Rail Routing: Using Decision Analysis to Evaluate Objectives

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April 22, 2004

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Scoping the Problem

- More than one rail route is available between any spent fuel site in the U. S. and Caliente, NV.
- Routes differ in several parameters, like route length, track quality, urban areas transited, and so on.
- Any particular route may not uniformly have more desirable parameters than another route; e.g. a shorter route may go through more urban centers.
- A consistent method for applying potential route selection criteria may be desirable.

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The Decision Analysis Method

- A semi-quantitative method to evaluate potential criteria
- Affords a method for evaluating parameters that make a route more or less desirable.
- Identifies alternatives by their measurable characteristics and, independently, by the importance of each characteristic to the selection.
- Allows rapid sensitivity analysis
- Provides documentation for selection

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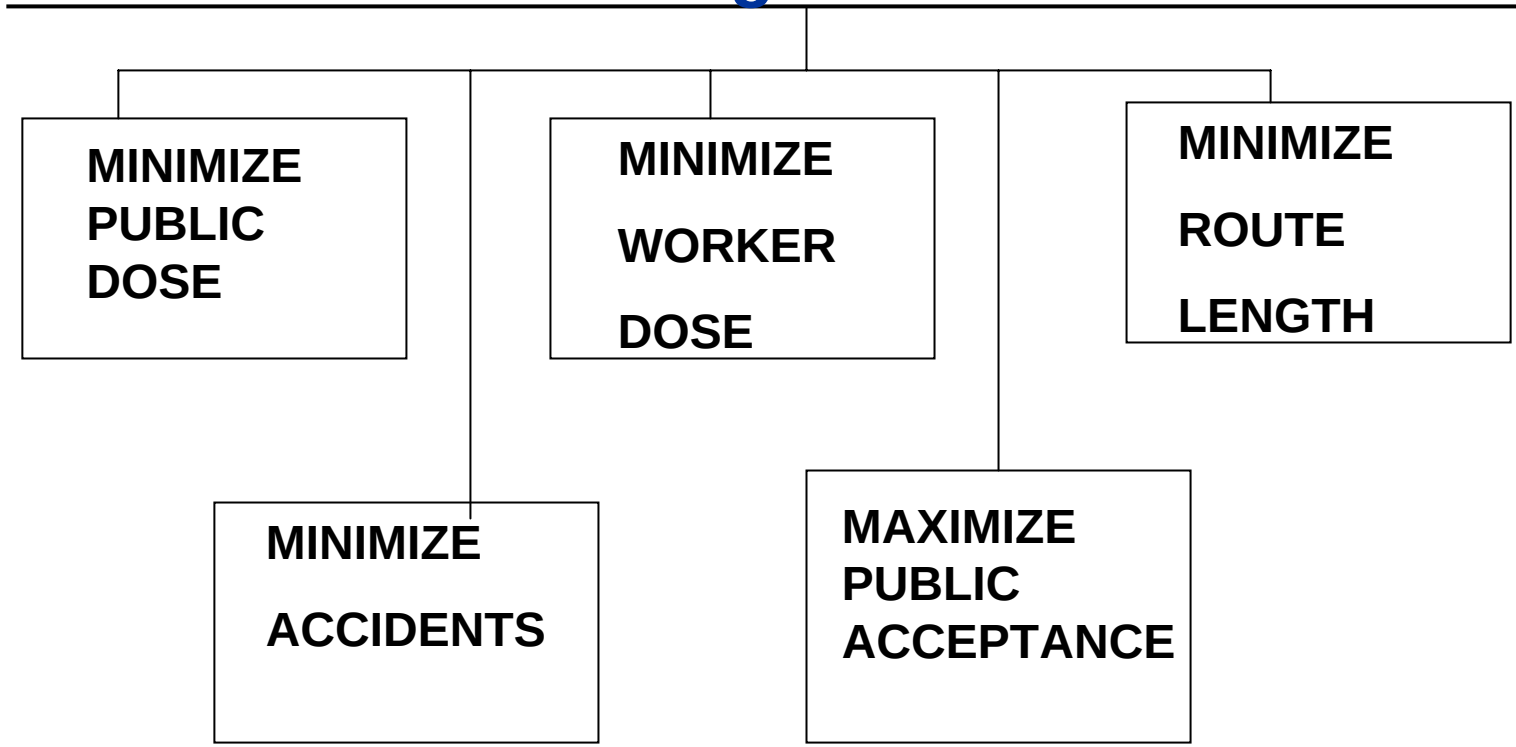
Safe And Acceptable Transportation Of RAM From Origin To Destination



Decision analysis assists decision-making when there are multiple objectives.

