Decision Making Systems and the Product-to-Service Shift

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Abstract: This paper reports on work completed as part of the Knowledge and Information Management – Through Life (KIM) Grand Challenge. The context of the work is outlined; the shift in industry towards a Product-Service paradigm in which the supplier delivers a capability and typically guarantees its service for the customer, allied to the implications of agility, both as an increasingly-important dimension of competition and as a cost-efficient component of the .Product-Service paradigm. A Decision Making Systems Framework and associated Decision Support System is introduced. The case studies which have aided development of these is outlined, along with a summary of the findings. The paper is intended to help researchers and practitioners (both in new and established service organisations) to understand the potential effects of complexity and the necessity of appropriately configured decision making systems.

Keywords: Decision Support Systems, Decision Making Systems, Through-Life Service, Complexity, Emergent Behaviour.

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Abstract: This paper reports on work completed as part of the Knowledge and Information Management – Through Life (KIM) Grand Challenge. The context of the work is outlined; the shift in industry towards a Product-Service paradigm in which the supplier delivers a capability and typically guarantees its service for the customer, allied to the implications of agility, both as an increasingly-important dimension of competition and as a cost-efficient component of the .Product-Service paradigm. A Decision Making Systems Framework and associated Decision Support System is introduced. The case studies which have aided development of these is outlined, along with a summary of the findings. The paper is intended to help researchers and practitioners (both in new and established service organisations) to understand the potential effects of complexity and the necessity of appropriately configured decision making systems.

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Introduction

This paper introduces the development of a tool (ToADS, Tool for Assessing Decision-making Systems), which has been developed to assist organizations to assess the configuration and operational efficiency of Decision Making Systems (DMS) within their organisations. DMS consist of people, process and technical subsystems and ToADS is about assisting Decision Makers to understand whether or not the particular DMS within their organisations is appropriate for different decision making contexts: ToADS does not provide guidelines on how to make good decisions.

This tool has been developed as part of work carried out for the KIM (Knowledge and Information Management through life) Grand Challenge, funded by EPSRC and ESRC. The KIM Grand Challenge is aimed at the construction and manufacturing industrial domains. More information about the KIM Grand Challenge can be found on the project website, www.kimproject.org. KIM recognizes that there are many challenges facing UK businesses in the modern commercial climate, both nationally and globally: one such challenge is the so-called 'product-service' shift (PSS), whereby organisations have moved from producing a product to the provision of through-life service support for the products within systems and systems of systems (SoS) (Oliva & Kallenberg, 2003), for example, the provision of 'integrated solutions' (Brady, Davies & Gann, 2005). This often manifests itself in so-called 'service level agreements' whereby companies guarantee to customers that a given capability will be available at least to the agreed level at all times, for the life of the capability.

The authors have adopted the perspective of Process Philosophy (Heracleitus, see(Davenport 1979)); (Whitehead 1925; Rescher 2000) as a paradigm for understanding the workings of organizations; hence the research reported in this paper takes a process view of how businesses operate within the PSS context, which is the focus of KIM, grounded in case studies. The authors therefore have not considered other possible views such as the business model or product model views, not because they are not valid models, but because the authors have selected a different focus for the work.

The work specifically reported in this paper has been carried out within the KIM project under the aegis of Work Package 3: Managing the Knowledge System Life Cycle, which is concerned with three main aspects: the implications for companies moving into the product-service supply chain in terms of organisation and governance; the human resource implications of this move to product-service contracts; and likely changes in requirements for appropriate decision-support mechanisms at particular points along the engineering life cycle, from initial conceptualization of the required capability through to the ultimate disposal. The authors' work is within the third aspect and focuses on the design, development and implementation of decision support in product-service projects across different sectors. Investigations have focused on (i) the nature of information and knowledge, (ii) dimensions of the decision context (iii) decision-making systems (DMS) and (iv) the process by which the decision situation is understood and options generated, analysed, evaluated and selected.

Industrial Context

With a changing focus from the product at the point of handover to the provision of service and capability over the longer term, the current change-over to product-service projects provides new challenges for decision-making. Tackling various issues related to time, such as increased risk and complexity, is a predominant concern.

From a systems engineering point of view, the amalgamation of product and service to form capability provision (e.g. an integrated solution) provides particular attributes that could not be achieved from the individual constituents in isolation (Brady, Davies & Gann, 2005). If performed well, the benefits for the customer lie in the consistency of support, the reduction of risk and the added agility of response. For the supplier, the benefits are in terms of continuous feedback of the customer experience and learning from use, and in the near-guaranteed cash flow arising from the long-term relationship (Azarenko, Roy et al. 2008).

Traditional engineering processes, tools and methods are considered effective at managing product development. However, the ever-increasing requirements for improved quality and performance on the products being developed (i.e. continuous evolution of technologies supporting even more integration and interoperability, greater functionality, improved reliability and adaptability) and the new demands placed on industry to develop logistic and operational support strategies as part of their products creates even more complex and extensive supply systems which in turn require new strategies for information and knowledge management and decision-making systems (DMS). As an example, in the military arena the UK Ministry of Defence (MoD) merged the Defence Procurement Agency (DPA) and Defence Logistic Organisation (DLO), forming Defence Equipment and Support (DE&S). This was enacted to integrate the procurement of products and their support packages into a single purchase, and improve financial planning by ensuring new equipment and the operational and support costs are included and coherently planned (CCTA, 1996).

Traditional engineering approaches used for much product development usually start with a static user requirements definition which is based on defined-use scenarios for the product and a clear understanding of the required capability, which is established by the customer and not generally subject to significant evolution over the life of the programme. In a simple, ideal world, once requirements are defined it is virtually a linear engineering process to turn requirements into systems and subsequently test them using the customer-provided scenarios of operation. The main iterative process within this development strategy is contained within the development of the customer requirements. This fixed requirement approach enables a number of engineering and decision making practices which can accelerate the development process at low risk. Concurrent engineering design and production can be more easily managed with a clear and static specification for each system component and its interfaces.

