

PAPER • OPEN ACCESS

Design and Implementation of spacecraft component-level test management system

To cite this article: J Zhang *et al* 2019 *J. Phys.: Conf. Ser.* **1213** 052087

View the [article online](#) for updates and enhancements.

You may also like

- [DFT calculation for adatom adsorption on graphene sheet as a prototype of carbon nanotube functionalization](#)
A Ishii, M Yamamoto, H Asano et al.
- [The Model of Plane-parallel Ship Movement Based on a Semi-linear System of Differential Equations using the Perturbation Method](#)
O V Solyakov, L A Uvarova, V V Yakunchikov et al.
- [On the possibility of individual forecasting of reliability factors of mechanical transport units](#)
L O Savin and A N Novikov



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Design and Implementation of spacecraft component-level test management system

J Zhang, H M Zheng, T Lu, W Guo, A R Chen and Y Liu

China Academy of Space Technology, 104 Youyi Road, Haidian District, Beijing

Email: 354476596@qq.com

Abstract. This article is to introduce the typical performance and configuration of component-level environmental test management system. Firstly, the characteristic of spacecraft component-level environmental test is analyzed and the main problems are pointed out. In order to address the shortcomings, the project of the test management system has been envisaged. Then, the composition, structure and implementation method are described. Results show that the management system solves many problems after its application. The system has the function of key parameter monitoring and a timed automatic inspection. It reduces the strength of the workforce and improves the quality of process control. The data packs of the product are enriched too. This system unifies the device drivers and communication methods of multiple manufactures, and completes the whole process automatic control of mechanics, thermal and comprehensive environmental tests. The system adopts the idea of modular design and has the function of convenient expansion. It has been deployed in many laboratories and can be promoted to other industries in the future.

1. Introduction

1.1 Background

In order to ensure survivability of spacecraft during launch and in space, spacecraft must be properly assembled, integrated and tested as per space industry prevailing practices and standards from component up to system level. Ground testing and validation process should simulate close to the environment, which will be experienced during lift-off and while in orbit. To ensure the qualification of on-board component and equipment before their delivery for system AIT activities of satellite, dynamic, thermal, comprehensive and climate tests shall be performed. Dynamic environment testing mainly includes acceleration, vibration and shock tests. Thermal testing generally contains ambient thermal cycling and thermal vacuum tests. Comprehensive tests generally refer to the combination of dynamic, thermal and humidity tests. There are many problems that affect quality control and productivity. An advanced digital management system is needed to resolve these problems.

1.2 Profile of the Project

The system caters for test center's needs pertaining to test preparing, test implementation and test withdrawal for all types of satellite components.

This system will perform the following functions:

- a) Data Acquisition
- b) Graphical display and printing
- c) Equipment information database



- d) Human resources database
- e) Test program and test assignment management
- f) Test procedure
- g) Monitoring system
- h) Test report generation and management

2. Methods and functions

Oracle database and Java design language are used to develop this management system. Oracle database is designed by ORACLE and uses distributed database as its core. B/S architecture is chosen as the software structure. This combination is the most popular management system model currently. The project is envisaged keeping in view the future expansion and upgrade requirement.

2.1 Java Design Language and JDBC

Java design language is essentially a network programming language. It is often selected by programmers as a necessary programming tool. As an object-oriented language, its internal modules can be shared and called each other.

JDBC is the abbreviation of Java database connectivity. It is a standard Java API between Java language and database^[1]. As a specification, JDBC provided sets of interfaces. JDBC is consists of interfaces and classes. Different databases are connected by calling different interfaces and classes. JDBC provides unified mode of operation and programming ideas for different databases. It is the bridge between the applications and the databases^[2].

2.2 Selection of the C/S and B/S Structures

C/S is the Client/Server model. High-performance computers are used as a server terminal to install server-side software and databases. Client computers are used to install client software.

