

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

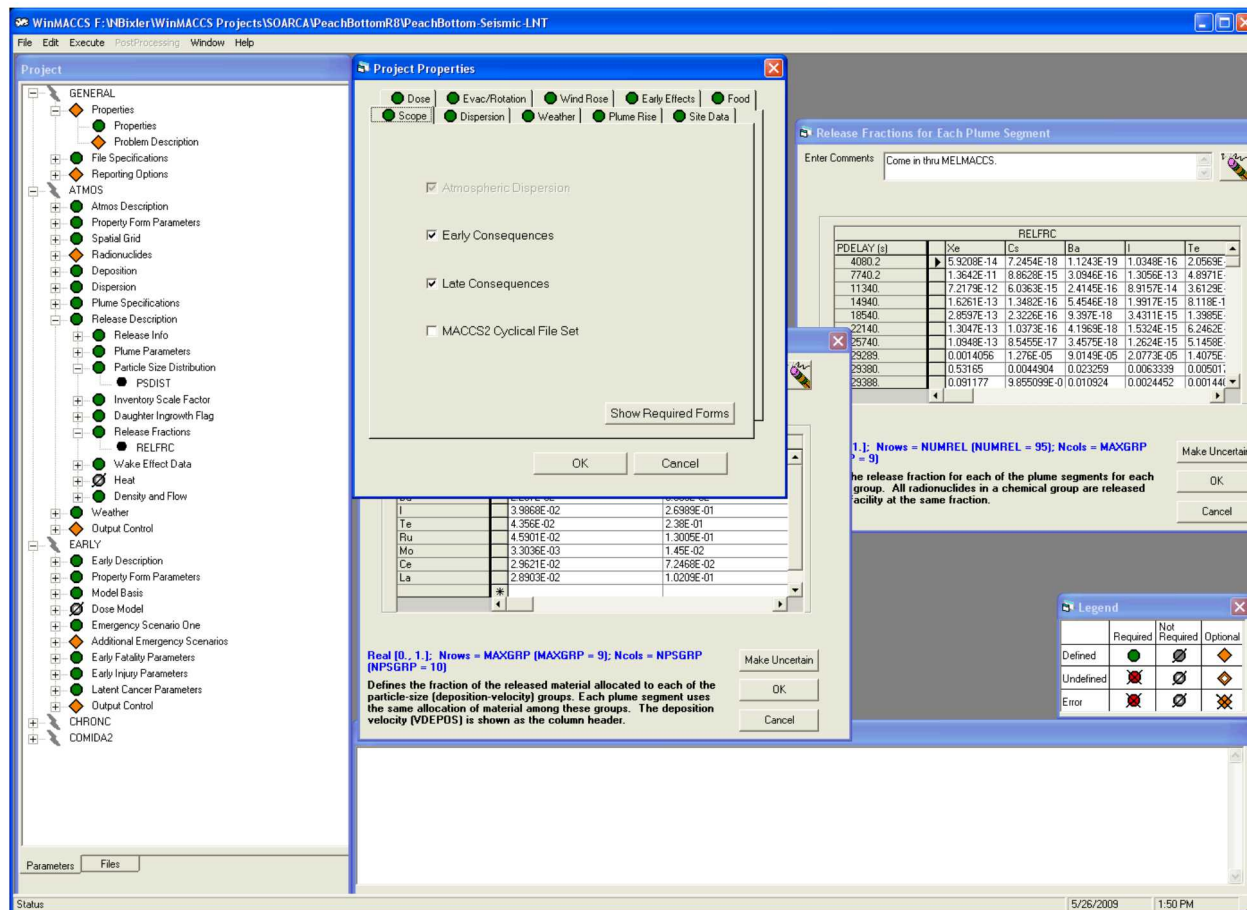
- MACCS is the NRC tool used to evaluate the offsite consequences of hypothetical radioactive releases into the atmosphere
- Evolved from codes going back to the 1970s
 - Calculation of Reactor Accident Consequences (CRAC)
 - Reactor Safety Study (WASH-1400)
 - CRAC2
 - 1982 Siting Study
 - MACCS v1.13.1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

