U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Probabilistic Risk Assessment (PRA)

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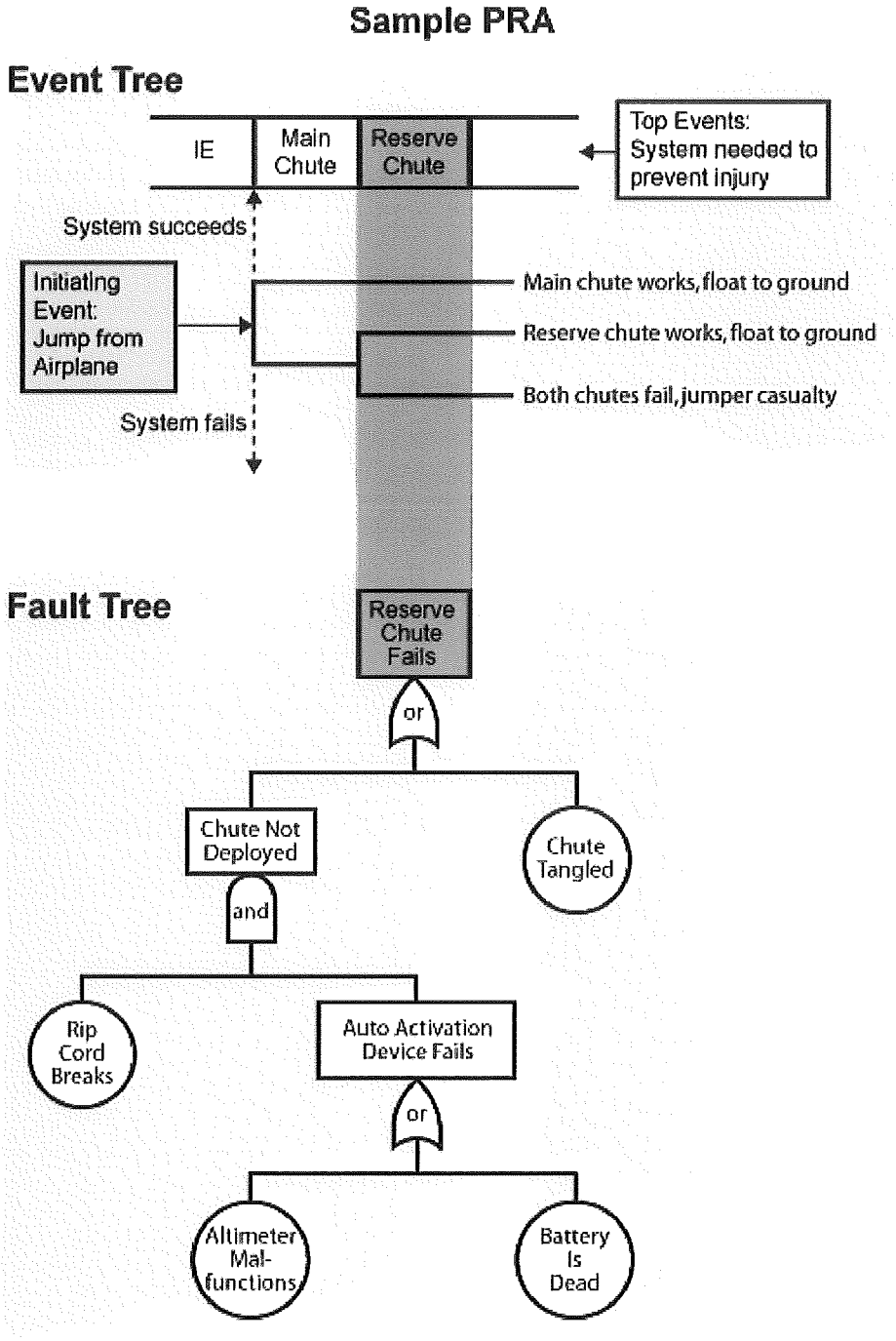
Definition of PRA

The NRC uses Probabilistic Risk Assessment (PRA) to estimate risk by computing real numbers to determine what can go wrong, how likely is it, and what are its consequences. Thus, PRA provides insights into the strengths and weaknesses of the design and operation of a nuclear power plant.

For the type of nuclear plant currently operating in the United States, a PRA can estimate three levels of risk.

- A Level 1 PRA estimates the frequency of accidents that cause damage to the nuclear reactor core. This is commonly called core damage frequency (CDF).
- A Level 2 PRA, which starts with the Level 1 core damage accidents, estimates the frequency of accidents that release radioactivity from the nuclear power plant.
- A Level 3 PRA, which starts with the Level 2 radioactivity release accidents, estimates the consequences in terms of injury to the public and damage to the environment.



