

Statistical and Analytical Tools for Understanding the Impact of Design, Maintenance and Operation Decisions on System Failure Performance

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Abstract

Fault Tree Analysis (FTA) has been the most commonly used method to predict the failure probability and frequency of industrial systems since its conception in the 1960s. The tree is a graphical representation of the causes of the system failure in terms of combinations of its component failures and their failure probability distributions. There are now excellent commercial tools to perform such an analysis. However, over the last 60 years engineering technology has made huge advances and this, together with the demands for improved levels of performance, have resulted in substantial changes in designs and operational and maintenance practices. Consequently, the underlying assumptions implicit in the commercial tools such as, independence of component failures, exponential component failure and repair time distributions, and simplistic maintenance strategies, limit its ability to model the performance of modern industrial systems. This clearly impacts on the quality of the decisions that can be supported.

The presentation will start with a summary of the features of the traditional FTA approach to system modelling and examine the assumptions implicit in the methodology. It will then describe a series of features, commonly exploited in the design, operation and maintenance of modern engineering systems from a range of industrial sectors, which violate these assumptions.

The talk will then proceed to discuss a recently developed approach to overcome these restrictions. Dynamic and Dependent Tree Theory or D^2T^2 , significantly increases the ability of FTA to represent the system characteristics. It exploits the analysis methods of Binary Decision Diagrams (BDDs), Petri Nets, and Markov models. Transparent to the user, the tool modularises the original problem into mutually independent sub-modules. This enables the most appropriate and efficient solution method to be utilised to quantify each aspect of the system model. An aircraft fuel supply system which pumps fuel from the tanks through to the engines will be used to demonstrate the method's features.

Finally, it will be demonstrated how the flexibility of the D^2T^2 framework enables the integration of many other analytical and statistical methods to improve the capability to represent real system performance.