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Working towards a holistic organisational systems model

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Abstract

This paper presents an integration effort of a number of soft factors modelling tools and considers the potential impact of such an overall tool in a system of systems environment. The paper introduces the tools developed and how it is envisaged they will work together to provide a comprehensive, coherent output.

It is suggested that a suite of interoperable tools of this form benefit any system whose lifecycle includes an organisational component, from bid to disposal, including the operational organisational support..

Introduction

It is generally accepted that organisational systems (large/ small, temporary/ permanent etc.) need better integration strategies and (re)configurable organisational architectures if they are to be able to achieve faster response times, improved decision-making processes, flexibility/ adaptability in the face of change, improved resilience, robustness etc. However, there is a severe lack of usable, integrated, dynamic enterprise simulation models that allow organisations to explore *prior to deployment* the implications of change initiatives, such as the introduction of new processes, new capabilities, new working practices, etc., particularly from an organisational and human performance perspective. The holy grail of being able to look into the future by evaluating the effectiveness, impact or added value of alternative organisational system configurations, prior to deployment, is still a long way off. Such a capability would greatly enhance an organisation's ability to dynamically (re)configure appropriate systems (people, process and technology) to achieve the requisite performance required to produce designated output in different contexts and to avoid structures most susceptible to adverse circumstances such as accidents, disasters and undesirable emergent behaviour.

This paper introduces work carried out by the Engineering System of Systems (ESoS) Research Group at Loughborough University. The aim of this group is to research the interoperability, sustainability and reconfigurability of socio-technical Systems of Systems (SoS) to improve their predictability and usability. To this end, the group has developed an emerging portfolio of tools that together enable an organisation to assess how it is organised to achieve its goals. The purpose of this exercise is to create a 'bigger picture' representation of an organisational system. Such an organisational systems model may help provide input to questions such 'are we doing the right things' and 'are we doing those things right', providing critical input to 'Engineering Governance'.

Three tools from the portfolio are described in this paper, the Role Matrix Technique (RMT), the Tool to Assess Decision-making Systems (ToADS) and the Soft Factors Modelling Tool (SFMT). One key constraint underpinning the development of all these tools is that they should be simple to use, negating the need for consultants.

Work in this area arose from four key projects, the first three funded by the UK Engineering and Physical Sciences Research Council through the Innovative Manufacturing and Construction Research Centre (IMCRC) grants and the fourth through the Ministry of Defence (MoD) funded UK Defence Technology Centre Systems Integration and Integrated Systems for Defence: Autonomous and Semi-Autonomous Systems. However, one project deserves particular mention: the IMCRC project VORTICS (Virtual Organisations Rig for Testing and Investigating Company Structures), which aimed to create the building blocks of a coherent enterprise modelling capability, comprising a portfolio of models of enterprise characteristics.

The multi-disciplinary approach taken is founded on a SoS point of view and hence takes into account the interlinking of issues which arises with through-life capability considerations. In addition, since global collaborations require whole supply chains to work in partnership, any work in this area must also focus on better alignment of organisational strategies, processes and structures throughout the supply chain.

This paper follows on from the work presented at CSER 2009 (Molloy et al., 2009a).

Organisational Systems Engineering

Organisational Systems Engineering (OSE) involves treating the enterprise as a system and modelling 'softer' organisational characteristics, such as role interactions, cultural values, knowledge distribution, competencies, decision-making systems, enterprise strategy and team reliability.

Why do we want to model enterprises?

Enterprise models allow a way to visualise, represent and analyse the inner workings of an organisation or enterprise. Where a change or transition is being experienced, enterprise modelling can provide insight into problems, diagnose symptoms, identify and compare alternatives and develop a plan for the future. In general, an enterprise model provides a common basis for discussion, allowing an opportunity to improve performance and increase profit – given the current economic climate around the world, any competitive edge could be very valuable for the organisations involved.

System of Systems

As noted in a precursor to this paper (Molloy et al., 2009a), a SoS environment enhances some of the challenges for organisations and necessarily for organisational systems engineering and organisational modelling: issues arising include the need for organisational agility, the impact of induced and intrinsic complexity, eliminating undesirable emergent behaviour and managing more efficient knowledge and information management systems.

Role Matrix Technique

The research group have been developing a technique called the Role Matrix Technique (RMT) for over a decade (Callan et al., 2006).

In the beginning, the RMT was intended to provide a relatively quick and easy method which enabled process owners, project managers and other practitioners to analyse, evaluate and select the most appropriate combination of human roles (class, profile, boundaries, interactions, authority and

responsibilities) for a given process. Over the years, it has expanded to become a means to explore and illuminate organisational structures, showing how roles fit together (or not), and providing some insight into the sources of the emergent behaviour that reduced so much of the organisational performance.

