Conference Paper

Creating mechanisms for inter-project learning in Complex Product Systems

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Introduction

This paper examines the problems of learning in organisations developing and supplying what we call complex product systems (CoPS). CoPS are capital-engineering- and IT intensive business-to-business products networks, constructs and systems. They are produced on a project basis, often in multi-firm alliances, as one-offs or in small customised batches for specific customers and markets. Examples include flight simulators, global business networks, jet engines, civil airliners, power stations, mobile telephone systems, and large civil engineering projects. Innovation processes in CoPS do not conform to conventional models derived from research in mass-production industries - such as automobiles or consumer electronics (Hobday, 1998). It follows that the process of innovation management is also likely to be different and many of the tools, techniques and practices derived from mass production inappropriate. In particular, mechanisms for learning that are appropriate for mass production firms may be less appropriate for CoPS firms.

In order to understand the difficulties of learning in CoPS firms, the first part of this paper will provide a more detailed analysis of the characteristics of CoPS which distinguish them from mass-produced goods. We then go on to discuss aspects of organisational learning and other literature which have some bearing on the specific problems of learning in CoPS. In particular, the creation of learning mechanisms is discussed.

The next part of the paper describes an attempt to develop one such learning mechanism in one CoPS firm in the form of a collaborative exercise between university academics (the authors of the paper) and the company as part of a research project examining problems of innovation in CoPS. The researchers worked with a representative from the company to produce a guidebook in an effort to capture the learning that took place in the course of a turnkey project with the hope of transferring some knowledge to future turnkey projects. We begin by describing the turnkey project and the main learning points. We go on to examine the process of developing the guidebook itself. Finally we draw together some observations about the process and the implications for developing cross project learning mechanisms.

Key characteristics of CoPS

There are a number of characteristics related to product complexity, production, markets and government policies, which tend to distinguish CoPS from other goods especially mass produced goods.

CoPS tend to consist of large numbers of components and subsystems involving multiple interactions between the various levels of system and sub-system hierarchy. Furthermore, -CoPS are generally supplied as one-offs or in small batches. Whilst the subsystems and components of CoPS may increasingly be assembled from standardised components, the design and the integration of the components and sub-systems into the end product involves a high degree of customisation to meet the specific requirements of (usually) large customers. The IT and software content of many of the components and subsystems is rising and software plays an important role in controlling and co-ordinating the subsystems. The control and co-ordination capabilities of software mean that previously distinct or separate systems are now combined into larger systems which are inherently more complex.

The typical process of manufacture for CoPS is in a project. The project often involves a temporary coalition of a number of organisations (some of which are responsible for the development of major subsystems or components of the overall system) usually with a prime contractor managing the integration of the various inputs into the assembly of the final product. The projects generally include a number of phases: a bid phase, preliminary and detailed design, manufacture, delivery and installation. For some CoPS servicing, maintenance and de-commissioning add to the lifetime of the project. IT and software in the form of electronic communications, databases and design tools, are increasingly providing an important means of co-ordination of the activities of the network of firms involved in CoPS development.

Whereas mass production markets tend to be characterised by a small number of large suppliers and a large number of individual consumers, CoPS industries tend to be bilateral oligopolies with just a few large suppliers and often just a few large but very demanding (and knowledgeable) customers (such as mobile telephone operators, commercial airlines, the armed forces, air traffic controllers etc.). Since their business survival often depends on the technical performance of CoPS products these customers take a more keen interest in the development process than the largely anonymous consumers of mass produced goods. They need to balance the desire to be technologically advanced with the requirement for these crucial systems to be reliable in service.

Many CoPS sectors are subject to a high degree of regulation at both domestic and international levels. Government thus influences CoPS not only as a purchaser of CoPS but also in terms of establishing technical and safety standards, and in regulating excess concentration in the market.

These characteristics of CoPS mean that processes of learning that have been developed in mass production firms may not be easily transferable to a CoPS setting. The next section of the paper addresses these particular problems.

