Modeling of Reef Distributed Reconnaissance and Early Warning System Based on DoDAF

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Abstract. In view of the new requirements of the reconnaissance and early warning system in the complex battlefield environment, a distributed architecture design method for the early warning and reconnaissance of reefs is proposed. This paper presents the design process of DoDAF based distributed reconnaissance and early warning architecture framework for reefs, constructs the architecture model of specific operational activities by using TD-CAP software, describes the relationship between various combat platforms from different perspectives through different views, and evaluates the consistency and operational effectiveness of the distributed detection and early warning system. The evaluation results show that the model has good integrity and consistency, and the combat effectiveness is significantly improved compared with the non-distributed reconnaissance and early warning system.

1. Introduction

Distributed maritime early warning system is based on a single early-warning detector, multiple detectors distributed in a certain range of sea areas, command and control authority to a certain extent, forming a larger defense network. The application of multiple sensors integrated in the detector for comprehensive detection enables the combat command department to timely understand the current situation of the sea surface and the sound information on the current sea surface, and compares it with the corresponding audio information of preset combat weapons to preliminarily predict the force strength. The video information is transmitted back through the camera to understand the general combat effectiveness distribution. And through the set detector information to understand the general position of the enemy situation, so as to fully understand the enemy's offensive ability and carry out effective defense deployment, so that the navy has the conditions to win advantages in the future information battlefield [1-3].

The current information battlefield requires the navy to have stronger attack and defense capabilities, better early warning capabilities, and more flexible to deal with various emergencies independently. Through the distributed maritime early warning and reconnaissance system, the navy can obtain the information of the enemy ahead of the current early warning mode, make timely combat deployment, reduce the loss in the war, and occupy an active position in the battle [4].

The distributed reconnaissance and early warning system of islands and reefs is a typical complex system with static and dynamic characteristics. In order to describe it more scientifically, DoDAF v2.0 is used to design the architecture. DoDAF is an architecture framework developed by the U.S. Department of defense. It has been 20 years since its birth. From the original C4ISR to the present DoDAF V2.0, the version of the architecture framework has been evolving. For complex combat systems, reasonable architecture design can ensure the effectiveness of system development, facilitate the understanding and management of complex combat systems, and help to improve the efficiency of equipment research and development and meet the needs of troops [5-6].
2. Construction Process and Method of Distributed Reconnaissance and Early Warning System for Reefs

After analyzing the mission requirements of the distributed reconnaissance and early warning system for islands and reefs, the top-down design method is adopted in combination with the content of operational concept design of distributed reconnaissance and early warning system. The architecture model is designed by selecting AV-1, CV-2, OV-1, OV-2, OV-4, OV-6c and SV-4a respectively. The relationship between the view models is shown in Figure 1.

![Figure 1. Relationship diagram of each view model](image)

3. Design of Distributed Reconnaissance and Early Warning System for Islands and Reefs Based on DoDAF

The existing reconnaissance and early warning equipment in our island and reef area includes reconnaissance satellite, early warning aircraft, balloon borne radar, UAV, shipborne radar and shore based radar. In order to build a three-dimensional early-warning system, give better play to equipment effectiveness and achieve operational efficiency, it is necessary to integrate these equipment organically to form a linkage and smooth reconnaissance and early warning system [7]. Therefore, according to the existing early warning equipment and the actual situation of Nansha Islands and reefs, the distributed reconnaissance and early warning system of islands and reefs is designed according to the steps in Figure 3.

3.1. Build an Overview and Summary Information Model (AV-1)

As shown in Table 1, through the full view model AV-1 in the form of table, this paper introduces the relevant summary information of the architecture design of the island reef distributed reconnaissance and early warning equipment.
Table 1. Overview and summary information of distributed reconnaissance and early warning equipment system for islands and reefs (AV-1)

