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Analysing the Organisational Risk and Change of CMM Software Process Improvement in a Nearshoring Firm

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Table of Contents

ABSTRACT 1

INTRODUCTION 2

A. CASE OVERVIEW 2

B. ANALYSING CHANGE AND RISK 4

C. CASE ANALYSIS 6

C1. RISK ASSESSMENT USING INITIAL DESIGN—REALITY GAP ESTIMATION 6

C2. ADDRESSING RISKS BY CHANGING THE DESIGN—REALITY GAPS OVER TIME ... 8

D. CONCLUSIONS 11

REFERENCES 11

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Abstract

Nearshoring and offshoring of software work to developing countries is an activity with high uncertainty. Developing country firms have tried to reduce uncertainty by adopting software process improvement initiatives – such as ISO 900X and CMM – that lead to appraisal or certification. Relatively little, though, is known about the organisational risks and change involved with such appraisal in developing countries. This paper provides a case study to address this issue: the attempt by a Mexican nearshoring software firm – Softtek – to attain CMM's highest level of quality measure.

Avoiding the limitations of simple factor-based approaches to analysing software process improvement the paper, instead, uses a contingent model – the design—reality gap model – as its framework for analysis. It applies the model to identify initial sources of risk, and then shows how those risks were addressed by management in order to successfully achieve CMM appraisal. The design—reality gap model is thus shown to be a useful tool for analysis of risk and change in software firms – nearshoring, offshoring, and others. Some tentative lessons for management of software process improvement are also drawn.

Introduction

In recent years, there has been rapid growth in the outsourcing of software services work to developing countries (Heeks & Nicholson 2004). This trade is still dominated by the "offshoring" model of outsourcing to software firms that are distant in geographic and time zone terms. However, there is growing interest in "nearshoring": outsourcing to more proximate locations e.g. from Western European clients to Eastern European vendors, or from North American clients to Central American vendors (Valimaki 2004).

In either case, cross-border software outsourcing has been impregnated with uncertainty; particularly with uncertainty about the quality of potential developing country vendors and their software processes. As a result, there has been great interest in software process improvement and its attendant appraisal among developing country software service exporters (Heeks & Nicholson 2004). Formal appraisal sends a strong signal to potential customers that reduces their uncertainty about both the vendor and its processes. ISO 900X certification has been popular, and so has appraisal under the Capability Maturity Model (CMM), an approach developed by the Carnegie Mellon Software Engineering Institute.[1]

Much has been written about quality appraisal schemes such as CMM from a technical perspective in relation to software processes; rather less has been written about software process improvement appraisal as an organisational change. In particular, very little is known about appraisal-as-change within developing country software firms. This paper addresses that knowledge gap, presenting a model to help understand the process of change experienced during the attempt by a Mexican nearshoring software firm – Softtek – to attain CMM's highest level of quality measure.

The next section presents an overview of both this firm and of CMM appraisal. Section B then introduces the "design—reality gap" model that can be used to analyse both organisational change and the risks associated with that change. The model is applied to the case of CMM in Softtek in Section C, before some brief conclusions are drawn. In all, the paper provides a new conceptual tool for analysing quality appraisal as a change initiative in software firms, and a practical means for identifying areas of risk during such initiatives.

A. Case Overview

Softtek is a software and services company founded in 1982 and headquartered in Monterrey, Mexico (Softtek 2005). It undertakes software development work for clients within Mexico but a major focus is on nearshoring to clients in Latin and North America (served by three development centres in Mexico) and in Europe (served by a development centre in Spain). This nearshoring does include Softtek

[1] More properly referred to since 2000 as CMMI, reflecting the adoption of a unified Capability Maturity Model Integration approach. The CMM/CMMI process does not currently certify a quality level but undertakes an appraisal of that level.

staff moving to work at their client's sites. Softtek began nearshoring to the US in 1997 and is now presented as the leading nearshoring firm, employing more than 3,000 staff (of whom about one-third serve the US market) and with an estimated 2005 turnover of just over US$140m (Marlin 2006). In addition to published sources such as those just cited, data for this paper was gathered by author Macias-Garza in her role as a software developer for Softtek, and through interviews and gap analysis activities with three managerial staff in the company.

