NRC-RADTRAN

RAMP 2020 Fall Users Group Virtual Meeting

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NRC-RADTRAN Presentation Overview

- Introduction to RADTRAN
- Overview of recent RADTRAN updates
- Introduction to new NRC-RADTRAN GUI
  - Example 1: Installation & simple incident-free transport scenario
  - Example 2: Basic accident scenario for medical isotope transport
  - Example 3: Realistic spent fuel transport with WebTRAGIS route
  - Possibilities for future development
- Selected RADTRAN modeling topics
- User Q&A

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Introduction to RADTRAN

- Risks and consequences assessment for transport of radioactive material
- Developed at Sandia National Laboratories starting with NUREG-0170 (1977)
  - RADTRAN 6.02 (last public version with full documentation) released 2014
- User provides input file describing:
  - Vehicle(s) used—road, rail, and water
  - Route to be traveled (links) and stops along the way
  - Type, quantity, and properties of radioactive materials
- RADTRAN calculates:
  - Consequences for each link and stop
  - Accident probabilities for each link
  - Uncertainties

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Introduction to RADTRAN:
Analysis Types

- Two types of risk calculation
  - Routine, incident-free transportation
    - Radioactive material package stays intact
    - Exposure to radiation from the surface of the vehicle can affect crew, handlers, and the public
    - Deterministic
  - Accident
    - Radioactive material may be released in a crash and disperse into the environment
    - Probabilistic (probability and consequences)
- Inputs for these two types are mostly separate
  - Certain route info is used for both

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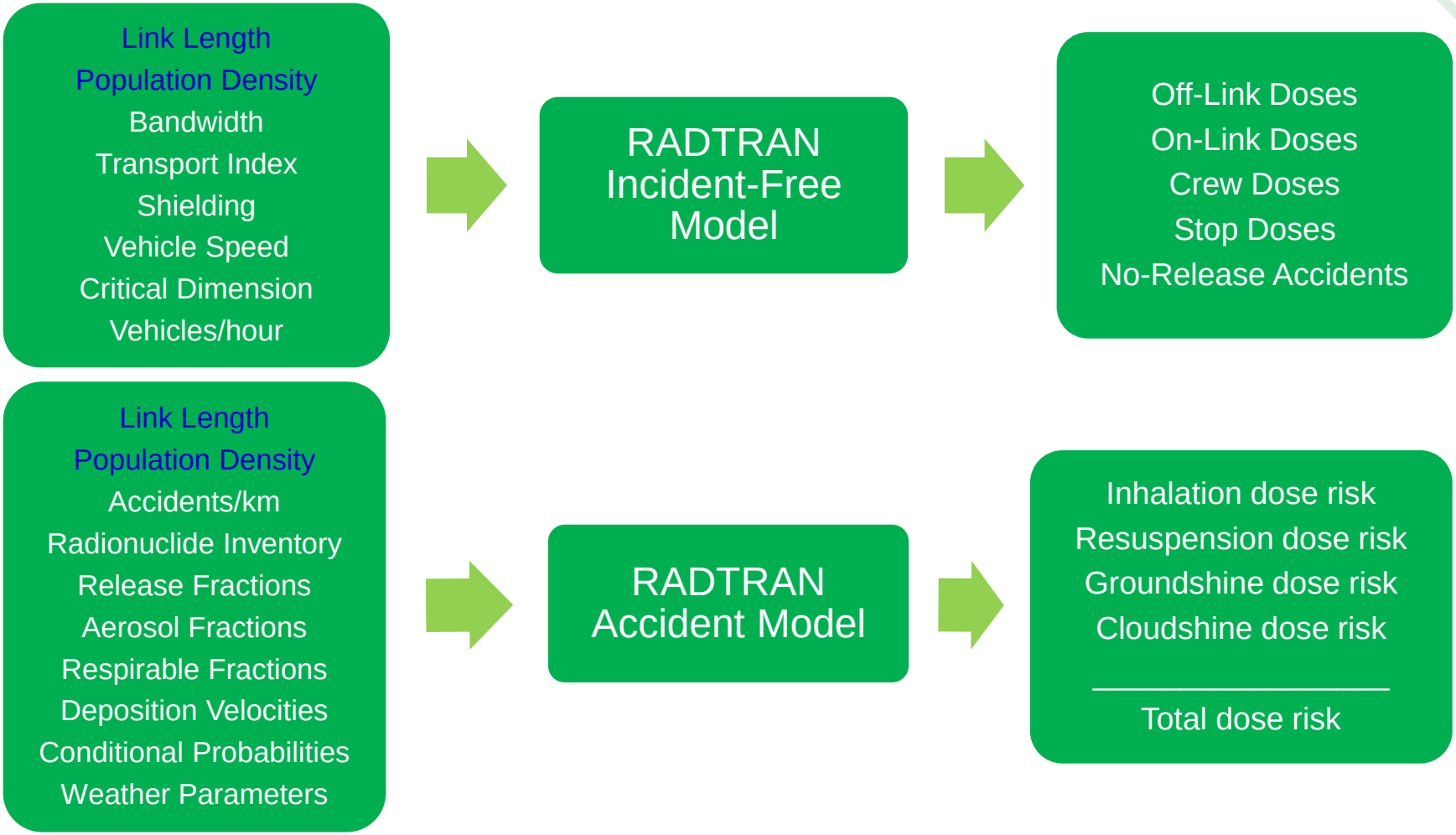
Introduction to RADTRAN

Inputs and Outputs by Analysis Type



Recent RADTRAN Updates

- Goals:
  - Make a modern, NRC-maintained version of RADTRAN available to the public
  - Develop a new, user-friendly interface and corresponding documentation
- Development by Energy Research, Inc (ERI) on behalf of NRC
  - No longer associated with Sandia or DoE
- Acknowledgments:
  - Ruth Weiner
  - Daniel Hinojosa (RadCat developer)
  - NRC Staff

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Recent RADTRAN Updates

- RADTRAN code changes (version 6.02.1)
  - Time restrictions removed
  - Output size 4 is no longer available
    - Obsolete, but some 6.02 executables still allowed it
  - No modeling changes
    - Calculation methods are identical to previously released RADTRAN 6.02
- NRC-RADTRAN Graphical User Interface (GUI)
  - Primary focus of the new development efforts
  - Windows application for creating/editing RADTRAN input files, running RADTRAN, and viewing output
- NRC-RADTRAN 1.0 available soon on RAMP

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Resources

NRC-RADTRAN Help Email: NRCRADTRAN_Help.Resource@nrc.gov

"**NRC-RADTRAN 1.0 Quick Start User's Guide**," E. Ball and M. Zavisca, ERI/NRC 20-208, 2020 (included with NRC-RADTRAN).

"**RADTRAN 6 Technical Manual**," R. Weiner et. al, SAND2014-0780, 2014. (RAMP website).

"**RADTRAN 6/RadCat 6 User Guide**," R. Weiner et. al, SAND2013-8095, 2013. (RAMP website).

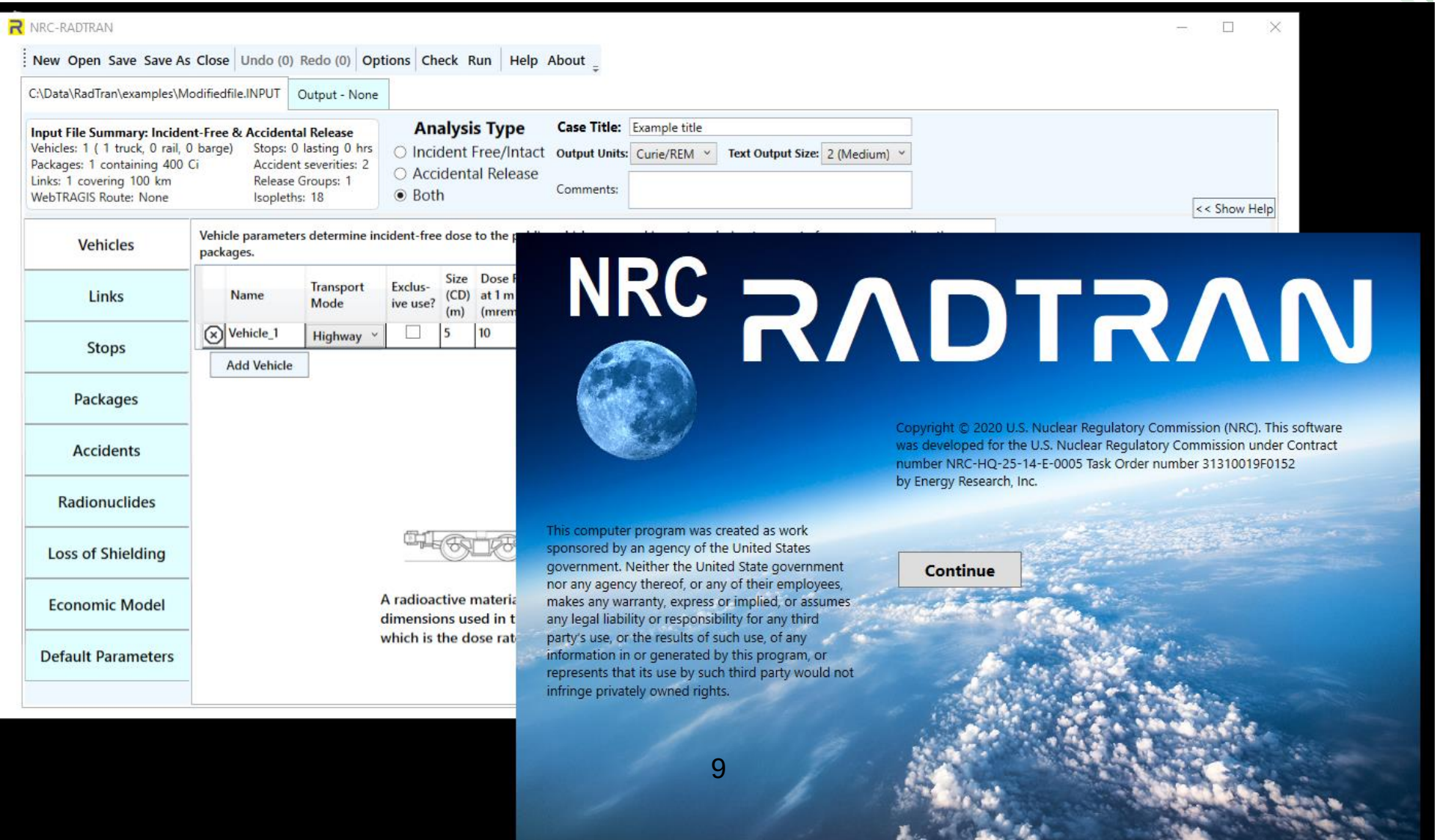
"Spent Fuel Transportation Risk Assessment," U.S. Nuclear Regulatory Commission, NUREG-2125, January 2014. (RAMP website).

"WebTRAGIS: Transportation Routing Analysis Geographic System User's Guide," S. Peterson, ORNL/TM-2018/856, 2018. (RAMP website).

"An Economic Model for RADTRAN," D. Osborn et. al, SAND2007-7120, 2007 (included with NRC-RADTRAN).

"Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," U.S. Nuclear Regulatory Commission, NUREG-0170, December 1977. (NRC website).