The RMT has two key elements: the first enables the representation of the nature of involvement of different kinds of roles for a given activity, as shown in figure 1. Roles are allocated to an activity within an overall process, depending on whether their contribution is in controlling or executing the activity or providing constraining or discretionary advice. There is only ever one main role in control of any activity, but there may be any number of roles executing or providing advice.

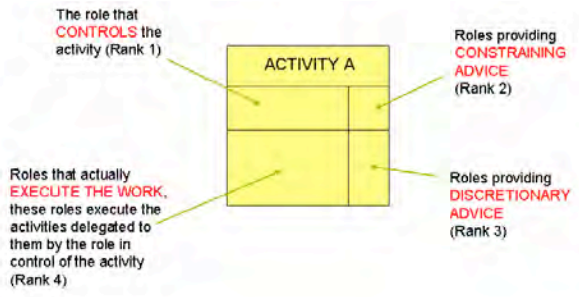

Figure 1 RMT quadrant

Constraining advice is typically that which comes down the organisational hierarchy, but not from those in the direct line of responsibility. Discretionary advice typically is that which arises from Communities of Practice (for example), which may extend beyond the organisation.

The second element of the RMT is the Role Matrix – its aim is to create and organisational structure for a given set of roles, which also offers a means of promoting discussions around the kinds of roles that should be involved within a process, and who should take on those roles to ensure the process is effective and efficient. Figure 2 provides a brief overview of the Role Matrix, showing its internal structure. When roles are placed on this matrix, together with the communication links (as shown in figure 5), it becomes possible to see the intrinsic problems in the proposed organisation.

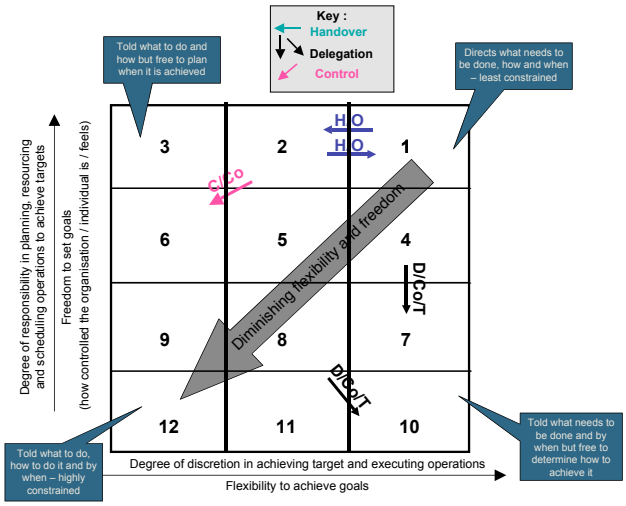

Figure 2 Role Matrix

Tool for the Assessment of Decision-making Systems

The aim of ToADS (Tool for the Assessment of Decision-making Systems) is to assist organisations in configuring their DMS (Decision-Making Systems), to help them cope with the risks and opportunities of long life, complex, engineered projects and systems (Molloy et al., 2009b). A top-level view of the DMF (Decision-Making Framework, a key part of ToADS, providing the ability to categorise issues) is presented in figure 3. Using the DMF and ToADS, stakeholders are able to analyse and investigate DMS in their organisations, to establish where and why they may not be working efficiently, both in retrospect and prospect.

Using ToADS in conjunction with the RMT, it is possible to expose roles (or teams) that stand little chance of delivering on the

goals given to them, thus adding friction to the organisation's performance.

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 3 ToADS DMF categoristation (simple version)

Culture

While the RMT and ToADS provide structural diagnosis, this is not enough. It is also necessary to consider the organisation's culture. This is accomplished using the Soft Factors Modelling Tool (SFMT) (Hodgson and Siemieniuch, 2009), which evaluates organisational culture at three levels of organisation, group or team and individual. The tool captures the cultural traits of individuals and systems and relates these to military mission requirements. A set of cultural factors (pairings) was chosen that reflects the concerns of Western military organisations, as show in figure 4.

The SFMT uses these cultural factors to create and compare profiles of (a) the intended mission and its environment, and (b) the set of assets available to carry out the mission. The SFMT could be utilised in order to answer a question such as the following:

Is the selected configuration of military assets capable of demonstrating appropriate decision-making, communication and adaptive skills and behaviour in an operational environment where the command style is control free, authority is delegated, operational tempo is unpredictable and the battlespace is ill-defined?

