Research on a Framework for Selecting and Applying Systems Engineering Tools for Australian Small and Medium Enterprises – II

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Abstract. Many of the subsystems developed by the Australian Small and Medium Enterprises (SMEs) are integrated into military systems developed by larger companies. If the SMEs cannot win and sustain defence contracts to develop the subsystems because of their lack of systems capability, then the ability of the Australian Defence to develop and deploy needed systems will be adversely affected. By systems capability it is meant effectual use of sound systems engineering (SE) processes and effective use of SE tools. Unlike most large organisations, many of the Australian SMEs engaging in defence work have not widely employed SE processes and tools in their endeavour. In addition, the SE software tools currently used by the Australian SMEs do not appear to have effectively aided the SMEs in their work. This paper describes a methodology employed in the development of a framework for aiding Australian SMEs in defence work in effectively acquiring and applying SE processes and tools and thereby helping to improve their systems capability. Specifically, the methodology involves a collection and analysis of information, using qualitative grounded theory as the fundamental analysis technique, and NVivo software as the analysis tool. The paper also discusses some preliminary results of the research and future work.

Introduction

Many of the subsystems developed by the Australian Small and Medium Enterprises[1] (SMEs) are integrated into military systems developed by larger companies for the Australian Defence Force (ADF). The system development performance of the SMEs[2] is therefore critical to the development and sustainment of the systems used by the ADF. If the SMEs are constrained by lack of systems capability required in the development of these subsystems, then the ability of

[1] An Australian SME is an organisation that is registered in Australia and/or New Zealand and has a workforce of no more than 250 full-time employees or with an annual turnover of less than $10 million CPG (2006).
[2] Unless otherwise explicitly specified, hereinafter, SMEs refer to the Australian SMEs in defence.

the ADF to develop and deploy its needed military systems will be adversely affected.

The Australian SMEs, which account for more than two thirds of defence procurement and sustainment spending (Mortimer 2008), struggle to be self-reliant and competitive in winning and maintaining exclusively defence business. Many SMEs also continue a proportion of civil contracts to smooth out the peaks and troughs between defence contracts. Their struggle is compounded by their inability to keep pace with e-business enabling technologies, the integration with electronically enabled supply chains, and the emerging focus on complex systems integration (AIGDC 2006). Furthermore, unlike most civil contracts, defence contracts require participating SMEs to conform to standards, such as CMMI and the ISO9000s, and to follow lengthy paperwork procedures. The SMEs therefore have to pay up-front cost to set up and maintain a defence-compliant quality management system. Failing to satisfy these requirements, the SMEs may lose their engagement and contracts with defence industry to their overseas competitors.

Recognising the struggle of the SMEs, and their dynamic and important role in supporting defence industry, the Australian government and prime contractors (Foley 2006; Stevenson and Gardener 2006; Nelson 2007) pronounce that research and development (R&D) efforts are needed to help boost the systems capability of the Australian SMEs. There are many ways to improve their systems capability: supply chain optimisation, organisational change management, technology adoption management, business process engineering, and improvement in skills, technologies, processes, methods, and tools. Although commonly implemented by large organisations, the application of SE processes and tools is still a novelty or even a luxury to most SMEs. In addition, those SMEs which use the current SE software tools appear not to have benefited from the tools (PFTW 2001). In responding to the need to help boost the systems capability of the Australian SMEs, a research on developing a framework for selecting and applying SE tools relevant to the needs of the Australian SMEs is conducted at the Defence and Systems Institute (DASI) at the University of South Australia. Achieving this objective requires a number of activities and steps, described in detail in (Tran *et al.* 2008a; Tran *et al.* 2008b).

Our goal in this paper is to report the progress to-date ─ in particular, the results of the analysis of the data obtained in interviews and online survey questionnaire.

The rest of the paper is organised as follows. We discuss the preparation of the interviews and the online survey. We then follow with a discussion of the conduction of the interviews and the survey and the data collection. We next discuss the analysis of the collected data. We then discuss the analysis results. We end with some conclusion remarks and a plan for future work.

