

Experience Report: Using Internal CMMI Appraisals to Institutionalize Software Development Performance Improvement

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Abstract

Critical to any successful performance improvement initiative is to achieve a state of continuous or institutionalized improvement. Some improvement can happen quickly, but long-term improvement is typically a matter of sustaining focus. This requires an infrastructure that keeps activities focused and drives them forward. In ABB, the IDEALSM model is used as a guide for setting up improvement activities in development centers. Central to the IDEALSM model is the diagnostic activity, i.e. the evaluation of current performance in the unit against a suitable reference model. Over the last eight years, ABB has used diagnostics in the form of internal CMM/CMMI appraisals to lay the foundation for improvement activities. In this experience report, the use of internal appraisals as a means for sustaining improvement focus will be discussed. Experiences and lessons learnt, as well as some of the specifics of ABB's internal appraisals will be presented.

1. Introduction

ABB, a global leader in power and automation technologies, has been developing industrial software products for more than 30 years. Over the years, several steps have been taken to transform ABB into an organization recognized for its software product development excellence. Key in this transformation is the use of the Capability Maturity Model Integration (CMMI) [1][2] and its companion IDEALSM model for organizational improvement [3], both from the Software Engineering Institute (SEI).

Using structured process improvement methods is a well-documented path towards increased maturity in product development organizations and different kinds of diagnostic activities play a critical role [5][6][7]. Over the last eight years, a number of different approaches to performance improvement have been used in different parts of the organization. Today, performance improvement activities are supported by a centralized team of experts through the ABB Software Process

Initiative (ASPI). The ASPI team is also responsible for coordinating all internal appraisal activities. A series of papers have accounted for the exploration of the use of internal CMMI appraisals within ABB, as a mean to establish an institutionalized improvement process in software development organizations [4].

So far, studies within ABB have established that the use of internal appraisals, although limited in scope and non-intrusive to the appraised organization, represents an effective means for establishing an improvement process.

We have also proposed ways to adapt the methodology based on the current state of the appraised organization. More specifically, the impact of organizational maturity and willingness to accept external intervention on how to approach an individual unit was explored.

Further, as capturing and maintaining the interest of the relevant stakeholders is of essence for a sustained improvement effort we explored how appraisals could be scoped to accommodate stakeholder involvement. It was found that by appropriately scoping appraisal activities, proved effective in maintaining sufficient focus on lower maturity process areas, thus avoiding unnecessary false starts.

Lately, our focus has been on finding ways of making sure that appraisal results are properly taken care of and used as a foundation for improvements.

Throughout this work, we have also shared the experiences and lessons learnt from ABB. In this paper we report on our experiences from using internal appraisals to institutionalize a continuous improvement process.

Section 2 of this paper gives a short background to the use of internal appraisals in ABB. Section 3 explains the specifics of our internal CMMI Appraisal Methodology, Section 4 provides some quantitative data that we have collected on our appraisals activities and Section 5 provides insight into the experiences we have made and the lessons we have learnt. Finally, Section 6 summarizes where we stand and the questions that remain to be answered regarding the use of internal appraisals to institutionalize software development performance improvement.

2. Software Process Improvement in ABB

The IDEALSM model, shown in Figure 1 represents the recommended work model for initiating, planning, executing, reviewing and evaluating performance improvement activities in development units. It consists of five phases, each serving a specific purpose in institutionalizing an improvement process. Here, focus will be on the Diagnose phase.

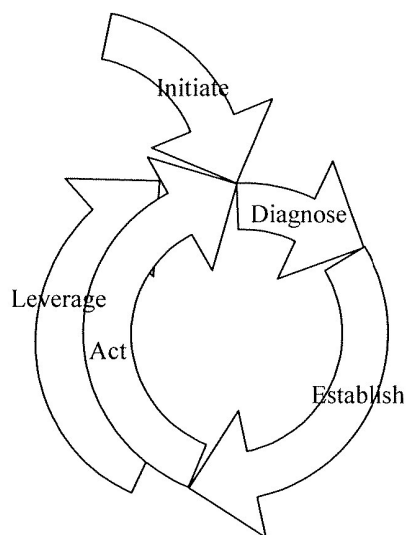


Figure 1: The IDEALSM model, adapted from [3]

The purpose of the Diagnose phase is to compare current organizational performance against a reference model, such as the CMMI, and to identify the most important areas of improvement.

As diagnostic findings are fundamental to the subsequent improvement activities, it is of utmost importance that the diagnostic activities are highly reliable and valid.