Problems of learning in CoPS

During the course of a recent research project we carried out two case studies of live projects in each of three CoPS companies. A particular problem identified in each of the case studies, in all collaborating companies, was the difficulty of capturing the knowledge created during the course of one project and transferring this knowledge to subsequent projects in order to improve performance. While knowledge acquisition does occur at the level of the individuals and teams involved in projects, there are few, if any, mechanisms in place to allow the exploitation of this knowledge at the level of the organisation as a whole. Subsequent canvassing of opinions from industrialists suggests the problem is widespread amongst CoPS developers and producers and becomes even more of an issue when multi-firm alliances are involved. Coombs and Hull (1997) point out that in certain types of very large projects such as the design and building of chemical plants or the building of a large civil engineering project such as an airport terminal, knowledge management presents specific difficulties. This relates to the fact that teams are assembled to do the work, they gain a lot of experience and skill which appears to be specific to getting the project done but which conceals some potentially generic and transferable lessons. They identify a problem of the culture of such work which is that the emphasis is on completion of the project after which the teams are broken up and the motivation to reflect on and document the transferable experience for re-use in future projects is low.

The problem is similar to that identified by Argyris and Schon (1978) in respect to single and double loop learning. Within individual projects new knowledge is created and shared among the project members in order to enable the completion of the project. During the lifetime of a project, various persons join and leave and once the project has been completed, the teams disband, individual knowledge is dispersed and the collective learning is often lost. Thus knowledge capture and transfer tends to occur around current practices and projects (single loop) and may be shallow and unsystematic.

There is a massive literature on organisational learning and the ability to capture and transfer knowledge has been addressed in some of this large body. there is not space in this paper to go into this in any depth but a number of useful reviews of the literature on organisational learning do provide some pointers. Shrivastava (1983) for example, identifies six different types of organisational learning systems:

- *one man institution* - in which a single individual who is knowledgeable about all aspects of a business acts as a broker of organisational knowledge.
- *mythological learning systems* - whereby much of the learning across the organisation is the result of exchange of stories about various activities and actors in the organisation.
- *information seeking culture* - certain organisations, because of the business and environment they operate in and the kind of people they employ, create a culture of inquisitiveness and curiosity. In such organisations information is routinely exchanged via informal networks usually by word of mouth. Knowledge capture and transfer takes place via these informal networks.
- *participative learning systems* - exist in organisations where participation in decision-making has become institutionalised via the practice of formation of ad hoc committees, working groups and teams for resolving all strategic and management control problems. In such organisations knowledge is transferred back through the organisation via the members of the various committees.

- *formal management systems* - are designed and implemented for information, planning and control. They involve the establishment of systematic procedures developed to guide many of the standard and non-standard organisational activities. This process involves drawing on the knowledge of individuals and standardising the ways in which this knowledge may be used.
- *bureaucratic learning systems* - these consist of an elaborate system of rigid procedures and regulations that all members of the organisation are expected to adhere to and which control both the flow of information, and the format in which it is collected, summarised and transmitted. The system is designed to be impersonal, objective and unvarying.

Levitt and March (1988) interpret organisational learning in terms of three observations drawn from behavioural studies of organisations. First, that organisational behaviour is based on routines. Second, that routines are based on interpretations of the past more than anticipations of the future. Third, that organisations are oriented to targets and their behaviour depends on the relation between observed outcomes and aspirations they have for these outcomes. By routines they mean both "the forms, rules, procedures, conventions, strategies , and technologies around which organisations are constructed and through which they operate... [and also] ...the structures of beliefs, frameworks, paradigms, codes, cultures , and knowledge that buttress, elaborate, and contradict the formal routines." (Levitt and March (1988), p.320). They suggest two ways in which routines and beliefs change: trial and error experimentation, and organisational search. However, they offer little in the way of examples of exactly how to carry out these processes apart from reference to learning by doing, and the creation of stories, paradigms and frames as a means to developing collective understandings of history.

Dodgson (1993) points out that the economics/management and business/innovations approaches to organisational learning argue that the prime motive for learning is to deal with uncertainty in markets and technologies and that while R&D is an important source of learning, it actually takes place throughout all the activities of the firm. However, he also notes that much of this body of literature "ignores or underestimates the problems and complexities in the process of learning" (p.390).

Huber (1991) suggests that information and knowledge acquisition takes place via five processes: congenital learning, experiential learning, vicarious learning, grafting, and searching. An organisation's *congenital knowledge* combines the knowledge inherited from its founders at the time of conception with the additional knowledge that has been acquired before the 'birth' of the organisation.

