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International Talents Cultivating System in Aerospace Engineering and Its Construction Practice

Chen Guoyu , Lu Jun, Huang Xin, Zhao Sheng, Zhang Wei

China Aerospace Science and Technology Corporation, Beijing 100094, China

Abstract: In the historical context of building “a community of shared future for mankind” and the Belt and Road initiative, international cooperation in space activities can help enhance consensus between China and the countries along the Belt and Road to achieve mutual benefit and common development. Moreover, with the continuous development of such international cooperation, the aerospace industry in China urgently requires a talent team to satisfy its need for leapfrog development. This study first defines and analyzes international talent cultivation in aerospace engineering. Subsequently, using the international talent cultivation practice of the China Academy of Space Technology of the China Aerospace Science and Technology Corporation as an example, this study elaborates on the implementation of the international talent cultivation system in this academy and presents the results of implementing it.
Keywords: aerospace engineering; systems engineering; internationalization; talent cultivation

1 Introduction

To support the implementation of the Belt and Road initiative, accelerate the construction of a community of shared future for mankind, and expand the global influence of China’s aerospace, the China Academy of Space Technology (CAST) has constantly promoted its internationalization by not only exporting satellites and providing space to ground solutions as well as application systems but also outputting the abilities of satellite R&D and applications. Undertakings are based on talents. With the deepening international cooperation on aerospace, CAST needs an influential team of international aerospace talents who have a global view and international communication skills to push forward aerospace internationalization and meet the demand of the leapfrog development for the aerospace industry.

2 Significance of international talent cultivation system in aerospace engineering science and technology

With the aim of boosting the internationalization in the field of aerospace engineering science and technology, the cultivation system of international talents in such field will be offered throughout the innovation-oriented development of aerospace enterprises. A cultivation system and mechanism will be established and developed, the overall design of the system will be improved, the cultivation platform will be perfected, the method of cultivation will be diversified, and the conditions for the growth of the talents will be optimized. All these are designed to develop effective aerospace talents who can contribute to the leapfrog development of the aerospace industry. It invites all countries to explore and utilize the outer space together. With a focus on talent cultivation and cultural exchange, it will expand the cooperation among the talents of aerospace engineering science and technology and extend talent cultivation across the world to promote international

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Corresponding author: Chen Guoyu, Senior engineer from the China Aerospace Science and Technology Corporation. Major research field is human resource management. E-mail: chenguoyu_cast@126.com
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cooperation, compatibility, and sharing of aerospace R&D and innovative achievements [1].

3 Establishment of the international talent cultivation system in aerospace engineering science and technology

The innovation-oriented development of China's aerospace industry coincided with China's cultivation of aerospace engineering science and technology talents. Motivated by such major national projects, namely, "Atom bombs, hydrogen bombs, and man-made satellites," manned spaceflight, lunar exploration, and BeiDou navigation satellite system, the aerospace engineering science and technology in China have been growing rapidly through the hard work of several generations, and have established a complete space science and technology system including space launchers, spacecraft and space tracking, and command systems. China's aerospace industry is making great strides ahead.

CAST has established a multi-layered and diversified business structure (Fig. 1), which comprises the space-based exportation (the exportation of satellite systems, subsystems, units, and components) and the space–ground-based exportation (the construction of overseas satellite ground stations and the design center and assembly integration and test (AIT) center of the country). Furthermore, CAST provides the training of aerospace engineering science and technology for international customers (the R&D, design, manufacturing, test, support, and application of satellite systems, subsystems, units, and components) to accomplish the exportation of China's aerospace industry capability.