Figure 1 represents this 'product only' context for the 'System Operational Capability' (the delivered system operated by the customer) and the 'Development Capability' (the contractor or organisational system that facilitates the conceptualisation, design, integration and testing of the system). It will be observed that the advantages of this model for the supply chain are that once the product or capability has been delivered, the onus of use, maintenance and deciding on upgrades or reconfigurations to meet future needs are problems to be solved by the customer and any demands the customer might make on the suppliers become profitable 'extras' (readers might wish to contemplate automotive maintenance as an example).

Within the new service-oriented development programmes companies do not have the luxury of rigidity within their requirements definition due to changing and evolving capability needs, often realised late by customers in response to their own changing environments. This changing capability requirement is endemic for long-life systems, such as hospitals, public utilities, and defence systems; in some cases system life is so long it could be considered as an 'immortal system'. These systems rarely remain the same through their development and operational life; they are subject to upgrades, additions, modifications and integration with other products. The longer timescales for development (because of the more abstract nature of capability definitions and because of the added complexities in the delivery of such systems) also mean customer scenarios and capability needs are more likely to change, and industry is under pressure to incorporate these new demands into their development and support programmes as they progress. This scenario, which requires flexible and agile DMS, is reflected in Figure 2.

FIGURE 1 & FIGURE 2 ABOUT HERE

Some Issues Associated with this Context

The increase in effort, co-ordination and control implied by Figure 2 is significant; if supplier companies do not rise to meet this challenge, the effects can be long lasting, as illustrated in Figure 3. This incorporates the CADMID lifecycle, well-known in the UK defence industry and originally specified by the Ministry of Defence. The diagram illustrates the possible knock-on effects of earlier unresolved problems (readers may well be familiar with these and may wish to add to the bullet points shown from their own experiences).

Other issues arise as well; Figure 4 indicates some of the information flows and required discontinuities that will impinge on a service supplier in both the construction and manufacturing domains. The product-service shift will substantially alter the supply chain relationships (Brady, Davies, & Gann, 2005). In this example, Company A (Comp A) and Company B (Comp B) are two companies in competition in a given market. The OEM (Original Equipment Manufacturer) is a capability supplier servicing these two companies and will have privileged information about each, which must be kept secure. Consider, for example, the case where Company A wishes the OEM to make a manufacturing change to a component which will have significant profitability prospects, but will mean a reduced service to Company B. How is this to be explained? In turn, it has a supplier of capability necessary for OEM's service to the two companies, and it may be that this change has significance for this supplier. If the supplier has some other contractual relationship with Company B, there may be a need for the OEM to restrict information flows to the supplier. The consultant, included for completeness, is servicing two sequentially-related organisations and again will have privileged information. It will be evident that the relatively free flow of information implied by the agility arguments above, and for that matter by the product-service contracts themselves, will require different arrangements and relationships between the participating organisations.

FIGURE 3 and FIGURE 4 ABOUT HERE

The two interacting drivers within an example such as this are firstly that companies in the extended enterprise are independent, though joined by contractual conditions. Hence, they have some freedom of decision for internal improvements, governance, profit-making etc. Secondly, interacting with this are the requirements for confidentiality of information, due either to commercial or national security requirements. Hence, a large degree of trust is required in the good intentions and good behaviour of the other agents in the extended enterprise, for the lifecycle of the collaboration; many decades, for example (Siemieniuch and Sinclair 2000)

Three particular considerations that arise from extended timescales involved in the product-service shift are: (a) the large increase in both the classes of risk and the magnitude of the risks that must be managed; (b) required changes to the function and provisions of service because of inevitable changes in the commercial environment and changes in technology; and (c) the turnover in the people who manage and provide the service – in the space of 30 years about 70% of them will be replaced, presenting the problem of the conservation of knowledge and experience, together with its constant elaboration (Siemieniuch and Sinclair 2004; Siemieniuch and Sinclair 2004).

This places a greater emphasis on the need for management of service-based projects, especially with regards to decision-making systems (DMS) and decision support systems (DSS), since the potential risks arising as a result of decisions made earlier in a lifecycle have a much longer period in which they may come to fruition.

Finally, there is a significant culture change required within organizations in the Product-Service paradigm. Two quotations illustrate this (Johnstone, Dainty et al. 2008):

"… spares always used to be a profit opportunity, now they're a cost, and that's a completely 180 degree turn for us" and

"The overriding demand for me is responsiveness. If a customer's got a problem, we can't say, 'Well, actually, we'll get all our engineers together and in about three weeks we'll have a committee and we'll come back and tell you what the problem is.' It doesn't work. They want an answer there and then. That requires us to be organisationally and individually nimble."

Taken together, it is clear that the new paradigm represents a major challenge to organizations, and especially for the ways in which they are managed.

What are Decision Making Systems (DMS) and Why Focus on Them?

The research started from an investigation into why things do not always go to plan in organisations and projects (why do bad things happen?). Following this, the research team decided to investigate the decision chains or systems in well-documented system failures or accidents to discover whether any patterns or commonalities between cases emerged. This initial work suggested there was a necessity to look beyond the actual decisions made and the decision support methodologies employed. Work focused on more on the components of decision-making systems, rather then purely on the processes of decision-making or goals of decision makers.. The sections below describe the process and research carried out.

