

MACCS Overview and Status

Nate Bixler, Sandia National Laboratories
Matt Humberstone and Jon Barr, US Nuclear Regulatory Commission

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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



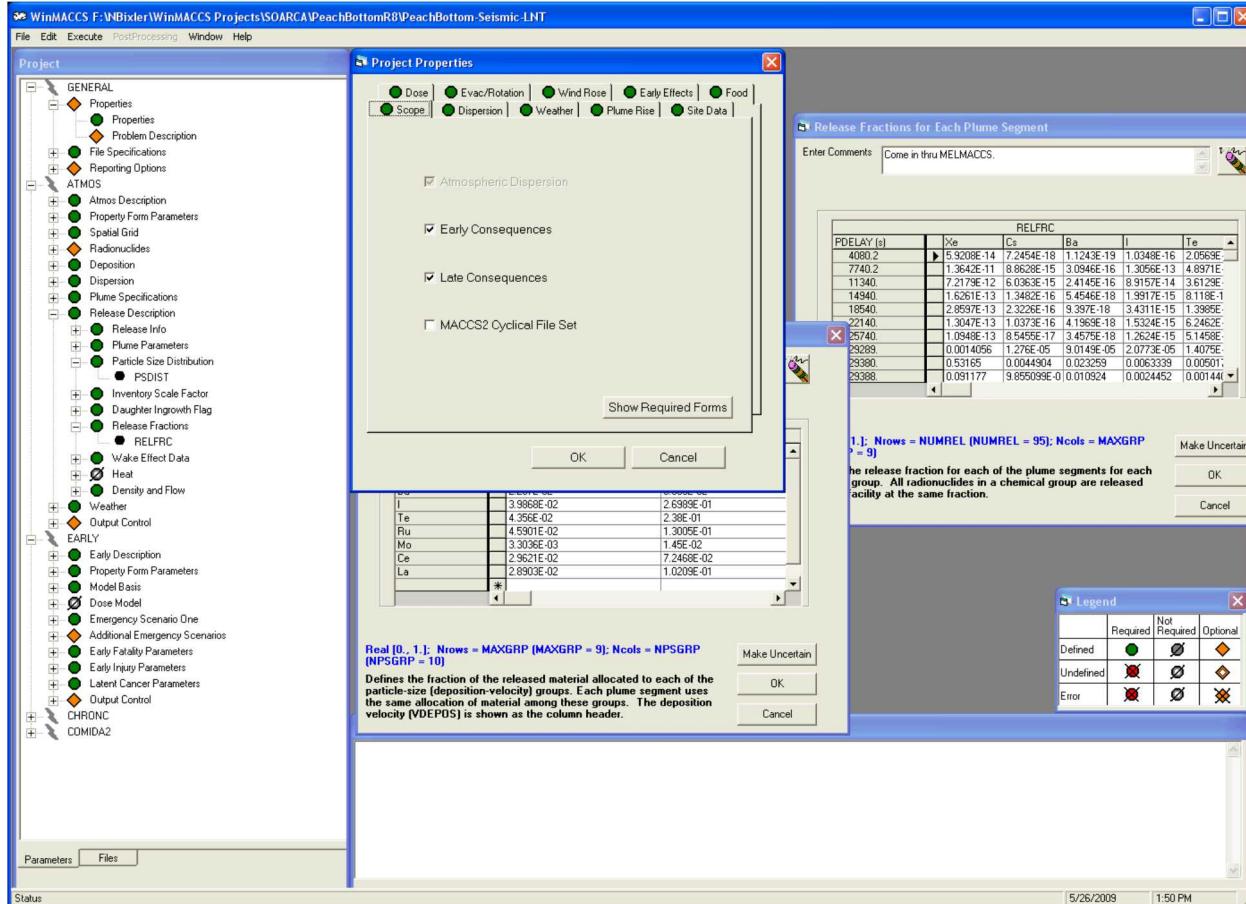
- MACCS is the NRC tool used to evaluate the offsite consequences of hypothetical radioactive releases into the atmosphere
- Evolved from codes going back to the 1970s
 - Calculation of Reactor Accident Consequences (CRAC)
 - Reactor Safety Study (WASH-1400)
 - CRAC2
 - 1982 Siting Study
 - MACCS v1.13.1
 - 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

