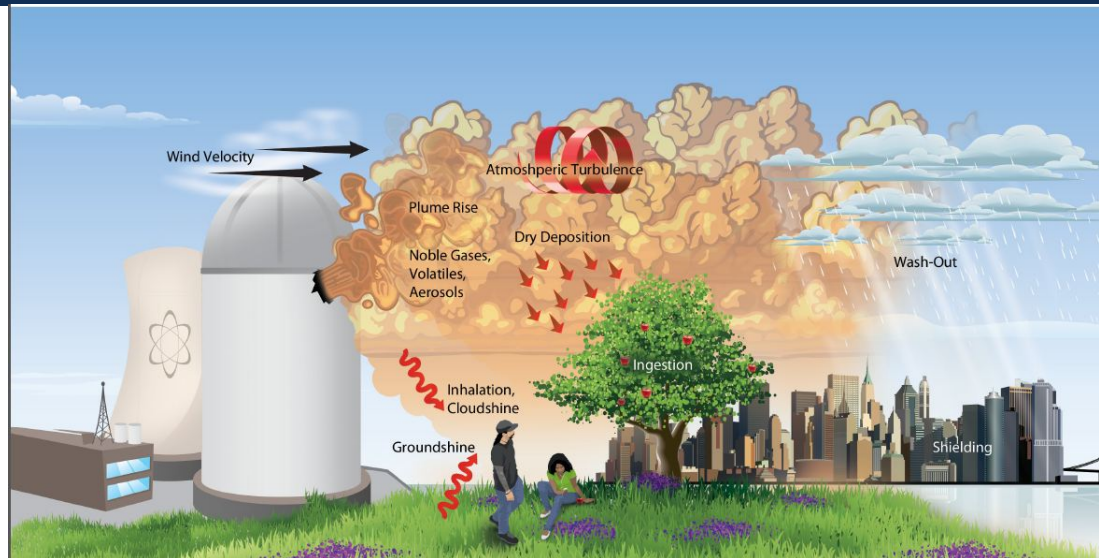


Exceptional service in the national interest



MACCS Overview

Nate Bixler, Sandia National Laboratories

Amy Sharp, Keith Compton, and Jon Barr, US Nuclear Regulatory Commission

Presented at the 8th International MACCS Users Group Meeting, Sept. 15 – 16, 2016



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2011-XXXXP

Outline

- MELCOR Accident Consequence Code System (MACCS) capabilities
- Improvements in the most recent versions
- New models being developed
- Improvements in preprocessor codes
- Summary





MACCS Capabilities

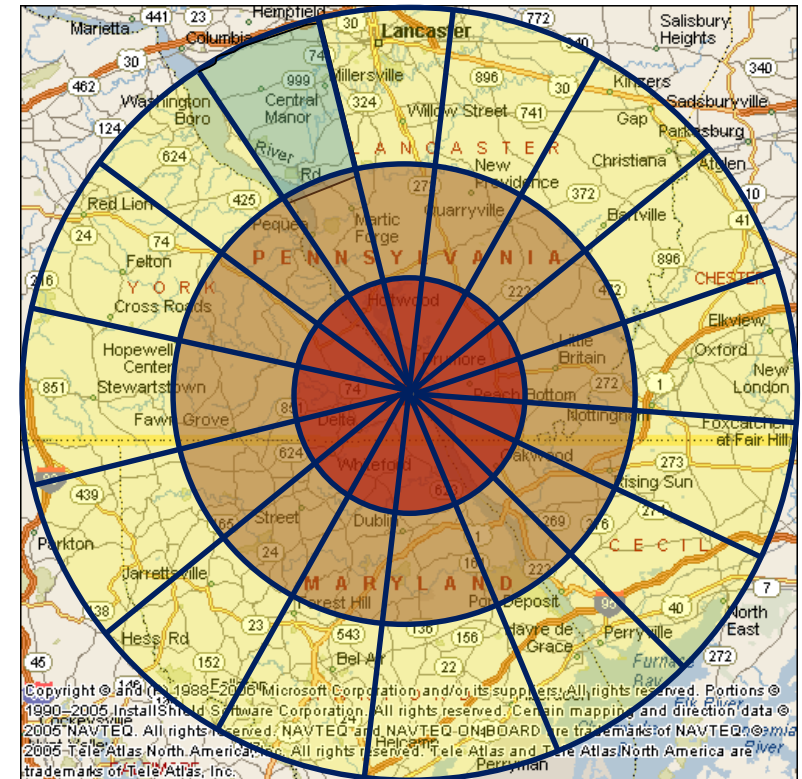
- Tool used to assess the risk and consequence associated with a hypothetical accidental release of radioactive material to the atmosphere
- Developed and maintained by Sandia National Laboratories under the direction of the U.S. Nuclear Regulatory Commission
- Evolved from codes used in the 1970's and the 1980's
- Accounts for
 - Transport and dispersion in the atmosphere and deposition to ground
 - Exposure due to inhalation, ingestion, and external irradiation
 - Protective actions during emergency and long-term phases
- Estimates consequences in terms of:
 - Health effects from short and long-term exposure
 - Economic impact of short and long-term protective actions
 - Land area / population potentially subject to protective actions

Improvements In MACCS 3.9 (9/14)

