Applying and Adjusting a Software Process Improvement Model in Practice: The Use of the IDEAL Model in a Small Software Enterprise

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ABSTRACT
Software process improvement is a demanding and complex undertaking. To support the constitution and implementation of software process improvement schemes the Software Engineering Institute (SEI) proposes a framework, the so-called IDEAL model. This model is based on experiences from large organizations. The aim of the research described here was to investigate the suitability of the model for small software enterprises. It has therefore been deployed and adjusted for successful use in a small Danish software company. The course of the project and the application of the model are presented and the case is reflected on the background of current knowledge about managing software process improvement as organizational change.

Keywords
Software process improvement, improvement models

1 INTRODUCTION

Software process improvement is a demanding and complex undertaking. To support the constitution and implementation of software process improvement schemes and projects, the Software Engineering Institute (SEI) proposes a framework, the so-called IDEAL model, which consists of five phases and which provides a structured approach for continuous improvement.

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This model is based on the SEI's experiences with their governmental and industry customers in the US. These are usually very large organizations. However, most software enterprises, even in the US, but more so in Europe and other parts of the world, belong to the category of small and very small software enterprises. Yet, although vital for both academics and practitioners in the field, insights about software process improvement in general and the use of such a model as IDEAL in minor organizations is still scarce (as exceptions, see for example [1], [2]).

The work presented in this article wants to contribute to that body of knowledge. We have therefore investigated the suitability of the IDEAL model for small software enterprises and report our experiences of deploying the approach in a young and small Danish software company. The approach was tailored to meet the organization's needs and this resulted in the successful completion of a first improvement cycle.

The aim of the undertaking was to change the practices in the involved organization, thus the research approach applied falls into the category of action research [3]. The authors participated, each to a different extent, actively in the process as change agents and mentors for the intended alterations. In addition to the involvement in the project, observations, informal conversations, formal interviews, official meetings and document studies were used as methods for collection of the data, on which this article is based.

The article is structured as follows. In the next section the IDEAL model is explained in more detail. Then, the course of the project and the application of the model are presented. Finally, the alignment process and the content of the adjustments and their impact on the improvement project as a whole are discussed and the case is reflected on the background of current knowledge about managing software process improvement as organizational change.

2 THE IDEAL MODEL

The IDEAL model has been developed by the SEI [4]. The objective of the model is to provide a path of actions that constitute a software process improvement program. The model defines five phases: the Initiating phase, the Diagnosing phase, the Establishing phase, the Acting phase, and the Leveraging phase. Each phase consists of up to 10 tasks and some tasks comprise 5 or 6 subtasks. The main activities in each phase are as follows:

