Research on Space Launch Information Integration

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Abstract. The key directions for the automation, intelligence and integrated development of space launch have been very clear. Within the scope of C3I systems, professional automation system, ground handling system, research is conducted on the overall technical architecture of the space launch information integration, including: (1) Research on technical specifications system to promote the systematization and consistency for technical specifications at each level of access, transmission, processing and application; (2) Research on system functional architecture, highlighting the unified terminal access, unified transmission carrying, unified basic application and unified information interaction; (3) In view of the future development direction of space launch informatization, research will be carried out on relevant information guarantee technologies for remote command operation, automatic detection and diagnosis, wireless object connection and unattended launch tower.

1. Introduction
In recent years, space launch is becoming more and more heavy, showing the characteristics of high launch density, more parallel missions, new security demand and great technical risk. In order to meet the crucial mission situation for space launch, we need study the method of construction of space launch informatization to improve the launch command efficiency and professional technical support level, and enhance the ability to carry out space launch missions in the new period.

Space launch informatization[1] is to use advanced information technology means to realize automatic acquisition, network transmission, intelligent processing and comprehensive application of key information in the core system of space launch, so as to provide information support for responding to various demands in the process of space launch timely. The purpose is to use information means to improve the efficiency of space launch. Due to the lack of integrated top-level design ideas, with the continuous progress of information construction, it was inevitable to produce many isolated and independent "chimney" systems. In order to integrate multi-source heterogeneous information resources by these systems, it's going to reduce the overall cost-effectiveness ratio of space launch, concrete manifestation in: (1) It cannot provide sufficient and valuable data sample support for assistant decision making, so the evaluation model and results are not convincing; (2) There is information asymmetry from the command and decision level to the operation and execution level, which is not conducive to the front and rear linkage and seriously restrict the execution of command operation; (3) Problems such as decentralized information application technology, insufficient financial support and repeated construction cause a great waste of resources, and the tight coupling between information processing application and C3I system is not conducive to information transformation; (4) The existing C3I sys-
tems are independent and difficult to adapt to multi-mission parallelism. In order to solve the above problems, the integrated experiment information system has been built, the C3I system has been re-formed, the digitization of ground handling facilities and equipment and the monitoring capability of ground handling system have been improved, and the launch spot remote technical support model has been established, however, due to the lack of necessary in-depth systematic research on theories, methods, technologies, platforms and other aspects, it was difficult to solve the problems of cross-regional and cross-system information sharing and fusion from the top, the overall situation and the long-term perspective, and the contradictions were still very prominent. In this context, the concept of space launch information integration is proposed, and it is expounded from the three aspects of concept connotation[2], technical approach and measure suggestions of launch information integration construction.

2. The Concept and Connotation

2.1 Basic concepts
Launch information integration refers to the creation of unified information technology support platforms at all levels of the functional architecture under a consistent information architecture standard system, to realize unified terminal access, unified transmission carrying capacity, unified basic application and unified information interaction for space launch mass information. Through intelligent information service means, the space launch mode will be innovated, the change of command decision will be guided, and the transformation of the space launch command system will be accelerated.

2.2 The connotation

2.2.1 Consistency standard system
In accordance with the long-term sustainable development goals and the internal links between rocket system, launch spot system, launch process, and command and control, promotes the systematization and uniformity of technical specifications for information access, transmission, processing and application at all levels, and constrains information formats, types, protocols and interfaces.

2.2.2 Integrated system architecture
Space launch information integration adopts the "four horizontal and two vertical" system architecture for unified planning, as shown in the figure 1.

Fig.1 System Architecture

(1) Information access layer. Telemetry and remote sensing, radio frequency identification, intelligent sensor and other technical means are adopted to identify, locate and collect various elements of
the launch, obtain relevant data of space launch mission, and then achieve data access through broadband access network connection. Broadband access mainly includes wired access methods such as LAN and optical fiber, as well as wireless access methods such as satellite communication, digital cluster network and special wireless communication based on VPN. The whole system shall realize unified terminal access, and the access interface shall be unique: (a) For the application of the Internet of things, a unified terminal access platform shall be built to support various communication devices and communication protocols, and then it shall be connected with the information system through TCP/IP protocol. (b) For the subsystem equipment of ground handling specialty, such as pendulum rod, air conditioning, filling, etc., information acquisition is mainly completed by PLC, which connects with ground handling network through TCP/IP protocol. The power distribution subsystem realizes information acquisition through power quality monitoring system and connects with ground handling network through TCP/IP protocol. Because the internal interface of the professional automatic control equipment is not open, the unified access is realized at the level of the professional subsystem. (c) Data such as launch, measurement control, communication, and meteorological are mainly obtained through the interaction between the C3I interface microcomputer and the external information system. Therefore, unified access is realized at the professional system level.

