

Development and Application of the Stakeholder Tool for Assessing Radioactive Transportation (START)-16516

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ABSTRACT

The U.S. Department of Energy, Office of Nuclear Energy is laying the groundwork for implementing interim storage of spent nuclear fuel (SNF) pursuant to the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*. This effort includes planning to address technical and logistical aspects of transporting SNF to an interim storage facility. A key project component is the development and utilization of a decision-support tool to evaluate transportation routing options and emergency preparedness. START (Stakeholder Tool for Assessing Radioactive Transportation) is a web-based application that utilizes geographic information systems (GIS) technology to represent transportation network operations as well as proximate features, such as tribal lands, emergency response capability, schools and environmentally-sensitive areas. Modes and routes between shipment origins and destinations designated by the user can be evaluated according to multiple routing criteria, and users can impose constraints that require the route to pass through or avoid specified locations. Considerable information is produced describing route efficiency, safety, security and environmental exposure that enable stakeholders to understand the implications of alternative route options. This paper describes START's capabilities and illustrates its use.

INTRODUCTION

The U.S. Department of Energy (DOE), Office of Nuclear Energy is laying the groundwork for implementing interim storage of spent nuclear fuel (SNF) pursuant to the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*. Much of this activity is taking place as part of DOE's Nuclear Fuels Storage and Transportation Planning Project (NFST). An important component of the NFST program involves planning to address technical and logistical aspects of transporting SNF to an interim storage facility.

To support this endeavor, DOE initiated development of the Stakeholder Tool for Assessing Radioactive Transportation (START). START is a web-based, decision-support tool developed for the purpose of visualizing geospatial data relevant to large-scale transportation of commercial SNF, as well as generating and analyzing routing options for transporting commercial SNF from nuclear power plants to interim storage or disposal facilities. At present, DOE expects these shipments to move primarily by dedicated trains operating on mainline freight track. However, where mainline freight track access is not directly accessible to a shipment origin, the access leg might involve use of short line railroads, or involve an intermodal movement by heavy-haul truck and/or by barge.

START makes extensive use of geographic information systems (GIS) data and technology for performing spatial analysis and map creation. Embedded within START are a variety of features and functions that enable the user to explore a wide range of operating scenarios and performance objectives. In doing so, the user has the flexibility to explore transportation options and attributes from multiple perspectives and at varying levels of detail.

DESCRIPTION

START is built upon ArcGIS server which offers a web-map interface that can easily be manipulated by the user to pan, zoom, and select points of interest – similar to the user experience with Google Maps or Mapquest. Although platform independent, it is recommended that users run the application via the Google Chrome browser, as this is the browser for which the application has been quality-controlled. Also, certain data export features within START can only be utilized with a spreadsheet program (e.g., Microsoft Excel, Apple Numbers, Google Spreadsheet) and mapping software (Google Earth, Google Maps, desktop GIS). If those START functions are considered necessary to support the user's application needs, these respective software programs should be obtained.

Basemap Selection

START provides a basemap at all times that serves as background geography to provide the user with a spatial reference as well as a visual aid. Several basemap options are available for the user to consider in selecting the desired background. These include topographic, street, terrain, satellite imagery, and canvas options.

Feature Layers

A considerable amount of spatial information is provided with START that is available to support transportation planning. These feature layers define both the transportation network itself as well as characteristics of the surrounding area. The user is provided with an extensive list of layer options from which to choose (see Table 1). These layers represent locations and characteristics of potential shipping origins and destinations, major surface and water freight transportation networks, including political boundaries, populations, facilities, and land uses in proximity to possible shipping routes.

