INTRODUCTION

This article provides an approach and mechanisms for making CMMI[SM] investment decisions based on impact to the organizational "bottom line".

Often, gains in product quality, productivity, cost reduction, cycle time reduction, and even customer satisfaction are offered to corporate decision-makers to justify investment in adoption of the CMMI. The affect on the bottom line has proven somewhat less quantifiable. However, corporate officers leaders that are responsible for making investment decisions are used to making such decisions based on estimated Return on Investment (ROI).

THE DECISION SPACE

The decision to adopt the CMMI within an organization is multi-faceted. The CMMI framework must be compared to other improvement options, such as ISO 9001-2000, the SW-CMM®, cleanroom methodologies, inspections, or software reuse. If the decision to adopt the CMMI is made, several options then present themselves. Is the Staged or Continuous representation more suitable? Which of the models (software, system engineering, etc.) should be adopted?

This paper does not attempt to deal with these alternatives, as they are well documented elsewhere.

In this paper, we will focus on the three most important variables affecting Return on Investment for a CMMI implementation effort. They are:

- Performance or Quality Goals
- Value Domains
- Contract Types

Quality or Performance Goals

Whatever the motivation for adoption of the CMMI, it is imperative that the organization focus early, sharply, and consistently on *defining what CMMI implementation is supposed to accomplish.* CMMI implementation will produce a toolset useful for both management and engineering. Whether the tools in that set are useful in supporting the organization's goals is up to the adopting organization.

A heuristic view of the potentially radical increase in ROI is provided in Figure 1. Please note that the curves are estimated boundary conditions for organizations that invest roughly equal amounts on their CMMI programs. The difference in ROI is the attention paid on understanding the organization's business environment, and then on focusing the CMMI effort on helping the organization to achieve important management and engineering goals through its CMMI program.

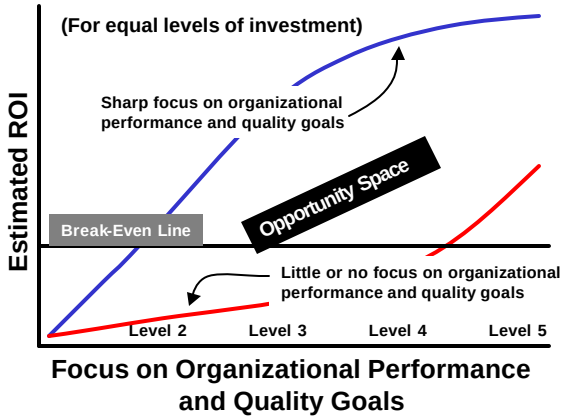

Figure 1. ROI Affected by Goal Setting

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This assertion is based on many years of engineering, management, and process improvement experience. It's proof is left to a future paper.

Value Domains

There are three *value domains* that may be affected or improved through successful CMMI adoption:

- Product life cycle
- Marketing value
- Intrinsic value to the organization

Table 1 reflects these value domains.

Life Cycle	Increased productivity, reduced time to market, higher product quality, reduced costs
Marketing	"Level 3 requirement", customer perception of schedule and cost predictability
Intrinsic Value	Responsive infrastructure, highly knowledgeable employees

Table 1. Organization's Value Perception Related to CMMI Implementation

Product life cycle value stems from increases in productivity and product quality (typically measured as a reduction in latent defects), reduced l costs, and reduced time-to-market. Product life cycle value has been the dominant focus of ROI calculations over the years.

Marketing value is based on the perception of the potential customer. If CMMI compliance is a condition of contract award, or if the acquiring organization is sufficiently aware of the value of CMMI compliance, that compliance would presumably have a direct impact on contract award.

Intrinsic value to the organization is defined as the knowledge or skills of its members, and the ability of its infrastructure to respond to the needs of the engineering organization.

The investment decision is also affected by the type of contract or nature of the business.

Contract Type

The type of contract under which the system or software development work will be accomplished directly affects ROI from the CMMI investment across the three value domains we have defined. We will consider Firm Fixed Price (FFP), commercial, Cost Plus, and Time and Materials efforts.

The FFP contract type is included with the "commercial" type- in both cases, all investments are attributable to direct or overhead costs at the organizational level, and all act to reduce profit.

