# 14 MEASURING PROCESS INNOVATIONS AND IMPROVEMENTS

Anna Börjesson
*Ericsson AB and*
*IT University of Göteborg*
*Göteborg, Sweden*

Anders Baaz
*Ericsson AB*
*Göteborg, Sweden*

Jan Pries-Heje
*IT University of Göteborg*
*Göteborg, Sweden*

Magnus Timmerås
*Ericsson AB*
*Göteborg, Sweden*

**Abstract** *A major challenge in process improvement is to understand process innovation and improvement efficiency and use. How do we know that process innovations and improvements give organizational benefits? We need a mechanism for measuring. In this paper, we report from a longitudinal action research study at the telecom company Ericsson where a measurement mechanism was designed and successfully used in practice to understand, learn, and measure process efficiency. In the concrete, the measurement mechanism was built through empirical testing combined with using a goal–question–metrics (GQM) approach. The resulting measurement mechanism consists of four correlated metrics that indicate process use, process commitment, process learning, and process improvement. The same measurement mechanism can also be used to obtain feedback and evaluation, thereby allowing the organi-*

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*zation to determine process efficiency and use, and to determine the success of the process improvements.*

**Keywords** Software process improvement, process innovation, measurement, metric, GQM

# 1 INTRODUCTION

Since the early 1990s, several organizations have embraced the idea of software process improvement (SPI). SPI is, however, a very complex, resource-demanding, and long-term process where many have reported a very high failure rate (SEMA 2002). For example, Goldenson and Herbsleb (1995), in a study of 138 individuals from 56 organizations that had invested in SPI, found that 26 percent agreed that "nothing much has changed" and 49 percent declared themselves to be disillusioned. Another report by Herbsleb et al. (1994), however, reported between 500 and 700 percent return on investment from SPI. So SPI seems to be difficult, but definitely worthwhile. This leaves us with the immediate question: How do we know that process innovations and improvements give organizational benefits? We need a mechanism for measuring.

Metrics are required to understand, evaluate, take action, and follow up on progress. It is difficult to improve what we cannot measure. Dybå (2000) conducted an extensive literature review combined with a survey including 55 software companies, which revealed that one of six key factors for process improvement success is concern for measurements. This concern for measurements can also be found in Deming (1986), Grady (1997), Humphrey (1989), and Zharan (1998). Basili et al. (1994, p. 528) claim that metrics and measurement are "a mechanism for creating a corporate memory and an aid in answering a variety of questions associated with the enactment of any software process." Schaffer and Thomson (1992) argue there are six reasons why improvement programs fail and one of them is delusional metrics of success. Schaffer and Thomson promote the use of empirical testing that reveals what works in practice.

What is measurement then? The IEEE Standard 1061 (IEEE 1998, glossary) defines an attribute as "a measurable physical or abstract property of an entity." Fenton and Pfleeger (1997, p. 5) define measurement as a "process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to characterize them according to clearly defined rules." Kaner and Bond (2004, p. 4) elaborate on this definition and come up with the following definition: "Measurement is the empirical, objective assignment of numbers, according to a rule derived from a model or theory, to attributes of objects or events with the intent of describing them." Thus you measure up against a model or a theory. An example of a generally applicable model that can be used to measure against is CMMI (Chrissis et al. 2003), which defines a framework for software processes. Several examples of how to measure software processes exists. See, for example, Garmus and Herron (1995) or Florac and Carleton (1999) for discussions on the use of measurement as a means for evaluating software processes statistically. However, an alternative measurement strategy is to measure against a model tailored specifically to the needs of the organization such as GQM (Basili et al. 1994; Basili and Rombach 1988; Basili and Weiss 1984).

To define a mechanism for measuring process efficiency and use, from 2001 through 2006, we conducted a longitudinal action research project at the telecom company Ericsson. As the underlying theory we decided to use the GQM (goal–question– metric) approach defined by Basili and his colleagues (Basili et al. 1994; Basili and Rombach 1988; Basili and Weiss 1984) to define, empirically test, and iteratively improve a number of metrics for SPI. Using SPI approaches helps Ericsson improve their vital research and development (R&D) processes. The resulting measurement mechanism consists of four correlated metrics called *processment* (indicating process efficiency and use), process commitment, process learning, and process improvement. Together these four metrics give an answer to our research question: How do we know that process innovations and improvements give organizational benefits?

The study is presented as follows. Section 2 describes the theoretical context for our research. Section 3 explains the research method used. Section 4 gives an account of the study. Section 5 reports our analysis and discussions of the study performed and section 6 concludes the paper.

## 2 THEORETICAL CONTEXT

A metric can be defined as a quantitative characteristic of one or more attributes in relation to the software process, product, or project (Daskalantonakis 1992). A direct metric does not depend upon a measure of any other attribute (IEEE 1998, p. 2). Examples of direct metrics are: Number of lines of code in a program and number of defects found in a program. An example of a more complex metric is function points (Albrecht 1979; Albrecht and Gaffney 1993), which measure software complexity. Metrics can then be combined to answer more complex questions about quality and productivity increase, as for example: Number of defects/function point or number of hours/function point.

Basili et al. (1994) define a metric as a set of data, being either direct or complex. A measurement is the result of using one or several metrics to measure. In the literature, the distinction between metrics and measurements is often blurred. In this paper we have chosen to use metric and measurement as defined by Basili et al.

