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Root cause as a U-turn

Luca Del Frate [a,*], Sjoerd D. Zwart [a,b], Peter A. Kroes [a]

[a] Philosophy Section, TPM, Delft University of Technology, Jaffalaan 5, 2628 BX, Delft, The Netherlands
[b] Philosophy and Ethics Section, IE&IS, Eindhoven University of Technology, P.O. Box 513, 5600 MB, Eindhoven, The Netherlands

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ABSTRACT

Failure analysis is the process of identifying the causes and factors leading to undesired loss of functionality. Failure investigators use several kinds of notions to explain this loss. An important one is that of a root cause, but investigators still disagree about the exact meaning of this term. We maintain that two approaches to define root causes can be found in the literature. One originates in backward-looking causal analysis, which aims at determining the causes and factors accompanying a specific failure event; it is token-based and comprises mainly deterministic reasoning. The other is associated with forward-looking effects analysis, which is type-based, and sets out to find correctable factors and prevent recurrence by mainly probabilistic reasoning. Drawing on case studies from the engineering failure-analysis literature, we propose to combine the two approaches to form a new sensible notion of root cause as a U-turn.

1. Introduction

Several engineering disciplines and activities deal with product or component failure, such as risk assessment, safety science, reliability engineering and failure analysis. Avoiding failure is an even more important aim of engineering design. The notion of failure, however, does not have the same meaning in the various disciplines and activities. In reliability engineering, for instance, the notion of failure is mainly associated with the statistical tools used to define the failure rate of an item. In risk assessment, the effects of failure are crucially important and, multiplied with the probability of failure, are used to calculate the risk of putting the item to work. Failure analysis has two related connotations. On the one hand, the term refers to a body of knowledge, which develops scientific and engineering tools (e.g., models, methods, theories) to analyse and explain failure phenomena. As noted by Wulpi [1], it is a very complex field based on contributions from many disciplines and from specialist fields as diverse as structural engineering, chemistry, fracture mechanics, fractography, stress analysis and metallurgy, to name but a few. On the other hand, failure analysis has to do with the *investigative process* regarding a specific failure event and to the application of the tools mentioned, and is synonymous therefore with failure investigation. To quote the definition given in the *ASM Handbook* [2], "failure analysis is a process performed in order to determine *the causes or factors* that have led to an undesired loss of functionality" (emphasis added). Although carrying out a failure investigation can have many reasons (e.g., to assign responsibility, to prevent recurrences or to improve productivity), it is widely accepted among practitioners that failure analysis *is* the process of finding the causes and factors that led to the failure in the first place. It is less clear what the nature of these causes and factors is. One consequence of this lack of clarity is the proliferation of terms and taxonomies, among which the distinction between causes and factors is a telling example. Other related terms that appear in the literature are: primary cause, immediate, direct, underlying, probable, latent, secondary and of course root cause that forms the topic of this paper and is probably the most controversial of all the terms.

* Corresponding author. Tel.: +31 (0)15 2789870; fax: +31 (0)15 2786439.
E-mail addresses: l.delfrate@tudelft.nl (L. Del Frate), S.D.Zwart@tudelft.nl (S.D. Zwart), P.A.Kroes@tudelft.nl (P.A. Kroes).

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