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Study on Equipment Health Management System Modelling Based on DoDAF

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With the development of the technology of prognostics and health management (PHM) and the improvement of integrated diagnostic technology for equipment, the maintenance support strategy of ordnance equipment gradually evolves from traditional corrective maintenance (CM) with a small amount of preventive maintenance (PM) to condition-based maintenance (CBM) and automatic logistic system (ALS) in last decade. In order to achieve those new maintenance support strategies, an appropriate equipment health management system must be established. But effective and feasible methods and tools of designing and modelling of equipment health management system is lacked at the present stage. Aiming at the requirements, this paper puts forward the descriptions of the equipment health management system from the different aspects of organizations, activities, information flows with the view products in DoDAF. The paper analyzes the relationship of nodes in the system, system architecture, activities, information and business flows among departments in the system, and discusses the interfaces among different organizations, functions of the system and the mapping relation between different functions and organizations with Operation Views (OV).Through the above analysis, the connections among different organizations, staffs, resources, functions in the equipment health management are established. And the progress of equipment health management system modelling is also proposed. The result shows that the model is intuitional, easy to understand and involves all the essential information of the system. The model can provide effective technical support for the design and establishment of the technology equipment health management system.

1. Introduction

Equipment health management is a reliable and efficient way to achieve the goal that the maintenance support strategy of ordnance equipment gradually evolves from traditional corrective maintenance (CM) with a small amount of preventive maintenance (PM) to condition-based maintenance (CBM) and automatic logistic system (ALS). Equipment health management is a process to totally manage impact factors of equipment health status and components. Equipment health management (EHM) is a complicated progress which manages equipment and factors such as management functions, technical means, and optimal combination of personnel, technology and information. It's not just micro problems involved in maintenance means but comprehensive ones in management and technology. Equipment health management system must be established in order to achieve functions above. Problems like multilateral cooperation and frequent changes in demand would make modelling process more difficult (Wagenhals, 2000). Moreover, because of the different understandings of different designers, traditional design methods using words and graphs lead to longer communication cycle, weaker strain capacity and lower recycling rate (Sage, 2007). In recent years, Department of Defence Architecture Framework (DODAF) provides a standardization support for the system engineering in military industry, and can be applied to complex system modelling.It provides a standard and efficient way to design complex system architecture. This paper introduces the modeling method and progress based on DODAF. And the analysis equipment support system internal organization, activities and information flow, and on the basis of

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proposed based on DODAF of equipment support system modeling process, with specific security examples of application of the modeling method.

2. System Architecture Design Method based on DODAF

2.1 DODAF Product

Department of Defence Architecture Framework (DoDAF) product is mainly composed of All view (AV), Operational view (OV), System view (SV) and Technical standards view (TV) (Kamal, 2011). Operational view is a set of graphical and text products which describes tasks and missions of the system, nodes and information exchanges. Architecture design is to determine system' mission, tasks, organize elements and information flows, to express combat functions and logical requirements including combat elements, information exchanges between personnel organizations supported by C4ISR system, to definite the type, frequency, combat mission and tasks it supported and information exchange characteristics of interactive information and to reveal its operational capability and interoperability requirements. The specific DODAF products and objects are shown in the Table1 below.

Table 1: Classification of operational views in DODAF

Product No.	Product Name	Object and Content Described
OV-1	High Level Operational Concept Graphic	High level graphical and textual description of operational concept (high level organizations, missions, geographic configuration, connectivity, etc.)
OV-2	Operational Node Connectivity Description	Operational nodes, activities performed at each node, and connectivities and information flows between nodes
OV-3	Operational Information Exchange Matrix	Information exchanged between nodes and the relevant attributes of that exchange such as media, quality, quantity, and the level of interoperability required
OV-4	Organizational Relationships Chart	Command, control, coordination, and other relationships among organizations
OV-5	Operational Activity Model	Activities, relationships among activities, inputs and outputs. In addition, overlays can show cost, performing nodes, or other pertinent information
OV-6a	Operational Rules Model	One of the three products used to describe operational activity sequence and timing that identifies the business rules that constrain the operation
OV-6b	Operational State Transition Description	One of the three products used to describe operational activity sequence and timing that identifies responses of a business process to events
OV-6c	Operational Event-Trace Description	One of the three products used to describe operational activity sequence and timing that traces the actions in a scenario or critical sequence of events
OV-7	Logical Data Model	Documentation of the data requirements and structural business process rules of the Operational View

2.2 DODAF Product

The views products in DODAF intrinsically linked the each other and should be created by the order. It is not necessary to use all the DODAF products when modelling. Appropriate views should be selected to meet the actual demands. The progress of modelling is as follows:

Step 1. Establish concept graphic model of equipment health management system

This step requires a deep analysis on the mission of system and a initial description about equipment health management and external environment, combining with military backgrounds at the present stage, also a confirmation of the conversation between organizations like command office and executive office. High level operational concept graphic (OV-1) is able to describe concept graphic model.

