DECISION MAKING WITH THE ANALYTIC NETWORK PROCESS (ANP) AND ITS "SUPER-DECISIONS" SOFTWARE THE NATIONAL MISSILE DEFENSE (NMD) EXAMPLE

Thomas L. Saaty
University of Pittsburgh
Pittsburgh, PA 15260
saaty@katz.pitt.edu

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Summary. *There are three phases in the creation of the structure of a complex decision, 1*) *the subjective personal, group or corporate values, 2*) *the interface- merits of the decision between the first* (*the subjective*)*, and the third* (*the objective*) *phases: Benefits, opportunities, costs and risks and their corresponding* (*control*) *criteria with respect to which the comparisons are made to derive the priority of influence in the third phase, and 3*) *the objective hierarchies and/or networks used to represent the influences that affect the ranking of the alternatives of the decision with respect to each control criterion. The many sets of priorities of the alternatives are then synthesized into a single outcome that determines their priorities for both, making a best choice and allocating resources among the alternatives. An application of this process to the decision by the United States on a National Missile Defense* (*NMD*) *system is illustrated along with sensitivity analysis.*

1. Introduction

Two ideas are discussed in this paper. The first is concerned with laying out the elaborate structure of a complex decision that involves three phases: personal or group subjective criteria, a merits framework of benefits, opportunities, costs and risks (BOCR) together with their control criteria, and finally an objective network representation of the decision with respect to each control criterion. The second idea explored in this paper 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 dependence and feedback, we use the Analytic Network Process (ANP) and its software *Super-Decisions* with its sensitivity analysis option to examine the NMD decision.

2. AHP and ANP

In making a decision, we need to distinguish between the hierarchic and the network structures that we use to represent that decision. In a hierarchy we have levels arranged in a descending order of importance. The elements in each level are compared according to dominance or influence with respect to the elements in the level immediately above that level. The arrows descend downwards from the goal even if influence, which is a kind of service, is sought for in elements in lower levels that contribute to the well-being and success of elements in higher levels. We can interpret the downward pointing of the arrows as a process of stimulating the influence of the elements in the lower level on those in the level above.

In a network, the components (counterparts of levels in a hierarchy) are not arranged in any particular order, but are connected as appropriate in pairs with directed lines. Again an arrow points from one component to another to stimulate the influence of the elements of the second component on those in the first. The pairwise comparisons of elements in a component are made according to the dominance of influence of each member of a pair on an element in the same or in another component. Influence may be evaluated in terms of importance, preference or likelihood.

In addition, in a network, the system of components may be regarded as elements that interact and influence each other with respect to a criterion or attribute that is outside the system of influences. That attribute itself must be of a higher order of complexity than the components and a fortiori of higher order than the elements contained in the components. We call such an attribute a control criterion. Thus even in a network, there is a hierarchic structure that lists control criteria above the networks. For each of the four BOCR merits we have a system of control criteria that we use to assess influence. The result is that such control criteria and/or their subcriteria serve as the basis for all comparisons made under them, both for the components and for the elements in these components. In a hierarchy one does not compare levels according to influence because they are already arranged in a predetermined order of importance from top to bottom. The criteria for comparisons are either included in a level, or more often implicitly replaced by using the idea of "importance, preference or likelihood" with respect to the goal, without being more finely detailed about what kind of importance it is. The control criteria for comparisons in a network are intended to be explicit about the importance of influence that they represent.

In a hierarchy, we ask the question for making a comparison, which of two elements is more dominant or has more influence (or in the opposite sense is influenced more) with respect to a certain element in the level above? In a network we ask, which of two elements is more dominant in influencing another element in the same or in another component with respect to a control criterion? **In both hierarchies and networks the sense of having influence or being influenced must be maintained in the entire analysis**; the two should not be mixed together.

The ANP frees us from the burden of ordering the components in the form of a directed chain as in a hierarchy. We can represent any decision as a directed network. While the AHP has a visibly better structure that derives from a strict understanding of the flow of influence, the ANP allows the structure to develop more naturally, and therefore is a better way to describe faithfully what can happen in the real world. These observations lead us to conclude that hierarchic decisions, because of imposed structure are likely to be more subjective and predetermined. Further, by including dependence and feedback and by cycling their influence with the supermatrix, the ANP is more objective and more likely to capture what happens in the real world. It does things that the mind cannot do in a precise and thorough way. Putting the two observations together, the ANP is likely to be a strongly more effective decision-making tool in practice than the AHP.

Figure 1 represents the three phase structure of complex decisions: *our subjective value system*, *the BOCR merits* of the decision, and *the hierarchies or networks of influences* and "objective" facts that make one alternative of the decision more desirable than another. In each of these phases there are major concerns that are subdivided into less major ones and these in turn into still smaller ones. The entire set of three levels may sometimes be structured into a single network as we have done in some decision problems. Knowledge about the top level of subjective values where one must use the absolute mode of measurement of the AHP can be enriched by information from the lower levels, but does not depend on it for its priorities. It provides the intensities on which the BOCR merits are rated one at a time and then normalized. This level cannot be conveniently integrated into a single structure with the other two, and thus it appears that most decisions, despite their use of network structure are embedded in a higher order hierarchic structure. A decision may involve three or four adjacent ranges of homogeneous elements in each to represent personal values (Maslow put them into seven groups). Roughly speaking, we have, in decreasing order of importance: 1) Survival, health, security, family, friends and basic religious beliefs some people were known to die for; 2) Career, education, productivity and lifestyle; 3) Political and social beliefs and activities; 4) Philosophical thoughts and ideas and things that are changeable, and it does not matter exactly how one advocates or uses them. There are similar values for a group, a corporation, a country and for the entire world as represented for example by the United Nations.

Figure 2 represents synthesis at the different parts of the structure shown in Figure 1 and also the overall synthesis. First we develop priorities for the subjective values. Next we rate each of the four BOCR merits on the personal values. Third, we create and prioritize the control criteria for each of the BOCR, and finally, we create and prioritize the decision networks for each of these control criteria. To obtain the answer we synthesize the priorities of the alternatives for benefits and then for opportunities and then for costs and finally for risks, thus obtaining four different rankings for each alternative.

