Design and implementation of flight test parameter calibration data management system

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Abstract. Given the shortcomings of current flight test calibration data management mode, in order to improve the calibration data management technology, based on user requirements, a test flight parameter calibration data management system with multiple functional modules was built under Visual C# and SQL Server platform. The C919 and HO300-903 flight test parameter calibration data was used for system function test. The efficiency of the system was tested with another sample of calibration data. The results show that the system is scientific and effective compared to the traditional file-based mode calibration data management method. The efficiency is increased by at least 2 times. The design of the system enhances the ability to calibrate data management techniques and reserve for calibration data mining for flight test sensors.

1. Introduction

The flight test parameter calibration data is used as the value transfer standard for post-flight data processing, which is the medium for converting recorded digital quantities into physical quantities. However, the number of calibration data is increasing because of the initial calibration, periodic calibration and visual calibration. It is urgent to carry out reasonable and efficient data management. At present, the flight test parameter calibration data management technology is still in the file stage. For one aircraft, each calibration data is named according to an independent name and stored in a computer in the form of an excel file [1]. Despite its long contribution, File storage method has a number of problems in use, such as poor sharing, large redundancy, and high data maintenance time cost. The current calibration data management mode is the supervisor retention system. Because different supervisors manage the calibration data in different ways, the same calibration data has different management modes according to calibration time, parameter type and so on, thus the management mode is difficult to unify.

With the development of computer application technology, database-based data management technology has emerged, and various industries at home and abroad are conducting data management technology research [2,3]. Test calibration is a special work link in the field of flight test. The storage situation of calibration data is unique. At present, advanced data management technology research has not been carried out. In order to improve the calibration data management technology, unify the data management mode, strengthen the standardization of test flight quality and standardize the operation process system, The .NET framework and SQL database technology is used in this paper to develop the flight test parameters calibration data management system based on the database model. The main aim of this paper is to design and implement a unified standardized management platform for all types of calibration data [4].

2. System requirements analysis

2.1. Functional design

The flight test parameter calibration data management system designed in this paper needs to have professional counterpart, convenience and good interactivity [5]. The system uses a top-down design, setting up three different user levels for common users, calibration supervisors, and system administrators. Through the construction of multiple management modules, all the functions of uploading, storing, querying, updating, deleting, exporting, parameter expiration management and data sharing of all flight test calibration data are realized. According to the calibration data supervisor responsibility system, set the data operation authority of different users to ensure the safety of calibration data operation. Set up system administrators to implement user management and resource configuration.
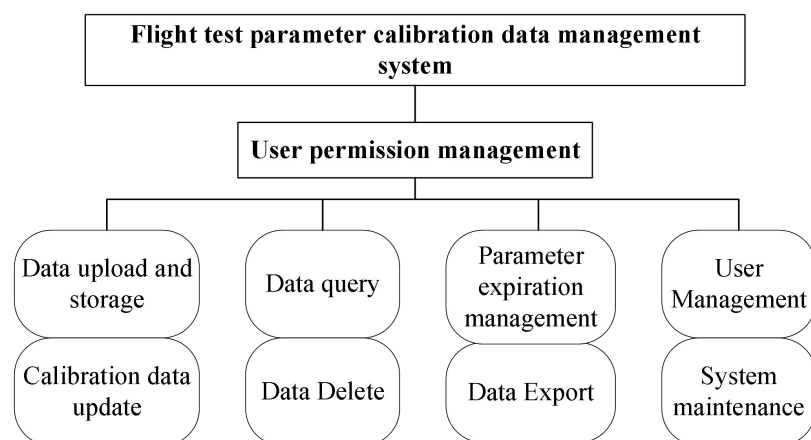

Figure 1. Function of the flight test parameter calibration data management system.

The overall function of the system is shown in Figure 1. The common user can use the calibration data query and export function. On the basis of this, the calibration supervisor has the authority to upload, store, update, delete and expire the calibration data; the system administrator is mainly responsible for the user rights management and database security maintenance.
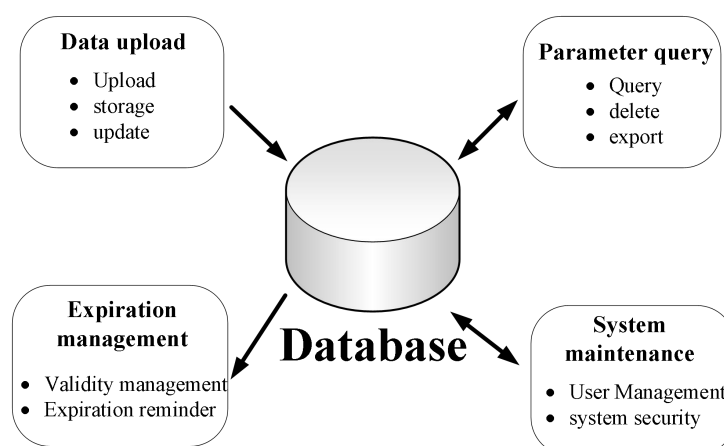