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Defining Objectives

- Selecting a route involves multiple objectives
- Overall objective is safe acceptable transportation of RAM
- Sub-objectives can sometimes conflict
- Criteria are selected so as to assess conflicting objectives
- Route selection involves different decision-makers including: shipper, carrier, NRC or DOE security, State and Tribal governments

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Potential Criteria

- Need to be measurable or otherwise quantifiable items
- Overlap as little as possible
- Should distinguish between alternate routes
- Should differentiate clearly between “better” and “worse” parameters

Let’s brainstorm some criteria.

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Potential Criteria Used in the Example

- Route length
- Accident likelihood
- Dose to the public during routine transportation
- Urban centers transited
- Indian lands transited
- Avoid my state
- Number of rail interchanges
- Track quality

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Evaluating Route Parameters and Their Importance

- Route parameters (e.g. route length, large cities transited, etc.) are ranked by some measurable criterion and by differentiation between “better” and “worse”:
  - Shorter routes are better than longer ones
  - Lower dose to the public is better than higher dose
  - Smaller likelihood of accidents is better than a larger likelihood
- Importance to the decision-maker is independent of the objective measure.
- The decision maker (or his or her surrogate) <u>independently</u> decides how important each parameter is <u>to him or her.</u>
- Finally, we will combine objective ranking with subjective importance to the decision maker.

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Information Sources for Evaluating Each Route Against Criteria

- Route length, urban areas transited, Indian lands transited, interchanges, track quality
  - WebTRAGIS or similar routing code and/or a GIS, maps
- Doses to public during routine transportation
- Likelihood of accidents
  - RADTRAN, RISKIND, or similar risk assessment code
  - Federal Railroad Administration; Bureau of Transportation Statistics

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Importance of Each Criterion

- The exercise we will do uses four alternate routes, across much of the United States, and we will evaluate a set of parameters to determine which route is most preferred.
- To begin the exercise:
  - A decision maker has 100 points to divide among the potential criteria. The more points you give a criterion, the more important you think it is.
  - You have not seen the routes. All you know about the potential criteria is what is desirable or undesirable about each criterion (e.g., short routes are more desirable than long routes).

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Example of Potential Criteria With Importance Weights

- Route length – 20 points
- Accident likelihood – 18 points
- Dose to the public during routine transportation– 5 points
- Urban centers transited – 15 points
- Indian lands transited – 15 points
- Avoid my state -- 9 points
- Number of interchanges -- 8
- Track quality -- 10

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Alternative Route Data

- The slides that follow summarize the data and ranking of the various criteria applied to the four routes in the example.
- "Rank" provides a common (0 to 1) scale for evaluating the route with respect to a potential criterion.
  - For example, it provides a way to compare kilometers of route length with the number of urban centers transited.
- The higher the rank, the better the route looks with respect to the particular potential criterion.

