

SPICE: IS A CAPABILITY MATURITY MODEL APPLICABLE IN THE CONSTRUCTION INDUSTRY?

Spice: A mature model

M. SARSHAR, M. FINNEMORE , R.HAIGH, J.GOULDING

Department of Surveying, University of Salford, Salford, UK

Durability of Building Materials and Components 8. (1999) *Edited by M.A. Lacasse and D.J. Vanier.* Institute for Research in Construction, Ottawa ON, K1A 0R6, Canada, pp. 2836-2843.

© National Research Council Canada 1999

Abstract

Currently the UK construction industry is in search of continuous process improvement mechanisms, in order to improve quality and reduce construction time and costs. Likewise the software industry has been in search of process improvement frameworks, in the past decade. The Capability Maturity Model (CMM), developed by the Carnegie Mellon University, is one of the most widely adopted process improvement initiatives, within the software industry. Many of the basic process improvement concepts in CMM appear generic and could potentially be applied in construction. A recent research project at Salford University set itself the task of investigating if CMM is applicable in the construction industry. The project is titled SPICE (Standardised Process Improvement for Construction Enterprises). SPICE is in search of a systematic step by step process improvement framework for the construction industry. It investigates whether the CMM framework and concepts can be reused in construction. SPICE has conducted several experiments to assess the applicability of CMM to the construction industry. So far the results show that most of the basic process improvement *concepts* of CMM are applicable. However, the CMM *framework* is not applicable in its current form. Much further research is needed to integrate the appropriate process improvement concepts from CMM and other research to develop a process improvement framework for the construction industry. In general the construction industry appears a more mature industry in its shared understanding of customs and working practices. Industry standards and data are more readily available. However, major problems stem from the supply chain arrangements. Also the cost of process improvement initiatives such as CMM may be too high for the construction SMEs, on most projects. This paper discusses the SPICE experiments undertaken to date. It high lights why the CMM framework can not be applied in construction in its present form and suggests future research directions.

Keywords: capability maturity model, construction process improvement, process maturity, supply chain processes



1 Introduction

Recent reports by Sir Michael Latham (1994) and Sir John Egan (1998) have emphasised the need for the UK construction industry to increase its productivity and improve quality. One method of achieving this would be to improve the management of construction processes. Initiatives such as BPR (business process re-engineering) have a revolutionary approach. BPR is a high-risk process improvement approach. A large number of companies have failed to deliver successful results, using BPR. Generally it is believed that the low profit margins in the industry prohibit businesses from undertaking high-risk approaches such as BPR. Until now the industry has lacked a methodological step-by-step mechanism that enables it to direct its improvement efforts and resources effectively, in an evolutionary fashion.

The Capability Maturity Model (CMM) (Humphrey 1992) is a model developed by the Software Engineering Institute (SEI) at Carnegie Mellon University. CMM is a software process maturity model. This model attempts to quantify a software organisation's capability to consistently and predictably produce high-quality software products. CMM is viewed as "the most pervasive effort to improve the software processes, in more than 30 years ..." (Saiedian and Kuraza, 1995).

CMM is an evolutionary step-by-step framework. The CMM assessment questionnaire allows businesses to assess where they are positioned within the framework. Then the framework provides guidelines on what are their process improvement priorities.

In general, an organisation's actual goal is *product* improvement. The assumption is that an improved process will improve the product in some perceivable way; costs may decrease or quality may rise. This assumed connection is essential to successful process improvement. Herbleb's (1994) analysis shows the link between product and process improvement. It 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 are promising for the construction industry, which is seeking 30% cost reduction and zero defects (Latham 1994).

The SPICE project at Salford University is funded by the DETR (Department of Environment, Transport & Regions). Its objective is to investigate if the success of CMM can be repeated in the construction industry. Three approaches were used to assess if CMM can be understood and applied in the construction industry. These were: (i) a questionnaire to the construction professionals; (ii) a CMM type assessment of a small architectural practice; and (iii) an experts' panel workshop. These initial investigations showed that the industry understands the value of the process improvement concepts in CMM. However, the CMM framework and assessment tool in their current form are inadequate for the construction industry. This paper provides a review of CMM and reviews the findings of the above investigations.

2 Capability maturity model

The CMM is a five level model (see Figure 1) (Paulk 1993, 1995). The model is designed so that capabilities at lower stages provide progressively stronger foundations for higher stages. Each development stage, or “maturity level”, distinguishes an organisation’s process capability.

