An Improvement Program Spreading Effective use of Reviews and Inspections throughout a Multinational Telecommunications Company

Robert MacFarland
Robert.macfarland@etl.ericsson.se
Ericsson Ltd
TC
RH159UB, Burgess Hill, England

Stjepan Golubic
Stjepan.golubic@etk.ericsson.se
Ericsson Nikola Tesla d.d.
ETK/D - R&D
10 000 Zagreb, Croatia

Daniel Grenner
Daniel.grenner@q-labs.se
Q-Labs
Ideon Research Park
S-223 70, Lund, Sweden

Abstract

The effective use of Reviews and Inspections (R&I) was one of a number of initiatives chosen within a program to increase the improvement pace globally in order to reduce costs. This was principally achieved by reducing the time to market and increasing the quality of software produced.

Presented here is an account of not only what has been done in the traditional document based development model, but also the way we are currently looking for the right solutions in the new object oriented development model.

I. Introduction

It is well known today that successful improvement programs that deliver lasting results are notoriously difficult to accomplish with most unfortunately ending in failure.

The difficulty is in building the necessary infrastructure and developing a culture that supports getting new working methods adopted and practiced successfully.

The development of software product is among the most labor-intensive and error-prone technologies. Studies in Ericsson show that about 40% of all problems in In- Service Performance stem from faulty software design. The R&I have been recognized as one of the crucial activity in improving the software development process [1]. The R&I are a proven approach that enables the detection and removals of defects in software artifacts during its creation and soon after these artifacts are created.

Most of the R&I improvements have so far been done in the traditional document based development environment. However, there is still room for additional exploitation of reviews and inspections potential. New problems have appeared with the introduction of visual modeling in the software development. Object oriented methods and requirement for the paperless R&I present new challenges for the successful implementation of reviews and inspection.

II. Large Scale Improvement Initiative Program

A. The beginning and Motivation to Change

During the course of 1995 within the Public Network Switching organization in Ericsson, it was generally recognized that it was time for a breakthrough to remain as a profitable operation. It was agreed the reason for this state of affairs was the long project schedule over runs and also the resulting poor product quality being experienced.

Various local design centers (LDC) were approached and visited, they were requested to offer participants who were interested and competent in the R&I improvement area. On hindsight, this was one of the factors for the successful introduction locally of the various outputs of the improvement initiative.

As the customers for implementing the improvements the local design centers had a say in and were involved in the actual development of the improvements produced. This helped to break down the “not invented here barrier” and meant that on the local level they saw peers from other design centers involved in the development of the improvements rather than just a elite Swedish core being involved.

A road show was set up to visit the design centers participating in the next major project that was titled *Helios*. The teams presented their ideas for the improvements needed and the views of the design centers in response were collected.

Fifteen design centers were visited in ten different countries by the R&I competence team. Apart from the presentations at the local design centers to those

interested, the usage of R&I at the local design centers was examined. Their areas of interest for support and further development were evaluated and discussed with the nominated responsible at the local design center.

It should be noted that those nominated locally as responsible for R&I were latter to form the backbone of the champions network that was to be developed latter.

The results of the interviews were analyzed and priority areas of improvement were selected. Suitable documents already available were identified and these were modified to produce a comprehensive package that consisted of R&I planning guidelines, work instructions for review procedures, inspection process improvements, data capture and data analysis guidance.

As a result of the analysis of the survey, it was also concluded that there was tremendous inconsistency in the usage of different R&I types at Ericsson. As well as a wide range in the maturity level of the implementation of the R&I process being employed. It was concluded that R&I education was to be a vital area to address the issues currently being raised.

B. R&I Definitions as used

Reviews and Inspections are two terms that are normally and wrongfully interchangeable. The benefits that reviews and inspections provide are often diminished because these two different types of evaluations are not used to their full extent.

A review is an evaluation of the software element(s) or project status to ascertain discrepancies from planned results and to recommend improvement. Different review methods have different purposes and they complement inspections.