Survey Preparation and Interviews

Formulation of Conjectures. Conjectures form a basic structure for the data analysis. The interviews were conducted based on a set of initial conjectures, whose formulation benefited from literature review and conversations with SMEs, primes and Defence personnel, and academia. The conjectures then evolved as the interviewing process progressed. Finally, they were re-organised in order to formulate a coding basis for the data analysis process. The conjectures pertain to these three core elements: SE processes, SE tools and Other Factors, as shown in Table 1. The conjectures formed under each core element are phrased as questions to allow emergence of concepts during the data analysis process.

Table 1: Research conjectures used in the analysis of data

Key Element	Conjecture
SE Processes	• Does the SME have SE processes? • How effective are the current processes?
SE Tools	• Does the SME have the tools to support their processes? • How effective are the current tools to SMEs? If not, what are the causes?
Other Factors	• What are the road blocks that hinder SMEs to win and sustain defence contracts? – Relationship of SMEs and primes and Defence - Government policy and support for SMEs - Characteristics, organisational structure and culture of SMEs - SMEs engineering capability and business background - …

Systems Engineering Processes. The systems engineering processes employed by a company vary according to the nature of the company business, structure, culture and the products, project types, and company sizes. To secure and sustain a Defence contract, the bidding company must meet some specific criteria such as product quality and technical standards. The criteria require the company to have SE processes in place. Although processes are often derived from standards, it does not necessarily mean that having chosen good standards would lead to good processes, because this translation requires knowledge, experience and sound methodologies. This paper will not go into detail of the translation from standards to processes, as such work is already explored by other researchers (Laporte, Alexandre et al. 2008; Rochet, Baron et al. 2008).

Making the SE process as one of the core elements in the coding of the interviews in this research would help focus on identifying gaps, if any, between the nature of SMEs' work and the processes they use and ascertaining whether these processes are already mature or still evolving.

Table 2: SE processes and sub-processes (INCOSE 2006)

Technical Process	Project Management Process	Enterprise and Agreement Process
- Stakeholder Requirements Definition Process - Requirements Analysis Process - Architectural Design Process - Implementation Process - Integration Process - Verification Process - Transition Process - Validation Process - Operation Process - Maintenance Process - Disposal Process	- Project planning Process - Project Assessment Process - Project Control Process - Decision-Making Process - Risk and Opportunity Management Process - Configuration Management Process - Information Management Process	- Enterprise Environment Management Process - Investment Management Process - System Life Cycle Processes Management Process - Resource Management Process - Quality Management Process - Acquisition Process - Supply Process

Systems Engineering Tools. Systems engineering tools are tools that support the activities carried out to help realise the objectives of SE processes. These tools are a combination of methods, methodologies, and computerised or software tools. This research focuses only on software tools. The goal of software tools is to help improve user productivity, accelerate processes, and reduce human errors.

Although tools are dictated by activities carried out in processes, it does not necessarily mean that having chosen a good process would lead to a successful selection and application of the right tools for the jobs, because, similar to the translation from standards to processes, this translation also requires knowledge and experience to make the right decisions. The knowledge and experience may be obtained by either (a) having experienced or skilled personnel in-house or (b) getting external expert advice. For most SMEs, constrained by their sizes, revenues, resources and skills, an effective framework for tools selection and application would assist these translations and compliment the two alternatives of obtaining the required knowledge and experience.

Processes evolve. Software tools also evolve. However, whereas the process evolvement is controlled by the process executors, an internal source, the tool evolvement is not controlled by the tool users but by the tool makers, an external source. To take control of the tool evolvement, the tool users need to have specific skills: programming skills and IT-related skills, which generally are not easily acquired by SMEs in the non-IT sector. Making SE tools as one of the key elements in the coding of the interviews in this research would thus help assess if SMEs select and apply appropriate tools for their work and whether the current SE tools assist them effectively.

