Working Together

Tools for an integrated construction supply chain

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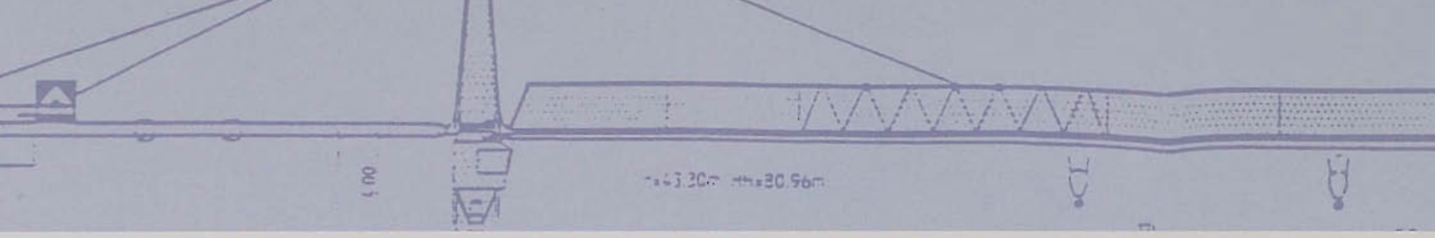


Foreword

We continue to strive for exceptional performance in all areas of our business, delivering a high level of capital efficiency with continuous improvement in our safety and environmental performance. Within BP Exploration there has long been the recognition that our performance is integrally related to the performance of the many supply chains which support our activity. BPX was one of the pioneers of the alliance concept in line with the CRINE initiative and continues to explore and promote the development of relationships and practices which improve performance through the supply chain. The tools within this handbook can make a difference, but a step change requires adoption of best practice by all, not just the enthusiastic few.

Mike Summers
Engineering Manager
BP Exploration
Wytch Farm

Contracting is as demanding as it is satisfying as each project contains something surprising and new. In this sense we are used to change but, as I hope you will see from this handbook, a large part of what we do is repeatable and can be viewed in terms of processes. Our job, along with the rest of the construction industry, is to develop systems and processes so that they match the client's needs now and in the future. If we do not continually change we will surely be left behind.

Mike Reed
Director
Trant Engineering Ltd.

The designer has to help the client to develop the brief. The contractor and suppliers have to help the designer with their details and the client has to help both designer and contractor with knowledge of the existing site conditions and with firm decisions. Close co-operation and the timely supply of information will lead to an improved construction process and benefit all parties.

Jim Gill
Design Consultant
R. J. Watkinson and Partners

Introduction

Objective

The objective of this handbook is to explain what is described as a Business Systems Engineering approach (BSE) to improve the performance of the construction project supply chain, in other words the whole of the construction operation from the client's specification of requirements through to the hand-over and subsequent operation of the project, be it a bridge, hospital, supermarket, dam, airport or highway.

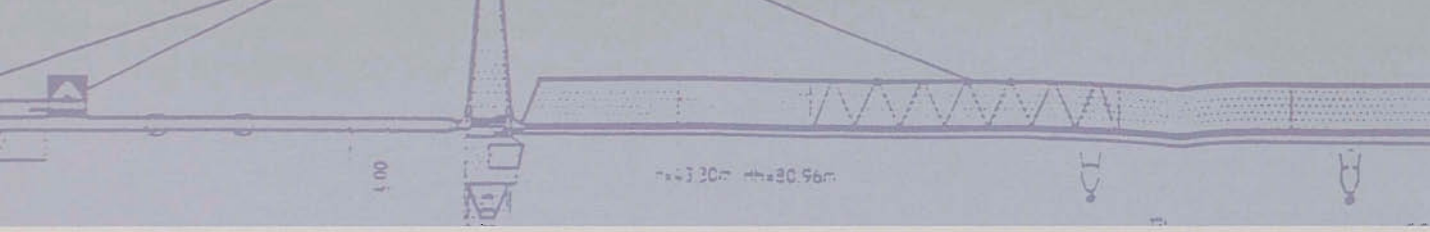
By improvement it is meant that the client will receive a better job in terms of cost, schedule and construction time, quality and operating efficiency i.e. – fitness for its task.

This is achieved by changing the attitudes of the parties involved in the construction process. Confrontation and competition within the project are replaced by a unity of purpose which is described as 'partnering' or 'alliancing'. It requires a high degree of mutual understanding and especially trust with the sharing of relevant information at all levels. The rewards for such practice have been shown to accrue not only to the client through the avoidance of duplication of effort, wasted time and unnecessary work but also to all the participants involved in the project since the improvements obtained reflect directly upon the viability and competitiveness of the project team as a whole.

Background

"The organisation which operates using a systems approach delivers better engineering throughout all its activities."
(John Parnaby, former Group Technical Director, LucasVarity plc., Institution of Electrical Engineers Presidential Address)

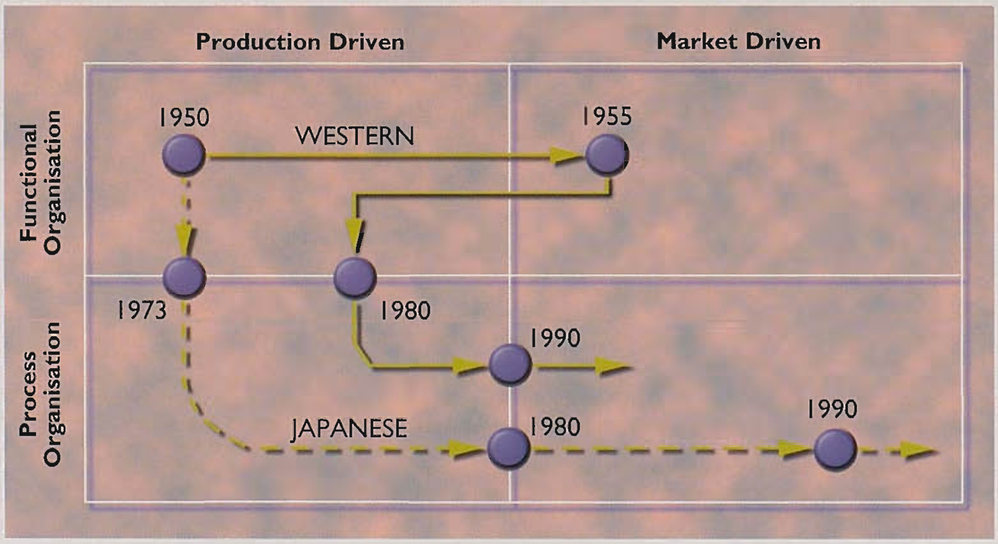
In 1995 the Royal Academy of Engineering set up the Construction Sector Inquiry Panel. In their final report the Panel were upbeat on the 'best practices' observed within the sector, but very concerned with the 'long tail' of poor industry performance. This gap between the best and the rest was thought to be largely responsible for the loss of UK construction projects to overseas competitors. One of the recommendations put forward by the Panel to close the gap was to accelerate the transfer of appropriate knowledge and techniques from other market sectors. Most notable was the concept of regarding construction as a manufacturing process, a theme strongly echoed by the Engineering and Physical Sciences Research Council's Innovative Manufacturing Initiative Research Programme of the same name. In this Handbook we explore how Business Systems Engineering (BSE) tools, techniques and methods may be successfully applied in construction supply chains. BSE has evolved over a number of years and through a variety of routes. It has been tried and tested in many market sectors including aerospace, automotive, banking, mechanical, electrical and pharmaceutical.



The use of BSE has led to many industries adopting a process orientated approach. This means that companies have had to move away from being driven only by the concept of their own individual production processes and recognise that they form a part, or link, in a total supply chain. They therefore learn to respond and relate to the larger market scene. The Japanese were amongst the first to realise that this required a fundamental rethinking of the whole organisational structure. In the West many industries initially attempted to solve the problem of complexity not by simplification but rather by the introduction of new technologies and automation. They soon came to realise that their market demands could only be met by the elimination of waste in all its forms including waste time, waste materials, waste management effort and waste computing power. The challenge for the UK construction industry is rapidly to adopt these techniques whilst recognising, and thereby avoiding, the many pitfalls which other industries have experienced.

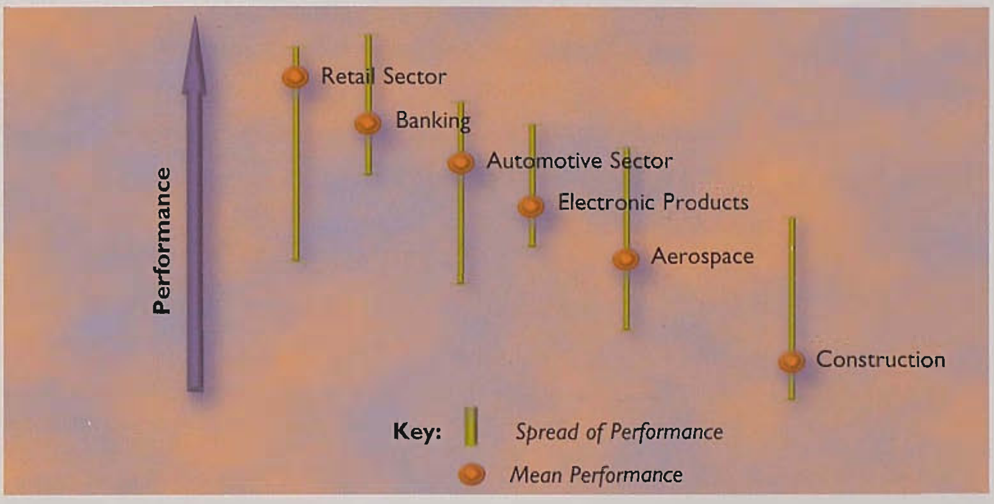
BSE is concerned with 'engineering' the whole business process in a manner which is exactly similar to that of 'engineering' the product or service which is provided for the client. It is a methodology (with a set of well tried management tools) which is aimed at improving the process system. The better understanding of the 'how' of doing things will, at the same time, lead to increased business profitability. The methodology concentrates on enhancing overall performance through improving important measures such as delivery lead time, total cost, adherence to schedule, compliance with safety requirements and quality. The discrete tools are, of course, already familiar in construction. The novelty is to weave them into a system in which all participants in the chain are fully involved and in total communication at all times.

Process Oriented Drive (from Merli, in Johansson et al., 1993)



The diagram above compares the routes taken by Japanese and Western industry in the drive towards process focused and market driven organisations. It can be seen that the route taken by Japanese industry is more direct than that taken by Western industry, with Western industry now lagging significantly behind the Japanese.

A Realistic Perception of Construction?

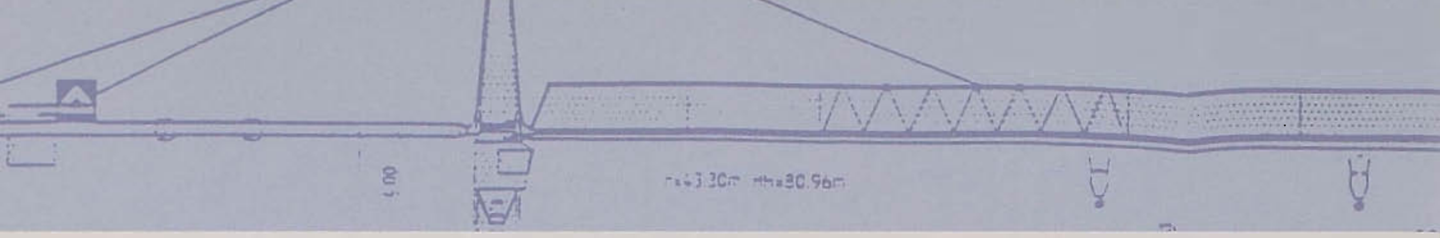


The diagram above shows the generally perceived view of the performance of the UK construction industry in comparison with the performance of other industrial sectors. It is through the use of BSE and the adoption of a process oriented drive that this situation can ameliorated.

Process Oriented Drive For Construction

The tools described in this handbook provide the means for the construction industry to make the step change depicted in the diagram above and thus provide the means for UK construction to lead the world.

A great advantage of learning from the past application of BSE to a wide range of market sectors is that it is already known 'what' needs doing. For example, there is considerable evidence that the key enabler in process improvement is to engineer the 'how' of doing things so as to reduce such things as cost, defects and Total Cycle Time (TCT).



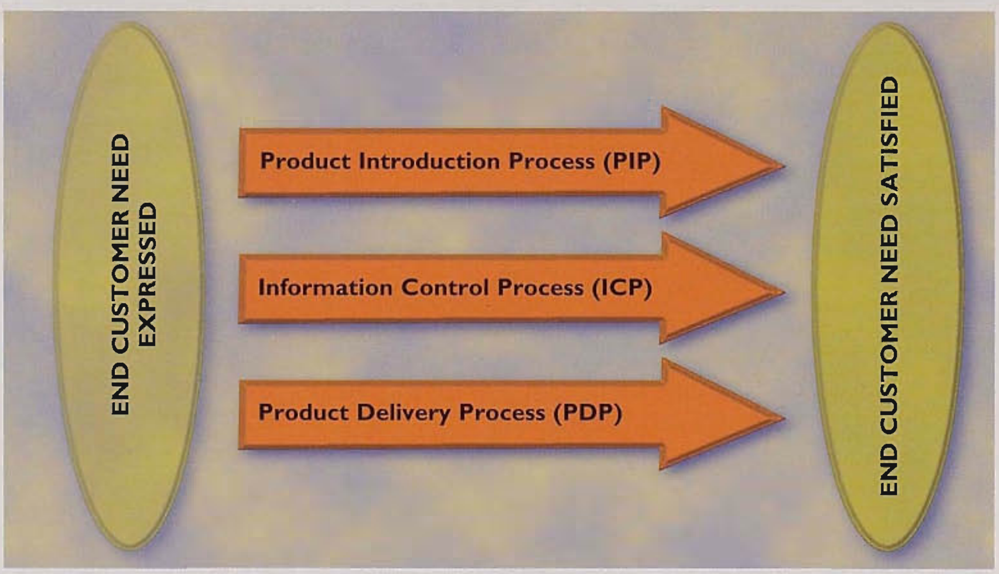
TCT is the time from conception to commissioning. By properly 'engineering' the business processes to reduce TCT the company's 'bottom line' performance is always leveraged. By adopting such a procedure, experience suggests that quality and safety levels will, not only be maintained, but significantly improved.

What is a Business Process?

"A linked and natural group of skills and competencies which start from a set of customer requirements and delivers a high quality total product or service to a competitive target cost and in a competitive lead time."
(Definition of a Business Process,
Royal Academy of Engineering Construction Industry Report, 1996)

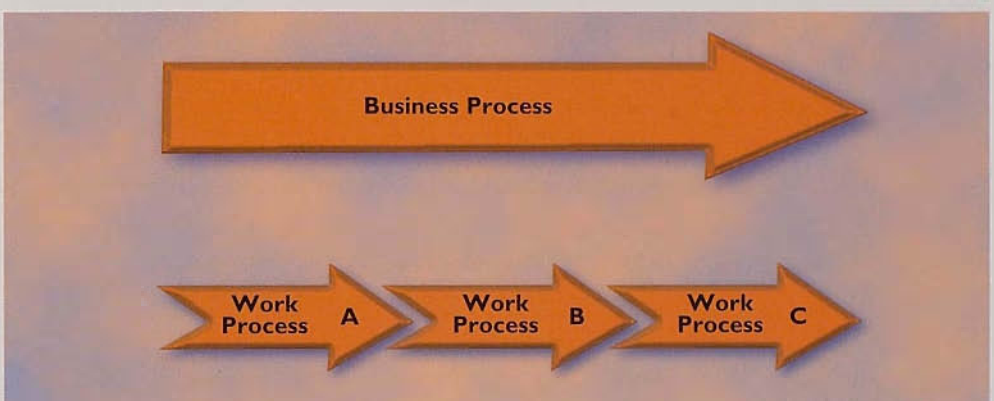
A single organisation or a whole supply chain will be made up of a number of business processes. Three generic candidate business processes, found in most manufacturing companies, are the Product Introduction Process (PIP), the Information Control Process (ICP) and the Product Delivery Process (PDP). The business processes should be focused on the end customer's requirements and not just the next customer in the supply chain. Therefore business processes must cut across organisational boundaries.

Candidate Business Processes



Each generic business process can be decomposed into sub-processes and work processes. Decomposition of business processes, as shown below, provides a clearer insight into the workings of an organisation and allows wasteful and inefficient processes to be readily identified and re-engineered.

Decomposition of Business Processes into Work Processes

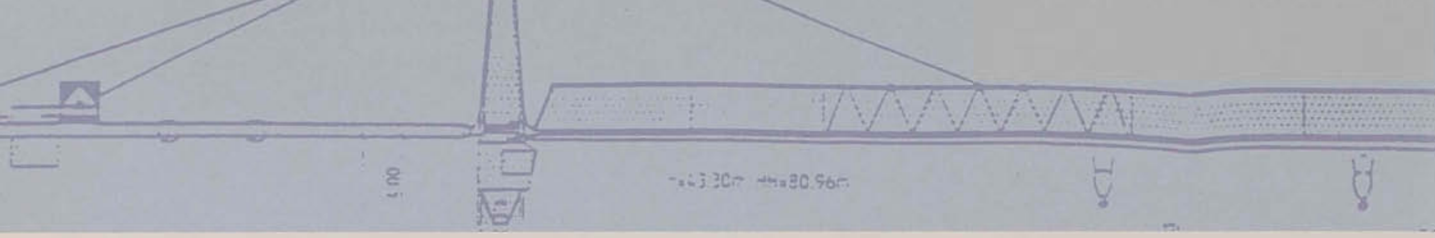


(Watson, 1994)

A BSE view of a business process considers not only the process itself but also the interfaces between sub-processes or work processes that exist within an enterprise and the flows that occur between them.

It is the ability to ensure a seamless flow of materials, cash, information and resources between all parties in the construction project that will enable a business to compete more successfully and provide greater value for money to the client.

> ***Each work process is a "kernel that may be used to grow the entire organisation as it is grafted onto other work processes to form business processes."***
> *(Gregory Watson, "Business Systems Engineering: Managing Breakthrough Changes for Productivity and Profit", 1994)*



What is a Construction Supply Chain?

A Supply Chain is the channel through which value is added to a product for delivery to an end user.

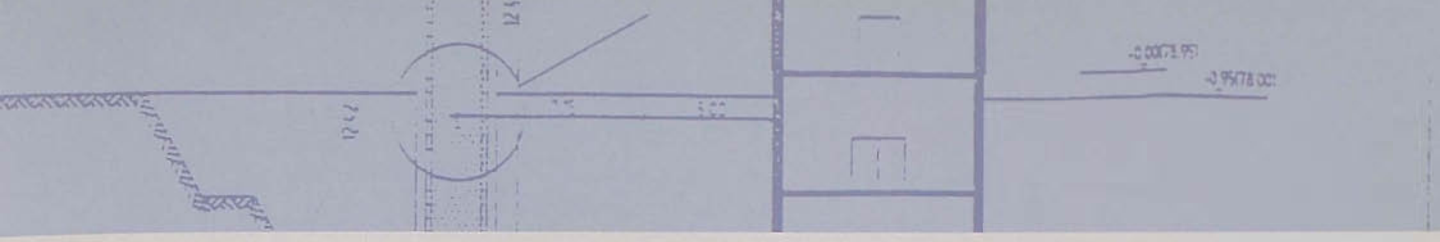
Value can be added by either supplying and installing physical artefacts or by provision of a service. This is achieved by assembling organisations, such as consulting engineers, architects, contractors, sub-contractors and suppliers of plant, labour and materials to deliver a finished product for a client. It is the client together with all of these organisations that form the supply chain for a particular project. Traditionally this supply chain disintegrates on completion of a project, but with contractors increasingly becoming involved in facilities management and with the Construction (Design and Management) Regulations 1994 requiring designers to consider the whole life cycle of a project, including decommissioning and re-cycling, supply chains are starting to remain intact over the whole life of a project. Frequently, however, the ***actual end user*** of a project is not involved in the supply chain at all. A project is often designed, built and handed over to a client, such as a property developer or an estates and buildings department, who believe that they know what the ***end user*** wants – a belief that is sometimes misplaced! So the ***actual end user*** should be part of the project supply chain if possible.