Many different review methods have been used in Ericsson without common terminology. The R&I initiative selected and recommends some review methods [2] to be used during the development of design in conjunction with the inspection process and these are termed internal reviews:

- **Frequent reviews,** which focus on finding defects during the development of a document or design. Each review examines only new, changed or influenced design. The review includes verifying compliance to applicable rules, procedures, and methods.
- **Walkthroughs,** which are similar to a lecture, are used to obtain early feedback and consider alternative solutions. The author of the design leads the audience through a document and the audience has an active participation in terms of asking questions and raising concerns, making comments about the presented solution, possible defects, etc.
- **1/3 Presentations,** which are particularly useful in new design, are held when the author of the document or design, has a good understanding of the problem to solve and has developed a preliminary solution for it. The document itself does not necessarily need to be presented because there are other possible means to present the proposed solution.

These internal reviews focus on early defect detection and feedback, and are performed while the document is under development. An inspection on the other hand is normally held when the document is completed (**Figure 1**).

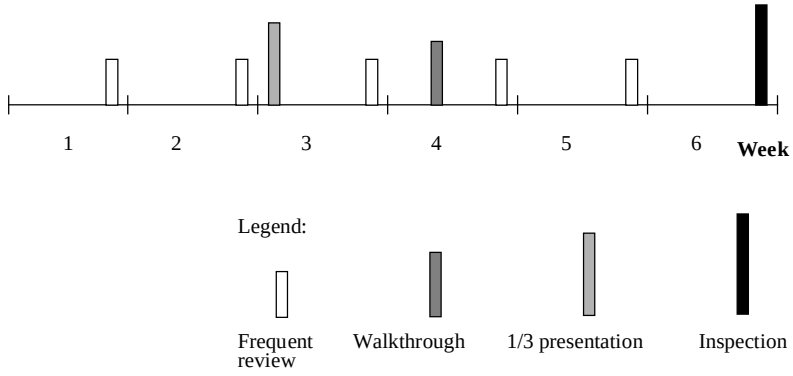

Figure 1. An example of reviews and inspection combination

An inspection is a formal evaluation technique in which software requirements, design, or code is examined in detail by more than one person to detect defects, violations of development standards, and other problems.
The review performed to technically approve a document by the system group is called an *external review*. It is carried out after the document has exited from an inspection.

C. Implementation procedure

1) Local Design Champions

The local design center managers were asked to nominate champions who would motivate the implementation not just within one project but as much as is practicable within all projects undertaken locally. They were asked to ensure that the correct support structure was in place to carry this out successfully and to document this in an updated implementation plan.

2) Training Program

Thirty champions from various design centers participated in the training. It was their job to assist at their local design center with the planning, training and to be able to provide on site support for the R&I process. The competence team provided detailed specialist knowledge backup support to these local champions.

3) Local Design Center Implementation Plans

Each participating design center produced an implementation plan detailing how they will implement the various elements of the R&I improvement package.

The competence team member allocated to support the design center reviewed the plan and checked that the implementation fulfilled the minimum requirements necessary and the support provided was sufficient to ensure successful results.

Minimum implementation requirements have been set up:

- A baseline of compliance with the proposed R&I processes.
- Planning must be performed with planning constants.
- All moderators and checkers have received training in the selected review and inspection methods.
- Data collection performed to aid process control.
- Project manager participates in the implementation.

4) Champions Network Established

After the planning of R&I activities within the local design center, sub-projects had been completed. At the next forum, the various local design center's implementation plans were presented and various workshops were held to identify what effective support could be given towards the implementation. The conclusion of the forum was that there was still need for a common understanding among champions. The result is establishment of champion's network, which is still alive.

5) Assessment of LDC

The champions received three days of auditing/ assessment training to further encourage implementation. The intention was for the LDCs to assess each other's practice of R&I on a peer review type basis.

D. The program Results

The R&I improvement program attended an experience exchange with the Helios main project team and the feedback given was generally favorable towards the R&I initiative resulting in recommending the result of the R&I initiative to other projects.

