

The Business Benefit of Root Cause Analysis, Ben Linders, Ericsson R&D, The Netherlands

Root Cause Analysis (RCA) has been used for many years to determine a fault's first or "root" causes in order to identify process improvement opportunities. Given the current economic climate, the business case for RCA has become more explicit than ever. That is because RCA can be applied, and has been proven, to give a significant boost to reaching business targets.

This paper describes how Root Cause Analysis can be implemented in a way that truly supports business targets. It explains why every RCA session should contribute to specific targets – to ensure that resolving causes found will indeed improve the performance of the organization. In the long run, the improvements also impact the efficiency of RCA sessions, and lead to better follow up for actions.

This paper consists of four parts. In the first part, RCA is explained in the context of running a business of software development. The second part describes key issues in performing RCA, and shows how these key issues contribute to reaching business targets. The third part contains results from a study done on the business results of RCA. The last part is an appendix, consisting of instructions and checklists from Ericsson R&D Netherlands for performing RCA sessions.

1 Business Context

The purpose of an R&D Design Center is to deliver and support products, within budget and on time, with a specified quality. The businesses are the products and services creating revenue for the company, used to finance current and future R&D investments.

To steer the R&D Design Center at top level, a Balanced ScoreCard (BSC) is used. The scorecard contains targets in perspectives such as employee, finance, customer/market, and internal efficiency. Top management uses this BSC to define yearly targets in perspectives, and for operational plans that enable the organization to meet targets. The question is: How can RCA contribute to business targets?

1.1 What is Root Cause Analysis?

I define RCA as "a technique to analyze a problem, to determine the causes that made that problem happen, and to define actions to prevent similar problems from happening".

The definition tells us that in order to do an RCA, there has to be a problem. You cannot do RCA on fictive problems or on vague issue. To do business effective RCA, you must have a problem that is real and significant, and has hindered in reaching business targets. Also, there must be a chance that similar problems happen in the future, when no action is taken.

The definition also mentions the investigation for causes. The purpose of an RCA is to

determine the root causes. These are not the direct causes for the problem, but may be 4, 5 or even 7 levels deeper. Note also that I use the plural "causes", as there is almost never one single cause for a problem. But the other way around, root causes are often responsible for multiple problems, now and in the future. Preventing these kinds of problems supports an organization in reaching its targets.

The last part of the definition mentions preventive actions. These actions are related to the root causes, not to the problem. Corrective actions are done to solve the problem. But, that does not lower the risk of similar problems happening. Preventive actions should clearly contribute towards the business targets, by eliminating causes at an elementary level. This is the cheapest, most effective spot to do actions, thus supporting efficiency and lowering costs of the organization.

1.2 How can Root Cause Analysis Contribute to Business Targets?

Most R&D companies have business targets related to Customer Satisfaction, Projects (lead-time, budget & quality), and Financial Performance, to give some examples. So, let's see how RCA contributes to those targets.

RCA can be done on customer complaints. With preventive actions, the number and significance of customer complaints can be reduced significantly, thus increasing customer satisfaction. Next to that, the amount of work to solve issues will reduce, and the likelihood

that a customer will buy upgrades or other products from your company increases.

Most R&D organization run many projects. Finding important causes why projects do not meet business targets, and take actions to prevent them in next projects, can give a big boost towards increasing quality, and reducing lead-time and costs. Summed up at the top level, the performance of the R&D center will improve. This results in products that are developed at a lower cost with better quality to be sold earlier, creating more revenue.

As the examples show, defining and doing the business related corrective actions will results in lower costs, and higher revenue. Better financial results enable the organization to do more R&D investments, thus closing the loop.

The targets mentioned here are examples; every company must investigate their own targets to determine where RCA can be beneficial. Chapter 3 will show results of an internal investigation of the contribution of RCA towards business targets.

1.3 What about assessments, audits, and improvement sessions?

One thing to clarify is how RCA compares with audits, assessments and improvement sessions. The end results are similar (improved performance), but application areas differ.

Audits (in the narrow sense) are done to verify if activities are done as defined. Deviations are stated as observations, and actions are defined to either allow the deviations and accept consequence, or to steer the organization back to adhering to the definition. This implies that audits focus upon processes and activities, and not on problems. If an audit is done to investigate a problem, it will only come with root causes if these causes are related to the processes; other causes will not be found. These causes are not necessarily the root causes, so actions on these causes do not prevent similar problems from happening.

