The Rosetta Stone Methodology – A Benefits-Driven Approach to SPI

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Abstract. The Rosetta Stone Methodology (RSM) has been developed which allows organizations to undertake Software Process Improvement (SPI) based on business- and organizational-driven goals and objectives. The methodology itself is fully customizable and allows organizations to make adjustments to the model where they feel it appropriate. To demonstrate the usefulness, appropriateness and practicality of this new approach, the Rosetta Stone IGSI-ISM to CMMI Instance mapping (RS-ICMMI) is developed. To aid in understanding, the Measurement and Analysis (MA) process area is used as an example of how to apply the methodology. The Rosetta Stone Methodology and the RS-ICMMI instance have been validated by experts.

1 Introduction

According to the Organization for Economic Co-Operation and Development [1], total worldwide spending on ICT was expected to reach $2.964 trillion in 2005, the last year for which the OECD has published estimates. Given the massive amount of spending involved, anything which can shave even a few percentage points off costs could potentially free up a large amount of capital that could be re-invested in the organization. From a Software Process Improvement perspective, there are several competing and, in some cases, complementary standards such as the Software Engineering Institute's CMMI for Development version 1.2 [2], the International Standards Organization's (ISO) 15504 [3], and the International Standards Organisation's ISO 9000-3 [4] and ISO 9001:2000 [5] standards, a process-driven approach to define, establish and maintain software quality within an organization that will allow organizations to meet their business objectives [6].

Following our literature review, we can summarise software process improvement benefits into the following categories:

- **Return on Investment (ROI):** We have noted evidence of a correlation between increased ROI and implementation of various SPI initiatives. Examples of studies which illustrate increased ROI are Hughes Aircraft (Humphrey et al. [7]), Boeing STS, a division of Boeing Inc. [8], Oklahoma City Air Logistics Center (OC-ALC) [9].
- **Productivity:** There are many studies which demonstrate that productivity increases as a result of software process improvement. These include Brodman and Johnson [10], Dion [11], and Herbsleb et al. [12].

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- **Quality:** Studies analysed demonstrate that as organizations implement more quality-oriented processes, the quality of code improves. Additionally, quality increases as process capability maturity levels increase. Studies in this area include Krasner, Pyles et al. [13] and Putnam and Myers [14]. We also note that it becomes more difficult, and therefore more costly, to increase quality between higher maturity levels.
- **Financial Benefit:** Evidence of the financial benefit resulting from the implementation of SPI may be expressed as a ratio of cost to benefit (or vice versa) or as a discussion of costs and benefits separately, and published research tends to centre on ratios rather than on costs and benefits. Example studies include the SEI [15] and Sapp, Stoddard et al. [16].

All these initiatives have demonstrated improvement in an organization's systems capabilities but these improvements were approached from an IT perspective. There is no ability within the established methodologies to define what benefits/objectives an organization would like to achieve and use business-centric objectives to drive what particular SPI initiatives should be undertaken. We also note that IT organizations have tended to drive the SPI agenda in order to achieve IT benefits as a primary objective, and organizational benefits as a secondary objective. However, this is typically not the way the commercial world works – in the commercial world it is the business which drives IT, not the other way around. The Rosetta Stone Methodology (RSM), which we developed and validated during this research, allows businesses to undertake business- and organizational-driven goals and objectives using SPI. In addition, we present a specific instance of the RSM, the RS-ICMMI (Rosetta Stone - Implementation for CMMI) mapping, presenting details on the Measurement and Analysis (MA) process area.

Section 2 of this paper describes the Research Methods used in developing both the meta-model and the operationalisation of the methodology. Section 3 describes the Rosetta Stone meta-model. This meta-model provides an abstract representation of the relationships between business objectives, software process improvement process areas, and the indicators/metrics which may be used to demonstrate progress or regression of the implementation of SPI within an organization. Section 4 describes the methodology used to arrive at a concrete implementation of the meta-model. In section 5 we create an instance of a mapping. The implementation presented here is a mapping from the IGSI-ISM benefits model, a generic benefits model developed by IBM India [17], to the CMMI (Staged) SPI model and will hereafter be referred to as the Rosetta Stone IGSI-ISM to CMMI implementation or RS-ICMMI for short. We discuss the validation of this model through interviews with experts. Section 6 concludes the paper.