The scope of the supply chain varies from project to project but may include:

- Clients
- Consultants
- Local Authorities
- Environmental Agency
- Architects
- Design and Engineering Agencies
- Main Contractors
- Sub-contractors
- Material Suppliers
- Plant Suppliers
- Labour Suppliers
- Commissioners
- End Users.

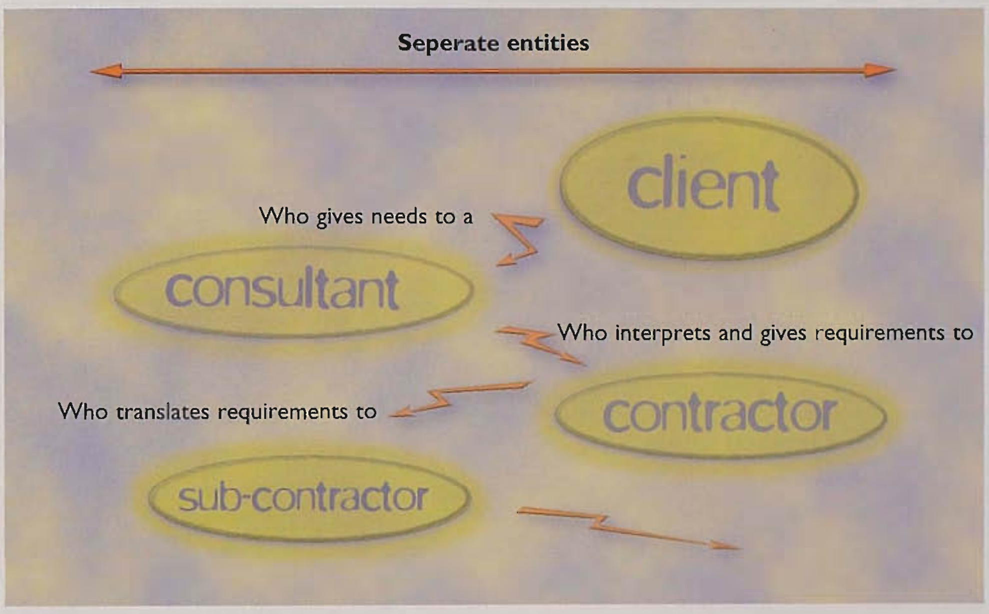
The supply chain is therefore composed of a large number of interested parties who participate to deliver the project. Each player is seen as simply one link in a long chain. The underlying connections are the flows of information, resources, materials and cash within the chain and this is fundamental to understanding how the supply chain can become effective in meeting clients' needs. Supply chain management is the concatenation of these parties.

The Business Systems Engineering approach to supply chain management requires a big picture view first and a realisation that the individual parts of a system in themselves do not make up the whole; it is the parts and the linkages between them that constitute the whole. It is how the separate parts are brought together that yields the maximum leverage when competing for a client's business. In order to do this it is necessary to focus on what the client wants, enabling products to be delivered faster, cheaper, better and safer than by competitors. To achieve this it is essential to ensure that seamless

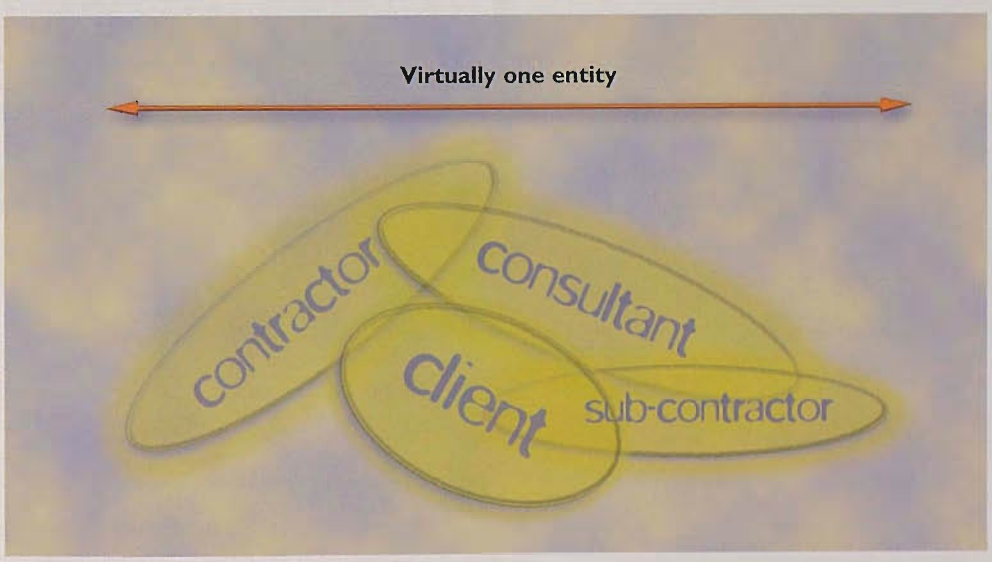


interfaces are created between individual businesses. This helps ensure that the flows in the supply chain are unobstructed and that, as far as possible, only value adding activities are undertaken in the process.

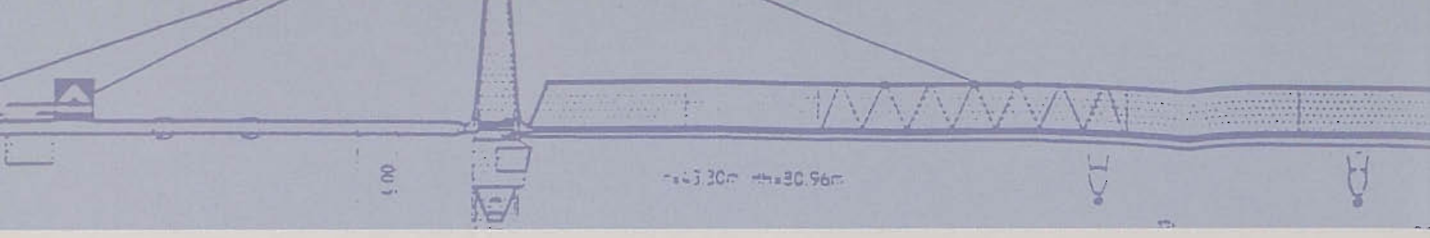
The Traditional Fragmented Construction Supply Chain



The Integrated Construction Supply Chain



In the above diagrams sub-contractor includes both domestic and nominated sub-contractors and suppliers of plant, labour, materials and specialist consultants. By forming one virtual entity, as indicated in the above diagram, the project participants are better equipped to deliver a project which meets with the client's expectations.



Understanding your Internal Supply Chain

A clear understanding and efficient management of one's own internal company 'supply chain' is nescessary before embarking on the management of the supply chain of the entire construction project. A start to achieving this clear understanding is from the formal records and other written documentation within a company including quality assurance management systems, quality assurance records, purchase orders, sub-contractor procurement systems, health and safety records and non-conformance reports. However, care needs to be taken to ensure that these identified procedures are followed in practice.

Investigation of the internal supply chain of Trant Engineering Ltd used a range of data and information sources as shown in the table below. This investigation was conducted by informal conversations, 'walking the process', formalised interviews and questionnaires.

Information and Data Sources and Their Usefulness for Internal Supply Chain Analysis Undertaken within TEL

Information & data sources	Degree of utilisation			Value of contribution		
	High	Medium	Low	High	Medium	Low
Contracts			●			●
Databases			●			●
Manuals		●			●	
Directors		●		●		
Managers	●			●		
Documentation	●					●
Foremen/operators			●			●
On Site Analysis	●			●		
Process Mapping	●			●		
Input-output Analysis	●			●		

Practical Example

One particular project undertaken by Trant Engineering Ltd. required that the client be provided with formalised information on the progress of the works. Input-output analysis and process mapping together highlighted two wasted activities for one particular person on-site. Every week a report was generated for the client, but tracking the report into the client organisation highlighted that the report was never read. Additionally, the process chart, reporting internal daily returns, showed duplication. Four hours spent on process mapping this person's entire work practices resulted in an annual saving of 80 hours wasted time.

Many main contractors require, as in this example, similar weekly plant and labour returns from their sub-contractors. These frequently have to be produced in a format that is different to that used by the sub-contractor concerned for their internal use and in spite of the time and effort needed to produce them by the sub-contractor they are often just filed away by the main contractor.

Internal Process Hierarchy

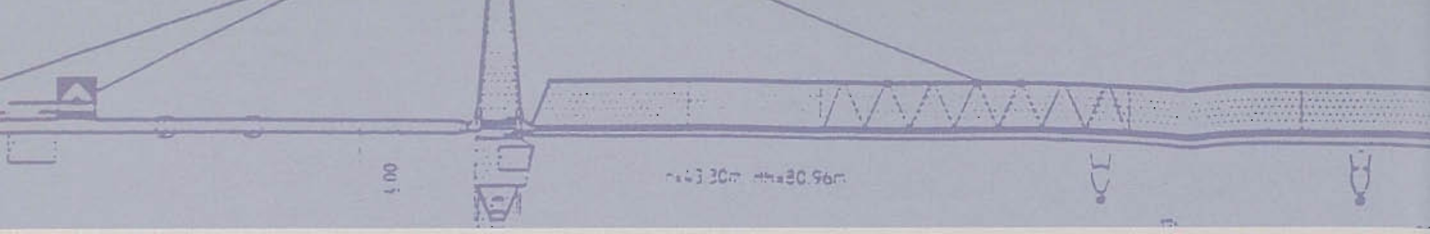
The core business processes describe the main sequence of activities which start with a customer expressing a need and finish with the customer's need being satisfied by using the company's resources. It is the reason that the client comes to the company's door in the first place. For Trant, the client asks for two fundamentally different things:

1. To provide a price, tender or schedule of rates for a scope of works.
2. To perform the works as specified in a contract.

Many construction companies will include marketing as a distinct third core business process. Marketing is the linked set of activities that ensure that a match is found between the client's needs and the attributes of the company. It is the first work process of Trant's 'bidding and acquiring business', core business process.

In order for Trant to satisfy their clients' needs requires the planning and co-ordination of a number of periphery activities to enable the core business processes to function effectively over the short, medium and long term. These additional activities can be described as non core business processes; and include planning, co-ordination, control and cash flow management. Making a clear distinction between core business processes, non core business processes and work processes allows structured management effort to be focussed on any subsequent re-engineering of the processes.

Modelling the business processes allows the costs and reasons for committing resources to be questioned.

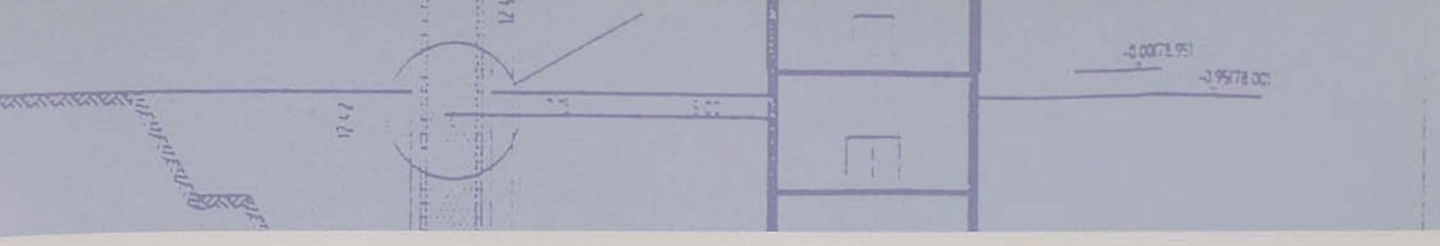


Within a construction company a large number of work processes are present which combine to form business processes. As an example, within Trant Engineering Ltd., 28 work process, two core business processes and two non core business processes have been identified. These are shown in the following table.

Breakdown of Business Processes into Work Processes within Trant

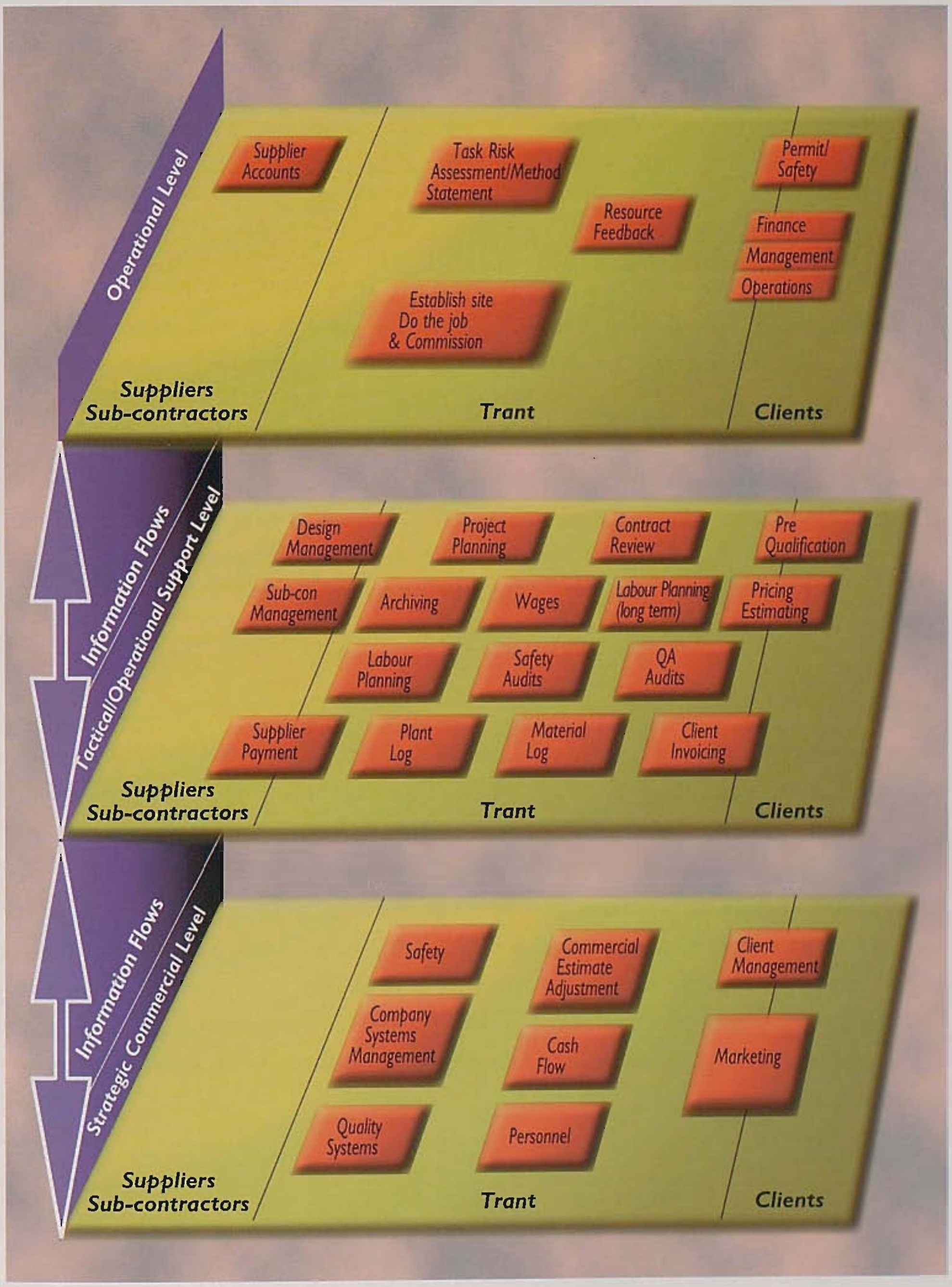
	Business Processes			
	Core		**Non Core**	
Work Process	Bidding & Acquiring Business	Construction and Commissioning	Planning Co-ordination and Control	Cash Flow and its Management
1. Marketing / Pre-qualification	✓		✓	
2. Estimating, pricing, budget enquiries	✓	✓	✓	✓
3. Client management	✓	✓		✓
4. Contract review		✓	✓	✓
5. Design management	✓	✓	✓	
6. Project planning & technical support			✓	
7. Site establishment		✓		
8. Material / Purchasing control		✓	✓	
9. Plant allocation			✓	
10. Safety management action		✓		
11. Labour planning (short term)			✓	
12. Labour supervision		✓		
13. Raising permits		✓		
14. Manage sub-contracts / Suppliers		✓	✓	
15. Physical site tasks		✓		
16. Resource feedback to client				✓
17. Client invoicing				✓
18. Hand-over		✓	✓	
19. Supplier payment			✓	✓
20. Company systems			✓	
21. Labour planning (long term)			✓	
22. Personnel function			✓	
23. Wages		✓	✓	✓
24. Archiving			✓	
25. Accounts - other				✓
26. Cash flow management				✓
27. Office admin. misc.	✓			
28. Research	✓			
Total Labour only (%)	**4.9**	**68.5**	**20.1**	**6.5**
Total (Turn Over - Profit) (%)	**1.9**	**82.0**	**7.8**	**2.5**
Unallocated Costs (%)	**5.8**			

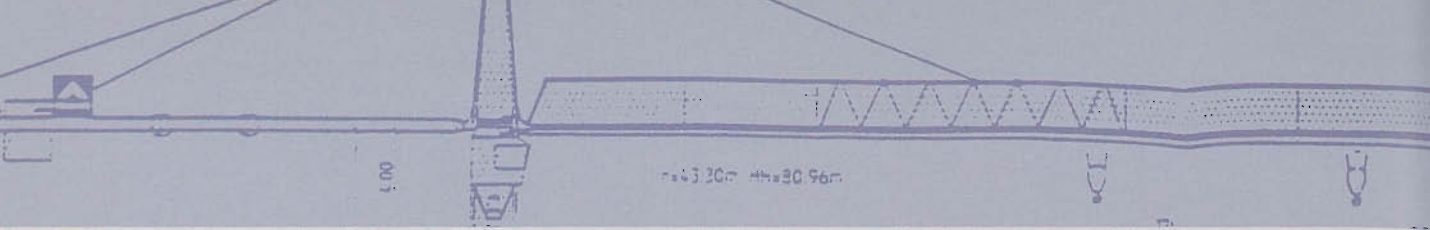
Key: ✓ Included in the Business Process



A three layer work process model, shown below, was developed to describe the nature of work processes within Trant and their positioning in terms of strategic or commercial, planning or tactical and operational requirements. The model was built using the BSE toolkit and has subsequently been utilised in determining the interaction between work processes, their inputs, their outputs, their internal mechanisms and procedures and resources they utilise.

A Layered View of Work Processes within Trant





The Business Systems Engineering Toolkit

The steps in the practical application of BSE are mapping, analysis, simplification, improvement, action and follow up. Simplification is very important, the more complex the process or task, the more management effort is required in its execution. Typically twice the complexity requires four times the effort. Each of these steps is achieved by using a range of management tools which have been collected together here as the Business System Engineering Toolkit.

