Standardised Process Improvement for Construction Enterprises (SPICE)

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ABSTRACT

The construction industry recognises the need for process improvement as means to improve their products and services. However at present the industry has no methodological mechanism to assess processes and prioritise process improvements. Businesses do not have a clear set of guidelines as to where to direct their efforts and how well they are doing in comparison with other organisations. A major initiative to bridge this gap has been the benchmarking approach, which has gained relative acceptance within the industry.

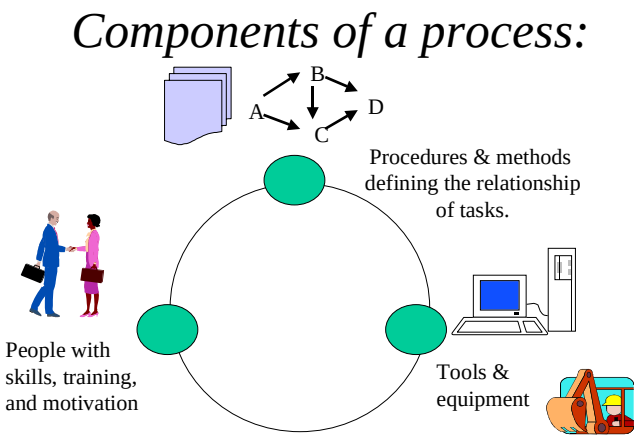
This paper introduces new research at Salford University, namely SPICE. SPICE aims to develop a framework, which can distinguish levels of increasing process capability. In this framework, 'immature' organisations will be characterised by difficulties with project costs and timescales. They often face product quality problems and have difficulty in managing people as well as the introduction of new technologies. Organisations of increasing maturity will be characterised by capabilities to progressively master project costs timescale, and product quality. Mature organisations align technology and people management with process improvement efforts. This paper explains some of the concepts behind process maturity and expands on SPICE's work on developing a process maturity framework for construction.

1 INTRODUCTION

For decades, the businesses within the construction sector have been applying new methods and technologies to improve productivity and achieve quality gains. Nevertheless, Latham's targets for quality and productivity achievements have yet to be achieved. One fundamental limitation to advancement is the challenge of improving the management of *construction processes.* The synergistic benefits of isolated improvements in methods and technologies can not be realised in a co-ordinated and repeatable manner in an undisciplined, chaotic process. Construction projects

frequently lack the optimised infrastructure and the support necessary to fulfil Latham's challenges. There is a need to develop a discipline for continuous process improvement within the construction industry.

Figure 1- Components of an integrated process



A process is a sequence of steps performed for a given purpose. The process integrates people, tools and procedures together, as shown in figure 1. Construction processes are what people do, using procedures, methods, tools and equipment to transform materials into a product (e.g. building) that is of value to the client. There is increasing evidence from other industries [Imai 1986, Paulk 1993] that continuous process improvement is based on many small, evolutionary steps, rather than revolutionary measures. Standardised Process Improvement for Construction Enterprises (SPICE) is a new research project, which attempts to develop an evolutionary step-wise process improvement framework for the construction industry. The SPICE framework will enable construction organisations to improve their processes over various levels of maturity.

2 THE SPICE PROJECT

SPICE will be based on the experiences gained in the IT sector for step-wise process improvement. SPICE will specifically refer to the Capability Maturity Model (CMM) [Paulk 1993, Saidian 1995], which was developed for, and is used by the US Department of Defense (DoD) who are a major software purchaser. The software industry had contended with poor quality software, missed schedules, and high costs. In 1991, the Software Engineering Institute (SEI) at Carnegie Mellon University produced the Capability Maturity Model (CMM) for DoD [Paulk 1993]. The CMM serves as a framework to continuously measure, evolve and improve processes. CMM has rapidly gained acceptance amongst the IT, telecommunications and engineering based companies in the recent years. Successful implementers of CMM have reported high productivity results. Hughes Aircraft [Saidian 1995] reported that it spent $400000 in a two-year improvement program. Hughes calculated that its initial return on this investment amounted to $2 million annually, a 5:1 ROI. Raytheon's numbers are even more remarkable. Investing almost $1 million annually on improvements, Raytheon [Saidian 1995] achieved a 7.7:1 ROI and 2:1 productivity gains. Herlab's [Herlab 1994] analysis showed that an average of 35% productivity improvements, and an average of 39% post delivery defect reduction was achieved in companies implementing CMM. These figures promise to support Latham's requirements of 30% cost reduction and zero defects.