2 Research Methods

Once we had established through literature review and expert interviews that there was no readily usable approach which supported businesses in deciding which software processes to improve to gain specific business benefits, we commenced the development of an objectives-driven approach whose use should allow this. The first step was to create a generic methodology, the Rosetta Stone Methodology (RSM).

This was done by creating a meta-model of all the elements involved in an SPI implementation. After this, a step-by-step approach was developed which guides practitioners in using an SPI methodology combined with a benefits model. We defined a mapping between business-focused benefits and individual SPI process areas. In essence, this process allows practitioners to substitute the meta-model with a concrete implementation instance of the model. This mapping is then used as the basis to decide upon and prioritise which process areas should be implemented to achieve specific business benefits.

To demonstrate the implementation of the RSM in a specific instance, we investigated available return on investment (ROI) models which did not deal exclusively with software process improvement, but with which existing SPI models could be combined. We chose to work with the IGSI-ISM Benefits Model [17] and CMMI Version 1.2 [7] This is done as follows:

1. Define the mapping (relationships) between Objectives/Benefits and Software Processes
2. Answer the questions that are relevant to the individual organization.

The initial methodology, meta-model and implementation instance were developed as described and were then reviewed by a small group of peers for validity. For triangulation purposes, they were validated through an expert panel review of 17 people with an average work experience in the software industry of 19 years along with an average of 11 years of SPI experience. Additionally, to validate the implementation instance, a group of experts was interviewed about each relationship within the RS-ICMMI model. Out of a pool of ten experts, two experts were randomly selected to review a set of IGSI-ISM Benefit/CMMI Level 2 combinations. They discussed whether they agreed with the relationship presented, and where they had seen these relationships work in practice. This process was repeated until all combinations had been reviewed. In some cases, the RS-ICMMI was modified as a result of these interviews.

3 Rosetta Stone Meta-model

Many valuable studies of the benefits resulting from implementation of CMM/CMMI and Software Process Improvement (SPI) in general have been undertaken over the last several years. These studies have focused on SPI along one or two of three aspects – organizational, improvement methodology, or metric-based. In contrast, our research has developed a consolidated model which would allow practitioners to view organization, improvement programs and metrics concurrently using one, unified framework – a “Rosetta Stone”, if you will, of SPI.

The Rosetta Stone meta-model is composed of 5 basic elements, as well as the relationships between them (Figure 1), with further detail in [18].

- Elements: The most important element is the *set of Business Objectives* or *Benefits* which an organization wishes to achieve. Ideally, these should be hierarchical so that the achievement of one leads to the achievement of others.
- Relationships are defined between Business Objectives and Process Areas (PAs).
- Return, Costs and ROI: it is now possible to tie SPI to specific benefits due to the fact that the benefits may be defined at a very granular level.

