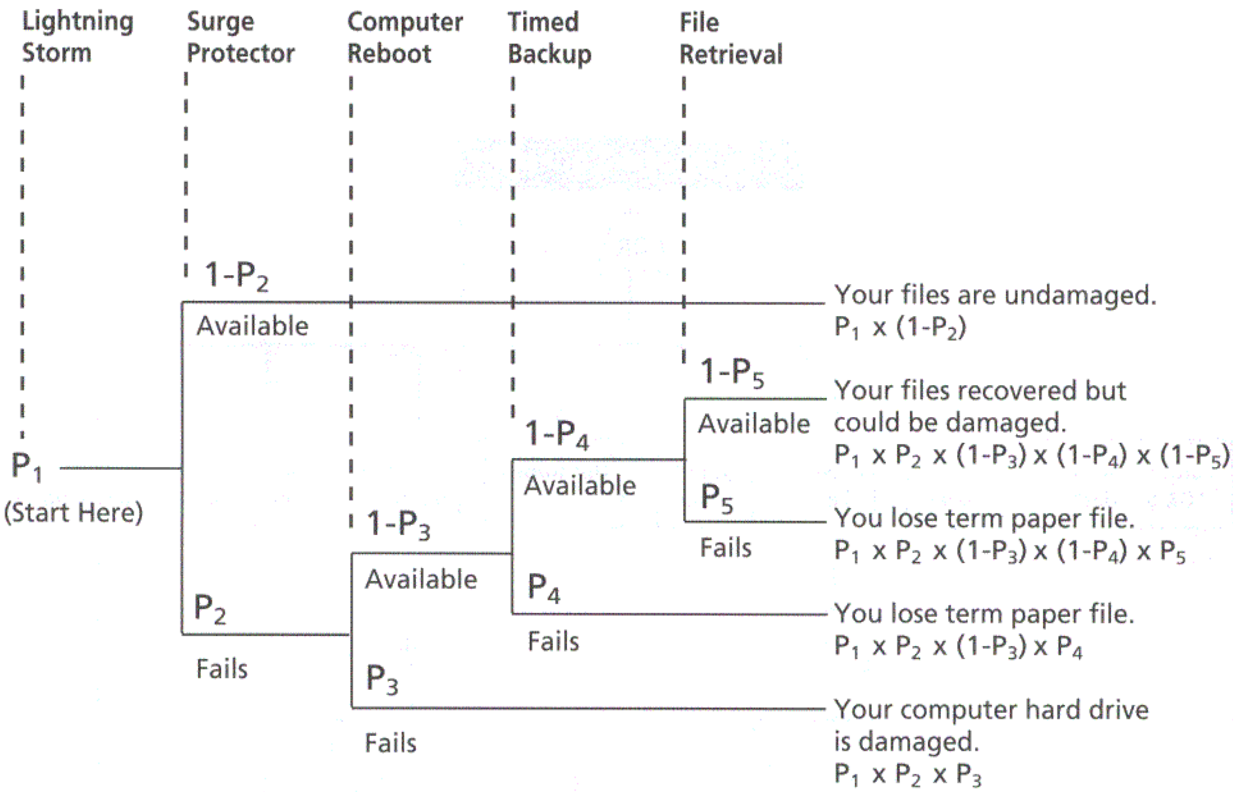
Table of Tools

Risk Assessment Tool	Main Components	Advantages	Limitations (Sources of Uncertainty)	Examples of Output
(1) Event Tree Analysis— An event tree begins with an initiating event that leads to a set of possible outcomes. Each event has two possible outcomes: success or failure. The probability (P) of the final event is calculated as the product of the failure (or success) probabilities along its path.	▸ Initiating event ▸ Subsequent events ▸ Final event ▸ Probability of success (1-P) ▸ Probability of failure (P)	▸ Organizes the information ▸ Breaks down the problem into smaller, more manageable parts ▸ Shows how the different events are connected	▸ Is difficult to include all possible sequences of events	The chance of a sewage system pipe break that can result in a large release of effluent is 0.001.
(2) Fault Tree Analysis— Fault tree analysis is a technique used to better understand the failure of a system. It starts with the definition of the undesired outcome, then works backward to define all possible causes of the failure.	▸ Undesired outcome at the top of the tree ▸ Possible events leading to the undesired outcome ▸ "And"/"Or" gates leading to the next event	▸ Increases understanding of the system being analyzed ▸ Organizes the information ▸ Shows the relationship between the different parts of a system	▸ Is difficult to cover all possible causes of the undesired event	Your document did not print because the paper in the tray was folded, creating a paper jam.
(3) Toxicity Testing— The results of a toxicity test are plotted on a dose/response curve. This curve, based on experimental data, represents the relationship between exposure (dose) and the resulting effects (response) of a chemical.	