ПРОБЛЕМИ ПРИЙНЯТТЯ РІШЕНЬ І УПРАВЛІННЯ В ЕКОНОМІЧНИХ, ТЕХНІЧНИХ, ЕКОЛОГІЧНИХ І СОЦІАЛЬНИХ СИСТЕМАХ

UDC 519.5

THE ANALYTIC NETWORK PROCESS. EXAMPLES. PART 2.3

THOMAS L. SAATY

We give here the details of an application of the ANP to National Missile Defense (NMD), a $60 billion decision (one of the costliest undertaking ever) by the United States to deploy an anti-nuclear-missile missile defense system. This study I did in September 2000 developed with its strategic criteria, and benefits, opportunities, costs and risks. Deploy NMD is the highest priority outcome, that is validated by sensitivity analysis. It was presented to the National Defense University in Washington in February 2002. In mid-December 2002 the US Government announced that it planned to develop the NMD — at best an interesting coincidence. Another example, done in September-October 2002, was about the strategy that the US should follow to remove the Saddam Hussein regime in Iraq. Going with the UN was the best outcome followed by a going alone or with a coalition.

1. INTRODUCTION — THE NATIONAL MISSILE DEFENSE (NMD)

Having given the steps of the Analytic Network Process (ANP) in Part 2.2, we will dedicate Part 2.3 to full blown examples of applications of the ANP.

Not long ago, the United States government faced the crucial decision of whether or not to commit itself to the deployment of a National Missile Defense (NMD) system. Many experts in politics, the military, and academia had expressed different views regarding this decision. The most important rationale behind supporters of the NMD system was protecting the U.S. from potential threats said to come from countries such as North Korea, Iran and Iraq. According to the Central Intelligence Agency, North Korea's Taepo Dong long-range missile tests were successful, and it has been developing a second generation capable of reaching the U.S. Iran also tested its medium-range missile Shahab-3 in July 2000. Opponents expressed doubts about the technical feasibility, high costs (estimated at $60 billion), political damage, possible arms race, and the exacerbation of foreign relations.

The idea for the deployment of a ballistic missile defense system has been around since the late 1960s but the current plan for NMD originated with President Reagan's Strategic Defense Initiative (SDI) in the 1980s. SDI investigated technologies for destroying incoming missiles. The controversies surrounding the project were intensified with the National Missile Defense Act of 1996, introduced by Senator Sam Nunn (D-GA) in June 25, 1996. The bill required Congress to make a decision on whether the U.S. should deploy the NMD system by 2000. The bill also targeted the end of 2003 as the time for the U.S. to be capable of deploying NMD. The idea explored in this project is to develop and illustrate the three phases with a timely example, the intricate and very costly decision regarding a National Missile Defense (NMD) system. Because of the possibility of de-

pendence and feedback, we use the Analytic Network Process (ANP) and its software Super-Decisions with its sensitivity analysis option to examine the NMD decision. On February 21, 2002 this author gave a half-day presentation on the subject to National Defense University in Washington. In December 2002, President George W. Bush and his advisors decided to build the NMD. This study may have had no influence on the decision but still two years earlier (September 2000) it had arrived at the same outcome. The alternatives we considered for this analysis are: Deploy NMD, Global defense, R&D, Termination of the NMD program.

2. CRITERIA AND DECISION NETWORKS

The second column of Tabl. 1 shows the criteria of each BOCR. For example, there are four benefits criteria: Economic (0.157), Political (0.074), Security (0.481) and Technology (0.288). The priorities attached to each are obtained through pairwise comparisons. Each criterion under benefits has subcriteria such as Local Economy and Defense Industry under Economic. Again, the priorities of the two subcriteria are obtained from pairwise comparisons and similarly for the remaining criteria and subcriteria under opportunities, costs and risks. Opportunities and risks have no subcriteria. The total number of criteria and subcriteria used as control criteria for the comparisons made in the networks is 23. The global priorities of these criteria (subcriteria) shown in the last column of Tabl. 1 are obtained by weighting their priorities by those of their parent criterion if there is one. For example, for local economy we have $0.157 \times 0.141 = 0.022$. We will see later, after the BOCR merits are weighted, that the priorities of nine of these (shown in boldface), Military Capability, Technological Advancement, Arms Sales, Spin-Off, Security Threat, Sunk Cost, Further Investment, Arms Race, and Technical Failure account for approximately 0.760 of the total. To economize effort, we used these nine as control criteria each with its decision network to do the analysis. Actually we simply chose the top ones under each merit without being fully consistent about the cutoff point. For example we left out U.S. Reputation under Risks. All economic cost factors were included. We proceeded as if these nine criteria and subcriteria, called covering criteria for the alternatives, were the only criteria to drive the outcome. Their decision networks and connections are shown in Fig. 1–9. A more thorough analysis might include a few more criteria or subcriteria.

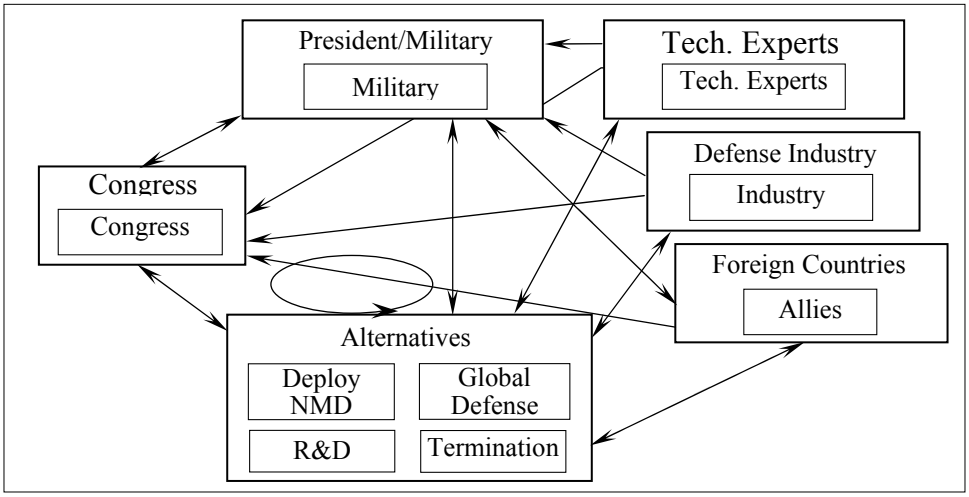


Fig. 1. Decision Network under The Military Capability.
Control Subcriterion of Benefits

Table 1. Criteria and Their Priorities

Merits	Criteria	Sub-criteria	Global Priorities (Normalized)
Benefits	Economic (0.157)	Local Economy (0.141)	0.022
		Defense Industry (0.859)	0.135
	Political (0.074)	Bargaining Power (0.859)	0.064
		U.S. Military Leadership (0.141)	0.010
	Security (0.481)	Deterrence (0.267)	0.128
		Military Capability (0.590)	**0.284**
		Antiterrorism (0.143)	0.069
	Technology (0.288)	Tech. Advancement (0.834)	0.**240**
		Tech. Leadership (0.166)	0.048
Opportunities		Arms Sales (0.520)	**0.520**
		Spin- off (0.326)	**0.326**
		Space Development (0.051)	0.051
		Protection of Allies (0.103)	0.103
Costs	Security Threat: Vulnerability to the security threat		**0.687**
	Economic (0.228)	Sunk Cost (0.539)	**0.123**
		Further Investment (0.461)	**0.105**
	Political (0.085)	ABM Treaty (0.589)	0.050
		Foreign Relations (0.411)	0.035
Risks		Technical Failure (0.430)	**0.430**
		Arms Race (0.268)	**0.268**
		Increased Terrorism (0.052)	0.052
		Environmental Damage (0.080)	0.080
		U.S. Reputation (0.170)	0.170