SPICE aims to develop a similar framework, for the construction sector. The CMM framework, as it stands, addresses the needs of information systems development projects. SPICE will use many of the basic concepts of process capability and maturity from CMM. However, SPICE will concentrate on construction processes and address some construction specific issues, such as the virtual company nature of the projects, the dispersity of project teams, and the low ROI in the construction industry, which requires tight business justification of new initiatives. The scope of SPICE will initially be medium to large sized design and construction companies. This can then be tailored towards the needs of smaller organisations.

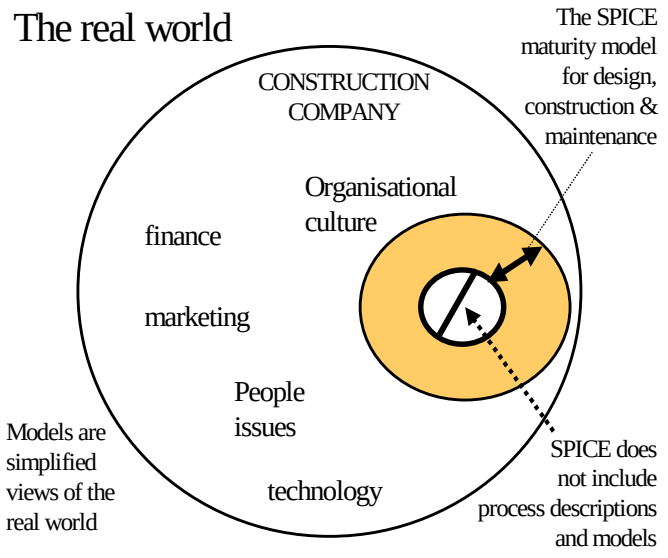


Figure 2- The scope of SPICE research

SPICE is scoped to address the processes related to design, construction and maintenance activities within construction companies. It does not concentrate on all the processes related to a company, such as finance or marketing. This is depicted in figure 2. However, experience with CMM proves that through creating an emphasis on core product development processes, organisations gain a process improvement culture. This benefits the whole company, long term.

The research is jointly funded by the Department of Environment, Transport and the Regions (DETR) and the project partners. The partnership consists of Salford University, AMEC Construction Ltd. (a large UK / European based Contractor), Cruickshank & Seward (a small UK based firm of architects), and Oxford software Engineering (a UK based software management consultancy).

3 IMMATURE VERSUS MATURE CONSTRUCTION ORGANISATIONS

Setting sensible goals for process improvement requires an understanding of the difference between immature and mature construction organisations.

In an immature organisation, construction processes are generally improvised by practitioners and project managers during the course of the project. Even if a construction process has been specified, it is not rigorously followed or enforced. The immature organisation is reactionary, and managers are usually focused on fire fighting. In an immature organisation, there is no objective basis for judging product quality or for solving product or process problems. The product quality assurance is often curtailed or eliminated when projects fall behind schedule.

In an immature organisation, product quality is difficult to predict. Activities intended to enhance quality such as reviews are often curtailed. Many of the quality assurance activities are left until the "snagging" stage at the end of the project. At this point the problems can be too costly to rectify and lead to conflict of interest among the project team.

Even in undisciplined and immature organisations, sometimes individual projects produce excellent results. When such projects succeed, it is generally through the heroic efforts of a dedicated team, rather than through repeating the systematic and proven methods of a mature organisation.

On the other hand, a mature construction organisation possesses an organisation wide ability for managing design, construction and maintenance activities. The processes are accurately communicated to both existing staff and new employees, and activities are carried out according to the planned processes. The processes mandated are fit for use and consistent with the way the work gets done. Roles and responsibilities within the defined processes are clear throughout the project and across the organisation. In mature organisations, managers monitor the quality of the products and client satisfaction. There is an objective, quantitative basis for judging product quality and analysing problems with the product and process, and a reflective element to the organisational culture. In general, a disciplined process is consistently followed because all of the participants understand the value of doing so, and the necessary infrastructure exists to support the process.