SPI and measurement has always been closely related. In the widely used SPI model CMM (capability maturity model), for example, "measurement and analysis" is a common feature for every key practice (Paulk et al. 1995). The newer CMMI model (Chrissis et al. 2003) has maintained this key role for measurement. In the European Bootstrap model (Kuvaja et al. 1994) for SPI, "process measurement" is one of the key features. That is also the case for the more recent ISO 15504 standard (2003, 2004, 2006). Thus measurements and model-based improvement are closely intertwined. However, an organization can also undertake SPI without a normative model. The Danish company Brüel and Kjær, for example, used existing defect reports to measure that they needed to improve requirements and testing and undertook a successful improvement program based on this measure (Vinter et al. 1998).

Measurements, however, are not only used for SPI. Measurements are a key part of software engineering. Nevertheless, the success rate is surprisingly low. Daskalantonakis (1992) found that only one out of ten industrial measurement programs were perceived to be positively successful, and Pfleeger (1993) found that only one out of three

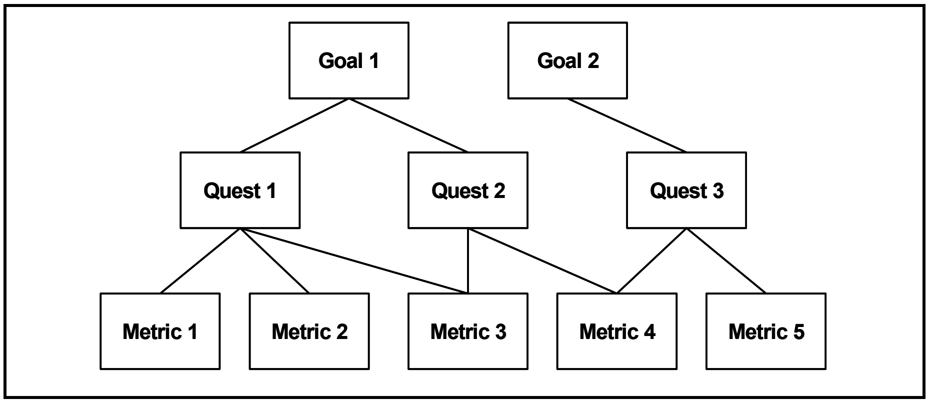


***Figure 1*. Basili, Caldiera, and Rombach's GQM Approach**

measurement programs were continued after the second year. One of the approaches that seem to have had more success than the average is GQM.

GQM (goal–question–metrics) is a measurement approach developed by Basili and his colleagues (Basili et al. 1994; Basili and Rombach 1988; Basili and Weiss 1984) at the University of Maryland in cooperation with NASA. It is built on the assumption that for an organization to measure in a purposeful way it must first specify the goals for itself and its projects, then it must trace those goals to the data that are intended to define those goals operationally, and finally provide a framework for interpreting the data with respect to the stated goals (Basili et al. 1994, p. 2). The measurement model has three levels: the conceptual level (goal), the operational level (question), and the quantitative level (metric) (see Figure 1).

The process of using GQM consists of six activities.

(1) Elicit characteristics for the organization and projects including purpose, object, issue and viewpoint.
(2) Define goals from business plan and business goals.
(3) Break down goals to questions and then to metrics. The same metric can be used in order to answer different questions under the same goal or different questions for different goals. Metric data can be either objective (depends only on object and not viewpoint) or subjective (depends on both object and viewpoint).
(4) Measure and collect data.
(5) Conduct feedback sessions where measurement data are analyzed and synthesized.
(6) Package the measurement data so they become understandable and useful.

In Figure 2, we give example (derived from our own practice) on what the outcome of a GQM approach could be.

The GQM approach facilitates the process of defining valuable metrics to related questions and goals (Mashiko and Basili 1997). It is, however, also important to be familiar with related enablers and barriers having impact on the main goal. The literature on SPI and metrics reveal several promising reasons to understand success and failure of process innovations and improvements. Below we elicit four of the more dominant explanations.

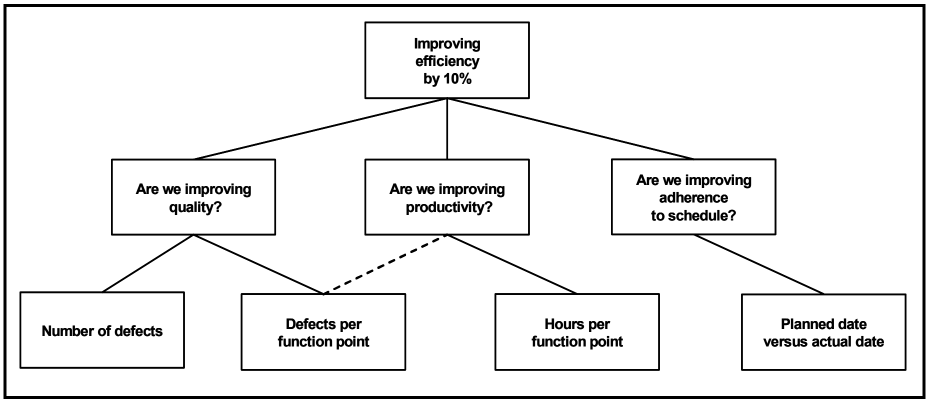


***Figure 2.* A GQM Example**

*Actual use of processes*: Delone and McLean (1992) observe that information technology use is the most frequently reported measure of IT implementation success. Seddon and Kiew (1996) have modified IT use to IT usefulness. They argue a non-mandatory usage of an innovation is a good proxy of usefulness. Abrahamsson (2000) argues user satisfaction (i.e., level of satisfaction, fulfillment of the needs, solving experienced problems, and actual use) is valued as an important indicator of successful innovations and improvements. Rogers (2003) has shown that the rate of adoption is determined by the characteristics of an innovation perceived by the potential adopter, and not whether it has produced any advantages for competitors.