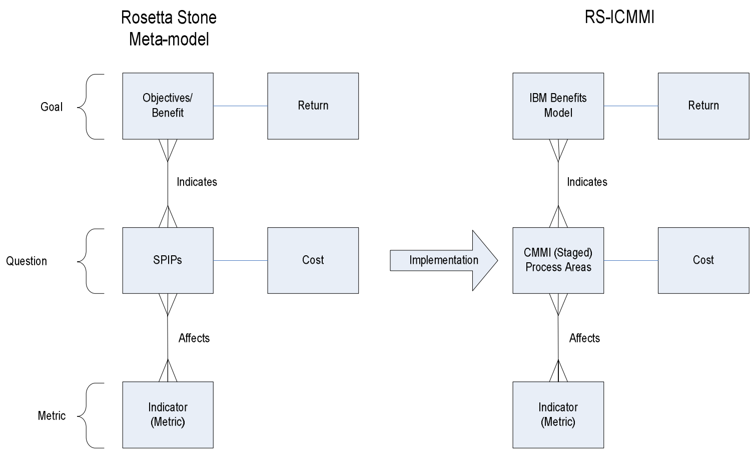

Fig. 1. Rosetta Stone Meta-Model and Implementation Mapping

4 The Rosetta Stone Methodology

The Rosetta Stone methodology is the translation process whereby an abstract meta-model is transformed into a concrete implementation which may be readily used by practitioners. At a high level, each abstract entity as described in Figure 1 must be replaced with a concrete entity. Frequently the choice of both the SPI methodology (Step 1) and benefits model (Step 2) is performed at a strategic level within an organization. The mapping between benefits and process areas (step 3), the determination of the implementation order (step 4) and the determination of which metrics to use (step 5) are performed by SPI practitioners; and the monitoring of costs and benefits (step 6) is performed by the "front-line" staff involved in the running of projects and support organizations.

Step 1 – Choose the SPI Methodology: There are several SPI models and methodologies currently in use within ICT and several factors influence an organization's decision on which SPI methodology to use. Reasons for SPI implementation include improving the software process, external requirements such as supplying a contract, and enabling the business in a particular market segment.

Step 2 – Choose the Benefits Model: Different organizations have different organizational goals and missions. Some, like IBM and Microsoft, are for-profit companies while others such as universities, charities, and local government bodies have different goals and missions. What both the for-profit and not-for-profit organizations have in common, however, is that both types of organization try to use their use their resources most efficiently to achieve their organizational objectives.

Step 3 – Mapping between the SPI Methodology and the Benefits Model: One of the core questions we asked is how do we determine the benefits associated with the implementation of a Process Area? This is based on the Goal Question Metric (GQM) approach [19-22] and is performed by creating a mapping between Goals (Business

Objectives) and Questions (Process Areas) using a reverse mapping between Process Areas (Questions) and Business Objectives (Goals).

Step 4 – Determine Implementation Order: This step allows us to determine which Process Areas should be implemented, and in what order, to achieve those specific business benefits. A prerequisite for this step is an understanding of what business objectives an organization wishes to achieve. This understanding may come from many sources – for example, a Six Sigma review of existing business processes. Given that an organization knows what business objectives it wishes to achieve, it must then use the map which was built up in Step 3 to determine which Process Areas contribute to the desired business objective.

Step 5 – Identification of Metrics/Indicators for Benefits: The organization has now decided which business objectives it wishes to achieve. Each potential benefit must be capable of being monitored in order to determine if the benefit is being received by the organization or not. GQM [19-22] is a well-established methodology for defining measurable goals and has been used to establish successful measurement programs in industry. Specifically with regard to the Rosetta Stone Methodology, each Goal is the analysis of a particular Benefit from the Benefits model. The Question is "what are the objective measures which can be used to determine if a benefit is being achieved?" and the Metrics are "what is going to be measured?".

Step 6 – Tracking of Costs and Returns: The final step involves tracking both the Costs and the Returns and is operational in nature. This step will typically be performed by the front-line staff involved in developing software such as the Project Management Office, the development staff, and the QA staff. Note that, as this step has not been implemented as part of this work, this step will not be discussed in Section 5.

5 Operationalization of the Rosetta Stone Methodology

Having discussed the methodology at a high level in section 4, we now present a specific instance of operationalizing the methodology.

Step 1 – Choose SPI Methodology – CMMI (Staged): In this paper, we present SEI's CMMI (Staged) methodology [23] as the demonstration SPI. It was chosen primarily as it is one of the most popular SPI methodologies in use today and is therefore widely understood and used by many practitioners.

Step 2 – Choose Benefits Model – IGSI-ISM Benefits Model: Goyal at al. [17] developed a generic for-profit benefits model, with the ultimate goal being an increase in revenues/profits and which will appeal to a broad spectrum of for-profit organizations – the IGSI-ISM model. This model, shown in Figure 2, determines 21 separate identifiable benefit areas[1], and the relationships between them. This model is

[1] We recognize that there are some benefits which are not described as we might like within this model. An example is 'Image' which should read 'Improved Image'. We have not clarified such changes in this paper.