The CMM and the associated questionnaire have two major uses: *assessments* and *evaluations* (Humphrey 1992). With *assessments* organisations use the maturity model to study their own operations and identify the highest priority areas for improvement. Results form the basis for an organisation’s self-improvement action plan. Clients use *evaluations* to identify qualified bidders and monitor existing contracts. Results help develop a risk profile that augments the traditional criteria used to select the most responsive and capable vendors.

2.1 CMM levels

The five CMM levels have been abbreviated as initial, repeatable, defined, managed, and optimised. These levels have been selected because they (Saiedian and Kuzara, 1995):

- Reasonably represent historical phases of evolutionary improvement,

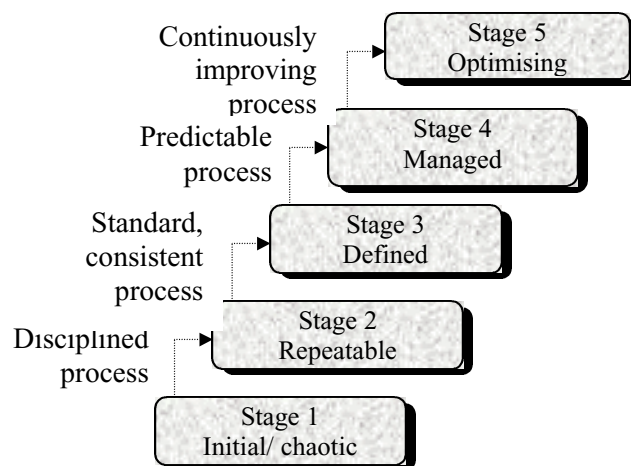


Fig. 1: CMM Levels

- Provide achievable improvement steps in reasonable sequence,
- Suggest interim improvement goals and progress measures, and
- Provide immediate improvement priorities once an organisation’s status in this framework is known.

Generally, the levels are characterised and distinguished as:

1. *Initial*- While there are many degrees of management control, the first step is to roughly predict schedules and costs. This level has been described as “ad-hoc” or “chaotic”. At this level the businesses produce products, however, the processes are not under systematic management control.
2. *Repeatable*- The organisation has achieved a stable process with a repeatable management control level, by initiating rigorous project management of commitments, costs, schedules and changes.
3. *Defined*- The organisation has defined the process as a basis for consistent implementation and better understanding. At this point, the risk of introducing advance technology is greatly reduced.
4. *Managed*- The organisation has initiated comprehensive process measurement and analysis. This is when the most significant quality improvements begin.
5. *Optimising*- The organisation now has a foundation for continuously improving and optimising the process.

Table 1: CMM’s Key process areas

Level 5: Optimising	Defect prevention Technology change management Process change management
Level 4: Managed	Quantitative process management Software quality management
Level 3: Defined	Organisation process focus Organisation process definition Training programme Integrated software management Software product engineering Inter-group coordination Peer reviews
Level 2: Repeatable	Requirements management Software project planning Software project tracking Software sub-contract management Software quality assurance Software configuration management

2.2 Key process areas

Each CMM level except Level 1 includes key process areas (KPAs) that identify where an organisation must focus to improve processes (see Table 1). Because at Level 1 the organisation has not achieved systematic process

improvement in any areas, there are no KPAs for this Level. When an organisation collectively performs the activities defined by KPAs, it can achieve goals considered important for enhancing process capability. All KPAs include both project and organisation responsibilities, but primarily the project is responsible for addressing many KPAs. The organisation is responsible for providing the resources and the necessary infrastructure.

3 Applicability to the construction industry

Many of the CMM concepts appear generic. At first glance it appears that if you replace the word “software” with “construction” in Table 1, the KPAs would remain meaningful. This raises the issue of the possibility of benefiting from the productivity improvements of CMM, in construction.

The above hypothesis was put to test in the SPICE project. The project conducted three studies to investigate. These are discussed below:

3.1 The questionnaire

As part of the initial SPICE research, a reduced and modified version of the CMM assessment questionnaire (Paulk 1993) was sent to industry professionals across a broad spectrum of disciplines (Finnemore 1998). The questionnaire was distributed to organisations within the industry (contractors, architects etc.) and also organisations not directly involved in the industry, such as clients and suppliers. The intention was to capture an internal and external perspective. The objectives of the questionnaire were to:

- Generate industry awareness
- Establish if the adapted KPAs were applicable to construction
- Identify additional KPAs
- Align research with the construction industry (terminology etc.)

At this stage the questionnaire was **not** attempting to establish industry maturity.

