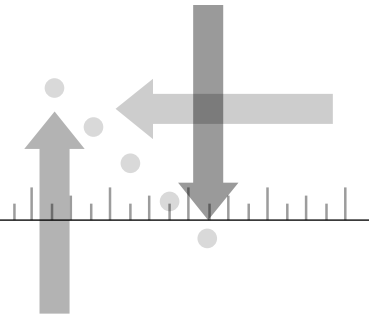# FAULT TREE ANALYSIS

Purpose

A fault tree analysis (FTA) is a step-by-step procedure that is used to logically identify, evaluate, and quantify potential problem causes for a performance gap (failure) in a system and to determine strategies for preventing these causes.

Needs Assessment Applications

In a needs assessment, the typical function of a fault tree analysis is to identify the *causes* of performance gaps in a system (for example, your organization, a division within your organization, or a government unit). FTA is especially useful when specific failures within the system lead to performance gaps. The FTA provides a systematic process for analyzing situations and determining the relevant causes.

An FTA can help you to recognize the interrelationships among causes in the system and to evaluate the potential effects of causes in terms of the failure of the system. By addressing multiple causes, the FTA can also help you identify strategies that can be used to reduce the probability of future problems in the system.

The analysis procedures in an FTA are based on creating a visual representation (a fault tree) that identifies each of the potential causes, the relationships (failure sequences) between the causes, and the prioritized prevention strategies. Fault tree analysis is used widely in many engineering disciplines, but it can also be used in needs assessment as a root cause analysis technique. It can be an effective tool for increasing the chances of success for a specific system. The technical nature of the technique does, however,

likely require additional preparation beyond the process overview we provide here.

Advantages and Disadvantages

Advantages

• An FTA can be used with both a large and a small numbers of participants.

• The FTA displays information in a structured, graphic way that makes it easy to interpret and communicate.

• The FTA technique solicits input and insight from a wide number of experts.

• The focus in the FTA technique is on the system being analyzed, rather than on the individual people in the system. Thus, it may be easier to get a buy-in because people are less likely to feel threatened.[1]

• Agreements and diverging views on system inputs are represented in the FTA.[2]

• An FTA can be used effectively for analysis of recurrent and persistent problems, because such problems are likely to have common causes and contributory factors.
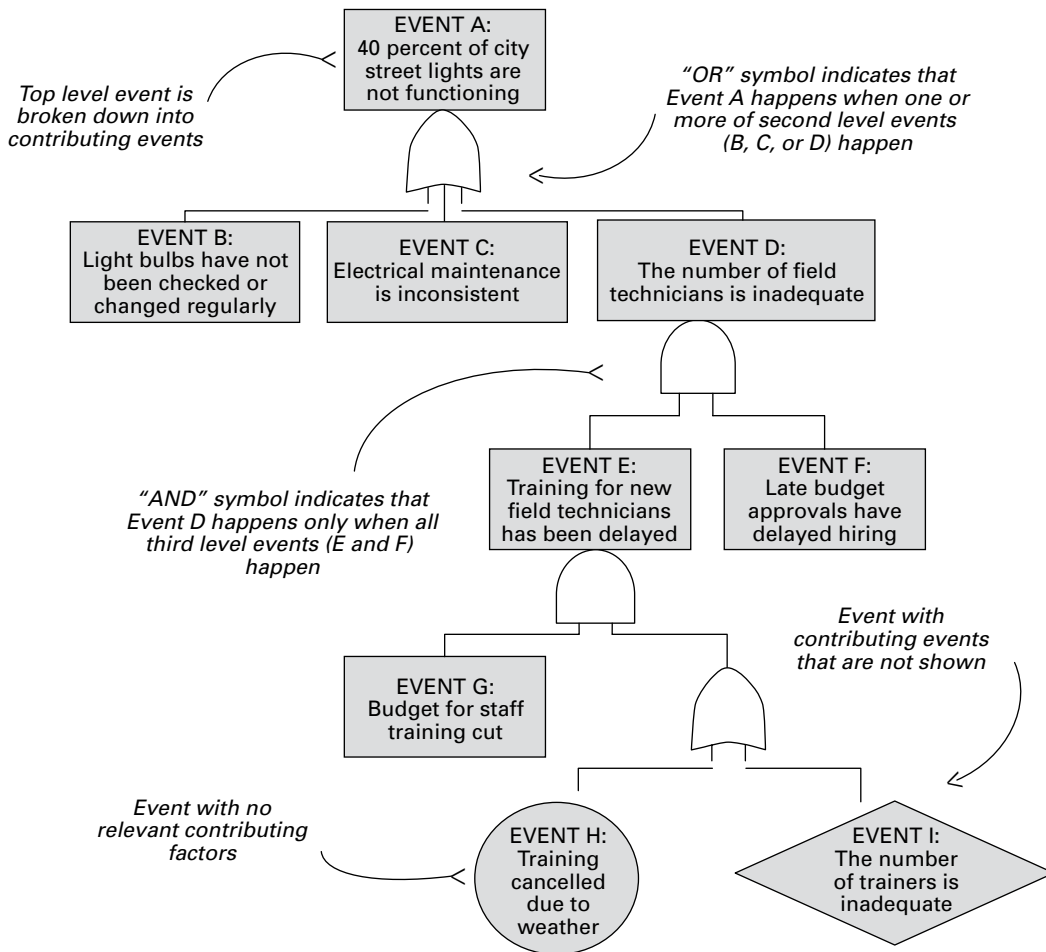
Disadvantages

• Because this technique is highly reliant on judgment and insight that are based on subjective opinions, there is a risk of inaccurate information, which compromises the accuracy of the results.

