TEST DATA MANAGEMENT FOR AIRCRAFT HYDRAULIC SYSTEM TESTING

Hongfang Cheng*, Gaomin Li*, Hugh H. T. Liu, Dengfeng Zhang*****
*** The Department of Flight Control and Hydraulic System, the First Aircraft Institute,**
**** Institute for Aerospace Studies, University of Toronto，**
***** The Department of Information System, the First Aircraft Institute**

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Abstract

This paper briefly describes a Test Data Management (TDM) software system designed for aircraft hydraulic system testing on the ground. This system was developed based on a database management system (SQL Server). All the information related to hydraulic system test is collected into one system for integrated management, which ensures data integrity, consistency and security. In addition, the data mining function designed in the TDM supports the achievement of some valuable information that hidden behind test data. The TDM was developed for the purpose of the hydraulic test of one certain aircraft.

1 Introduction

Simulation testing on the ground is an important phase of hydraulic system validation, the test results are critical to the assessment of hydraulic system design function and performance. Based on these test results, the optimization and improvement of the system can be achieved.

A variety of test data is used frequently during the design of hydraulic system. For a long time, however, test data exists in the form of data file or printed document. There are two primary disadvantages, namely the low efficiency and error-proneness. Obviously, designers have to spend much more time to dig out the data they expect from a huge number of data files, bringing efficiency further down or leaving valuable data on shelf. Also, valuable information implicated in these test data is hard to achieve, and some critical data may be exposed to security breach.

To address these challenges, we designed an integrated management platform for hydraulic system test to manage all test data efficiently. A series of functions, such as test flow design, test data analysis, historical test data mining and so forth, contribute to the reduction of workload and the improvement of efficiency of data processing and utilization. The paper introduces the TDM from different aspects, including system architecture, function description and software structure.

2 System Functions and Features

The TDM plays an important role during the design of aircraft hydraulic system. It provides real-time access to test data generated from a variety of testing environments for engineers and technicians through flexible access control to database.

The main function of the TDM is to maintain and manage test data. However, if only the final result data is collected, it may not ensure information integrity. Accordingly, the TDM comply with a rule of data integrity, so-called “full data” rule. That is, an extensive data involved in test will be collected from the whole experiments. All data can be categorized into five groups, describing as follows in more detail.

- Testing objects information: testing objects play an important part in test. Testing objects information is usually related with test tasks, and each test task is associated with a corresponding testing object.

- Test facility information: this information is related to sensors, secondary meters and data acquisition facilities. Furthermore, the data acquisition facilities are still identified as different hosts, acquisition cards and channels.
- Test environment information: this information is related to test rig and other support facilities.
- Test task information: each test task is an item, so the TDM actually fulfill the management to items.
- Test data: the data is generated during the test.

We define four elements for test, including test facilities, test environment, test objects and test tasks. Apparently, the test objects are the data sources generated test data; the test facilities are the tools to get test data; the test environment refers to support facilities, and the test tasks are the requirements to be validated.

Some primary features of the TDM are listed as follows:

- All the test data to be managed in one platform.
- Privilege management mechanism on role.
- Test data analysis and report generation.
- Test flow design.
- Data mining.
- Interface with other systems, such as Office Automation (OA), Product Data Management (PDM) and so forth.

3 System Architecture

The primary elements of the TDM are shown in Figure1. It is based on Browser/Server model, communicating between them via Ethernet. Users can visit the system with Web Browser on any computer that connected with the Server. All data is processed at server end, and Microsoft SQL Server DBMS was adopted to manage these data in background.

Gathering all the data associated with test together to process, the TDM implements the concept of integration management to test data, which makes it possible to share resources within a corporation. Not only do engineers have access to the test data using IE browser, but they also can download data for further analysis

Client end users include administrators, engineers in hydraulic system, testing engineers, facility checkers and test investigators. Based on this platform, data security will be improved through privilege management, data backup and recovery. With the analysis of test results, the engineers responsible for hydraulic system design can validate the requirements for hydraulic system. Testing engineers make a primary analysis on testing data and produce the corresponding testing report. At the same time, files with different formats (text file, Excel file etc) can be imported into database directly as a basis for validation. Facility checkers take charge of updating facility information. Test investigators assess the design performance according to testing data and analysis results.