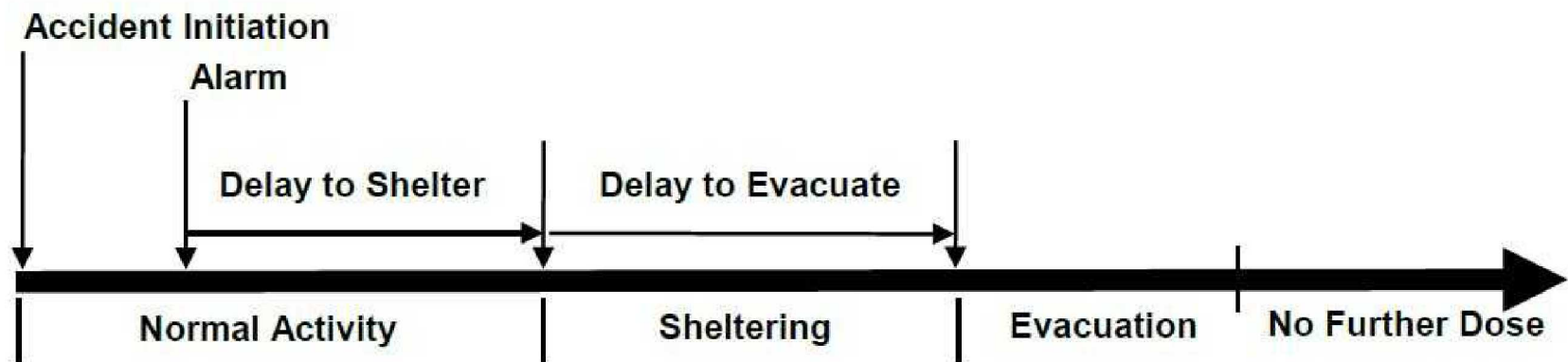
Improvements In WinMACCS 3.9

- 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

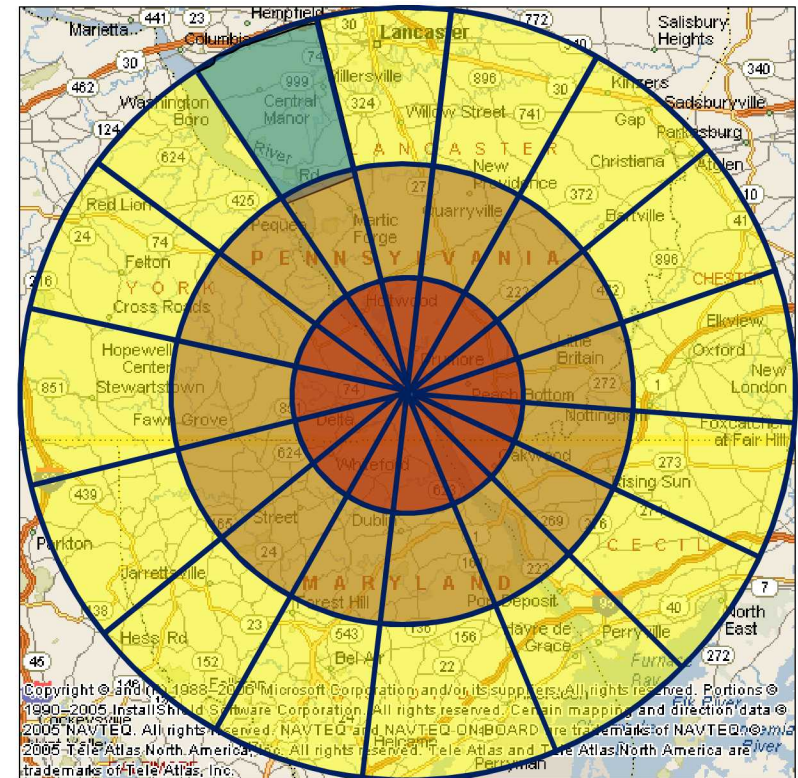
- Cohorts represent emergency response of distinct segments of the population
- Each cohort follows a timeline of actions