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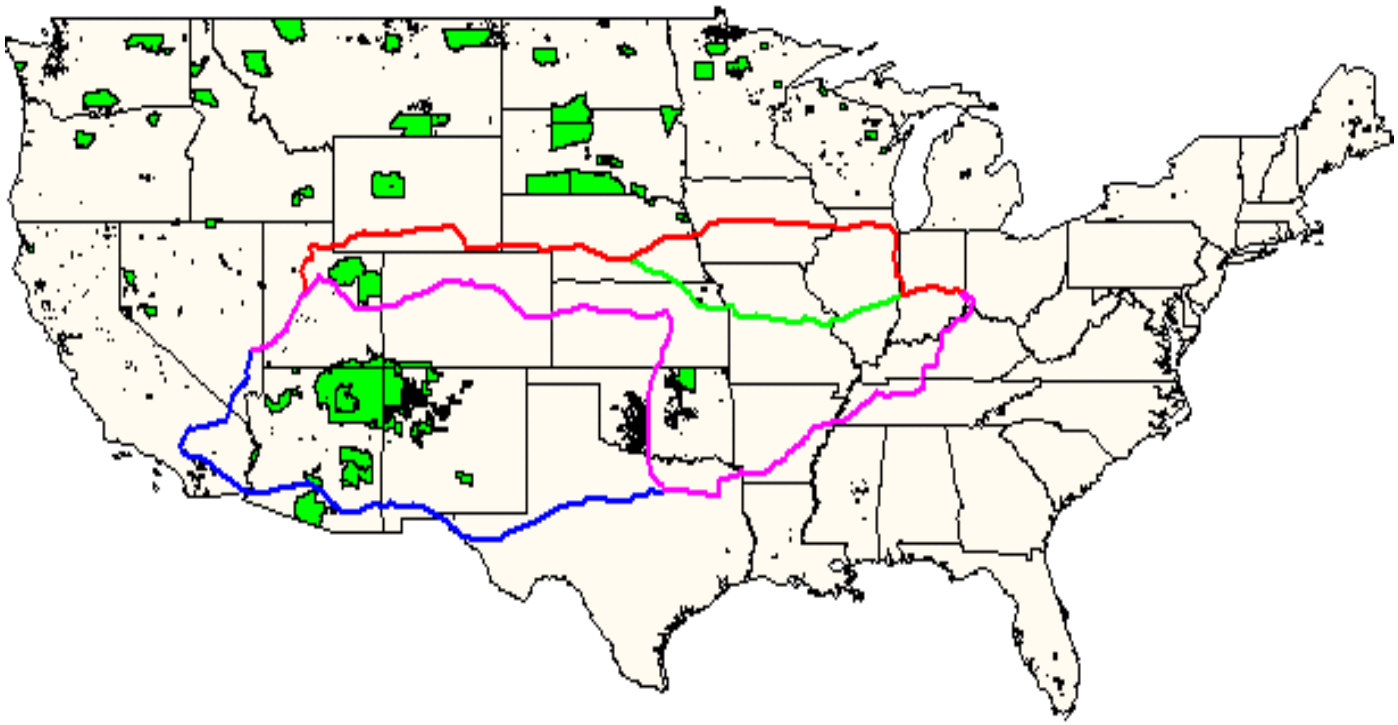
Example: Four Alternate Rail Routes From Fernald, OH to Caliente, NV



Map source: WebTRAGIS

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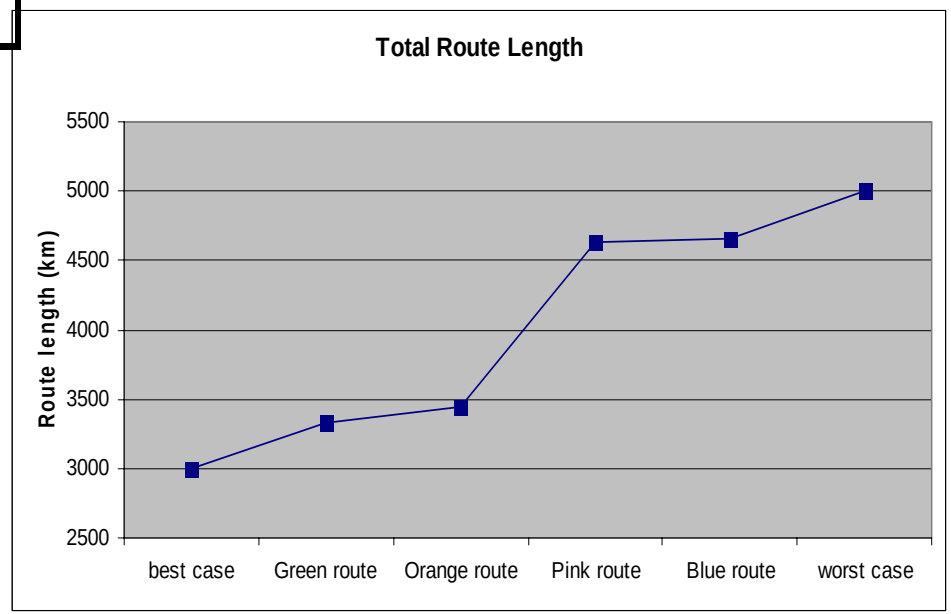
Ranking Route Length