(2) Information transmission layer. Adopting next generation Internet technology[3] based on unified interface standards and IP system, a unified transmission carrying platform with large capacity, flexible dynamic network scheduling and refined traffic allocation, supporting the interconnection of everything and highly intelligent characteristics is built to realize the integrated transmission and the interconnection and interoperation among various systems[4,5]. The communication network is responsible for the business load of a system across the launch spots, inside the launch spot respectively. According to business, it is divided into experiment mission network, C3I network, ground handling network, where experiment mission network is mainly used for inter-district data exchange and inner launch, measurement control, communication, meteorological data exchange between systems, C3I network is mainly used for launch command monitoring system internal data transfer, and ground handling network is mainly used for ground handling subsystem equipment connection, status information and control instructions transfer, etc.

(3) Information processing layer. Build a unified basic application platform, based on SOA, big data, artificial intelligence, visualization and virtual reality technology, for realizing the information collection, management, monitoring, authorization and distribution, analysis and pretreatment, providing a unified view of data and data analysis service, and implementing open sharing, on-demand access to resources.

(4) Information application layer. Build a unified information interaction platform with command display, professional support and video conferencing functions and the real-time, networked, intelligent, visual information interaction mode. Through highly integrated, fully Shared and efficient flow of information, realizes new capabilities of the command decision-making with rapid migration, flexible reconstruction, systematic disaster recovery and destruction resistance and system rapid construction. It will full play to the advantages of remote expert technology diagnosis, and improve the capability of cross-mission parallel command and the ground facilities and equipment comprehensive support.

Command display is refers to the realization of consistent display of C3I information, ground handling information, ascent measurement control information, mission image information and command dispatch information during space launch missions, including the main display content, layout structure, display style, operation mode, term definition and other aspects of consistency, to provide basic information about each system to command decision makers and technical experts, and support remote personnel to work together.

Video consultation refers to construct the video consultation system between mission participants, through communication and consultation functions such as remote command decision, technical support, filling review, for effectively improving work efficiency.
Professional support refers to take digital construction as the center for carrying out space launch mission support, mission life cycle digital experiment, the realization of the ground equipment on-line comprehensive guarantee decision-making technical support, and equipment life cycle management, and providing information services on demand.

2.2.3 Integrated functional system
(1) Establish a distributed information service center, construct the 1 + N distributed information management mode, responsible for the maintenance and management of data, design a unified data dictionary and shared data model, establish algorithms library and model library which are needs of the uniform data represent, construct a global data view, provide WEB based retrieval and data sharing service, maintenance resources and address mapping relations, locate the required data, and provide data access service.

(2) Establish a centralized information center, build launch information theory system, carry out key technology research on the mission planning, data processing and experiment analysis, fault diagnosis, facilities equipment comprehensive support, risk analysis and quality control, mission process management, digital experiment support, construct of large computational simulation environment, promote the transformation of technical achievements in the application of launch information, construct professional guarantee and multi-level decision support platform with multiple participation, and provide external information application services.

(3) Build a distributed launch command monitoring system to support the joint experiments between launch spots[6], through the effective combination with the information center and the information application center, give full play to the center’s information fusion and analysis and processing capabilities, realize the wisdom and transience of transforming data into decision-making, and simplify the organization of command personnel.

2.3 Development direction
The key directions of the subsequent development of rockets and launch spots include remote command operation, automatic detection and diagnosis, wireless connection of things and unattended tower. The remote command operation needs to provide the rear personnel with real-time and comprehensive mission information to realize the whole process, full latitude technical cooperation linkage of front and rear. Unattended tower means to change the product interface design, simplify the launch process, replace manual operation by automatic means, and replace manual inspection by remote monitoring, so as to realize the unmanned status on the launch tower during the filling, testing and launching phase. Automatic detection and diagnosis refers to automatic detection and identification of fault characteristics and development trend, real-time diagnosis of abnormal conditions and safety assessment, through intelligent perception, identification, positioning, tracking and mining of the status characteristics of products, facilities and equipments[1,7]. Wireless connection of things refers to the connection of rocket, facilities, equipment, personnel for information interaction on demand and automatic control, so as to realize the goals of casual access, intelligent identification and on-demand information distribution

3. Technical Approaches

3.1 Information standard technology
Research and establish unified information architecture standards, constantly promote information acquisition, information transmission, information processing, information application standards and specifications, to achieve cross-system integration and information sharing. (1) Information acquisition standard specifications include information interface, acquisition method, data type, data format and other contents; (2) Information transmission standard specifications include information IP group packet, network transmission protocol, data format, interaction protocol and other contents; (3) Infor-
information processing standard specifications include data storage and management, information interaction, protocol transformation, rule base, model base, data warehouse, etc.