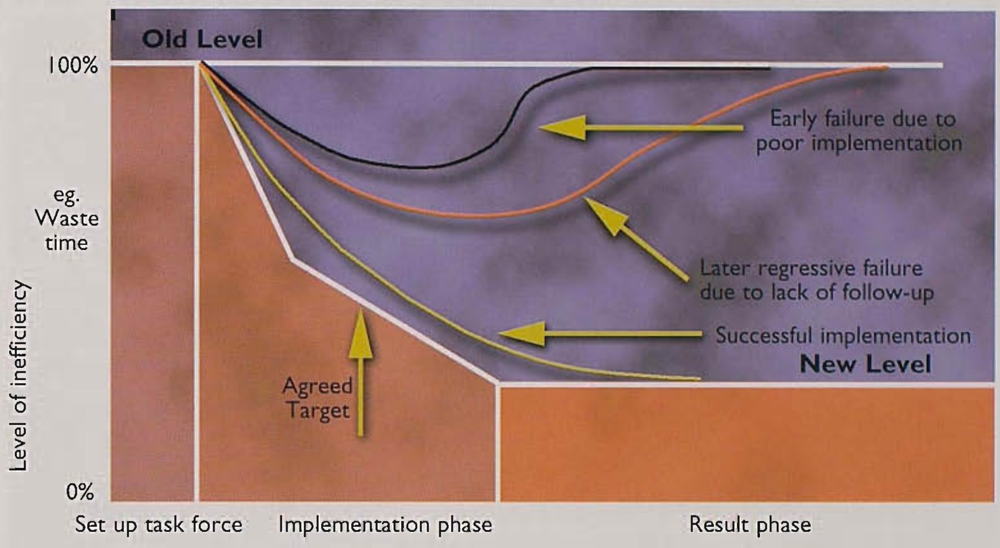
"There are initially always four Business Process States - what we are told it is, what the managers think it is, what the managers would like it to be and what the Process actually is. To achieve effective change we must distinguish between these states and eventually obtain agreement on the actual Process Map."
(Denis Towill, IEE Management Journal, 1997)

The simple tools required to achieve significant improvement in performance are available to even the smallest company in the construction supply chain. The question arises of how can the benefits which are there for the taking be obtained? The answer is by undertaking a systematic application of the management tools within the toolkit to ensure that permanent progress is made rather than just achieving temporary improvement which is often disappointingly followed by regression back to the status-quo. It is important to emphasise that there are two major causes for such fallbacks in performance. The first is due to poor implementation such as not creating the trust between players in the supply chain or not training people to change their 'confrontational' mind set to an atmosphere of 'partnering'. The second is poor follow-up where failure to monitor progress allows old habits and attitudes to return.

To maximise the opportunity of achieving success in the application of BSE in construction the following pitfalls need to be avoided:

1. Failure to relate the proposed process improvement to company commercial strategy.
2. Failure to involve the right people in the process improvement programme.
3. Failure to agree on a clear brief with associated accountability.
4. Failure to understand how changes affect the people involved.
5. Failure to understand that success critically depends upon implementation follow-up.
6. Failure to set realistic targets for process improvement, with a clearly sign-posted time horizon for achieving success.

Driving Change through Measured and Agreed Performance Indicators



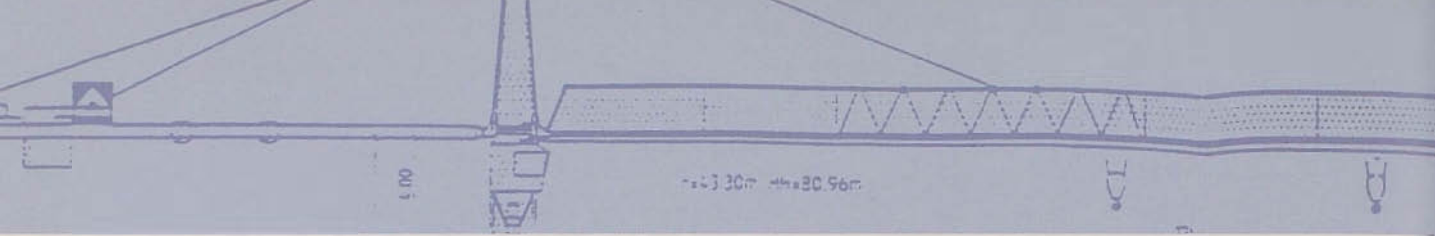
- ***Hospital pipe fitting tasks – productivity up 35%***
- ***House building process – productivity up 20%***
- ***Supermarket building process – productivity up 20%***
- ***Electrical services tasks – productivity up 25%***
- ***Introduction of IT – processing time down 20%***
- ***20% cost reduction identified by reengineering the interface with the client***
- ***8 – 16% cost reduction identified by time compression techniques***

Examples of savings using the BSE tools

(Source: CPN Workshop Report 721S)

The above box highlights the benefits of using BSE tools. The aim is to work more efficiently thereby providing improved value for money for the client and in turn increasing profits, improving quality and reducing delivery times.

The BSE tools are used to obtain data on the innefficient 'as is' processes, to suggest the more efficient 'could be' processes and then to re-engineer the existing processes to obtain these more efficient 'could be' processes.



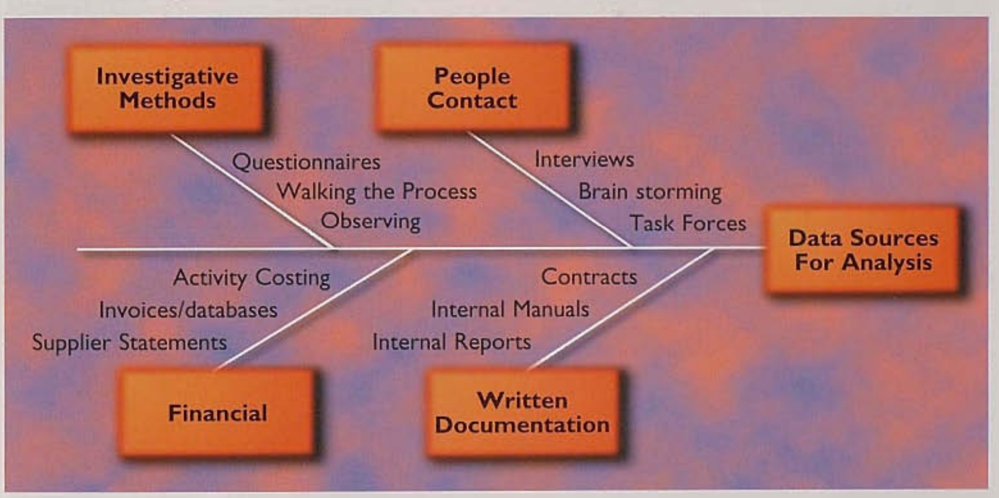
Tools Used in this Handbook

Primary tool used	Example application of tool	Page number
Activity Based Costing	To determine cost allocation between Work Processes and Business Processes	19
Fishbone Diagram	As a means of identifying the root causes of a problem	18
Gantt Chart	To simulate the impact of process changes on a project's total time as part of a post-mortem	41
Input-Output Analysis	To show duplication of data generation and the potential benefits of IT	21
Pareto Analysis	To focus on areas with greatest potential for improvement	49
Perception Analysis	To determine the clients perception of your performance versus those of your competitors	26
	To determine the gaps between project team partners	37
Process Mapping	For the documentation of an internal set of activities	23
	To show how re-engineering an interface leads to fewer non value added activities	31
Zoom & Focus Charts	To determine the value added and non value added break down of activities	45

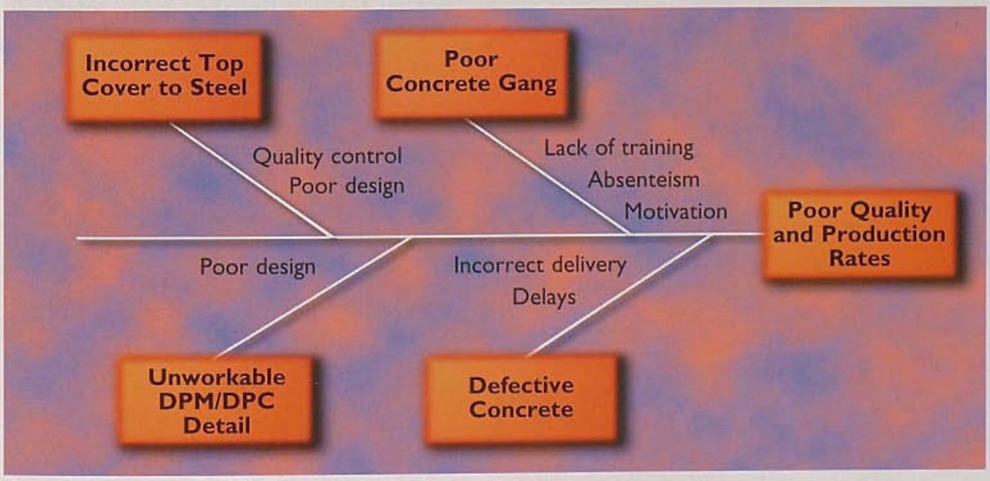
The Toolkit in Use: Fishbone Diagram

This tool is used in brainstorming exercises where a problem associated with the efficiency of a particular business process, work process or activity needs to be analysed. This is primarily a visualisation tool that helps in focusing on the root causes of a particular problem. The 'bones' leading up to the problem contain general headings. Under each of these headings more detailed statements are attached which are believed to have an impact on the problem. Discussion of each of these detailed statements helps to prioritise the component factors in order of greatest impact on the problem.

Fishbone Diagram – Generic Structure Showing Data Sources for Analysis



The fishbone diagram below shows how this tool was applied to addressing problems of poor quality and production rates in the casting of power-floated concrete slabs. Analysis of the 'bones' subsequently showed that poor production rates were due to the DPC collapsing into the wet concrete and poor quality was due to inability to maintain correct top steel cover.



The Toolkit in Use: Activity Based Costing

This is a technique for accurately costing an activity or process within the company. Activity Based Costing (ABC) can provide quantifiable evidence of true cost generators which leads to better insight and ultimately a better focus on resources employed.

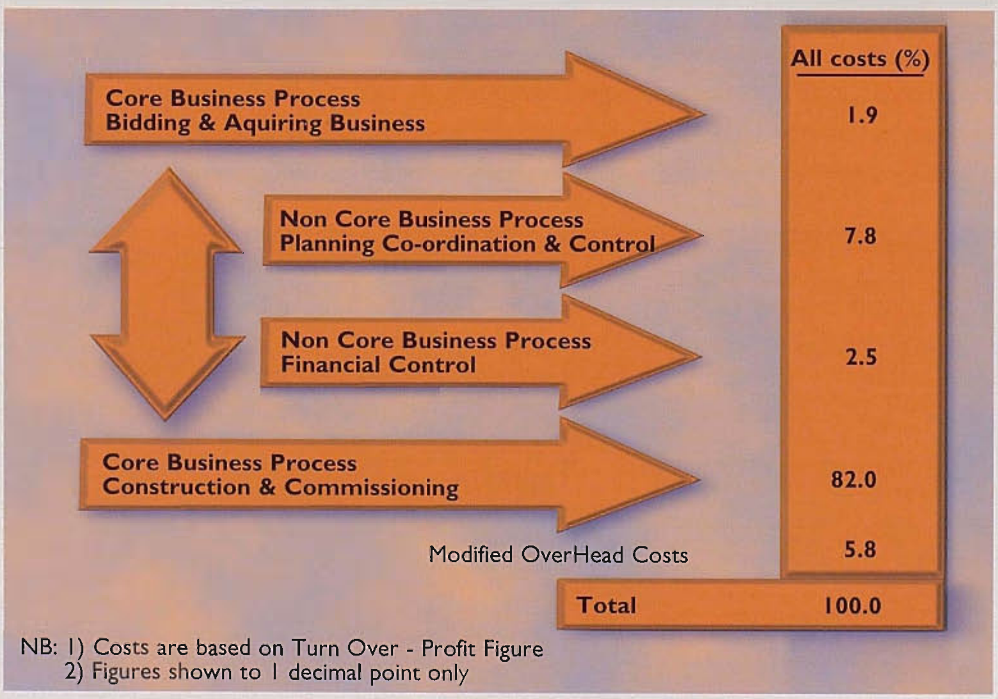
Combining ABC with process mapping allows self assessment using, for example, the following 'what if' questions:

What is the sensitivity of overall activity costs if there are changes in labour, plant or duration?
What is the saving if the activity is sub-contracted out?

A company (rather than a single project) perspective of business costs can be built up by distributing the company costs to each work process, individual or task group. An example is shown on page 20, which is based on the work process table on page 13. Construction of this table provides another way of examining and analysing cost distribution and thus investigating any areas of potential savings or apparently excessive cost areas.

An example of the total turnover of a company by business process is shown below using the ABC philosophy.

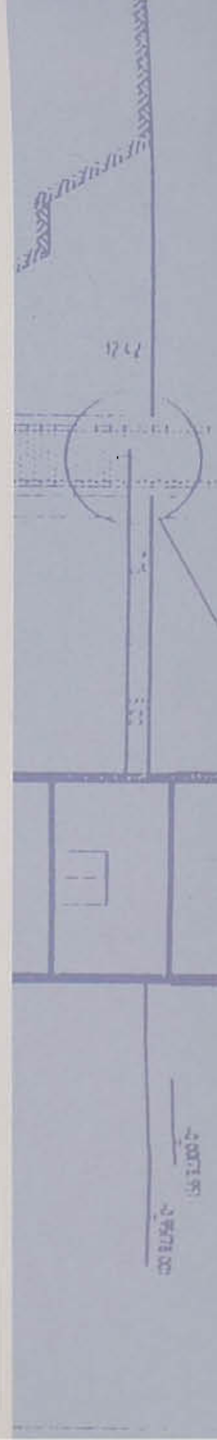
Aggregating Costs into a Business Process View

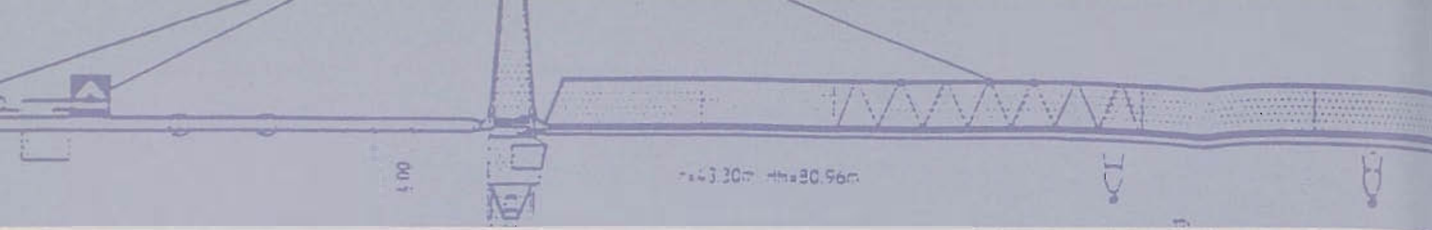


Example of Labour Cost Distribution by Work Process

	Individual / Grouping								Cost £k						Total
Work Process*	Directors Total	Safety Officer	Systems Manager	Estimator	Accounts	Office Support	Contract Managers	Site Agents	Foremen	Gangers	Work Force	Site Admin	Personnel	Quantity Surveyors	WP labour cost
1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	22
2	10	0	0	23	0	0	5	0	0	0	0	0	0	8	46
3	19	0	0	0	0	0	5	0	20	0	0	0	0	0	44
4	9	0	0	0	0	0	12	5	22	0	0	0	0	4	52
5	5	0	0	0	0	0	5	0	0	0	0	0	0	0	10
6	4	0	0	0	0	0	13	9	0	0	0	0	0	0	26
7	1	0	0	0	0	0	5	9	45	0	0	0	0	0	60
8	6	0	0	5	0	0	12	9	17	8	0	12	0	4	73
9	12	0	0	0	0	0	3	5	44	17	0	8	0	0	89
10	15	23	0	0	0	0	17	9	35	12	63	0	0	0	174
11	13	0	0	0	0	0	6	9	45	0	0	0	0	0	73
12	2	0	0	0	0	0	3	0	63	44	0	0	0	0	112
13	3	0	0	0	0	0	1	5	40	2	0	0	0	0	51
14	3	0	0	0	0	0	12	5	0	0	0	0	0	4	24
15	2	0	0	0	0	0	0	0	18	20	1366	0	0	0	1406
16	6	0	0	0	0	0	6	5	17	0	0	8	13	8	63
17	23	0	0	0	0	0	8	0	0	0	0	0	1	12	44
18	3	0	0	0	0	0	8	4	0	0	0	0	0	0	15
19	7	0	0	0	0	0	5	0	0	0	0	8	1	3	24
20	17	5	33	0	0	0	0	0	0	0	0	0	1	0	56
21	9	0	0	0	0	0	0	0	0	0	0	0	0	0	9
22	7	0	0	0	0	0	0	0	0	0	0	0	2	0	9
23	3	0	0	0	0	0	0	4	0	0	0	4	2	5	18
24	2	0	0	0	0	0	2	0	0	0	0	0	1	0	5
25	11	0	0	0	34	0	0	0	0	0	0	0	0	0	45
26	19	0	0	0	0	0	0	0	0	0	0	0	0	4	23
27	6	0	0	0	4	14	0	0	0	0	0	5	1	0	30
28	5	0	2	0	0	0	0	0	0	0	0	0	0	0	7

*The work processes come from the table on page 13





The Toolkit in Use: Input-Output Analysis

Input-output analysis is a tool which is useful for process mapping. It uses a box to represent an individual, a function, a company or any general system under study. All inputs and outputs are described using arrows entering the box called inputs and arrows exiting the box called outputs. It is then possible to trace all the inputs back to their sources and all the outputs to their destinations. Questions can then be asked to assess if the outputs are really required, does anybody use them, are they just filed away or if changes can be made to improve the outputs? Deriving the input-output diagram also helps ensure total capture of all the activities in the system of interest.

