"WICKED PROBLEMS, RIGHTEOUS SOLUTIONS" BACK TO THE FUTURE ON LARGE COMPLEX PROJECTS

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ABSTRACT

Most large, long and complex projects are "Wicked" Problems. To deal with change and uncertainty on such projects, the project Delivery Process (Definition, Design, Manufacture and Assembly) needs to be considered with the Development Process (Business case, statement of need, Functional Brief) as a total system. The Development Process needs to deliver a minimum usable subset of Business, Customer and Operational requirements to enable the Delivery process to start. In return the Delivery Process needs to improve flexibility to allow the Business, Customer and Operator to respond to changes due to technology improvements or market conditions and still improve efficiency and be "lean".

The project team for Terminal 5 at Heathrow Airport has identified tools and techniques to help solve the wicked problems of Project Development and also to improve flexibility of Delivery through the use of Last Responsible Moment (LRM) for information transfer and decisions. These are established by working backwards from completion. The LRM concept together with lean techniques and "decoupled" project delivery systems has given a new view on traditional Project Management techniques and project processes. "The world's most refreshing Interchange" project of Terminal 5 at Heathrow costing some £1.9Billion is starting the delivery process utilising LRM concepts in an information driven project system developed in-house using simple rules and a simple visual basic programme which links process mapping, planning & programming and information control

KEY WORDS

Last Responsible Moment, Information Driven Project System

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INTRODUCTION

SOLVING THE RIGHT PROBLEMS

"Successful problem solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem" Russell Ackoff 1974

We live in turbulent , fast moving times. The days have gone when certainty could be measured for years ahead. The cycle of change winds ever tighter and businesses and organisations need flexibility to respond to changes in market conditions and technology, often played out on a global stage. Construction projects are generally only a means to an end and form only one part of the response in the chain of identifying and meeting business needs. Too often the construction industry has failed to respond to this basic requirement of flexibility by demanding fixed requirements at the start of a project and then complaining when the customer or owner changes his mind. Large, complex and long projects suffer from requirements volatility. If there are comments and thoughts such as "Just tell me what you want and we will do it." or "The customer keeps changing their mind" or "Where is the brief?" then there is probably an underlying "wicked" problem (Rittel and Webber 1973).

"For every complex problem there is a simple solution. And it is wrong." H.L.Menken

"Wicked " problems are often those where the dynamic and behaviourial complexities are high; where different groups of key decision makers hold different assumptions, values and beliefs, and where component problems cannot be solved in isolation from one another. Conversely "tame" problems (Rittel and Webber 1973) have low dynamic and behaviourial complexity and can be solved using conventional analytical methods involving data collection and "static" analysis (i.e. analysis that does not require dealing with delays, multiple feedback loops, and non-linear relationships). Tame problems can be solved in isolation, can be broken down into parts which can be solved independently by different groups of people. Solutions to different parts of a larger problems can then be integrated into an overall solution. There is an old Japanese saying "If all you have is a hammer , then everything looks like a nail" and trying to solve "wicked" problems using "tame" problem solving techniques will cause the wrong problem to be solved.

AIRPORTS OF THE FUTURE

BAA plc is the world's largest commercial operator of airports, operating seven UK airports handling some 112 million passengers each year and all or part of eight other airports in the rest of the world. Competition is played on the world stage. Airlines form into global alliances with passengers offered routes not through adjacent UK airports but via Paris, Schipol or Frankfurt. Providing capacity to meet air traffic growth is one of BAA's primary duties. Terminal 5 at Heathrow was foreseen prior to BAA submitting a Statement of Case in January 1995. The Public Inquiry into the proposal to build a fifth terminal at Heathrow Airport started in May 1995 and finally finished after having sat for

525 days, in March1999, making it the longest public Inquiry in British planning history. The Inspector is currently writing his report recommending whether the terminal should go ahead. A Government decision is expected in 2001 with an anticipated start on site in spring 2002 and an operational date of Spring 2007. Evidence offered at the Public Inquiry to persuade the Inspector becomes effectively a constraint within the scheme and is extremely difficult to change. Against this linear timeline background the airline and airport businesses are subject to continuous change and pressure.