▸ X axis—dose ▸ Y axis—response ▸ Test subject ▸ Route of exposure ▸ Duration of exposure	▸ Uses controlled experiments ▸ Provides useful chemical toxicity information	▸ Involves extrapolation from animals to humans ▸ Involves extrapolation from high to low doses ▸ Assumes causality between chemical and response (that the effect is a result of the toxin) ▸ Assumes that the response is related to the dose	The lethal dose of chemical xxx is 0.05 milligrams of the chemical per kilogram of body weight for mice (0.05 mg/kg = 50 parts per billion)
(4) Epidemiological Study— The results of an epidemiological study can be used to generate rate, ratio, and proportion calculations. These calculations are obtained from the observation of patterns of disease in a population. The goal of such a study is to characterize and identify high-risk groups in a population.	▸ Exposed population ▸ Control population ▸ Total population ▸ Time frame	▸ Uses actual human data ▸ Can provide the most convincing evidence for human risk when done well	▸ Is extremely difficult to replicate ▸ Maintains a chance that a contributing factor has not been accounted for ▸ Allows bias in subject selection and data collection ▸ Often deals with multiple exposures, making it more difficult to identify a causal relationship between one exposure and an adverse effect	According to a National Cancer Institute study, women under the age of 40 are more likely than men to get skin cancer, and men over the age of 40 are more likely to get it than women.[a] [a] Ellis & Associates Inc. "Skin Cancer: Messages from the Centers for Disease Control." <http://www.jellis.com/news/feb97/cancer.htm>, accessed April 27, 1998.

Examples of Risk Assessment Tools

1) SIMPLIFIED EVENT TREE FOR LOSS OF A TERM PAPER COMPUTER FILE DURING A LIGHTNING STORM



P_1, P_2, P_3, P_4, P_5 = probability that the function fails

$1-P_1$, $1-P_2$, $1-P_3$, $1-P_4$, $1-P_5$ = probability that the function is available and works

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Examples of Risk Assessment Tools

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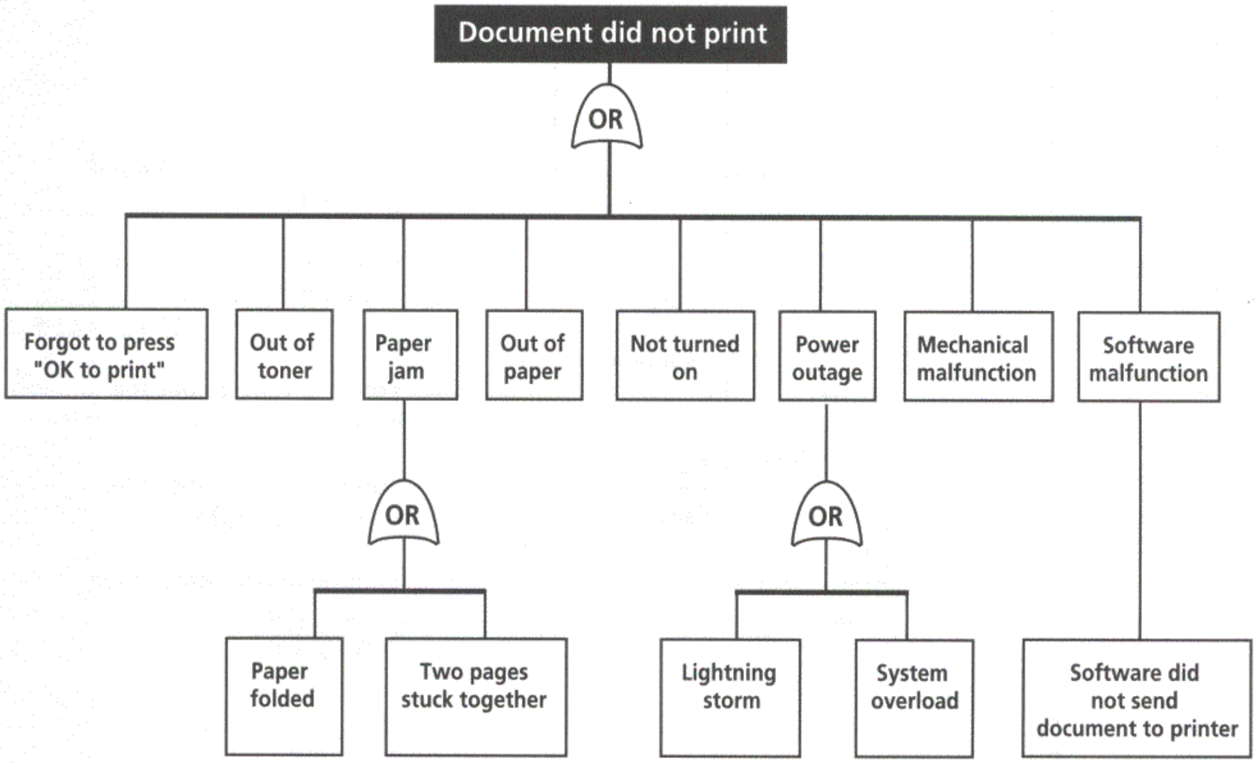
2) SIMPLIFIED FAULT TREE FOR A COMPUTER-GENERATED DOCUMENT THAT HAS FAILED TO PRINT



