MACCS Overview and Status

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Outline

- MELCOR Accident Consequence Code System (MACCS) overview

- Improvements in the most recent versions

- New models being developed

- Improvements in preprocessor codes

- Summary

History of NRC Consequence Code Development

- MACCS is the NRC tool used to evaluate the offsite consequences of hypothetical radioactive releases into the atmosphere
- Evolved from codes going back to the 1970s
  - Calculation of Reactor Accident Consequences (CRAC)
    - Reactor Safety Study (WASH-1400)
  - CRAC2
    - 1982 Siting Study
  - MACCS v1.13.1
    - NUREG-1150
  - MACCS v2.4 – 3.8
    - Security Studies
    - Protective Action Recommendation Study
    - State-of-the-Art Reactor Consequence Analyses (SOARCA)
    - Spent Fuel Pool Consequence Study
    - BWR Mark I and II Containment Venting Study
    - Level-3 PRA

MACCS Models and Capabilities

- 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 Interface

- Graphical interface improves usability
  - Organizes problem definition
  - Provides visual cues
  - Defines parameters and ranges
- Automates evaluation of uncertainty
- Incorporates post processing of output
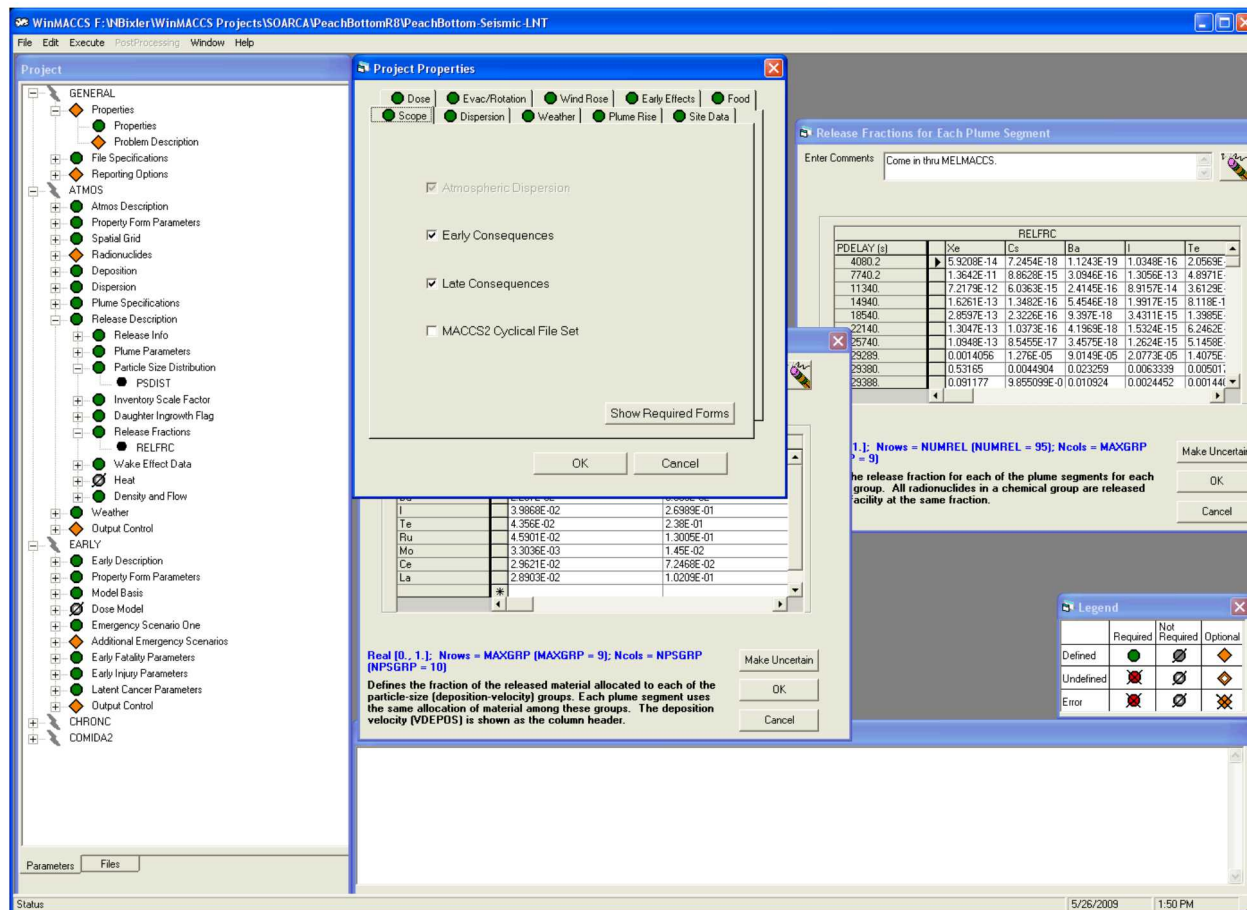
Status of WinMACCS/MACCS Development