1) Spreading of Improvement to other projects

It was decided to improve and encourage the implementation of the R&I initiative throughout all projects undertaken by the switching organization.

The principal strategy for R&I to achieve this goal was getting the package of improvements that were developed incorporated within an Ericsson standard process suite. This was the one used in the design of the software for their AXE10 switch, termed MEDAX (MEthods for Design of AXe).

An expanded competence team was established based upon the original and now including members from Southern Europe, USA and Australia. They were given the task of developing and supporting this globally.

2) Promotion

The competence team produced a promotional package. The promotional package was carefully constructed so that selected part's of the argument put forward was aimed at different target groups.

This was in order to persuade as many of the possible audiences in the future to adopt the outputs from the R&I initiative to achieve a 'critical mass' of adopters

3) Level of Design Center Adaptation

Out of 24 local design centers associated with the switching organization 21 applied to become apprentices as part of the R&I initiative. Fifteen local design centers actually provided implementation plans detailing how R&I would be implemented by them and supported locally.

4) Return of Investment

One design center calculated their savings based upon the assumption that each major defect discovered resulted in a saving of 10 design hours later. The inspection process employed at another design center also asked the actual designer discovering the defect to estimate how much saving they thought discovering the defect would provide.

Hardly surprisingly, this came to a similar figure to 10 hours. All developers had undergone the same training where the definition of a major defect is one that is considered to give a saving of approximately 10 hours or more.

More significant though, is the fact that the other LDC's success stories calculated their savings from inspections by a different method. This was based upon the estimation of the savings due to reduction in the cost of rework of implementing the associated trouble reports and corrections.

The range of return on investment (ROI) figures obtained by the other success stories (4-to-1, 5-to-1 and 6-to-1) are all very similar to the 4-to-1 figure obtained. This supports and validates both methods of calculating the benefit.

The low 4:1 ROI figure is because the high initial costs of implementation are included within the calculation. The ROI figure for subsequent periods can be expected to be more favorable, especially with the introduction of process improvement and root cause analysis within the inspection process by certain LDCs.
In spite of this, the figure for the Master LDC is assumed (**Table 1**) as a representative figure of savings obtained per local design center for calculation purposes [1].

Table 1. The R&I savings figures reported by Master LDC (1997)

Support expenditure (process, tool and training)	207.2 K$
Training costs of inspectors	65.8 K$
Executions of inspections	358.4 K$
Estimated savings from inspections	2524.2 K$
Estimated total savings less costs	1892.8 K$

Then a "guess" can be made of the potential total savings gained from implementing the R&I initiative globally (assuming 20 LDCs both official and unofficial participating over the last five years) using the following formula:

Number *of design centers * expected saving per year * number of years = total savings.*

In this way the saving is 189.42 M$ (20 * 1892.8 K$* 5). This rough-and-ready calculation whilst extrapolated from only one local champion's figures for the year 1997 is certainly valid to within + or – 140 M$. This is supported by other LDCs reporting figures obtained for their ROI ranging from 4-to-1 to 6-to-1 based on real rework cost reduction calculations.

An estimate for the central corporate sponsorship funding is around 1. 4 M$ + or - 0.7 M$. This was to seed corn the local R&I initiatives globally over the last five years. In summary, it certainly proves the case that whichever way one looks at these figures, from the corporate global perspective, a very good return on investment has been obtained.

5) Institutionalization

It was no longer a requirement for local design centers to provide implementation plans detailing their level of R&I implementation. The level of local practice now was seen their own responsibility.

It should be noted that now that adoption of the methods and participation of the local design centers within the network was now very much on a voluntary basis.

Institutionalizing the process locally meant ensuring that they were:

- defined and documented,
- supported,
- trained,
- practiced and enforced,
- measured and improved, and
- tailored.

E. Expanded Responsibility

At the forums, and also from the communications received during 1999 from the R&I champions representing both wireline and wireless, it was good news to see that both organizations held similar views and had the same needs as this made it easier in supporting them.