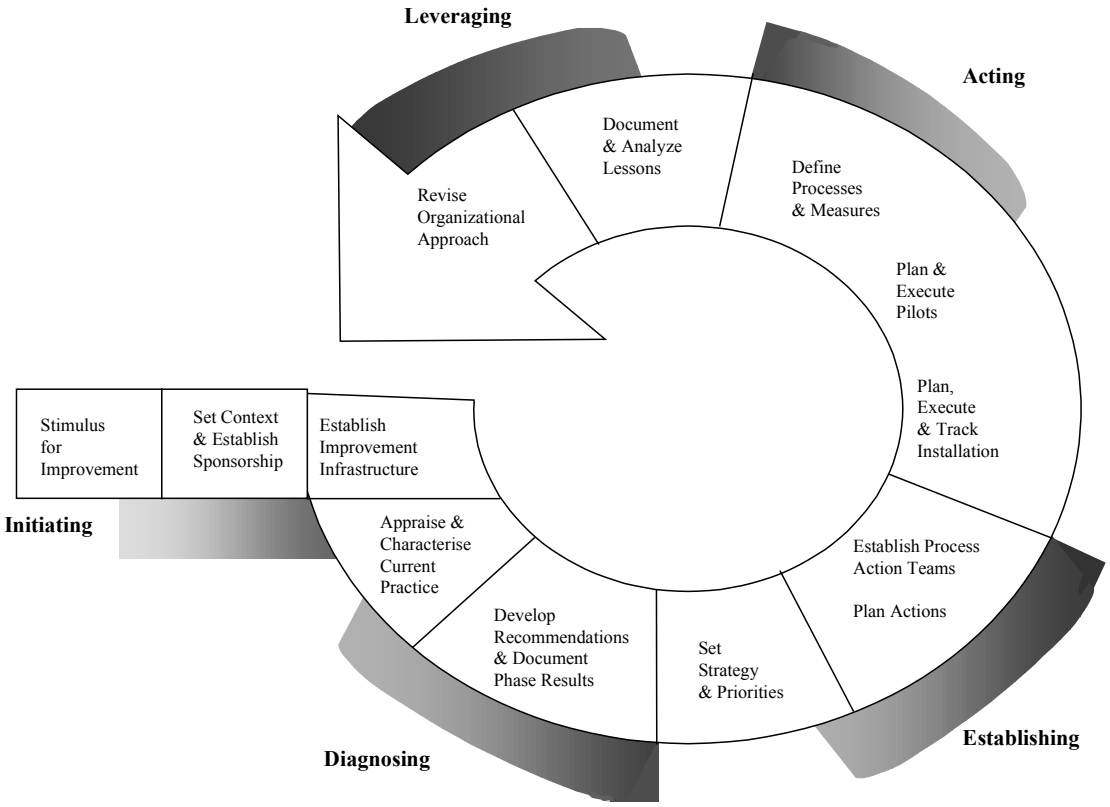

Figure 1: The Ideal Model

In the Initiating phase an improvement infrastructure is established, the roles and responsibilities are initially defined and initial resources are assigned. The general goals of the initiative based on business needs are defined and a management steering group and a software engineering process group are typically established. In addition, an initial improvement plan to guide the organization through the next two phases is created.

In the Diagnosing phase appraisal activities are performed to establish a baseline of the organization's current state. The results and recommendations from the appraisals are included in a first version of an improvement action plan.

In the Establishing phase, the issues that the organization has decided to address are prioritized and strategies for pursuing the solutions are formed. The action plan draft is completed and measurable goals and metrics to control goal achievement are developed.

In the Acting phase solutions, which address the areas of improvement discovered during the Diagnosing phase are created, piloted, and deployed throughout the organization. In the Leveraging phase the information collected in the earlier phases, lessons learned, and metrics on performances, are evaluated to make the next pass through the IDEAL model more effective. By doing this, adjustments of the strategy, the methods and the infrastructure used in the SPI program can be performed.

This description, which is a very brief summary of a 220-pages long, very detailed document, the above included graphical representation of the phases, and the tasks' presentations in process flow charts as a series of activities in the user's guide, suggest a sequential course through all phases and tasks.

Such a sequential pass is indeed recommended as a best case scenario. However, it is acknowledged that "real-life events prevent organizations from following a set sequence" – a formulation that seems to convey an attitude, where deviations from a model are seen as a problem rather than an opportunity. Therefore, it is expected that organizations will, respectively must tailor the steps to their particular situation and it is affirmed that the boundaries between the phases are not as clearly defined as shown in

the graphical representation of the model. Furthermore it is indicated that many activities can be pursued in a parallel fashion.

Little advice is however given of how to tailor the approach and which factors and their interdependencies have to be taken into account other than that the adjusted methodology has to fit an organization's vision, business objectives and resources.

The model is based on the SEI's experiences with their governmental and industry customers, which are usually very large organizations. However, most software companies belong to the category of small and very small enterprises. Therefore, insight about the use of such model as IDEAL in minor organizations is vital, but still scarce.

The work presented here wants to contribute to that body of knowledge. We have investigated the suitability of the IDEAL model for small software enterprises and report our experiences of deploying the approach in a small Danish software company.

3. THE CASE

The company NP was founded in early 1997 by 2 persons, with a business and an IT background, respectively. The company's business idea is to pursue a solution for the problem of how to present 20000 warehouse items on a 14'' screen through a slow network in a fast and structured way.

At the start of the investigation in early 1998 it had 25 employees of whom 15 were directly involved in software development and the rest in business administration, marketing, and sales. The two founders function as management. Software development is roughly divided in 2 divisions of the same size: A production division, which delivers standard intra- and internet solutions. This division generates the company's income for the time being. It consists besides software developers also of operational - network administration - staff and art designers.

The other part of the organization's operation is largely financed by public money and takes place in the other division, which is called research and development. It deals with *the* future product of the organization.

It is this division, which is in the main focus of our investigation. During the period of time, which is described here, the first version of the product was still under development, though some of its modules underwent internal integration tests already.

