MODULE L

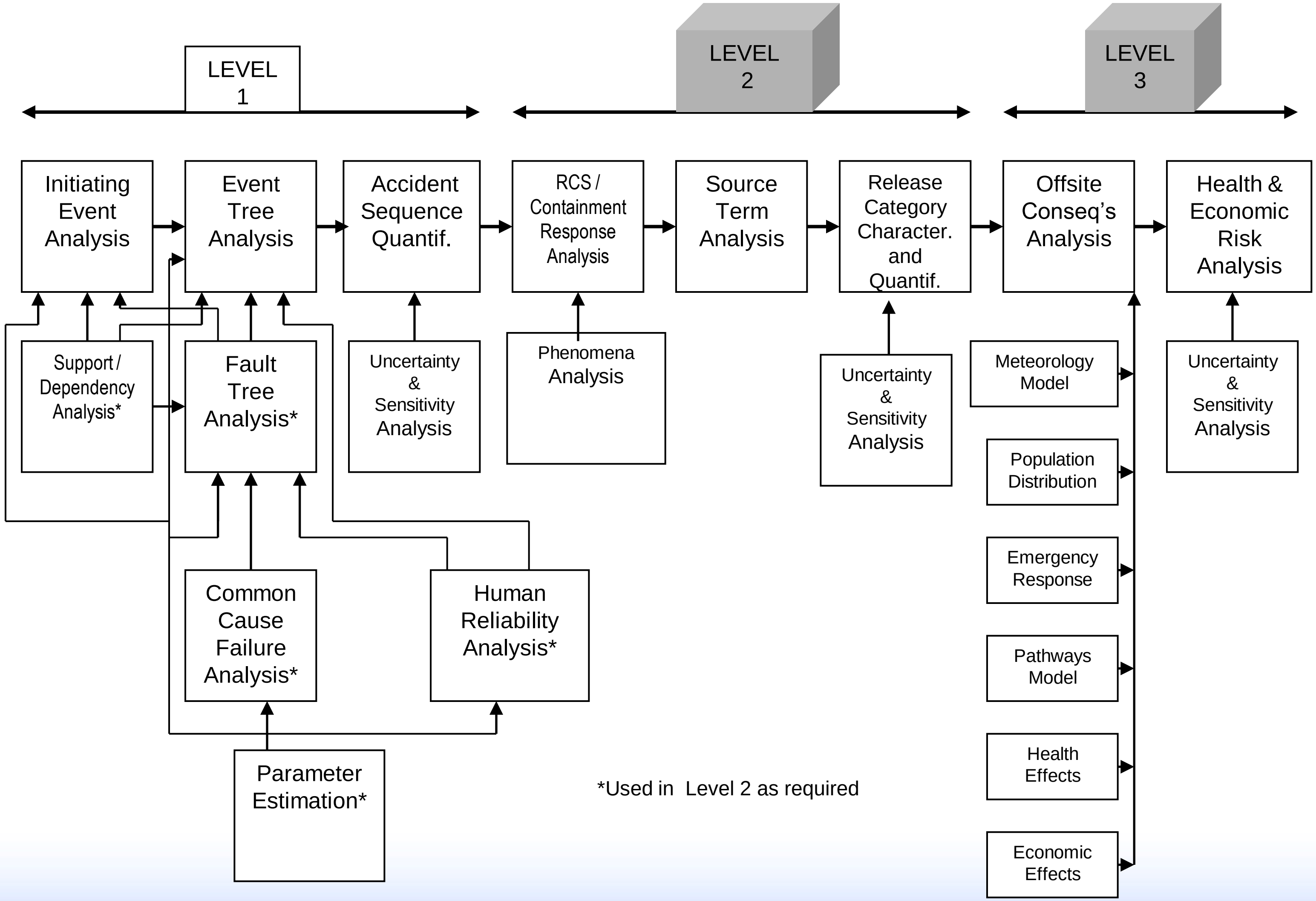
LEVEL 2 & 3 ANALYSIS

Idaho National Laboratory

Level 2 & 3 Analysis

- Purpose: Introduce the students to the purposes and scope of Level 2 (accident progression) and Level 3 (accident consequence) analyses.
- Objectives:
  - Describe the general purpose of Level 2 and 3 analyses
  - List typical types of consequences from a Level 3 PRA
- References: NUREG/CR-2300

