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Measurable Software Quality Improvement through Innovative Software Inspection Technologies at Allianz Life Assurance

Authors:

Bernd Freimut
Brigitte Klein
Oliver Laitenberger
Günther Ruhe

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Fraunhofer IESE is directed by
Prof. Dr. Dieter Rombach
Sauerwiesen 6
D-67661 Kaiserslautern

Abstract

The development of high quality software satisfying cost, schedule, and resource requirements is an essential prerequisite for improved competitiveness of life insurance companies. One major difficulty to master this challenge is the inevitability of defects in software products. Since defects are known to be significantly more expensive if detected in later development phases or testing, companies in this marketplace must use cost-effective technologies to detect defects early on in the development process. A particular promising one is software inspection.

This paper describes the ESPRIT/ESSI Process Improvement Experiment "High Quality of Software Products by Early Use of Innovative Reading Techniques (HYPER)". The core of this project has been the transfer of innovative software inspection technologies to the Allianz EURO conversion projects. The innovation in the area of software inspection is based on a systematic reading technique, that is, Perspective-based reading (PBR), that tells inspection participants what to look for and - more important - how to scrutinise a software artefact for defects. Although numerous controlled experiments have shown the PBR technique to be particularly cost-effective, few results have been reported on its use in the context of development projects.

The paper presents in a quantitative manner the final results regarding the application of PBR inspections on requirements and design documents in the ESSI PIE. The results are based on 9 requirements and 44 design inspections and demonstrate the benefits to be expected from PBR inspections in an industrial environment.

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1 Introduction

Software has become an integral part of products and services in many organisations, such as insurance companies. However, software development projects are often not performed according to engineering principles resulting in products that exhibit a large number of defects. To push software development more towards an engineering principle, software development methods need to be constantly monitored and improved. Empirical investigations are promising for achieving this goal, since they allow a better understanding of the various methods. Moreover, by empirically validating software engineering research results, such as, principles, methods, techniques, or tools, knowledge is gained how to tailor and transfer research findings to industrial application.

This paper reports on a Process Improvement Experiment (PIE) performed at two pilot projects at Allianz Life insurance company and complements the initial results presented in [4]. The PIE investigated the use of innovative reading techniques that can be used for defect detection in the context of software inspections. Therefore, the object of study was an innovative reading technique, called Perspective-based Reading (PBR). This technique was selected because several controlled experiments demonstrated its benefits in comparison with other, state of the practice techniques, such as ad-hoc or checklist-based reading [2],[6]. However, few results have been reported in using the PBR approach in real projects. Hence, the objective of the PIE was the investigation and the quantitative evaluation of this kind of inspections in case studies at Allianz Life.

The remainder of this paper is structured as follows: In Section 2, we characterise the context and baseline the project situation at Allianz Life. Technological underpinnings of the investigations are perspective-based inspections and goal-oriented measurement. Both technologies are described in Section 3 and 4, respectively. Main quantitative results are presented and discussed in Section 5. Lessons learned on the human impact are reported in Section 6. Finally, conclusions and future research are given in Section 7.

2 The Improvement Situation – Case Study Setting

2.1 Allianz Life Assurance

Allianz Life Assurance, the market leader of life insurance companies in Germany, is part of the Allianz Group, which has become the largest insurance group in the world. The IT Department of Allianz Life consists of more than 500 employees, with 350 of them being application developers. As one of the earliest users and innovators of IT Technology, Allianz Life has a long and very successful tradition of developing commercial software mainly in the area of online-transaction applications with very large databases.

Competition on the insurance market is largely based on quality and functionality of information systems. In the past, IT Technology supported mainly the administrative parts. Quality was defined in terms of performance, reliability, effort of development and operation, etc. Today, competition is much stronger and services and products must be adjusted to the requirements of the changing markets. Therefore, criteria like time-to-market, flexibility, ease-of-use, etc. have a much higher significance. To master this challenge Allianz Life Assurance sets a specific priority on software quality assurance and software process improvement.