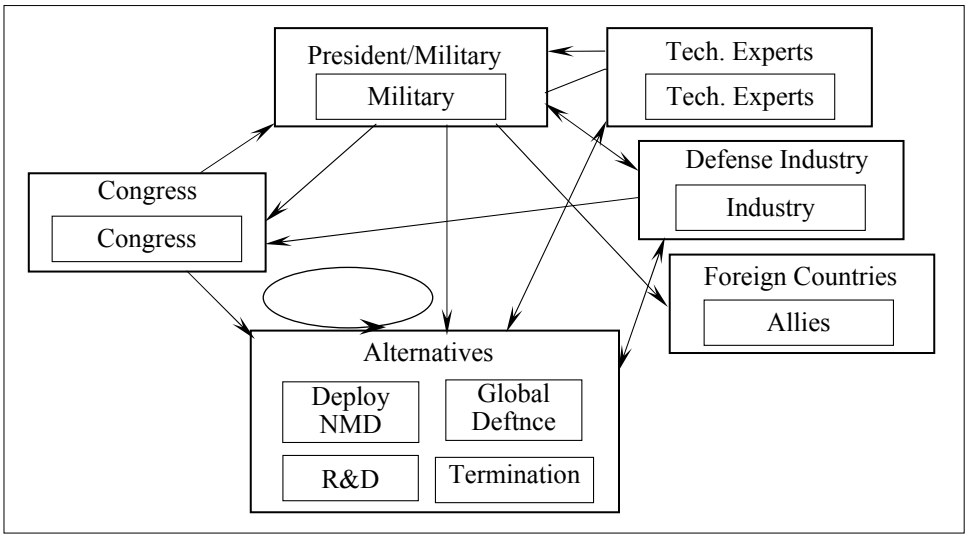


Fig. 2. Decision Network under The Technological Advancement. Control Subcriterion of Benefits

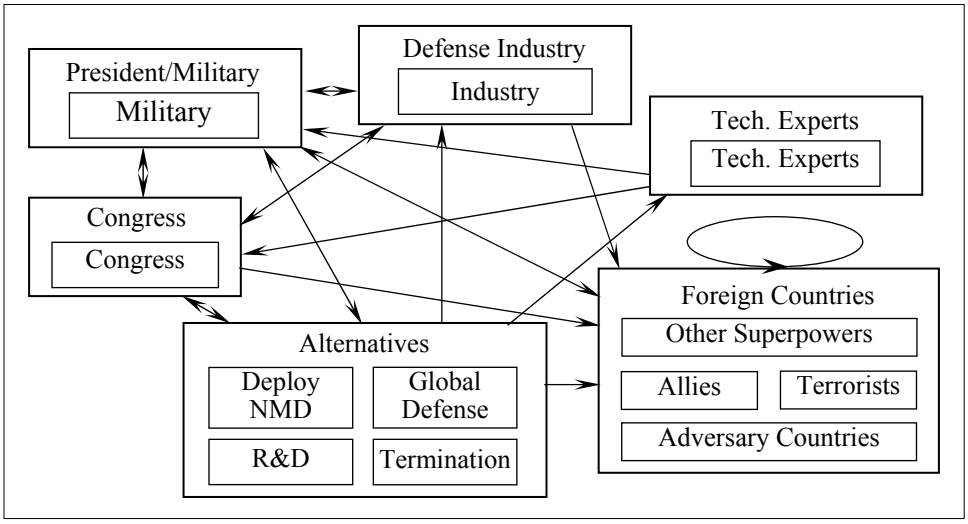


Fig. 3. Decision Network under The Arms Sales.
Control Criterion of Opportunities

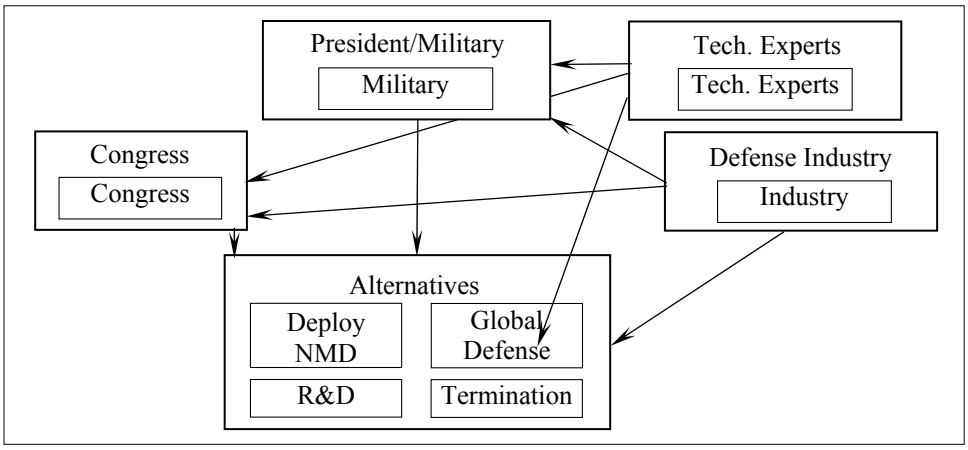


Fig. 4. Decision Network under The Spin-Off.
Control Criterion of Opportunities

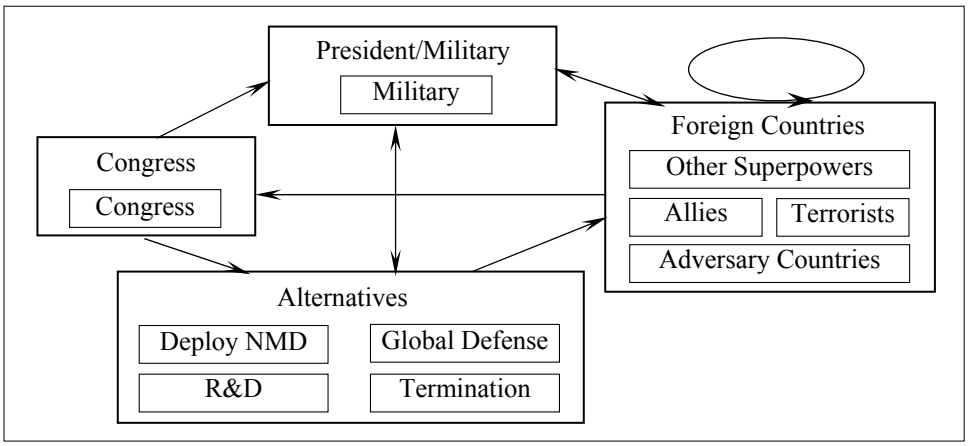


Fig. 5. Decision Network under the Security Threat.
Control Subcriterion of Costs