Decision-making is affected by a number of things. There will be external environmental and commercial pressures, but there are also internal effects and pressures. Many of these, such as established processes, organisational structures, and incentivisation policies are typically determined by the company's overall strategy (for example, having an aim to work 'faster, better, cheaper' than competitors). It is important that strategy is developed and implemented in an arena of good governance, otherwise the endeavour to make good decisions will be academic and detrimental emergent behaviour will be a near-certainty.

DMS are the combination of people, process, technology, knowledge and information which may all be involved in the overall decision-making process within an organisation. DMS will of course be affected by time (time available in which to make the decision, time by when the decision must be made, time when the output or effect of the decision is realised, and the expected duration of the decision) and the style or process of decision-making.

Initial Studies in the Development of a Tool to Explore DMS

Investigation into accident cases (as mentioned earlier, such as the Kegworth air disaster, the Enron collapse, the Hillsborough disaster) helped to identify the elements of the initial decision making framework, and the development of the concept tool (ToADS, described below). Both of these elements are described in more detail in a later section. The next two sub sections describe briefly the literature review and initial pilot studies that were used to develop the concept of ToADS.

Literature Studies

A series of well documented case studies in the literature were investigated, including the Kegworth Air Accident (DfT, 1990), a variety of unmanned spacecraft accidents (Leveson, 2004), the Columbia Space Shuttle accident (CAIB, 2003) and many others. This investigation led to the identification of a number of commonalities in issues between the incidents, for example, poor communication, complacency, people not available to do the work, etc. Assessment and categorisation of these issues and commonalities allowed initial identification of the attributes of DMS (e.g. agents, activities, infrastructure, knowledge and information) and the organisational aspects which could be affected by the DMS e.g. (internal and external variables, organisational culture and level of decision-making), and hence the development of the initial framework.

Pilot studies

A number of pilot studies were carried out, both to aid in development of the framework and to develop methodology for the subsequent studies.

Two student-based studies were investigated. Both of these studies were on design projects that specifically mimic many of the typical organisational and technical aspects of full-scale design and engineering projects. These were followed by a construction study, looking at the design and build of an innovative educational building and an engineering study, looking at enterprise modelling in a research and engineering setting. All of the studies looked at the identification of key decision points and the mechanisms of decision-making and decision support employed.

This work led to further development of the framework (and associated system) along with some key initial findings, such as: (1) not all decisions are consciously made, creating a rich environment for miscommunication and emergent behaviour; (2) corporate and top level strategy is not always flowed down or instantiated in day to day activities, which can have a strong impact on decision rationale and the likelihood of latent decision conflicts; and (3) small scale organisational success with stakeholder involvement does not always scale up to extensive success and can have unexpected outcomes, meaning the right processes may not work as expected if applied for misguided reasons.

ToADS – Tool for Assessing Decision-making Systems

Following the initial work outlined, the next step was to determine the components of the tool and how it could best be used within organisations. The decision making framework (a key component of ToADS) allows data to be captured and represented in a common format. A detailed version of the framework is included in figure 5, with a snapshot version included in figure 5a.

FIGURE 5 & FIGURE 5a ABOUT HERE

The row headings are the component parts of a DMS:

- Agents – software or human based, who are involved with decisions,
- Activities – the decision making activities which enable decisions to be made,

- Infrastructure – which enables decision making and may include computer based support,
- Knowledge and information – necessary for decision-making. It is the distribution of these across the organisation (the 'knowledge configuration') that will determine the quality of the decision-making process and of the decisions made.

The column headings are those variables which are external to any single DMS but which have the potential to impact on the performance of the DMS. When issues are identified within a case study they may be oriented with regards to this framework, according to the components of the DMS and impacting variable concerned. Figure 6 shows a typical pattern produced from mapping of such issues. This mapping allows 'quick-view' comparisons, for example of clusters and voids and highlights key areas for investigation. The significance of this lies in its ability to surface issues, and to allow the important stakeholders to to commence the discussions to enact improvements; it is essentially a tool to initiate discussion and to remove heat from those discussions, not to present ready-made solutions. The numbered circles indicate different identified issues (for example, issue number 2 is the lack of personnel in charge of specific part of the process), which are categorized as outlined above. It is this categorization and visual grouping which allows for further analysis. Typically, one might consider a clustering of issues, indicating a particular kind of problem; alternatively, one might consider the voids in the diagram, from the perspective of "Are we overlooking some kinds of issues? Are we being single-minded?'

The purpose of the ToADS is to allow for the assessment of a DMS within an organisation to aid in the configuration and dynamic reconfiguration of DMS within the extended lifecycles integral in the product-service shift. The aim is not to ensure that the organisation always makes the correct decisions, but rather to illustrate the configuration of a DMS (often including areas not considered in standard DM processes) and to enable its reconfiguration to allow organisations the possibility of making the best possible decision given the circumstance they find themselves in.

FIGURE 6 ABOUT HERE

Figure 7 shows the overall components and basic process flow for ToADS. The process is relatively linear. It is triggered by the identification and scoping of an organisational situation. The issues associated with the situation (which may be positive or negative) are oriented on the decision-making framework. Such a populated framework can then be analysed. At a top level, this is done by identification of issue clusters and comparisons with cases from the incident database (which may be previous situations from with the organisation or examples from disaster/ accident situations, such as those outlined earlier). Advice arising from such analysis suggests tools, which may prove useful (either for analysis in a retrospective situation) and may highlight key information to be included in risk management processes, which may otherwise have gone unheeded. For example, a brief analysis of the situation on figure 6 would highlight key areas as definition/ appropriateness of activities with regard to the Engineering Life Cycle (ELC) and availability/ appropriateness of knowledge and information for the organisational culture.

