Research on Management Methodology of Large Spacecraft Testing

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ABSTRACT

Focusing on feature and technical difficulties of complex task, tight development multi-vehicle coupling and difficulty in verification of difference between space and ground, and on the basis of the mature technology and experience in managing, methods of determining the state of design and products as soon as possible, arranging test plan reasonably, testing point forward, and carrying out test coverage analysis abundantly have been adopted. Based on actual work, large spacecraft test management has been proposed to make sure that development assessment goes well.

1 INTRODUCTION

Large spacecraft design has a feature of state complex, task difficult, and its structure and difficulty have leap-forward development compared with other satellite, which lead to multiple workload compared to conventional aircraft. Besides, many species and quantities of new facilities result in heavy workload, and what make development progress more haste is that the comprehensive electrical properties testing and hundreds of large trials need to be taken in the development stage.

Methodology of large spacecraft comprehensive testing researched in this paper analysis the application in determining technical state of model, optimizing process, validating comprehensive coverage, reducing the risk, in order to meet the demand of functional performance, and to complete engineering tasks with ensuring the quality of products.

2 RESEARCH ON TEST METHOD OF LARGE SPACECRAFT BOTH AT HOME AND ABROAD

By analyzing and researching on spacecraft, ground-based weapons, and vehicle testing technology, we have explored deeply on testing technology and management of large spacecraft.

2.1 The integrated authentication method of electrical system performance testing in "Columbus" cabin

"Columbus" cabin, whose development was undertaken by ESA, is used to provide outside cabin experimental capabilities for the International Space Station, and it is European's largest spacecraft in the ISS program, designing on-orbit lifetime of 10-15years.

Columbus cabin electrical system includes power supply, date processing, data routing, data storage, image, voice processing, and control system and management functions, which consists of several different nodes computers performing command and control communication via 1553B bus, and contains An Ethernet, ,what's more, almost all devices are installed in three floor system equipment cabinet which is in sealed cabin.

Columbus module has no independent energy and attitude control systems, so energy is generated and distributed by huge solar wings. There is no completed data communication system, so data downlink to the ground via the other modules of ISS. Thus, Columbus module cannot be operated autonomously.

Testing in Columbus module is divided into the following phases:

(1) Software Integration Test Environment, which is carried out in SITE, is mainly used to prepare for ETM test.

(2) Electrical Test Model, which is based on completing majority test of electrical features, and interface verification, last a long period.

(3) RLTF: Rack Level Test Facility is also part of ETM test, because RTLF ETM is based on the expansion, with an increasing in mechanical and thermal interface for fight state to support load interface acceptance test. After completion of the RLTF test, cabin integrate the load into formation state for next test, while related testing work is continued in ETM, until the space station ends its life.

(4) PFM: Proto flight Model: this test includes that equipment cabinet mounted to the hull structure, aircraft state is consistent with flight in orbit, implementing microgravity disturbance testing, electromagnetic compatibility test, mechanical testing, thermal testing and other tests in order to complete the test that cannot complete in ETM.

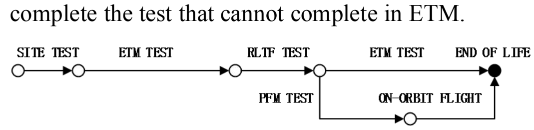

Figure 1： Basic process of Columbus cabin test

One of the key factor to success of Columbus module is effective system integration and verification testing measures in its assembly system integration test (AIT) stage. Columbus module system integration and verification testing cleverly use a test model called Electrical Test Model (ETM), a comprehensive system-level test mode composed of electrical model based of foundational platform and other replaced simulator. Using electrical test model can not only reduce test cost, but also enhance the flexible of verification work. We can upgrade according to test need to improve test efficiency. In addition, the electrical properties model test can upgrade to Rack Level Test Facility mode for subsequent stage after increasing thermal and mechanical interface for verifying effective load rack interface test. Even Columbus module has been launched into space and docked with ISS in orbit fight, this method can be applied to verify effective rack load in the following launch phase.

Based on actual test, the main advantage of ETM and RLTF is to provide all electrical function verification test environment as modular, easily configurable manner. For example, ETM is able to adapt to test needs of subsequent on-orbit technology upgrades and requirements expansion, while it supports engineering of on-orbit life cycle and fault location. What's more, ETM can assist the electrical verification and test for on ground supporting system EGSE of Columbus module, and supply assistance for development of on-ground supporting system (GSE) during runtime of Columbus module.

