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Analysis and Correction of Common Comprehensive Parameter Connotations in Equipment General Quality Characteristic Demonstration

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Abstract: *This project addresses the issues present in the selection of comprehensive parameters during the argumentation for general quality characteristics of equipment. By selecting three typical cases and decomposing the connotations of related parameters, it analyzes the unscientific and unreasonable aspects therein. It clarifies the applicable range and scenarios of commonly used parameters, providing reference and support for argumentation units in subsequent demonstrations of general quality characteristics.*

Keywords: *General Quality Characteristics, Comprehensive Parameters, Correction*

1. Introduction

The argumentation for general quality characteristics of equipment refers to the stage of equipment model project initiation and the overall requirements development phase, starting from the need to meet combat mission requirements. It studies the level of general quality characteristics that the equipment should achieve. With the goal of realizing general quality characteristic objectives, it balances various related factors and analyzes the scientific and feasibility aspects of the equipment plan, thereby proposing general quality characteristic requirements. Due to reasons such as deviations in the understanding of indicators, unclear sources and backgrounds of indicators, there exists a certain range of unscientific and unreasonable parameter selections during its argumentation process. This paper, based on common error cases in the selection of comprehensive parameters during the argumentation for general quality characteristics, refers to relevant standards and domestic and international literature to parse their connotations, thereby clarifying applicable scenarios and correcting certain misconceptions [1].

2. Overview

In the argumentation for general quality characteristics of equipment, it is required to propose comprehensive parameter indicators and reliability parameter indicators. Comprehensive parameters are comprehensive characteristic measure parameters that lie between system performance and the quality inspection of system individual characteristics, mainly reflecting the readiness and mission success of the equipment. Common general quality characteristic comprehensive parameters for equipment include readiness rate, inherent availability, attainable availability, mission success rate, and re-sortie preparation time, totaling 11 parameters. Table 1 [1] lists the main RMS comprehensive parameters and applicable objects for weapons and equipment.

3. Case Studies and Analysis of Parameter Connotation

3.1. Re-sortie Preparation Time

Case Study: A certain communication system uses re-sortie preparation time as a comprehensive parameter of general quality characteristics.

Re-sortie preparation time refers to the time required for equipment, which is performing tasks consecutively, to prepare for the next mission after returning from the previous one, under specified usage

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and maintenance support conditions [2].

From the parameter name, re-sortie preparation time includes "sortie," implying that the equipment characteristic involves " mobility capability " Based on its definition, this indicator is applicable to equipment capable of continuous back-and-forth task execution, with the scenario being "from return to re-sortie," and the keyword is "continuous," implying relatively rapid mobility capabilities, with airplanes being the most typical example. Re-sortie preparation mainly includes: pre-sortie checks, refueling, oiling, replenishing special fluids and gases, installing and/or removing additional equipment required for the re-sortie, and arming, etc. This parameter reflects the equipment's supportability design level and the troops' support capability, mainly used for equipment like aircraft that perform tasks consecutively.

For communication systems, since the equipment does not possess mobility capability, it does not require refueling or arming support work; it belongs to systems that may "continuously" work within a single mission (subordinate devices within the system may not work continuously) rather than types that perform tasks "back-and-forth" multiple times; before performing tasks, it might only need hot starts and system checks, not relying heavily on support resources. After performing tasks, it might only require shutdown or routine maintenance. Therefore, using re-sortie preparation time as an indicator is obviously unscientific. Referring to Table 1, its use can be analogized to radar equipment, which also belongs to electronic equipment, making inherent availability and achieved availability suitable as its comprehensive parameters.

Table 1: Main Comprehensive Parameters of General Quality Characteristics for Weapons and Equipment

Comprehensive RMS Parameters	Ground-to-Ground Ballistic Missile	Ship-to-Air (Ground-to-Air) Missile	Air-to-Air Missile	Military Aircraft	Warship	Main Battle Tank	Air Defense Surveillance Radar	Armored Vehicle
Operational Readiness Rate					√			
Operational Availability		√	√	√	√	√		√
Inherent Availability					√		√	
Achieved Availability						√	√	√
Utilization Rate				√				
Mission Capability Rate				√				
Re-sortie Preparation Time				√				
Sortie Generation Rate				√				
Technical Readiness Rate	√							
Standby Readiness Rate	√							
Inspection Pass Rate		√	√					

3.2. Mission Capability Rate

Case Study: A missile weapon system initially considered the mission capability rate as a comprehensive parameter in its argumentation. The process of argumentation is as follows:

The mission capability rate is defined as the ratio of the time within a specified period that the equipment can perform at least one specified task to the total time under the control of combat troops. It is the sum of the rate of capability to perform all tasks and the rate of capability to perform partial tasks. The specified tasks for this missile include being on combat readiness duty and striking. As long as the equipment can perform the combat readiness duty, it can carry out strike tasks. Therefore, the mission capability rate can be chosen as a comprehensive parameter. Its calculation formula is the mission capability rate = cumulative combat readiness duty time ÷ (total lifespan - lifespan extension period).

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The mission capability rate, by its definition, is the average time actually capable of performing tasks during the lifespan divided by the required task duration, accordingly, there are also rates for inability to perform tasks, capability to perform all tasks, and capability to perform partial tasks [2] .It was first adopted by the US Air Force as one of the top parameters for reliability, maintainability, and supportability, and was included in the series of indicators for Air Force aircraft [3]; however, the US Air Force only provided a definition and did not offer an analytical model. The mission capability rate level for military equipment can only be assessed through operational tests and usage data. Currently, simulation methods are commonly used internationally to predict the mission capability rate for early warning aircraft fleets.