There is a risk activities are not understood or planned correctly and it is likely the knowledge and information will not enable appropriate flexibility or collaboration. Figure 8 goes on to explain the first step in more detail, outlining the type of information needed to scope an organisational situation for use is ToADS. The main components are the DMS Framework and the Database of Incidents (garnered initially from the literature case studies and expanded based on data from other case studies carried out within the KIM project), which together allow for comparison and assessment of organisational decision-making system configurations. This is currently implemented through a database system and produces guidelines for potential risks arising from the situation (if used prospectively) and suggestions of tools to aid with problems arising.

FIGURE 7 & FIGURE 8 ABOUT HERE

At this stage in the research it was envisaged that application would be possible both for prospective and retrospective work. It was anticipated that final use will incorporate a lessons learned type database, allowing organisations to record their own examples and learn from their experiences.

The development stage reported in this section was then augmented using case studies in an industrial context. These are outlined in the following section. These were followed by a a separate set of studies (a combination of expert evaluation in workshops and a user evaluation in a case study) for validation of both the tool itself and also the process for use.

Industrial Case Studies

The research involved two main case studies, in addition to the pilot studies outlined above.

In both studies a qualitative approach to data gathering was used. Preliminary work involved analysis of existing documentation followed by a combination of email communication, interviews and workshops.

The industrial studies took place within a multinational aerospace organisation and were selected as the organisation is experiencing some of the issues involved in the product-service transition.

The studies focussed on the pre-bid stage of the organisation's operations lifecycle (i.e. the process of deciding whether or not to bid for a contract), tackling identified problems at different levels of activity decomposition. Data was gathered on activities and roles involved, information flows and decision points, along with process and problem perception and other contextual details.

Views were gathered from across the operating or business units within the organisation to allow for comparison. Table 1, below provides an overview of the case study context and a summary of key findings that emerged following the application of ToADS.

Study	Problem statement	Overview of key findings
Industrial study 1	The bid stage of the capability lifecycle was perceived to have become congested with mandated activities and reviews, leaving little time to complete all	• A change of focus has occurred with contracts written on service based instances and a more delicate balance of capability and profit. For

	necessary work to progress the bid for a contract.	the bid process, this represents new risk and the analysis is not as mature as it should be to deal with this. • The move outlined above has also encouraged overlap in review activities between different functions • It is not enough to adapt existing processes to deal with these new contracts – new process must be developed and employed • Not all decisions are consciously made, especially during status review.
Industry study 2	There was concern about the quality and consistency of one of the technical reviews, which takes place pre-bid. It was perceived that there was a lack of understanding of the training requirements for those involved with the review; one obvious knock-on effect being an incorrect assessment of the technical issues in bids. This could be very unfortunate in 'bet the company' bids.	• Confusion arises when progressing a service based contract through the auspices of a technical review with regards to what should be reviewed and a concern that some things are not reviewed at all, leading to unknown risk. • Purpose and importance of activities is not clear, which has issues for tailoring and consistency of output. • These things need to be addressed before appropriate training can be developed.

Table 1 Industrial Case Study Summary

These findings suggest a requirement for tailorable DMS processes with appropriate guidelines to allow for configuration and reconfiguration along with the need to make decision support integral within the organisation's processes. It is widely accepted that future organisational and technological systems will not be stand alone, but will interoperate with other systems. It is important that the processes designed to manage these systems are also interoperable and their objectives clear (i.e. it is evident what value they add rather than just being paper work exercise to allow people to feel better about the inherent uncertainties).

The case studies do have limitations, as they are restricted to a single organisation. Further work would be needed to ensure applicability across sectors. It is anticipated that further consultation with industry, through a validation study which is currently being analysed will provide adequate validation of the final output system from this research. This validation study is based in a smaller manufacturing company, which is also experiencing impacts of the product-service shift and the accompanying expectations from the customer.

Conclusions

In summary, the main, public findings from initial use of the DMS are:

- Decisions are not always consciously made. People cannot actively look for support for something they are unaware they are doing; nor will they communicate these decisions.
- There is a tendency to adapt (sub-optimally) existing processes for new projects rather than develop new ones. The product-service shift demands new processes to avoid ignorance of potential risks.
- Discontinuities between the individual's view of self and view of the organisation. ("It's not me/ us that get things wrong, it's them!" – a classic and pervasive symptom of induced complexity alive and well in the organisation)
- Assumptions made about others rather than communicating (another classic symptom).
- There is a lack of strategy flow-down. Strategies set at high level with little visibility afforded for the "workers", leading to issues with realizing the strategy (and problems for DM).
- Lack of visibility of purpose and value of activities can impact on proper tailoring and effective DM.

With regard to the onward development of ToADS the authors recognise that there are some issues that the tool does not currently address. These include training and workload, albeit the framework can be used to investigate problems in these areas. Furthermore, the use of the ToADS and associated processes will rely heavily on successful, honest identification of issues and subsequent categorisation. Given that few people are able to understand more than a small part of their own organisation, and given the power relationships and politics to be found in any organisation, these are difficult goals to achieve. It is also intended that an upgrading process will be available for the Framework, to allow it to be tailored for a given organisation and its ever-changing context.

Future work both within and without the KIM project context will include an investigation into the implications of time in decision-making and further development of the processes for applying ToADS and analysing its output. Time is a key issue for decision-making. Consideration must be made of the time available to make the decision, time by which the decision must be made, validity period for the decision, etc.

The paper has tried to emphasise that the product service shift will have implications for DMS and DSS for both existing service organisations and new service organisations With new contract and project types, there will be a requirement for new operational and decision making processes. These new processes may require more (or different) people and resources and will certainly require more (different) knowledge. These processes will need to be accepted within the organisation and integrated into the overall organisational system if they are to be effective. The requirements for flexibility and agility referred to in the section on Industrial Context indicate that a paradigm shift is required; the really hard bits of the organisation to change will need to adapt – culture, trust, leadership style and the like.