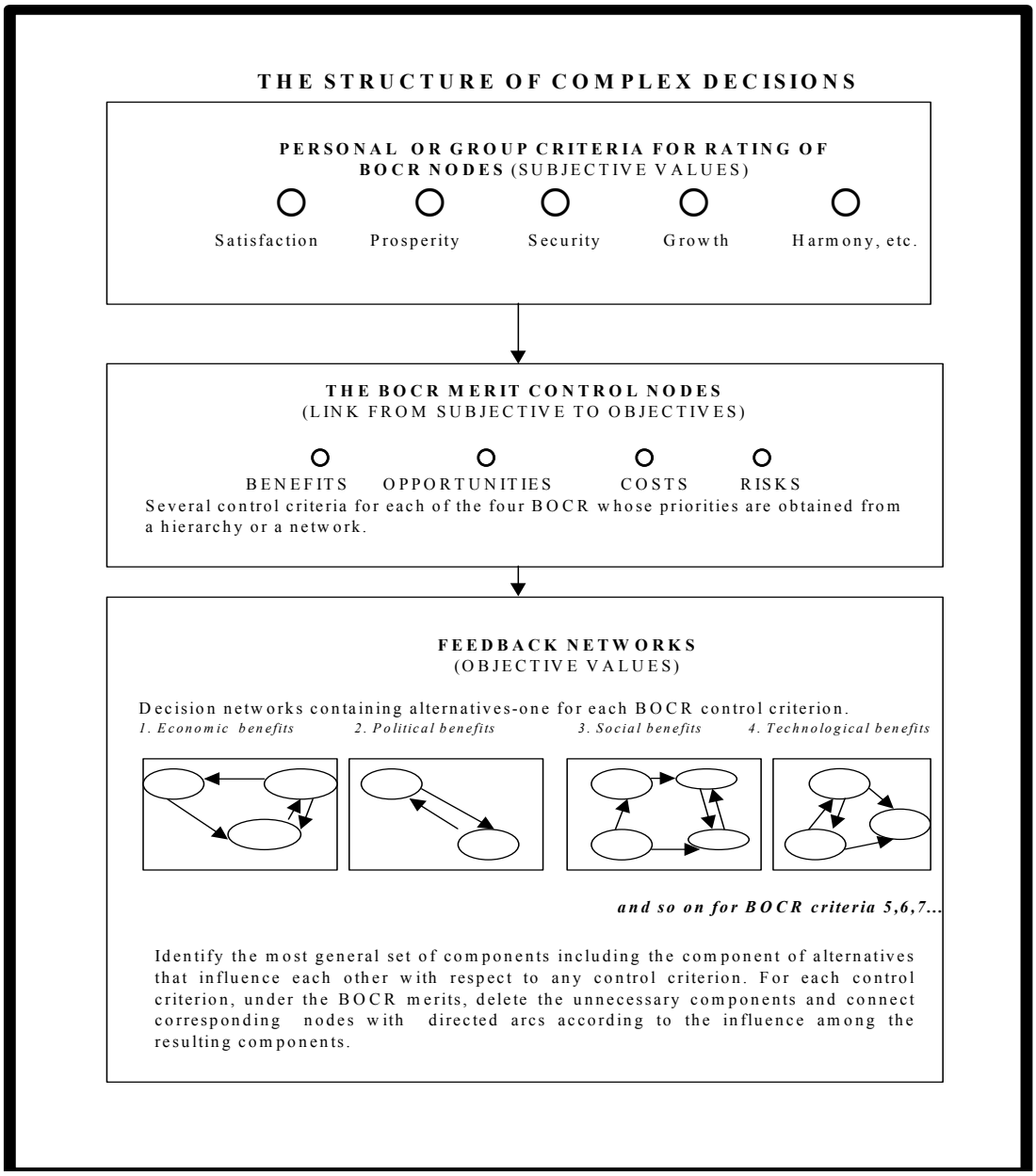

Figure 1 The Structure of Complex Decisions

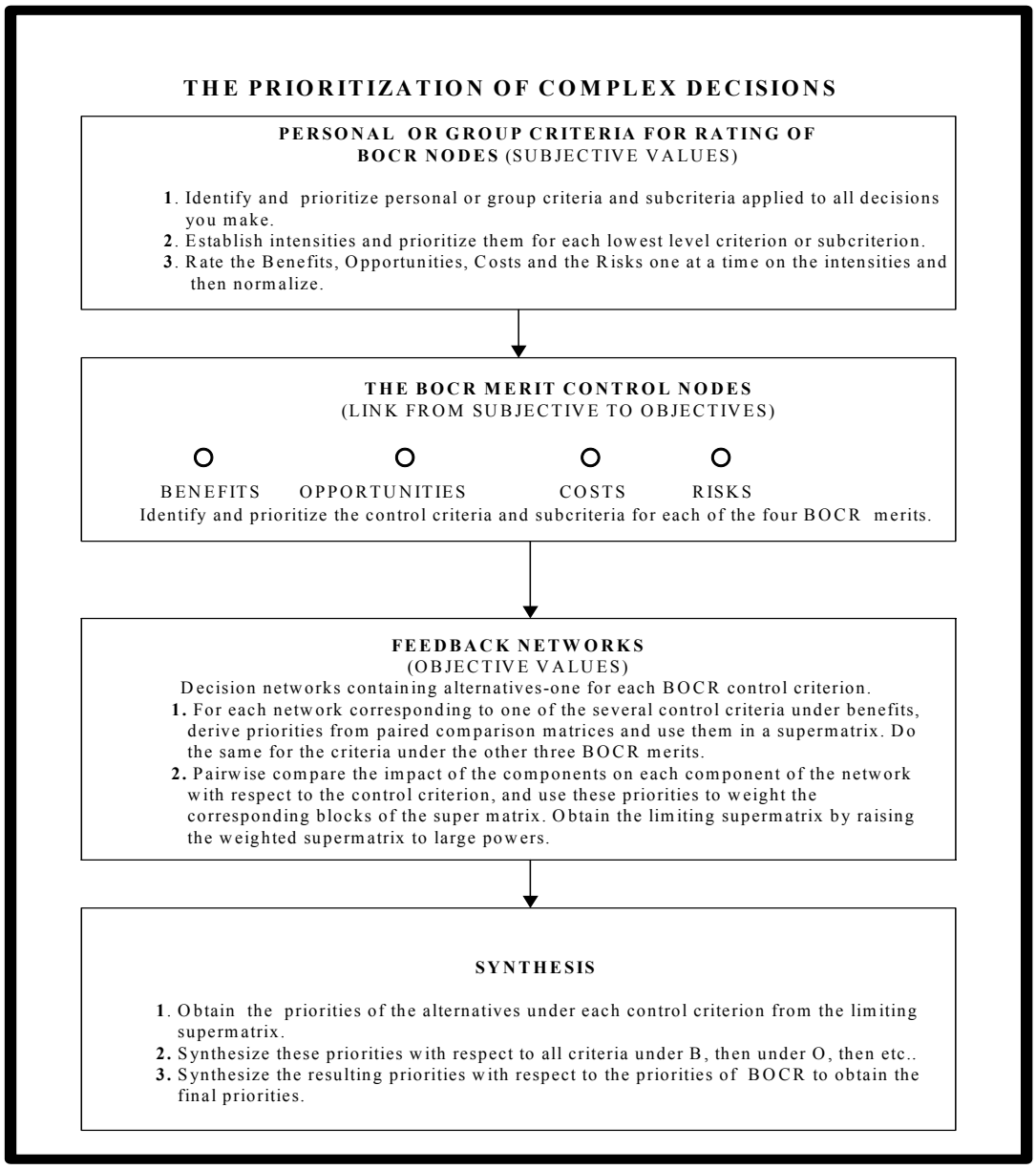

Figure 2 The Prioritization of Decisions

We use the priorities of BOCR to weight and synthesize the overall weights of the alternatives obtained from the four merit structures. In this process we must use the reciprocals of the synthesized *final* priorities of the alternatives under costs and risks obtaining high priorities for the least costly and least risky alternatives instead of the original high priorities for the most costly, and most risky. Recall that paired comparisons enable us to ask for the dominance of the larger of two elements over the smaller because we need the smaller as the unit for the comparison. Thus we can only ask which is more costly or risky and then take the reciprocal at the end for the less costly and less risky. *Pragmatically, the analysis can be performed backwards from the hierarchies and networks of influence at the bottom of the three stages, upwards to the BOCR level to obtain deeper understanding and appreciation of the BOCR merits of that decision.*

Why do we use the reciprocals of the synthesized results for the alternatives under costs and risks instead of some other way? A good and easy way to show that is to use the old classic example of choosing among several alternatives with costs under two criteria both measured in dollars. To get the correct final values for the alternatives, one must first assign each criterion a priority consisting of the sum of the costs of all the alternatives under it to their sum under both criteria. Only then can one normalize the costs of the alternatives under each criterion, weight by the priority of the corresponding criterion and add to get the correct outcome. One can then take the reciprocals of the final outcomes and normalize them. One does not get a meaningful result by separately taking the reciprocals of the weighted values of the alternatives under each criterion and then add and normalize.

The Decision Problem: Outline of the Steps to follow in the Analytic Network Process
Focuses on components and their elements (one or more) and the influence among them indicated by arrows from one component to another (outer dependence) and by loops on a components for inner dependence, if any, within it. The connections are made between the elements. If elements of two components are connected, so must the components also be connected.

The Structures for Representing the Decision Problem (hierarchy or network for each)
1) Personal value structure
2) BOCR merit control structures and their control criteria and subcriteria
3) The real world feedback decision and its substructures for each covering control criterion

Judgment and Evaluation
Note that a zero is assigned to an element (component) when it has no influence on another element (component).

1) Pairwise comparison of the elements as necessary in each substructure with respect to the covering control criterion
2) The use of absolute measurement to rate and create priorities for BOCR