Intro to NRC-RADTRAN GUI



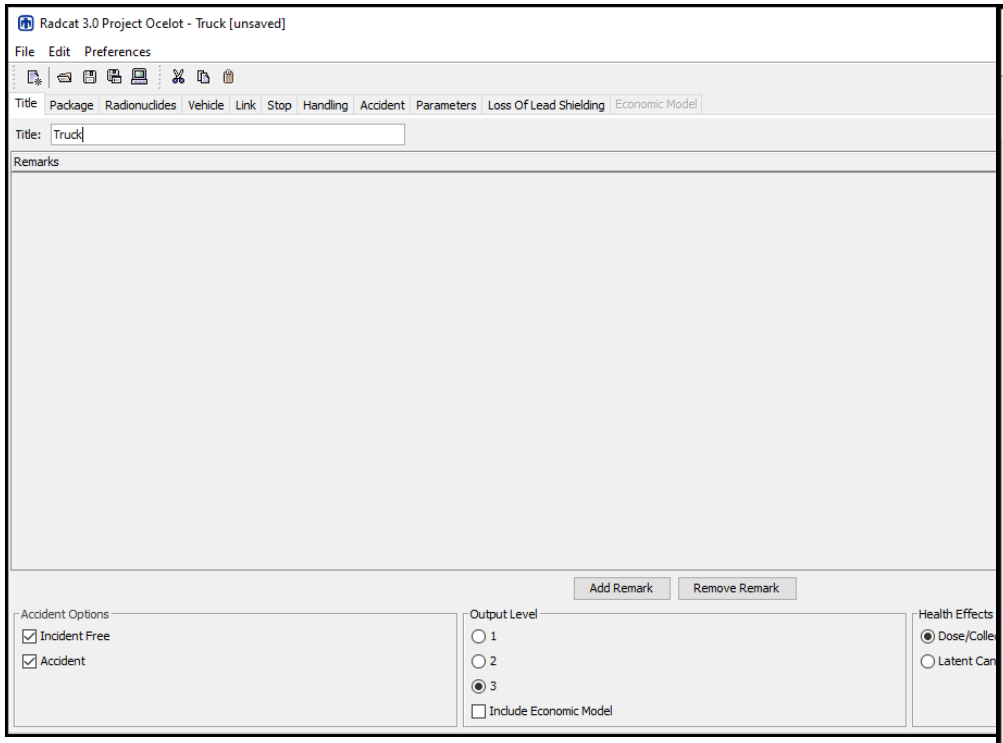
Intro to NRC-RADTRAN GUI

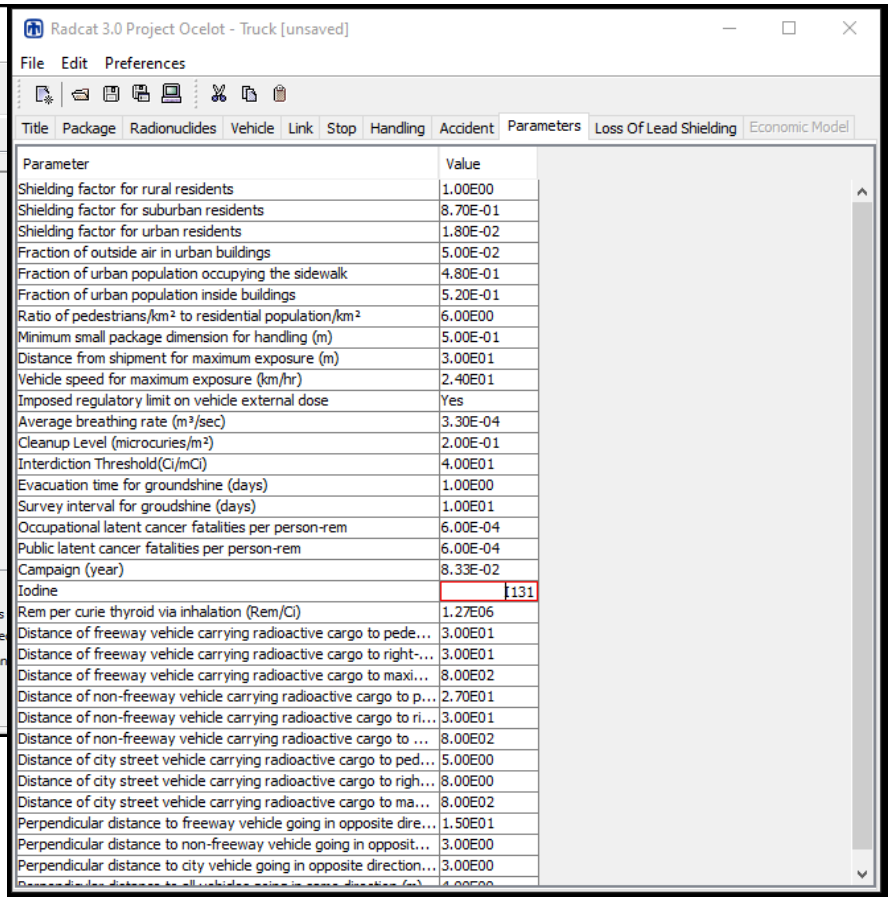
- Using RADTRAN 6.02.1 separately is unnecessary
  - All RADTRAN features are accessible through the GUI
- User interface philosophy
  - Self-explanatory controls (labels, tooltips, error and warning messages)
  - Program guides the user to appropriate sections of the documentation (double-click labels to navigate help)
- Consists of two functional components
  - Backend for reading and writing RADTRAN input/output text files
  - Graphical input file editor and output viewer
- Written in C# with Windows Presentation Foundation (WPF)

Intro to NRC-RADTRAN GUI

Replacing RadCat

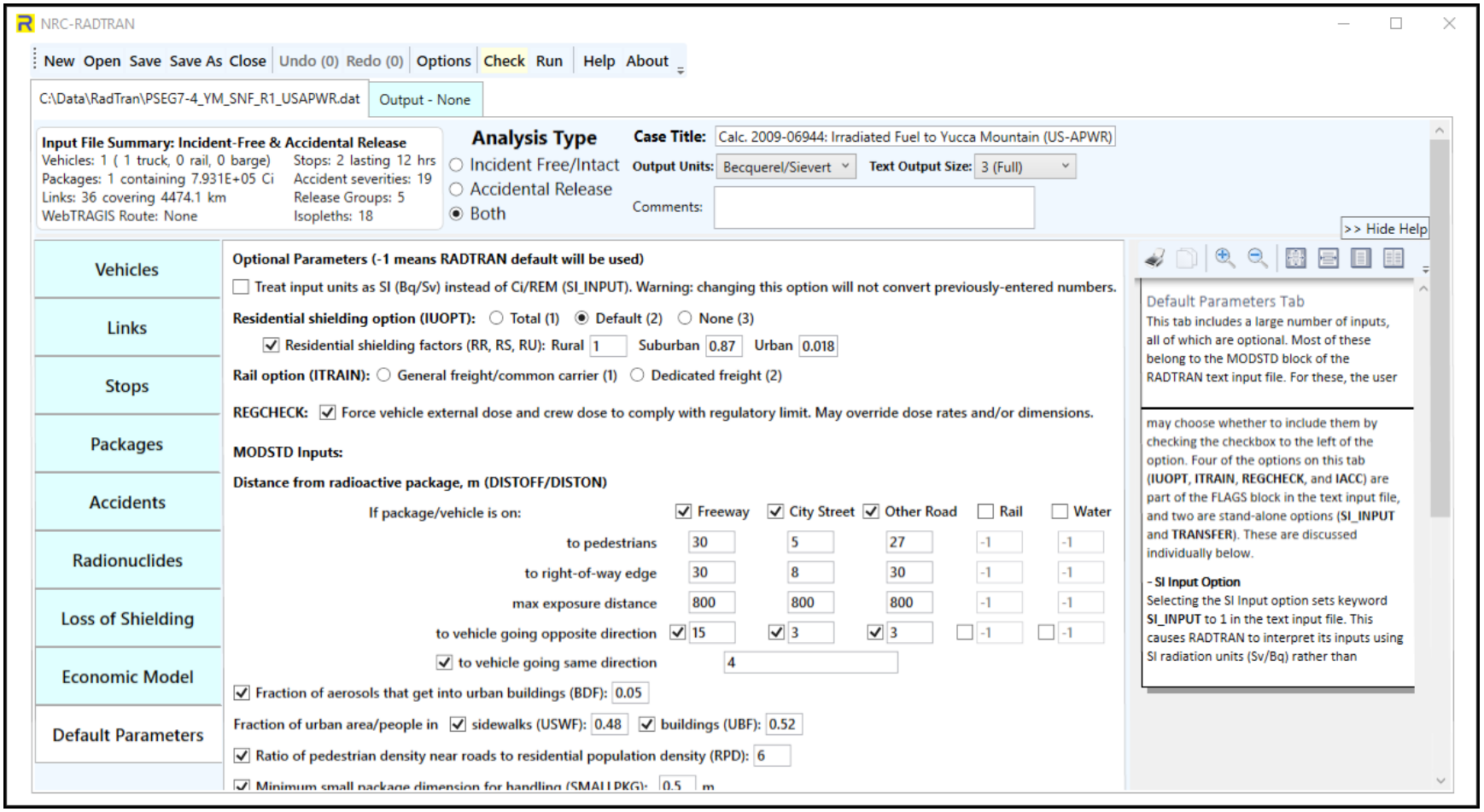
- RadCat (previous RADTRAN GUI) will not be maintained or released in the future





Intro to NRC-RADTRAN GUI

- New GUI is a native Windows application
  - Runs on Windows 7 and 10 (no Java required)



Example 1: Installation and simple incident-free scenario

- NRC-RADTRAN features to cover:
  - Overview of interface
    - Toolbar (open/save/close, undo/redo, run)
    - Summary pane
    - Analysis type
    - Title and comments fields
  - Error checking function
  - Running a new (empty) file
  - Input echo viewer and output viewer
  - Manual entry of vehicles and links
    - Basic meaning of vehicle and link input fields
  - Integrated help viewer