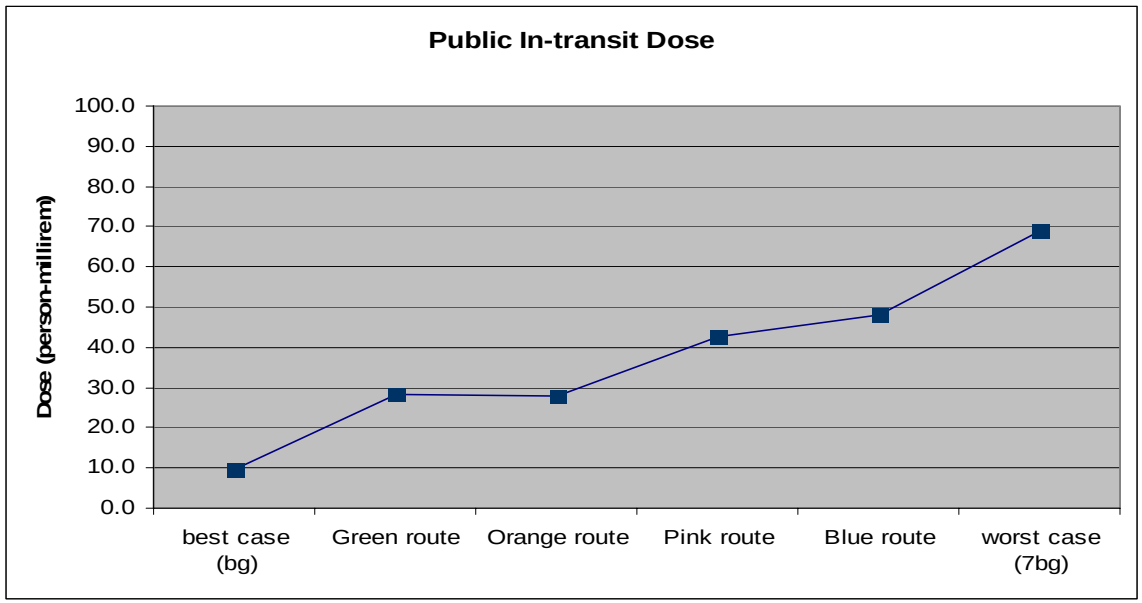
	TOTAL KM	RANK
best case	3000	
Green route	3334.3	0.56
Orange route	3450.6	0.52
Pink route	4638.1	0.12
Blue route	4654.1	0.12
worst case	5000	



Data source: WebTRAGIS

Ranking Dose To The Public From Routine Transportation

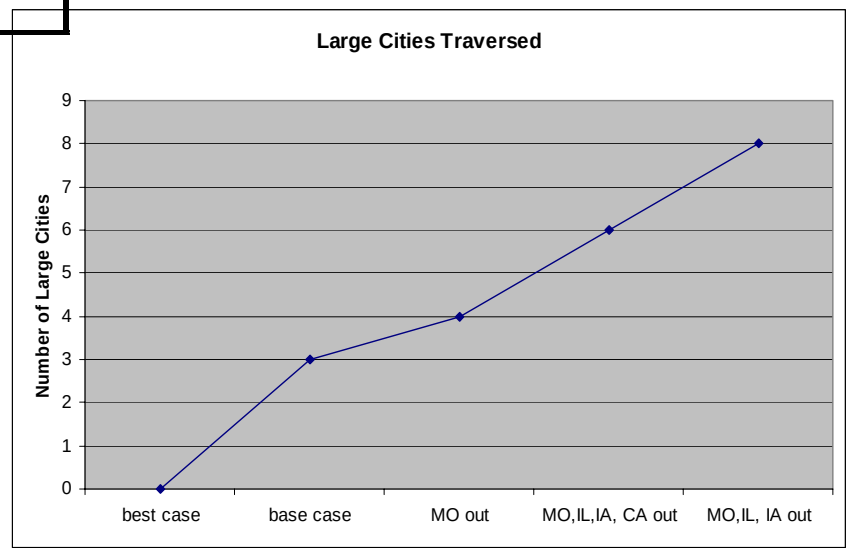
	DOSE	RANK
best case (bg)	9.9	
Green route	28.3	0.69
Orange route	27.7	0.70
Pink route	42.8	0.44
Blue route	48.0	0.35
worst case (7bg)	69.0	