There is specific information about tested objects to maintain in the PDM, including names, numbers, and pictures etc. This information is available to users through the interface with the PDM.

The data source related to database is composed of landing gear system, hydraulic power source system, inverse thrust device, and flight control system. The data acquisitive system captures data from varieties of sensors that the majority of them were installed on the test rig. According to test tasks, test outlines and test technics flows, the test flow design can plan test objects, test environment condition, instruments, and test members. After that, a complete test work state flow can be established. The checking module for facilities and instruments carries out initial state testing of test objects, calibrating test instruments, sensors, and exciting sources, and also recording the calibrated data as reference for test result data. The integrated control module, which is the control center for hydraulic system test bed, manages the other subsystems, controls test process, monitors test state, and exchanges information with the flight control system and avionics system.

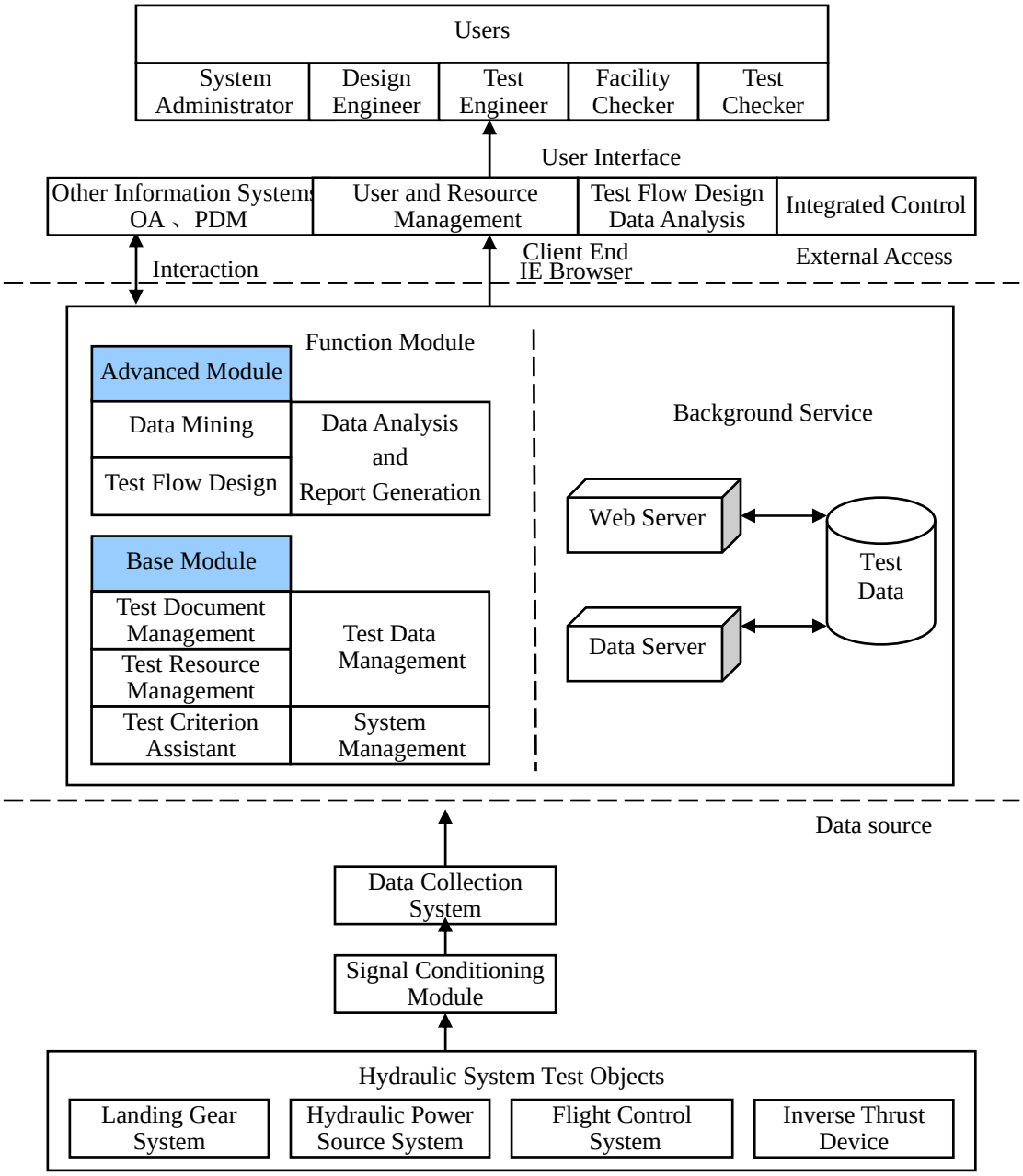

Fig. 1. System Architecture of the TDM

4 Description of the Database

The TDM is a powerful platform that provides users with a comprehensive set of engineering data management approach, including basic module and advanced module. The basic module includes test document management, test resource management, test criterion assistant, test data management and system management; and the advanced module consists of test flow design, data mining, test data analysis, and report generation. The TDM module structure is shown in Figure 2.