2.2 ATV Verification Test

Automated Transfer Vehicle (ATV), a spacecraft developed by European Space Agency, is used to supply logistics Services for ISS. ATV can achieve delivering goods, removing and destructing waste, lifting space station orbit and adjusting attitude with a cargo capacity of 7.667 tons.

Due to the complexity of ATV, a design pattern based on incremental development and model is adopted, so as modular design and modular test, that is, each module is designed, developed and verified separately.

To achieve ATV test verification, multiple specialized test beds for verification is designed, including Real-Time ATV Test Facility and ATV Simulator, to support verification and test mission. Adopting this technology, ATV has high a flexible and reusable ability for cross platform design, making it reliable for design verification and test work.

For different test validation purpose, multiple test bed for ATV is developed, mainly including the following categories:

(1) Functional Simulation Facility (FSF)

This is the most complicated test bed which is used to verify function of ATV, and it use real device or simulation device.

(2) Software Validation Facility-Qualification (SVF-Q) :

SVF-Q adopts real monitoring and safety unit, and coordinate simulation equipment for testing.

(3) Software Validation Facility to validate the Flight Application Software (SVFFAS)

In this platform, real Data Processing Unit (DPU) and multi-level 1553B bus control device is used, while other devices adopt simulator to replace.

(4) Software Validation Facility Light (SVF Light)

It is a simplified flight software verification platform, that is Data Processing Unit (DPU) and multi-level 1553B bus control device adopt simulator.

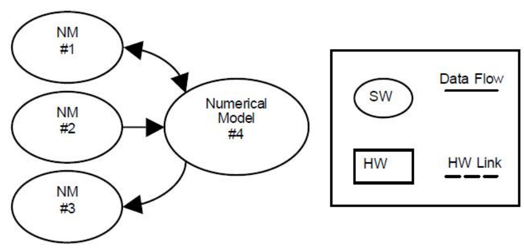

Figure 2： Mathematical Model

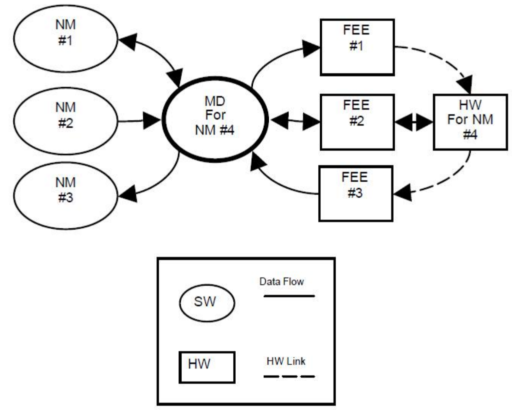

Figure 3： Hybrid model and architecture model composed of mathematical model and real hardware model

(5) Interface Validation Facility-Moscow (IVF-M) and Interface Validation Facility-European Proximity Operation Simulator (IVF-EPOS)

These are used for verifying the interface between the ISS and ATV (including European and Russia cabin).

Above platforms completely support Hardware In the Loop. Tested real hardware devices link to Front End Simulation Equipment (TEE) imitating real devices, which is used to simulate and monitor electrical characteristics with an ability of electrical safety protection.

Because ATV adopts advanced design ideas, uses common hardware with a high degree, and relies on different software for various functions, verification test of ATV aims at mathematical model (including hybrid model) first to confirm design reasonability and accomplish system-level debugging of software on this basis, after that, increment verification test gradually develop and interface test between systems in ISS, with development progress going on, until all test are completed.

2.3 Automobile test

Comprehensive test of cars aim at performance test before new model put into operation to determine whether this model has the conditions to product, and it is similar to the current test of AIT for spacecraft. After putting into mass production, detection of cars belongs to maintenance aspects of the test, which is similar to self-test of spacecraft in orbit.

Electrical test of cars mainly focus on controllers, networks and vehicle electrical system in the car, wherein the controller corresponds to the stand-alone product in spacecraft, and network corresponds to information system (bus and various interfaces) in spacecraft. Besides, vehicle electrical systems including controller and network make up the complete car electrical system, and its integrity test is similar to matching and mold testing between subsystems in spacecraft.

Automotive electrical system test includes the following major components: bread board test, bench test, racing car test, operational test, the quiescent current test. What is more important and has high correlation with spacecraft is bread board test, bench test.

(1) Bread board test.