Assessments (also in the narrow sense) are done to evaluate an organization with a model (e.g. CMMI, EFQM), to improve performance. The focus is upon improvement of output, but again only causes related to the model are

likely to be found. Note that with the new ISO 9000:2000 standard, the distinction between audits and assessments are smaller, therefore in the broad sense the results will be comparable. But they will often not find the root causes.

Improvement sessions are not limited by processes or models, but provide a free context to explore and investigate problems. However the focus is more on finding solutions, then on understanding the causes of the problem. There is a risk that solutions that come up are related to symptoms of the problems, and not to the root causes. So again the problem is not prevented from happening again.

Does this mean that there is no need for assessments, audits and improvement sessions? Certainly not! In situations where there is no clearly defined and isolated problem, or where there is need to do a global exploration to get overview, assessments and improvement sessions are very effective. Audits are an ideal tool to verify the implementation of processes. However on specific problems, doing an RCA to find the root causes is often more effective.

2 Key Success Factors of RCA

The basics for our RCA implementation are used from [REF 1], [REF 2] and [REF 4]. Based on them we have developed instructions (see the appendix of this paper). In order for RCA to contribute towards business targets, we defined the following key success factors:

- Select appropriate problems
- Use problem knowledge & analytic skills
- Have a knowledgeable session leader
- Communicate results

These key success factors are described in more detail in the next sections.

2.1 Select appropriate problems

When starting with RCA it is tempting to use every opportunity to do a session. It seems like the more RCA sessions you do, the better it is. Every session you find root causes and define actions, which give opportunities to improve. But after some time you get a lot of actions. Then it becomes clear that, to deliver results, all the actions need to be done. However most

organizations are not capable of changing a lot at the same time. So you postpone actions, and do only high beneficial ones. As a result you have wasted time coming up with actions that you cannot do. Also, people get frustrated, knowing that there are problems and preventive actions, but no time to do them.

Instead of making the selection for actions after the RCA, you want to do just enough RCA sessions that come up with actions the organization can cope with. But how can you figure out which RCA session to do that will give the most beneficial actions?

First, for any problem that is to be investigated with RCA, the loss must be significant in terms of business targets. Also, there must be a significant chance that similar losses will occur in the future, if no preventive actions are taken.

We also did an investigation, to determine the contribution towards business targets of RCA sessions performed. This helped us to get insight for which problems/areas RCA can be beneficial. This is elaborated in chapter 3.

2.2 Use problem knowledge & analytic skills

Problem analysis should be done with persons that were involved in solving the problem, and who know all ins and outs. However these are often key people in the organization, with a full agenda. Getting them into the RCA session turned out to be more difficult as expected.

First here's some data we collected from RCA sessions. The sessions took on average 76 minutes with 5 persons, giving 6.5 man-hours per meeting. Adding preparation and reporting gave a total of 15-20 man-hours per RCA session. The sessions investigated 1 to 14 issues; the most effective ones had 1-4 issues.

The data above, which was not available when we started with RCA, helps convincing managers that we need key persons for limited time, to get good results. But what happened if other people instead came to the session, which had been less involved? The main problem we saw was that many questions remained open after sessions, and we could not get good insight in main causes. And people with insufficient involvement did speculations

what might have happened. But, for root causes, you must be certain what happened!

A problem was that initially people did not understand the difference between the cause-effect diagram, and Ishikawa or fishbone diagram, which they were familiar with. Instead of analyzing a problem at hand, they categorize causes, and guessed what could have been causes. The result doesn't reveal the actual root causes, at best it shows potential cause areas, at worse it end with causes which had nothing to do with this problems.

So it is important to get the persons that really were involved in the problem into the session, and have them analyze the problem at hand. Good analysis could partly be influenced in the sessions, but for a large part it was directly related to the attendants. Some person are good in problem analysis, some are not, how hard you try to get them to do that. You can learn analytic skills, but not in one or two sessions! An organization should invest in training and coaching for this, if they consider it important.

2.3 Have a knowledgeable session leader

In the years that we piloted RCA, experienced quality engineers who had worked in projects and maintenance for a long time did the sessions. They knew the products, understood how the design teams worked, what processes they used, and spoke their language. The question arose if this was an important factor in RCA, or that less experienced quality persons or engineers could also lead sessions?

As an experiment, we had a graduate student on RCA ([REF 3]) attend two sessions: One with myself as experienced session leader, and one with a quality engineer that worked with the company for some years, but never did RCA sessions before.