In ABB, the CMMI is the preferred reference model and, hence it is used in our internal diagnostic activities, i.e. our internal CMMI appraisals. Internal CMMI appraisals serve multiple purposes in ABB. The most important is to provide a sound basis for prioritization and planning of improvement actions, but appraisals also provide an effective way to identify good practices that can be shared between development sites. In addition, internal appraisals are useful in preparing units that are aiming for a formal demonstration of a CMMI level. Finally, appraisal results can of course also be used to compare individual development centers with each other to identify which is the more mature. However, a note of caution is in place regarding comparing units based on appraisal results, as too much focus on comparison might

reduce chances of successful improvements, as it can have a negative effect on the quality of collected data.

3. Internal CMMI Appraisal Methodology

An appraisal is an examination of one or more processes that an organization does to and for itself for the purposes of process improvement. It is conducted by a trained team of professionals using an appraisal reference model as the basis for determining strengths and weaknesses [1].

The Appraisal Requirements for CMMI (ARC 1.1) [9] defines three classes of appraisals (Class A, B and C). All three classes are used in ABB and they all display different strengths and weaknesses [6]. Class A appraisals are the most comprehensive, but require substantial resources and may be considered very intrusive by the organization being appraised. As the number of Class A appraisals performed so far in ABB and hence the available data, is quite limited, these will not be addressed any further in this paper. Class B appraisals are less comprehensive and consequently less intrusive, but still require considerable resources. Finally, Class C appraisals are the least comprehensive, but again require fewer resources and are less intrusive. The comprehensiveness of the appraisals of course influences the reliability and validity of the appraisal results. Table 1 summarizes the main characteristics of the different appraisal classes.

Table 1: Appraisal Class Characteristics

Class of appraisal	A	B	C
Size of appraisal team	8-10	3-4	1-2
Appraisal time	10 days	3-4 days	1-2 days
Minimum # of data collection methods	3	2	1
On-site interview required	Yes	Yes	No
Cost	High	Medium	Low
Intrusiveness	High	Medium	Low
Validity	High	High	Low
Reliability	High	Medium	Low

In ABB, a set of formal requirements have been established that regulates the way internal CMMI appraisals are performed. These requirements apply to the actual appraisal methodology itself, but also to the team members that participate and/or lead the appraisals. Further, a number of steps have been taken to increase the quality of our appraisals:

- 1) The methodology has been thoroughly documented.
- 2) Criteria for leading and/or participating on an appraisal team have been defined.
- 3) All appraisal team members have received extensive training, both from external providers and internally.
- 4) Team members from different countries rotate between appraisal teams to synchronize interpretation of the reference model.
- 5) Experiences are shared between teams.
- 6) Appraisal data, e.g. scope, planning effort, onsite duration, # interviews, etc., are collected and analyzed to fine tune the process.

The reason for enforcing strict requirements is of course to maintain an appropriate level of integrity of the appraisals. Although the prime purpose of the appraisals is not to compare units within ABB with each other, it is inevitable that results may come to be used this way. Therefore, taking steps to protect the integrity of the appraisals is necessary. Conducting the appraisals with appropriate levels of integrity also helps secure the benefits of using internal appraisals.

A diagnostic activity typically consists of three phases: 1) The Planning Phase. 2) The Data Collection Phase. 3) The Deliberation and Reporting Phase.

During the Planning Phase the lead appraiser is responsible for developing a detailed plan for the Data Collection and the Deliberation and Reporting Phases. This involves scoping the appraisal, identifying the interviewees, deciding on interview questions, solving on-site logistics etc. This phase also includes training the appraisal team.

During the Data Collection Phase, the appraisal team uses a variety of techniques to gather data on the current state of the appraised organization. Techniques typically include questionnaires, document reviews, interviews, and process modeling, and can be conducted both on-site and remotely. The typical scenario is that questionnaires and/or document reviews are conducted prior to going on-site and interviews are then used while on-site to elicit additional information as well as confirming findings from the pre on-site data collection.

Finally, during the Deliberation and Reporting Phase, all the collected data is analyzed and aggregated into appraisal findings. Findings are then prioritized and reported back to the organization. Ideally, reporting back to the organization also entails some form of workshop on how to proceed based on the reported findings.

Based on experiences from over 40 internal appraisals, the ASPI team has developed several useful tools and practices that support the three phases of the appraisal process and help make appraisals more efficient and effective. In the following paragraphs, some of these practices are more thoroughly described.