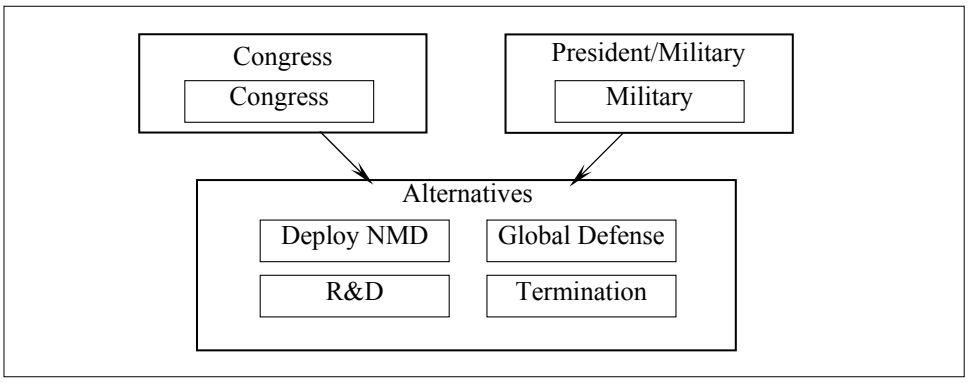


Fig. 6. Decision Network under the Sunk Cost.
Control Subcriterion of Costs

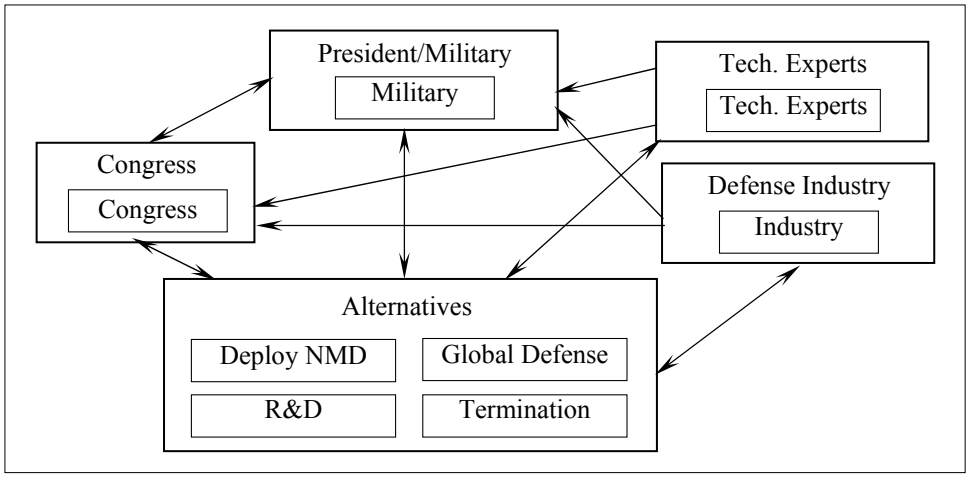


Fig. 7. Decision Network under The Further Investment.
Control Subcriterion of Costs

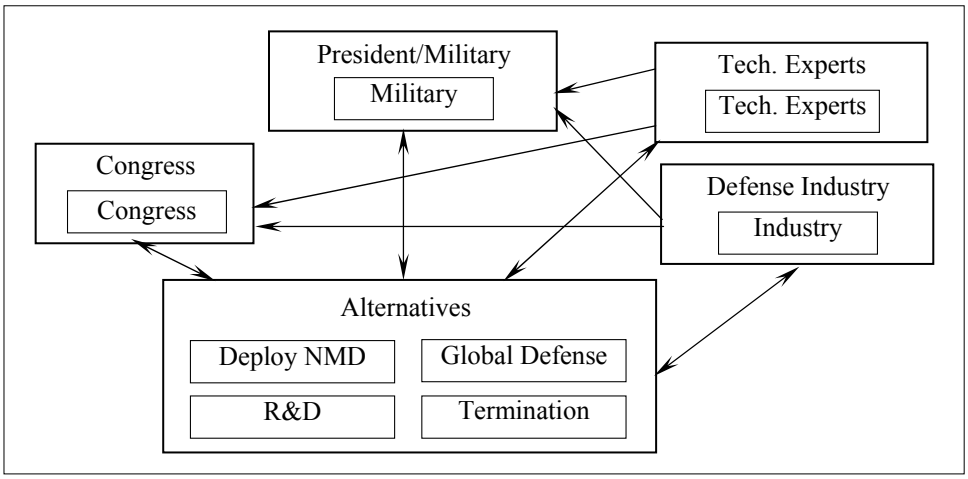


Fig. 8. Decision Networks Under the Technical Feasibility.
Control Criterion of Risks

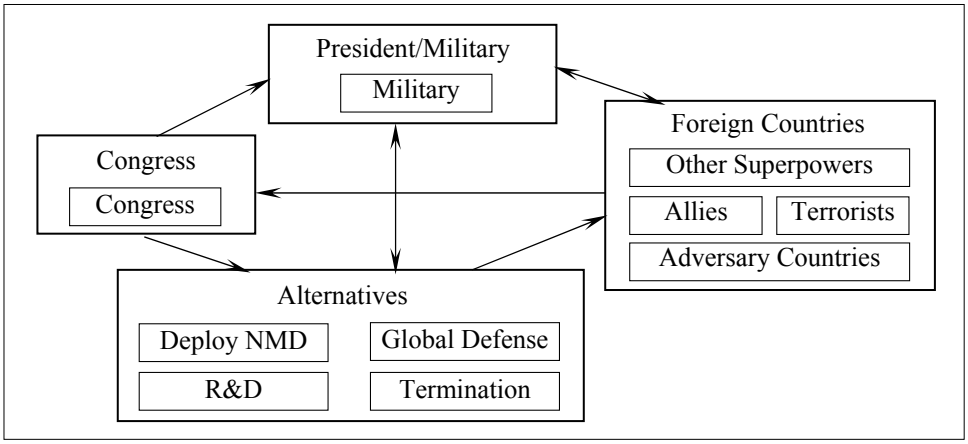


Fig. 9. Decision Network under the Arms Race. Control Criterion of Risks

3. FULL DEVELOPMENT OF THE ANALYSIS WITH RESPECT TO A SINGLE CRITERION

We explain in outline form our thinking about the network under one of the criteria. We have chosen Military Capability, one of the main control subcriteria, to elaborate the details of its decision network. There are five main parties involved in the decision making process of NMD: Congress, President/Military, Foreign Countries, Technical Experts and the Defense Industry. The latter two influence Congress and President/Military by providing their professional expertise and technical information. Allies among Foreign Countries can have a partial influence on Global Defense among the four alternatives through economic and technological cooperation.

The first block of four rows and four columns in Tabl. 2, *a*, The Unweighted Supermatrix, indicates that Deploy NMD (NMD) and R&D (R&D) are influenced by Global Defense (Glob~) with priorities of 0.5760 and 0.4240 respectively. The next five columns and first four rows of Tabl. 3, *a.* The Unweighted Supermatrix, summarize the different views of actors on the contribution of each of the four alternatives to U.S. military capability. Congress, President/Military, Defense Industry, and Technical Experts all have a say as to what extent the decision contributes to the Military Capability of the U.S. All domestic actors think that Deploy NMD will increase military capability followed by Global Defense, R&D and Termination (Term~) but to different degrees. Deploy NMD (0.5587) was given the highest priority by Defense Industry, followed by the priority given by President/Military (0.5158), and Congress (0.5060). The lowest priority given to NMD is by Technical Experts (0.2878). It reflects the opinion of scientists who think Deploy NMD is technically infeasible and would not contribute to the enhancement of U.S. military capability. Only Global Defense is influenced by Allies and thus the priority of Global Defense is equal to 1.0000.