| Serial number | Outline      | Concrete content                                                                                                                                 |
|---------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | Background   | An island and reef in the South China Sea is threatened by air attack from the sea. The reconnaissance and early warning forces of the island and reef aviation force and the relevant shore based, sea based and space-based reconnaissance and early warning forces cooperate to carry out air defense and antimissile reconnaissance tasks to protect the safety of our islands and reefs. The main reconnaissance objects of the system include incoming missiles and combat aircraft of the enemy. The blueprint of distributed reconnaissance and early warning system for islands and reefs is planned to provide reference for the rational construction of each subsystem. The construction of the model should be in accordance with the actual situation of our island's air defense and antimissile forces, the development plan of weapons and equipment, the characteristics of combat environment, and the relevant rules and regulations. |
| 2             | Objective    | System for islands and reefs is planned to provide reference for the rational construction of each subsystem. The construction of the model should be in accordance with the actual situation of our island's air defense and antimissile forces, the development plan of weapons and equipment, the characteristics of combat environment, and the relevant rules and regulations. |
| 3             | Restrictions | The development plan of weapons and equipment, the characteristics of combat environment, and the relevant rules and regulations. |
| 4             | Model selection | Seven architecture design perspective models are selected. |
| 5             | Conclusion   | The design scheme is basically feasible after self-evaluation and expert review. |

3.2. Build Capability View Model (CV-2)
In order to clarify the requirements of distributed early warning capability, system capability planning, straighten out the capability elements required for distributed early warning, audit the distributed reconnaissance and early warning capability, and analyze the gap, so as to provide reference for the distributed early warning system structure of islands and reefs, a capability classification structure model CV-2 is constructed.

In CV-2 model, the distributed early warning capability is simply described, and the capability support to realize the distributed early warning capability is clarified, which provides some guidance for the construction of distributed early warning capability, and provides the basis for the construction of advanced operational concept model OV-1.

3.3. Building Advanced Operational Concept Model (OV-1)
Therefore, according to the existing early-warning equipment, combined with the operational requirements of the island and reef reconnaissance and early warning mission, i.e. the actual battlefield environment, etc., the advanced operational concept map OV-1 of the distributed early warning system in the island and reef area is constructed.

In the distributed early warning system, reconnaissance satellites are mainly responsible for early reconnaissance of enemy bases and shore guided forces; early warning aircraft are mainly responsible for monitoring and early warning of ships, aircraft, missiles and other targets attacking on the surface and in the air; UAVs are responsible for approaching reconnaissance of enemy bases, shore guidance forces and warship formations to obtain accurate and real-time intelligence; Surface ships are responsible for monitoring the enemy's incoming ship formation, missiles and aircraft within the detection range; balloon borne radar, as a floating detector with long-term endurance, is mainly used for early warning and detection of incoming missiles and near shore targets; shore based radar is mainly responsible for monitoring incoming missiles, UAVs and other enemy targets that break through the outer defense.
3.4. Build Operational Activity Model (OV-5b)
Ov-5b model is used to describe the operational activities and the input / output flow between the activities. The main operational activities in the operation scenario of island reconnaissance and early warning start with the reconnaissance, early warning and tracking of air raid targets. Under the command of command and control system, the reconnaissance and early warning platforms carry out reconnaissance and tracking, complete the identification and numbering of targets, and finally improve the effect of reconnaissance and early warning Evaluation.

3.5. Building Operational Organization Relationship Model (OV-4)
In order to describe the organizational relationship of the distributed early warning system on islands and reefs, and to construct the operational organization relationship model OV-4 for the command structure or relationship of post personnel role, organization structure or organization type.

The role-based operational organization relationship model ov-4 shows the real organizational structure of the distributed reconnaissance and early warning system at a specific point in time, as well as the relationship between various combat organizations and combat personnel, and describes the command structure or relationship of post personnel role, organization structure or organization type. Among them, the OV-4 view focuses on the composite relationship in each combat platform, that is, the resources of an organization are part of the higher level organization [8-9].

3.6. Building Operational Resource Flow Model (OV-2)
In order to realize the distributed reconnaissance and early warning system, we need not only these weapons but also distributed architecture technology to complete the interconnection of the whole system. Therefore, it is necessary to install sensors and communication equipment on the existing combat platform to collect the relevant information of each combat platform, and submit data to the summary module in the distributed information network for the processing module to synthesize and judge. In order to achieve the above capabilities, it is necessary to install corresponding sensors, information processing modules and establish data link [10].

Based on the advanced operational concept map OV-1, the operational resource flow model OV-2 describes the operational tasks of Distributed Early Warning System in the form of structure diagram, focusing on the composition and structure of the system[11].

