A Study on Traceability Management Using SWBS for a Naval Ship Acquisition

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Abstract : Korean Naval Ship acquisition processes are very complicate. There are 4 phases, Feasibility Study, Concept Design, Basic Design, Detail Design and Construction. A number of organizations and support groups exist to acquire naval war ships. Thus, It is very important how to establish traceability about requirements . This work has investigated how to improve traceability about requirements using Shipboard Work Breakdown Structure.

Key Words : Systems engineering; Naval ship design; Traceability; Simulation Based Acquisition.

1. INTRODUCTION

Korean Naval Ship acquisition processes are very complicate. There are so many different things from weapon systems acquisition processes. We need to improve that process. Systems Engineering is a good methodology to solve that.

Systems Engineering is defined 'An inter-disciplinary approach and means to enable the realization of successful systems' . One of main issues is traceability.

2. Naval Ship Acquisition Process

There are 4 phases, Feasibility Study, Concept Design, Basic Design, Detail Design and Construction.

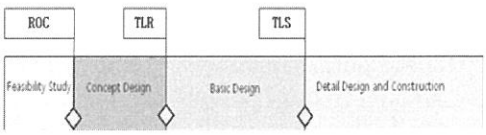

Fig 1. Acquisition phases

2.1 Feasibility Study

Feasibility Study' s major work scope is to obtain plural proposal based on the approximate operational capability requirement so as to draw up the new requirement proposal report and design personnel. It takes 6~12 months generally. DAPA take charge of it. Requirement proposal means decision and proposal of proper requirement based on Feasibility Study. JCOS take charge of it.

Primary work scope for Feasibility Study consist of the following:

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- The development trend analysis of naval ships
  - Hull type analysis
  - Equipment systems analysis
  - Cost and effectiveness analysis
  - Technical alternative. etc

2.2 Concept Design

Concept Design is about The Design Step for the Hull-form and Specific Characteristics Decision for the purpose of defining Ship Concept and ROC, and draw up a Construction Plan of Basic Design. It needs 4~10 Design personnel and 6~12 Months period generally. ROC/TLR Decision based on Concept Design Result is a role of JCOS.

Primary work scope for Concept Design consist of the following:

- Design Concepts
- Ship size estimation
- Hull form design
- General arrangement
- Stability analysis
- Weight estimation
- Speed/power estimation
- Propulsion systems analysis
- Power systems analysis
- Crew analysis
- Cost analysis

2.3 Basic Design

Ship acquisition program becomes serious through Basic design. Shipyard carry out Basic design and DAPA supervise it. It' s a Design Step to confirm TLR on the design process, Confirm the Ship Dimension/Specification etc, Draw up Ship Contract Drawing, Calculate the approximate Shipbuilding cost and Confirm TLR from Basic Design. It may takes 50 personnel and 2~3 yrs period generally.

Test and Trial means Evaluation of Basic Design Result by Data and Decide the possibility as combatant in order to proceed a leading ship with the following ship. DAPA take charge of it.

2.4 Detail Design and Construction

Detailed Design/Shipbuilding means real construction of new warship. It may takes about 80 personnel and 4~5 yrs period. And makes about 2,000 Drawings & Reports generally.

3. Characteristics of Naval Ship Acquisition

There are a number of characteristics in Naval ship acquisition processes.

The first characteristic is Naval ship is a integrated weapon system. There are so many systems in shipboard. This concept is system of systems. It is different from a complex system. Generally, one weapon system has one acquisition process. Also, it means that one acquisition process has one acquisition organization. In Army or Air Force field, each weapon system has one acquisition organization. But, despite a war ship has many systems for performance it has just only one organization in a naval ship acquisition.

The second characteristic is Ship design process is the worst case design. An entire ocean environment should be considered including a typhoon, a tropical hurricane/cyclone, etc. all system equipped for a ship system should withstand the most extreme of circumstance. Also it is differ from a land-use equipment. It is a 3 dimensional moving object. It should be considered 6 degrees of freedom, roll, pitch, sway, surge, yaw and heave. Moreover, it should be adopted a special design to protect hull and equipments from salt.

The third characteristic is spatial optimization.