Though the session leader had enough skills to lead the meeting, she was unable to ask effective questions to find the underlying causes. The fact that she did not know the product and the process limited her to asking only general questions, which did not reveal the root causes. Important to note is that the session result was also related to the analytic skills of the engineers, as mentioned in the previous paragraph. There was only one person

in the session with sufficient problem analysis skills, the other engineers had been involved in solving the problems but had much difficulty relating their work back to the processes and the organizational context.

The conclusion is that the interaction between the session leader and the engineers is crucial. They have to have the same technical, process, and organizational language in order to come up with the actual root causes.

A future idea is to have RCA sessions lead by experienced engineers with strong analytical skills. They would need training in leading meetings, but the big advantage is that they speak the language and ask the right questions. One major drawback is that the number of engineers with these skills is quite limited. Also these are the same persons with full agenda's, which are already difficult to get for analysis of existing problems. This strengthens the need for organizations to develop analytical skills of employees even more.

2.4 Communicate the results

Of course it isn't over after the RCA session. On the contrary, this is where the real work starts, with doing the preventive actions from the session. Communication plays a very important role, to change an organization.

First of all the result of RCA sessions can be communicated to people working in the problem area where sessions were done. This helps engineers to learn from problems, and to be prepared when similar problems occur.

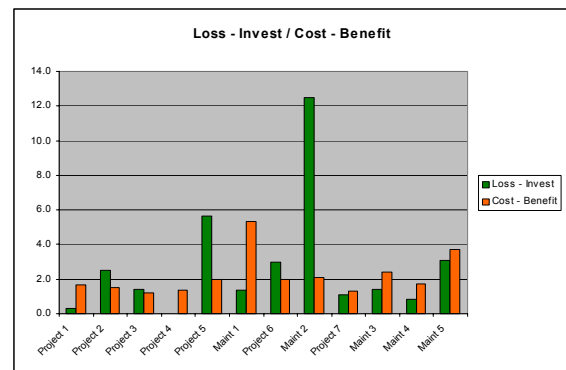
The preventive actions must be assigned to people in the organizations. Communicating the actions, responsible persons, and the expected business results from the actions, will support implementing the actions. People will know which actions are done, and (very important) why. They will be more willing to support the actions, if they are aware of the problems that they prevent, and the benefits.

An organization should communicate how the preventive actions from RCA have contributed towards the targets of the organization, in quantified terms. Communicating the results will give buy in for future actions, and help an organization to see where RCA has been

beneficial. In the end, the results in business targets should make it worthwhile to do RCA!

3 Investigation of Business Results

At Ericsson we did a pilot with RCA. After 12 RCA sessions an investigation was done on the effectiveness and contribution towards business targets ([REF 3]). At that time, 60% of the actions were still open (either unfinished or not started yet). We simply had too many actions, due to too many sessions! The loss was calculated, and costs and benefits of actions were estimated: Expected cost/benefit (C/B) would be 1:1.8 if all actions are done. Note that benefit was calculated for only one next project, which is conservative. Detailed loss- & cost/benefit data is shown below.



The graph shows a difference in C/B between project and maintenance RCA sessions. The average C/B for projects is 1:1.5, while for maintenance it is 1:2.5. Also the cost per RCA session for maintenance was lower than for projects: 115 man-hours compared to 162 man-hours. So RCA pays off more for maintenance, with lower investment!

If we look at the losses of the investigated issues, then the difference is smaller: The loss-investment for projects was 1:1.7, for maintenance 1:2.0. Also individual sessions differ more, the biggest loss was with one customer problem where the loss was 300 hrs; preventive actions would take only 24 hours and would save at least 50 hours in a next project. Note however that average loss in projects is bigger than in maintenance: The conclusion is that many project losses cannot be prevented, even when root causes are clear.

Based on this data the decision was taken to use RCA primary for major customer problems

from maintenance, as RCA showed to be both very effective and result in actions with low investment costs. For projects, alternative tools for preventive actions could be considered, but still RCA can also be an effective tool here.

4 Conclusions

Our experiences with RCA have shown that it is a strong tool that contributes towards reaching business targets. RCA sessions have revealed the root causes of customer related problems, knowing these causes has made it possible to successfully define and implement preventive actions.

RCA has a significant cost/benefit in maintenance, with limited investments. To do effective RCA, engineers are needed with the right skills to analyze problems. A solid understanding in the problem area is essential, to find the most important causes. The RCA session leader must also be knowledgeable in the problem area and speak the language of the engineers, to support analysis. The results are communicated, so that the organization learns, and to enable buy in for preventive actions.