TABLE 1. START Version 1.2.1 Feature Layers

Shutdown Sites	Malls	Highway Bridges
Potential Transload Sites	National Monuments/Icons	Hazmat Routes
Nuclear Reactors	Schools	Waterway Network
DOE and Other Facilities	Colleges/Universities	Dams
Fire Departments	Child Care	Water Terminals
TEPP Trained Personnel	Nursing Homes	Parks
Police	Rail Network	Sensitive Env Areas
Hospitals	Rail Freight Stations	Military Bases
State EOCs	Rail Yards	Tribal Lands
Theme Parks and Zoos	Intermodal Rail Terminals	Congressional Districts
Casinos	Railroad Bridges	Counties
Performing Arts Centers	Railroad Tunnels	States
Stadiums and Arenas	Highway Network	Coast Guard Districts

When a selection is made, START automatically populates the map with icons (points, polygons or polylines) demarcating where the selected features are located (see Figure 1). Points are used when the feature is a specific facility, such as a school or fire department. Polygons are used to represent an area expanse, such as a tribal land or state boundary. Polylines are reserved for representing freight transportation networks (rail, truck, barge), where each line in the network corresponds to a segment of the transportation system.

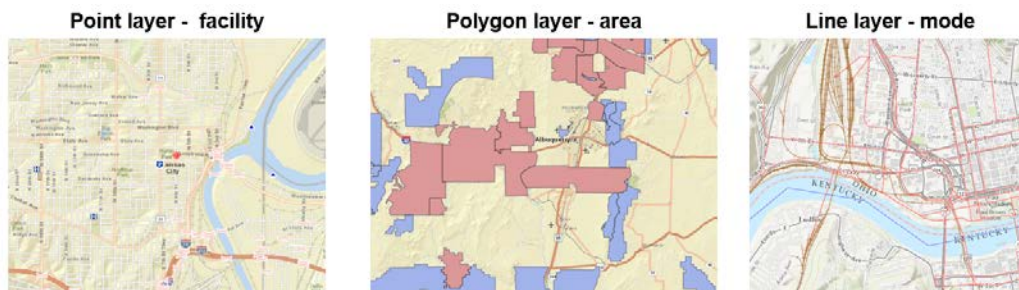


Figure 1. Representation of Point, Polygon and Polyline Layers

The attribute table within a feature layer contains associated information that is unique to each feature (e.g., road or rail segment, police station, county). This information enables the user to understand the descriptive characteristics of the specific feature, helping to ascertain the extent to which the location is important in the transportation planning process. Once a feature layer is selected to be displayed on the map, the user can click on a feature icon, segment or polygon to display the attributes of that feature in a pop-up window. Examples of these attributes are shown for a rail segment and a fire department in Figures 2 and 3, respectively. In the case of the rail segment, note that several attributes have been appended to identify the extent of other features in proximity to the segment itself.