*Commitment to process innovations and improvements*: Commitment plays an important role for the outcome of innovations and improvements (Abrahamsson 2001; Grady 1997; Humphrey 1989; McFeeley 1996). Wiegers (1998) claims lack of adequate management commitment is the first trap to avoid. Successful process innovations and improvements depend on the commitment to the project from both managers and software developers (Humphrey 1989).

*Ability to learn the process*: Individuals in an organization that can learn from each other facilitate reflective practice and organizational learning. Argyris and Schön (1978) view knowledge as something acquired through experience and the way practitioners work, and claim that organizational learning contributes to organizational memory. In this sense, documented and accepted processes are one important part of an organizational memory. Merriam and Caffarella (1999) argue a more constructivist approach to learning emphasizing situated cognition, meaning that organizational culture plays a key role in learning and that learning cannot be separated from the situation in which learning takes place. Brown et al. (1989) share this view of learning as a product of the activity, context and culture. Another mechanism influencing the ability to learn is communities of practice (Leave and Wenger 1991; Wenger 1998), through which knowledge is designed and can be managerially instilled.

*Progress in process improvement work*: Grady (1997) states, based on lessons learned from industry failure analysis activities, that we seldom record adequate data to understand progress. This data is vital to understand environmental aspects that have effect on potential improvements. Börjesson (2006) has shown that progress of process innovation and improvement work is an important prerequisite to process innovation and improvement success. Without this progress, there is no chance for the innovation work to become successful in the end.

## 3 RESEARCH METHOD

This study has the dual goal of both improving measurement mechanisms in practice and contributing to the body of knowledge on the same theme. Collaborative practice research (CPR) (Mathiassen 2002) supports the realization of this dual goal, while at the same time supporting the insider/outsider perspective (Bartunek and Louis 1996) that has been a beneficial aspect of this research project. Three of the authors have been working within Ericsson with measurements definitions, empirical testing, try-outs, learning sessions, and data collection during the period 2001 through 2006 and have taken the insider role. The fourth author joined the research project in the final phases, taking the outsider role and contribing with analysis, discussion, and questioning in an unbiased way. The data collection design and research method used as presented below have helped us to answer the research question: How do we know that process innovations and improvements give organizational benefits?

The study is based on action research (Baskerville and Wood-Harper 1996, 1998; Galliers 1992; Davison et al. 2004) with a focus on understanding valuable mechanisms for measuring process efficiency and use. Baskerville and Pries-Heje (1999) argue that the fundamental contention of action research is that a complex social process can be studied best by introducing changes into that process and observing the effects of these changes. The authors collected data throughout the research project in iterative cycles as defined by Susman and Evered (1978). Figure 3 describes how we related the six GQM activities to Susman and Evered's cyclical approach in this study.

Table 1 summarizes the data sources used in the study. The many different data sources have facilitated triangulation (Patton 1987; Yin 1994) and analyses in an unbiased way.

***Table 1*. Data Sources**

| Data Sources | Explanation |
|---|---|
| Direct involvement | We were directly involved in and responsible for experimental testing, execution of the survey, and the result of the surveys |
| Open-ended, semi-structure interviews | We had informal interviews and discussions with practitioners who answered the surveys and with managers responsible for acting on the results |
| Process survey working group | We presented, analyzed, and discussed both survey and results with selected manager and senior practitioners |
| Process improvement steering groups | We presented, discussed, and suggested actions for managers on regularly held steering group meetings for process improvement issues |
| Questionnaires | We authored and sent out the questionnaires as defined in Figure 4 |