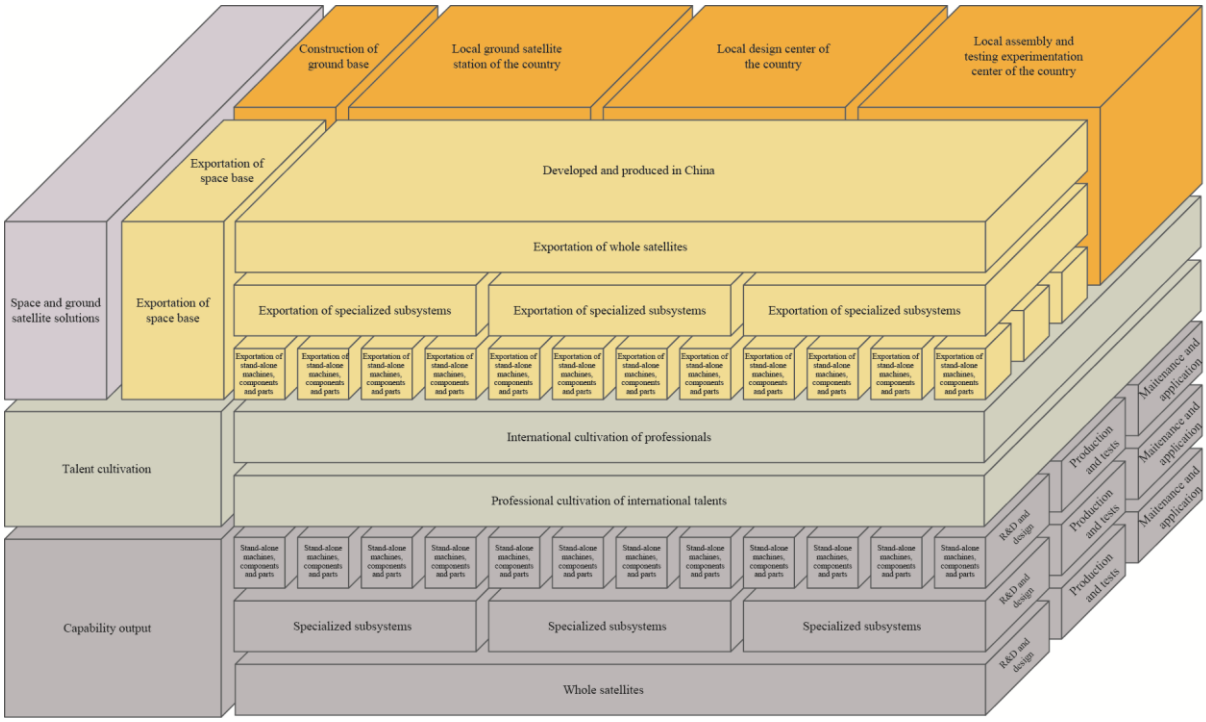

Fig. 1. International business structure of CAST.

To satisfy multi-layered and diverse international business needs, CAST considered the objectives of cultivating international talents of aerospace engineering science and technology and established a complete cultivation system (Fig. 2), which consists of "two integrations of talent," "trinity," and "platform establishment." "Two integrations of talent" refers to the internationalization of domestic professionals and the professionalization of international talents of aerospace engineering science and technology. "Trinity" refers to the combination of three cultivation forms, namely degree-oriented education, on-the-job training, and practice. "Platform establishment" means building a globally influential enterprise college (Shenzhou Institute) to establish a platform on which CAST can nurture internal talents and communicate with external partners internationally.

3.1 Domestic cultivation system for aerospace technology talents

3.1.1 Structure of the domestic cultivation system for aerospace technology talents

Guided by the aerospace system engineering theories and according to its experience in science and technology talent

