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A study on the development of the OMS/MP based on the Fundamentals of Systems Engineering

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Abstract

The Systems Engineering method is increasingly recognized as a central in the Acquisition of Weapon Systems in South Korea. Because of these trends, issues concerned with improving weapon system design are increasingly raised. This paper presents a development of Operational Mode Summary/Mission Profile (OMS/MP) in terms of Weapon Systems Acquisition for application to Systems Engineering method. For a systematic approach, a precise concept of OMS/MP is derived by analyzing the concept of conventional OMS/MP. This paper reviews the results of a series of previously reported examples aiming to develop the OMS/MP of a weapon system. Based on this, the limitations of the conventional OSM/MP applications are investigated. And these limitations can be resolved by the Fundamentals of Systems Engineering. Finally, the OMS/MP framework based on the Fundamentals of Systems Engineering has been proposed and is successfully implemented for the Harbor Underwater Surveillance System.
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Keywords: OMS/MP; ORD; Systems Engineering; Weapon system; Naval ship design; Weapon system acquisition; RAM; ILS; Shipbuilding; Harbor Underwater Surveillance System

1. Introduction

The objective of this paper is to develop an Operational Mode Summary/Mission Profile (OMS/MP) in terms of weapon system acquisition using the Fundamentals of Systems Engineering approach. According to the DAPA regulation in South Korea, Systems Engineering approach must be applied in order to acquire effective weapon systems. In general, the weapon systems acquisition process is divided into four phases: Precedent Study Phase, Exploratory Development Phase, System Development Phase, and Operations and Support phase. OMS/MP is a basic document which describes the acquisition process of weapon systems. It provides foundation information from logisticians, testers and evaluators, capability developers and analyst. OMS/MP used to be the appendix of Operational Requirements Document (ORD) and is the document which is written right after naval ships or weapon systems' Precedent Study phase in the early phase of the weapon system acquisition. In addition, the OMS/MP describes how to operate weapon systems during wartime and peacetime. The contents covered by OMS/MP are as shown below (DAPA, 2017) (Table 1).

However, it is difficult to say there has been sufficient research about the development of OMS/MP during the acquisition of warships and weapon systems. Even though OSM/MP has been compiled during the acquisition of most of the recent warships and weapon systems, they are unavailable due to confidentially restrictions. There are barely a few examples of foreign naval applications and these along with some portions of opened OMS/MP that are primarily process oriented are available Unfortunately these few example do not provide a coherent and systematic approach for developing OMS/MP.

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Table 1
Definition of OMS and MP.

Definition	Contents
OMS (Operational Mode Summary): Description that a variety of expected behavior will be used for the system to carry out the operational mission	- Documentation of the use of the system, which serves as a reference for basic input value or test and evaluation of the system design - It is necessary to include all the major mission (primary missions), which are listed in the Mission Profile - Must include the percentage of various mission frequency or system used in each mission - Percentage of system during the life cycle of the system which is the details of the exposure time for each of the environmental conditions
MP (Mission Profile): Temporally narrative of operational incident and the environment in which the system until the end from the start of the specific mission are facing	- Identification of task, event, period, operating conditions and environment in which the system is encountered at the stage of the mission - Include the typical mission scenario - It is required to identify the need to complete mission, Task or operation Event to successfully complete the mission. - Descriptions of the specific capacity (time, times, miles, cycle, etc.) of the essential functions of each mission - It must be consistent with the doctrine and tactics

Thus, this paper suggests the idea of applications for Fundamentals of Systems Engineering. This can be achieved by deriving implications of the domestic and overseas examples related to writing the OMS/MP. Based on this, Fundamentals of Systems Engineering are introduced to suggest the development tools of systematical OMS/MP.

2. Previous works

The requirements of OMS/MP writings are recently standardized but it is rare that they are opened due to the security constraint associated with acquiring weapon systems. Therefore, four cases of OMS/MP developed by domestic and overseas are investigated in this paper. Three cases are domestic and the other case is overseas.