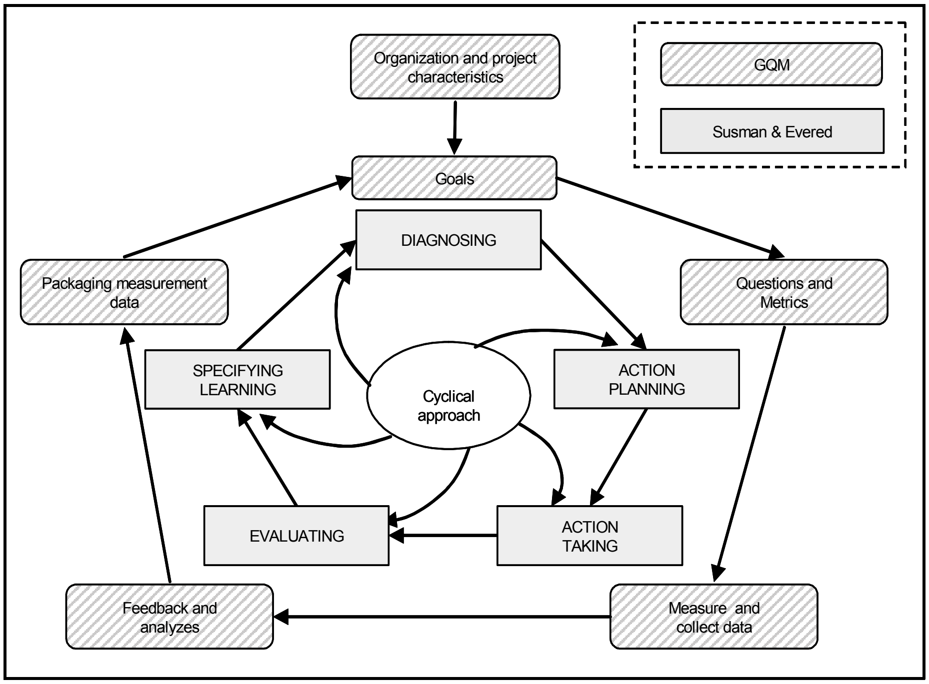


***Figure 3*. The Six GQM Activities and Susman and Evered's Cyclical Approach**

***Table 2.* Canonical Action Research Principles (Davison et al. 2004) and Our Adaptation of Them**

| Principle | Adoption in this research project |
|---|---|
| Researcher-Client Agreement | Three authors work in industry and one in academia. There is commitment from the client (i.e., Ericsson) to support academic research and the researchers are committed to research results that are useful; thus one industry author is also working in academia. |
| Cyclical Process Model | Susman and Evered's (1978) cyclical action research method (Figure 3) was used. |
| Theory Principle | The GQM approach (Basili et al. 1994; Basili and Rombach 1988; Basili and Weiss 1984) was used as theory to build up and explain the measurement mechanism. Through all learning cycles, the theory in the form of the current GQM design was made explicit. |
| Change Through Action | One of the study's dual goals was to improve the measurement mechanism in practice at the client site. |
| Learning Through Reflection | The results from surveys were regularly analyzed and reflected upon in process survey working groups and steering groups for process improvement. |

Davison et al. (2004) elicited a set of five principles and associated criteria to ensure and assess both the rigor and relevance of canonical action research. The term *canonical* is used to formalize the association with the iterative, rigorous, and collaborative process-oriented model developed by Susman and Evered which has been widely adopted and hence gained canonical status (Davison et al. 2004). Table 2 lists the five canonical principles and how we adopted them in this research project.

# 4 ERICSSON CASE

This section describes our case, the action research cycles we went through, and the learning elicited. We have organized the case according to the six activities in the GQM process: (1) organization and project characteristic, (2) goals, (3) questions and metrics, (4) measure and collect data, (5) feedback and analyses, and finally (6) packaging measurement data.

## 4.1 Organization and Project Characteristics

Ericsson is a worldwide telecommunication company developing products and services for the global telecommunication market. The R&D unit within the company consists of more than 16,500 employees. In most of the R&D development projects, there will be hundreds of employees working together for several months using globally and locally defined processes to facilitate efficiency in the product development. The R&D processes are vital for the company to stay competitive in a global market. SPI is a well-used approach to improve the R&D processes within Ericsson.

## 4.2 Goals

A measurement mechanism is necessary to stay focused on SPI and continuously improve the R&D processes. Measuring SPI and R&D efficiency is, however,a major challenge depending on several factors such as data collection difficulties (Humphrey 1989), system complexity (Albrecht and Gaffney 1993), and system size (Flaherty 1985; Humphrey 1989; Jones 1993, 1994). Figure 4 describes how Ericsson systematically has worked to overcome these measurement obstacles and define a measurement mechanism to understand and improve both SPI progress and R&D process efficiency and use. Each action research cycle (ARC) contributed to the goal of finding a measurement mechanism valuable for understanding Ericsson's SPI progress and R&D process efficiency and use. The main goal was discussed during the nine ARCs, but never changed. This indicated a strong will from the organization to understand and improve SPI progress and thereby the R&D process efficiency and use.

## 4.3 Questions and Metrics

Ericsson wanted to ensure that valuable SPI initiatives made progress and that the R&D processes were efficient and used. They also wanted to know how they could facilitate the actual use of their processes. To deal with these questions, Ericsson started to send

