

# A Study on the AoA Based Defense Decision Making

Kyoung Haeng Lee<sup>1\*</sup> Yong Soo Kwon<sup>1</sup>

<sup>1</sup>Department of Weapon Systems, Korea National Defense University, Seoul, Korea

**Abstract** : This work describes a study on the Analysis of Alternatives (AoA) based defense decision making. Future battle-space is transformed into a System of Systems (SoS) concept which is accomplished missions and their functions through network based battle management systems under forming their grids of various sensors and shooters in a single theater. The acquisition process is, therefore, changing over from single system requirements to capabilities based acquisition of SoS. AoA help to justify the need for starting, stopping, or continuing an acquisition program. AoA identify potentially viable solutions and provide comparative cost, effectiveness, and risk assessments of each solution to a baseline. The decision making must consider not only cost-effectiveness, risk, and military worth, but also domestic policy, foreign policy, technological maturity of the solution, the environment, the budget, treaties, and a host of additional factors. In this point of view, this paper analyzes AoA template which are critical elements of the defense decision making. From results of this analysis of AoA template for Korean acquisition environment are presented.

**Key Words** : AoA, SoS, Acquisition Process

## 1. INTRODUCTION

A future war is being changed into the concept of new composite system (a new system of systems) that various sensors and shooters form the respective grids in a single battle area and carries out the task and function by the network-based battle management system. Namely, as the unified concept of the network base, it will be the networked multi-dimensional non-linear battle being composed of the complex system that is made of the interception system, early warning and monitoring system, and battle management and direction/control system.

AoA has played the important role to decide

whether to acquire the object system. AoA should not identify the most excellent alternative in the cost to effect and not be limited to the capabilities to acquire such alternative to be provided and the military value. AoA is the important device to provide the information that might be used by the high-rank commanders to discuss and evaluate the operation capability and economic efficiency of the program with the potentiality.

AoA is the interpretative comparison for the operation effectiveness, cost and risk of the material solution proposed for the insufficient ca

---

\* corresponding author : onego77@naver.com

pability in the aspect of the operation capability. AoA identifies the priority solution or general solution for the identified insufficient capability and records the basic reason for the recommended matters. The AoA may occur may occur from the threatening change, technical lack and progress in the technical aspect. In this point of view, this work present the basic concept and template of AoA that can bestow the interpretative and scientific priority sequence for the various alternatives in making the military decision. The presented template for AoA might be used for the high-level decision making like Enterprise Architecture (EA) framework.

## 2. Decision making System of National Defense and AoAs

As for the decision-making support system of the national defense to attain the capabilities that are required by the warfighters, there are three kinds as follows: required decision system of Department of Defense (DoD), acquisition management system and Planning, Programming Budgeting and Execution (PPBE).

JCIDS, which is the required decision system, is commenced and executed through CBA. CBA utilizes Functional Need Analysis (FAA) to decide the battle performance capability, Functional Area Analysis (FNA) to decide the capability gap and Functional Solution Analysis (FSA) to decide the optimal approach method to reduce the gap. CBA-related activity in JCIDS shall be completed before commencement of the analysis of the alternatives.

There are various milestones and decision-making times in the defense acquisition management system. New system in any acquisition milestone or decision-making time may be initialized, continued, corrected or

cancelled. Also, PPBE system is the integrated DoD system developed for establishment, improvement, execution and revision of the national defense budget system. As AoA is the essential factor of these three systems, Office of the Secretary of Defense (OSD) has supervised AoA activity with much concerns.

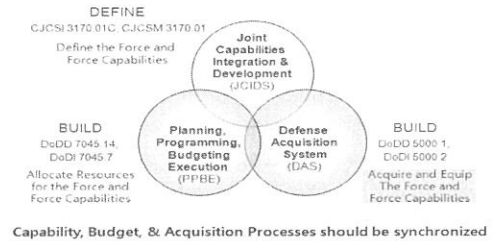


Fig 1. Decision making support system of national defense [1].

### 2.1 JCIDS and DAS

AoA process plays the important role in MSA stage of the defense acquisition management framework. After the program is approved in Materiel Development Decision (MDD), AoA process will select the material factor solution giving the priority on the point that satisfies the documented capability requirement in the approved ICD. Fig. 2 shows the analytic support role at the decision-making time of AoA during MSA and TDP. In the review of MDD, Director, Program Analysis & Evaluation (DPA&E) or each military under DoD presents the research guideline for AoA. The research guideline for AoA is provided to each military after it is approved by MDA.