Despite the signal for senor and control between each controller in automotive electrical system, a variety of digital information are linked by bus connection, and a variety of bus systems are used depending on application requirements. Information interaction between different bus systems is achieved through a bridge-like mechanism to form a complete unified vehicle-mounted bus system.

Due to extensive use of the bus, automotive electrical test specially designs a “bread board test” project to verify the bus protocol.

Breadboard test focus on bus communication protocol between each controller, especially on software correlative with protocol without considering electrical characteristics between each interface. Only controllers attached to bus can be tested during verification, then devices bus interface is connected to form a complete bus network system. To cooperate with bus system, an external simulator is needed, for example: the car door signal simulator and actuator status indication signal simulator to simulate some important signal of the vehicle and meet the implementing network protocol operating conditions, these simulators only output related signals without adopting real product, just as simulators or equivalent device during spacecraft test.

If a tooling making it easy to install and connect bus is adopted during the breadboard test, controllers can be adjusted to any places where it is easy to link network and signal simulator, and bus cable connection is also easy to adjust and to access various kinds test equipment bus. As tooling is similar to a large breadboard plate, its name is “breadboard test”.

If real product cannot be prepared abundantly during breadboard test, related product can be adopted to replace that.

The terminal result of breadboard test will determine the software associated with bus communication protocol.

(2) Bench test

Bench test is a various of complete system test connecting all electrical system related product, it mainly test matching property between electrical interface and actuator. Bench test in First Automobile of ChangChun adopt 2 types of bench: simulation bench and real bench. Simulation bench which achieve cache link by wiring closet adopt the frame approximate to real car, and each controller’s install position is close to real position. Real bench adopt mechanical structure the same as vehicle, similar to situation of spacecraft AIT test.

Advantage of simulation bench is that it is easy to debug, but simulation’s reality in detail is interior to real bench. Test state of real bench is close to final state, but it is not easy to debug.

The final result of bench test will determine the software and hardware version of the vehicle electrical system, then, this version will become the actual production version after operational test and racing test.

2.3 Manned spacecraft united test

Previous manned spacecraft united test is divided into two phase: the desktop united test and aircraft test. Firstly, after collecting subsystem electrical devices, link cache, and on-ground test system, electrical devices are installed in the mental frame in desktop condition, and integration test is done after matching commission between cabin system and on-ground system. While electrical test is completed, devices can be installed on the cabin to do the integrating electrical test after improving and changing, if device is moved. The basic test process is shown in figure 4.

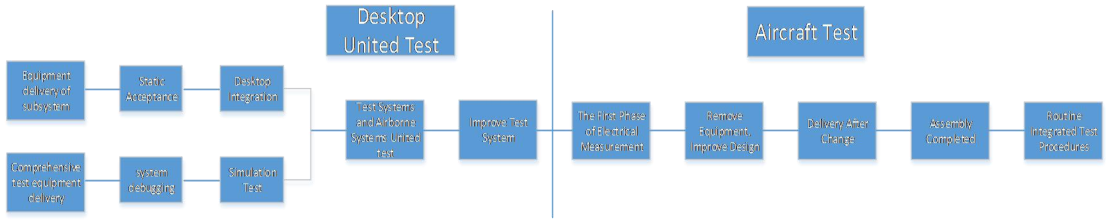

Figure 4： Flow diagram of manned spacecraft development technology

2.4 Test conclusion and enlightenment at home and abroad

(1) Pay full attention to software test, adopt increment mode to do the conduct modular test organizational mode in different stages, finish communication protocol and interface matching test in advance before assembly integration test to reduce the difficulty of subsequent stages test and to adapt the situation that tested equipment is prepared successively. So engineer can use simulation technology to replace equipment which is not prepared well to move test point forward.

(2) The current spacecraft adopts a lot of software and bus based mechanisms, leading to the a majority of software and communications protocol problems, and gradually reducing hardware problems, which put forward higher requirements for the test software and communication, so such tests are easy to achieve putting test center forward by means of simulation to conduct system integration test mode.

(3) The reason why desktop united test in previous manned aerospace engineering has a low efficiency is that not this test mode is unreasonable, but the object adopts abundant dedicated special interface due to limitation of traditional technology, and lacking perfect simulation method expand influence of this negative factor. With development of design technology, and support capability of on-ground simulation, these problems can be solved effectively.