3) Form an unweighted supermatrix for each covering control criterion substructure
4) Compare the components according to their connections to weight the blocks of the supermatrix according to each covering control criterion and thus obtain the weighted supermatrix
5) Raise the resulting weighted supermatrix to powers to obtain the answer for the alternatives. Extract from the software the normalized values of the answer
6) Two kinds of outcomes for the limit. The first has all the columns the same and one gets the result from any column. The second is a cycle of supermatrices from which one gets the answer for the alternatives by taking the average over a cycle
7) By weighting and adding with respect to the personal values, then the BOCR, then their criteria and subcriteria and finally the normalized limit values of the alternatives (their reciprocals in the cases of C and R) we have the overall synthesis of the priorities of the alternatives.

3. Decision on National Missile Defense Program - An Application of the ANP

3-1. Introduction

The United States government faces 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 have expressed different views regarding this decision. The most important rationale behind supporters of the NMD system is 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 express 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 next year the Senate Armed Services Committee approved the National Missile Defense Act of 1997 by winning 10 votes out of 18, along party lines. This Act mandated deployment of an anti-missile system, consisting of 100 ground-based interceptor missiles at a single site, plus ground-based radars and space-based sensors. The intelligence community estimated a shortened warning time for the U.S. against intercontinental ballistic missiles (ICBMs) deployment. However, the deployment of NMD by 2003, analyzed by an independent Commission to Assess the Ballistic Missile Threat to the United States, concluded that it would generate high risks and possible failure. Accordingly, the administration adjusted its plan to deploy NMD in 2005. Some scientists, including 50 Nobel laureates have been skeptical about the technical feasibility of NMD. Others, encouraged by the 1999 National Missile Defense Act stating U.S. policy to deploy NMD "as soon as technologically possible," are more positive and see it as a long term undertaking.

The deployment of NMD is not solely based on technological development. President Bush has to deal with international politics. The Anti-Ballistic Missile (ABM) treaty signed by the U.S. and the former Soviet Union in 1972 would ban NMD, and the U.S. president should be able to persuade or renegotiate the ABM treaty with Russia's president, Vladimir Putin, who has strongly opposed the plan. How to deal with the reactions of China and NATO is another issue for the U.S. president to consider.

3-2. Alternatives

Given the situation in October 2000, what is the best direction for NMD to take? There are four alternatives to be considered.

