique are not addressed further here.

Subsequent to the main body of research activity ADePT has been employed on a wide variety of live projects within the industrial collaborators' businesses varying in value from £2 to £180 million and there have been a number of significant findings that are described here. These findings fall into two distinct, but interleaved, groups:

- Hard issues
    - Change Management
    - Risk Management
    - Elimination of Waste
    - Integration and Co-ordination
- Soft issues
    - Trust
    - Confidence
    - Commitment
    - Collaborative Working

The range of project types (including hospitals, office developments, hotels, police and leisure facilities) and suitability of the generic Design Process Model have clearly demonstrated one of the Rethinking Construction principles, namely that whilst construction projects are unique, the underlying project processes are repeatable.

4.2 Change Management

The incidence of change within a construction project is generally unwelcome, but, many clients see change as an integral feature of their business and it is necessarily important to differentiate between opportunities for change to enhance the product and the typically harmful changes that so often inflict a project with time overruns and cost escalation. ADePT has been proven to make a positive contribution in a number of ways, in that it provides:

i. a more considered design programme leading to reduced incidence of change;

ii. a sound basis for the assessment of change impact;

iii. a mechanism for clear demonstration of such impact; and

iv. a finite programme for deferred decisions to be scheduled.

4.3 Risk Management

As introduced earlier one of the foundations of ADePT is the process of informed decision making. Every project upon which ADePT has been applied has required that interdependencies between tasks and their classifications be revisited in order to evolve the optimum design programme. It is usual that the design manager responsible for ADePT identifies a number of opportunities for optimisation and 'tests' these with representatives of the appropriate design disciplines (often involving several organisations). Responses may vary from acknowledgement of errors within the original input through acceptance of a lower classification (with or without implications), to rejection of the proposal (another solution must be sought). If a modified classification is accepted there is high likelihood of a commensurate risk with implications on cost, resources, time or quality. Such risks can be easily populated into the project risk management process and effective control measures applied.

4.4 Elimination of Waste

Of primary importance to the members of the design team is the efficiency gains that a properly analysed and sequenced design programme can bring to the process. These will result in two significant benefits:

i. direct efficiency in the design production process, saving on design fee expenditure and, ultimately, potential reduction in design fees; and

ii. benefits carried through in the form of reduced disturbance to construction – resulting from unwelcome design changes, late delivery of design information, lack of fit and need for rework – resulting in improved cost and programme performance, including predictability.

Despite the limited extent of factual supporting evidence there are lessons already being learned from applications to date. One example was on a hospital project in Scotland where it was demonstrated to the building services engineer that a short term hold on certain aspects of design would then allow that design to proceed with the benefit of all necessary inputs thus avoiding the need for subsequent rework (that has subsequently found to have occurred on a previous, similar project). Another example was on the second of two projects undertaken by the same design and construction teams where an element of cross-project learning led to a more intuitive approach to the design programme that immediately demonstrated efficiency in the design process.

4.5 Integration and Co-ordination

As indicated earlier ADePT demands and delivers, a process of integration across the project team. This has manifested itself in the effective use of design workshops, recognition of design co-ordination issues, truly collaborative working whereby the whole team recognises and focuses upon the key issues, influence upon team and

organisational structures and confidence to allow design to influence construction – refer to section 2 referring to design compromises. DOES IT?

4.6 Culture

As important as the tactile benefits detailed above, ADePT contributes towards project team performance by instilling an environment of trust, confidence, commitment and collaborative working. In such an environment individual members and parts of a project team cease to be as introverted as is typified within the industry, rather one finds greater emphasis upon shared ownership of the challenges and possible solutions that, in themselves, can deliver significant benefits to all participants.