Figure 1. Translation from Standards to SE Processes to SE tools

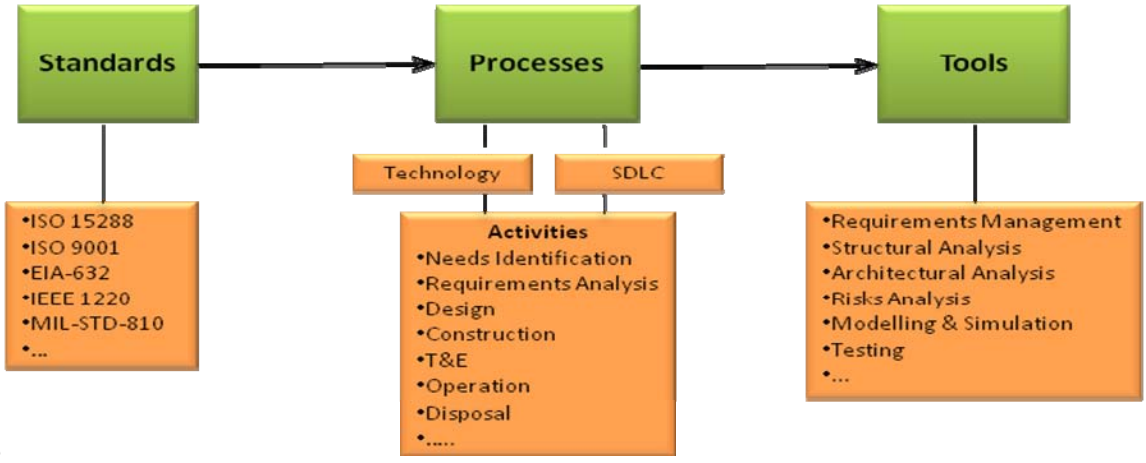


Figure 1 illustrates the translation from standards to processes to activities that drive the tool requirements. Depending on the nature of the company business, structure, culture, products, project types and sizes, several standards can be appropriately chosen among the shown standards (ISO/IEC 15288, EIA-632, IEEE 1220, etc.). To fully harmonise the selected standards, processes are then derived, using the selected standards and taking into account the company's technical capability and the product development lifecycle. To effectively and efficiently carry out the activities dictated by the processes, shown in the 'Activities' box, tools are selected to support the methods enumerated in the box below the 'Tools' box.

Other Factors. These are any factors from Defence, primes and SMEs that affect the effectiveness of the acquisition and application of SE processes and tools in SMEs.

SME Sampling Criteria. To build a database of SMEs to be interviewed, the SME size and its defence category were identified using the data from the 2008 Australian and New Zealand Industry and Defence Equipment and Capability Catalog (ANZIDECC 2008). The ANZIDECC is a database listing the registered Australian and New Zealand companies in the defence industry. A simple search and filtering process on this database produced the results summarised in Table 3. As shown, more than half (59%) of the defence SMEs are small in size, having fewer than 26 employees; only 31% have 26 to 100 employees; and 10% have more than 100 employees.

Table 3 also indicates the relative proportions of the defence SMEs specialising in the various categories, in the order of decreasing number of SMEs per category: General Support, Heavy Engineering, Vehicle and Land Supply, Electronics, IT and Communications, Aerospace, Marine, and Weapons and Ammunitions.

Table 3: Numbers and percentages of SMEs of different sizes in various defence specialisation categories (ANZIDECC, 2008)

SIZE (Number of employees) / CATEGORY	1 to 25		26 to 100		Over 100		TOTAL	
	No.	%	No.	%	No.	%	No.	%
General Support	768	59	399	31	124	10	1291	55
Heavy Engineering, Vehicle & Land Supply	229	52	152	34	63	14	444	19
Electronics, IT, Communication	192	59	100	31	32	10	324	14
Aerospace	113	72	31	20	12	8	156	7
Maritime	68	60	34	30	11	10	113	5
Weapons & Munitions	11	55	9	45	0	0	20	1
TOTAL	1381	59	725	31	242	10	2348	100

Therefore, ideally, the SMEs participating in the interviews and the survey should have the size and be in categories that most represent the defence SME community, i.e., small companies of less than 26 employees and in the Heavy Engineering, Vehicle and Land (19%), the Electronic, IT and Communications (14%), and the Aerospace (7%). Note that although the General Support group has the largest proportion, it is quite diverse; hence, it is not the target group in this research.

In addition, the interviewees should have at least 5 years working in SMEs and ideally in the systems engineering or management roles.