THE AIRPORTS WE DESIGN TODAY MUST BE FIT FOR THE WORLD TOMORROW.

What will it be like travelling through Heathrow Airport in the next century? Will there still be queues? Will we travel at all, or just use virtual travel? BAA spends well over £1 million a day on building pieces of airport and an equivalent amount on maintaining and developing them. The buildings will be there for decades so we need to ensure that they will respond to needs of tomorrow. The Airports of the Future will be a response to the aspects of the future and these are intertwined and interdependent:

Aspect	**Examples**
Environment	climate, resources, pollution, noise
Technology	communications, users interfaces, intelligent buildings, materials
Future Society	global politics, (de)regulation, security, tax, welfare, culture
Future Business	globalisation, supply chains, retail, money, employment patterns
Future Passengers	demographics, lifestyles, expectations
Future Aviation	alliances, aircraft developments, market segmentation, congestion

WHY LOOK AT FLEXIBILITY?

Can we Predict the Future? No. There are plenty of well known examples of famous people getting it wrong. But we don't have to be able to predict a single future to be doing useful work: we can design for flexibility.

In some areas we can have more certainty than in others. In the more clear cut cases we can plan in greater detail with higher confidence; in others we should aim to build in flexibility. But which are which? And what sort of flexibility is needed where?

If we can't predict the future we should be aiming for flexibility, so that we will be better poised to cope with future events. If it is done systematically, being prepared for likely eventualities can give critical business advantages and save large amounts of money: building in flexibility doesn't always mean adding cost.

LEAN AND FLEXIBLE

A significant body of literature now exists to describe lean production methods as well as lean construction theory and applications. The weight of this knowledge lies generally within the construction phase of projects and there is less case history of its application to design. With certain and known requirements the principles to achieve lean design and construction are understood. However this may not lead to a flexible solution. Many development projects fail to meet the expectations of the end users.

Such project failures can be classified into one of five basic types :

1) The solution fails to meet the business requirements for which it was developed. The solution is either abandoned or expensive adaptive maintenance is undertaken.
2) There are performance shortcomings in the solution, which make it inadequate for the users' needs. Again, it is either abandoned or amended incurring extra costs.
3) Errors appear in the developed solution causing unexpected problems. Modifications have to be applied at extra cost.
4) Users reject the solution, for political reasons, lack of involvement in its development or lack of commitment to it.
5) The solution is accepted but over time becomes unmaintainable and so passes into disuse.

Conversely it is also relatively simple to include flexibility either in the design process through including extra design iterations, or developing multiple designs or incorporating redundancy or duplication or provision into the built solution. This however is not lean or efficient. The solution will probably be late and over budget through numerous changes.

SYSTEMS THINKING

The ability to see the big picture is fundamental to solving the right problem. "Systems thinking" (Senge 1990) is needed to understand the complexity and interactions of the various parts of a whole framework. For Terminal 5 the goal is to create "the world's most refreshing interchange" .This means that we have to balance the short and long term views. What might be happening in the future depends on how far ahead we are looking. The aim is to balance on the one hand looking forwards from today's position by following current trends, with on the other hand stepping back and trying to create a vision of the future in say 20 years time. This might sound a long way off, but it's less than half way through the life of Terminal 5.
We can portray this as follows:

Is it any wonder therefore that the traditional starting point for delivery of a matching brief and business case tends to be the holy grail that is never achieved on large, complex and long projects? Yet without this matching set the delivery process can not start and be lean and efficient. We can usefully use function modeling IDEF0 techniques to explore the principal elements of the system (Figure 2). This will show what information is required to provide the sufficient and correct flow to start the delivery process and what information can be given later to give the business flexibility of response.