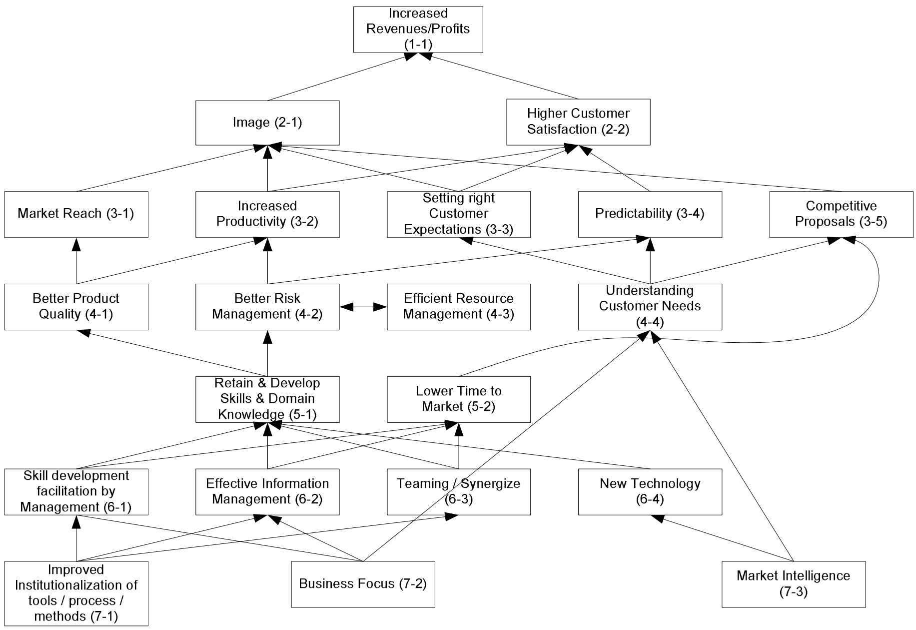

Fig. 2. IGSI-ISM ROI Model

a hierarchy of benefits – higher level benefits are derived from elements that are lower in the benefit tree. Not all benefits are equal and the model differentiates between primary and secondary benefits. A *primary* benefit of a Process Area is one that is brought about as a *direct* result of implementation of a process area where the cause and effect relationship between the Process Area implementation and the benefit is very strong. *Secondary* benefits are those benefits which have a secondary impact or which are *derived* as a result of achieving another benefit. A *Derived* benefit is a benefit which is a hierarchical ancestor of either a primary or secondary benefit. For example, using Figure 2, if Better Product Quality (4-1) can be achieved, this will lead to Increased Productivity (3-2). We refer to Better Quality Product (4-1) as a primary benefit and Increased Productivity (3-2) as a derived benefit. As Increased Productivity (3-2) is a derived benefit of Better Quality Product (4-1), it is also classed as a secondary benefit

Step 3 – Map between SPI Methodology and Benefits Model: To arrive at the mapping, each PA and its associated Generic Goals (GGs), Specific Goals (SGs), and Sub-Processes (SPs), with [24] as the reference document, were reviewed. This allowed us to determine which ones have particular relevance to the IGSI-ISM benefit model. In effect, we questioned "What objectives does this PA answer?" As a demonstration of how the mapping was created we illustrate using the CMMI Level 2 Process Area – Measurement and Analysis (MA).

Measurement and Analysis (MA)

Definition

The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability that is used to support management information needs [25]. MA consists of 2 specific goals (SG) – the alignment of Measurement and Analysis activities (SG1) and the obligation to provide measurement results (SG2). Measurement and analysis of appropriate metrics is essential in order to provide feedback to an organization on the current and potential future state of a project. SG1 provides several important specific practices (SP) to enable the benefits described below. In particular, it provides for the specification of metrics (SP 1.2-1), the specification of data collection and storage procedures (SP 1.3-1), and the specification of analysis procedures (SP 1.4-1). SG2 in general provides for the feedback loop to enable an organization to act on the results of the results obtained in SG1.