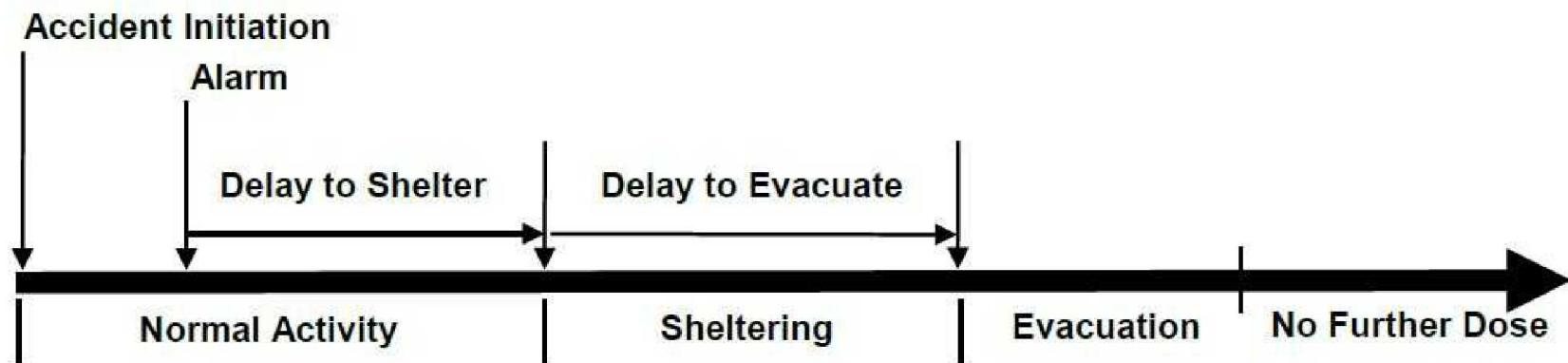
Improvements In WinMACCS 3.9

- 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

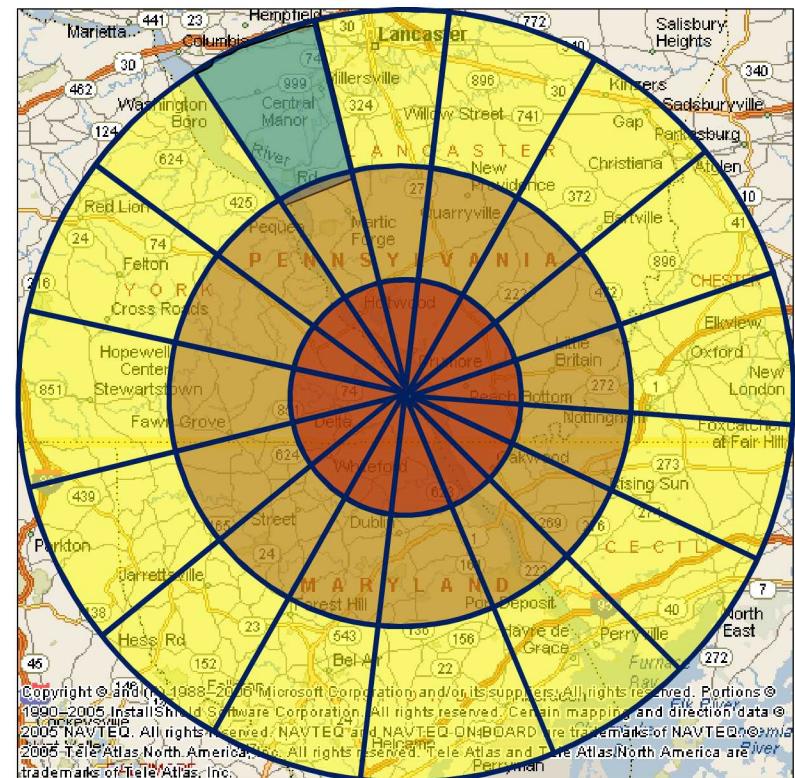
- Cohorts represent emergency response of distinct segments of the population
- Each cohort follows a timeline of actions