- WinMACCS/MACCS 3.7 released November 2012
- WinMACCS/MACCS 3.9 released September 2014
- WinMACCS/MACCS 3.10 is currently being developed
- Development beyond version 3.10 is also ongoing

Improvements In WinMACCS 3.9

- Flexible capability to define the location of cohorts
- Keyhole evacuation model
- Tracking population movement
- Resizable parameter input screens
- Choice of units
- Improvements in reporting options
- Change-card paradigm for cohorts eliminated
  - Auto-propagation of cohort values added to facilitate conversion
- Upper limits increased
  - Up to 150 chemical groups
 - Up to 500 plume segments

Defining Cohorts

- Cohorts represent emergency response of distinct segments of the population
- Each cohort follows a timeline of actions

SOARCA Cohorts	Peach Bottom	Surry
Cohort 1	0 to 10 Public	
Cohort 2	10 to 20 Shadow	
Cohort 3	0 to 10 Schools and 0 to 10 Shadow	0 to 10 Schools
Cohort 4	0 to 10 Special Facilities	
Cohort 5	0 to 10 Tail	
Cohort 6	Non-Evacuating Public	
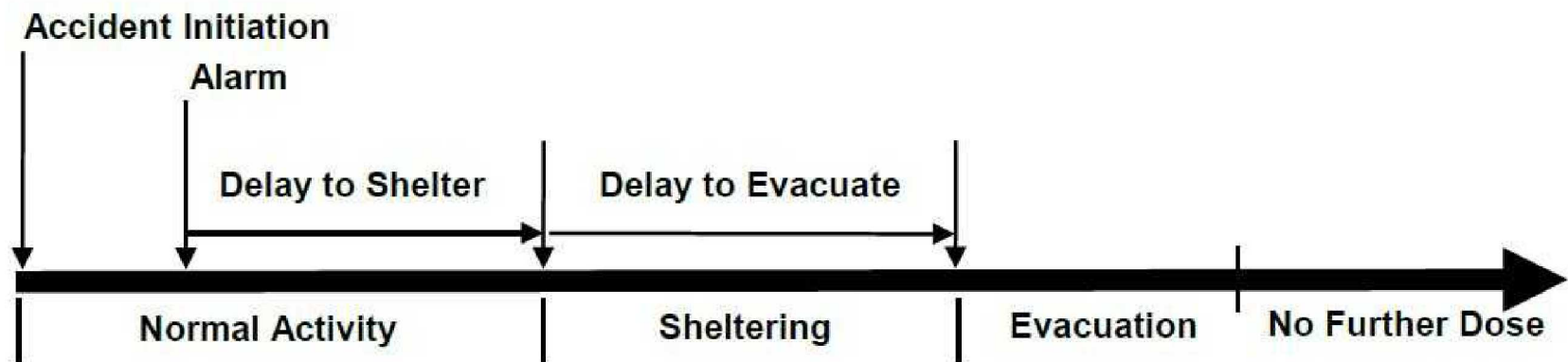
Added Flexibility in Defining Cohorts

