Introducing the Role of Process Architecting

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Abstract[1]. The work done in the development of systems is currently split between the three interdependent and apparently overlapping organisational roles of systems architecting, systems engineering, and project management, which interdependently produce a product to (the correct) specifications within the constraints of resources, budget and schedule. This paper first identifies a reason for the overlapping roles, and then attempts to resolve the difficulties in defining the roles of systems engineering, systems architecting, and project management, and the difficulty in defining the body of knowledge for systems engineering by identifying a gap in the functions performed by the three organisational roles, when viewed from the perspective of planning and implementing the development of a system, via the Roles Rectangle. A gap, which when filled by the new defined role of process architecting, has the potential to bring some order into the current chaos and resolve many if not all of the current difficulties.

Background

There have been many discussions in the literature about the overlapping of, and differences in, the roles of systems engineering, systems architecting, and project management, e.g. (Brekka, Picardal, et al., 1994), (Roe, 1995), (Kasser, 1996), (Sheard, 1996), (Mooz and Forsberg, 1997), and (Kasser, 2002b), and the depth of speciality knowledge required for each of the three roles in the development of systems (Kasser and Schermerhorn, 1994), (Maier and Rechtin, 2000), (Kasser, 2000), and (Kasser, 2002b). For example, according to (Roe, 1995) the knowledge and skills of systems engineers are the same as those of project management in the areas of management expertise, technical breadth and technical depth. Roe adds that the difference in application is that the system engineer has more technical breadth, while the project manager has more management expertise. In these discussions, the situation tends to be represented by overlapping shapes as shown in Figure 1.

In addition the difficulty in defining the body of knowledge for systems engineering has also been discussed in several places including (Leibrandt, 2001) and (Kasser and Massie, 2001). As a result of these difficulties, it has been difficult to separate the content of postgraduate courses in systems engineering, systems architecting and project management, at least at the University of South Australia, so the current courses contain some overlapping content (although treated from different perspectives).

This paper first identifies a reason for the overlapping roles and then attempts to resolve the difficulties in defining the organisational roles and their bodies of knowledge. It does this by identifying a gap in the functions performed by the three organisational roles when viewed from the perspective of planning and implementing the development

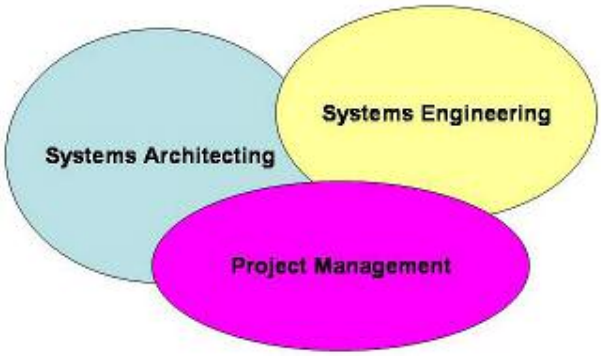

Figure 1 Overlapping organizational roles in the development of systems

of a system. When this gap is filled by a new defined role of process architecting, the four interdependent organisational roles have the potential to bring some order into the current chaos and resolve many if not all of the current difficulties.

The Three Current Organisational Functions in the Development of Systems

The task of developing systems is currently split between the three interdependent organisational functions of systems architecting, systems engineering, and project management which interdependently produce a product to (the correct) specifications within the constraints of resources, budget and schedule. These functions are performed by people with various roles. For the purposes of this discussion, consider the following terminology:

- **Roles** – the title or job description of a person in an organisation. These are variations of various job titles such as System Architect, System Engineer, and Project Manager.
- **Functions** – activities performed by a role in an organisation. Some functions performed by a role in one organisation may be performed by a different role in another organisation.

Now consider the three interdependent organisational functions of systems architecting, systems engineering, and project management.

Systems Architecting. (Maier and Rechtin, 2000) define systems architecting as "*the art and science of creating and building complex systems. That part of the systems development most concerned with scoping, structuring, and certification*". The function of the systems architect is to apply architectural methods analogous to those used in civil works. This function is concerned with meeting the overall client needs, directing the high-level design, focussing on keeping the interfaces between contractors manageable, and working for the client to ensure that the resulting system satisfies the client's expectations, even if the expectations are not clearly articulated.

Systems Engineering. According to (INCOSE, 2002), **"***systems engineering is an interdisciplinary approach and means to enable the realisation of successful systems. It focuses on defining customer needs and required functionality early in the system*

development life cycle (SDLC), documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem".