| 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 |



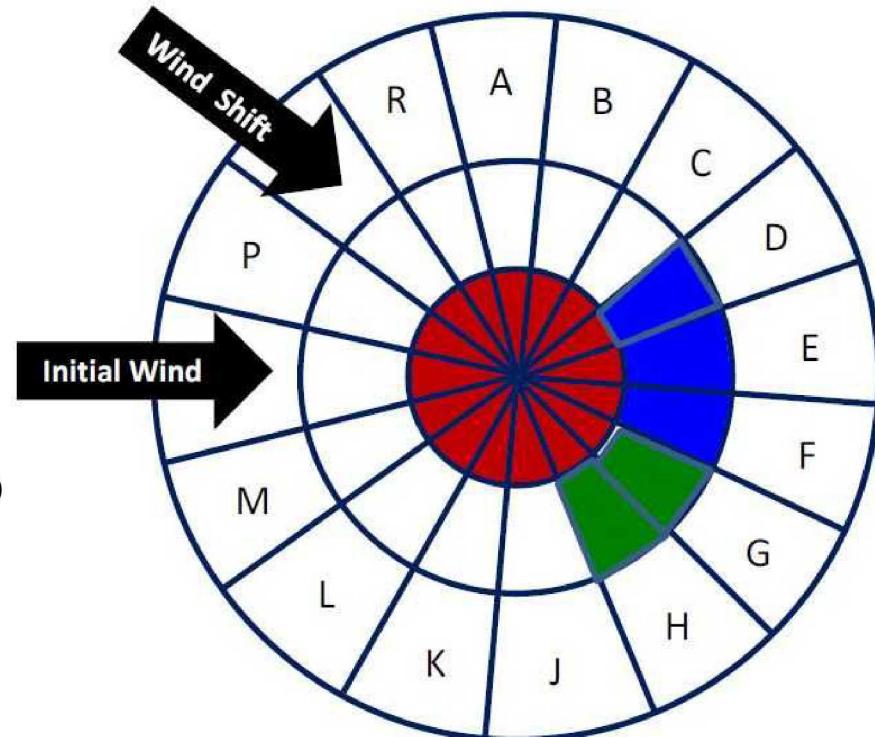
Added Flexibility in Defining Cohorts

- 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 



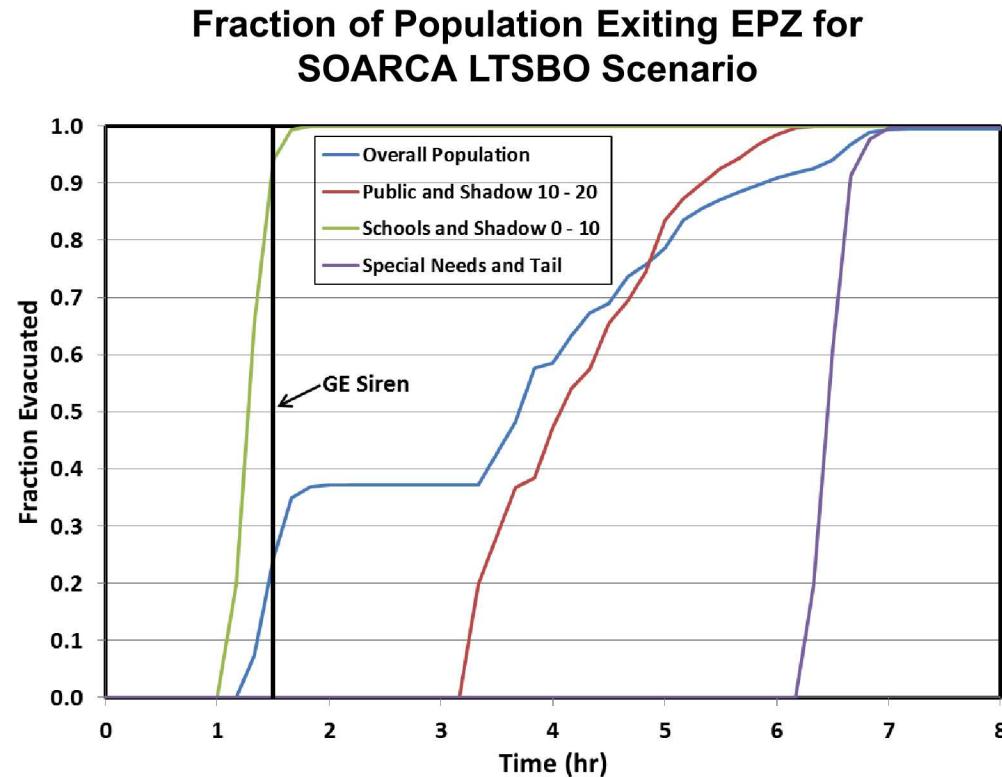
Keyhole Evacuation Model

- 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)