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Level 1 PRA

A Level 1 PRA models the various plant responses to an event that challenges plant operation. The plant response paths are called *accident sequences*. A challenge to plant operation is called an *initiating event*. There are numerous accident sequences for a given initiating event. The various accident sequences result from whether plant systems operate properly or fail and what actions operators take. Some accident sequences will result in a safe recovery and some will result in reactor core damage. The accident sequences are graphically represented with event trees. Each event in the event tree (called a *top event*) generally depicts a system that is needed to respond to the initiating event. An analysis is performed for each top event in the event tree. This analysis is graphically represented with a fault tree.

The frequency for each core damage accident sequence is estimated, and the frequencies for all core damage sequences are summed to calculate the total core damage frequency. In that way, the Level 1 PRA provides the first measure of risk -- core damage frequency -- which is the input to the Level 2 PRA.

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Level 2 PRA

A Level 2 PRA models the plant's response to the Level 1 PRA accident sequences that resulted in reactor core damage. Such core damage sequences are typically referred to as *severe accidents*. Toward that end, a Level 2 PRA analyzes the progression of an accident by considering how the containment structures and systems respond to the accident, which varies based on the initial status of the structure or system and its ability to withstand the harsh accident environment. Thus, a Level 2 PRA must consider the key phenomena that affect accident progression. The following are two of the countless examples that illustrate the phenomena that must be considered:

- Do tubes in the steam generator rupture?
- Is the reactor core debris in a coolable configuration?

Once the containment response is characterized, the analyst can determine the amount and type of radioactivity released from the containment. Thus, the Level 2 PRA estimates the second measure of risk -- radioactivity release -- which is the input to the Level 3 PRA.

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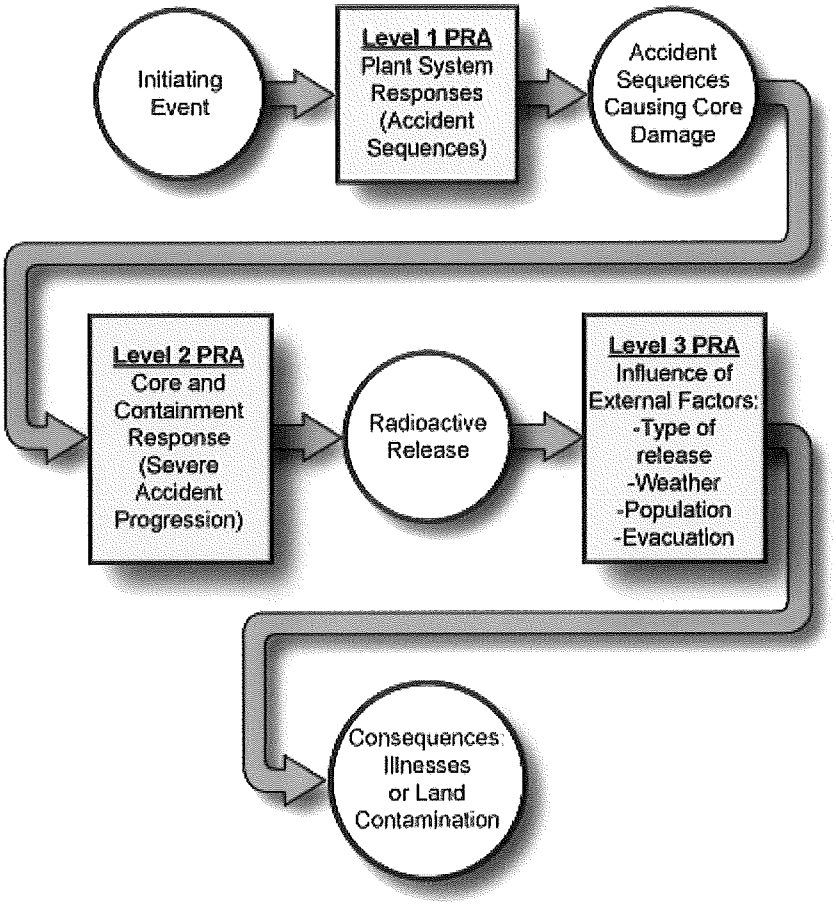
Level 3 PRA

A Level 3 PRA is often called a *consequence analysis*. Consequences result from the radioactive material released in a severe accident. A Level 3 PRA estimates those consequences in the following terms:

- Health effects (such as short-term injuries or long-term cancers) resulting from the radiation doses to the population around the plant
- Land contamination resulting from radioactive material released in the accident

Consequences are estimated based on the characteristics of the radioactivity release calculated by the Level 2 PRA. Those consequences depend on several factors. For example, health effects depend on the population in the plant vicinity, evacuation conditions, and the path of the radioactive plume. The plume, in turn, is affected by wind speed and direction, as well as rainfall or snowfall. Similarly, land contamination depends on the characteristics of the radioactivity release and how the land surrounding the plant is used.

The Level 3 PRA estimates the final measure of risk by combining the consequences with their respective frequencies. (What can go wrong, how likely is it, and what are the consequences?) For instance, a Level 3 PRA might estimate that an accident would create one chance in a million that a person living near the plant would experience radiation exposure equivalent to a chest x-ray, and one chance in a billion that some people would develop cancer over the next 50 years.



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