Study on Vessel Maintenance Support System Modelling Based on DODAF

Wang Chaowei¹, Ding Lvhui¹, Wu Qian²*, Zhang Jie¹ and Li Peichang¹

¹China Ship Develop and Design Center, Wuhan 430064, China
²China National Institute of Standardization, Beijing 100191, China

*Corresponding author’s e-mail address: ustbwuqian@163.com

Abstract. The vessel maintenance support system, which consist of aboard and onboard two parts, is different from the other equipments, with the characteristics of tasks varied, complex structures and onerous business. It is a virtual system rather than a material system. So the traditional modelling method which is used to describe the material objects has some defects of long communication period, weak reusability and poor expansion in describing support system in design process, which apparently cannot meet the current demands. It is imperative to introducing standardized design and modelling approach to establish the vessel support system. The study firstly analyses the function, organization, resource and operation of vessel support system. The support system modelling method is introduced based on the analysis of different view products in DODAF framework. The support system model, which is consists of organization model, activity model and information exchange matrix is given based on active based model. It can provide guidance in support system design, support concept generation under new situation, even in integrated joint operation system design in the future.

1. Introduction
Vessel is one of the most important equipments in integrated joint operation with the characteristics of complex structure, long developing period, high cost and wide range of service cycle and user. The vessel maintenance support capability determines the whole equipment efficiency as well as its performance. Whereas the maintenance support capability of vessel is more complicated and tremendous than other ordnances, such as aircraft, tank and armored car. The traditional modelling method with words and diagrams or chats doesn’t meet the modernized equipment’s design and operation requirements. Nowadays, the design project of support system involves many relevant stakeholders. A new modelling approach must be found to establish the relationship of all the fundamental data and sub-models and integrate all the joint developers effectively on the concurrent activities during the design phrase. This association work can guarantee consistency, veracity and timeliness the modelling

The paper presents an approach of vessel maintenance support system modelling based on DODAF with the principles of system architecture building, which takes organization, personnel, activity and information into consideration. Firstly, the DODAF products are introduced. Then the ABM modelling method with DODAF operational views is given with the reviewing of functions. The relationship among the views and the modelling steps in ABM are also analysed. The make-up factors of vessel maintenance support system are introduced by the way of three-dimensional model. The reflection between the support factors and DODAF products are analysed. Finally, the model of
maintenance support system. It shows that maintenance support system modelling based on ABM with DODAF is more efficient and convenient. The model can be used repeat and is able to expand, which aid a larger amount of developer distributed to work more coordinately.

2. **DODAF products applied in system modelling**

2.1. **DODAF Framework**

2.1.1. **DODAF introduction.** The Department of Defence architecture framework (DODAF) is developed by DoD of USA based on C4ISR system (Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance) according to the military experience in combat. Nowadays it applies in more and more engineering system. The DODAF 1.5 and 2.0 is published gradually, which emphasises the data centred design opinion [1][2].

2.1.2. **DODAF products.** The DODAF 1.5 products consists of four parts: all view (AV), operation view (OV), system view (SV) and technical system view (TV). The AVs shows the reviewing and environments of the whole system. The OVs describes the types, activity, organization and other related information within businesses that system deals with. The SVs determines the requirements of function and performance of system. The TVs is used to expatiate the technical standards and guidance which support the system during the design. It should be noticed that not all the products will be used in system establishment. It varies according to the specific demands of user or designers’ purpose[3].

2.1.3. **Modelling procedures with DODAF.** The modelling progress in which a system with clear characteristics and meet certain requirements has to be guided under a certain means or principles due to the complexity of both the system in expectation but also the modelling progress itself. Firstly, the users should be aware that it is impossible to build a full-fledged model consisting of all elements of the system. all the project participates must acknowledge the purposes and applied situations of model and confirm the key points in analysis and modelling to make the project more efficiently. Secondly, the application background, operation scenario, geographic area and management factors which would influence the above aspects should be determined. Thirdly, the characteristics and features of the system have to be confirm in case of a useless modelling if ignoring the details. Similarly, the model can be huge and hard to recycle if many needless characteristics are included. Then cut off the unnecessary view products, which may decide the amount of work to a certain extent. Furthermore, all the useful data should be gathering as soon as possible, which is a continuous work started in early phrase. The data may be updated with the development. Finally, the DODAF product would be developed as well as the related documents. The verification of model can be conducted according to the user’s demands[4].

