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One company – two outcomes

Knowledge integration vs corporate disintegration in the absence of knowledge management

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Abstract

Purpose – To learn to avoid pitfalls there is need to accept and understand failures. This anonymous case study aims to report a major organisational failure due to the absence of effective knowledge management, where both the reasons for, and organisational consequences of, the failure are fairly clear.

Design/methodology/approach – Within a theoretical framework of organisational autopoiesis, the case study compares knowledge management styles from two eras in the history of one engineering project management company: as it grew from an acquired site with a single project to a multi-divisional leader in its regional market, and then as it failed in its original line of business to the point where it divested most of its assets.

Findings – In the first era, the executive and line managers were permissive, allowing project teams to work out local solutions for business problems as they arose producing successful and profitable solutions. The decline began and accelerated when management strengthened hierarchical command and control that stifled knowledge sharing and solution development at the work face and exceeded line managers' limits of rationality.

Research limitations/implications – This study has the limitations of any historical study of a single case, exacerbated by a need to maintain the anonymity of the surviving company.

Originality/value – Few studies so clearly highlight the critical importance of personal knowledge and its sharing in knowledge intensive organisations for maintaining successful operations. Success may have many parents, but in this case the internal comparisons identify specific factors that caused a successful organisation to disintegrate.

Keywords Knowledge transfer, Project management, Knowledge management, Business failures

Paper type Case study

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1. Introduction

In a time of global change, very large, innovative and knowledge intensive engineering projects will be needed to moderate and remediate effects of global climate change, rising sea levels, and consequent impacts on many other areas of human endeavour. More than just economic considerations are risked if such projects are not successfully completed in organisationally sustainable ways. To date, many of the largest high technology projects relate to national defence – a realm notorious for failures to meet specifications, cost and schedule blowouts (e.g. Tyler, 1986; Yule and Wollner, 2008); and even the outright cancellation of failed projects (e.g. Australia's recent cancellation of the Seasprite Helicopter – Hammer, 2008). We can learn from such failures.

The study reported here follows on from an earlier methodology and case study by Nousala *et al.* (Nousala, 2006; Nousala *et al.*, 2005, 2007; Nousala and Terziovski, 2007) within a large multi-divisional engineering project management organisation ("EPMO") specialising in large, high technology and long-lived defense projects. This Team Expertise Access Mapping ("TEAM") study focused on mechanisms and tools for identifying and transferring tacit knowledge. This work has been conducted within a framework of theories of organisation and organisational knowledge (Hall, 2003, 2005, 2006; Hall *et al.*, 2005, 2007; Else, 2004; Nousala, 2006; Nousala *et al.* 2005; Nousala and Hall, 2008; Vines *et al.* 2007) based on a combination of Maturana and Varela's theory of autopoiesis (Maturana, 1975, 2002; Maturana and Varela, 1980; Varela, 1979; Varela *et al.*, 1974), Karl Popper's (1968, 1972, 1982) evolutionary epistemology, and hierarchically complex systems (Simon, 1962, 1973; Salthe, 1985, 1993, 2004). The TEAM study was conducted as EPMO began finishing and closing out a successful long-running multi-billion dollar project for a demanding client ("Project A") and negotiating for and mobilising to begin a shorter term project ("Project B") for a different client worth about a tenth the value of Project A. EPMO considered that winning Project B was essential to sustain the organisation through a period between completing Project A and the likely availability of new long-term contracts. Thus, the TEAM study focused on methodologies that would help EPMO transfer knowledge and expertise between projects.

However, for reasons explored here, EPMO failed to transfer knowledge from Project A to Project B, and Project B suffered major cost and schedule overruns. Following a strategic review around the time Project B was contractually scheduled to be delivered, EPMO's owners decided to auction "all or part" of the company to "position it for future growth", with the result that all of the company's defense industry components were divested by its owners. Given that the sale included a multi-billion dollar order book, we believe that the published auction price was hundreds of millions of dollars less than what its value might have been prior to its difficulties with the supposedly simple Interim project.

Here we extend data and ideas originally collected and developed by Nousala (2006) and explore subsequent events. The extended material is based on contacts with a range of individuals within EPMO over most of two decades of its history. Factual references have been paraphrased and anonymised. Based on the TEAM study and our interactions with EPMO over its history, its knowledge-related activities are well known to us. Given our detailed knowledge of EPMO's history in relation to our studies of organisation theory, and the importance of the lessons that can be drawn from this case, we think it essential to share our observations on events and changes in organisational dynamics within EPMO that culminated with the divestment of its defence assets.

1.1 Theoretical framework

Here we follow EPMO's history as a complex system entity that we consider was autopoietic (i.e. "self producing" or living) during most of its existence. Maturana and Varela (1980) define autopoiesis as ". . . a machine [i.e. a system] organised (defined as a unity [i.e. as an entity in its own right]) as a network of processes of production (transformation and destruction) of components which: (i) through their interactions and transformations continuously regenerate and realise the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realisation as such a network."