Project Management. According to (Kezsbom, Schilling, et al., 1989) project management is defined as "*the planning, organizing, directing, and controlling of company resources (i.e. money, materials, time and people) for a relatively short-term objective. It is established to accomplish a set of specific goals and objectives by utilizing a fluid, systems approach to management by having functional personnel (the traditional line-staff hierarchy) assigned to a specific project (the horizontal hierarchy)***"**.

Mapping the Three Roles

Given the overlapping nature, and commonality, of the functions performed by the three roles, no wonder it has been difficult to separate them. For example, (Kasser, 1996) noted that for any phase in the SDLC, the optimal cost to perform the phase is the "right mix" of planning and doing, but failed to separate out activities unique to the functions of systems engineering, since all the activities identified in that research as pertaining to the functions of systems engineering overlapped those of the project management functions. However, that was research was from the perspective of job descriptions.

An Alternative Perspective

Consider the situation from the perspective of planning and implementing the development of a system. While planning and implementing are common functions to all three roles in all organisations, the degree of planning and implementing is different at different points in the SDLC (in general, there tends to be more planning in the early phases of the SDLC and more implementation in the latter part of the SDLC). Moreover there is also a distinction between the attributes of the product being produced and the process that produces it. Thus all the functions involved in the development of systems can be mapped into the quadrants of a rectangle in which

- the continua of planning and implementing are at the bottom showing the change in focus from planning to implementing over time (the SDLC on the horizontal axis), and
- the product or process attributes of the final system are at the side (vertical axis).

When the three organisational functions are mapped in this way the result is as shown in Figure 2 in which the role of:

- **System architect** maps into product-planning or the functions of systems architecting.
- **System engineer** maps into product-implementation or the functions of systems engineering.
- **Project manager** maps into process-implementation or the functions of process engineering.

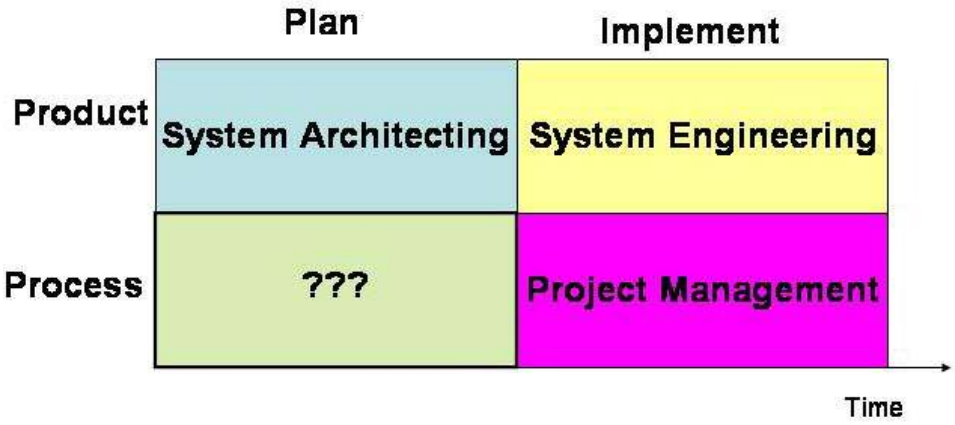

Figure 2 Mapping Organisational Functions

Introducing the Role of Process Architect

Figure 2 appears to show that the activities (functions) of process-planning are not, in general, performed by any of the three roles. This is not so, in practice the functions tend to be incorporated in project management or in the other two roles in an ad-hoc and sometimes overlapping manner. As such, the tasks involved in project development during the planning stage of a project tend to be difficult to distinguish from those performed in project management (Kasser, 2004) and hence difficult to explain to students. If, for the purposes of this discussion, the functions of project management can be constrained to the process-implementation quadrant, it can be seen that the area of process-planning in the development of systems is not covered in Figure, namely a gap has been identified.

This paper proposes that the gap be filled by a defining a fourth organisational role to:

- institutionalise and organise the process-planning functions;
- remove the overlaps between the three current organisational roles;
- resolve some of the difficulties in teaching the roles; and hence