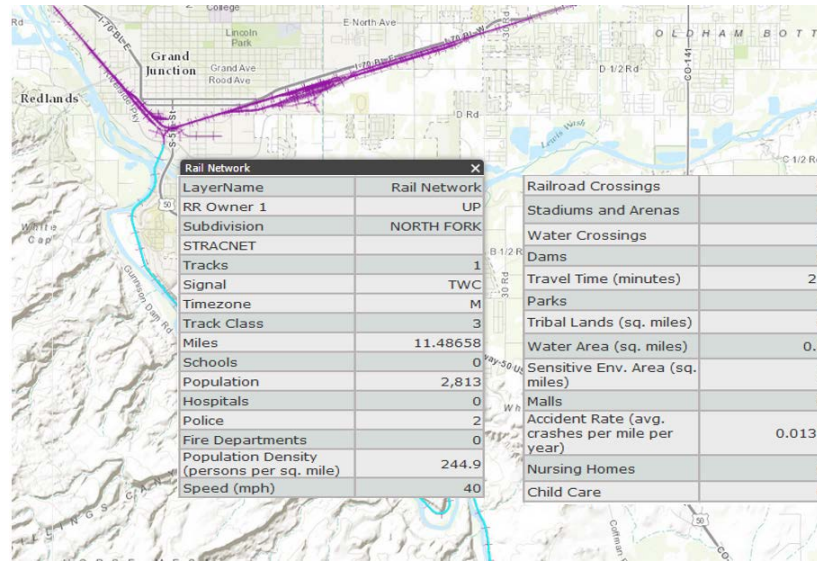


Figure 2. Attributes Associated With a Sample Rail Segment

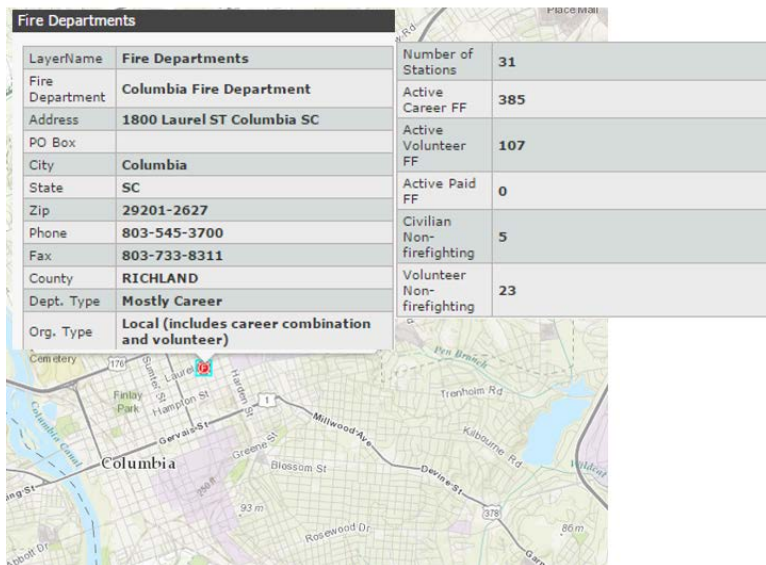


Figure 3. Attributes Associated With a Sample Fire Department

An additional component of the feature layers is the ability to associate electronic files with a specific location. This could represent photographs showing the physical characteristics of relevant infrastructure or could refer to documents that define operational practices at a facility. Figure 4 illustrates this capability in the form of a photograph showing the condition of a portion of the rail infrastructure at a potential truck to rail transload site.

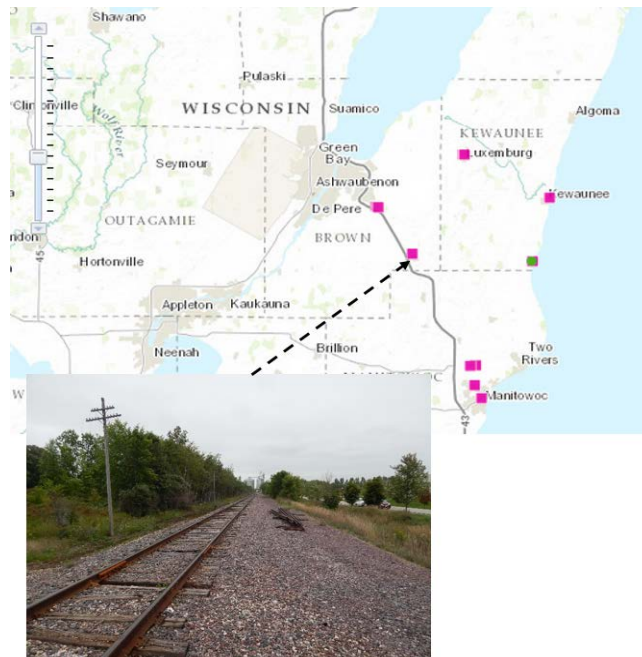


Figure 4. Condition of Rail Infrastructure at Potential Transload Site

Performing a Routing Analysis

In addition to visualizing geospatial data, START offers the capability to generate transportation routes from user inputs, using ArcGIS's Network Analyst Extension based on Dijkstra's algorithm for finding shortest paths. A routing analysis in START is initiated by prompting the user to select a shipment origin, destination and mode(s). Several options exist for the user to specify a shipment origin or destination:

- Shutdown (nuclear power plant) site
- Railhead
- DOE or other shipping facility
- Nuclear facility
- Draw origin

With the exception of the draw origin option, when any of the other selections are prompted, icons appear on the map showing eligible locations. Hovering over the symbol and clicking the mouse permits the user to specify the location as either a shipment origin or destination. By contrast, the "draw origin" option allows the user to place the cursor over any location in the continental U.S. and designate it as the shipment origin/destination.