Step 2. Establish organizational relationship model of equipment health management system

Equipment support system organizational relationship is description about relationship of internal composition in system. It generally consists of management report relationship, command and control relationship, command obedience relationship and cooperation relationship. The organizational relationships chart (OV-4) could be obtained with functional decomposition based on the first step of modelling and determination of relationship between organizations.

Step 3. Establish activity model of equipment health management system

The decomposition of activities should be progressively broken down to analyze the business and information flows. All levels of tasks should be completed by appropriate activities in system. Operational activity model (OV-5) could be used to describe activities.

Step 4. Establish node connection relationship model of equipment health management system

Equipment support node indicates how generates, uses and process information in the system. It's the executor of mission and also the completer of activity. Description of the connection between the nodes of equipment support is used to determine its interaction of the information flow and business flow for the accomplishment of support activity. Operational node description (OV-2) is able to describe the relationship of equipment support nodes and to determine "who is going to do" and "what to do". At the same time, operational information exchange matrix (OV-3) is able to describe the information connection relationship of each support nodes.

3. Progress of Equipment Health Management System Modelling based on DODAF

3.1 EHMS High Level Operational View OV-1

In order to visually describe the mission, nodes and main tasks in health management system from macro perspective, it is need to draw out the EHMS high level operational view OV-1. The high level operational view shows the interactive relationship among the nodes in the EHMS and the information exchange between the system and its external environment.

EHMS high level operational view can be divided into three levels. The core level is the decision-making level. Military command center is belonged to this level. The guide level mainly consists of two parts, ordnance equipment command office and health management center, which is the most important agency in the system. The depots, logistic support units, maintenance factory and other logistic support force constitute the execution level.

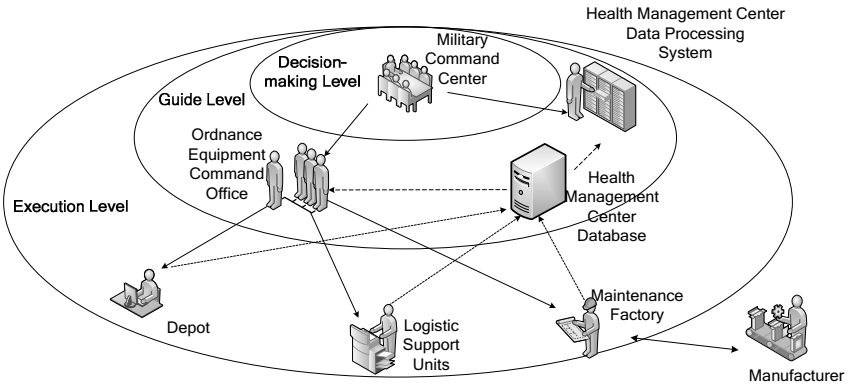

Figure 1: EHMS High Level Operational View OV-1

In the figure 1, the solid lines indicate the business flows, such as command order issue. And the dotted lines indicate the information flow, such as data collection and information transmission. The health management center could be divided into two parts, database part and data processing system part from function perspective. In this way, the business and information exchange between health management center and other organizations can be shown clearly and intuitively.

3.2 EHMS Organizational Relationships Chart OV-4

After the EHMS high level operational view is accomplished, it is necessary to analyze the relationship among all the organizations and agencies in EHMS by the EHMS organizational relationships chart (OV-4). The subordinate agencies of the military center, health management center, and the organizations are presented in the chart. And the types of the organizations, which mean tasks or mission that agencies are charge of, also should be studied. The chart analyzes not only the relationship among different organizations but also the relationship between the external organizations and EHMS. The relationships mentioned above vary according to the function and the type of the organizations, such as manage and order, command and report, control and obey, or cooperate.

In EHMS, all the organizations and agencies can be divided into four parts. The military command center is on the top in the EHMS organizational structure and it is in charge of the supreme management authority. The military command center commands all the other organizations and makes the guidance

and criterion. The main task of the ordnance equipment command office , which is the executive organization of the command center , is issuing the order according to the different kinds of equipments under the leadership of the military command center. The health management center undertakes the core function of EHMS and commits the data proceeding and analyzes activities. It mainly consists of three parts; database part, health management plan system part and knowledge manage system part. The specific tasks and activities they undertake are shown in the figure 2. The logistic support force such as depots, logistic support units and maintenance factory execute the entire logistic support mission under the command of the ordnance equipment command office and collect basic data of the equipment for the health management system. The manufacture belongs to the external organization. It provides manual and other information