Hall and his colleagues (Hall, 2003, 2005, 2006; Nousala and Hall, 2008; Vines *et al.*, 2007) extended Maturana and Varela's canon with regard to the integral role knowledge plays in the maintenance of autopoietic organisation. We define "knowledge" in Karl Popper's (1972) sense as "solutions to problems [of life]", where all knowledge is necessarily fallible (i.e. we can never prove we know the truth) because it is internally constructed in living things by the selective elimination of errors and in conscious beings, through rational criticism. Popper argues (loc. cit) and we agree that all knowledge is generated by living things. Hall (2006) also argues that autopoiesis (and thus, life) is impossible without the knowledge embodied in the organisation of the autopoietic system that enables the system to "compensate" (Varela, 1979) for perturbations and thus maintain its autonomy to continue producing its autopoietic self in the face of these perturbations. Knowledge failures can lead to organisational failure, and organisational failure leads to dissipation and loss of knowledge embodied in the organisation's structure. In the present paper we will explore how EPMO's knowledge failures led to its failure and demise as an independent entity.

An autopoietic theory of organisation helps us focus on and identify those imperatives an organisation must satisfy to maintain its autopoiesis. If any of these imperatives is not met for more than a short period where problems can be compensated for from surpluses or capital injection, disintegration (bankruptcy) or assimilation (acquisition) of the autopoietic organisation will ensue. Whether understood and articulated by the organisation's leaders or not, the obvious imperatives for an engineering project management and production organisations are to:

- complete contracts profitably;
- satisfy customer requirements;
- qualify and win more contracts; and
- satisfy statutory requirements (environmental, occupational health and safety, taxation).

Subsidiary imperatives help to ensure the four principal ones can be satisfied are to:

- identify and manage risks to ensure adequate reserves and compensatory capacity exist in organisation;
- maintain competencies; and
- return value to shareholders.

To remain viable, organisations must know how to meet these imperatives. Except for the imperative to avoid negative cash-flows for prolonged periods, performance against the imperatives in a competitive environment is relative to competitors. Significant competitive failures in any of the areas lead inevitably to negative cash flows and loss of organisational viability in bankruptcy or acquisition.

Other areas of background and theory also important to the EPMO case include bounded rationality – based on limited availability of time and the information processing capacity of human brains (Simon, 1955, 1957, 1979; Else, 2004; Nousala *et al.*, 2005; Hall *et al.*, 2007); boundaryless careers – highlighting the fact that people (and their personal knowledge) are not tied for life to single organisations (e.g. Arthur, 1994; Arthur and Rousseau, 1996; Bird, 1994; Baruch, 2003; Ito and Brotheridge, 2005); Greiner's (1998) observations of phase changes as organisations grow, and some difficulties managing knowledge specific to project management organisations (Ford and Sterman, 2003; Mønsted, 2004).

1.2 EPMO's organisational history

EPMO existed as a discrete entity employing a few thousand people for about two decades after its formation. It was formed initially to bid for Project A – a multi billion dollar defence contract; and it ended in the auction of its defence industry assets and order book to another player in its industry.

Although the ongoing success of Project A funded EPMO's acquisition of other defence industry divisions and non-defence business units during its life, the history that concerns us relates primarily to the founding division's management of Project A and then its various failures with new work that should have built on capabilities and knowledge developed in Project A. Project A involved design, engineering, production and delivery of massively engineered products. It also included production and delivery of a complete support engineering package incorporating technical data; technical, maintenance and operating manuals; operator training; and initial spares. Project A involved negotiating and managing some ten subcontracts each in the $100 million range, and some 100 subcontracts around or more than $1 million each. The prime contract also had several novel features requiring innovative solutions:

- stringently fixed price including the support engineering package;
- extended in-service warranty period over some 10 years of in-service experience with the products – where EPMO had to demonstrate the support package was able to support achieving of particular operational availability thresholds; and
- delivering a comprehensive technical data and documentation package into the client's computerised maintenance management environment.

Major liquidated damages were payable if contractual milestones for the acceptance of production and support packages by specified dates.

We divide EPMO's two decade history into two eras of starkly different knowledge management styles, each consisting of two phases:

(1) Era 1:
   - *"Mobilisation"*. The initial period of about two years while EPMO was established by acquiring a pre-existing and troubled production engineering enterprise operating from a single site, and then won and mobilised

Project A. Mobilisation included rationalising an existing workforce, some with a decade or more of practical experience, and completing a long-overdue project that came with the acquired enterprise.

- *"Expansion"*. More than a decade while major engineering and production difficulties were identified and solved, leading into the efficient serial production of engineering, production and documentation deliverables. Substantial revenues and profits earned during Expansion supported acquisition of other defence project management organisations, plus new non-defence business units. Personnel with significant management skills were also transferred from Project A into the new engineering units to maintain their success. Although the division responsible for Project A continued to bid on new work, it won no major bids during this phase.