B/S is the abbreviation of Browser/Server. Client needs to be connected to the network and installed the browser. Server-terminal needs to be installed IIS (Internet Information Services) or Web logic as an application server^[3]. The browser and server make data exchange using HTTP protocol. The biggest difference is that C/S structure needs specialized client software but B/S structure just needs browser and network. According to the previous experiences, C/S structure has the characteristics of safeness and is easy to be developed^[4]. As a Client/Server model, all the client software needs to be re-installed if the system needs to be exploded or updated. In consideration of the update convenience, B/S structure is finally selected^[5].

2.3 System Physical Structure

This system uses B/S architecture. Server-terminal is deployed on the server. The client is deployed on the operation computers.

- a) Test comprehensive platform: to view and manage the test assignments, test progress and test data
- b) Data acquisition system: collecting all the test data to the Oracle database
- c) Image acquisition system: getting and storing image data

The function construction of the system is shown in figure 1.

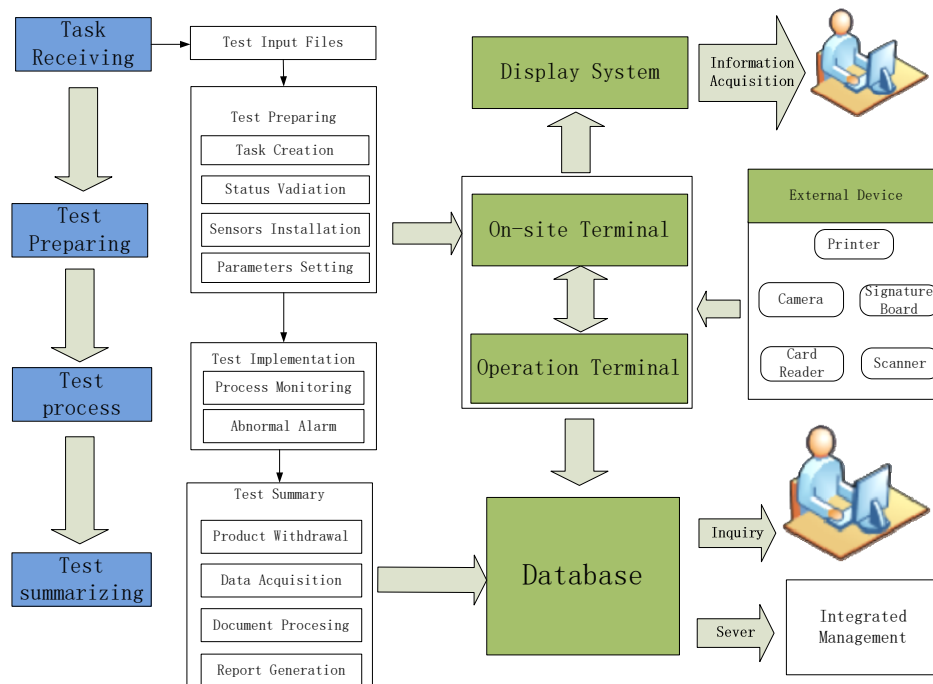


Figure 1. Function construction of the system.

2.4 System Function Composition

The server is deployed in the equipment room of the test lab. The multi-function operation terminal and the public information server terminal are deployed on the test site. The multi-function operation terminals are equipped with card readers, code scanners and cameras. Public information terminals are shown on screen monitors. All the computers on-site can get information from the server Terminal. This system has scalable features. It can be expanded to other labs with sub-servers. The sub-servers and the master server can synchronize the data automatically.

