Research in Differentiated Management of Aerospace Components

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Abstract. To ensure the success of aerospace mission, differentiated management of components should be implemented based on mission-specific requirements, namely through the classification of application levels. These application levels are determined through comprehensive evaluation of multiple factors including component qualification, verification, supply, usage, and failure rates. This enables specific component selection and quality assurance activities, enhances working efficiency, effectively controls project costs, and mitigates component application risks.

Keywords: aerospace, components, differentiated management.

1 Introduction

With the development of aerospace technology, the number of aerospace products has increased significantly all over the world. For NASA, an increasing number of projects are driving the use of non-standard components (e.g. COTS) to meet challenging MEAL (Mission, Environment, Applications and Lifetime) and SWaP (Size, Weight, and Power) requirements[3]. China’s aerospace projects are seeking the similar solution for component usage to meet “High-Quality, High-Efficiency, Low-Cost” requirements. The present scenario is that components of a specific quality level may be suitable for various application scenarios; however, the standards currently provide only vague specifications regarding which types of components are applicable to which specific scenarios. Moreover, there are no standardized regulations for non-standard components. The core question is: How to properly select and test components with appropriate component categories, for different project risk classes. Different approaches are recommended according to program/project risk classification levels, which will likely be driven by a mission's resources and associated risk posture[1].

2 Research on Standardization of Quality Levels

Component’s quality level is an important factor, which reflects the quality control during component manufacturing, inspection, and screening, and constitutes critical

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information for circuit designers' component selection, and users' quality assurance activities. Designers will select components in accordance with the requirements of the component Quality Assurance Outline. component levels must be accurately reported in the component list of the design drawings, and serve as the basis for selection review, electronic equipment reliability prediction, and quality inspection confirmation. Quality assurance measurements implemented by users, such as factory-supervision and factory-acceptance, incoming goods re-inspection, and re-inspection for exceeded valid storage term, all require relevant tests and corresponding quality certification documents to be reviewed in accordance with the component level.

2.1 Purposes of Standardizing Component Quality Levels

By standardizing quality levels, the following objectives can be achieved: clarify the standard system on which the components are based, specify the concrete quality control level of components, and verify the implementation of special requirements from aerospace mission.

The standard system for components determines their manufacture and inherent reliability. In China's aerospace and high-reliability fields, imported components primarily adhere to US military standards (MIL-SEPC components), industrial-grade specifications (both manufacturer high reliability components and commercial components), and ESCC system. Selected domestic components comply with national military specifications (GJB components), enterprise military standards (QJB components), and the "G-grade" system (G-grade components). In some special conditions, commercial components have been also restricted-used.

2.2 Scope of Quality Level Standardization

Quality level is primarily categorized across following four dimensions:

-Component origin: domestic and imported.

-Production line certification and product qualification status: GJB/MIL, QJB/883(quasi-military grade), automotive (AECQ), G-grade/High-Rel (industrial quality and medical quality), and Commercial Components/COTS.

-Product assessment level: divided according to actual quality assurance level or failure rate level, such as GJB(B), QJB(JANTXV), etc.

-Domestic components with additional aerospace special requirements must be regulated according to specific aerospace quality grade specifications.

3 Principles for Determining Application Levels

Application level is the representation of quality level in the operation of components at the user's side, and therefore, application level primarily corresponds to the component's quality level, while also is determined by the component's application maturity, user's assessment, supply and usage conditions, and other relevant factors.

Application levels are divided into following four levels:

-Components at level 1 represent components with the highest available reliability, suitable for critical missions or work scenarios with the highest reliability requirements;

-Components at level 2 are components with relatively high reliability, suitable for work scenarios where risk control requirements can be moderately relaxed;

-Components at level 3 exhibit certain reliability risks and are suitable for work scenarios with relatively relaxed requirements;

-Components at level 4 have significant inherent reliability risks, and are not recommended for aerospace applications unless necessary control measures are adopted.

The determination of application levels shall adhere to the following principles.

Firstly, application levels must correspond to quality levels. In fact, due to the long-term non-standardization of component quality level codes, some ambiguously-defined labels have been widely used, resulting in components' inherent reliability not being accurately reflected by quality levels. Therefore, the prerequisite for determining application levels is to standardize product quality levels based on the inherent technical status of components. Judgment basis: complete quality level standardization documents, clear definition of quality level codes, and one-to-one matching relationship between application level and quality level can be formed.