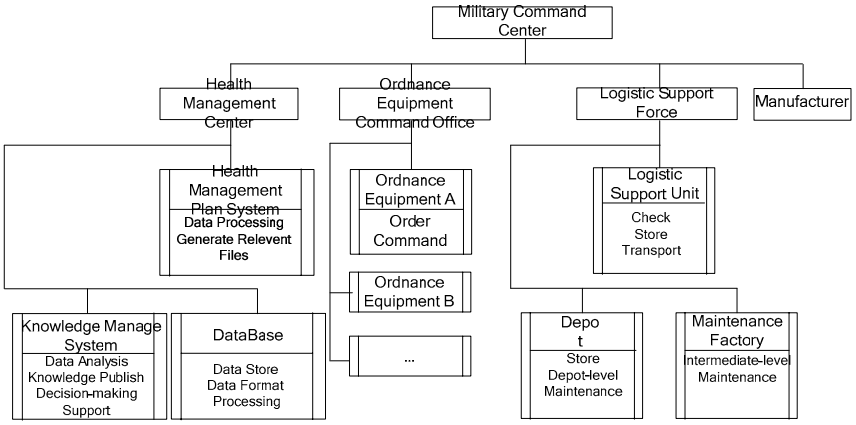

Figure 2: EHMS Organizational Relationships Chart OV-4

3.3 EHMS Operational Activity Model OV-5

The operational activity model in the system architecture design method based on DODAF contains activities name, data and business flows among activities and information exchanged with the external environment, if needed. In order to describe the inputs, outputs, support and constraint principles of the numerous activities in EHMS, it is necessary to build the EHMS operational activity model (OV-5).The operational activity model can be decomposed by levels to meet the designer's requirement.

IDEF0 is a kind of structured way to describe activities, which is able to analyze and study complex systems. To illustrate a system, activities in the system should be breakdown into sub-activities according to the different levels with IDEF0. Nowadays, it is applied to describe the inputs, outputs and other information in OV-5. Therefore, the operation of the entire system can be depicted in details and completed. The military command center and the ordnance equipment command office are merged into the same type of organization in the model to simplify the operational activity model for the purpose of facilitating the analysis and modelling progress. Such treatment does not affect the analysis and description of the business and information flows in the EHMS operational activity model. The entire activity in EHMS can be summarized as four parts: military authority command, ordnance equipment health management plan, ordnance equipment knowledge management and logistics support activities. After the army accepts the certain equipment, they need to submit the equipment logistics support data package related to the equipment to health management center. Logistics support data package includes a large amounts of data of the support analysis of the equipment, not only some maintain data like annual task number, annual task, mean time to repair and maintenance hours, but also support element data about personnel, spare parts, support facilities and security equipment like reliability, availability and maintainability, reliability entered maintenance analysis and transportability engineering analysis data. The factory manual material which is needed in health management planning but not involved in the data packet, such as design atlas, tutorial and maintenance rules is also needed to be submitted. Health management center analyzes the data according to specific requirements and standards. The result, as part of the equipment knowledge, would be analyzed in knowledge manage system. The health management plan system also needs to generate an empty equipment logistic files which is used to record equipment basic data during logistic support actives. The knowledge management system mainly has two functions: provide support for making decisions and generate and distribute equipment knowledge in the health management system. The knowledge is finally distributed in different ways to assist in making decisions and to guide activities in logistics support force and published in various kinds of ways ,such as

wiki, BSS, BLOG and knowledge map. The command office makes corresponding decision and guidance according to ancillary information provided. In the end, through a set of logistics support activities, the equipment is well supported and the logistic record and health management basic data is collected. Through the management activities, the health management knowledge is generated based on basic data.

