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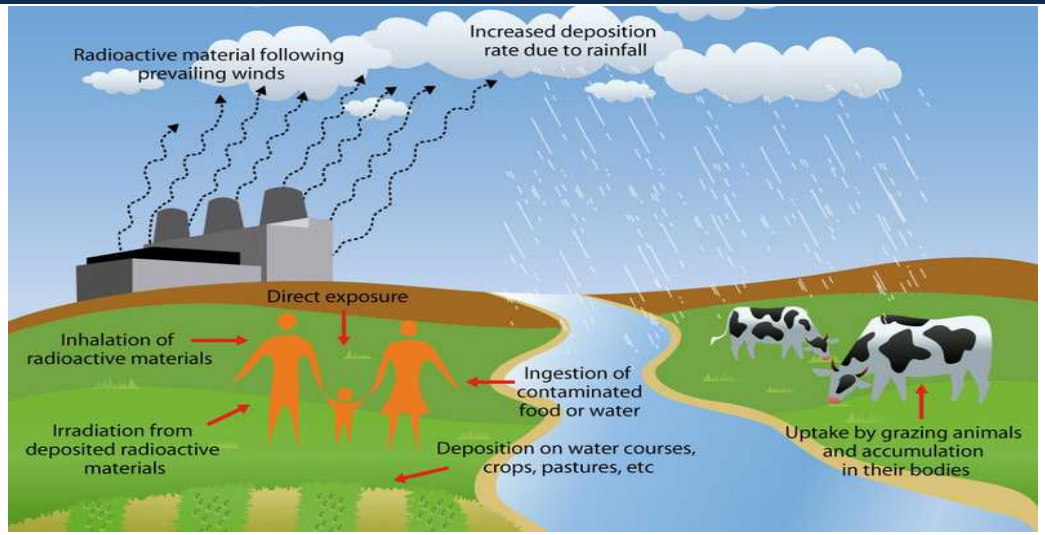

A Methodology for Performing Consequence Analysis for Multi-Unit/Spent Fuel Pool Source Terms

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Outline

- MELCOR Accident Consequence Code System (MACCS)
- Concepts for Multi-Unit Consequence Analysis
- Process for Multi-Unit Consequence Analysis
- Summary

MACCS Is a Tool for Level-3 Consequence Analysis

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- Developed as NRC's tool for evaluating the consequences of atmospheric releases
- PSAs and other severe accident studies (NUREG-1150, SOARCA)
  - Risks from operating a facility
  - Relative importance of the risk contributors
  - Insights on potential safety improvements
- NEPA Studies (National Environmental Policy Act) such as: License extension and new reactor applications
  - Environmental Impact Statements (EISs)
    - Results are typically used to compare the accident risks posed by various alternatives
  - Severe Accident Mitigation Alternatives (SAMAs) and Design Alternative (SAMDAs) required for license renewal and for new licenses