The work in this division is rather project-oriented. Two project leaders function as coordinators for a varying number of subprojects where the employees, in groups of 4 – 5, perform all sorts of development tasks. These project groups often only exist for a short period of time and are dissolved when the problem, which led to the establishment of the subproject, is solved. To solve these problems quite regularly also members, especially the art designers, of the production group are involved.

From the start, the organization showed an originative interest in quality and quality management matters. In addition, the company's economical foundation is for a limited period largely based on EU support for the development of new businesses. In its business plan, which functions as a contract with the sponsor, the organization has committed itself to create a quality assurance group or division and it is determined that some of the support actually has to be used for this objective.

Management therefore, continuously explores the market both with respect to improve the product and to improve its business processes and took contact with the university[1] as they had heard about research there concerning software process improvement.

This set the stage for the first period of an ongoing improvement project. Here we report our experience with the deployment of the IDEAL model during a 10 weeks period in 1998: one week initiating, three weeks diagnosing, and six weeks establishing and acting in parallel. Leveraging, respectively learning, took place throughout the whole period.

The improvement project is still going on and is subject of a longitudinal study.

3.1 The Initiating Phase

As a consequence of the initial contact, a start-up meeting between company management and university personal took place. On that meeting management stated their vision for their organization as a company known for high quality products based on professional craftsmanship. Therefore they wanted to have all basic work practices established and kept under control as soon as possible, especially with regard to the expected increase of personal. The researchers explained how an improvement project could look like.

As a result, it was determined that two researchers should be hired as full time consultants for an initial 10 weeks project with options for extension to start a process improvement initiative. One project leader was directly assigned half time to the project.

The consultants' first tasks were to prepare a contract and to draft a general improvement plan to be discussed at an introductory meeting 2 days later. The contract comprised the mutual commitments between management and consultants, in particular resources, which the organization was willing to use. It was for example determined that each

[1] At the time of performing the study, all three authors were members of the Department of Computer Science at Aalborg University, Denmark.

employee was granted at least 90 minutes interview time for an appraisal. The first version of the improvement plan, which served as a project plan contained preliminary descriptions of the objectives for the project, of possible approaches and of a time schedule. The plan was inspired by the known Plan-Do-Check-Act cycle and as a more concrete refinement of this approach the course of the work was oriented tentatively at the IDEAL model.

At the introductory meeting management and both project leaders participated and the documents were discussed. The consultants gave a short introduction into software process improvement in general and – due to the organization's earlier stated interest in the US marked - specifically into CMM-based improvement[2].
The overall objectives as stated by management gave the initiative a long-term perspective. To establish a short-term perspective as well, these were refined on that meeting. Whereas management was most attracted by a quantitative profile of the organization with regard to CMM level 2 and general project and quality management practices, the project leaders were most interested in concrete project planning and estimation techniques. Also at the meeting expectations concerning the effort could be clarified and adjusted. Management had hoped that getting the practices in place would only take some weeks and had a hard time understanding that this would take at least a year.

After the meeting, the need and conditions for and the benefits of process improvement were clear for management and project leaders. They were therefore well equipped to inform the other employees why such a project was relevant for all of them. The improvement plan was refined and contained now a goal description based on the CMM level 2 processes, and a concise schedule for an appraisal and the resulting establishment and enactment of the actual improvement activities during the 10 weeks period. The plan also included a proposal for the establishment of a small software engineering process group (SEPG) to define, monitor and track the course of the project. This group was formally approved and from then on consisted of the project leader and the two consultants. A first SEPG meeting was held directly after the introductory meeting to prepare an orientation meeting for all employees.

At that meeting all employees were informed about the project, management communicated the objectives and their origin and introduced the consultants who gave a presentation on software development, its problems and possible solutions.

The developers could identify themselves with many of the problems described. There was a consensus among the developers that something should be done to improve the work practices and they were looking forward to the initiative to be implemented. The whole initiating phase took a total of one week.

3.2 The Diagnosing phase

In the diagnosing phase a tailored CMM-inspired approach [5] was chosen to perform a development process specific appraisal and a more general organizational analysis. The two project leaders filled in a questionnaire especially designed for CMM level 2 assessments and 6 people were interviewed before and after the questionnaire sessions, in all 7 out of 11 employees involved in R & D tasks were directly involved in these activities. In addition, documents were reviewed and observations were made.

The questionnaires, which were filled in while the consultants were present for necessary clarifications, delivered the basic material for the requested, quantified profiles. The answers from the questionnaires were then supplemented and substantiated by the interview results.