Figure 2. Structure of the flight test parameter calibration data management system.

2.2. Key technologies

The flight test parameter calibration data management system is oriented to the parameter calibration data of the full test flight cycle. The client/server mode is adopted as its technical architecture in order to facilitate the interface with the automated calibration system. Select Visual C# and SQL Server

under Visual Studio platform to realize its functions [6]. Data interactive operations are implemented through ADO.NET technology in the .NET framework.

2.3. System structure
According to the top-down modular design concept, design data upload, parameter query, expiration management, system maintenance four parts to achieve all the functions of the calibration data management system as shown in Figure 2.

3. Calibration data management system design

3.1. Database design
The key to the design of the flight test parameter calibration data management system is database construction. The system realizes the storage of the calibration curve and the setting of the system management authority by creating the information table, the data table, and the user table according to the content of the calibration data. The integrity of the calibration data storage is achieved by setting the aircraft model plus the parameter name as the primary key of the information table and the foreign key of the data table. The construction of data tables, information tables and user tables is shown in Tables 1 to 3.

Table 1. Calibration information table.

No.	Field name	Type	No.	Field name	Type
1	Aircraft Type	Varchar	13	Humidity	Varchar
2	Parameter	Varchar	14	Air pressure	Varchar
3	Standard	Varchar	15	Physical unit	Varchar
4	Sensor model	Varchar	16	Correction unit	Varchar
5	Sensor number	Varchar	17	Precision	Varchar
6	Collector model	Varchar	18	Calibration date	Varchar
7	Collector number	Varchar	19	Calibrator	Varchar
8	Regulator model	Varchar	20	Proof reader	Varchar
9	Regulator number	Varchar	21	Remarks	Varchar
10	Board model	Varchar	22	Date of Expiry	Date
11	Board number	Varchar	23	Page number	Varchar
12	Temperature	Varchar			

Table 2. Calibration data table.

No.	Field name	Type	No.	Field name	Type
1	Aircraft Type	Varchar	7	Code value3	Int
2	Parameter	Varchar	8	Code value4	Int
3	Physical quantity	Varchar	9	Voltage value	Small int
4	Correction	Varchar	10	Average code value	Int
5	Code value 1	Int	11	ID	Big int
6	Code value 2	Int			

Table 3. User table

No.	Field name	Type
1	User number	Varchar
2	Name	Varchar
3	Department	Varchar
4	Password	Varchar
5	Permission	Varchar

3.2. System module design

The flight test parameter calibration data management system realizes the design and function realization of the interface of the system main interface, user login, data upload, parameter query, expiration management and system maintenance through the WPF-based user interface framework.

3.2.1. User login and system main interface. To maintain the login rights of the operating system, perform user authentication before entering the main interface. First, the user enters the job number and password, connects to the user table in the SQL database for security verification, and then obtains the login qualification after confirming the identity security exists; Secondly, before the user enters the main interface, his rights need to be confirmed. Only the administrator user has the right to access the system maintenance module. The module is hidden from other users, and at the same time, restricts the uploading, deleting, and expiration management functions of the ordinary users. Users are provided with three consecutive password error opportunities. Once the user is proved as unauthorized, the system enters a locked state and exits the login interface.

After the user successfully logs in, the welcome dialog box and the main interface of the system pop up, and the test data calibration system is officially entered. The user personal information maintenance module is provided in the system, which is convenient for the operation user to update and maintain the information.

3.2.2. Data upload. The data uploading module realizes the uploading, storing and updating functions of the calibration data. The data uploading module is designed with a calibration data selection unit, a database connection and upload unit, an upload process control unit, and an upload result display unit. Through the specific class to achieve the selection of multiple calibration data, after confirming, click the upload button. Through the OLEDB interface, the calibration data in the EXCEL template is read into the Dataset, uploaded to the database through the SQL connection class to achieve storage and update. The upload control module displays the parameter information of both waiting for upload and uploaded, and the parameter information of the upload failure is marked red to realize the user reminder. The upload result display module implements the statistics of the number of parameter upload results.