2.1. Domestic case

For the domestic case, a submarine which is an Integrated Weapon System and one of the most complicated weapon systems (Jang et al., 2011), the army's combat vehicle mounted with weapon systems (Yoo et al., 2013) and a SONAR system of submarine (Song et al., 2015), are the main cases of OMS/MP applications.

2.1.1. Submarine OMS/MP

OMS/MP applications of submarine consist of three phases; Mission Area Analysis, Composition of combat scenarios, quantification of OMS/MP during wartime and peacetime. Descriptions are given below (Jang et al., 2011).

As seen in Fig. 1, the first phase is Mission Area Analysis. This phase investigates the external battle environment considering future global situations, and science & technology which are related to submarine operations. Furthermore, the future navy's operational concepts for a submarine are determined and derived. Finally, the submarine's required capability is suggested.

The second phase is to compose combat scenarios. Based on the Mission Area Analysis results, several combat scenarios are written by considering specific operations related to the submarine. And then, the Switch ON List has been composed. It indicates the ON or OFF state of the required equipment to operate for the finalized combat scenario.

The third phase is quantification during wartime and peacetime. By selecting the mission-area related to the worst case, quantifications are determined. The Template of OMS/MP is shown as a table below (Table 2 and 3) (Jang et al., 2011).

2.1.2. SONAR System's OMS/MP

In order to apply OMS/MP on the submarine's SONAR System, OMS/MP setting results of the submarine at which the SONAR System is mounted, are referred. Per the results of investigations for submarine's operation condition and Mission Area Analysis, sonar system's OMS/MP has been applied based on the composed wartime combat scenarios and peacetime operation scenarios. Procedures for the applications are as follows (Song et al., 2015) (Fig. 2).

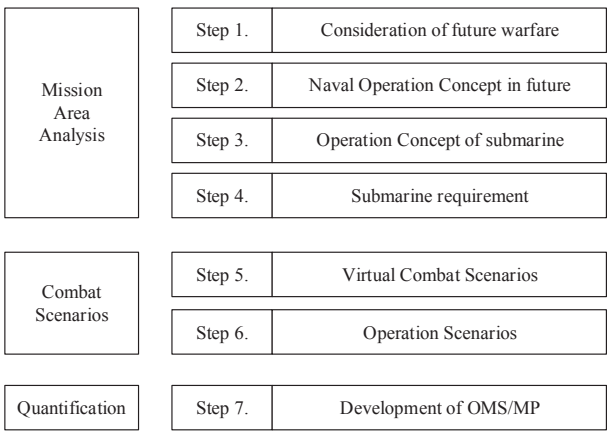

Fig. 1. Process of submarine's OMS/MP.

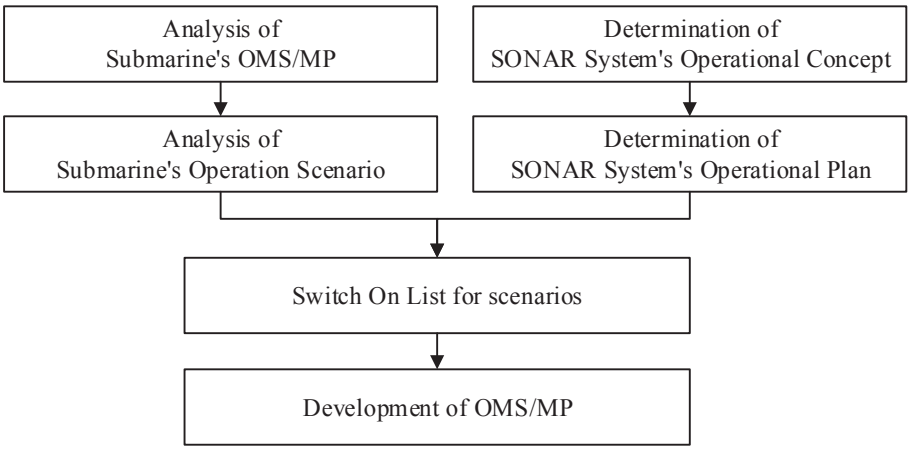

Fig. 2. Procedure of establishing OMS/MP of SONAR.