DAILY Forms for Informing Client of Actual and Planned Labour Hourly Usage

Staff Name ➤
Staff Trade ➤
Normal Hours Worked ➤
Overtime Hours Worked ➤
Date Worked ➤
Works Order Number ➤
Job Number ➤
Contractors Supervisor ➤
Client Site Co-ordinator ➤
Job Location ➤
Job Description ➤
Day-works/Unit Rate ➤

Total Hours

➤ Daily labour return (actual and planned)

Italics indicate common inputs

DAILY Forms of Actual and Planned Plant Usage

Plant Description ➤
Fleet Number ➤
Hours Used ➤
Hours Idle ➤
Date ➤
Works Order Number ➤
Job Number ➤
Contractors Supervisor ➤
Client Site Co-ordinator ➤
Job Location ➤
Job Description ➤
Day-works/Unit Rate ➤

Plant Usage

➤ Daily plant return (actual and planned)

Italics indicate common inputs

WEEKLY Forms of Actual and Planned Labour Hourly Usage

Inputs		Outputs		Result
Staff Name	➤	**Staff Total**		
Staff Trade	➤	**Hours**		
Daily Details	➤	**Cost**		
Dates Worked	➤	**Labour Total**		
Hourly Rate	➤		➤	Weekly labour return (actual and planned)
Works Order Number	➤	**Weekly Labour**		
Job Number	➤	**Cost**		
Contractors Supervisor	➤			
Client Site Co-ordinator	➤			
Job Location/Description	➤			

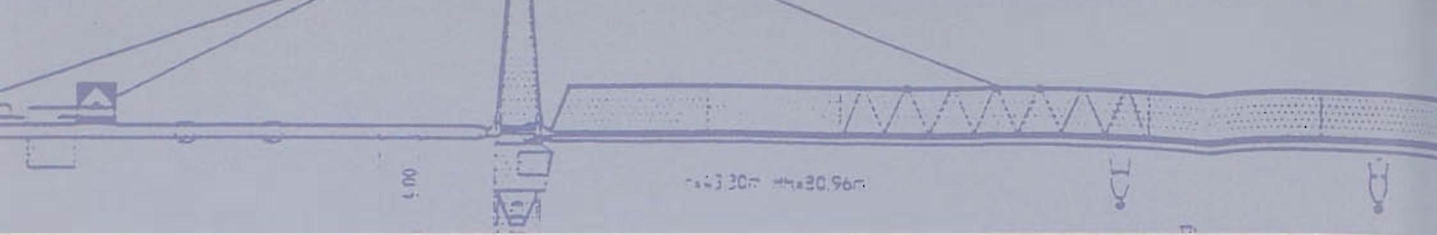
Italics indicate common inputs

WEEKLY Forms of Actual and Planned Plant and Materials Usage

Inputs		Outputs		Result
Equipment description	➤	**Equip. Total Hours**		
Fleet number	➤	**Cost**		
Daily Hours	➤	**Equip. Total**		
Hourly Rate	➤			
Dates Worked	➤	**Materials Cost**		
Materials Description	➤	**Materials Net Cost**		
Quantity Used	➤	**Handling Fee**	➤	Weekly labour returns completed
Unit Price	➤	**Materials Total**		
Works Order Number	➤			
Job Number	➤	**Weekly Cost**		
Contractors Supervisor	➤			
Client Site Co-ordinator	➤			
Job Location/Description	➤			

Italics indicate common inputs

The input-output diagrams coming from TEL show that the same data is required on a number of forms and duplication therefore occurs. In this case a simple IT system is being developed which will take the inputs just once and utilise those inputs to produce the different forms required by the client. Thus the foremen will fill in the daily sheets identifying the plant, labour and materials assigned to each job just once. The complete suite of daily returns to the client can then be produced automatically. The end of week totals will also be compiled automatically using the IT system. The advantages of the system will include fast and accurate collation of information, fewer non value added activities and agile responses to client queries.

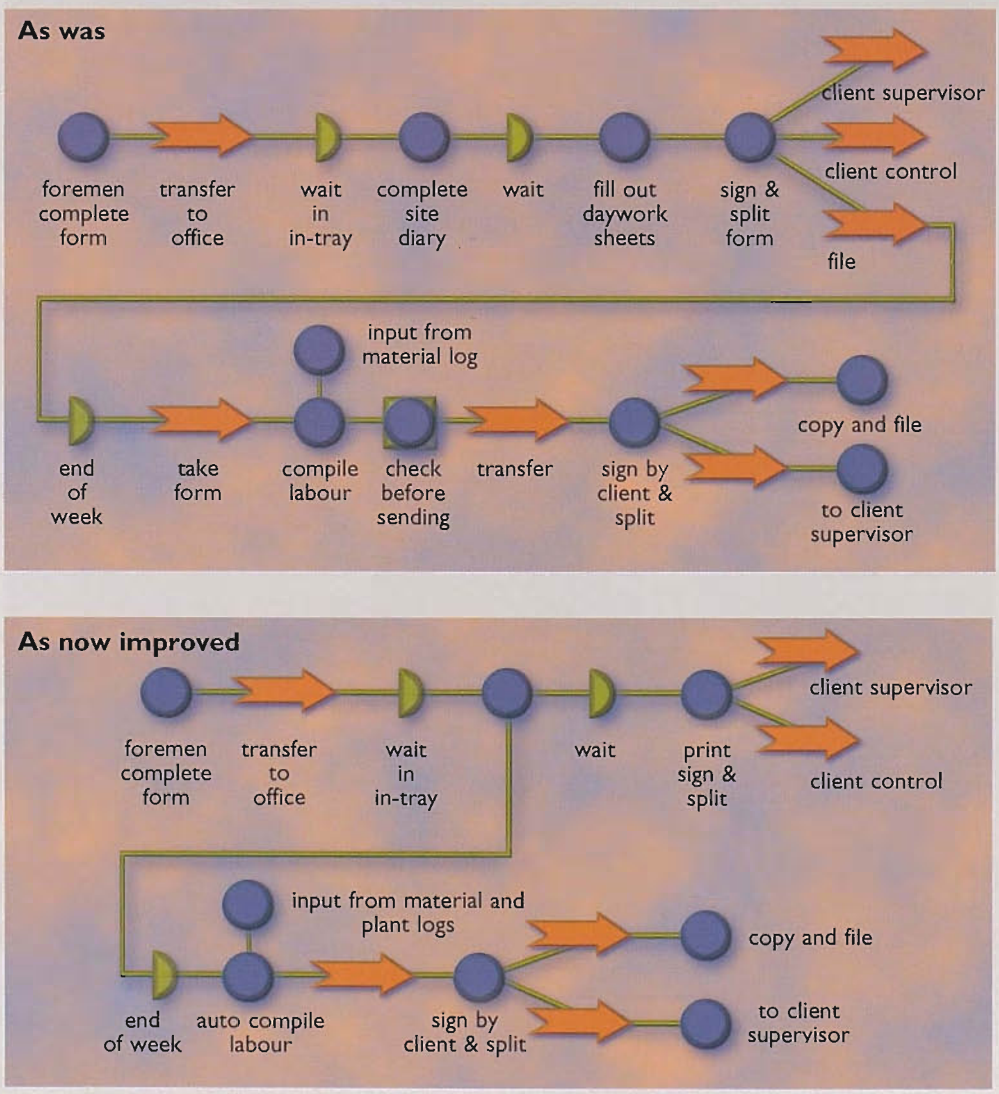


The Toolkit in Use: Process Mapping

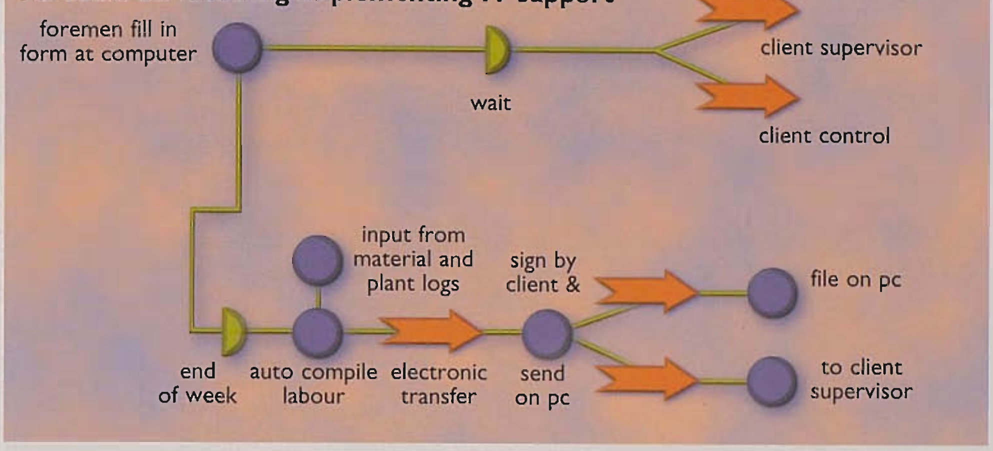
Process mapping is a graphical tool which records the activities that take place within the processes that deliver the project. The process map (also called the process flow chart) should display the flow of materials, information, capacities and money from the start of the project to completion. Each stage in the map should be identified according to whether it is Value Added (VA), Non Value Added (NVA) or Essential Non Value Added (ENVA).

An example of process mapping is shown. This mapping is based on the scenario described in the preceding input-output analysis section.

Example of Process Mapping in Action



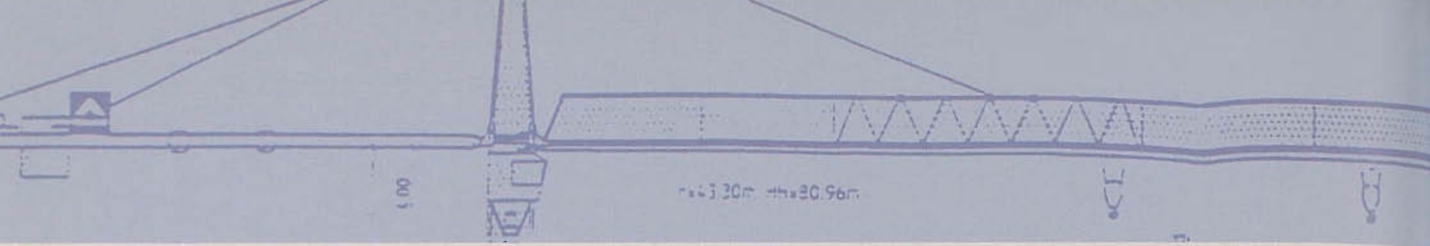
As could be following implementing IT support



"The effort put into IT is worth it as long as the whole process is viewed and the IT systems developed to take a whole process view. The next step is to integrate with outside clients to eliminate paper-work altogether."

(Fran Ravizza, Director Trant Engineering Ltd)

Information Technology (IT) has the potential to make a considerable impact on quality, service, cost and lead-times. Unfortunately, all too often, IT has been seen as a panacea to business problems with IT being implemented by practitioners having only a limited understanding of the company's business activities and this has led to many disappointed companies. However, it is imperative that IT is seen as part of an overall BSE strategy and IT implementation should only follow after an exhaustive business process analysis. It is imperative that existing processes are redesigned to maximise the benefits of IT implementation rather than implementing IT simply to automate existing processes.



Potential Improvements Due to IT Implementation

System	Manual	Automated
Production of daily labour returns	Labour intensive, repeated copying from foreman's diary to site diary to day-work sheet once per day	Input information from foreman's diary to database once per day
Daily plant returns	Labour intensive; as above	As above
Daily labour allocation	Weekly allocation sheet amended daily for all jobs; information collated onto daily returns for all jobs	Input information from allocation sheet - quicker, easier to change
Production of weekly labour returns	Labour intensive; copying from site diary to weekly return sheet	Automatic and rapid production of sheets. Automatic, error free cost calculations
Production of weekly plant returns	Labour intensive copying as above	As above
Production of weekly materials returns	Materials list must be searched for record of material by location; unit price unknown at time of completion	List of materials for that location produced automatically; unit price unknown at time of completion. Time consuming manual sorting is eliminated
Production of weekly day-works progress sheets	List of jobs must be revised from previous week; hours worked collated; remaining hours left calculated	Information already present; output by report no sorting of information; visual check to see jobs before output
Materials Received	Materials delivery tickets collated; location of usage recorded	Materials delivery tickets collated; details transferred to system; location and contract type recorded. Flexible reporting output (MIS)
Materials Received	GRN manually re-indexed by supplier; no new information recorded	Automatically collated - fast and accurate
Reporting system	Flexible reporting but extremely labour intensive	Moderately flexible reporting; very fast production of information; common reports can be attached to 'buttons' and produced immediately. Client changes quick to adopt. Common reporting facility

The long term benefits of IT implementation will be considerably greater than the immediate benefits as processes are re-engineered to exploit the full potential of IT.

The Toolkit in Use: Perception Analysis

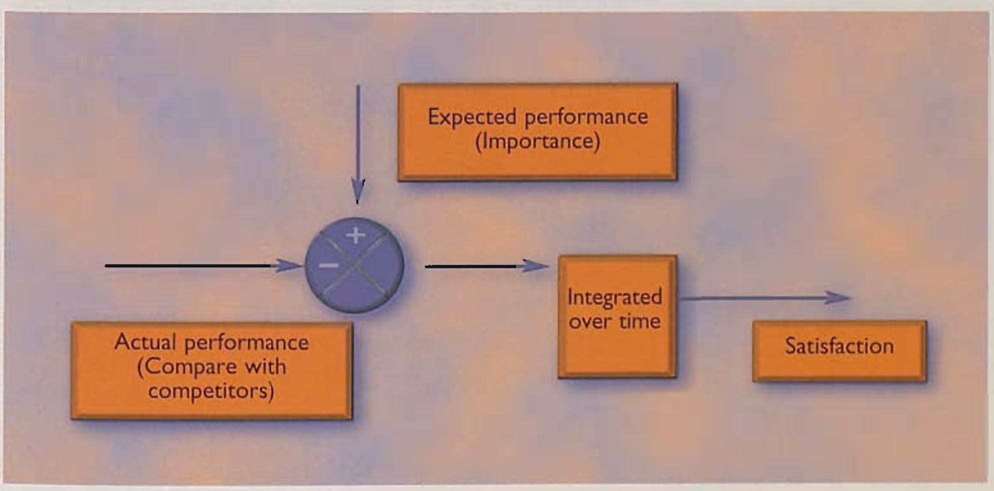
> ***The main contractor stated "our actions at tender stage, in respect of the queries raised, were to seek clarity in order to be able to price what the client actually wanted; to avoid disputes and misunderstandings should we win the contract; to create a 'level playing field'."***
> *(Brown and Riley 1998)*

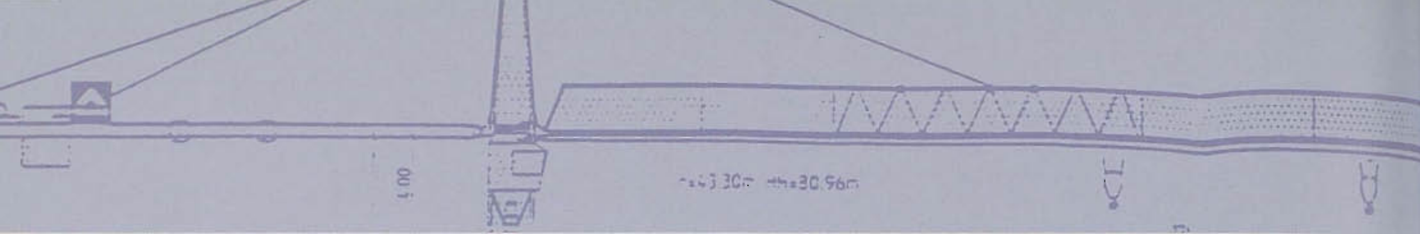
All businesses have to be client focused and it is essential to know what the client's perception of your business is. Even if a company has an 'excellent' set of performance metrics if is still possible that a client may perceive a company as providing poor performance. It is important to close such a perception gap. In order to do so a number of questions must be answered:

What are the fundamental services offered to the client?
What performance criteria are important to the client?
What are the detailed actions performed that form an impression on the client?

The first issue is usually easy to identify and may include estimating or pricing, designing and building and contract management. The second issue can be dealt with by considering the idea that performance can be determined in terms of Service Level, Quality, Cost and Lead-time. It is crucial that health and safety is included in the performance list. The third issue can be addressed through interviews and questionnaires with the client.

Components of Satisfaction



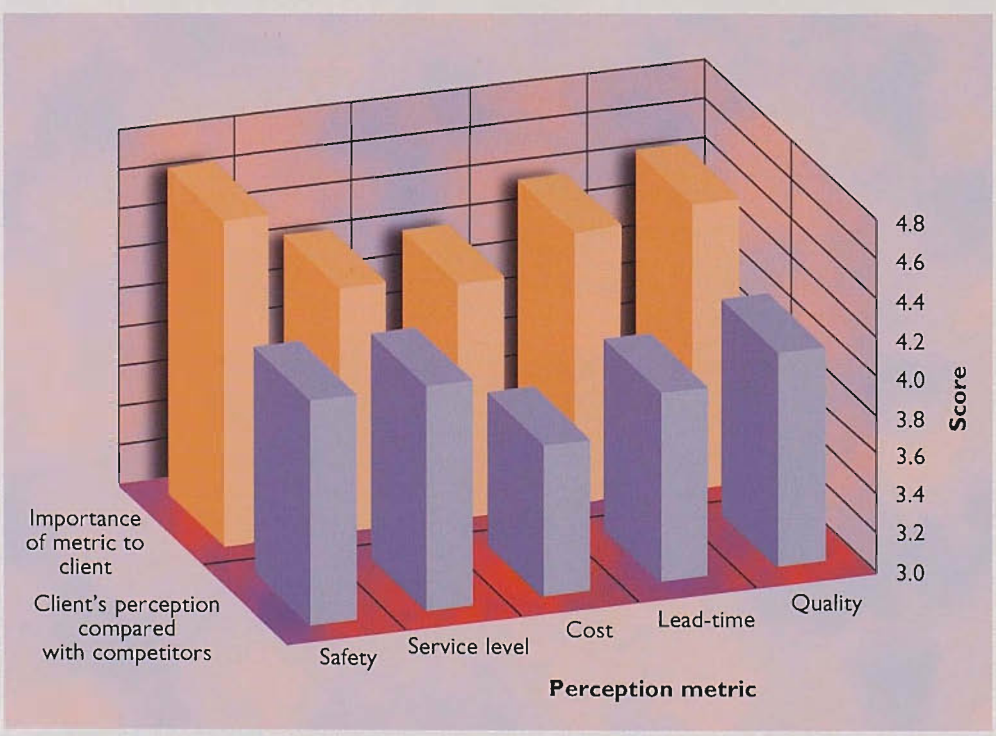


In Trant a questionnaire was developed and distributed to the clients in their portfolio. The results provided an insight into the clients' views on the performance of Trant. A five point scoring scale was used. The scores relate to importance and performance so that

Score	Importance	Performance
5	Very high	Best
4	High	Good (Top 3 contractors)
3	Medium	OK (Top 5 contractors)
2	Low	Poor
1	Very low	Very poor

The clients were asked to score the importance of safety, quality, service level, lead-time and cost using the 1 to 5 scale above.The results indicate that for the most important criteria (i.e. safety) Trant excelled. Trant's lowest score corresponded with their clients' least important metric. This analysis indicated that Trant's strategy is successful and areas for improvement were clearly identified. (It should be remembered that Trant work within the petrochem sector).

Example of the Perception Approach

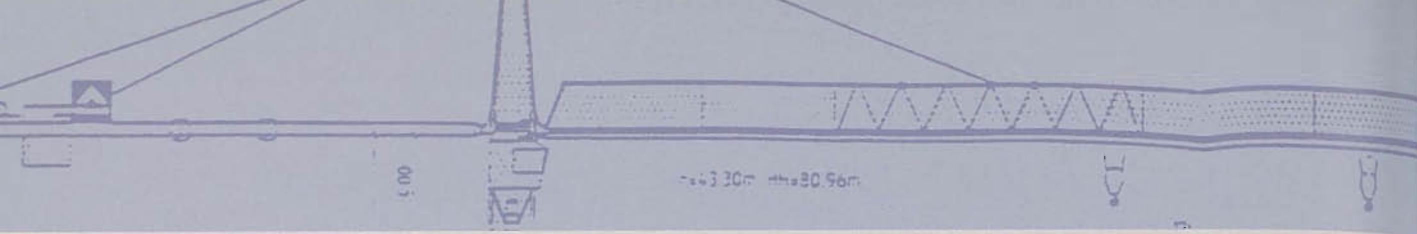


The next stage is to investigate each metric in greater detail to examine individual issues affecting each of the performance measures. As an example, the safety issue may be examined based on questions relating to risk assessment, safety record and health and safety plans. This list is of course specific to individual contractors and what is important to particular clients. The list should be generated through discussion or brainstorming sessions with clients. An example is shown below.