3.1. Planning Phase Specifics

To ensure proper and consistent planning of appraisals, a detailed Planning Template has been developed. The appraisal plan identifies goals and objective of the appraisal, as well as the scope, i.e. what part of the organization and what projects that will be appraised. The plan also introduces the appraisal team members and the process areas that will be evaluated. Further, the plan identifies the roles and responsibilities that are involved in the appraisal, including the functional area representatives to be interviewed. The plan also details all the steps and activities that will be carried out as part of the appraisal, including pre on-site, on-site and post on-site activities. Finally, the plan contains a schedule for the on-site period, detailing the individual interview sessions, participants, interview rooms etc. Sometimes, the plan also contains a list of typical documents or work products that will be analyzed during document reviews. The list serves as a help to the unit being appraised in preparing for the appraisal.

We have found that using the Planning Template has improved the quality of our appraisals. Primarily, because it helps clarify objective and expectations, as well as roles and responsibilities, but also because it helps ensure that nothing is overlooked when preparing for the appraisal.

To support the interview sessions, a complete set of specific and generic interview questions have been developed for each process area in the CMMI. The questions are kept in an Interview Question Database and are designed to help elicit enough information from the interviews to enable proper evaluation of CMMI process area practice implementation. Today, the database consists of approximately 200 individual questions.

The standard set of interview questions has helped the internal appraisals in several ways. The development of the questions turned out to be an excellent opportunity for competence development, as it required an in-depth understanding of the process areas. Once in place, the set of interview questions now greatly facilitates preparing for the interview sessions. The set of questions is also continuously reviewed and improved based on experiences from the appraisals.

To support the scheduling of interviews, an Interview Planning Matrix has been developed. The matrix identifies all the functional areas that are involved in an appraisal and the number of specific and generic interview questions (collected from the interview question database) that are necessary to cover in-scope process areas. This way, it is easy to identify the number of questions per interview and how much time is needed for that interview.

Fundamental to the appraisal methodology is of course the competence of the appraisal team and in particular the lead appraiser. Apart from the general training that all members of the ASPI team have taken, the lead appraiser

Question	Practice	Interviewee	Response
1. Please state your name, and describe your position and the specific activities you perform on your job.	N/A	3	Section Manager for development of 3D models, maintenance drawings, I CAD
2. Please describe how the scope of the project is defined for assigning effort, schedule, and responsibility.	SP 1.1	1	Project manager's planning, he tries to find the project opportunities.
3. Please explain the Project Life Cycle Model used for development of the product.	SP 1.3	2	Not involved in the project

Figure 2: Excerpt from an Interview Form

is responsible for training the appraisal team in preparation for each individual appraisal. This training covers the tools and templates used within ABB, specifics on the appraised organization and the projects in scope, as well as some fundamentals of the appraisal methodology. Appraisal team training is especially useful for any local representatives included on the team.

3.2. Data Collection Phase Specifics

The result of an appraisal very much depends on the quality of collected data. As interviews often represent the major source of data-it is important to make these as effective as possible. One issue facing lead appraisers is reluctance on the part of the interviewees to be open and honest. In ABB, appraisals are primarily used as a basis for improvement and consequently, if interviewees do not feel that they can be open and honest in the interviews, the whole point of the appraisal activity is lost. In our appraisals we emphasize that the result of the appraisal remains the possession of the local unit and we use a formal Confidentiality Agreement, signed by the local sponsor and all of the appraisal team members, to visually emphasize that interviewees can feel protected during interviews.

During interviews, a projector is used to show interviewees the questions at the same time as the question is asked by the lead appraiser. This way, interviewees can see the questions and think about their answers as other

interviewees are speaking. We have found that this is an effective way of keeping the attention of interviewees, even when groups grow bigger. Of course the lead appraiser can add details to the question or explain the meaning of the projected question if it is perceived as unclear. This is extra relevant if the appraisal is conducted in an organization where English is not the native tongue.

As the lead appraiser conducts the interview, remaining team members take notes using special Interview Forms that have been generated using the Interview Planning Matrix and the Interview Question Database. An excerpt from an Interview Form is shown in Figure 2. Forms allow team members to take notes in a way that helps efficient tagging, i.e. mapping of individual and relevant pieces of data to the specific and generic practices of the CMMI.

The appraisal team is divided into several mini-teams, each responsible for a set of process areas. The mini-team concept allows delegation of some of the responsibilities that normally lie on the lead appraiser. In particular, the mini-team is responsible for ensuring that enough data is being collected to confidently evaluate their process areas and advise the lead appraiser if special attention should be given to particular interview questions. Further, the mini-teams are responsible for tagging their notes between interviews and at the end of the day. Tagging is done using special Observation Forms, one for each process area, in which relevant data is replicated from the Interview Forms. An excerpt from an Observation Form is shown in Figure 3.