5 How long does it take to apply ADePT?

Application of ADePT occurs in a number of distinct steps:

a) The project team are introduced and invited to commit to the ADePT process;

b) Data is gathered regarding the specific project;

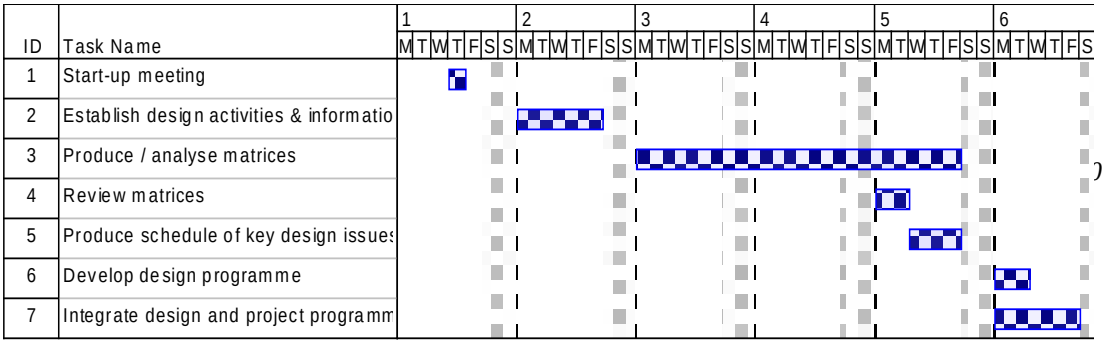
c) The process of data entry and initial analysis is executed;

d) The schedule of key design issues (declassifications) is reviewed;

e) The optimum design programme is produced;

f) Design is integrated with procurement and construction.

The baseline period for the planning process amounts to some five to six weeks; however, experience shows that this can be extended due to a shortfall in available



project data, maybe from a single discipline, or interruptions caused by other project priorities. A typical baseline programme is shown in figure 7.

Figure 7 – Baseline Programme for ADePT Planning

The matrix and programme are then used routinely through the project to completion to manage the process, particularly change control.

5 Summary

The testing and application of ADePT have demonstrated that it is a viable technique with which to plan, manage and control design work and aid integration of the design and construction processes. Through the use of process modelling, DSM analysis and the production of design programmes, the planning of building design can be approached in a more systematic, informed manner compared to current practice. This research has proven the viability of ADePT as a technique to plan and manage the detailed building design process, with benefits to be gained at all stages of the technique's application. Practising designers and design managers shown the ADePT methodology have been enthusiastic about the effectiveness of the approach and the detailed level of information that is represented: dissemination of the findings of this research project have generated interest from design managers from consulting, client and contracting backgrounds, totalling some 100 companies, reflecting the industry's need for improved design planning and management.

Given this enthusiasm for this innovative approach, the ADePT project team look forward to sharing the proven benefits of this technique with the global construction market through the launch of the web-based version of the application.

References

Austin S A, Baldwin A N and Newton A J (1994), 'Manipulating the flow of design information to improve the programming of building design', *Construction Management and Economics*, Vol. 12, , pp 445-455.

Austin S A, Baldwin A N and Newton A J (1996), 'A data flow model to plan and manage the building design process', *Journal of Engineering Design*, Vol. 7, No. 1, March 1996, pp 3-25.

Austin S, Baldwin A, Li B and Waskett P (2000), *The Analytical Design Planning Technique (ADePT) Projects: Design Information Methodology and Tools for the Management of Detailed Building Design and Link IDAC100 ADePT Technology Transfer Projects*, Final report for the EPSRC, Department of Civil & Building Engineering, Loughborough University, March, 22 pp.

Egan Sir J (1998), *Rethinking Construction: the Report of the Construction Task Force*, Department of the Environment, Transport and the Regions, London.

Contact and Submission Details

Authors:

David Scott
Laing Limited
Maxted House
13 Maxted Road
Hemel Hempstead
Herts
HP2 7DX
T: 01442 286682
E: david.j.scott@laing.com

Simon Austin
Department of Civil and Building Engineering
Loughborough University
Loughborough
Leics
LE11 3TU
T: 01509 222608
E: s.a.Austin@lboro.ac.uk

Paul Waskett
AMEC Capital Projects Ltd
On secondment to:
Department of the Environment, Transport and the Regions
3/F2, Eland House
Bressenden Place
London
SW1E 5DU
T: 020 7944 5724
E: paul_waskett@detr.gsi.gov.uk

Submission Details:
Dr Anne Beesley
Innovation & Research Manager
Chartered Institute of Building
Englemere
Kings Ride
Ascot
Berks
SL5 7TB
T: 01344 630734
E: abeesley@ciob.org.uk