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	



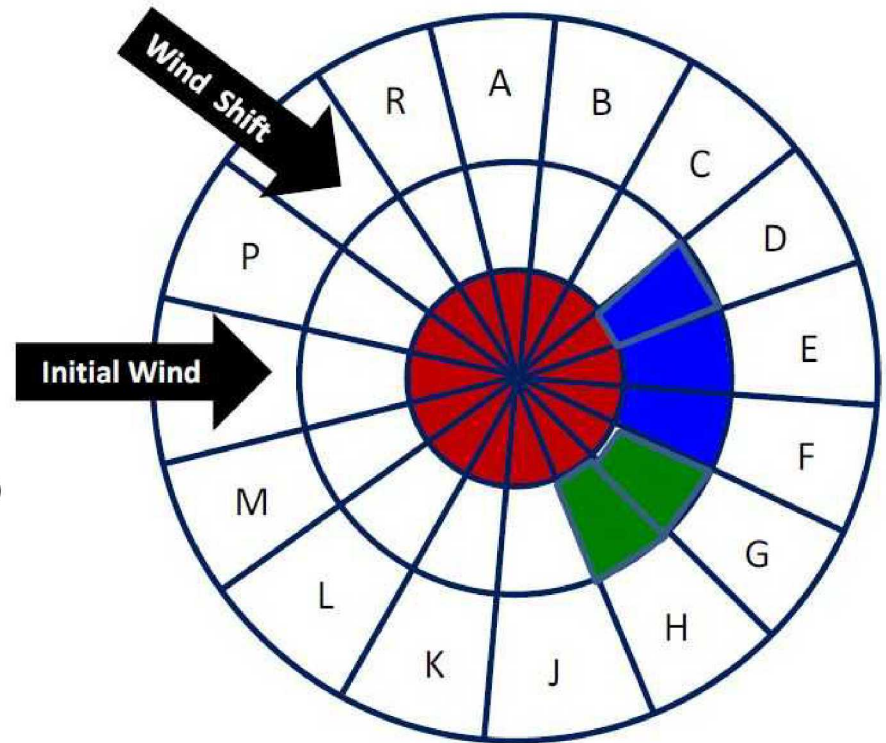
Added Flexibility in Defining Cohorts

- 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 



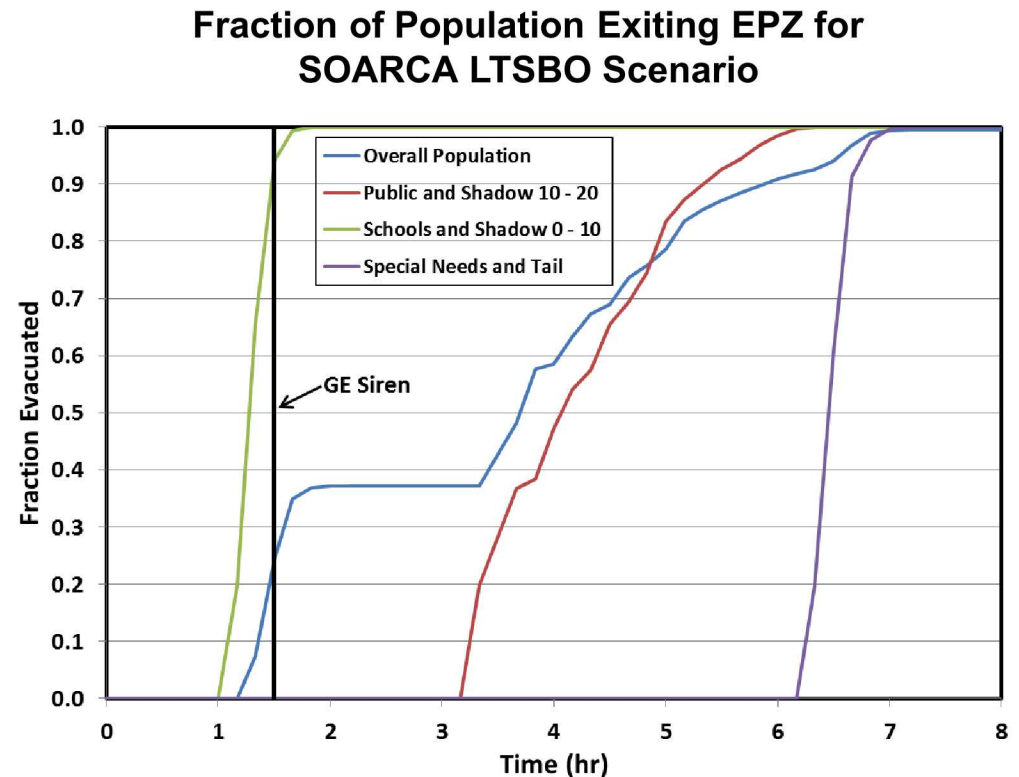
Keyhole Evacuation Model

- 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)