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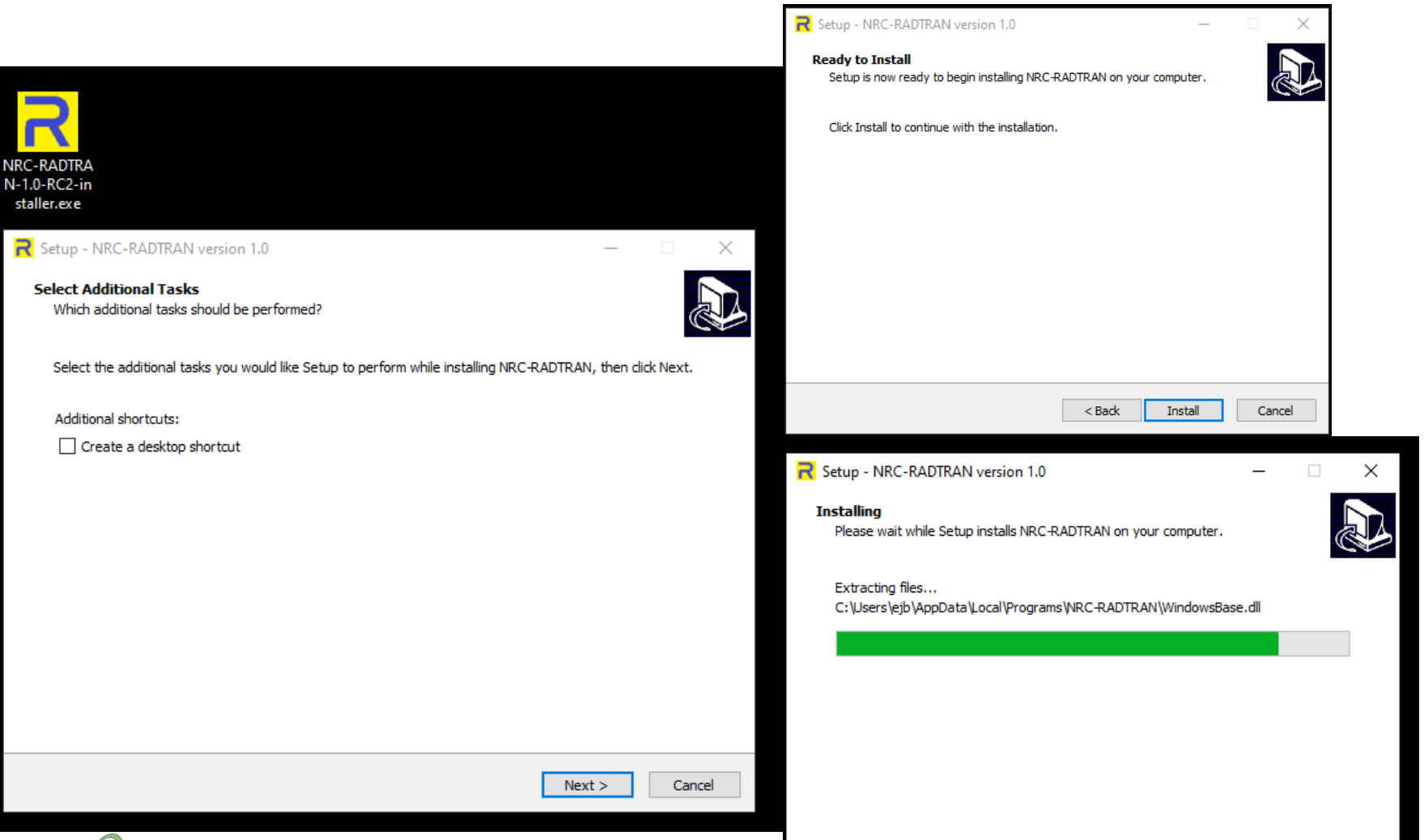
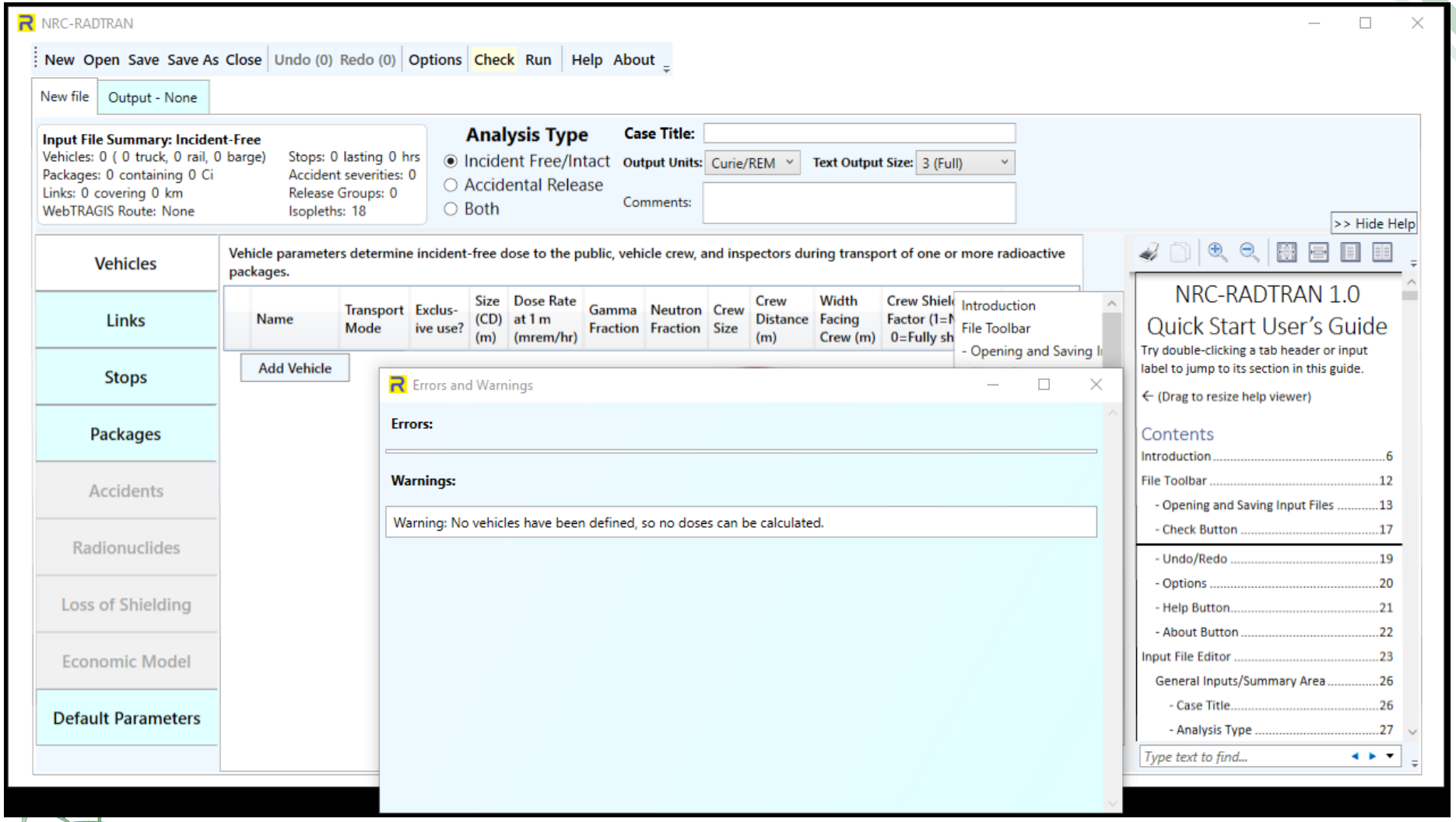
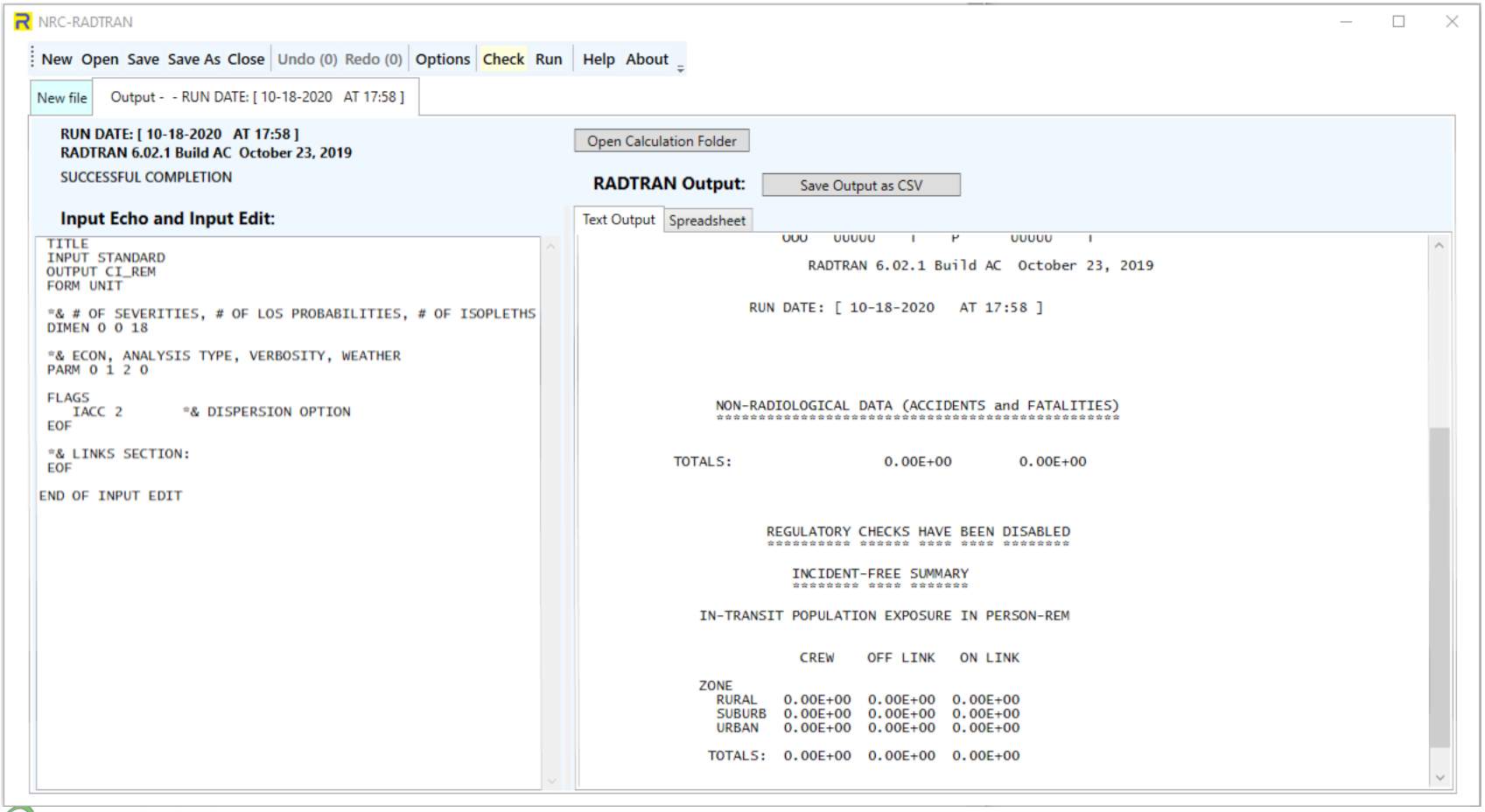
Example 1: Installation



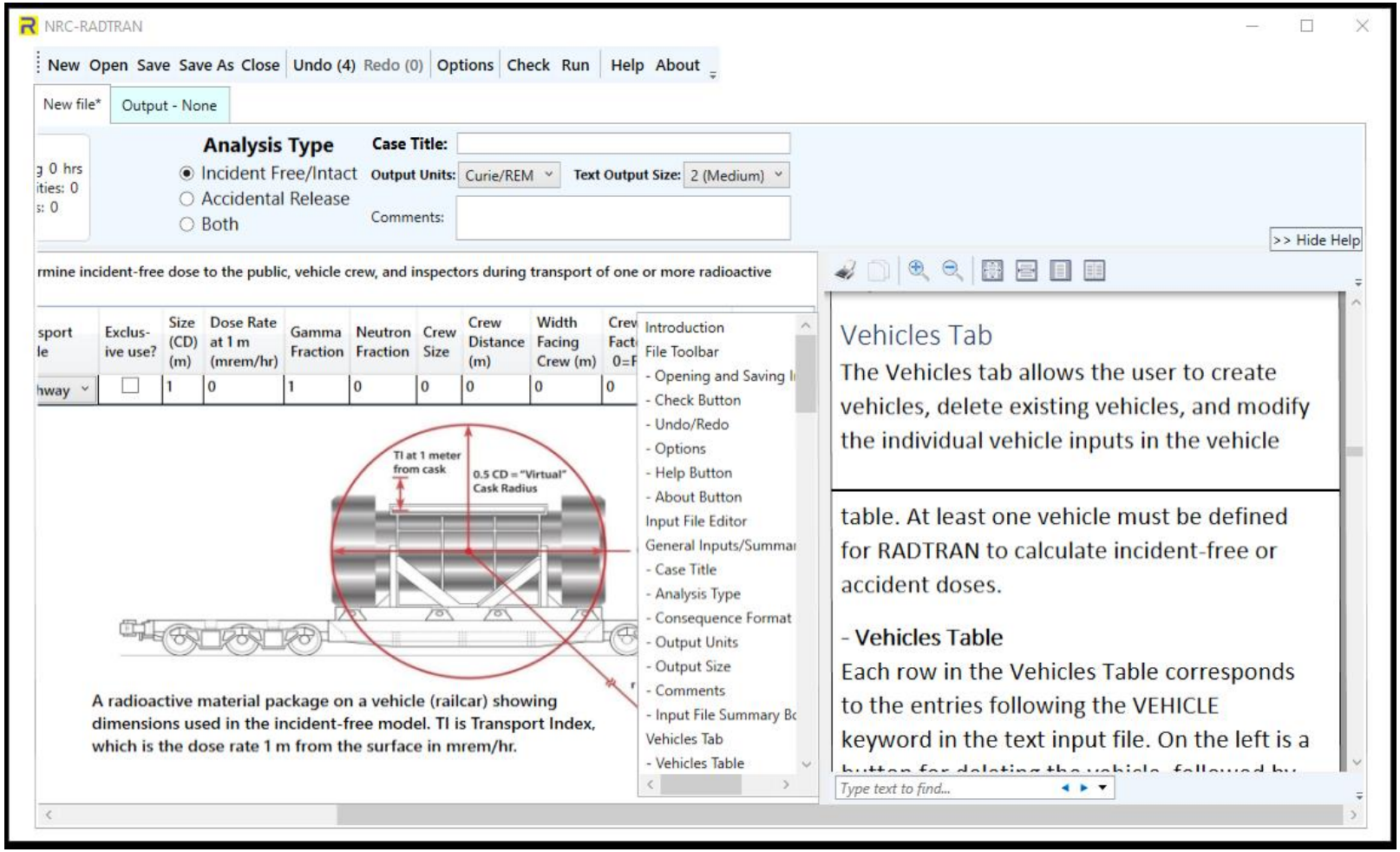
Example 1: Interface basics



Example 1: Blank output



Example 1: Integrated Help Viewer



Example 1: Vehicle Input

NRC-RADTRAN

New Open Save Save As Close | Undo (10) Redo (0) | Options | Check Run | Help About

New file* | Output - - RUN DATE: [10-18-2020 AT 17:58]

Input File Summary: Incident-Free
Vehicles: 1 (0 truck, 1 rail, 0 barge)
Packages: 0 containing 0 Ci
Links: 0 covering 0 km
WebTRAGIS Route: None
Stops: 0 lasting 0 hrs
Accident severities: 0
Release Groups: 0
Isopleths: 18

Analysis Type
(•) Incident Free/Intact
( ) Accidental Release
( ) Both

Case Title:
Output Units: Curie/REM
Text Output Size: 2 (Medium)
Comments:

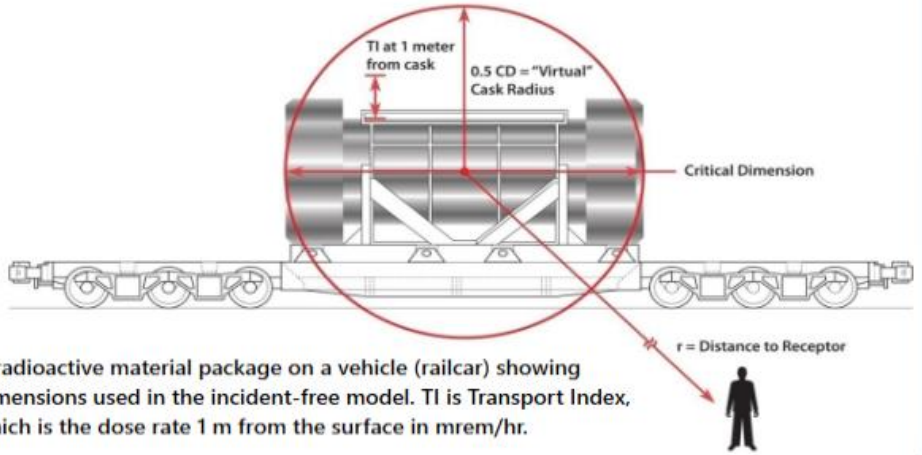
<< Show Help

Vehicles
Links
Stops
Packages
Accidents
Radionuclides
Loss of Shielding
Economic Model
Default Parameters

Vehicle parameters determine incident-free dose to the public, vehicle crew, and inspectors during transport of one or more radioactive packages.