Once Softtek had begun to promote itself as a nearshoring vendor in the late 1990s, it soon recognised the value of external audit of software process improvement, and chose in 1998 to seek appraisal under the Capability Maturity Model approach. CMM is a structured approach to the improvement of software development processes, consisting of six levels – 0: incomplete; 1: initial; 2: repeatable; 3: defined; 4: managed; 5: optimising (SEI 1995)[2]. Each succeeding level represents a step-change in the amount of time and effort that firms invest in the planning, measurement and improvement of their software development processes (Hassan 2002). Softtek decided that it would seek to achieve the highest CMM level – level 5 – something achieved by only a small minority of even those firms which are appraised (SEI 2005).

In doing so, two types of benefits were sought (Softtek 2003). On the one hand, there are a set of "soft" benefits from CMM appraisal. Chief among these is the reduction in uncertainty and increase in trust that it will engender among actual and potential clients; especially potential clients in the US where CMM had a fair degree of recognition. In turn, of course, it was hoped that this would produce the hard benefit of a greater number of software outsourcing contracts. Although not a significant incentive for Softtek, it was also recognised that CMM appraisal could be a motivational force for staff since it could provide the basis for acquiring a new and valuable set of quality-related skills.

Quality appraisal like CMM is mainly sold, though, in relation to hard benefits (e.g. SEI 1995, SEI 2005). In quality terms, this typically relates to a reduced rate of errors within the software produced by the company, leading to lower error-correction costs and, potentially, greater repeat business for Softtek. Process improvement can also deliver efficiency benefits – shorter timescales for software delivery and/or higher productivity levels in terms of code per employee – again with a positive knock-on in terms of benefits for customers. More generally, there is also the softer benefit of greater management understanding – and hence control – of software processes within the firm. In specific terms, the performance, experience and task responsibilities of each staff member could be mapped; more generally, greater management knowledge and ongoing learning would increase predictability and reduce risk.

Balancing these benefits were a series of costs that Softtek would incur. Most obviously, there were a set of tangible costs – new software and hardware to run process and project management information systems that, for example, helped track and manage software defects; new staff to administer quality appraisal; training programme costs; and the cost of payment for the US-based CMM appraiser.

[2] Under CMMI, the levels are now, respectively, Incomplete, Performed, Managed, Defined, Quantitatively Managed, Optimising.

Alongside these ran the much less tangible costs of staff time taken up with planning, leading, documenting, learning, changing, and operationalising new quality procedures.

However, these costs were seen as worth bearing because the main driver was the desire to attract more customers; using CMM level-5 appraisal as a source of competitive advantage and imitating a strategy used by other onshore and offshore software firms serving the North American market. This was particularly needed in the attempt to ensure nearshoring could challenge India-based software offshoring, where – by the end of the 1990s – 20 of the 37 firms audited worldwide to CMM level 5 were Indian (Moitra 2001).

B. Analysing Change and Risk

As can be seen from the description of costs, the decision to seek CMM level-5 appraisal required a significant investment, significant changes to the way that software development was managed in Softtek and, hence, a measure of risk. Yet, as noted in the Introduction, there have been few if any analyses of change and risk in relation to software process improvement appraisal in developing country locations.

A few studies done in other locations (e.g. Stelzer & Mellis 1998, Dyba 2000, Jakobsen et al 2003) take a prescriptive factor-based approach that has a key shortcoming. By being factor-based, it provides a single "menu" of prescriptions that is not responsive to different organisations and contexts. Thus, for example, it makes typical assumptions – drawn from industrialised country cases – that may not apply in developing country situations. We therefore need to understand change from a contingent perspective: one that is sensitive to different contexts and which does not claim that "one size fits all".