Table 2
Template of submarine's wartime OMS result.

Mission profile	TUT (Total Up Time)			Number of operation times
	OT (Operating Time)	AT (Alert Time)	ST (Stand by Time)	
Operation preparation	–	–	–	–
Ship moving (departure)	–	–	–	–
Operation A (1st)	–	–	–	–
Operation A (2nd)	–	–	–	–
Ship moving (arrival)	–	–	–	–
Total	–	–	–	–

Table 3
Template of submarine's wartime MP result.

Mission Profile	Average distance	Max. distance	(Equipment A) Operating time (hour)	(Equipment B) Operating time (hour)	(Equipment C) Operating time (hour)	Number of rounds	
Operation A	–	–	–	–	–	–	Scenario 1
Operation B	–	–	–	–	–	–	Scenario 2
Operation C	–	–	–	–	–	–	Scenario 3

As seen in the procedures above, Operating Time (OT), Alert Time (AT) and Standby Time (ST) are computed after the writings of the Switch ON/OFF List based on the operation guide-lines of each SONAR systems. The template of OMS/MP on SONAR scenario is described in the Table 4(Song et al., 2015).

2.1.3. Armed combat vehicle's OMS/MP

A Combat vehicle equipped with weapon systems is a type of Maneuver Weapon Systems. A typical example of OMS/MP about Maneuver Weapon Systems is indicated and the development processes of OMS/MP model are displayed in Fig. 3 (Yoo et al., 2013).

Tactical operation methods and operation terrains are investigated. And then, MAA (Mission Area Analysis) with the combat scenarios are composed. Finally, OMS/MP is composed. Table 5 shows an example of wartime OMS. The example of wartime MP is shown in Table 6 (Yoo et al., 2013).

2.2. Case studies for the overseas

OMS/MP for the Joint Light Tactical Wheeled Vehicle (JLTV) of the U. S. Army is one of the exemplary foreign cases. It displays the anticipated missions, roles and environments of JLTV. Also, it describes system modes, mission profiles and usage conditions that the JLTV will encounter for its operating life.

Table 7 shows OMS/MP for Major Combat Operations (MCO). And OMS/MP for IrW (Irregular Warfare) is shown in Table 8 (TRADOC, 2013).

2.3. Case studies results

It is significant that all the case study results are only focusing on the development procedure of OMS/MP which is illustrated in Fig. 4. It means that a feasible methodology has not been described for the OMS/MP writings.

Table 4
Template of OMS/MP on SONAR scenario.

Scenario A						
OMS	MP (Mission Profile)					
	Mission 1	Mission 2	Mission 3	Mission 4	Mission 5	Total
Total (hour)	–	–	–	–	–	–
OT (Operating Time)	–	–	–	–	–	–
AT (Alert Time)	–	–	–	–	–	–
ST (Standby Time)	–	–	–	–	–	–
ON/OFF	–	–	–	–	–	–

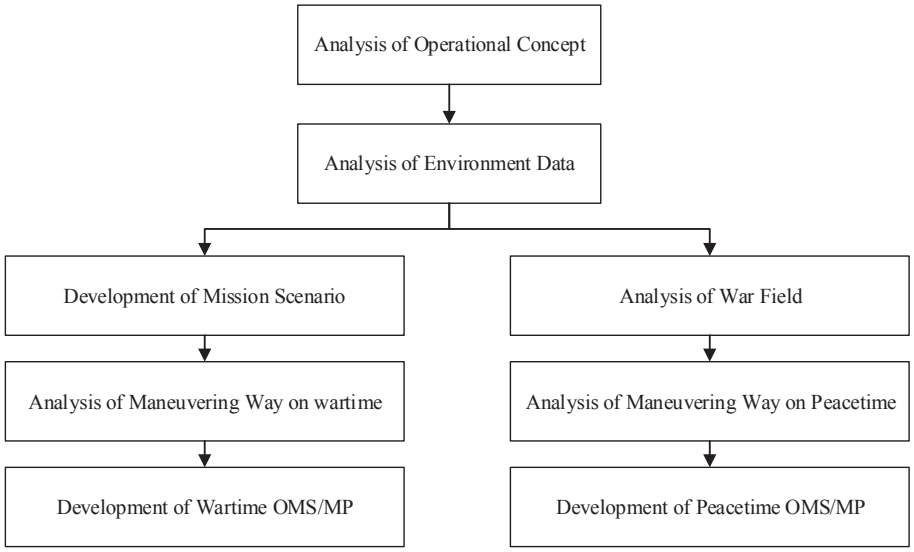

Fig. 3. OMS/MP model process.