3.7. Building Operational Event Tracking Model (OV-6c)
The distributed early warning operational event tracking model (OV-6c) mainly describes the operation related events. In ov-6c, it provides a time sequence test of resource flow as a result of scenario scenario scenario. The operational process of distributed reconnaissance and early warning system for islands and reefs can be defined as a group of operational activities with sequential time attributes, including the resources required to complete these networked early warning operations. Combined with the requirements of early warning task, the operational event tracking model OV-6c of distributed early warning system is constructed.

Ov-6c describes the transformation process of operational concept of distributed reconnaissance and early warning system to a more detailed level. Through this model, the interaction and operational process in the early warning system can be defined, and the distributed early warning operational activities and nodes can obtain the necessary information at the right time to complete the reconnaissance and early warning tasks assigned to it by the command end [11].

3.8. Constructing the Function Decomposition Model of Reconnaissance and Early Warning System (SV-4a)
The function decomposition model sv-4a of reconnaissance and early warning system mainly describes the system functions of the distributed reconnaissance and early warning system of islands and reefs, and decomposes the system functions to the appropriate granularity by using the function hierarchical classification method [12-13].
4. Conclusions
In order to meet the new requirements of the island reef air defense and antimissile mission in the new era of joint operations and global operations, it is necessary to accelerate the construction of distributed reconnaissance and early warning system to adapt to the new environment. In this paper, the DoDAF architecture framework is used to design the equipment composition, operational process, capability classification and organization relationship of the distributed early warning system. The results show that the distributed early warning and reconnaissance system is complete, which is helpful to improve the air defense and antimissile capability of our reefs.

5. References
[1] ZHANG Chunming, XUN Teng, ZHANG Huaping. Naval Combined Operation Architecture Framework in Island-Reef Area Based on DoDAF[J]. Command Information System and Technology, 20-24, 2017
[2] LI Daxi, YANG Jianjun, SUN Peng, et al. Operational Requirement Analysis and Conceptual Study of Airborne Antimissile[J]. Modern Defence Technology, 17-23, 46. 2015
[3] ZHOU Baoliang LEI Zijian ZHOU Dongming, et al. Early-warning Detection Technology of Distributed Aperture Coherent radar[J]. Journal of Signal Processing, 1330-1338. 2018
[4] WANG Jianguo, E Qun, YAO Keming, et al. Early Warning System of Antisubmarine Based on Detonation Assistant and Its Tactics Application. Modern Defence Technology, 13-17, 23. 2016
[5] DoD. DoD architecture framework version 2.02, change 1[M]. Washington D.C.: DoD, 4-11. 2015
[6] JI Haoran. Research on the C4ISR systems based on the mobile cloud computing[D]. National University of Defense Technology, 12-16. 2015
[7] JI Meng-Qi, YANG Feng. Construction of Conceptual Elements of “Quantum Cloud” Combat System[J]. Journal of Command and Control, 160-164. 2017
[8] Jean-Charles Ledé. Collaborative Operations in Denied Environment (CODE) program overview. AIAA workshop. 2018 Rao jie, Chen Dejun, Li Xianfang. Research and Realization of a Distributing MOM for Early Warning Detection System[J]. Informatization Research, 63-70. 2012
[9] GUO Xiaochuan, CHEN Guiming, SHEN Junling, et al. Construction of Missile Early-warning and Counter-attack System and Effectiveness Evaluation[J]. Journal of Equipment Academy, 75-81. 2016
[10] YANG Guang, DUAN Xiaowen. Design of Air Defense Distributed Collaborative Decision System Based on Data Driven[J]. Modern navigation, 362-366. 2018
[11] LI Jinlan, HU Song, LIU Jia, et al. Development analysis of key weapon programs driven by the U.S. navy’s concept of distributed kill and kill operations[J]. Winged Missiles Journal, 1-6, 2016.
[12] YANG Mu, CHEN Changxing, WANG Xiaodong, et al. An Effectiveness Evaluation of Capability in the Air Combat in Cooperation with Early-Warning Aircraft Based on Data Link[J]. Journal of Air Force Engineering University (Natural Science Edition), 43-47. 2018