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The China Aerospace Science and Technology Corporation and the Concept of Integrated Innovation: A Case Study

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Summary

The China Aerospace Science and Technology Corporation (CASC) has embarked on a new, more comprehensive approach to innovation involving a commitment to research, developing an organizational structure that integrates research and development, adopting modern business techniques, and investing in workforce development. This comprehensive approach, dubbed integrated innovation (集成创新), is described by CASC as the “core idea” of its system engineering efforts. This policy brief examines CASC’s integrated innovation efforts in regards to long-term planning, research and development, talent development, and business strategy. It then assesses CASC’s performance during the Eleventh Five-Year Plan and compares its performance to that of the U.S. aerospace industry. Although CASC still lags behind the U.S. space industry, its commitment to knowledge retention and its relatively young workforce could help sustain its progress.

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INTEGRATED INNOVATION AND ITS APPLICATION TO CASC

The China Aerospace Science and Technology Corporation (CASC), China's leading space industrial enterprise, has embarked on a new, more comprehensive approach to innovation involving a commitment to research, developing an organizational structure that integrates research and development (R&D), adopting modern business techniques, and investing in workforce development. This comprehensive approach, called integrated innovation (集成创新), is a Chinese concept that draws heavily on the work of Harvard Business School professor Marco Iansiti and his work, *Technology Integration: Making Critical Choices in a Dynamic World*. According to Iansiti, innovation relies on many factors that affect a corporation's ability to effectively bring a technology to the marketplace. The demands of integrating multiple technologies into a product that can meet market demands has become increasingly complicated due to the rising sophistication of technology, the science used to create it, and the rapidity with which new technologies are brought to market. To operate in this increasingly complex world, Iansiti concludes that companies must be able to excel across a broad range of capabilities. This includes an emphasis on research, an organizational system that facilitates the integration of research and development, an emphasis on training and retaining employees, and strategies to both develop technologies and bring them to market.

CASC describes integrated innovation as the "core idea" of its system engineering efforts. As such, CASC's leadership has combined long-range technology planning, an R&D organizational structure integrating basic and applied research with systems integration, human resource development, and a business strategy emphasizing both civilian and defense technologies and domestic and international markets, into an overall strategy designed to transform CASC into a world-class aerospace corporation. The adherence of CASC to the concept of integrated innovation has resulted in significant advances in China's space capabilities and improved financial performance. China is now launching more satellites on more rockets each year, including an increasing number

of commercial launches. As a result, while much focus has been placed on the role of technology transfer in accelerating China's defense industrial innovation, the role of institutional change may be a better indicator of the ability of China's space industry to become internationally competitive over the long term. Indeed, the adoption of integrated innovation and its focus on excelling across a broad array of performance factors suggests that CASC's performance can be sustained. Consequently, China's space program will likely continue to improve and may become an increasingly competitive global player in the international space market. Nevertheless, even though CASC has made great strides in manufacturing increasingly capable space technology, it still lags behind its U.S. competitors in terms of technology levels, efficiency, and financial performance, indicating that the U.S. space industry will remain dominant for years to come.

LONG-TERM PLANNING

China's space industry, like every other industry in China, is governed by a series of plans intended to build the country into an innovation nation. China's space industry was designated as one of China's strategic emerging industries under the Twelfth Five-Year Plan, and human space flight, lunar exploration, and earth observation were prioritized under the 2006 Medium- and Long-Term Plan for Science and Technology Development. This prioritization sets goals, presumably increases funding, and provides a set of benchmarks on which China's space industry leaders will be judged, motivating the industry to meet its goals. This top-down approach has often been criticized for stifling innovation at lower levels, where breakthroughs most often originate. Such an approach may have utility when applied to the space industry, however, which is primarily dependent on government markets for funding.

THE RESEARCH AND DEVELOPMENT SYSTEM

CASC states that it places a great emphasis on R&D. CASC views basic and applied research as the source of its overall research efforts, system

engineering as providing an overall plan for R&D, and system integration and manufacturing as the core of its R&D efforts. In addition to applying for government funding, CASC supplements government funding with its own funds. In 2010, CASC for the first time devoted five percent of its revenue to this effort.

CASC has also established a system of academies, research institutes, and laboratories designed to bridge the divide between R&D. At the top of this organizational structure are eight academies that report directly to CASC as prime contractors. These academies are each responsible for a different technology area and facilitate technology integration at the system level.