Sources: RADTRAN;WebTRAGIS

Ranking Number Of Large Urban Centers Transited

	number of large cities	rank
best case	0	
Green route	3	0.625
Orange route	4	0.5
Pink route	6	0.25
Blue route	8	0
worst case	8	



Sources:U. S. Census Bureau; WebTRAGIS

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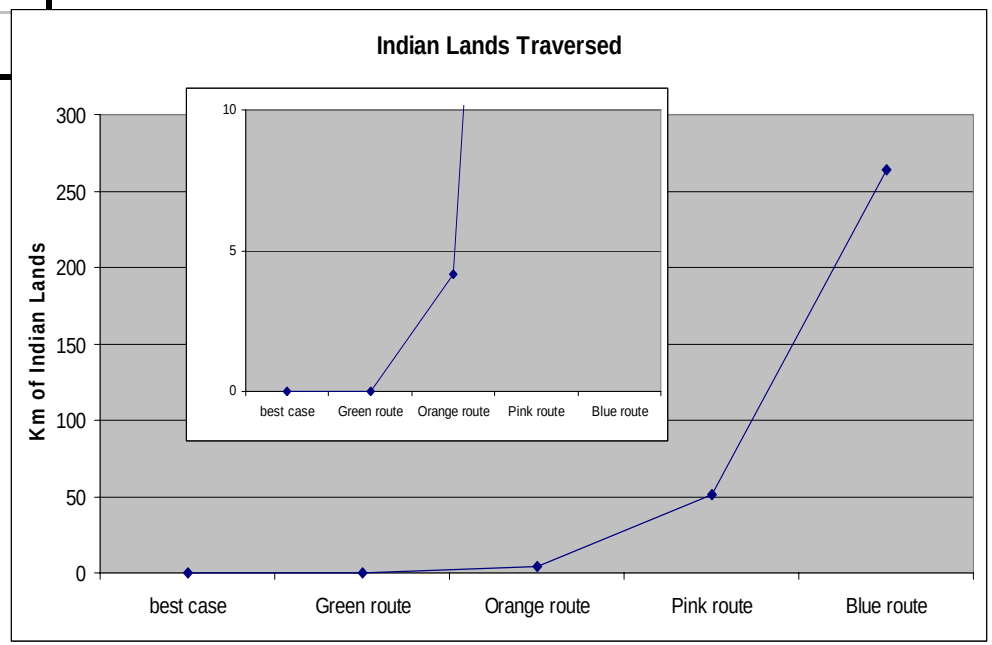
Ranking Of Indian Land Transit