Selection of Data Analysis Methodology and Tool. The grounded theory qualitative research methodology of social science (Glaser 1992; Charmaz 2000; Charmaz 2006) is adopted for this research, because it provides an established methodology for generating a theory directly from reflection and analysis of unstructured data sources, such as case study reports and interview transcripts. Grounded theory helps minimise the bias of the interviewers while focussing on the information that surfaces during the interviews. The grounded theory research methodology is an incremental qualitative analysis technique which enables the objective theoretical concept to build up as information grows. It will thus help to identify factual and theoretical concepts from

the information collected. Although grounded theory qualitative research methodology was originally developed for social science, it can be applied to other science disciplines such as systems engineering, because systems engineering is an interdisciplinary approach (INCOSE 2006), which involves the interaction between humans and technology (Sage and Rouse 1999).

The emerging concepts from interview and survey data were coded using the NVivo software tool (NVivo7) to develop theoretical concepts for the framework for selecting and applying SE processes and tools for SMEs. NVivo is a research software tool that helps eliminate the laborious and time consuming process of identifying, manual coding, crosschecking, and analysing large number of textual documents. As more documents are analysed, similar concepts in multiple documents will be persistently compared, modified, and updated based on their emergent relationships. Ideas and theories will also be accounted for to eventually formulate the final theory.

Interviews and Survey Conduction and Data Collection

The data collected for analysis are obtained from two approaches: the theoretical approach and the practical approach. The first approach, an on-going activity throughout this the research, involves searching journals and conferences for publications containing reports of individual or organisational experiences with SE processes and tools in SMEs. The selection of publications is based on the following criteria:

- The publications appear in peer-reviewed conference proceedings and archived journals.
- The publications contain a case study report or personal experiential perspective relating to SE process and tools used by SMEs.
- The publications describe one or more characteristics of SE processes and tools suitable for SMEs.

The second approach involves collecting information through interviews and survey questionnaire with a number of SMEs, primes, and defence personnel. Specifically, the questions asked during interviews with SMEs focus on:

- Their development lifecycles and factors influencing these cycles
- SE processes and tools used at each e stage of a cycle
- Their perspective on SE processes and current tools
- Their organisational cultures
- Their relationships with defence and primes
- Their sustainability and rationale behind their sustainment

Most interviews were conducted in person, with a few exceptions where they were via Skype[3] or over the telephone. When possible and permitted, face-to-face and telephone interviews were conducted and recorded using a portable digital recorder, whereas interviews conducted via the internet were recorded directly onto the computer. In preparation for analysis, recorded

[3] A software that allows users to make telephone calls over the Internet Skype. (2008). "http://www.skype.com."

interviews were then transcribed into Microsoft Word® documents[4] before being loaded into the NVivo qualitative research tool.

Since the purpose of the interviews was to elicit the interviewees' perspective on the effectiveness and efficiency of SE processes and tools used by the SMEs for the problems they face, the interviews were semi-structured with open-ended questions and conversations. This would allow time for further discussion on points of interest and for the interviewees to indicate the important aspects, both positive and negative, without specific directions from the interviewers, while maintaining a relaxed atmosphere. Most of the time, the topics of the ensuing conversation were driven by the interviewees.

The online survey questionnaire, however, was more structured with specific and detailed questions on the types of SE processes and tools and their applications at each phase of the system development lifecycle in the SE process.

Interviews and Survey Data Analysis

The purpose of the analysis is to identify the gaps between what SMEs practice and the SE processes, the SE tools, and any other non-scientific issues that may emerge. These emergent issues will serve as the foundation for the formulation of a framework for selecting and applying SE processes and tools for SMEs.

To this end, the NVivo software is used as the analysis tool to help accelerate the analysis and reduce human errors. Following the approach to developing grounded theory, the analysis began with reading carefully each interview transcript and identifying emergent concepts that seem to be important to the researcher and the interviewees. As each concept emerged, it was coded as a node in NVivo. When the same concepts emerged numerous times, they became one of the major concepts. Simultaneously, similar concepts were sorted and then grouped hierarchically according to the conjectures formed in the pre-analysis phase. Grounded theory, which is not a hypothesis testing method, works on the basis that concepts emerge ─ and are not forced. Hence the analysis needs to be carried out carefully without or with minimum pre-conceptions so that not only are gaps identified between what SME practice, the SE processes, the SE tools, but also any other non-scientific issues may emerge. This analysis phase is tedious and time consuming.

Online Survey Questionnaire Analysis Results

The total number of responses to this survey is 37. The participants in this survey come mostly from the Electronics, IT, Communications, and Aerospace sectors. A rough 71% of them are from South Australia, and 68% of them are SMEs.