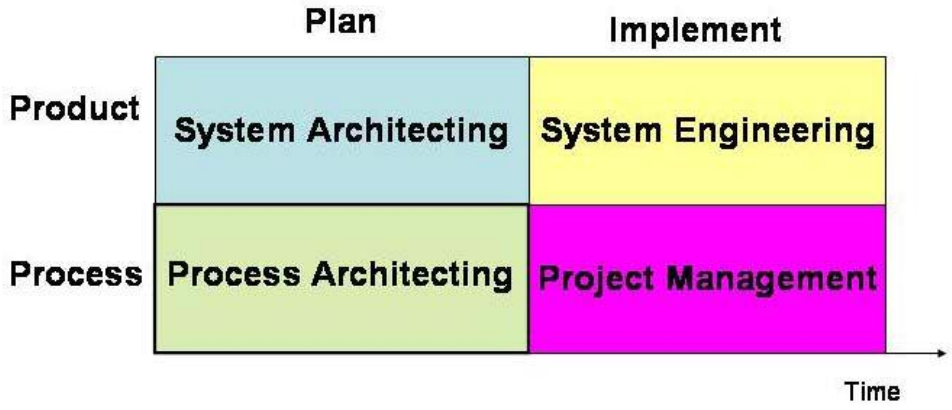

Figure 3 The Roles Rectangle

- clarify the bodies of knowledge for each of the roles.

This paper also proposes that the name of the fourth role be Process Architect as shown in the Roles Rectangle of Figure 3. The Roles Rectangle of Figure 3 can be used to show how the four organisational roles reinforce each other as follows:

- **System architecting** - responsible for the architecture of the system that will be produced;
- **System engineering** - responsible for the technical implementation of the design;
- **Process architecting** - responsible for the process that will produce the system; and
- **Project management** - responsible for managing the implementation of the process.

Process architecting and project management. The difference between process architecting and project management may now be summed up as follows. Project management manages the implementation of the specific goals and objectives of the project (Kezsbom, Schilling, et al., 1989) described by the Work Breakdown Structure (WBS), and the Gantt and PERT charts, while process architecting is the creation of the initial (high-level) version of the WBS, the Gantt and the PERT charts used by the project manager.

In general it can also be said that the process and system architecting functions cover more than a single project because both product and development process systems must be architected to be compatible with their adjacent systems, while the system engineering and project management functions tend to be limited to a single project since they are (inwardly) focussed on the completion of their systems.

The Role of Process Architecting

The functions performed by the process architecting role are not new, they are being, or should be, performed in organisations. For example, (Sheard, 2003) discussed many of these functions, and in their Case Study of a requirements elicitation and elucidation project performed in 1989, (Kasser and Mirchandani, 2005) state

> *"During the course of this task, we thought of the systems engineer as the project expert who ensures that the process is optimally planned and implemented during the course of the project life cycle (Kasser and Schermerhorn, 1994). Thus not only did we perform the organizational role of systems engineering in determining the requirements for the MCSS, we also performed the organizational role of systems architecting (Maier and Rechtin, 2000) in developing the candidate architectures for the MCSS, and the role of process architecting in developing the transition plan."*

This paper uses the Roles Rectangle to group the functions of process architecting into the role of Process Architect. Some of the functions performed by the role of the process architecting are described in this section.

Process design. The major organisational function of process architecting is to design, set up, and continuously optimise, the process for the development of the specific system

being produced by the specific organisation over the specific time period of the SDLC to optimise productivity. Moreover, since a process is in itself a system the process architecting function will use the systems engineering approach to produce the process. As (NASA, 1992) stated

> "*Total Quality Management (TQM) is the application of Systems Engineering to the work environment*".

This is not so surprising because many of the tools used for TQM are the same as for systems engineering, but with different names. Again, (NASA, 1992) stated

> *"Statistical process control is akin to the use of technical performance and earned value measurements"*.

Once the initial development process is designed it is turned over to the systems engineering and project management functions to construct the system.

Now there are a range of methodologies for use in the development of systems (Avison and Fitzgerald, 2003), the traditional waterfall methodology being only one of them. Each methodology fits specific scenarios; however the real world tends to be more complex than the scenarios taught in the classroom. As (O'Reilly, 2004) stated

> *"Real world problems do not respect the boundaries of established academic disciplines, nor indeed the traditional boundaries of engineering"*.

The optimal development process

- will probably not be a straight-forward unmodified out-of-the text book methodology;
- is as important to the success of a product development as is the optimal architecture of the product; and
- is a multi-phased time-ordered sequence of activities with constraints on start dates for each activity.

The WBS for the process looks like a hierarchical system-subsystem view of the product. However, little attention seems to have been paid to architecting optimal development processes and consequently, an untailored process may not be optimal in a specific situation. This organisational function of process architecting is to identify the best methodology for the situation and then tailor that methodology to the situation. To make the function more complex, the optimal methodology may be different at different phases in the SDLC or the situation may be such that there is no one optimal methodology and parts of several methodologies may be to be assembled into the methodology for the project as per (Kasser, 2002a). The methodology must be tailored to the situation, not the other way around. Once the methodology is chosen, the process for implementing the methodology must be developed. The choices faced by the process architecting function include

- **Choice of life cycle** – such as the traditional requirement driven methodology or a capability driven methodology.