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Examples of Risk Assessment Tools

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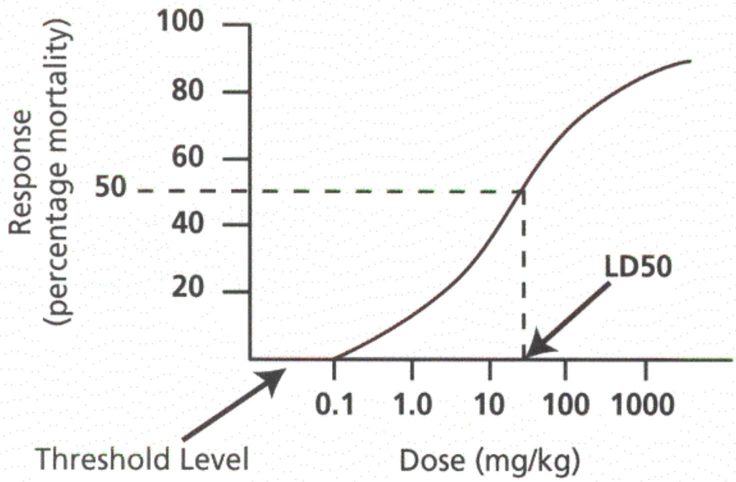
3) DOSE/RESPONSE CURVE FOR ACUTE TOXICITY OF A CHEMICAL ADMINISTERED ORALLY TO RATS (SINGLE DOSE)



LD50 = single dose expected to be lethal to 50 percent of the test animals (80 mg/kg)

mg/kg = milligrams of chemical (solid or liquid) per kilogram of body weight of the test animal

Threshold level = dose below which the probability of a response is zero (0.1 mg/kg)

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Examples of Risk Assessment Tools

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4) EPIDEMIOLOGICAL DATA (EXPRESSED AS THE RATE OF ILLNESS OR INJURY IN THE OBSERVED POPULATION)

a. **Ratios**—A ratio is a comparison of two numbers with the same units. For example, the ratio of people in school with colds to people in school without colds is 40:200 (units = people). A ratio can be written as a fraction (40/200), a decimal (0.2), with a colon (40:200), or with words (forty to two hundred).

b. **Proportions**—A proportion is an equation stating that two or more ratios are equal. For example, 40/200 is proportional to 1/5.

c. **Rates**—A rate is a comparison of two quantities with dissimilar units. For example, 55 miles per hour compares distance with time. Two basic types of rates used to characterize epidemiological data are incidence rates and prevalence rates.