It was agreed that the benefits that could be gained from implementing R&I were available to a much wider scope of applications than just design.

It was also agreed that in order to keep up with the changing development environment it was also necessary that the R&I process within Medax needed to be updated.

The outcome was that it was agreed by the champions network that a generic Ericsson R&I process needed to be developed. It should support R&I of all types of outputs, including those from modeling. It should also be adopted for use by all those currently working within Ericsson today.

III. Establishment of the New Improvement Project

A. Change in Standard Process Owner

During the course of 1999 within Ericsson there was a move away from the use of their own standard propriety processes (Medax) to making more use of externally available commercial tools and processes. The purpose was to help with the development of open systems for the future.

An agreement was made between Rational and Ericsson to make available, supply support and provide training of their Rational Unified Processes (RUP) to the users within Ericsson.

This resulted in a major change in the "ownership" of the propriety Medax processes. Ericsson Business Consulting took over the responsibility for part of these.

This was to ensure that legacy systems that generated much of Ericsson's revenue at the time were still supported.

The scope covered both the wireline (fixed network) and wireless (mobile) areas of Ericsson's organization as they both made use of the current Medax processes.

The supporting of this was however made easier due to the merging of the wireless and wireline design centers operation'' resources, naturally leading to a distribution of the R&I champions to cover both previous areas.

B. Generic R&I Framework

During the beginning of 2000 it was possible for Ericsson Business Consulting to secure the funding to start up a project to produce a Generic process framework that could provide assets for implementation of the R&I in any conceivable situation.

The subsequent project was called *Gforce*, and its goal was to produce an R&I framework for supporting organizations of differing levels of R&I process maturity.

This was to ensure that as many design centers and implementation projects as possible would be able to make use of the output produced.

The *Gforce* competence team was established with participation of champions from USA, Netherlands, Spain, Ireland, England, Croatia, and Sweden.

It was decided that in order to keep the costs down of developing the new process framework that it would reuse as much of the old Medax R&I process elements as possible.

In addition, the intention was to be compliant with the IEEE Standards as much as possible [2]. The solution enabled the team to capitalize upon any recent improvements developed locally. Most of the local design centers used the Medax R&I process as their base, and published their processes on the web thus making their identification and transfer easier.

A similar approach and structure was adopted by the Gforce project as the initial TTM15 R&I initiative namely by involving the local design centers with the review and development of the new process artifacts. Part of this approach involved the trial of the preliminary versions of the outputs at the last R&I champion forum in 2000.

C. Identification of improvement areas

To fit the local design centers and project needs the generic R&I process, presented in **Figure 2**,should be tailored. Based on Tom Gilb's improvement principles [3] and interviewing potential customers, several improvement areas, which could help in better R&I performance, have been identified.

1) Culture change

Elements which could be taken into consideration:

- The inspection culture should be defined (better understanding of its importance, benefits, commitment).
- Take into consideration that to err is human.
- Software development is error prone technology.
- When error appears don't blame the people, blame the process.
- It is not possible to develop fault-free software product without controlling development process (reviews and inspections, testing).
- Document local inspection culture.

2) People stimulation

Elements which could contribute to people stimulation:

- Understanding the importance of early fault detection and prevention.
- Feeling that reviews and inspections help him/her in getting the product better in easier way.
- Awareness that better input document will help people in the next developing step.
- Learning during reviews/inspections.
- Feedback from data analysis and project results.