- The user can locate cohorts in regions anywhere within MACCS grid
  - Feature was supported previously, but not user friendly
  - Map layer can be used to facilitate cohort locations
- E.g., regions might represent
  - Emergency Planning Zone (EPZ)
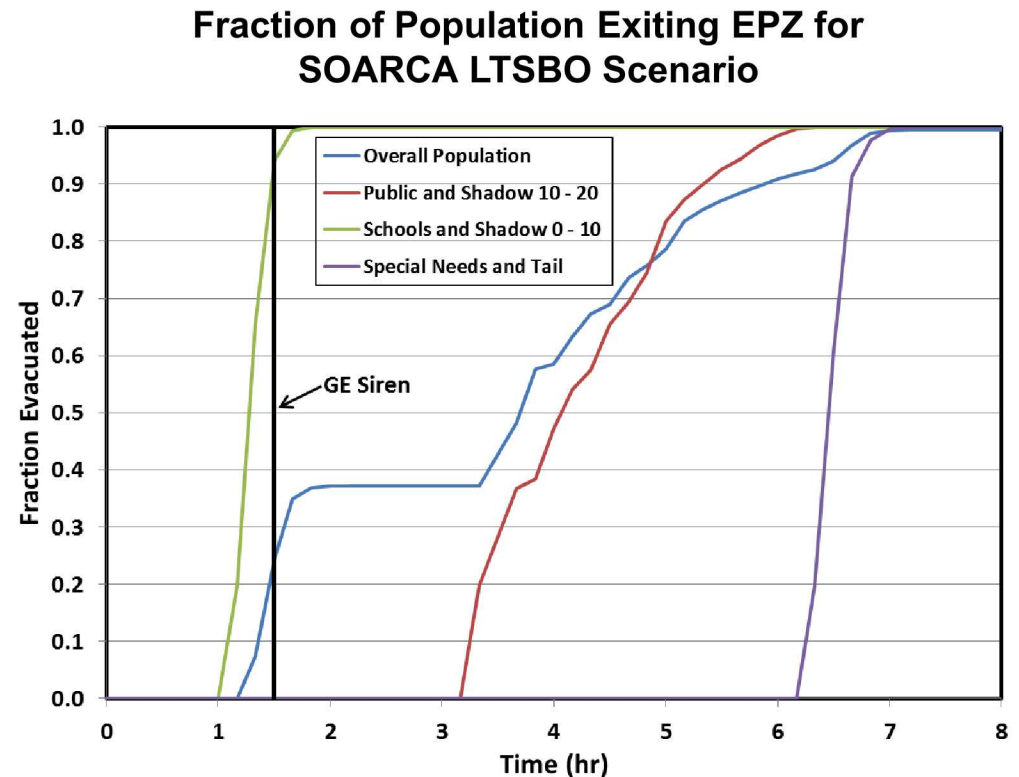 - Shadow evacuation
  - No evacuation
  - Special facility
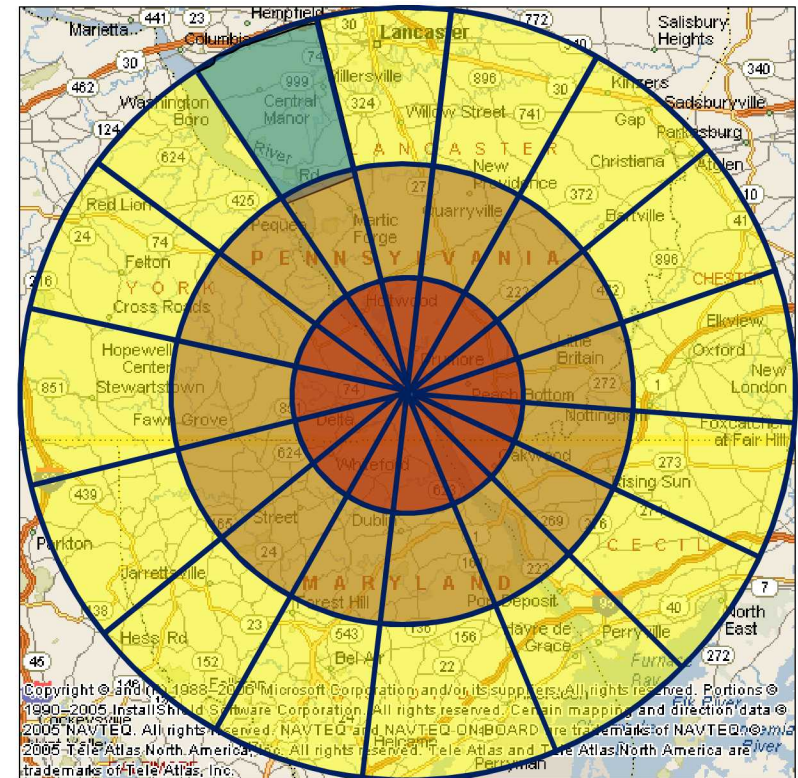
Keyhole Evacuation Model