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management in the past 50 years, CAST proposed and established an overall structure of the cultivation system for leading aerospace technology talents, which has "time and space two-dimensional attributes" [2]. The "time attribute" refers to the structure of the maturity of aerospace technology talents, whereas the "space attribute" indicates the structure of specialty distribution of aerospace technology talents. Moreover, it designed a multi-layer, multi-specialty, and wide-ranging talent cultivation system. "Multi-layer" refers to the four layers of the time attribute, namely "top," "senior," "middle backbone," and "young" [3]. "Top" indicates the top leading technology talents who will be able to drive the development of the national aerospace technology. "Senior" refers to the high-end leading technology talents who perform duties in a high innovation-oriented position and play an important role in strengthening the independent innovation in the national aerospace technology. "Middle backbone" denotes the backbone academic and technical leaders who have remarkable academic achievements and sharp skills and are able to direct the development of their specialty. "Young" refers to excellent young talents who have great potential. "Multi-specialty" is defined as the combination of specialties of the space attribute, including system innovation, special research, and product development. "Wide-ranging" means that the cultivation system covers all CAST leading talents.

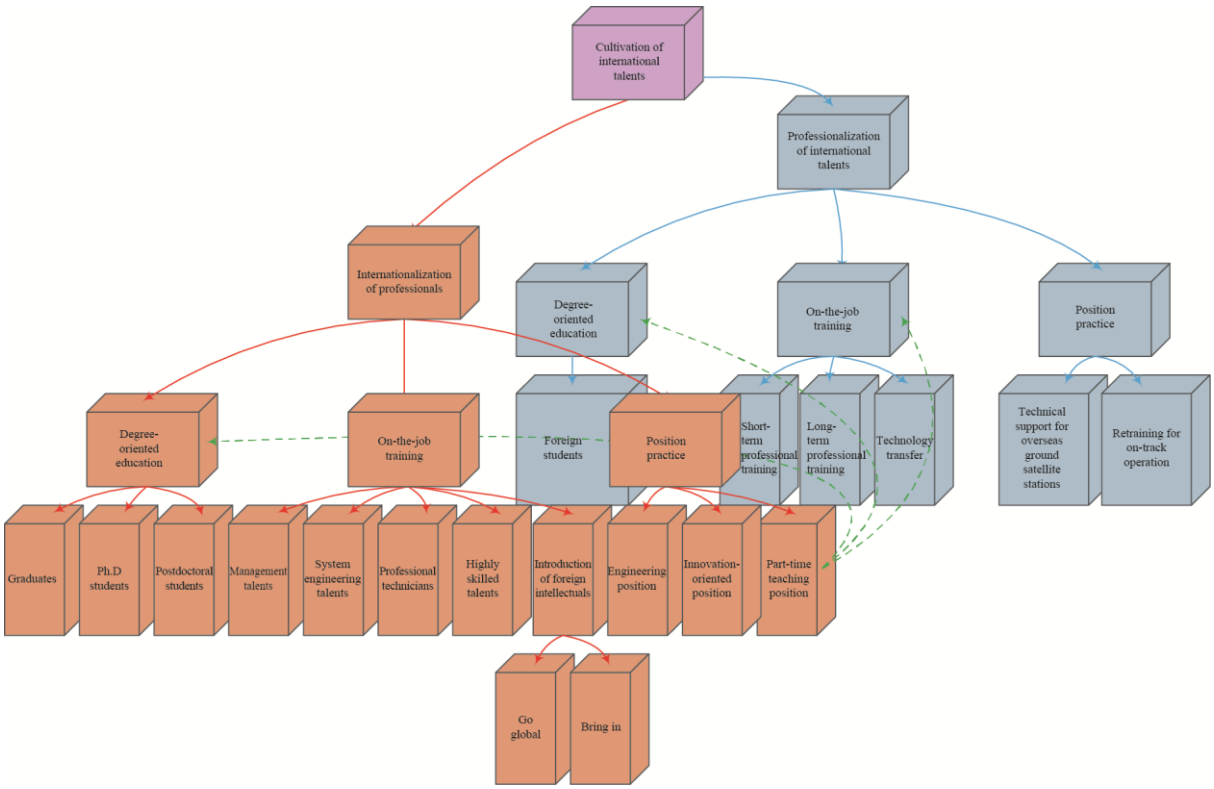

Fig. 2. Structure of the cultivation system for international talents of aerospace engineering science and technology.