After its birth an organisation may acquire knowledge as a result of *experiential learning*. This may be as a result of intentional, systematic efforts or it may be acquired unintentionally or in haphazard forms. Huber distinguishes five groupings in terms of organisational experiments, organisational self-appraisal, experimenting organisations, unintentional or unsystematic learning, and experience-based learning curves. He notes that despite the importance of organisational experiments, the literature contains very few studies of experimentation by organisations.

Vicarious learning is about acquiring experience on a second-hand basis by borrowing what other organisations have learnt, by imitation of their approaches etc. *Grafting* involves acquiring knowledge in the form of new personnel who possess capabilities and knowledge previously non-existent in the organisation. Learning by *searching* involves scanning the external environment, in a general way or in more focused searches.

Huber concluded that while there were quite extensive literatures on experiential learning and search there was not much conceptual or cumulative analysis done. Furthermore, relatively little has been learnt about congenital learning, vicarious learning and grafting other than the fact that they occur.

Thus, despite the extensive literature, the discussion of interventions aimed specifically at introducing organisational learning is surprisingly slim (Lipschitz et al, 1996). Popper and Lipschitz (1995) introduce the concept organisational learning mechanisms - institutionalised, structural and procedural arrangements that allow organisations to systematically collect, analyse, store, disseminate, and use information. They claim that it is the existence of these mechanisms that is relevant to the effectiveness of the organisation and that enables it to learn (Popper and Lipschitz, 1995).

Such mechanisms are seen as important in improving organisational performance in relation to developing capabilities in continuous improvement (CI) in manufacturing (Caffyn and Bessant, 1996; Bessant and Caffyn ,1997); by Bartezzaghi et al (1997) and Caffyn (1997) with respect to improving the new product development (NPD) process; and by Coombs and Hull (1997) in relation to the mechanisms through which knowledge affects possibilities for innovation.

Caffyn and Bessant's capability-based model views CI as a set of 'key behaviours', or 'routines' which are generic to all organisations and which evolve over a period of time. The building up and subsequent embedding of key behaviours depends on the existence of enabling mechanisms (exemplified by procedures, subsystems, methodologies etc.). The particular form these enabling mechanisms take and whether they are appropriate or not is contingent on an organisation's history, its structure, its culture, the commercial environment it operates in and many other factors.

Bartezzaghi et al's emphasis is on trying to understand the inner mechanisms that regulate the process of improvement in NPD and to propose adequate enabling mechanisms to facilitate it. They define inter-project learning as the accumulation of knowledge about product development and its transfer to subsequent projects.

They point out the difference in continuous improvement in mass production operations and NPDs. In particular they refer to the plan, do, check, act (PDCA) model for CI (Deming, 1986)) and suggest that for inter-project learning the process takes place at a more abstract level than within specific projects because of its cross project nature. These factors also lead to inter-project learning being characterised by specific peculiarities which make the process very complex. For example, there may be significant time gaps between various phases in a project so that problems in an early phase are not revealed until months later during a different phase. This time separation makes it very difficult to determine cause and effect. Furthermore the feedback is collected by different project members in different phases which means that analysis of variances is neither implicit nor spontaneous. Thus the collection of feedback, the analysis of variances and the identification of the causes of such variances require explicit processes or mechanisms to be put in place.

The last step in the PDCA cycle, the implementation of corrective actions is particularly complex and articulated for NPD projects. This is because plans and feedback are project-specific and hence analysis of variances between initial plans and final feedback can not directly result in corrective actions to be taken in future projects.

Bartezzaghi et al (1997) suggest a number of organisational mechanisms and processes which might enable the development of systematic learning at the inter-project level: managing project feedback; using vehicles for embodying and disseminating improvements; and adopting project classification schemes. They suggest that the most effective inter-project learning mechanism is the analysis of variances during project termination and project audit stages (the former is the final phase of the NPD project, while the latter is carried out about 6 months after manufacture of the new product has commenced.

Much of the research on which the CI model is based (and most other work on continuous improvement) refers to the operations side of organisations and very often on mass produced goods. The nature of mass production means that firms are able to learn by gathering data on routines and improving group practices (Stata, 1989; Garvin, 1993). However, the nature of CoPS production - one-off or small batch - means that data collection is not possible in the same way. There are some examples of learning by doing in CoPS - studies of the airframe industry have shown how the costs of production decline along with labour costs depending on the cumulative number of aircraft manufactured (Wright (1936) and Asher (1956) cited in Levitt and March (1988). But many CoPS are one-offs without the same opportunity to attain economies of scale. Furthermore, the temporary nature of CoPS projects means that there is less scope for routinised learning.

