TRIZ-Based Cause and Effect Chains Analysis vs Root Cause Analysis

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Abstract

This article represents a comparative study of the benefits and shortcomings of two analytical tools widely adopted in industry: Root Cause Analysis (RCA) tools and Cause and Effect Chains Analysis of disadvantages (CECA) that is used in modern TRIZ. Both RCA and CECA are aimed at identifying the deep underlying causes (called 'root causes' in RCA and 'key disadvantages' in CECA) of a target problem; both employ cause-effect analysis for this purpose, which sometimes leads people to think that these two approaches are essentially the same. There are, however, significant differences in how CECA and RCA are performed, which allow CECA to avoid the shortcomings of RCA and generally make it more robust than RCA. In this paper, the author is trying to highlight these differences and show the advantages of CECA.

Keywords: Cause and Effect Chains Analysis, CECA, key problems, Root Cause Analysis, RCA, root causes, TRIZ, TRIZ tools

1. Introduction

Root Cause Analysis (RCA) [1] is a structured methodology that (1) identifies underlying root cause(s) responsible for the target problem and (2) develops corrective actions aimed at eliminating the root cause(s).

In this paper, we will focus only on the cause-effect analysis tools aimed at identifying root causes through the construction of cause-effect chains. These tools in the RCA are [1, 2]:

• Cause-and-Effect Charts (also known as Fishbone diagrams or Isikawa diagrams)

• Five Whys (also known as Gemba Gembutsu) analysis

• Fault Tree Analysis (FTA).

Since Fishbone diagrams do not show all cause-effect relationships contributing to the target problem, they are not very helpful in understanding the nature of the problem. Therefore, this paper will focus on RCA's most useful cause-effect analysis tools: the Five Whys and FTA.

Both the Five Whys and FTA involve building cause-effect diagrams that link target problems with their direct causes and, further down the diagram, with root causes.

At present, the RCA is widely used in industry not only by itself, but also as a critical part of the Six Sigma approach [3, 4] where it is used at the analytical stage of the DMAIC (Define, Measure, Analyze, Improve, Control) process. However, RCA has important inherent shortcomings that reduce its efficacy and limit its applicability to analyzing and solving problems only in relatively simple systems [5].

Modern TRIZ, e.g. GEN3 TRIZ, also has a tool, the Cause and Effect Chains Analysis (CECA) of disadvantages, aimed at identifying underlying key disadvantages and the key problems [6] that are aimed at eliminating the key disadvantages. At first glance this tool may look similar to that of RCA, which often causes the misconception that CECA and RCA use essentially the same approach and that a 'key disadvantage' is just a synonym for 'root cause', which, in fact, is not the case.

In this paper, the author is trying to highlight the differences between CECA and RCA and to show how these differences allow CECA to avoid the shortcomings of RCA.

2. RCA and its shortcomings

In RCA, a root cause is considered to be the basic reason behind a target problem or undesirable event (also called 'non-conformance'). It is the contributing factor that, if removed, will eliminate the undesirable event or problem and prevent it from recurring. Root causes in the RCA are always at the end of cause-effect chains.

In order to identify root causes, either the Five Whys analysis or FTA (Fault Tree Analysis) is applied. These analyses are done by continuously asking the question "Why?" or "Why did this happen?" starting from the target problem and continuing through a few levels of intermediate causes until the root cause is identified.

The Five Whys suggests asking this question at least five times assuming that by the fifth "why?" you will normally arrive at the root cause. In practice it may be necessary to ask "why?" more than five times, and sometimes less than five. This analysis is simple and straightforward, but its applicability is limited to relatively simple target problems.

The FTA analysis is more sophisticated and has detailed rules and instructions [7], which allow for building branched cause-effect chains (fault trees) that include "AND", "OR", and other logical gates linking all causes to the target problem. The rules cover all steps of analysis including (1) how to identify causes (faults or failures); (2) how to link them in a fault tree using logical gates; (3) to what depth/level of details the analysis should be done; (4) where to terminate the fault tree.

As the FTA is a well-developed tool, it is included in the industry standard SAE ARP 4761. This analysis is applicable to more complex engineering systems than Five Whys and in many ways is closer than other RCA tools to the CECA. Nevertheless, even for complex systems, most RCA practitioners prefer to use the simpler Five Whys rather than FTA.