The TDM for hydraulic system is designed based on computer network and database management system (DBMS). The main unit of data storage is a database, which is a collection of tables with typed columns. SQL Server is one of DBMS to be used in our TDM, that is a relational database management system (RDBMS) produced by Microsoft. The tables belonging to test database include test object table, test facility table, test rig information table, test document table, test data table, test

criteria table, test flow table, test configuration table and so on.

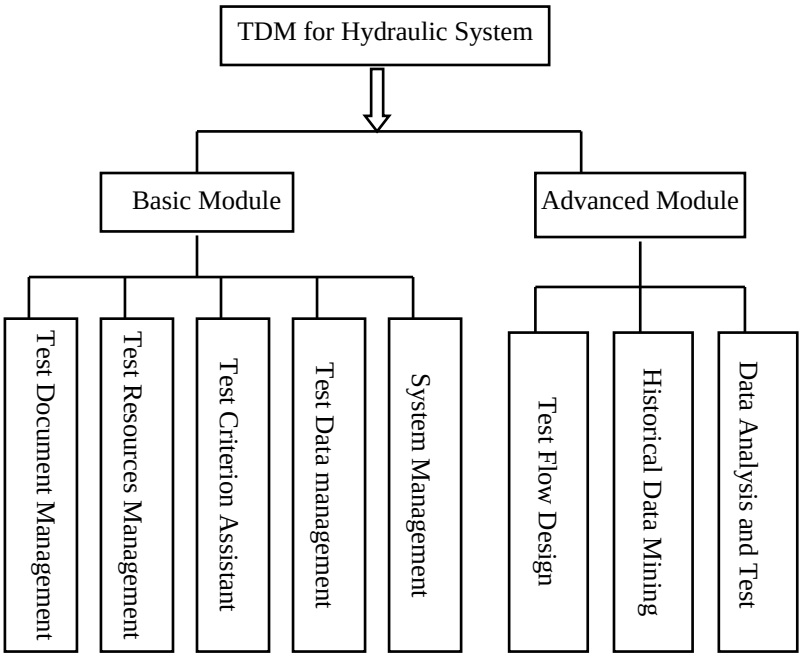

Fig.2. TDM Module Structure

All documents generated in the process of test lifecycle are stored in the name of test document, including the initial stage documents, such as test task book, test outline, test schedule; the test stage document, such as test channel configure information, review reports; as well as summary reports and final review reports in the test end-stage.

The test resource management organizes and maintains hardware resources that involved in test, including test objects, test facilities, test beds. The test facility information refers to the information about sensors, amplifiers and acquisitive instruments.

The test criterion assistant provides the standard information serving as hydraulic system test. The test criterion consists of three parts: naming criterion, test data dictionary, and test criterion. The naming criterion defines the naming method to standardize names, symbols, characters, parameters, dimensions etc. With the test data dictionary, it is easy to query the test information, and also standardize the terms for test information.