The fifth to the last row of Tabl. 2,*a* show connections among components (clusters) each consisting of a single element except for the component of Alternatives that has four elements. The priorities of the entries in these rows must be either 1.0000 or 0.0000 depending on whether there is influence among them. For

example, the fifth to the ninth entries of column one have unit entries obtained from answering the question "Is the component of Congress influenced by Deploy NMD?," "Is the component of Defense Industry influenced by Deploy NMD?" and similarly for the other three alternatives. All actors are influenced by the three alternatives of Deploy NMD, Global Defense and R&D. Note that an entire column under Termination in the Unweighted Supermatrix of Tabl. 2,*a* consists of zeros because nothing is influenced by Termination and that leads to dropping the entire matter of missile defense. It is worth noting that under the Security Threat criterion of Costs (not shown here), the column under Termination in the Unweighted Supermatrix consists of non-zero values because security threat to the U.S. would continue particularly if Termination is chosen as it accentuates vulnerability of U.S. security.

Tabl. 2,*b* shows the pairwise comparisons of the components. The judgments were obtained by answering the question "Which of two components is influenced more by a third component with respect to military capability?" The eigenvectors of the pairwise comparisons of the components in the matrices of Tabl. 2,*b* are exhibited in Tabl. 2,*c*, augmented by zeros in those positions where the components on the left are not influenced by the component on top of the column. The Weighted Supermatrix of Tabl. 2,*d* illustrates the weighting of the blocks of the supermatrix by the priorities from the corresponding eigenvector of comparisons of the components in Tabl. 2,*c*. Tabl. 2,*e*, The Limit Supermatrix, yields the stable priorities of all the elements. From it, the priorities of the four alternatives are extracted and normalized. We obtain for (Deploy NMD, Global Defense, R&D, and Termination) the corresponding values (0.1532, 0.0968, 0.0438, 0.0201) which when normalized by dividing by their sum yields the priority vector (0.488, 0.308, 0.140, and 0.064). This vector is included on the right of the first row of Tabl. 3,4. Similar computations are done for the remaining eight high priority criteria and their normalized results are included in Tabl. 3. An entry in each subcolumn of the supermatrix indicates the relative priority within the block to which that subcolumn belongs that an element on the left is influence by the element on top of the column with respect to Military Capability. Each subcolumn is an eigenvector imported from a corresponding pairwise comparisons matrix not shown here because its elements can be approximately formed from the ratios of the corresponding priority vector. A subcolumn of zeros indicates no influence and therefore no comparisons matrix is needed.

Table 2. All Matrices for the Military Capability Decision Network of Benefits

Table 2,*a*. The Unweighted Supermatrix

MilCap		**Altern~**				**Cong~**	**Def. Ind~**	**For~**	**Pre/Mil~**	**Tech~**
Unweighted		NMD	Glob~	R & D	Term~	Cong~	Industry	Allies	Military	Tech~
Altern~	NMD	0.0000	0.5760	0.0000	0.0000	0.5060	0.5587	0.0000	0.5158	0.2878
	Glob~	0.0000	0.0000	0.0000	0.0000	0.2890	0.2574	1.0000	0.2929	0.2623
	R & D	0.0000	0.4240	0.0000	0.0000	0.1307	0.1382	0.0000	0.1367	0.2369
	Term~	0.0000	0.0000	0.0000	0.0000	0.0744	0.0457	0.0000	0.0546	0.2130
Cong~	Cong~	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000
Defense Ind~	Industry	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
For~	Allies	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
Pre/Mil~	Military	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000
Tech~	Tech~	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2,*b*. Pairwise Comparisons Matrices and Priorities of Components

Pairwise comparing components with respect to the Alternatives component							
Q: Which of a pair of components is influenced more by the Alternatives component with respect to Military Capability?							
	Altern~	**Cong~**	**Def. Ind~**	**For~**	**Pres~**	**Tech~**	**Prior.**
Altern~	1.0000	0.1667	0.2500	1.3300	0.1429	0.5556	**0.0486**
Cong~	5.9999	1.0000	2.2000	6.2000	0.7407	3.2000	**0.2889**
Def. Ind~	4.0000	0.4546	1.0000	4.0000	0.4115	2.2600	**0.1653**
For~	0.7519	0.1613	0.2500	1.0000	0.1250	0.5263	**0.0425**
Pres~	7.0000	1.3500	2.4300	8.0000	1.0000	5.1000	**0.3742**
Tech~	1.8000	0.3125	0.4425	1.9000	0.1961	1.0000	**0.0805**

Pairwise comparing components with respect to the Congress component			
Q: Which of a pair of components is influenced more by the Congress component with respect to Military Capability?			
	Altern~	**Pres~**	**Prior.**
Altern~	1.0000	0.5638	**0.3605**
Pres~	1.7736	1.0000	**0.6395**

Pairwise comparing components with respect to the Defense Industry component				
Q: Which of a pair of components is influenced more by the Defense Industry component with respect to Military Capability?				
	Altern~	**Cong~**	**Pres~**	**Prior.**
Altern~	1.0000	0.6769	0.5388	**0.2292**
Congr~	1.4773	1.0000	0.6600	**0.3181**
Pres~	1.8561	1.5152	1.0000	**0.4528**

Pairwise comparing components with respect to the Foreign Countries component				
Q: Which of a pair of components is influenced more by the Foreign Countries component with respect to Military Capability?				
	Altern~	**Cong~**	**Pres~**	**Prior.**
Altern~	1.0000	0.5556	0.3259	**0.1671**
Cong~	1.8000	1.0000	0.4632	**0.2781**
Pres~	3.0682	2.1591	1.0000	**0.5548**

Pairwise comparing components with respect to the Presidnet/Military component				
Q: Which of a pair of components is influenced more by the President / Military component with respect to Military Capability?				
	Altern~	**Cong~**	**For~**	**Prior.**
Altern~	1.0000	2.1887	3.6604	**0.5735**
Congr~	0.4569	1.0000	2.0377	**0.2799**
For~	0.2732	0.4907	1.0000	**0.1467**

Pairwise comparing components with respect to the Technical Experts component				
Q: Which of a pair of components is influenced more by the Technical Experts component with respect to Military Capability?				
	Altern~	**Cong~**	**Pres~**	**Prior.**
Altern~	1.0000	2.5379	2.5379	**0.5593**
Congr~	0.3940	1.0000	1.0000	**0.2204**
Pres~	0.3940	1.0000	1.0000	**0.2204**