MACCS Models and Capabilities

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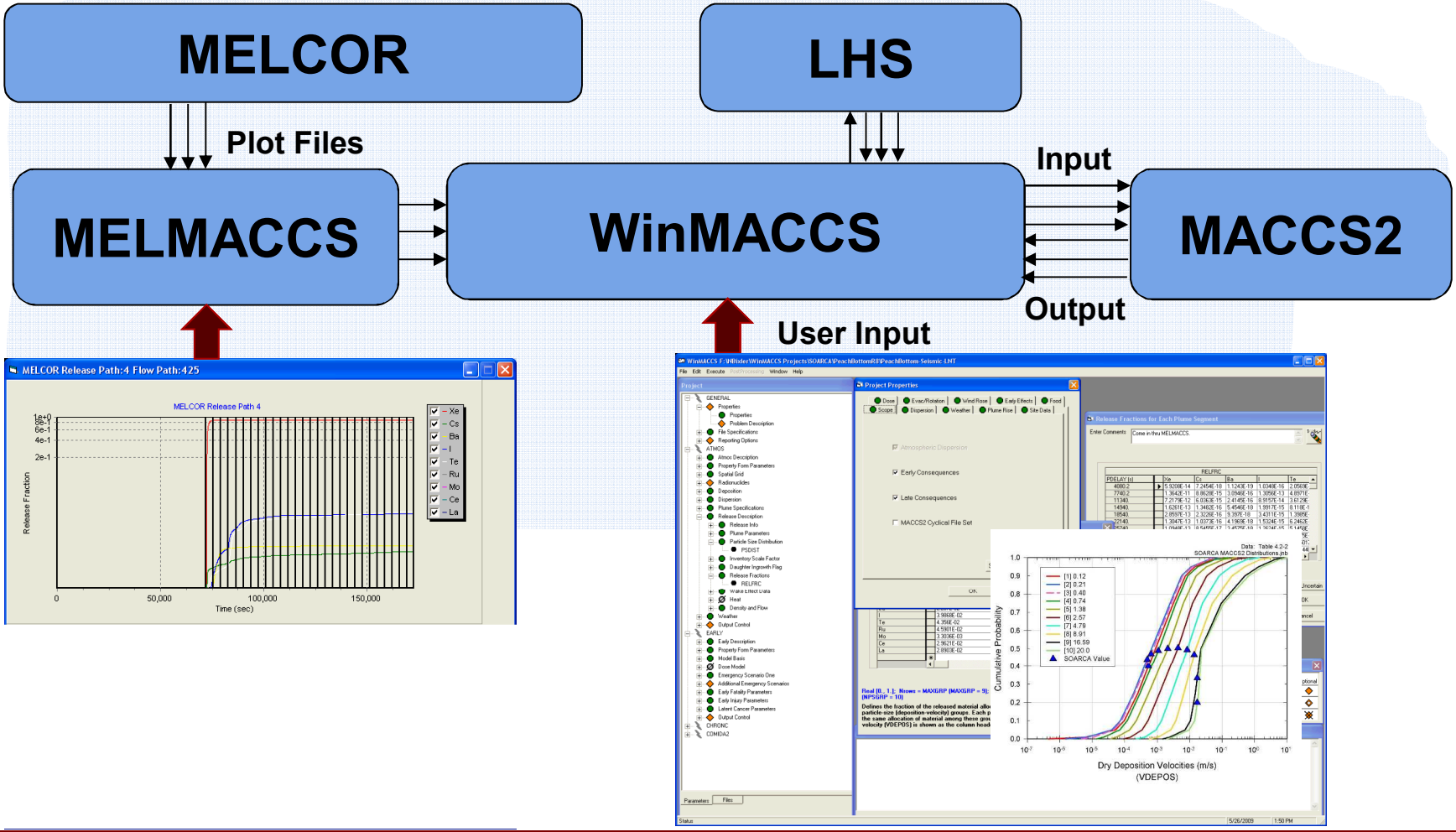
- Models treat
  - Atmospheric transport and deposition onto the ground
  - Statistical effect of variability in weather
  - Dose pathways for cloudshine, groundshine, inhalation, ingestion, and deposition onto skin
  - Protective actions during emergency, intermediate, and long-term phases
- Calculates offsite consequences
  - Doses
  - Health effects
  - Economic costs
  - Land contamination

WinMACCS Calculation Framework for a Level-3 PSA Analysis



Requirements to Support Multi-Unit Consequence Analyses

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- Ability to treat multiple, overlapping source terms
  - Different accident initiation times
  - Different release signatures
  - Different isotopic inventories
- Spent fuel pools present a special case
  - Multiple fuel cooling times (different inventories)
  - Release signature may be a function of cooling time
- Overall release may continue for more than a week