4.1 Testing Data Management

The testing data is made up of test configuration parameters and testing data, both of which are stored in database separately. The test configure sub-module implements the parameter configuration at the very beginning of each test, such as setting testing channel properties, configuring communication channel parameters, setting alarm information and setting test configuration template. The testing data sub-module organizes and maintains raw testing data, filtered testing data, processed testing data, data analysis results, and multimedia information about test. All kinds of data which are mentioned above are described as follows in further detail. They are stored in corresponding repository respectively.

- Raw testing data: these data maintained stringently come from the data acquisitive facilities.
- Filtered testing data: these data are remains after filtering singular points and invalidating points.
- Processed testing data: they are those of which have gone through a series of preprocessing, such as dimension conversion, sensor parameters process, digital filter, maximum value search and so forth.

- Results of testing data analysis: they are final results after processing with analysis tools.

On the demand of practical application, test data management has been designed in two layers. One is data management layer, which manages and maintains middle data, final result data and related files; the other is raw testing data management layer, which manages and maintains raw testing data stored in a database table in the form of record. Figure 3 shows the management and storage structure of testing data.

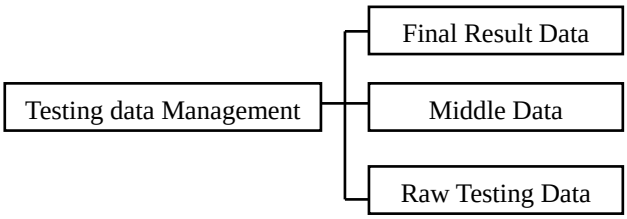

Fig.3. Management and Storage Structure of Testing Data

4.2 Test Flow Design

The test flow design module implements the split of a complex task into some subtasks and assigns them to corresponding test people with date and requirements. The period of a test task can be divided into three phases: test preparation, test implement, and test end.

The test flow design module provides the storage of information referred to test, such as principals, test tasks, attached departments, complete date with the day name and month name, final state and results. In addition, some test flowcharts can be stored as templates in order to use directly when doing similar experiments again in future.

4.3 Test Data Analysis and Report Generation

The test data analysis module provides data analysis, data processing and preprocessing for users. The data preprocessing is responsible for data integrity and consistency check, data conversion, and singular value filter. The data analysis supports correlation analysis, spectrum and character analysis, failure diagnosis, and time domain analysis. The data processing supports data statistic, data calculation, static processing, data continuity processing, rationality check, maximum value achievement, interpolation and fitting etc.

Usually, the test report generation gathers requested information from database in terms of users' request. It creates and prints out test report, including requested export data, corresponding relation curve etc.

Both test data analysis and report generation can complete most of works in the test data processing instead of engineers, making them have more time to focus on test design and result analysis. Meanwhile the current design performance of hydraulic system can be fed back to engineers in system design to modify design, shortening the design time consequently.

4.4 Historical Data Mining

It plays a very important role in the design of aircraft hydraulic system that extracting some valuable information from large amounts of historical data. The historical data mining module we developed is based on Analysis Service of SQL Server, which provides a solution for data mining. Figure 4 is the flowchart of data mining.

The first step of data mining is data preparation, whose quality directly affects the efficiency, accuracy, and validity of data mining. The data selection module firstly searches for the data information related to objects, and then digs out the expected data. The data preprocessing module researches into the quality of data to prepare for the following analysis, and decides which kind of algorithm to select for next data mining in terms of the features of hydraulic system and information structure of database. According to the selected algorithm, data conversion module converts the desired data into an analysis model. After that, the data mining module extracts the desired information through a number of iterative cycle processes. Lastly, the data assessment module carries out the representative of obtained information in a clear and understandable form, as well as analysis and validity assessment[1].