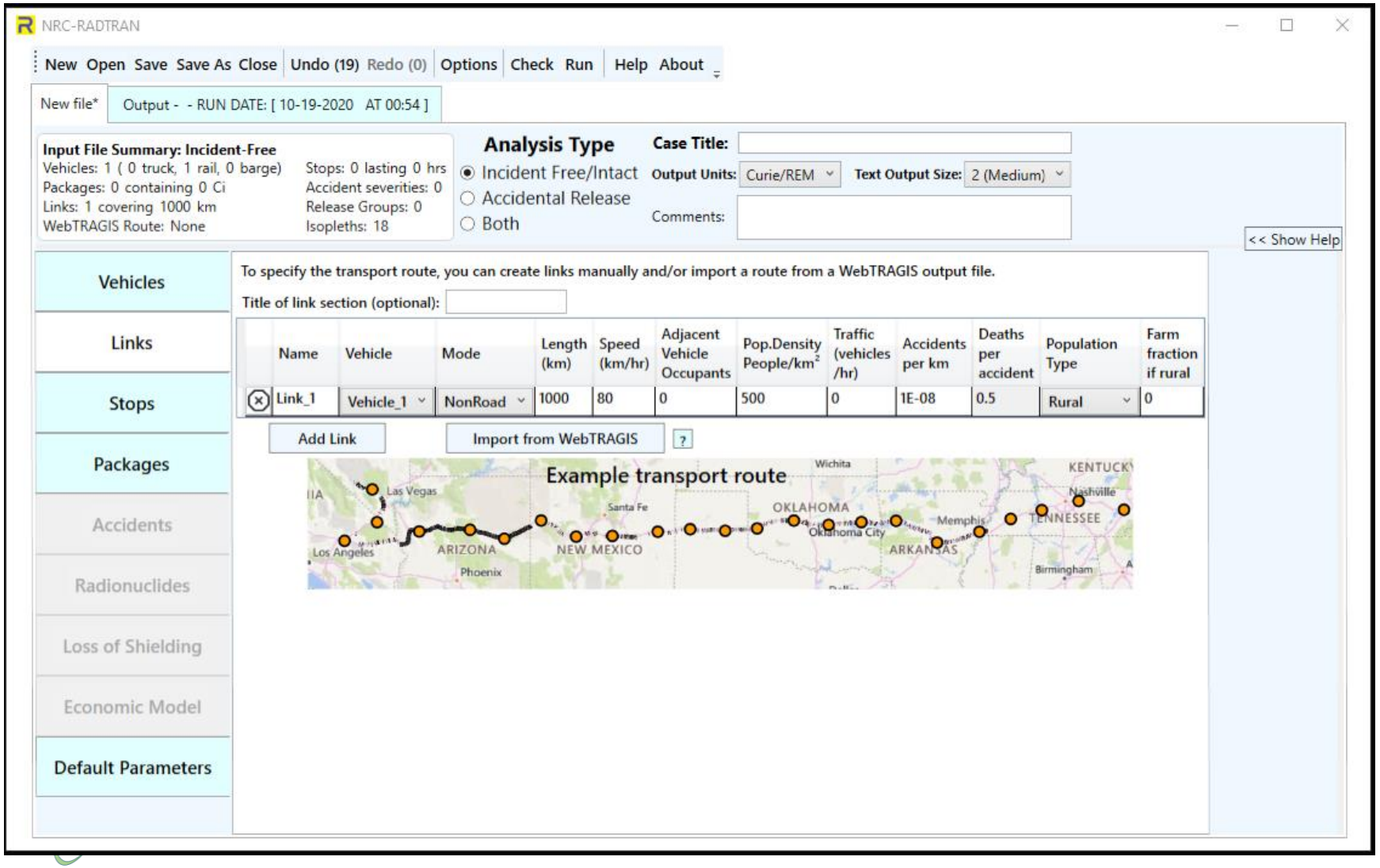
	Name	Transport Mode	Exclusive use?	Size (CD) (m)	Dose Rate at 1 m (mrem/hr)	Gamma Fraction	Neutron Fraction	Crew Size	Crew Distance (m)	Width Facing Crew (m)	Crew Shielding Factor (1=None, 0=Fully shielded)	Number of Shipments
⊗	Vehicle_1	Rail	☑	5	13	1	0	5	30	2	0.2	1

Add Vehicle

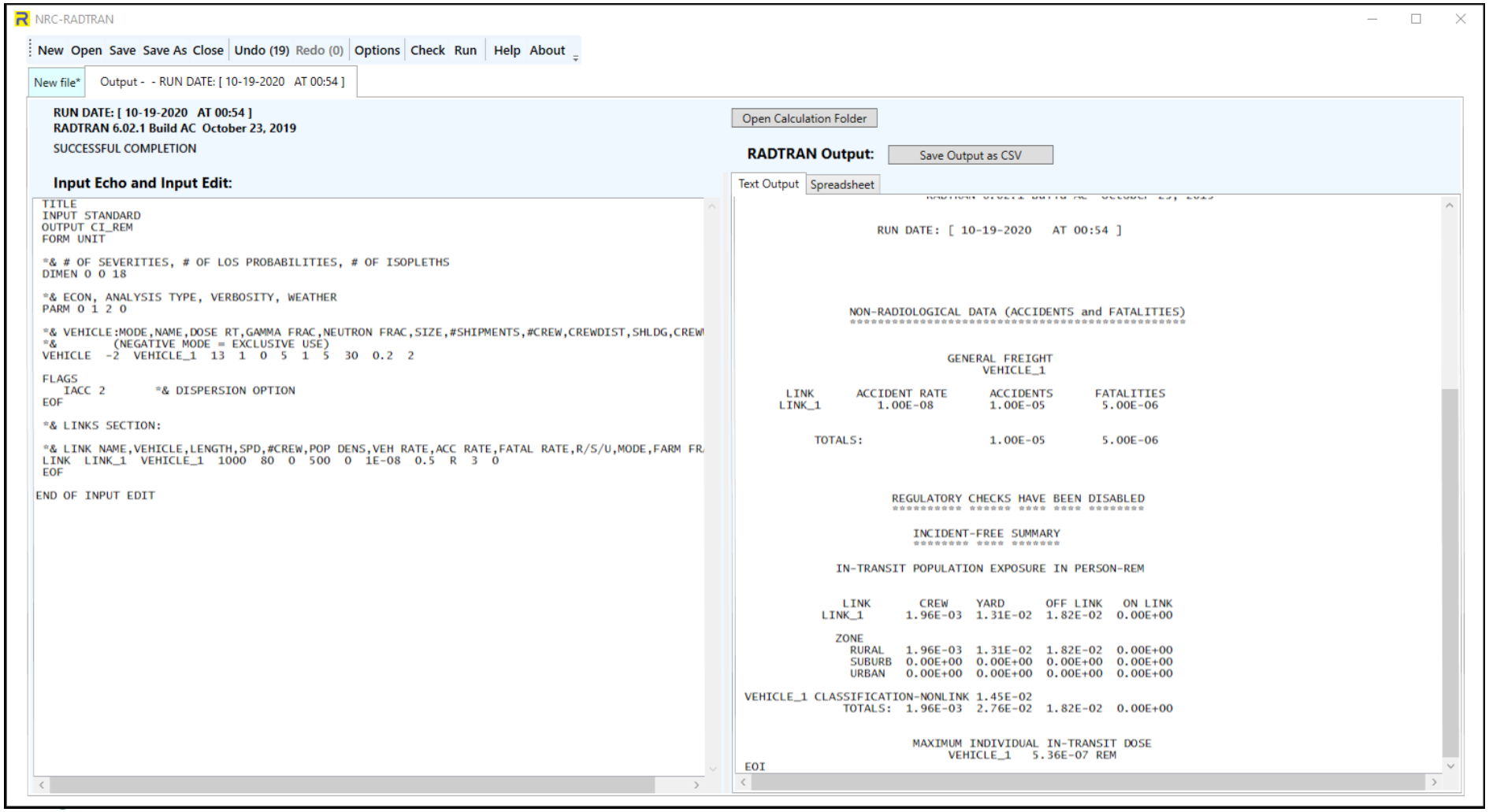


A radioactive material package on a vehicle (railcar) showing dimensions used in the incident-free model. TI is Transport Index, which is the dose rate 1 m from the surface in mrem/hr.

Example 1: Link Input



Example 1: Incident-Free Output



Example 2: Basic accident scenario (medical isotope transport)

- NRC-RADTRAN features to cover:
  - Accident severity levels
  - Release groups
  - Adding package radionuclides
  - Saving output as a CSV
  - Structure and naming of the calculation folder
  - Overview of the Options tab
    - Display settings
    - Auxiliary input and output files
    - Legacy input options
- Questions?

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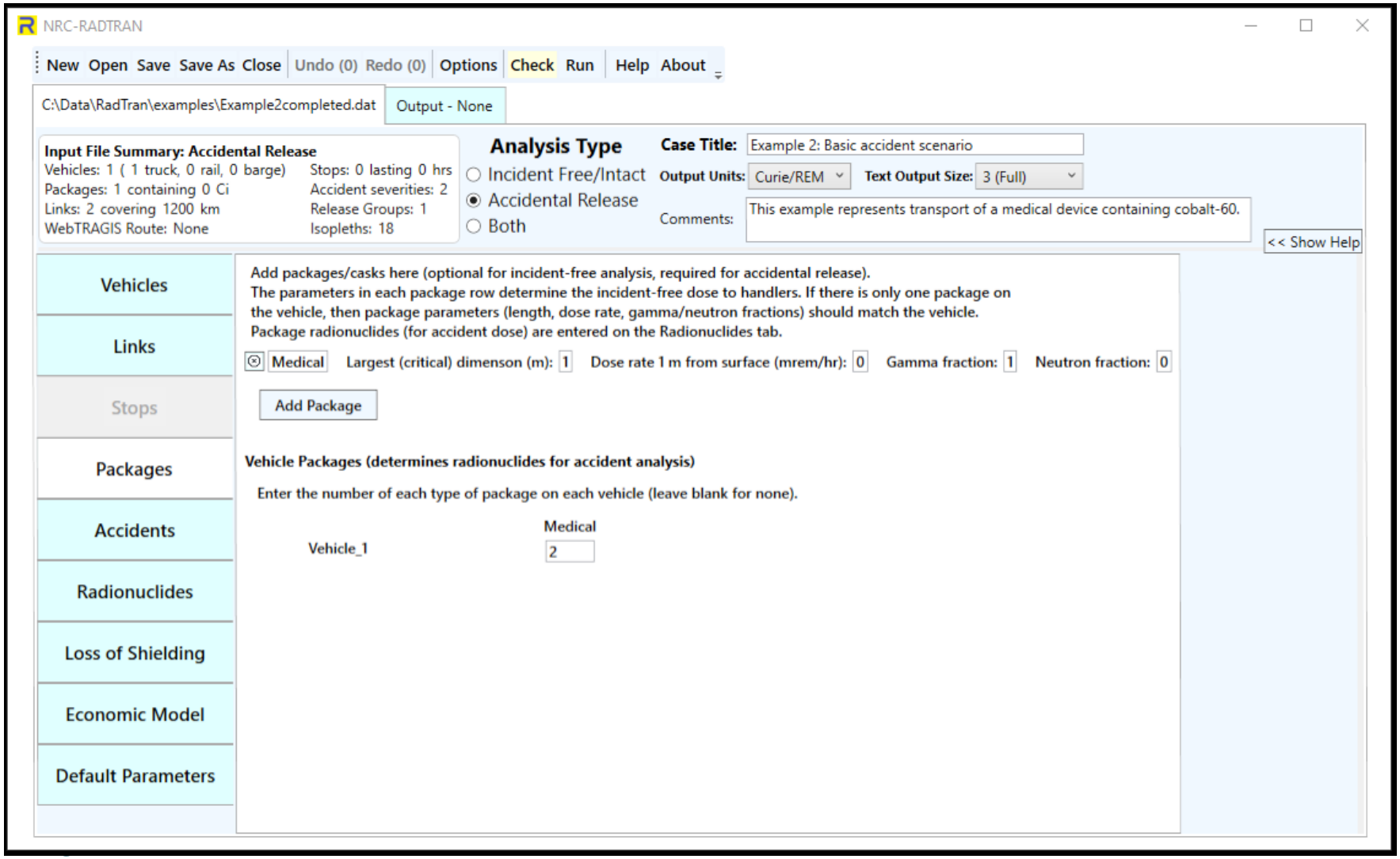
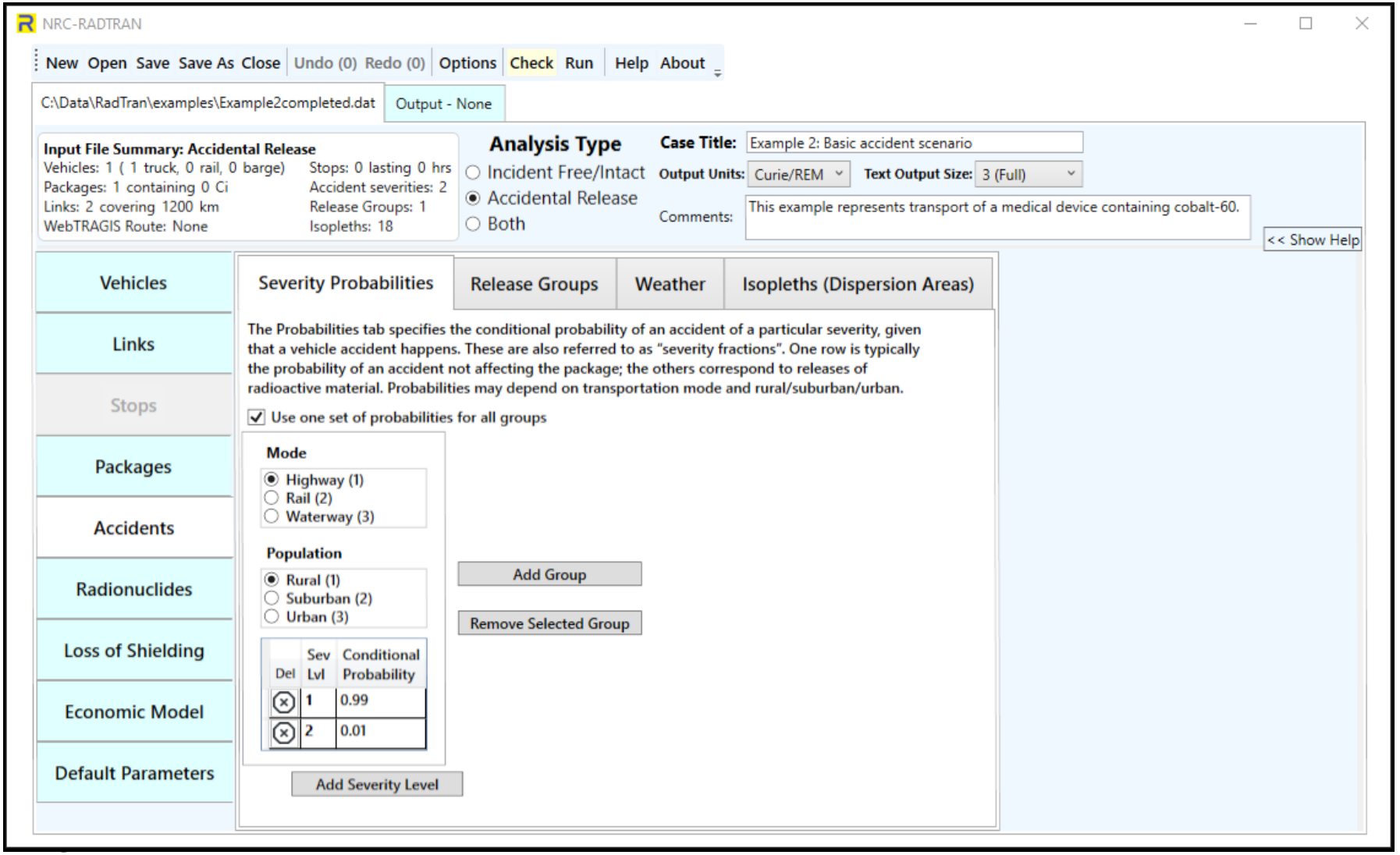
Example 2: Open from file browser