Safety Issues

How do we compare with our competitors in the following safety related issues?	Very Poor	Poor	OK Top 5	Good Top 3	Best
The diligent formulation of risk assessment by the contractor					
Safety record					
H & S management plans					
Compliance with COSHH regulations					

The value in assessing the importance and performance comparison against competitors is significant as the strengths and weaknesses of the company can be easily identified. Changes can then be undertaken in the areas of weakness. In other words, measuring a customer's perception of performance in a structured way allows the efforts of change managers to be clearly focused.



Re-engineering The Supply Chain Interface

"Some clients, including some Government Departments, display no discernible interest in subcontractors. Other clients take an intense interest in all participants on and off site. Some clients go to considerable lengths to brief subcontractors and their operatives on-site to ensure that they are fully part of the construction team."

(Sir Michael Latham 1994)

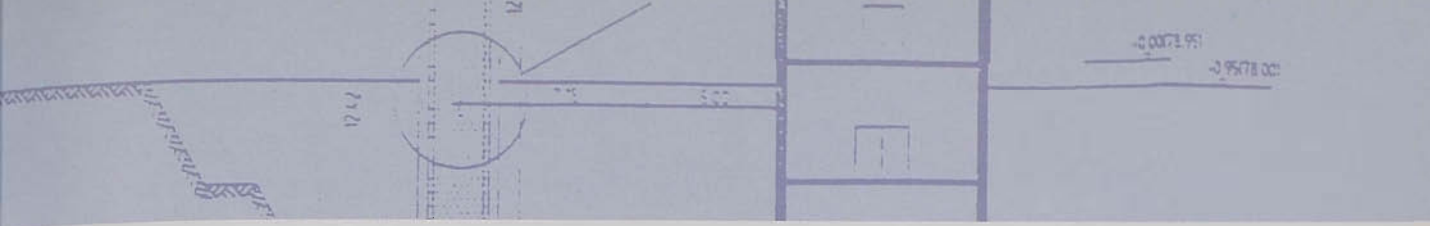
A key challenge facing companies in the construction sector is managing a supply chain which can extend from the client through several tiers of sub-contractors. As contractors have reduced their direct labour and in house capability and become to rely, almost universally, on sub-contractors, so the level of complexity between client and supply base has risen dramatically.

A similar situation arose in manufacturing industry as companies outsourced non-core activities and developed unmanageable supply chains. The problem is being resolved in manufacturing by reducing the supplier base and using a limited number of preferred suppliers and creating well managed supply chains. The challenge for construction is to follow the lead set by manufacturing and start to proactively manage the interfaces between the parties in the supply chain.

There are a range of information sources for helping to analyse the client-contractor interface and those used within Trant Engineering Ltd are shown below.

Data Sources for Analysing the Client Contractor Interface

Data sources for analysis	Usage			Insight		
	High	Med	Low	High	Med	Low
The Contract	●				●	
Internal Reports			●		●	
Procedures Manual		●				●
Question Client Managers		●		●		
Invoiced Amounts		●			●	
Invoice Documentation		●		●		
Question Contractors			●		●	
On Site Analysis			●		●	
Process Flow Charts		●		●		
Input-Output analysis			●		●	



The following problems were identified in Trant Engineering Ltd:

- Long lead-times to respond to simple tasks due to the number of people and organisations involved
- Poor time co-ordination between sub-contractors
- Poor co-ordination between trades
- Multiple visits by sub-contractors due to poor co-ordination
- Multiple invoices for same task due to multiple visits.

Having identified the problems the routes to improvement can be drawn up as shown below.

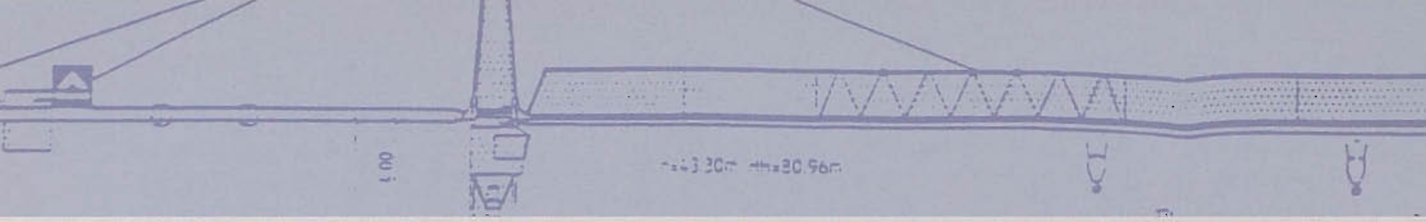
Routes to Improvement at the Interface – Some Examples

Interface has been improved via
Improved planning
Knowledge of contractors' core expertise
Use of alternative payment strategy
Knowledge of labour skills base and remuneration rates
Identify scope and implement multi-skilled workforce
Improved tender selection process of suppliers
Reducing the frequency of checking contractors on site
Improved feedback from site and changing attitudes
Improved planning for payment
Improved feedback from site
Request for standard data
Improved checking of the invoice

The solution was to implement a 'help desk' run by the contractor to improve and formalise communications between the client and sub-contractors.

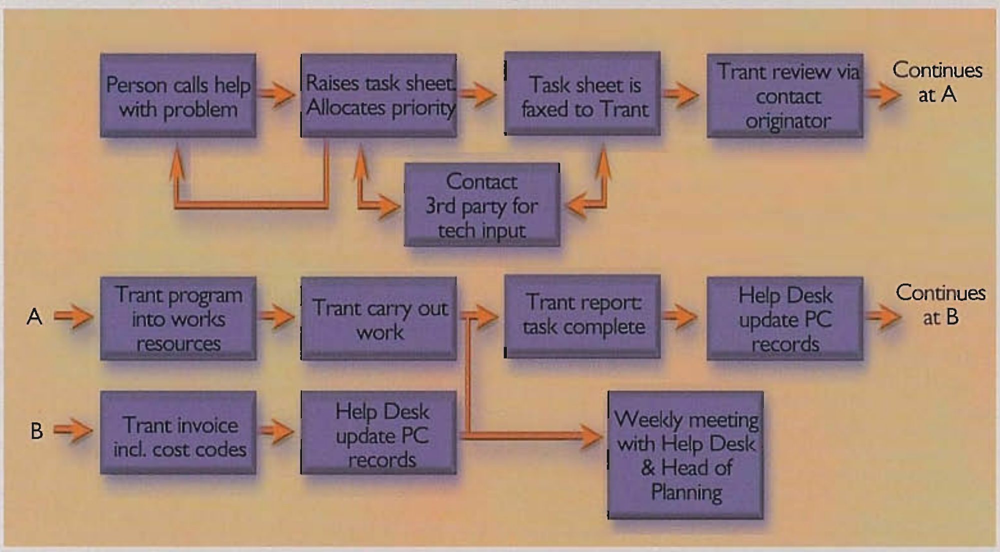
The benefits so far obtained are:

- Reduction of abortive site visits
- Reduction of multiple visits to site
- Improved synchronisation between sub-contractors
- Reduced daywork costs to the contractor and client
- Better use of site based resources
- Shorter delivery times.

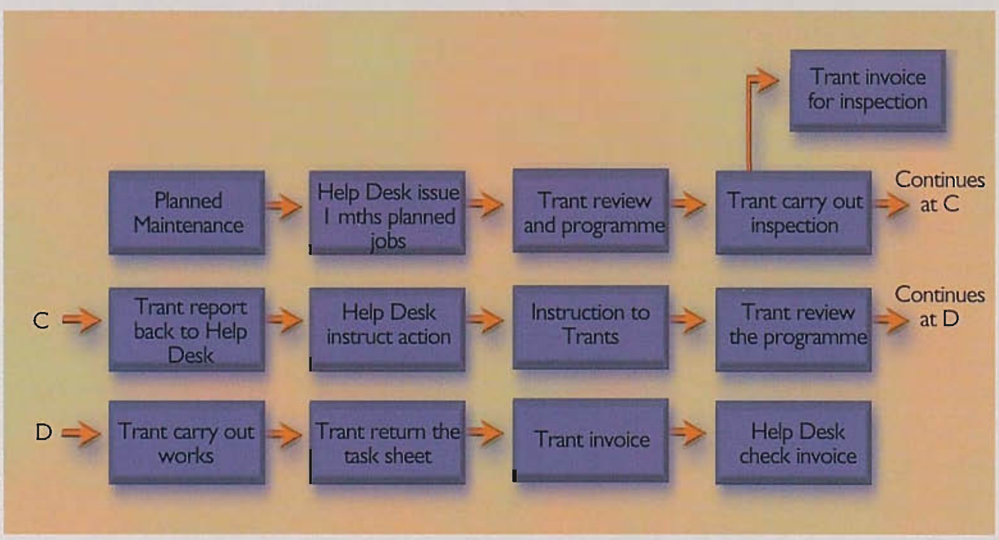


To assist in the improvement, process maps were constructed of the interface system used by Trant Engineering Ltd. The process maps showed that TEL used two different systems for planned tasks and unplanned tasks. The process maps of the two interface systems are shown below:-

The Old Interface System for Performing Tasks



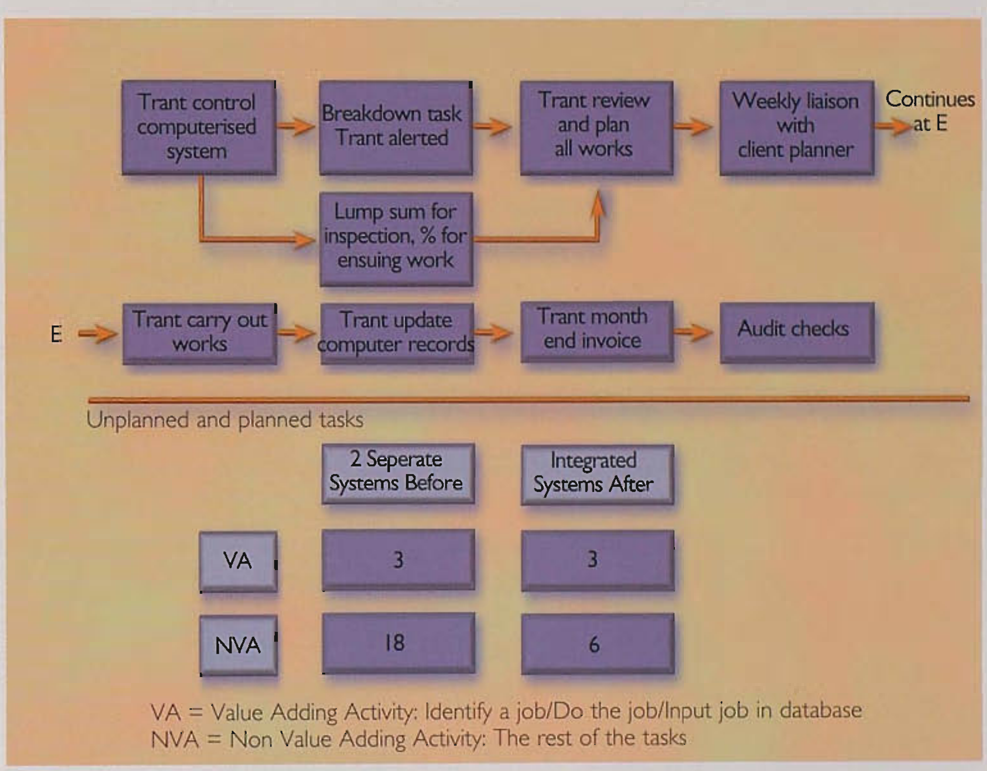
Unplanned tasks as a result of variation orders



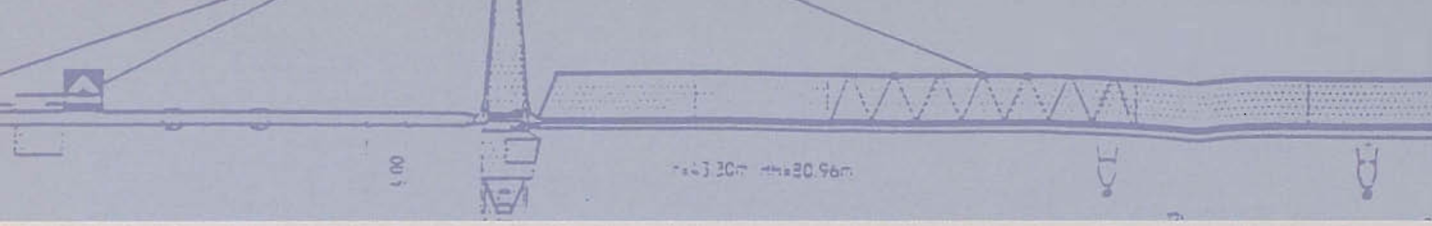
Planned tasks

The challenge was to simplify and integrate the two systems to reduce costs by elimination of inefficient and duplicated processes. The new integrated interface system is shown below:-

The Current Simplified Interface System for Performing Tasks



The revised system for planned and unplanned activities led to the number of non value adding steps being reduced from 18 to 6.



Partnering

"For our original scope of works we came in on target – which under a traditional contract we only had a 30% chance of doing so. The company then went on to pick up an additional scope of works which was going to be out-sourced."

(Mike Reed, Director, Trant Engineering Ltd.)

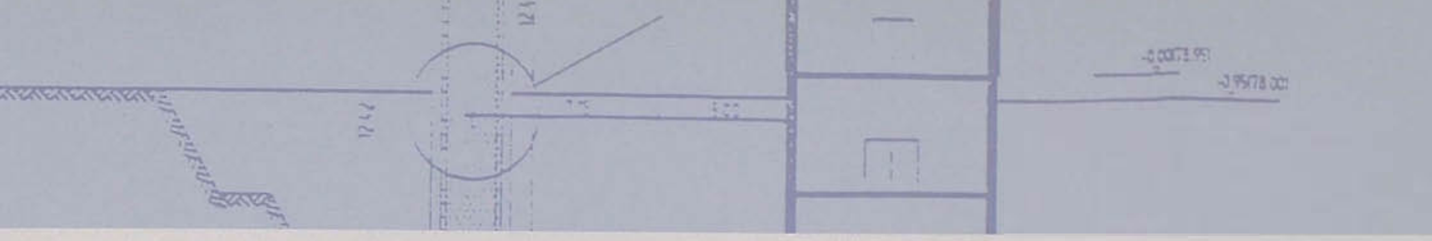
There has been a considerable amount of information published about partnering. A review of the general partnering literature would be inappropriate but based on the experiences of the research team three main issues arise:

1. Defining the partnering process
2. Adequately selecting partners
3. Monitoring the partnering project

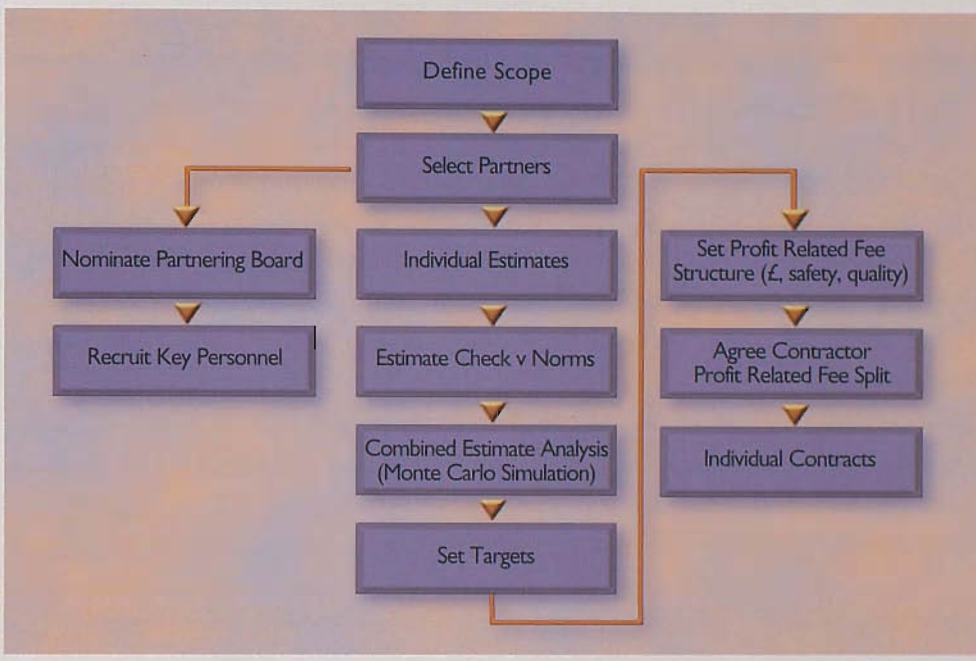
Examples of Successful Partnering in Construction

Staffordshire County Council: contract value £10m, reduced by £0.4m	(CIB, 1997)
BP Andrew: CAPEX forecast £450m, actual £260m	(Brown, 1995)
BP Cleeton: CAPEX of £30m with a forecast of £40m due to partnering arrangements	(Review, 1995)
BP Hyde Gas Field: the goals and objectives of both the client and contractors were aligned achieved a project being delivered on-time and 25% below budget	(Tuft, 1995)
Sainsbury's: construction times for stores of 30,000 sq ft have been cut from 45 weeks (1990) to 24 weeks (1997)	(Johnston, 1997)
Natwest Property Holdings: contract value £19m achieving a £0.4 m cost saving	(CIB, 1997)

Partnering is not simply a banner heading under which freedom is given to all parties to step out of their traditional roles, but a mind set to seriously question what and how things are done as a group and then to change things for the better. Each step in the process is lengthy with a large amount of management time being required. This is costly and could potentially out-weigh the savings accrued through not tendering. For partnering to be successful the philosophy of co-operation must replace that of conflict and partnering must be recognised as a new way of working and not just a new form of contract.



The Initial Process of Partnering



The end goal is to give the client a better job in terms of cost, schedule, quality and health and safety performance together with an improved focus on achieving the client's objectives. It is also important to understand the motives for doing this. The basis for partnering is to eliminate conflict and problems at source and to focus on delivery of the clients expectations. Within this environment all parties to the contract will benefit. This requires things to be done differently!

In a partnering contract recently undertaken by Trant Engineering Ltd the following outcomes were observed. It should be noted that this is just one means of achieving a partnering way of working.

Contract - Differences From Traditional

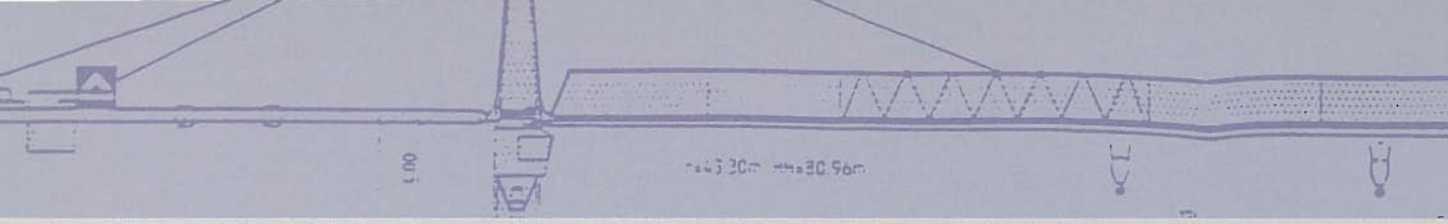
- Reimbursed at cost
- Fixed fee with overhead recovery
- Open book policy
- Extensive pre-contract negotiations in lieu of tender.

Main Risks

- Profit dependent on the performance of everyone
- Overhead recovery against original estimate
- Safety, quality and programme penalties.

Reduced Risks

- Cannot make 'a loss' as costs are reimbursed.