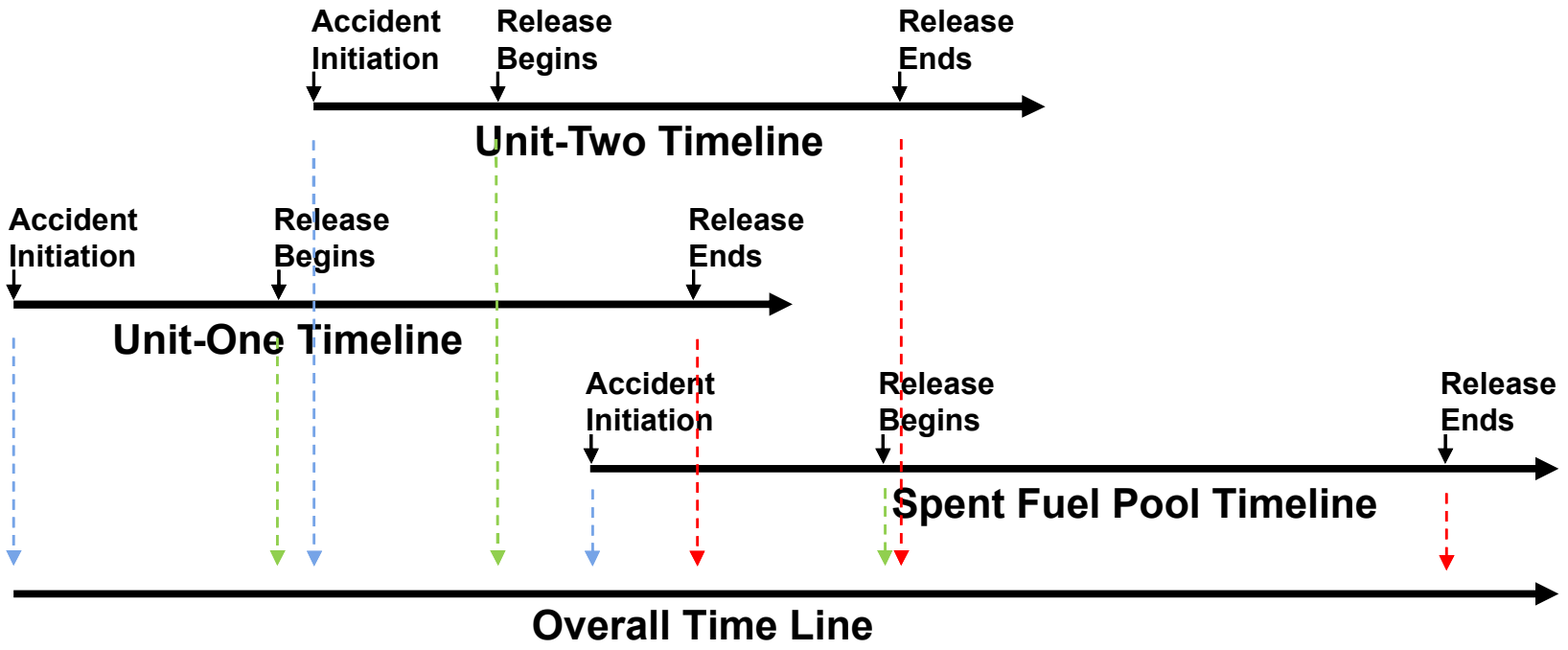
Concepts for Multi-Unit Consequence Analysis
Source Terms

- Multiple source terms can generally be evaluated independently
  - Initiating events may be simultaneous or time-offset
  - Initiating events may be common cause, dependent, or independent
  - Units may share equipment
- Source term is estimated for each unit and spent fuel pool
  - When initiating events are time-offset, offset may be variable or uncertain

Concepts for Multi-Unit Consequence Analysis

Multiple Timelines

- Accident initiation times (i.e., reactor shutdown) can differ between units
- Radioactive decay begins at shutdown at each unit
- Release timing is relative to reactor shutdown
- Each release is represented by multiple plume segments