3. **Vessel Maintenance Support System Modelling based on ABM with DODAF products**

3.1. **ABM method.**

The total products in DODAF is 26 views. If the system is going to be built with all the views, it would take a large amount of personnel, time and cost. As the development of DODAF, the researchers make several inductions of modelling methods. ABM is one of the methods proposed by Steven J Ring. Compared to the traditional modelling, which focuses on the products, ABM is a data-centred modelling method base on the three kinds of views. ABM supports the cross of different views and automatically data generation. Once the relationships among some certain views are confirmed, the remaining views can automatically generate by software tools. The system structure can be divided into three objects: entity, relation and attribute. The entity is used to store and process the data in system. The relation is the link among the entities. And the attribute is the features and characteristic of entity and relation[5].
3.2. **Modelling steps based on ABM.**

According to 3.1, the modelling steps based on DODAF is shown in figure 1. The first step is to establish the operational activity views (OV-5), which includes the logic relationship among activities, and the inputs and outputs among activities and environments. The second step is to establish nodes in OV-2. The whole OV-2 consists of two parts, nodes and requirement lines. The requirement lines can automatically generate. So the nodes should be determined at first. The third step is to establish roles and units in OV-4. The OV-4 is mainly used to describe the structure relation among entries in system, which includes manage, command, report and other relation. The former three steps separately describe activities, nodes and roles. And the fourth step in modelling is to relate them manually. The fifth step is to generate the relationship among activities, nodes and roles. Thus, the activities and role would in the corresponding nodes in OV-2. So would the other two views. The sixth step is to generate the information exchange requirements in OV-2. This step can be also accomplished by software automatically. Essentially, the information exchange is conducted by the activities in the nodes. The seventh step is to generate the requirements line in OV-2, which is to map the information to the exchange line. The eighth step is to generate the information exchange matrix, which is OV-3. OV-3 describes the reason for information exchanging, direction and way of information exchanging and the specific information. Thus, the ABM provides a certain flow and standard for products selecting in DODAF.

![Diagram](image_url)

**Figure 1.** Modelling steps based on DODAF

4. **Vessel Maintenance Support System Modelling Based on ABM**

4.1. **Vessel Maintenance Support System.**

Vessel maintenance support system refers to the combination of support resources and management factors which vessel requires during maintenance, including on-board and base support activities. The support resources consist of all the personnel, material, information and other kinds of resources. The support resources are distributed in every node in support system. And support functions of system can be executed through the support activities operated by the corresponding organization. As shown in figure 2.
4.2. OV-5 of Vessel Maintenance Support System.

The activities within vessel maintenance support system are integrated into the functions of system. The activities are hierarchy, in which the maintenance function includes corrective maintenance activities and preventive maintenance activities. The two kinds of maintenance consist of various maintenance procedures. The modelling method of IDEF0 is applied to establish OV-5 of Vessel Maintenance Support System. The five factors have to be described clearly in IDEF0, as shown in figure 3. The first is activity, which describe the specific progresses of maintenance, the activities are arranged in a certain logic way and can be decomposed. The second is the input of activity, which can be actual martial or virtual data or information. The actual martials compose of spares, oil and other consumption. The virtual data can be administration order or intelligence. The third is output of activity, which is the recovery equipment with supporting and records. The forth is mechanism of activity, which support the activity. The mechanisms can be specific person or a kind of organization, and even the support nodes. In the paper, Support tools, facilities and equipments are regarded as the mechanisms. The fifth is control of activity, which is mainly the regulations and laws support system should obey. The technical manual is one of the typical controls. Other factors which may influence the system can also be control, such as battle field environment and support budgets.