3.2.3. Parameter query module. The parameter query module implements the query, delete and export functions of the calibration data. The system designed two query modes, one is the hierarchical retrieval mode based on aircraft model, parameter type, and parameter name, and the other is a fuzzy query mode based on four keys information: aircraft model, parameter name, sensor model, and sensor number. The list of related items that are queried is displayed in the table of the interface. Double-click the parameter name to pop up the new interface to display the full calibration data. The last column of the table displays the delete button, and the calibration supervisor double-clicks to confirm the deletion of the calibration data. In order to realize data transfer, download and local save function, the calibration data management system opens the download and export port to the user, through the check box, realizes the selection of multiple parameter calibration data, clicks the export to local button, and writes the calibration data to the excel template.

3.2.4. Expiration management. This module mainly implements the expiration management function of the flight test calibration data. The validity period management of calibration data is an important part of the quality and safety management of flight test. The validity period of different types of parameters varies according to the calibration standard of the flight test. For example, the displacement parameter calibration data is valid for 1 year; the electrical parameter and pressure parameter calibration data are valid for 2 years; and the strain and temperature parameters are valid for 3 years. When the calibration data is uploaded, the calibration standard information is used to judge the parameter type, and the expiration time is calculated according to the calibration time, and is set to the Date format and stored in the corresponding field of the calibration information table.

In the expiration management module, we first set the query time period, and then click the query button to achieve the expiration parameter statistics. The system also provides the list local save

function, which is convenient for the calibration supervisor's expiration control.

3.2.5. System maintenance. The system maintenance module mainly implements user management and database maintenance functions. System user management mainly implements system user addition, query, deletion, information update and password reset by accessing the user table in the database. The database maintenance function mainly includes backup and recovery of the database.

4. System implementation and testing

4.1 The specific implementation of the system
Using Visual C# under Visual Studio platform, the developer writes the program to realize the function module of the flight test parameter calibration data management system. The system is connected with the SQL Server database, the main interface and login interface of the data management system are shown in Figure 3 and Figure 4.

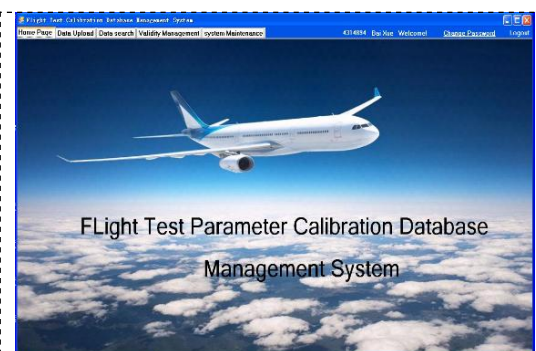**Figure 3.** Login interface of the flight test Parameter calibration data management system.

Figure 4. Main interface of the flight test parameter calibration data management system.
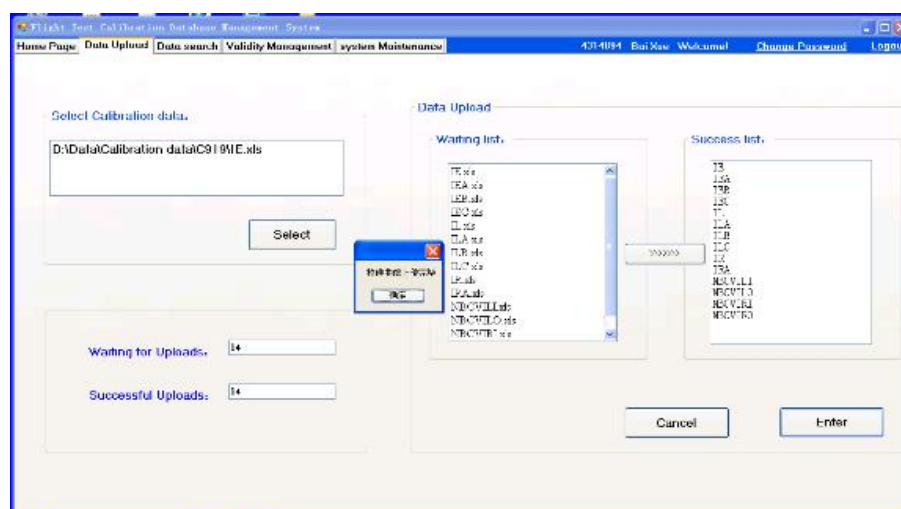
4.2. Functional test

Figure 5. Data upload module test chart.