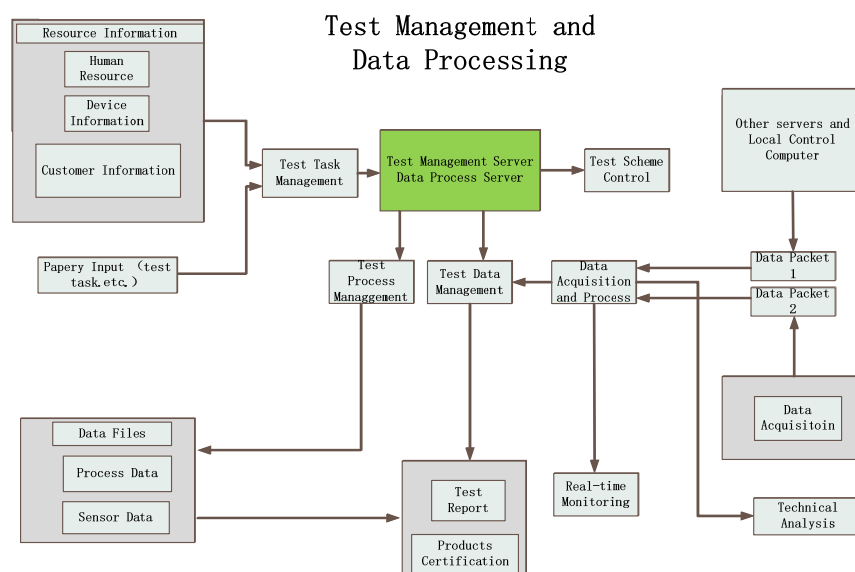


Figure 2. Function model and data flow.

2.5 System Expansibility

- a) This system has scalable features. It can be expanded to other test centers with sub-servers. The sub-servers can be easily added to the system.
- b) For the sub-server, the test equipment can be added or removed by simple configuration.

2.6 Test Process and Management

2.6.1 Test Flow Configuration. The test process contains preparing phase, implementation phase, withdrawal phase and so on. All the test status is managed by system configuration using design tools. The process can be easily adjusted when the process changes. The Configuration Interface is shown in the table below.

Table 1. Process configuration interface.

| NO. | Items | Key Point | Work Content | Work Content 2 | Key Process | Note |
|-----|-------------------|-----------|------------------------------------|---------------------|-------------|------|
| 1 | Technical File | Y | Test Task through the Review | Stamp Seal | NO | |
| 2 | Test Staff | NO | Position Statement and Description | - | NO | |
| 3 | Technical File | NO | Detailed Rules and Regulations | - | YES | |
| 4 | Technical File | NO | Test Procedures | - | NO | |
| 5 | Test Staff | NO | Operator on Duty | - | NO | |
| 6 | Technical File | NO | Operation | - | NO | |
| 7 | Device Management | NO | Measurement Conditions | Qualified, Disabled | NO | |
| 8 | Device Management | NO | Device Status | - | NO | |
| 9 | Human Resource | NO | Test Leader | Permissions | NO | |
| 10 | Technical File | NO | Quality Assurance Outline | Review condition | YES | |

2.6.2 Form Configuration. All the forms in the system can be configured using stencil. Operators just need to add or remove items referring to the template. All the forms can be exported as excel or word documents.

2.7 Test Mask Management

2.7.1 Test Mask Creation. Test assignments and test program can be generated or modified with reference to previous tests. Test assignments and test program contains the basic information of the test. For example, the test requirement, quantity of the products and the test schedule.

2.7.2 Test Mask Query. System provides several inquiry methods. Operators can retrieve a test by specimen type, test equipment, test task or test date. Displayed information contains appointment status, reservation units, task progress and so on.

2.7.3 Test Statistics. The system can perform multi-character query, supporting bar chart, pie chart, line chart drawing. Annual statistics of different tests are shown below.

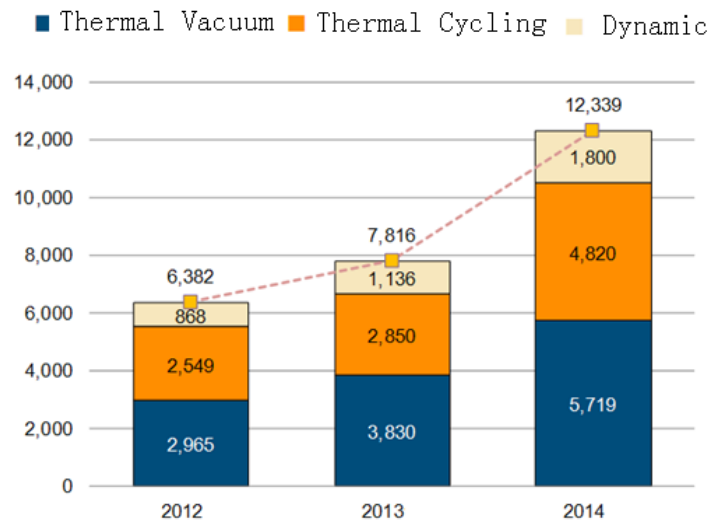


Figure 3. Annual statistical table of different tests.