- **Choice of methodology** – such as (which) soft-systems, functional, object-oriented, waterfall, rapid, spiral, etc.
- **Choice of process for implementing the methodology, milestone process-products and the checkpoints within the process**. The process must be scaled to the size of the project. Sometimes this may require combining activities or products, e.g. combining the operations concept with the systems requirements documents for small projects, or even choosing to produce milestone documents in the form of PowerPoint presentations instead of text mode documents.
- **Build – buy decisions**. The decision to build or buy components of the product affects the development process as well as the product architecture. This decision must be made after considering its implications on both the product system and development process.

Process improvement. The process architecting function is responsible for monitoring and improving the process. Process improvement should be performed by persons outside the process, but intimately acquainted with it (Kasser, 1995). The outsider is important because apart from the different perspectives they bring, those involved in the process generally are too busy to spend any time improving the process, and if they are not too busy, they generally are not open to change. The process architecting function is that of the Quality Guru as far as the development process is concerned.

Process change agent. Changes to the process may become necessary during the implementation phase of the SDLC. These changes arise for various reasons including the necessity to reduce time to market, major changes in the product specifications, and changes in the resources available for the development process (new resources become available or reserved resources become unavailable, or a combination of both). In this scenario, the process architecting function redesigns the methodology for producing the product, the analogy in the product arena is responding to changes in product requirements. This function requires close cooperation with the other three organisational functions.

Ensuring Standards and CMM compliance. The process architecting function has the organisational responsibility of ensuring compliance to the various standards and capability maturity models (CMM) appropriate to the development, or mandated by the customer. Should the organisation not be complaint, and need to become so, the process architecting function designs the compliant process and the transition approach. The actual conversion to compliance may be assigned to a project management function.

Keeper of the flame (process). This is the function of responsibility for knowledge management and organisational learning within the organisation for process related matters including,

- management of process related lessons learned on various projects by documenting them and making them available for subsequent projects;
- defining process-related training needs;
- a knowledge of applicable government and other regulations and standards to which the process must conform; and
- ensuring that all appropriate supply chain requirements are levelled on the product design. In the Defence industries, an example of a supply chain requirement is the

need to ensure that preassembled equipment designed for use on a submarine will fit through the entry hatches at installation time. In the commercial arena, it may have to do with storage requirements, packaging requirements, third-party installation requirements, ensuring that shipping containers will fit on the vehicle, etc.

Business process reengineering. This is a process architecting function. In fact the process architecting function should be responsible for designing the structure of the organisation in which the development system exists in accordance with the ISO 15288 standard.

Interdependence in the Roles Rectangle.

The two dimensions of the Roles Rectangle provide a simplified representation of the four organisation functions (not the roles with similar names) from the perspective of planning and implementing the product and the development process producing the product. Each architecting function requires knowledge of the functions of both implementation functions since for example:

- There is little pointing designing a product that cannot be produced either because the specifications are unachievable (i.e., requirements to travel faster than the speed of light are not achievable with today's technology).
- There is little point in setting schedules that are not feasible due to lack of resources, or time.

In addition, each implementation function also uses some planning. Moreover, each quadrant in the Roles Rectangle contains the functions performed by the speciality disciplines. For example, (Eisner, 1988) describes 38 speciality disciplines in systems engineering alone. Some of these disciplines are present in the other three quadrants. For example risk management is a function that has attributes in all four quadrants. The Roles Rectangle can be used to show that risk management should be applied in all four quadrants, and the nature of risk management in each quadrant can be identified. Bodies of knowledge, hence courses teaching risk management can be organised in the quadrants of the Roles Rectangle.

Mapping the Organisational Functions to the Organisational Roles

If there was a one-to-one mapping of the roles to the functions, then there would be little discussion as to the differences between roles of the systems engineer and the roles of the project manager. All the functions in the systems engineering quadrant would be performed by the systems engineer and all the functions in the project management quadrant would be performed by the project manager. It is when the boundaries of a role, as defined by the job description, contain functions in another quadrant that discussions arise.

