Using a Combination of Analysis Tools for Effective Risk Assessment

Relex Case Study: Heavy Equipment Manufacturer Benefits from Quantitative Risk Analysis

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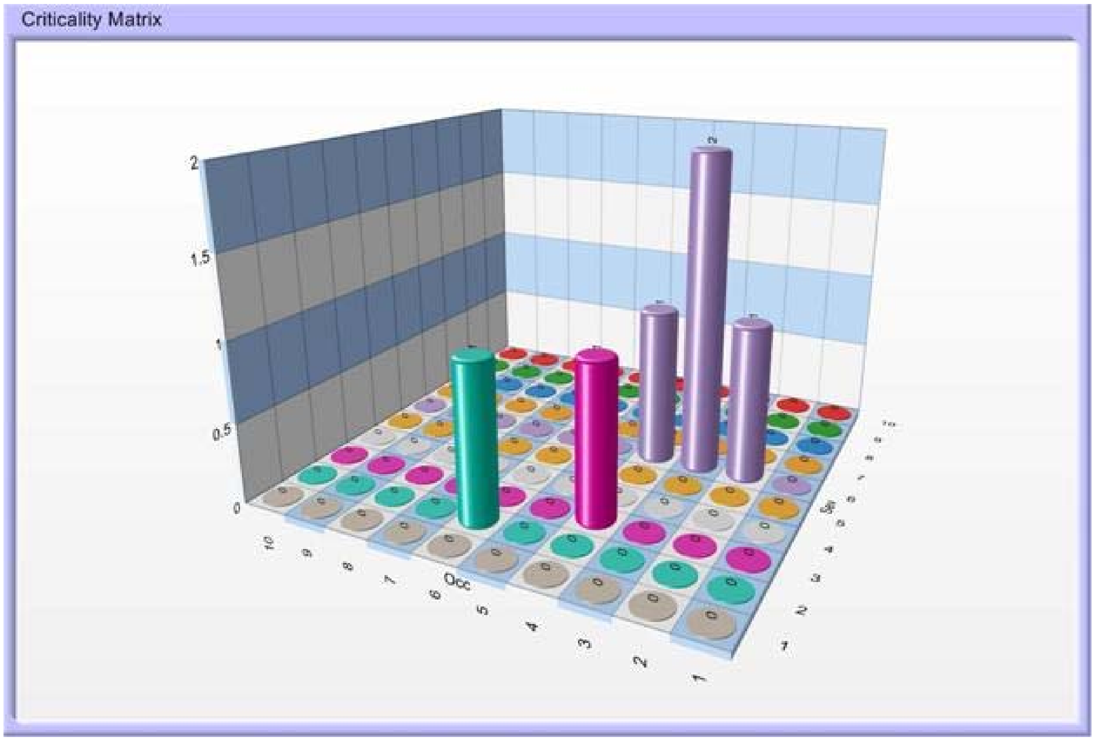
Risk analysis is a key component of product reliability evaluation, providing a framework for analyzing, assessing, and ultimately reducing risk. Risk can be thought of as the probability of harm or loss occurring. Risk analysis is the means of quantifying the type, likelihood, and magnitude of potential system risks. Overall, the goal of any risk assessment is to reduce, eliminate, or mitigate risk to produce a safer, more reliable product or process. Risk analysis is applied in a broad range of industries and markets, including medical devices, aerospace, defense, automotive, and electronics.

Risk analysis can be performed in both a qualitative and quantitative manner. A Failure Mode and Effects Analysis (FMEA) generally provides a qualitative approach to risk assessment. FMEAs can be used to analyze failure modes, single point failures, and their resulting effects on the system. In some cases, FMEAs can include more quantitative information, such as numerical rankings of Risk Priority Numbers (RPNs), which provide numeric rankings of the risk associated with particular failure modes. Fault tree analysis (FTA) can also be used for risk assessments in both a qualitative and quantitative manner. Using cut set analysis, fault trees can provide information on the paths of events that lead to an undesirable system event. For a thorough quantitative analysis, a fault tree analysis can be used to evaluate the probability of a detrimental event.