Principal Steps in PRA



Purpose of Level 2 & 3 Analyses

- **Level 2 & 3 analyses bridge the gap between the engineering and operations associated with a reactor and the potential risk that it presents to the public**
  - **Level 2 (Containment) Analysis starts with the Level 1 plant damage states and calculates a set of radionuclide source terms released to the environment**
  - **Level 3 (Consequence) Analysis calculates potential ranges (probability of occurrence and magnitude) of adverse impacts (consequences) of an accidental release of radionuclides**

Level 2 Analysis Overview

- **A Level 2 Analysis evaluates the radionuclide releases from accidents that result in a severely damaged core. It considers the following elements:**
  - **fission product transportation, deposition, and release in the reactor coolant system,**
  - **fission product transportation, deposition, and release in the containment.**
  - **determining source terms from the containment**

Plant Damage State Binning

- **Plant-damage states are groups of accident sequences with certain similarities regarding plant response, timing, and equipment status.**
- **The containment analyst provides guidance as to which types of sequences are aggregated into which plant- damage states.**

Transportation, Deposition, and Release in the Reactor Coolant System

- **The following issues concerning the transportation through, deposition in, and release of radionuclides from the reactor coolant system needed to be considered in the level 2 analysis:**
  - **vessel pressure and inventory,**
  - **recovery of injection prior to or after vessel breach,**
  - **hydrogen released prior to or after vessel breach, and**
  - **hydrogen burn prior to or after vessel breach.**

Transportation, Deposition, and Release in the Containment

- **The following issues concerning the transportation through, deposition in, and release of radionuclides from the containment needed to be considered in the level 2 analysis:**
  - **Debris coolability**
  - **Pressure increase due to hydrogen burn**
  - **Interactions between molten fuel and water**
  - **Debris-concrete interaction**
  - **Containment pressure**

Source Term from the Containment

- The release of radionuclides from the containment is dependent upon:
  - radionuclide chemistry,
  - the physical form of the fuel, and
  - the environment into which it is released.
- The source term specification should include:
  - the magnitude of the release,
  - the release rate, and
  - the chemical and physical forms of the release material.

Source Term from the Containment (cont.)

- **The following potential release processes need to be considered:**
  - **Cladding-rupture release**
  - **diffusion release**
  - **Leach release**
  - **Melt release**
  - **Melt/concrete release**
  - **Fragmentation release**

Level 3 Analysis Overview

- A Level 3 Analysis evaluates the effects of the release of radioactive materials on the surrounding population and environment. It can consider the following adverse impacts (commonly referred to as "public risk"):
  - Early and long-term deaths
  - Early and long-term injuries
  - Contamination of property, land, or water
  - Economic impacts

Major Areas of a Level 3 Analysis

- **The following areas are the major considerations that must be taken into account during a level 3 analysis: atmospheric transportation and deposition model, including meteorology**
  - **Pathways model**
  - **Dosimetry model**
  - **Health effects model**
  - **Population distribution model**
  - **Emergency response model**
  - **Economic effects model**

Dominant Risk Contributors Sometimes Not Dominant With Respect to CDF

- For PWRs, SGTR and bypass sequences (e.g., ISLOCA) dominate LERF and therefore early fatalities
- SGTR and bypass not dominant contributors to core damage frequency
  - If SGTR or bypass occur, consequences are large
  - Remember: risk = frequency x consequence

Student Exercise

- **Answer the following for your choice of a plant's IPE:**
  - **In either the summary sections in the front of the IPE, or in the plant unique design features section (often Section 6), note any particular strengths or weaknesses cited from a containment capability perspective.**