4 PROCESS CAPABILITY & PROCESS MATURITY

Process capability describes the possible range of expected results that can be achieved by following a construction process. The process capability of an organisation provides one means of predicting the most likely outcomes to be expected from the next project, in terms of cost, time and quality. On the other hand, process performance represents the actual results achieved by following a process. It therefore provides historic data on the project.

Since process capability focuses on results expected it can provide predictability for the project. This is an important feature for the clients as well as for the construction organisations. New categories of construction projects often lead to many new surprises and challenges. Process capability of an organisation can provide predictability on the expected outcome of these projects.

Process maturity is the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective. Maturity implies a potential for growth in capability and indicates the richness of an organisation's processes and the consistency with which they are applied in projects throughout the organisation. The construction processes are well understood throughout a mature organisation, usually through documentation and training. The processes are continually being monitored and improved by their users. The capability of a mature construction process is known, hence the expected results from the process are predictable. Construction process

maturity implies that the productivity and quality of the products can be improved over time through consistent and disciplined focus on process improvement.

As a construction organisation gains process maturity, it institutionalises its construction processes via policies, standards, and organisational structures. Institutionalisation entails building an infrastructure and a corporate culture that supports the methods, practices, and procedures of the business so that they endure after those who originally defined them have gone.

Based on the context, within which a project is conducted, the actual performance of the project may not reflect the full process capability of the organisation, i.e. the capability of the project can become constrained by its environment. Examples of external constraints, which often influence process capability, are economic recessions, new supply chain relationships, or acquisitions and mergers.

5 OVERVIEW OF THE FRAMEWORK

Continuous process improvement is based on many small, evolutionary steps [Imai86]. The SPICE framework organises these evolutionary steps into maturity levels that lay successive foundations for continuous process improvement. These maturity levels define a scale for measuring the maturity of a construction organisation's processes, and evaluating its process capability. They provide guide-lines for prioritising process improvement efforts.

*A maturity level is a well-defined evolutionary plateau toward achieving a mature process. Each maturity level provides a layer in the foundation for continuous process improvement. Each level comprises a set of process goals that, when satisfied, stabilise an important component in the "*construction*" process. Achieving each level of the maturity framework establishes a different component in the "construction" process, resulting in an increase in the process capability of the organisation* [Paulk 1993].

The draft of the SPICE maturity levels is depicted in figure 3. This framework is still under development and figure 3 will be refined and improved throughout the research. The maturity framework is split into six levels. At each level some "key processes" are identified. These key processes are still under development and are not listed in this paper. An assessment tool accompanies the framework in figure 3. An organisation can only be at one level of maturity at any stage. Organisations conduct an assessment to establish what level of maturity they are at. Judging by the experience in the software industry, most companies are initially at level 1. They then need to focus on and implement all the key processes at the next level, i.e. level 2. The characteristics of each level of the maturity framework are described in the next section.

5.1 Level 1- Chaotic

At this level project visibility and predictability are poor. Good project practices are local and can not be repeated across the company in an institutionalised fashion. Ineffective planning and co-ordination

undermine good engineering practices. Organisations make commitments that staff or the supply chain can not meet. This results in a series of crisis.

During crisis, projects typically abandon planned procedures. Time and costs are often under tight control in construction. Hence the crisis often leads to compromises on quality. Success depends entirely on having an exceptional manager and a competent team. When these managers leave, their stabilising influences leave with them.