Risk Quantification Methods

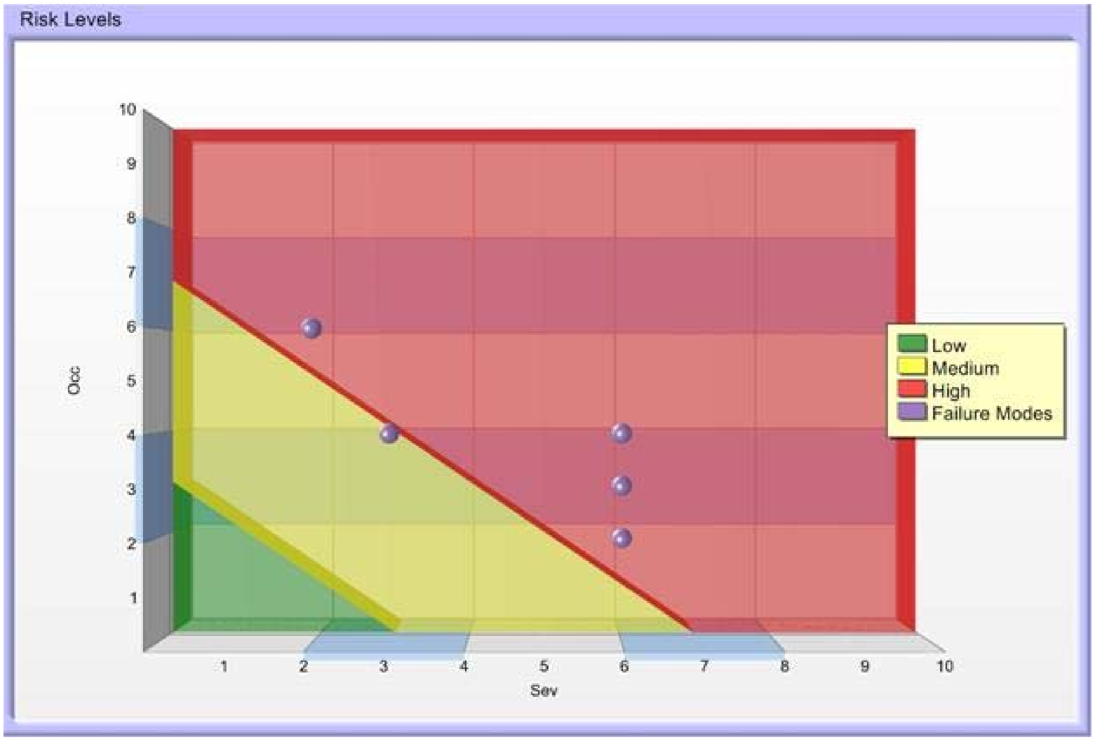
Quantifying risk can be subjective or objective. Various standards exist in the commercial and military markets that provide methodologies for the analysis and measuring of risk. For example, a quantitative but subjective approach commonly used is the classification of failure modes within the FMEA. Failure modes can be categorized by calculating a Risk Priority Number (RPN) for each failure mode. This is done by assigning Severity, Occurrence, and Detection values to each failure mode and then multiplying these values together to yield a single result. A threshold can be set for RPNs greater than some value, such as 125, to flag those failure modes that may require corrective action.

Additionally, assigned Severity and Occurrence values can be plotted on graphs in various ways. For example, a Criticality Matrix is typically generated by plotting the Occurrence and Severity values for failure modes to easily identify those modes whose severity and occurrence are above some unacceptable level.



Criticality Matrix

A Risk Level graph shows how failure modes are distributed over defined risk levels. The risk levels are typically based on Severity and Occurrence values, as shown in the following Risk Level Graph.



Risk Level Graph

While classifying risk in terms of Severity, Occurrence, and/or Detection values is adequate for many applications, it may be insufficient for others. In cases where a system failure could result in excessive cost or loss of life, engineers may want to look for hard numbers as a more solid basis on which to make their decisions. In this case, it becomes necessary to look at quantitative risk measurements.

Real-world Risk Assessment Example

Relex Professional Services recently completed a consulting engagement to provide a quantitative risk analysis of a rescue hoist. The driving need to conduct this analysis came from the manufacturer's requirement to conduct the FMEA down to the component level by their customer. The manufacturer also needed to understand the probability of specific functional failures that would affect search and rescue missions. To this end, both the Relex FMEA and Fault Tree tools were used.

