2/8/08

Nimisha Mittal

100

ASE 379L

Assignment 3 – Analytical Hierarchy Process

Problem 1

Figures of Merit
crew safety
cost
schedule
extensibility

Mission Modes
EOR
LOR
Nova Direct

Prioritization Matrix

Score:

	crew safety	cost	schedule	extensibility
crew safety	1.00	5.00	3.00	8.00
cost	0.20	1.00	0.25	5.00
schedule	0.33	4.00	1.00	7.00
extensibility	0.13	0.20	0.14	1.00
	1.66	10.20	4.39	21.00

crew safety	cost	schedule	extensibility	Score:
0.60	0.49	0.68	0.38	0.54
0.12	0.10	0.06	0.24	0.13 ✓
0.20	0.39	0.23	0.33	0.29
0.08	0.02	0.03	0.05	0.04
1.00	1.00	1.00	1.00	1.00

Are the resulting weightings and order what you expected?

The resulting weightings are according to my expectations. Crew safety was the most important factor, followed by the schedule of launch (due to the space race with the Soviets). The cost was secondary, since money was being poured into the space program by the government. Extensibility, for this mission, was not as important as the other attributes in this case, because the primary goal of this mission was to follow the Presidential directive of taking man to the moon and bringing him back to earth safely. ✓

2/8/08

Nimisha Mittal

Crew safety	EOR	LOR	Nova Direct
EOR	1.00	2.00	0.50
LOR	0.50	1.00	0.33
Nova Direct	2.00	3.00	1.00
	3.50	6.00	1.83

EOR	LOR	Nova Direct
0.29	0.33	0.27
0.14	0.17	0.18
0.57	0.50	0.55
1.00	1.00	1.00

Score

0.30
0.16
0.54
1.00

✓

Schedule	EOR	LOR	Nova Direct
EOR	1.00	0.25	5.00
LOR	4.00	1.00	8.00
Nova Direct	0.20	0.13	1.00
	5.20	1.38	14.00

EOR	LOR	Nova Direct
0.19	0.18	0.36
0.77	0.73	0.57
0.04	0.09	0.07
1.00	1.00	1.00

0.24
0.69
0.07
1.00

✓

Cost	EOR	LOR	Nova Direct
EOR	1.00	0.14	0.33
LOR	7.00	1.00	5.00
Nova Direct	3.00	0.20	1.00
	11.00	1.34	6.33

EOR	LOR	Nova Direct
0.09	0.11	0.05
0.64	0.74	0.79
0.27	0.15	0.16
1.00	1.00	1.00

0.08
0.72
0.19
1.00

✓

Extensibility	EOR	LOR	Nova Direct
EOR	1.00	4.00	0.20
LOR	0.25	1.00	0.14
Nova Direct	5.00	7.00	1.00
	6.25	12.00	1.34

EOR	LOR	Nova Direct
0.16	0.33	0.15
0.04	0.08	0.11
0.80	0.58	0.74
1.00	1.00	1.00

0.21
0.08
0.71
1.00

✓

2/8/08

Nimisha Mittal

Summary	crew safety		schedule		cost		extensibility		Final Score
	Weighting	Score	Weighting	Score	Weighting	Score	Weighting	Score	
EOR	0.54	0.30	0.29	0.24	0.13	0.08	0.04	0.21	0.25
LOR	0.54	0.16	0.29	0.69	0.13	0.72	0.04	0.08	0.38
Nova Direct	0.54	0.54	0.29	0.07	0.13	0.19	0.04	0.71	0.37

✓

Which mission mode is the most preferred? Do your results agree with the decision made by the Apollo program? Briefly discuss.

According to the above AHP analysis, Lunar Orbital Rendezvous (LOR) is the most preferred , Nova Direct is second (although very close to the LOR score), and Earth Orbital Rendezvous (EOR) is third. The final result agrees with the decision made by the Apollo program, which chose the LOR mission mode to accomplish the manned lunar landing. The Apollo program would probably have placed EOR second on its list of preferred mission modes, which does not agree with the above results. This may be due to the figures of merit (FOMs) that we considered in this analysis.

