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Abstract Title: Sustainable Service Network Design: A Framework for Integrating
Competing Priorities in Through-life Product Service Systems

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1.0 Introduction

Many manufacturing firms have developed a service dimension to their product portfolio. However, the provision of product service solutions has placed an increasingly heavy reliance on networks of multiple partners to deliver services across the whole of the Concept, Assessment, Demonstration, Manufacture, In-service and Termination (CADMIT) cycle, from requirement identification to disposal.

Within a highly partnered, multi-organisational network, emerging customer-supplier and supplier-supplier relationships have given rise to the creation of a shared “multi-entity” environment. Multi-entity service model concepts need to be developed, in order to aid partners in understanding their role and inter-relationships in service delivery. With these complex service arrangements there is a growing need for firms to know how best to configure these multi-partner/cross-lines of business networks for the effective re-cycle, re-use, modification and product-life extension of equipment, sub-systems and components (both internally and with suppliers/partners).

A key challenge for the design of sustainable service operations within a multi-partnered environment is the integration of service supply network design methods and Through-life Capability Management (TLCM) analysis contributes to more sustainable operations. A framework that integrates strategic priorities across the CADMIT cycle to inform service network configuration and design is presented, focusing on the development of a sustainable supply network to enhance operational effectiveness in an environmentally sustainable manner.

2.0 Background and Aims

Existing approaches to the design and operation of service networks are largely product-oriented and pay little attention to the intangible, customer-involving and relationship-based nature of services. With the growing trend of servitisation in manufacturing, companies (particularly those that are engaged with complex, long-lifecycle products and systems) may need to reconfigure their networks to support more integrated product-service offerings.

The aim of this research is to develop a methodology that supports sustainable supply network design, in a complex equipment service environment.

3.0 Research Approach

This research integrates service network configuration design methods with through-life assessment techniques that span Concept, Assessment, Demonstration, Manufacture, In-service and Termination.

A generalised framework to describe network configurations is developed. The framework is tested in exploratory case studies within a sector involving complex equipment service provision. The defence sector was chosen as it exhibits the complex multi-partnered environment, increasingly requires equipment provider-based service solutions, and has products that have extensive in-service life.

The applicability of the framework was tested in this instance within a single organisation consisting of three diverse lines of business with differing priorities across the CADMIT cycle: cases X, Y and Z to demonstrate the difference between product orientation and service orientation. The case studies involved the evaluation of alternative configuration options. Each of these configuration options were also assessed in terms of the processes that might support service network integration, to capture ‘touch-points’ between the lines of businesses, and the enable process inter-linkages and hierarchies that support target ‘output-based’ capabilities. The integration of the multiple partners, across the CADMIT cycle was a key element of the sustainable supply network design approach and informed which configuration was most suited to achieving this aim.

4.0 Analytical Framework Development

The integration of supply network ‘configuration’ design approaches and the analysis of through-life cycle management is developed in this section; each from their strategic and operations management perspective.

4.1. Service Supply Network Configuration

Firm based configuration concepts are widely recognised in the strategic management and organisational structure literature. Strategic management literature identified different types of configurations with distinguishable strategic objectives, target markets, critical resources, and operational behaviours (Chandler 1962; Khandwalla 1970; Rumelt 1974; Mintzberg 1979; Miles *et al*, 1978; Miller 1996). Firm configurations are usually described by the

characteristics of organisational structures and coordination mechanisms (Chandler 1962; Mintzberg 1979; Miller 1996). Mintzberg (1979) considered configuration as a combination of a certain characteristics of structure and situation which organisations naturally fall into. Organisations will not function effectively when such characteristics are mismatched. Organisational elements should be logically configured into internally consistent groupings because they are usually interrelated in complex and integral ways (Miller 1986). Firms may be driven towards common configurations to achieve internal harmony among elements of strategy, structure and context (Miller 1986). Cohesive configurations are composed of tight constellations of complementary and mutually reinforcing elements, which could be predicatively useful because the number of possible ways in which constructional elements are combined is reduced. With this viewpoint, configuration can be viewed as a constellation of organisation elements that are pulled together by a unifying theme. The description of configuration includes a firm's core mission and its fundamental means to accomplish the mission in a certain market, and the systems, processes, and structures to support the core operations.