With the prevalence of 'through life capability' contracts comes a shift in responsibility. As suppliers have a responsibility to provide a through life service, so the decisions they made and the impacts they have are now of their own concern. Risks, financial or otherwise, can no longer be passed along to others down the lifecycle. This calls for better decision support, along with better identification and assessment of risk (both technical risk and business risk). These form part of the new decision-making processes and systems that are required. If, as suggested in the studies, some decisions are not consciously made, these processes must be easy to use, if not implicit within regular working practices. If a decision is not consciously made, the outcome is not known nor accounted for. This can lead to unanticipated behaviour (emergence), increasing risks and missed opportunities.

With such an interlinking of issues, a multi-disciplinary approach is an absolute necessity, especially in the initial stages of any such contract. The new collaborations born from the product-service shift mean that whole supply chains may be working together rather than in competition and customer and supplier will be working in partnership. This means that the multi-disciplinary approach may cross-organisational boundaries, calling for a need for better alignment or congruency between different organisational and decision-making processes, as noted in the industrial studies. The implications of this may have issues for Intellectual Property Rights and logically leads to a discussion of trust (well documented in the literature, but outside the scope of this paper). In the absence of full information flows, trust and partnerships are essential ingredients. The design of organisations to deliver these characteristics is a long and complex task for leaders (Siemieniuch & Sinclair, 1999, 2000, 2001, 2006), but one that must be undertaken.

Leading on from this, resilience must be a paramount concern for the leadership of any such organisation. The time scales of the projects arising from the product-service shift may be upwards of 30 years. In the absence of long-term (accurate) future predictions, an organisation must be adaptable enough to cope with the complexities of change. It may not be possible to detail what the changes may be, but it is certain that change will occur. Such resilience should be considered at the organisational, project, team and individual levels. The tenets of High Reliability Organisations (HROs) will be relevant here (Roberts & Bea, 2001; Sullivan & Beach, 2003; Weick & Sutcliffe, 2001; Weick, Sutcliffe, & Obstfeld, 1999).

By focussing attention away from the facility at the point of handover to the services supported by that facility over the longer term, the current changeover to product-service projects provides new challenges for decision-making. Through life service places increasing emphasis on the decisions made by the supplying company as risk can no longer be passed on to the client or customer. With service typically being consumed or used as it is produced, it is probable that each instantiation will be different. This makes it incredibly important for a service organisation to ensure that the decision-making systems within their organisations are capable of delivering the levels of performance required to cope with a very changeable environment. It is believed that a tool such as ToADS would assist organisations to do this.

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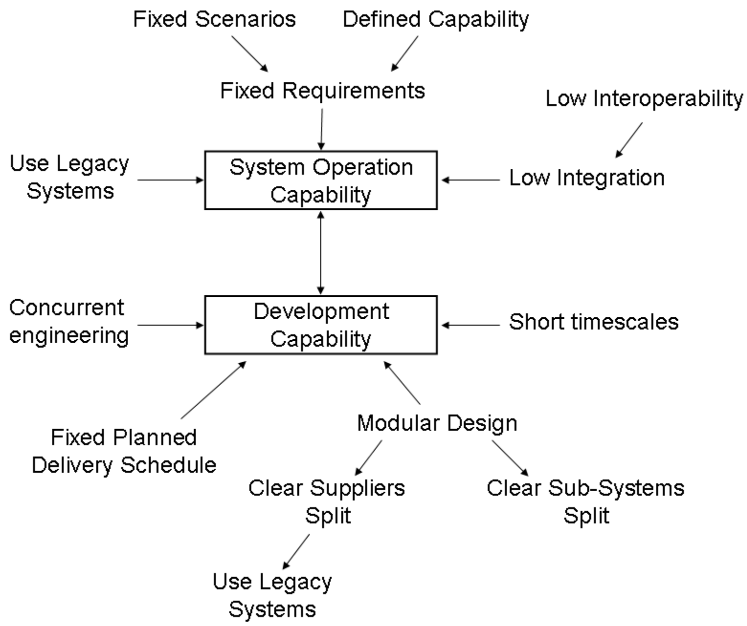