For the mission capability rate, it is necessary to clearly propose the purpose and significance of this parameter, as well as its differences from task reliability and mission success rate [4]. According to the definition, the mission capability rate is the ratio of the average actual working time to the average required working time, whereas task reliability is the ratio of the actual number of tasks completed to the number of successful sorties, and the mission success rate is the ratio of the actual number of tasks completed to the number of sorties required. The connotations of the three are different; the mission capability rate focuses on the time of task execution, while mission success rate and task reliability focus on the number of tasks completed.

The operational availability parameter, like the mission capability rate, is also related to working time; it is the ratio of average actual working time to average required working time. The difference between it and the mission capability rate is that the former is applicable to a continuous working state task profile, while the latter applies to an intermittent working state task profile; the former's required working time is calendar time, while the latter is determined as needed, with required working time being part of calendar time, the other part being necessary and allowable downtime.

The task profile of an aircraft is a typical intermittent working state, and its reliability parameters are determined by the nature of its model and the nature of the tasks it undertakes. For transport aircraft, reliability parameters must be based on task reliability and mission success rate, because once a functional failure occurs during the flight mission duration, i.e., before reaching the destination, forcing the aircraft to land, it constitutes a mission failure as it cannot complete the required transport task; for early warning aircraft responsible for monitoring airspace friend/foe information and commanding operations, a fault occurring during the mission duration and returning to the ground is considered effective working time before the fault occurred, thus focusing on the working duration within the mission period, not on whether a fault occurred during the mission period. Therefore, the aforementioned early warning aircraft fleet uses the mission capability rate as the parameter indicator. In Table 1, the mission capability rate is applicable only to aircraft types.

The keyword in the definition of the mission capability rate is "continuous," suitable for equipment that works continuously, while missiles, as typical long-term storage (duty more closely resembles storage state) and one-time use equipment, from missile launch to target hit, take a very short time, making it inappropriate to use the mission capability rate as a comprehensive parameter for general quality characteristics.

From the above analysis, it is known that in this missile weapon system, apart from the missile body, parts like the weapon control system, analogous to electronic equipment, can use operational availability and inherent availability as comprehensive parameters. However, it is not suitable to use the mission capability rate as a comprehensive parameter for missiles. Instead, the inspection pass rate could be considered as a comprehensive parameter for the missile itself.

3.3. Mission Capability Rate

Case Study: A certain electronic jamming device uses the "Rate of Normal Operation on First Attempt" as a reliability indicator during its argumentation.

The process of selecting this parameter is as follows:

According to the "Requirements for Argumentation on Equipment Reliability, Maintainability, and Supportability" [4], "Success Probability () refers to the probability of successfully completing specified functions under specified conditions. This parameter is applicable to products that are used once."

The calculation formula is:

$$P_s = \frac{N_s}{N_T} \times 100\%$$

In formula:

N_s For the Number of Successful Missions;

N_T For the total number of Missions.

Additionally, in the "Requirements for Argumentation on Equipment Reliability, Maintainability, and Supportability,"[5] it is further clarified that, considering the customary usage in some military branches, it is permissible to refer to success probability as reliability, such as in the reliability indicators for ammunition and missiles, which can be referred to as functional reliability, launch reliability, flight reliability, or flight probability. However, it should be noted that their definitions are consistent with the success probability as defined in GJB 451A ("Terminology for Reliability, Maintainability, and Supportability").

Upon interpreting the above argumentation process, the argumentation party's proposed "Rate of Normal Operation on First Attempt" fully aligns with the connotation of the mission success rate. Through research, it has been found that in the artillery shell domain, the "functional reliability" indicator has been used, similar to flight reliability and launch reliability, but the term "effectiveness rate" has never been used. Nor has this parameter name been employed within the arms industry, nor has it become a customary term. Therefore, it is recommended to change the parameter name to the more familiar and commonly used "mission success rate" mentioned in section 2.2.

4. Cause Analysis and Summary

In conclusion, combining case analysis, the reasons for the above issues can be attributed to three aspects: ①Doctrinal adherence to regulations without a detailed understanding of the concepts, resulting in unfamiliarity with the applicable objects and scenarios for the parameters identified above; ② Inadequate understanding of the parameters and unclear sources of the parameter backgrounds; ③Blind innovation of parameter names, artificially increasing the difficulty of understanding the indicators.

In the argumentation of comprehensive parameters, there are also some misconceptions, such as misunderstanding the concept of comprehensive characteristics, mistakenly interpreting "comprehensive" as "composite" at the equipment level, believing that comprehensive parameter indicators should target the overall level of equipment, constraining the entirety of the equipment, leading to deviations in the argumentation.

This paper, based on introducing the functions, classifications, and applicable objects of general quality characteristic comprehensive parameters, selects re-sortie preparation time, mission capability rate, and mission success rate parameters for detailed analysis of their connotations and the characteristics of applicable equipment. Interwoven throughout the discussion are explanations of the connotations of comprehensive parameters such as task reliability, mission success rate, and operational availability, clarifying the differences, applicable objects, and scenarios of the aforementioned parameters.

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