The model applied here is the contingent "design—reality gap" model (Heeks 2002). This relates the degree of risk in an organisational change initiative – such as software process improvement – to the degree of change involved: put simply, the greater the change required, the greater the risk of initiative failure. That degree of change is estimated by investigating the difference between two things: on the one hand the requirements or assumptions within the design of the initiative, on the other hand the current realities of the software firm. More simply, we can say that the degree of change is represented by the "design—reality gap", with that gap being assessed qualitatively along a number of dimensions. Case experience suggests seven key dimensions need to be assessed, summarised by the ITPOSMO mnemonic:

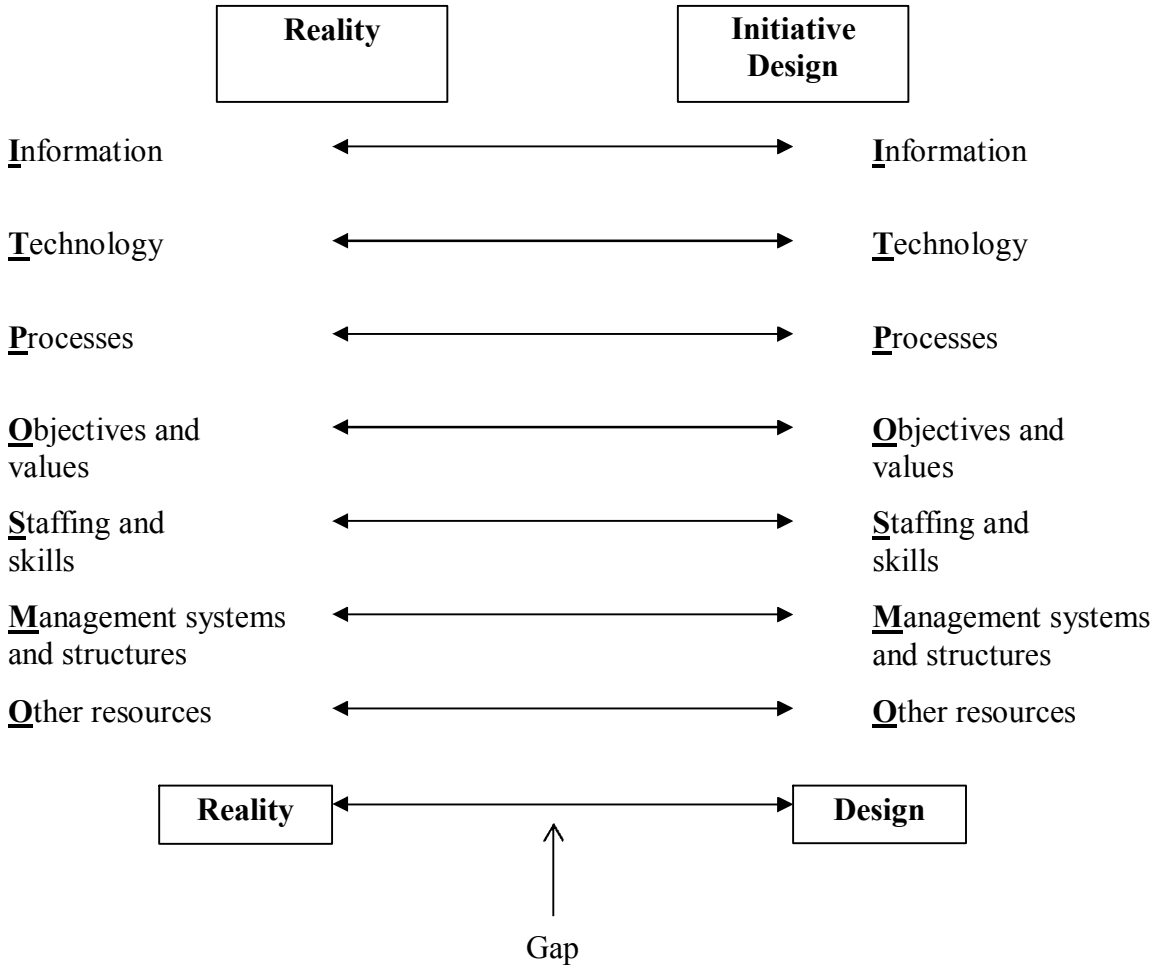
- **I**nformation: includes both formal and informal information, held on both IT-based and other types of information system
- **T**echnology: mainly focuses on information-handling technology (particularly IT but also paper, telephones, etc), but can cover other types of technology such as production machinery
- **P**rocesses: the activities undertaken by the relevant part of the organisation – both information-related processes and broader business processes
- **O**bjectives and values: often the most important dimension since the 'objectives' component covers issues of self-interest and organisational politics, and can even

be seen to incorporate formal organisational strategies; the 'values' component covers organisational culture: what stakeholders feel are the right and wrong ways to do things

- **S**taffing and skills: covers both the number of staff and their competencies (particularly skills, but also knowledge)
- **M**anagement systems and structures: the overall management systems required to organise plus the way in which the organisation is structured, both formally and informally
- **O**ther resources: time and money

Figure 1 summarises the design—reality model.