2.2 Baseline Situation – Results from earlier measurement programs

Since 1988 Allianz Life has been performing several steps of a software process improvement initiative. Based on measurement programs it was concluded that about 50% of the defects detected in testing had their origin in the early phases resulting in high rework cost. This result showed the need to improve the quality assurance techniques for the early phase. A set of recommendations on checking analysis and design artefacts existed, among which the project leader could choose reviews, walk-throughs, or inspections. However, the effectiveness and efficiency of these quality assurance techniques was considered too low.

Moreover, the measurement programs determined the testing effort of the development projects to 30% of the total IT development effort, which was considered too high and therefore must be reduced. Finally, it was observed that the communication and common understanding among different departments involved in product development offered improvement potential as well.

Based on the above-mentioned needs for improvement Allianz Life has started the ESSI PIE project „High Quality of Software Products by Early Use of Innovative Reading Techniques“ (HYPER). HYPER aimed at a measurable improvement of the productivity in the software development process and the quality of the resulting products at Allianz Life. Such improvement was achieved by introducing a very promising quality assurance methodology: inspections using PBR on artefacts of the early phases of the life-cycle (requirements analysis and design) [2]. Experiments in practice have shown that PBR has cost-effectiveness benefits in comparison with state of the practice techniques, such as ad-hoc or checklist-based reading [2], [6].

The PIE was performed in the context of a project with strategic importance for the company: the Euro-Conversion project. The EURO project represented an overall effort of about 300 person months and was divided into several sub-projects from which two subprojects, in this paper called Project A and B, serve as baseline projects for the experiment.

Project A had an effort of 38 person months, 28 person months of which were effort from the IT department. It comprised two stages and had the task to adapt applications to the EURO currency for the Allianz Investment Trust (KAG), a subsidiary of the Allianz Group. The project team consisted of 4 project members each from the IT and investment departments.

Project B had an effort of 33 person months, 22 person months of which were effort from the IT department. It also comprised two stages to convert the amounts of insurance policies to the EURO. The project team consisted of 6 project members from IT departments and 11 project members from the insurance departments.

3 The Improvement Approach: Perspective-based Inspections

3.1 Scope of Perspective-based Inspections

Software inspection in general and Perspective-based inspection in particular involves activities in which qualified personnel determine whether software documents are of sufficient quality for the subsequent development phases. An inspection consists of numerous activities including planning, detection, collection, and correction.