CMMI Practice	Tagged Data from Document Reviews	Tagged Data from Interviews	Compliance Evaluation	Observations
SP-1.3	Define the project life-cycle phases upon which to scope the planning effort.	FAR1	High	+Several life-cycle models are used (v-model, waterfall-model, gate model, integration points) to scope the planning effort. -Inconsistent use of life-cycle model.
		5		Lifecycle in Project Plan RR-C-ACAD-9xxx-xxx Lifecycle described in project documentation (ID:xx-xx)
		6		The gate model MRC are used on some projects.
		5		The gate model and the v-model
		5		Waterfall The gate model (It is not a development life-cycle model)

Figure 3: Excerpt from an Observation Form

Practice	Equl	PP	PLM	MA	SAM	PPQA	CI
Specific: Ges11							
SP1.1	High	Medium	Medium	High	High	High	High
SP1.2	High	High	Medium	High	High	High	High
SP1.3	High	Medium	High	High	High		High
SP1.4	High	Medium	High	High			
SP1.5	High		Medium				
SP1.6			High				
SP1.7			Medium				
Specific: Ges12							
1		High	Medium	High	High	High	High

Figure 4: Excerpt from a Compliance Matrix

3.3. Deliberation and Reporting Phase Specifics

Care must be taken to make the appraisal results as reliable and valid as possible. In ABB, a multi-step deliberation process is used to turn collected data in to reliable and valid observations. First, each mini-team is responsible for generating draft observations for their process areas, based on the Observation Forms generated when tagging notes. Care is taken to be as specific as possible relative to the CMMI practice, i.e. accounting for what the organization is actually doing in support of the process area practices and what is missing that might put them in jeopardy. The mini-teams also propose a Compliance Evaluation, i.e. a color code and a confidence level, for each individual practice. The color code represents the appraisal team's view of the organization's current implementation of the practice (Green: full implementation, Yellow: partial implementation and Red: no implementation), and the confidence level indicates how certain the team is that the color code is correct.

Next, the work of the mini-teams are reviewed for consensus in the entire appraisal teams, to allow remaining team members an opportunity to add, alter or subtract from the proposed observations and Compliance Evaluations.

After reaching consensus on the Observation Forms, the mini-teams, go back and generate draft Final Findings, which then go through the same review for consensus as the Observation Forms. Final Findings are used during the feedback presentation to the organization and represent an aggregate of what has been found during the appraisal. The feedback presentation also contains the Compliance Matrix, i.e. all the individual Compliance Evaluations put together as a snapshot of the organization's current state. An excerpt from a Compliance Matrix is shown in Figure 4.

We have found that many times the Final Findings are too aggregated to function as a meaningful basis for improvement planning. Instead, we put a lot of effort into making the Observation Forms as detailed and informative

as possible. The Observation Forms are sanitized, i.e. all information that can be traced back to an individual interviewee is removed, before they are handed over to the organization as the main result of the appraisal.

The final responsibility of the lead appraiser is to report on the appraisal activity in the ASPI appraisal database. The report consists of the appraisal plan and the appraisal results for future reference, as well as a set of pre-defined measurements. The measurement data is later analyzed and used for planning future appraisals.

4. Appraisal Data

Based on the data that are reported at the conclusion of all internal appraisals, we have aggregated a few metrics. Data is reported in Table 2 for Class B and Class C appraisals.

Table 2: Class B and C Appraisal Data

<i>Class B Appraisals</i>	<i>Class</i>	<i>Min</i>	<i>Mean</i>	<i>Max</i>
Size of Organization	B	6	90	210
[# Development Staff]	C	12	44	140
Ratio of Organization	B	15%	56%	100%
Interviewed	C	0%	25%	60%
Appraisal Team Size	B	3	5	8
[# Persons]	C	1	2	3
# In-scope Process Areas	B	2	7	10
	C	1	5	10
Planning Effort	B	10	70	130
[Hours]	C	2	28	85
Data Collection Effort	B	42	134	280
[Hours]	C	3	31	108
Deliberation and Reporting	B	24	70	126
Effort [Hours]	C	3	30	114

It is obvious from the data that it contains great variation, but there is also consistency in the expected differences between Class B and Class C appraisals. For example, Class B appraisals are rather used in larger organizations, whereas Class C appraisals are preferred by

smaller ones. It is also clear that the Ratio of Organization Interviewed is higher for Class B appraisals.