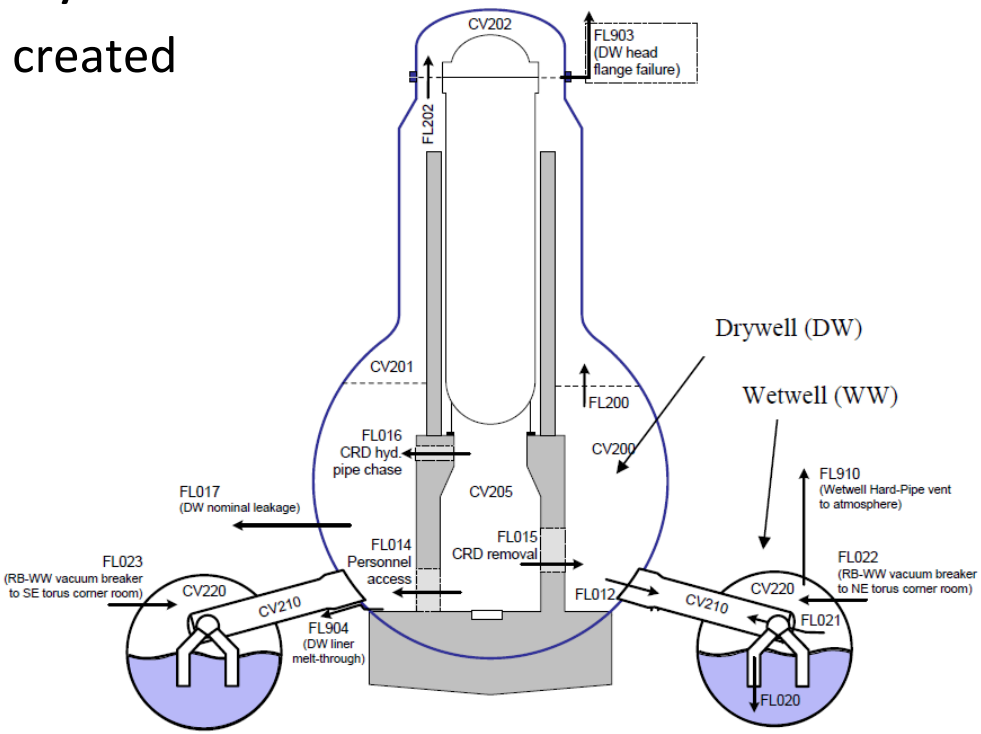
Multiple Inventories

- Release fractions are relative to inventory
  - MELCOR does not model isotopic inventories
  - Fission product behavior is calculated by chemical class, e.g., Cs, I,…
    - Tracks masses of chemical groups
    - Tracks decay heat associated with chemical groups
- MELCOR was modified to better treat spent fuel pools
  - Release fractions can be estimated by ring
  - MelMACCS can associate each ring with a different isotopic inventory
- A general treatment needs to associate release fractions with a specific inventory

Process for Multi-Unit Consequence Analysis

Unit Source Terms

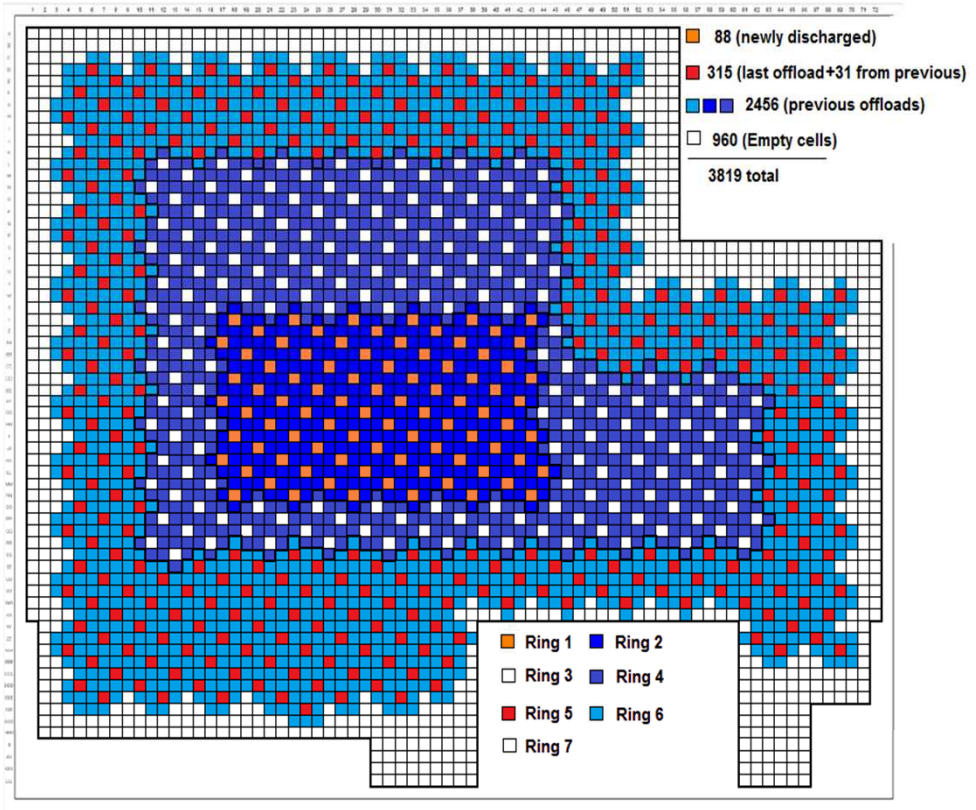
- For each unit
  - An isotopic inventory is calculated or estimated with ORIGEN
  - Release fractions are estimated for each chemical class by MELCOR
- MelMACCS is run separately for each unit
  - A single source term file is created
    - Isotopic inventory
    - Release fractions