The appendix of this paper contains a step-by-step process description and checklist. They are usable to lead RCA sessions. It is of course advised to do some RCA sessions together with an experienced RCA session leader first, when using this process and checklist.

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Ben Linders is Specialist Operational Development & Quality at Ericsson R&D, in the Netherlands. He is a Bachelor in Computer

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Since 2000 he leads the Defect Prevention program. He coaches implementation of Root Cause Analysis (RCA), and has done many RCA sessions. Also he is local champion for Reviews and Inspections. He has defined and applied a Project Defect Model, used for quantitative management of the quality of products and effectiveness of verification.

He is a member of several (national and international) SPI, CMMI, and quality related networks, has written several papers, and regularly gives presentations on related subjects. He can be reached at +31 161 24 9885, email ben.linders@etm.ericsson.se.

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- [REF 1] CMMI, Causal Analysis & Resolution Process Area. Software Engineering Institute.
- [REF 2] Learning from Our Mistakes with Defect Causal Analysis. David Card IEEE Software, Jan 1998.
- [REF 3] Root Cause Analysis in Ericsson EuroLab Netherlands, A search for the contribution of RCA to the strategic business goals of Ericsson EuroLab Netherlands. O. de Medeiros Carneiro. Nov. 2001
- [REF 4] Apollo Root Cause Analysis, Effective Solutions to Everyday Problems Every Time. Dean L. Gano. 1999.

Web sites about RCA

- <http://www.sei.cmu.edu/cmmi/>
- <http://www.apollorca.com/>
- <http://www.rootcauselive.com/>
- http://www.reliabilityweb.com/fa/root_cause_analysis.htm

Appendix: Root Cause Analysis at Ericsson R&D Netherlands, Ben Linders.

Root Cause Analysis Process

The purpose of Root Cause Analysis (RCA) is analyzing a problem to identify important causes that lead to the problem, and to initiate actions to prevent similar problems from occurring. RCA can be applied on any problem case; most often it is done on defects that were found by customers or during test, major project disturbances, or findings from earlier (CMMI, risk or other) assessments.

Note that there have to be one or more concrete and known problem occurrences to investigate. You cannot do a RCA on a vague problem of which nobody has a clear insight. In such cases, use a brainstorm to explore the problem, possibly extended with a fishbone diagram to organize causes.

Step 1: Preparation

Do the following steps for the RCA investigation assignment with the orderer of the RCA:

- Identify and isolate the problem to be investigated
- Find out what the significance of the problem: Is there a business case for RCA?
- Agree upon the expected results of the RCA sessions (report, presentation, etc)

The RCA should investigate how the problem has hindered the organization in reaching their targets. Actions resulting from the RCA meeting should contribute towards these targets. Also the significance check is very important. If the problem caused much damage, or happens frequently, then investigate it. If it happened only once, or with little to no effect, then don't spend time on it.

Do the next steps to prepare for the RCA session:

- Find out who has knowledge of the problem, and invite her/him to the RCA
- Find out who has authority to decide about and take action, and invite her/him to the RCA
- Plan the RCA session

Usually an RCA session needs 3-5 persons, and takes about ½ to 1 hour. For multiple problems, plan 45 min per problem, maximum of 3 problems per session. State the problem to be investigated and RCA approach in the invitation, and ask to think about the loss that occurred due to the problem.

Step 2: Meeting

Start the meeting with explaining how RCA is done. Use the checklist that shows the steps and the rules, it should shortly be explained (unless everybody is familiar).

In an RCA meeting there are the following steps:

- Define the Problem
- Create a Cause and Effect Chart
- Identify Effective Solutions

Step 2.1: Define the Problem

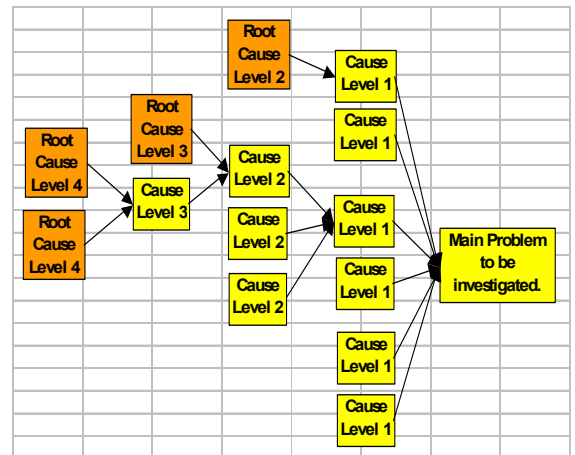
To get the problem view aligned of the meeting participants, ask the following questions:

- What is the problem? When did it happen? Where did it happen?
- What is the significance of the problem, and what has been the loss for the organization?