An estimate of 43% of these participating companies use the V-model of system development process in their engineering work. They exchange with external sources information such as Requirements Documents, Detailed Designs and Test Data. They use a variety of means to communicate the information ─ face-to-face meetings and telephone (38%), emails and CDs

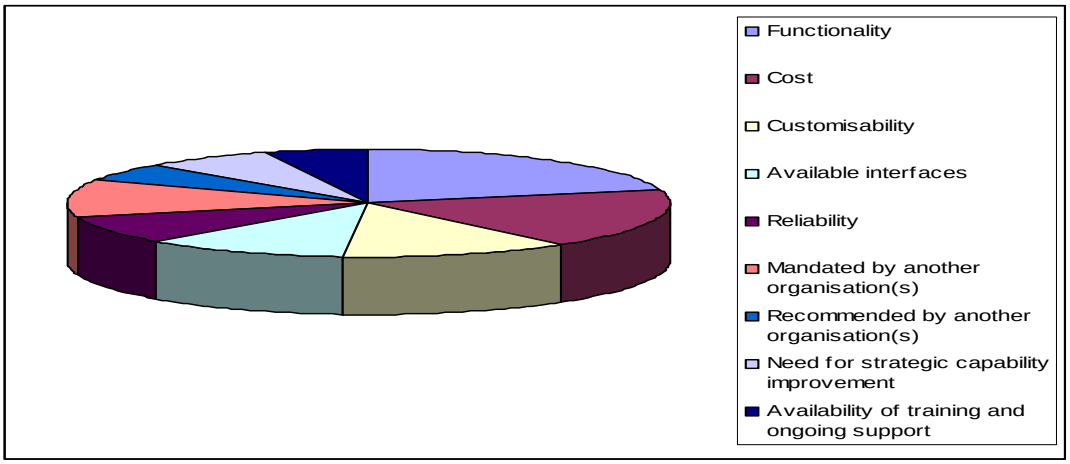
[4] Although NVivo offers a function to transcribe interviews directly onto NVivo, the first author finds that using this feature is more cumbersome than simply transcribing them directly to a Word document, which is then imported to NVivo for analysis.

(40%), and FTP or classified networks (27%). Less than half of these externally exchanged communications can be formally traced (43%).

Regarding the use of systems engineering tools, nearly half of the participants use the following tools daily:

- Project Management Tools
- Requirements Management Tools
- Design Tools (conceptual and preliminary design)
- Test and Evaluation Tools
- Software Development Tools
- Configuration Management and Bug Tracking Tools
- Modelling and Simulation Tools
- Others (including in-house)

Most companies use Windows Platforms (46%) with Unix and Linux (24% and 16%, respectively). In general, 41% of them select tools that meet a required functional capability; 35% choose tools that meet their budget; 32% adopt tools that are required or mandated by other organisations; and 14% select tools that satisfy a need for strategic capability improvement. Figure 3 depicts the rationales for tool selection by the participated SMEs. On average, each of these companies spends more than $10,000 to set up the tool environment and another $10,000 annually for maintenance and upgrades.



Most participants agree that the tools and the tool environment support have improved their company's business and engineering processes. Indeed, they are satisfied with their current tool environment (most give 3 or 4 out of 5 on the rating scale), because the tool environment provides uniformity and formality in their outputs, which help gain customer confidence, and also because it helps reduce the cost of sharing the same licenses among users within the companies. The tools, however, do exhibit some limitations. For instance, they are cumbersome, inflexible, not tailorable, and complicated to use; designed for big companies with big projects, they tend to provide functionality not needed by the SMEs and are often unsuitable for small companies. Furthermore, a rough 46% of the participating companies did not respond to the

question on their aspiration for optimal SE tools, while 24% of them rather prefer “an integrated suite of tools”.

In summary, the answers of the participants in this survey indicate that most tool users in South Australia who work in defence related companies are fairly satisfied with their current tool environment and that the tools currently employed, however, do exhibit some limitations. Furthermore, it must be added that this survey captures ‘yes’ and ‘no’ types of answers and thus cannot fully capture the ‘soft’ responses in a face-to-face interview environment.