Secondly, verifiable application history. This primarily refers to whether the product has successful application experience, particularly flight test experience. Judgment basis: complete application record files, flight test appraisal reports and in-service operation data available for review.

Thirdly, a clearly defined technical status. This primarily refers to the solidification of the product's material, process, structure, and key assessment conditions, providing sufficient information for users to perform technical status evaluations of the component. Judgment basis: complete technical status solidification documents, finalized material specifications, process files, structural design schemes and key assessment condition parameters.

Fourthly, clear records of technical status modifications. This primarily refers to whether the product's material, process, structure, and key assessment conditions have changed, enabling to timely assess the application risks of components following changes in technical status. Judgment basis: full modification record files, change approval procedures, and complete application risk assessment reports after technical status adjustments.

Fifthly, clear component qualification (certification)/evaluation results. This mainly refers to whether the user or a user-designated third party has conducted an effective evaluation and verification of the components. Judgment basis: official qualification certification documents, third-party evaluation reports and verification conclusion records with validity confirmation.

Sixth, clear evaluation results concerning the production line status. This mainly refers to whether the component production line has been certified, effective control measures have been implemented, and the organizational structure is stable. Judgment basis: production line certification documents, process control implementation records and stable organizational structure confirmation materials.

Seventh, clear evaluation results regarding supply capability. This mainly refers to the user's evaluation of the product's supply channels, period, price, quantity, etc. Judgment basis: supply channel qualification documents, supply cycle verification data, price and batch supply capacity evaluation records[2].

4 Connotation and Usage Conditions of Application Levels

4.1 Determination of Application Levels

Based on the principles for determining application levels, it is first necessary to establish the corresponding relationship between application levels and quality levels. According to the definition of five application levels, the corresponding relationship between application levels and quality levels is shown in Table 1.

Table 1. Correspondence between application levels and quality levels.

Application Level	Quality Level for Domestic Components	Quality Level for Imported Components
Level 1	1. GJB for aerospace [GJB(S), GJB(K), GJB(JY), GJB(T), GJB(Y), etc.] 2. GJB for military [GJB, GJB(B), GJB(H), GJB(JCT), GJB(JT), GJB(L), etc.]	Military and above specified in relevant military standards [MIL(T) , MIL(K) , MIL(V) , MIL(JANS) , MIL(H) , MIL(B) , MIL(Q) , MIL(JANTXV) , MIL(JANTX) , etc.]
Level 2	QJB	Quasi-military Grade (883)
Level 3	G-Grade	Automotive Quality (AECQ), High-Rel(industrial quality and medical quality)[4]
Level 4	Commercial Components	COTS

The final determination of application levels for domestic components shall be made after conducting evaluations in accordance with Principles 2 to 7:

-Application level 1 requires conducting and passing all evaluations specified in Principles 2 to 7;

-Application level 2 requires conducting and passing evaluations specified in Principles 2, 3, 4, 6, and 7;

-Application level 3 requires conducting and passing evaluations specified in Principles 2, 3, 4, and 7;

-Application level 4 is not recommended for formal application in aerospace missions. When necessary, control measures shall be adopted.

4.2 Adjustment of Application Levels

When components fail to pass the evaluation, their application levels shall be adjusted. The application level of components under the following circumstances shall be downgraded by one level:

- Newly selected components without verification;
- Changes in component technical status involving unverified materials, structures, or processes;
- Components adopting outdated processes;
- Components adopting structures, processes, or materials with reliability hazards;
- Components at risks of supply interruption or discontinuation;
- Delayed supply or poor after-sales service support capabilities;
- Frequent quality problems of components;
- Unstable organizational structure or poor management.

After thorough verification, if component reliability meets the usage requirements and higher-level components are unavailable, the application level may be upgraded by one level.

4.3 Usage of Application Levels

The main function of application levels is to classify components according to their usage risks, facilitating designers' selection and subsequent quality assurance work.

When standardizing components selection and management work, application levels shall correspond to applied systems and components[5]. Equipment is divided into 3 categories according to criticality and risk: Class 1 (critical equipment of mission carriers), Class 2 (non-critical equipment of mission carriers and critical ground mission equipment), Class 3 (general ground mission equipment), and Class 4 (other equipment). The selection requirements for component application levels are shown in Table 2. The component application levels shall be specified in the component Selection Catalog, and the specific application level selection requirements for components of each mission shall be clarified in the component quality assurance outline for each mission.

Table 2. Selection requirements for component application levels.