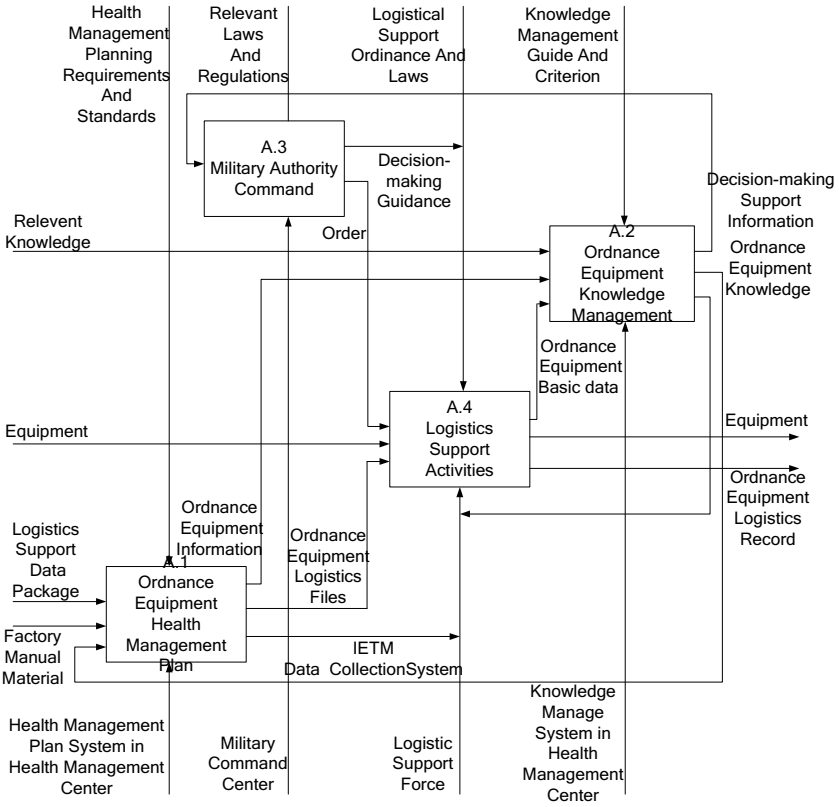

Figure 3: EHMS Operational Activity Model OV-5

3.4 EHMS Operational Node Connectivity Description OV-2

The EHMS organizational relationships chart OV-4 and operational activity model OV-5 provides adequate input information for the EHMS operational node connectivity description OV-2. The EHMS operational node connectivity description shows the information exchange between the nodes in EHMS intuitively and clearly. In OV-2, the oval represents each node in EHMS including the name, task and activity information.

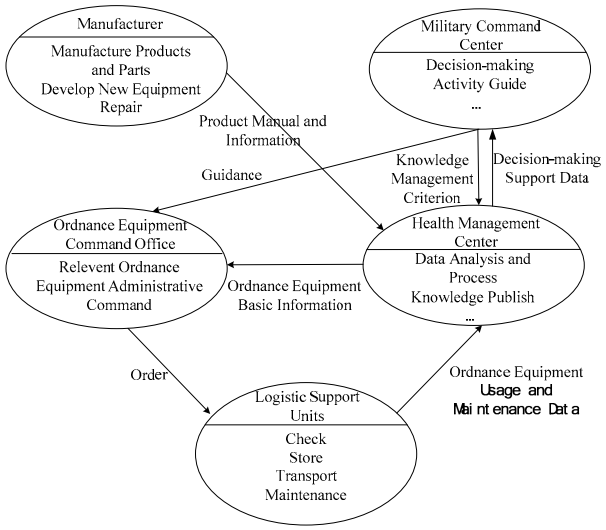

Figure 4: EHMS Operational Node Connectivity Description OV-2

The lines between ovals indicate the exchange information between nodes. Each line may represents a plurality of information flows.

3.5 EHMS Operational Information Exchange Matrix OV-3

EHMS information exchange matrix can be summarized from OV-5 and OV-2. It indicates the specific contents of information exchange among the nodes. The chart consists of the information sender, receiver, sending activity and receiving activity. The purpose and format of information would be included if necessary.

Table 2: EHMS Organizational Relationships Chart

No.	Information	From Node	From Activity	To Node	To Activity
1	Ordnance Equipment Logistics Files	Health Management Plan System(HMPS)	Ordnance Equipment Health Management Plan(OEHMP)	Logistic Support Units(LSU)	Logistics Support Activities(LSA)
2	IETM Data Collection System	HMPS	OEHMP	LSU	LSA
3	Ordnance Equipment Information	HMPS	OEHMP	Knowledge Manage System (KMS)	OEHMP
4	Order	Military Command Center (MCC)	Military Authority Command (MAC)	LSU	LSA
5	Decision-making Guidance	MCC	MAC	LSU	LSA
6	Ordnance Equipment Basic data	LSU	LSA	KMS	OEHMP
7	Ordnance Equipment Knowledge	KMS	OEHMP	HMPS	OEHMP
8	Ordnance Equipment Knowledge	KMS	OEHMP	LSU	LSA
9	Decision-making Support Information	KMS	OEHMP	MCC	MAC

4. Conclusion

The activities and business and information flows in EHMS are analyzed in details and the model of EHMS based on DODAF is established. It shows that the model can provides effective technical support for the design and establishment of the technology equipment health management system and indicates that the model is intuitional, easy to understand and involves all the essential information of the system. This paper establishes the architecture framework of health management through the research on the aspects of comprehensive diagnosis and health management system based on the information platform construction, such as the key technical, feasibility and implementation. It provides the guidance and basis for comprehensive diagnosis, which is for specific equipment, and health management system. It also provides practical methods for achieving CBM and AL, which has great significance to effectively improve the support ability of equipment

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