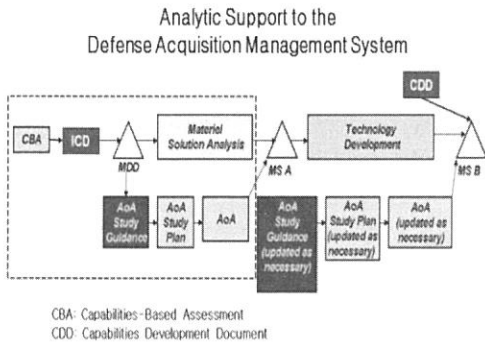


Fig 2. Role of AoA in defense acquisition management system[2].

As the research guideline plan for AoA and the plan for AoA are some parts of JCIDS, it shall be made being based on the analysis previously executed, JCIDS analysis course linked to the approved ICD is made of CBA analysis. CBA provides the recommendations (merits) documented in ICD for the identified capability gap material factor solution being satisfied with the confirmed capability requirements.

CBA does not provide the specific recommendations for the specific material factor, In this way, ICD can be used to fix the restriction factors for the domain designation of the alternatives considered in the following AoA. The research guideline plan for AoA shall be precisely made to provide the fair balance between the role to be focused to AoA and the role to guarantee that AoA considers the various, new and imaginative alternatives.

The final AoA to decide Milestone A is provided to DPA&E, DPA&E evaluates AoA and provides the independent evaluation of AoA to the brain center of each military and MDA. The evaluation standards submitted in this evaluation have been inserted in Department of Defense Instruction (DoDI) 5000.02.

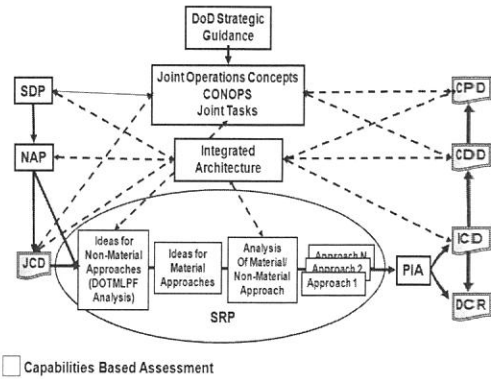


Fig 3. JCIDS-CBA relations and result document[3].

AoA is used to identify the material solution in the final condition with the most feasibility and plays the incidental role to make the effective and balanced acquisition strategy compared with the cost. The alternatives considered in AoA may be inclusive of the evolutionary courses making the alternative choice. The ones composed of respective courses of the intermediate nodes that are lead to the proposed final condition of solution. MSA plays the role to decide the optimal course in the final condition of solution being based on the balanced evaluation of the technical maturity, risk, cost, performance and specific considerations like the following diagram. The theoretical explanation for the evaluation acquisition strategy will be documented as a part of technology development strategy. There are the research plan of AoA, summary report of the intermediate progress, documented result report and final result report in the major outputs through AoA.

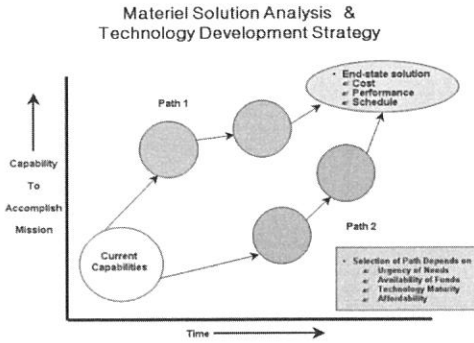


Fig 4. Evolutionary acquisition strategy[3].

## 2.2 AoA Process to Support Decision Making

MSA is the course drawing the acquisition portfolio, refined operation concept and target architect by selecting the requirement with priority being based on execution of AoA and integrated database by using the input of ICD and CONOPS before TDP in the capability evolution planning like Fig. 5.

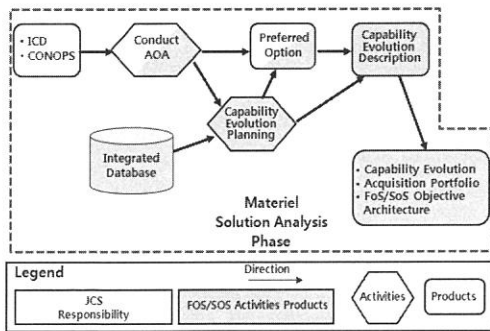


Fig 5. MSA procedure and output[4].