- 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

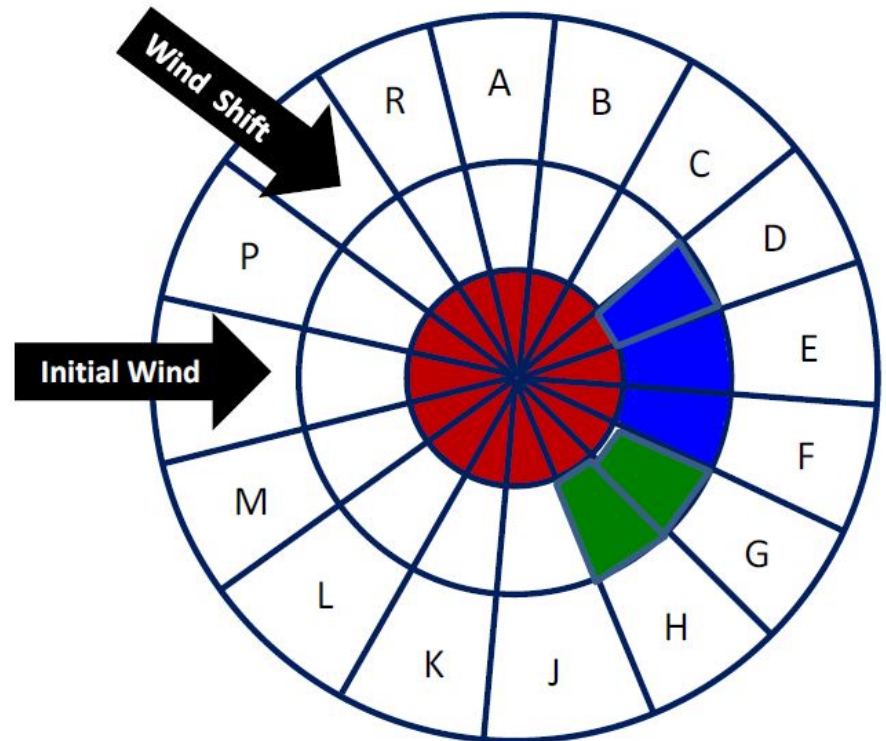
Added Flexibility in Defining Cohorts

- 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

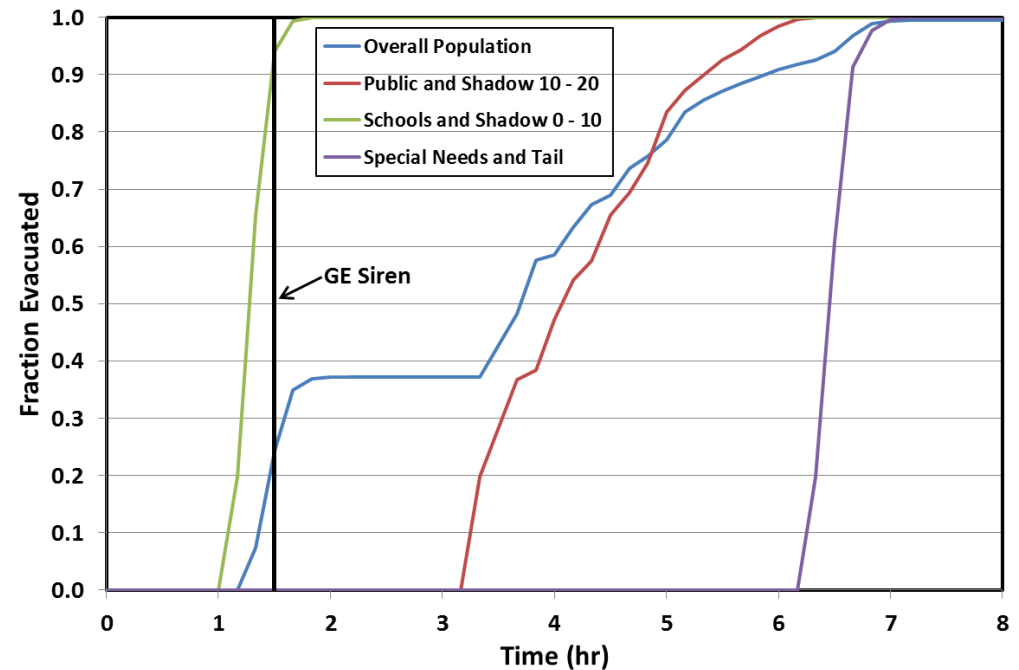
- Keyhole consists of
 - A central circular region
 - An pie-shaped outer region
- User defines initial dimensions of keyhole
- Shift in wind direction causes pie-shaped region to expand
- Model allows for foreknowledge of weather (forecasting)