Table 5
Example of wartime OMS.

OMS/Maneuver condition	Distance (km)	Operating time (hour)	Weapon (rounds)		Operation	
			Primary	Secondary	Communication Equipment	Etc.
Total	–	–	–	–	–	–
Defense/normal	35	13	200	3000	On/00 min. Standby/00 min.	–
Defense/High speed	5	3	150	3200	On/00 min. Standby/00 min.	–

Table 6
Example of wartime MP.

Surface	Slop (%)	Distance (km)	Average speed (km/h)	Operating time (hour)	Weapon (rounds)		Equipment	
					Primary	Secondary	Communication equip.	Etc.
Improved surface (normal speed)	0–10	–	–	–	–	–	–	–
	10–20	–	–	–	–	–	–	–
	20–30	59	25	2.34	5	50	On/0.3 Standby/2.1	–
	30–40	–	–	–	–	–	–	–
	40–50	–	–	–	–	–	–	–
…								
Unimproved surface (high speed)	–	–	–	–	–	–	–	–
…								

Table 7
OMS/MP for MCO (Major combat operations).

OMS	MP							
	Offense				Defense		Stability	Total
Full spectrum element MCO war game phases	Littoral/Air assault	Movement to contact	Attack	Pursuit	Area defense	Mobile defense	Civil Security	
Distance (miles)	4.6	128.9	18.5	32.5	19.2	17.5	14.7	235.9
4 Seat CTV category								
General purpose	6.8	134.1	19.4	43.0	18.3	17.8	17.7	257.2
Heavy gun carrier	7.0	146.5	19.8	19.5	20.8	13.9	17.6	
Close combat weapons carrier	5.4	112.4	19.3	12.9	23.6	10.7	16.7	201.1
2 Seat CSV category								
Shelter carriers	0.0	144.6	14.9	60.7	12.8	28.8	14.0	275.8
CSV utility	7.2	117.4	20.9	41.1	21.0	26.5	17.9	251.9

Table 8
OMS/MP for IrW (Irregular warfare operations).

OMS	MP						
	Stability			Defense		Offense	Total
Full spectrum element IrW war game phases	Civil security	Restore services	Support government	Mobile defense	Area defense	Attack	
Distance (miles)	111.5	38.0	20.3	25.3	43.1	15.2	253.5
4 Seat CTV category							
General purpose	91.6	31.2	16.7	20.8	35.4	12.5	208.2
Heavy gun carrier	154.7	52.7	28.1	35.2	59.8	21.1	351.6
Close combat weapons carrier	78.8	26.8	14.3	17.9	30.4	10.7	179.0
2 Seat CSV category							
Shelter carriers	79.1	27.0	14.4	18.0	30.6	10.8	179.8
CSV utility	125.6	42.8	22.8	28.6	48.5	17.1	285.5

Table 9
Template of OMS/MP.

