RADTRAD – Past, Present, and Future

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Objective

- The purpose is to present an overview of the development of SNAP/RADTRAD including the history, present status and future plans.

Purpose of SNAP/RADTRAD

- Purpose of SNAP/RADTRAD is to determine the dose from a release of radionuclides during a design basis accident to the following locations:
  - Exclusion Area Boundary (EAB)
  - Low Population Zone (LPZ)
  - Control Room (or Emergency Offsite Facility)

- Focus of SNAP/RADTRAD is licensing analysis to show compliance with nuclear plant siting and control room dose limits for various LOCA and non-LOCA accidents.

Background of RADTRAD

- RADTRAD initially started as a DOS application in 1997 (See NUREG/CR-6604).
- RADTRAD 3 introduced by NRC in 1999 – included Visual Basic GUI for preparing input, incorporation of the ASH solver. Became RADTRAD Version 3.01 (See NUREG/CR-6604, Supplement 1).
- NRC took over the development of RADTRAD in 2000 – 2001 time frame. Maintained a distribution and periodic maintenance program for about 12 years with ISL. RADTRAD 3.03 released in 2002 became the "official" NRC code version (See NUREG/CR-6604, Supplement 2).

Background of RADTRAD

In the meantime, Terry Heames, a key RADTRAD developer, left Sandia to work for Innovative Technology Solutions Corporation (ITSC) – later Alion Sciences.

- Continued RADTRAD development, contributing code changes and new versions to the NRC
- Formed a RADTRAD Users Group for nuclear industry participants
- Periodically releases new versions – latest version is Version 3.10 (?)
- The website for this version is www.radtrad.com. This version is independent of the NRC version.

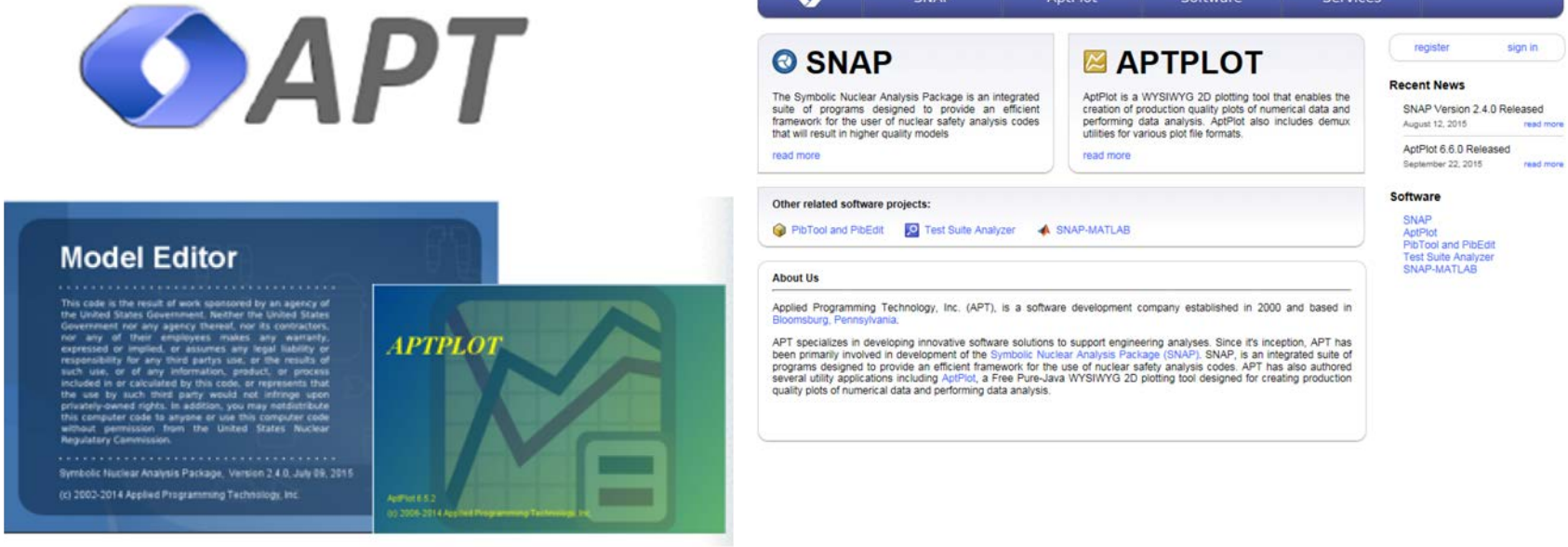
Background of SNAP/RADTAD

About 7 years ago, NRC decided to incorporate RADTRAD into the SNAP graphical user interface due to maintenance difficulties:

- RADTRAD 3.10 was translated into JAVA.
- Additional output (text based) was incorporated into SNAP/RADTRAD.
- A SNAP plugin was developed to provide GUI capability for developing RADTRAD models. Input checking incorporated.
- Initial verification and validation was done on SNAP/RADTRAD.
- RADTRAD 3.03 status change to a legacy code with distribution by Radiation Safety Information Computation Center (RSICC) (https://rsicc.ornl.gov).
- The future of RADTRAD at NRC is SNAP/RADTRAD.