Concerning the interviews it is important to know that we asked the employees what they experienced as problems and not what a model like the CMM defined as a potential problem area. This approach uncovered problems, which were outside the direct scope of the CMM, but invaluable for a professional, improvement-oriented organization. An example here was the meeting culture. Many meetings were hold, but resulting information was not communicated to all relevant persons. There was a lack of structure and documentation rules. Other results were the lack of an overall life cycle model, of project estimation routines and of code documentation. It has to be mentioned that during the interviews the employees did not only describe the status quo, but also made significant proposals for improvement. Finally, the interviews had the effect that the consultants and employees got to know each other, which facilitated the further cooperation.

The document reviews either delivered further evidence or uncovered other problems. An example was that both questionnaires and interviews postulated that detailed time schedules were produced as part of the planning. The documents showed however that no data was kept after revision of plans about the old plans and the reasons for the change. Another example was the above-mentioned meeting culture. The document review revealed that no minutes of the decisions were taken.

The general organizational analysis unveiled as described above a project-oriented organization in which a creative, dynamic, energetic and at times hectic atmosphere prevailed. Project groups emerged frequently on an ad-hoc basis and were determined by the situations.

The company can be characterized as a simple structure where the directors determine the overall scope and frame,

[2] In the context of this article it is assumed that the reader is familiar with the basic concepts of the Capability Maturity Model (CMM).

take the strategic business and product related decisions, negotiate deadlines with account officers and the project leaders, and control and co-ordinate that commitments and contracts are kept. They expect that everyone takes responsibility, can see the company's aim and works for a common interest. They decide what has to be done, but not how it has to be done. The management style is management-by-walking. The project leaders keep overview over the technical tasks and achievements and the developers have a relatively large liberty and right of self-determination. They have technical responsibility and decisions concerning detailed technical problems as well as the purchase of tools are taken autonomously by them. They show commitment and motivation and often work overtime.

An open office landscape mirrors the organization's wish for an open and relaxing atmosphere where the employees can develop a feeling of community and security, and which supports internal communication and in a natural way a co-ordination mechanism of mutual adjustment. Finally, to support this culture, the organization employs to a great extent young, newly graduated staff with an education both in information systems or computer science, who have no 'bad' habits and who are open for innovations.

The initial assessment with interviews and questionnaires itself took one week, while writing the full report based on additional collection of evidence through the documents reviews and observations took another 2 weeks.

The assessment report [6] concluded that NP was a typical level 1 organization with relative strengths in project tracking and oversight and in project planning, and some control over requirement management. Weaknesses were found for configuration management and quality assurance. This however was partly related to the fact that the organization only worked on the first version of its product and had not reached the test phase yet. Besides the CMM related findings, the report contained the identified problems from outside the model and a list of recommendations for both areas as well as a slightly refined plan for action.

Finally, the outcome of the investigation was presented to the organization on two meetings. Initially, the report was exposed to management in a 2 hours session and after they had accepted and approved the document, the results were introduced to all employees. On that meeting first the overall maturity profile was shown. Then, the most acute and concrete problems, whose solution was judged by the SEPG to be a precondition for any CMM-related improvements and whose settlement was considered to have a direct effect on the organization, were presented.

All improvement proposals were without further prioritization discussed by placing them in a concrete life-cycle model. The spiral model was used for this purpose and showed to be most appropriate for the organization's situation.

This approach illustrated that fast progress was possible and made the relationship between the individual findings and recommendations visible. It supported a holistic understanding of the situation and the necessary actions, and provided an overall structure for all development and improvement activities.

Although three weeks without any action seem to be a long time, the consultants - as they were present every day in the organization - could keep the momentum going. This was manifested in the next two phases.

3.3 The Establishing Phase

The transition between this phase and the preceding one was somehow blurred. The presentation of the diagnosis results went, as described above, beyond a mere account of possible improvements: it contained the distinction between acute problems and principle – process-centered - problems and utilized a particular model to explain their relationship and their effect. These were both used again during the performance of the three main tasks the SEPG worked upon in this phase, namely a further refinement of the improvement proposals, a prioritization of the proposals and the development and documentation of the final plan for action.

The leading principle for the subsequent processing of the improvement proposals was to avoid too much bureaucracy in the form of extensive documentation and of numerous inspections, reviews and audits, but to still keep in the range of the CMM.