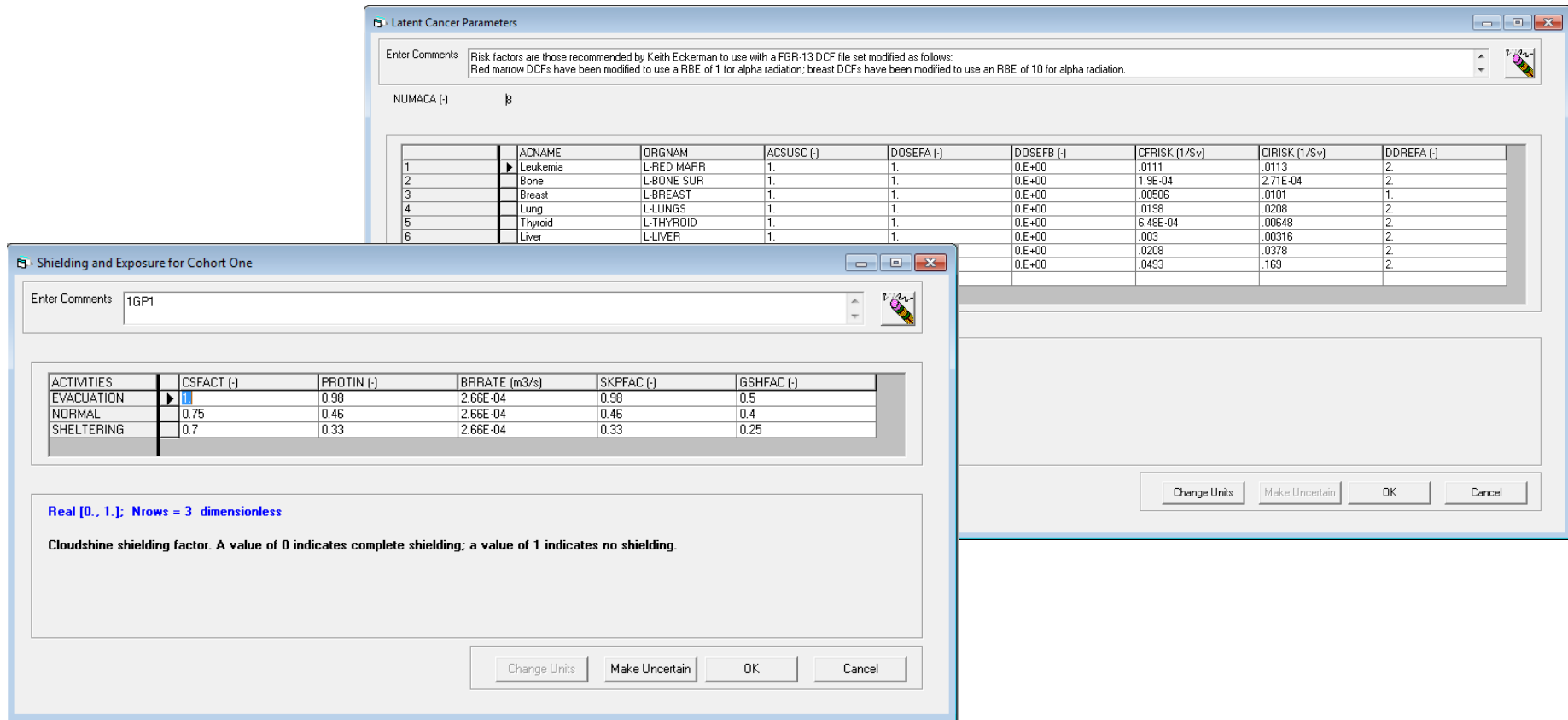
Tracking Population Movement

- 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



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	1.	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

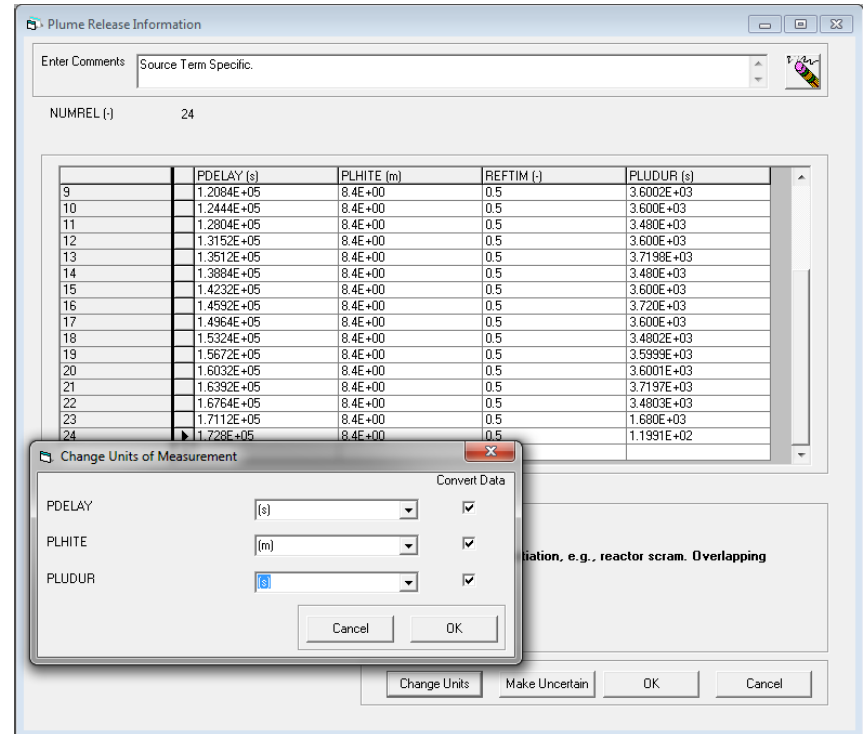
Real [0., 1.]: Nrows = 3 dimensionless

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

- Screens can 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



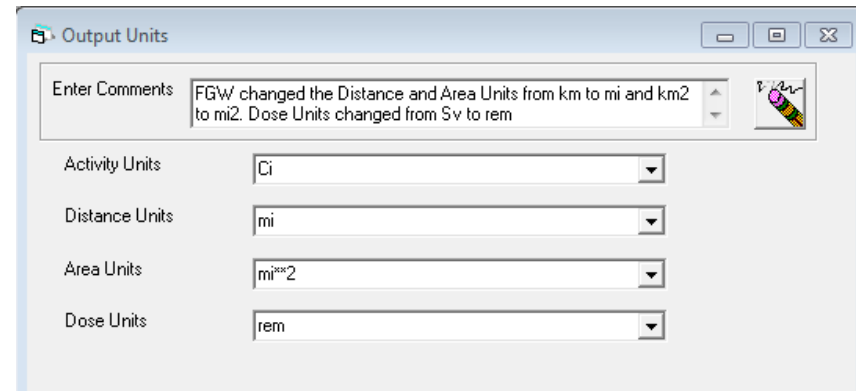
The 'Plume Release Information' dialog box shows a table of release data for 24 sources. The 'Change Units of Measurement' sub-dialog is open, allowing selection of units for PDELAY, PLHITE, and PLUDUR.