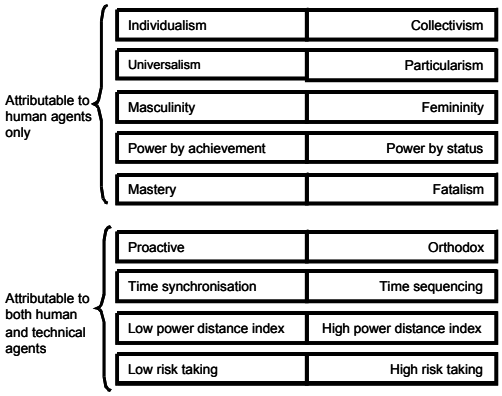

Figure 4 Cultural factors used in SFMT

The SFMT identifies mismatches between available resources and the demands of both the tasks that must be executed and the task environment, thus adding depth to the diagnostics arising from the RMT and ToADS. It is believed that as a result, organisational change towards a better utilisation of the available human resources will become easier to plan and accomplish.

Other Areas

Two other tools are under development. The first is a Role Competency Tool (RCT). This is premised on the notion that one can treat an organisation as a knowledge engine, which both captures knowledge to carry out its mission, and realises that knowledge in the capabilities that it delivers. Consequently, for efficiency, it is necessary to ensure the configuration of knowledge (i.e. which role should know what) across the organisation is at least appropriate.

The second is the Performance Evaluation and Assessment for Teams (PEAT) tool. This is a predictive tool. Having used the other tools to diagnose the issues, and having generated a possible to-be structure, PEAT

can then be applied to evaluate the likely performance of the revised structures.

Integrating the Tools

Current work is focusing on the combination and integration of this suite of tools into a single, holistic tool, so that there would be a seamless transfer of work from one tool to another, in whatever order the user thinks fit (a suggestion of how this could be done is presented in figure 5). Given the work of the group, it has also been identified as a requirement that provision should be made to enable the integration of new tools or allow tools to be updated as research and development continues. The integration of the tools into a single system is represented graphically in figure 5.

The challenge is to develop an integrated approach to define and evaluate (pre and post any planned change) whether the configuration(s) of human resources identified/ selected is capable of making decisions and carrying out identified tasks in pursuit of an identified goal-set efficiently and effectively, given the constraints of a particular type of operational environment. Ideally, this will be encapsulated in a decision support system (DSS), which will include a simulation capability. This would allow managers to explore organisational system models with alternative configurations and improve project processes by having the ability to evaluate whether a particular organisational context could inhibit or facilitate the introduction of a new capability.

The SoS consideration also requires the modelling of organisations throughout the supply chain. This will be even more important with the shift of responsibility which comes with the growth in consideration of through life capability.

Conclusion

Before embarking on any large organisation systems modelling, it is important to remember that development and interpretation will be context dependent and will vary depending on the aim and objectives of the organisation or system of systems.

Models can be developed to simply explain what is going on with an organisation, to identify lessons learned or best practice or to tackle a specific problem such as issues regarding training, human resources or a specific process phase.

A significant challenge, particularly for engineering organisations, is the shift to the provision of through-life capability support (Oliva and Kallenberg, 2003). This will affect companies in their internal organisation and will demand changes to the processes employed. Such new processes will require different people and resources, including a wider pool of available and accessible knowledge. These processes must be accepted and integrated into existing/ legacy organisational systems if they are to be effective. An organisational systems modelling and analysis tool could help facilitate such an integration. Considerations from agility suggest a paradigm shift is required, including elements notoriously difficult to change, such as culture and trust. Understanding how these things permeate through an organisation (and indeed beyond the an individual organisation throughout the supply chain) may help organisations avoid continual and non-value added series of organisation restructuring.

