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# Research on Maintenance Period of Military Civilian Integrated Equipment Maintenance Support Based on DUANE

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**Abstract.** In order to improve the integration of military and civilian scientific equipment maintenance warranty period is determined, aiming at the shortage of existing methods to determine the warranty period, the warranty period for the integration of military and civilian equipment maintenance is studied, through the establishment of DUANE model and the expected total cost model, determine the reasonable warranty period in the total expected cost minimum, to solve practical problems, to meet the equipment maintenance practice requirements, for as soon as possible equipment readiness, has important significance to reduce the cost of maintenance.

## 1. Preface

With the injecting of new and high technologies, the complexity of equipment has gradually increased, and its maintenance has become more and more difficult. The Army's own maintenance support alone cannot meet the increasingly heavy tasks. Under such circumstances, the use of local maintenance support forces to complete the maintenance tasks of the indicators has become an inevitable choice for resolving contradictions and problems in the maintenance of complex equipment. However, how to determine the time limit of maintenance tasks has become an urgent problem to be solved. To carry out maintenance support for military-military integration equipment, it is necessary to solve the problem of the contractor's warranty period, determine a reasonable length of warranty period, improve combat readiness, and reduce warranty costs.

In the existing equipment maintenance warranty research period, domestic and foreign scholars have continued to explore. Won Young Yun [1] analyzed the influencing factors of warranty cost and compared the similarities and differences between the minimum maintenance and incomplete maintenance strategies and presented the cost optimization model for incomplete maintenance; Wang Luchao [2] based on warranty costs and availability. Target variables, under the premise of measuring the needs and interests of manufacturers, established an incomplete preventive maintenance model; Liu Weidong [3] for the reliability of the existence of hardware products, establish AMSAA model, design the product of the optimal warranty period; Zhao Wen [4] discussed the different warranty strategies, equality analyzed the problems during the warranty period and gave the calculation method of the optimal warranty period.

The warranty period for military-military integration equipment maintenance guarantees is determined mainly by determining the DUANE model and expected total cost model for equipment maintenance during the warranty period, comprehensively analyzing all the influencing factors, and finally determining a reasonable warranty period.

## 2. The Basic Idea of the Warranty Period

At present, the current status of military-military integration equipment maintenance guarantees is that the warranty period is not scientifically established, and the warranty period is set to be unreasonable. If the warranty period is too long, the cost of the troops will increase, and the short-warning force cannot be completed in time. By establishing a reasonable warranty period, equipment maintenance costs can be reduced, and readiness for war preparations can be improved to provide a

solid guarantee for winning informatized warfare. The basic idea of establishing the warranty period is to collect and analyze relevant influencing factors, establish a warranty model based on Duane's equipment maintenance guarantee, obtain the equipment failure rate, and establish a total cost model for warranty expected. When the expected total cost is minimum, determine the equipment's Determine a reasonable warranty period.

## 3. The Establishment of a Model

### 3.1 Determination of DUANE Model and Failure Rate

The Duane model is an empirically determined model proposed by the American engineer JTDuane in 1964.The DUANE model states that: with constant maintenance after a failure, the number of maintenance guarantees $N(t)$ divided by the maintenance time $t$, compared with the maintenance time, and the double logarithm the axis approaches a straight line.

After the equipment is installed in the unit's warranty period, after continuous learning and maintenance, the capability of maintaining and maintaining the troops will become a growth trend. This article assumes that the maintenance capacity is increased to the DUANE model to determine the warranty period and to distinguish equipment maintenance tasks.

According to the DUANE model there are:

$$\theta(\mathrm{t})=\theta_1(\frac{t}{t_1})^n\frac{1}{1-n} \tag{1}$$

In the ismula: $\theta(\mathrm{t})$ is average maintenance interval time; $n$ is maintenance capacity growth rate (Size is in the range of 0-1,its size reflects the speed of the maintenance capacity of maintenance support power growth rate); $\lambda$ is failure rate; $\theta_1$ is maintenance capacity growth The average initial maintenance interval; $t_1$ is the starting point is maintenance capacity growth; $n$ is the growth rate is maintenance capacity.