Alternatives:

1. Deploy NMD. Fully deploying the NMD program (NMD).
2. Global Defense. Implementing joint-development of a worldwide defense system (GLOB).
3. R&D. This alternative is not concerned with deployment, but proceeds with research and development of missile defense technology (R&D).
4. Termination of the NMD program. Disregarding any further R&D and deployment plan (TERM).

3-3. BOCR Weight Development

The judgments used in this analysis where 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 Figure 3. 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 indicates 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 which 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 Figure 3 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.

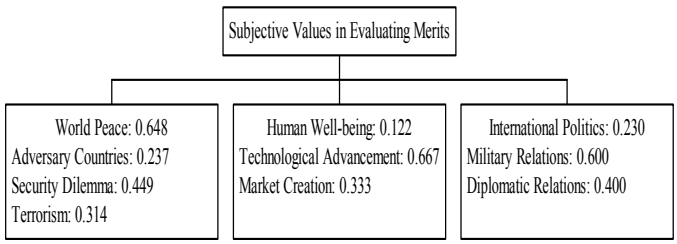

Figure 3 Hierarchy for Rating Benefits, Opportunities, Costs and Risks

The four merits of BOCR were rated according to five intensities listed below along with their priorities. The outcome is summarized in Table 1. The intensities immediately above Table 1 were derived from pairwise comparisons.

Table 1 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.

3-4. Criteria

The second column of Table 2 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 Table 2 are obtained by weighting their priorities by those of their parent criterion if there is one and then also by priority of their merit. For example, for local economy we have 0.264 x 0.157 x 0.141 ≈ 0.006. 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. We renormalized the priorities of these nine and proceeded as if they were the only criteria to drive the outcome. Their decision networks and connections are shown in Figures 4–12. Note that the nine criteria received their higher priorities as a result of the prioritization of BOCR. With different priorities of BOCR, one may have a different set of distinguished criteria or subcriteria. However, with few exceptions most of what we have here are sufficiently dominant that perturbing the priorities of BOCR is unlikely to replace them with other factors. A more thorough analysis might include a few more criteria or subcriteria.

Table 2 Criteria and Their Priorities

Merits	Criteria	Sub-criteria	Global Priorities (Normalized)
Benefits (0.264)	Economic (0.157)	Local Economy (0.141)	0.006
		Defense Industry (0.859)	0.036
	Political (0.074)	Bargaining Power (0.859)	0.017
		U.S. Military Leadership (0.141)	0.003
	Security (0.481)	Deterrence (0.267)	0.034
		Military Capability (0.590)	**0.075**
		Anti-terrorism (0.143)	0.018
	Technology (0.288)	Tech. Advancement (0.834)	**0.063**
		Tech. Leadership (0.166)	0.013
Opportunities (0.185)	Arms Sales (0.520)		**0.096**
	Spin- off (0.326)		**0.060**
	Space Development (0.051)		0.009
	Protection of Allies (0.103)		0.019
Costs (0.361)	Security Threat: Vulnerability to the security threat (0.687)		**0.248**
	Economic (0.228)	Sunk Cost (0.539)	**0.044**
		Further Investment (0.461)	**0.038**
	Political (0.085)	ABM Treaty (0.589)	0.018
		Foreign Relations (0.411)	0.013
Risks (0.190)	Technical Failure (0.430)		**0.082**
	Arms Race (0.268)		**0.051**
	Increased Terrorism (0.052)		0.010
	Environmental Damage (0.080)		0.015
	U.S. Reputation (0.170)		0.032

3-5. The Decision Networks

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 (see Figure 4 and Table 3). 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 Table 3a, 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 Table 3a, 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 Table 3a 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 Table 3a consists of zeros because nothing is influenced by Termination which 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.

Table 3b 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 Table 3b are exhibited in Table 3c, 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 illustrates the weighting of the blocks of the supermatrix by the priorities from the corresponding eigenvector of comparisons of the components in Table 3c. Table 3e, 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 Table 4. Similar computations are done for the remaining eight high priority criteria and their normalized results are included in Table 4.

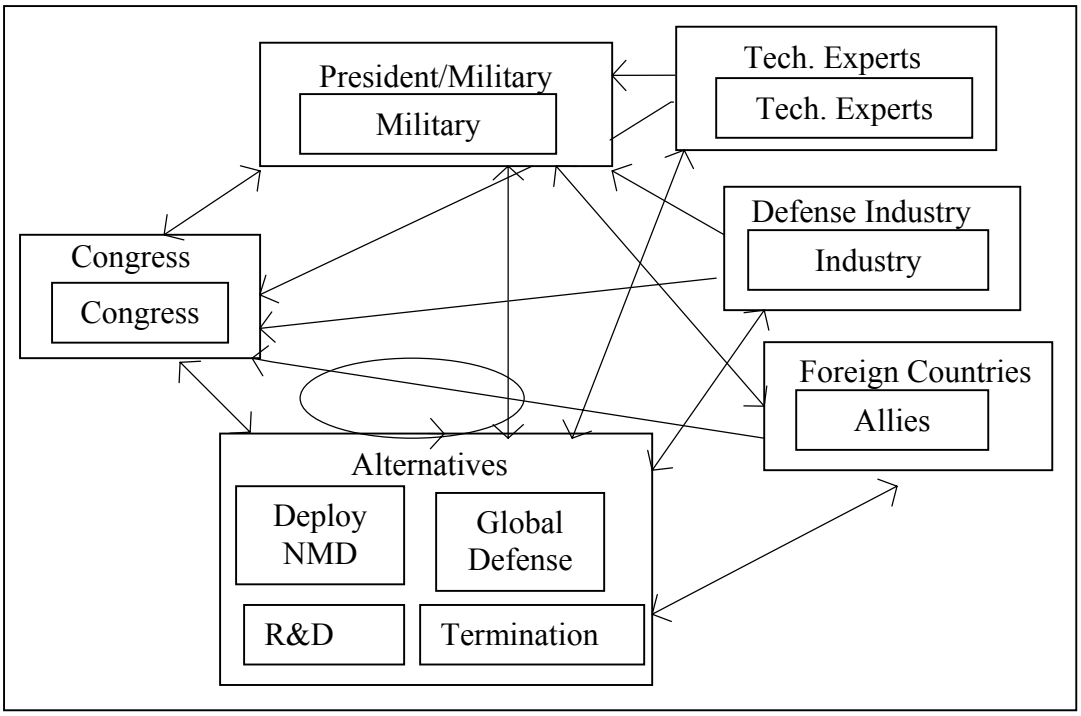

Figure 4 Decision Network under The Military Capability Control Subcriterion of Benefits

