Determination of Maintenance Time of Radar Seeker Based on ABC Method

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Abstract: According to the health state grade classification standard of seeker and the corresponding performance state description, the health state grade corresponding to the predicted value of performance index parameters of transmitter and antenna servo mechanism is evaluated. As a result, the health status grade of the seeker system is obtained. In order to determine the maintenance time of the seeker more accurately, the comprehensive performance index of the seeker in the stage of "deterioration" is divided by the application of ABC analysis rule. Finally, the best maintenance time of seeker is determined by calculation.

1. Introduction
Health means that a person is in good physical, mental and social condition. At present, the concept of "health state" is not limited to the medical field, but also introduces the concept of health in the field of engineering, environmental protection and administration. "Health status" is also used as a reference index to evaluate the performance and working status of equipment [1].

The health state degradation of seeker components is a process, which usually begins with the components or components of the components. Finally, it leads to the degradation of the overall health state of the system until it fails. The main characteristics of component health degradation are as follows [2]:

(1) Relevance. When the health state of a component is degraded to a certain extent, the function of the associated component will also be affected, which is mainly reflected in the part of the component with common performance index parameters. Habitually, it is called "lateral degradation" of health.

(2) Continuity. Components are usually composed of different levels of units, which are hierarchical in structure and function. For example, the health degradation of an electronic component in the system will lead to the degradation of the health state of the device in the previous layer. Layer-by-layer transfer will eventually lead to the degradation of the health state of the whole component system.

(3) Concurrency. The health state of an unit component in a component is degraded, which leads to the overall health state degradation of the component system through the joint action of "transverse degradation" and "longitudinal degradation". This "concurrency" mode is not only the most common fault development model in weapon equipment system, but also a difficult and complex development model.

2. Classification of health status of seeker
Health status assessment is divided into two levels: component level and system level, in which component level health status assessment is the basis of system level health status assessment. The
health status of the whole system was analyzed by evaluating the health status of different types of components [3]. The seeker transmitter and antenna servo mechanism are selected as the representatives of typical electronic and electromechanical components for research and analysis.

There are two main methods of health status evaluation: qualitative evaluation and quantitative evaluation, in which the qualitative evaluation is mainly to determine the health status grade of the components, and the quantitative evaluation is mainly to determine the health degree [4]. In this paper, the method of qualitative evaluation of health status grade is used to analyze the health status of the heavy parts of the guide head, so as to evaluate the health status of the whole system.

According to the series of research data of equipment reliability and the experience of maintenance support engineering, the health status of seeker is usually divided into five grades, and the corresponding states are "excellent, normal, general, deterioration and failure" [5].

After the initial detection data of the seeker transmitter and the antenna servo mechanism are maximized and normalized respectively. The health status grades corresponding to the comprehensive performance indexes of the two components are obtained, as shown in Table 1.

| parts                      | fault    | deteriorate | common  | normal  | excellent |
|----------------------------|----------|-------------|---------|---------|-----------|
| transmitter                | [1.0000, | (1.0600,   | (1.2000, | (1.4000, | (1.8000,  |
|                            | 1.0600]  | 1.2000]     | 1.4000]  | 1.8000]  | 2.0000]   |
| Transmitter antenna servo  | (0.0000, | (0.7000,   | (0.7500, | (0.8000, | (0.9000,  |
| mechanism                  | 0.7000]  | 0.7500]     | 0.8000]  | 0.9000]  | 1.0000]   |

### 3. Prediction method of health state of seeker

According to the health status grade division of the performance index parameters of seeker transmitter and antenna servo mechanism in Table 1. The health status grade prediction of each quarter in 2019 can be obtained according to the measured data of the performance parameters of the two components, as shown in Table 2.

| time             | transmitter | transmitter antenna servo mechanism | seeker health grade |
|------------------|-------------|-------------------------------------|---------------------|
|                  | predicted   | Health grade | predicted | Health grade | status |
| first quarter    | 1.1125      | deteriorate | 0.7929    | common       | deteriorate |
| second quarter   | 1.0836      | deteriorate | 0.7667    | common       | deteriorate |
| third quarter    | 1.0712      | deteriorate | 0.7435    | deteriorate  | deteriorate |
| fourth quarter   | 1.0550      | fault       | 0.7198    | deteriorate  | fault |

