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Organization as Innovation: China's Human Spaceflight Program's Efforts to Instill a Quality Management System

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SUMMARY

Space industries confront unique challenges in successfully bringing programs to conclusion, primarily due to the harsh environments in which spacecraft operate and the technologies needed to send them into orbit. Developers of successful space systems place great emphasis on reliable technologies, exacting manufacturing processes, and strict and documentable quality assurance measures. China's greatest accomplishments in creating its human spaceflight program may not be the development of new technologies. As China increasingly relies on domestically-sourced components and systems to manufacture spacecraft, the internal processes it has developed may be a more reliable indicator of its ability to sustain a successful space program than technological advances. These processes may have a more lasting effect on the space industry's ability to innovate than the role of technology itself.

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Space industries confront unique challenges in successfully bringing programs to conclusion. These challenges are primarily due to the medium in which spacecraft operate and the technologies needed to send spacecraft into orbit. The launch, space, and reentry environments are the harshest of environments and place great stress on technologies involved. No other type of technology poses the same degree of difficulty as that encountered in transporting spacecraft from the Earth's surface to orbit and back again. This difficulty in developing successful space systems places great emphasis on reliable technologies, exacting manufacturing processes, and strict and documentable quality assurance measures. Moreover, space programs require long-term support from a country's top leadership along with adequate funding.

CHINA'S HUMAN SPACEFLIGHT PROGRAM

China's human spaceflight program is the country's largest and most complex technology program. In successfully sending astronauts into space since the early 2000s, China has surmounted numerous difficult challenges. China's success is even more remarkable when considering the relatively low technological base from which it started. Indeed, at the outset of the program, China's space industry was staffed with an aging workforce nearing retirement saddled with poor work habits, backward technology, and an insufficiently strict commitment to quality.

In overcoming these challenges, China's space industry followed the same principles in developing human spacecraft as the United States did in its development of the Apollo/Saturn programs. However, because China's space program inherited a legacy industry that was underfunded, unfamiliar with modern systems engineering, technologically backward, and generally lacking in commitment to quality, China's human spaceflight program cannot be said to have become mature until at least 2005, or 13 years after the approval of its human spaceflight program and two years after China's first manned flight.

Top-Level Leadership Support

The most important factor in overcoming these challenges was political support from the top political leadership and the resulting allocation of funding. Similar to the U.S. Apollo program, which received support from Presidents Kennedy and Johnson, China's human spaceflight project received initial approval from China's paramount leader Deng Xiaoping in 1991 and, after extensive feasibility analysis, formal approval from the Communist Party's Politburo Standing Committee in 1992. This political support, as well as sufficient funding, has continued to the present day through the administrations of Jiang Zemin and Hu Jintao.

Quality Control and Project Management

In addition to political support, China's space industry has established an ever-increasing commitment to quality. At the beginning of the program it was evident to the leaders of the Shenzhou program that China's quality management system was not suitable to the requirements of human spaceflight. China's space program did not directly manage individual projects nor did it use project management technology or properly control quality and costs. Whereas the U.S. space industry benefitted from its well-developed aerospace industry that could draw upon a young workforce and extensive experience developing aircraft and missiles, as well as the expertise of German rocket scientists who moved to the United States after World War II, China had no such luxury.

The story of China's human spaceflight program, then, is as much about developing an effective systems engineering program as it is about developing new technologies. China did develop new technologies for its Shenzhou space capsule and Shenjian rocket, but a successful human spaceflight program would not have been possible if a carefully managed system made up of testing and standards did not inculcate a commitment to quality from the prime contractor down to third-tier suppliers.

COMPARING THE U.S. AND CHINESE PROGRAMS

Both the U.S. Apollo/Saturn programs and China's Shenzhou/Shenjian programs had to institute a strict top-to-bottom management system to ensure proper implementation and attention to quality. In both programs, senior leaders realized that a loose management style and lax oversight would be unable to enforce the strict quality standards needed for human spaceflight, especially at the component and subcomponent level of manufacturing.

In the case of the U.S. space program, a close government-industry team was formed in which the government conducted direct oversight of contractors. In the Chinese case, the China Academy of Space Technology, which was responsible for the development of the Shenzhou space capsule, and the China Academy of Launch Vehicle Technology, which was responsible for the development of the Shenjian rocket, had to take direct roles in supervising the work of second- and third-tier suppliers.

This system, however, took 13 years before it was fully developed. China did not finalize its component specification list until 2005, after it had already launched its first manned spaceflight in 2003. Nor has China's level of testing equaled that of the U.S. Apollo/Saturn programs.

The Saturn V launch vehicle used to send the Apollo spacecraft into orbit was tested in whole or in part sixteen times before use on a manned mission. This testing started with the first stage, then multiple stages, then the complete rocket with mock versions of the Apollo command and service modules and then launches with real command and service modules. By comparison, China conducted no test launches of the LM-2F rocket before the launch of Shenzhou 1 and conducted just four unmanned launches before sending an astronaut into space.

THE ROLES OF ORGANIZATIONAL STRUCTURE AND PROCESS IN ENABLING INNOVATION

While China's quality assurance rigor may not have equaled that of the U.S. Apollo program, its enhanced commitment to quality places the role of technology innovation in a broader context. Technological advancement is not just the simple product of talented individuals, but is also the result of a system led by an effective organizational structure implementing a strict quality assurance system made of standards, testing, documentation, and inspections.

The role of organization in technological innovation also places foreign cooperation and technology transfer in a new light. Discussions of Chinese defense programs most often focus on the role of foreign cooperation and technology transfers as the single most important determinant of success. The role these two factors have played in the advancement of China's defense technology should of course not be underestimated. In fact, China has acknowledged the critical support it has received from Russia in human spaceflight technology. Nevertheless, while foreign assistance may have been necessary, it alone has not been sufficient to guarantee success of the human spaceflight program.

CONCLUSIONS

Viewing technological innovation as a system rather than as an individual act demonstrates that China's greatest accomplishment may not be the development of new technologies, but the organizational skills that were necessary to orchestrate a large number of organizations into a united effort to conduct the exacting business of spacecraft manufacturing. This has important implications for China and the United States. As China increasingly relies on domestically manufactured components and systems to manufacture spacecraft, the internal processes it has developed will play a more important role and will be a more reliable indicator of China's ability to sustain a successful space program. As a result, the invaluable lessons China has acquired in developing a human-rated spacecraft and launch vehicle will have a more lasting effect on the space industry's ability to innovate than the role of technology itself.

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