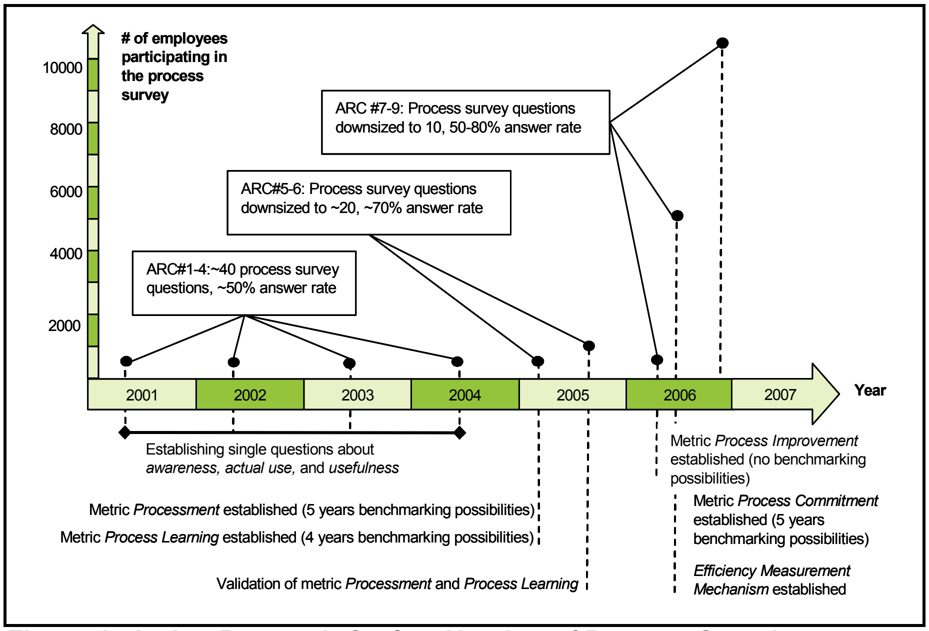


***Figure 4*. Action Research Cycles, Number of Process Questions, Answering Rate, and Established Metrics**

out process survey questions to their employees. In the first ARC in 2001 (ARC#1), approximately 40 questions were defined based on three perspectives: awareness about the process, actual use (Delone and McLean 1992) and opinion about its usefulness (Seddon and Kiew 1996). The questions were also defined to understand change agent communication, process training satisfaction, and practice support. Initially there was no intention by the process survey project to combine questions into predefined metrics.

Six-point bipolar Likert scales were used for the majority of the process questions. A few process questions had nominal scales or only yes–no alternatives. Previous research indicates that reliability is highest when using five-point scales (Dybå 2000). The reason for using even-numbered scales was that our experience from other surveys in the same organization showed that a large number of the respondents only used the middle alternative. In order to get more information from these respondents, we choose the six-point scales, which require them to take a stand for either the negative or positive side.

During ARC#1 to ARC#4, we found it important to stabilize the questions to attain benchmarking effects over time, thereby obtaining commitment to the process survey. The number of process questions were, therefore, relatively stable (approximately 40) during this period. To further increase the answering rate and facilitate analysis of the result, we decreased the number of questions to approximately 20 in ARC#5. In ARC #5, the metrics *processment* (based on a combination of four of the survey questions) and *process learning* (based on a combination of two of the survey questions) were established. The definition of processment and process learning were inspired by Sigurd and Tedsjö (2005). Ericsson defines processment as "how Ericsson employees know, follow, get support from and get process material from the R&D process they are expected to use." Likewise, process learning is defined as "how Ericsson employees believe they can learn from others and how they believe others can learn from them in the R&D process." In ARC #6, we used the same number of questions, but for a larger population of people to validate the usefulness of the defined metrics. There was a positive correlation between the increase in processment and units where successful process improvement work had been executed.

To further facilitate analysis of the result, we decreased the number of questions to 10 in ARC#7. In ARC#7, the metrics *process improvement* (based on a combination of two of survey questions) and *process commitment* (based on a combination of two of the survey questions) were established. Ericsson interprets process improvement as "how Ericsson employees believe they perform R&D process improvement work where it is needed that are good" and process commitment as "how Ericsson employees believe in the R&D process and how they feel their organization promote the R&D process."

In ARC#8, the measurement mechanism for process efficiency and use was established. It was based on the 10 process survey questions composed into the four established metrics. No survey questions contributed to more than one metric. The measurement mechanism was also statistically tested and the result showed a strong correlation between processment and the three other metrics. The three constructs process commitment, process learning, and process improvement are determinants of processment. Based on a thesis work using the PLS-Graph tool for statistical analysis (Enskog 2006), we have calculated that the three constructs explain 76 percent of the variance of processment where numbers greater than 49 percent indicate strong correlation. Finally, in ARC#9, the same 10 survey questions was sent out to approximately 10,500 employees and the measurement mechanism (i.e., the four established metrics) was calculated and communicated to 168 different units.

Figure 5 presents the 10 process survey questions, the resulting metrics, the selection criteria, and how the measurement mechanism was described and deployed within Ericsson. A measurement mechanism had been established as a model to understand, improve, and follow-up R&D process efficiency and use.

## 4.4 Measure and Collect Data

For ARC#1 to ARC#4, we used a web-polling tool developed and maintained in-house by the process survey project. This home-made web-polling tool was used only for the process survey and no alignment or prioritizations were needed. For ARC#5 to ARC#8, another web-polling tool developed and maintained by Ericsson in general was used. Fortunately, web-polling solutions evolved during the early years of this decade, which meant that the work for the process survey project regarding using the new Ericsson web-polling tool was very limited.

In ARC#1 to ARC#5, the process survey was sent to approximately 500 employees. In ARC#6, the process survey was sent to approximately 1,000 employees. Two units, each consisting of 500 employees, participated in the survey to try out and unify the newly established metrics processment and process learning. In ARC#7, the process survey was again sent to 500 employees (one of the development units) to pilot the newly defined measurements process improvement and process commitment. In ARC#8, the

| Metrics | Process Survey Questions |
| --- | --- |
| Processment | Q1:I am familiar with the R&D process I am expected to follow<br>Q2:I think I work according to the R&D process I am expected to follow<br>Q3:I think the R&D process I am expected to follow supports me in my work<br>Q4:I use the R&D process I am expected to follow to get the process material I need in my work |
| Process Commitment | Q5:I think the R&D process I am expected to follow is needed<br>Q6:I feel that my organization promotes the use of the R&D process I am expected to follow |
| Process Learning | Q7:I think I have good enough knowledge in the R&D process to help my colleagues<br>Q8:I have colleagues with good enough knowledge in the R&D process to help me with solving problems |
| Process Improvement | Q9:I think my organization does R&D process improvements where it is needed<br>Q10:I think my organization does R&D process improvements that are good |