(2) Era 2:

- *"Closeout"*. A period of about six years, during which Project A was profitably completed, on budget for the fixed price negotiated nearly 20 years before, with every major information or engineered product delivered on or before schedule. In the defence industry, notorious for cost and schedule blow-outs (Tyler, 1986; Yule and Wollner, 2008), Project A was one of the most successful projects of its size and complexity in the world. Client satisfaction led to continued engineering and product support work for Project A's products that may be carried on in the successor company for the decades of products' expected life in-service. As Project A was ramping down, the division won three new contracts, including Project B. The first contract, a small one, was completed successfully by Project A personnel. Compared to Project A, the second contract, Project B, was about ten percent of the value, one-fifth the duration, and with similar – but supposedly simpler – engineering requirements. However, within three to four months after the contract was agreed, Project B was clearly in trouble. Late in the closeout period the division won a new major contract.
- *"Failure"*. As the new major contract was won, Project B was way over budget and past its contracted completion with much work still to be accepted by a very unhappy client. In these circumstances the shareholders advertised that EPMO was to be auctioned as a single entity or in pieces. Subsequently, all EPMO's defense industry divisions were acquired by another industry player, with only non-defence business units remaining in the shareholder's hands. The sale was complete in about nine months, for a published price that we believe discounted the value of the company by at least 25 per cent or in the vicinity of $250 million dollars.

This history begs the question, how could a large engineering project management company that had just profitably finished one of the most successful projects in the history of its industry with a profit with another large project in its order book, fail as a consequence of problems with what was a similar but comparatively minor interim project?

2. Characteristics of EPMO during its two critical periods

2.1 Constant factors

EPMO's shareholders' prior experience was with large but comparatively short term and low technology engineering contracts. From its birth, EPMO was highly knowledge intensive and focused on winning, designing and delivering costly, long-lived, high technology products, where EPMO was the prime contractor in "extended" engineering and production enterprises with large "virtual" components (Browne and Zhang, 1999). Executives in a deep line management hierarchy were located in a Head Office in a different state from all engineering and production activities.

A "command and control" culture existed, discouraging disagreement with the boss. Projects were executed by dedicated teams under project managers whose performances were measured retrospectively against "shareholder added value" (i.e. profit), and where most staff and IT systems "belonged" to projects rather than the company as a whole. The result was structurally conducive to the development of typical project specific "silos" with a potential to develop "liars' clubs" and related pathologies in project cost and schedule reporting (Ford and Sterman, 2003; Mønsted, 2004; Repenning and Sterman, 2001). Line and project managers were sometimes sacked for "errors" and "mistakes", resulting in a turn-over of senior managers on a two to three year cycle and little opportunity to learn from the mistakes. Finally, and most pervasively, executives and most line managers did not understand IT (some were self-confessed "pencil and paper people"). For example, shortly after EPMO took over the existing site, the Chief Executive required all computers to be removed from desks and locked up to force people to work on paper – a decision that could not be sustained for long. Then, particularly in the latter half of era 1, executives delayed by years the implementation of enterprise content management systems that people at the workface understood were critically important.

Even within projects, most innovation and problem solving (i.e. knowledge development) took place in small functional teams that were often informally constituted, and thus invisible to executives and senior line managers (Nousala and Terziovski, 2007).

2.2 Expansion

EPMO's growth phase was supported by Project A – whose long duration also provided time and resources for organisational learning at the workface. The work force was stable and conscientious. Some workers began with EPMO after more than ten years experience with the prior engineering organisation. Most workers ("old hands" and early recruits) were motivated more by belonging to the exciting high-status project rather than by EPMO's average salaries. In these early days there was no concept of managing organisational knowledge.

During the expansion phase several costly data and content management problems arose in engineering design, product support engineering, and early production, including:

- difficulties getting subcontractor IP and technical data;
- managing engineering changes and configuration; and
- in authoring and delivering coherent technical data and documentation in forms acceptable to the client.

These problems impacted both production and support engineering deliverables, and threatened schedule delay. More than once, due issues with manual processes to develop data and document deliverables, the client threatened to refuse major milestone deliverables that would have incurred major liquidated damages claims and reputational costs. Also, finance and admin managers in head office greatly delayed IT investments for solutions to the above problems they did not understand.

However, middle-level managers facing crises, and sometimes working without head office authorisation, implemented critical IT by paying suppliers "time and materials" from operating budgets. Aided by the new technologies, people at the workface avoided impending schedule slippages, and all the client's outstanding concerns were resolved by end of EPMO's expansion phase. The client was highly satisfied, and left ongoing support and engineering changes for Project A's delivered products in EPMO's hands to ensure continuing "bread and butter" income for decades to come.

It should be emphasised that the IT solutions developed by workers near the workface also allowed deliverables in these areas to be completed for substantially less labour than anticipated in the fixed-price contract, releasing contingency reserves. Resolution of the engineering change control and configuration management issues also reduced production costs through reductions to nugatory work and rework. The workface solutions ensured Project A's overall profitability by more than compensating for cost overruns in other areas. Had the IT solutions been implemented when first recommended two to three years earlier, even more profits might have been realised against the fixed price contract.