The RCA approach to identifying root causes is presented by a simple case study shown in Fig. 1 and Fig. 2:

• Fig. 1 illustrates a target problem arising when hollow bricks are drilled by a rotary hammer drill designed to drill concrete. As shown in Fig. 1, two types of failure may occur during this operation: (1) a big crater is formed at the end of the drilled hole; (2) the entire wall of the brick is destroyed. Either failure makes it impossible to install a screw anchor in the hole tight enough, which is the target problem in this case study. Fixing this problem at the construction site takes too much time; using separate drills for concrete and hollow bricks eliminates the problem, but doubles the load that a construction worker has to carry and increases cost.

• Fig. 2 shows how the RCA has identified the root cause for this target problem by asking "why?" in five steps. (Comment: the Five Why analysis and the FTA yield the same result in this particular case.) As shown in Fig. 2, the identified root cause is 'lack of impact energy control', which results in too strong impact delivered to the brick. Obvious corrective action is to implement some means for controlling the drill's impact energy.

Interestingly, one difference between RCA and CECA is that it is normal for RCA to include 'lack of control' in a cause-effect analysis, but not for CECA as this tool deals only with components already in the system.

Fig. 1. Typical failures that may occur when drilling hollow bricks by a rotary hammer drill designed for drilling concrete

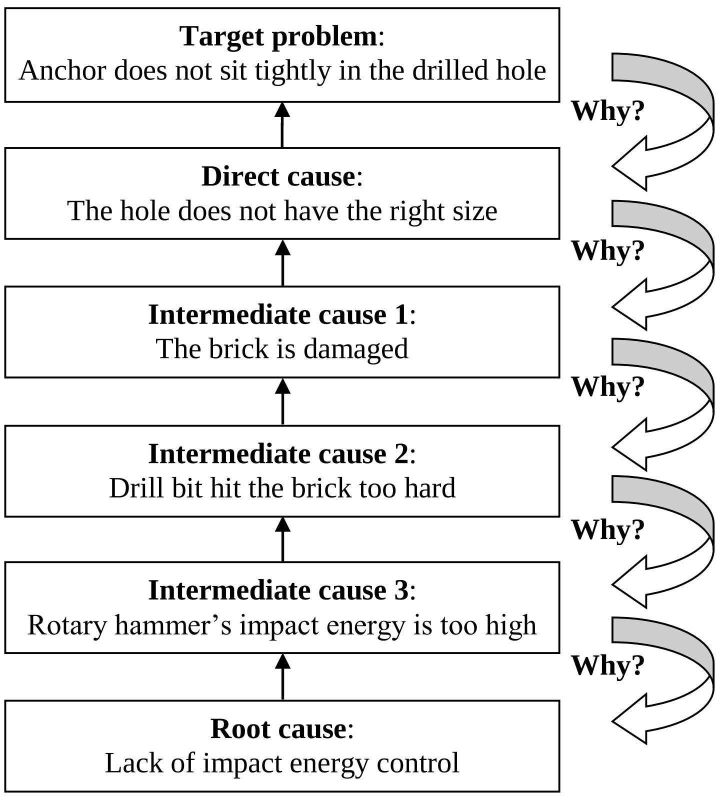

Fig. 2. RCA of the target problem shown in Fig. 1

RCA has been practiced for years. Nevertheless, as shown in paper [5], none of the RCA tools demonstrates a holistic approach nor do they help to understand the problem fully, which is often more important than simply pinpointing a root cause. This means that RCA cannot competently resolve problems in more complex systems.

A few examples of RCA pitfalls listed in the Mini-Guide [2], and their sources, are given in Table 1 below. These pitfalls can easily make RCA fail if, for example, the target problem is incorrectly understood and/or incorrectly defined, or may lead to identifying a suboptimal solution or corrective actions if the most important root causes were not identified.

Table 1

RCA pitfalls and their sources

RCA pitfalls [2]	What causes these pitfalls
Not understanding the problem and therefore not defining it correctly	The main tools used in RCA to understand the problem and system operation are (1) brainstorming, (2) interviews, and (3) expert's knowledge. These tools are too subjective and do not guarantee that all important causes will be captured and included in the analysis.
Not understanding how the system should operate	
Not considering all possible failure modes/causes	Analysis is not deep enough. For example, in the FTA it is not recommended to go deeper than a major component level [7]. This approach does not allow for identifying all causes/failures that relate to subcomponents.
Not identifying all root causes	Cause-effect chains terminate at root causes, i.e. at first encountered causes that, if eliminated, would eliminate the target problem. However, these causes may have their own underlying root causes, which, if discovered, could lead to better solutions.

3. How CECA addresses the shortcomings of RCA

In modern TRIZ, cause-effect analysis is actively used for revealing underlying key problems. A number of TRIZ developers have proposed different approaches [8 - 10] for performing this type of analysis so as to avoid RCA's pitfalls.