	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	3.5399E+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 'Change Units of Measurement' sub-dialog shows the following settings:

- PDELAY: (s) [checked]
- PLHITE: (m) [checked]
- PLUDUR: (s) [checked]

Buttons: Cancel, OK, Change Units, Make Uncertain, OK, Cancel.



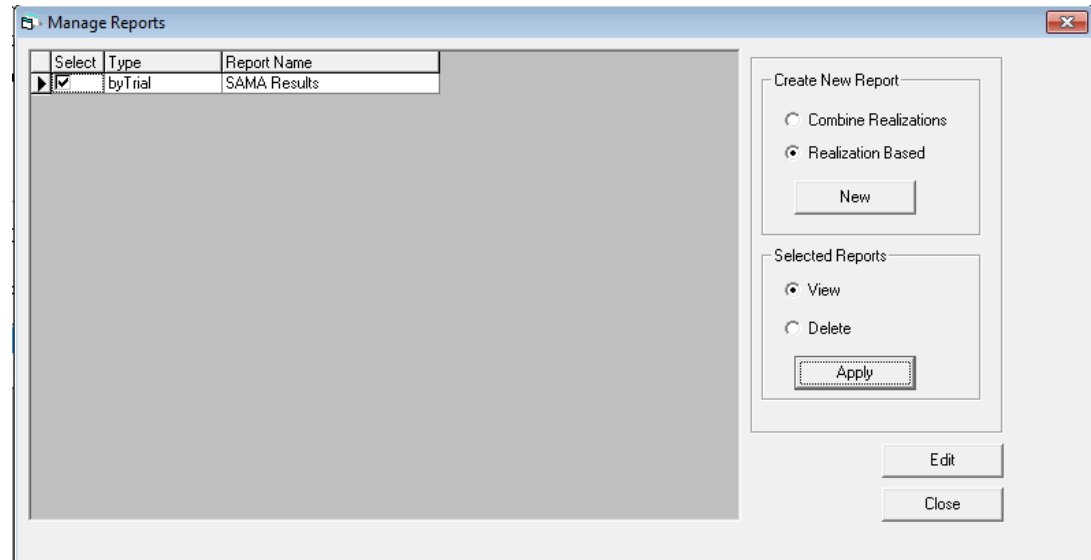
The 'Output Units' dialog box shows the following settings:

- Activity Units: Ci
- Distance Units: mi
- Area Units: mi²
- Dose Units: rem

Buttons: OK, Cancel.

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									
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

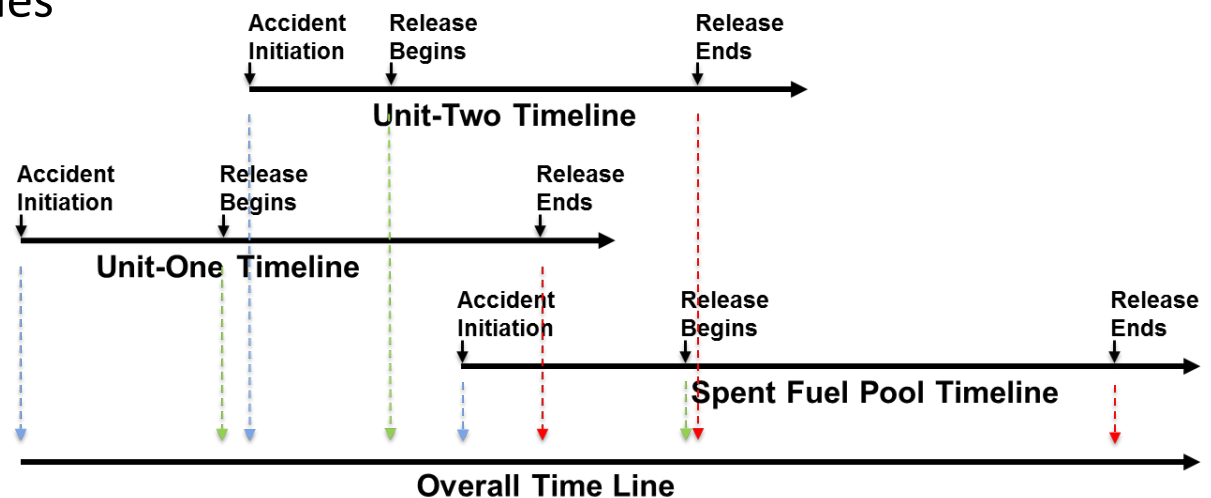
Total Economic Costs (\$)	Evacuation CHRONC [0.,30.](mi)	5th Quantile	10th Quantile	50th Quantile	90th Quantile	95th Quantile	99th Quantile	99.5th Quantile	Peak Concentration	Peak Probability
Peak Trial	Probability Non-zero	Mean								
Realization 1	1.E+00	4.849E+07	2.099E+06	5.499E+06	3.344E+07	1.067E+08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