The relevant research that has been carried out suggests that the most fruitful approach to inter-project knowledge capture and transfer in CoPS is to develop enabling mechanisms will encourage the management of knowledge and which foster a positive attitude towards learning. The work on new product development suggests that post-project reviews may provide the best opportunity to try to capture learning. Unfortunately, they either often become a forum for blame attribution or at the other extreme the reviews go out of their way to avoid blame attribution, neither of which are conducive to learning from the experience (Kransdorff, 1996). The long time that elapses between a project start-up and its completion exacerbates the problems - recall is selective and/or flawed and defensive reasoning practices abound. These factors combine to make it very difficult to achieve inter-project learning in CoPS.

This brief survey of literature indicates that there is very little in the way of mechanisms which might be directly applicable to the peculiar circumstances that arise in CoPS. However, as noted above, the problem of inter-project learning is recognised by all CoPS firms and there is a willingness to try to devise ways of addressing the problem. The next section of the paper describes one such attempt.

Developing a mechanism for capturing and transferring project knowledge

Background

As part of research into processes of innovation in CoPS the authors entered into a collaboration with the mobile telephone equipment division of a UK business unit of a world-wide telecommunications equipment manufacturer, let's call them Telco, in an attempt to try to capture some of the lessons that were learnt during the course of the implementation of a major turnkey project to roll out a mobile telephone network for a mobile operator, who we shall call Mobitel.

Our involvement with the company had started the year before in another part of the organisation. We had undertaken a series of interviews with key managers in the company and had developed an understanding of the business and its processes and procedures. We had also completed a study of a development project which spanned seven countries and eleven different research groups intended to create a new generation of mobile telephone base stations. Part of the remit of our research project was to work with companies to develop useful tools to help them in their management of technology. Our main contact in the organisation (who was located in the product development area) knew of a new project elsewhere in the UK division which he thought would provide a good opportunity to develop such a tool. Accordingly he put us in touch with the Director of Turnkey Projects and it was agreed that we should track the implementation of the turnkey project with the broad aim of capturing some of the lessons that could be learnt and applied in future turnkey projects. Before going on to describe the process by which this was carried out the next section of the paper will outline the key features of the turnkey project and its implementation.

The Turnkey Project

In 1995 Telco became one of the first telecommunications equipment suppliers to provide turnkey product in an advanced industrialised country. Previously Telco had only been involved in turnkey projects in developing countries where operators lacked the experience and competencies to build networks.

Prior to the turnkey project Telco was already involved in the design and installation of its latest technology in the Mobitel mobile telephone network, Cellfone, which entered service in July 1993. Mobitel was responsible for all major system integration activities including cell planing, transmission planning, site acquisition and civil builds, with Telco responsible for the supply of the equipment.

In early 1995, Mobitel was under increasing competition from its main competitor, whose network roll-out was driven by a marketing strategy to provide nation-wide coverage. To achieve similar rates of growth, Mobitel sought help from its suppliers to assist in the accelerated roll-out of the Cellfone network to provide national coverage. It put out a tender for a full turnkey contract.

The ITT was presented in two parts: equipment supply and a request for the management of a full turnkey solution. The turnkey activities included cell planning, site acquisition, civil builds, network design, installation, test, acceptance, and project management. The decision to proceed with the tender proposal had the corporate backing of Telco on the grounds that the contract provided a strategic opportunity to secure future orders and move early in the market to supply turnkey solutions in advanced industrialised countries.

Telco put together a bid for a full turnkey solution and, following some further negotiations, won the contract which was signed by the end of July 1995. At the time, it was the largest telecommunications turnkey project undertaken in Europe and the first time Telco had undertaken a project of this kind in an industrialised country. Under the terms of the contract, Telco took over responsibility for the entire range of activities entailed in the provision of a full turnkey solution: cell planning, network design, site acquisition, civil builds, installation, test, acceptance and project management activities.

The objective of the project was to help accelerate the roll-out by installing around 1,500 base stations and 15-20 mobile switching and base station controller sites in the Cellfone network by the end of 1997. The turnkey project was being implemented in parallel to the existing rollout programme and two further contract variations awarded to Telco during late 1995 and early 1996.