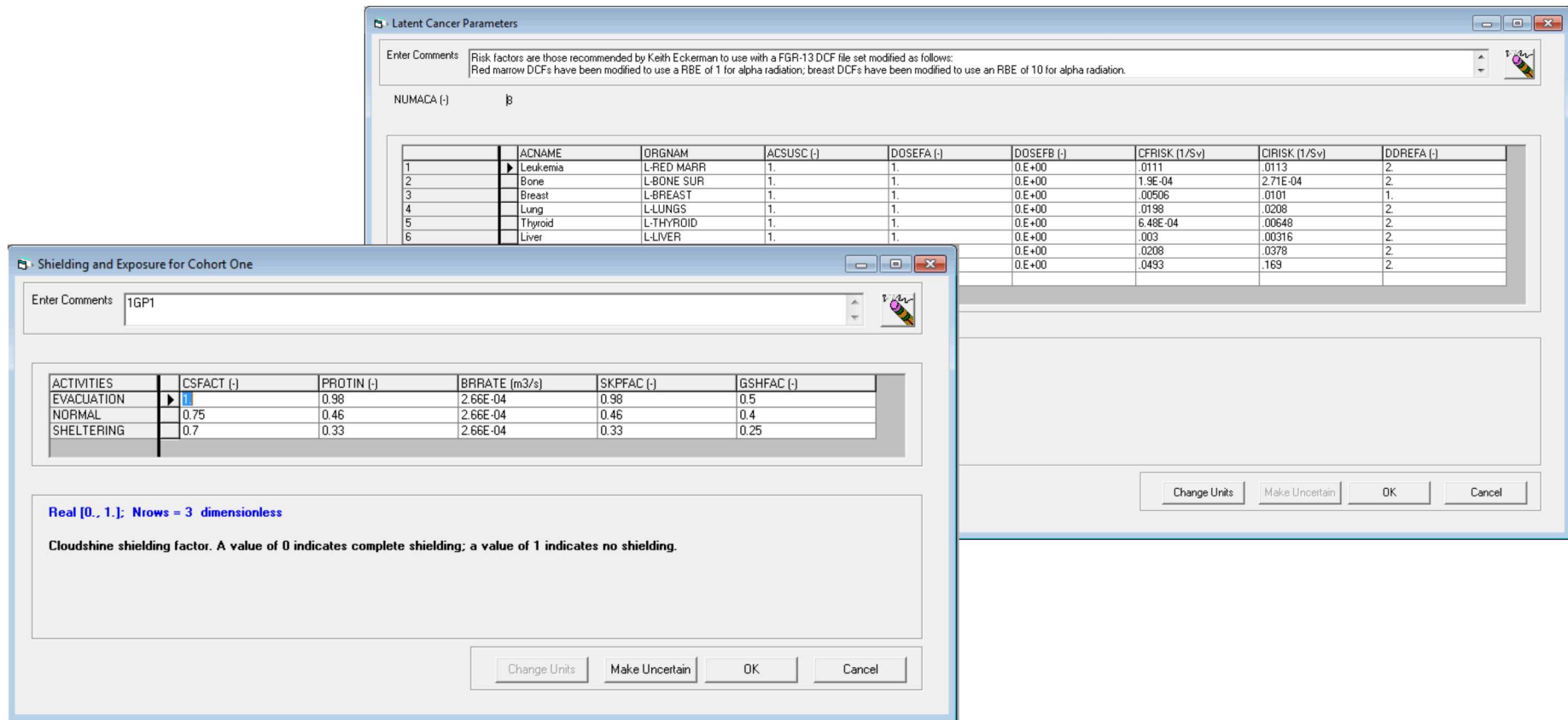


Tracking Population Movement

- 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



Latent Cancer Parameters

Enter Comments: Risk factors are those recommended by Keith Eckerman to use with a FGR-13 DCF file set modified as follows:
Red marrow DCFs have been modified to use a RBE of 1 for alpha radiation; breast DCFs have been modified to use an RBE of 10 for alpha radiation.