Cost Plus contracts may be either with Fixed Fee or Award Fee. Here, we consider the case of Cost Plus Award Fee. Cost Plus Fixed Fee is lumped with Time and Materials contracts.

Time and Materials contracts provide potentially the least incentive to adopt the CMMI- unless the organization must meet a "mandated" Level 3 compliance requirement.

Figure 2 provides an initial view of how an organization might value CMMI adoption based on the contract type.

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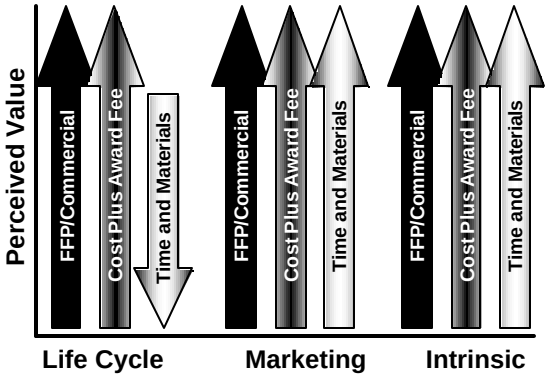

Figure 2. Perceived Value Changes Due to CMMI by Type of Contract

Organizations with FFP contracts or commercial efforts might place a very high value on CMMI implementation, if the expected outcome promised faster time-to-market, enhanced quality, etc. On the contrary, CMMI adoption might be perceived to be of lesser overall value for organizations conducting T&M efforts, since the organization would presumably be paid for all costs and materials, along with a fee- no matter what the outcome in terms of schedule or quality. For such organizations, CMMI compliance would presumably help improve customer relations and help to position the organization for the next procurement.

Now that we have defined the decision space, we attempt to provide a top-level process diagram that may aid the business leader in making the CMMI investment decision.

INVESTMENT DECISION PROCESS

ROI is the single merit of importance to the bottom line. We have identified *Value Domains* that, when viewed in light of the organization's *Contract Types*, provide an initial view of the value of CMMI adoption. We have also indicated that the ROI may be multiplied by the act of setting and consistently striving to achieve performance or quality goals through the CMMI implementation program.

We will now attempt to provide a decision process that is intended to be of value to an organization's leaders or to those responsible for advising such leaders. The "end point" of this decision process is that the organization's leadership is prepared to make a decision on whether to commit to CMMI adoption. Figure 3 provides a top level view of this process.

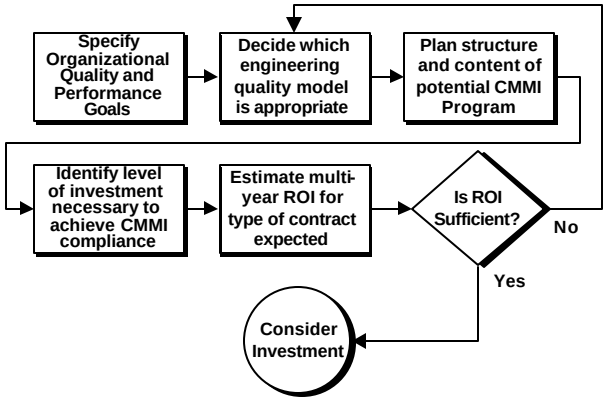

Figure 3. Decision Process for Adoption of CMMI

This is of course a very simplified decision process. The third block includes such challenging issues as the definition of the organization (for CMMI adoption), selection of the CMMI representation and model(s), and organization in support of the CMMI implementation effort.

Careful consideration and analysis of the organization's quality and performance goals is critical. The practitioner should be careful to not under-scope goals based on expected norms of the kinds of things that CMMI

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implementation might help with. A growing body of knowledge indicates that a wide variety of management and engineering problems can be well addressed through a carefully focused CMMI effort.

A CMMI effort should be able to form a significant part of the solution space for goals such as "Increase our systems engineering business base by 15% in two years", or "provide an approach and reliable mechanisms to allow us to respond to new engineering needs in a matter of days." More typical goals such as increasing product quality and decreasing time-to-market are also appropriate. The second and third steps in the decision process are not the focus on this paper. Much excellent material is available on these topics- or the reader may contact the author to discuss these steps further.