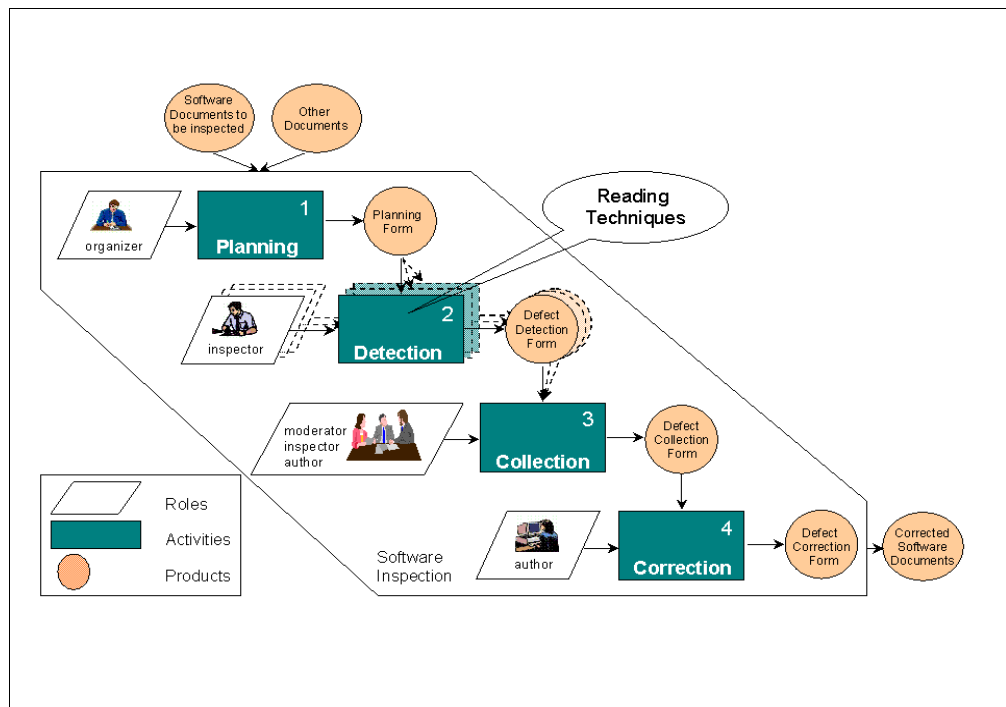


Figure 1: Software Inspection.

As depicted in Figure 1, the planning activity is performed by the organiser who schedules all subsequent inspection activities. Throughout the defect detection step inspectors individually scrutinise the software documentation to be inspected for potential defects using a particular reading technique, such as Perspective-based Reading. Other documentation, such as company-specific guidelines, may support this activity. Inspectors record all potential defects they find on a defect report form. As some of the potential defects might prove not to be real ones, inspectors together with the author and a moderator perform an inspection meeting. The main goals of the team meeting are to agree on

the potential defects that inspectors have detected individually, to eliminate false positives, and to specify the real defects for correction. Throughout the meeting, one of its participants records the agreed upon defects on a meeting report form. In the final activity, the author corrects the defects.

Although each of these activities is vital for an effective inspection, it is the defect detection activity, or "reading" as it is commonly called, that is considered the key part of an inspection [1] and which therefore needs to be supported with adequate reading techniques. The PBR technique together with the presented inspection approach is denoted Perspective-based inspection or PBR inspection.

3.2 Description of Perspective-based Reading

3.2.1 Goal of Perspective-based Reading

The basic goal of PBR is to examine the documentation of a software artefact from the perspectives of the artefact's various stakeholders for the purpose of identifying defects. An inspector in a perspective-based inspection reads the documentation from the perspective of a particular stakeholder in such a way as to determine whether it satisfies the stakeholders' particular needs. A stakeholder perspective may be, for example, a future user of the system who wants to ensure the completeness of the inspected requirements document. If the documentation of the artefact meets the stakeholders' quality requirements, the end product, that is the final software artefact will meet the specified quality goals. The reading process itself is driven by a perspective-based reading scenario.

3.2.2 Perspective-based Reading Scenarios

Throughout the reading process, an inspector follows the instructions of a perspective-based reading scenario (in short: scenario). A scenario tells the inspector how to go about reading the documentation from one particular perspective and what to look for.

A scenario consists of an introduction, instructions, and questions framed together in a procedural manner. The introductory part describes the stakeholder's interest in the artefact and explains the quality factors most relevant for this perspective. The instruction part describes what kind of document an inspector is to use, how to read the document, and how to extract the appropriate information from them. While identifying, reading, and extracting information, inspectors may already detect some defects. However, the motivation for providing guidance for inspectors in the form of instructions on how to perform the reading activity is three-fold. Firstly, instructions help an inspector

gain a focused understanding of the artefact. Understanding involves the assignment of meaning to information in a particular document and is a necessary prerequisite for detecting more subtle defects, which are often the expensive ones if detected and removed in later development phases. Secondly, the instructions require an inspector to actively work with the documentation rather than passively scanning it. Thirdly, since the attention of an inspector is focused on the information most relevant for a particular stakeholder, the inspector is not swamped with unnecessary details.