The health state of the seeker system is evaluated comprehensively by the transmitter in the electronic components and the antenna servo mechanism in the electromechanical components. In order to more accurately grasp the maintenance opportunity of electronic and mechanical and electrical components represented by two heavy components, the following ABC analysis rule is proposed, through the ABC partition of the component performance index parameters in the "deterioration" stage. To reduce the maintenance time range of the whole system, so as to more accurately determine the best maintenance time of the system.

### 4. Determination of maintenance time of seeker

The accurate prediction of the maintenance time of the seeker is of great significance in the research of equipment reliability. The research in this aspect provides a reference for ensuring that the missile can extend the service time as long as possible in the controllable time range. In order to ensure the
integrity of the train on the basis of better savings in time, manpower and financial costs. In the following, the ABC rule analysis of the whole and components of the seeker system is used to predict the maintenance time of the seeker system.

### 4.1 Analysis of ABC rule

ABC analysis method [6], also known as Pareto analysis method, mainly according to the technical characteristics of things to sort, to distinguish the most important, important and general three levels. When it is applied to the evaluation of the health status grade of seeker components, the deterioration degree calculated according to the performance index parameters of each component can be divided into three grades: reliable, general and unreliable, and the deterioration degree calculated by the "deterioration" stage of the health status grade can be divided into three grades: reliable, general and unreliable. And make the corresponding maintenance work arrangement for the three grades. The main analysis process is as follows:

1. **Collection of data.** According to the prediction of the performance test index parameters of the seeker transmitter and antenna servo mechanism and the division of the corresponding health status level, the health status grade of the seeker in the fourth quarter is evaluated as "fault" and needs to be repaired immediately. The first, second and third quarters are in "deterioration" and need to be included in the maintenance cycle plan. In this paper, the health status grade of seeker and heavy parts in the first three quarters is selected as the research content, and the corresponding health status grade range is selected with reference to the predicted value of index parameters in the first three quarters, as shown in Table 3.

| Table 3. Range of performance parameters of heavy parts corresponding to health status in the three quarters. |
|---------------------------------------------------------------|
| time                  | Health grade | predicted value | Health grade | predicted value |
|----------------------|--------------|-----------------|--------------|----------------|
| first quarter        | 1.1125       | (1.2000, 1.0600) | 0.7929       | (0.8000, 0.7500) |
| second quarter       | 1.0836       | (1.2000, 1.0600) | 0.7667       | (0.8000, 0.7500) |
| third quarter        | 1.0712       | (1.2000, 1.0600) | 0.7435       | (0.7500, 0.7000) |

2. **Processing data.** According to the structure composition and fault mechanism of seeker transmitter and antenna servo mechanism, we can know that the fault development mode of the two components is cumulative fault on the whole, and the degree of deterioration can be used to characterize the degree of fault development. It is expressed as.

\[
L = \left( \frac{I - M}{J - M} \right)^K \quad (K \text{ ranges from } 0.5 \text{ to } 2)
\]  

(1)

Combined with the analysis of engineering test data, there are some differences between the deterioration curves of electronic components and electromechanical components, but the values generally fluctuate around 1. In this paper, 1 is taken as the calculation formula of the deterioration degree of the two components. In the formula for calculating the deterioration degree, for the transmitter components, the values are the predicted data of 1.1125, 1.0836 and 1.0712 for three quarters respectively, and the critical values of the corresponding interval are 1.0600, 1.0600 and 1.0600, respectively. The initial values of the corresponding interval are 1.2000, 1.2000 and 1.2000. For the antenna servo mechanism, the values are the predicted data of 0.7929, 0.7667 and 0.7435 for three quarters respectively, and the critical values of the corresponding interval are 0.7500, 0.7500 and 0.7000, respectively. The values are the initial values of the corresponding interval 0.8000, 0.8000, 0.7500.
The predicted values of the performance index parameters and the corresponding deterioration degree of the transmitter and antenna servo mechanism can be obtained by calculation, as shown in Table 4.