In the recent years, business activities are increasingly dispersed across geography and ownership boundaries. There is a growing research community working on network configurations, especially in operations management and strategic management (Shi *et al*, 1998; Bosarth *et al*, 1998; Oltra *et al*, 2005; Zhang *et al*, 2007; Srai *et al*, 2008). Shi *et al* (1998) contended that the dispersion and coordination of manufacturing networks require different international manufacturing capabilities from the perspectives of efficiency, mobility, resource accessibility and learning ability. The dispersion dimension refers to the structure of a network; and the coordination dimension emphasises on the relationship between network members. Zhang *et al* (2007) identifies four types of contextual environments of global engineering networks; captures the core capabilities of engineering

networks in each context; and demonstrated the organisational features to deliver the capabilities. Engineering network configuration has been described from the perspectives of network structure, governance and coordination, and support infrastructure. The research introduces two new dimensions- governance system and support infrastructure, which have strong relationships with the capability and context of engineering networks. Srari *et al* (2008) describe the configuration of supply networks from the perspectives of network structure, flow of information and material between/within operation units; relationships between network partners; and product structure. The research highlights the importance of relationship with internal and external partners. Although different type of products demand for different network capabilities, and the hence the network configuration to deliver the capability, products themselves should not be a part of supply networks.

The above literature demonstrates the incremental process to understand the organisational features of different types of networks, including intra-firm and inter-firm operations for manufacturing, engineering and supply chain functions.

Drawing on the literature essential network configuration elements are identified and previous work by the authors as:

- Structure: to describe the geography footprint of a network, including the dispersion of network units and their interdependence.
- Operations flow: to describe the operational processes adopted by network members.
- Governance and Coordination: to describe the governance system and coordination mechanism of a network. Performance measures are also included.
- Support infrastructure: to describe support infrastructures of a network, including IT systems, resources, people, and cultures.

- Relationships: to describe the linkage between network members, e.g. customers, suppliers and users.

Reflecting these configuration dimensions, a framework for capturing alternative configuration states, at a descriptive level was developed. This is shown in figure 1.

Service Network Configuration					
Structure					
Dispersion	MA&B wide/Enterprise Centres	MA&B wide/Enterprise Centres for Key Activities	Project specific/Group Centres	LoB Centres	Individual site Centres
Interdependence	Interdependent across the MA&B/Enterprise	Interdependent across MA&B/Enterprise on Key Activities	Interdependent within Projects/Groups	Interdependent within LoB	Independent Centres
Process Model					
Standardisation	Common Processes across the MA&B/Enterprise	Mandated Processes for Key Activities across the MA&B/Enterprise	Common Processes within Projects/Groups	Common Processes Tailored for Individual site Needs	Ad-hoc Practices
Governance & Coordination					
Commercial Control	MA&B wide/Enterprise Level Control	Project specific/Group Control with Central Influence	Project specific/Group Control	LoB control	Distributed Individual site Control
Engineering Control	MA&B wide/Enterprise Level Control	Project specific/Group Control with Central Influence	Project specific/Group Control	LoB control	Distributed Individual site Control
Support Infrastructure					
Engineering Systems	Common Systems across MA&B/Enterprise	Common Baseline Systems across MA&B/Enterprise	Common Systems within Projects/Groups	Customised Systems for Individual site Needs	Isolated Individual site Systems
Engineering Resources	MA&B wide/Enterprise Resource Management	MA&B wide/Enterprise Management of Key Resources	Project specific/Group Resource Management	Resource Management within LoB	Individual site Resource Management
Culture	Common Culture across MA&B/Enterprise	Common Orientation for Key Activities across MA&B/Enterprise	Project specific/Group Cultures	LoB Cultures	Individual site Cultures
Relationships					
Supplier Partnership	Strategic Partnership across MA&B/Enterprise	Strategic Partnership on Key Activities across MA&B/Enterprise	Project specific/Group Partnership	LoB Partnership	Transactional Relationship
Customer Partnership	Strategic Partnership across MA&B/Enterprise	Strategic Partnership on Key Activities across MA&B/Enterprise	Project specific/Group Partnership	LoB Partnership	Contractual Relationship

Figure 1. Network Configuration

4.2. Through Life Capability Management (TLCM)

Through Life Capability Management (TLCM) is an approach that brings together the behaviours, systems, processes and tools to deliver and manage projects through the acquisition lifecycle (AOP, 2010).