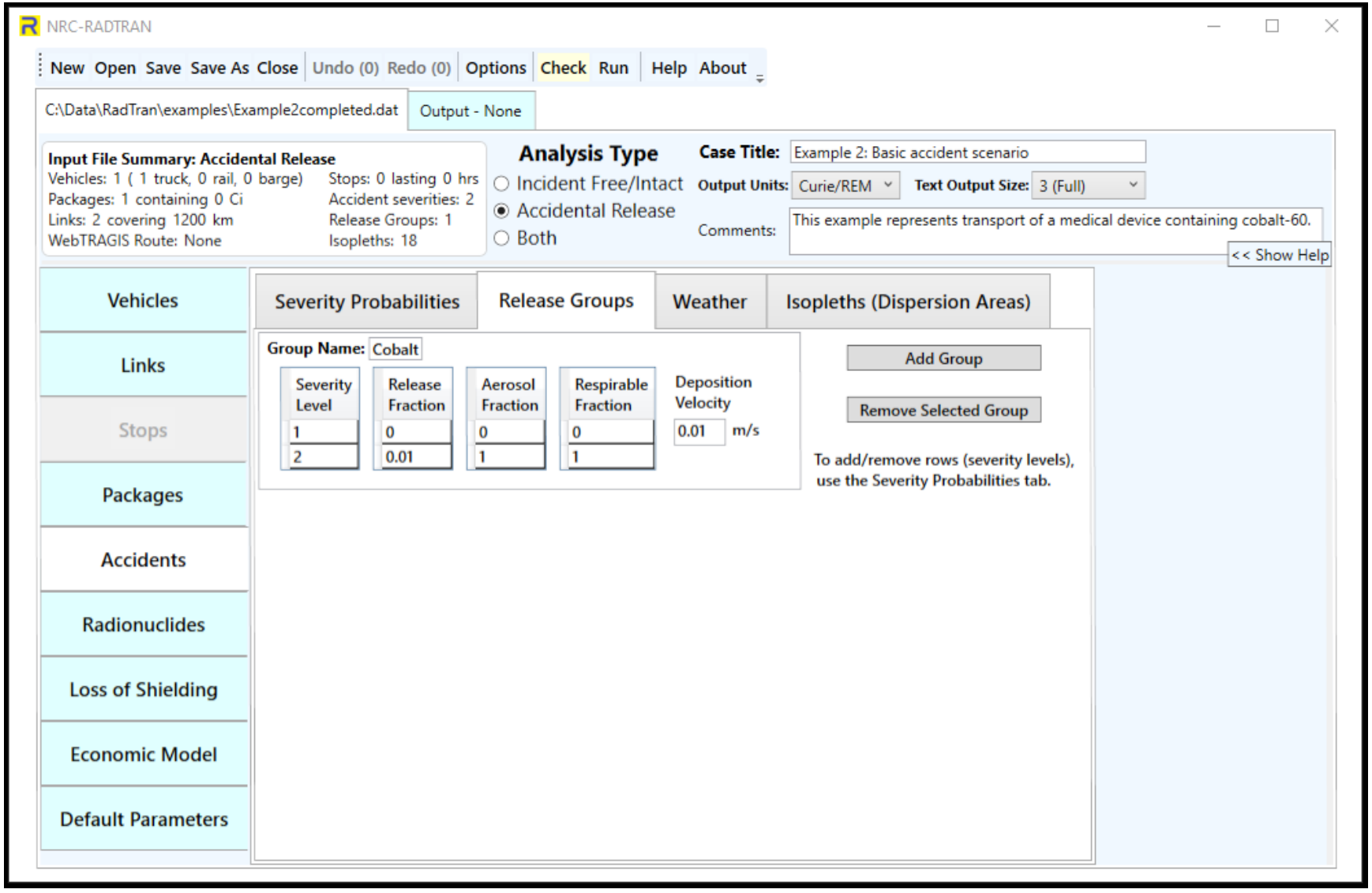
Example 2: Package input



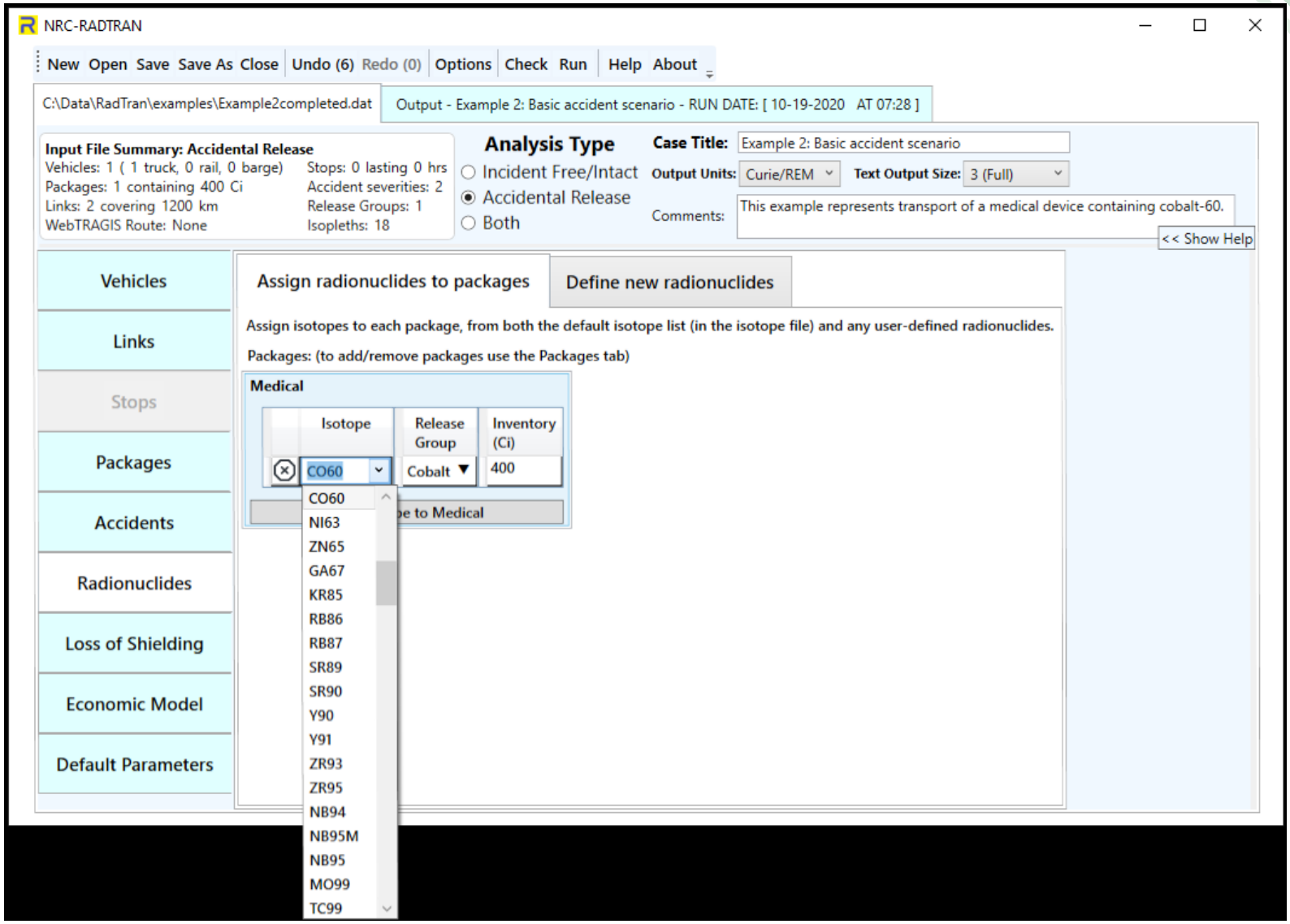
Example 2: Severity Levels



Example 2: Release Groups



Example 2: Radionuclides



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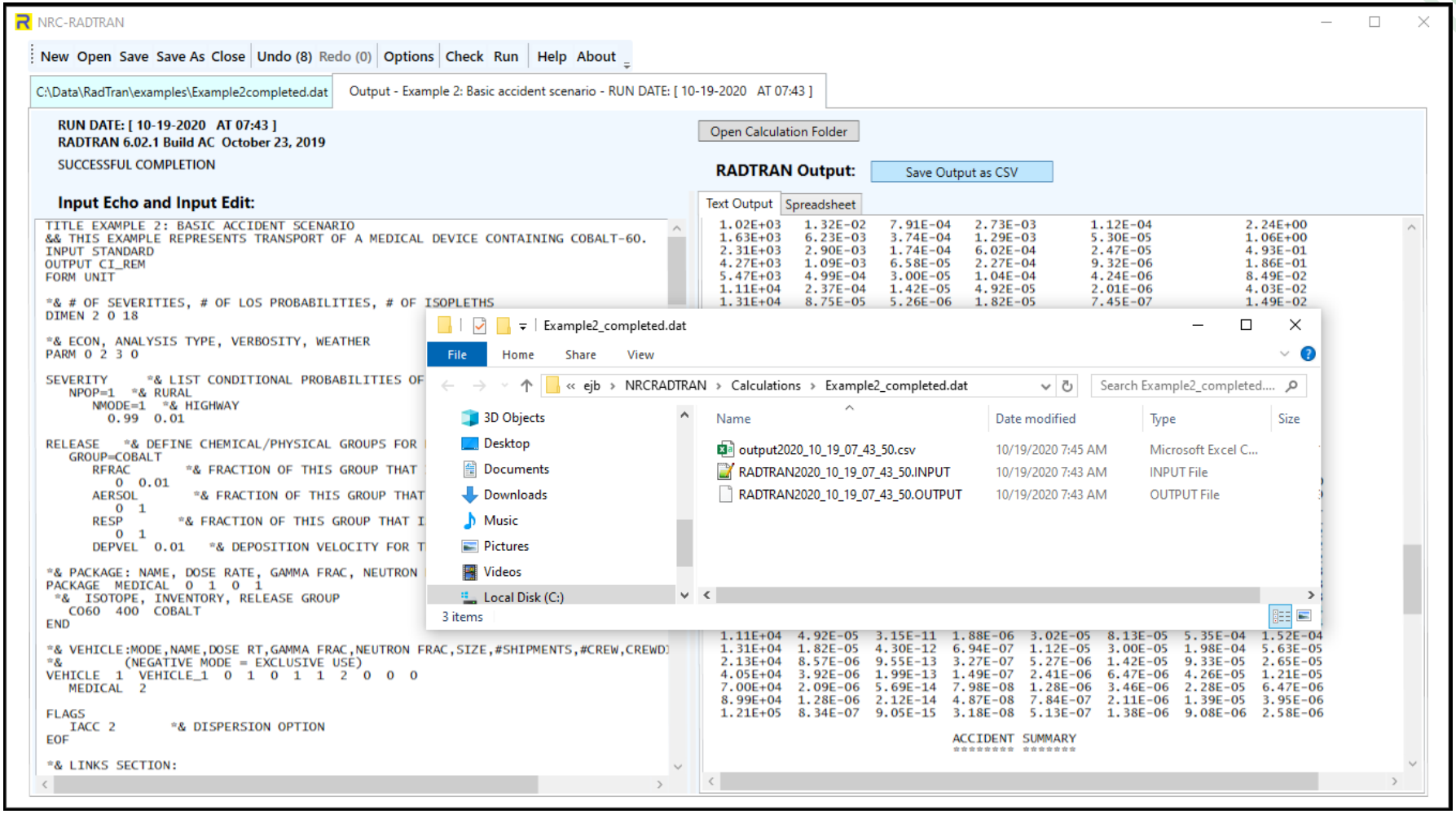
Example 2: Saving as CSV