Telco drew upon its existing competencies in project management, network design, manufacture and supply of equipment, and implementation and support of equipment, software and services. While Telco had considerable experience in project management and systems integration, the turnkey project raised new and unknown organisational problems. To carry out the turnkey solution Telco's cell planning resources had to be developed and new competencies had to be acquired in site acquisition and site construction. Previously Telco had only delivered and installed equipment in sites already prepared in advance by the customer and its sub-contractors.

The design and construction of the turnkey product can be illustrated with a simple flow chart diagram (see Figure 1).

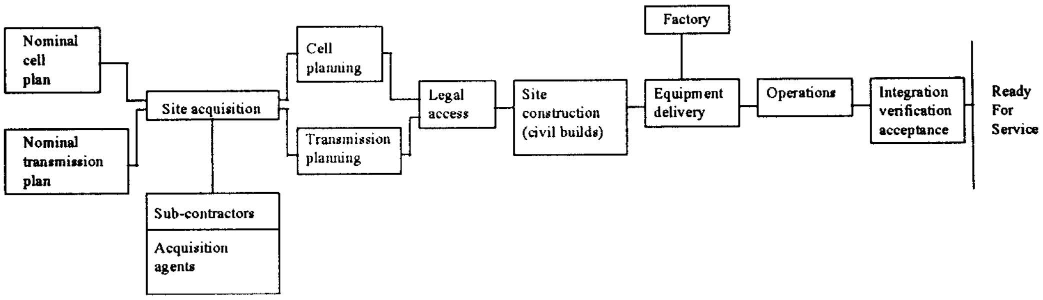

Figure 1: Cellfone projectactivities and flow chart

A number of activities are involved in project implementation and handover to the customer:

- The process begins with a nominal cell plan and nominal transmission plan carried out by Telco's central project departments using data supplied by Mobitel. These provide theoretical plans of how to proceed and nominate search areas for base transceiver stations (BTS) and switching sites (BSC and MSC).
- Telco's project management team is responsible for controlling the site acquisition activities carried out by its three sub-contractors who use acquisition agents to acquire sites in a search area. Other civil build sub-contractors are responsible for preparing the site for the installation and mounting of equipment.
- New cell plans and transmission plans are drawn up when the reports of sub-contractors searching for sites have been evaluated.
- These plans are the trigger for the rollout of the network involving legal access, site construction, equipment delivery and installation.
- Telco's factory in the UK is responsible for the delivery of pre-packaged containers to the sites. A third party supplies transmission systems used in the Cellfone network.
- The Telco local company's operations department is responsible for ordering equipment, site commissioning and integrating base transceiver stations into the network switching system. An integration, verification and acceptance (IVA) test ensures that base stations are ready for service (RFS) and can extend the geographical coverage of the overall Cellfone network.

The front-end in the flow chart involves the establishment of a project organisation comprised of specialised cell planning, transmission, site acquisition and project management departments. The middle stage involves installation and civil builds. At the back-end, the project recedes as the operations department in the line organisation takes over responsibility for finishing the project.

Project implementation

The contract was won by the Telco local company responsible for cellular systems but the contract specified that a new organisation had to be established to manage the project. Telco created a new organisation called 'Turnkey Projects Group' to set up a project management organisation and acquire and develop a new set of competencies in cell planning and civil builds. The project gradually expanded to reach of a peak of 80-100 employees by May 1996. Around 50 per cent of the project employees had to be recruited from outside of the group to establish the new areas of competencies.

Telco had sufficient in-house experience in project management and system integration to install equipment in the Cellfone network. It was in unfamiliar areas - such as project reporting in a project of this size and complexity, cell planning and site acquisition using sub-contractors - which gave rise to new and unknown problems and more than 20 changes in organisational structures to remedy them.

One important change concerned the need to establish a standard Telco approach to project management. In August 1995, Telco had to establish a project management department and acquire new competencies in civil builds and cell planning. Emphasis was placed on developing time plans and milestones based on its standard project management procedures (SPMP) for the detailed implementation of the project, including cell planning and site acquisition. But there was no clearly defined organisationally planning at this stage and attempts to create flow charts to guide processes and handovers in the project were not implemented.