A note of caution on the identification of the level of investment. A large body of knowledge strongly indicates that a significant investment, on the order of $500 to $2000 per engineer per year, is not out of line. Attempting to avoid necessary investment costs leads to early failure and often threatens the long term success of the improvement program. See the author's article in the December 2002 issue of *Crosstalk*, titled "A CMMI Case Study – Process Engineering Vs. Culture and Leadership".

CALCULATION OF ROI

We will consider the calculation of ROI over each of the *Value Domains* we have defined.

Life Cycle ROI

Most of the literature (summarized in "A Business Case of Software Process Improvement Revised", A DACS State-of-the-Art Report, 30 September 1999) focuses on increases in productivity (9% to 67%), reductions in cycle time (15% to 23%), and reductions in post-release defects (10% to 94%). The ROI for these types of improvements range (for software) from 420% to 880%. These numbers, although phenomenal, do not tell the whole story. For example, reduction in cycle time or even increases in productivity for organizations who are developing systems or software under T&M contracts will act to *decrease* profit in the short term.

These numbers are meaningful only for the Life Cycle Value Domain- and only in light of the contract type under which the development effort is performed.

For commercial efforts, or FFP contracts, these numbers should act as valid indicators of ROI performance. For Cost Plus (Award Fee) contracts, we would hope that the award fee rewards reduced cycle time, higher quality, etc., such as to motivate continued improvement on the part of the contractor. Since the monetary value of costs savings due to reduced cycle time, increased product quality, and increased productivity are not directly passed to the contractor, the ROI will be somewhat less. If we consider that a "typical" award fee might be in the range of 5% to 10%, and that a moderate investment in CMMI might be in the range of 2% to 4% of program value, we are looking at a range of about 20% to 500% ROI for Cost Plus Award Fee efforts. See Figure 4.

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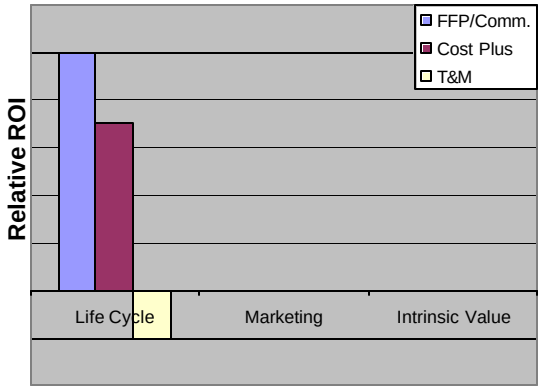

Figure 4. ROI for Life Cycle Domain

For T&M efforts, it seems that the immediate ROI during the Life Cycle value domain is negative. In other words, the CMMI success probably helped the contractor win the effort, but will not support the generation of fee or profit during the actual development of the product (see Figure 4).

Marketing ROI

ROI for marketing of a successful CMMI effort is based on an educated guess (including surveys and expert and customer opinions) of the marginal probability of win (P[Win]) due to CMMI compliance or marketed organizational performance improvement (such as reduced cost and schedule). Although these estimates are difficult to make, and are equally difficult to verify statistically, they are worth making.

For example, for a two year, $4M effort, a company determines a probability of win of 80%- of which 25% is attributable to CMMI compliance or performance improvements.

In order to form the basis for ROI calculations, the CMMI investment must be expressed in terms of an investment profile (dollars over years). ROI is then considered for the current year, and for multiple year periods.

For the marketing ROI analysis, let's say that the investment in the two years during which the contract will be executed is projected to be $80,000 ($1000 per engineer per year). The returned value of the CMMI investment in the marketing value domain is 32% of the contract value (25 points of the 85% win probability was attributed to CMMI compliance). After the win, this 25% translates to 32% (of 100%). 32% of contract value is 1.28M. Given these numbers, the ROI in the *Marketing Value Domain* would be about 150% in terms of returned profit on investment.

See Figure 5 for a depiction of ROI for the Marketing Value Domain.