Process for Multi-Unit Consequence Analysis

Spent Fuel Pool Source Terms

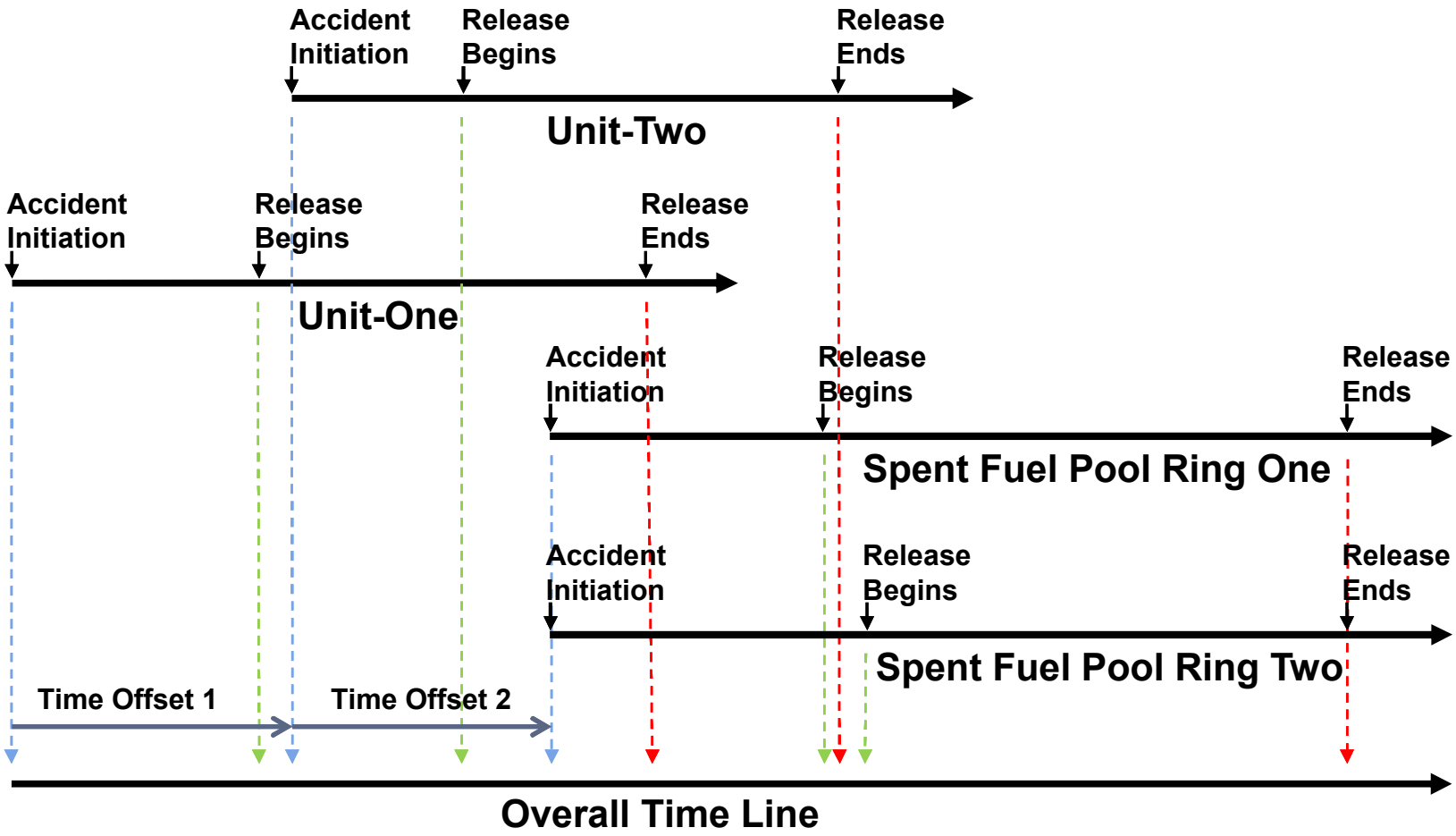
- For each spent fuel pool
  - An isotopic inventory is estimated for each ring with ORIGEN
  - Release fractions are calculated by chemical class and by ring with MELCOR
- MelMACCS is run once for a spent fuel pool
  - Separate source term files are based on release fractions by ring