Revenue from Project A enabled EPMO to acquire and incorporate independent enterprises as additional divisions to provide complete coverage of the industrial domain in which it operated. EPMO's owners also acquired and established business units in non-defence areas. Significant EPMO knowledge and experience from Project A was transferred into the new divisions via staff transfers. Although all the new divisions contributed revenue to EPMO, none became as large or successful as the division managing Project A, and even collectively, the other divisions were unable to compensate for the costs of Project B's problems during the closeout phase.

2.3 Closeout phase

Closeout began when Project A was about 50-60 per cent complete in terms of the delivery of engineered products. By then, all of the knowledge intensive engineering and support problems had been solved to the client's satisfaction and the major products were in serial production. Consequently the division substantially reduced its engineering staff.

As Project A wound down, it was imperative for the division to win new contracts. EPMO prepared bids for a sequence of large projects (some in the billion dollar range – where each bid cost a million dollars or more to make). Teams for these bids were formed by internal secondment and by contracting outside skills. All bids were treated as separate and tightly bounded projects, controlled by dedicated bid managers. Some bid managers were also contracted in from outside (not unusual in the industry). Although EPMO was often short listed, up through the early years of the closeout phase, all bids failed. In time-critical bidding activities, there was work loss, inefficiency, and rework by critically overworked staff. Much of the time loss was due to misuse of authoring and document control technologies never understood by managers who learned their trade working with manual typewriters, pencil and paper. Arguably, without this inefficiency, EPMO's bids would have been more competitive. When a bid failed, the teams were disbanded and the bid managers were released from the company or demoted. Little effort was made to analyse failures, record lessons learned, or even to properly review and archive relatively standard document parts to provide labour-saving templates for future bids.

After a long string of failed bids, EPMO won Project B – valued at somewhat less than one tenth the value of Project A – to design, build and supply products similar to Project A's products, but to supposedly less exacting "commercial" standards. Unlike Project A, that included a long serial production phase, Project B was contracted to finish in a few years and required the parallel design and production of three different products. In fact, Project B offered little opportunity for serial production and no time to learn from mistakes. However, EPMO's costing and schedule for the new project assumed staff knowledge, skills and efficiencies developed for Project A would be fully transferable. However, new staff were hired for Project B; attempts to implement KM processes to transfer knowledge from Project A to B were ignored, stifled or obviated; and EPMO did not survive this failure.

At the end of Closeout, EPMO with a partner won a multi-billion dollar contract that should have been able to help sustain the organisation for another two decades. However, by then, the failure phase was essentially complete.

3. Specific failures and actions during closeout led to failure

Besides general issues of relating to absentee executives, the way Project A was closed out stifled and destroyed critical knowledge. The following specific factors and events contributed to mismanagement of organisational and personal knowledge during the closeout phase.

3.1 Executives failed to understand the criticality of personal knowledge

EPMO's executives were engineers and accountants. Despite spending hundreds of thousands of dollars on KM consultants, all of whom emphasised the importance of personal knowledge and its management, executives seemed unable to accept the organisational importance and value of tacit aspects of personal knowledge and its sharing. With one minor exception – to hold two cross-divisional engineering conferences, no proposals focusing on improving tacit or social aspects of work-face knowledge development and exchange were funded.

3.2 Project accounting and retrospective bonuses devalued knowledge transfer

EPMO's owners appointed an overseas "close-out" specialist as Executive GM (EGM) with no mobilisation or early project experience to wind down Project A. His bonus was based on added profit squeezed from the project. Also, due to the turnover of line managers discussed above, his "direct reports" only had experience with Project A's smooth running serial production phase. The EGM's autocratic style also tended to stifle or reduce innovative thinking by direct reports. All staff time was required to be costed to project line items, and no staff time was allowed for anything that could not be booked against a cost code. Experienced and high salaried "old hands" in Project A, including long-serving middle managers, were coerced into extensive unpaid overtime to complete routine closeout tasks and then made redundant when no longer needed for Project A – even when Project B was being mobilised and lower-paid staff without specialist experience were being hired from outside. EGM signed approval was required for anyone outside Project A to meet staff. Even people from other divisions or Head Office could not meet divisional staff during business hours without the EGM signature. On the job social activity and "shop talk" were seen to be time wasting. Morale became very poor – even among those with continuing support work for the Project A products.

3.3 Erroneously assuming that organisational knowledge was not also personal

The EGM also controlled Project B. Project B was assumed to be simpler work than A, because it was subject to commercial rather than defence standards. However, the fixed price EPMO negotiated in competitive bidding for Project B assumed existing knowledge and efficiencies would transfer from Project A. The fact that Project B involved parallel production of three different products and provided no slack for organisational learning was apparently not considered. Then, rather than redeploy expensive experienced old hands to Project B who knew how to solve the likely problems, such people were kept in routine jobs or made redundant while new (cheaper) people and managers were hired for Project B. Although well qualified on paper, few new staff had prior experience in EPMO's particular industry. Similarly, rather than using proven IT that old hands knew how to use, new and supposedly simpler/cheaper systems were implemented. A monitored security fence was built between the projects, and line managers on both sides discouraged cross-socialisation as time-wasting.