A naval ship is a system with limited space. According to ROC, principal dimensions, lengths, breaths, depth and draft, are determined. And then, ship size and volume are fixed. It should be optimization a given space to carry out ship' s mission.

The forth characteristic is a Construction period is long term. It means that a huge shell plate with a massive weight is handled. One shell plate is equal to a tank. There are so many shell plate to construct a naval ship.

The fifth characteristic is ship construction method is a job-order production. It means that ship' s specification is differ from each order

The last characteristic is leader ship concept. A prototype ship does not exist for a naval ship. Generally, it is building a prototype for Army and Air Force. A prototype is the first production before proceed to mass production. It will be test and evaluate to meet requirements. After test and evaluation, it is disposed. Also, A naval ship is tested and evaluated. But it is not disposed for service. The premise of Ship acquisition program is definitely success. Then, Risk management is very important things. The key point for Risk Management in a naval ship acquisition program is establishing traceability about requirements

4. Traceability Management

This paper utilized SWBS(Shipboard Work Breakdown Structure) to establish Traceability in ship acquisition program.

4.1 SWBS

The Shipboard Work Breakdown Structure is a kind of WBS(Work Breakdown Structure) for a Naval ship or a Submarine. The Work Breakdown Structure (WBS) is a means of organizing system development activities based on system and product decompositions. And the WBS is a direct derivative of the physical and systems architectures. The WBS is used to define the total system, to display it as a product-oriented family tree composed of hardware, software, services, data, and facilities, and to relate these elements to each other and to the end product. Program offices are to tailor a program WBS using the guidance provided in MIL-HDBK-881.

The WBS provides a coordinated, complete, and comprehensive view of program management. It establishes a structure for organizing system development activities, including IPT design, development, and maintenance. The WBS establishes a structure for identifying products, processes, and data and organizing risk management analysis and tracking.

A WBS has an end product part and an enabling product part. The end product part of the system typically consists of the prime mission product. The "enabling product" part of the system includes the products and services required to develop, produce, and support the end product.

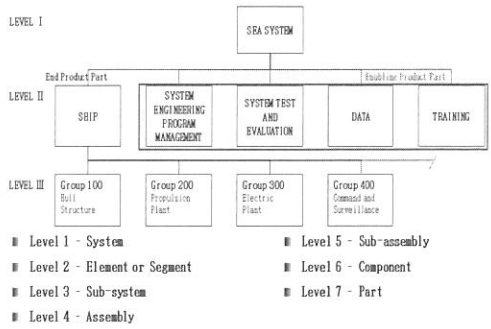


Fig 2. Architecture of WBS

The Ship Work Breakdown Structure provides definitions for a Naval Ship or a Submarine.

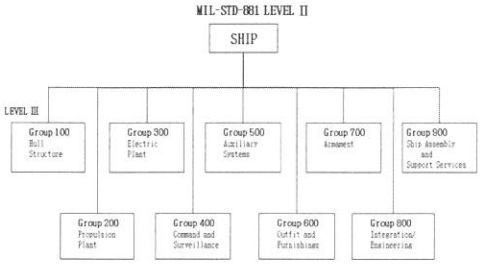


Fig 3. Architecture of SWBS

The SWBS is developed initially to define the top three levels just like the WBS. The first three SWBS Levels are organized as:

- Level 1 - Sea System
- Level 2 - Ship, Systems Engineering / Program Management, System Test and Evaluation, Training, Data, Peculiar Support Equipment, Common Support Equipment, Operational/Site Activation, Industrial Facilities, Initial Spares and Repair Parts.
- Level 3 - Hull Structure, Propulsion Plant, Electric Plant, Command, Communication and Surveillance, Auxiliary Systems, Outfit and Furnishings, Armament, Total Ship Integration/Engineering, Ship Assembly and Support Services (in ship - end product)

The Group 100 is Hull Structure. It is assembled main hull body including all hull support structure, superstructure, bulkheads, platforms, masts, and foundations.

The Group 200 is Propulsion Plant. It is the major components installed primarily for propulsion and the systems necessary to make these components operable

The Group 300 is Electric Plant. It is the power generating and distribution systems installed primarily for ship service and emergency power and lighting

The Group 400 is Command, Communication and Surveillance. It is the equipment and associated systems installed to receive information from off-ship source, to transmit to off-ship receivers, and to distribute information throughout the ship.