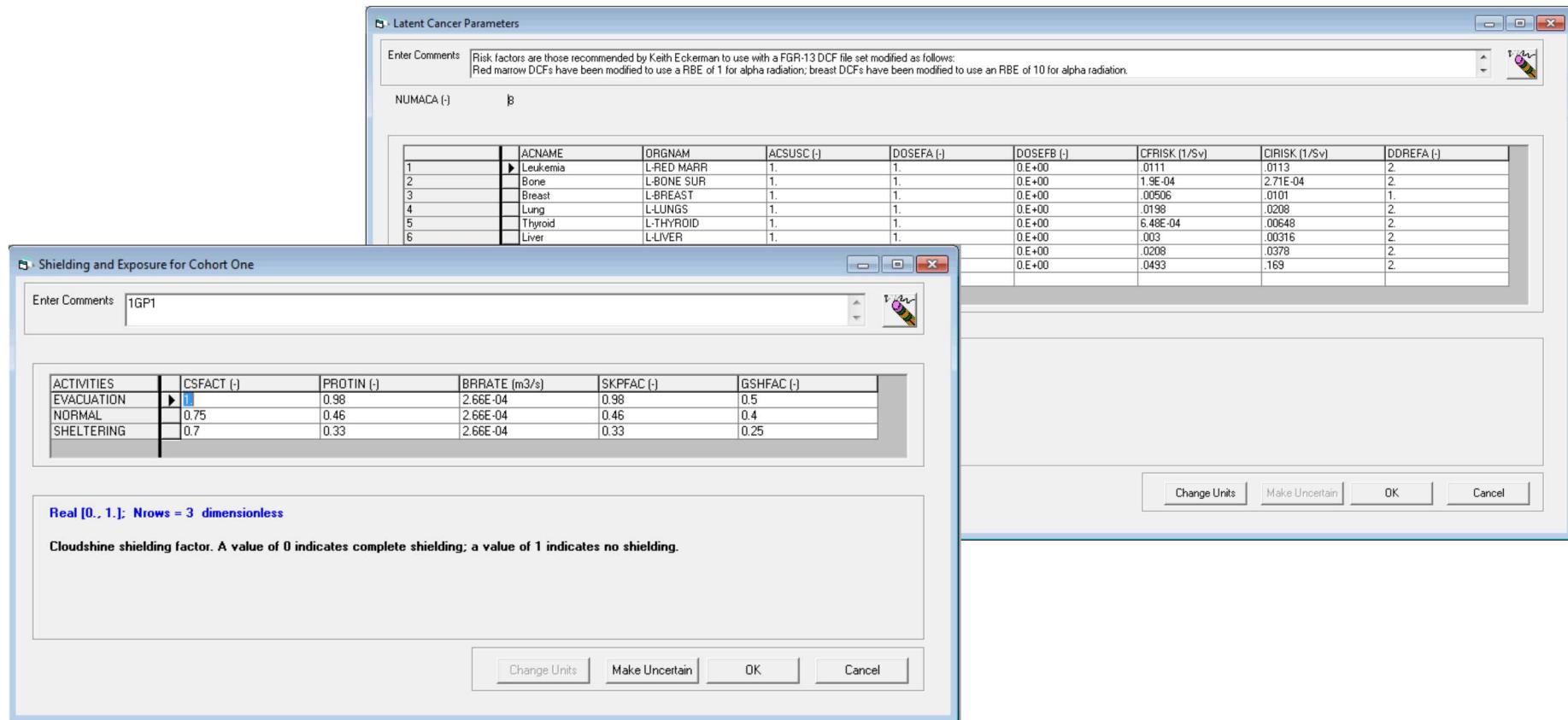


Tracking Population Movement

- 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



Resizable Parameter Input Screens



The image shows two overlapping software windows. The top window is titled "Latent Cancer Parameters" and contains a table of risk factors for various organs. The bottom window is titled "Shielding and Exposure for Cohort One" and contains a table of shielding factors for different activities.