As can be expected, Class B appraisals spend a greater portion of the total effort in the Data Collection Phase, compared to Class C appraisals.

It can be noted that for both Class B and Class C appraisals, a substantial part of the total effort is spent on planning. We feel that the benefits of good planning more than motivate the planning effort.

5. Experiences and Lessons Learnt

Based on the internal appraisals that have been conducted so far within ABB, we have come up with a quite extensive list of experiences and lessons learnt. Here, we will share our top ten on that list:

1. *Never underestimate the power of a good plan*

Successful appraisals require solid planning. Our data suggests that we spend up to 30% of the total appraisal effort on planning. This is effort well spent as it helps make sure that we don't run into any critical problems when the team is on location.

2. *Local representatives on the team facilitates logistics*

Involving a representative of the local organization on the appraisal team ensures easy access to documentation, effective logistic arrangements, and, not least important, someone that fully understands the background of the appraisal results and quickly can step in as the carrier of the information.

3. *Growing and nurturing a network of trained appraisal team members require some effort.*

It takes time to build a competent and motivated appraisal team. Generally, more than one set of appraisal team members is also needed, as conducting appraisals requires traveling and long hours. Appraisals also have a tendency to cluster during certain parts of the year. Maintaining a network of skilled professionals like this requires a long-term plan and committed leadership.

4. *Open and honest interviews require communication and integrity.*

Effective data collection requires a trusting relationship with the individuals of the appraised organization. This requires clear communication of appraisal goals and appropriate levels of confidentiality, as well as enough integrity to maintain that confidentiality. We also emphasize that any results of the appraisal activities remain the possession of the local unit, and that we will never spread appraisal results without the explicit consent of the appraisal sponsor.

5. *Good tools help*

Tools help the process, but they are not the process. We use simple forms to collect, structure and aggregate our data and observations. This helps us, but can never replace the competence of the individual team members.

6. *Standard set of questions has pro's and con's*

The Interview Question Database is very helpful in planning and preparing for the interviews. However, if the set of questions is not continuously reviewed and improved as our experience grows it can easily have a conserving effect on data collection.

7. *Don't miss out on the opportunity to do some training.*

Appraisals represent an excellent opportunity to increase the knowledge and understanding in the organization, not only for the actual process areas, but also for continuous improvement. This rare moment when you have the full attention of the development staff is a chance to influence people's perception of improvement and should not be wasted.

8. *Good appraisal results are easily wasted without immediate action.*

An appraisal activity represents a major undertaking in any organization. As such, it creates a lot of energy and a lot of expectations that need to be channeled properly to benefit the organization. If appraisal results are not promptly acted on, not only will the effort invested in the appraisal be wasted, but there might also be great frustration among the members of the organization.

9. *Don't force feed an organization that isn't ready.*

Although you yourself might be convinced that the CMMI is a proven path to success and that internal appraisals are instrumental in achieving that success, you have to adapt to the needs and conditions of every individual unit.

10. *Make sure that appraisal results are as detailed and actionable as possible.*

We have found that chances of successful use of the appraisal results are greatly improved if individual observations are detailed enough to be truly actionable. It must be obvious to the appraised organization what needs to be done to address a reported weakness. Therefore, we put a lot of effort into Observation Forms.

Of course, there are many additional experiences, and our list of things to remember is continuously added to. However, the ten points above will get any aspiring appraisal team off to a good start.

6. Conclusions and Future Work

In conclusion, we have found strong support for the positive impact of the use of internal appraisals on the success rate of improvement activities. In particular, we have witnessed how regularly recurring appraisals, whether of Class B or Class C, have helped maintain a critical mass of improvement activity in our development units. We have seen sustained vitality of improvement activities, where normally improvement was regarded as “something that would go away soon”. This way, our internal appraisals have very much contributed to the institutionalization of a continuous improvement process.

However, there is a pressing need to further reduce the costs of performing the appraisal and to some extent also reduce their intrusiveness. Further, as maturity increases the appraisal methodology must facilitate evaluation of a greater number of process areas, without becoming too bulky. All, while increasing reliability and validity of the results. This dilemma makes for an interesting area for new research and development of new and improved appraisal practices.

Another area of interest is how to avoid creating perceived appraisal attrition in the organizations, i.e. ways to keep the appraisals current and acceptable to the people involved.

With this paper, we hope to contribute to increasing the efficiency and effectiveness of internal appraisals, with increased reliability and validity as a result.

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