SAND2007-6943C

APPLICATION OF DECISION-AIDING TECHNIQUES TO TRANSPORTATION ROUTES

Ruth F. Weiner, Sandia National Laboratories

PATRAM

October 22-26, 2007

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.

Decision Analysis Literature

- **Keeney, Ralph and Raiffa, Howard: *Decisions With Multiple Objectives,* 1986.**
- **Keeney, Ralph: *Siting Energy Facilities*, 1987**
- **Weiner, R. F. and Quiggle, R. " Multiattribute Decision Analysis for the HLW Repository Sites Selected for Characterization" *Research Notes; Northwest Environmental Journal*, 1987, pp. 165-166.**
- **Keeney, Ralph and Raiffa, Howard: *Decisions With Multiple Objectives,* 1993**
- **Prindle, M. H., Tierney, M., Weiner, R. F., Boak, D. M., Hora, S. "Decision-Making for Geological Repositories" International Conference on Geologic Disposal of Radioactive Waste, Winnipeg, Canada, September, 1996.**
- **Prindle, M. H., et al. *Second Iteration of the System Prioritization Method v. III: Analysis for Final Programmatic Recommendations*, Sandia National Laboratories, Albuquerque, NM, 1996.**

Sandia National Laboratories

Characteristics of a Multi-Attribute Decision Analysis

- Many goals
- Some goals conflict with others
- Often includes tradeoffs
- The analysis has a large subjective component – different decision-makers will make different decisions

Sample Decision Analysis

Example: selecting a transportation route

Goals:

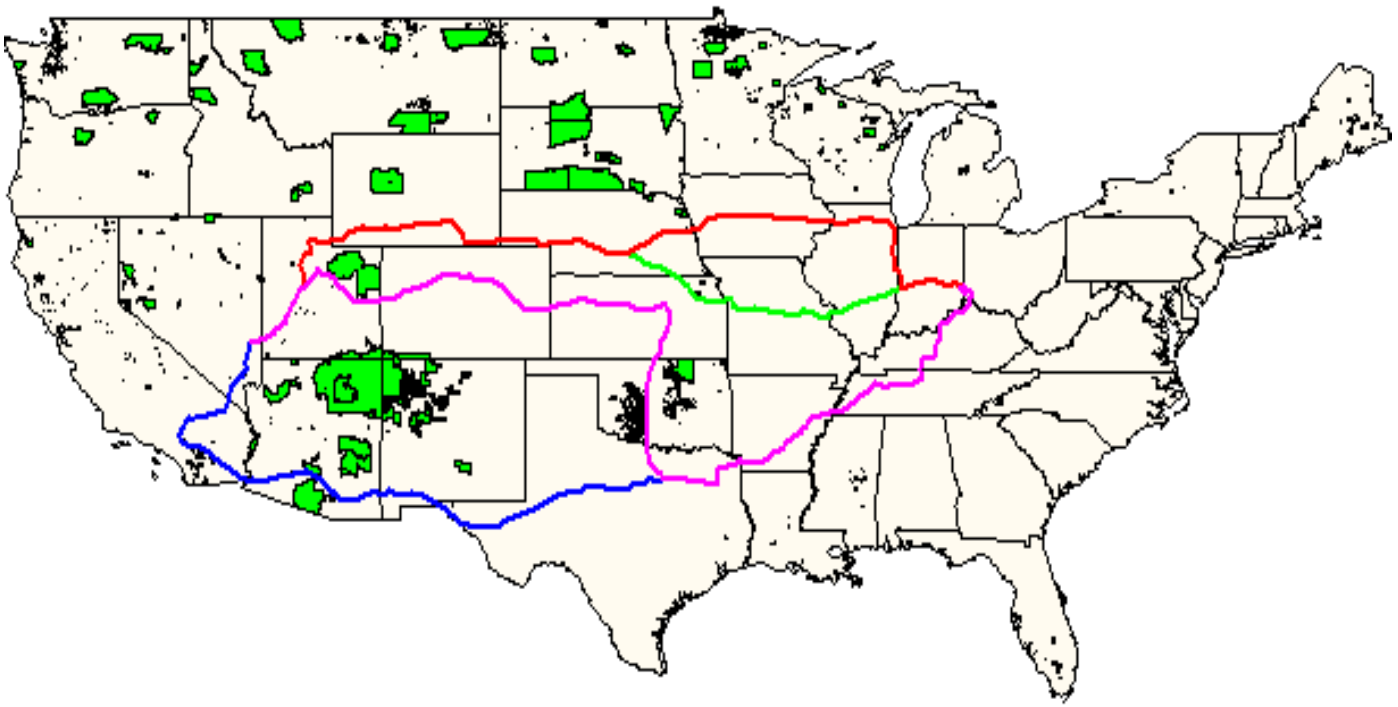
- **Avoid certain states**
- **Minimize transit through urban areas**
- **Minimize transit across tribal lands**
- **Minimize route length**
- **Minimize likelihood of accidents**