In the absence of a standard Telco approach to management, the new organisation evolved its own distinctive organisational structure. In particular, the manager recruited from outside Telco to establish the new civil builds department emulated the structure he had worked with in his previous job. Civil builds carried out site preparation and construction as well as project management activities and interfaces with the customer and sub-contractors. In January 1996 an overall project manager was assigned to the Cellfone project to establish processes based on SPMP and create an organisation with specialised functions and a clear division of responsibilities between central projects, such as civil engineering, cell planning and transmission design, and project management departments organised into regions as existed elsewhere in Telco (see Figure 2). This enabled civil builds to focus on providing engineering solutions and allowed project managers to take over responsibility for site acquisition work previously undertaken by civil builds and to provide a single point of contact for the customer and sub-subcontractors.

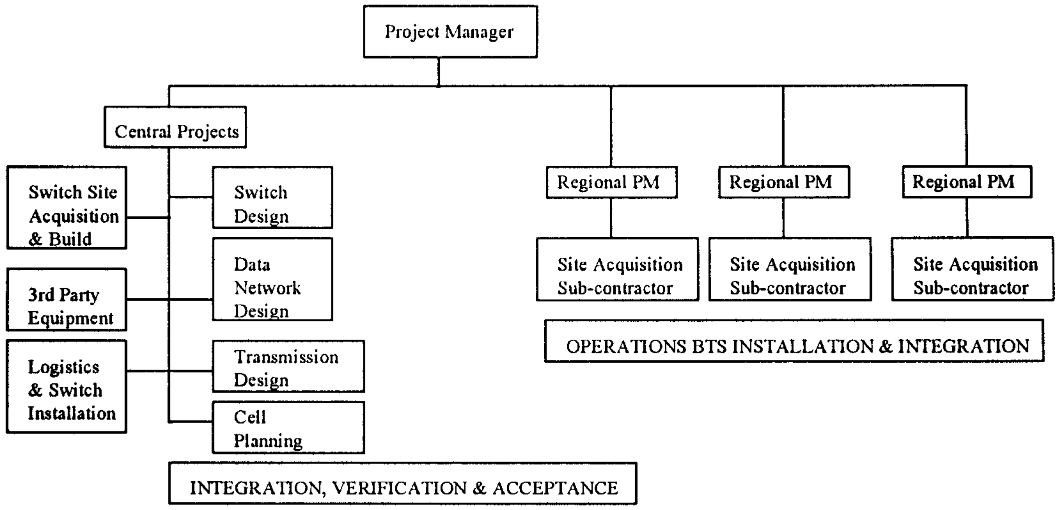

Figure 2: Imposing a Telco management structure

The major problem, however, was in the area of sub-contractor management. As the flow chart (Fig.1) suggests in an optimal situation the turnkey project would follow the nominal cell and transmission plans. In practice, the rollout and configuration of the network is driven by the process of site acquisition, which one manager compared to the difficulties entailed in 'arranging to buy a house a thousand times'. The potential difficulty in acquiring sites was identified in its pre-contract risk assessment, but Telco failed to guard against future delays, problems with reporting mechanisms and other issues in the writing of the sub-contractor contracts. The problem was compounded by Telco's lack of civil builds knowledge at the time the contracts were drawn up. In particular, Telco assumed it had drawn up a back-to-back contract with its other sub-contractors, but this was true only in respect to the work that had to be done and not in relation to the payment structures. They were best-endeavour contracts which offered no incentives for performing on time and no penalties were incurred if sub-contractors failed to perform. TelcoÕs sub-contractor contracts did not include liquidated damages for failure to perform which were written in the contract with Mobitel. Proper back-to-back contracts would have forced the sub-contractors to meet costs if they failed to meet agreed project time and quality deadlines for site preparation prior to the installation of Telco's BTS equipment.

As a result of difficulties in monitoring and controlling the progress of its sub-contractors, the whole project was delayed during the first year of implementation and many organisational changes were made to improve sub-contractor control. At one point, Telco had to locate project managers in one of the sub-contractor's premises to monitor progress of site acquisition and provide more accurate project reporting. However, problems persisted and it became necessary to make a another major reorganisation in October 1996. The overall project manager's time was dedicated to solving problems with this particular sub-contractor and a new project manager was brought in to oversee other project activities.

Aside from these organisational problems there were other difficulties for the implementation The lack of back-to-back contracts created an imbalance in the payment structures which had financial implications for the project. Telco had to pay subcontractors before they had firm confirmation that the work had been carried out. In cases where it had not, Mobitel refused to pay Telco creating a cash-flow problem for the project. The two contract variations which meant that three separate projects were being implemented concurrently made it difficult for project managers to know what targets to focus on. Consequently, project managers were often led to believe that milestones had been reached before the work had actually been completed.