Complete Risk Analysis through a Combination of Relex Tools

This particular project demonstrates how FMEA, Fault Tree, and Reliability Prediction analyses can be collectively used to provide a complete quantitative risk analysis. In this example, the manufacturer was required to supply their customer with a Task 102, MIL-STD-1629A FMECA, which is supported by Relex's FMEA tool. They also needed to have a Fault Tree for all critical end effects, which Relex's Fault Tree tool was able to provide. Additionally, because underlying probability data is based on failure rates of system components, the necessary failure rate data could be obtained by using Relex's Reliability Prediction package.

To complete a thorough quantitative analysis, Relex Reliability Prediction was used to provide key metrics of failure rate (MTBF) data. Because the failure data was from several different sources, the ability and flexibility Relex Reliability Prediction provides in being able to evaluate failure rate values from a variety of sources was critical. “The primary source of the failure rate data for the electrical components in the systems was a MIL-HDBK-217 reliability prediction,” said Duane Huffman, Senior Application Engineer, ASQ CRE on this project for Relex Software. “For mechanical items, we were able to leverage field failure data and information collected from the NPRD library, which is supplied with the Relex Reliability Prediction module.”

MIL-STD-1629A, Task 102 Usage for the FMEA

Using Relex Reliability Studio 2007, which includes out-of-the-box support for MIL-STD-1629A, Task 102, the engineers were able to dynamically link failure rate data between the Reliability Prediction and FMEA modules. The Task 102 FMECA is a standard Aerospace and Defense FMECA format that includes using failure information to compute a failure mode criticality number and an item criticality number.

Failure Mode Criticality

Failure mode criticality is used to assess failure mode risk for hardware components based on actual failure rate and part configuration data. If the failure rate of a component is established in some manner, you can assign a mode percentage to each possible failure mode of the component. For example, assume a component has two failure modes. If one of these modes accounts for failures 75% of the time, you would assign a mode percentage of 75 to this mode and a mode percentage of 25 to the other mode.

According to Huffman, lists of failure modes for components and their associated mode percentages are available in various databases. Relex Reliability Studio comes packaged with several different FMEA Modes Library files that contain this data. You can choose to use the information supplied in any of these files or create your own custom FMEA Modes Library files. In Relex FMEA, a failure effect probability can then be assigned to each mode, which is the likelihood of occurrence for the failure effect. Using this information, a mode failure rate can be calculated by multiplying the failure rate by the mode percentage. The equation for failure mode criticality is:

Failure Mode Criticality = Failure Effect Probability * Mode Failure Ratio * Item Failure Rate * Operating Time