Sample Decision Analysis

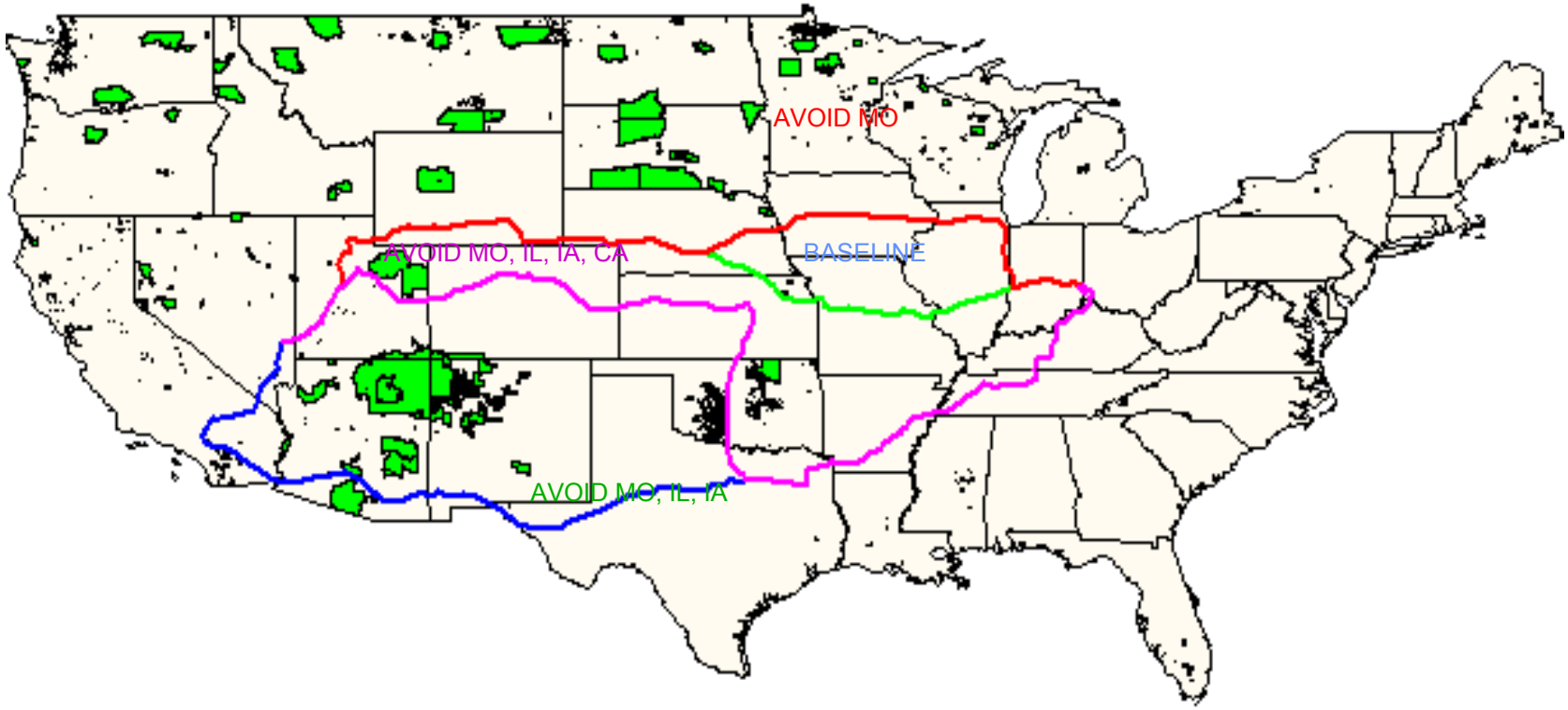
Goals contain the attributes of the decision:

- **Minimize transit through urban areas**
  - **Length of route segments through urban populations**
- **Minimize transit across tribal lands**
  - **Distance across tribal lands**
- **Minimize route length**
  - **Total distance traveled on each route**
- **Minimize likelihood of accidents**
  - **Accident frequency on each route (state by state)**