With the principle of exploring intrinsic motivation, CAST persists in striking a balance between career development and personal improvement and combines the cultivation of leading talents at all levels and specialties with the innovation of aerospace technology to make dynamic and differentiated talent cultivation strategies [4]. For top talents, it integrates talent cultivation with career development, focuses on the directions of career development and the objectives of talent growth, insists on classified instructions, and formulates and implements differentiated cultivation strategies. For senior talents, it relates talent cultivation with position requirements and carries out the strategy of double promotion for both the talent and the position. For middle backbone talents, it connects talent cultivation with technical advancement. In terms of young talents, it emphasizes the creation of an innovation environment and encourages the talents to make progress in innovation and exploration.

3.1.2 Diverse ways of cultivating talents

CAST has completely developed its abundant resources for talent cultivation, established an integrated cultivation platform featuring "learning and practice," reinforced the forefront of technology talent cultivation, and created a seamless connection between technology talent cultivation and technological innovation and engineering project developments to help

excellent people to stand out as soon as possible. For the young technology talents who have little engineering experience, it independently developed a concurrent design software platform for virtual satellites, a satellite in-orbit operation virtual platform, and a satellite AIT operation and practice platform to simulate a complete satellite development from the initial scheme design, system R&D, assembly, and testing to in-orbit management. With these three platforms, CAST helps young technology talents apply their knowledge to scientific research and improve their overall abilities to make innovations. As for the backbone technology talents who have more experience, it has organized expert lectures such as "Lectures by Chief Commander and Chief Designer" and "Lectures by Academic and Technical Leaders" to encourage backbone creative talents to share their knowledge and experience so that they will play a sustainable function of facilitating the growth of younger talents.

To accelerate and adapt to the growth of technology talents from different levels, CAST summarized the influential achievements it has attained in the past five decades, sorted out the main domains, specialized theories, and practical achievements of space technology, and published the *Space Technology and Science Research Series* (23 volumes). With a focus on the scientific technology, industrial foundation, and engineering practice of China's space science, these volumes introduce all aspects of space science, technology, and application. Aside from elaborating on basic scientific and technological concepts and the application of these concepts in current engineering projects, they attach equal importance to the technological advancement in the future. As a combination of theory and practice, they are based on the aerospace engineering practice and have been refined. Therefore, they feature high theoretical value and strong universality and offer disciplinary and technological information to technology talents at all levels [5].

3.1.3 Internationalization of the talents of aerospace science and technology in China

With the internationalization process of China's aerospace driven in a comprehensive manner and in-depth implementation of a series of international aerospace cooperation projects represented by China–Brazil Earth Resources Satellites and China–France Oceanography Satellite, the demand for cultivating international talents of aerospace science and technology in China has further increased.

Relying on international cooperation projects, CAST continues to explore effective methods used by other countries to reduce the shortcomings of its talent cultivation system with international resources. It fosters the international thinking and ideas of domestic talents in aerospace science and technology by adopting multiple ways such as assigning more outstanding talents for overseas short-term study and academic education, and introducing overseas high-end intellectual resources to give lessons and guidance, in a bid to develop more talents having international vision and awareness, knowledge of international rules, international communication skills, and capability of participating in international affairs and competitions.

3.2 Cultivation of international aerospace engineering science and technology talents

To meet the needs of the vast number of developing countries and teach others to develop their aerospace industry all by themselves, CAST has launched large-scale aerospace talent cultivation programs for other countries through international cooperation projects such as the exportation of whole satellites. According to the domestic cultivation models of aerospace technology talents, it has built effective international cultivation models of aerospace engineering science and technology talents. Besides, it has trained a large group of excellent engineers for the governmental aerospace departments and companies of many countries and advanced their aerospace technologies. By doing so, it has effectively promoted the economic and social development of the Belt and Road countries.