Figure 1: Dimensions of Design—Reality Gaps



C. Case Analysis

C1. Risk Assessment Using Initial Design—Reality Gap Estimation

The design—reality gap model will now be used to analyse the change/sources of risks involved in CMM appraisal for Softtek, analysing the gap between CMM design assumptions and requirements, and the realities of Softtek as they stood in 1998 when the company first began working towards appraisal. Each dimension is given a gap rating by the authors based on qualitative analysis including discussions with other members of Softtek staff.[3] A 0-10 scale is used where 0 represents no difference between design and reality; 5 represents some degree of difference, and 10 represents a complete and radical difference between design and reality.

Information

A fundamental of CMM design is its requirement to generate rigorous data about software processes and projects, and for that data to be fed into the management process and used. Softtek – with more than 15 years' experience of software project management, and some established software methodologies – already had some of the required data in reality so, overall, the change requirement was reflected in a gap rating of 4 on this dimension.

Technology

The introduction of CMM methods is mainly a management- and people-based activity. However, as noted above, there was a design requirement for the introduction of some new IT to drive the information systems. Within Softtek itself, this was relatively limited as compared to the overall IT infrastructure of the company. The same was true within most client companies, and a design—reality gap of about 4 was assigned.

Processes

Not surprisingly, given its process-orientation, CMM appraisal's design requirements were quite different in many ways from the reality of existing processes in Softtek. Introduction of quality management would mean not just new processes at all stages of the software development lifecycle, but also new project management processes, and even new processes in the broader organisation in areas such as resource allocation, payroll, staff appraisal, and so on. Not only did this differ from the realities found in Softtek itself, it also – more challengingly – differed from the reality of the processes found in Softtek's clients; yet it was within those client companies that a number of development and project management processes took place. In all, this dimension was given a gap rating of 7.

Objectives and Values

Gap assessment needs to take into account the objectives and values of different stakeholder groups. The designed objectives of CMM – both explicit objectives of better controlled and better understood development processes, and more implicit objectives of enhanced company reputation and earnings – were shared in

[3] Gap ratings are typically undertaken using a group in this way. Further discussion of gap rating techniques can be found in Heeks (2005).

reality by many of Softtek's senior management team. Some of the middle managers and software team leaders did not, in reality, share these objectives but their own objectives – of boosting their careers by being involved with a software process improvement appraisal initiative – did not mismatch the designed outcomes of CMM. Operational staff and lower-range software development team members, though, tended to value their own time, effort and rewards, and they were hesitant about the design implications of greater clarity around performance. The reality of their focus on personal objectives, then, did not necessarily match CMM's inscribed goals which required them to commit time and procedural change to an initiative that delivered no clear individual benefit, such as more pay or other compensation. This suggested an overall gap rating of 5.

Staffing and Skills

CMM has an intrinsically-designed requirement for a set of internal staff with CMM-appropriate competencies: specific deep skills and knowledge within a core group, and shallower knowledge within a broader staff grouping. In reality, though, there was limited knowledge about CMM within the organisation: limited in relation to general issues such as the CMM model itself, about key process areas and practices that would need to be changed, and about the need for changes to more strategic management processes. There were already a few staff with CMM expertise in the company, which did help. However, they were not enough to supervise the roll-out of process change both within the company and within its outsourcing to clients as intended within the Model's design. Taken as a whole, this meant a gap rating of 4 on staffing and skills.

