Idaho National Laboratory

INL

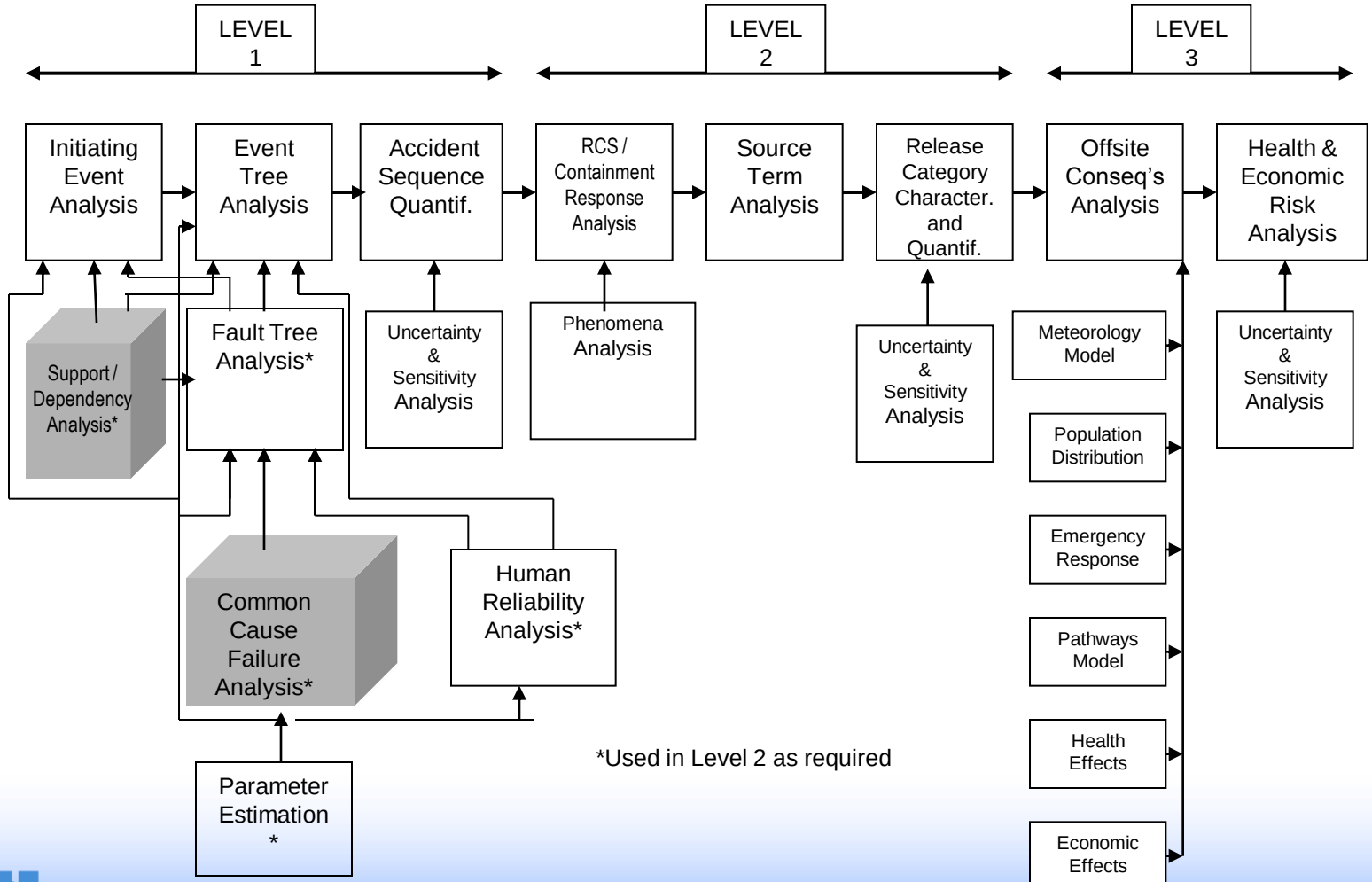
MODULE H

COMMON CAUSE FAILURES

Common Cause Failures

- **Purpose: Students will be introduced to the concept of how common cause failures and other dependencies are treated in the PRA**
- **Objectives: Students will be able to:**
  - **Define several types of dependent failures and how they are modeled**
  - **Give examples of dependent and common cause failures**
  - **Describe the importance of modeling common cause failure in PRA**
- **References:**
  - **NUREG/CR-4780, Procedures for Treating CCF in Safety & Reliability Studies**
  - **EPRI NP-3967, Classification and Analysis of Reactor Operating Experience Involving Dependent Events**
  - **NUREG/CR-5485, Guidelines on Modeling Common-Cause Failures in PRA**
  - **NUREG/CR-5497, Common-Cause Failure Parameter Estimations**
  - **NUREG/CR-6268, Common-Cause Failure Database and Analysis System: Event Definition and Classification**