It is known that the average service interval $\theta(\mathrm{t})$ is the reciprocal of the failure rate $\lambda(\mathrm{t})$,that is $\theta(\mathrm{t})=1/\lambda(\mathrm{t})$ ,if it is substituted into formula (1), it is:

$$\lambda=\theta_1\left(\frac{t_1}{t_F}\right)^n(1-n) \tag{2}$$

In the formula: $t_F$ is the total test time to reach the growth target.

### 3.2 Warranty Model

The benefits of warranty equipment vary with the duration of the warranty period. on the one hand, the warranty increases the contractor’s costs. On the other hand, it also affects the operational performance and readiness of the equipment. Due to the existence of the warranty, it also brings profits to the contractor [5]. The expected total cost consists of three parts: the expected cost associated with the warranty benefits, the expected warranty expenses, and the fixed management costs related to the warranty. Based on this, the mathematical model for establishing the total cost of equipment warranty is as follows:

$$L(\mathrm{W})=\mathrm{N}+\mathrm{C}_F(W)+\mathrm{C}_X(W) \tag{3}$$

In the formula: $L(\mathrm{W})$ is the total cost of the warranty is expected; the constant $N$ is the fixed equipment management cost associated with the warranty; $\mathrm{C}_F(W)$ is the equipment warranty cost forecast function, which is an increasing function of the warranty period as an independent variable; and $\mathrm{C}_X(W)$ is the expected cost curve associated with the warranty benefit. The warranty period $W$ is a decreasing function of the independent variable.

The forecasting function of the warranty cost of the unit equipment during the warranty period is the sum of the repair expenses for each failure during the warranty period.

$$\mathrm{C}_F(W)=C_0+C_1\lambda W \tag{4}$$

Where: $C_0$ is the unit product during the warranty period and the warranty period related to the fixed costs; $C_1$ is the unit product during the warranty period, a failure of the average warranty costs.

The expected cost associated with warranty benefits is an exponential function,

$$\mathrm{C}_X(W) = \partial e^{-\mu W} \tag{5}$$

Where: $\partial$ is the initial maintenance cost without a warranty period; $\mu$ is the cost reduction rate for the warranty.

So, the expected total cost is

$$L(\mathrm{W}) = \mathrm{N} + C_0 + C_1 \lambda W + \partial e^{-\mu W} \tag{6}$$

Find the extremum of the above objective function and get the following result:

$$C_1 \lambda - \mu \partial e^{-\mu W} = 0 \tag{7}$$

which is:

$$W = \frac{\mu \partial - \lambda C_1}{\mu^2 \partial} \tag{8}$$

Substituting formula (1) into (10), get the following result:

$$W = \frac{1}{\mu} - \frac{C_1 \theta_1 t_1^{\,n} (1-n)}{\mu^2 \partial t_F^{\,n}} \tag{9}$$

## 4. Application Analysis

Taking a self-propelled gun as an example, suppose that the initial warranty cost for a self-propelled artillery unit is 100 yuan, the warranty cost declining rate is 0.0625,the average cost of single-fault maintenance is 300 yuan, and the average annual failure rate of self-propelled artillery is 0.013 ( Times/year),the average time between failures is 24.72 hours, the initial average maintenance interval for maintenance capacity growth is 100 hours, the starting point for maintenance capacity growth is 0.001 hours, and the maintenance capacity growth rate is 0.8,by (11),Calculate the warranty period, get the following result: $W = 0.8718$.

In other words, the optimal warranty period is 0.8718 years.

## 5. Conclusion

Based on the DUANE model and the expected total cost model, this article investigates the shortcomings of the existing methods for determining the warranty period and conducts research on the warranty period for the maintenance of military-military integration equipment. This facilitates the solution of practical problems, meets the practical requirements for equipment maintenance and guarantees, and forms equipment as soon as possible. The readiness of combat readiness and the reduction of maintenance costs are of great significance.

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