✓

Problem 2

1. Scientific significance and Security

   Meaning: The contribution of the mission to the NASA vision. Success will be measured based on how valuable the mission is to the scientific community on Earth, and how the technology developed will assist with US Security and advancement.

   Importance: With so many goals and objectives in the NASA vision, prioritizing missions will become a huge factor in determining the route the space program takes. This is an extremely important figure of merit because it concerns political factors such as US superiority in science and technology, and national security.

2. Crew Safety

   Meaning: Every space exploration vehicle and mission should be designed in a way that poses the least threat to human life; even if the mission fails, life must not be lost due to technical errors.

   Importance: Crew safety is vital for future space exploration and continuity of the space program. Extra precautions will be needed since humans will be exploring new and hostile environments.

3. Cost

   Meaning: This includes the cost of research, development, construction and operation of the mission.

   Importance: Cost overruns are extremely important due to changing governments and limited budgets. More missions will need more funds, and tax-payers money must be used wisely – to give tangible results.

4. Schedule

   Meaning: The time spent in planning, building, testing and executing the mission.

   Importance: Every mission should have a definite and realistic schedule. Long term missions are likely to fail or remain incomplete due to changes in government funding.

2/8/08

Nimisha Mittal

Problem 3 – AHP

The Analytic Hierarchy Process (AHP) is a method commonly used for multicriteria decision making. It is an accepted technique which is also recommended for use in the NASA systems engineering handbook. The method uses pairwise comparisons of different figures of merit (FoM's) as attributes to determine their relative weightings, and finally a score which can be used to rank mission modes or other variables.

The two papers "Some comments on the Analytic Hierarchy Process" by R. D. Holder, and "Response to Holder's Comments on the Analytic Hierarchy Process" by Thomas L. Saaty, present some very interesting arguments which criticize and defend AHP respectively. Holder disapproves of AHP's scale and ranking system, and calls it "illogical" while Saaty vehemently defends AHP, citing a more-updated method, and justifying changes in ranks amongst the attributes.

I think that AHP is a useful method that attempts to simplify a complex decision-making process by prioritizing, weighting and scoring attributes. Its main advantage is that it makes use of pairwise comparisons to tabulate the relative importance of concepts and attributes. It considers all feasible alternatives that satisfy the mission requirements. According to Saaty, AHP is a non-numerical method equipped to make unambiguous decisions. ✓

However, AHP has certain flaws, as Holder pointed out. Its scaling system from 1-9 is rather arbitrary, and leads to uncertainties because it is often difficult to rate the importance of one concept relative to another. Holder suggested a non-linear (power) scale, which Saaty

refuted with the argument that 'the problem is ... of finding the right number to represent comparison s of objects that are close on one property'. AHP is highly subjective, and the person using this technique must have a very thorough knowledge of all the figures of merit, and enough background information to rate the attributes correctly. AHP also experiences changes in rankings (rank reversal) when a new concept is added or removed from a system.

Since AHP is widely used in many professional settings, it cannot be completely rejected either. NASA has listed it as one of its recommended decision making approaches. In my opinion, AHP is a technique which cannot stand alone due to its ambiguities. A more specific scaling system should be developed (for example, one that defines what rating one attribute should be given over another, based on performance or risk values). However, it is a valuable method, and can be used to gain insight into a system, as well as in making preliminary decisions. Other decision-making methods should be used in conjunction with AHP to get an accurate picture.

AHP can be implemented in certain engineering problems to get a subjective perspective, because it is important to think of problems in more than just a numerical sense. AHP will not work for all engineering problems, primarily the ones which are complex, detailed, and involve engineering judgment. As seen in problem 1, the final score for two mission modes are extremely close; therefore, AHP cannot be relied on for accurate numerical results, and should also be treated as a basic subjective analysis.

✓

good!