Principal Steps in PRA



Definition of Dependent Failures

- **Three general types of dependent failures:**
  - **Certain initiating events (e.g., fires, floods, earthquakes, service water loss)**
  - **Intersystem dependencies including:**
    - **Functional dependencies (e.g., dependence on AC power)**
    - **Shared-equipment dependencies (e.g., HPCI and RCIC share common suction valve from CST)**
    - **Human interaction dependencies (e.g., maintenance error that disables separate systems such as leaving a manual valve closed in the common suction header from the RWST to multiple ECCS system trains)**
  - **Intercomponent dependencies (e.g., design defect exists in multiple similar valves)**
- **The first two types are captured by event tree and fault tree modeling; the third type is known as common cause failure (i.e., the residual dependencies not explicitly modeled) and is treated parametrically**

Common Cause Failures

- **Failure of 2 or more components, subsystem, or system due to shared causes which have not been accounted for explicitly**
- **Common cause failures are important since they:**
  - **Defeat redundancy and/or diversity**
  - **Often have a high probability of occurrence relative to the combination of random independent failures of components, subsystems or systems**

Common Cause Failure Mechanisms

- **Environment**
  - **Radioactivity**
  - **Temperature**
  - **Corrosion**
- **Design deficiency**
- **Manufacturing defect**
- **Test or Maintenance error**
- **Operational error**

Common Cause Modeling in PRA

- **Three parametric models used**
  - **Beta factor (original CCF**

$$\beta = \frac{\text{Number of common cause failures}}{\text{Total number of failures}}$$

  - **Multiple Greek Letter (MGL) model (expanded on beta-factor)**
  - **Alpha factor model (addressed uncertainty concerns in MGL)**
- **Apply to cut sets containing same failure mode for sample component type**
  - **Diesel generators**
  - **MOVs, AOVs, PORVs, SRVs**
  - **Pump**
  - **Batteries**

Beta Factor Example

- **High pressure pumps**
  - **β = 10 CCF ÷ 47 total failures ≈ 2.1E-1**
  - **Motor-driven pump fail to start = 3.0E-3 per demand**
- **Cut set: HPI-MDP-FS-A * HP1-MDP-FS-B**
  - **Independent failure ≈ 3E-3 * 3E-3 = 9E-6**
- **Cut set: HPI-MDP-CF-CCFAB**
  - **CCF ≈ 3E-3 * β ≈ 6E-4**

Current Limitations of CCF Modeling

- **Limited data; hence generic data often used**
  - **Applicability issue for specific plant**
- **Screening values may be used**
  - **Potential to skew the results**
- **Not typically modeled across systems since data is collected/analyzed for individual systems**
- **Not typically modeled for diverse components (Motor- Driven Pump/Turbine Driven Pump)**
- **Causes not explicitly modeled (i.e., each failure mechanism not explicitly modeled); treatment is statistical**

Student Exercise

- **Using the North Anna AFWS fault tree pages and schematic;**
- **Identify the CCFs modeled by identifying all basic events with the following labels in the basic event names;**
  - **XXXXXX-LEAKAGE**
  - **XXXXXX-CC-XXXXXX**
  - **Postulate why (i.e., causes) such CCFs might exist.**
  - **Compare the CCF basic event failure probability with the corresponding component independent failure probability.**

Common Cause Student Exercise

- **Injection system has:**
  - **A tank with a line through a normally open valve V1 to two pump trains**
  - **Pump train 1 has a pump P1, a check valve CKV1, and normally closed valve V2**
  - **Pump train 2 has two pumps P2 and P2A, a check valve CKV2, and normally closed valve V3**
  - **Both pump trains discharge to a common header to the reactor vessel**
  - **Assuming the system is a standby injection system with 2 –100 % trains, including 3 -100% pumps…**
    - **Which components and what corresponding hardware failure modes would you expect to be modeled in the PRA as Common Cause Failure (CCF) events?**
    - **If the CCF Beta-factor for valves failing to open is 0.05 and the valve failure-to-open probability is 0.005, what are the CCF and independent failure probabilities for the combined failure of V2and V3 both failing to open?**