Sample Alternate Routes

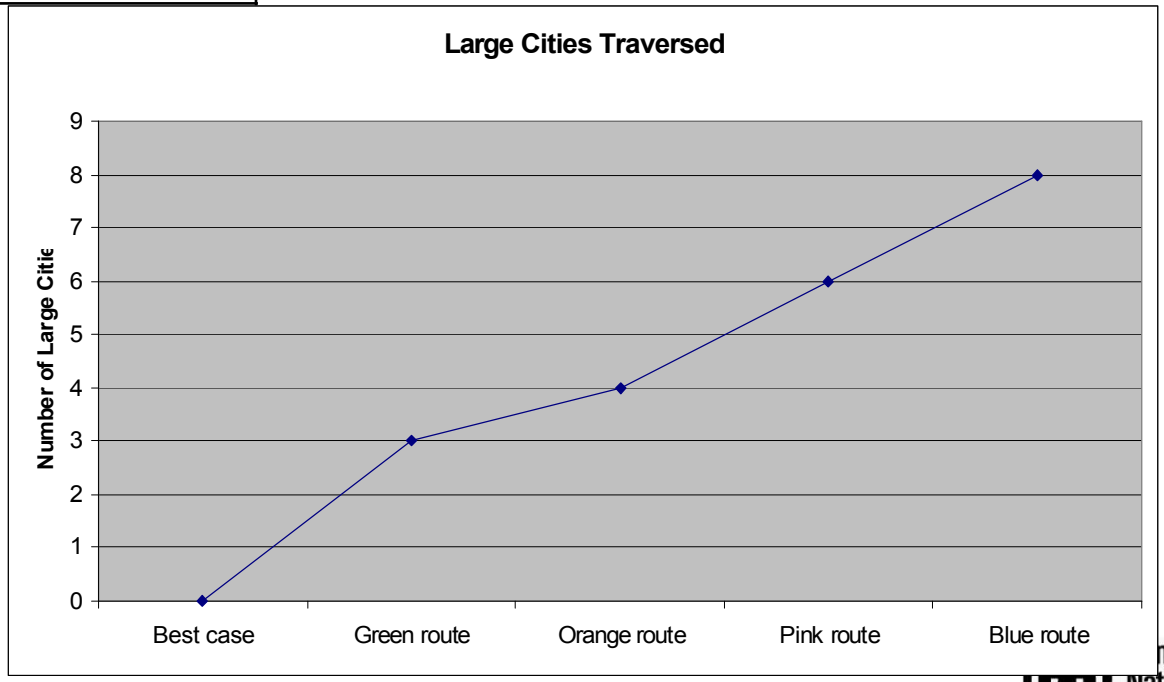


Sandia National Laboratories


AVOID MO
AVOID MO, IL, IA, CA
BASELINE
AVOID MO, IL, IA

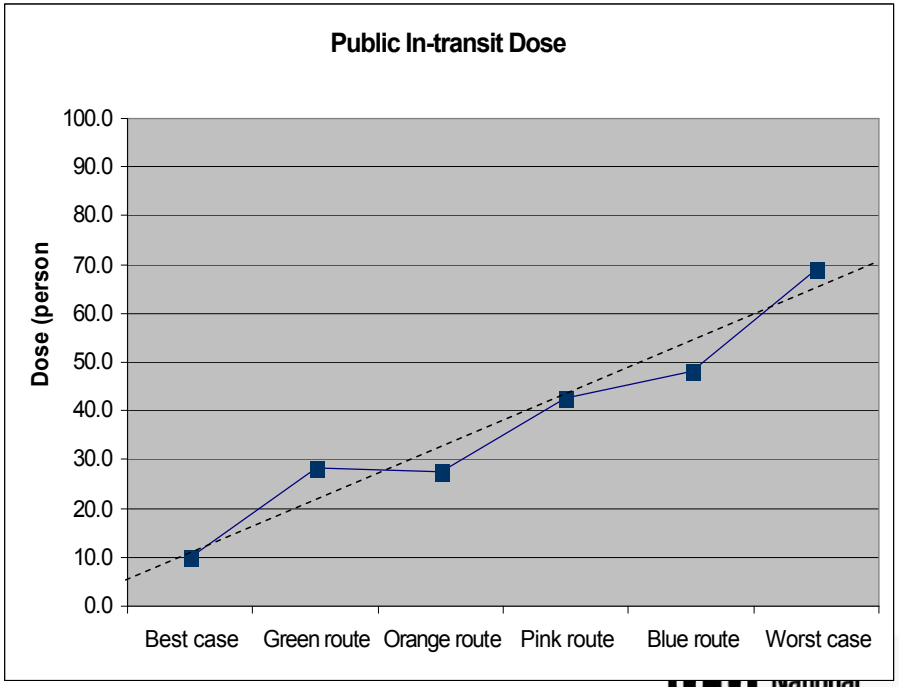
Ranking the Attributes

	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	



Ranking the Attributes – Another Example

	PUBLIC IN-TRANSIT DOSE (person-mrem)				
	R	S	U	TOTAL	RANK
Best case				9.9	
Green route	1.297	12.003	0.805	28.305	0.69
Orange route	1.382	12.797	1.159	27.738	0.70
Pink route	1.844	21.55	1.311	42.805	0.44
Blue route	1.899	24	1.735	48.034	0.35
Worst case				69.0	



Weighting the Attributes

Original Importance Weights

	Sample importance	Rankings				Importance x Rankings			
		Green	Orange	Pink	Blue	Green	Orange	Pink	Blue
route length	22	0.67	0.62	0.14	0.14	14.7	13.6	3.1	3.1
accident likelihood	20	0.64	0.58	0.48	0.15	12.8	11.6	9.6	3.0
routine dose	10	0.65	0.7	0.44	0.35	6.5	7.0	4.4	3.5
urban centers	20	0.625	0.5	0.25	0	12.5	10.0	5.0	0.0
indian lands	15	1	0.65	0.41	0.12	15.0	9.8	6.2	1.8
avoid IL	13	0	0	1	1	0.0	0.0	13.0	13.0
						61.5	**52.0**	**41.2**	**24.4**

Weighting the Attributes

State Acceptance Least Important

	Sample importance	Rankings				Importance x Rankings			
		Green	Orange	Pink	Blue	Green	Orange	Pink	Blue
	weights	Green route	Orange route	Pink route	Blue route	Green route	Orange route	Pink route	Blue route
rte length	24.6	0.7	0.6	0.1	0.1	16.5	15.3	3.4	3.4
accident prob	22.6	0.6	0.6	0.5	0.2	14.5	13.1	10.8	3.4
routine dose	12.6	0.7	0.7	0.4	0.4	8.2	8.8	5.5	4.4
urbanctrs	22.6	0.6	0.5	0.3	0.0	14.1	11.3	5.7	0.0
indian lands	17.6	1.0	0.7	0.4	0.1	17.6	11.4	7.2	2.1
