Functional Modeling of Mechanical Scanning Radar Based on IDEF0 Method

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Abstract. At present, research of radar survivability is another important research field after the six characteristics of radar equipment. Research on the vulnerability of radar equipment is the key issue among them and function analysis of radar equipment is the basis of it. Aiming at the traditional mechanical scanning radar, by analyzing the traditional function tree modeling method and on the basis of it, a radar function modeling method based on IDEF0 is proposed. This method comprehensively analyzes the radar early warning function, comprehensively considers the relationship between its internal functions and the connection with external activities. Finally, through comparison with the traditional function tree modeling method, it shows its superiority and is vulnerable to radar equipment, which can provide some reference for the research of radar equipment vulnerability.

1. Introduction
At present, radar equipment is developing rapidly and phased array radar is gradually replacing the traditional mechanical scanning radar. However, the process of installing troops is cumbersome, and there are still a large number of mechanical scanning radars in service. Relatively speaking, traditional radar is more threatened by modern new weapons. Therefore, for traditional mechanical scanning radar, the technical requirements for radar equipment damage and rapid assessment of survivability are extremely urgent, and the research on the vulnerability of radar equipment is a key issue. Before studying the vulnerability of radar equipment, it is necessary to carry out functional analysis of radar equipment, that is, functional modeling. At present, the research of radar function modeling mainly focuses on the detection function of radar equipment for the target, or the mathematical modeling based on signal analysis, with less consideration of other factors such as functional realization methods and intelligence purposes. And the functional modeling method of other kinds of equipment is mainly based on function tree or modular modeling.

This article first analyses the overall idea of the IDEF0 modeling method, based on the existing function modeling method, combined with the process and characteristics of the radar early warning
function, this paper proposes a modeling method based on IDEF0. It gives the concrete modeling process, and compared with the traditional function tree modeling method and analysis.

2. The overall thought and analysis of characteristics of the modeling method based on IDEF0

The IDEF method is a method used in the analysis and design of complex systems, which was applied in the Integrated Computer Aided Manufacturing (ICAM) project announced by the United States in 1981. IDEF is the abbreviation of ICAM Definition. The IDEF0 method is mainly used to describe the functional activities and connections of the system and establish the functional model of the system. The IDEF0 method uses graphic symbols and natural language to describe or establish the functional model of the system according to a top-down, layer-by-layer decomposition method, that is, the functions of each part of the system and their interactions, as shown in Figure 1.

Figure 1. The hierarchical decomposition structure of the system for the IDEF0 method

The basic element of the model is the functional unit structure, which is generally composed of five parts: functional unit, input, output, control, and mechanism, as shown in Figure 2.

Battlefield damage is not only longitudinally transmissible, but also laterally transmissible. Therefore, traditional function tree modeling cannot solve this problem well. Moreover, the IDEF0 modeling method can decompose the entire system into multiple functions at the same level and perform analysis, which can directly reflect the relationship between these functions, and can effectively make up for the shortcomings of the traditional function tree modeling method. At the same time, the radar system already has the functional structure characteristics of the system. When the IDEF0 method is used for functional modeling, it can better fit and describe the radar system functions more comprehensively, which can be used for radar equipment and provide certain reference for the battlefield damage assessment of radar equipment.

3. The steps of modeling on IDEF0 method

In the preliminary design of the system, the process of establishing a functional model is divided into the following stages:

1) Determine the scope and purpose of establishing the function model of radar;
2) Establish the diagram A-0 of the system;
3) Draw the diagram A0 on the top of the system;
4) Decompose the system and draw the functional model diagram of each layer;
5) Check and modify;

The diagram A-0 of system mainly plays a role in determining the scope of the system and also reflects the purpose of establishing the model. The diagram A0 is formed after a decomposition of the diagram A-0, which can directly reflect the main functional components of the entire system and their interactive relationships. In the decomposition process of radar system functions, the decomposition is
mainly carried out in accordance with the functional structure, as shown in Figure 3.