Figure 1 Product-only context

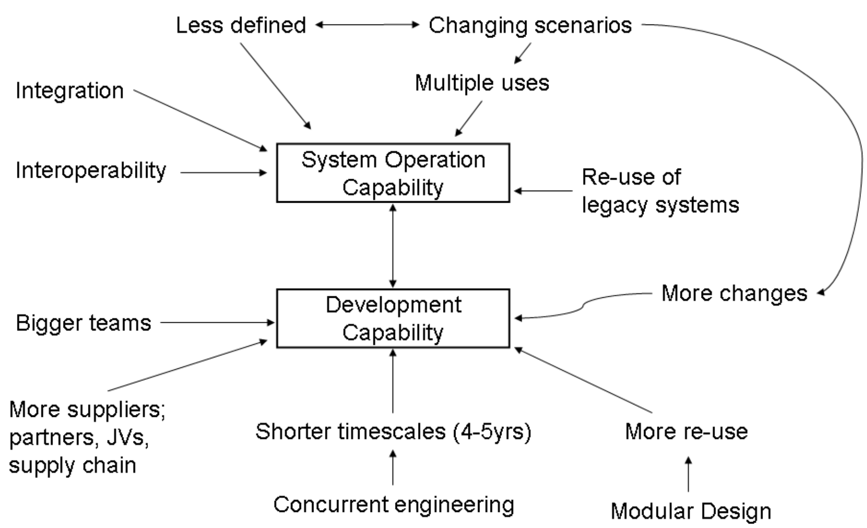

Figure 2 Product-service context

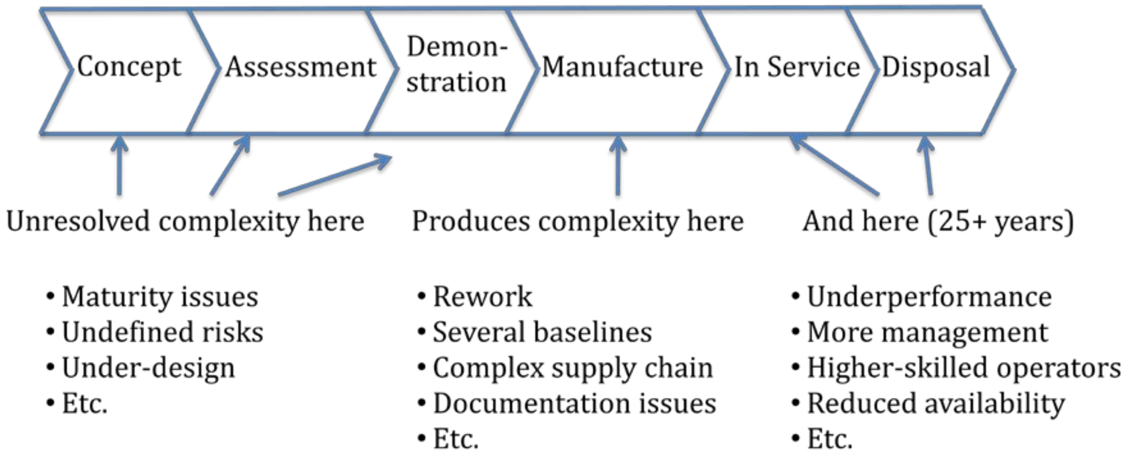
Concept
Assessment
Demon-
stration
Manufacture
In Service
Disposal
Unresolved complexity here
Produces complexity here
And here (25+ years)
• Maturity issues
• Undefined risks
• Under-design
• Etc.
• Rework
• Several baselines
• Complex supply chain
• Documentation issues
• Etc.
• Underperformance
• More management
• Higher-skilled operators
• Reduced availability
• Etc.

Figure 3 The CADMID lifecycle from the UK Ministry of Defence. Associated with it are some of the effects of complexity.

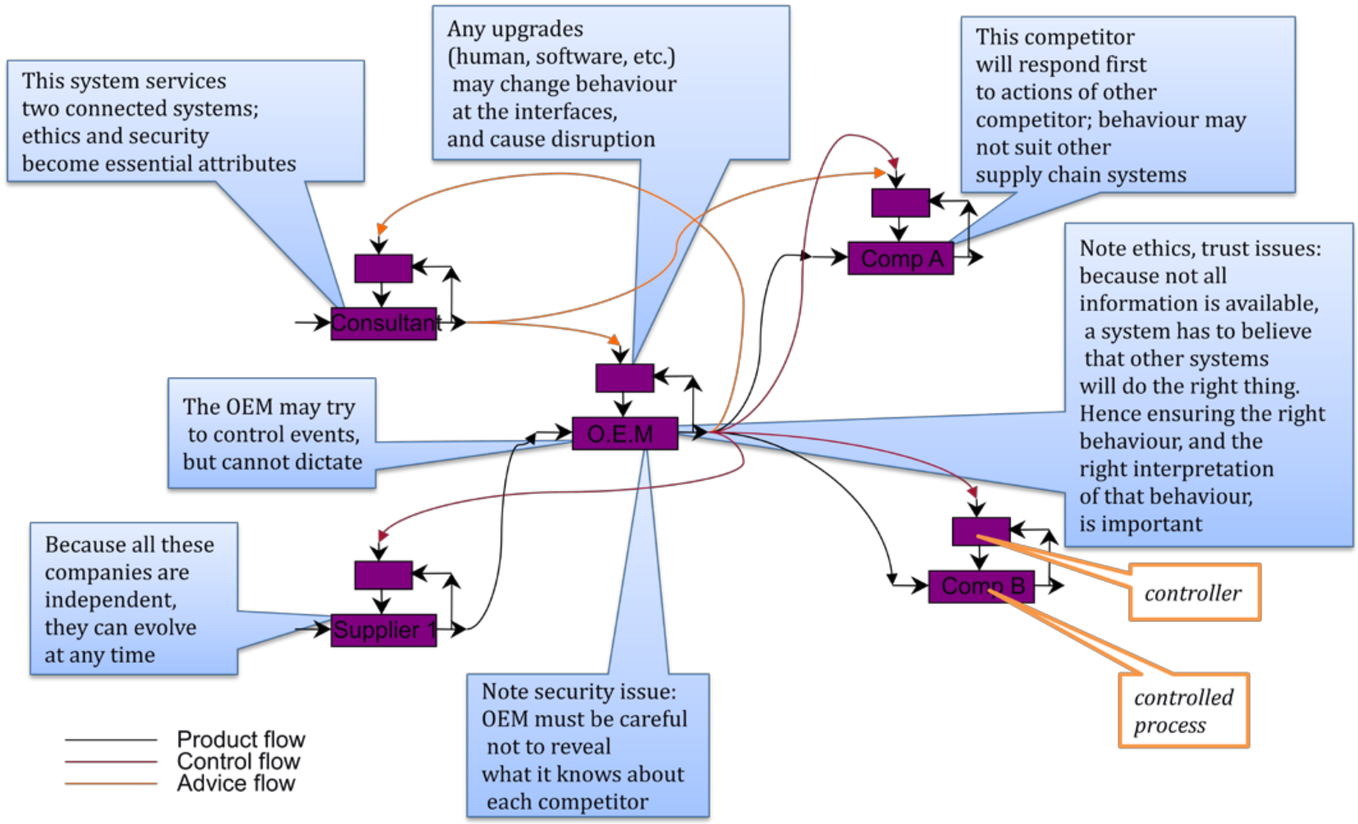

Figure 4 Example of a section of a supply chain, exhibiting some of the influences that will not affect the flow of transactions, but can affect significantly the flow of information.