NRC-RADTRAN GUI

Writes Input Files in a Standard Format

- Text input file written by user vs. NRC-RADTRAN
  - Opening and then saving a file will change the format

```
RADTRAN 6

TITLE Example title

INPUT STANDARD    OUTPUT CI_REM     FORM
UNIT

DIMEN 2 0 18
&& Dimensions for various arrays

PARM 0 3 2 1
&& No econ. Verbosity medium. Pasquill weather.


RELEASE
  GROUP = Group_1
    RFRAC     0.0  0.10
    DEPVEL    1.0e-2
PSPROB  2.0e-1  3.0e-1  2.0e-1  1.0e-1  1.0e-1  1.0e-1

SEVERITY
NPOP=1       NMODE=1  9.99e-1  1.0e-3
```

```
RADTRAN 6      NRC-RADTRAN 2020
TITLE Example title
&& Dimensions for various arrays
&& No econ. Verbosity medium. Pasquill weather.
INPUT STANDARD
OUTPUT CI_REM
FORM UNIT

*& # of severities, # of LOS probabilities, # of isopleths
DIMEN 2 0 18

*& econ, analysis type, verbosity, weather
PARM 0 3 2 1

SEVERITY     *& List conditional probabilities of different severity levels in a vehicle accident
  NPOP=1  *& Rural
    NMODE=1  *& Highway
      0.999  0.001

RELEASE   *& Define chemical/physical groups for radionuclide behavior
  GROUP=Group_1
    RFRAC       *& Fraction of this group that is released in each accident severity level
      0  0.1
    AERSOL       *& Fraction of this group that is aerosolized
      0  0
    RESP       *& Fraction of this group that is respirable
      0  0
    DEPVEL  0.01   *& Deposition velocity for this rel group
  PSPROB       *& Weather: Pasquill stability class fractions A-F
    0.2  0.3  0.2  0.1  0.1  0.1
```

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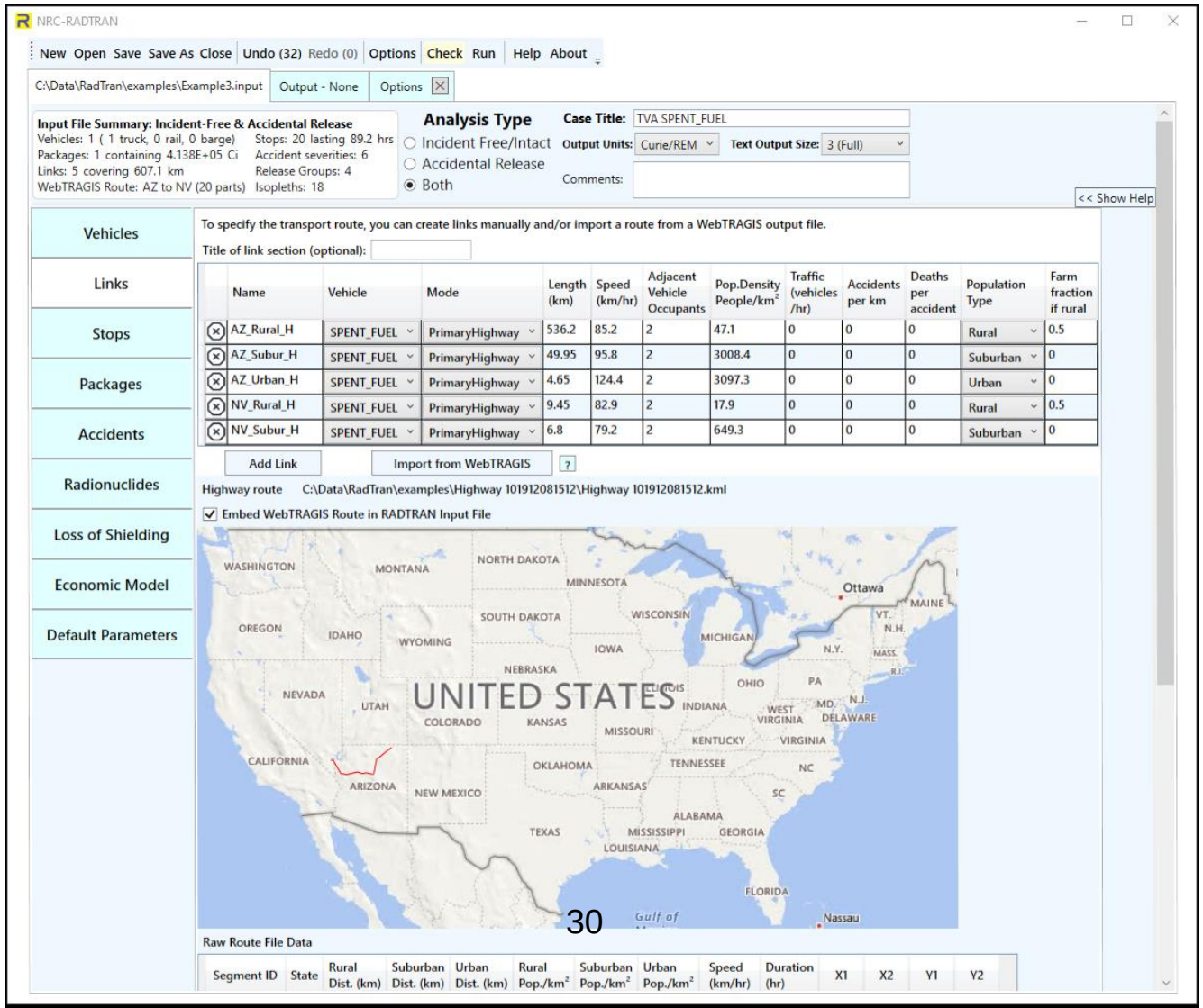
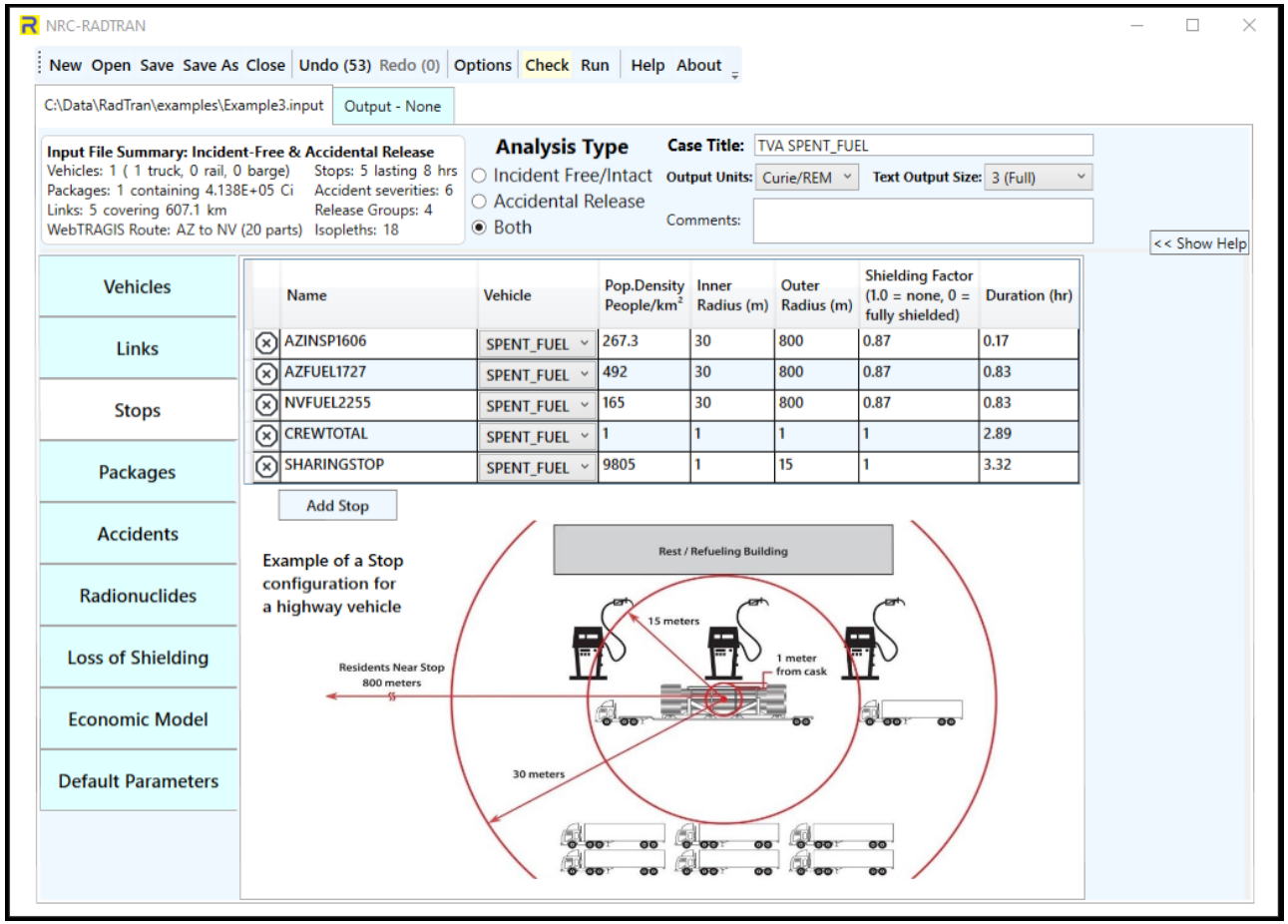
Example 3: Spent Fuel Transport

- NRC-RADTRAN features to cover:
  - Importing a WebTRAGIS route
  - Stops
  - Weather
  - Isopleths
  - User-defined radionuclides
  - Economic model
  - Loss of Lead Shielding
  - Modifying default parameters
    - SI input units option (set first)
    - DISTOFF/DISTON parameters and their physical meaning
    - REGCHECK option