For example, the following suggestions were made:

• Terminate branches of cause-effect chains only at the causes representing limitations of the project [8], which guarantees that none of the key disadvantages (in RCA these are "root causes") will be missed;

• Use deeper analysis, i.e. instead of limiting the analysis by a major component level, include causes and effects at the subcomponent level and at the microlevel [8, 9], which helps to discover "hidden causes" that would not be discovered otherwise;

• Find and include causes that appear between two consecutive events [8], which helps to discover hidden causes too;

• In order to reduce laboriousness of the analysis, apply the two previous recommendations only to the causes and effects closest to root causes [8] (i.e. causes terminating cause-effect chains – see first bullet);

• Check completeness of cause-effect chains using the "Parameter-Function Pair Nexus" [9] method, which assumes that cause-effect chains always consist of an alternating parameter-function (or condition-action) type of link;

• Identify technical contradictions (conflicts), which need to be solved in order to eliminate the target problem, by checking what positive effect (if any) each cause in the chain produces [10]. This approach helps to better comprehend the target problem and the system under analysis.

Most of these suggestions are implemented in GEN3 Partners' CECA, which was developed at the end of the 1990s and has been used successfully in hundreds of consulting projects since then [6]. CECA has become an important tool in GEN3's TRIZ-Assisted Stage-Gate Process [11] for developing new products.

Unfortunately, CECA has been documented and taught only within GEN3 (the author contributed to these activities), and has never been published. In this paper, the author is trying, in part, to fill this void.

Table 2 shows how GEN3's CECA addresses the RCA pitfalls (see Table 1).

Table 2

How CECA addresses RCA pitfalls

<table>
<tr><th>RCA pitfalls [2]</th><th>How CECA's answer</th></tr>
<tr><td>Not understanding the problem and therefore not defining it correctly</td><td rowspan="2">The main tools used to define the target problem and to understand the system operation are (1) Function Analysis, and (2) Flow Analysis. Both of these TRIZ tools also utilize expert's knowledge of the system.
These tools are much less subjective than that used in the RCA. They guarantee that all important causes/disadvantages will be captured and included in the analysis.</td></tr>
<tr><td>Not understanding how the system should operate</td></tr>
<tr><td>Not considering all possible failure modes/causes</td><td>• The resolution (depth) of CECA is flexible: important causes and effects are analyzed deeper than others - at the subcomponent level and microlevel if needed.
• Cause-effect chains are built so as to make sure that a parameter-related cause is followed by an action-related cause and vise versa.
This ensures completeness of cause-effect chains and identification of all possible failure modes/causes.</td></tr>
<tr><td>Not identifying all root causes</td><td>Cause-effect chains always terminate at causes that represent (1) project constraints or requirements, (2) legal limitations, or (3) limitations implied by nature's laws. These causes cannot be eliminated, and, so, they are not further analyzed. This approach guarantees that cause-effect chains include exhaustive set of causes that can be eliminated, and, hence, all key disadvantages (RCA's "root causes") are identified.</td></tr>
</table>

The CECA approach is illustrated in Fig. 3, which shows the results of an analysis of the target problem shown in Fig. 1.

As can be seen from Fig. 3, CECA yielded four root causes representing either project requirements or nature's laws (e.g. brick's material properties that cannot be changed). None of these root causes can be eliminated, which is normal for CECA (see the last row in Table 2).

The causes that should be eliminated in order to eliminate the target problem are called in CECA 'key disadvantages'. Each key disadvantage can be easily converted into a key problem aimed at eliminating this disadvantage.

Although the algorithm for selecting key disadvantages from the pool of intermediate causes in the cause-effect chain is out of this paper's scope, it should be mentioned that this can be done using methods similar to those used in the FTA for identifying 'cut sets' [7].

Fig. 3 shows that the following three key disadvantages have been identified:

1. "Rotary hammer's impact energy is too high (for a brick)." This suggests introduction of some means for controlling the drill's impact energy so as to reduce it when drilling bricks.

2. "Impact duration is too short (for a brick)." This means that longer impact would not destroy the brick even if the impact energy is kept high.

3. "Drill bit's penetration speed in the brick is too low." This means that a drill bit penetrating a brick faster than cracks in the brick can propagate, would solve the target problem.