	1. Internal (Contextual) Variables	2. External (Environmental) variables	3. Organisational Culture	4. Level of DM
A. Agents/ Roles	Poor role/ agent definition for phase of lifecycle	Poor role/ agent definition cannot deal with external variables	Poor role/ agent definition prevents effective collaboration Poor role/ agent allocation due to organisational structure/ power distance	Poor role/ agent definition at all levels of DM
	Poor role/ agent allocation for phase of lifecycle	Poor role/ agent allocation cannot deal with external variables	Poor role/ agent allocation prevents effective collaboration Non-availability of roles/ agents due to organisational structure/ power distance	Poor role/ agent allocation at all levels of DM
	Non-availability of roles/ agents for phase of lifecycle	Non-availability of roles/ agents to deal with external variables	Non-availability of roles/ agent willing to take required risk Non-availability of roles/ agents prevents effective collaboration	Non-availability of roles/ agents at all levels of DM
B. Activities	Inappropriate activities for phase of lifecycle	Inappropriate activities, cannot deal with external variables	Inappropriate activities, cannot provide level of required flexibility Inappropriate activities prevents effective collaboration Inappropriate activities prevents effective risk management	Inappropriate activities at all levels of DM
	Poor definition of activities for phase of lifecycle (unclear or fuzzy boundaries)	Poor definition of activities, cannot deal with external variables (unclear or fuzzy boundaries)	Poor definition of activities prevents effective risk management Poor definition of activities cannot provide level of required flexibility Poor definition of activities, prevents effective collaboration.	Poor definition of activities at all levels of DM
C. Infrastructure and Technology	Inappropriate infrastructure for phase of lifecycle	Inappropriate infrastructure, cannot deal with external variables	Inappropriate infrastructure, not compatible with organisational structure Inappropriate infrastructure, not enable effective risk management Inappropriate infrastructure, not enable level of flexibility required Inappropriate infrastructure prevents effective collaboration	Inappropriate infrastructure at all levels of DM
	Non-availability of infrastructure for phase of lifecycle	Non-availability of infrastructure to deal with external variables	Non-availability of infrastructure, not compatible with organisational structure Non-availability of infrastructure, not enable effective risk management Non-availability of infrastructure prevents effective collaboration	Non-availability of infrastructure at all levels of DM
D. Knowledge and Information	Inappropriate knowledge and/ or information for phase of lifecycle	Inappropriate knowledge and/ or information, cannot deal with external variables	Inappropriate knowledge and/ or information due to organisational structure/ power distance Inappropriate knowledge and/ or information, not enable effective risk management Inappropriate knowledge and/ or information, not enable level of flexibility required Inappropriate knowledge and/ or information prevents effective collaboration	Inappropriate knowledge and/ or information at all levels of DM
	Non-availability of knowledge and/ or information for phase of lifecycle	Non-availability of knowledge and/ or information, cannot deal with external variables	Non-availability of knowledge and/ or information due to organisational structure/ power distance Non-availability of knowledge and/ or information, not enable effective risk management Non-availability of knowledge and/ or information, not enable level of flexibility required Non-availability of knowledge and/ or information prevents effective collaboration	Non-availability of knowledge and/ or information at all levels of DM

Figure 5 The Decision Making Framework

Feature of DMS	Issue
A. Agents/ Roles	Poor role/ agent definition
	Poor role/ agent allocation
	Non-availability of roles/ agents
B. Activities	Inappropriate activities
	Poor definition of activities (unclear or fuzzy boundaries)
C. Infrastructure and Technology	Inappropriate infrastructure
	Non-availability of infrastructure
D. Knowledge and Information	Inappropriate knowledge and/ or information
	Non-availability of knowledge and/ or information