3 MANAGEMENT THOUGHT OF NEW TYPE LARGE SPACECRAFT TEST.

Purpose of large spacecraft test: verifying the rationality and efficiency of overall aircraft, sub-systems and single product and determining technology state of spacecraft lay the foundations for launching spacecraft in orbit.

Previous spacecraft test conduct system-level test after completing vehicle assembly, and the process is developed in single product development, single product acceptance, general assembly of aircraft, system-level test. But for complicated designed large spacecraft, it has a number of single products, a long period of development, acceptance and assembly with relationship complicated and coupling tight, thus, any minor defects are likely to cause a chain reaction affecting the overall progress, so traditional test process and organizational management have a low efficiency, unable to meet the mission requirements.

To solve this problem, we need to optimize the test management mode, adopting way of putting test point forward, that is : carrying out verification test simultaneously during design and development stage, improving design by test iterative feedback, completing technology state before spacecraft assemble. This mode can decoupling test work and assemble work, making it possible to do that separately, so not only are efficiency and progress enhanced, but also problems can be found and solved as early as possible to obtain more time optimizing system-level design and to reduce technique risk and progress risk. Large spacecraft has a feature of various types, large quantity, tight coupling, so once quality problem is found, product need to be designed repeatedly as well as leading to an increase of cost. Thus, the earlier problem can be solved, the smaller the cost and risk is.

Ideological core of large Spacecraft test method are: putting test point forward and begin test work during design and development process make it early to determine state of electrical product; compressing the test process, arrange test project reasonably, optimizing test process and reducing composite test time of spacecraft with the condition of completing test project in the technique process, and including aircraft used in space; finding problem early to save the cost of test. Thus, the large spacecraft implement “three step” test method, that is: “core network test”, “system integration test”, “aircraft grade comprehensive test”. Completing the test and related tasks gradually, we can accumulate experience and data for on-orbit support.

(1) Core network test: during the design period, using shelf to test system-level product between

subsystems and determining design state of product draws the concept of breadboard test in the automobile test. Introducing core network test during design period may have possible in exposing and solving complicated technique problem, and master advanced test methods to lay foundation of following work.

(2) System integration test: before delivering vehicle to assemble, system level test is conducted using test platform to determine baseline of product. Drawing the concept of ETM and RLTF in ISS Columbus cabin, and concept of ATV, FSF, SVF-Q, SVF Light, IVF-M, IVF-EPOS, layout of test platform simulation cabin is adopted to put forward test point, executing aircraft class integrated test processes and management mode. When verifying each security conditions in advance, correctness of single product software and hardware need to be examined fully to determine product baseline in advance.

(3) Aircraft grade comprehensive test: after assembly work is completed, a comprehensive verification for vehicle with mechanical, electrical, thermal interface are done, completely validating functions and tasks of aircraft grade with drawing concept of PFM and bench test in automobile test. After the aircraft assembly work is completed, all aspects of the test are carried out over the system level, while arranging launch of occasions to practice, EMC test, noise, maintenance, large system interface test to complete aircraft grade comprehensive test for functions and tasks.

debugging.

The occasion for carrying out core network test: design stage before the electrical properties product deliver to acceptance. That is, for large spacecraft, newly designed "high-speed, multi-network" complex information system make full use of advanced testing techniques and digital simulation technologies for core network test in advance, which is helpful for solving complicated technique problem during design stage, exposing design problem early to determinate state of techniques, mastering advanced test methods, and laying a good foundation for the subsequent stages of test.

(1) United test scheme

Large Spacecraft information system includes four functional subsystems: communications system between spacecraft and ground, engineering network management, communication networks, load test network.

communications system of spacecraft and earth: with support of space-based repeater satellite, ground-based monitoring stations and sea-based monitoring ship, these functions are completed: trajectory track measurement, remote telemetry, communications repeater, high-speed data transmission, image communication, voice communication and other functions.

Engineering network management: combination platform device and load device achieve telemetry, command and mode control relying on layered bus and computer attached to each layer bus.