avoid IL	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
						70.9	59.9	32.7	13.4

Weighting the Attributes

Route Length Least Important

	Sample importance	Rankings				Importance x Rankings			
		Green	Orange	Pink	Blue	Green	Orange	Pink	Blue
	weights	Green route	Orange route	Pink route	Blue route	Green route	Orange route	Pink route	Blue route
rte length	0	0.67	0.62	0.14	0.14	0	0	0	0
accident prob	24.4	0.64	0.58	0.48	0.15	15.6	14.2	11.7	3.7
routine dose	14.4	0.65	0.7	0.44	0.35	9.4	10.1	6.3	5.0
urbanctrs	24.4	0.625	0.5	0.25	0	15.3	12.2	6.1	0.0
indian lands	19.4	1	0.65	0.41	0.12	19.4	12.6	8.0	2.3
avoid IL	17.4	0	0	1	1	0.0	0.0	17.4	17.4
						59.6	49.0	49.5	28.4

Weighting the Attributes

State Acceptance, Dose From Routine Transportation Least Important

	Sample importance	Rankings				Importance x Rankings			
		Green	Orange	Pink	Blue	Green	Orange	Pink	Blue
rte length	27.8	0.7	0.6	0.1	0.1	18.6	17.2	3.9	3.9
accident prob	25.8	0.6	0.6	0.5	0.2	16.5	14.9	12.4	3.9
routine dose	0.0	0.7	0.7	0.4	0.4	0.0	0.0	0.0	0.0
urbanctrs	25.8	0.6	0.5	0.3	0.0	16.1	12.9	6.4	0.0
indian lands	20.8	1.0	0.7	0.4	0.1	20.8	13.5	8.5	2.5
avoid IL	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
						71.9	58.5	31.2	10.2

Some Observations

• The MUA method combines an objective criterion, **rank**, with a subjective criterion, **weight.**

• This is a decision **aiding** method, not a method that makes decisions.

• "Weight" is the importance of any attribute or parameter of a decision **to the decision maker.**

• These numbers are meaningful only in comparison

• "Gaming" this type of system is not easy or trivial

• MUA is not a popular decision aiding method.