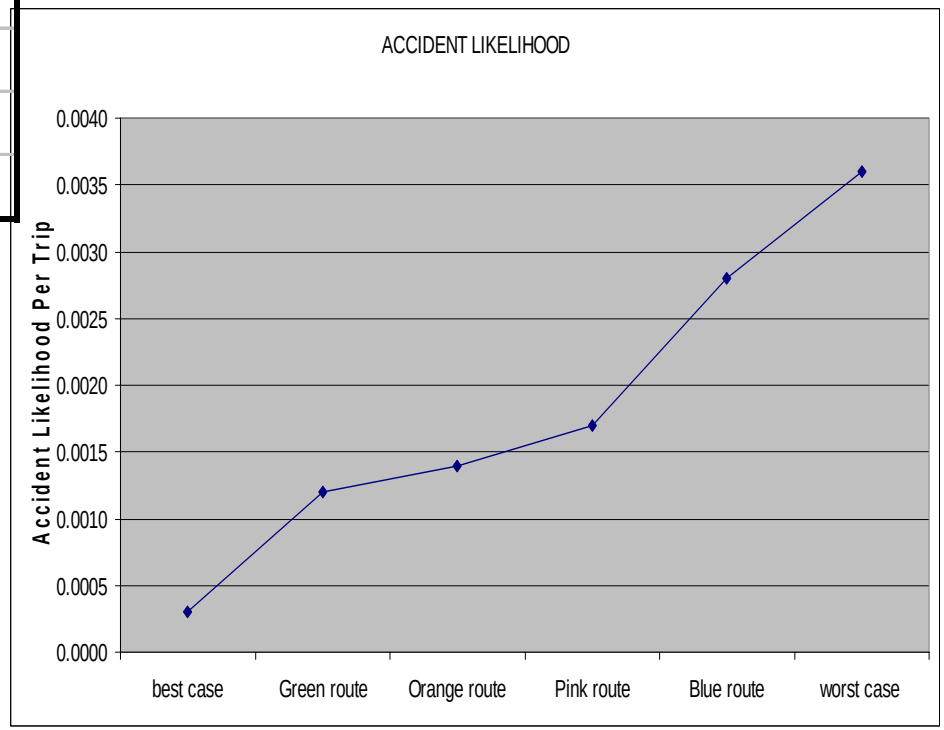
	km Indian land	rank
best case	0	
Green route	0	1.00
Orange route	4.2	0.65
Pink route	51.3	0.41
Blue route	264.0	0.12



Source:; WebTRAGIS

Ranking Accident Likelihood

	accidents	rank
best case	0.0003	
Green route	0.0012	0.64
Orange route	0.0014	0.58
Pink route	0.0017	0.48
Blue route	0.0028	0.15
worst case	0.0036	



Source: Federal Railroad Administration

Ranking Avoidance Of One State

AVOID MY STATE (e.g., Illinois)		
		rank
best case	1	
Green route	5	0
Orange route	5	0
Pink route	1	1
Blue route	1	1
worst case	5	

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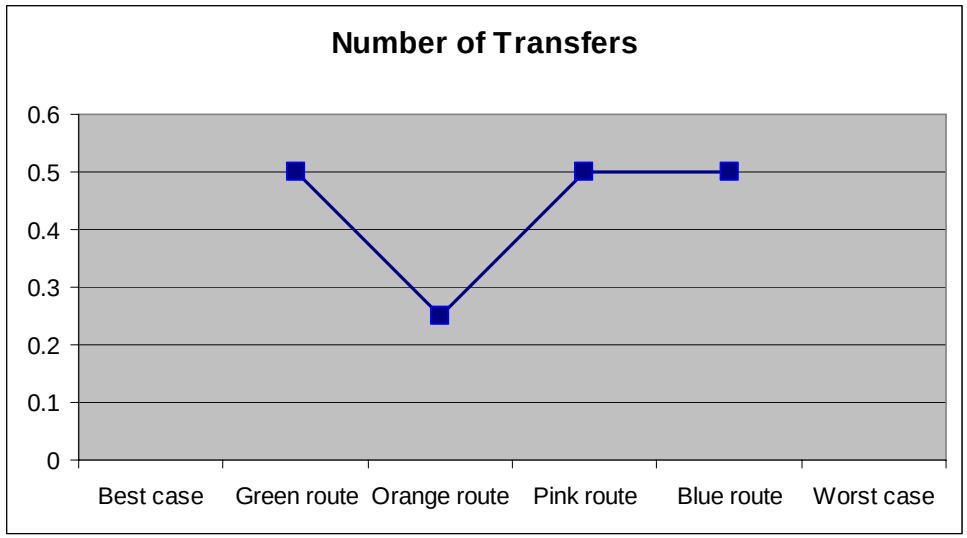
Ranking Number of Interchanges

	interchanges	rank
Best case	0	
Green route	2	0.5
Orange route	3	0.25
Pink route	2	0.5
Blue route	2	0.5
Worst case	4	