- Keyhole consists of
  - A central circular region
  - An pie-shaped outer region
- User defines initial dimensions of keyhole
- Shift in wind direction causes pie-shaped region to expand
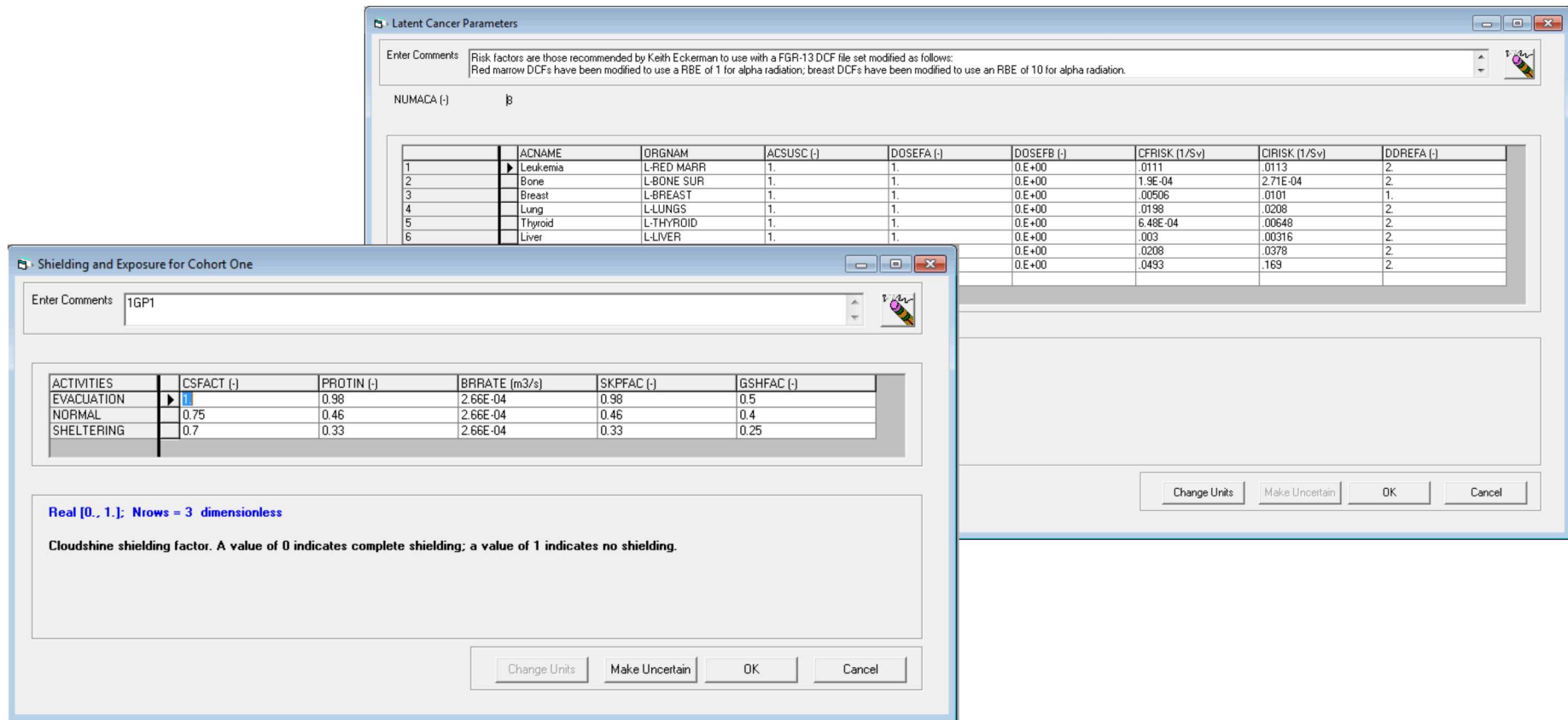- Model allows for foreknowledge of weather (forecasting)
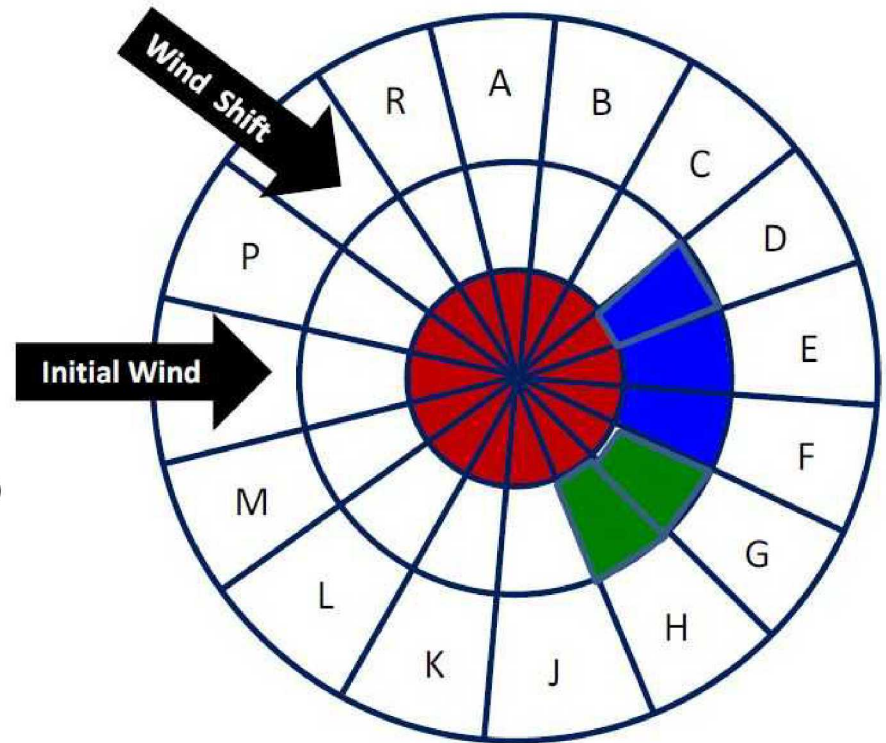
Tracking Population Movement