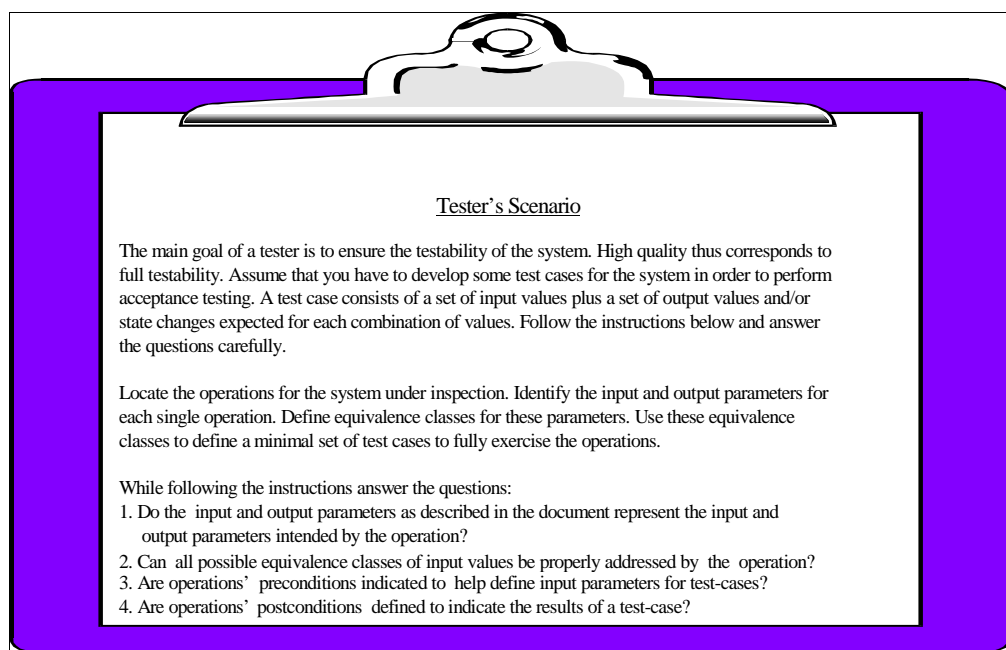


Figure 2 Reading from a tester's perspective.

Once an inspector has achieved an understanding of the documented information about an artefact, he or she can examine and judge whether it fulfils the required quality properties. For making this judgement an inspector is supported by a set of questions that are answered while following the instructions. Figure 2 shows an example for reading from the perspective of a tester.

4 Measuring the Quality Improvement

In addition to the implementation of PBR inspections at Allianz Life, their evaluation was an integral part in the PIE to perform quality improvement systematically. Systematic quality improvement always requires the identification of weaknesses in the development process (as shown in Section 2.2), the selection and implementation of appropriate process improvements (as described in Section 3), but also the evaluation of the process improvements. For this evaluation purpose we characterised in a quantitative manner the inspection process itself and its impact on the development process.

As basis for this quantification a GQM-based measurement program was performed. The GQM approach provides guidelines for defining measurement goals, refining them into measurable entities, and providing a context for data analysis and interpretation [3],[7]. Two major processes characterise this approach. Firstly, the explicit measurement goals are refined in a top-down manner into measures via questions and models tailored to the environment where measurement takes place. Secondly, the collected data are interpreted in a bottom-up manner in the context of the defined models and measurement goals. During both processes, the expected stakeholders are actively involved in the definition of measurement goals, the derivation of measures, and in the interpretation of measurement results.

Within the framework of HYPER, the measurement goals were motivated by the expected benefits from inspections: Inspections are supposed to reduce the number of defects introduced in the early phases of the development but detected late during testing. This early defect detection should decrease the testing and rework effort. Additionally, the inspection process and its cost-benefit relationship were analysed. The GQM measurement goals (and their related questions) as presented in this paper are to

- **Characterise** the overall verification and validation (V&V) approach with respect to the defect slippage from the viewpoint of the project leader in the context of the Allianz EURO Conversion
- **Characterise** the development process with respect to the effort for the development activities from the viewpoint of the project leader in the context of the Allianz EURO Conversion
- **Evaluate** PBR inspections with respect to their cost-benefit from the viewpoint of the project leader in the context of the Allianz EURO Conversion.