Modal options include legal-weight truck, heavy-haul truck, rail and barge. Intermodal shipments can also be specified by selecting more than one modal option.

The user may elect to require the route to pass through one or more specified point locations. Similarly, the user can impose barriers (either points or areas) requiring the route to avoid one or more specified locations.

The user is presented with several options from which to select the method by which START searches for a preferred route. The user can opt to minimize one of the following:

- Travel time
- Trip distance
- Population exposure
- Proximity to environmentally sensitive areas
- Proximity to large gathering areas

With this selection, the user is also prompted to choose a buffer distance associated with the analysis. This defines the distance on either side of the transportation network for which information on proximate features is desired. Finally, the user is presented with a list of route performance measures from which to designate those to be included in the analysis output.

Figure 5 displays all of the menu options that correspond to performing a route analysis. Note that a scroll bar is necessary to display all available performance measures.

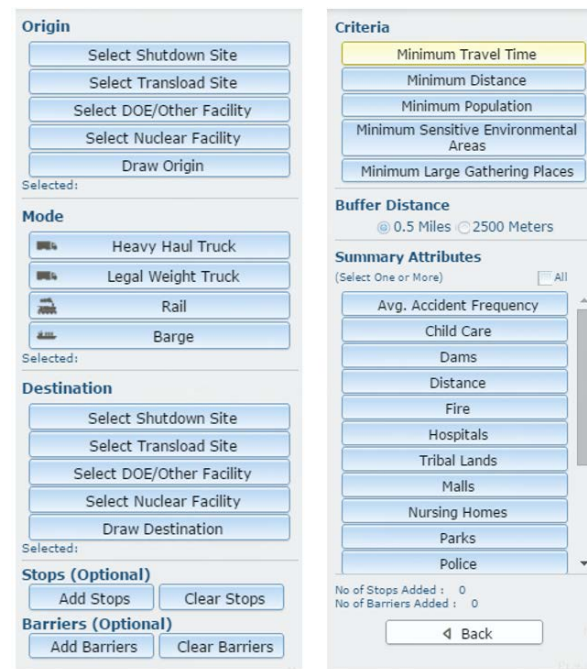


Figure 5. Route Analysis Options

START then begins executing the routing analysis based on the user's selections. If a feasible route cannot be found, for example rail access is not available at the designated origin or destination when a user opts to route exclusively by rail, START will return an error message indicating a route could not be found. Otherwise, the analysis is completed, with the route results available in both map and tabular form.

Route Analysis Results

One of the outputs that START provides is a summary report, comprised of two sections: 1) a review of the user-defined routing inputs (i.e., shipment origin, destination, mode, criteria, performance measures), and 2) the overall route performance metrics for the identified route.

In the example shown in Figure 6, the user is considering a rail route from a hypothetical location near the mid-Atlantic coast to a hypothetical destination in eastern Colorado. Three separate routing analyses have been performed, each involving a one-half mile buffer: 1) minimize rail travel time (green route), 2) minimize population in proximity to the route (red route), and 3) minimize rail travel time subject to avoiding Kansas City and requiring the shipment to pass through Tulsa (blue route).