The metrics are calculated from the positive half in the Likert scale (4, 5 or 6) of the process survey questions

o1 o 2 o 3 o 4 o 5 o 6

Fully Disagree Fully Agree

The questionnaire includes 3 selection criteria:
- State which unit you primarily contribute to
- State which area you work primarily with
- State which documented R&D process you are primarily expected to follow
- *Organization found through connecting survey answer with Ericsson Global Directory*

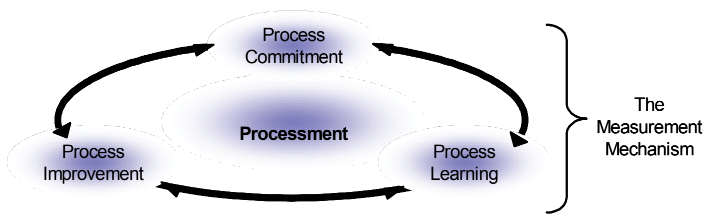


***Figure 5.* The Survey Questions, Metrics, Selection Criteria, and Resulting Measurement Mechanism**

process survey was sent out to a broader Ericsson community, most of them working in Sweden, Ireland, Germany, and Spain (approximately 5,000 employees) to pilot the full measurement mechanism as shown in Figure 4. Finally, in ARC#9, the process survey was sent out to an even broader Ericsson community. It is planned that the process survey will be sent out biannually to establish benchmarking both for specific units and for Ericsson R&D as a whole.

## 4.5 Feedback and Analyzes

The result was analyzed through first identifying the positive (1–3) and negative (4–6) halves of each question (see Figure 5). Each metric was then analyzed through combining two or four questions. For example, the metric process commitment was calculated through the positive half of question five and the positive half of question six. This resulted in the metric explaining how many percentages were positive to both question five and question six (i.e., process commitment).

The feedback and analyses of the results changed focus during the study from process orientation to a management tool to deal with process efficiency and use. In ARC#1 through ARC#4, the analyses were made by process engineers. The results of the analyses were then communicated to management by the process engineers. Typically an analysis was made by looking at single questions, benchmarking questions over time, and, in some cases, also through combining questions; for example, questions about use and questions about skills. In ARC#5, the analysis involved managers and senior engineers. A special group, headed by the process survey project, was assigned to analyze the result. The result of this analysis was communicated to management and management then communicated the result to employees and suggested unit-specific actions to deal with the result. The same analysis group and procedure was used in ARC#6 and ARC#7.

In ARC#8 and ARC#9, the result was analyzed by both management teams and process engineers up in the organizational hierarchy. The four metrics in the measurement mechanism were calculated for 74 organizational units in ARC#8 and 168 units in ARC#9, that is, all units having 20 respondents or more (at least 20 respondents secured employee anonymity). The process survey project was responsible for driving the process survey project, sending out the survey, collecting the data, communicating the result to management, and maintaining the result. The calculation and communication of the result to the many different organizational units was important as the units operate based on several different processes. The units needed their specific result from the process survey to fully understand their own situation.

Management teams responsible for units up to 1,000 employees coordinated and made sure the result was communicated and actions were taken. The process survey project was still responsible for analyzing and giving feedback on the overall R&D result. The most valuable part was to get managers to reflect on how processes actually were used and how efficient they were. Statements from managers such as "It does not surprise me that my test engineers have such a low result" and "I'm happy to see that my initiatives to improve our way of working pay result" strengthened the belief in the result shown in the measurement mechanism. The measurement mechanism also revealed some less expected results. It was, for example, surprising to see how many employees felt a personal commitment to processes compared to how they believed their organization promoted the use of processes. Management has rather often argued the opposite (e.g., "our employees believe documented processes are not needed"). Furthermore, when making qualitative studies of specific units to understand the relation between ongoing SPI initiatives and metrics, we come to understand that there was an obvious correlation between the metric process improvement and ongoing SPI initiatives. We could find both increase and decrease in process improvement, which correlated to increase or decrease in SPI efforts.

## 4.6 Packaging Measurement Data

In ARC#1 through ARC#4, the process survey project packaged the metrics into a Power Point presentation available only for the process engineers. The presentation was approximately 100 slides. Selected parts of this package were made available for management through process improvement steering group presentations. These smaller presentations

| Q5: I think the R&D process I am expected to follow is needed | | Q6: I feel that my organization promotes the use of the R&D process I am expected to follow: Negative (1-3) | Q6: Positive (4-6) |
|---|---|---|---|
| | Positive (4-6) | 25% | 30% |
| | Negative (1-3) | 20% | 25% |

***Figure 6*. The Metric Process Commitment (Note that numbers are fabricated)**

were available for all affected employees, but the result was not formally communicated to them.

In ARC#5 through ARC#7, the result was again packaged into PowerPoint presentations. The presentations were, however, downsized to approximately 30 slides focusing on the established metrics and benchmarking between units and over time. This downsizing and focus aimed to increase usability and understandability of the result in order to facilitate communication and action taking. It was also a natural result of fewer questions to analyze. In ARC#8 and ARC#9, the result was packaged into three different PowerPoint packages aiming to fulfill the communication needs for different target groups: one presentation of approximately 20 slides summarizing the overall R&D result, one presentation with approximately five slides plus one slide per unit having their own result as described in Figure 5, and one complete presentation of approximately 50 slides for the process engineers and upwards in the organizational hierarchy. This packaging of the results was defined and agreed upon before the process survey in ARC#8 was sent out. The communication packages were well received by the organization. Figure 6 shows how the process commitment metric was described in the communication packages.