Mission Category	component Application Levels
Class 1	Level 1
Class 2	Level 1, Level 2
Class 3	Level 1, Level 2, Level 3
Class 4	Level 1, Level 2, Level 3, Level 4

For quality assurance work, specific test items such as qualification inspection, QCI (Quality Conformance Inspection), and screening tests shall be formulated for different types of components according to their application levels, and the reliability of components shall be assessed.

4.4 Top-level Recommendations

The number one rule in using aerospace components is respect the specification or datasheet and verify the component works for the intended purpose.

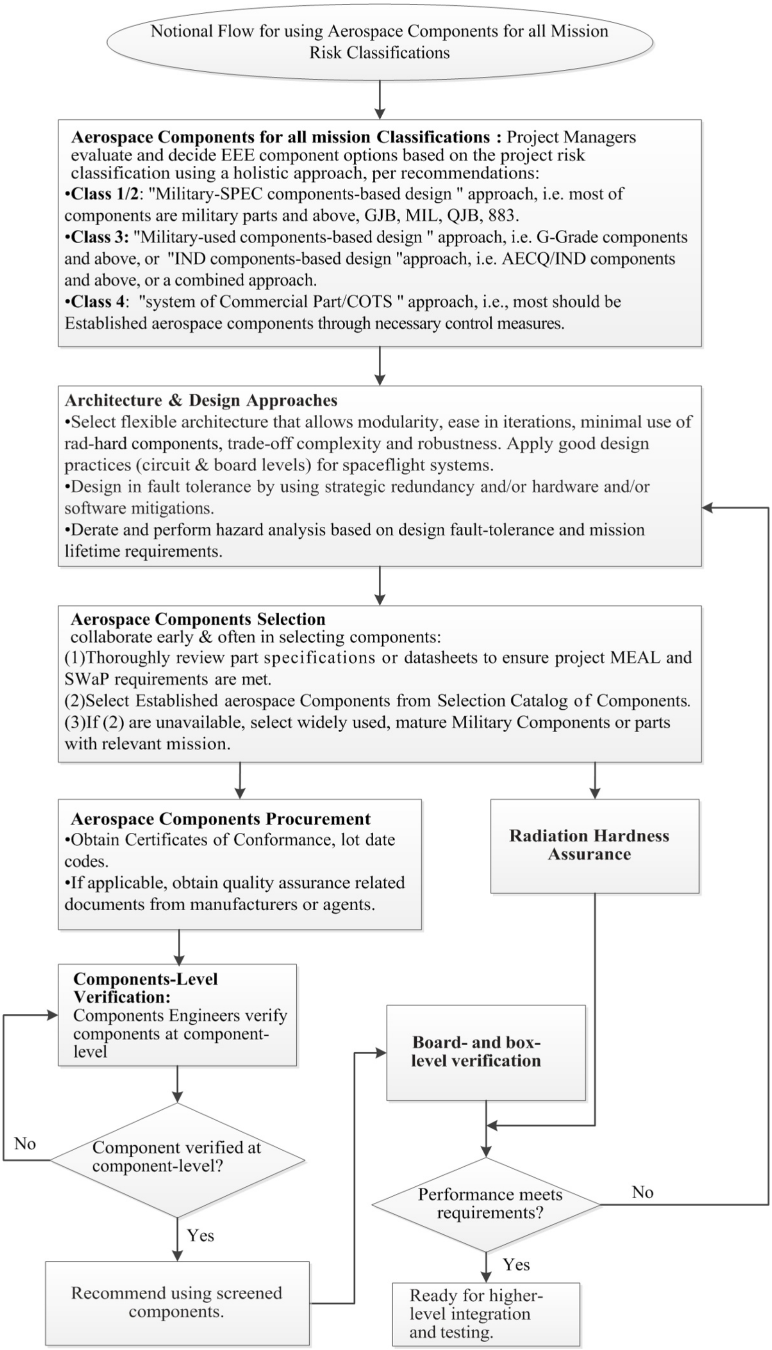

Fig. 1. Top-level recommendations.

Therefore, understanding the component, its specification or datasheet parameters, and its manufacturer's processes are the most important steps in selecting, verifying, and applying aerospace components. Figure 1 outlines the top-level flow on recommending using aerospace components for all mission risk classifications.

5 Conclusion

This paper establishes a hierarchical and classified system for aerospace components, and implements precise control based on component criticality. It balances equipment reliability, cost and efficiency, providing managerial support for high-quality development of aerospace equipment.

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