Management Systems and Structures

CMM has a design requirement that there be new management systems to support the new approach to software development and some level of new management structures. This would not represent a root-and-branch change – most fundamental systems and structures would remain in place – but it was still appreciably different to Softtek's reality in 1998, particularly in relation to the growth of onsite working that had emerged with Softtek's promotion of nearshoring, as software engineers moved to work at client sites in the US. A gap rating of 5 was allocated.

Other Resources

By design, CMM appraisal requires some significant financial investment. Softtek had, in reality, the resources to deal with all of the expected and tangible investments, but not some of the less tangible requirements around individual financial rewards. This pattern was even more pronounced as regards time. Explicit time requirements within the design of CMM appraisal in terms of both staff and total elapsed time are much smaller than the implicit requirements; the latter only being exposable through very detailed analysis of the process. As a result, in reality, Softtek had made some staff time allowances – sufficient for the explicit requirements of CMM, but not sufficient for the implicit requirements, leading to a gap rating of 6 on this dimension.

This provides a total gap rating of 35, which can be compared with the guidelines in Table 1, which suggests likely outcomes based on a totalling of gaps for the seven ITPOSMO dimensions (Heeks 2005).

Table 1: Design—Reality Ratings and Likely Outcomes

Overall Rating	*Likely Outcome*
57 – 70	The change initiative will almost certainly fail unless action is taken to close design—reality gaps.
43 – 56	The change initiative may well fail unless action is taken to close design—reality gaps.
29 – 42	The change initiative might fail totally, or might well be a partial failure unless action is taken to close design—reality gaps.
15 – 28	The change initiative might be a partial failure unless action is taken to close design—reality gaps.
0 – 14	The change initiative may well succeed.

In all, then, this suggested a danger of partial or even total failure of CMM appraisal in Softtek unless action was taken.

C2. Addressing Risks by Changing the Design—Reality Gaps Over Time

What action can you take if a change initiative like the one just described seems to be at risk of failure? The actions can be summed up by ZABC:

- **Z**ap the initiative: abandon it.
- **A**lter the initiative: make some changes to either design or reality, particularly on those dimensions showing large gaps.
- **B**e selfish: focus on personal goals and personal gains.
- **C**hange your job: move either within or outside the organisation in order to leave the initiative.

Some individuals did adopt options B and C: just using the CMM appraisal process to build experience for their own career trajectories, or seeking work with a different company. Organisationally, however, neither of these options are appropriate and nor, given the strength of the driving forces behind appraisal, was discontinuation contemplated.

Instead, then, Softtek's management had to undertake change. The choices for situations of large design—reality gaps are simple: either the initiative's design must be altered to make it more like current reality, or current realities must be changed to make them more like the initiative's design assumptions/requirements. In the case of

CMM, design is pretty much a "given" – set in stone and non-alterable by a firm seeking appraisal. Therefore, the only choice that Softtek managers had was to alter company realities until they were more closely aligned with CMM design. Various gap-reduction activities were undertaken:

Information

The keyword for gap reduction on this and most other dimensions was "incrementalism". The realities of Softtek information systems were changed so that the company could deliver the data required for CMM level-5 management, but that change was made slowly and gradually over a six-year period. It was only in 2004 that the full requirements of CMM were met in data terms.

Technology

The introduction of new software in Softtek was relatively straightforward. As with some other dimensions, what proved more difficult was to change realities in the client companies in which Softtek staff were developing software. In some cases, this led to renegotiation of the division of labour such that work was moved from the client site into Softtek where the required technological systems were in place to support a CMM level-5 approach.

Processes

Using the incremental approach that changed only a few processes at any given time, allowing for staff reflection and participation in reviewing process change, and spreading the change of realities over six years – backed by the continuous driving force of perceived marketplace necessity for CMM appraisal – meant that Softtek was able redesign its software, administrative and managerial processes. This proved more difficult to achieve in those client sites whose process realities differed from CMM design requirements. Ultimately, a mix of negotiation and advocacy was needed by Softtek relationship managers, assisted as clients perceived benefits their own organisations could achieve from alignment with CMM standards. As noted, a shift from onsite to Mexico-based development was needed on rare occasions.