Table 2,*c*. Priorities Matrix of Eigenvectors

How much components are influenced by each component; imported from the matrices of Tabl. 3b above						
Clusters	**Altern~**	**Cong~**	**Def. Ind~**	**For~**	**Pres~**	**Tech~**
Altern~	0.0486	0.3605	0.2292	0.1671	0.5735	0.5593
Cong~	0.2889	0.0000	0.3181	0.2781	0.2799	0.2204
Def. Ind~	0.1653	0.0000	0.0000	0.0000	0.0000	0.0000
For~	0.0425	0.0000	0.0000	0.0000	0.1467	0.0000
Pres~	0.3742	0.6395	0.4528	0.5548	0.0000	0.2204
Tech~	0.0805	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2,*d*. The Weighted Supermatrix

Priorities from Tabl. 3c are used to weight corresponding blocks of unweighted supermatrix of Tabl. 3,*a*										
MilCap		**Altern~**				**Cong~**	**Def. Ind~**	**For~**	**Pre/Mil~**	**Tech~**
Weighted		NMD	Glob~	R & D	Term~	Cong~	Industry	Allies	Military	Tech~
Altern~	NMD	0.0000	0.0280	0.0000	0.0000	0.1824	0.1280	0.0000	0.2958	0.1610
	Glob~	0.0000	0.0000	0.0000	0.0000	0.1042	0.0590	0.1671	0.1680	0.1467
	R & D	0.0000	0.0206	0.0000	0.0000	0.0471	0.0317	0.0000	0.0784	0.1325
	Term~	0.0000	0.0000	0.0000	0.0000	0.0268	0.0105	0.0000	0.0313	0.1191
Cong~	Cong~	0.3037	0.2889	0.3037	0.0000	0.0000	0.3181	0.2780	0.2799	0.2204
Defense Ind~	Industry	0.1737	0.1653	0.1737	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
For~	Allies	0.0446	0.0425	0.0446	0.0000	0.0000	0.0000	0.0000	0.1467	0.0000
Pre/Mil~	Military	0.3933	0.3742	0.3933	0.0000	0.6395	0.4528	0.5548	0.0000	0.2204
Tech~	Tech~	0.0846	0.0805	0.0846	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2,*e*. The Limit Supermatrix

The weighted supermatrix raised to sufficiently large powers to stabilize within rounded off four place decimals										
MilCap		**Altern~**				**Cong~**	**Def. Ind~**	**For~**	**Pre/Mil~**	**Tech~**
Limited		NMD	Glob~	R & D	Term~	Cong~	Industry	Allies	Military	Tech~
Altern~	NMD	0.1532	0.1532	0.1532	0.0000	0.1532	0.1532	0.1532	0.1532	0.1532
	Glob~	0.0968	0.0968	0.0968	0.0000	0.0968	0.0968	0.0968	0.0968	0.0968
	R & D	0.0438	0.0438	0.0438	0.0000	0.0438	0.0438	0.0438	0.0438	0.0438
	Term~	0.0201	0.0201	0.0201	0.0000	0.0201	0.0201	0.0201	0.0201	0.0201
Cong~	Cong~	0.2224	0.2224	0.2224	0.0000	0.2224	0.2224	0.2224	0.2224	0.2224
Defense Ind~	Industry	0.0513	0.0513	0.0513	0.0000	0.0513	0.0513	0.0513	0.0513	0.0513
For~	Allies	0.0619	0.0619	0.0619	0.0000	0.0619	0.0619	0.0619	0.0619	0.0619
Pre/Mil~	Military	0.3255	0.3255	0.3255	0.0000	0.3255	0.3255	0.3255	0.3255	0.3255
Tech~	Tech~	0.0250	0.0250	0.0250	0.0000	0.0250	0.0250	0.0250	0.0250	0.0250

4. BOCR WEIGHT DEVELOPMENT

The judgments used in this analysis were our interpretation of what experts thought about the various issues obtained from the vast reading of the literature we examined and from following the news closely for a period of more than six months. We also consulted some knowledgeable people on the subject in the area. We quickly realized there is no single expert in all the criteria we considered. Sensitivity analysis given later would essentially vary these judgments widely to determine the stability of the outcome. The assessment criteria used to determine the priorities of the BOCR merits are shown in Fig. 10. These are World Peace, Human Well-being, and International Politics. All these criteria have subcriteria under them. The three subcriteria, Adversary Countries, Security Dilemma and Terrorism cover all the causes disturbing or stabilizing peace in the world. The first subcriterion, Adversary Countries, concerns the potential threats by adversary countries. The second criterion, Security Dilemma, means that increasing one country's security inevitably decreases other countries' security. Terrorism indi-

cates any possibility of the rise or decline of terrorism in the world. Human Well-being includes Technological Advancement and Market Creation. Technological Advancement driven by the NMD research and development process can ultimately benefit all people, particularly in providing possible space exploration that can lead to the creation of new markets. Moreover, the 21st century is characterized as a post-industrialization era. Service industries in communication and transportation will benefit not only businesses associated with these industries, but also consumers who can enjoy the products from the new market. The last criterion is International Politics. It is composed of two subcriteria, Military Relations and Diplomatic Relations. Military Relations refer to the impact of NMD on relations with U.S. allies for better or for worse. Also, the impact of NMD on diplomatic relations among all countries should be considered. The priorities shown next to the criteria and subcriteria in Fig. 10 were obtained through the usual pairwise comparison process of the AHP according to their importance with respect to their higher-level goal or parent criterion.

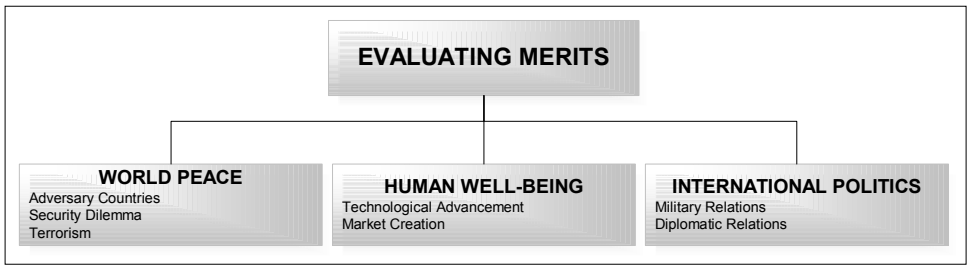


Fig. 10. Strategic Criteria for BOCR Ratings

The four merits of BOCR were rated according to five intensities listed below along with their priorities. The outcome is summarized in Tabl. 3. The intensities were derived from pairwise comparisons.

Table 3. Priority Ratings for the Merits: Benefits, Opportunities, Costs and Risks

Very High (0.419), High (0.263), Medium (0.160), Low (0.097), Very Low (0.061)					
		Benefits	**Opportunities**	**Costs**	**Risks**
World Peace	Adversary Countries	Very High	Medium	High	Very Low
	Security Dilemma	Very Low	Very Low	Very High	Very Low
	Terrorism	Medium	Very Low	High	High
Human Well-Being	Technological Advancement	High	High	Low	Very Low
	Market Creation	Medium	High	Very Low	Very Low
International Politics	Military Relations	High	High	Medium	Very Low
	Diplomatic Relations	Low	Low	Low	Very High
Priorities		0.264	0.185	0.361	0.190

Note that BOCR are rated one at a time and are not obtained from paired comparisons. They are obtained using the rating approach of the AHP.