Improvements In MACCS 3.10 (5/15)

- Multi-source releases (requires MelMACCS 2.0)
- Extended durations
 - Alarm time (30 day)
 - Delay to release (30 day)
 - Emergency phase (40 day)
- User-defined dose projection periods for emergency and intermediate phases (previously duration of phase)
- Detailed output for number of people affected by countermeasures for each phase
- Increase in weather hours from 120 to 1200
- User-defined return time for evacuees unaffected by release (previously duration of emergency phase)

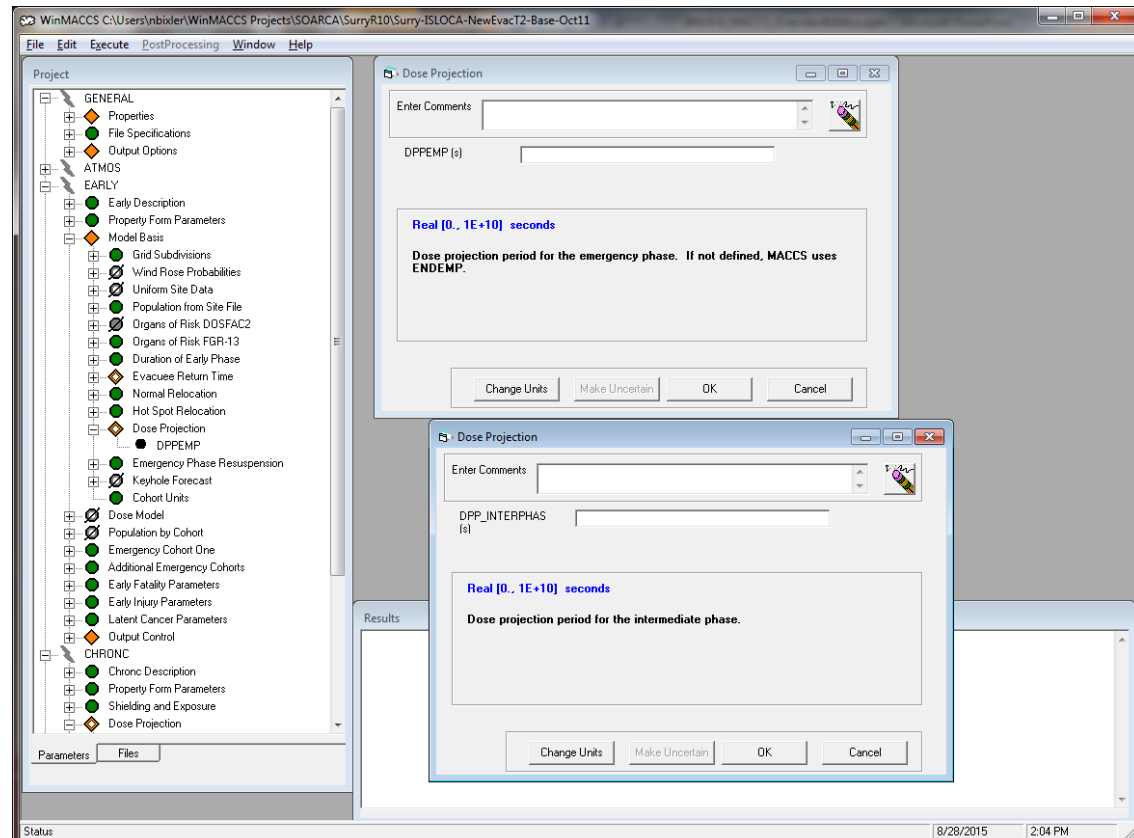
Multi-Source Release Model

- Allows releases from multiple units with independent
 - Accident initiation times
 - Release time line
 - Isotopic inventories
- Allows releases from a spent fuel pool with multiple rings (cooling times) with independent
 - Release time line
 - Isotopic inventories



User-Definable Dose Projection Periods

- User-definable dose projection periods for
 - Emergency phase
 - Intermediate phase
- Long-term phase model previously supported a user-definable dose projection period



Detailed Output for People Affected by Countermeasures

- EVACUATED & RELOCATED PEOPLE 0-50.0 mi
 - EVACUEES NOT AFFECTED BY PLUME
 - EVACUEES AFFECTED BY PLUME
 - NORMAL EMERGENCY PHASE RELOCATION
 - HOTSPOT EMERGENCY PHASE RELOCATION
 - INTERMEDIATE PHASE RELOCATION
 - LEVEL 1 DECONTAMINATION RELOCATION
 - LEVEL 2 DECONTAMINATION RELOCATION
 - LEVEL 3 DECONTAMINATION RELOCATION
 - DECONTAMINATION+INTERDICTION RELOC
 - CONDEMNATION RELOCATION

Important Bugs Fixed in MACCS

3.10.1.2 (9/16)

- Times entering and leaving grid element have been corrected for middle and late phases of evacuation when TRAVELPOINT = BOUNDARY.
- Centerline dose calculation has been corrected.
- Implementation of the keyhole evacuation model has been fixed.