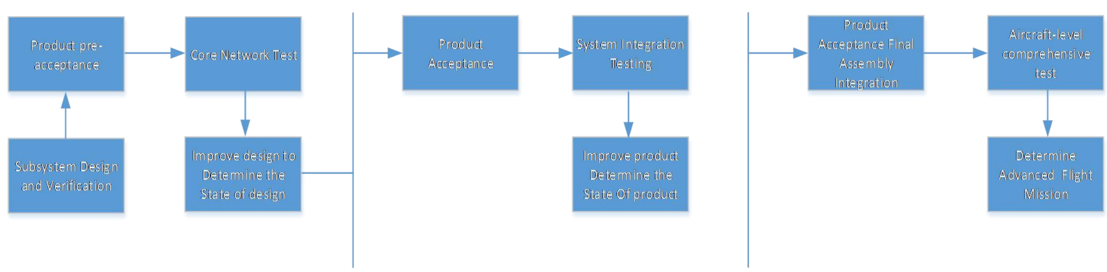

Figure 5：　Large Spacecraft test schedule

4　AIRCRAFT TEST SCHEDULE

4.1 Core network test

Large Spacecraft adopts unified information system, new electrical product have different progress, especially in cabin production, because of its huge processing capacity, and long development period, and large devices and simulator's complicated verification problem, long period of on-ground automated test device's software development and

Communication network: relying on high-speed interconnected communications network achieves image, voice, instrument display, mobile information services.

Load test network: relying on engineering management network and management computer achieve operation of remote telemetry, command and inputting data; data transmission, data storage, and downlink management functions are acquired for load test by optical cable.

Core network test items includes communications interface test between spacecraft and ground, engineering management network interface matching test, communication network interface matching test, load test network interface matching test, and each type of test can be decomposed into a special united trial test depending on different test purpose. To maximize the information systems integration test, project manage network and radio frequency link test at the same time, so as the united test of high-speed network and corresponding high-speed radio link. Then, two test projects integrate to entire information systems to carry out integration test and commissioning work.

(2) Test method and effect

Before product delivery to spacecraft-level test, "pre-acceptance" management is adopted to control technique state of software and hardware in electrical product. Bench form is adopted to place participant product for united test with using existing laboratory resources; subsystem is required to have charging equipment itself, test device on ground, internal cables in subsystem and cables between subsystem adopt aircraft cable to reduce cost; to ensure the united test smoothly, test need to be done with the difficulty increasing, that is: Ethernet testing, project management network testing and dynamic testing.

Before the aircraft level test, arranging the core network test allows users to communicate with the designers in advance to confirm the state of design, validating the design and realization of communication protocol effectively, especially for research of new Ethernet and wireless networks, and multiple redundant bus network, carrying out full load test to ensure hardware stable, software robust and protocol correct; For the interface between subsystems, through the core network test, we can fully verify the matching of electrical interface between subsystems. By test coverage analysis, we can avoid different designers in different units having understanding differences which lead to design defects. Proposing dynamic united test project can finish the design verification of flight module; adopting shelf form, subsystem supply cable and mating on-ground devices, which effectively alleviate development progress pressure in huge work load of cabin design and manufacture, huge difficulty in solving large device and complicated test function for automated device software.

4.2 Integrated system test

Core network test mainly use subdivision equipment of the subsystems and prosecutors equipment to test on the information interface and information protocol of the subsystem, not testing on the internal subsystems, cannot override the verification on system-level features and performance indexes. Before the test of the aircraft AIT, in order to determine as soon as possible the technical state between the subsystems, aircraft-class, aircraft and other features and interface design of large-scale systems, has arranged for a system integration testing, verified the electrical function's properly and rationality of system-level in advance, verified the key performance indicators of system-level to meet the situation, compressed the functional testing time of AIT stage system, enhance the verification to AIT stage of simulation flight testing and fault disposal function.

The timing to carry out the integration testing of system is: after completing development and acceptance checking on the electrical properties of the product. Through the integration testing of system, can early detect the matching problem on the electrical properties design of system-level, before the final assembly should mainly focus on solving the design correctness and reasonableness of stand-alone product's hardware or software, fully assess of product performance, Meanwhile, make use of the test platform which approximate aircraft's layout, the environment of electromagnetic compatibility for the aircraft can be effectively simulated, early make sure of the product status.

(1) United test scheme

To complete the validation requirements of system integration testing, aircraft overall use a test platform to make assessment for electrical performance, use advanced automated testing means to comprehensively verify the correctness of every electrical function design performance for the aircraft, On the one hand, though the assessment test to verify system-level functionality and performance and the matching of every product's electrical interface on the cabin, the other hand, verify in advance to test the matching of AIT ground test support systems with the aircraft.

The project of system integration testing includes: system functional testing, simulation flight testing, the testing of aircraft's interface, and the testing of large system's interface.

System functional testing: mainly verify the correctness of systems functionality and performance design for the aircraft.

