

# ***Decision Analysis for Toxic by Inhalation (TIH) Material Routing***

## Railroad Team

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# Problem Definition: Overview

- Toxic by Inhalation (TIH) materials
  - Formally defined by the Federal Government
    - “Gases or liquids that are known or presumed on the basis of test to be so toxic to humans as to pose a health hazard in the event of a release during transportation”<sup>1</sup>
    - Six TIH chemicals account for 90%+ of TIH risk:<sup>2</sup>
      - Ammonia, chlorine, SO<sub>2</sub>, hydrogen fluoride, fuming nitric acid, sulfuric acid
  - 21.6 million ton-miles of TIH movements/yr<sup>3</sup>

For example, each year, 8500 tank cars of chlorine move by rail through the middle of Washington, DC, passing within 2 blocks of the US Capitol.

**The complete release of just one of these 90-ton cars in the center of DC = death & injury of 100,000+ people.**

1) 49 Code of Federal Regulations Part 171.8

2) Brown, D.F.; Dunn, W.E.; Policastro, A.J. “A National Risk Assessment for Selected Hazardous Materials in Transportation ANL/DIS-01-0,” Decision and Information Sciences Division (Argonne National Laboratory) US Department of Energy, Jan 2001

3) Office of Freight Management and Operations, Federal Highway Administration “Freight Facts and Figures 2006,” US Department of Transportation, Washington DC

# Problem Definition: Specific

- Of the TIH-material routes possible between Washington, DC, and Philadelphia, which is the least risk route that is economically viable?
  - Tools are currently being built to automate route planning, but as of yet, there are no easy-to-use tools for railroad traffic managers that allow useful interpretations of complex routing solutions
    - Current tools can analyze only two routes at a time
    - Do not take economic utility of route into consideration
    - Take too many variables into account (27)
      - Managers (decision makers) need to understand the effects of a more limited set of variables
    - Current tools:
      - Rail Routing and Visualization Application(RRVA)
      - Transportation Routing Analysis Geographic Information System (TRAGIS)
  - Sponsors determined that the DC-Philadelphia routing is at an appropriately small scope yet will yield significant (useful) new knowledge
    - DC-Baltimore considered to be a trivial case

# Preliminary Requirements

- Determine a set of different routes between Washington, DC, and Philadelphia
  - Must be key routes
    - Wayside defect sensors no more than 40 miles apart
    - All main track inspected min 2x a year, all track has periodic inspections
    - Track FRA Class 2 or higher
  - Information publicly available
- Group to read Hartong & Goel's unpublished "A Risk Assessment Framework for TIH Train Routing"
  - Foundational study that identifies the concepts of how to route trains based on minimization of:
    - Rate of accidents resulting in hazardous material release
    - Rail route population exposure
    - Rail route length
    - Economic impacts of rerouting
- Obtain TRAGIS model and RRVA prototype or at least their results for DC-Philadelphia TIH routes and sufficient sensitivity analysis for comparison to our model

# Technical Approach

- Develop a fast-track route planning algorithm based on five selected attributes
  - Basis of a “quick and dirty” assessment tool
  - Identify the five most relevant route attributes
    - E.g.: cost-effectiveness, safety, public interest, minimization of death, effects on military
  - An economic attribute will be one of the five
  - Define “why” these are the top five of 27 and how they interrelate
- Formulate route metrics to measure attributes
- Standardize units for these metrics
- Optimize routes based on metrics
- Perform sensitivity analysis for each of the attributes
- Compare “simpler solution” to more complex TRAGIS, RRVA
- Suggest an implementation of the Team’s route optimization methodology.

# Initial Attributes

- Subsequent to the Team's initial review of available information, the following five attributes have been selected as the starting set.
  - Cost of Sending Freight (cost/ton) for each rail
  - Volume of TIH per Train
  - Areas of High Consequence Severity
  - Emergency Response Capability Along Route
  - Rail Track Metric (Composite), may include:
    - Track type, class, and maintenance schedule
    - Track grade and curvature
    - Presence of signals and train control systems along route
    - Number of wayside hazard detectors per unit distance
    - Number and types of grade crossings
    - Distance on single versus double track
    - Frequency and location of track turnouts
    - Proximity to en-route storage or repair facilities

# Expected Results

- A reasoned selection of 5 metrics to determine the optimal route
- The optimal route according to these metrics
- Sensitivity analysis for each of these metrics
- Comparison of these results to those of TRAGIS, RRVA
- A suggested implementation of the Team's route optimization methodology.

# Initial Project Plan

Week Complete	TASK	Duration/Resource (scaled back)	Resource	Total Hours Allocated
	<b>PROJECT MANAGEMENT</b>	140		
2	Develop Project Scope	10	DM, D	
3	Define Project Components	10	DM, D	
3	Generate Cost/Resource/Task	20	DO, D	
	<b>PROBLEM IDENTIFICATION</b>	116		
3	Identify approach	20	AR, R	
4	Identify rail routes	2	DM, A	
5	Identify and classify risks	10	DM, A	
6	Identify algorithm framework	10	MA, A	
	<b>CUSTOMER INTERACTION</b>	150		
4	Define customer requirements	10	DM, D	
13	Conduct status/progress meet	20	DM, D	
	<b>TECHNICAL APPROACH</b>	140		
5	Determine and identify 5 opti	10	DM, D	
6	Develop metrics and weightin	10	DO, D	
8	Perform Sensitivity Analysis	20	MA, D	
	<b>DELIVERABLES:</b>	185		
11	Website Development/maintain	15	AR	
1	Project Plan and Proposal	5	DM, A	
2	Status Report Deliverable 1	5	DM, MA	10
4	Progress Report	5	AR, MA, DM	15
5	Status Report Deliverable 2	5	AR, RL, DO	15
8	Team Progress Review Meetin	5	DM, DO, AR, RL, MA	25
9	Formal Progress Presentation	5	AR, DO, MA	15
11	Formal Dry-Run Presentation	5	RL, AR, DO, MA, DM	25
13	Final Presentation and Final R	10	RL, AR, DO, MA, DM	50
	<b>TOTAL HOURS:</b>	731		731