Advantages

- Maximises contractor input (including local knowledge) into early design phase
- Contractors 'on hand' to prepare accurate cost estimates for design alternatives
- Incentive for inter-discipline co-ordination/cost saving schemes
- Single design/construction programme – multi-disciplinary
- Cross skilling – minimal trade demarcation
- Sharing of common facilities
- Performance gains through the creation of a virtual multi-disciplinary design, management and build enterprise without the overheads of a large organisation.

Disadvantages

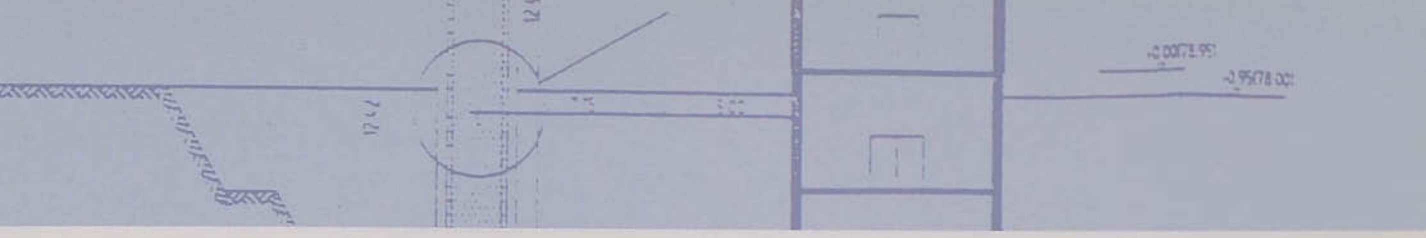
- Co-ordination procedures for short term 'partnering projects' have to be prepared and running effectively very quickly.

Overall the advantages can be significant.

Partnering can be exciting and produce changes to reduce costs to the client. The following list identifies some changes which took place during a recent Trant partnering project.

- Novel design ideas were put into the design loop in an effort to reduce CAPEX.
- The contractors knowledge of the client's site was used at the early design stage. This resulted in design changes which transferred work between contractors in order to reduce CAPEX. Such a change would not have occurred in a traditional contract.
- A procedure was changed to reduce costs after a risk assessment indicated the cheaper option carried little additional risk.
- Cross skilling and shared plant hire occurred during construction.
- Safety audits were performed by a single contractor for all the contractors, a position which was rotated. This helped reduce overhead costs.
- A permit liaison officer was employed specifically for the project which resulted in improved on-site communications, reduced safety risks and improved productivity.
- Effort to resolve early engineering queries was focused upon technical solutions and not setting up a change order system as in traditional construction practice.

Partnering can work but it is important to have a team of like-minded individuals and companies working together, thus selecting the right partner is crucial.



A New Project Procurement Process

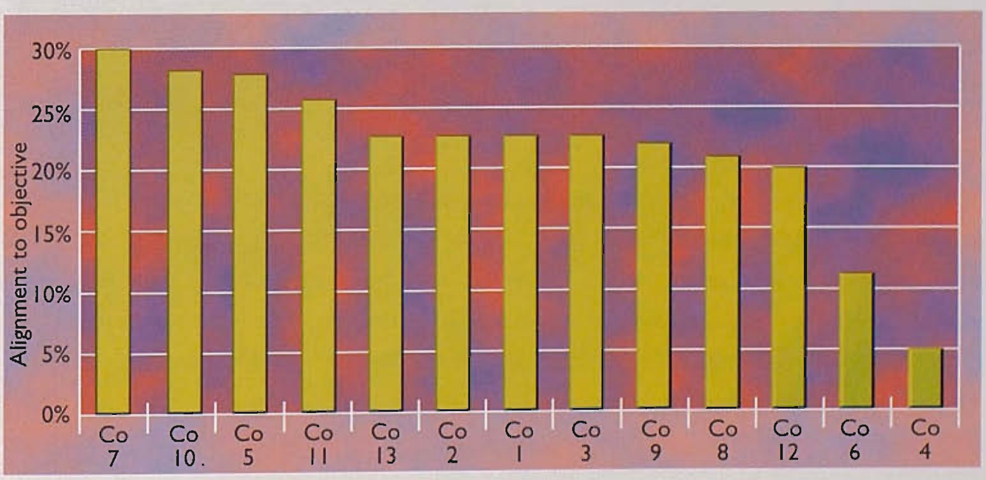
Most partnering arrangements in the construction industry are between the client and contractor. Whilst this provides a co-operative working environment the benefits available through partnering with the consultant and allowing the contractor to become involved in the design process would not be realised. Various studies have shown that up to 30% of project costs can be attributed to failures in the design-construction interface. In the petro-chemical industry this problem has been addressed by the use of a procurement process known as an alliance. In this process the consultant, the contractor and major sub-contractors are assembled into a team before design begins and work to agreed performance targets. However, this requires long term relationships to exist between the client and the other parties to avoid a tendering process.

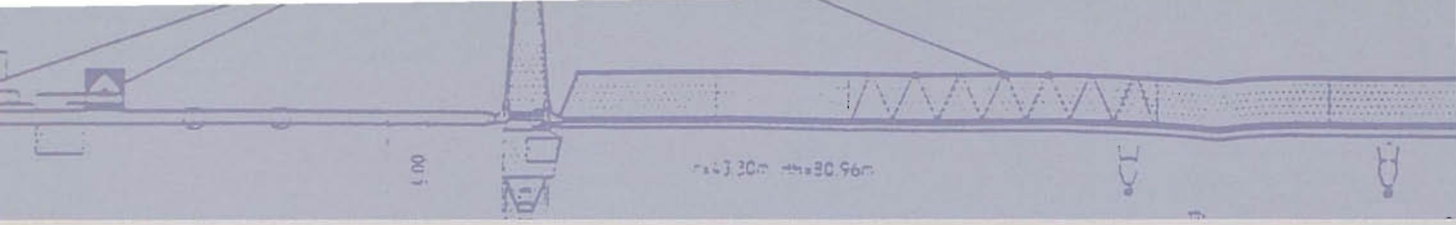
In the traditional construction industry, with one-off projects, a new procurement process needs to be developed bringing together the client, the consultant and the contractor before design commences but still using a form of tendering. This will realise the benefits of concurrent engineering by allowing the consultant and the contractor to work jointly on the design and produce a design which exploits the contractor's specialist abilities.

A new procurement process has been developed to achieve this by adopting multi-criteria decision making as the principle tool for selection of both the consultant and the contractor. The process also uses design workshops and performance targets to support the final selection.

This procurement process has been used on a £1.5m construction project with four success criteria being identified as the multi-criteria objectives. Thirteen contractors expressed interest in the contract and their alignment to the project objectives were evaluated via a structured questionnaire. The results are tabulated below and show that the higher the score the closer they are aligned to an 'ideal' previously elicited from the client for the objectives of the project.

Example of the Selection Process by Contractor Number (Co)





In the course of this selection process it was found that some consultants considered that contractors had no role to play in the design process and that some contractors thought that they had nothing to input to the design process. The consultants and contractors that expressed this opinion were not selected for this project and this highlights the importance of changing the culture within companies.

Determining the Gap Between Project Partners

Partnering does produce differences in the way of working by re-engineering the contractor, consultant and client interfaces. It is still possible, however, for differences of opinion or differences in attitude to occur between companies even after a rigorous selection process. These differences can affect the working relationship but can be detected as part of a risk management exercise. It is possible to assess attitudes of the parties to the contract by asking them to indicate how important various issues are in the partnering project. An example of this is a project in which each member of the team was asked to rate the importance of the final design in contributing to the overall success of the project. Significantly the contractors ranked the importance of the design higher than the consultants. These differences of opinion often go undetected within the partnership until site work has commenced and this can lead to conflict between the parties.

An alliance contract involving TEL with three other contractors and a consultant was studied using perception analysis to identify the causes of problems occurring on site. The analysis focused on the differences arising between the contractors and the client and the differences arising between the contractors and the consultant.

For the perception analysis of this project, questions were asked of the parties on both sides of the interface. A five point scale from Very Low to Very High was used to assess the respondents' feelings on various issues against questions such as 'how important are the following areas for a successful project outcome?' The following issues were raised that influence attitude and some emerged as problem areas as soon as construction started. It was, therefore, easy to address these issues early in the project to ensure improved interface management between the parties to the project.

Issues Between the Contractors and Client

- Amount of planning of the project by the project manager
- Amount of on the job checking
- Importance of completion on time
- Importance of health, safety and environmental performance
- Importance of alliance planning
- Importance of product quality
- Importance of prompt client payment
- Importance of directors talking to each other
- Importance of managers talking to each other

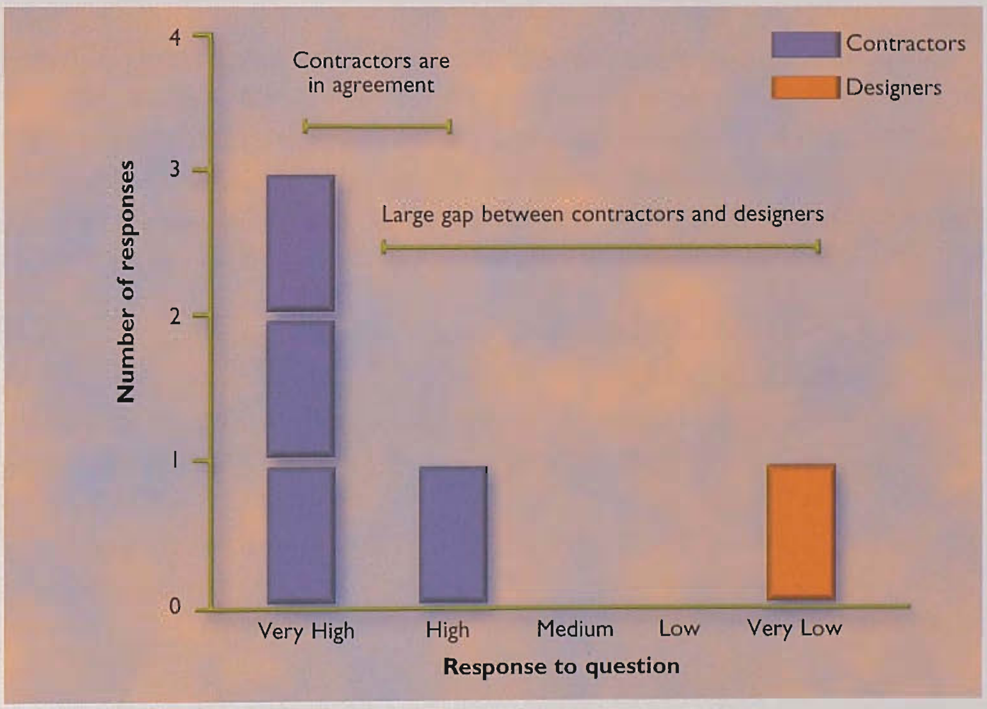
- Importance of people doing the job talking to each other
- Importance of rapid resolution of problems.

Issues Between the Contractors and Consultant

- Fitness for purpose of the final design
- Importance of overall design
- Importance of communication of the design
- Importance of the quality of the product
- Importance of talking with the designers
- Importance of design flexibility.

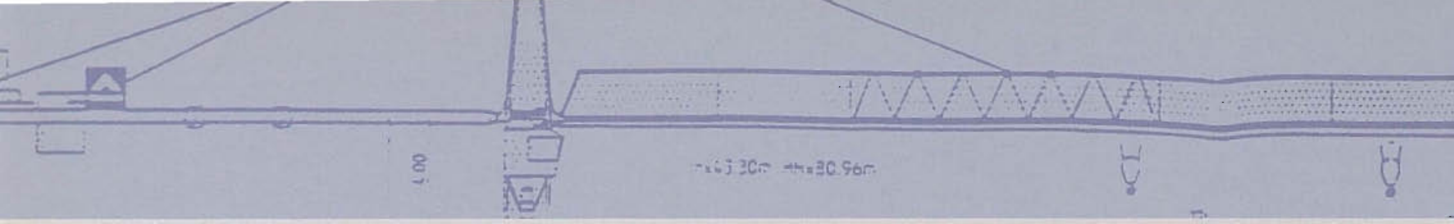
A typical set of responses to these questions are shown below.

Response to Problem Issue



This type of analysis on the alliance project found site problems occurred over an issue when either:

1) The contractors as a group disagreed over an issue by two response categories (e.g. the difference between High and Low or Very High and Medium).
2) The gap between the contractors as a group and the other parties (e.g. the consultant and the client) was greater than two response categories (e.g. the difference between High and Very Low).



This procedure for identifying potential conflicts between the contractors and other important project participant (designers, project managers, project engineers, clients and so on) ensures that any misalignments in the partnering project may be detected before they lead to a possibly detrimental effect in the running of the project. Adequate time is required to derive suitable questions to determine the project members' perceptions and also for taking action on the results.

Time Compression

"Time is on the cutting edge of competitive advantage. The ways leading companies manage time....are the most powerful new sources of competitive advantage."

(George Stalk, Jr. and Thomas M. Hout, Competing Against Time: How Time Based Competition is Reshaping Global Markets, 1990)

A commonly held perception among construction professionals is that reducing the Total Cycle Time (TCT) involves increased costs. The reasoning for this is that different and more expensive technology needs to be used and more resources needed to accelerate a project that is running behind schedule. This logic is supported by the use of acceleration claims in construction projects. However, results already obtained within the construction sector following the use of BSE indicate that the opposite can be true. There is, therefore, a need for improving time management and a case for reducing TCT if appropriate.

Examples of Time Compression

1. During the Hurst Spit Stabilisation project a 45% time compression for construction was achieved at no extra cost. (Brown and Riley, Proceedings of the Institution of Civil Engineers, November 1998)

2. Reduction in total delivery time for a large institutional building complex in the USA: down from 52 weeks to 15 weeks with a minimum of 50% time savings in each of the planning; procurement, and construction phases.

3. Reduction in total delivery time for specialist construction materials supply chain in Scandinavia: down from an average of 78 weeks to an average of 17 weeks. One company is already achieving 4 weeks TCT with a target of 1 week to be achieved in the foreseeable future.
   (Persson and Engham 1992)

4. A 25% faster than expected completion of a remodelled bookstore that led to increased rental revenues for the client who shared the benefits with Skanska.
   (Skanska, 1993)

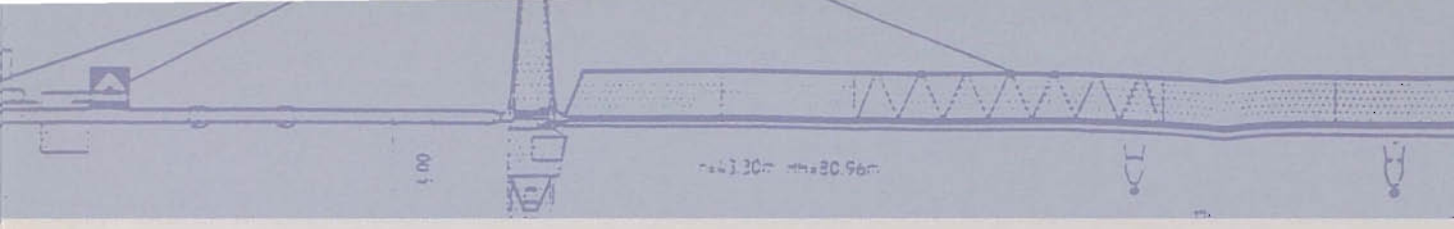
5. Renovation projects that now take four days when in the past they used to take two to three weeks. That is a dramatic 60-75% reduction in lead times. The shorter completion times meant less disruption for the client so that tenants rents were only temporarily reduced.
(Skanska, 1993)

6. The reduction in lead time for a road rebuilding project from 13 to 9 weeks meant less disruption for traffic and cost savings for the public agency client through reduced traffic re-routing and control measures.
(Skanska, 1993)

7. Completion of a design-construct dam project two years ahead of schedule. 30% of the construction costs were recouped due to the generation of electricity during those two years.
(Skanska, 1993)

It is clear from the above examples that in the right circumstances the practice of targeting TCT reduction can generate a considerable pay-off within the construction sector. How much is a question still to be answered. For example, in the case of a USA house builder, a healthy increase in market share followed a reduction in lead time from 26 to 4 weeks coupled with wider customer choice. This is due, in part, to a BSE programme being aimed at providing a 'one-stop' service to prospective clients. The consequence is that customised new houses may be delivered in a time-frame directly competitive with second-hand house acquisition times.

These examples also highlight that the best managed projects were completed in half the TCT typical for that type of project. In contrast the worst managed projects needed a TCT of twice the average. Also the best performers were consistently good, but the worst performers were consistently poor. The difference between them can be explained via differences in the application of the BSE principles.



The Toolkit in Use: Gantt Charts

Gantt Chart

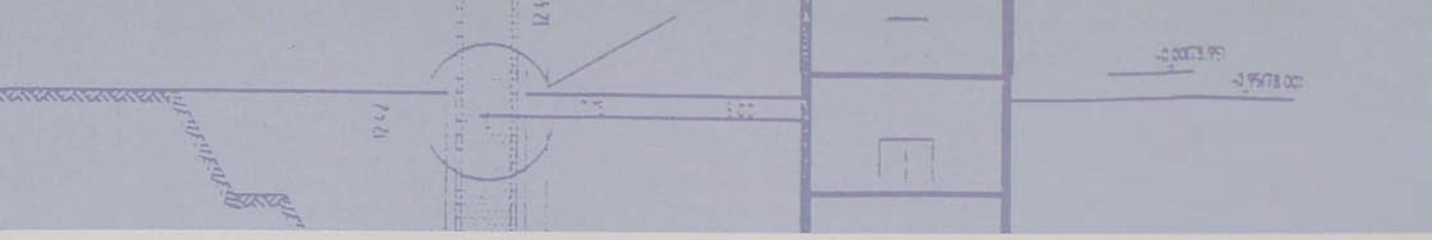
Gantt charts are named after their originator, the American industrial engineer, Henry Gantt (1861-1919). These charts have been in widespread use for considerable time and they continue to be a very valuable planning aid. Not only are these charts easy to construct and interpret, but they are readily adaptable to a great variety of tasks.

In this handbook Gantt charts are used as a tool to aid time compression of individual tasks within a particular project. The example given has been produced using project planning software, but it is equally viable to use a hand drawn Gantt chart. Using a Gantt chart in this manner can produce significant time compression in construction projects. As a project post-mortem tool they help focus on the difference between planned and actual activity duration and permit investigation of the best that can be achieved.