Operational mode summary	Mission profile						
	Detect	Track	Classify	Localize	Identify	Report	Analysis
Dynamic operation time	–	–	–	–	–	–	–
Static operation time	–	–	–	–	–	–	–
Idle time	–	–	–	–	–	–	–
Stop time	–	–	–	–	–	–	–

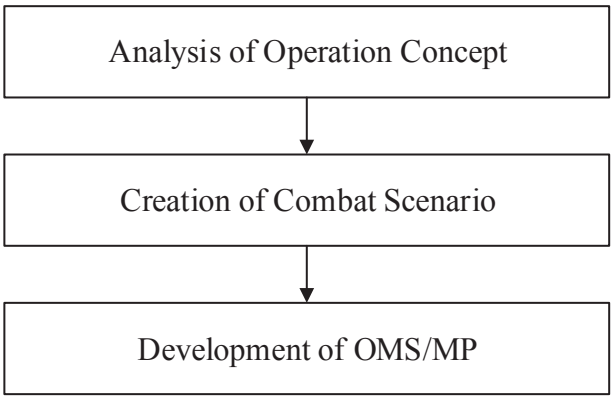

Fig. 4. Procedure of OMS/MP development.

In addition, the procedures described in Fig. 4 are not aligned with the acquisition process of the weapon systems. The right process is shown in Fig. 5. During the acquisition process, it is decided down to strategy, capability and requirements. Also, the requirements are structured down to Mission Requirement, Operation Requirement and Performance Requirement. The combat scenario writings are to be considered during the ROC writings before the Precedent Study phase. Specifically, the ROC must be written according to the decision of combat strategy, capability and, requirement. Accordingly, the analysis of Operation Concepts should be achieved. Finally, the ORD and the OMS/MP must be composed based on the Analysis of Operation Concepts. The ORD (Operational Requirements Document) describes operation requirements and concepts of weapon systems.

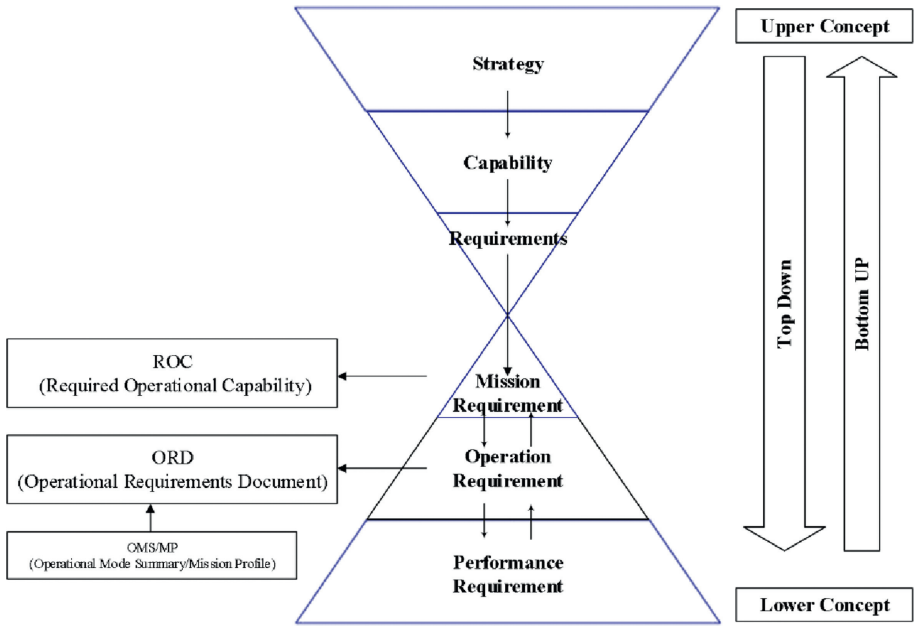

Fig. 5. Requirements hierarchy of system.

Thus, this paper proposes the effective development of OMS/MP using Systems Engineering approach.

3. Development of the OMS/MP based on the Systems Engineering approach

3.1. Systems Engineering approach

Systems Engineering is defined by an interdisciplinary approach and it proposes to enable the realization of successful systems. The Systems Engineering approach means to follow the concepts and procedures of the Systems Engineering. More specific methods are described below. The basic procedure of the Systems Engineering approach is, needs definitions, requirements analysis, functions analysis, design synthesis, verification, validation and transition. By using the coordinates as shown in Fig. 6, X-axis expresses approximate progress, and Y-axis illustrates approximate depth and level of the works.

As shown in Fig. 6, eight kinds of basic concepts exist (Jeong, 2010).