The purpose of these questions is to get information about the problem, and its context. The loss should be stated in man-hours that the organization has wasted due to this problem. Consensus must be reached on the answers, and they should be written on a flip over.

Step 2.2: Create a Cause and Effect Chart

The cause and effect chart is a horizontal tree diagram identifying the causes that lead to the problem. To start, draw a box at the left side with the problem statement, and ask the question: Why did this happen? Collected answers (one answer per post it), and stick them on the flip over right to the problem statement in a vertical line. For every effect, try to find 2-5 causes. Take one item from the causes, and ask again why. Write answers on post its, and repeat the process. After 4 to 7 levels you either get to a situation where nobody knows the answer, or there is no need to go deeper. Don't stop too early; make sure you get good insight in the problem! Also do not discuss solutions in this step; there will come in the next step. At the end check the diagram on completeness, and clearness.



Step 2.3: Identify Effective Solutions

Effective solutions must fulfill three criteria:

- Prevent recurrence
- Be within control of the involved groups/persons
- Meet targets of the RCA investigation (acceptable, effective, good cost/benefit)

The approach to come up with solutions is as follows: Start on the right side of the chart, and challenge the causes and ask for solutions. Don't judge the solutions, but for now only attach them to the causes. Stimulate creativity, techniques can be to ask for the most radical solution (as if there are no limits) and then check why it shouldn't be possible, or ask for the first thing that comes to mind.

The next step is to check the solutions. Discard solutions that do not meet the three criteria above. Give special attention to meeting the targets that were endangered by the problems being investigated: Would these actions prevent endangering the targets in the future?

Also, be carefully with solutions in areas of:

- Punishment, reprimand, issue a warning
- Investigate, write a new procedure
- Ignore, say it won't happen again

These kinds of solutions do not solve the problem; instead they postpone finding a real solution. Be aware of solution killers, like "it will never work", "we've done that", "that's impossible". Challenge the issuer; ask him/her to explain, this might lead to additional causes.

For every solution, do two estimates:

- How much time is needed to do the action (in one project)?
- What are the savings (benefits) of this action, in man-hours?

These figures should be added on the post it. Together they give input for a cost/benefit decision.

Step 3: Report

Document all solutions in an RCA report, sent it to the participants for completion and checking of the content. After corrections, sent it to the orderer of the RCA with a request for a decision on actions that will be done. Preferably the action follow up meeting is arranged by the RCA session leader, to have a good handover between the session and the line and project organization.

Appendix: Root Cause Analysis at Ericsson R&D Netherlands, Ben Linders.

Root Cause Analysis Checklist

This checklist can be used for effective Root Cause Analysis meetings.

Before the meeting

- Are there problem cases selected (TRs, CRs, etc)? Are they clear?
- Which project/department targets have been endangered? What has been the loss?
- Are persons invited who know the case (TR, problem, event) in detail?
- Is there a prepared presenter for each case?
- Are persons invited who can decide which action of the meeting will be done?
- Will there be times/resources available who can take corrective actions?
- Is sufficient time planned (45 min per investigated case)?
- Is a room arranged with enough space, so that people will feel comfortable?
- Are facilities reserved (flip-over, electronic whiteboard, laptop)?

In the meeting

- Explain the rules of the meeting, have people add additional rules:
 - First understand problem, then look for solutions.
 - No storytelling, nagging, blaming.
 - Only 1 person speaking at the time, others listen.
 - “In god we trust, all others bring facts”.
- State the problem to be investigated, and the scope of the investigation.
- State department/project targets that have been endangered, and check the loss with the people.
- Get the problem clear: What happened, when, where?
- Repeatedly ask: What was the reason? 4-7 levels deep, 2-5 causes per effect.
- Stop story telling, instead look for as many causes as possible.
- Determine: How can it be prevented from happening again in the future?
- Or: How can we identify it earlier, and how can effects be limited when it happens again?
- Look for things that went well and shouldn't be forgotten, learned, still puzzling us?
- Challenge the solution killers and “nay sayers”; try to have them contributing also!
- Determine the expected cost of the actions, and the benefit for a next project.

After the meeting

- Thank everybody for his or her contribution!
- Finalize the report, have it reviewed, and plan for action (see communication checklist).
- Publish results on the web, and update the measurements and graphs on RCA.

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