While the academies are responsible for systems integration, CASC's five engineering research centers (工程研究中心), 30 key technology R&D centers (重点专业研发中心), 13 key laboratories (国家级重点实验室), and 15 industry-academic research collaboration innovation platforms (产学研合作创新平台) are the primary drivers of research. These organizations are subordinate to research institutes and conduct basic research, applied research, and product design. Engineering research centers, for example, are responsible for practical research and demonstration platforms, such as small satellites and satellite navigation. The 30 key technology R&D centers focus on individual technologies, such as software or electrical wiring and cables. Key laboratories, on the other hand, are responsible for broad science and technology disciplines, such as microwaves or spacecraft propulsion.

CASC also has cooperative relationships with universities that it calls "industry-academic re-

search collaboration innovation platforms." CASC uses the university system to supplement its own research and provides grants to these schools to conduct basic research on new concepts, methods, technology, processes, and materials.

TALENT DEVELOPMENT

CASC identifies its management structure and human resources development as key factors in its pursuit of technology innovation. In order to conduct effective program management, CASC assigns a commander and chief designer for each project. Under this construct, the commander is responsible for overall management of the project while the chief designer is responsible for design, research, testing, test production, solving technical issues, and ensuring system and subsystem compatibility.

CASC has also established a modern, more effective human resources system in which employees can be both promoted and demoted and are offered equal pay for equal work. Exceptional employees can be given bonuses, recognized with meritorious service, achievement, and innovation awards, or promoted. Moreover, promotions are based on merit and not on age or academic degree.

CASC places a strong emphasis on education and training for managers, project teams, technicians, and those involved in business affairs and devotes significant resources to education and training. This emphasis on providing training and outside educational opportunities for its staff has increased both in numbers of training events, numbers of personnel participating, and funding since 2008 (Table 1).

Table 1. Training

Year	Person-training events	Training hours (millions)	Funding (millions of yuan)	Personnel receiving higher education
2008	218,000	6.51	85	1,500
2009	278,000	6.84	86	1,200
2010	305,000	8.07	92	1,400

BUSINESS STRATEGY

CASC has also developed a two-pronged business strategy to bring space and civilian products to market. This strategy moves away from relying so heavily on the manufacture and sale of satellites and launch vehicles to a model that provides more balance between manufacturing and service, between space products and civilian products, and between domestic and international markets.

Balancing Between Space and Civilian Products

CASC's transition to a more balanced approach to manufacturing and services and space and civilian products is conducted through eight industrial parks called "aerospace bases," formed through partnerships between CASC and the local governments of Beijing, Shanghai, Xi'an, Chengdu, Tianjin, Inner Mongolia, Shenzhen (Hong Kong), and Hainan. These bases are not only designed to manufacture space products, but also to leverage CASC's capabilities in space technologies to build civilian products. These include high-end manufacturing, alternative energy, new materials, alternative energy automobiles, and new generation information technologies.

Balancing Between Domestic and International Markets

CASC realizes that it must be successful in international markets if it is to become a world-class aerospace corporation. According to one analysis, since U.S. export control laws bar most satellites from being launched on Chinese rockets, China must offer Chinese-made satellites launched on Chinese rockets so that it can completely break free of U.S. trade restrictions.

CASC promotes the export of satellites, commercial launch services, and military arms, and increasing space technology exports; expands international cooperation and exchanges; and focuses on strengthening markets in South America, Africa, Southeast Asia, and Europe. During the Eleventh FYP, CASC launched two satellites for foreign customers and signed contracts for four communication satellites and seven launch services. These contracts also included financing, training, technology transfer, and orbital positioning services. CASC exported and launched satel-

ites for Pakistan, Venezuela, and Nigeria, provided commercial launch services to Indonesia, and signed contracts with Laos and Bolivia for communication satellites and with Venezuela for a remote sensing satellite.

ACHIEVEMENTS DURING THE ELEVENTH FIVE-YEAR PLAN

Technological Achievements

During the Eleventh FYP, China's space program achieved its highest level of productivity, conducting 48 successful launches resulting in the orbiting of 59 spacecraft, twice as many as during the Tenth FYP. At the end of the Eleventh FYP, China had 50 operational satellites in orbit, the most at any time in its history.

CASC lists its most important accomplishments during the Eleventh FYP as:

- The successful flight of the Shenzhou-7 mission, in which China became the third country to conduct a space walk.
- The successful completion of the Chang'e-1 and Chang'e-2 missions, in which China became the fifth country to explore the moon.
- The successful establishment of a preliminary satellite navigation and positioning system, which makes China the third country to set up such a system.

Financial Accomplishments

CASC also had a strong financial performance during the Eleventh FYP. CASC's total assets for the period reached 18.28 billion yuan, a 127 percent increase over the Tenth FYP, with an operating income of 84.3 billion yuan, an increase of 172 percent of the Tenth FYP. This resulted in a total profit of 8.47 billion yuan (Table 2). Although impressive, statistics provided by other sources appear to reveal serious problems with CASC's business operations. The number of CASC companies with a revenue of more than 1 billion yuan increased from three to 13, indicating that CASC's revenue should be at least 13 billion yuan and not the 8.43 billion yuan cited by its 2010 Social Responsibility Report. This suggests that CASC's overall profit margins remain low.

