Research on Civil Airborne Software Reuse Technology

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ABSTRACT： Civil Airborne software reuse technology is an important way to improve airborne software development efficiency, reduce development cost and improve software reliability. As the C919 completes its airworthiness certification, the airborne software faces the problem of how to reuse previously developed software for new equipments. In this paper, the application status and development of software reuse technology are analyzed, and the development of software reuse standardization technology and the requirements of DO-178C standard for software reuse are discussed. At the same time, this paper also analyzes the current situation and development trend of airborne software reuse in China. The research results indicate that airborne software reuse technology has been widely used and has a broad development prospect in the future.

Keywords: Civil ariborne; Airborne software; Sotware reuse; DO-178C

1. INTRODUCTION

With the development of avionics technology, the system functions of modern aircraft are becoming more and more complex, and the proportion of software implementation in the functions is increasing. Civil aviation airborne software has the characteristics of embedded, real-time, high complexity and high security, etc. With the vigorous development of domestic civil aircraft, the quality of airborne software is becoming more and more demanding. Especially with the completion of airworthiness certification of C919, the problem faced by airborne software has gradually changed from how to develop qualified software that meets airworthiness requirements to how to learn from the experience and lessons learned in the previous development process, reuse software that has been developed or even passed airworthiness certification, further improve software quality and software development efficiency, and better apply to the development of new models.

Reusing the previously developed software into the current software development in a reasonable and correct way can help solve some of the problems faced in the airborne software development process.Airborne software reuse technology can apply existing code, components and modules to the new software development process, avoiding the process of repeated development and testing, thus improving the efficiency of software development. Reuse techniques can reduce errors and defects in the development process, thus improving the quality and reliability of the software. Reused software has been optimized and practiced, and even verified, which can improve the performance and stability of the system, and the defect rate will be much less compared with newly developed software. Civilian airborne software reuse technology needs to meet strict safety and reliability requirements, therefore, it needs to be

ICIDC 2023, June 02-04, Nanchang, People's Republic of China

DOI 10.4108/eai.2-6-2023.2334651

studied and explored in depth.

The purpose of this paper is to study the development status of civil airborne software reuse technology, discuss the development of software reuse standardization technology and the requirements of DO-178C standard, analyze the gap and development trend of domestic and foreign airborne software reuse technology, and provide reference for the research and application of airborne software reuse technology.

2. OVERVIEW OF SOFTWARE REUSE

Software reuse, also called software reuse or reuse, is the process of implementing or updating a system using existing software assets. Among these, software assets can be software components (e.g., software libraries, operating systems, communication protocols, etc.), software requirements, software designs, source code, and other software lifecycle information (including plans, standards, verification use cases and protocols, and tool qualification information, etc.). Software reuse can be distinguished into horizontal and vertical reuse according to whether the reuse activities span multiple application domains with less similarity [1]. Vertical reuse is the focus of software reuse technology and the direction of research in airborne software reuse technology.

In the aerospace field, software reuse technology has been widely used. For example, NASA has developed a software reuse library that contains various types of software modules and components that can be reused in different aerospace projects.EASA promotes consistency in software development and improves software reusability by developing uniform software standards and specifications. The civil aviation sector has also successfully applied software reuse techniques in several projects [2]. For example, Boeing 737 MAX airliner, the on-board software contains about 5,000,000 lines of code, in order to improve the efficiency and quality of software development, Boeing used several reusable software components, including avionics system, communication system, navigation system, etc.

Domestic civil airborne software reuse technology is still in its infancy, but there has been some progress. For example, some aircraft systems have started to use ARINC 653 and ARINC 661 and other software reuse technology platforms. In addition, civil aviation research units are also actively promoting the application of software reuse technology, and the Commercial Aircraft Research Institute of China has established a software reuse platform for managing and maintaining software reuse libraries. There are also many papers in China foucus on this technology. In terms of reusable components, Xueying Li, Yongbing Wang [3] have studied the management method of aerospace embedded software components and analyzed it based on the component repository entry and reuse. In software requirement reuse, Yuanxiu Ba,Fengyu [4] proposed a project-level reuse method based on software requirement analysis. In the study of test case reuse, Jiang Rong,Cui Shiying [5] proposed a model-based test case reuse method, designed a reuse-oriented test case model, and gave a test case self-learning reuse algorithm. Yao Jiayu [6] conducted a specific study on the test case analysis process and reuse process in software testing. In terms of airborne software airworthiness, Fang Xu [7] introduced the airworthiness requirements for reused software in detail from the consideration of software reuse in airworthiness validation, and the applicant needs to provide change impact analysis for review by the Civil Aviation Administration of China.