Expected Benefits

MA involves the creation and reporting of various metrics to support management information needs. Such metrics will allow a project team to review important information with regard to the progress of a project. This will allow them to adapt their strategies to most efficiently bring a project to market. Therefore, Lower Time to Market (5-2) is a primary beneficiary of MA. We identified Better Quality Product (4-1) as another primary beneficiary, as product metrics such as quality are a major factor in establishing the quality of a product. With such metrics, it is possible to alter processes and procedures to increase the quality of products. Without the ability to measure various facts, it would be virtually impossible to determine if a project is at risk. Once a project team is aware of a risk, only then can they remediate the risk. Thus MA provides a project team the ability to better manage risk. Therefore MA provides a primary benefit to Better Risk Management (4-2). Predictability (3-4) is also a primary benefit. This is because Predictability is gained when, over time, accurate measurements are taken of various aspects of projects. Only when accurate measures are available, is it possible to predict costs, times, and quality. By developing and maintaining a measurement capability within a project and organization, we will enable the organization to quantify various aspects of the whole development lifecycle. This will allow the organization to see where certain elements break down and do not live up to their full potential. As a result, the organization should be able to make appropriate changes to projects and processes to product better quality products, better manage risk, lower time to market, and increase predictability.

When we validated Measurement and Analysis (MA), both interviewees, based on their experiences, agreed with the model. With regard to the impact of MA on Better Quality Product (4-1), the first interviewee stated that, in his experience, projects that aren't measured tend to bow to pressures about release dates while the second interviewee has specific experience that shows when people are aware they're being tracked, they change their mindsets and consequently improve the quality of the product being produced. The second interviewee stated that MA impacts Predictability directly. According to him, he has seen that if you don't have historical data then "project planning is more of an art than a science."

The only non-derived (secondary) benefit of MA was Setting Right Customer Expectations (3-3). This is because one of the most important factors in setting the right customer expectations is in ensuring predictability – a product should be ready when an organization says it should be ready. One of the main elements in aiding predictability is the collection of metrics across various projects which will allow an organization to create an organizational metric database. This database will aid in increasing predictability and, as a result, help in setting the right customer expectations.

When we validated the model with two interviewees discussing each relationship, we found that

- 10 combinations are 100% compliant with the original mapping
- 6 combinations are 50% compliant with the original mapping
- 2 combinations are 0% compliant with the original mapping

There were 6 Process Area/Benefit combinations which were 50% compliant with expectations. In stating that there is a positive cause and effect relationship between MA and Competitive Proposals (3-5), the second interviewee states that it makes sense because if you measure accurately, you put just the right amount of resources in place and therefore cut down on waste. This then leads to competitive proposals. Again according to the second interviewee, there is a positive correlation between MA and Skill Development Facilitation by Management (6-1). The reason that the interviewee gives for this is that if accurate measurements are taken of the development process and specific components are buggy, the developers writing the buggy code may be identified and targeted training can then be given to the developers in question. The same interviewee also states that there is a positive correlation between MA and Teaming/Synergize (6-3) as he saw this effect in a consulting firm he worked for when low-level measurements were being taken on a daily basis. The second interviewee thought that there was a logical positive relationship between MA and New Technology (6-4).

Table 1. Post-validation Expected Benefits of Measurement and Analysis

Expected Primary Benefits	Expected Secondary Benefits
Lower Time To Market (5-2) Better Quality Product (4-1) Better Risk Management (4-2) Predictability (3-4)	Improved Institutionalization of Tools/Process/Methods (7-1) Skill Development Facilitation by Management (6-1) Efficient Information Management (6-2) Retain and Develop Skills and Domain Knowledge (5-1) Market Reach (3-1) Setting Right Customer Expectations (3-3) Competitive Proposals (3-5) Image (2-1) Higher Customer Satisfaction (2-2) Increased Revenues/Profits (1-1)

The complete list for Measurement and Analysis after validation is given in Table 1. There were 2 combinations which were 0% compliant with expectations. For the relationship between MA and Market Reach (3-1), the second interviewee did not feel she was competent to answer this question and, in order to be consistent with how weak or inconclusive answers are dealt with, the answer was deemed to be a "no." For the relationship between MA and Improved Institutionalization of Tools/Process/Methods, (7-1) both interviewees disagreed with expectations. The second interviewee's analysis was that if things are being measured and analysed, issues (if there are any) will be seen. This may in turn lead to institutionalization of new technology or methods in order to solve the issues.