The first concept is Top-down and Bottom-up. The Top-down means to transfer general properties to specific properties and shows the lower branch of implemented system's upper level. The system mission is assigned to lower-level and is decomposed to its corresponding function by achieving the design. And it is the left step of the Vee-model. On the other hand, the Bottom-up is integrated to the upper level and it is the right step of the Vee-model which applies the implemented results.

The next concept is Decomposition and Integration. The decomposition is a segmentation when top down concept is applied and the main mission is segmented to specific mission.

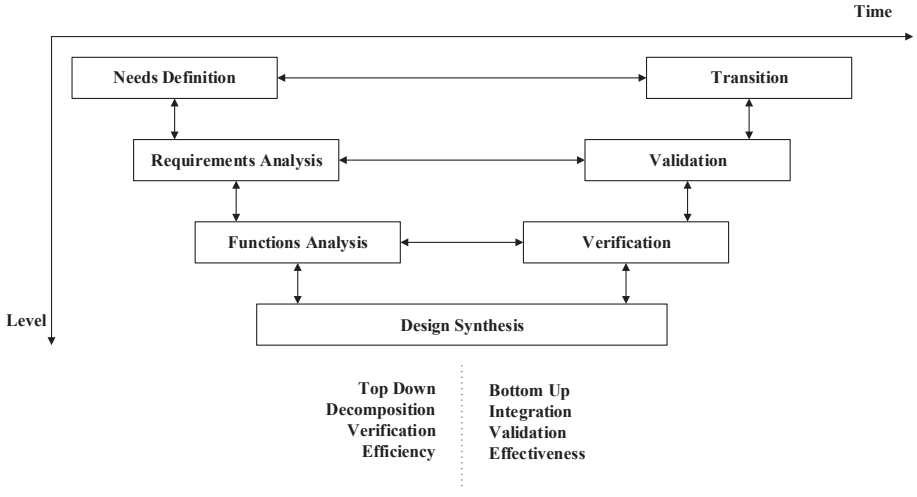

Fig. 6. Systems Engineering approach by Vee-model.

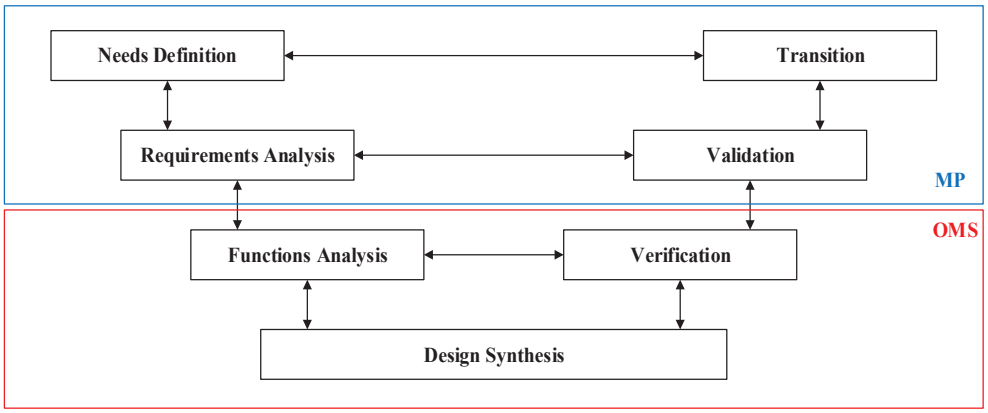

Fig. 7. OMS/MP framework.