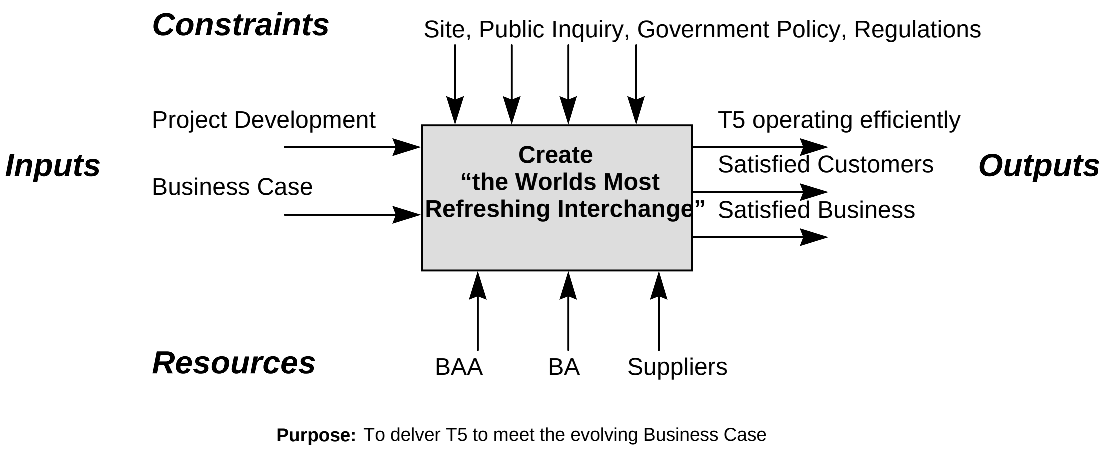

Figure 2: T5 as a high level IDEF0 Diagram

This high level function diagram can be decomposed two further levels see Figure 3

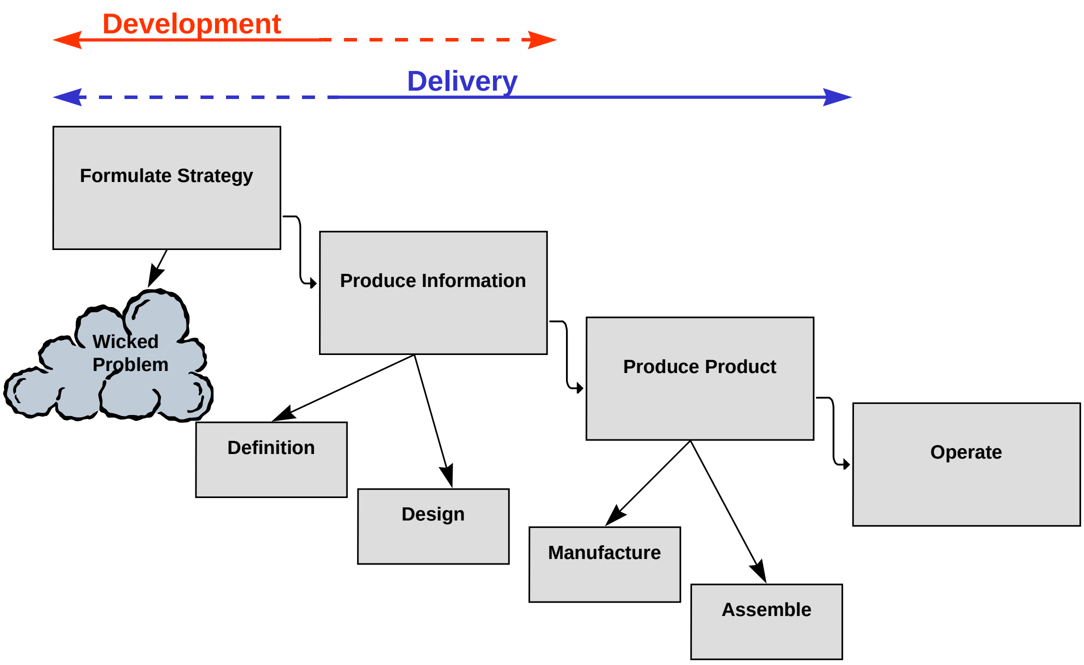

Figure3: T5 as a system at levels 2 and 3

T5 AS A SYSTEM

Viewing "the World's Most Refreshing Interchange" as a system then:
The Strategy phase needs to deliver a minimum usable subset of Business, Customer and Operational requirements to enable the Delivery process to start
and
the Delivery process needs to improve flexibility to allow the Business, Customer and Operations to respond to changes due to technology or market conditions and still be lean and efficient

ENABLING DELIVERY

"WICKED PROBLEMS, RIGHTEOUS SOLUTIONS"

This wonderful title comes from a book (DeGrace & Stahl 1990) which describes methods of solving software development problems. Software development projects also contain dynamic and behaviourial complexities and it is therefore useful to look at the tools and methods that have been adopted in that industry and to draw learning for our own paradigm. To start the Delivery process we need output from the Strategy phase of the project. This entails solving "wicked" problems.