AoA is the consultative term identifying/analyzing the possible alternatives against the issue or enquiry. In the operation aspect of the alternatives satisfying the capability requirements, which are confirmed as the important factors of the defense acquisition process in the military, it means the analytical comparison of effectiveness, propriety and life cycle cost. AoA is necessary for all the major systems

by the acquisition regulations, and it is a process but not a simple temporary business. Namely, AoA is not the work by the standardized form and any checklist, but the decision making is a recursive, iterative, comprehensive process of the identification, evaluation, fusion and decision courses by the interest concerned and the decision maker like Fig.6[5]

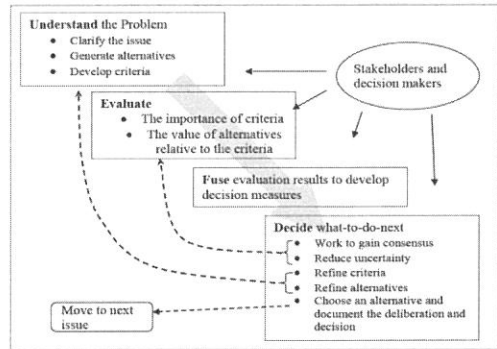


Fig 6. Decision making process.

As the methods for AoA, there are the optimization technique, heuristic technique, hybrid technique, collection of the expert's opinion, comparison of the similar weapon system and etc.

The optimization technique is the method analyzing the optimal alternative through use of Linear Programming (LP), non-LP, mathematical statistic model and etc. being based on the mathematical programming or optimization theory. The heuristic technique is the analytical method through the genetic algorithm, Fuzzy-neural. The hybrid technique is the method seeking the optimal solution by mixing various techniques to solve the specific problem. As other methods, there is the self-analysis and the method generally reviewing the expert service analysis besides comparison of the similar weapon system inclusive of collection of the expert's opinion that can utilize it at the initial

stage of the business by applying the Delphi method, which a few of experts use the intuitive judgment in the expert' s position.

### 3. AoAs Conduct Template

Most of the items defining the scope of AoA are established through JCIDS analysis. The items used to define the scope are the required capability, capability gaps, mission areas, threat, scenario, approach method used for the development of alternative, scheduling and so on. AoA justifies the decision-making for commencement, interruption and continuance of the acquisition program. As the decision makers need the reliable and objective assessment of the selective item to provide the essential capability, they carry out AoA. The AoA identifies potentially viable solution, and generally provides the comparative cost, effectiveness and risk analysis of each solution to the baseline of the present operation. The AoA team is composed of various government departments and the contractors, and it is performed by Working-level Integrated Product Team (WIPT) that is operated by the research manager. In general the research team is organized per function of each working groups. The typical function scope for the business groups is the threat, scenario, technology and alternatives, operation concepts of the alternatives, effectiveness analysis, risk analysis and cost analysis. The management and integration of the output of each business group shown in Fig. 7, are executed by each committee and the core group being composed of the representative of OAS, research manager and agent in the service. The content of the AoA plan as shown table.1 is described through the CBA process.

Table 1. AoA conduct template.

1. Introduction
1.1. Background
1.2. Purpose
1.3. Scope
2. Acquisition Issues
2.1. Capability Gaps
2.2. Scenarios
2.3. Threats
2.4. Environment
2.5. Constraints and Assumptions
3. Alternatives
3.1. Description of Alternatives
3.2. Nonviable Alternatives
3.3. Operations Concepts
4. Determination of Effectiveness Measures
4.1. Mission Tasks
4.2. Measures of Effectiveness
4.3. Measures of Performance
5. Effectiveness Analysis
5.1. Effectiveness Methodology
5.2. Analysis Tools, and Data
5.3. Effectiveness Sensitivity Analysis
5.4. Effectiveness Results
6. Cost Analysis
6.1. Life Cycle Cost Methodology
6.2. Cost Tools and Data
6.3. Cost Risk Methodology
6.4. Life Cycle Cost Results
7. Risk Assessment
7.1. Risk Assessment Methodology
7.2. Risk Assessment Tools
7.3. Risk Analysis Results
8. Alternative Comparisons
8.1. Alternative Comparison Methodology and Presentations
8.2. Criteria for Final Screening of Alternatives
8.3. Alternative Comparison Results
8.4. AoA Conclusions and Recommendations
9. Organization and Management
9.1. Study Team/Organization
9.2. AoA Review Process
9.3. Schedule

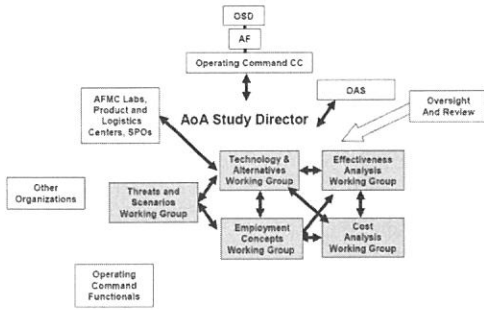


Fig 7. Structure of AoA study team.