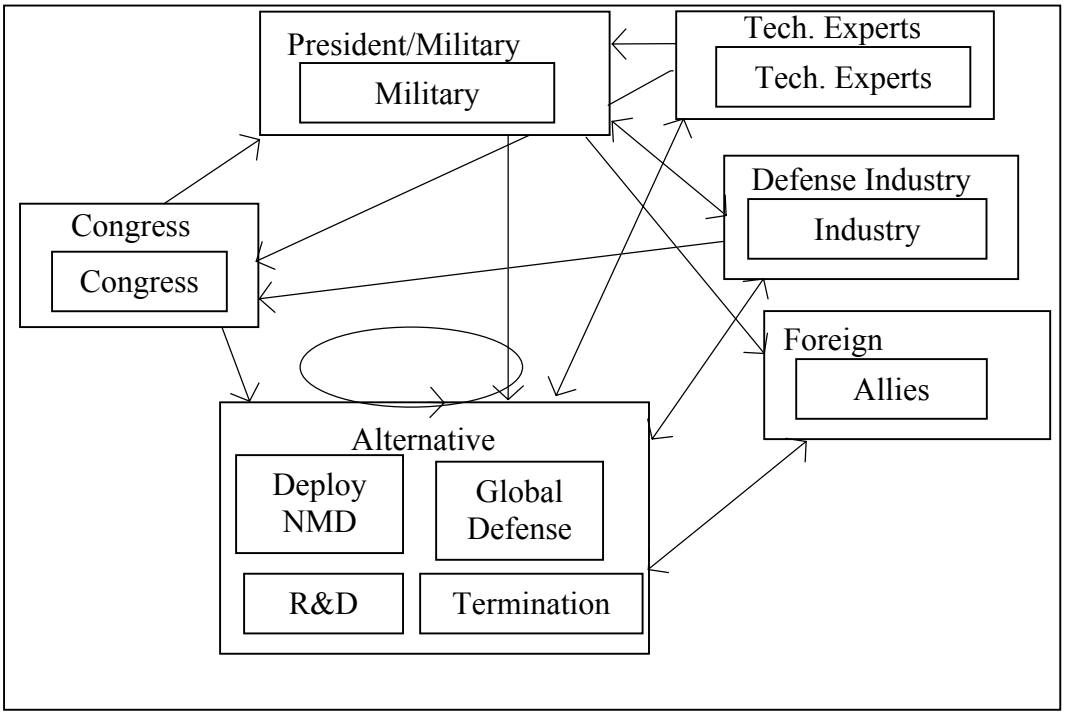

Figure 5 Decision Network under The Technological Advancement Control Subcriterion of Benefits

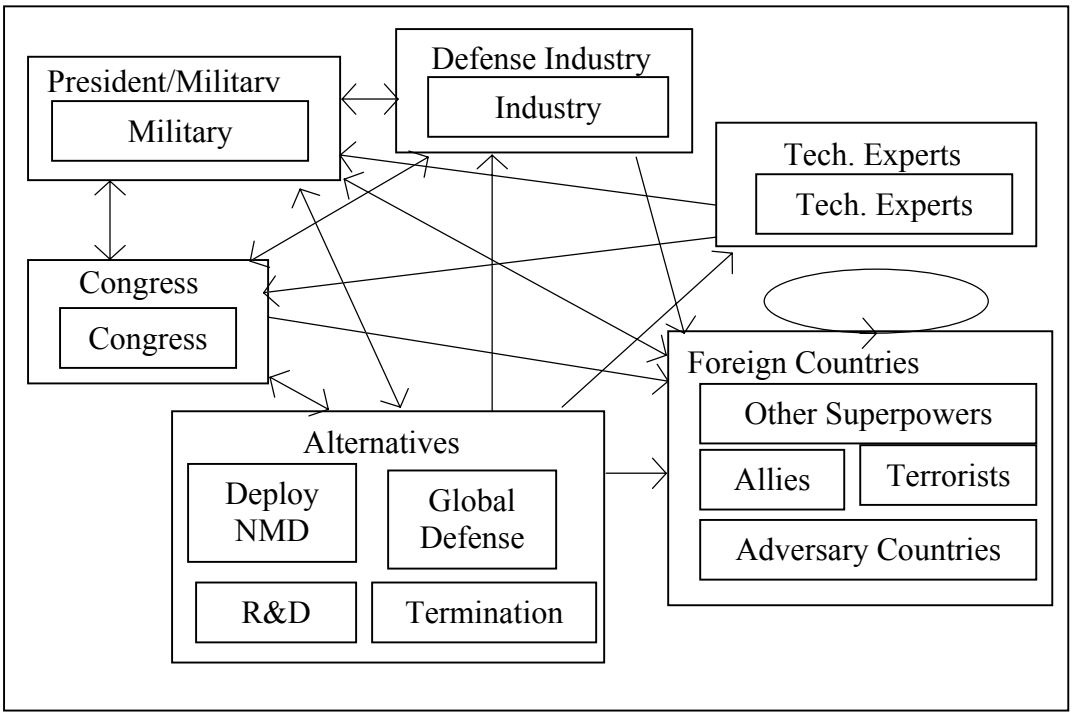

Figure 6 Decision Network under The Arms Sales Control Criterion of Opportunities