The issues and constraints relating to T5 are shown in Figure 4.

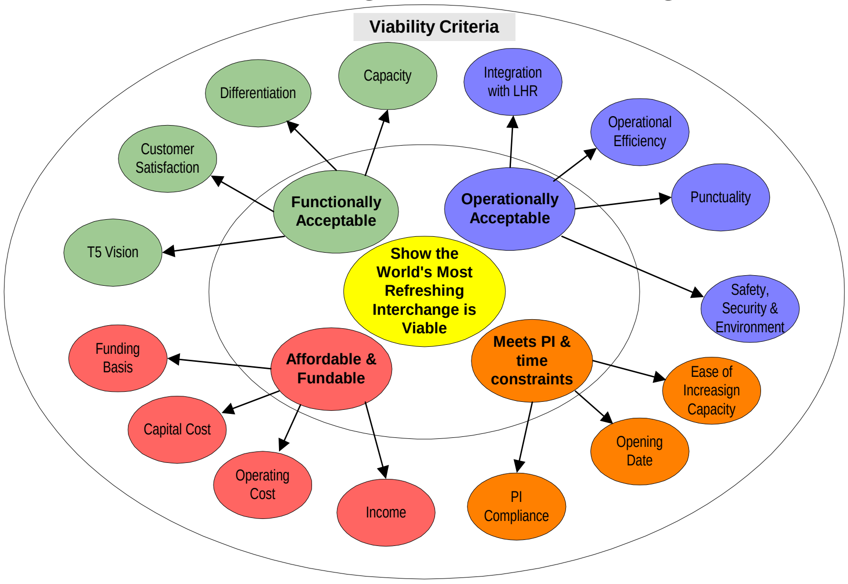

Figure 4: Viability Hierarchy

The viability hierarchy represents the dynamic and behaviourial complexities of the project and as such there is no "ideal solution" that meets these all of these requirements. The "satisficing" solution,(Simon 1957), is the one good enough to satisfy the stakeholders. A backward pass down the timeline from an operational open date of 2007 dictates when the first outputs from the strategy phase need to be delivered to the Delivery process. BAA has for the past 5-6 years adopted a long term partnering/framework approach with its suppliers this has enabled an integrated team of Customer, Operator and the Delivery team (comprising of the designer, manufacturer and assembler of all the primary systems) to develop trial solutions using incremental prototyping .

The prototyping of solutions is undertaken within fixed time cycles. The purpose of each cycle is to make and test something. Customers , operators and the business are an active part of each cycle. The output of each cycle comes from a prioritised list according to MoSCoW rules:

- **M**ust Have for requirements that are fundamental to the system. These must be delivered and represent the minimum usable subset of a solution.
- **S**hould Have for important requirements that should be there or a short term work around is available
- **C**ould Have but could be omitted this cycle
- **W**ant to have but probably wont for this iteration

The o's are just for fun.

After some six cycles over fifteen months there is now emerging the fundamental requirements that enable the Delivery process to start. Time has now run out for further iterations unless a delay to the opening is acceptable.

IMPROVING THE DELIVERY PROCESS

Solving "Wicked" problems means that the Strategy phase is now able to provide a usable set of input information flows to start the Delivery Process. The Delivery process needs to respond to its part of the system by allowing flexibility and still be lean and efficient . Flexibility is improved by the adoption of Last Responsible Moment (LRM) for information transfer. LRM is analogous to Just In Time (JIT) for construction but can be universally applied to milestones for transfer of any type of information or product. Lean Thinking is applied to value streams by improving flow of information or product through the system and removing waste. Essential but non value adding support processes such as resourcing and approvals are run concurrently adopting a "smile and wave" support approach.