4.3. OV-2 of Vessel Maintenance Support System.

The support node is the combination of support organizations, which may include one or more organizations. The amount of nodes varies with the requirements of support. The rule of nodes sort is the function of organizations rather than the geographic distribution. The OV-2 of Vessel Maintenance Support System includes three parts. The first one is support nodes, which is the basic factor that generate, apply and process information. The node can be a concrete organization (e.g. strategy office of DoD, manufacture), or a node in functional or logic aspect (e.g. logistic node, intelligence node). It should be noted that the OV-2 should be established according to the actually executed mission. The specific location or buildings should not be described as a node. The second is the information lines, which describe the information exchange requirements among nodes. The information is generated or applied to accomplish the support activities. The third one is business activities. All the nodes should a certain set of business. The OV-2 of Vessel Maintenance Support System is shown in figure 4.4. The model of OV-2 is established by the method of UML. Additionally, the activities and information lines can be generated automatically with the modelling tools (e.g. IBM SA) once the connection among three views is built. The repair level of vessel can be divided into three levels, the operational level (O), the immediate level (I) and the depot level (D), with the growth of maintenance capability. The operational level in vessel maintenance support system refers to the on-board and dock maintenance.
The immediate level refers to the maintenance at the repair ship or institute. The depot level refers to the repair factory of navy or civil use.

![Figure 3. OV-5 Modelling based on IDEF0](image)

![Figure 4. OV-2 of Vessel Maintenance Support System](image)

4.4. **OV-4 of Vessel Maintenance Support System.**

The main purpose of OV-4 is to describe the roles and authorities to realise the objections and functions of support system. In other words, it is to illustrate the activities conducted by whom. The logic links and connections among the organizations, which provide foundation of normal work of system should be established. The organizations in the support system have the following characteristics: hierarchy, dispersiveness, coordinated and autonomy. The hierarchy means that one support organization can be divided into several sub-organizations, which can be also divided. The organizations are multilevel. The dispersiveness refers to that the organizations are disperse everywhere. It is necessary to build material and information exchange channel among the organizations. The coordinated means that the sub-organizations constitute an entire one to accomplish the specific mission. The autonomy refers to that though sub-organizations are subject to the upper ones, they are autonomy under some situation in certain period and can make decision about affairs of themselves. The figure 5 shows a template in common use for OV-4. The lines that are used to link organizations in the template is divided into two parts. The full lines refer to the relation of command, and the dotted lines refer to the relation of coordinate, cooperate or other relation.
4.5. **OV-3 of Vessel Maintenance Support System.**

The OV-3 is a matrix (or called chat) which describe the information exchange’s reason, flow direction, category, specific context, method and other required factors among nodes. The information in OV-3 is a generalized concept, which can be maintenance plan, material apply order or spares. In DODAF, there is no concrete describing items about OV-3. The user can define it according to the project, such as the period, language, confidentiality. Not all the details of information exchange need to be record. The content, input nodes, output nodes, and attribute of activities should be emphasized. The same content should be separated if the receive node is different. The types of information (e.g. command, intelligence and so on) also have an effect on the line number of matrix. Generally, the OV-3 can be generated automatically by DODAF modelling software.

5. **Conclusion**

This study presented a method of vessel maintenance support system based on DODAF. The DODAF views products are introduced, then the procedures of ABM modeling method are present to give ways to build the support system in a certain reasonable way. The concept and connotation of vessel maintenance support system is introduced. Then the views products of OV-2, OV-3, OV4, OV-5 is built. The reflection between DODAF models and support system’s function, organization and resource is established. The method can improve the recycle rate of modelling and the work efficiency. The simulation can be conducted based on the DODAF model. It can aid the developer to make the decision and optimization at the early stage in design phase.

**References**

[1] Department of Defense Architecture Framework Working Group. DoD Architectural Framework, Version 1.0, 2003

[2] Department of Defense Architecture Framework Working Group. Department of Defense Architecture Framework Version 2.0, 2008

[3] Kelly Griendling, Dimitri N. Mavris. Development of a DODAF-based executable architecting approach to analyze system-of-systems alternatives[C]. 2010 4th Systems Conference

[4] A. Biswas J. Hayden, M. S Phillips, K. B. Bhasin, C. Putt, T. Sartwell Applying DODAF to NASA Orion Mission Communication[C], Aerospace Conference, 2008

[5] Xing Pan, Baoshi Yin, Jianmi Hu Modeling and Simulation for SoS Based on The DODAF Framework[C] The 5th Asia-Pacific System Engineering Conference, 2011