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Assigning responsibility for a structural failure

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Fault Tree Analysis (FTA) is typically used during the engineering design process to plan for the avoidance of in-service failure. This paper presents a variation of FTA; this has been adapted to assist non-engineers with the identification of the causes of structural failures and to indicate the relationship between these causes and the party or parties who should accept responsibility for them. Examples are provided to illustrate the methodology and its application.

1. Introduction

A structural failure, particularly when the financial costs are high or the consequences involve human life, is likely to be followed by an insurance claim. The claim may further be accompanied by a legal action to seek redress from the party or parties held to be responsible. The investigator may, therefore, be tasked (specifically or by implication) with determining the 'proximate cause' of the failure and preparing an incident report for use by the insurance adjuster or an attorney.

Central to the consideration of any insurance claim is the identification of the proximate – also referred to as the 'legal' or 'direct' – cause of the incident; this is required by the insurance company to establish that the loss is, in fact, insured. Defined in 1908 [1] as "*the active and efficient cause that sets in motion a train of events which brings about a result, without the intervention of any force started and working actively from a new and independent source*", the proximate cause is the single act without which the event would not have occurred – it is the catalyst of the structural failure to which the insurance claim or legal case relates.

In a simple failure case there may be a more or less straight line between the proximate cause and the outcome, and indeed this is so for the vast majority of insurance claims. However, and particularly when the failure incident is serious, major or catastrophic, it is probable that a complex combination of events and/or decisions – most attributable, ultimately, to human error – by multiple parties will have led to the failure incident. In such cases, the search for the proximate cause may be less relevant than the identification of the *relative blameworthiness* of the implicated parties.

Bradley [2,3] developed a coded approach based on FTA in order to analyze system failures in terms of human errors. This paper reviews Bradley's approach and failure classification criteria, and applies these to several cases of serious structural failures.

The authors suggest that Bradley's post-incident methodology could be of benefit to those who, without a sound background of engineering or failure analysis, will need to grasp very quickly pertinent engineering and technical issues, identify key parties, map the chronology of an incident, and – just as significantly – eliminate any time-wasting red herrings at an early stage. Use of

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the FTA methodology during an incident investigation has the ability to deliver a robust reference document with value to assist an insurance adjuster or an attorney with the process of assessing the relative blameworthiness of the various factors and parties involved in an insurance claim or litigation.

2. Assignment of proportionate responsibility

The need for an approach that can support the assignment of relative blameworthiness, or proportionate responsibility, for a structural failure arises from the fact that almost all major or catastrophic structural failures will be found to "… *have multiple causes and … each incident arises when an appropriate combination of causes comes together at one time and place*." [4]. It is very seldom that one act, factor or mechanism can be assigned sole responsibility for a large-scale failure event.

The NASA Space Shuttle Challenger disaster of 1986 is frequently used to illustrate an interdependency in a sequence of events that results in catastrophic failure: the failure was due to four separate events that followed one after the other [4,5]. All had to occur for the failure to happen.

Thus, an insurance claim or lawsuit following a large failure incident may be highly complex and expose an apparently opaque picture of interlinked actions enacted by multiple parties. Each party may bear a degree of responsibility for the failure outcome. Additionally, numerous contributory factors including design, materials, inspection, operation, and so on, may be implicated. All or several parties may become enmeshed in a complex web of lawsuit and counter-suit, at which time they will be represented by insurance adjusters or legal counsel; highly skilled as these persons will be in their own professions, it is entirely possible that they will lack expertise in engineering or in failure analysis relevant to the case in hand.

In particularly impenetrable cases there may be a cynical tendency to attempt to seek financial recourse from the party considered to have the 'deepest pockets'. Unwarranted blame may be assigned, by name or by implication, to a party or parties deemed 'responsible' for the failure and resultant economic loss, with consequent and perhaps undeserved damage to business reputation, viability and longevity.

Therefore, seeking a proximate cause may not, in all circumstances, accurately reflect the development or sequence of a complex structural failure event, and this may in turn lead to a shortfall in the evenhandedness of the assignment of blame and/or financial liability.

A more equitable approach, which has the capacity to analyze and assess a complex situation, and apportion the degree of responsibility of a party or parties together with the financial and moral responsibility on a relative basis, is therefore indicated. Such an approach would allow the identification the *relative blameworthiness* or *proportionate liability* of the parties to an insurance claim or legal case. The allocation of proportionate economic and/or moral redress would represent the degree of input to the event itself.

A codified diagnostic approach, based on modified Fault Tree Analysis (FTA), has the potential to provide some transparency to the process of an insurance claim or legal case to assist in the logical and systematic identification of the root issues and relevant parties, and to assist both insurance companies and legal firms in (a) weeding out any red herrings at an early stage and (b) to identify positively the contributing actions and the parties on whom an investigation should focus. It may also ensure no damage is done to parties who should be exempt from blame.

Several caveats accompany the approach at this stage: it is most appropriate where more than one party is involved in a claim; it can be developed further in order to assign codes to the individual parties; and a system of weighting to determine the degree of relative responsibility of each party can be introduced. This paper does not attempt to explore any legal arguments or the ability of parties to discharge their economic responsibilities. The codified approach is not suitable for (although it may assist with) the development of a multi-level accident analysis scenario.

3. Codifying errors contributing to a failure event

The traditional and primary use of FTA aids in testing new engineered systems and predicting where and when failures will occur in order that counter-measures can be prepared. Bradley [2,3], in contrast, devised a post-incident methodology using the principles of FTA. In effect, Bradley's methodology provides for the construction of the fault tree on the basis of a historical failure and works backwards from a failure event in an inversion of classic FTA.

Table 1
Error codes.

Code	Error type
B	Buying (Was the correct item or equipment ordered and provided?)
C	Commissioning (Did the item or equipment operate correctly?)
D	Design and specification (Were the design and the operation of the equipment satisfactory?)
M	Management (Were the specifications checked and proper instructions provided?)
O	Operating (Were proper procedures in place in operating equipment?)
P	Production (Were there any errors in manufacture or installation?)
R	Repair (Were any repairs required and, if so, were they done properly?)
F	Failure of equipment (no direct human error)