PROJECT PROCESSES RE-EXAMINED

TRADITIONAL PROJECT PROCESS

The standard BAA Project Process is illustrated in figure 5.

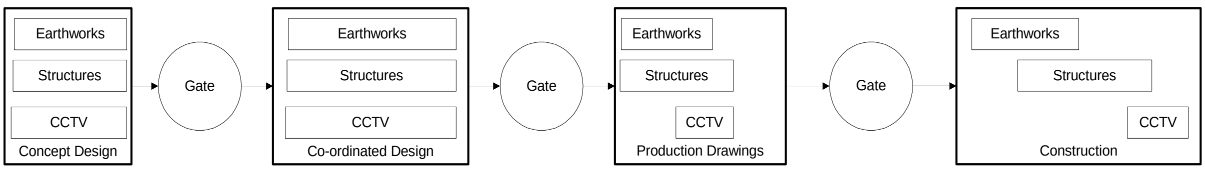

Figure 5: The BAA Project Process

It is similar to numerous other project processes. It was developed and works well for medium sized projects with a fixed brief at the start of Concept Design. There are a series of gates at which the solution is considered by the stakeholders and approval given to proceed with the next stage.

It has a number of disadvantages for a project such as T5:

- It is a batch and queue process which trades efficiency in the delivery process for security to the business.
- It is inflexible and does not work well if the business case and customer requirements evolve after the start of Concept Design.
- It does not inherently cater for fast moving technologies where manufacture and assembly and therefore design have no need to start early and considerable advantages may be obtained by delaying design to ensure that the most up-to-date technology is incorporated.
- The high level map is based on traditional construction stages and other disciplines cannot satisfactorily map their own processes to it.

LAST RESPONSIBLE MOMENT PROJECT PROCESS

The Last Responsible Moment (LRM) is defined as the latest moment for starting an activity without compromising cost or programme whilst maintaining maximum flexibility for the Business. The LRMs identify key programme drivers such as:

- information flows between systems (such as structural grid from building concept to structural frame)
- technical decisions (choice between pre-stressed or conventional aircraft pavements)
- business decisions (trading between retail space and check-in space)

The LRM dates are established by working backwards from end dates for each major system of the project. These dates are not the last possible dates but change later would have cost or programme implications. The principles of the LRM Project Delivery Process is shown in Figure 6

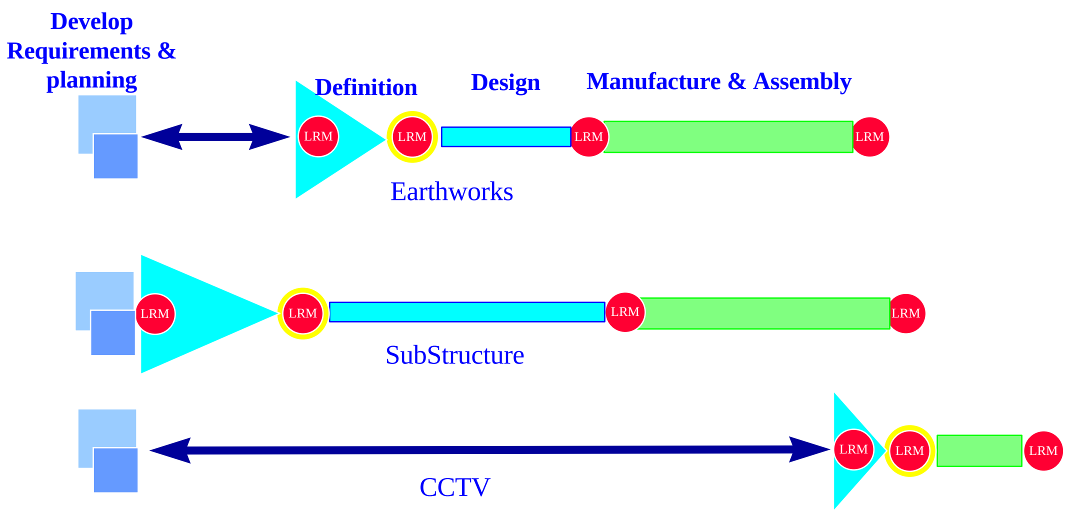

Figure 6: LRM Delivery Project Process

Principles

The key principles for the process are:

- Identify key systems for the project (Earthworks, Aircraft Pavements, Substructures, Building Services, Envelope etc.)
- Process map the value streams of systems.
- LRMs are milestones for information transfer
- Project programming and monitoring is based on the LRMs of systems and the flows between systems.
- The project management system is driven by information flows

INFORMATION DRIVEN PROJECT MANAGEMENT SYSTEM

All activities require information to be processed. Information is required before activities can be started and each activity produces information once it is completed. Understanding the flow of information is therefore fundamental to planning and doing work. If we can track and control information rather than monitor activities we can ensure that the right people have the right information at the right time and when this does not happen it pinpoints the source of the difficulty.

THE HIGH LEVEL PROCESS

Figure 7: Information Flows and Black Boxes

The high level process represents the conversion of inputs to outputs by adding value (Figure 7). Outside of those undertaking the process or activity we do not need to understand the conversion process other than to ensure that it is as efficient as possible. Inputs are those pulled by the activity and are milestones. Similarly the outputs are those required as inputs by following activities within the system being mapped or in other systems.

MAPPING THE T5 SYSTEMS

Mapping is carried out in at system level with, as far as possible, the Business, Customer, Operator and Delivery team being represented. The sessions are facilitated and concentrate on identifying the inputs and outputs working backwards from the Operate phase back through to Definition (Figure 3). Some 30 systems need to be mapped to establish the high level LRM programme. Time is allocated to the activities such that programmes can be created. The process maps are drawn into VISIO™ and then automatically transformed into programmes using an internally developed Visual Basic programme. Figures 8 & 9 illustrates part of the process map for substructures and the resulting programme.