Current Status

- SNAP/RADTRAD is distributed in two separate program packages:
  - SNAP with the RADTRAD plug-in – basically the graphical user interface package. The RADTRAD plug-in provides the code to allow RADTRAD-specific features to be displayed in the SNAP Model Editor. Default data used in RADTRAD also programmed into the RADTRAD plug-in code. (https://www.snaphome.com/)



Current Status

- RADTRAD-AC – the RADTRAD analytical code (AC) that performs the actual radionuclide activity levels and dose calculations.
  - Input files used by RADTRAD are exported by the Model Editor plugin. (https://www.usnrc-ramp.com/)

Current Status

- Changes made to the SNAP/RADTRAD code package since RADTRAD 3.03:
  - The original Visual Basic GUI has been replaced by the SNAP/RADTRAD Model Editor.
  - The analytical code was converted to Java.
    - Originally, the analytical code was part of the RADTRAD plugin but was later separated for code maintenance purposes.
  - The entire ICRP-38 radionuclide set has been incorporated into SNAP/RADTRAD.
    - The user can make changes to the radionuclide library through the Model Editor, but usually not necessary.

Current Status

- Changes made to the SNAP/RADTRAD code package since RADTRAD 3.03 (continued):
  - The ICRP-30 dose conversion factor library tabulated in the Federal Guidance Report No. 11 and No.12 published by the U.S. Environmental Protection Agency (EPA) has been incorporated into SNAP/RADTRAD.
    - User can specify DCFs if desired.
  - The ability to model non-LOCA accidents has been made easier:
    - Source term models for fuel handing accidents, rod ejection or control rod drop accidents have been added.
    - Models for determining the reactor coolant inventory activity have been added so that tube ruptures and other reactor coolant related accidents can be modeled. Pre- and Co-incident iodine spiking can be modeled.

Current Status

- Changes made to the SNAP/RADTRAD code package since RADTRAD 3.03 (continued):
  - Multiple source terms can be analyzed
  - Multiple release pathways can be analyzed
  - Plotting of results through APTPlot available
  - Other SNAP features (Ex. multiple problems, parameter variation, model comparison) are available.
- Removal models (natural deposition, sprays, filters) are generally unchanged from RADTRAD 3.03.

Testing Approach

- Testing was done on SNAP/RADTRAD by developing problem sets and running them with SNAP/RADTRAD. Then, a mathematical model of the same problem was programmed into Mathcad and the results compared.
  - Mathcad Version 14 used.
  - Generally relied on the AdamsBDF solver, but also used Runge-Kutta and Radan solvers.
  - Interfaces with spreadsheets for problem input, radionuclide data and dose conversion factors used.
  - Comparisons made in terms of relative error. Calculations of maximum, minimum, averages of the error along with plots and results inspections used to judge the fidelity of the results.

Testing Approach

- Over 60 RADTRAD problems tested. Scope of testing includes:
  - Inter-compartmental Transfer
  - Production Processes – TID-14844 and NUREG-1465 release models, ICRP-38 DCFs with corresponding FGR11&12 DCFs
  - Decay – with and without daughters, release delay
  - Removal within a compartment – aerosols (user-specified removal rates, Henry's model, Power's model)
  - Removal within a compartment – elemental iodine (user-specified removal rates, Power's model)
  - Removal Processes – Flow Pathways – filters, piping (user-specified removal coefficients, Brockman/Bixler model)

Testing Approach

- Over 60 RADTRAD problems tested. Scope of testing includes:
  - Control Room – intake/exhaust from environment, internal recirculation with filtration, flow pathway filtration
  - Multiple source terms, multiple compartment pathways
  - Various source term models – fuel handling accident, steam generator tube rupture, tritium release, rod ejection/control rod drop accident

Test Results

- Error Results for the Exclusion Area Boundary Based on Dose Results

	Error Range (%)			
	EAB		EAB	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	9.35	1.24E-03	12.91	1.56E-03
Min Error Range(%)	1.61	8.38E-06	2.89	1.03E-06

- Error Results for the Low Population Zone Based on Dose Results

	Error Range (%)			
	LPZ		LPZ	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	9.35	3.34E-03	16.10	3.17E-03
Min Error Range (%)	1.64	7.87E-06	2.75	2.53E-06

Test Results

- Error Results for the Control Room Based on Dose Results

	Error Range (%)			
	CR		CR	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	9.90	6.58E-01	8.70	6.31E-01
Min Error Range (%)	0.86	1.17E-05	0.87	7.39E-05

Test Results

- Overall Averages based on Dose Results Comparisons:

	Average of Averages (%)	
	EAB	EAB
	Thyroid	TEDE
Avg Error (%)	0.44	0.92
	LPZ	LPZ
	Thyroid	TEDE
Avg Error (%)	0.47	0.85
	CR	CR
	Thyroid	TEDE
Avg Error (%)	0.58	0.72

Future Plans

- Continue to resolve issues raised by users.
- Features that may be incorporated into future versions:
  - Better specification of input for problems involving reactor coolant
    - Currently volume units are used (ft3, ft3/min). Works because f/V (1/hr) is the key parameter.
    - Mass units would be more convenient
    - Make the use of user-specified RCS activities more apparent
  - Update to current standards:
    - Ex: ANS/18.1 for the specification of RCS coolant activity was recently reactiviated.
    - Standards should be consistent across codes used in RAMP (ex. GALE).

Future Plans

- Features that may be incorporated into future versions:
  - New dose conversion factors
    - NRC is proceeding with an analysis of the impact of the ICRP 103 dose conversion factors on plant dose limits.
  - Further testing with real problems including more comprehensive testing of daughter nuclides.
  - Improve performance of adaptive time stepping algorithm
  - Update the Mathcad files to the current version of Mathcad
    - Currently Mathcad V14 is used
  - Integrate the original and NRC output files
  - Automatic interface with other RAMP codes possibly using spreadsheets generated as part of the output.