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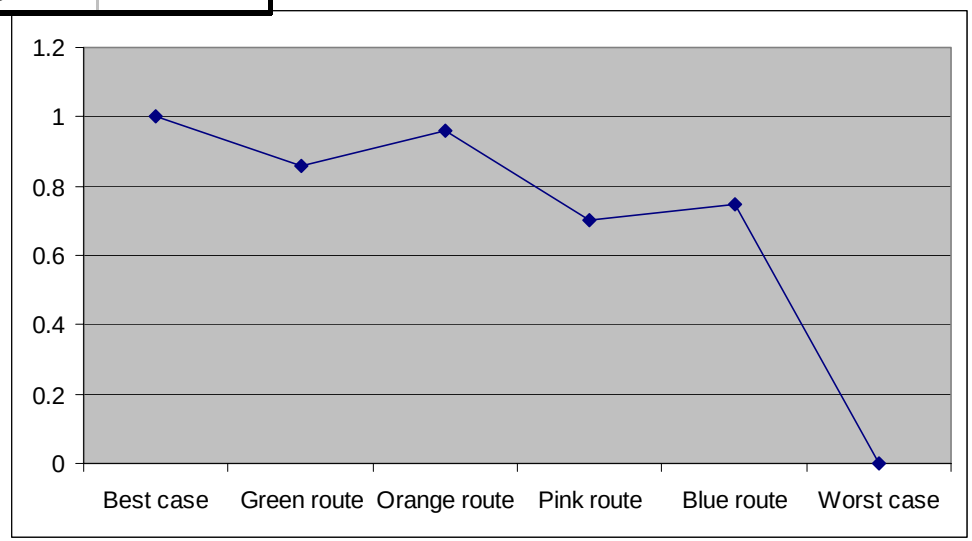
Ranking Track Quality

	fraction A track	
Best case	1	
Green route	0.86	
Orange route	0.96	
Pink route	0.7	
Blue route	0.75	
Worst case	0	



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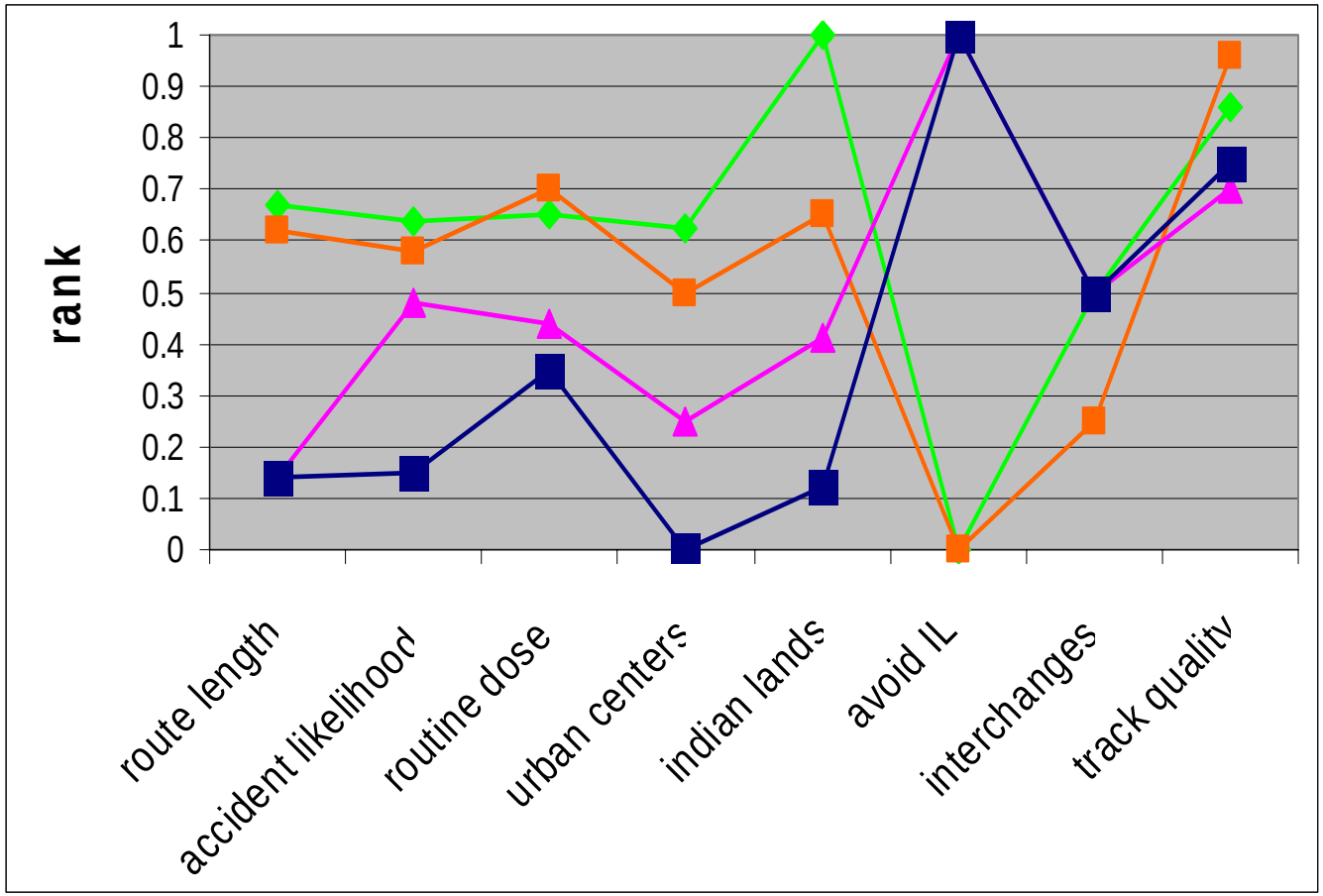
Comparison of Ranks