1. **Incidence rate** = $\frac{\text{number of } \textit{new} \text{ cases}}{\text{population at risk}}$ (calculated over a period of time)

For example,

$$\frac{\text{the number of new cases of lead poisoning } \mathbf{(20)}}{\text{the number of people exposed to water transported in lead pipes } \mathbf{(100{,}000)}} \text{ (over 5 yrs.)}$$

The rate of lead poisoning per 1,000 people over a 5-year period was 0.2 (or 0.02 percent of the exposed population was affected).

Incidence rates may be used to calculate the **relative risk** of illness or injury. This measure compares the incidence rate for those exposed to a risk to the incidence rate for those not exposed. It is important for determining whether there is an association between exposure and effect (illness or injury).

2. **Prevalence rate** = $\frac{\text{number of } \textit{existing} \text{ cases}}{\text{total population}}$ (at a point in time)

For example,

$$\frac{\text{the number of } \textit{existing} \text{ cases of lead poisoning } \mathbf{(15)}}{\text{the total population of residents in Smithtown, USA } \mathbf{(250{,}000)}} \text{ on 1/1/98}$$

Some of the sources of epidemiological data include census data; vital statistics (births, deaths, marriages, divorces); health records; and autopsy reports.

Fault Tree for Car Failing to Start

Car Won't Start

Battery Charge Insufficient

1. Faulty ground connections
2. Terminals loose or corroded
3. Battery weak

1. Paint
2. Corrosion
3. Dirt
4. Loose connections

1. Lights left on, motor off
2. Age
3. Cold weather
4. Defective generator
5. Loose or broken fan belt
6. Electrolyte fluid low or improper
7. Cable wires broken
8. Alternator defective
9. Voltage regulator defective
10. Internal short circuit
11. Too many electric accessories operating
12. Electric leakage
13. Continuous small drain (package on front seat of 1974 models)
14. Battery too small

Starting System Defective

1. Switches defective
2. Transmission not in park or neutral
3. Seat belt problem (1974 cars)
4. Faulty starter motor
5. Starter drive defective

1. Ignition switch
2. Starter relay
3. Neutral start switch
4. Solenoid

1. Belts not fastened
2. Driver's belt switch defective
3. Heavy object on front seat with belt unfastened
4. Belt fastened before driver sits down

Fuel System Defective

1. Insufficient fuel
2. Excess fuel (flooding)
3. Defective choke
4. Defective air filters

1. Car out of gas
2. Clogged fuel line
3. Leaks in fuel line
4. Dirt in the fuel line
5. Fuel line frozen
6. Improperly sealed valves
7. Defective fuel pump
8. Cracked carburetor bowl
9. Intake manifold gasket loose

1. Fuel pump pressure too high
2. Leaking inlet valve
3. Float out of adjustment
4. Excess pumping of accelerator
5. Excess fuel pressure on hot day
6. Electric fuel pump floods carburetor (foreign cars)

1. Choke valve open
2. Valve linkage sticks
3. Failure to choke
4. Electric choke misfunction (Volkswagen)

Ignition System Defective

1. Coil faulty
2. Distributor faulty
3. Spark plugs defective
4. Defective wiring between elements

1. Cap cracked
2. Electrodes corroded
3. Improper point gap
4. High point resistance
5. Faulty condenser
6. Shaft frozen
7. Timing off
8. Motor not keyed properly

1. Gap incorrect or fouled
2. Plug shorting
3. Loose or defective wiring
4. Plugs firing in wrong order

Other Engine Problems

1. Oil too thick
2. Pistons frozen
3. Poor compression

1. Wrong type
2. Weather too cold

1. Broken ring
2. Excess heat
3. Ring groove damaged, fouled, or loose

1. Leaking head gasket
2. Cracked cylinder
3. Valve burnt, improperly adjusted, or sticking
4. Pistons, piston rings, or cylinder worn or broken
5. Gas washdown on cylinders

Mischievous Acts or Vandalism

1. Theft or breakage of vital part (e.g., battery)
2. Siphoning of gas
3. Disruption of wiring

All Other Problems

Please note: *This chart was generated using 1978 information; therefore, some of the steps may not apply to more recently manufactured cars.*

Source: Fischhoff, Baruch, Paul Slovic, and Sarah Lichtenstein. "Fault Trees: Sensitivity of Estimated Failure Probabilities to Problem Representation," *Journal of Experimental Psychology: Human Perception and Performance* 4 no. 2 (1978):331.