Future Development

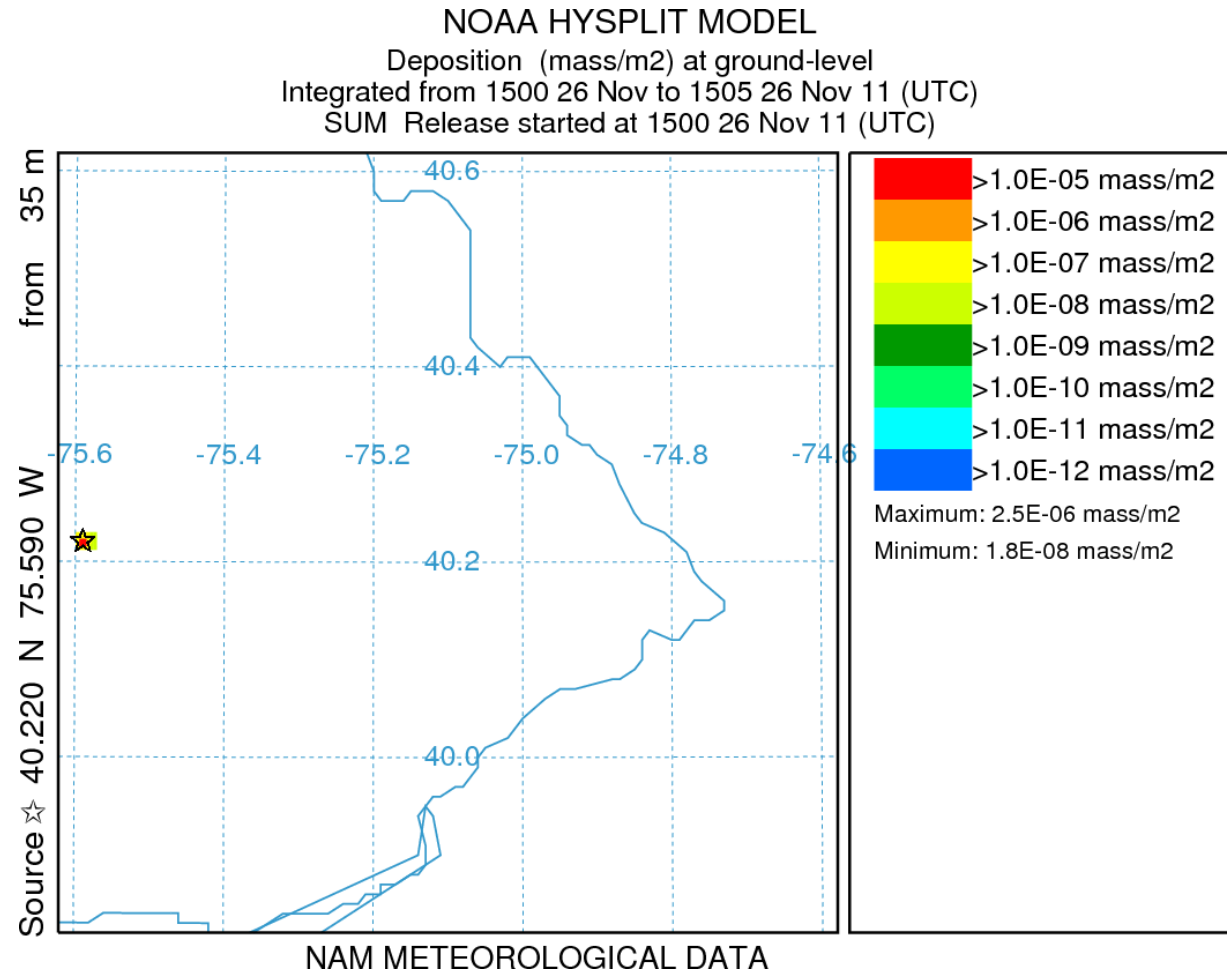
- Dosimetry improvements – allow all organs and tissues in dose coefficient file to be used
- Alternative economic model to evaluate GDP losses
 - Performed a peer review with group of experts
 - Jeff Werling from UMD
 - Haydar Kurban from Howard U.
 - Neil Higgins from Public Health England
 - Model implementation is being revised to address recommendations
- Alternative atmospheric transport model (HYSPLIT) to evaluate special issues
 - Initial implementation is complete
 - New capability is being evaluated and tested
 - Expect public release in first half of 2017

Future Development (Cont'd)

- Animation capability
 - Plume segment animation has been developed
 - Concentration isopleth animation is being developed
 - Dose and dose-rate isopleth animation not started
- Ability to set OALARM independently for each cohort
- Increased range for decontamination costs and times
- User-defined tabular results for post processing
- Input parameter guidance
 - Keith Compton (NRC) is leading effort
 - Document will lay out a recommended approach for defining MACCS input parameters
 - Less prescriptive than previous approaches have been