The Group 500 is Auxiliary Systems. It is the support systems for ship control, main propulsion components, ship safety, deck operations and environmental control

The Group 600 is Outfit and Furnishings. It is the outfit equipments and furnishings required for habitability and operability which are not specifically included in other ship elements.

The Group 700 is Armament. It is the complex of armament and related ammunition handling, stowage, and support facilities; and cargo munitions handling, stowage, and support facilities.

The Group 800 is Total Ship Integration/Engineering. It is the engineering effort and related material associated with the design, development, and rework to provide the ship as a whole exclusive of that included under the Systems Engineering/Program Management element.

The Group 900 is Ship Assembly and Support Services. It is the efforts and material associated with construction which cannot be logically and practicably identified with, or related to, other Level 3 elements.

The LEVEL 4 subdivide the level 3. In the Group 100, it consists of 110 Shell and supporting structure, 120 Hull structural bulkhead, 130 hull deck, 140 hull platform, 150 deck house structure and so on.

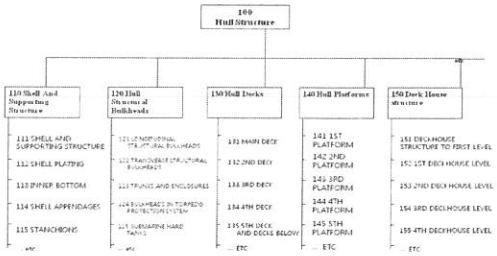


Fig 4. Architecture of the SWBS Group 100

4.2 Requirement Documents

The Requirement Document describes the main missions and subsystems for a naval ship. The ROC(REQUIRED OPERATIONAL CAPABILITIES), TLR(Top Level Requirements) and TLS (Top Level Specifications) are representative documents written ship' s missions and subsystems

4.2.1 ROC

The ROC is a simple document. It describes just primary and secondary warfare mission. It may be summarized as follows.

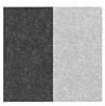
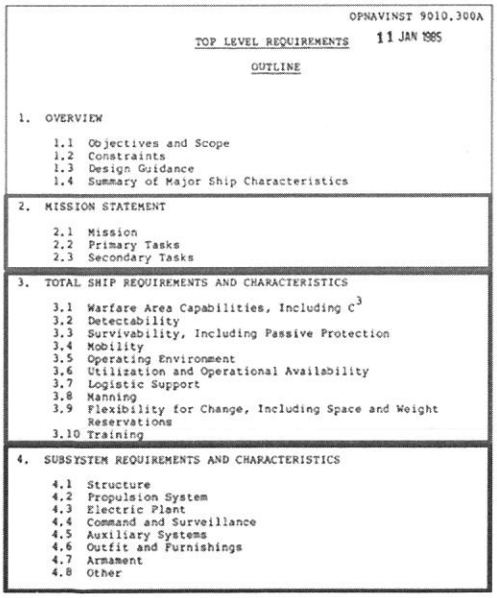


Fig 5. ROC sample

4.2.2 TLR

The TLR consist of 4 parts: OVERVIEW, MISSION STATEMENT, TOTAL SHIP REQUIREMENTS AND CHARACTERISTICS, and SUBSYSTEM REQUIREMENTS AND CHARACTERISTICS.



OPNAVINST 9010.300A

TOP LEVEL REQUIREMENTS 11 JAN 1985

OUTLINE

1. OVERVIEW
   - 1.1 Objectives and Scope
   - 1.2 Constraints
   - 1.3 Design Guidance
   - 1.4 Summary of Major Ship Characteristics
2. MISSION STATEMENT
   - 2.1 Mission
   - 2.2 Primary Tasks
   - 2.3 Secondary Tasks
3. TOTAL SHIP REQUIREMENTS AND CHARACTERISTICS
   - 3.1 Warfare Area Capabilities, Including C^3
   - 3.2 Detectability
   - 3.3 Survivability, Including Passive Protection
   - 3.4 Mobility
   - 3.5 Operating Environment
   - 3.6 Utilization and Operational Availability
   - 3.7 Logistic Support
   - 3.8 Manning
   - 3.9 Flexibility for Change, Including Space and Weight Reservations
   - 3.10 Training
4. SUBSYSTEM REQUIREMENTS AND CHARACTERISTICS
   - 4.1 Structure
   - 4.2 Propulsion System
   - 4.3 Electric Plant
   - 4.4 Command and Surveillance
   - 4.5 Auxiliary Systems
   - 4.6 Outfit and Furnishings
   - 4.7 Armament
   - 4.8 Other

Fig 6. TLR outline

It may be summarized as follows.