- The timing of evacuating cohorts crossing boundaries can be evaluated to verify consistency with the Evacuation Time Estimate (ETE)

- Overall timing of the entire population can also be evaluated

Fraction of Population Exiting EPZ for SOARCA LTSBO Scenario

Legend:
- Overall Population
- Public and Shadow 10 - 20
- Schools and Shadow 0 - 10
- Special Needs and Tail

GE Siren

X-axis: Time (hr)
Y-axis: Fraction Evacuated

Resizable Parameter Input Screens

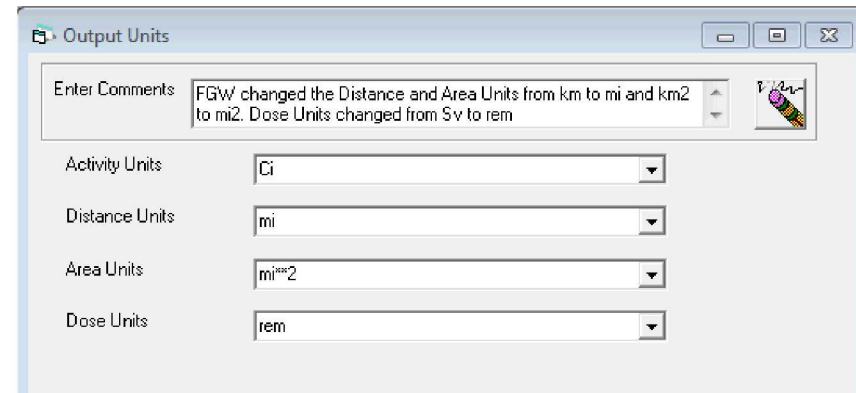- Screens can usually be expanded to view all parameters at once

Choice of Units

- **WinMACCS input units can be chosen for most dimensional parameters, e.g., time can be specified in seconds, minutes, hours, days, or years**

- **MACCS output units can be chosen for activity, distance, area, and dose**

Reporting Options

- Reports can be created, e.g., with just the most essential results

Development of WinMACCS 3.10

- Ability to calculate consequences from multiple reactor units and/or spent fuel pools

  - Multiple accident initiation times

  - Multiple fission product inventories

  - Extended release durations

- User-specified dose projection periods in emergency and intermediate phases

- New output category to report number of people displaced during each phase

Development Beyond 3.10

- Dosimetry improvements – allow all organs and tissues in dose coefficient file to be used

- Alternative economic model based on GDP losses
  - Based on input-output economic model
  - Uses modified REAcct code developed for DHS

- Alternative atmospheric transport model (HYSPLIT) to evaluate special issues
  - Gaussian puff model
  - Lagrangian particle tracking model