NUMACA (-) 8

	ACNAME	ORGNAM	ACSUSC (-)	DOSEFA (-)	DOSEFB (-)	CFRISK (1/Sv)	CRISK (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.
					0.E+00	.0208	.0378	2.
					0.E+00	.0493	.169	2.

Shielding and Exposure for Cohort One

Enter Comments: 1GP1

ACTIVITIES	CSFACT (-)	PROTIN (-)	BRRATE (m3/s)	SKPFAC (-)	GSHFAC (-)
EVACUATION	0.98	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.]; Nrows = 3 dimensionless

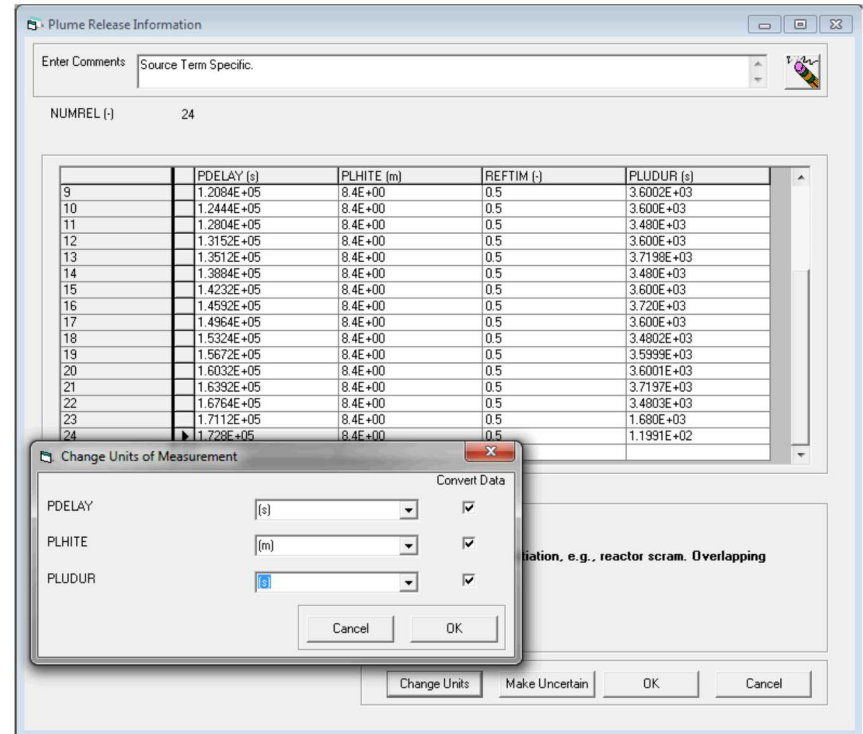
Cloudshine shielding factor. A value of 0 indicates complete shielding; a value of 1 indicates no shielding.

Change Units Make Uncertain OK Cancel

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

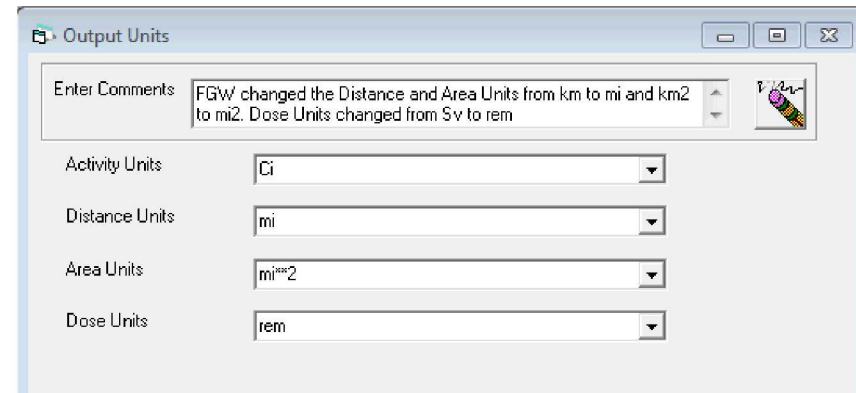
Choice of Units

- 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



The 'Plume Release Information' dialog box shows a table of release data. A 'Change Units of Measurement' sub-dialog is open, allowing users to select units for PDELAY, PLHITE, and PLUDUR. The 'Convert Data' checkbox is checked for all three parameters.