Historically, the Through Life Capability Management (TLCM) approach has been used to translate Defence policy into an approved programme that delivers the required capabilities, through life, across all Defence lines of Development (DLoDs).

The acquisition lifecycle is broken down into a number of discrete phases. The phases of the CADMID/ CADMIT cycle are:

- Concept
- Assessment
- Demonstration
- Manufacture / Migration
- In-service
- Disposal / Termination.



Figure 2. CADMIT diagram

The prioritisation of stages of the CADMIT cycle from an efficiency, innovation and flexibility perspective need to be captured in order to understand potential trade-offs between the stages, and which stages were amenable to common management structures where operational priorities are similar, and which stages require different priorities. The framework (see figure 2) was developed to capture the strategic intent of each functional unit within the individual CADMIT stages.

5.0 Sustainable Service Network Design – An initial case study

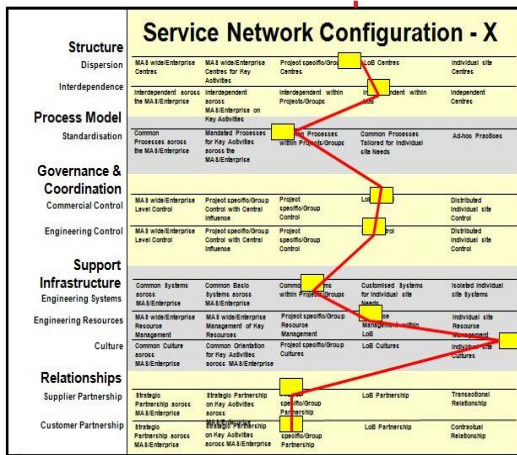
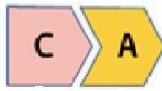
For each of the cases, the network configurations were mapped through interviews with groups of front-line managers. Firstly, how the strategic intent of the organisation for efficiency, innovation, and flexibility may vary across the lifecycle was investigated. The configuration framework was then used to capture the ‘current state’ and provide a basis for exploring reconfiguration options for the future business. Given the diverse nature of the organisation, the resultant service network configurations for three lines of business (with diverse priorities) are presented, as follows:

- Case X can be described as ‘Corporate Support Centre’, spanning all lines of business with priority in the concept and assessment (CA) stages of the CADMIT cycle.
- Case Y can be described as a relatively ‘new line of business’ with most growth potential and operates primarily within the Design and manufacture/migration (DM) stages of the CADMIT cycle.
- Case Z is a ‘mature line of business’ but looking to expand the Support business with the focus on maintenance and upgrades, hence, the in-service (I) element is critical. It was noted that the termination/disposal stage is currently a relatively immature area of business.

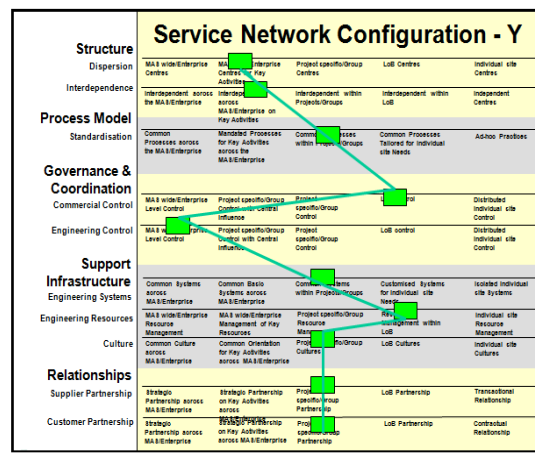
Figure 3 below captures the current configuration states of the three lines of business, effectively three key product categories in this complex equipment service business. For

each of these configurations, the dominant CADMIT dimensions are included to demonstrate the linkage between the configuration state and the CADMIT priority.