The questionnaire was developed by re-wording the descriptions and individual questions of the original CMM questionnaire (Pulk 1993) to reflect construction industry terminology as closely as possible. For example, ‘requirements management’ became ‘brief / scope of work management’. The questionnaire was then issued to over 100 individuals of which 30 have replied to-date. The limited scope of the questionnaire and inexact target audience means that the collected data is unsuitable for any detailed analysis but nonetheless has returned some useful indications.

It was apparent from the responses that not only were the questions read but also understood.

- The key process areas were recognised and confirmed as relevant.
- The comments and suggestions made gave direction on future terminology.

3.2 The assessment case study

A small firm of architects participated in a case study of a process maturity assessment. The purpose of the case study was to examine the applicability of the CMM's process improvement concepts and assessment mechanism to the construction processes. A firm of IT management consultants conducted a short version of CMM assessment.

The general findings of this assessment that could be gleaned from the case study were as follows:

- Construction participants generally understood the issues addressed in the CMM questionnaire.
- The assessors (from the IT industry) could relate to, and interpret the pattern of the responses (in a construction company). The responses reflected some organisational characteristics, which are also encountered in software development organisations.
- Organisation culture and communications issues in construction are similar to those encountered in software development organisations.
- With one or two notable exceptions, process capability characteristics are broadly similar to that in the software industry.
- Systematic quality management, change management and other project control mechanisms would have similar benefits in the construction industry, to those anticipated in the software industry.

Some of the differences between the construction and software development industries, which were noted by the IT management consultants were that:

- In construction, professional qualifications, customs and working practices are better established.
- In construction industry standards and data are more readily available.

3.3 The experts' opinion workshop

A panel of experts was invited to review the findings of SPICE. The panel consisted of 24 senior industrialists and academics. The academics had construction expertise. The industrialist represented the contractors, sub-contractors, consultants, architects and facility management specialists. Around half the experts were industrialists. The findings can be summarised as follows:

- The panel generally was supportive of the process maturity approach and concepts. It embraced the definition of process maturity and found value in the framework.
- The major concern regarding the framework was its applicability to the construction supply chain. CMM applies to single organisations. In order to improve the product in the construction industry, the framework must address the project supply chain.

- The assessment mechanism appeared similar to existing quality assessments, with little differentiation. The cost of the process was seen to be too high for construction companies in general and construction SMEs in particular.

4 Summary

SPICE is a current research project that is attempting to tailor the successful Capability Maturity Model (CMM) from software industry to a construction industry specific model. The model will provide an evolutionary framework for business process improvement and also an assessment tool for organisational maturity.

An industry questionnaire, a case study, and a meeting of industry representatives have indicated that a construction industry CMM model and process improvement in general are feasible. On-going research will continue to develop this concept.

Some of the main findings to date have been:

- Organisation culture and communications issues in construction are similar to those encountered in software development organisations.
- Quality management, change management and other project control mechanisms would have similar benefits in the construction industry, to those anticipated in the software industry.

Some of the main differences between the software industry and construction are:

- In construction, professional qualifications, customs and working practices are better established, and also standards and data are more readily available.
- The cost of the process was seen to be too high for construction companies in general and construction SMEs in particular.
- There was concern about the single organisation focus of CMM, as opposed to the complex supply chain arrangements in construction projects.

Three studies (i.e. questionnaire, case study and expert opinion workshop) in this paper all indicate that there is value in attempting to tailor to the construction industry, and that the major process improvement concepts in CMM are applicable. However, the major issues are finding the right framework, which:

- appropriately addresses the supply chain;
- provides the appropriate tools for the different organisations within the supply chain, in terms of organisations size, financial status and business focus.

5 References

- Finnemore, M., Sarshar, M. (1998) *SPICE*, Bizzare Fruit Conference, Univ. of Salford, November.
- Herbleb, J. et. al. (1994) *Software Process Improvement: State of the Payoff*, American Programmer, September.
- Humphrey, W.S. (1992) *Introduction to Software Process Improvement*, Tech. Report CMU/SEI-92-TR-7, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, June.
- Paulk, M. C. et. al.(1993)*Capability Maturity Model for Software, version 1*, Software Engineering Institute, Carnegie Mellon University, February.
- Paulk, M.C., Weber, C.V., Curtis, B., Chrissis, M. B., (1995) *The Capability Maturity Model: Guidelines for Improving the Software Process*, Addison-Wesley.
- Saiedian, H., Kuzara, N. (1995) *SEI Capability Maturity Model's Impact on Contractors*, *IEEE Computer*, January.
- Sarshar, M., Hutchinson, A., et.al., (1998) *Standardised Process Improvement for Construction Enterprises (SPICE)*, Proceedings of 2nd European Conference on Product and Process Modelling, Watford.