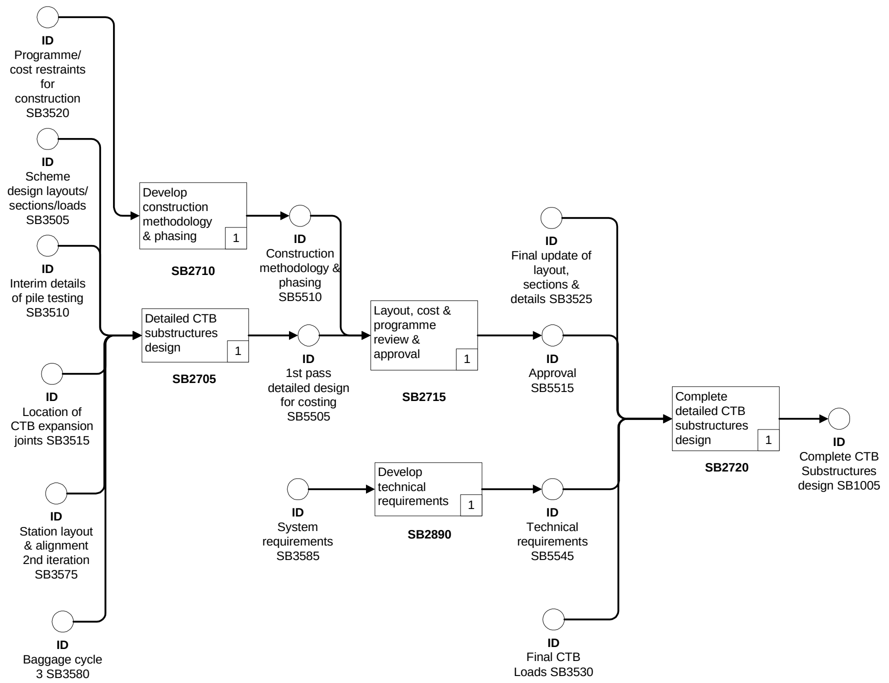

Figure 8: Part of Substructures process map

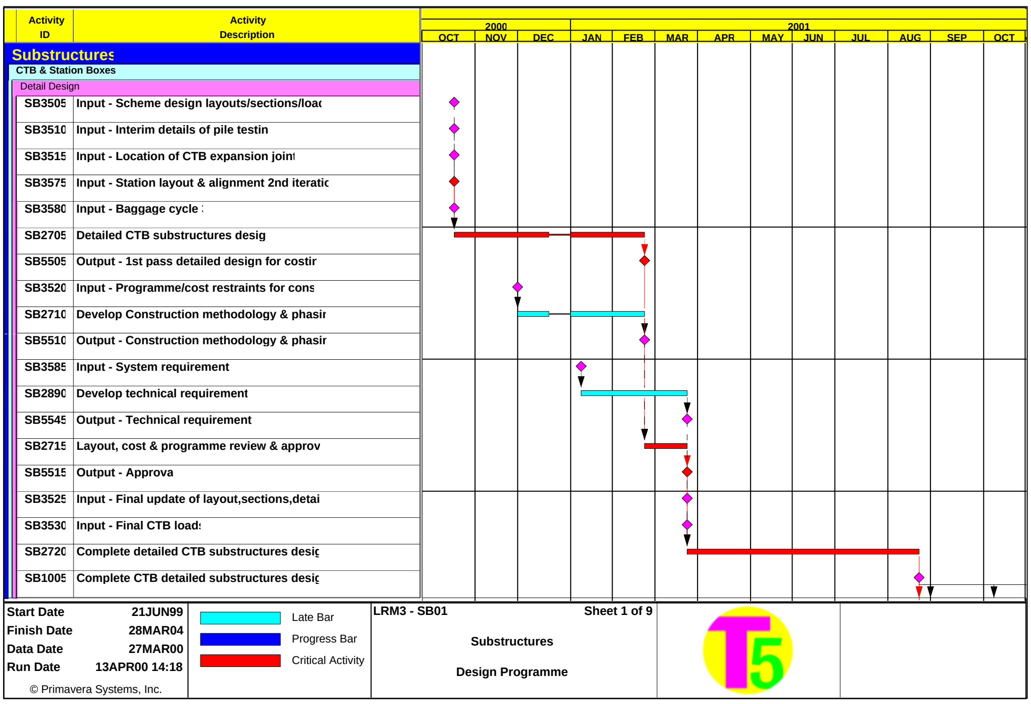

Figure 9: Corresponding part of the Substructures Programme

The main apparent difference from a conventional programme is that all the inputs and outputs are milestones and these are used to monitor progress.

WHAT INFORMATION?

The process sessions need to be structured to ensure the correct information is captured:

- What are the critical external information flows with other systems(including the Functional Requirements)?
- What are the critical internal information flows that affect the timing of the external flows?
- What are the critical internal information flows that define the Last Responsible Moment for the start of the next sub-process?
- Is the level of detail sufficient to model the critical internal and external flows?

Added value

Dealing with information flows rather than activities gives further advantages. Inputs and outputs (datasets) are ideally suited to document management systems with control over versioning and transfer of information and workflow control. With each piece of data additional information can be attached such as:

- Approvals and reviews undertaken
- Risk and opportunity (does the data contain an assumption, what are the transfered risks?)
- Interface control information (what activity provides the information and what activities receive the information)

The future worth of these datasets is greatly enhanced and facilitates knowledge retrieval.

SO FAR -SO GOOD

The understanding and the adoption of the principle of LRM and information flows has been pivotal in allowing the project to move forward. The Business now has an understanding that decisions need to be made by certain dates to avoid waste and meet operational timings. The delivery team acknowledges that a comprehensive brief is not available at the start of the project. Systems thinking has allowed us to see the wood **and** the trees. However, much needs to be done and we have only just taken our first few steps down a long road. We are currently exploring methods of optimising the information flows which is currently being done using experienced judgement. The use of Design Structure Matrix (DSM) techniques will be a useful tool. So far we have concentrated the effort on the strategy and design phases and much process mapping work needs to be done for the Manufacturing and Assembly phases. We hope to report back in the future.

ACKNOWLEDGEMENTS
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