Because SPMP was not used in the start-up phase of the turnkey project, the turnkey organisation began to develop its own organisation and culture which was atypical for Telco. A strategic decision was taken to overcome this problem by installing an experienced Telco manager who quickly imposed SPMP methodology and established a standard Telco approach to project management. Telco normally develops an optimum process map which shows the ideal ways of developing the product from sub-components for delivery to the customer. The failure to use SPMP early in the project meant that process mapping did not take place until the project was already underway. This meant that processes were mapped to fit the functions in a sub-optimal structure rather than the process determining the correct functions and organisational structure.

Even when a process map was finally developed, it was not used consistently. For example, the process map showed the existence of switch development activities but was not used to identify the early requirement for a switch project manager. Another problem emerged because of the split between the project and operations. Cell planning became the focus of project management attention while operations was focusing on dimensioning of the switch. Only in network planning was a whole picture available. Had an optimum process map been available early on in the project this problem might have been foreseen and an appropriate organisation developed.

In the Cellfone turnkey project, resourcing was discussed before the signing of the contract but was not well planed once the contract was signed. The scope of the task involved in the turnkey project was underestimated and insufficient people were allocated to the project early on. By the time recruitment did take place some of the other project management problems discussed above had become evident which warranted further resource.

Another major problem for the Cellfone project was the inadequacy of IT support tools and a proliferation of stand-alone databases. Under the terms of the contract, Telco had to make use of Mobitel's database for reporting requirements. In this database all the products were broken down into components and every component had a part number. This detailed breakdown was unnecessary for many project reporting activities and meant that standard project management software was inadequate to deal with the large number of events.

As was usual practice in Telco, the project was to utilise an existing database, PRS (Project Reporting System) that had been developed on another large mobile project, in Germany which involved a lot of site acquisition and build activities.. It was assumed that this tool would be appropriate for the larger and more complex

Cellfone project but it proved unsatisfactory in a number of ways. There were difficulties in installing and developing PRS because there was no 'owner' responsible for the database and PRS needed to be tailored to meet the specific requirements of Cellfone. PRS was not available in Windows format until December 1995 and furthermore was originally designed as a stand-alone system whereas in Cellfone it had to integrated into the project network. Once installed PRS was too slow to produce the number of reports required by Mobitel. Telco had to hire a third party software company to develop and Excel-based tool to allow third parties to put information into PRS which was also connected to an invoicing package.

While PRS allowed Telco to keep track of daily events in the project, it was only able to supply information related to major milestones. It provided no information concerning the dimensioning of the equipment which meant that Telco's logistics people had to develop their own spreadsheets to forecast equipment requirements. Although logistics had begun using PRS, the information it supplied was so unreliable that they ignored it. Worse still PRS did not provide the reporting structure that Mobitel wanted.

Other IT project management tools proved to be problematic because of the size and complexity of the Cellfone project. The preferred tool, Microsoft project could only handle 10,000 events whereas Mobitel's reporting requirements meant that the project was originally broken down into 170,000 events. Telco managed to reduce this by aggregating events but even so they could not reduce it below 23,000 events. This meant they had to search for another PM system. They installed APB Artemis and this provided a more effective reporting mechanism which offered overall control of the interface with the customer. Unfortunately, Artemis did not communicate with PRS.

As a result there was a proliferation of tools in Telco consisting of stand-alone databases for cell planning, project reporting, customer interface, transmission plans and site acquisition. The problem was exacerbated by the sub-contractors each having their own databases. In the end what emerged was a "Tower of Babel" with information being conveyed in many different tongues, with no-one really sure which information was correct at any particular time. The lack of an integrated system had major knock-on effects for the financial control of the project - it became virtually impossible to extract a set of accounts for the turnkey project.

The Turnkey Project Start-up Guide

It is clear from this account that this first turnkey project did not run as smoothly as had been hoped by Telco. By the time we first met with the Project Director a number of these difficulties were already apparent and this may have contributed to the desire to involve us in monitoring the implementation. The Director was aware that Telco was likely to be involved in more turnkey projects in its world-wide operations in future and was keen to try to avoid repeating mistakes in