Simulation flight testing: comprehensively inspect of the aircraft's dynamic performance, check the coordination about various subsystems equipment software, hardware and ground equipment hardware and software work ,and check the correctness of program's arrangement, inspect the coordination of flight procedures, verify the correctness of normal flight procedures and emergency flight procedures.

The testing of aircraft's interface: make use of the aircraft simulator, to complete the simulation tests on the electrical properties of the interface with other docking aircraft.

The testing of large system's interface: verify the correctness and matching to the electrical interface between large systems.

The real products and cable of system integration test using devices, fixed up on the test platform, make use of the test system with four-layer structure, associated with the digital model and simulator and equivalent unit, comprehensively make system-level verification tests on the electrical properties of aircraft.

(2) Test method and results

In accordance with aircraft grade comprehensive test management methods to be strictly manage the system integration testing, using real power distribution system and the ground test system, fully verify the functionality and performance of aircraft electronic systems; To complete the validation testing of software, go into the controlled library to delivery, ensure that the software state version to be unique, and comprehensively test; Make use of the test platform which approximate the cabin layout to put the equipment, and use the cabin cable and ground integrated test system; According to the process of aircraft testing technology, design the project about system functional testing, simulation flight testing, the testing of aircraft's interface, and the testing of large system's interface, comprehensively verify the designs on the aircraft about electrical properties of the interface, hardware and software, cable network and flight mode.

In the system integration testing that can use the method "real equipment and simulator" to verify the electrical interface of large equipment, meanwhile simulate the flight work in orbit, ensure the coverage of test; Use the AIT management of aircraft, be able to verify the interface coordinating relations in advance about testing team, machinery and equipment, integrated test equipment, space environment, relevant design input and rules and regulations and other guarantee conditions, covering the aircraft's AIT process; Using the solutions of test platform, can maximize and be the most real to approach the aircraft testing, simulate the environment of electromagnetic compatibility, fully use the cabin cable, ground equipment and other ancillary products of AIT, early making sure the baseline of production. Reasonably make arrangements for system integration testing project, proposed about checking the power supply, the system functional testing, the simulate flight testing, aircrafts testing, and large systems testing, Throughout the integrated testing process part of the projects are no longer to arrange, for example, checking the power supply, the interface matching test between the subsystems and special testing of subsystems, the testing process of optimizing aircraft.

4.3 Aircraft comprehensive test

Aircraft comprehensive test include two stages—soft connection and rigid connection. According to technique flow of the positive sample test, every stages are strictly arrange test tasks, verify the correctness and rationality of various design fully; arrange launch of occasions, comprehensive coverage entire test procedure of positive launch pods in launching site, guarantee test coverage.

Aircraft comprehensive test need to be carried out after the aircraft final assembly completed. Its purpose is, on the basis of the core network testing and system integration testing on the aircraft to conduct a comprehensive mechanical, electrical, thermal design validation and product technical state inspection, examination and aircraft overall performance, determine aircraft overall mission and technical state baseline for future positive samples and lay a solid foundation in orbit.

(1) testing program

Aircraft electrical performance test focus on system-level testing, through enhancing advance, cancel subsystem function test in system-level electrical performance testing, compress matching test between subsystems to compress the testing time. Ground test detection system of aircraft increase the allocation of aircraft simulator to verify function fusion design between spacecraft in advance.

a. Electrical performance test program

After completion of aircraft assembly, test the soft connection state between sealed capsule and unsealed capsule, verify the correction of functional design and subsystem interface design. After the soft connection test is completed, dock the sealed capsule and unsealed capsule, complete comprehensive test of aircraft rigid connection and verify the large system interface design.

b. Aircraft testing

Simulate the electrical interface and characteristics of other aircraft by an aircraft simulator , test the power supply interface, network switch, network interfaces and flight scheduling.

c. Large Aircraft experiment

Aircraft in EMC test status is rigidly connected state, after a single vehicle EMC test finished, arrange the simulator in the EMC laboratory to simulate the electromagnetic characteristics of the docking aircraft and conduct aircraft assembly EMC test, electromagnetic compatibility test between aircraft. Meanwhile, in the process of aircraft soft connection and rigid connection during testing, reasonable arrange medicine, ergonomics, microorganisms, noise, maintenance, verification and other special tests.

d. Experiment between large system

Through astronaut system interface validating mechanical, heat, gas, electricity, communication interface; through space application system interface validating working load control, data transmission and functions to achieve; through delivery systems interface validating outgoing power section, test data transmission path .Through launch system interface verification testing data signal interface and testing processes correctness; and monitoring and controlling communication system interface to validate world data transmission path.