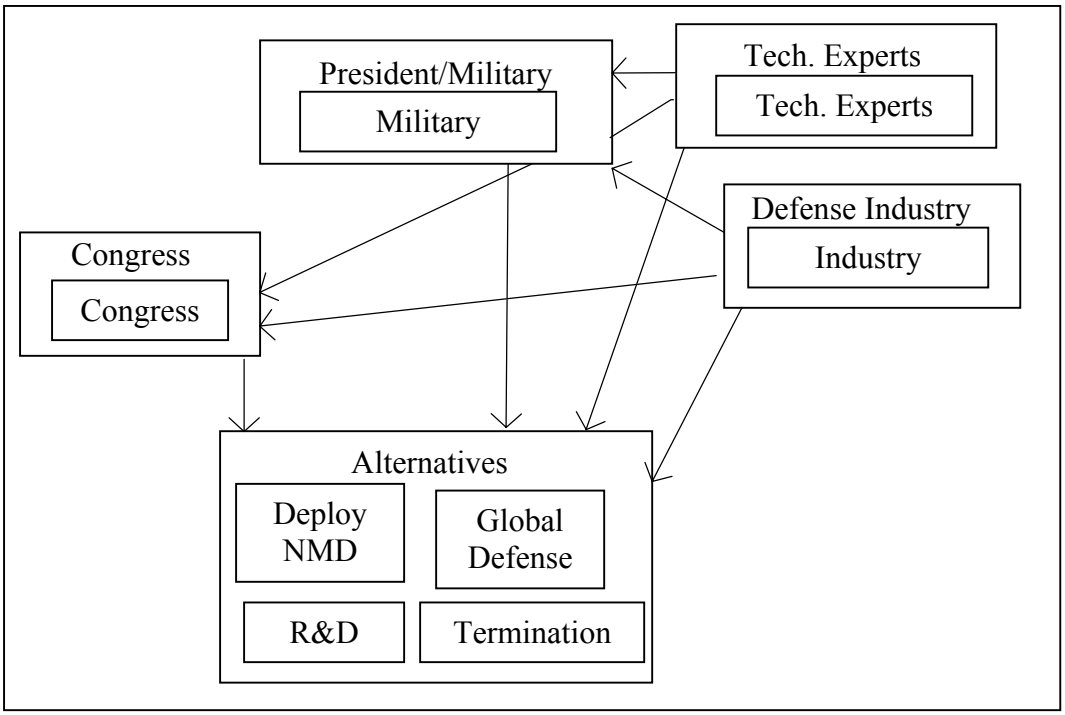

Figure 7 Decision Network under The Spin-Off Control Criterion of Opportunities

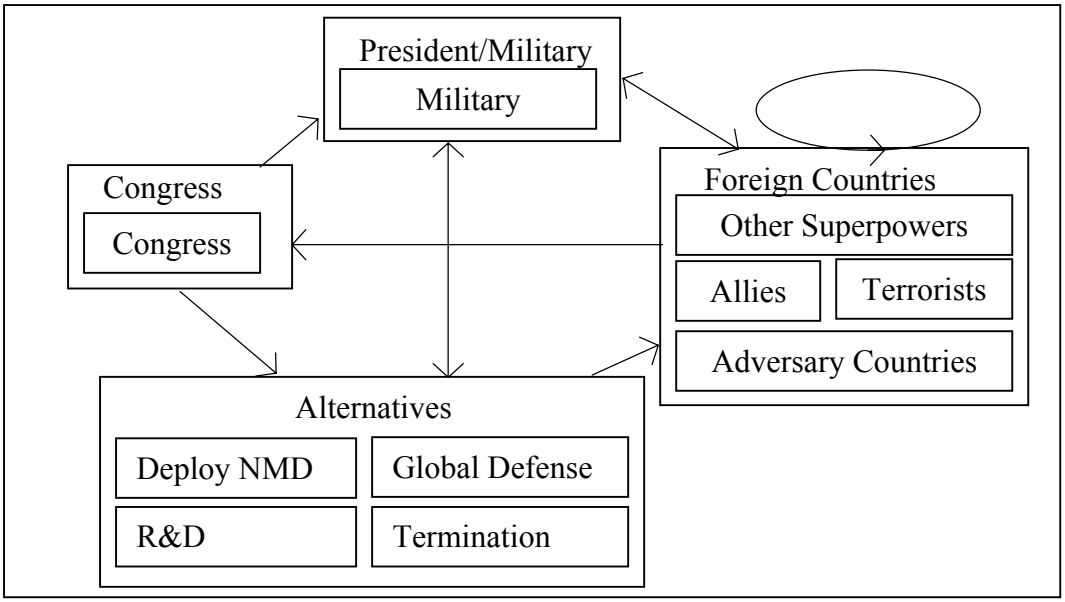

Figure 8 Decision Network under The Security Threat Control Subcriterion of Costs