Case X



case Y



Case Z

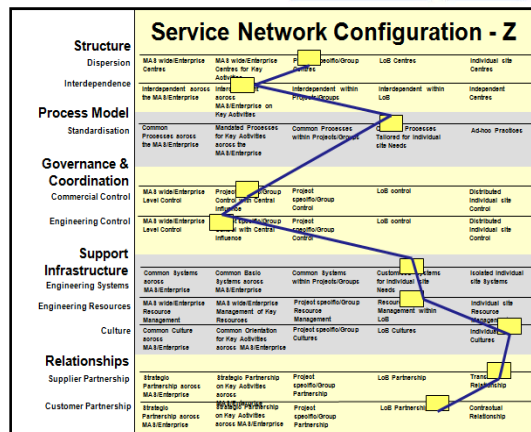


Figure 3. Current Service Network Configuration, for cases X, Y and Z

Figure 4 captures the views of the three product groups on the priorities across the CADMIT cycle and the optimum configuration that would support this requirement.

Analysis of the responses of the three groups are colour coded with the following observations on their suggested configuration selections:

- good alignment across the different business areas with respect to the configuration of the future business;
- however, allowance needs to be made for the particular dispersion and governance requirements
 - of case Z where in-country service delivery capability is required in addition to more centralised competency centres.
 - partnering arrangements of case Y are required to ensure rapid innovation based on integrating supplier capabilities (circled).

Results from this configuration analysis suggest the following considerations may inform sustainable supply network design approaches:

- Innovation and responsiveness are critical across CADMIT but efficiency is crucial in manufacturing and service.
- Traditional business tended to focus on the CADM role with reactive involvement in the in-service phase.
- Synergies across lines of business are driving more central capability and the need to develop more generic solutions to exploit economies of scale.

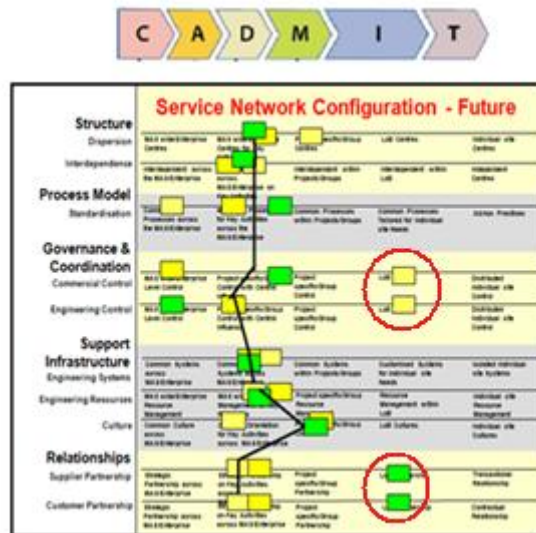


Figure 4. Future Service Network Configuration, incorporating cases X, Y and Z

Results from the through-life capability analysis suggest the following groupings have similar priorities and can be effectively managed within a common operating philosophy.

- | Phase | Priority |
|-------------------|--------------------------------|
| • C and A phases | Innovation, Flexibility |
| • D, M and I | Efficiency, Innovation |
| • I (Home Market) | Efficiency, Flexibility |
| • T | Remains Immature at this stage |

6.0 Conclusion

An approach has been developed to understand how the strategic intent of the organisation for innovation, flexibility, and efficiency may vary across the product service lifecycle, and how this might inform the design of a sustainable service network.

The application of the approach within three product categories (lines of business) of a complex equipment service provider in the defence sector, a case which meets the combined challenge of multi-entity integration and extended through-life maintenance and support, has shown:

- The utility of the approach
- The ability to characterize current configuration states for individual lines of business and as an integrated entity
- The ability to characterize future configuration states that best meet the competing priorities of through-life management, through the individual assessment of CADMIT priorities
- The CA-DMI-I (Home Market)-T groupings represent coherent clusters where the strategic intent of the functional leads are similar and maybe managed in an integrated way

The research also suggests particular archetype configurations support specific capability outputs, and involve trade-offs across the design-build-service and support elements of the product lifecycle.

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