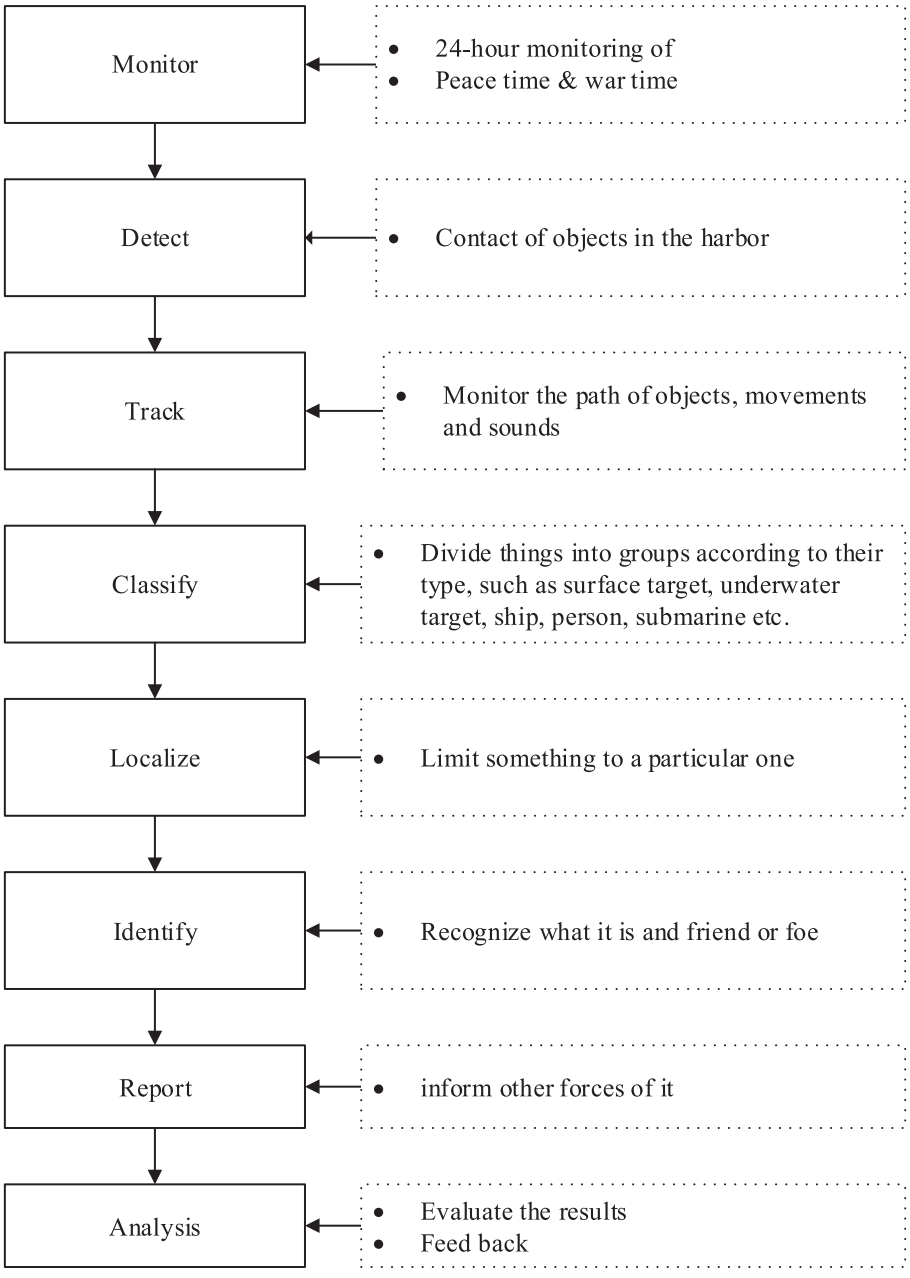

Fig. 8. Operational concepts.

In other words, a main function is segmented to specific function. Like top-down, it is the left step of the Vee-model. However, integration is integrated from upper to lower-level when the bottom-up concept is applied. And it is the right step of the Vee-model.

The next concept is Verification and Validation. The verification is used to check if the design process is correctly done and if the data is precisely expressed on the developer's side. The validation is used to check if the designed entity is well aligned with the real environment and if the data is correctly implemented to the real environment. In the case of the programming work, the verification means the coded works without any error and the validation means that the coded results are well applied to the real environment. When it comes to manufacturing and ship-building, verification means the confirmation process that the manufactured or built things are the same as the designed results. The validation process must check to see if the expected results are derived in the real world from the view point of the customer's requirements. The validation process is for the customer's requirements, and the verification process is for functions of the system.