	PDELAY (s)	PLHITE (m)	REFTIM (-)	PLUDUR (s)
9	1.2084E+05	8.4E+00	0.5	3.6002E+03
10	1.2444E+05	8.4E+00	0.5	3.600E+03
11	1.2804E+05	8.4E+00	0.5	3.480E+03
12	1.3152E+05	8.4E+00	0.5	3.600E+03
13	1.3512E+05	8.4E+00	0.5	3.7198E+03
14	1.3884E+05	8.4E+00	0.5	3.480E+03
15	1.4232E+05	8.4E+00	0.5	3.600E+03
16	1.4592E+05	8.4E+00	0.5	3.720E+03
17	1.4964E+05	8.4E+00	0.5	3.600E+03
18	1.5324E+05	8.4E+00	0.5	3.4802E+03
19	1.5672E+05	8.4E+00	0.5	3.5999E+03
20	1.6032E+05	8.4E+00	0.5	3.6001E+03
21	1.6392E+05	8.4E+00	0.5	3.7197E+03
22	1.6764E+05	8.4E+00	0.5	3.4803E+03
23	1.7112E+05	8.4E+00	0.5	1.680E+03
24	1.728E+05	8.4E+00	0.5	1.1991E+02



The 'Output Units' dialog box allows users to select units for activity, distance, area, and dose. The 'Enter Comments' field contains the text: 'FGW changed the Distance and Area Units from km to mi and km2 to mi2. Dose Units changed from Sv to rem'.

Activity Units: Ci

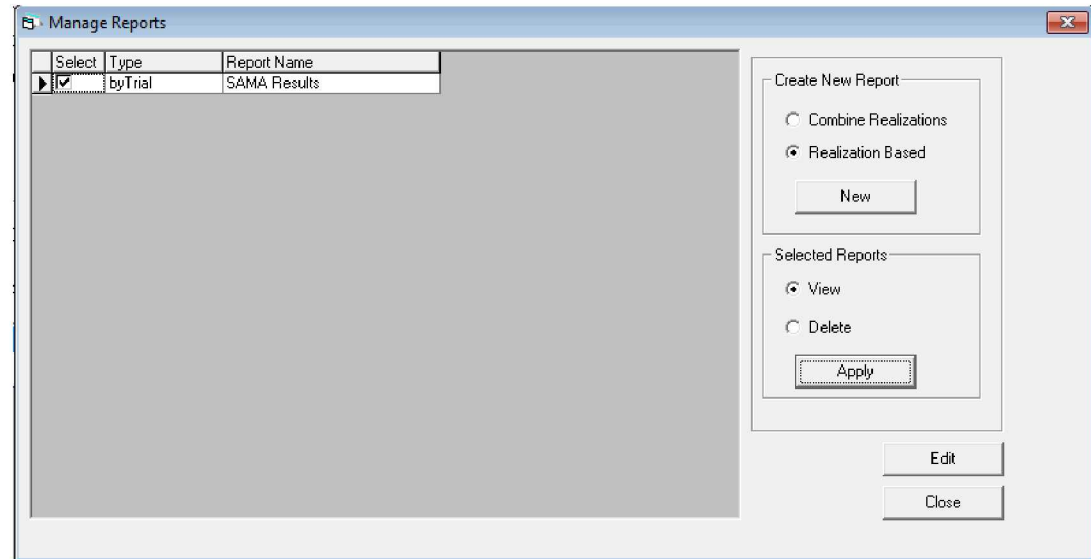
Distance Units: mi

Area Units: mi²

Dose Units: rem

Reporting Options

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



SAMA Results.txt - Notepad

File Edit Format View Help

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.,15.](mi)	5th Quantile	10th Quantile	50th Quantile	90th Quantile	95th Quantile	99th Quantile	99.5th Quantile	Peak Concentration	Peak Probability	
Peak Trial	Probability Non-zero	Mean	5th Quantile	10th Quantile	50th Quantile	90th Quantile	95th Quantile	99th Quantile	99.5th Quantile	Peak Concentration	Peak Probability	
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)	5th Quantile	10th Quantile	50th Quantile	90th Quantile	95th Quantile	99th Quantile	99.5th Quantile	Peak Concentration	Peak Probability		
Peak Trial	Probability Non-zero	Mean	5th Quantile	10th Quantile	50th Quantile	90th Quantile	95th Quantile	99th Quantile	99.5th Quantile	Peak Concentration	Peak Probability	
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