**Table 2. CASC's Financial Performance
(Billions of Yuan)**

	2010	2005	Percent change
Total assets	18.28	8.04	127
Owner's equity	7.43	2.35	216
Operating income	8.43	3.10	172
Total profit	8.47	1.95	334

HOW DOES CASC MEASURE UP?

CASC's progress during the Eleventh FYP begs the question of how it is performing in comparison to other countries' space programs. In 2010 China and the United States both conducted 15 launches and in 2011 China conducted 19 launches compared to 18 by the United States. Based on the 10-year period from 2001–2010, China's Long March launch vehicles successfully completed 72 of 73 launches for a 98 percent success rate, a rate comparable with international competitors.

Although China's launch success is impressive, a simple counting of launches ignores the number of satellites launched and penalizes countries that are more efficient. For example, in 2011, China successfully orbited 21 satellites compared to the United States' 26. Similarly, in 2010 China launched 16 satellites compared to the United States' 21 spacecraft. In fact, by the end of 2010 China had just 50 operational satellites in orbit out of a total of 957 satellites.

CASC also has much work to do to develop the commercial market. China plans to capture 15 percent of the commercial launch market and 10 percent of the commercial satellite market. According to forecasts published by the U.S. Federal Aviation Administration, China will need to launch approximately 5 satellites and 7–8 rockets per year to reach this goal. In 2010, however, China conducted no commercial launches and exported no satellites. In 2011 China conducted two commercial launches involving two satellites,

capturing 11 percent of the commercial launch market and 5 percent of the commercial satellite market. Most of China's launch services, however, have been in support of satellite exports to developing countries, which would normally not have been able to afford higher-end satellites manufactured by European or U.S. manufacturers. In this respect, these commercial activities have minimal effect on other commercial launch providers and satellite manufacturers, although the experience gained from these efforts may make China more competitive as their technology improves.

CASC would also appear to have much work to do before it can compare itself to the world's leading aerospace corporations in terms of revenue. U.S. companies Boeing and Lockheed Martin dwarf CASC in terms of revenue. Boeing and Lockheed Martin generated over \$64 billion and \$45 billion in revenue in 2010, respectively. CASC, on the other hand, generated nearly 84.3 billion yuan, or nearly \$13.3 billion, in 2010.

Despite their much larger revenues, the U.S. companies employ comparable numbers of employees. At the end of 2011, CASC had 140,000 employees while Boeing and Lockheed Martin had 160,500 and 132,000 employees, respectively. On average, every Boeing employee generates over \$400,000 per year in revenue whereas the average CASC employee generates just over \$95,000 per year in revenue.

CASC's research expenditure of approximately CNY 4 billion, or 5 percent of its total revenue, represents a strong commitment to developing new spacecraft. U.S. aerospace companies, however, do not necessarily spend less on R&D than CASC. Boeing spent more than USD 4.1 billion, or 6.4 percent of its revenue, on research in 2010. Similarly, Lockheed Martin spent \$639 million, or 1.4 percent of its revenue, on research.

Even though CASC still lags behind the U.S. space industry, its commitment to knowledge retention could help sustain its progress. CASC's relatively young workforce (most workers are 30–40 years old) means that it could potentially benefit from a large experience base for decades to come. The U.S. space industry, on the other hand, is aging, with most employees between 40 and 60 years old. Moreover, just 25 percent of the U.S.

Table 3. Aerospace Workforce Age Profiles

CASC	35 and younger	36–45	46–54	55 and older
	53.8%	27.4%	15.5%	3.3%
U.S. Space Industry	34 and younger	35–44	45–54	55 and older
	25%	18%	34%	23%

aerospace workforce is 34 or younger and government cutbacks and reduced educational benefits offered by aerospace companies may result in increased attrition among this age group (Table 3).

CONCLUSION

Of course, neither U.S. supremacy in space nor continued Chinese progress is guaranteed. Although a company’s legacy may affect its culture, the performance of a company is ultimately determined by the decisions of its top leadership. The adherence to modern business management techniques by CASC suggests that it has identified its organizational weaknesses and the challenges associated with bringing high technology products to market and has taken steps to overcome

them. Carrying through with these principles will be important as CASC’s goal is to finish building an innovative, pioneering, integrated space industry by 2015, at which time its astronautic, missile, space technology application, and space services industries will be at the top world level. As a result, mastering these principles may not only allow CASC to better manage and adapt to technological change but also may allow it to eventually influence the market through internationally competitive products.

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