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 SNAP/RADTAD

About 10 years ago, NRC decided to incorporate RADTRAD into the SNAP graphical user interface due to maintenance difficulties:

- RADTRAD 3.10 was translated into JAVA from Fortran.
- Additional output (text based) was incorporated into SNAP/RADTRAD.
- The original Visual Basic GUI was converted to a SNAP plugin to provide GUI capability for developing RADTRAD models. Input checking was 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](https://rsicc.ornl.gov)).
Background of SNAP/RADTAD

SNAP/RADTRAD is currently being used both domestically at the NRC and at licensee organizations as well as internationally.

• SNAP/RADTRAD is available to any organization that is a member of RAMP.
  • Membership privileges include access to the latest code executables, documentation on the use of the code and test reports.
• SNAP/RADTRAD training was provided in 2014 through 2018 either at the NRC or internationally (South Africa, Taiwan, UAE)
• NRC is continuing development and maintenance of both the SNAP GUI and the RADTRAD code.
SNAP/RADTRAD is distributed in separate program packages:

- SNAP with the RADTRAD plug-in – basically the graphical user interface package. Maintained by Applied Programming Technology, Inc.
  - 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 is also programmed into the RADTRAD plug-in code.

- RADTRAD-AC – the RADTRAD analytical code (AC) that performs the actual radionuclide concentrations and dose calculations. Maintained by ISL, Inc.
  - Input files used by RADTRAD are exported by the Model Editor plugin.

- APTPlot – a plotting package that permits the user to plot dose results. Maintained by Applied Programming Technology, Inc.
Other Changes made to the SNAP/RADTRAD code package:

• 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.
• 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 through the SNAP interface.
Current Status

• 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 based on guidance in NRC Regulatory Guide 1.183.
  
  • 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-incident and co-incident iodine spiking can be modeled.
Current Status

• Other features in the SNAP/RADTRAD code package:
  • 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 earlier RADTRAD versions (V3.03).
SNAP/RADTRAD Model Editor

- SNAP/RADTRAD input specification revolves around the use of the SNAP Model Editor
  - Up-to-date input specification with drag and drop interface
  - Good input error checking features
- Model Editor presents a standard interface across a large number of NRC codes.
  - Codes include TRACE and MELCOR, SCALE among others
SNAP/RADTRAD Model Editor (Test 23)
SNAP/RADTRAD Model Editor (Test 23)
SNAP/RADTRAD Model Editor (Test 23)

Current Model
Categories
Connections
Compartments
Pathways
Component Navigator Window
Job Streams
2D Views
SNAP/RADTRAD Model Editor (Test 23)

General Model Options
SNAP/RADTRAD Model Editor (Test 23)

Flow Pathway Input
SNAP/RADTRAD Model Editor (Test 23)

- The user can also add a new file clicking on the Add New File.

**Nuclide Editing Icons**
- Delete Nuclide
- Import Nuclide File
- Export Nuclide File
- Add Nuclide
- Move Nuclide Up/Down in List

**File Editing Icons**
- Add New File
- Delete Existing File
- Copy Existing File
- Open RCS Activity Calculator
SNAP/RADTRAD Model Editor (Test 23)

Nuclide Input

Source Location and Chemical Form Input
SNAP/RADTRAD Model Editor (Test 23)

X/Q Input
SNAP/RADTRAD Model Editor (Test 23)
SNAP/RADTRAD Testing

• 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 in Mathcad.
  • 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.
SNAP/RADTRAD Testing

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)
SNAP/RADTRAD Testing

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
## SNAP/RADTRAD Testing

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

<table>
<thead>
<tr>
<th>Error Range (%)</th>
<th>EAB</th>
<th>EAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Max Error (%)</td>
<td>3.59</td>
<td>1.24E-03</td>
</tr>
<tr>
<td>Min Error (%)</td>
<td>1.78</td>
<td>8.38E-06</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Error Range (%)</th>
<th>LPZ</th>
<th>LPZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Max Error Range (%)</td>
<td>5.38</td>
<td>3.34E-03</td>
</tr>
<tr>
<td>Min Error Range (%)</td>
<td>1.78</td>
<td>1.70E-06</td>
</tr>
</tbody>
</table>
SNAP/RADTRAD Testing

- Error Results for the Control Room Based on Dose Results

<table>
<thead>
<tr>
<th>Error Range (%)</th>
<th>Control Room</th>
<th>Control Room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thyroid</td>
<td>TEDE</td>
</tr>
<tr>
<td>Max</td>
<td>9.95</td>
<td>13.75</td>
</tr>
<tr>
<td>Min</td>
<td>2.92E-05</td>
<td>2.92E-05</td>
</tr>
<tr>
<td>Max Error Range (%)</td>
<td>2.64E-01</td>
<td>3.20E-01</td>
</tr>
<tr>
<td>Min Error Range (%)</td>
<td>1.03</td>
<td>2.92E-05</td>
</tr>
</tbody>
</table>
### SNAP/RADTRAD Testing

- Overall Averages based on Dose Results Comparisons:

<table>
<thead>
<tr>
<th></th>
<th>Average of Averages (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EAB</td>
</tr>
<tr>
<td>Thyroid</td>
<td>EAB</td>
</tr>
<tr>
<td>Avg Error (%)</td>
<td>0.41</td>
</tr>
</tbody>
</table>

|          | LPZ                     |
| Thyroid  | LPZ                     |
| Avg Error (%) | 0.42 | 0.49 |

|          | CR                      |
| Thyroid  | CR                      |
| Avg Error (%) | 0.49 | 0.49 |
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 reactivated.
    • Standards should be consistent across codes used in RAMP (ex. GALE).
Future Plans

- Features that may be incorporated into future versions:
  - Updated dose conversion factors possibly based on ICRP 103
  - Improve performance of adaptive time stepping algorithm
  - Integrate the original and NRC output files
  - Automatic interface with other RAMP codes possibly using spreadsheets generated as part of the output.