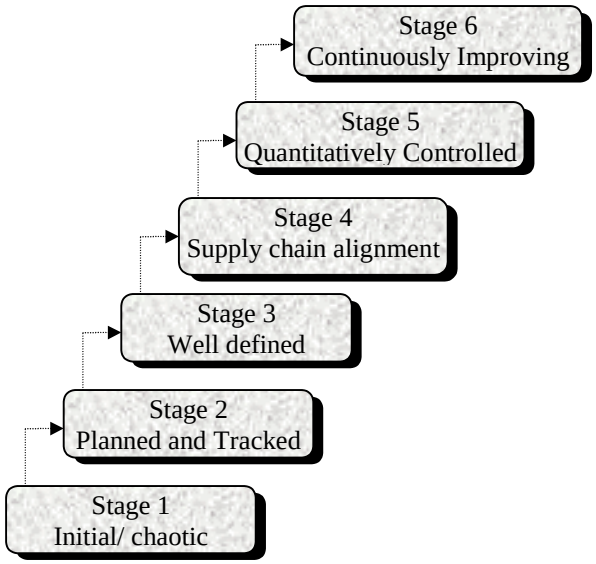
The construction process capability of level 1 organisations is unpredictable because the process is constantly changed or modified as the work progresses. Performance depends on the capabilities of the individuals, rather than that of the organisation.

5.2 Level 2- Planned & Tracked

At this level there is a degree of project predictability. Policies and procedures for managing the major project based processes are established. A major objective of level 2 is to focus on effective management processes within construction projects. This allows organisations to repeat the successful practices on earlier projects. An effective process can be characterised as practiced, documented, enforced, trained, evaluated and able to improve.

At level 2 organisations make realistic commitments, based on the results obtained from previous projects and on the requirements of the current project. Managers track quality and functionality as well as time and costs. Problems in meeting the commitments are identified as they arise. The integrity of the project requirements are maintained throughout the project. Standards are defined and organisations ensure that they are faithfully followed. Projects work with sub-contractors to establish strong relationships.

Figure 3- The draft of the SPICE maturity levels.



5.3 Well defined

At level three both management and engineering activities are documented, standardised and integrated into the organisation. These standard processes are referenced throughout the organisation. All projects use approved, tailored versions of organisation's standard processes, which accounts for their unique characteristics.

A well-defined process includes standard descriptions and models for performing the work, verification mechanisms (such as peer reviews) and

completion criteria. Because the process is well defined, management has good insight into progress. Quality and functionality of all projects are well tracked.

Up to this stage process improvement efforts are still at an organisational level. They do not address virtual company issues.

5.4 Supply chain alignment

This level is specific to the construction industry. This level advocates that all the organisations along the supply chain should individually improve their processes up to level 3. They can now direct their efforts jointly to align the virtual company processes. This level assumes a degree of stability among the supply chain. It will be more successful among companies who are involved in long term relationships such as partnering relations or PFI contracts.

The key processes at this level require further research as well as empirical data, before they are finalised.

5.5 Qualitatively controlled

At this level organisations have the capability to set quality goals for (i) the product, (ii) the process, and (iii) the supply chain relationships. Productivity and quality are measured for important construction process activities across all projects as part of an organisational measurement program. This forms an objective basis for measuring the product, the process, the degree of customer satisfaction, and the level of harmony across the supply chain.

Projects gain control by narrowing the variations in their process performance, to fall within acceptable quantitative boundaries. Meaningful variations can be distinguished from random variations. The risks involved in moving up the learning curve either due to undertaking new categories of projects, or engaging in new procurement and supplier chain arrangements can be managed.

5.6 Continuously improving

At this stage the entire supply chain is focused on continuous process improvement. The organisations have the means to identify weaknesses and strengthen the processes pro-actively, in a collaborative manner. Data on the effectiveness of the processes is used to perform cost benefit analysis of new technologies and proposed changes to the organisation's processes. Innovations that exploit the best business management practices are identified and transferred throughout the organisations.

Project teams across the supply chain analyse defects to determine their causes. Construction processes are evaluated to prevent known types of defects from recurring, and lessons learned are communicated to other projects.

6 SPICE VS CMM

SPICE builds upon the basic concepts of process maturity, which were introduced by CMM. However, SPICE specifically addresses construction processes. The IT industry's processes are different to that of construction. The two industries face different challenges, different cultures and different contractual and supply chain arrangements. Tailoring SPICE to construction requirements is not a trivial task and requires significant input from the construction industry and its representatives.

The draft model depicted in figure 3 already reveals differences with the CMM model. This model attempts to address the supply chain complexity of the construction industry in a step by step fashion. Specifically, SPICE has six levels, rather than the five levels of CMM. Level 4, the "supply chain alignment" level in the SPICE framework is a new level devised specifically for the needs of the construction industry.