In the above figure, The Red box is related to ship' s mission and the black box is related to ship' s subsystems based SWBS. But there is no special way to express relations between two items. Therefore, the requirements concerned with ship' s missions are unable to trace ship' s subsystems. It lead to discontinuities in a naval ship acquisition process.

4.2.3 TLS

The TLS consist of 5 parts: SCOPE, SHIP SYSTEMS DESCRIPTION, DESIGN DIRECTION, FUNCTIONAL PERFORMANCE, and SUBSYSTEM PERFORMANCE.

The FUNCTIONAL PERFORMANCE is mentioned about mission support in a few comments. The SUBSYSTEM PERFORMANCE consists of the SWBS: hull structure, propulsion plant, electric plant, command and surveillance, auxiliary systems, outfit and furnishings, armament system, consumables, personnel and training, general guidance and administration, and integration/engineering.

Therefore, like the TLR, the TLS has the same problems.

4.3 Traceability establishment

The process to establish traceability is following:

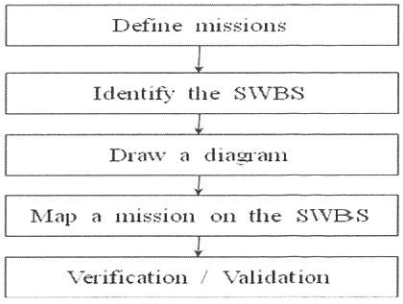


Fig 7. Process to establish traceability

4.3.1 Define missions

The first step is Define missions. The ship' s missions are defined by designers and users. The mission type is following;

1) AAW(ANTI-AIR WARFARE)
   - AAW 1 provide anti-air defense in cooperation with other forces
     .....
   - AAW 6 DETECT, IDENTIFY AND TRACK AIR TARGET
   - AAW 6.1 Measure aircraft altitude
   - AAW 6.2 Recognize by sight friendly and enemy aircraft
   - AAW 6.3 Maintain accurate air plot.
   - AAW 6.4 Detect, identify and track air targets with radar.

2) MOBILITY
   - MOB 1 OPERATE SHIP'S PROPULSION PLANT TO DESIGNED CAPABILITY.
   - MOB 1.1 Operate ship's propulsion plant at full power.
   - MOB 1.2 Operate ship' s propulsion plant with split plant operations.
     .....
   - MOB 3 PREVENT AND CONTROL DAMAGE
   - MOB 3.1 Control fire, flooding, electrical, structural, propulsion, and hull casualties.
   - MOB 3.2 Counter and control NBC contaminants/agents.

4.3.2 Identify the SWBS

The second step is Identify the SWBS. The SWBS of a design war ship is identified from SWBS standard of MIL-HDBK-881.

4.3.3 Draw a diagram

The third step is Draw a diagram. In a diagram, the vertical lines are the SWBS, and the horizontal lines are missions.

4.3.4 Map a mission on the SWBS

The forth step is Map a mission on the SWBS. It is as in the following.

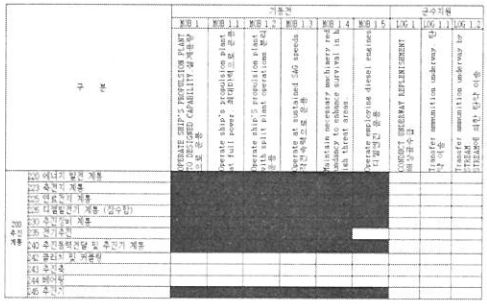


Fig 8. Traceability Diagram

4.3.5 Verification/Validation

The last step is Verification/Validation. It track down the missing mission or SWBS using a empty cell.

5. CONCLUSIONS

This paper attempted to improve traceability about requirements using Shipboard Work Breakdown Structure. I did an analysis of the problem and proposed solutions to it. I checked the process, proposed solution, using a case study about ship acquisition process

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