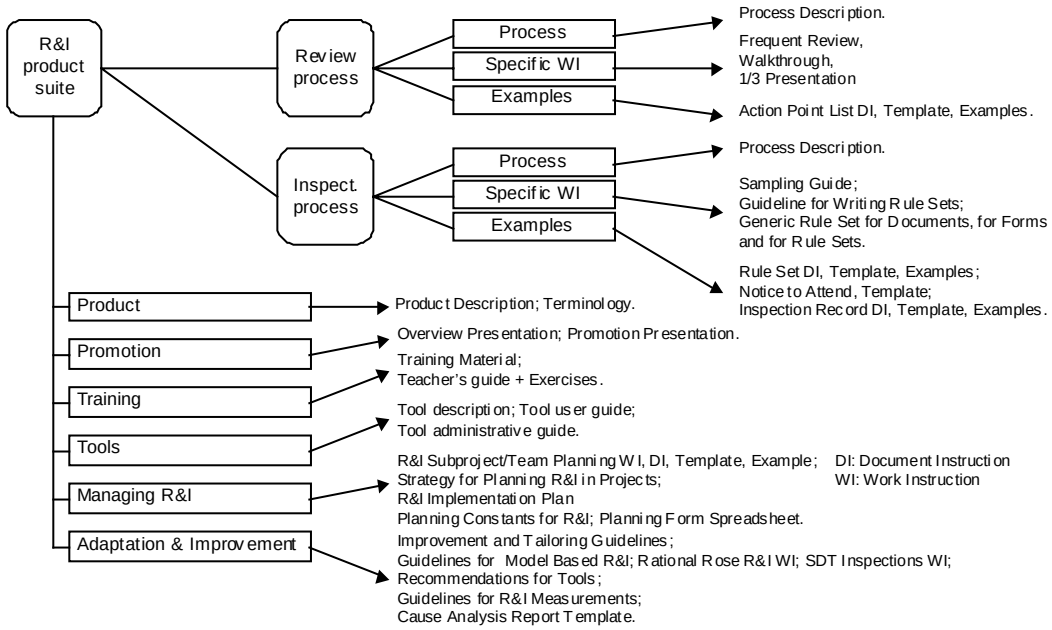

Figure 2. The generic R&I process framework

3) Competence

Adequate training should be done for all roles involved in R&I, including project and line management:

- Designer/tester: to perform reviews and inspections as integral part of development activities.
- Moderator: to co-ordinate reviews and inspections in the project and to participate in fault classification / root cause analysis.
- Management: to recognize the importance of reviews and inspections in reaching the business goals.

4) Planning

Planning should not be underestimated what includes:

- Deciding on strategy adapted to the project (combination of reviews, inspections, testing, audits).
- Definition of critical documents to be inspected.
- Definition of inspection technique (all document, partitioning, sampling…).
- Use of local planning constants.
- Adequate competence for defined roles.

5) Fault modeling

Define fault model for local development environment:

- Defect types you are looking for.
- Make fault classification.
- Implement method for Root Cause Analysis.
- Implement fault prediction method.
- Develop the model to estimate remaining defect number.
- Local guideline to make the defect finding easier and objective.
- Insure forward and backward link to testing based on defect root cause analysis.

6) Reading technique

Implement adequate reading technique when searching for defects (for example rules, checklists, defect-based reading).

7) Insight of each inspection

Perform inspections in unique way:

- Use entry/exit criteria.
- Use locally adapted checklists.
- Analyze the performance of inspection (what is good, what is bad, what to change).

8) Metrics

Measurements are a part of the software development process and performed in day-to-day operations. Define and measure only key parameters on which effectiveness and efficiency could be calculated.

9) Moderator role

The role of moderator should be spread over the whole development process:

- Moderator role should be an analogy to the test leader role (basic test, function test…).

- Co-ordination of all reviews and inspections in the project.
- Competence to decide on fault classification.
- Authority to delay an inspection (even a project) when necessary.

10) Project Internal-external link

Insure the close link between the project and the bodies outside the project such as Product Committees (PC) and Technical Committees (TC):

- Include the PC/TC in planning.
- The PC/TC's members participate at 1/3 presentation
- Use the same inspection process.
- Reduce duplication work.

11) R&I Tool implementation

The tool is not prerequisite for performing reviews/inspections, but is necessary for:

- Improving administration.
- Better and easier planning.
- Data collecting and analysis.
- Forecasting.
- Establishing on-line feedback to the project and line management.