Latent Cancer Parameters

| NUMACA (-) | ACNAME | ORGNAME | ACSUSC (-) | DOSEFA (-) | DOSEFB (-) | CFRISK (1/Sv) | CIRISK (1/Sv) | DDREFA (-) |
|------------|----------|------------|------------|------------|------------|---------------|---------------|------------|
| 1 | Leukemia | L-RED MARR | 1. | 1. | 0.E+00 | .0111 | .0113 | 2 |
| 2 | Bone | L-BONE SUR | 1. | 1. | 0.E+00 | 1.9E-04 | 2.71E-04 | 2 |
| 3 | Breast | L-BREAST | 1. | 1. | 0.E+00 | .00506 | .0101 | 1. |
| 4 | Lung | L-LUNGS | 1. | 1. | 0.E+00 | .0198 | .0208 | 2 |
| 5 | Thyroid | L-THYROID | 1. | 1. | 0.E+00 | 6.48E-04 | .00648 | 2 |
| 6 | Liver | L-LIVER | 1. | 1. | 0.E+00 | .003 | .00316 | 2 |

Shielding and Exposure for Cohort One

| ACTIVITIES | CSFACT (-) | PROTIN (-) | BRRATE (m ³ /s) | SKPFAC (-) | GSHFAC (-) |
|------------|------------|------------|----------------------------|------------|------------|
| EVACUATION | 0.98 | 2.66E-04 | 0.98 | 0.5 | |
| NORMAL | 0.75 | 0.46 | 2.66E-04 | 0.46 | 0.4 |
| SHELTERING | 0.7 | 0.33 | 2.66E-04 | 0.33 | 0.25 |

Real [0., 1.]: Rows = 3 dimensionless

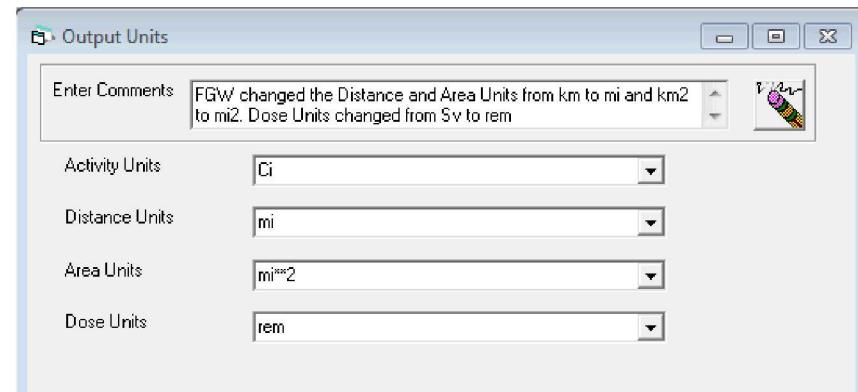
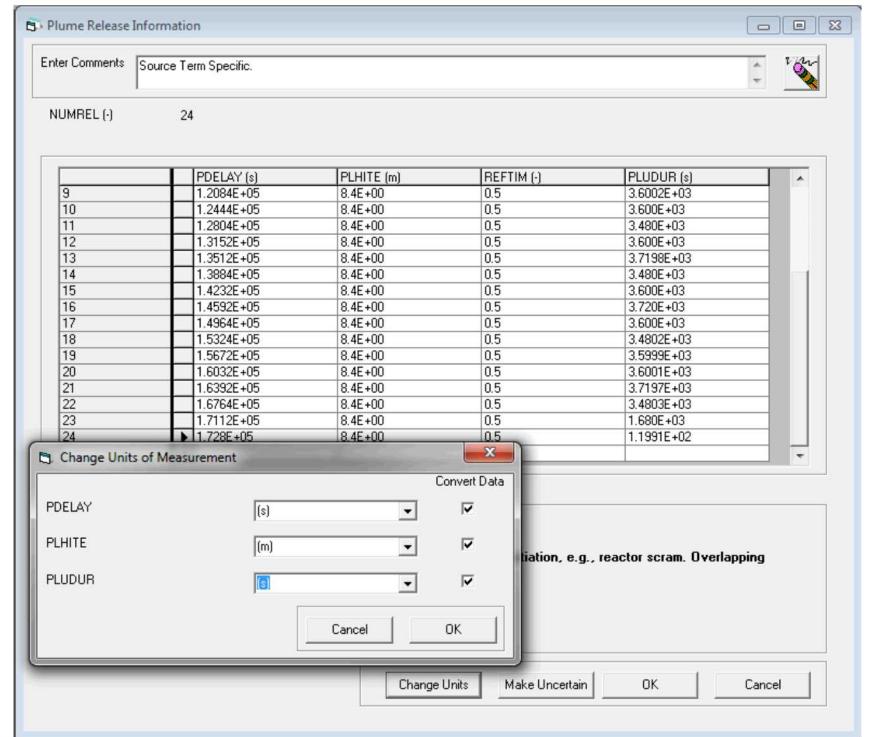
Cloudshine shielding factor. A value of 0 indicates complete shielding; a value of 1 indicates no shielding.