3.2.1 International cultivation system for aerospace engineering talents

Guided by demand, CAST considered the domestic cultivation system for aerospace engineering science and technology talents and established a multi-type, multi-specialty, and wide-ranging international cultivation system for such talents. Multi-type refers to the different cultivation demands of international clients. Currently, the international aerospace engineering talent cultivation demands can be classified into four types. The first is short-term cultivation, which lays emphasis on the basic knowledge and application domains of satellites. The second is mid-term cultivation, which focuses on the operation and application of the subsystems and unit products of satellites. The third is technology transfer-oriented long-term cultivation, which gives priority to the design, assembly, testing, and in-orbit operation of the general systems, subsystems, and maintenance of ground facilities as well as the design of unit products of satellites. The fourth is degree-oriented educational cultivation, which attaches importance to the systematic education with specialized courses on aerospace. Multi-specialty refers to the basic courses about aerospace and different academic directions of different spacecraft. Wide-ranging means that the cultivation system covers all types of international aerospace engineering talents.

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3.2.2 Diverse ways of training international aerospace engineering talents

As an internationalized talent cultivation platform for foreign countries, CAST Shenzhou Institute offers diverse forms of cultivation according to international business needs. In addition to creating distinctive cultivation modules for international aerospace engineering talents, it offers different forms of cultivation according to different user demands.

To satisfy the demand for the short-term cultivation, it offers courses on satellite application, so that the knowledge of satellite application can be spread through lectures by experts.

To meet the demand for the long-term cultivation on the operation and application of satellite subsystems and unit products, it provides theoretical courses and the AIT operation cultivation for international users.

To satisfy the demand for the long-term technology transfer, it has established an integrated international cultivation system featuring theory and practice. By enrolling in the specialized courses on satellites, international aerospace engineering talents will acquire knowledge on scheme design, system development and manufacturing, assembly, testing, and the on-track operation of the general systems and subsystems of satellites. With the concurrent design software platform for virtual satellites and relevant satellite design software, it has launched semi-physical simulated virtual satellite projects and equipped international aerospace engineering talents with higher awareness of the overall situation and a stronger ability to design independently. The satellite AIT operation can deepen the talents' understanding of the theories on satellites and strengthen their abilities to assemble and test satellites.

Regarding the education for international students, it offers customized educational plans and teaching strategies according to the different demands of countries for aerospace engineering professionals. With the tutor responsibility system, it has established a refined and targeted graduate cultivation model. Aside from developing special academic courses, Shenzhou Institute makes good use of CAST's well-established engineering research foundation and the advanced Spacecraft Virtual Integration Design Environment. Focusing on project motivation in its management, it offers distinctive instructions on aerospace and simulation engineering practice, which requires full participation of overseas students. In this way, it provides international students with a good environment for participation, so that they can experience the aerospace culture and spirit and develop their innovation abilities.

3.2.3 International satellite engineer project

The international satellite engineer project is a distinctive cultivation project for international aerospace engineering talents in CAST. It is launched according to the demands of commercial satellite contracts. Through the cultivation of professional aerospace technology and management, it helps international talents acquire the knowledge of the domains related to spacecraft and develop the ability to practice. In this way, it performs the contracts of international cooperation projects, promotes the implementation of national development strategies, and carries out the Belt and Road initiative from two perspectives: technical exchange and cultural communication.

In November 2004, China signed the NIGCOMSAT-1 contract with Nigeria, which marked the inauguration of the exportation of China's first whole satellite. According to the contract, China needed to train 54 satellite engineers for the Nigerian space agency. As an institution that conducts research on and constructs satellites and the main provider of international satellite engineer training, CAST fully developed the cultivation system for international talents of aerospace engineering science and technology and fulfilled China's first international satellite engineer project. After the 15-month training, the Nigerian trainees were able to control and operate NIGCOMSAT-1 and independently design a satellite system. The students have become the founders of the aerospace industry in Nigeria. Since then, CAST has provided the cultivation service to other international clients. The project has become an indispensable product and service of China's satellite turn-key project and has been well received by the governments of relevant countries.