The governing parameters for the prioritization were to delimit extra economical resources and to delimit the additional workload for the employees. Through placement in the now known life cycle model for the product development it had become clear which improvement proposals fitted best to which development activities. Thus, due to the fact that the next actual life cycle activity in the development project was testing the first version of the product, quality assurance which had been judged weak got the highest priority together with the actual introduction of the life cycle model. As a result the CMM-related, process-centered improvements and those problem-centered improvements, which fitted into the life cycle, were planned such that they followed the organization's life cycle for (the) product development.

As a result of this phase a report including a detailed improvement and action plan was produced and delivered at the end of the 10 weeks period. The establishment phase took a total of six weeks. Many of the subtasks were performed in accordance with the IDEAL model. Yet, explicit reviews of the organization's vision and business plan were judged to be not necessary as these had been

discussed only a few weeks earlier. In addition, the report did not comprise a concrete metrics program. This was considered too early given the fact that the organization first should establish some basic processes. Instead a proposal for the establishment of routines to gather both qualitative and quantitative knowledge was included. In contrast to the IDEAL model where a distinction between problem-centered and process-centered improvement is first introduced for the acting phase, such a differentiation took already place here and was helpful in constituting the improvement plan.

The work tasks in this phase were also influenced by the fact that the SEPG and the participants of the meeting where the diagnosis results were presented judged two of the acute problems as so important that they immediately after the meeting founded two technical working groups with the approval of management to solve these problems. This concerned the lack of meeting structure and meeting guidelines and the lack of code documentation routines. Thus no proper prioritization and long-term plans for these activities were developed.

As a consequence an unforeseen, direct transition from the diagnosis phase to the acting phase to deal with these issues took place and in parallel work was performed in both phases.

3.4 The Acting Phase

The first activity in the acting phase, which can also be considered as an establishing activity was the founding of the two working groups (TWGs – Technical Working Groups in terms of the model) which should work with two of the acute problem areas.

In accordance with the organization's work routines, all meeting participants, thus all employees of the R & D department were in line with their own preferences assigned to one of the two temporary project groups. The SEPG members scheduled dates for first group meetings and appointed one person as responsible for the preparation of that meeting. The SEPG members also participated in the first meeting of each group. The 'meeting' group needed two more sessions to develop a solution, whereas the 'code documentation' group only met once more.

Finally, on a common meeting the two groups informed each other and accepted the prepared proposals. The whole process took one week and the remaining time was used to pilot and to implement the new routines. No special action had to be taken for these tasks as all employees had been involved in the definition process.

At the end of the period two new groups, a 'life cycle' group and a 'quality assurance and test' group, were established who documented their work in two short reports. However at the end of the 10-week period none of the routines, and thus no process-centered and CMM-related improvement had been implemented. This has however happened afterwards and a life cycle model, quality assurance, configuration management, project planning and measurement routines are now in use [7].

3.5 The Leveraging Phase

A distinct leveraging phase in the sense of the IDEAL model did not take place as part of the first 10 weeks period. Learning happened of course during the whole project and the lessons learned were already collected during each phase.

After the original project period however, the two process improvement specialists evaluated the whole process and produced an additional report [8]. The report stated that the only improvement, which really had been institutionalized were the meeting performance rules as all meetings now had an agenda and minutes. In the beginning everyone followed the code documentation guidelines, but after a while some employees stopped using them. According to one project leader this was due to time pressure and lack of control. In general, management liked things as little bureaucratic as possible, whereas the developers themselves would have liked a little more formalism.

Nevertheless both groups considered the project a success and the lessons learned, together with a refined action plan have been used to continue the improvement effort of the organization and to introduce the new, above mentioned processes and procedures. More then a year after the initial project, the two process improvement specialists are still full-time employed by the company and work there as process improvement specialists.

4. DISCUSSION AND CONCLUSION

In the preceding sections we have presented a successful software process improvement endeavor. To perform the project activities the IDEAL model has been applied and adjusted. The IDEAL model guide [4] itself recommends tailoring the approach to fit the organization's resources, their visions and their business objectives. In the following we want to revisit the case and discuss in more detail which adjustments were made, which criteria guided that process and in which environment this took place. In doing so, we want to emphasize what lessons other, especially small organizations can learn from the case.

The first lesson for small organizations, which wish to perform improvement activities, is that it makes sense to use a structured model to organize the process. The second lesson is that is makes sense to adjust the model to the particular conditions of the organization; and the third lesson is that it makes sense to perform the improvement activities as a project with clearly assigned and documented roles, responsibilities and resources.