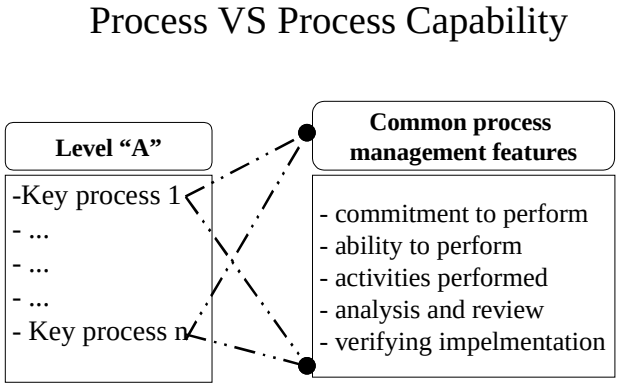
7 COMMON PROCESS CAPABILITY FEATURES

SPICE framework is not prescriptive. It does not tell an organisation how to improve. SPICE describes the major process characteristics of an organisation at each maturity level, without prescribing the means for getting there. The intention is that it does not unduly constrain how the construction processes are implemented by an organisation. It simply describes what the essential process attributes of an organisation would normally be expected to be.

The capability architecture for SPICE is shown in figure 4. This model separates construction specific processes from capability-related characteristics. The key processes identify the main construction processes to be addressed. As the model develops, the list of these processes will accompany the levels in figure 3.

Each of these key processes requires a disciplined management focus in order to be realised. The realisation of these management activities is referred to as the process capability. A process is capable if it posses a number of features. These features are termed the "common process capability features".

Figure 4- The SPICE capability architecture



The five "common process capability features" which need to be demonstrated by each key process are listed below.

1. **Commitment to perform-** This criterion ensures that the organisation takes action to ensure that the process is established and will endure. It typically involves establishing organisation policies. Some processes also

require organisational sponsors or leaders. Commitment to perform ensures that leadership positions are created and filled and the relevant organisational policy statements exist.

2. **Ability to perform-** This describes the preconditions that must exist to implement the process competently. It normally involves adequate resourcing, appropriate organisational structure, and training.
3. **Activities performed-** This describes the activities, roles and procedures necessary to implement processes. It typically involves establishing plans and procedures, performing the work, tracking it, and taking corrective action as necessary.
4. **Analysis and evaluation -** This describes the basic evaluation practices that are necessary to determine the status of a process. These evaluations are used to control and improve the processes.
5. **Verifying implementation-** This verifies that the activities are performed in compliance with the process that has been established. It includes reviews by management as well as the quality assurance group.

The SPICE assessment mechanism ensures that each key process has reached capability, by testing it against the above "common process management features". For example a process which is well designed and has a policy statement to support it, but is inadequately resourced, will fail the process capability test. This is because the process can not satisfy the "ability to perform" requirements.

8 SUMMARY

SPICE is a research project, which attempts to develop an evolutionary business process improvement framework for the construction industry. A process assessment tool will accompany this framework. Businesses can use the assessment tool to identify the maturity of their processes. They can then refer to the SPICE framework to establish what their process improvement priorities are likely to be and where to focus their efforts.

The model is not prescriptive. It does not provide any guide lines on how to improve the processes. Instead it provides a set of common process capability features, which all processes need in order to achieve capabilities. These common management features are: (i) commitment to perform; (ii) ability to perform; (iii) activities performed; (iv) analysis and evaluation; and (v) verifying implementation.

SPICE is based on the Capability Maturity Model (CMM), which is used widely in the software industry. However, SPICE is construction specific and addresses construction industry issues. The main characteristics of the construction industry, which differentiate it from the software industry are perceived to be: (i) the virtual company nature of the projects; (ii) the dispersity of project teams; and (iii) the low ROI in the construction industry, which requires tight business justification of new

initiatives. This paper presents the draft of the SPICE maturity levels. Each of these levels will have a list of "key processes" associated with them. This list is still under development, and is not presented in this paper. These key processes will provide guidelines on where to concentrate the process improvement efforts.

SPICE will test the validity of these models in case studies within AMEC and Cruickshank and Seward, in the next eighteen months.

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