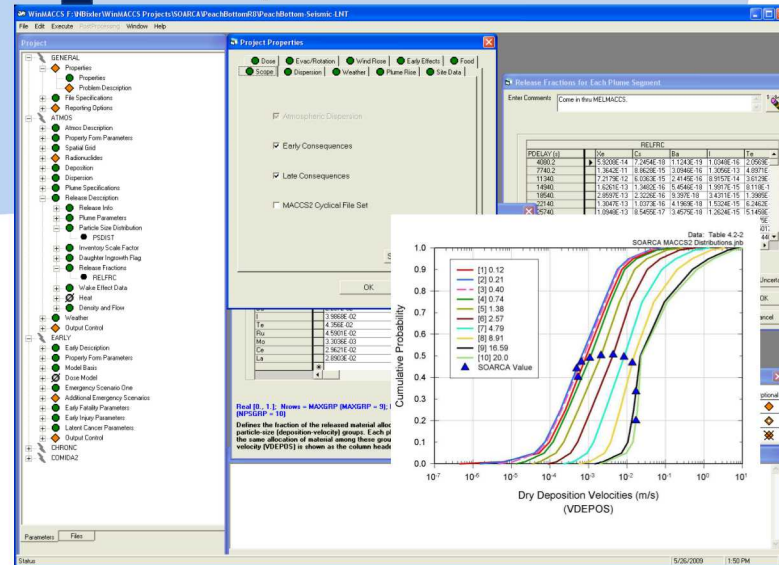
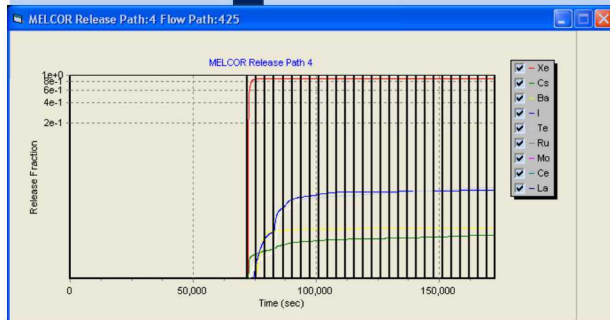
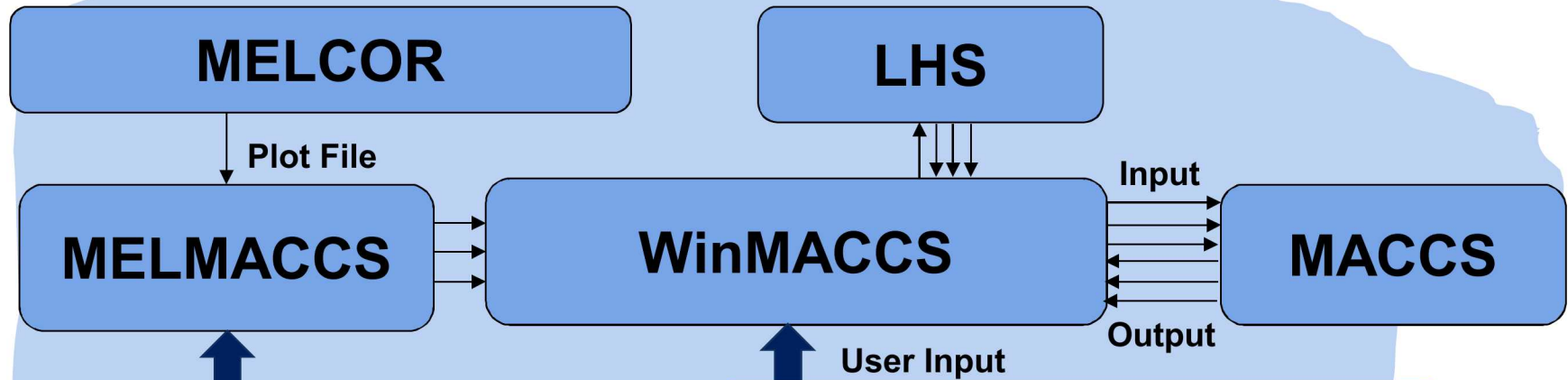
Development of WinMACCS 3.10

- 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