The result was inevitable.

4. Discussion

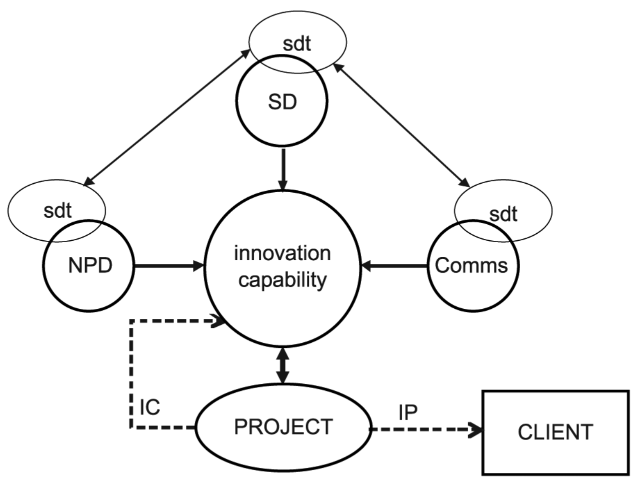
We conclude that differences in the management styles during the two main periods of EPMO's life were responsible for the very different outcomes. During the Expansion phase of era 1, EPMO executives involved themselves only minimally with Project A, and devoted most of their attention to acquiring additional business units and bidding on large projects (as enabled by revenue and profits from Project A). This allowed Project A's project engineering and production organisation to work autopoietically, locally building and sharing problem solving knowledge as required locally for innovation and organisational success. Aside from knowledge built into formal organisational procedures and the design and production of deliverables, know-how was largely personal and anecdotal, and concerned a range of important issues (problems and their solutions) not well suited to be documented, for example:

- Need to contractually bind subcontractors and suppliers to provide all technical data and engineering documentation for products, as enforced with data "discovery" visits to suppliers to collect documents and data.
- Need to preserve and index for retrieval all documentation so collected.
- Know-how to mange impacts of engineering change on engineering and logistic support data to produce consistent logistic support deliverables.
- Rules of thumb to select lowest level components to be treated as configuration items.
- Understanding routines and practices for managing engineering changes against configuration items.

- Understanding problem solutions and underlying philosophies behind all of the existing IT and procedural solutions.
- Knowing who in the organisation might know things about arising issues.

During expansion, problems in product innovation and other areas were solved locally by individuals and small teams in departments or divisions (Figure 1 – small divisional teams – "SDT") that worked autopoietically to meet known organisational needs and goals. Nousala and Terziovski (2007) studied EPMO's ("DEPC" in that paper) capabilities for innovation in the development of new products. Where new products were concerned, major factors in the organisation's capability for successful innovation were: clearly stipulated goals, availability of human resources, and improving access to them (collectively "NPD"). Other major organisational "structures" (Varela, 1979) contributing to innovation capability were the development of organisationally sustainable processes and procedures ("SD"), and establishing effective communication networks among the various individuals and groups involved in developing innovations ("comms"). The actions of formally appointed and *ad hoc* SDTs formed dynamic organisational structures within which innovative solutions were developed. Some of the same people contributed to STDs at different places and times.

Even in necessarily formal processes such as responding to a tender, innovation leading to proposed solutions involved informal and tacitly organised interpersonal networks and routines for sharing personal knowledge from other areas of the organisation. Nelson and Winter (1982) and Vines *et al.* (2007) call this "tacit



Notes: IC = Innovation capability; NPD = new product development; SD = sustainable development (of the innovation capability); Comms = internal communication networks. Small Development Teams (SDTs) create and support innovation capability through their ability to work across all necessary areas within organizational divisions. This is due to the SDTs abilities to be flexible (being small and dynamic) with many individual members interchanging within and across teams as required

Source: From Nousala and Terziovski (2007)

Figure 1. Development of an innovation capability

organisational knowledge". Because these knowledge sharing processes were often *ad hoc*, they were invisible to absentee executives and overworked managers who had not experienced Project A's early problems. This led to crucial knowledge management errors in era 2 during closeout:

(1) *Micromanagement.* An outside EGM was appointed to micro-manage what had been a relatively smooth running project. This made EPMO's principle "cash cow" effectively allopoietic, i.e. centralising decisions isolated them from problem areas. Greiner (1998) discusses the kinds of organisational changes that need to take place as companies grow in size. Basically, while EPMO was still expected to grow, its management regressed from what Greiner called a Phase 3 structure, depending on "delegation" and local action, to a Phase 2 structure of centralised "direction", which lacked the capacity to deal with the volume of data, information and knowledge required for mobilising and completing a new project over a comparatively short timescale. We argue that, beyond a certain organisational size, operational decisions must be delegated towards the periphery where local processes are able to build realistic knowledge required to support the decisions without exceeding the bounds of rationality. Simon's idea of "bounded rationality" (Simon, 1955, 1957, 1979; Else, 2004; Hall *et al.*, 2007) explains why that even with satisficing, EPMO's central decision-makers lacked the time and cognitive capacity to collect the necessary knowledge to understand and effectively manage issues at the work face.