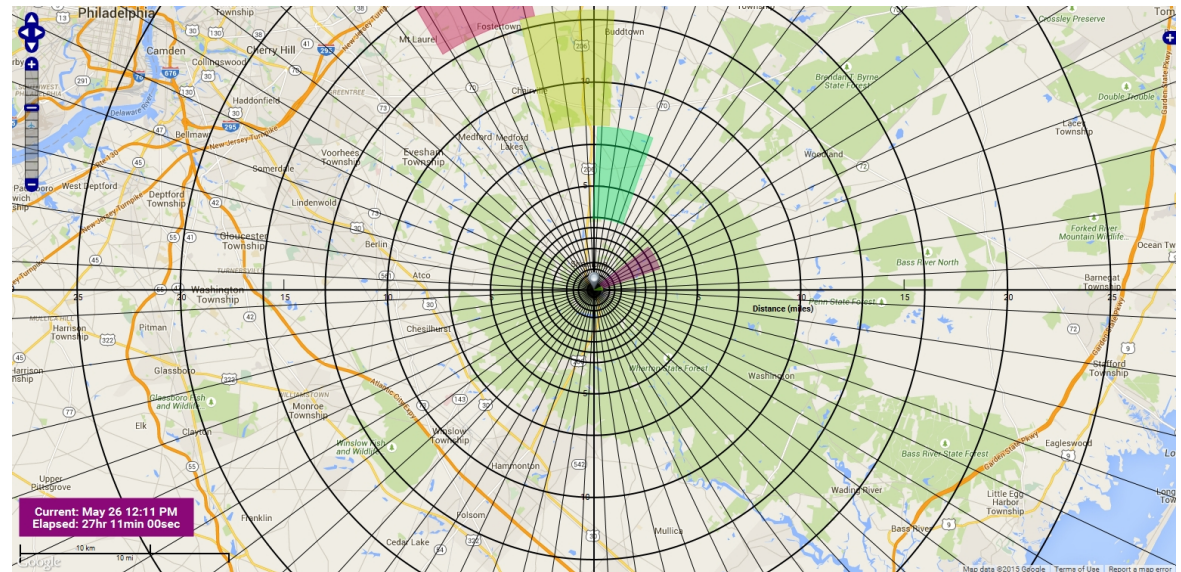
New Optional Atmospheric Transport Model (Cont'd)

- Sandia is developing an approach for integrating HYSPLIT (from NOAA) with MACCS.
- Initial implementation is complete.
- Assessment and validation are expected in 2017.

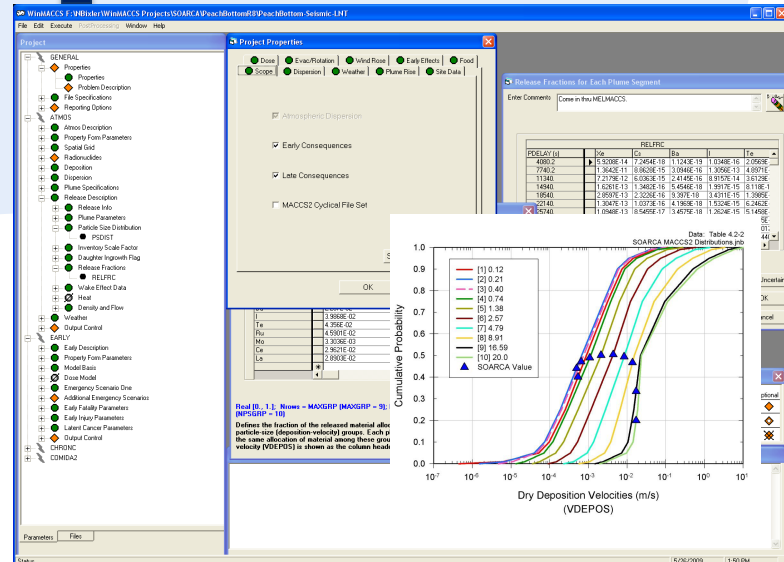
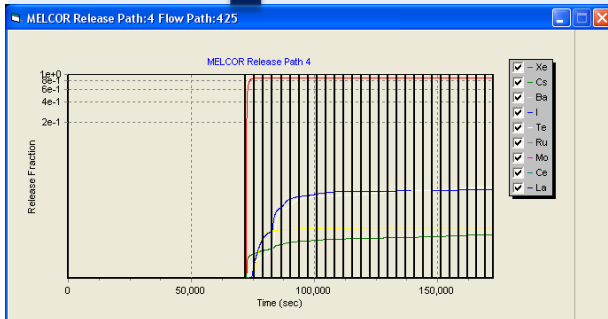
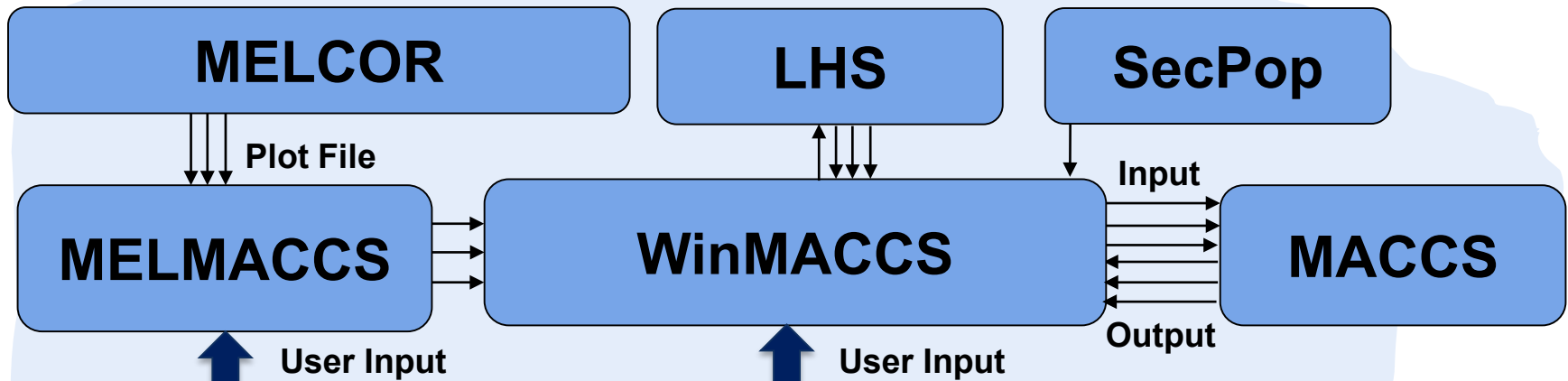