Step 4 – Determine Implementation Order: In many cases, organizations are not so much concerned with faithfully implementing all CMMI Levels or all PAs as they are with achieving specific results within a mature and repeatable framework. Examples of specific results that organizations may want to achieve are Increasing Productivity and/or Lowering Time to Market.

The process to achieve this is as follows:

1. Determine which of the IGSI-ISM objectives that we wish to achieve.
2. Using the IGSI-ISM model, determine which other objectives, if any, contribute to achieving our primary objective.
3. Establish which PAs contribute to both the primary and secondary objectives and rank the PAs in order of relevance and implementation.

Determine the IGSI-ISM Primary Objective to achieve. The choice of which IGSI-ISM objective to aim for is usually determined for us by outside forces such as senior management or, in some cases, external clients. For this example we discuss Lower Time to Market (5-2).

Determine IGSI-ISM objectives contribute to the Primary Objective. From the IGSI-ISM model (see Figure 2), Lower Time to Market (5-2) depends on the lower-level objectives of Skill Development Facilitation by Management (6-1), Effective Information Management (6-2), Teaming/Synergize (6-3) and Improved Institutionalization of Tools/Process/Methods (7-1).

Determine which PAs contribute to IGSI-ISM Objectives and rank them for implementation. Based on the full analysis of RS-ICMMI, there are several PAs which have an effect on Lower Time to Market (5-2). Most organizations have finite resources and so will not be able to implement them all concurrently so we are forced to prioritize them for implementation. There are many different ways to rank them but there are two very important factors to keep in mind when deciding on an order. Firstly, more consideration should be given to those PAs that primarily satisfy a particular objective. By this we mean that those PAs that satisfy an objective as a primary objective should be given higher ranking than those that do not. For example, both Process and Product Quality Assurance (PPQA) and Configuration Management (CM) both help to us attain Lower Time to Market. PPQA has Lower Time to Market as a primary objective while CM does not. As a result, PPQA should be implemented before CM. The reasoning behind this is that PPQA fully satisfies the Lower Time to Market objective while CM satisfies the Teaming/Synergize (6-3) objective which is only a contributing objective to Lower Time to Market. Secondly, more consideration should be given to those PAs that, in the Staged Model, are lower in the Stage phases. For example, both Requirements Management and Requirements Development directly satisfy Lower Time to Market but, as Requirements Management is a Level 2 PA, it should be undertaken before Requirements Development.

Using these principles, the recommended order for implementation of four Process Areas to improve Time to Market would be:

- Requirements Management;
- Supplier Agreement Management;
- Measurement and Analysis;
- Process and Product Quality Assurance.

Step 5 – Identify Metrics for Benefits: Metrics which may be used to determine if an organization is succeeding in achieving its business objectives should be identified. A given metric may be associated with one or more benefits and a given benefit may be associated with one or more metrics. As a result, a metric may appear as an indicator for more than one benefit. For example, to measure the Better Quality Product (4-1), possible metrics include defect density at various phases in the lifecycle, costs due to lack of quality [26], loss of reputation to the firm, any lost bids, software reliability, software rate of change [27], or increase/decrease in software complexity [28].

6 Conclusion

The RSM methodology is a flexible and straight-forward methodology that can be readily and easily modified by practitioners to fit their own particular needs. The RS-ICMMI instance presented uses an industry-standard SPI model and is of immediate use by practitioners with little, if any, modification. In addition, by describing in abstract terms what a metric/indicator is, what a generic benefit/objective is, what an SPI is, and the relationships between them, the door is open for practitioners to use the model on whatever SPI initiative of choice they wish to implement. Finally, the model is highly extensible in that practitioners can add their own metrics and benefits/objectives either as replacements or in addition to the ones currently described in the RS-ICMMI implementation instance. In short, RSM model is truly a Rosetta Stone Methodology allowing personnel in the field to freely translate between SPIs, Benefits/Objectives, and Metrics.

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