5 Quantitative Results of the Measurement Program

In both projects a total number of 9 analysis inspections, one high-level-design inspection, and 43 low-level-design inspections were performed. We present the results regarding:

- i) the defect slippage of the overall V&V approach,
- ii) the cost-benefit ratio of inspections,
- iii) the impact of inspections on the development effort, and
- iv) indirect, qualitative benefits of inspections.

To characterise the defect slippage, the number of defects found in each development activity is shown in Figure 3.

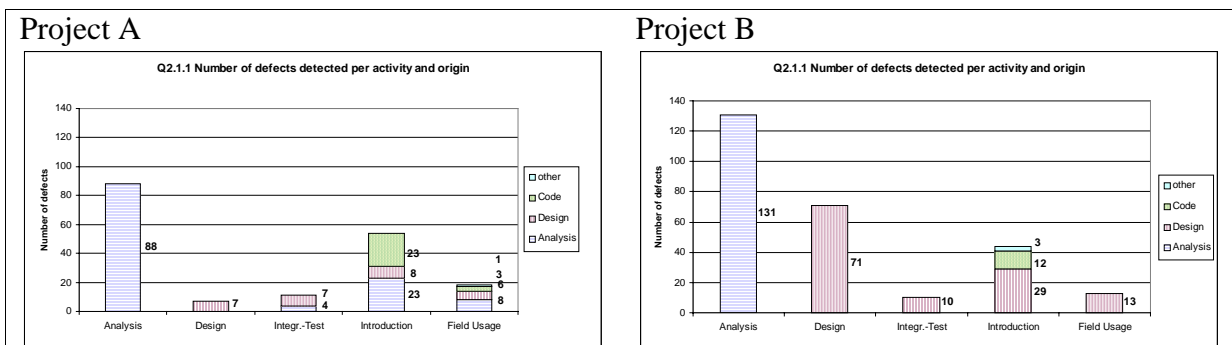


Figure 3: Number of defects broken down by origin and detection activity.

This figure shows for each defect detection activity the number of defects detected in this activity¹. Additionally, this number of defects is separated according to the origin of the defects. It can be seen that in Project A 95 defects were detected in early analysis and design inspections, whereas in Project B 202 defects were detected in early inspections. These figures contain only defects of criticality “very critical” and “critical”, which could have resulted in a test defect. Thus, this result demonstrates that due to inspections defects are detected much earlier in the life cycle than with testing alone.

This also means that defects were detected more locally, i.e. defects were mainly detected in the phase in which they were introduced. In Project A 72% of all analysis defects were already found at the end of the analysis phase by inspections whereas in Project B 100% of all analysis defects were detected by inspections. For Project B, however, this figure has to be interpreted with care.

¹ During integration test only data regarding analysis and design defects found in the second stage of the project were collected.

In this project the analysis documents dealt more with strategic aspects of the Euro-Conversion whereas details were refined during design. Defects from later (testing-) phases were traced back to the detailed documentation being the design. Thus, no defect was traced back to the analysis phase.

In Project A 25% of all design defects were detected at the end of the design phase by inspections whereas in Project B 58% of all design defects were detected at the end of the design phase. The developers of Project A explained the low proportion with the rather high time pressure prevalent in the Euro-Conversion. Due to this time pressure the design inspections could not be performed as thoroughly as desired. By scheduling more effort for inspections in future projects the effectiveness of design inspections should also increase.

The fact that overall defects are found earlier and more locally in the life-cycle should have an economical impact on the development costs, since the effort for finding and fixing defects can be expected to be lower in earlier phases than in later (testing) phases. To investigate the economical impact of inspections, their costs are compared with their benefits. The costs of inspections are determined by the effort spent on inspections (e.g., training, creating scenarios, planning, preparation, meeting, etc.). The benefits of inspections were subjectively assessed by the project members after the inspection meeting has taken place. For this purpose, the project members estimated the effort saved in later phases due to the early detection of defects. In Table 1, the costs and the estimated effort savings are compared.

| | Costs of Inspections | Estimated Savings |
|-----------|----------------------|-------------------|
| Project A | 52 person days | 89 person days |
| Project B | 44 person days | 102 person days |

Table 1

Cost-Benefit of Inspections

It can be observed that in both projects the estimated effort savings are clearly larger than the invested effort. Based on this result, the project members regarded the introduction of inspections as beneficial and profitable from an economical point of view.