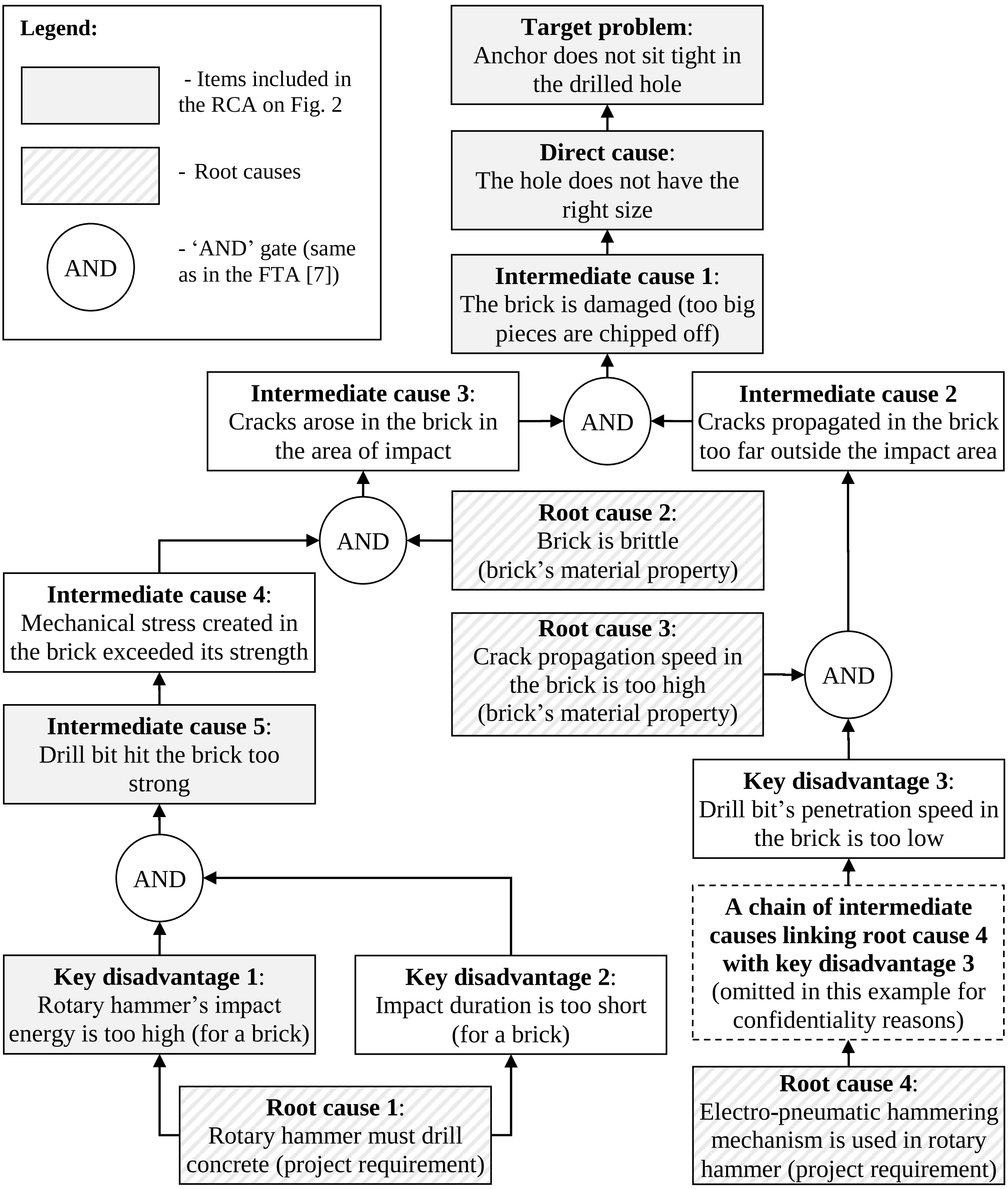

Fig. 3. CECA of the target problem shown on Fig. 1

The first key disadvantage is essentially the root cause yielded by RCA (see Fig. 2). Two others were missed by RCA and discovered by CECA due to a higher resolution of analysis (at the 'cracks-in-the-brick' level) in the "operating zone" (in the ARIZ sense) where the target problem occurs. Eliminating either of these key disadvantages may yield an engineering system with a completely new principle of operation, e.g. a drill with ultra high speed-penetrating drill bit, or a drill with controllable impact duration instead of controllable impact energy.

4. Discussion

Despite the fact that, at first glance, RCA and CECA look similar, they are essentially different in important details, which are summarized in Table 3.