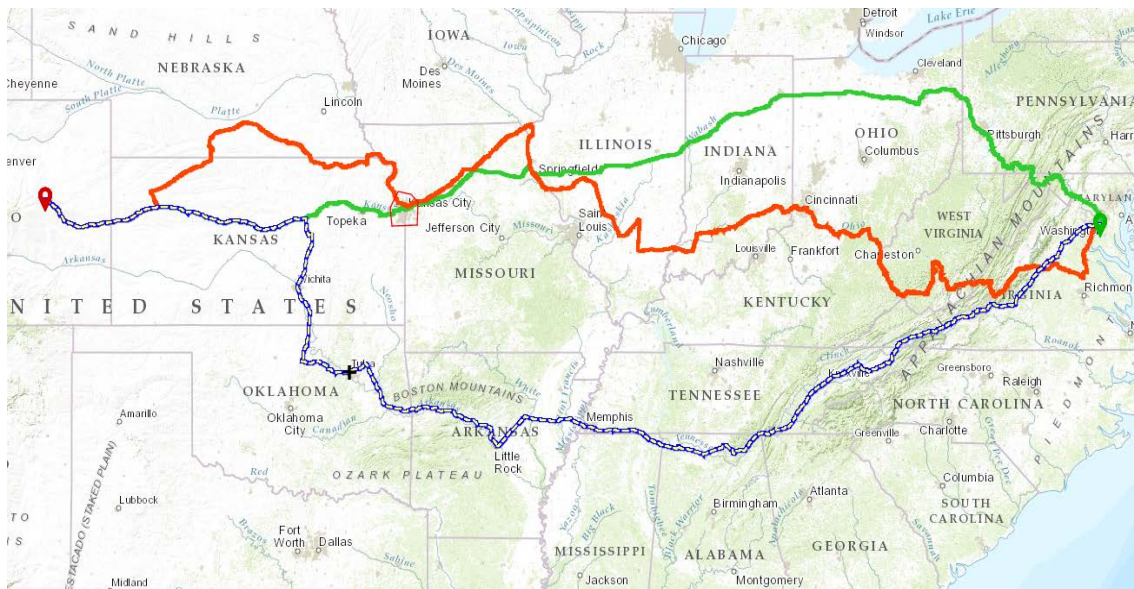


Figure 6. Alternative Routes Based on Different Criteria and Restrictions¹

The corresponding route performance measures are shown in Figure 7. From a comparative analysis perspective, there are tradeoffs as to which route performs best depending on the measure in question. For example, as expected, the minimum travel time route is considerably shorter than the minimum population route and, conversely, the minimum population route has far fewer people located in proximity to the route. What is important to recognize is that while any route will have its pros and cons, understanding where the tradeoffs occur and the corresponding magnitude of their differences helps support an informed route selection discussion.

¹ These are example routes for illustrative purpose only and do not reflect a selected destination site.



Figure 7. Comparative Routing Analysis Results²

Also available as an output option is a route details table. This table presents, in sequence from route origin to route destination, every transport segment associated with the highlighted route. The user may scroll down the table to continue viewing each segment that comprises the route, or across to see the attributes associated with each route segment.

When a routing analysis is completed, the route map and corresponding performance metrics are automatically saved within START and labeled with the date and time the route was generated. Users have the option to edit saved route names and colors according to their preference. Since START provides the user with the ability to recall and overlay one or more saved routes, prior analyses can be reviewed and route comparisons can be made.

START also provides the capability for the user to export route results to a spreadsheet program using comma separate value (CSV) text file format, and to mapping software using keyhole markup language (KML), as shown in Figure 8. This enables the user to perform manipulations that can leverage the functionality that such tools offer. Tabular data in CSV format can also be read into a GIS desktop software application, such as ArcGIS Desktop or ArcGIS Explorer, and joined with transportation feature layers using unique link IDs. Newer versions of ArcGIS or other GIS applications supporting KML files may allow import of KML route shapefiles, which can then be joined with the attributes in the CSV table, enabling users to conduct more detailed geospatial analysis or generate sophisticated map products, as desired.

² These are example routes for illustrative purpose only and do not reflect a selected destination site.