One thing that we considered was whether there was any "self-selection" evident in the survey responses. Stated another way, were the people who took the time to respond to the survey exactly the ones who were the most "committed" and thereby unrepresentative of the population as a whole? As said earlier, we had a 50 to 80 percent response rate. We had many very positive but also quite a few very negative answers. Thus our closer-look analysis did not reveal any self-selection to be evident.

## 5 ANALYSIS AND DISCUSSION

Jeffery and Berry (1993) found four aspects to be of equal importance when evaluating the success of a measurement program: context, inputs, process, and product. *Context* refers to the organizational context in which the measurement program is situated. *Input* is about resources that go into the program. *Process* is the method used for designing and using the measurement program. *Product* is the outcome in the form of measurement data, reports, etc. In this section, we use these four aspects to analyze and discuss the success of the process survey project and to answer the research question: How do we know that process innovations and improvements give organizational benefits?

## 5.1 Context

Ericsson needed a measurement mechanism to understand and improve both SPI and R&D process efficiency and use. This Ericsson goal did not change over time, even though it was iterated, questioned, and discussed.

The stability of the goal throughout the ARCs implies to us that the goal was well defined and based on relevant organizational needs. We believe *the well-defined goal* contributed to a successful measurement mechanism. This belief is supported by Gopal et al. (2002), who used industry-wide survey data and regression testing to determine the influence of factors that may affect the success of a measurement program. They found the factor goal alignment to have great influence on success.

If the goal had been changed several times or contested by different stakeholders in the organization, then the suitability of our chosen GQM approach could have been questioned. But it worked very well for us in this case.

## 5.2 Inputs

The resources used in the process survey project did not change over time. Some were added, but there was a core of employees (two of the authors) that stayed current during the entire project. This made it possible to stabilize the questions and to attain benchmarking effects over time. Three of the four established metrics in the measurement mechanism were possible to analyze based on four or five years of benchmarking (see Figure 4). The combination of the same dedicated resources involved and the benchmarking possibilities facilitated receiving commitment to the process survey. It is well known that successful improvement initiatives are highly dependent on commitment (Abrahamsson 2001; Humphrey 1989). We believe *the use of the same resources throughout the process survey project* and *the longitudinal benchmarking possibilities* contributed to a successful measurement mechanism.

The process survey project did not spend any major efforts on what tools to use to collect the data. There was no discussion and prioritization about what features to include in the tool. We believe *the effort not spent on tools issues* contributed to a successful measurement mechanism.

The process survey project used an iterative approach to empirically test and try-out what worked in practice. Schaffer and Thomson (1992) argue empirical testing that reveals what works in practice is a useful approach to increase understanding of what works best. It was also possible to see a positive correlation between the increase in metrics and units with ongoing improvement initiatives. The measurement mechanism helped Ericsson measure whether process innovations and improvement gave organizational benefits or not. We believe *the iterative approach using empirical testing* contributed to a successful measurement mechanism.

## 5.3 Process

The GQM approach (Basili et al. 1994; Basili and Rombach 1988; Basili and Weiss 1984) helped us to structure and evolve the measurement mechanism. Figure 7 describes

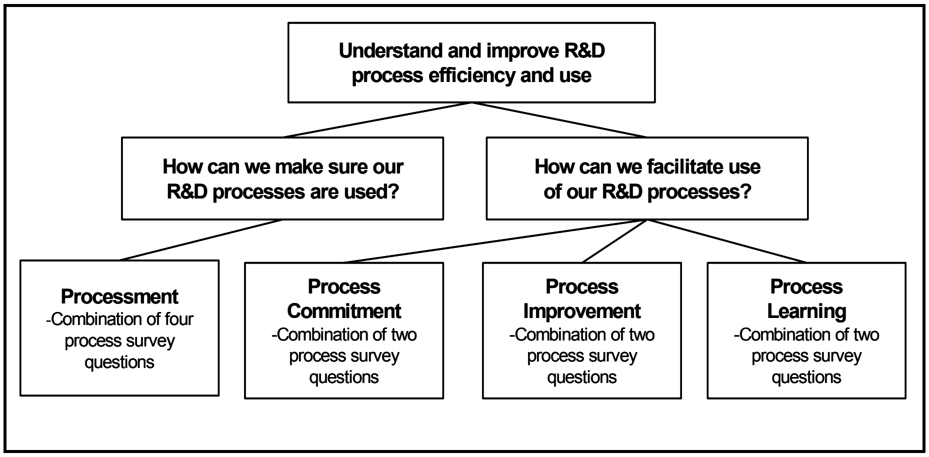


***Figure 7*. The Ericson GQM Adoption for Evaluating Process Efficiency and Use**

how the GQM approach was adopted and used to identify valuable metrics for process efficiency and use.

The main goal for Ericsson was to understand and improve R&D process efficiency and use. SPI was the preferred approach to execute these improvements. The main goal represented the conceptual level in the GQM approach. The goal was then refined into two questions: How can we make sure our R&D processes are efficient and used? How can we facilitate use of our R&D processes? These questions represented the operational level in the GQM approach. Each question was then, based on empirical testing, refined into metrics. These metrics represent the quantitative level in the GQM-approach. We believe *the use of the GQM approach to structure and evolve a measurement mechanism* contributed to a successful measurement mechanism.