To investigate whether the effort savings estimated by the project members have a visible effect on the overall development effort, we determined the effort breakdown for the various development activities as shown in Figure 4.

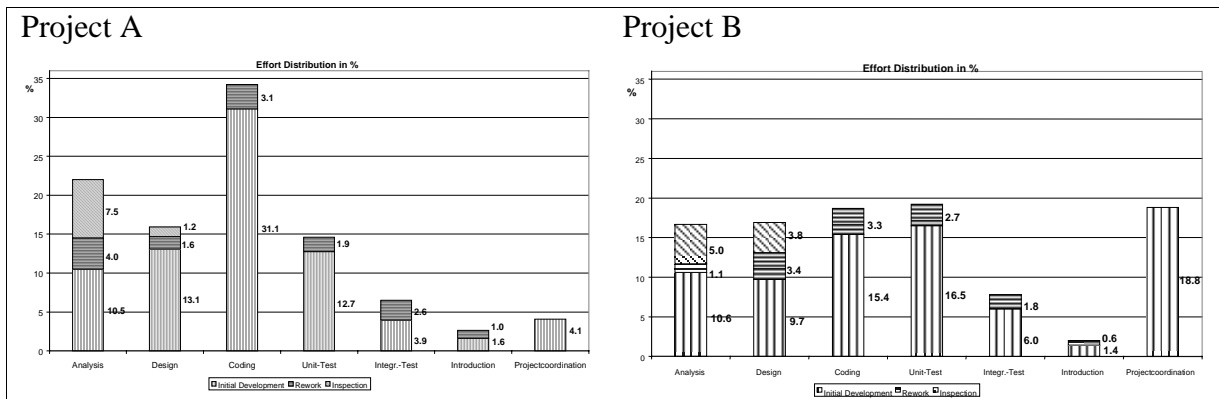


Figure 4: Breakdown of the projects' effort on the development activities

This figure shows for the development activities the relative effort broken down as initial development, rework, and inspection. It can be seen that in Project A the IT-Department devoted 23.7% of the total development effort to testing activities (Unit-Test, Integration-Test, Introduction) whereas in Project B 29% of the total development effort was devoted to testing. Results from earlier measurement results on two projects similar in size to Project A and B had determined the IT Department to spend testing effort of 47% resp. 32% of the total development effort on these testing activities.

Thus, in comparison to this baseline, the two projects using inspections show a reduction of the testing effort. Although several factors contributed to this reduced testing effort, the project participants considered inspections as one important factor responsible for the decreased testing effort. This decreased testing effort contributed to an overall reduction of the development effort, as in Project A and B the effort for inspections and testing together account for 32.5% resp. 37.8% of the total development effort, which is on average still less than the testing effort of the baseline projects.

Besides this economical impact of inspections, additional and indirect benefits could be observed. The focus of Project A's inspections was on user-output descriptions such as letters to be send to customers and screen definitions to be targeted to people working in call-centers. Due to the definition of scenarios for this target group and the involvement of the future internal clients from the call-centers, who also know about the requirements of the external clients, in early phases as inspectors, many defects regarding the user-friendliness could be detected. This led to the definition of a more appropriate system contributing to Allianz Life's business objective "Better customer satisfaction of delivered products" that also motivated the introduction of inspections.

The emphasis of Project B was to design and implement crucial and complex requirements for which many different aspects such as financial, legal, and implementation issues had to be taken into account. The involvement of experts in the respective domains as inspectors contributed to the learning of the developers since the document authors could gain insight into the various domains. As a result, the document authors considered this additional knowledge as valuable for future development activities.