|        | transmitter | transmitter antenna servo mechanism |
|--------|-------------|---------------------------------------|
| time   | Health grade| predicted value | Health grade | predicted value |
| first quarter | 1.1125 | 62.50% | 0.7929 | 14.20% |
| second quarter | 1.0836 | 83.14% | 0.7667 | 66.60% |
| third quarter | 1.0712 | 92.00% | 0.7435 | 13.00% |

(3) Determine the ABC classification of key parts. In the ABC analysis rule, according to the degree of influence, the technical index is generally divided into three categories, namely, class A index (the most important influence index), the influence degree is 0%-80%, the influence degree is 80%-90%, and the influence degree is 80%-90%. Category C indicators (general impact indicators), the degree of influence is 90% to 100%. In the analysis of the health state of the transmitter and antenna servo mechanism, through the deterioration index, the health state grade of the predicted value of the performance index parameters of the two components is subdivided into three intervals: A, B and C.

(4) Drawing ABC analysis diagram. The deterioration degree of the health status index of seeker transmitter and antenna servo mechanism is obviously different in the stage of "deterioration", and the trend of deterioration is also obviously different. The deterioration trend of the seeker system is mainly reflected by the transmitter with high degree of deterioration and obvious deterioration trend. Combined with the previous ABC partition analysis of the health status level according to the deterioration degree, the health state distribution of the seeker in the "deterioration" stage can be obtained, as shown in figure 1.

![Fig. 1. Analysis of the health status of the seeker during the "deterioration" phase.](image)

Among them, area A indicates that the deterioration degree of the seeker system does not exceed 80%. In the relatively reliable range, there will be no failure, but it needs to be included in the maintenance cycle plan. Area B indicates that the deterioration of the seeker system is in the range of 80% to 90%, and the deterioration situation is aggravated, so it is necessary to advance the maintenance plan and start the improvement and implementation of the maintenance plan. Area C
indicates that the deterioration degree of the seeker is more than 90%, which may fail at any time, and the maintenance plan needs to be started immediately.

4.2 Determination of Maintenance Time of Seeker.
Combined with the predicted values of the performance index parameters of the seeker transmitter and the antenna servo mechanism, according to the above provisions, the best time to obtain the maintenance plan to avoid the failure of the seeker can be preliminarily calculated. The two points in figure 1 represent the critical points of the two zones, and the timing of the occurrence of the points is the best time for the implementation of the seeker maintenance plan to be studied. In practical application, The implementation time of the maintenance plan should be slightly earlier than a little time, in order to improve the reliability of the system and ensure that the occurrence of failure can be avoided. Next, combined with the specific data, the corresponding time of the point is calculated.

Assuming that the missile is in service throughout the year, the seeker comprehensive test time is the last month of each quarter, a total of 3 months in each quarter, that is, the comprehensive test time in the first quarter is the third month, and the comprehensive test time in the second quarter is the sixth month. The comprehensive performance index deterioration degree of the seeker in the third month is 62.50%, and the comprehensive performance index deterioration degree in June is 83.14%. The value in the formula for calculating the degree of deterioration is 1, indicating that the value of the degree of deterioration is linear. If the occurrence time of the point is set to be, the following formula can be obtained:

\[ T_a = 3 + 3 \times \frac{80.00\% - 62.5\%}{83.14\% - 62.5\%} = 5.54 \] (2)

The value of \( T_a \) is 5. It can be concluded that the best time for maintenance of the missile radar seeker is the fifth month.

5. Conclusion
According to the health state grade classification standard of seeker and the corresponding performance state description, the health state grade corresponding to the predicted value of performance index parameters of transmitter and antenna servo mechanism is evaluated. As a result, the health status grade of the seeker system is obtained. In order to determine the maintenance time of the seeker more accurately, the comprehensive performance index of the seeker in the stage of "deterioration" is divided by the application of ABC analysis rule. Finally, according to the deterioration curve of each component, The best maintenance time of seeker is determined by calculation.

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