2.8 Process Monitoring and Terminal Display

External devices are provided to get information or provide means for operators to perform easy operation during patrolling. These devices contain public information terminals and multi-function terminal. Test staffs can use multi-function terminal and operation terminal to record test results and sign.

2.8.1 Public Information Display Terminal. Task information and devices usage condition can be displayed by public information terminal. The monitor station can give dispatch information using voice broadcast. The test equipment usage of different sub-stations is shown in figure 4.

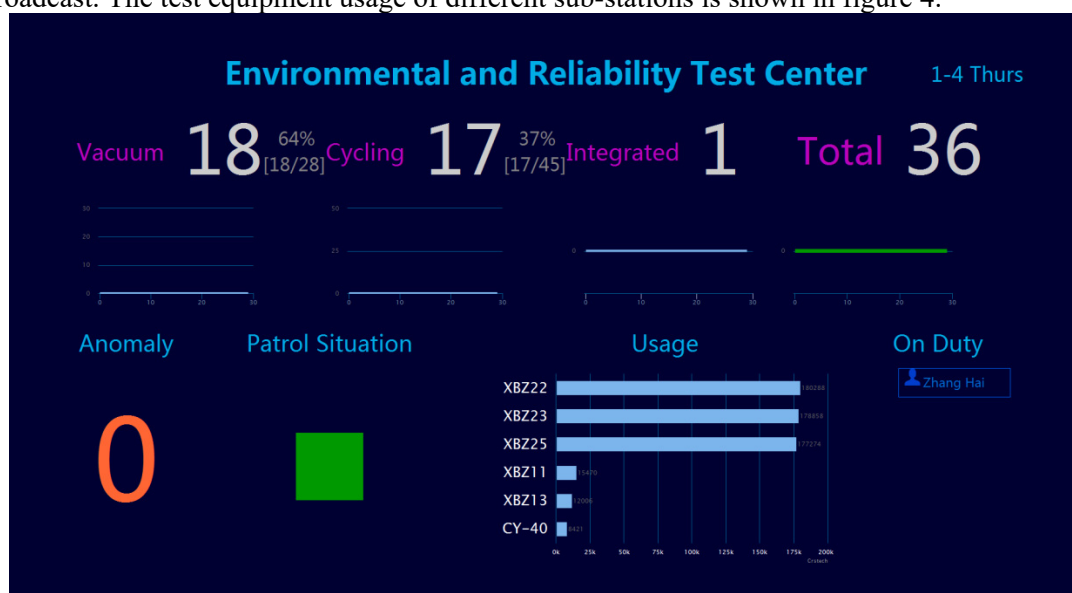


Figure 4. Device boot situation in different areas.

2.8.2 Multi-function Operation Terminal. Multi-function terminal is a platform integrated with several functions such as code scanner, image acquisition and card certification. The interface of the terminal is shown in figure 5.



Figure 5. Interface of the multi-function operation terminal.

2.8.3 Ordinary Client. Test operation computer is also used as ordinary client computer too. Most of the operation actions such as parameters modifying, procedure adjusting, can be completed using ordinary client. Test status can be checked in the client computers.

2.9 Test Data Management

2.9.1 Data Acquisition. Component-level environmental tests contain dynamic, thermal, comprehensive and climate tests. Different ways of data acquisition are used for different test types. Actually data is stored in different ways as shown in figure 6. All the data is stored in the data server.