Interviews Analysis Results

The interview sample collected to date consists of 23 interviews with Australian SMEs, six interviews with primes, and one interview with Defence personnel. In addition, nine interviews with overseas SMEs, primes and Defence personnel from the United States, Europe and Asia were also conducted for comparison and lesson learnt purposes. Table 4 contains the descriptive statistics of the 23 Australian SMEs interviewed, their categories, the nature of their work with Defence, their sizes, the mapping of their systems engineering levels and systems development life cycle (SDLC) phases in which they engage to the appropriate cells in the Hitchins-Kasser-Massie (HKM) framework (Kasser and Massie 2001; Kasser 2007a), the percentage of their defence contracts, and the existence of their SE capabilities (in term of SE process and tools they apply).

Table 4: Summary of interviewed Australian SMEs

ID	Category	Products/Services	No of staff	Size	HKM	% of Defence work	SE Process	SE Tools
A	IT	Software development	19	S	[2] A B C D E F G	90	✓	✓
B	IT	Sensor support systems	19	S	[2] A B C D E F G	90	✓	✓
C	IT	Satellite Communication solution	17	S	[2] B C D E F G	15	✓	✓
D	IT	Aircraft PC solution	30	M	[2] A B C D E F G	15	✓	✓
E	IT	Sensor support systems	21	S	[2] A B C D E F G	45	✓	✓
F	IT	Software solution	8	S	[2] B c D E F G	90	✓	✓
G	IT	Simulation solution	25	S	[2] B C D E F G	60	✓	✓
H	IT	Communication system	18	S	[2] C D E F G	80	✓	✓
I	IT	Software solution	22	S	[2] A B C D E F G	70	✓	✓
J	IT	Software solution	16	S	[2] C D E F G	20	✓	No
K	IT	Simulation software	92	M	[2] A B C D E F G	20	✓	✓
L	Manufacturing	Containers and vaults	23	S	[2] A B C D E F G	5	✓	✓
M	Manufacturing	Simulation equipment	120	L	[2] A B c D E F G	80	✓	✓
N	Manufacturing	Aerospace equipment	145	L	[2] A B C D E F G	80	✓	✓
O	Manufacturing	Steel pipes	120	L	[2] c D E F G H	5	✓	No
P	Manufacturing	Marine furnishings	4	S	[1] G	5	No	No
Q	Manufacturing	Marine battery	62	M	[2] B c D E F G	90	✓	✓
R	Manufacturing	Aerospace equipment	11	S	[2] A B C D E F G	90	✓	✓

S	Manufacturing	Vehicle & Land equipment	67	M	[2] C D E F G	40	✓	✓
T	Manufacturing	Maintenance Equipment Supplier	14	S	[2] A B C D E F G	5	✓	No
U	Manufacturing	Hydraulic pumps	95	M	[2] c D E F G	15	✓	No
V	Testing	Material testing	15	S	[2] E F	20	✓	No
W	Testing	Aerospace testing	101	L	[2] E F	80	✓	No

Categorisation. The interviewed SMEs are classified into three groups: IT, Manufacturing, and Testing, based on the nature of processes applied in their work. The IT group consists of the SMEs which mainly work in software development, such as providing software solutions to satellite communications systems, simulation systems, sensor support systems, communications systems. The Manufacturing group includes the SMEs whose products vary from simple to high-tech engineering, such as repairing and maintaining hydraulic furniture on ships and submarines, manufacturing vaults and containers, steel pipes, hydraulic pumps, ultrasonic cleaning equipment, vehicle and land equipment to manufacturing medical equipment, submarine batteries, aerospace equipment. The Testing group covers the SMEs that mainly provide testing services on material testing and aerospace equipment testing.

Size. As shown in Table 4, 61% of the SMEs interviewed are in the small SME category (up to 25 employees), 26% in the medium SME category (between 26 to 100 employees) and 13% in the large SME category (between 100 to 250 employees). This sample matches closely to the distribution of SME sizes represented in the ANZIDECC: 59%, 31%, and 10% of the SMEs are, respectively, small, medium, and large in size.