The last concept is Efficiency and Effectiveness. The efficiency is the standard of the verification process. And the effectiveness is the barometer of the validation process.

3.2. OMS/MP

Nowadays, the definition of the OMS/MP in Korea is unclear. As noted above, although it is mentioned on the regulations of the Defense Acquisition Program Administration (DAPA), it is still hard to develop the OMS/MP using that. This is because there is no clear and specific definition available, but, only an overall vague definition is available. In addition, there are no composition instructions.

In the case of the overseas, it is more clarified. Operation Mode Summary (OMS) can be defined as below.

- A description of an operational role which must be completed by the system from the viewpoint of a user or an operator.
- A description for the relative frequency of mission that must be completed. And a system's exposed frequency or times from environmental condition.
- Fundamentals of test and evaluation. A document which is related to system usage and that can be applied to the default input of the design process.

OMS describes all the main missions which are already expressed on the mission profile. Mission Profile (MP) can be defined as below.

- A description for the operational event which is the system, should get through from the start to the end and environmental factors with respect to time.
- Assorted results of time, elapsed time, operational condition, environment during which the system faces for each mission.
- Inclusion of mission scenario.
- Featured quantities in terms of operation which is a necessary function of the mission completion within the feasible task. Specifically, it corresponds with the doctrine and strategy and referred to time, cycle and frequency.

Therefore, OMS expresses the requirement conditions with respect to the system which is being developed from the viewpoint of the user. Thus, the contents contained on the OMS are Dynamic Operation, Movement Time, Static Operation, Idle Time, Silent Watch Operations Time, System and Engine Off Time.

MP is the expression of the operational concepts for a user in the viewpoint of system. Thus, the contents included on the MP are Offensive Operations such as Movement to contact, Attack, Exploitation, Pursuit, Defensive Operations such as Mobile defense, Area defense, Retrograde, and Stability Operations such as Civil Security, Civil Control, Restore Essential Services, Support to governance, Support to economic and infrastructure development.

3.3. OMS/MP framework based on SE

A framework for development of an effective OMS/MP using Systems Engineering approach can be seen as below. As shown in the figure, MP deals with the user-area and organizes operational concepts of the user with respect to system perspective. OMS deals with the system and with the system operation in terms of the users' perspective (Fig. 7).

Therefore, the verification checks the OMS in the era of the system. And the validation confirms the MP in the era of the user.

4. Implementations

In this paper, the method above was conceptually applied to the Harbor Underwater Surveil System (HUSS) conceptually.

The Harbor Underwater Surveil System (HUSS) is installed at naval bases or ports. It monitors threat targets which invade either above or under the water. At the initial stage, HUSS detects enemy threats that penetrates the ports and has the capabilities to report this detection information to others (Fig. 8).

Thus, by investigating user needs, the missions that the system should complete are determined to detect, track, classify, localize, identify, report, and analysis. These are the Mission Profiles of HUSS. MPs have expressed operational concept of users in terms of HUSS. These operational concepts can be applied to sensor devices such as a SONAR commonly.

The System should complete the Mission Profile that is the user's operational concept. This expresses how the system works and is defined as dynamic operation, static operation,

idle time and stop. These are Operational Mode Summary (see Table 9).

5. Conclusion

This paper presents development of the Operational Mode Summary/Mission Profile (OMS/MP) in terms of weapon systems acquisition by application of the Systems Engineering method. The Harbor Underwater Surveil System is conceptually implemented by using the proposed methods.

In Summation, OMS expresses the physical requirement of the development system from the view point of the user. This reflects Systems Engineering's concepts which are Top-down and decompose the requirements, finally results in testing during the verification process.

MP describes operation concepts with the functional perspective which deals with how to operate the system that the user requested. This reflects Systems Engineering concepts which are Bottom-up and integrated, and it is validated.

This paper applies the Systems Engineering method and proposes initial methods to develop OMS/MP. And it successfully reflects specific data as the development stages progress. Final contents are confirmed and can be used as fundamentals of investigations of system's Reliability, Availability, Maintainability-Cost (RAM-C)development.

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