3.2 Internet of things technology
Construct the three-layer Internet of Things architecture[8] for terminal devices to realize low-cost and low-risk connectivity of a large number of widely distributed launch spot facilities and equipments. Three layer architecture includes equipment, forwarding and convergence layer. The equipment layer mainly includes the mass terminal equipments in the edge area of the Internet of Things, which are divided into two categories: (1) For terminal devices with high reliability, real time and bandwidth requirements, such as video monitoring system, need to direct connect to the Internet via TCP/IP protocol; (2) For the terminal equipment with low speed, lossy and intermittent connection characteristics, the Internet of Things protocol is used to communicate with the forwarding layer nodes through simple modulation, transmission and reception technologies, as well as open space optical communication links, etc. The forwarding layer implements the networking of terminal devices through the Internet of Things protocol, performs necessary clipping, transformation and encapsulation of the business data flow of the Internet of Things, and implements Internet forwarding through IP protocol. The convergence layer provides mass data flow analysis, terminal equipment configuration and Internet of Things management functions. Through the publish/subscribe model, we can extract the needed information from huge amounts of data, establish corresponding scene model, carry out real-time monitoring and evaluation, and terminal control. For example, by subscribing to data from temperature and humidity sensors, gas concentration sensors, fire alarms, and rocket critical parts cameras in the large enclosed area of the launch tower during the mission, we can understand the safety status of the refueling and launching stage of the tower comprehensively.

3.3 Transmission carrying technology
According to communication 4.0 network design[5], study and promote the deep integration of network function virtualization and software definition network technology, and reconstruct the communication network architecture of the launching spot. (1) Promote the generalization of hardware resources and the flexible sharing of virtual resources such as virtual computing, virtual storage and virtual network services, and realize the software-oriented network carrying on the unified cloud infrastructure; (2) Build a standardized network basic component with three-layer decoupled structure of universal hardware, virtual operating environment and network functional software. According to business needs, deploy and equip with corresponding business systems at the remote, spot and site levels respectively, for example, the application platform is deployed at the remote level, the IP multimedia subsystem is deployed at the spot level, and the broadband remote access server is deployed at the site level. Through rapid configuration and adjustment, finally build a three-layer architecture IP high-speed network with flexible scheduling and dynamic programming.

3.4 Information application technology
Promote C3I system and experiment mission network integration design, improve launch data acquisition ability, strengthen the interconnectivity ability between measurement control system, ground handling system, meteorological system, and communication system, realize the real-time video monitoring for the whole launch process, key operating parts and important facilities, as well as virtual and real combined image fusion analysis, processing and display. Through complete testing, measurement, monitoring, secure information acquisition and correlation analysis, finally carry out the tower unattended, emergency support decision making and emergency rescue and safety evaluation in the ready launch period. Develop digital simulation experiment evaluation system, to carry out parallel launch experiment evaluation and virtual simulation training, optimize the launch process, and improve the operation ability. Improve the automation level of the launch process, through remote launch and control system, command, monitor and control rocket system and ground handle system working state, especially realize the cable on tower, gas liquid and filling pipeline automatic connection, finally im-
plement product automatic test, control and filling. Research on unstructured decision support technology based on unstructured data association analysis and information mining technology, and demand-oriented big data command decision analysis technology, to enhance the efficiency, accuracy and automaticity of command decision.

4. Measures and Suggestions
With the rapid development of space industry today, the functional mission and capability requirements of information construction have undergone profound changes, and the construction of information integration is an inevitable trend. Up to now, it has made remarkable achievements in information construction, formed the concept of information development, and steadily improved the level of information, laying a solid foundation for information integration construction. In order to realize the goal of space launch information integration, measures and suggestions are given from the following three aspects.

4.1 Full demonstration and sustainable development
Space launch information integration should be based on the present situation and the long-term development. Adhere to innovation driven, overall planning and orderly implementation, establish standards, deep application, follow the principle of safe and reliable, efficient and real-time, and handle the relationship between information sharing and security, mode transformation and smooth transition, overall promotion and pilot construction, intelligent advanced and simple practical.

4.2 Scientific planning and steady progress
First of all, the system standards and supporting service system should be established to ensure sustainable institutional guarantee for information integration construction. Secondly, it is necessary to strengthen infrastructure construction, including building the space launch spot’s Internet of things and communication network based on communication 4.0 technology[5] to improve the acquisition and transmission of information sources; Finally, realize big data application and data fusion based on cloud technology to provide data services, carry out research on key technologies of information application and promote the construction of information application projects to realize refined management of space launch, and greatly improve safety, reliability and work efficiency.

4.3 Strengthen innovation and talent training
Information integration construction is a process of integrating and intelligent transformation of space launch informatization in new technologies and new fields represented by 5G network, new generation Internet of Things[8], smart city[9-10], etc. First, strengthen technical cooperation and exchanges, establish and improve exchange and cooperation mechanisms, and avoid blind planning and repeated construction. The second is to strengthen the training of professional talents. Relying on the construction of information center, we should strengthen key technological breakthroughs, cultivate talents with advanced technologies, and accelerate the transformation of information technology achievements.

5. Conclusion
This paper expounds the construction assumption from three aspects of basic concept, connotation and development direction, considers the way of technology realization from the aspects of information standard technology, transmission and bearing technology and information application technology, and proposes measures from three aspects of the demonstration of development, scientific promotion, innovative talents. The next step is to carry out in-depth theoretical research and practical application, strengthen the connotation and characteristics of information integration research, comb the system components, system composition and capability requirements, formulate the space launch information integration technology development strategy suitable for national conditions and system, and reconstruct launch informatization with a new concept.
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