Figure 5a Snapshot view of the framework

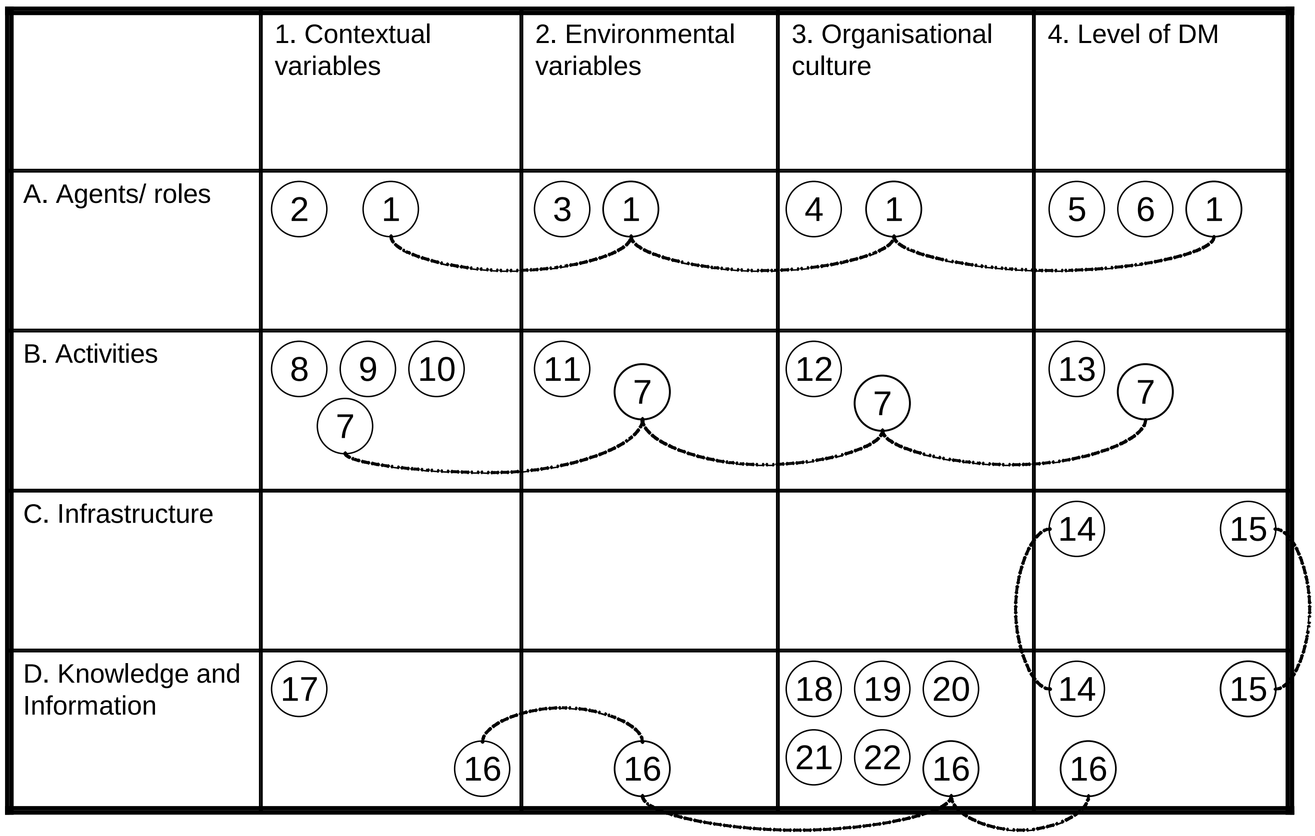

Figure 6 Completed example of Framework

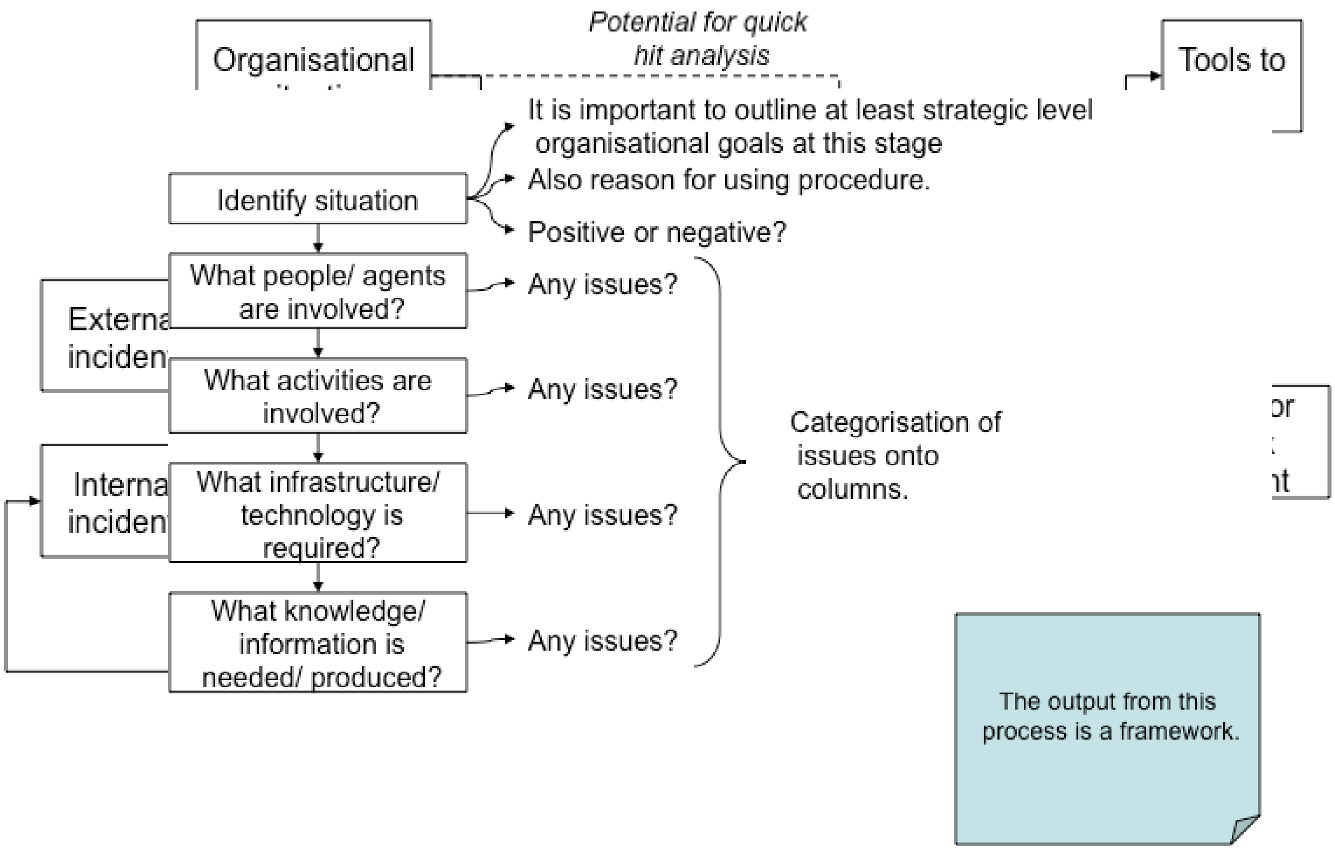

Figure 8 Scoping the organisational situation