Buttons at the bottom of both windows: Change Units, Make Uncertain, OK, Cancel.

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

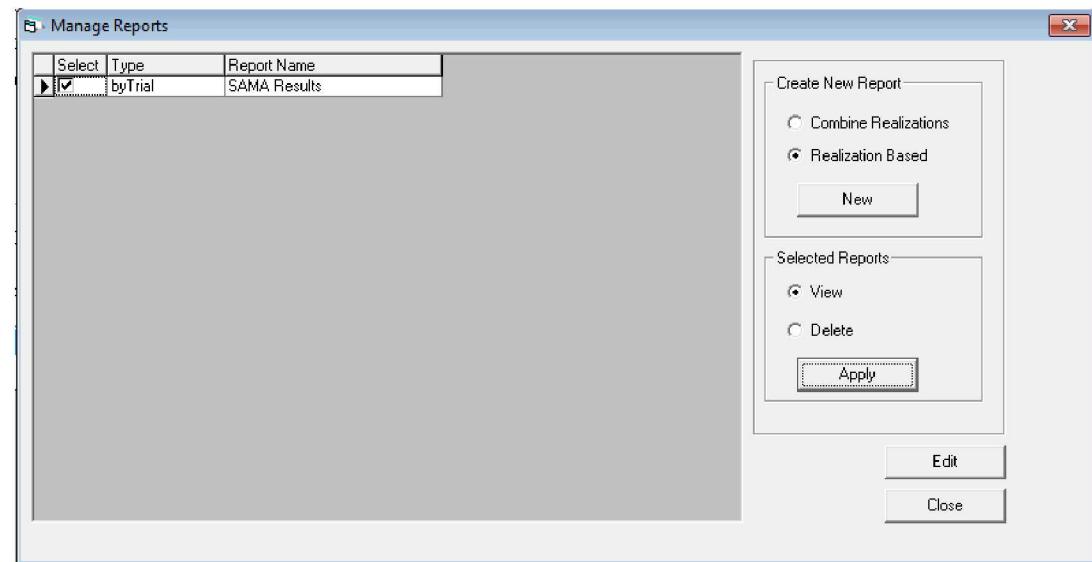
Choice of Units

- 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



SAMA Results.txt - Notepad

Report based on Project C:\Users\nbixler\winMACCS Projects\VEGP Base Case 08 18 14\VEGP Base Case 08 18 14.mxd
 WinMACCS Version 3.9.1 SVN:2188
 Report based on MACCS Version 3.9.0.6
 First binary file date/time stamp 09/04/2014 14:56
 9/5/2014 10:30:44 AM

Population Dose (rem) Evacuation overall L-ICRP60ED [0.,30.](mi)
 Probability Non-zero Mean 5th quantile 10th quantile 50th quantile 90th quantile 95th quantile 99th quantile 99.5th quantile Peak Concentration Peak Probability
 Peak Trial
 Realization 1 1.E+00 1.207E+04 2.331E+03 3.613E+03 1.077E+04 2.028E+04 2.158E+04 2.493E+04 2.653E+04 3.317E+04 1.332E-04 2.15E+02