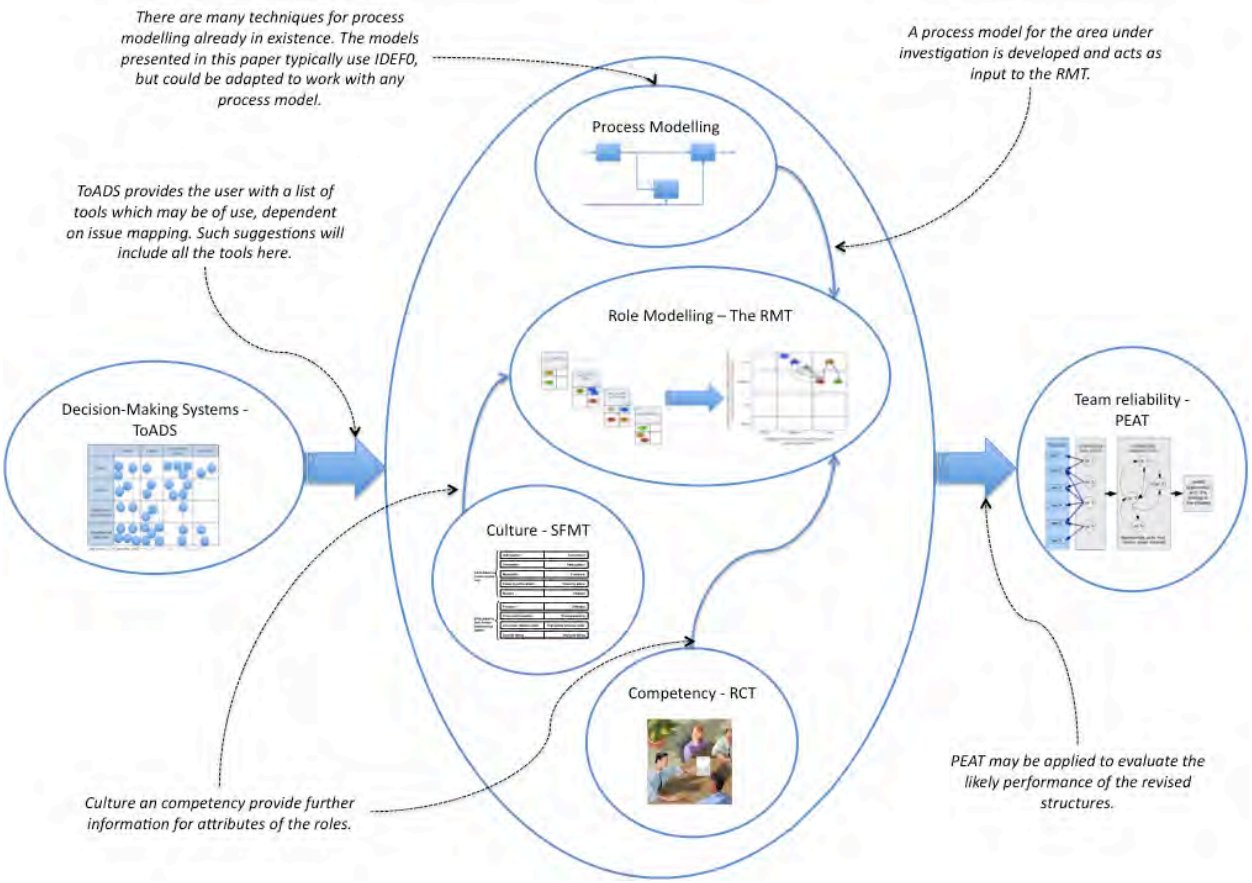

Figure 5 Integrated tools

References

Callan, K., Siemieniuch, C.E. and Sinclair, M.A., "A case study example of the role matrix technique", *International Journal of Project Management*, 24, pp. 506-515, 2006.

Hodgson, A. and Siemieniuch, C.E., "The evaluation of cultural factors and their potential effects on military operations", Paper B2 in the Proceedings of the 4th SEAS DTC Technical Conference, Edinburgh, UK, July 2009.

Molloy, E.M., Siemieniuch, C.E. and Sinclair, M.A., "Fit For Purpose Organisations in a System of Systems Environment", 7th Annual Conference on Systems Engineering Research, Loughborough, 2009a.

Molloy, E.M., Siemieniuch, C.E. and Sinclair, "Decision-Making Systems and the Product-to-Service Shift", *Journal of Manufacturing Technology Management*, 20(5), pp. 606-625, ISSN: 1741-038X, 2009b.

Oliva, R. and Kallenberg, R., "Managing the transition from products to services", *International Journal of Science Industry and Management*, 14, pp. 160-172, 2003.

Biographies

Ella-Mae Hubbard obtained her MEng. in Systems Engineering in 2005 and Ph.D. in 2009, both from Loughborough University. She is a lecturer in the Department of Electronic and Electrical Engineering at Loughborough University. Her research interests are in organisational systems engineering, particularly in the context of systems of systems and also in the education of systems engineering. She is a member of INCOSE and the UK institute of Ergonomics and Human Factors.

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Murray Sinclair is an research engineer, following retirement from a post as Senior Lecturer in the Department of Human Sciences at Loughborough University. He was involved in many collaborative projects in integrated manufacturing in the extended enterprise. Research interests include decision making in complex systems, good engineering governance and wisdom within organisations. He is a Fellow and ex-Council Member of UK Institute of Ergonomics and Human Factors, member of IEEE Technical Management Institute and is qualified as a European Ergonomist. He was the UK Representative on CEN/TC 310/WG4 – Ergonomics in Advanced Manufacturing Systems and is on the UK Nuclear Safety Advisory Council.