In order to verify the validity of the data management system, the calibration data of the civil aircraft C919-01 and the seagull HO300-903 are used as test samples to verify the function of the system. Upload nearly 1000 calibration data to the database to test the system's upload, query, delete,

download and export, expiration management, and maintenance functions. The test chart of the upload and parameter query function module is shown in Figure 5 and Figure 6. After half a year of practical application, the validity and convenience of the data management system is proved. The test flight parameter calibration data management system developed in this paper solves the shortcomings of the current file management mode and provides a scientific information management platform for calibration data. Efficient management of calibration data is achieved, which improves the standardization of calibration work quality.
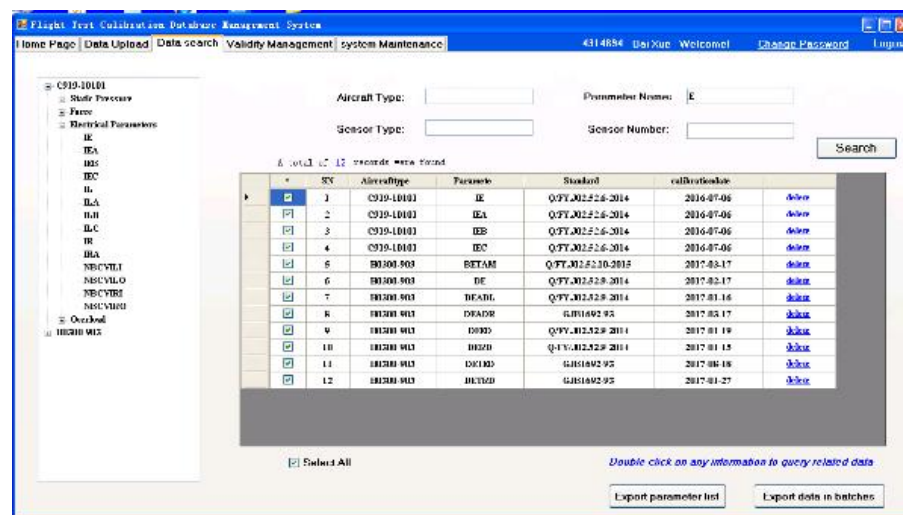

Figure 6. Parameter query module test chart.

4.3. Efficiency test

In order to test the execution efficiency of the flight test parameter calibration data management system, the software tester selects the traditional file-based data management method and the system designed in this paper to carry out the efficiency comparison experiment. A total of 5000 calibration data of 30 aircraft were selected as test samples, and the average query time of the data and the expiration management query time were compared and analyzed. The experiment compares the time taken by the two systems to query the calibration data of 50 specified parameter names, and the time taken to count and list the expiration parameters of the past three months. The comparison results are shown in Table 4.

Table 4. Efficiency comparison.

	Time spent querying 50 calibration data	Time spent counting three-month expiration parameter
Traditional file management mode	10min	30min
The system designed in this paper	3min	1min

After testing, it was found that the efficiency of calibration data operation was improved by at least 3 times. The calibration data management system designed in this paper uses ado.net technology, through the establishment of a database, to achieve unified import, query, list display and export of parameters, to make up for the lack of human-based file operations, showing the advantages of systematic and systematic data management. It has been verified that the test data calibration system using the flight test parameters improves data management efficiency and shortens the data management time of technicians.

5. Conclusion

Test calibration is one of the important technical aspects in flight test. Calibration data is a measure of the value of post-flight data processing, while scientific and efficient management of it is of great

significance. The flight test parameter calibration data management system designed and implemented in this paper realizes the functions of uploading, querying, exporting and expiring the calibration data, and at the same time improves the efficiency of various management operations of the calibration data by at least 3 times, makes up for the shortcomings of traditional file system-based data management methods and improves the efficiency of the work. As a standardized flight test calibration data management system, not only can the current relatively backward calibration data management mode be changed, but also the centralized analysis and mining of the calibration data stored in the system can be facilitated. The system has been successfully applied to the data management process of multiple testing machines such as C919 and ARJ, and achieved good results.

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