3. CIVIL AIRCRAFT SOFTWARE REUSE STANDARDIZATION DEVELOPMENT

With the development of software reuse technology, various software reuse standards have emerged. Standardizing the process or methodology for identifying and developing reusable software will greatly facilitate the practice of software reuse and is important for advancing the development and application of civilian airborne software reuse technology. NATO (North Atlantic Treaty Organization) has developed a set of guidance standards for software reuse [8] to assist NATO and its contractor program management in effective software reuse. The U.S. Department of Defense has developed MIL-STD-498 and MIL-STD-2167A standards to guide the application of software reuse technologies. In addition, the International Organization for Standardization (ISO) has developed ISO/IEC 12207 and ISO/IEC 15504 standards to guide the software development process and quality management.In 2010, China released the national standard "GB/T 26224-2010 Information Technology Software Life Cycle Process Reuse Process", which specifies the reuse process and links the reuse process with the software life cycle process, providing a basis for the application of software reuse technology to the software development process practice.

In civil aviation, the FAA has also published a number of Advisory Circulars and Orders to guide the application of reusable software in the airborne airworthiness process at multiple reuse granularities. The most widely used ones are as following:

Table 1. FAA AC and Order

FAA Software Reuse Related Documentations	Reuse Granularity	Main Points
FAA AC 20-115D[10]	Previously developed software according to DO-178/178A/178B	For the Previously Developed Software (PDS) according to DO-178/178A/178B, the document described how to evaluate the software history, how to upgrade baseline including all software processes, how to conduct change impact, how to modify the software and associated life cycle datas using DO-178C.
FAA AC 20-148[11]	Reuse software component	For reuse software component, the document guide the RSC developers, integrators, and applicants on developing or using an RSC. It provides typical activities the RSC developers, integrators, and applicants can expect for the first acceptance of an RSC. It also discussed common issues to address when developing and using RSCs. The document provides one acceptable means of compliance for reusable software component (RSC) developers, integrators, and applicants.
FAA Order 8110.49[12]	1. COTS; 2. Previously developed software NOT according to DO-178B.	For COTS or Previously Developed Software NOT according to DO-178B , the document provides guidelines to apply RTCA/DO-178B to PDS that is categorized as Level D. It can be used as a reference for other level software reuse.

Although there are some differences in the content and application areas of the various standards and guidelines, they are all dedicated to improving software development efficiency and reducing software development costs, and promoting the application and development of airborne software reuse technologies. Therefore, it is essential for those who carry out civil airborne software reuse research and application to understand and apply these standards.

4. SOFTWARE REUSE REQUIREMENTS IN DO-178C

DO-178C is the primary standard for airborne software development, which specifies a series of process activities and compliance requirements for software development. Among them, for the reuse of previously developed software (Previously Developed Software, PDS), DO-178C also made clear requirements in section 12.1. Before reusing PDS software, it should be evaluated to ensure its reliability and safety. When evaluating previously developed software, the following steps can be taken [9]:

1) Assess whether the PDS software installation environment has changed: By analyzing the new installation environment, system architecture, and functional security level, we determine whether the PDS usage area has changed, and if the functionality has changed, the PDS needs to be modified, and if the PDS cannot meet the current software level requirements, the PDS software has to be upgraded.

2) Evaluate whether the application environment and development environment have changed: By analyzing the new development environment, software application environment, code generation tools, compiler and compiler configuration, processor and interface, determine whether the environment of the PDS have changed.

3) Evaluate whether the PDS needs to be modified: If the functional safety level, requirements or design, failure modes, and error handling methods have changed, the PDS software needs to be modified, and the software to be modified should be analyzed for safety and change impact.

4) Assess whether the PDS software needs to be upgraded: If the software level of the PDS cannot meet the current software level requirements, a gap analysis based on the PDS life cycle data is required to supplement the compliance target and compliance data, and the PDS software should be modified if necessary.