12) Improvement infrastructure

Create an infrastructure, which in an operative way conducts the improvement work, e.g. Process Change Management Team. This is a team of people who are charged with managing improvements in the software development process. The Process Change Management determines which changes are most valuable, and implements the changes according to their plans.

D. Paperless reviews and inspections

The introduction of the SDL (Specification and Description Language) and UML (Unified Modeling Language) and Unified Process (UP) in the software development projects present new challenges for the reviews and inspections. The tool suppliers (for example Rational and Telelogic) give a lot of information on testing, but very few on inspections. The reason could be that R&I are considered as a mature process in the traditional document oriented development, and that it is just simple and mechanical job to implement them in the object oriented development.

In the meantime, a new AXE system development concept, called System 108, has been introduced for supporting multiple platforms. The AHEAD improvement project has been established as the part of World-Class Provisioning (WCP) program. The WCP has been launched in the Ericsson wireless (mobile) area dedicated to the market supply flow through improved performance on Time to Market (TTM). AHEAD's goal was to be the central coordination project for innovations in the area of methods, tools, and training. One of the requirements, which have been set up in AHEAD, was to investigate the implementation of reviews and inspections in the paperless environment. The key attributes of the paperless review were defined as:

- Basis for a paperless development environment.
- Review of *paperless* information (for example UML-models in Rose, or SDL-models in SDT).
- Creating paperless review and inspections records (for example using specific IRDATA tool, or entering data directly in Rose or SDT).
- "Virtual" reviews using Webcam and NetMeeting.

The link between the Gforce and AHEAD has been established. Some results of investigations are presented in the next chapter.

IV. Changes due to model based development

Model based development differs in several ways from document based development. The work is performed in a model based, tool supported development environment. Furthermore, the information that previously was on paper and was inspected document by document, is now stored in the modeling tool. This leads to new requirements on the reviews and inspection process [4].

There is currently a lack of support of R&I in several of the most common environments for modeling development.

A. Differences and configuration management issues

A model is not necessarily linear in the same way as documents. This means that the selection of what to inspect becomes a large part of the planning effort. It also makes it more difficult to know what has been inspected, and what has not. Documents can be marked as inspected, but there is not the same possibility in a large model, when parts of it have been inspected. To be able to get support from the configuration management tools the selection of review or inspection objects have to correspond to the configuration units.

Another feature that would be helpful is the possibility to create a report with review and inspection status. This should describe what has and what has not been inspected. Without this type of support, it is difficult to ensure that all parts of the model have been inspected.

B. Identifying changes

Changes should be highlighted between two arbitrary versions. This is necessary to see what has been changed since the last review. The functionality should be provided on both individual diagrams, and on larger parts of the model, with the purpose to make changes easy to find.

If the development is iterative or incremental, it is even more important to have this support. Otherwise, the manual planning efforts become larger.

C. Tool-based R&I versus R&I generated documents

The model can be reviewed or inspected directly in the development tool (on-line), or by looking at a document or a web page that has been generated from the model.
Most development tools have some possibility of adding notes in the model, and this could be used for making comments on the model. The benefit from this is somewhat limited due to collisions with the configuration control tools. The possibilities are:

- Create one branch of the system for each reviewer, and merge the branches after the individual checking.
- Have small enough granularity of the version control, to minimize the risk of several people trying to access the same parts.
- Plan the individual inspection efforts so they do not collide.
- Do the individual inspection without noting comments directly in the development tool. It can instead be done on a separate piece of paper, a printout, in a PDF file or in an external inspection tool.

Generating documents has to be simple and reliable. All the relevant information from the development model should be represented in the generated document. In addition to the contents of the model changes since the last review or inspection should be marked.

Experience from several projects has shown that this can be difficult. This is partially due that the tools are not easy to use without training, and that they are time-consuming to use. Despite these problems, a combination of printing the model and looking in the development tool seems to be the best.

D. Controlling the Inspection

It is desirable to check the reliability of the inspection process, and the quality of the inspected material. This means that:

- The inspection effort should be measured.
- The quality of the inspection object should be measured.