Animation of Plume Segments

- Current development
 - Animation of plume segments
- Future plans
 - Air and ground concentration isopleths
 - Dose and dose rate isopleths
 - Movement of evacuating and relocating public

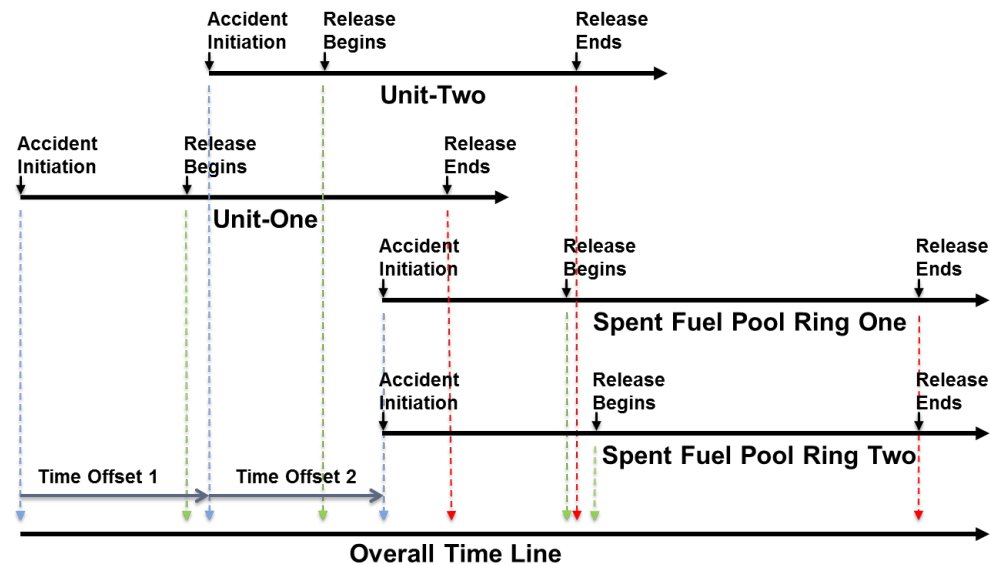
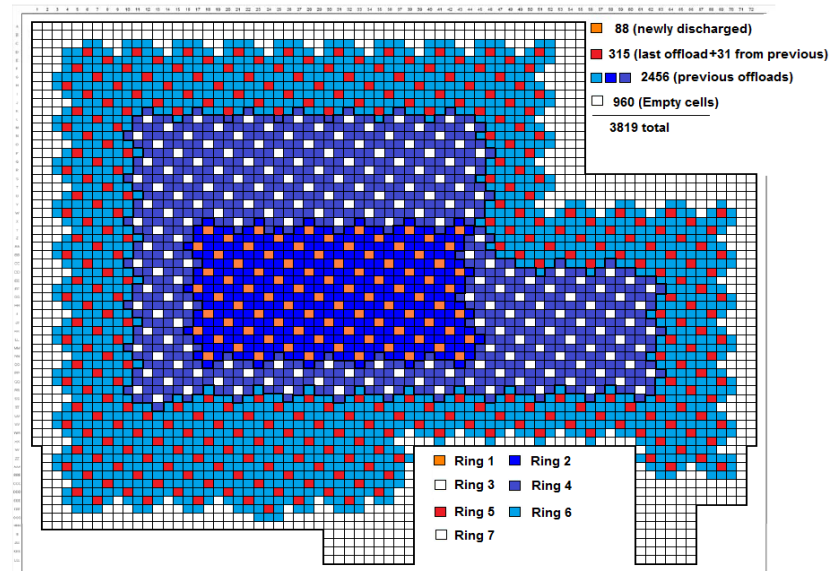


Typical WinMACCS Calculation Framework



MelMACCS Status

- MelMACCS 2.0.0 (6/2015)
 - User-definable fission product inventories
 - Support for multi-unit source terms
 - Support for multi-ring spent fuel pool source terms



MelMACCS Status (Cont'd)

- MelMACCS 2.0.1 (7/2016)
 - Fixes double counting problem associated with case variations in isotopic names
 - Provides additional information that can help diagnose inconsistent inventory inputs
- Next version of MelMACCS – under development
 - Only calculates aerosol size distribution for release paths used in calculation

SecPop Status

- SecPop 4.2.0 released (10/2013)
 - 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 (9/2014)
 - 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
- 2012 economic data file (7/2016)
- Considering new version to support international users

Summary

Recently added modeling options

- Multi-source releases
- Multiple-age fuels in spent fuel pool
- User-defined dose projection periods

Ongoing improvements are addressing

- Complete set of organs and related cancer types
- Estimation of GDP losses with optional economic model
- Alternative models for atmospheric transport and economic analysis
- Animation of plume segments

List of Acronyms

- CRAC Calculation of Reactor Accident Consequences
- MACCS MELCOR Accident Consequence Code System
- NAM North American Mesoscale Forecast System
- NISAC National Infrastructure Simulation and Analysis Center
- PRA Probabilistic Risk Assessment
- SECPOP Sector Population, Land Fraction, and Economic Estimation Program
- SOARCA State-of-the-Art Reactor Consequence Analyses