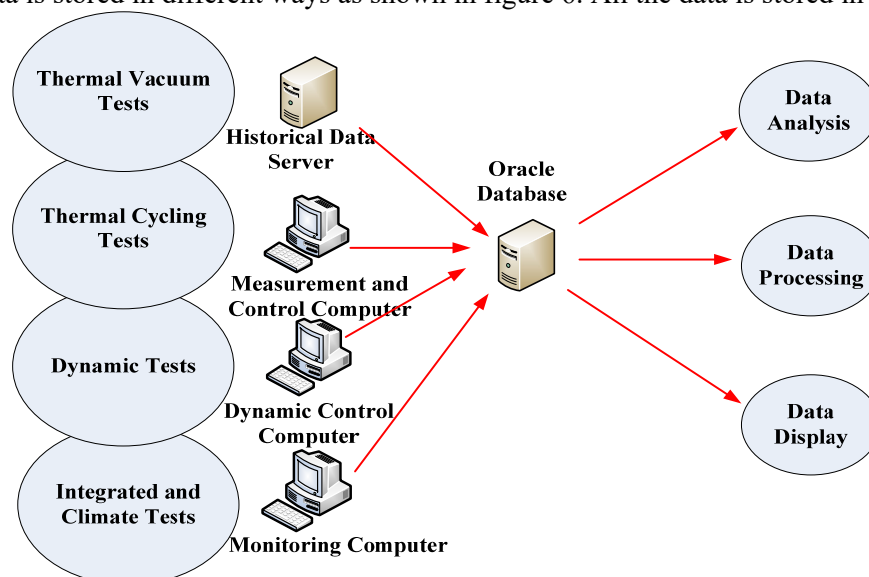


Figure 6. Different acquisition ways of the test data.

- Thermal vacuum test data acquisition and import
Test data is obtained from historical database. The database is connected to the SCADA server.
- Thermal cycling test data acquisition and import

Data for thermal cycling chambers is uploaded to the data server of the management platform. Operators can configure whether to monitor a device according to need or requirement.

➤ **Dynamic test data acquisition and import**

For dynamic tests, test data is obtained by the data acquisition device. The data is stored in the local control computer after been processed by specific software. The test data is synchronized to the database with a certain time delay.

2.9.2 Image Acquisition and Import. Cameras without storage card are connected to the multi-function operation terminals to obtain pictures of the specimen or their installation conditions. The pictures obtained can be automatically stored to the system and used for test report.

2.9.3 Data Processing and Output. The test data obtained can be used to draw different curves. The system supports time histories curve, histogram drawing, pie charting and 3D drawing functions. All the test data can be exported to specified format for later usage. The system is compatible with other processing software too.

2.10 Test Report Generation

Test report can be generated automatically and all the information or data generated in the process can be used. The report number is automatically generated too.

Two test report templates using ISO9000 and CNAS are supported currently, which can be extended later.