Figure 3. Block diagram of IDEF0 hierarchy

4. Modeling of radar warning function

4.1. Determination of modeling scope and construction of diagram A-0
On the battlefield, the operational effectiveness of a kind of equipment mainly depends on its function, while radar equipment mainly depends on its early warning function. In the face of the threats of many weapons on the battlefield, it is urgent to study its vulnerability if its early warning function can be fully realized. For this, we establish the overall system function model of radar early warning function as shown in Figure 4, which abstractly describes the main information of radar early warning function.

Figure 4. Diagram A-0 of early warning function

4.2. Decomposition of system and construction of diagram A0
Diagram A0, shown in Figure 5, represents the same system functions as diagram A-0. According to the requirements of radar early warning function, it can be decomposed into five main functional units: detection function, power distribution function, monitoring function, intelligence formation and position adaptation. Diagram A0 is the top layer diagram of radar early warning function model, which reflects the operation mode of radar early warning function from the structure, and describes the functional composition of the whole radar system in detail and systematically. From this we can clearly see that the realization of these functions is not only affected by external factors, they also have an interdependent relationship.
4.3. Functional hierarchical decomposition

4.3.1. The construction of diagram A2 for detection function.
The detection function is the main functional unit structure in the radar early warning function and the internal functional structure is relatively complex. In order to make the detection function model more refined, the flow clearer and the analysis more accurate, we decompose the detection function into a lower-level diagram A2, as shown in Figure 6.

4.3.2. Diagram A21 for the model of emission function.
The radar system is a large and complex electronic system with a complex internal functional structure. Only three levels of decomposition are not enough to understand its internal functional structure in detail, and its functional units need to be further decomposed. Take emission function in detection functional unit structure as an example, as shown in Figure 7.
4.4. Comparison and analysis

On the basis of the traditional function tree modeling method, the radar function modeling method based on IDEF0 is proposed. Taking the traditional function tree modeling as the comparison object, the comparative analysis is conducted from the five aspects of hierarchy, comprehensiveness, universality, functional structure correspondence, and comprehensibility, as shown in Table 1.

|                        | Function tree modeling | IDEF0 modeling |
|------------------------|------------------------|----------------|
| Hierarchy              | Obvious                | Obvious        |
| Comprehensiveness      | Not enough comprehensive | Comprehensive |
| Universality           | Strong                 | Stronger       |
| Functional-structure   | Not accurate enough    | Accurate       |
| correspondence         |                        |                |
| Comprehensibility      | Easy to understand     | Easy to understand |

Both the traditional function tree modeling method and IDEF0 modeling method decompose the structure of radar function. However, the function tree modeling only considers the functions of vertical integration. IDEF0 modeling method adapts a tower type structure, with a section corresponds to a level of function, step by step down decomposition, can directly reflect the function relationship between the same level. It not only consider the vertical connection between functions, also consider the horizontal connection between the functions, also considering the connection between the functions and external activities. The analysis is more comprehensive, makes up for the deficiency existing in the function tree modeling method. At the same time, IDEF0 modeling method is more universal, functional structure correspondence is clearer, its damaged parts can directly correspond to the relevant functional units, no longer affected by its location structure.

5. Conclusion

The IDEF0 modeling method comprehensively analyzed the radar early warning function, comprehensively considered the relationship between its internal functions and the relationship with the external activities, made up for the traditional function tree modeling method in the same level of functional relationship analysis, the consideration factors are more comprehensive. At the same time, the method is more universal, the corresponding relation of functional structure is more accurate, the
damaged parts can directly correspond to the relevant functional units, and are no longer affected by the structure of their position. In the analysis of radar vulnerability, the tower structure of IDEF0 modeling method is more conducive to the analysis of the degree of influence of various levels of functions on the overall system function, which has certain advantages and can provide certain reference for the research of radar equipment vulnerability related issues.

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