As we said earlier if we weight the priorities derived in Tabl. 1 by the corresponding priorities of the merits just derived and then add we get:

$$0.264 \times 0.284 + 0.264 \times 0.240 + 0.185 \times 0.520 + 0.185 \times 0.326 + 0.361 \times 0.687 +$$

$$+ 0.361 \times 0.123 + 0.361 \times 0.105 + 0.190 \times 430 + 0.190 \times 0.268 \approx 0.76 .$$

In most of our studies we attempt to use factors whose total weight in not less than 70%.

5. OVERALL OUTCOME

Tabl. 4 shows the priorities of the nine control criteria or subcriteria, the corresponding priorities of the alternatives that are normalized from Tabl. 2,*e*, The Limit Supermatrix, their synthesis for each of the BOCR merits together with the normalized reciprocals under costs and risks. The final outcome in Tabl. 5 is derived by weighting the synthesized priorities of the alternatives of Tabl. 4 by the priorities of the BOCR merits, again using the reciprocals of the synthesized priorities of the alternatives under costs and risks.

Table 4. Synthesized Priorities of the Nine Control Criteria and Subcriteria

Merits	Criteria	Subcriteria	Deploy NMD	Global Defense	R&D	Termination
Benefits (0.264)	Security (0.481)	Military Capability (0.590)	0.488	0.308	0.140	0.064
	Technical (0.288)	Technical Advancement (0.834)	0.364	0.398	0.172	0.066
Benefits Synthesized			0.226	0.183	0.081	0.034
Benefits Normalized			0.431	0.349	0.155	0.065
Opportunities (0.185)	Arms Sales (0.520)		0.483	0.300	0.145	0.072
	Spin-Off (0.326)		0.506	0.264	0.146	0.084
Opportunities Synthesized			0.416	0.242	0.123	0.065
Opportunities Normalized			0.492	0.286	0.145	0.077
Costs (0.361)	Security Threat (0.687)		0.087	0.164	0.275	0.475
	Economic (0.228)	Sunk Cost (0.539)	0.476	0.273	0.158	0.092
		Further Investment (0.461)	0.525	0.258	0.143	0.074
Costs Synthesized			0.173	0.173	0.223	0.345
Costs Normalized			0.189	0.189	0.244	0.377
Costs Reciprocal			0.305	0.305	0.236	0.153
Risks (0.190)	Technical Failure (0.430)		0.473	0.269	0.154	0.103
	Arms Race (0.268)		0.410	0.284	0.181	0.124
Risks Synthesized			0.313	0.192	0.115	0.078
Risks Normalized			0.448	0.275	0.165	0.112
Risks Reciprocal			0.107	0.174	0.291	0.428

Table 5. Overall Results

Alternatives	Benefits	Opportunities	Costs	Risks	Overall
	0.264	0.185	0.361	0.190	
Deploy NMD	0.431	0.492	0.305	0.107	0.335
Global Defense	0.349	0.286	0.305	0.174	0.288
R & D	0.155	0.145	0.236	0.291	0.208
Termination	0.065	0.077	0.153	0.428	0.168

Deploy NMD (0.335) scores the highest. It is a comprehensive result that takes into consideration all BOCR. The conclusion of this analysis is that pursuing the deployment of NMD is the best alternative. This is because, as it is shown in Tabl. 5, Deploy NMD has the highest priorities for three (benefits, opportunities and costs) of the four merits. But we must now examine how realistic this outcome is.

6. SENSITIVITY ANALYSIS

One might have different judgments in comparing the importance of BOCR or of the nine control criteria. To ensure the stability of the outcome of our analysis, we conducted sensitivity analysis.

A. Sensitivity Analysis at the BOCR Level

First, we increased and decreased one of the four merits of BOCR keeping the others proportionally the same. For example, if benefits were to be increased from its original priority 0.264 to 0.500, the sum of the other three merits would comprise the other 0.500 and the proportion among them would remain the same as before and their new priorities would be: opportunities, 0.124, costs, 0.246, and risks, 0.130. We found that no matter how much we increased or decreased the priorities of benefits, opportunities and costs the overall ranks of the final outcome were preserved although these experiments changed the magnitude of the superiority of the best alternative, Deploy NMD (for example, from 0.301 to 0.431 for benefits as Fig. 11 shows). Only changing the priority of risks reversed the ranks of the four alternatives. This occurred only when the priority of the risks were as large as 0.375 or more. Then, Termination gradually became third then second and finally the best alternative as the priority of risks was increased more and more (Figs 12).

B. Sensitivity Analysis at the Control Criterion Level

We did similar tests for the nine criteria that have decision networks. We found that the outcome was very stable and did not change the overall ranks except for changes of the three criteria: Security Threat, Sunk Cost and Further Investment all under costs. When the priority of Security Threat decreased to about 0.172 from 0.687 (Fig. 13) or the priority of Sunk Cost increased to 0.753 (Fig. 14) or the priority of Further Investment increased to 0.734 (Fig. 15), Termination gradually began to move to third, second and finally to first rank position.

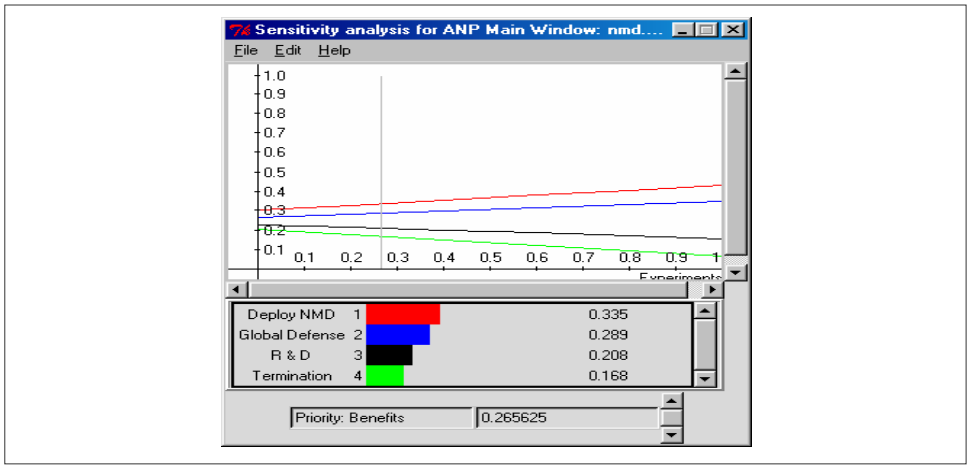


Fig. 11. Sensitivity Analysis for Benefits. The rank remains the same regardless of the priorities of benefits