Mapping to the HKM framework. This is the mapping of the interviewed SMEs to specific areas in the HKM framework (Kasser and Massie 2001; Kasser 2007a) as depicted in Figure 2. In Table 4, the numbers [1] and [2] thus refer to the product and system layers of systems engineering, respectively, and the letters (A, B, C ...) to the phases of the SDLC. This mapping, described in detail in (Tran *et al.* 2008a; Tran *et al.* 2008b), is based on the activities carried out in the process of delivering the promised products or services to Defence. The phase designated by the lowercase letter 'c' in the HKM column in Table 4 indicates that it exists through personnel dedicated to interface with external sub-contractors who actually carry out this phase. Except for the disposal phase (H), which is covered by only one SME, nearly half of these SMEs carry out activities that cover most of the phases of the SDLC.

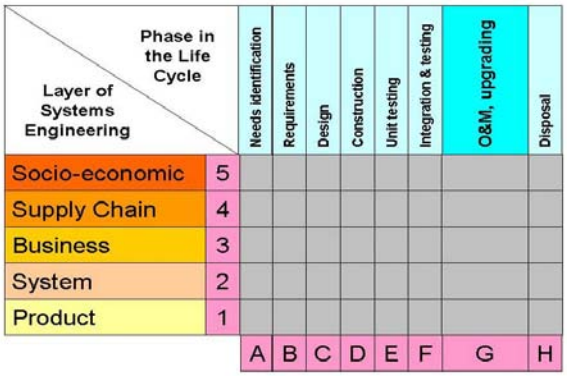


Figure 2 - The HKM Framework
(Kasser and Massie 2001; Kasser 2007a)

Percentage of defence contracts. Some SMEs acquire and maintain more Defence contracts than do the others, depending on the niche of their products and skills, and their background, experience and knowledge in Defence. In general, most SMEs have niche products and highly specialised skills which provide them an advantage over primes and other SMEs whose products are more general. SMEs whose staff has background, knowledge, and experience with Defence would have better understanding and appreciation of Defence complex policy, lengthy tendering

process, and its emphasis on quality and standards for products and services. As a result, these SMEs are more effective in responding to the tenders and not too frustrated with the bureaucracy and formality in Defence paperwork. Most of the smaller SMEs want to expand and extend their contracts with Defence, whereas the larger SMEs enjoy their established contracts with both commercial and Defence sectors

SE processes. Most SMEs have processes corresponding to the ISO/IEC15288 with some major or minor modifications to suit the nature of their projects, products, resources and (engineering) skills. In general, due to the small and limited nature and timeframe of their projects, not all the phases in SE processes are applicable to SMEs, and in some instances, theses phases are not constantly applied.

All SMEs have certified ISO standard compliance (9000s, 17025 …) depending on the nature of their products and services. One SME has CMMI accreditation up to level 3. Nearly half of the SMEs have processes that cover most of the phases in the SDLC. However, with the Manufacturing group and Testing group, not all the phases in the SDLC take place in-house. Instead, they are outsourced to other SMEs subcontractors, some of whom do not have ISO or MIL standard certifications.

Most SMEs in the IT and Communications category believe that strong IT background is the key ingredient to effectively applying SE. Their argument is that software development process is a subset of systems engineering, and hence the transition and adaptation to SE processes in their work are smoother than those of the SMEs with non-IT background.

SE tools. The majority of the SMEs apply some sort of requirements engineering and management tools in their work. Four SMEs use COTS (Commercial Off The Shelf) tools that are designed specifically for this purpose. However, only one SME (4%) can afford to use it requirements tool in-house, because the license is financed by its overseas parent company. The other three SMEs (13%) use COTS tools when they are located at the prime or Defence offices. The rest of the SMEs (82%) either use FOSS tools (which they modify to suit their needs) or develop their own IDS tools.

There is a mixture of views concerning COTS tools for requirements management. Those SMEs which are able to use COTS tools on a short term basis are not totally satisfied with them; they find the tools are too cumbersome, having too much redundant functionality, and being neither tailorable nor intuitive for SMEs niche needs. However, the SME that uses COTS tools for requirements management states that adequate training and proper and frequent use of the tools help bring out the potential of the tools. This SME also states that since these COTS tools are very powerful and provide different utilities for users of different levels and tasks, appropriate allocation of responsibilities and roles would help users use the tools effectively, and thereby improve the execution of SE processes.