• If the wrong failure sources are identified in an FTA, the subsequent results yielded may experience a ripple effect of this error. Results may, therefore, not be valid or accurate.

• FTAs may fail if the technique is not implemented in a disciplined fashion or if the system problem is so complex that multiple levels of potential causes exist for each problem type.[3]

• When the system of focus for the FTA is very large, quantitative analysis software may be required to analyze the results.

- FTA can be a relatively time-intensive and complex technique; in this book, we provide an overview of the process although additional readings are likely required for a successful application.

Process Overview

1. If the technique is being applied in a formal, scheduled session, take the necessary steps to prepare for conducting the FTA.

   a. If technological methods will be used, acquire concept mapping software, a computer, a projection device (for example, a video projector), and a projection surface or screen.

   b. If nontechnological methods will be used, ensure that you have access to a large surface area (that is, a whiteboard or chalkboard) on which you can create the concept map, as well as thick markers in various colors, tape, and so on.

   c. If you are doing the concept mapping session with a large number of participants, consider identifying a colleague or assistant who is able to create the actual concept map while the facilitator mediates the session.

   d. Identify and invite participants who are experts on the system that will be the focus of the FTA.

   e. Schedule the FTA activity session.

2. Using your list of information required for the needs assessment, define the system that will be the focus of the FTA.

3. Identify the "what should be" for the system either by identifying the system's mission, purpose, or goals, or by defining the criteria for what the "ideal situation" would look like.

4. Working with an expert on the system of focus, begin the process of building the fault tree (see figure 3B.3). Determine, in specific terms, "the top undesired event" for which you want to identify the underlying causes. Write the top undesired event at the top of the tree.

   a. This undesired event will be the foundation on which the FTA will be constructed, so it is important that it be identified in clear terms.

5. Identify the factors (conditions) that are in the immediate vicinity of the top undesired event and that could be causing it. Write those key factors immediately below the top of the tree.

A Guide to Assessing Needs

Figure 3B.3 Example of a Basic Fault Tree Analysis

Top level event is broken down into contributing events

EVENT A:
40 percent of city street lights are not functioning

"OR" symbol indicates that Event A happens when one or more of second level events (B, C, or D) happen

EVENT B:
Light bulbs have not been checked or changed regularly

EVENT C:
Electrical maintenance is inconsistent

EVENT D:
The number of field technicians is inadequate

"AND" symbol indicates that Event D happens only when all third level events (E and F) happen

EVENT E:
Training for new field technicians has been delayed

EVENT F:
Late budget approvals have delayed hiring

Event with contributing events that are not shown

EVENT G:
Budget for staff training cut

Event with no relevant contributing factors

EVENT H:
Training cancelled due to weather

EVENT I:
The number of trainers is inadequate

Source: Based on examples from http://syque.com/quality_tools/toolbook/FTA/example.htm and http://syque.com/quality_tools/toolbook/FTA/how.htm.

6. Look at each of the key factors you have identified in the previous step. What subfactors could be causing the key factors? Identify the subfactors, and place them underneath the appropriate factor on the tree.

   a. Do not move on to the next level of analysis until there is consensus that all factors at the current level have been identified.

7. Continue this procedure—building the tree-like graphic—until there is a general consensus that the tree is finished.

8. After the fault tree has been completed, work with experts to carefully and systematically analyze it for accuracy. Compare the fault tree's factors and structure against the actual system being analyzed.

9. Analyze the fault tree. This analysis can be done either statistically or through informal nonstatistical methods (such as brainstorming). To analyze quantitatively, use statistical analysis to determine the probability of all the contributing factors you have listed in the tree.[4] This analysis can be complex, and we recommend doing additional readings before completing the analysis.

10. By drawing on your analysis, you should be able to identify the potential factors, as well as the sequences of factors, that may account for the performance problem that you identified as the top undesired event.

11. Focus particularly on the factors that appear lowest in the tree, because remedying or preventing these root causes is the most effective and efficient way to obstruct or eliminate the critical paths leading to the top undesired event.

Tips for Success

- The FTA technique works best for problems that have a medium level of complexity. For very complex problems, this technique can be difficult to manage or overwhelming for people to interpret.

- Remember that the expert insight that is used to construct the fault tree is generally of a very subjective nature. Take steps to consult as many experts as possible and to externally validate the fault tree and its outcomes. Both of these steps will reduce the subjectivity to some extent.

Notes

1. Based on Jonassen, Hannum, and Tessmer (1989).
2. Ibid.
3. Based on http://www.greatsystems.com/rootcause.htm#FTA.
4. Based on Jonassen, Hannum, and Tessmer (1989).

References and Resources

Jonassen, David H., Wallace H. Hannum, and Martin Tessmer. 1989. *Handbook of Task Analysis Procedures*. Westport, CT: Praeger.

Vesely, William E., F. F. Goldberg, Norman H. Roberts, and David F. Haasi. 1981 *Fault Tree Handbook (NUREG-0492)*. 1981. Washington, DC: U.S. Nuclear Regulatory Commission. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0492/.

Websites

Detailed discussion with description of the meaning of each figure in an FTA graphic is available at http://www.weibull.com/basics/fault-tree/index.htm.

Discussion of fault tree analysis with examples and how-to procedures is available at http://syque.com/quality_tools/toolbook/FTA/how.htm.