Item Criticality

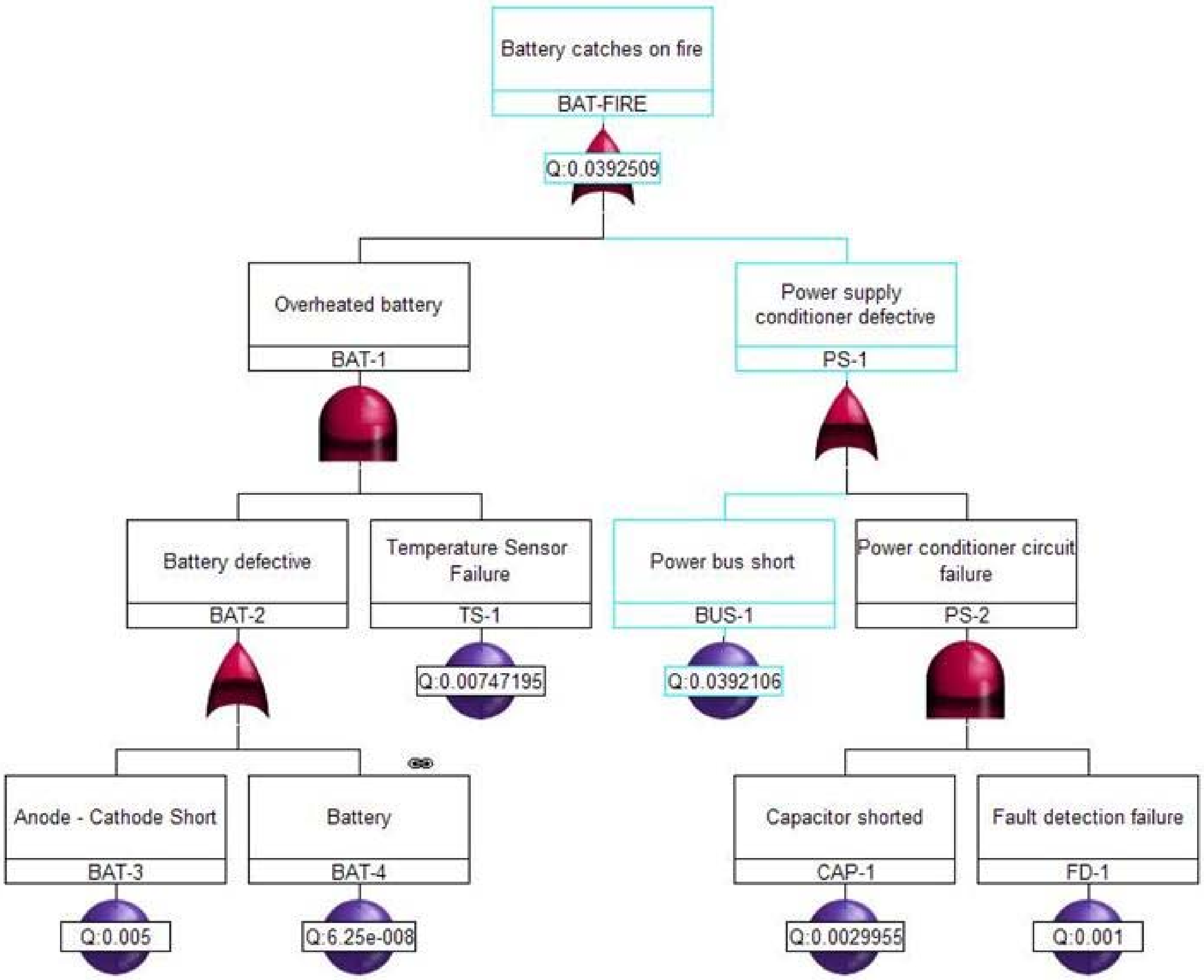
The criticality value for an item (component or part) is the number of system failures of a specific type expected due to its failure modes. The item criticality is calculated by summing the failure mode criticality for each value mode under a severity classification. The equation for item criticality is:

Item Criticality = Sum (Failure Mode Criticalities)

In this particular case, mode failure rates were calculated in Relex FMEA. “Based on such data, design decisions can be made,” said Huffman. “If failure mode probabilities for certain electronic circuits are unacceptable, design changes may be necessary to minimize the probability of certain failure modes occurring. For example, adding redundant systems might be necessary.”

FMEAs and Fault Trees: Complementary Partners in Risk Analysis

FMEAs effectively identify single point failures. These failures are assumed to lead to a specific end effect not considering any type of system redundancy. Some of these end effects may be designated "critical" to the system. For these critical end effects, additional insight can be obtained by further evaluation in a more quantitative manner. This can be done with the use of fault tree analysis, which can analyze critical failures in more detail, down to the events that contribute to the failure. "We identified the component failures that contributed to critical end effects," said Huffman. "We were then able to leverage the FMEA by pulling the mode failure rates into our fault tree to calculate cut sets and failure probabilities for all of the critical end effects."



Sample Fault Tree with a Cut Set Shown Highlighted

With the help of a completely integrated software package like Relex Reliability Studio, passing quantitative data from one analysis tool to the next is easy. In Relex Reliability Studio, data can be dynamically linked and shared between the Relex Reliability Prediction, FMEA, and Fault Tree modules. This type of integration makes using a combination of tools for risk analysis easy as well as effective and efficient.

Summary

Companies across all industries choose Relex software as their reliability platform because it provides them with powerful modules for performing all types of reliability analyses in one integrated package. Additionally, Relex Software has a first-rate Professional Services team, supplying reliability expertise in areas of consulting, implementation, training, and customer service.

For the particular project noted in this article, the primary reason Relex Consulting Services was contracted was to establish a sound baseline for all future reliability tasks within the organization. According to Huffman, an expert team was needed to help establish a system hierarchy and to be able to respond quickly to questions and concerns. With so many Certified Reliability Engineers (CREs) and staff members with advanced engineering and reliability degrees onboard at Relex Software, no one was better qualified to help establish this baseline. In addition to being the developers of the best-in-class reliability analysis software, Relex Software has vast consulting experience, assisting all types of manufacturers in many different industries with their analysis needs.

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