(2) Test method and results

Manned Ground Test System inherits the second phase [9] and the successful experience of other satellite models, full use of advanced technology to mature and versatile equipment for the foundation to achieve optimal configuration; use common equipment and a small amount of special equipment to make up the system to ensure resources optimal; improve the overall level of automated testing system, reducing manual operations, reduce the possibility of false negatives, false judge and other errors; modular design, reduce hardware types, improve equipment interchangeability; system architecture design consider extendibility to adapt to technical updates; introduction of fault diagnosis technology, put the result of the automatically interpret system as the input of fault diagnosis, combining with the knowledge of subsystem testing model and professional experts in the field, automatically initial locate and analyze the fault diagnosis, and assisted trouble shooting work.

According to the process of positive comprehensive test, testing strictly can verify the feasibility and rationality of the process, overall inspect of the security conditions and the implementation of the situation , to ensure full test coverage; molding flight test arrange items according to flight on orbit, specially the test of failure mode flight test, cover of in-orbit conditions roundly, validate of aircraft system level tasks.

5 DISCUSSION AND ANALYSIS

Manned spacecraft accomplishs as a representative of the large-scale spacecraft, the lack of pre-test mainly due to: Only after substantially complete the electrical equipment can you begin testing, because of the distinctive on device schedule, it's not conducive to joint testing work; It's necessary to remove the equipment once problems found, if problems occurs on the crucial control computer or network core managerial computer, the order and telemetric functions will be missing, and the testing process will stop, therefore it can not be applied on the situation of the large –scale and complex spacecraft when their elementary stage products immature in terms of hardware and software design. After the completion of the previous phase of the desktop testing, all products need to be removed to install on electrical cabins, testing process is terminated, the dynamic joint testing work lacks, the product baseline and aircraft technical program and state are not fully determined, the subsequent assembly and integration tests still need to duplicate, and it's inefficient; There exist numerous special dedicated interfaces of the tested products, but it's short of the means for simulation when aimed to this situation, it result in that real products must be adopted to achieve testing, a few unsuccessful products format the chain reaction and leads to test schedule be discontinued; There exists a larger difference between the test platform structure and layout of desktop and the actual design for aircraft, it's difficult to do fixing and installing of stand-alone, paving of cable, plugging of connector, and can't simulate the environment of aircraft electromagnetic compatibility, when under the case of plenty of testing equipment, problem identification and localization of specific stand-alone will be extremely difficult.

This paper proposes some test method of the large spacecraft which references for the test program about abroad aerospace, defense, industrial, international space station and other large aerospace projects, leading into the center of gravity forward test, modular test, the incremental test, the test bed mode, simulation technology and other advanced testing concept and technology and successful experience, when there exists an effective solution to the insignificance of past manned spacecraft testing capability, it contributes to track testing in the field of cutting-edge technology development, then renew and complete test mode, it can increase testing capacity and level of domestic spacecraft, to improve test efficiency and effectiveness, improve the ability of multi-spacecraft's synchronization testing and rapid testing. "Three-step" test method has good flexibility, customizability, reusability, their equipment and technology can be used for design verification and testing work of aerospace engineering in future, lay the foundation for spacecraft to deal with complex design verification and testing work and the development and production of high-density and emission in future, and may be popularized to other spacecraft models, enhance the aerospace capacity. At the same time, reasonable arrangements for the "three-step" test plans, significantly save the design, time, and other cost of resources, comprehensively enhance the developing efficiency.

6 CONCLUSION AND PROSPECT

Faced with many difficulties and risks like the new design condition, the complex relationship between the interface, the tight product schedule and the difference of world's verification, relying on the test experience about satellites and manned space flight, draw domestic and foreign testing technology and management concepts, through the study of large spacecraft test management methods, proposed the three-step strategy including "core network test", "System Integration Testing" and "aircraft grade comprehensive test," making the test center of gravity forward, letting the design and test iterations, gradually established a design baseline, product baseline and system-level tasks baseline, ensure comprehensively verify the state of aircraft, pragmatic the testing coverage. Later, it need to strive to enhance the level of digital design and simulation, vigorously develop digital spacecraft, in the premise of ensuring the quality of the model , reduce the costs of design and verification, model mission a complete success.

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