(2) *Stifled knowledge sharing.* Management actions made during Closeout in the name of increasing project profits, effectively stifled opportunities to transfer personal knowledge from the old to the new project and for the *ad hoc* emergence of small cross-project teams able to effectively apply lessons learned from the nearly completed project to the new one. For example, the TEAM authors (Nousala, 2006; Nousala *et al.*, 2005, 2007, 2009) were part of an *ad hoc* knowledge management team on the premises occupied by Projects A and B, and they clearly understood the need to identify and transfer knowledge from the old project to the new one. As described, they developed and successfully prototyped methods to identify and map project knowledge, and demonstrated that remaining "old hands" and "alumni" who had moved to other divisions or left the company would all happily share experience and "war stories" relating to likely problem areas. The KM team submitted three formal proposals over two years, each offering more resources, to implement a knowledge mapping/transfer program. However, senior line managers would not release experienced knowledge workers even for the one to two hour interview required by the TEAM methodology, or pay travel funds to invite alumni with critical knowledge from other divisions, and would not allow meetings to involve new staff with old. This is a situation that may be common in organisations with distributed profit centres (Mønsted, 2004), where the cost of sharing is clearly visible to the donor project but the benefit from doing so may only be realised several years later or in another project's profits. The focus on immediate profit across all departments and teams strengthened this effect to make silos impossible to breach without specific direction from the EGM – which was not forthcoming.

As today's organisations become more knowledge intensive, issues of managing personal knowledge grow to be critically important in ensuring their future. It is people belonging to the organisation who know:

- what knowledge the organisation needs;
- who may know the answer;
- where in the organisation explicit knowledge may be found;
- why the knowledge is important or why it was created;
- when the knowledge might be needed; and
- how to apply the knowledge (Nousala *et al.*, 2005).

This personal knowledge is critical to organisational survival and adaptation. Organisations do not own their personnel and are limited by the abilities of their members to work together to build and share organisational knowledge. Autopoietic organisations have a self-organisational capacity for *ad hoc* teams and groups to emerge and address problems as they arise. Allopoietic managers who are effectively outside the organisation fail to recognise problems soon enough or lack the capacity to understand them well enough to dictate effective solutions.

Careers of individuals in their organisations are boundaryless (Arthur, 1994; Arthur and Rousseau, 1996; Bird, 1994; Baruch, 2003; Ito and Brotheridge, 2005). In today's free societies, each individual's participation in an organisation is voluntary. Personal knowledge is volunteered; it cannot be conscripted. People always know more than can be told, and will tell more than can be written down; and only know what they know when they need to know it (Snowden, 2002). People will bring useful personal knowledge from their careers into the organisation, and will build additional personal knowledge relating to the organisation. However, if this personal knowledge is not shared or "captured", it is lost to the organisation when the member departs (Vines *et al.*, 2007).

Autocratic (i.e. allopoietic) organisations are limited by the bounded rationality of their autocrats. Because people are naturally social, some knowledge will be shared under almost any circumstance. However, where autocratic leaders fail to recognise the importance of human knowledge, in knowledge intensive environments their organisations are bound to fail in competition with more autopoietic organisations.

5. Conclusion

EPMO was knowledge intensive, and its executives and line managers failed to understand the personal and social dynamics of knowledge development and exchange, and the importance of these dynamics to organisational success. In its first period, while EPMO was expanding, executives were concerned to acquire new divisions to expand its scope. This allowed the core division to function autopoietically, to develop problem solutions locally. Necessary decisions were able made close to the periphery by people who realistically understood the problems and had time to think rationally about how to solve them. The outcome for the organisation was exemplary and profitable performance envied by its industrial peers. Attempting to maximise profits during its second period, emergent autopoietic processes were replaced by hierarchical micro-management (i.e. EPMO essentially became allopoietic). Central decision makers failed to understand the crucial nexus of people, processes and infrastructure (Starns and Odom, 2006) for managing knowledge in their knowledge intensive business. They exceeded their own rational bounds to understand problems and also stifled the building and exchange of knowledge at the workface critical to organisational survival. The outcome was the auction of their main assets to a competitor at a fraction of what would have been a reasonable value a few years earlier.

References

Arthur, M.B. (1994), "The boundaryless career: a new perspective for organizational inquiry", *Journal of Organizational Behavior*, Vol. 15 No. 4, pp. 295-306.

Arthur, M.B. and Rousseau, D.M. (1996), "Introduction: the boundaryless career as a new employment principle", in Arthur, M.B. and Rousseau, D.M. (Eds), *The Boundaryless Career: A New Employment Principle for a New Organizational Era*, Oxford University Press, Oxford, pp. 3-20.

Baruch, Y. (2003), "Career systems in transition: a normative model for organizational career practices", *Personnel Review*, Vol. 32 No. 2, pp. 231-51.

Bird, A. (1994), "Careers as repositories of knowledge: a new perspective on boundaryless careers", *Journal of Organizational Behavior*, Vol. 15 No. 4, pp. 325-44.