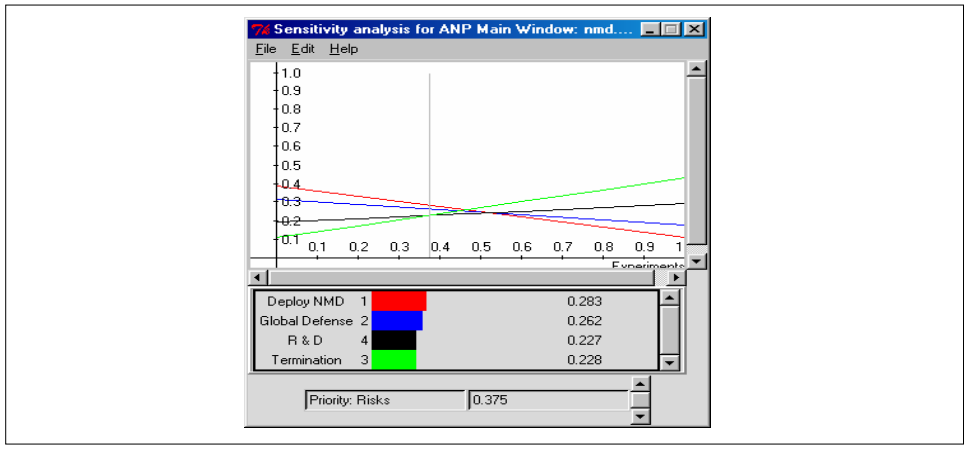


Fig. 12. Sensitivity Analysis for Risks. Termination becomes the more preferred alternative as the priority of risks increases

Some are highly concerned with risks associated with NMD, such as Technical Failure and Arms Race. We did another test using larger priorities for risks to see if it would change the outcome. In that case, the control criterion, U.S. Reputation, under risks replaced the control criterion, Further Investment, under costs. Interestingly enough, the ranks of the alternatives were the same as in Tabl. 5 with a slightly higher priority for Deploy NMD.

Our sensitivity analysis indicates that the final ranks of the alternatives might change, but such change requires making extreme assumptions on the priorities of BOCR and of their corresponding control criteria. **The outcome in Tabl. 5 is very stable and the United States should choose Deploy NMD as the best alternative for the decision**.

I am grateful to my colleague Professor Dr. Klaus Dellmann for his careful reading and suggestions to improve the paper and to my student Yeonmin Cho for her untiring efforts in preparing the case study and above all Mujgan Ozdemir for helping me prepare this final version.

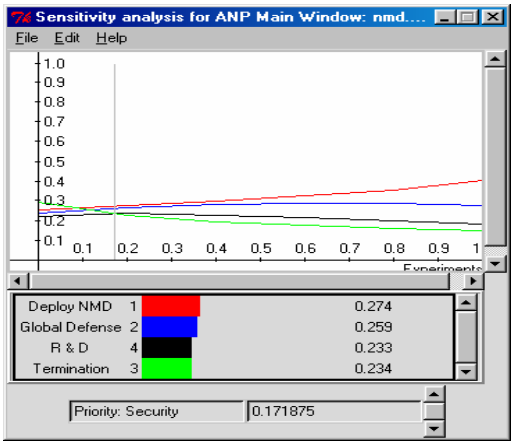


Fig. 13. Sensitivity Analysis for Security Threat: If the priority of Security Threat becomes less than about 0.172, Termination becomes the more preferred alternative

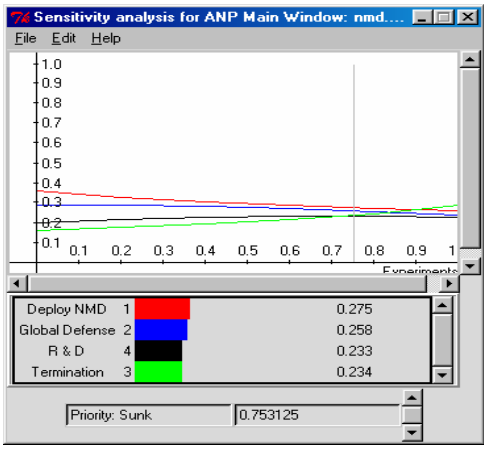


Fig. 14. Sensitivity Analysis for Sunk Cost. If the priority of Sunk Cost becomes larger than about 0.753, Termination becomes the more preferred alternative

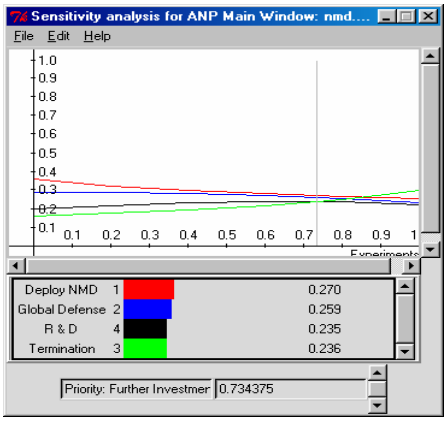


Fig. 15. Sensitivity Analysis for Further Investment. If the priority of Further Investment becomes larger than 0.734, Termination becomes the more preferred alternative

7. US POLICY TOWARDS IRAQ

For this example done jointly with my student Bethany Simunich in October 2002, we give the Tabl. 6 and Figs 16–20 without as much discussion as in the previous example. This is a two level model with the decision subnets directly attached to the merits and with no control criteria.