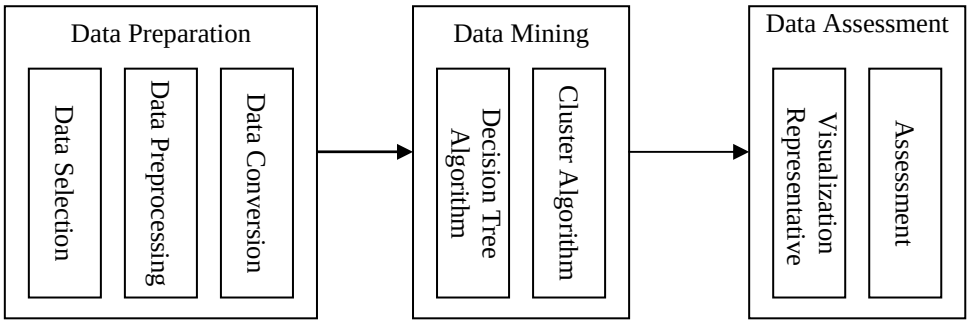

Fig. 4. Data Mining Flowchart

4.5 System Management

The system privilege management supports role-based access control, which is a basic function provided by Microsoft SQL Server. It is an effective access control manner to realize the security plan. In view of the requirements of the TDM for aircraft hydraulic system, we adopted role-based access control, and defined 5 roles: system administrator, engineer in hydraulic system, test engineer, facility checker, and test investigator. Each role has different privileges, and different users can play different roles.

The tool for test data import implements the storage of test data into database, and creates relationships and indexes between test data and corresponding test information. In addition, the tool for test data export implements the export of test data from database in the several formats that adapt to Matlab、DiDasp、Labview and Excel respectively.

5 Software Structure

The system software was developed based on Visual Studio.NET in C# language. The main idea is from the currently popular Web service technique. We defined a software framework for implementing the TDM requirements in three layers: representative layer, logic business layer and data access layer[2]. Control is passed from one layer to the next, starting at the presentation layer, and proceeding to the bottom layer. The representative layer provides access to application; the business logic layer and data access layer implement the main functions of TDM. Figure 5 shows the software structure.

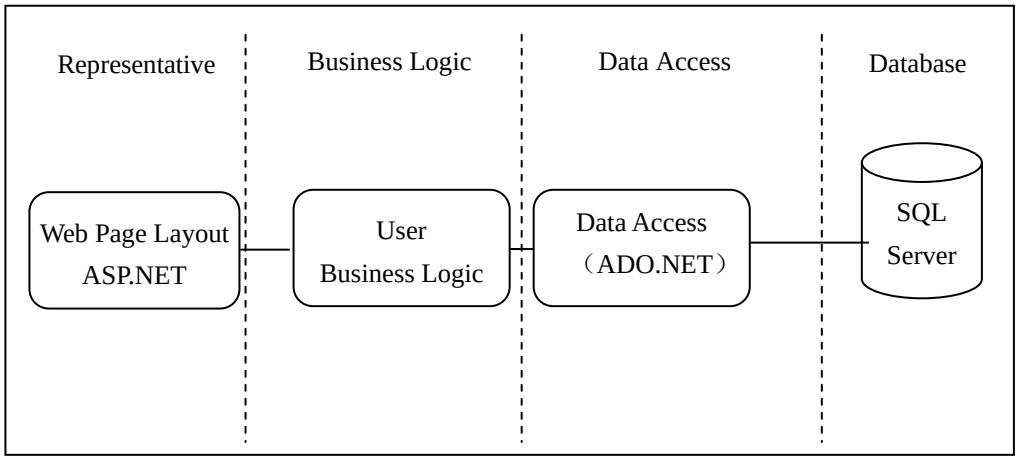

Fig. 5. System Software Structure

6 Conclusions

Test data is very important for system validation, but how to store, maintain and use them is primary object of the TDM. The TDM collects all data related to hydraulic system test in one database for integrated management, improving data integrity, consistency and security, and also makes them available to users on a department scale by the way of authorization. It simplifies uses' operation, and improves use efficiency of test data through test flow design, data analysis, report generation and data mining. Although this TDM was developed for aircraft hydraulic system, it also can be used for the TDM for other aircraft system with few modifications.

References

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[2] Jiufeng Ji, Zhi Li. Developer's guide for ASP.NET office automation. 1st edition, Publisher, 2004.

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Authors:

Hongfang Cheng, Engineer, chf3647@126.com.
Gaomin Li, Senior Engineer, lgmfai@yahoo.com.cn.
Hugh H. T. Liu, Associate Professor,
liu@utias.utoronto.ca.
Dengfeng Zhang, Engineer, zdf3663@126.com.