Spreadsheet (Excel)

FRA Link ID	State	State FIPS	County FIPS	RR Owner	Tracks	Signal	Siding	Direction	Density	Track Class	Miles	Schools	Population	Hospitals	Police	Fire Depts	Pop Density	Speed (km/hr)
258393	VA	51	510	NS	1	MAN	3	2	1	1	0.67	3	8844	0	0	1	13289.7	16.1
164057	VA	51	510	CSXT	3	CTC	1	2	6	4	0.24	2	7978	0	0	1	33830.2	80.5
258394	VA	51	510	CSXT	3	CTC	1	2	6	4	0.39	1	5752	0	0	0	14730.2	80.5
258394	VA	51	510	CSXT	3	CTC	1	2	6	4	0.12	0	4098	0	0	0	35594.2	80.5
258394	VA	51	510	CSXT	3	CTC	1	2	6	4	0.66	3	4515	0	0	0	6866.68	80.5
164167	VA	51	510	CSXT	2	CTC	1	2	6	4	0.05	21	1986	0	0	0	37366.7	80.5
164167	VA	51	13	CSXT	3	CTC	1	2	6	4	0.20	0	3024	0	0	0	15310.5	80.5
164164	VA	51	13	CSXT	3	CTC	1	2	6	4	0.54	1	7953	0	0	0	14832.5	80.5
164163	VA	51	13	CSXT	3	CTC	1	2	6	4	0.42	0	11905	0	0	0	28216.2	80.5
164163	VA	51	13	CSXT	2	CTC	1	2	6	4	0.25	0	10712	0	0	0	42337.9	80.5
164163	VA	51	13	CSXT	2	CTC	1	2	6	4	0.51	1	9037	0	0	0	17617.3	80.5

Google Earth

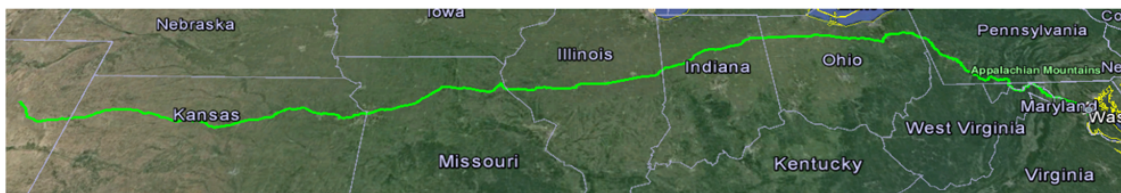


Figure 8. Route Results Export Options

Besides options to export START routing analysis results to outside spreadsheet and mapping software, the user has the ability to produce maps within START by manipulating the base map, feature layers, routing analysis results and zoom feature to create the desired product. These capabilities aid the user in understanding what is occurring on each route segment and may enhance communication with various stakeholders.

User Support

A user manual has been prepared to guide registered users through the tool's features and functions. START training sessions have also been held to familiarize DOE staff and contractors, state and tribal representatives, and other stakeholders with the tool's capabilities. Users have commented favorably on START's ease of use, comprehensive level of information to support transportation planning, and visual appeal provided by the mapping capabilities.

DISCUSSION

START is being served by Idaho National Laboratory, accessible via the following url: <https://gis.inl.gov/start>. As START has been designated for official use only, prospective users must register for an account when accessing the web site, and must meet certain eligibility criteria to receive access.

The START development effort is ongoing, with data enhancements, routing algorithm improvements and additional functionality to be included in future version releases. An important driver of the development process has been the constructive feedback on data

and features provided by federal, state, tribal and local government officials; support contractors; and other relevant stakeholders. For example, by virtue of START including feature layers that locate and characterize response assets (e.g., police, fire departments, hospitals), states and Tribes interested in performing training needs assessments to support future emergency response training strategies recognized the value of accessing START to obtain information about assets in proximity to prospective transport routes. Other synergies within NFST that are evolving include the use of START to support: 1) stakeholder communication and information sharing, 2) development of route selection criteria, 3) origin and destination site infrastructure assessments, and 4) overall waste management system integration.

CONCLUSIONS

The decision to develop START was based on a vision that stakeholders involved in the transportation of radioactive materials would benefit immensely from being able to leverage state-of-the-art GIS platforms and databases in evaluating transportation strategies. The system design and platform should provide DOE with an effective decision-support tool for years to come.

REFERENCES

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