Process for Multi-Unit Consequence Analysis

Integrating Multiple Source Terms

- Time offsets account for delays between initiating events
- Radioactive decay is relative to each initiating event



Calculating Consequences

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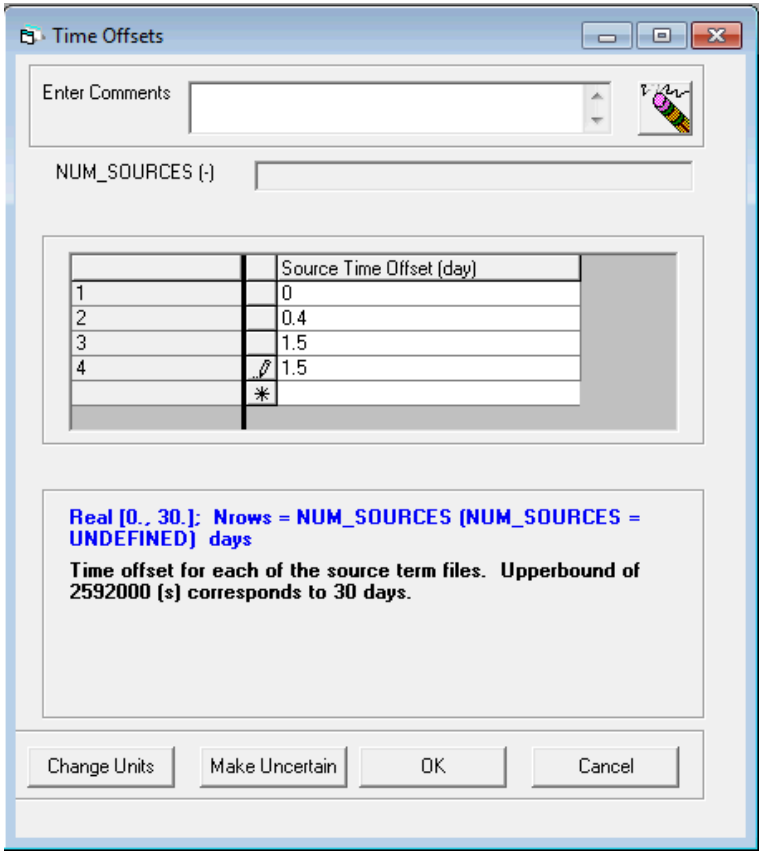
- User enters times for each initiating event
- MACCS calculates atmospheric transport and dispersion for each unit or spent fuel pool
- Results are superposed to estimate consequences



Summary

- A framework has been developed for evaluating multi-unit accident
- A source term is calculated independently for each unit
- Multiple source terms are calculated for a spent fuel pool
- WinMACCS/MACCS integrates the source terms into a single calculation