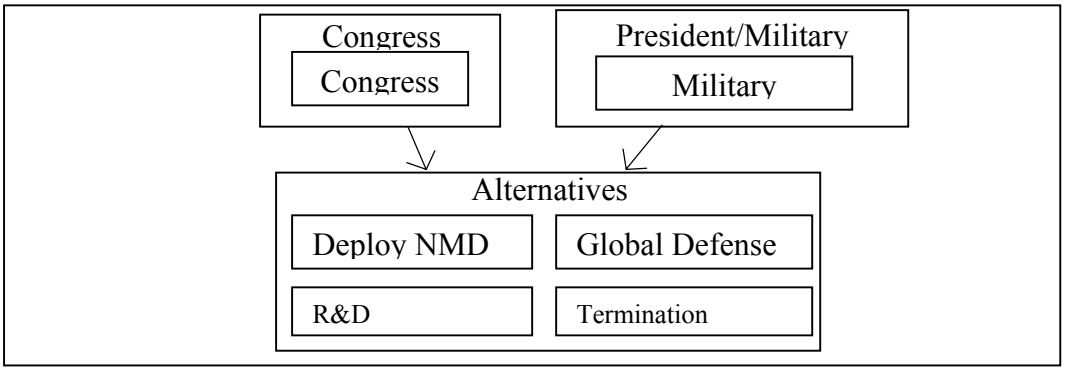

Figure 9 Decision Network under The Sunk Cost Control Subcriterion of Costs

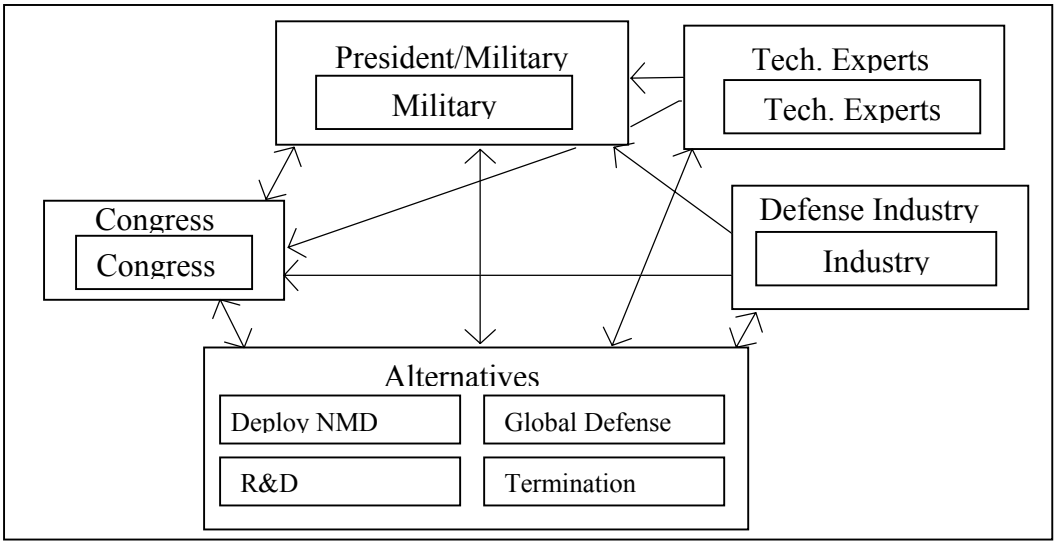

Figure 10 Decision Network under The Further Investment Control Subriterion of Costs

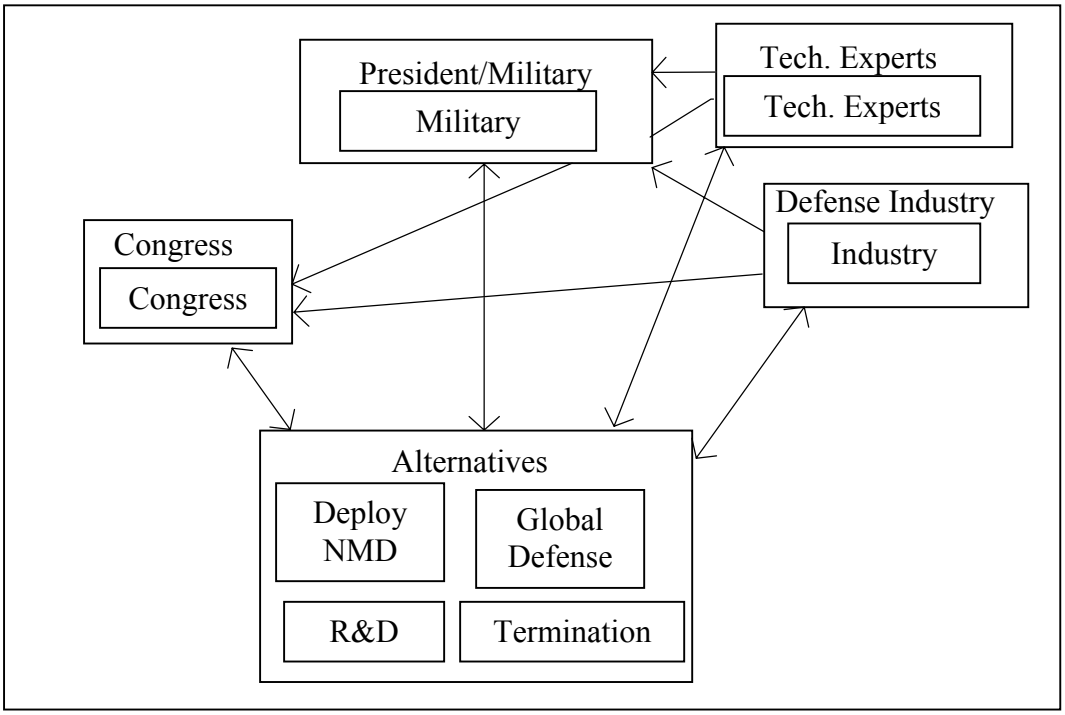

Figure 11 Decision Network under The Technical Feasibility Control Criterion of Risks

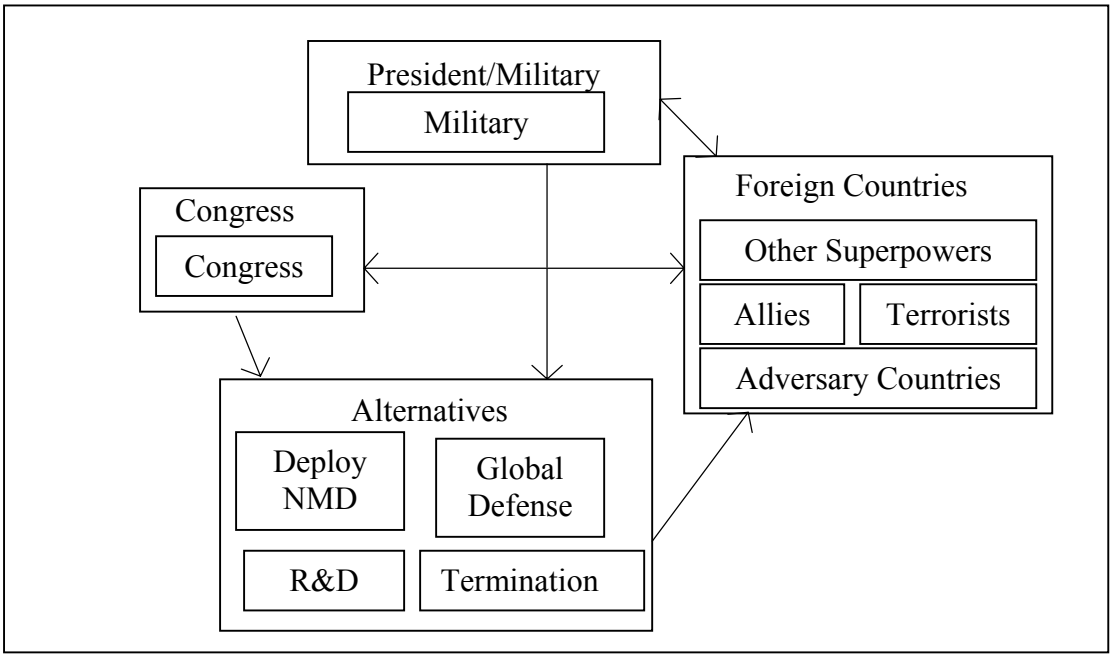

Figure 12 Decision Network under The Arms Race Control Criterion of Risks

Table 3 All Matrices for The Military Capability Decision Network of Benefits

Table 3a The Unweighted Supermatrix

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.