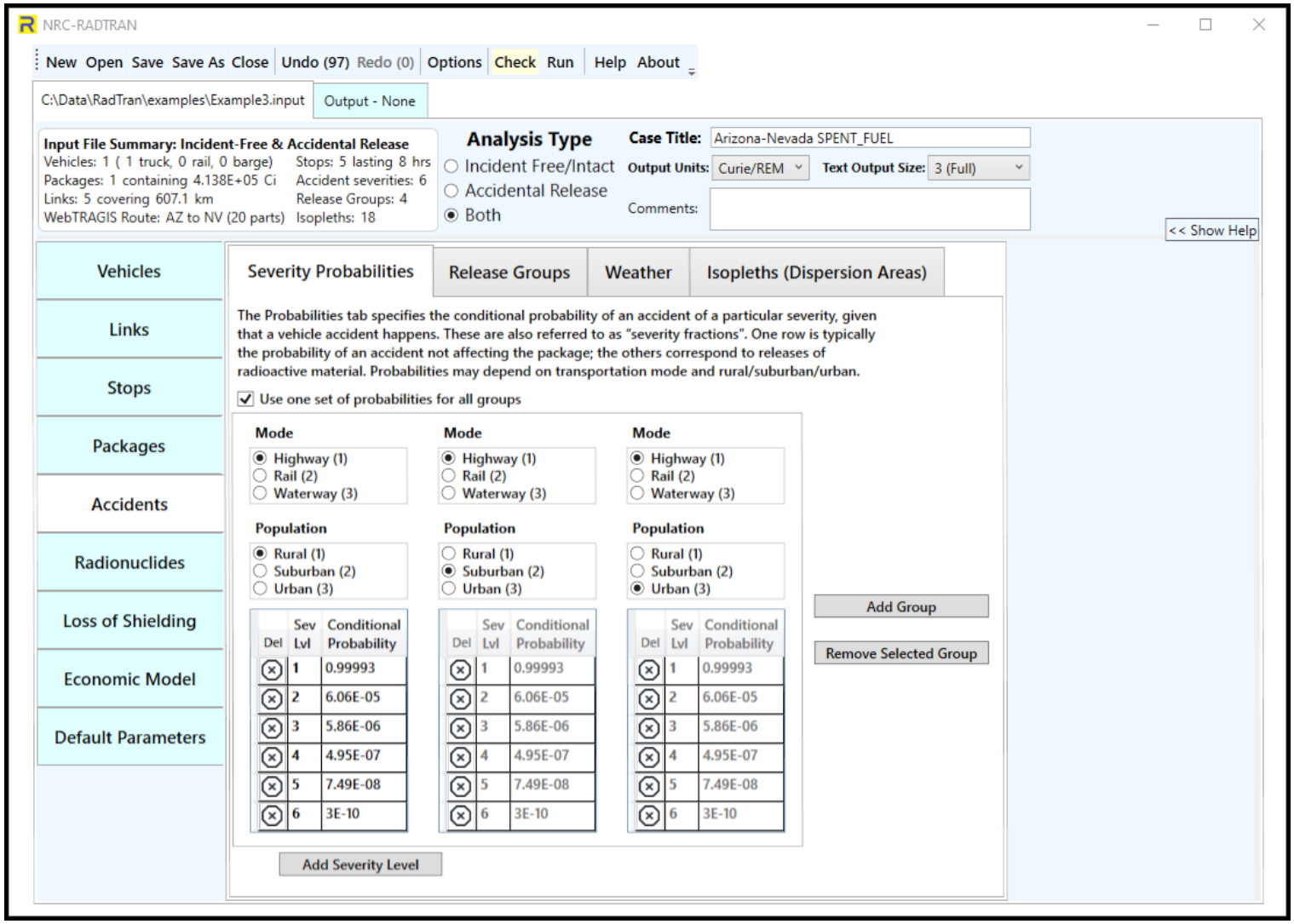
Example 3: WebTRAGIS



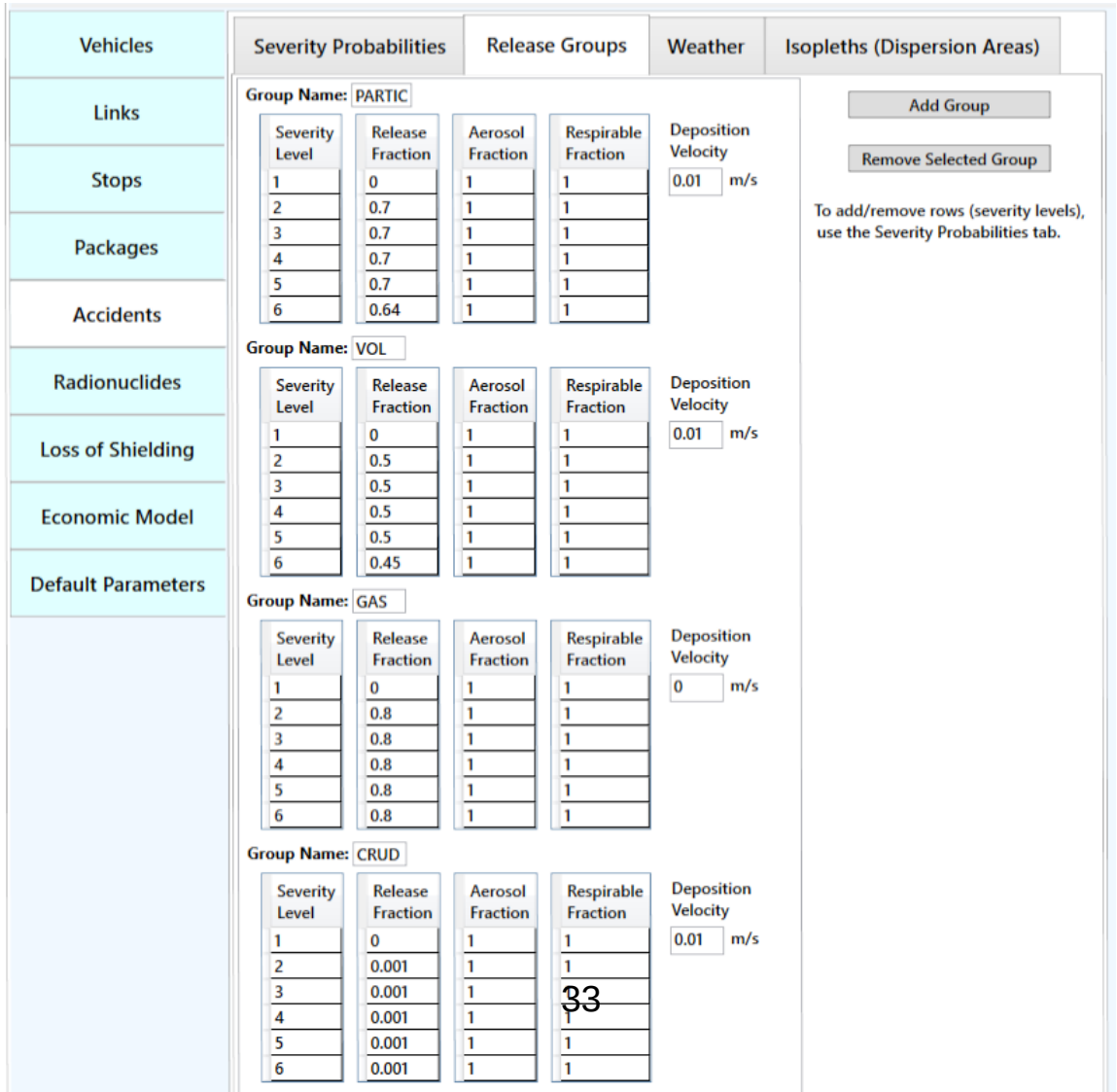
Example 3: Stops



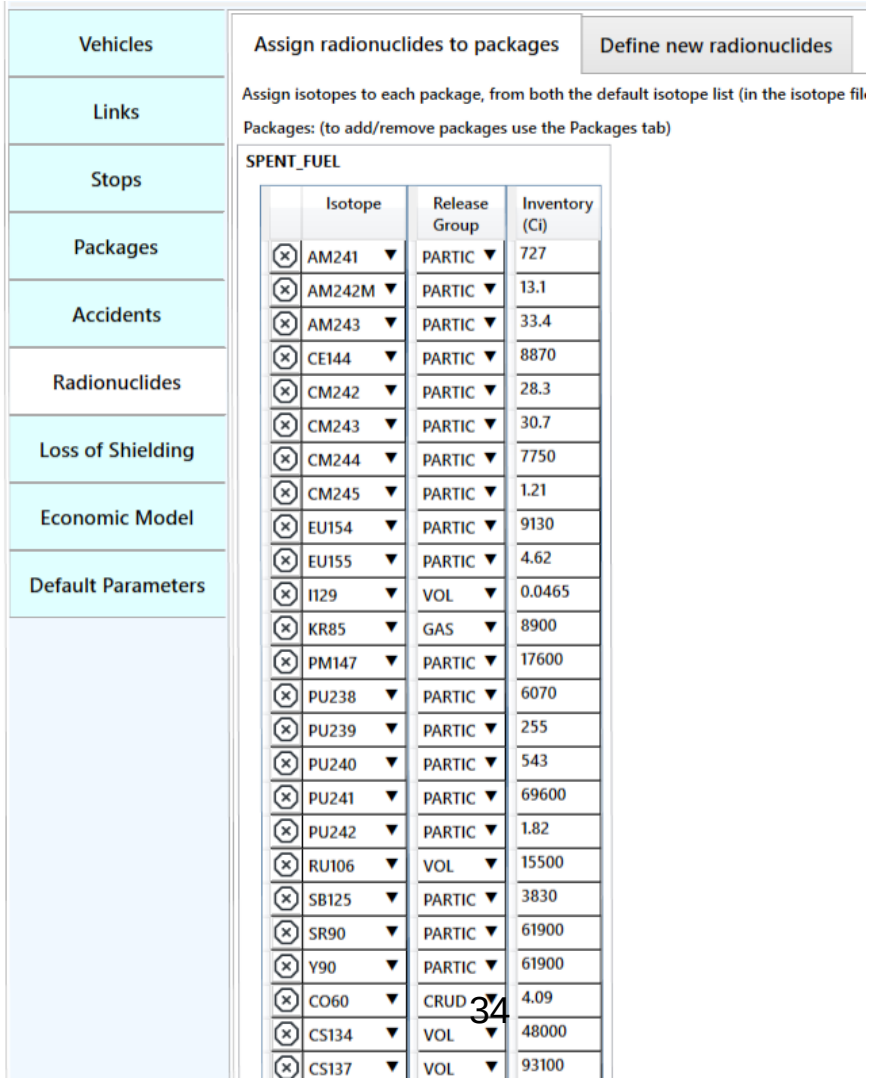
Example 3: Severity Levels



Example 3: Release Groups

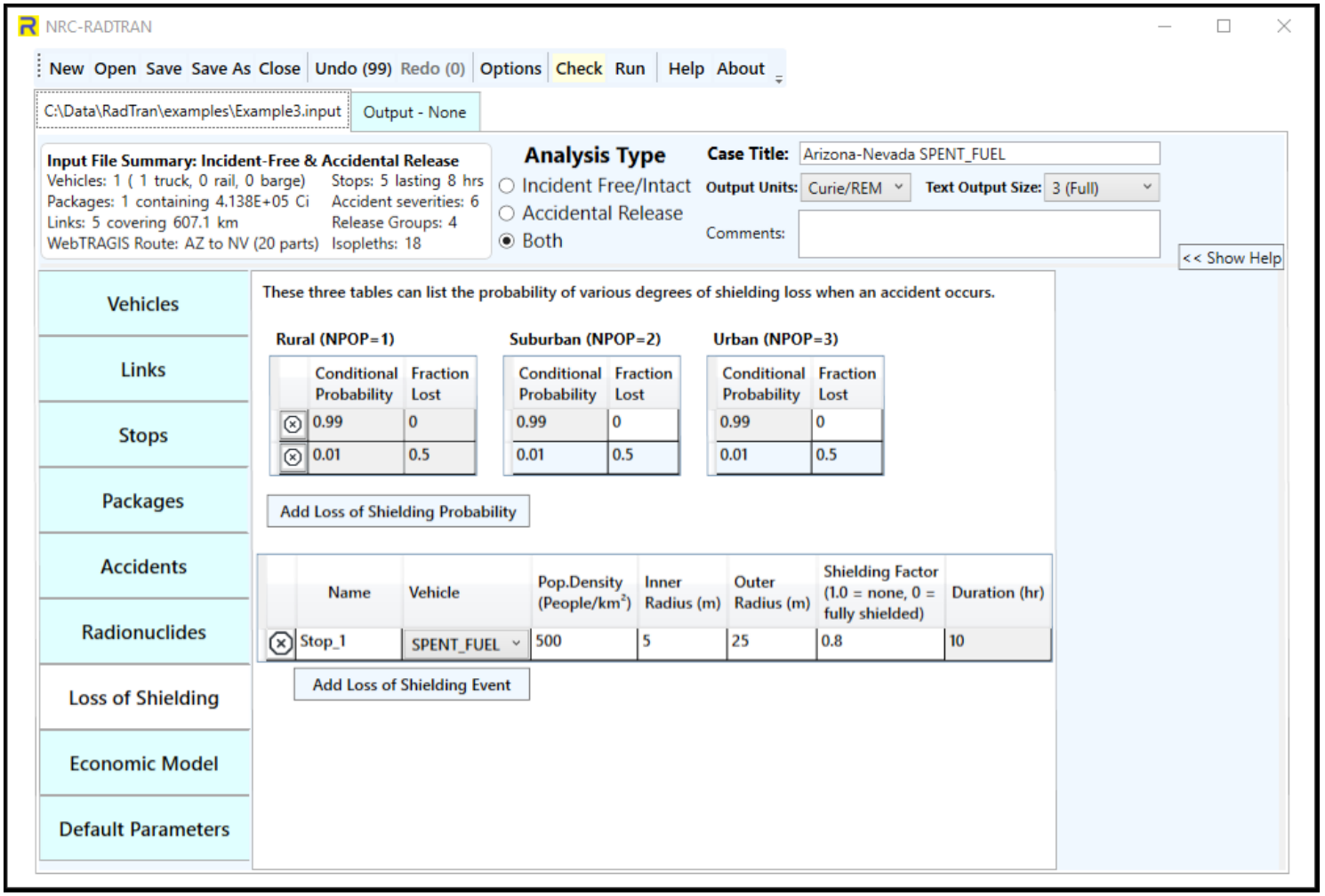


Example 3: Radionuclides

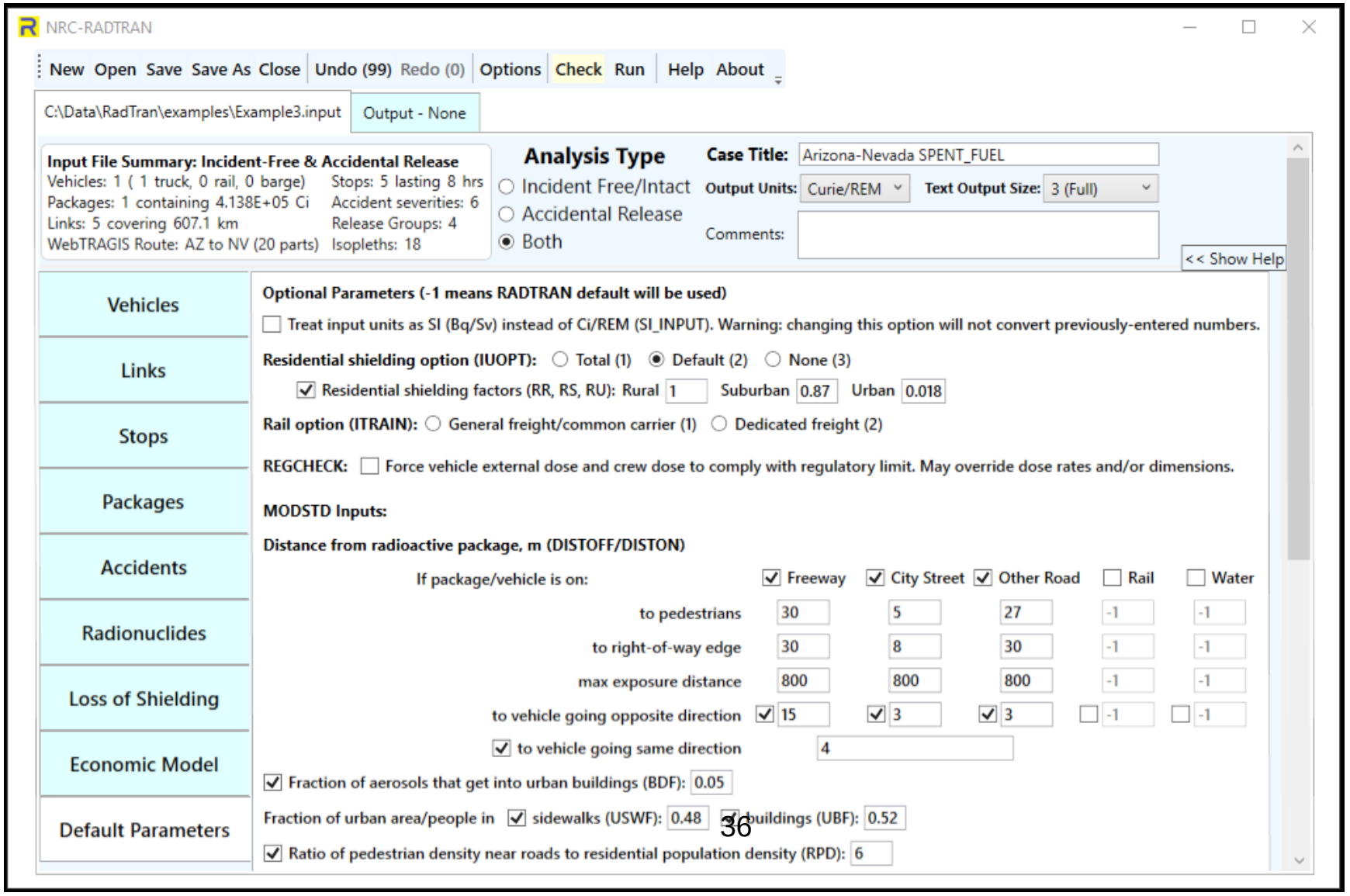


Isotope	Release Group	Inventory (Ci)
AM241	PARTIC	727
AM242M	PARTIC	13.1
AM243	PARTIC	33.4
CE144	PARTIC	8870
CM242	PARTIC	28.3
CM243	PARTIC	30.7
CM244	PARTIC	7750
CM245	PARTIC	1.21
EU154	PARTIC	9130
EU155	PARTIC	4.62
I129	VOL	0.0465
KR85	GAS	8900
PM147	PARTIC	17600
PU238	PARTIC	6070
PU239	PARTIC	255
PU240	PARTIC	543
PU241	PARTIC	69600
PU242	PARTIC	1.82
RU106	VOL	15500
SB125	PARTIC	3830
SR90	PARTIC	61900
Y90	PARTIC	61900
CO60	CRUD	4.09
CS134	VOL	48000
CS137	VOL	93100

Example 3: Loss of Shielding



Example 3: Default Parameters



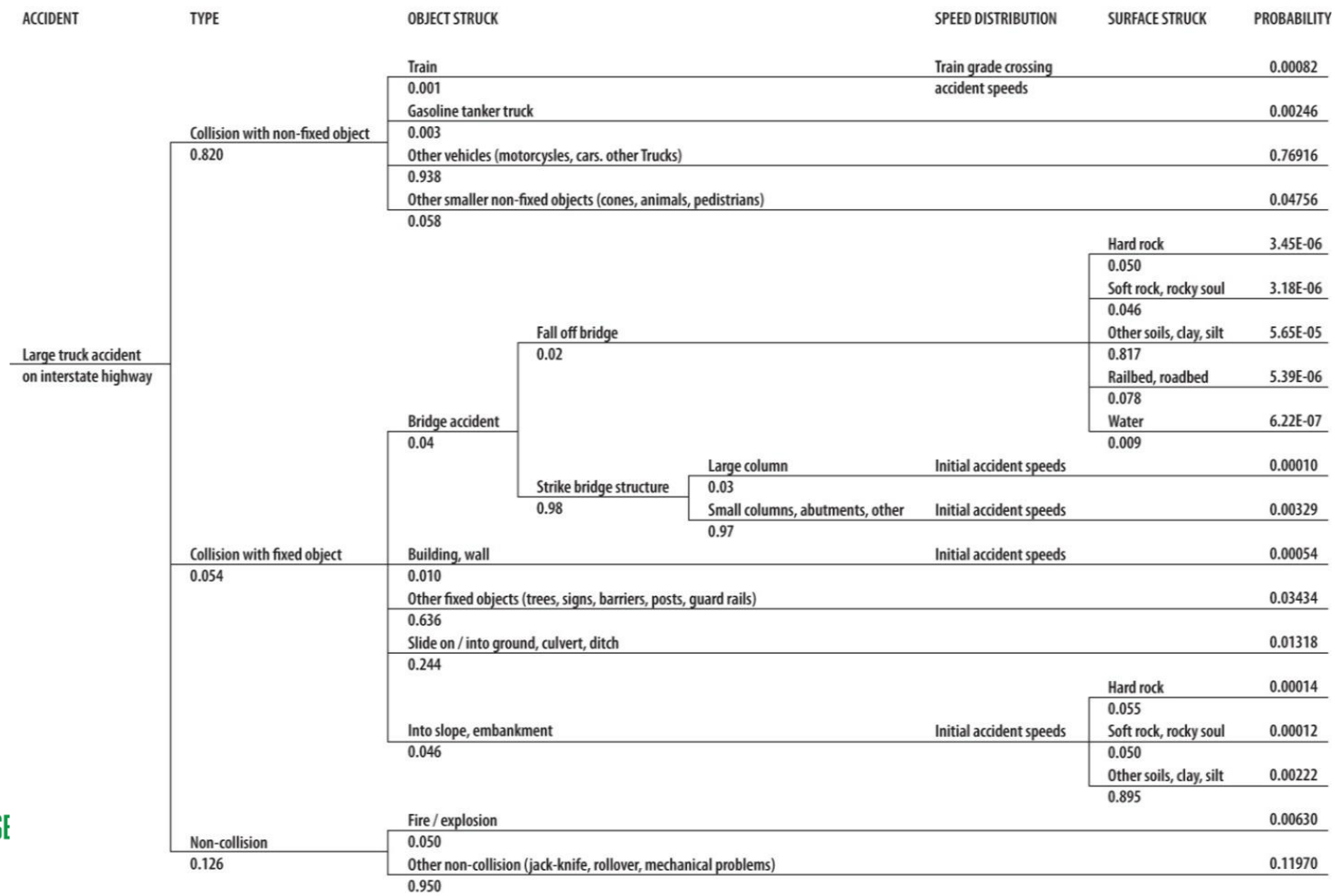
RADTRAN Modeling

- Dose risk
  - The risk triplet normally separates probability from consequences
  - Dose risk multiplies them together to provide an overall risk measurement