Objectives and Values

A mixed approach was used to help align the real objectives of software staff with those implicit within CMM's design. Some additional financing was made available to direct overtime payments and performance-related pay rises to those who were investing particularly in the CMM initiative. Those whose objectives and values remained intransigently misaligned left the company, to be replaced by new staff who were brought into a situation where CMM-type procedures were taken to be an expectation and, increasingly, a norm. Senior managers also appointed a series of CMM champions from among middle management, whose role was to act as internal advocates – promoting and defending the introduction of new standards and practices, and thus helping to change "hearts and minds".

Staffing and Skills

As often with design—reality gaps on this dimension, gap reduction was addressed through a broad and long-term programme of general awareness-raising and specific training. After some years, this produced a reality of competencies within the company that matched CMM's design needs.

Management Systems and Structures

As with processes, incremental change within Softtek itself over some years gradually changed the realities to meet CMM's requisites. New managerial systems were also introduced for onsite work – instead of just delivering "bodies" to the client – a Softtek manager was allocated to supervise such work. This alongside the other reality changes enabled it to be brought into the ambit of CMM appraisal.

Other Resources

As observed above, some additional funds were made available to deal with the unforeseen design implications of CMM. Finding the required time in reality was not easy: staff tended to be fully occupied on their work for clients. Stretching the appraisal time horizon well beyond its initially-anticipated deadline was one element. Others were negotiations with clients to allow staff time off for CMM training, payment for the additional hours that managers and others had to work in order to implement CMM, and shifting of training and other CMM activities to weekends, again with a corresponding payment.

As a result of steadily closing the gaps between company reality and CMM design requirements, Softtek was able to successfully implement this software process improvement appraisal initiative, receiving its level-5 audit in April 2004. Through a mix of advocacy, staff turnover, new recruitment, and financial incentives what began as an initiative mainly of top management has now percolated down to most Softtek staff. There will always remain some tension over software methodologies like CMM given the continuing argument over "software as art, software as science", reflected in the belief of some software developers that their creativity and imagination may be stifled by methodologies, and reflected in the dangers that quality management can degenerate into mere bureaucracy (Flowers 1996).

In Softtek, though, the CMM approach has become part of everyday work in the organisation. Charting the exact impact of appraisal is not easy, particularly given the confidentiality of most company data. However, it certainly gave the company the anticipated highest-level benchmark which it has been able to use as a marketing tool with clients. This has helped the company grow, for example, from US$64 million turnover in 2001 to US$146 million in 2005. The internal benefits of CMM are demonstrable from the fact that a number of clients – seeing those benefits in action as part of their Softtek contracts – have themselves decided to seek CMM appraisal for their software operations.

Overall, we can say that, at worst, CMM appraisal has created a level playing field for nearshoring as compared to offshoring. At best, it has helped reduce internal errors and costs, and increase revenues significantly.

D. Conclusions

The design—reality gap model has proven to be a simple but useful framework for understanding sources of risk in the introduction of change initiatives in software companies. This has included software process improvement initiatives such as ISO 900X certification and CMM/CMMI appraisal.

We have presented design—reality gap analysis here in *post hoc* mode: helping to understand a change that has already taken place in the software firm. In very simple terms, the model provided a clear and robust framework for discussing and analysing that change. It also suggested a number of potential lessons:

- the need for an incremental approach to appraisal;
- the need to allow money and, especially, staff time to cope with implicit requirements that may not be easy to recognise;
- the need to incorporate plans for motivating staff and for coping with those whose objectives cannot be aligned with the requirements of appraisal; and
- the need to plan how to incorporate onsite working into the quality management processes.

However – mindful of the contingency underlying this model – one must take care in assuming that such lessons can be generalised to all software firms. One further lesson, though, may be more generalisable – that strong external driving forces will help to ensure the success of a change initiative even where design—reality gaps are initially large.

Design—reality gap analysis can also be used as a *pre hoc* tool: as a means to identify likely sources of risk for change projects within a software company. Of course, the ratings given on any particular dimension are not an exact science. Indeed, it may be better to step back and see the design—reality gap model as a vehicle rather than a destination; as a means to stimulate discussion about change within the firm. The actual process of gap rating – creating a shared understanding of issues, meanings, priorities through debate – may therefore be more important than the specific outcome of the ratings themselves.

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