6 Lessons Learned on the Human Impact in Improvement Programs

It has been reported in the inspection literature [5] that the success of an inspection initiative is highly dependent on the psychological nature of human beings. Since this was also the case in our improvement program, we report our lessons learned so that others can benefit from them in their improvement initiatives. The lessons learned can be classified according to participant motivation, training, positive atmosphere, and terminology.

- **Participant Motivation**

We experienced in our endeavor the necessity to motivate and inform all people that were involved in the introduction of new technologies. This was the case not only for the developers who directly participated in perspective-based inspections and the associated measurement program, but also for the managers. This stems from the fact that management commitment is an essential prerequisite for a successful transfer initiative. If managers are not convinced of the benefits of inspections, they might be tempted to assign to inspections those employees who are readily available and not those who are most qualified. Therefore, managers have to understand the entire scope and general conditions under which inspections and data collection take place.

- **Training**

The simplicity of the inspection approach leads many to believe that no training effort is required. However, we have experienced in this project quite the opposite. The training courses performed by FhG IESE were an essential means for the motivation and education of the participants. The courses themselves were developed taking into account the characteristics of the Allianz Life domain. After the training the participants were in the position to perform PBR inspections and collect all the required inspection information as part of the measurement program.

- **Atmosphere of Confidentiality**

Another important success factor for inspections and the associated measurement program was the creation of an open and constructive atmosphere during inspection meetings. We experienced that it is the main task of the moderator to create and maintain this atmosphere. For example, s/he has to be able to cope with possibly antagonistic participants. Special moderator training is therefore helpful for this responsibility. A positive atmosphere throughout the meeting is also positive for the dissemination of product information, the exchange of experience, and the enhancement of team spirit. Each of these aspects speeds up the quality assurance process, since

the decisions made during the inspection meeting, with the consent of all inspectors, would have taken weeks at Allianz Life without the inspection initiative. Managers and developers regard this as a major intangible benefit of the improvement initiative.

- **Terminology**

Although we have used the term “defect” in this paper, this was not the official terminology at Allianz Life. To promote a positive atmosphere, Allianz Life uses a special word for issues raised during inspections: “finding” (German: Erkenntnis). This word is not a synonym for “defect”, because it denotes, on the one hand, defects in a narrower sense and on the other hand, questions, improvement proposals, and comments. Besides, the meaning of the word “finding” is entirely positive, so that negative associations do not arise at all. This was of psychological importance, since the term “finding” conveyed a positive meaning, which facilitates the acceptance of inspections.

7 Summary and Conclusion

This paper described the successful application of PBR inspections in an industrial setting. Based on two real-world projects of strategic importance for Allianz Life, it was shown in quantitative terms that the usage of innovative defect detection techniques in an inspection context throughout the early phases of the development life-cycle

- detect the defects more locally as 72% to 100% of analysis defects are detected in the analysis phase and 25% to 58% of design defects are detected in the design phase;
- have a cost-benefit ratio of about 1:2;
- reduce the testing effort from an average 39.5% to between 23.8% and 29%;
- reduce the overall development time as the additional effort for inspections is less than the saved testing effort.

From the Process Improvement Experiment we could also learn about the influences of the human factor on the success of the transfer initiative. The main success factors were :

- a careful and role-dependent motivation of all participants of inspections, including management;
- training in the basic technologies (PBR inspections and goal-oriented measurement) as an initial investment;
- creation of an open and constructive atmosphere during inspection meetings;
- usage of an appropriate terminology.

As a result of the case studies Allianz life decided to broaden the application of PBR inspections in future development projects. However, additional work is required to optimise the cost-effectiveness of inspections and to investigate further improvement opportunities regarding the overall verification and validation process.

8 Acknowledgements

Without the support of all project participants, the measurement program would not have been possible. Therefore we would like to thank all participants in this PIE for their trust and the willingness to provide correct measurement data.

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