Total Economic Costs (\$) Evacuation CHRONC [0.,30.](mi)
 Probability Non-zero Mean 5th quantile 10th quantile 50th quantile 90th quantile 95th quantile 99th quantile 99.5th quantile Peak Concentration Peak Probability
 Peak Trial
 Realization 1 1.E+00 4.849E+07 2.099E+06 5.499E+06 3.344E+07 1.067E+08 1.203E+08 1.59E+08 1.793E+08 2.345E+08 7.583E-04 2.30E+02

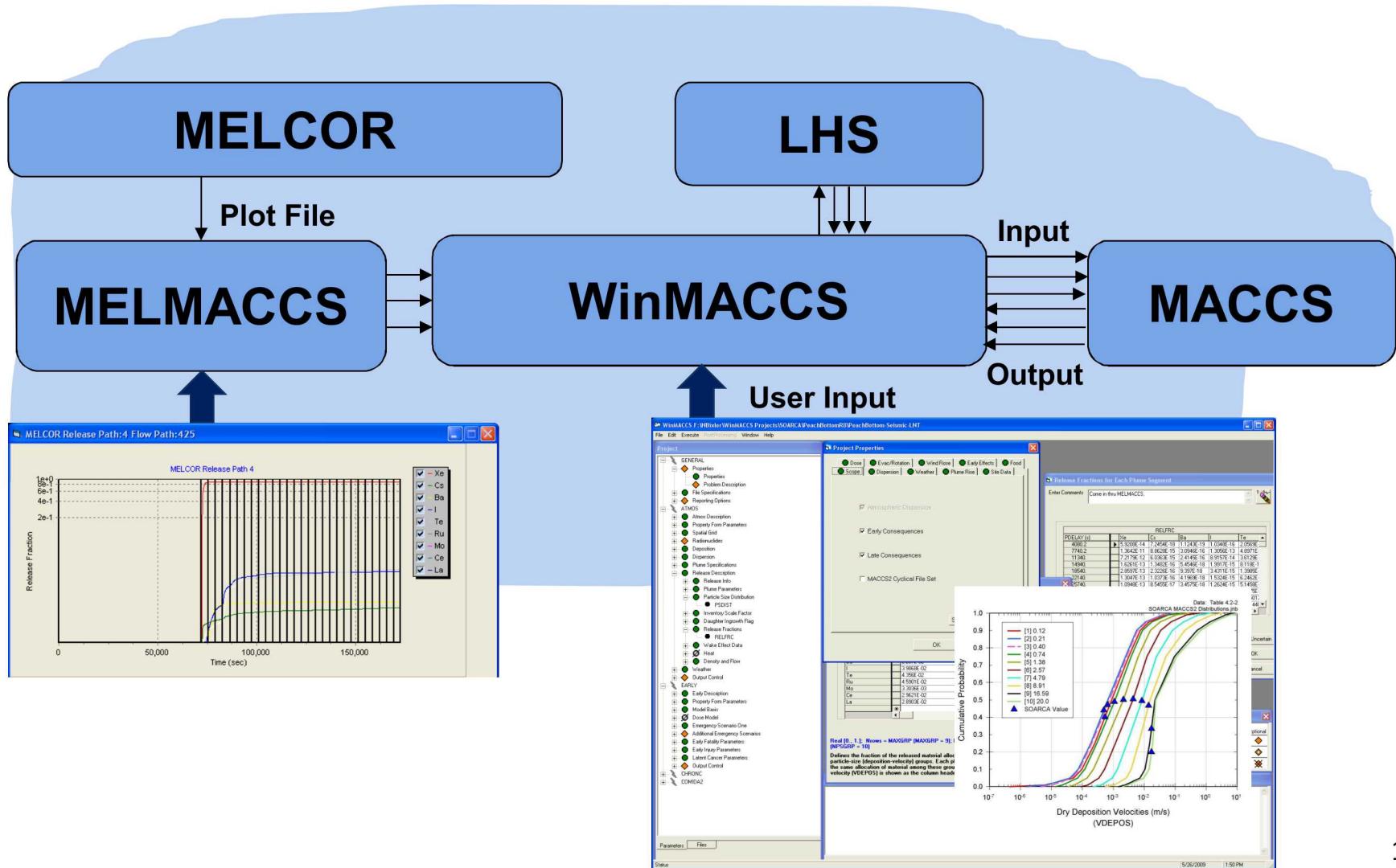
Development of WinMACCS 3.10

- 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