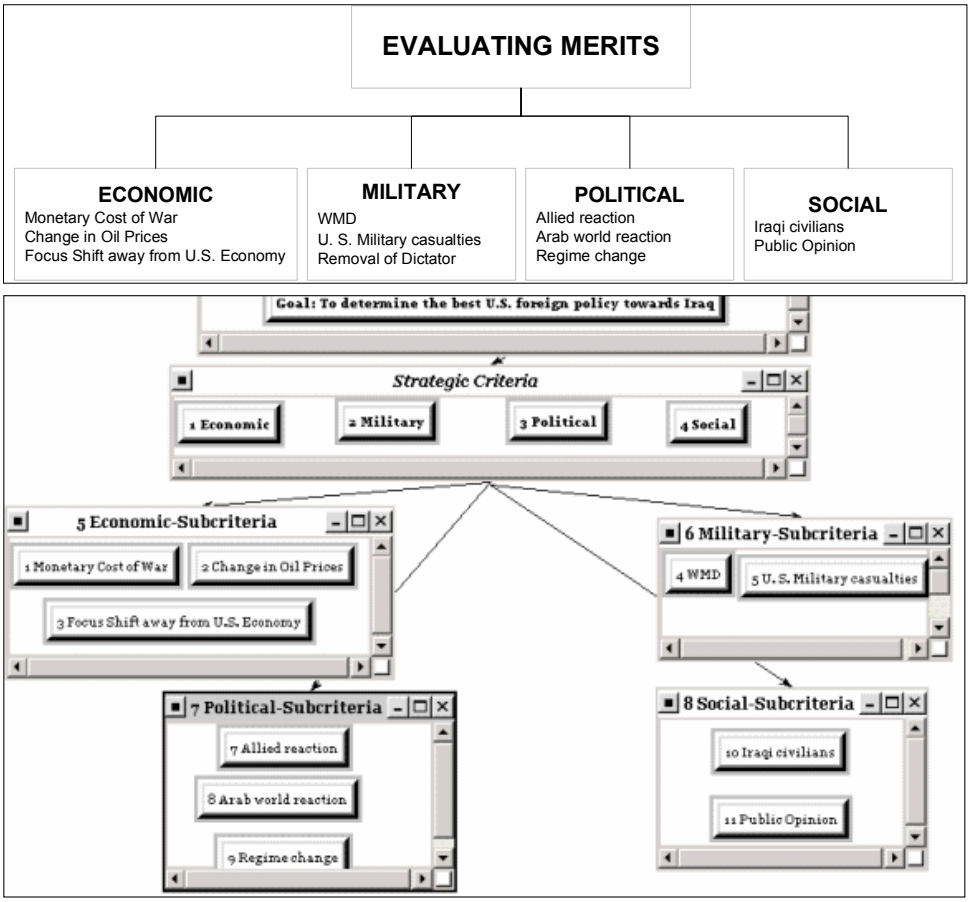


Fig. 16. Strategic Criteria for Rating the BOCR Merits

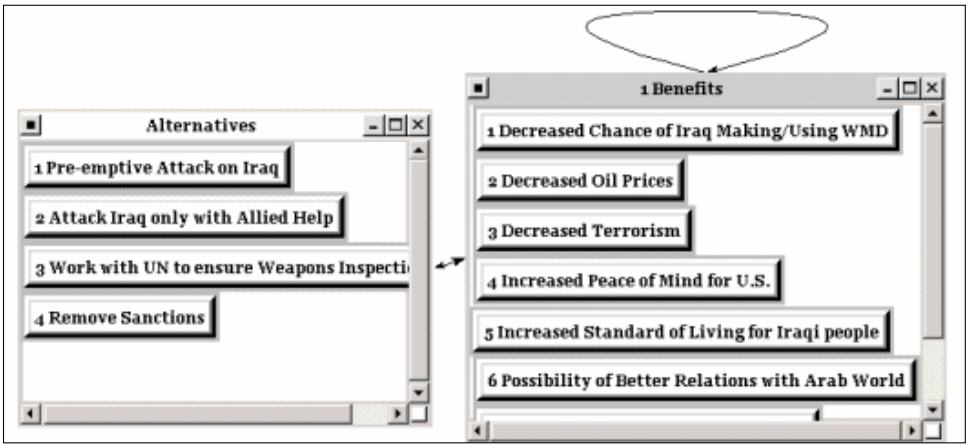


Fig. 17. The Decision Subnet under Benefits

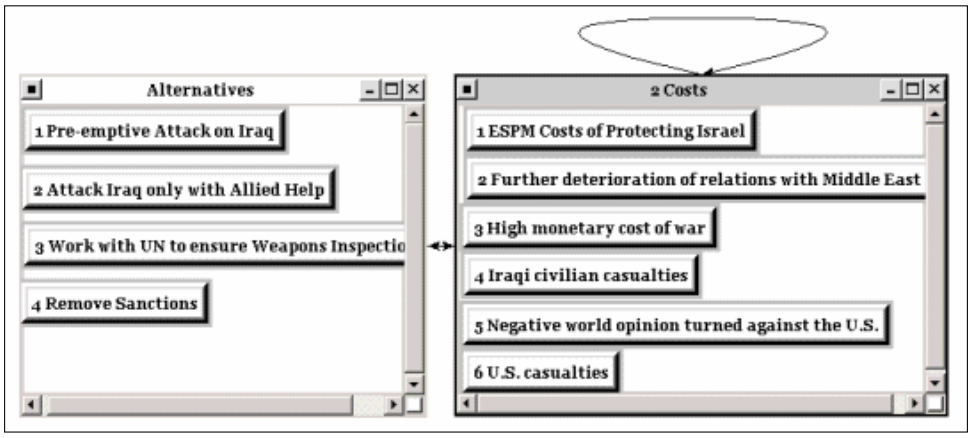
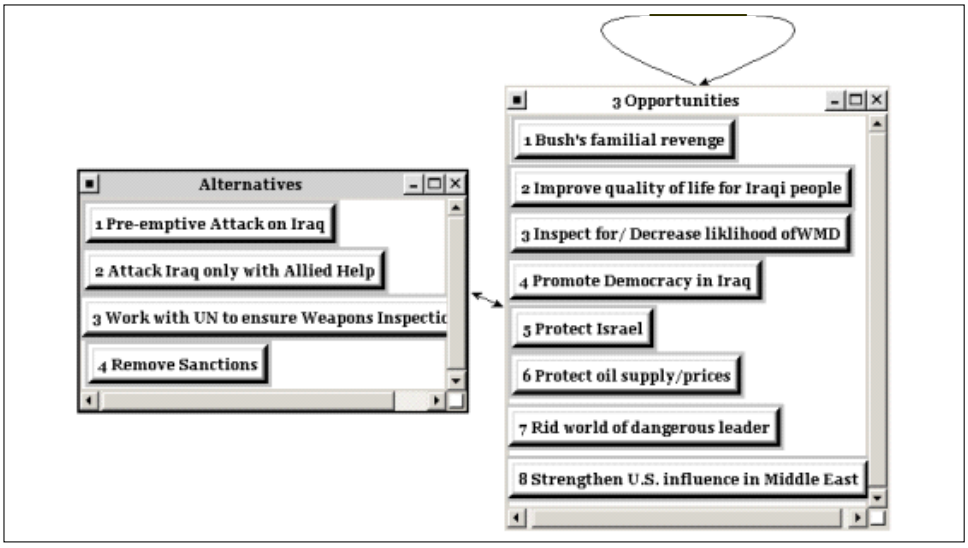


Fig. 18. The Decision Subnet under Costs



Puc. 19. The Decision Subnet under Opportunities

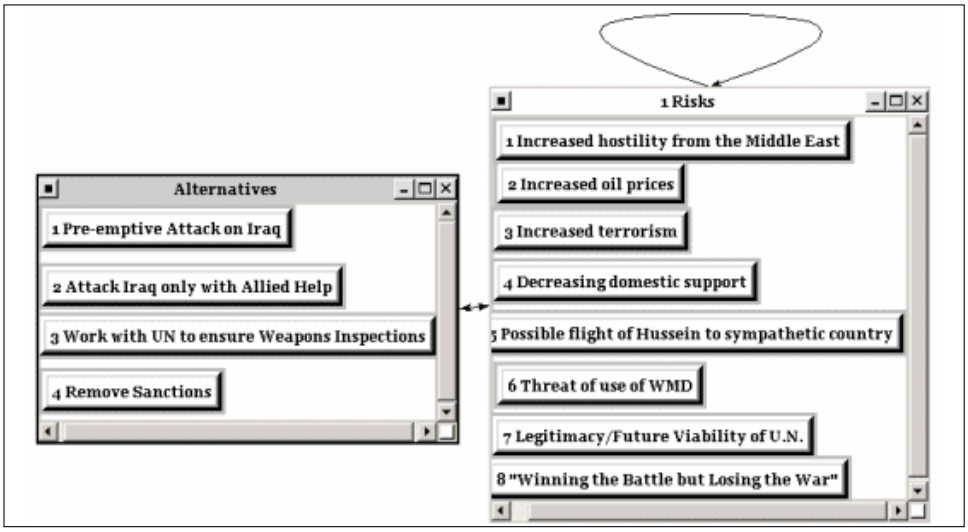


Fig. 20. The Decision Subnet under Risks

Table. 6. Overall Outcome

Alternatives	Priorities
Pre-emptive Attack on Iraq	0.17
Attack Iraq only with Allied Help	0.27
Work with UN to Ensure Weapons Inspections	0.37
Remove Sanctions	0.19

It appears at this writing, the war has just begun, that it would have been better for USA to work with the U.N. although by combining the priorities of the first two alternatives, one may infer that the course followed in practice is also justified by this analysis.

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