Typical WinMACCS Calculation Framework
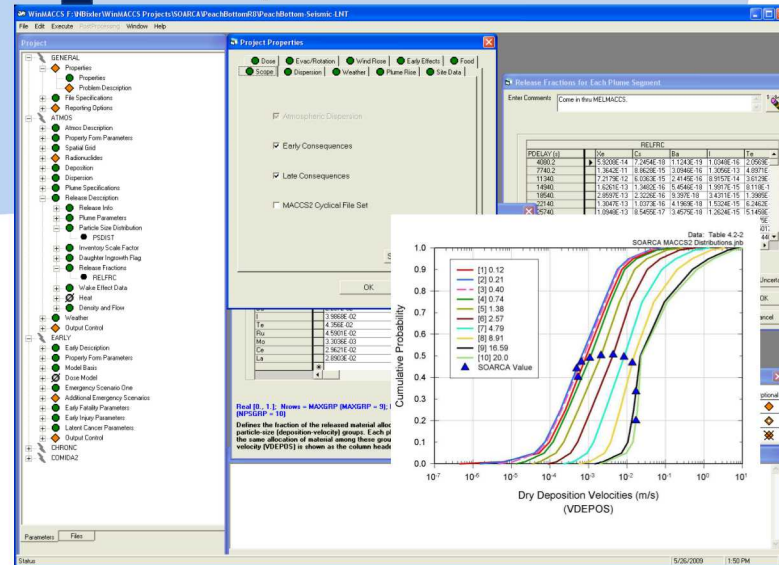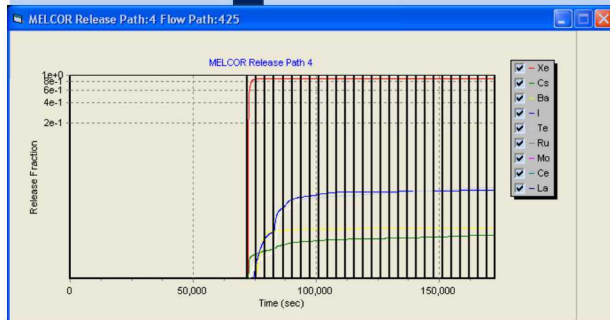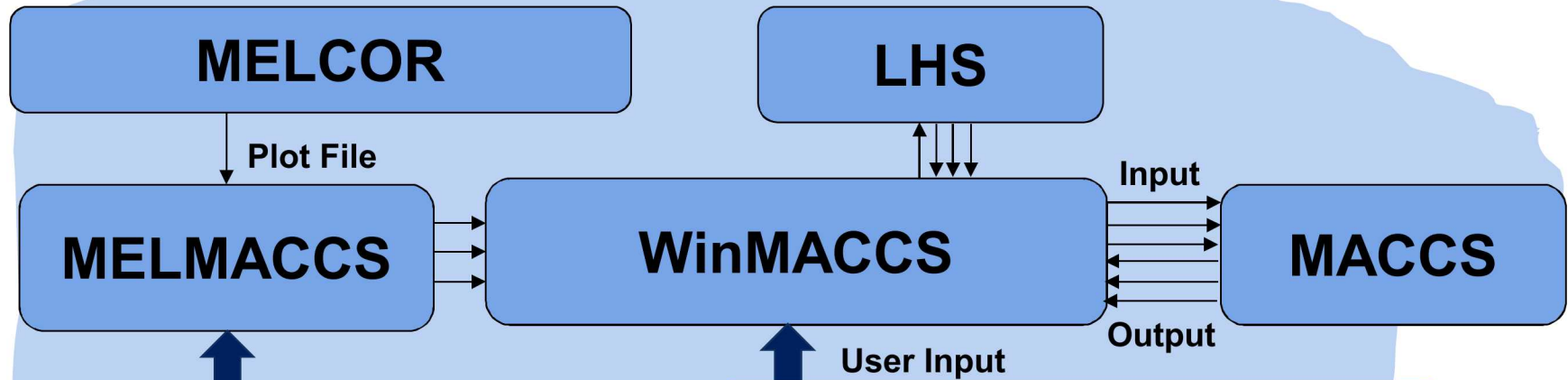
MACCS Preprocessors

- **MelMACCS**
  - Extracts and processes source-term data from MELCOR plot files

- **SecPop**
  - Evaluates census, land use, and economic data for a MACCS site file

- **COMIDA2**
  - Evaluates dose coefficients for the food pathway

MelMACCS Status

- MelMACCS 1.7.1 released in January 2011

- MelMACCS 1.8.0 is currently being developed

  - User-definable fission product inventories

  - Support for spent fuel pool source terms

SecPop Status

- **SecPop 4.2.0 released in October 2013**
  - Uses 2010 census data
  - Allows 16, 32, 48, or 64 compass sectors
  - Uses a smart algorithm for defining economic regions
  - Supports alternative economic model development
  - Supports Windows 7 operating system

- **SecPop 4.3.0 released in September 2014**
  - A bug related to the calculation of farm fraction was fixed
  - The first three economic regions are automatically assigned as follows:
    - Region 1 is the exclusion area – population and economic values are zero
    - Region 2 – no land area
    - Region 3 – no census blocks

Summary

Recent MACCS, WinMACCS, and SecPop developments improve modeling fidelity and add user efficiency

- More flexible definition of cohorts
- Explicit modeling of keyhole evacuation
- Choice of units
- Output of population movement for verification against ETE data
- Updated population and economic data

Ongoing improvements address

- Requirements for NRC's Level-3 PRA project
- Alternative models for atmospheric transport and economic analysis

List of Acronyms

- CRAC   Calculation of Reactor Accident Consequences
- DHS   Department of Homeland Security
- PRA   Probabilistic Risk Assessment
- REAcct   Regional Economic Accounting tool
- SECPOP   Sector Population, Land Fraction, and Economic Estimation Program
- SOARCA   State-of-the-Art Reactor Consequence Analyses