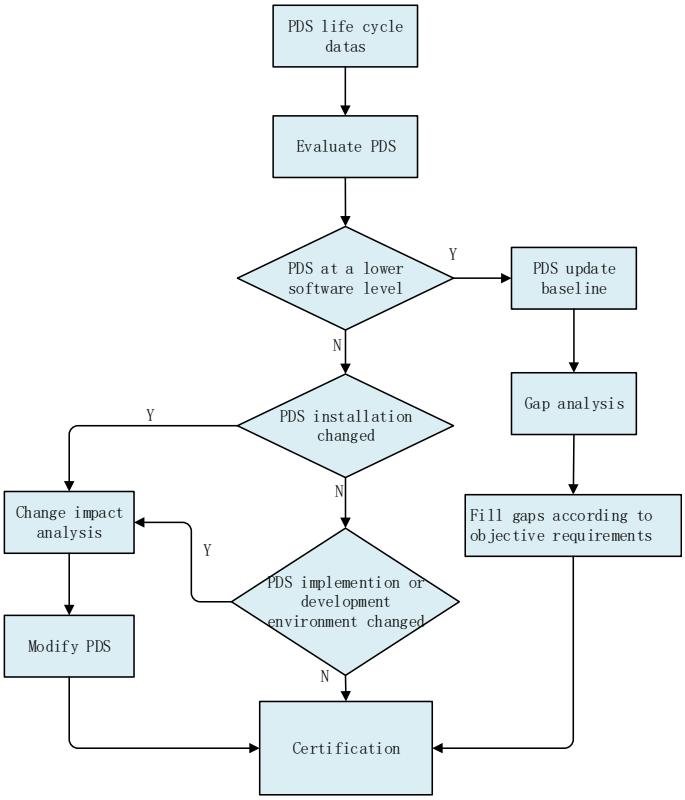

Figure 1. Process of Previously Development Softwre (PDS) in DO-178C

5. DEVELOPMENT GAPS AND TRENDS

Civilian airborne software reuse technology has been relatively well established abroad and has been applied on several aircraft types. Foreign aviation software is typically reused in the following ways:

1. software component repository: Airlines and manufacturers typically create a software component repository to store developed and validated software modules. New projects can access existing modules from the repository to improve development efficiency and quality.

2. software platformization: Software platformization refers to the use of a shared software platform as the basis for new software development projects to promote software reuse and scalability.

3. software standardization: through the development of unified software standards and specifications to promote the consistency and interoperability of software development.

Domestic civil aviation airborne software reuse technology is still in the primary stage, mainly in the following aspects:

Table 2. Development Gap and Reason

Development Gap	Reason
Lack of uniform standards and specifics	Civil airborne software reuse requires unified standards and specifications to regulate the software development and reuse process, such as interface specifications, design standards, etc., but currently there is a lack of relevant regulations in China. This makes it difficult to share and reuse software resources among different software development units.
Insufficient cooperation and sharing among development companys	There is relatively little cooperation and sharing among domestic airborne software development units, and each unit is developing independently, which prevents analysis and integration of existing software resources, and makes it impossible to build an effective component library, resulting in software resources that cannot be reused and can only be developed repeatedly in an inefficient manner.
Insufficient technical talent reserve	Airborne software reuse requires a high level of technical personnel, including professionals in airborne software security, systems, requirements, design, verification, etc. However, there is a relative lack of technical personnel for airborne software reuse in China, which is difficult to meet the needs of industry development.
Lack of awareness of reuse of civil aviation software	Civilian airborne software development units generally lack awareness of aviation software reuse, and there are few specialized institutions and teams to carry out related work, unable to refine common modules or methods in similar areas, leading to greater challenges in software reuse.
High safety and reliability requirements	The security and reliability requirements of aviation software are very high, which also increases the difficulty and complexity of aviation software reuse.

As modern technology continues to evolve and upgrade, the number and complexity of software systems on aircraft continues to increase, and airborne software continues to evolve and develop in the following ways:

Requirements for airborne software safety and reliability will become increasingly high: future airborne software will need to adopt more stringent development standards and verification methods to ensure software reliability and safety.

Application of artificial intelligence technology: Artificial intelligence technology has been widely used in several fields, including aircraft design and manufacturing. Applying artificial intelligence technology to the development and optimization of airborne software can effectively improve the performance and efficiency of the software.

The application of open architecture: open architecture is conducive to the collaboration and integration between different software, and has been widely used in the military field, can improve the reusability and scalability of software, the introduction of civilian airborne software development will also be an inevitable trend.

6. CONCLUSION

In conclusion, the foreign civil aviation industry has a wealth of experience in civil software reuse technology and has achieved success in the development of several aricrafts. These successful experiences prove that by analyzing and integrating existing software resources and improving software reusability, the efficiency and quality of software development can be substantially improved, and the time and cost of software development can be reduced, while the safety and reliability of software can also be improved. Domestic airborne software reuse still faces many challenges due to methods, specifications and talents. With the development of civil aviation, China's civil airborne software will face higher safety and reliability requirements. By introducing more modern technologies, the reusability of civil airborne software can be improved, and the development efficiency and quality of civil airborne software will definitely become better and better in the future.

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