The IDEAL model stresses these features. It is suitable for tailoring and the case demonstrates how such tailoring can look like in a concrete situation.

Resource assignment was taken seriously at NP and was performed according to the organization's objectives and capabilities and thus was no major problem. Two process improvement specialists were hired full-time, one project leader was assigned half time to the SEPG and all developers were granted time to participate in the project. Resources were scarce in terms of time, the organization wished first results in a short time period, and thus the whole first improvement cycle was determined to be 10 weeks. For the actual implementation of some of the improvement proposals, resources were more critical. Therefore, they were planned in such a way to cause as little additional work for staff as possible.

Instead of the organization's vision and business objectives, more concrete structural and cultural elements were the shaping forces. Structurally, the fact that the organization was comparably small with a relatively flat hierarchical configuration and short communication ways, and culturally that it was open, energetic, dynamic, fast reacting, action-oriented enterprise geared towards fast results played a major role.

In this respect two adjustments were most significant. The IDEAL model proposes to first distinguish between problem-centered – easily identifiable, fast fixable, short term effective – and process-centered – key process area related, long-term effective – issues in the acting phase. In contrast at NP this distinction was already introduced at the end of the diagnosing phase. It was used to present all findings in a meaningful way and to rapidly prepare potent actions.

This lead to the second adjustment. For the problem-centered issues, no separate establishing phase other than forming the TWGs was necessary and the establishing phase for the process-centered issues was run in parallel to the acting phase of the problem-centered issues.

Concerning the use of the model within the individual phases, the tasks' and subtasks' lists were taken as guidelines and checklists to secure that all important questions had been taken into account rather than procedures which had to be followed sequentially and fully as the IDEAL document recommends for a perfect course of activities.

As mentioned earlier, due to the short time interval between the initiating phase and the establishing phase, some of the review tasks of the latter phase were judged unnecessary by the improvement specialists. Another example can the found in the initiating phase itself where a separate Management Steering Group was found dispensable as the required information was exchanged through the daily contact between management and all projects, and most wanted meetings could easily be arranged without an additional organizational structure. The model's request for education in this phase was also adjusted. As the employees were well educated with university degrees, only two theoretical lectures to familiarize them with the basic concepts of software process improvement were needed.

This reinforces that the project took place in an environment characterized by openness and a high level of education, which was well suited for innovation, change and improvement [9]. Beyond the adjustment of general models, Kautz [10] points out the significance of factors like management support and commitment, project planning and organization, education and training, assessment, monitoring and evaluation, staff involvement, support and knowledge transfer by external consultants, usability and validity of the introduced changes and cultural feasibility for process improvement in software organizations.

Taking these factors adequately into account, is another lesson to be learned by small organizations.

Many of the factors can be found in the organization independently from the IDEAL model; some of them like management commitment and teamwork were strengthened; others like project planning and staff involvement were made explicit and thus supported by the model; whereas yet others would not specifically be fostered by the model. IDEAL, for example, recommends to assess the climate for software process improvement and suggests as a consequence to develop strategies to reduce barriers, to manage resistance, and to increase the organization's capacity for change, but leaves open how this could be done.

This brings the discussion finally to the wider context of the IDEAL model as part of an organizational change strategy. Borum [10], f. ex., distinguishes between a technical-rational and a humanistic change strategy and describes their main dimensions.

In the technical-rational strategy, the objective of change is effectiveness and efficiency and organizations are seen as production systems. To achieve the aim, the change agents, namely management and analysts, apply re-design and rationalization methods which are often imposed on production units to accomplish better output in quantitative terms.

In contrast, in the humanistic strategy, the aim is to adjust the work milieu and to adopt novelties and innovation in organizations, which are seen as hierarchical, diverse, but nevertheless open, social systems. The change agents, primarily management and process consultants, apply reflection and learning processes and modify interaction and communication channels. The targets are groups, which, to accept changes in behavior, norms and artifacts, are informed, involved and trained.

The IDEAL model can definitely be used within both strategies. Due to the characteristics of the organization, in

the case of NP, the application of the humanistic change strategy seemed most adequate. One might speculate whether embedding the IDEAL model in a less fitting strategy would have lead to the same positive results.

However, applied in the right context with the appropriate adjustments, it showed to be apt and fairly flexible for the organization of a software process improvement endeavor in a small enterprise; it supported the project and provided a framework for a smooth performance of all respective activities.

As such it provided further insights about software process improvement in small organizations and might serve as an inspiration for other companies.

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