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 3b 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***
Congr~	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 3c Priorities Matrix of Eigenvectors
How much components are influenced by each component; imported from the matrices of Table 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 3d The Weighted Supermatrix
Priorities from Table 3c are used to weight corresponding blocks of unweighted supermatrix of Table 3a

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 3e 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

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 Final Outcome

	Benefits (0.264)	Opportunities (0.185)	Costs (0.361)	Risks (0.190)	**Final Outcome Additive**
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**

Table 4 shows the priorities of the nine control criteria or subcriteria, the corresponding priorities of the alternatives that are normalized from Table 3e, The Limit Supermatrix, their synthesis for each of the BOCR merits together with the normalized reciprocals under costs and risks. The final outcome in Table 5 is derived by weighting the synthesized priorities of the alternatives of Table 4 by the priorities of the BOCR merits, again using the reciprocals of the synthesized priorities of the alternatives under costs and risks.

3-6. Overall Outcome and Sensitivity Analysis

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 Table 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.

3-6. A. Sensitivity Analysis at the BOCR Level

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. 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 Figure 13 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 (Figure 14).

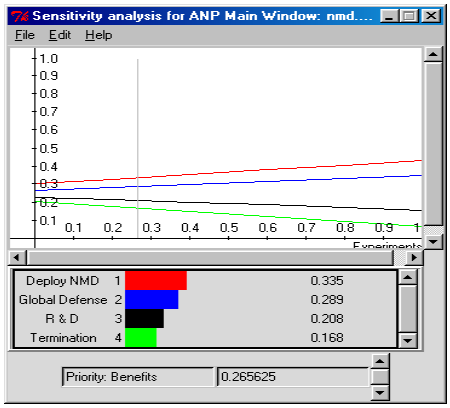

Figure 13 Sensitivity Analysis for Benefits: The rank remains the same regardless of the priorities of benefits

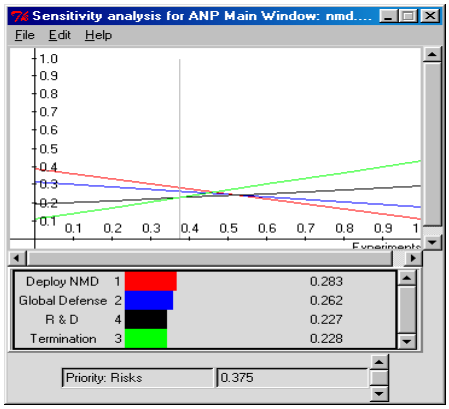

Figure 14 Sensitivity Analysis for Risks: Termination becomes the more preferred alternative as the priority of risks increases

3-6. 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 0.248 (Figure 15) or the priority of Sunk Cost increased to 0.753 (Figure 16) or the priority of Further Investment increased to 0.734 (Figure 17), Termination gradually began to move to third, second and finally to first rank position.

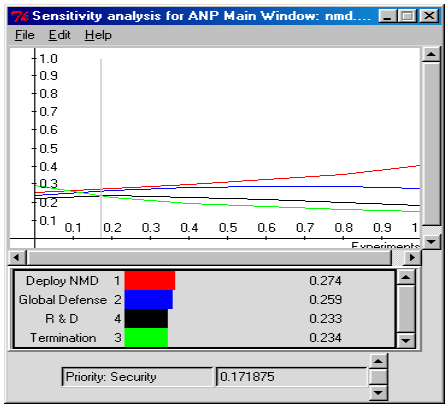

Figure 15 Sensitivity Analysis for Security Threat:
If the priority of Security Threat becomes less than about 0.172,
Termination becomes the more preferred alternative

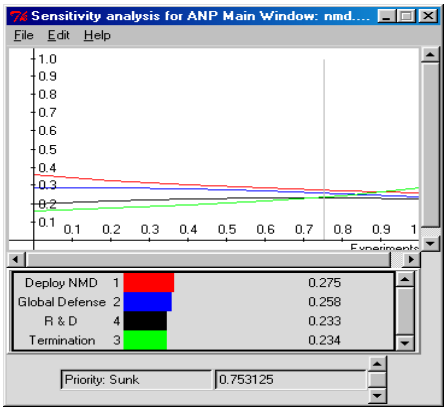

Figure 16 Sensitivity Analysis for Sunk Cost
If the priority of Sunk Cost becomes larger Than 0.753, Termination becomes the more preferred alternative

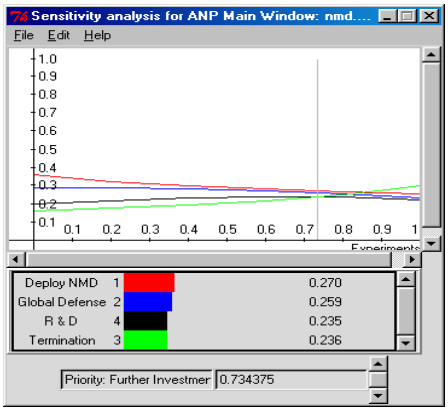

Figure 17 Sensitivity Analysis for Further Investment
If the priority of Further Investment becomes larger than 0.734, Termination becomes the more preferred alternative

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 Table 5 with a slightly higher priority for Deploy NMD.

Our sensitivity analysis indicate 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 Table 5 is very stable and the United States should choose Deploy NMD as the best alternative for the decision**.

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