4 Implementation of the international satellite engineer project

To date, CAST has finished many international cultivation projects that involve many countries, including Nigeria, Venezuela, Pakistan, Indonesia, Belarus, Laos, and Algeria. In addition, it has trained over 800 international aerospace engineering talents. Thus, it has promoted the advancement of the aerospace technologies in these countries and boosted the economic and social development of the Belt and Road countries. Consequently, it has become an essential part of the aerospace cooperation between China and other nations.

4.1 Project implementation

With the support from CAST Shenzhou Institute, the project bases cultivation on the demands of international clients. Through different teaching approaches, it aims to equip international clients with relevant theories and the ability to practice.

4.1.1 Demand-oriented, it offers customized and different cultivation systems

According to the international business of CAST, the current demands for international satellite engineers can be divided into three types (Fig. 3). The project offers different cultivation schemes according to the demands of these three types. In consideration of the model engineering practice and the experience in the cultivation of international satellite engineers, CAST has created distinctive cultivation modules for international aerospace engineering talents. These modules cover the basic courses on aerospace and different academic directions of different spacecraft. Different cultivation courses are provided according to the different cultivation demands of international satellite engineers.

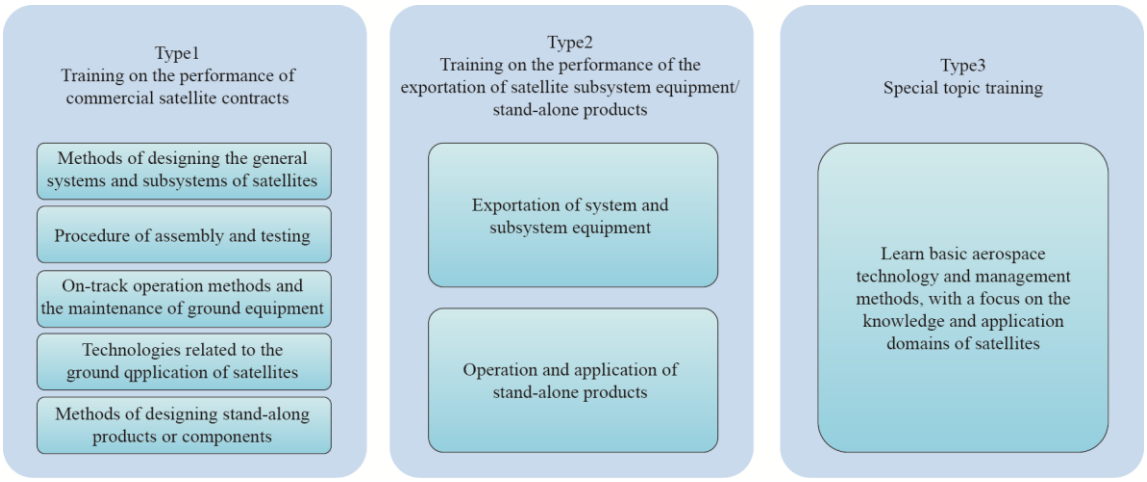

Fig. 3. Classification of the international satellite engineer training markets.

4.1.2 Completely develop the resources and establish a distinctive aerospace cultivation model featuring “theory + simulation + practice”

The project offers special academic courses and lectures by selected satellite professionals in China to equip international satellite engineers with rich knowledge on satellites and help them build a solid foundation for the subsequent design and practice.

The project establishes virtual software platforms and uses a concurrent design software platform for virtual satellites to realize semi-physical simulated virtual satellite projects, so that students will be able to effectively understand and absorb knowledge and enhance their awareness of the overall situation and ability to independently design. The virtual platform for the in-orbit operation of satellites is designed for the simulated in-orbit operation of satellites. It enables students to simulate the in-orbit operation of satellites and develop their abilities to operate satellites and distinguish and solve satellite problems.