Those SMEs use FOSS (Free and Open-Source Software) because these tools are free (or do not cost as much as do the COTS tools), flexible, and effective for SMEs' simple projects and have a great community support. Some argue that these tools perform as well as the larger COTS tools. On the other hand, some find that these tools do not offer a full range of functionality and are not polished. In addition, IP address can be an issue that needs to be considered when using FOSS tools. It is also a time consuming task to look for the right FOSS tools that suit the nature of their projects.

Only a small number of SMEs with strong IT background can develop IDS (In-house Developed Software) tools. Being designed and developed by their owners, the IDS tools can provide some cost benefit to those SMEs and are tailorable and user-friendly. However, these IDS tools are small and simple tools, designed by a small staff, sometimes by one person, for minor and immediate needs. Sometimes, improper documentation and configuration of the development of these tools make them hard to maintain and upgrade.

Most SMEs use MS products, such as MS Access (requirements database), MS Project (scheduling), and especially MS Excel (requirements traceability), because they are simple and have familiar features. However, these SMEs do express the need for a low-cost, simple, and intuitive version of a COTS requirements management tool.

Other Findings

Most SMEs are flexible (able to tailor their products to meet Defence unique needs), adaptive (grasping new technology quickly), responsive (open and quick to respond to Defence's queries), because they have flat organisational structure allowed by a small staff. Most have high innovation drive and are high risk takers. Although working long hours and wearing many hats, they are highly motivated, dedicated, excited about the nature of their work, and have a strong work ethic and a strong teamwork mind-set. In addition, the smaller SME employers relate to their employees in a more relaxed and family-oriented manner than do larger companies.

Those SMEs that are in the first-tier contact with Defence or primes often find the communication and relationships with Defence less strenuous and lengthy than those who are in lower tiers. Those who have worked previously with or for a long time with Defence enjoy their established and continuing relationship with Defence. However, it seems the route taken to get the first foot in the Defence's door is a challenging task for most SMEs. This is mainly due to the inability to thoroughly understand the expectations of quality and compliance with standards required in Defence tendering and contracts, the inability to estimate and quote appropriately for the amount of work and documentation effort involved in responding to these requirements, and the inability to team up with other SMEs to satisfy the gaps in their skills and resources. Often enough, most SMEs that are newcomers in the Defence industry tend to underbid and get burnt-out in their first contracts; as a result, their survivability in the Defence industry can be adversely affected.

Some SMEs do not have the right network or the confidence to team with other SMEs to bid for defence contracts. A small number of SMEs, however, is able to team with others and manage this co-operative relationship successfully. This teaming relationship brings them the benefit of reduced bidding cost while increasing their bidding success probability. They confirm that teaming with other SMEs to win large Defence projects would require a vigorous SE approach.

Some SMEs realise that the standards imposed by Defence contracts have improved their company quality. A minority of the SMEs have used standards that exceed Defence expectations. These SMEs are either well established or large companies that have applied mature SE processes effectively.

Finally, most SMEs face the dilemma of peaks and troughs in Defence contract work. This dilemma has an adverse impact on the sustainability of their SE capability, because the capability gained during the "peak" period may be lost during the "trough" era as skilled staff move on.

In summary, most of the Australian SMEs interviewed for this research have a flat organisation structure with hard working personnel and are agile, flexible, and adaptive. Most apply SE processes and tools in their work, some more vigorously than do the others. Most suffer with the peaks and troughs in Defence contract work and do not see the benefit in the amount of paperwork required by Defence. The analysis of the effectiveness of their application of SE processes and tools and the analysis of the results pertaining to the overseas organisations will be discussed in a future publication.

Conclusion

This paper reports the preliminary results of the analysis of the interview and online survey data the current progress of the research on developing a framework for selecting and applying SE tools relevant to the needs of the Australian SMEs. The paper discusses the analysis process, the pre-analysis phase, the analysis methodology and tool, the analysis itself, and the analysis results.

The results of the analysis of the online survey indicate that, although most tool users in Australian defence related organisations are fairly satisfied with their current tool environment, the tools do exhibit some limitations; more research thus need be done to address these limitations. Since the survey captures 'yes' and 'no' types of answers, it cannot fully capture the 'soft' responses in a face-to-face interview environment.

The preliminary results of the analysis of the interviews with the SMEs indicate that the majority of the SMEs use SE processes and tools in their work. The analysis of the effectiveness of their application of SE processes and tools and the analysis of the results pertaining to the overseas organisations are currently undertaken.

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