Traditional inspections often uses:

- Number of logical pages inspected per hour to measure the inspection effort,
- Number of defects per logical page to measure the document or model quality.

This means that some type of size measure like logical pages, or complexity measures like function points of the inspected areas of the model should be calculated. Since it is time-consuming to do this manually, there has to be support from the development tool to get a useful figure. Another alternative is to generate documents, and then count the number of generated pages. This does not account for the complexity of diagrams, but can still be a useful way to give a size estimate.

E. The Inspection Process

The inspection process does not change much due to the modeling situation. More planning is required, both on a project level and on the level of a single inspection. Apart from that, the issues are mainly technical, e.g. how to use video projectors to display the model in a meeting room.

The other difficulty as mentioned before is to get reliable metrics. That is something that hopefully can be done with more tool support.

V. Current status and future plan

Ericsson Business Consulting discontinued operations at the end of 2000. The part of that organization that formally owned the R&I process as well as other selected parts of the Medax processes was from transferred to a new operation called Ericsson Process & Applications Consulting (EPAC).

EPAC is keen on establishing the Ericsson Review and Inspection Academy (ERIA). This should offer support to the local champions and provide them with implementation advice as well as making contacts and partnerships with leading institutions and consultants in the field.

One of the main goals of the Gforce project was to align the process, tools, and training. Piloting of the process, tools, and training is currently being undertaken. Favorable feedback from their implementation during the pilots was received at the latest R&I Champions forum.

The next step will be to unify these into a simplified fully automated paper-less tool solution that addresses all needs of the users. A pre-study will need to be made to specify and analyze what is

involved in its production. One proposal for the tool development is given in [5].

VI. Conclusion

It is gratifying to see just how many local design center R&I processes today are on a voluntary basis based upon the Medax R&I process. This is despite the fact that there is no longer a central improvement program driving membership, now all participants do so on a voluntary basis.

Despite this all forums are self-financing and the R&I champion's network is lively and well subscribed. One reason for this could be that the network acts as a reference group on behalf of the users towards the corporate standard R&I process owner and help to suggest, participate, and direct the improvements.

Many of the most motivated local design centers participating within the network are now assessed internally within Ericsson as at level 3 of the Capability Maturity Model (CMM). The measurements aspects, process improvement and root cause analysis capability of the R&I package are becoming more important as the local design centers strive towards levels 4 and 5 of the CMM and may require yet still further development.

It is to this end that the major update currently being undertaken by the Gforce project is to keep the process relevant in today's paper-less model based development environments, and starting to incorporate already identified improvements necessary for CMM level 4 and 5 organizations.

On the other side, reviews and inspections in a model-based development environment are possible, although there are some technical aspects that have to be considered during the planning stage. There are some issues regarding metrics that still have to be worked out to reach the same level of quality control as document-based R&I methods.

Establishment of the Ericsson Review and Inspection Academy is welcomed. Through contacts and partnerships with leading institutions and consultants in the field, it should find the optimal solutions for internal use. It is hoped that by Ericsson having their own propriety world class R&I process framework, that this will provide Ericsson with a business advantage resulting from its implementation.

VII. References

[1] R. MacFarland, "Case Study of an Improvement Program Featuring Reviews and Inspections, *Software Quality Professional*, Volume 3, Issue 3, June 2001

[2] IEEE Standard for Software Reviews, *IEEE Std 1028 –1997*, Copyright 1998 IEEE

[3] T. Gilb, D. Graham, *Software Inspection*, Addison-Wesley, 1993

[4] O. Laitenberger, K. Kohler, C. Atkinson, "Architecture-centric Inspection for the Unified Development Process (UP)", *Proceedings of the 8th European International Conference on Software Testing Analysis and Review, EuroSTAR 2000, Copenhagen*

[5] S. Golubic, D. Maruši, "Reviews and Inspections - An Approach to the Improvement of Telecom Software Development Process", *Proceedings ConTEL 99*, 5th International Conference on Telecommunications, pp. 283-290, Croatia 1999