The project encourages international satellite engineers to practice and lead them in a study tour to the site of satellite development and manufacturing. Through the on-site interpretation of satellite professionals, students will understand the functions of the different parts of satellites. Further, the satellite AIT operation and practice platform can improve the students’ abilities to assemble and test satellites.

The project offers workshops on a regular basis, where students are divided into small groups to discuss different topics. In the workshop, brainstorming is adopted to develop students’ creative thinking and teamwork spirit as well as strengthen their abilities to explore the knowledge and skills of satellite-related domains.

4.2 Implementation results

4.2.1 Training aerospace talents for the countries of clients

Most of the students who were trained for international clients have become backbone technicians and management staff of their corresponding countries, and some have become discipline directors and senior officers of space agencies. With their important status in the space agencies, they have reformed the organizational structure and provided more technical cultivation opportunities for new engineers, thereby pushing forward the aerospace technologies of their respective countries.

4.2.2 Accelerating the growth of international talents of aerospace engineering science and technology in China

The international satellite engineer project has provided a great platform for domestic aerospace technology talents in CAST. In addition to offering a favorable environment featuring foreign-language communication, it provides students with an opportunity to have a more systematic study of their business and broaden their horizon through cultural exchange with students from other countries. Thus, domestic aerospace technology talents become more geared to international standards.

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To date, CAST has 13 academicians in the International Academy of Astronautics, 9 members in the Russian Academy of Astronautics, and 17 experts who work for well-known international organizations such as International Academy of Astronautics and International Astronautical Federation.

4.2.3 Deepening the scientific and technological cooperation among countries

Since its participation in the bid to the international projects of OPTUS in 2003, CAST has signed over 80 export contracts with 26 countries and regions. In 2004, China made a breakthrough by exporting its first whole satellite: NIGCOMSAT-1. So far, 23 whole satellites have been exported from China.

The international exchange among aerospace engineering science and technology talents has not only deepened the scientific and technological collaboration between countries but also enhanced the mutual understanding and friendship among nations. To date, the heads of over 50 countries, including France, Sweden, Chile, Nigeria, Venezuela, and Belarus, have paid a visit to and negotiated in cooperation with CAST. On October 29, 2018, the Chinese French Oceanography Satellite was launched. Aside from showing a deeper cooperation in the combat against climate change between China and France, it has expanded the collaboration in the peaceful development and space exploration between the two nations and improved their oceanography satellite engineering and satellite application services. Moreover, it has made new contributions to the economic and technological advancement of China and France and is of great significance to the establishment of a community of shared future for mankind.

5 Conclusion

The joint implementation of the Belt and Road initiative has been transformed from idea into action and from vision into reality, and the initiative has become a public product that is popular worldwide. China will face more international cooperation in its high-tech industry full of both opportunities and challenges. The desire for new technologies will compel all countries to speed up the internationalization of their engineering technology talents in all fields. The cultivation of international talents should provide greater support to national development, constantly improve the top-level design, and create new work mechanisms as well as place more emphasis on the integration of diverse cultures, inclusiveness, and mutual learning to advance the construction of a community of shared future for mankind.

References

[1] Zhu Y L. Space soft strength, internationalization and leading power [J]. Spacecraft Engineering, 2013, 2(2): 7–8. Chinese.
[2] Qian X S. Systems engineering [M]. Shanghai: Shanghai Jiao Tong University Press, 2007. Chinese.
[3] China Aerospace Science and Technology Corporation. The way to the growth of aerospace science and technology talents: The law of training high-level science and technology talents [M]. Beijing: China Aerospace Press, 2011. Chinese.
[4] Wang S Y, Liu J Q. China engineering education [M]. Beijing: Social Science Academic Press (China), 2013. Chinese.
[5] Yang H. Manned spacecraft technology [M]. Beijing: Beijing Institute of Technology Press, 2018. Chinese.