At first, if the effectiveness result, cost estimate and overall risk information is made and if the sensitivity analysis and the compromise trade are researched, all of the information collected and the alternative comparison through the comparative analysis executed. To compare the alternatives is the simultaneous consideration for the judgment meaning the cost, effectiveness, related risk and decision making of the alternatives. As the alternative elimination is the technology acquired from the experience, there is no fixed formula, and each alternative should apply the technique under the specific circumstance. Generally, the alternatives are carefully separated through the continuous AoA process, and as for a lot of insufficient AoA data, it is useful to remove the unrealistic alternatives before they are used to analyze the alternative.

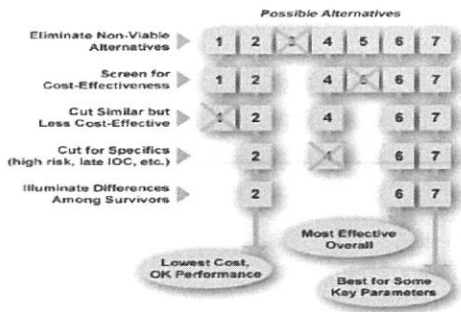


Fig 8. Eliminating alternatives in AoA[6].

If the analysis is submitted in the report or summary report, it will be useful to show the summary of the important identification factors for each alternative side by side before the conclusion and the recommendation are submitted. The following Table 2 is the example for the report form of such alternative comparison.

Table 2. Notional matrix of alternative comparison[6].

	Critical									Non-Critical			Risk	Total LCC (\$/M)
	Mission Task 1			Mission Task 2			Mission Task 3							
	MoE 1-1	MoE 1-2	MoE 1-3	MoE 2-1	MoE 2-2	MoE 2-3	MoE 3-1	MoE 3-2	MoE 3-3					
Alt 1 (baseline)	G	Y	R	G	G	Y/G	G	R	G	R			\$1,200	
Alt 2	R	Y/G	G	R/Y	R	G	G	Y/G	Y				\$1,450	
Alt 3	Y/G	G	R	G	Y	Y/G	Y	R	G	R			\$1,457	
Alt 4	G	R	G	R/Y	G	Y	R/Y	G	R	G			\$1,786	

#### 4. CONCLUSIONS

Among the capability evolution process, which is the system engineering approach method of the complex system environment, it is necessary to draw the operation concept through the AoA-centered MSA stage, and the operation scenario on the concept level shall be drawn that as for the established alternatives, the priority alternative is identified through AoA on MSA stage and then it is utilized in constructing the future military power.

This paper is the conceptive research for AoA to decide the reasonable military decision being based on the system engineering and preparation of the template. It is judged that the presented AoA template will bestow the big help on the scientific and objective decision making, especially as it is applied to the weapon system acquisition field of the national defense.

## REFERENCES

1. Yong Soo Kwon, "Considerations on the Application of Capabilities Based Planning to the SoS Environment", *4th APCOSE*, p.348, 2010.
2. *Configuration Control Board, Analysis of Alternatives Plan Overview*, DPAS, 2005.
3. *Capabilities-Based Assessment(CBA) User's Guide Version 3 Force Structure*, Resources, and Assessments Directorate(JCS J-8), March 2009.
4. Siel, C. R., *Naval SoS Systems Engineering Guide Book*, Vol. 1, p.12, ASN(RDA), 2006.
5. David G. Ullman, *Decisions Based on Analysis of Alternatives (AoA)*, 2009.
6. *Analysis of Alternatives (AoA) Handbook A Practical Guide to Analyses of Alternatives*, Office of Aerospace Studies, 2008.
7. *GIG Architectural Vision, Vision for a Net-Centric, Service-Oriented DoD Enterprise*, DoD CIO, June 2007.
8. *AIR FORCE ROADMAP 2006~2025*, U.S. Air Force, June 2006.
9. Scott Wolff, *Dynamic Appearance Model: Analysis & Alternatives* Captain Peter Hope, MA Department of National Defence Microsystems, Inc. 2003.