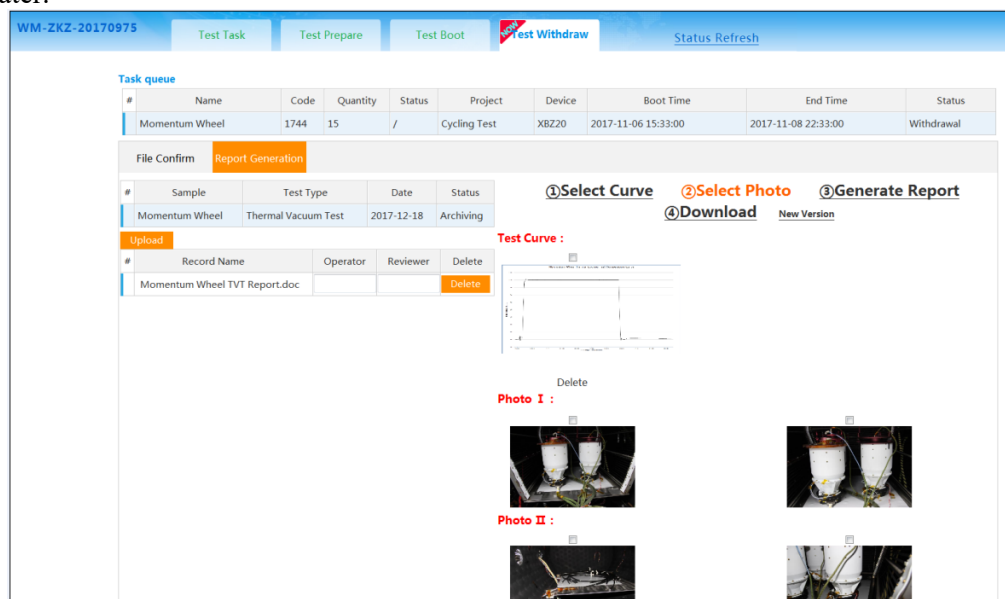


Figure 7. Interface of the test report generation.

2.11 Resources and Permissions Management

2.11.1 Test Resource Library. Test resource management contains test equipment management, fixture and tooling management, software management, staff management, specimen management, customer management, etc.

➤ **Staff and customer management**

Staff management system contains basic information and attendance information. Basic information contains the name, genders, position and telephone. Attendance information contains rotation situation of the staff. Customer management module contains the function of managing the basic information and phone number of the customers.

➤ Device management

This module contains the management of equipment ledger, calibration and measurement information, maintenance information and so on. Relevant information can be easily obtained by input keyword search.

2.11.2 Permission Management. The system can assign different permissions based on the different roles of the operators. System supports four authentication methods, credit card, bar code scanning, user name + password and signature.

2.12 Test Files Management

2.12.1 Test assignment Management. The information of the test assignment is entered by the operators. System provides several models that have similar requirements or same test items or the same products. Operators just need to input the basic information and modify test requirements.

2.12.2 Process Documents Management. System contains all forms of the third level management documents. All the documents have their numbers and bar codes. Data packages contain all the forms and the test data.

2.13 Log Management. Log management contains local log management, remote device log management, alarm log management.

3. Function Test

Test work is required when the system is completed. System test is the final ring of the management platform development. The purpose of the test is to validate the characters can satisfy the performance requirements.

Sub-system test, system test and final test are carried out in sequence during the development. There are two main methods to test software, one of them is test the character according to the performance requirements, the other is according to the scheme or specification^[6]. The later one was chosen to validate the rationality and correctness of the system. In case of any anomaly during test, developers are responsible for anomaly investigation and corrective action. However, if the anomaly is due to software logic, then the test process will be returned to former module for root cause analysis and correction.

This management system reaches its design specifications after 2 months modification and 3 months trial. Various types of operators give their recommendations in the developing process. This system is currently applied.

4. Conclusions

Space industry is the symbol of the national comprehensive strength. It can drive a series of industry development. As a key part of the development process, spacecraft environmental test is crucial to the success of the spacecraft. This system solidifies the test process, reduces the strength of the workforce, improves work efficiency and enriches the data packs of the product. It can be applied to other industry areas or test centers.

References:

- [1] Wei H Q. 2014 Discuss the technology of Java connection to Oracle database using JDBC. J. *Computer CD Software and Applications*. **7** 299.
- [2] Lu L. 2013 Using JDBC to achieve automatic weather station element information retrieval. J. *Journal of Anhui agricultural sciences*. **41** 11755.
- [3] Yang D. 2010 BS-based Hospital Information Management System Design and Implementation. J. *Computer Simulation*, **27** 342-343.

- [4] Feng W K. 2013 Development of power equipment test management system. J. *Urban construction theory research(e-edition)*. **33** 4.
- [5] Yang L L. 2013 BS-based Student Status Management System Design and Implementation. J. *Science & Technology Information*. **21** 30-31.
- [6] Wang S Q, Wu Y M and Lu M Y. 2012 An approach of software reliability accelerated testing and assessment. J. *Journal of Harbin Engineering University*. **33** 1359