Why the functions overlap. The work in developing systems is interdisciplinary. It incorporates a large number of engineering, management, and other functions that have to be performed (e.g. requirements management, design, decision making, problem solving, validation and verification, test and evaluation, risk management, reliability, and

logistics, process design and improvement, etc.). In small projects, one person might perform all the functions. On larger projects, the functions tend to be grouped (slightly) differently in different organisations in different jobs that are not exactly aligned with the organisational functions. Thus a systems engineer's job does not exactly align with the functions of systems engineering. As both (Roe, 1995) and (Sheard, 1996) noted, a systems engineer can perform some systems engineering functions and also perform some project management functions. They can also perform architecting functions, yet the job description is "Systems Engineer". However, in a different organisation, the partition of work into different jobs is also not exactly aligned with the organisational functions but in a different way. This means that in different organisations, the partition of work between the jobs of Systems Engineer, Project Manager, and Systems Architect will probably be different. Thus the same systems engineer might perform a different subset of systems engineering, project management, and systems architecting when moving from one organisation to another, but the same job names are used, eg. "Systems Engineer". This situation means that in any one organisation, in general, the roles (descriptions) of the jobs of systems engineer, systems architect and project manager do not map directly into their corresponding organisational functions, nor do they overlap each other's jobs (unless there is a turf war in progress). The functions only overlap job roles when compared across different organisations.

Traits for a process-architect

The traits for a process architect can be identified by building on those for the systems engineer. (Hall, 1961) provided the following specifications or traits for an "ideal systems engineer". Hall's specifications are grouped in several areas as follows:

- A**n ability to see the big picture** - the most important trait. It means that the systems engineer is not concerned primarily with the devices that make up systems, but with the concept of the systems as a whole -- its internal relations and its behaviour in the given environment.
- **Objectivity** - the ability of appraisal with complete objectivity.
- **Creativity** - a vital part of the SDLC, so imagination is very necessary.
- **Human Relations** - not just the ability to get along with people, but the positive attributes of leadership, tact, diplomacy and helpful concern, so essential in effective teamwork.
- **A Broker of Information** - the gift of expression - oral, written, and sometimes graphic.
- **Education** - Graduate training in the relevant field of interest (application), as well as courses in probability and statistics, philosophy, economics, psychology, and language.
- **Experience** - Experience in research, development, systems engineering and operations.

Hall concluded by stating that as the ideal is not available, mixed teams of specialists and generalists are used. The specifications or traits for process-architecting are basically the same but in the methodology and process domain rather than in the application or product domain. Thus an understanding of the methodologies described by (Avison and Fitzgerald, 2003) and when each should be used, or similar knowledge, would be a fundamental requirement. Moreover, as stated above, an effective process architect must

have some understanding of, and experience in, the functions performed in the other quadrants of the Roles Rectangle.

Summary

The job description (role) of a systems engineer, in general does not map directly into the functions of system engineering in the work of developing systems. Similarly the job descriptions (roles) for project managers and systems architect do into map directly into the functions of project management and systems architecting. Since, in general, the jobs (roles) overlap when compared across different organisations, because the boundaries of the job functions allocated to the jobs are different in different organisations, confusion has arisen as to the differences between the responsibilities of the job descriptions and the functions.

The role of process architecting has been introduced as a way to resolve these difficulties in differentiating between the roles of the systems engineer, system architect, and project manager, and the functions of systems engineering, system architecting, and project management in the development of systems across organisations. The use of the Roles Rectangle which views the development of systems from the perspective of the difference in the degree of planning and implementing over the SDLC and a distinction between the product being produced, and the development process producing the product, portrays the roles and functions in a simplistic manner which clarifies the roles at a conceptual high level. However, it must not be forgotten that the functions performed in the speciality disciplines are embodied in each of the roles. Yet when discussing the speciality disciplines with respect to the Roles Rectangle, the aspect of the discipline associated with each rectangle can be readily identified.

Conclusions

The introduction of the Roles Rectangle makes it easier to define the organisational roles of the systems engineer, system architect, and project manager, and the functions of systems engineering, systems architecting, and project management, as employed in the development of systems by adding the fourth role of process architect and identifying the functions of process architecting.

The use of the Roles Rectangle assists in:

- teaching about the arrangement of work in the development of systems place,
- the organisational roles by which work is partitioned, and
- the mapping of job descriptions into those roles.

Consequently it provides a way to partition knowledge across a number of courses on systems engineering and project management with less overlap than in the current syllabus.

Lastly, the role of systems engineering in the development of systems is more clearly and tightly scoped. This sets a boundary for the body of knowledge for systems engineering focussed on the product-implementation phases of the SDLC, which can be used in a certification program for systems engineers (Kasser, 2000) such as that proposed by INCOSE.

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