Table 3

Main differences between RCA and CECA

Item	RCA	CECA
Tools that are used to define the target problem and intermediate causes	- Brainstorming - Interviews - Experts' knowledge	- Function analysis - Flow analysis - Experts' knowledge
Resolution of analysis	Not too deep. Normally at a major component level.	Flexible – from major components to subcomponents, and even to the microlevel where needed (e.g. in an operating zone)
Terminating element(s) in a cause-effect chain	Root Cause(s) to be eliminated to solve the target problem	Root Cause(s) that cannot be eliminated as they represent fundamental requirements or constraints of the project
Ability to identify "hidden causes"	No	Yes (ensured by maintaining 'parameter-action' sequence of links in cause-effect chains)
Ability to identify technical contradictions	No	Yes (ensured because the cause-effect chains are complete)

This table shows the higher efficacy of the CECA approach, reflected in the case study presented in Figs. 1 through 3.

5. Conclusions

Based on the results presented in this paper, the following conclusions can be made:

• CECA is an essentially different and more advanced tool relative to RCA. It uses objective modern TRIZ tools, such as Function and Flow Analyses, rather than the brainstorming and interviews used in RCA.

• RCA's root causes are not the same as CECA's root causes, which are absolute terminations of cause-effect chains that cannot be eliminated, nor are they the same as CECA's key disadvantages, because the latter are located above CECA's root causes and in most cases represent deeper level causes than RCA's root causes.

• CECA is superior because it identifies an exhaustive set(s) of key disadvantages to be solved in order to eliminate rather complex target problems.

• Unlike CECA, RCA does not guarantee that all root causes will be identified and, hence, does not guarantee that the most promising solutions will be found.

• Therefore, RCA seems to be suitable mostly for express analyses aimed at identifying near-term solutions for less complex target problems; for more complex tasks CECA is preferable.

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References

1. Andersen B., Fagerhaug T. Root Cause Analysis: Simplified Tools and Techniques, 2nd Edition, Milwaukee, Wisconsin, USA, ASQ Quality Press, 2006.

2. Vorley G. Mini-Guide to Root Cause Analysis, Guildford, Surrey, U.K., Quality Management & Training (Publications) Ltd, 2008. Available: http://www.root-cause-analysis.co.uk/images/Green%20RCA%20mini%20guide%20v5%20small.pdf, accessed March 29, 2015.

3. Pyzdek T. The Six Sigma Handbook, Revised and Expanded: A Complete Guide for Green Belts, Black Belts, and Managers at All Levels. USA, The McGrow-Hill Companies, Inc., 2003. eBook available: http://www.gmpua.com/QM/Book/The%20six%20sigma%20handbook.pdf, accessed March 21, 2015.

4. El-Haik B., Roy D. Service Design for Six Sigma. Hoboken, New Jersey, John Wiley & Sons, Inc., 2005.

5. Yuniarto H.A. "The Shortcomings of Existing Root Cause Analysis Tools". Proceedings of the World Congress on Engineering 2012, Vol III, WCE 2012, July 4 - 6, 2012, London, U.K. Available: http://www.iaeng.org/publication/WCE2012/WCE2012_pp1549-1552.pdf, accessed March 19, 2015.

6. GEN3 Partners, Inc., "Key Problems", GEN3 Partners Web site, http://www.gen3partners.com/methodology/innovation-processes/key-problems, accessed March 22, 2015.

7. Vesely, W., et al. Fault Tree Handbook with Aerospace Applications, Version 1.1, NASA Publication, August 2002. Available: http://www.barringer1.com/mil_files/NASA-FTA-1.1.pdf, accessed March 25, 2015.

8. Pinyayev A.M. "Functional Why-Why Analysis". July 7-8, 2007, TRIZ Developers Summit 2007 Conference Paper. TRIZ Developers Summit Web site, http://triz-summit.ru/ru/203798/203654/203814/203844/, accessed March 19, 2015.

9. Yoon H. "Occasion Axis and Parameter-Function Pair Nexus for Effective Building of Cause Effect Chains". Proceedings of the 10th International Conference TRIZfest-2014, September 4-6, 2014, Prague, Czech Republic, pp.184-194. Available: https://www.dropbox.com/s/mkfgyhudpc3fymk/TRIZFest2014_Proceedings.pdf?dl=0, accessed March 21, 2015.

10. Souchkov V. "A Guide to Root Conflict Analysis (RCA+)". ICG Training & Consulting, Enschede, The Netherlands, 2011. Available: http://www.xtriz.com/publications/RCA_Plus_July2011.pdf, accessed March 21, 2015.

11. Abramov O.Y. "TRIZ-assisted Stage-Gate Process for Developing New Products". Journal of Finance and Economics, 2014, Vol. 2, #5, pp. 178-184. Science and Education Publishing. http://pubs.sciepub.com/jfe/2/5/8, accessed March 19, 2015.