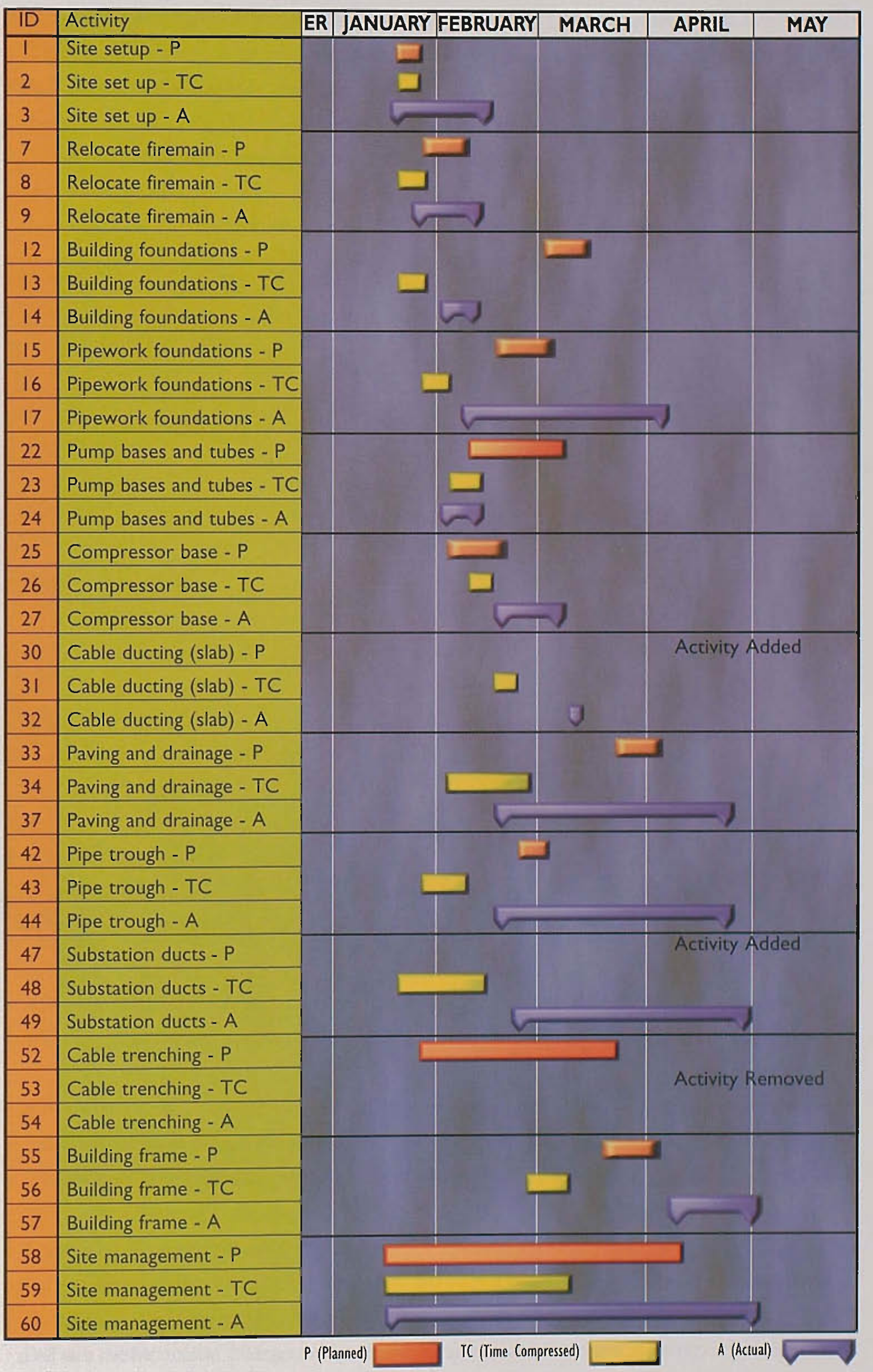
One way of assessing where an organisation can save time and improve profits is to perform a post-mortem on a recently completed project. The general idea is that a shorter construction time leads to lower costs and increased profits. An example of this follows for a project undertaken by Trant Engineering Ltd that was, technically, a straightforward civil engineering job. It involved the construction of concrete bases foundations and drainage as well as the management of the construction of the building frame. Examples of time barriers in this project were incorrect set-up information, late design information, site politics and a sub contractor delay.

The job progressed from January through to April when Phase I was regarded as complete.
A re-planning exercise then took place to see how the work might have been performed within a shorter time scale by asking the people managing the job on site how it might have been done better with hindsight. It was then possible to draught a new Gantt chart as shown opposite.

In this case, given good information flow from the entire supply chain then the time on site for Phase I could have been halved. Such action could have easily doubled the profit from this job.



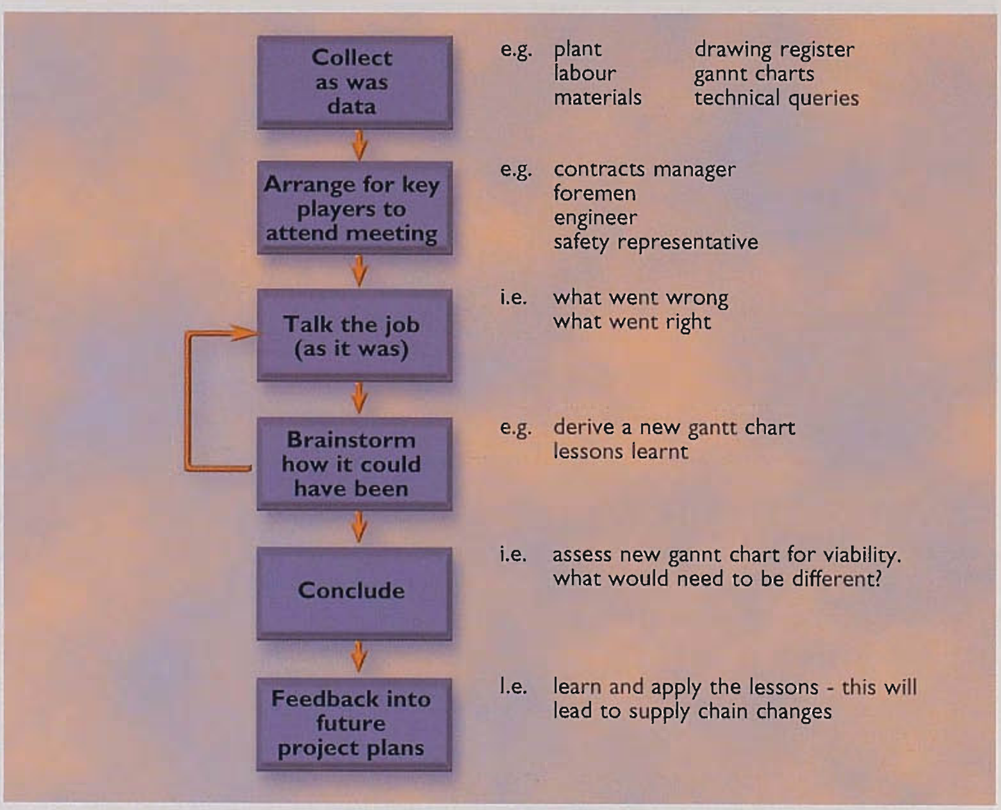
Potential for Time Compression – the Gantt Chart



The steps to perform this are outlined below along with tips on the data to collect and what to discuss. Although it is recognised that good contractors and clients will perform post-mortems on projects, there is a risk that the focus turns to small items that went wrong. Focusing on the bigger picture resolves this problem and small issues are only discussed if they trigger a major event.

The idea is to formulate a minimum reasonable time to complete the project.

Steps to Assessing Minimum Reasonable Times for Activities



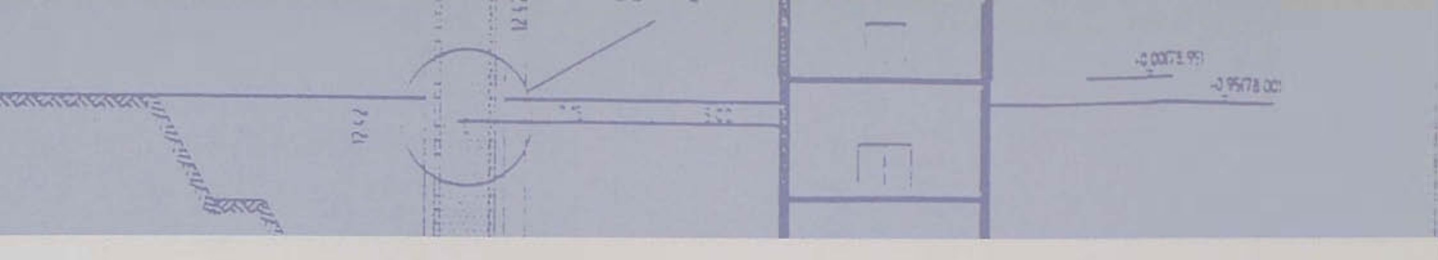
The following four points from manufacturing translate well into the construction industry when attempting to reduce total cycle time (based on Fry 1990):

Identify a control point

Within manufacturing this is what is limiting the input to better serve the output. In construction the input flows are materials, other trades, plant, and information. The control point is thus the timely drawing together of these elements driven by the construction plan.

Establish an appropriate buffer

Inventory and spare capacity act as buffers within a manufacturing plant but is replaced with time acting as a buffer in the construction plan and spare man-power and plant capacity on site. Within the Time



Compression analysis, a rethinking of the timing and duration of activities needs to take place based on the assumption that inputs will be reliable.

Assess source of fluctuation

Obtaining consistency for each of these inputs is key for smooth construction. This requires trust and experience of fellow supply chain partners. Many argue that this is difficult to achieve due to the one-off nature and geographical dispersion of construction sites. However Skanska found building relationships with the supply chain was a key to success. The supply chain is the prime source of fluctuation especially when clients desire late design changes. A re-education and development of the supply chain therefore needs to occur.

Change the performance evaluation system

The aim of many construction companies has been to achieve maximum profits from a contract. Fluctuations and late changes have been warmly welcomed financially (with claims being generated for such changes and charges for delays) although these were less welcomed by site staff. The new performance system must be minimum cost in as short a Total Cycle Time as possible. As has been seen with Skanska and many manufacturing and other companies such a policy automatically leads to additional profits.

Skanska launched a successful campaign between 1991 and 1993 and proved to themselves that shorter lead-times ensures quality and lowers costs on some projects. The involvement of the supply chain was critical as Skanska recognised that by stimulating cross learning with suppliers, consultants and sub-contractors the job would flow smoother:

> ***"Close long lasting collaborations with everyone who influences a construction project helps us to save time and cut costs. This means higher value-added for the client."***
> *(Skanska 1993)*

In order to compress time the programme needs to be assessed to see if any of the following are feasible:

- Eliminate the tasks
- Parallel the tasks
- Shorten the tasks (content)
- Improve operators productivity on the tasks
- Take tasks off-line (split the task into two separate tasks but the combination of which takes less time)
- Put more resource on the task (beware: law of diminishing returns exist)
- Technology (use faster construction methods - e.g. prefabrication)
- Remove the Non Value Adding content of the task (e.g. waiting time and re-work)

- Improve the Safety on the task (impacts lost time although can show diminishing returns)
- Less pessimism in the original plan (trust the people on the ground).

However, these can only be achieved where there is some degree of confidence in the information and trade interactions from surrounding supply chain members. The sources of fluctuation need to be identified and controlled for Time Compression to happen.

The first step towards Time Compression is the elimination of an activity. This is where the Zoom and Focus charts may prove to be of use and are described in the next section.

The Toolkit in Use: Zoom and Focus Charts

> ***"My experience indicates that if we improve performance by 5 minutes in every hour then profit can be doubled."***
> *(C Barnes, General Manager, SCC)*

Little evidence actually exists in companies that achieving this goal is realistic. Nevertheless, assessing productivity is important although it can be misconstrued as good old fashioned work study methods by which to 'beat with sticks' rather than 'reward with carrots'. Productivity analysis using Zoom and Focus is a non-controversial method of assessing where productivity losses are occurring during a job and hence determining what corrective action needs to be taken either during the life of a job or for the next project. The layout here is simply a Zoom and Focus chart where the previous level is shown in more detail in the next level down. The data can be for a whole project or for an individual partner in a project.

Hourly data is collected and significant items and times are noted which fall into any category which is not directly adding value to the job at hand. The Productivity Analysis feeds into the Time Compression analysis so that the hourly data can again be classified as Non Value Adding (NVA) or Essential but Non Value Adding (ENVA). NVA covers hours such as rework or searching for information. ENVA covers items such as induction courses and temporary works. ENVA activities must be performed but they should be minimised. Level 0 of the Zoom and Focus identifies the level of NVA and ENVA for a particular job. Level 1 then shows the NVA / ENVA split.

The number of individual NVA activities may be large so attempts should be made to cluster the activities. The following four categories were found to be effective when feeding back to construction managers and may be shown as Level 2 of the Zoom and Focus:

Doing nothing	e.g. standing time
Doing re-work	e.g. re-work because of a late drawing change

Doing wrong thing e.g. incorrect installation
Taking longer e.g. chasing information

Level 3 then indicates more detailed clusters which give a better idea of the specific areas of waste. It is important to note such things as excessive lunch breaks or late arrivals should not be examined due to the possible industrial relations problems this may pose.

All business processes or activities can be classified into three types:
(a) Value Added (VA): business processes or activities during which the product is enhanced in value.
(b) Essential Non Value Added (ENVA): business processes or activities which are regarded as essential, such as safety training or re-measurement, but add no value to the product.
(c) Non Value Added (NVA): business processes or activities which are wholly waste and contribute nothing to the product, safety or quality.

Waste in Construction – Other Peoples Views

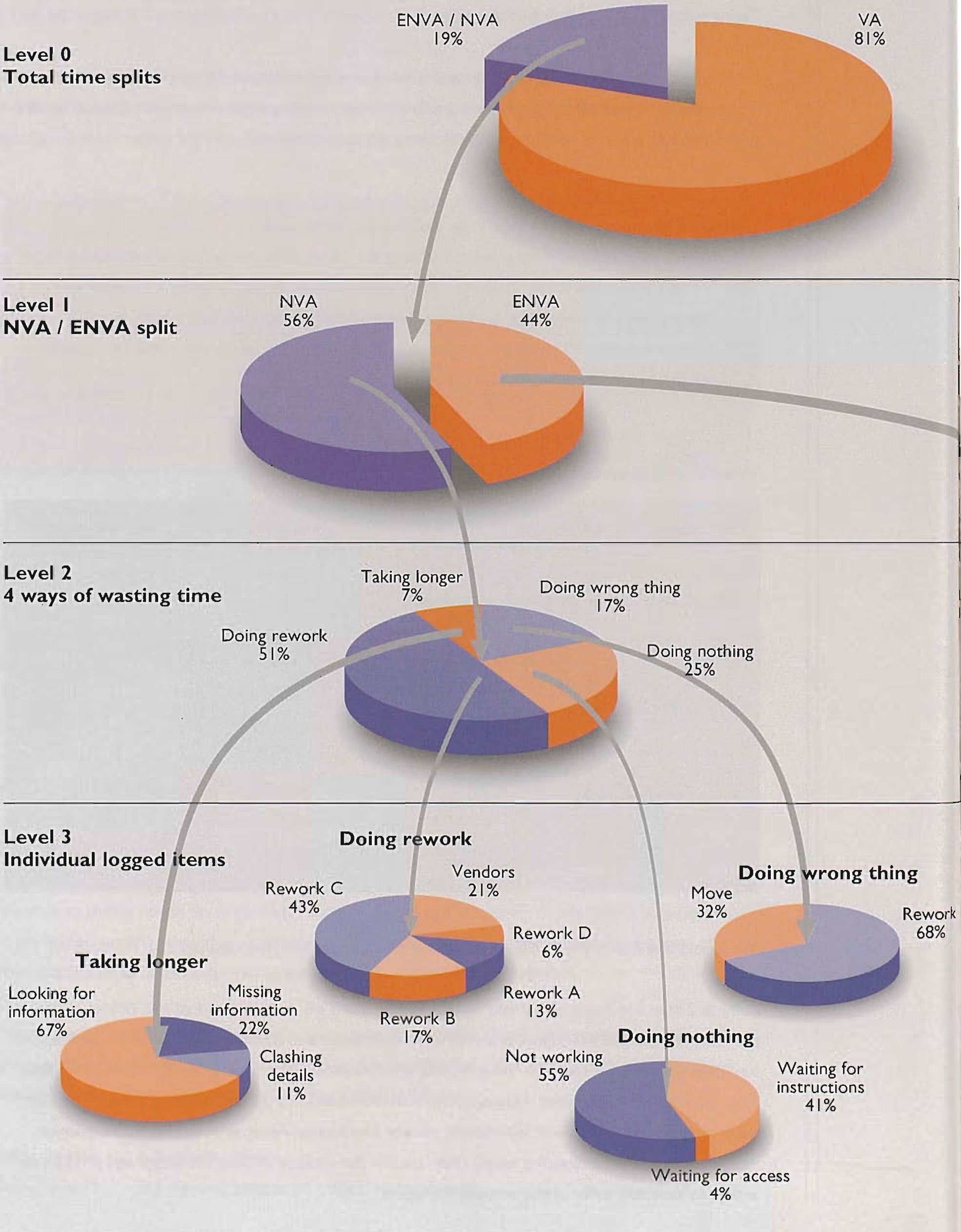
42% of site hours are unproductive *(Nedo 1990)*
20% of defects are created by operatives
80% of defects are created by managers

12-15% of construction costs are rework
10-20% of construction costs are waste *(Stanhope 1992)*

The Zoom and Focus charts overleaf illustrate the use of the tool in an analysis of a TEL contract.

In these Zoom and Focus charts only significant time items are recorded so that the 19% of all hours spent on NVA and ENVA activities are an underestimate (this is approximately 7% of the contractors turn-over for this job). The Non Value Adding activities account for approximately 10.5% of the total time and should be eliminated. However, much of this waste is forced upon the contractors through design changes and poor client led material control procedures. Again, as in the Time Compression example earlier, the surrounding supply chain creates disturbances to the contractors and productivity and costs inevitably suffer unless properly managed.

Zoom and Focus Charts in Use



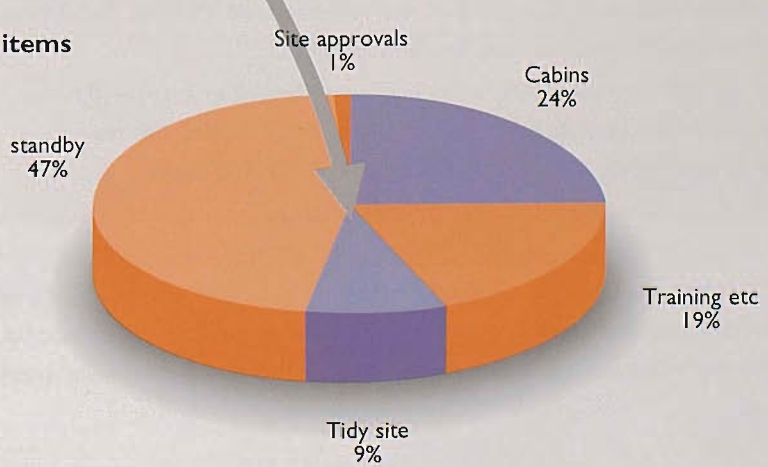
Aggregate view of waste

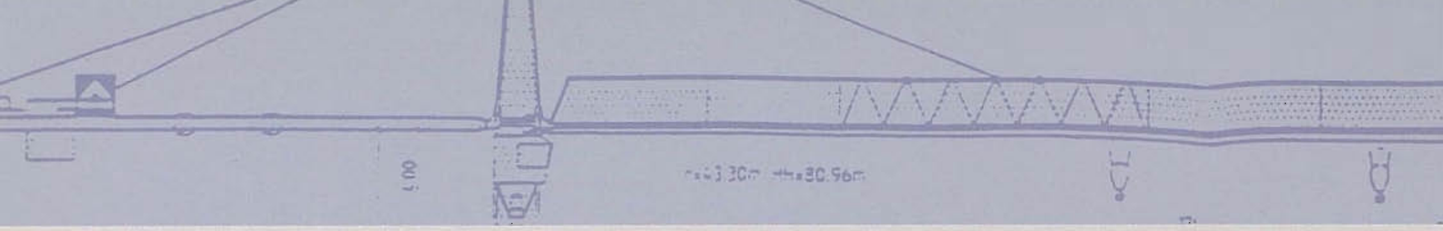
Some waste (NVA) should be eliminated

Some waste (ENVA) is unavoidable but should be minimised

The detail at levels 2 and 3 directs management action

Level 3
Individual logged items





The Toolkit in Use: Pareto Analysis

This is a simple method for identifying what actions are likely to generate best results for impacting the bottom line. It requires that the effects be ranked in order of their contribution to the loss in performance being investigated. Typically, it is found that 80% of the total loss is due to only 20% of the causes (the 'Pareto Law'). This generates a relatively short action list in anticipation of considerable increase in performance.