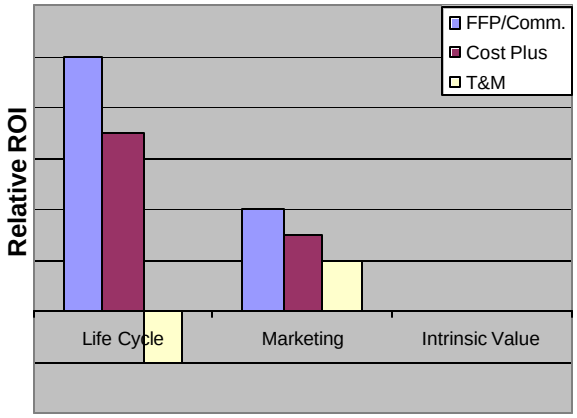

Figure 5. Marketing ROI

Intrinsic ROI

Improvements to the organization's infrastructure can have a direct bearing on both the probability of win, and on the ability of the engineering

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organization to carry out the contract once it is won.

Advanced Knowledge Management programs can assure an expert (and highly productive) workforce. A focused Human Resources department can support rapid formation of the engineering staff, and ensure that qualified candidates are assigned to the right positions. A highly motivated information systems staff can ensure that the engineering and management staff has the right information at the right time to make the best real-time decisions possible.

Financial management processes, mechanisms, and tools can help the project manager support the organization's billing and cash flow monitoring processes.

By far the most difficult to estimate, the intrinsic value of CMMI investment is something that is palpable to managers and leaders. Employees are more knowledgeable and more satisfied (which reduces turn-over). This ROI reduces overhead, and is directly calculable. Other contributions to ROI by infrastructure may best be calculated as contributions to improvement in engineering or management performance (Life Cycle Value Domain) or in supporting the probability of win (Marketing Value Domain).

Figure 5 indicates this assignment of ROI to other domains.

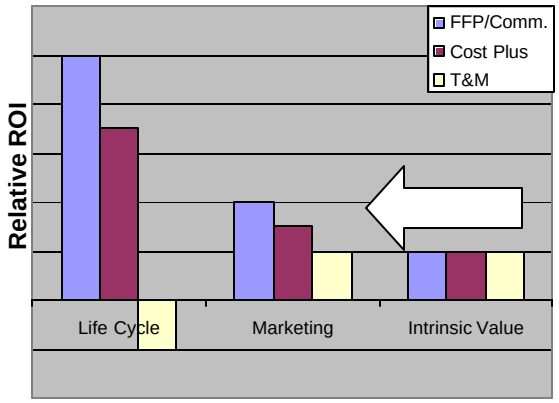

Figure 6. Intrinsic ROI

BOTTOM LINE ROI CALCULATION

In order to avoid duplicate counting of ROI, the reader must ensure that the ROI is assigned against the investment in the right year or time frame. For example, Marketing ROI should be calculated against prior-year CMMI investment, while current savings or added profit may be calculated against current-year CMMI investment.

In practice, an actuarial approach is the needed- in which a pre-determined time frame is considered from a CMMI investment point of view. For the first year or so, no benefit may be realized from the CMMI investment- so the investment costs should be amortized over a pre-determined time frame.

This amortization schedule should be consonant with the organization's overall business approach and strategy, and should be agreed-to (along with the quality and performance goals) before the CMMI effort is kicked off.

BIOGRAPHY

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Jeffrey L. Dutton is the Technical Director of the Engineering Performance Improvement Center. He provides leadership, solutions, and management of process and technology improvements in the way Jacobs Sverdrup's Advanced Systems Group conducts and manages engineering programs. The principal focus of EPIC is on adoption and institutionalization of the Capability Maturity Model-Integrated, for Systems and Software Engineering. Jeff's was a member of the Software Engineering Institute's Product Development Team for the CMMI-SE/SW. In the Government, Jeff was assigned to the Office of the Secretary of the Air Force (Research and Development), HQ Air Force Operational Test and Evaluation Center, and the Foreign Technology Division (predecessor to NAIC) as an Astronautical Engineer and Operations Research Analyst. He has a B.S. in Aerospace Engineering from the University of Arizona, and an M.S. in Operations Research from the Air Force Institute of Technology. He has presented CMMI papers at the SEPG, the STC, the SES and the ESEPG.

Jacobs Sverdrup's Advanced Systems Group is a CMMI Level 2 organization.

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