Browne, J. and Zhang, J. (1999), "Extended and virtual enterprises: similarities and differences", *International Journal of Agile Management Systems*, Vol. 1 No. 1, pp. 30-6.

Else, S. (2004), "Organization theory and the transformation of large, complex organizations: Donald H. Rumsfeld and the US Department of Defense, 2001-04", PhD thesis, Graduate School of International Studies, University of Denver, Denver, CO, available at: http://tinyurl.com/6xt89m

Ford, D.N. and Sterman, J.D. (2003), "The liar's club: concealing rework in concurrent development", *Concurrent Engineering: Research and Applications*, Vol. 11 No. 3, pp. 211-9.

Greiner, L.E. (1998), "Evolution and revolution as organizations grow", *Harvard Business Review*, Vol. 76 No. 3, pp. 55-67.

Hall, W.P. (2003), "Organisational autopoiesis and knowledge management", paper presented at Twelfth International Conference on Information Systems Development (ISD '03) – Methods and Tools, Theory and Practice, Melbourne, Australia, 25-27 August, available at: http://tinyurl.com/yehcqz

Hall, W.P. (2005), "Biological nature of knowledge in the learning organization", *The Learning Organization*, Vol. 12 No. 2, pp. 169-88.

Hall, W.P. (2006), "Emergence and growth of knowledge and diversity in hierarchically complex living systems", paper presented at Workshop "Selection, Self-Organization and Diversity" – CSIRO Centre for Complex Systems Science and ARC Complex Open Systems Network, Katoomba, 17-18 May, available at: http://tinyurl.com/p2fl7

Hall, W.P., Dalmaris, P. and Nousala, S. (2005), "A biological theory of knowledge and applications to real world organizations", Knowledge Management in Asia Pacific (KMAP05) Wellington, NZ, 28-29 November, available at: http://tinyurl.com/qflam

Hall, W.P., Dalmaris, P., Else, S., Martin, C.P. and Philp, W.R. (2007), "Time value of knowledge: time-based frameworks for valuing knowledge", 10th Australian Conference for Knowledge Management and Intelligent Decision Support (ACKMIDS 07) Melbourne, 10-11 December, available at: http://tinyurl.com/25z68k

Hammer, C. (2008), "$1bn write-off in helicopters deal", *The Age*, March 6, available at http://tinyurl.com/5cczgj

Ito, J.K. and Brotheridge, C.M. (2005), "Does supporting employees career adaptability lead to commitment, turnover or both?", *Human Resource Management*, Vol. 44 No. 1, pp. 5-19.

Maturana, H.R. (1975), "The organization of the living: a theory of the living organization", *International Journal of Man-Machine Studies*, Vol. 7, pp. 313-32.

Maturana, H.R. (2002), "Autopoiesis, structural coupling and cognition: a history of these and other notions in the biology of cognition", *Cybernetics and Human Knowing*, Vol. 9 Nos 3/4, pp. 5-34.

Maturana, H.R. and Varela, F.J. (1980), "Autopoiesis: the organisation of the living", in Maturana, H.R. and Varela, F.J. (Eds), *Autopoiesis and Cognition*, Riedel, Dordrecht, pp. 59-140.

Mønsted, M. (2004), "Profit centres as barriers for knowledge sharing", paper presented at The Fifth European Conference on Organizational Knowledge, Learning and Capabilities (OCLC 2004), Innsbruck 2-3 April 2004, available at: http://tinyurl.com/68gafj

Nelson, R.R. and Winter, S.G. (1982), *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, MA.

Nousala, S. (2006), "Tacit knowledge networks and their implementation in complex organisations", PhD Thesis, Aerospace, Mechanical and Manufacturing Engineering, RMIT University, available at http://tinyurl.com/49zdz6

Nousala, S. and Hall, W.P. (2008), "Emerging autopoietic communities – scalability of knowledge transfer in complex systems", *Proceedings of the 2008 IFIP International Conference on Network and Parallel Computing, Shanghai, China, October 18-19*, IEEE Computer Society, Washington, DC, pp. 418-25.

Nousala, S. and Terziovski, M. (2007), "Development and exploitation of innovation capability at a defence project engineering company (DPEC)", in Terziovski, M. (Ed.), *Building Innovation Capability in Organizations: An International Cross-Case Perspective*, Imperial College Press, London, pp. 121-39.

Nousala, S., Hall, W.P. and John, S. (2007), "Transferring tacit knowledge in extended enterprises", paper presented at IKE'07: The 2007 International Conference on Information and Knowledge Engineering, Las Vegas, NV, June 25-28.

Nousala, S., Miles, A., Kilpatrick, B. and Hall, W.P. (2005), "Building knowledge sharing communities using team expertise access maps (TEAM)", paper presented at Knowledge Management in Asia Pacific (KMAP05), Wellington, NZ, 28-29 November, available at: http://tinyurl.com/q4n8y

Nousala, S., Miles, A., Kilpatrick, B. and Hall, W.P. (2009), "Building knowledge sharing communities using team expertise access maps (TEAM)", *International Journal of Business and Systems Research*, Vol. 3 No. 3, pp. 279-96.