Supplier Assessment

Assessing suppliers is a continuous process within supply chain management. The idea is not just obtaining the lowest price but the best mix of price, quality, delivery flexibility, delivery accuracy, financial terms and so on. Such assessment is important for construction SMEs and should be seen as a key enabler for better competitive advantage through management of the supply chain.

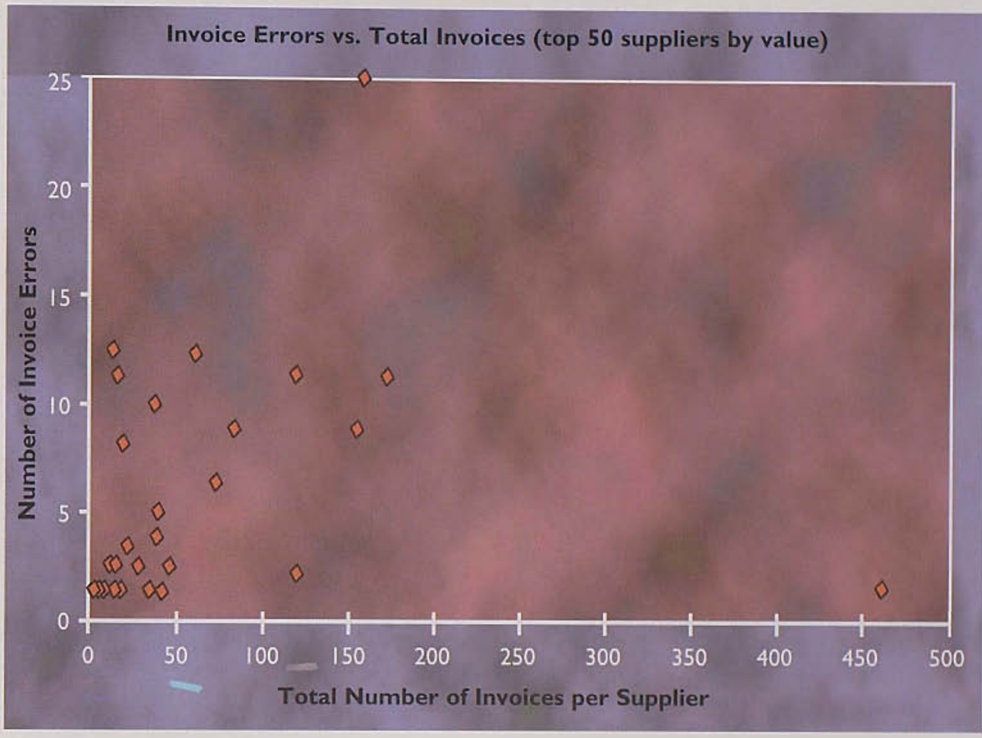
Suppliers may be assessed in terms of how well they perform over an extended period of time. Just as a client would monitor a contractor so should a contractor adequately monitor its supply base. An important element of supply chain management is to ensure that the linkages between suppliers and contractors and contractors and client are as seamless as possible. Thus, failure on the part of a supplier not to adequately meet standards set by a contractor could have detrimental effects on client satisfaction.

There is therefore a need to recognise that the total cost of purchased goods goes well beyond the purchase price. Late or defective goods can create significant delays impacting the end date, cost of doing the job and possibly the final quality.

One typical example was a supplier issuing an inaccurate invoice. The resultant failure by the supplier to correct this resulted in Trant being on stop with a total bill for £200. The resultant wasted costs for disruption to a worker was calculated at £115.51.
In any year Trant will pick up on suppliers inadvertently over-charging by 2 to 3%. This may not sound significant, but on a bought ledger of £6m this is up to £180,000. This type of supplier inefficiency does impact on you as a customer and can be easily monitored.

As an example of a supplier assessment, an analysis of invoices was undertaken within TEL using data easily obtained from an accounts database. The top 50 suppliers are listed in terms of frequency of invoice. The total number of invoices is indicated along the x-axis and the number of invoice errors plotted on the y-axis.

Analysis of Invoice Errors

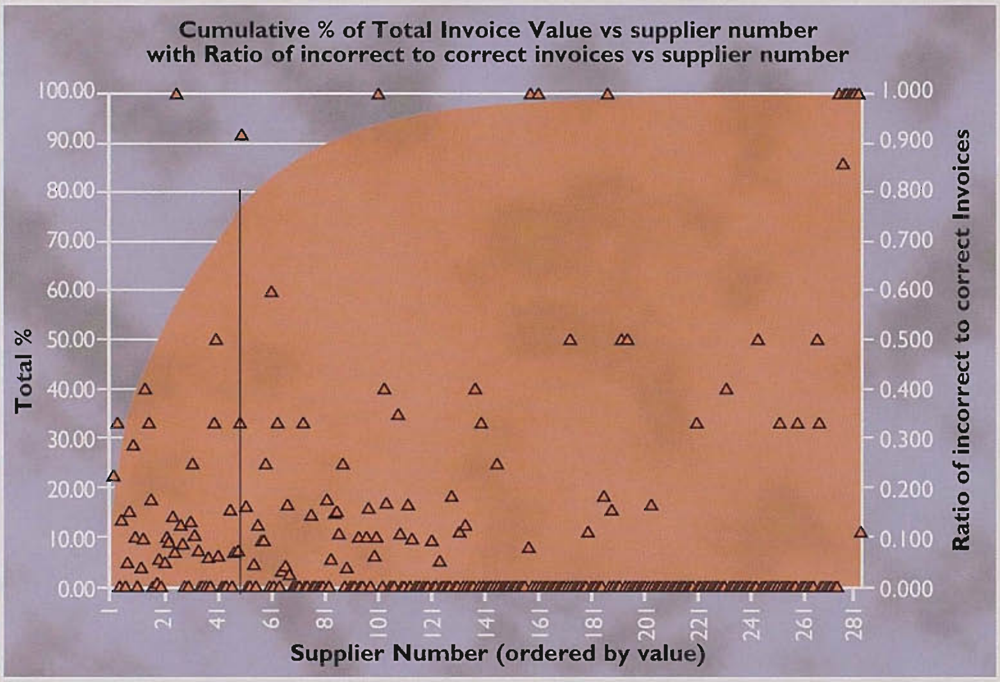


Two issues arise from this plot:

1. There are a number of suppliers who produce invoices with errors. These need to be eliminated in order to reduce overhead burden in re-processing these invoices within a company. Again the accounts system can be interrogated to assess the percentage of incorrect invoices from suppliers. For Trant this was just under 10% by volume.

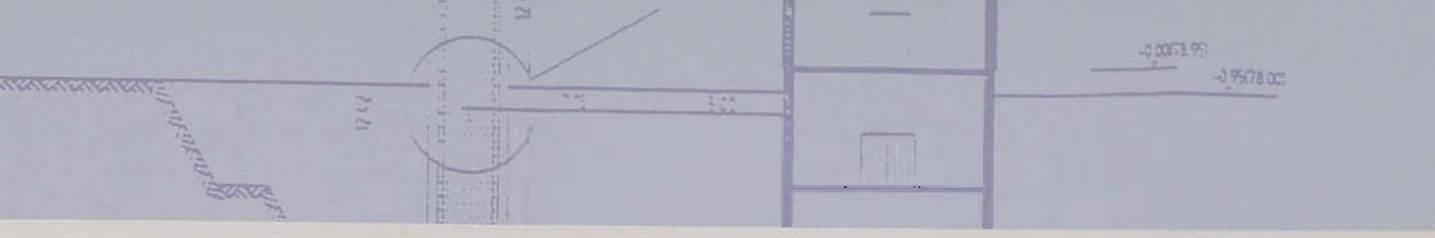
2. There are some suppliers that issue a large number of invoices. Further analysis shows the number of invoices issued and the total invoice values in a financial year.

Identification of Suppliers That Need Managing



The above diagram shows the cumulative contribution of suppliers to the total materials spend. The vertical line identifies the suppliers that contribute to 80% of this spend, in this case 57 suppliers. Superimposed on the diagram are the ratios of correct to incorrect invoices for each suppler (represented by triangles, right hand axis). The majority of suppliers issue no incorrect invoices but it can be seen that a significant number of suppliers issue incorrect invoices and hence need managing.

Focusing on the High Invoice Suppliers



Another element in analysing suppliers is the number of suppliers supplying the same material. Unless geographically difficult a single invoice for a category of material is both realisable and desirable. This does not eliminate the element of competition as other supplier prices can be spot checked at any time.

To summarise the supplier analysis, a smaller construction company may not have the resources to build supplier networks but the accounts database can be a valuable store of information. The result of invoice analysis has shown that:

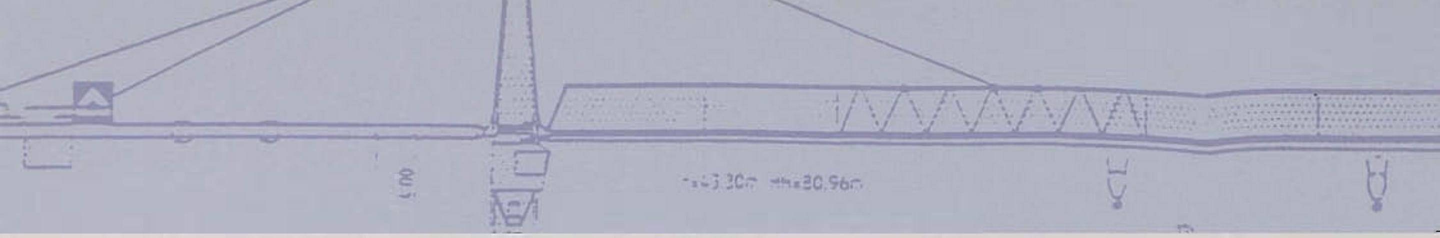
- The supply base should be kept to a reasonable size
- A large number of invoices and invoice errors creates direct overhead burdens and indirect site problems
- Suppliers may inadvertently try to overcharge and, in some cases, these are then passed on to the client – BUT are clients happy to bear this cost? Normally, in the case of re-measured contracts, this simply reduces profits.

Conclusions

Over recent years there has been a growing awareness that the construction industry's record for costs, schedule times, quality and safety is unacceptable and needs to significantly improve. This is recognised, not only for the UK, but also for Europe and America. As a result, considerable Government funds have been committed to research projects in order to ameliorate this situation. This handbook is the result of one such project funded by the Engineering and Physical Sciences Research Council.

It is estimated that, on average, in the UK 30% of project costs accrue as a result of failure to develop and manage an integrated supply chain. The same failure of the supply chain also has a significant negative impact on quality, schedule and safety. In addition, as a result of the quest for short term profits by the use of claims, the legal profession, specialising in construction litigation, are benefiting at the expense of construction profits and to the detriment of the client.

The tools adapted for construction and described in this handbook have been shown to provide benefits far in excess of the effort required to implement them. Each tool is stand alone and it is not necessary to utilise all tools simultaneously. It is, however, of vital importance to start with a 'big picture view' and work down to the more detailed operations. For this reason a good starting point is the use of process modelling to develop a clear picture of all the processes undertaken by the organisation. This can then be followed by a more detailed analysis of each of the processes identified.



The detailed analysis of each process can be undertaken using the tools described in this handbook as follows:

Is the process necessary?

Does the process contain non value adding activities?

Can the process duration be shortened?

Can the process be re-engineered to eliminate waste?

It is not necessary to use all of the tools to carry out this analysis. It is the choice of the individual as to which tools are most suitable for which processes within a particular organisation.

This handbook helps provide the construction industry with the means to make a step change by focusing on customer satisfaction and changing from a functionally based industry to a process based industry leading to improved quality, higher profit margins and shorter lead times.

The Research Partners

Trant Engineering Ltd

Trant Engineering Ltd. (TEL) are part of the Trant Group of Companies, based near Southampton. TEL was formed in the early eighties to specialise in building, civil and maintenance contracting within the Petrochemical sector. Their clients now include the major petrochem companies along with pharmaceutical and other proccess industries with bases in South Wales, Dorset and Hampshire. The Company has grown significantly in the last eight years with a current turnover of approximately £10 million. Quality, safety and environmental management by direct employees, indirect suppliers and sub-contractors is crucial within the environments in which they work.

The Business Engineering Group

The Business Engineering Group has just one key aim - To support Business in it's strive for increased efficiency and profits. It's key research objective is to develop new management technologies and support 'tools' for the construction and manufacturing industries based on a rigorous and sound understanding of the logic underlying the business problem.

The Business Engineering Group was established in October 1994 following discussions with industry that highlighted their requirements for practical support in all the areas of business management. It is the culmination of a broad based research agenda that has its roots in the construction industry but has recognised the influence and developments in the broader sphere of management and other industrial sectors. It works actively with other Departments across the whole University. The primary activity of the Group is to carry out high quality research and consultancy working in close partnership with industry. The Group is enthusiastic in extending the knowledge and understanding of Business Engineering by the provision of teaching and short courses at professional, postgraduate and undergraduate level.

Typically the Group comprises 2 academic staff supported by Research Fellows, Research Assistants and is supervising, at present four post graduate research students. A new lecturer in 'Business Process Re-engineering and Agile Manufacturing' was appointed to the Business Engineering Group in August 1998 with funding from the Vice Chancellor's Special Initiative Fund.

The Group is working in a broad range of sectors including engineering, construction, manufacturing, fashion textiles. It has worked with companies ranging in size from small to international. It has worked with central and local government organisations.

Although Business Engineering is particularly critical to large multinational businesses it must be remembered that their supply chain usually includes many small and medium sized enterprises. The Business Engineering Group has specifically addressed the needs of these smaller companies to ensure that the gains created are distributed across the whole of the economy.

For further information about the Group contact Michael Riley or David Brown at:
The Business Engineering Group
Department of Civil and Environmental Engineering
University of Southampton
Highfield
Southampton
SO17 1BJ
email beg@soton.ac.uk
Tel +44(0)1703 592134
Fax +44(0)1703 594986

Logistics Systems Dynamics Group

The Logistics Systems Dynamics Group has a history of successful application of Business Systems Engineering in a wide range of market sectors. The Group has developed a family of generic reference models which simplify the choice of re-engineering strategies for a given application. Such models have been successfully applied within individual businesses and whole supply chains.

As well as the project described in this Handbook the Group is involved in supply chain research in the automotive sector (with LucasVarity and Computer Science Corporation), innovative house building using standardised components (with Sussex University and industrial partners including Willmott Dixon Homes, Redland Roofing Systems, Southern Housing Association and NuAire Ltd.) and new product introduction in the aerospace industry (with Rolls Royce, three of its suppliers and De Montfort University).

Based on the research experience described in this Handbook the Group has given many presentations at CIB, BRE and CIRIA CPN conferences and seminars, has been invited to present work on Perception Analysis of partnering projects by the European Space Agency and its Director, Prof. Denis Towill, was a member of the Royal Academy of Engineering Construction Sector Steering Group.

The Group offers advice and training to industry as well as opportunities for undertaking joint research. It supports a number of Masters programmes in the UK and abroad including three at Cardiff; the M.Sc.'s in International Transport and in Systems Engineering, and the MBA in Supply Chain Management.

For further information about the Group contact Prof. D. R. Towill or Dr. M. M. Naim:
Logistics Systems Dynamics Group
Department of Maritime Studies & International Transport
Faculty of Engineering & Environmental Design
Cardiff University
P.O. Box 907
Cardiff
CF1 3YP
UNITED KINGDOM.

e-mail: NAIMMM@cardiff.ac.uk
tel: + 44 (0) 1222 874271
fax: + 44 (0) 1222 874301

The Research Team

Project Manager: Mike Reed
Field Researchers: Gary Evans, Andrew Bailey and David Brown
Academic Directors: Prof. Denis Towill, Michael Riley and Dr. Mohamed Naim

A research project funded by the Engineering and Physical Science Research Council's Innovative Manufacturing Initiative: Construction as a Manufacturing Process.

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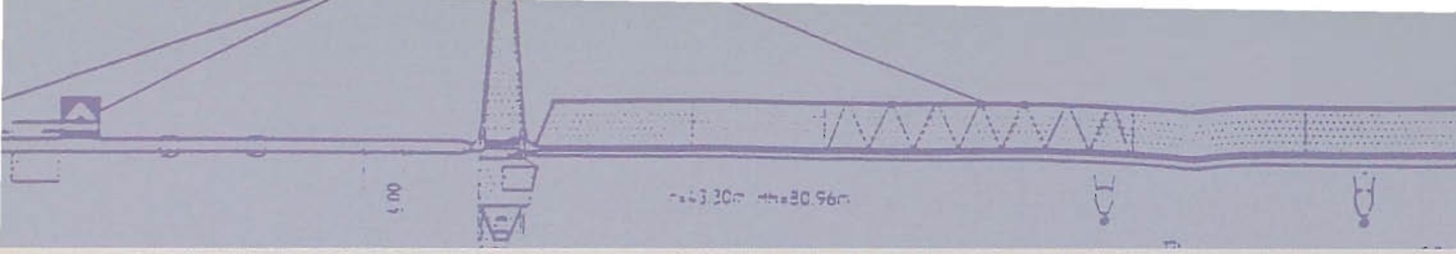

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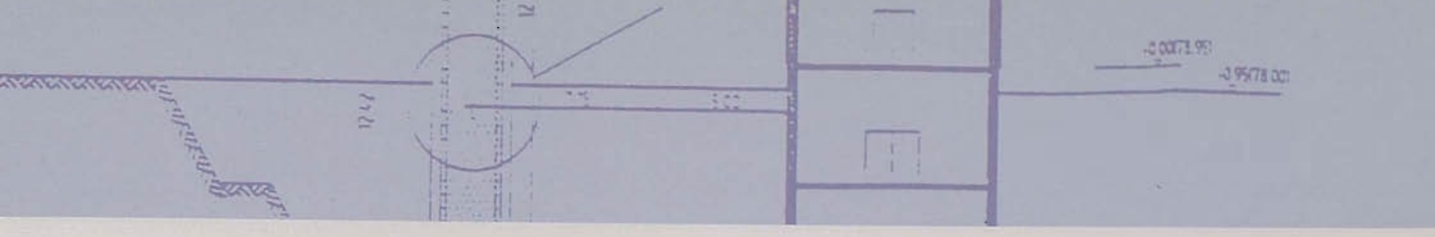

Glossary of Terms

BSE	Business Systems Engineering
BRE	Building Research Establishment
BPX	BP Exploration
CAPEX	Capital Expenditure
CIB	Construction Industry Board
CIRIA	Construction Industry Research and Information Association
CPN	Construction Productivity Network
CRINE	Cost Reduction In the New Era
DPC	Damp Proof Course
GRN	Good Recieved Notes
ICP	Information Control Process
MIS	Management Information System
MRT	Minimum Reasonable Time
PDP	Product Delivery Process
PIP	Product Implementation Process
SME	Small to Medium Enterprise
TCT	Total Cycle Time
TEL	Trant Engineering Ltd.

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