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Semi-quantitative Assessment of Preferences

	Sample importance	Rankings				Importance x Rankings			
		Green	Orange	Pink	Blue	Green	Orange	Pink	Blue
route length	20	0.67	0.62	0.14	0.14	13.4	12.4	2.8	2.8
accident likelihood	18	0.64	0.58	0.48	0.15	11.5	10.4	8.6	2.7
routine dose	5	0.65	0.7	0.44	0.35	3.3	3.5	2.2	1.8
urban centers	15	0.625	0.5	0.25	0	9.4	7.5	3.8	0.0
indian lands	15	1	0.65	0.41	0.12	15.0	9.8	6.2	1.8
avoid IL	9	0	0	1	1	0.0	0.0	9.0	9.0
interchanges	8	0.5	0.25	0.5	0.5	4	2	4	4
track quality	10	0.86	0.96	0.7	0.75	8.6	9.6	7.0	7.5
						65.1	**55.2**	**43.5**	**29.6**

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Sensitivity of Results

- **How sensitive is each criterion to its importance to the decision maker?**
- **Sensitivity analysis will indicate which criteria dominate (if any).**
- **Remember that ranking is usually *objective*, but importance weight is *subjective.***
  - **Example: accident rate is based on actual data, but the importance a decision maker gives to accident rate depends on the decision maker.**

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Sensitivity To Decision Maker's Importance Weights

	original importance weights	increase indian lands importance	increase track quality importance	increase urban areas importance	increase state acceptance importance
Green route	**65**	**66**	**74**	**65**	40
Orange route	55	48	70	54	*32*
Pink route	44	38	51	36	**56**
Blue route	*30*	*19*	*42*	*18*	45

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Observations

- **The Blue Route is the least preferred under all sensitivities except avoiding one state**
  - **It is the longest, goes through the most cities, goes through Las Vegas and California**
  - **Coincides with non-quantitative estimate of desirability**
  - **Applying most criteria, equally or unequally, shows this route to be least desirable**
- **Preferences among the other three routes depend on the decision maker and what is important to the decision maker**
- **How potential criteria would be applied is critical in route selection**
- **The decision-maker has options and flexibility.**

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Group Exercise

- Each group may decide the decision maker(s) whom they wish to represent.
- The same route parameters (route length, accident likelihood, etc.) will be used because we have data for these.
- Decision makers will indicate their importance weights using the “100 point” system.
- The spreadsheets have been set up so that importance weights can be entered and preferences are calculated immediately
- The groups can then compare results.
- A limited amount of additional data are available. If time permits,groups may suggest new criteria and repeat the exercise.

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