- Loss of Shielding
  - Applies only to lead shielding that may be used on highly radioactive packages (mainly spent fuel)
  - Slump fraction abstracts the effect of shifting or thinning
  - Damage to steel or depleted uranium shielding unlikely

RADTRAN Modeling

Severity Fractions

Truck Event Tree



NRC-RADTRAN GUI

Potential Future Improvements

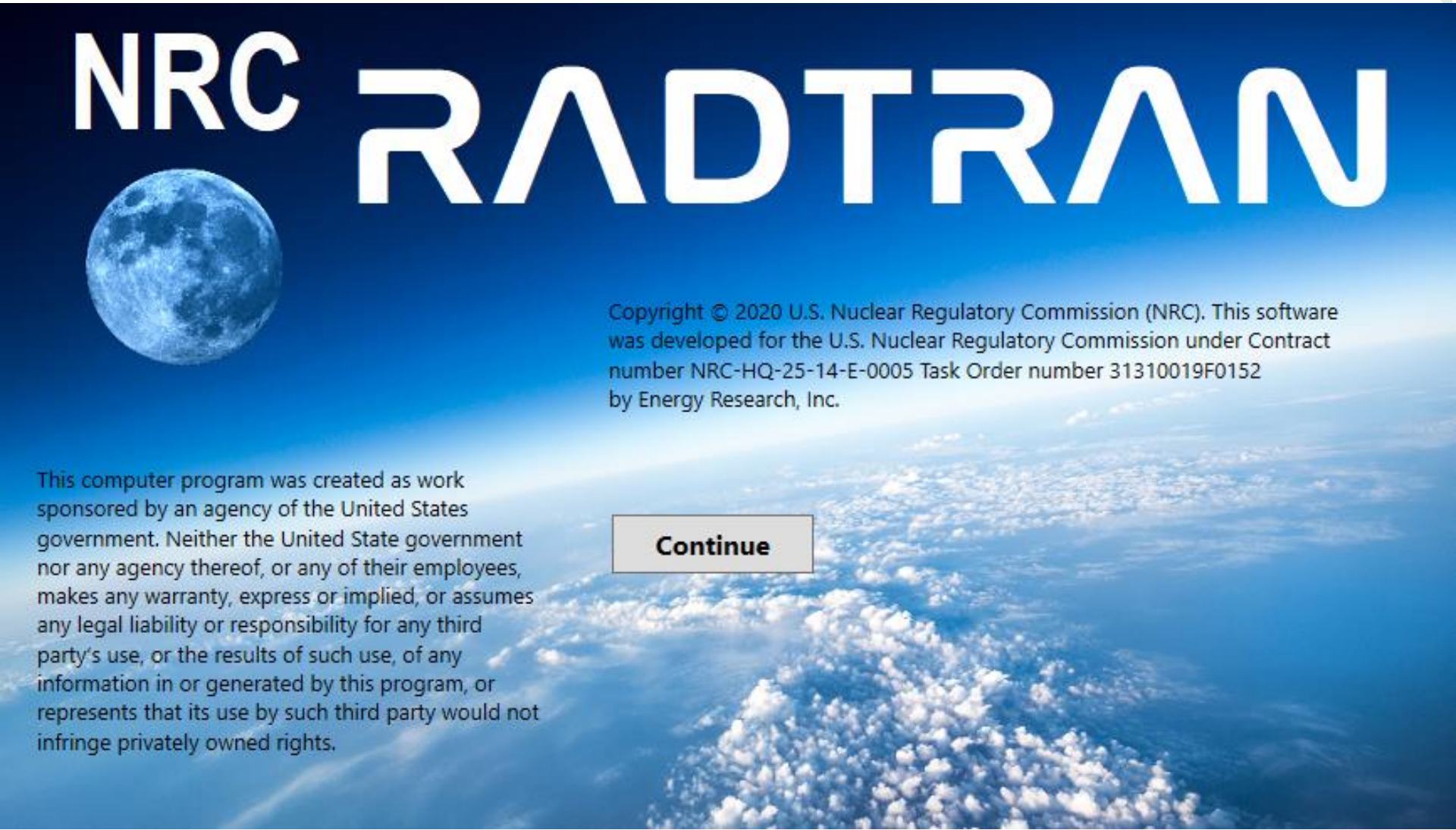
- RAMP is constantly seeking to improve our codes based on user needs.
- If you identify any future improvements or user needs you would like to see integrated into the code, send them the NRC-RADTRAN help resource email given below
- Send user feedback on the GUI to NRCRADTRAN_Help.Resource@nrc.gov

NRC-RADTRAN GUI

Potential Future Improvements

- Alternate routing software
  - WebTRAGIS limitations
    - Contiguous 48 states only
    - Requires US government sponsorship
    - Population density data no longer being updated
  - Possibly Google Earth or Google Maps could be added
    - Requires separate population density database

Questions?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