## 5.4 Product

The four metrics were empirically tested in practice and established as described in Figure 4. In parallel, as the metrics were established, the SPI and SPI-related literature focusing on improving software processes like Ericsson's R&D processes strengthened the belief in the importance of each metric. IT use and IT usefulness (Delone and McLean 1992; Seddon and Kiew 1996) strengthened the belief in processment. The importance of management commitment (Abrahamsson 2001; Grady 1997; Humphrey 1989) strengthened process commitment. Process learning was strengthened by organizational learning (Argyris and Schön 1978; Merriam and Caffarella 1999). Finally, process improvements was strengthened by the importance of progress reporting in SPI (Börjesson 2006; Grady 1997). The close relation between each metric and its relevance in the literature facilitated communication of the measurement mechanism. We believe *the strong correlation between the established metrics and established factors for successful process improvement* contributed to a successful measurement mechanism.

The four metrics in the measurement mechanism were calculated and deployed, as described in Figure 5, in as many as 168 organizational units in ARC#9. Managers analyzing the result believed in the result as shown through the measurement mechanism. They recognized similarities between the metrics and their own perception of the process efficiency and use situation. There was also, in ARC#6 and ARC#7, an identified positive correlation between the increase in processment and units where successful process improvement work had been executed. During the entire action research study, managers have been interested in viewing and interpreting the results from the process survey. The measurement mechanism, in both ARC#8 and ARC#9, was also well received by the organization when the result was communicated. We believe *the recognized similarities between the metrics results and reality* contributed to a successful measurement mechanism.

Furthermore, the measurement mechanism helped identify previous misunderstandings about personal and organizational commitment to processes. We believe *the recognized misunderstanding related to process commitment* contributed to a successful measurement mechanism.

Finally, the metrics process commitment, process learning, and process improvement explained 76 percent of the variance of processment. We believe *the strong correlation between the metrics in the measurement mechanism* contributed to a successful measurement mechanism.

## 6 CONCLUSIONS

This six-year action research project at the telecom company Ericsson aimed at answering the research question: How do we know that process innovations and improvements give organizational benefits? Ericsson wanted to improve both SPI progress and their R&D processes. The study answered the question by defining a successful measurement mechanism consisting of four correlated metrics. The use of this measurement mechanism made it possible for managers to understand the effects of process innovation and process improvement efficiency and use. Taking a step back we can summarize our lessons learned as follows:

We believe

- *the well-defined goal,*
- *the use of the same resources through-out the process survey project,*
- *the longitudinal benchmarking possibilities,*
- *the effort not spent on tools issues,*
- *the iterative approach using empirical testing,*
- *the use of the GQM approach to structure and evolve a measurement mechanism,*
- *the strong correlation between the established metrics and established factors for successful process improvement,*
- *the recognized similarities between the metrics result and reality,*
- *the recognized misunderstanding related to process commitment, and*
- *the strong correlation between the metrics in the measurement mechanism*

all contributed to a successful measurement mechanism, which then led to organizational benefits for Ericsson.

Finally, what can others learn from this study? First, a weakness in action research is the lack of specificity around how theory should be kept explicit through the action research cycles (Baskerville and Pries-Heje 1999). To overcome this weakness we found that the GQM approach worked well to make theory explicit and to update the theory when reflecting on the learning at the end of each action research cycle. Thus, in answering questions on benefit and improvement or similar questions, companies can use the GQM approach.

We believe the measurement mechanism with the four metrics (see Figure 5) is directly useful for other organizations pursuing improvement and asking the "does it pay off?" question. The usefulness of each of the four metrics will be as follows:

- Processment can be used as a measure of the quality of the process diffusion activity, in that it measures the degree to which employees have access to processes, know them, follow them, and are supported when doing so.
- Process commitment can show the extent to which employees have belief in the process and feel that the process is promoted by the organization.
- Process learning can show the extent to which employees believe they can learn from others and vice versa.
- Process improvement shows the employee perception of how they carry out relevant improvement work.

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## About the Authors

**Anna Börjesson** has more than 10 years of practical experience working with software development and software process improvement. She has been working at Ericsson since 1998. Anna holds a Ph.D. in Software Process Improvement from the IT University of Göteborg. Anna is also a member of ACM and IEEE. She can be reached by e-mail at anna.borjesson@ericsson.com.

**Anders Baaz** joined Ericsson in 1993. He has been manager of a broad range of disciplines. In 2002, he was appointed general manager for the Mobitex business. At present he works with measuring operational excellence in development projects and processes. He holds an M.Sc. from Chalmers University of Technology in Gothenburg. Anders can be reached by e-mail at anders.baaz@ericcson.com.

**Jan Pries-Heje** is professor at Roskilde University, Denmark, and part-time at the IT University in Gothenburg, Sweden. Jan's main research interests are information systems development, software engineering, and software process improvement. He has carried out action research with industry on specific topics such as process improvement, high-speed software development, and metrics. He can be reached by e-mail at jan-pries-heje@ituniv.se.

**Magnus Timmerås** is an SPI change agent at Ericsson AB in Gothenburg, Sweden. Magnus has 10 years of experience working with SPI and SPI-related areas. He holds a B.Sc. in Psychology from Stockholm University and a University Degree in Electrical Engineering from Chalmers University of Technology (Gothenburg). He can be reached by e-mail at magnus.timmeras@ericsson.com.