Popper, K.R. (1968), "Epistemology without a knowing subject", in van Rootselaar, B. and Staal, J.F. (Eds), *Proceedings of the Third International Congress for Logic, Methodology and Philosophy of Science, 25 August to 2 September 1967*, North-Holland Publishing Company, Amsterdam, pp. 333-73.

Popper, K.R. (1972), *Objective Knowledge: An Evolutionary Approach*, Oxford University Press, London.

Popper, K.R. (1982) in Bartley, W.W. (Ed.), *Postscript to the Logic of Scientific Discovery*, Hutchinson, London.

Repenning, N.P. and Sterman, J.D. (2001), "Nobody ever gets credit for fixing problems that never happened: creating and sustaining process improvement", *California Management Review*, Vol. 43 No. 4, pp. 64-88.

Salthe, S. (1985), *Evolving Hierarchical Systems: Their Structure and Representation*, Columbia University Press, New York, NY.

Salthe, S. (1993), *Development and Evolution: Complexity and Change in Biology*, MIT Press, Cambridge, MA.

Salthe, S. (2004), "The spontaneous origin of new levels in a scalar hierarchy", *Entropy*, Vol. 6, pp. 327-43.

Simon, H.A. (1955), "A behavioral model of rational choice", *Quarterly Journal of Economics*, Vol. 69 No. 1, pp. 99-118.

Simon, H.A. (1957), *Models of Man*, Wiley, New York, NY.

Simon, H.A. (1962), "The architecture of complexity", *Proceedings of the American Philosophical Society*, Vol. 106 No. 6, pp. 467-82.

Simon, H.A. (1973), "The organization of complex systems", in Pattee, H.H. (Ed.), *Hierarchy Theory: The Challenge of Complex Systems*, George Braziller, New York, NY, pp. 1-27.

Simon, H.A. (1979), "Rational decision-making in business organizations [Nobel Memorial Lecture Economic Sciences, Dec. 8, 1978]", *American Economic Review*, Vol. 69 No. 4, pp. 493-513.

Snowden, D. (2002), "Complex acts of knowing: paradox and descriptive self-awareness", *Journal of Knowledge Management*, Vol. 6 No. 2, pp. 100-11.

Starns, J. and Odom, C. (2006), "Using knowledge management principles to solve organizational performance problems", *Vine*, Vol. 36 No. 2, pp. 186-98.

Tyler, P. (1986), *Running Critical: The Silent War, Rickover, and General Dynamics*, Harper & Row, New York, NY.

Varela, F.J. (1979), *Principles of Biological Autonomy*, Elsevier-North Holland, New York, NY.

Varela, F., Maturana, H. and Uribe, R. (1974), "Autopoiesis: the organization of living systems, its characterisation and a model", *Biosystems*, Vol. 5, pp. 187-96.

Vines, R., Hall, W.P. and Naismith, L. (2007), "Exploring the foundations of organisational knowledge: an emergent synthesis grounded in thinking related to evolutionary biology", paper presented at actKM Conference, Australian National University, Canberra, 23-24 October, available at: http://tinyurl.com/3xpmbc

Yule, P. and Wollner, D. (2008), *The Collins Class Submarine Story: Steel, Spies and Spin*, Cambridge University Press, Port Melbourne.

Further reading

Arrow, K. (1974), *The Limits of Organization*, Norton, New York, NY.

Biggiero, L. (2001), "Are firms autopoietic systems", in Van Der Zouwen, G. and Geyer, F. (Eds), *Sociocybernetics: Complexity, Autopoiesis, and Observation of Social Systems*, Greenwood, Westport, CT, pp. 125-40.

Brocklesby, J. (2004), "Reconnecting biology, social relations and epistemology: a systemic appreciation of autopoietic theory", *International Journal of General Systems*, Vol. 33 No. 6, pp. 655-71.

Kay, R. (2001), "Are organizations autopoietic? A call for new debate", *Systems Research and Behavioral Science*, Vol. 18 No. 6, pp. 461-77.

Luhmann, N. (1986), "The autopoiesis of social systems", in Geyer, F. and van der Zouwen, J. (Eds), *Sociocybernetic Paradoxes: Observation, Control, and Evolution of Self-Steering Systems*, Sage, London, pp. 172-92.

Magalhaes, R. (1998), "Organizational knowledge and learning", in von Krogh, G., Roos, G. and Kleine, D. (Eds), *Knowing in Firms: Understanding, Managing and Measuring Knowledge*, Sage, London, pp. 87-122.

Mingers, J. (1995), *Self-Producing Systems: Implications and Applications of Autopoiesis*, Plenum Press, New York, NY.

von Krogh, G. and Roos, J. (1995), *Organizational Epistemology*, St Martin's Press, New York, NY.

Zeleny, M. and Hufford, K.D. (1992), "Application of autopoiesis in systems analysis: are autopoietic systems also social systems?", *International Journal of General Systems*, Vol. 21 No. 2, pp. 145-60.

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