

Research on Constraints Affecting the Improvement of Product Competitiveness of the "National Team" in Commercial Aerospace

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Abstract. At present, China's commercial aerospace industry is on the eve of an outbreak, with the entire industry chain ready to develop. On the basis of substantial early investment and support for the commercial aerospace industry, "national teams" such as China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC) are accelerating the launch of commercial aerospace products to enhance market competitiveness. This paper comprehensively analyzes the market competition models and comparative advantages of domestic and foreign commercial aerospace enterprises, and their enlightenment for the development direction of the "national team" in commercial aerospace. Starting from process links such as design, production, and test verification, it analyzes the constraints on the competitiveness of commercial aerospace products at the system, single-machine, and AIT (Assembly, Integration, and Test) levels. Focusing on the rigid demand for "cost reduction and efficiency improvement" in commercial aerospace, it proposes basic strategies for optimizing product competitiveness, aiming to further enhance the market competitiveness of the aerospace "national team" in commercial aerospace.

Keywords: commercial aerospace; cost reduction and efficiency improvement; excellent products

1. Introduction

Since the PRC government proposed "encouraging private capital to participate in aerospace activities" in 2014, local governments have introduced special support policies and action plans. More than ten provinces and cities including Beijing, Shanghai, Guangdong, and Hainan have actively deployed, forming multiple industrial clusters, laying a solid policy foundation for the development of commercial aerospace. In terms of the market: the scale of the commercial aerospace industry has expanded significantly, with an average annual market growth rate of over 20% from 2019 to 2023, reaching 2.34 trillion yuan in 2024 and is expected to reach 2.9 trillion yuan in 2025. In terms of production capacity: only from the perspective of the commercial satellite industry, the total production capacity of domestic factories in operation is conservatively estimated at over 3,250 satellites; the clear production capacity of under-construction factories is approximately 2,270 satellites. The Hainan Satellite Super Factory, with an annual output of 1,000 satellites, is under intensive construction, planning to form test capabilities in July 2025 and assembly and test capabilities in October^{[1][2]}.

Central enterprises such as CASC, CASIC, and China Satellite Network Group, as well as their second and third-tier units, have authoritative status, strong strength, and rich engineering experience in the overall design of various types of spacecraft, platform equipment, payloads, and the entire process of satellite/rocket AIT. Taking the commercial satellite industry as an example, CASC has trained a large number of technical talents for commercial aerospace enterprises represented by China Satellite Network and Yuanxin, developed on-board equipment and payloads for major constellations represented by GW and Qianfan, and supported the construction of clusters of satellite production and test equipment for major commercial satellite production bases such as the Hainan Satellite Super Factory and Gesit Satellite Factory. However, through communication and competition with various market entities, the shortcomings of the "national team" such as slow market response, high product prices, and low user fit have emerged, restricting the market

competitiveness of the commercial aerospace products provided. This has become a key issue that must be thoroughly analyzed and explored solutions for.

2. Comparative Analysis of the Development of Domestic and Foreign Commercial Aerospace Enterprises

In the process of researching and analyzing the successful experiences of domestic and foreign commercial aerospace enterprises, it can be found that the commercial aerospace industry has much in common with the successful paths of emerging high-tech industries such as the Internet and artificial intelligence, namely: (1) Competing for the right to define the industry and shape the business format, taking the lead in proposing new concepts and ideas, and seizing control of product standards and design architectures; (2) Conducting extreme design using cutting-edge technologies, fully considering market reactions and user needs for rapid iteration to ensure high product competitiveness; (3) Exploring optimal cost-efficiency solutions, pursuing the optimal realization path of quality, cost, and efficiency from perspectives such as supply chain management and lean production management. The following is a brief introduction to the research on SpaceX, Galaxy Space, and Spacety (Tianyi Space), as well as a comparative analysis of the current development status of the aerospace "national team" in commercial aerospace.

2.1 The Shaping of the Commercial Satellite Industry by SpaceX

SpaceX's STARLINK has built a closed-loop industrial chain from satellite manufacturing, rocket launch to global services through the strategic path of "technological disruption → cost revolution → ecological monopoly → vision-driven". Its business model is centered on user subscriptions, combined with government cooperation and industry customization, forming a diversified income structure. It has shaped the commercial aerospace business format, explored feasible business models and technological development routes, and promoted the transformation of aerospace technology from "national engineering" to "commercial infrastructure". In the future, with the maturity of direct mobile phone connection and 6G technology, Starlink will further penetrate daily life and become the core carrier of space infrastructure^{[3][4]}.

2.2 Beneficial Explorations of Galaxy Space in Commercial Satellite Development

Galaxy Space's "small steps, fast runs" strategy focuses on modular design, industrial-grade substitution, and rapid iteration. From the first-generation box-shaped satellites to the second-generation stackable flat satellites, and then to the third-generation "flying carpet satellites" with "integrated wings and arrays" (supporting direct mobile phone connection for broadband communication) under development, it has achieved the leap from single-satellite breakthroughs to constellation networking through dynamic matching of technical verification and market demand. It took the lead in establishing the "Future Aerospace Commercial Communication Satellite Technology Innovation Center" to carry out joint technological research, and made full use of national policies such as "new infrastructure" to integrate upstream and downstream resources. Its successful experience provides a "low-cost, high-frequency, scenario-driven" model for China's commercial aerospace. However, in the future, it needs to continue to make breakthroughs in large-scale applications, international layout, and ecological collaboration to cope with the dual challenges of global competition and industrial upgrading.

2.3 Spacety's Supply Chain Management Model

Spacety's concept of satellite single-machine and payload is centered on modularization, low cost, and rapid iteration. It realizes flexible configuration through satellite platform cascading and expansion, and adopts standardized interface design to achieve "plug-and-play" of payloads. Through industrial-grade substitution, open cooperation, and scenario-driven approaches, it has widely applied flexible manufacturing technologies and mass production models, achieving the leap

from technical verification to commercial operation. Its successful experience provides a model for improving product competitiveness centered on cost reduction and efficiency improvement for China's commercial aerospace. In the future, it needs to further break through mass production capacity and enhance the value of data applications to cope with the challenges of international competition and industrial chain integration.

2.4 Comparative Analysis of the Current Development Status of the Aerospace "National Team" in Commercial Aerospace

China's commercial aerospace industry is currently in a booming or even explosive state. However, in terms of business format shaping, it is still in the stage of "following foreign products and formats benchmarking against SpaceX, and focusing on domestic national investment project needs", with insufficient attention to discovering market demand and cultivating user habits. Restricted by the traditional management system and mechanism of central enterprises, the "national team" has a "task-oriented" work thinking throughout product development, paying insufficient attention to core issues such as product shaping and standard definition for the market, product design fit with user needs, iterative improvement of product performance indicators, and control and optimization of product production capacity and cost. As a result, the market competitiveness of products is difficult to improve iteratively.

At the same time, we should also note that as the "national team" has a deeper understanding of the above issues, various units are continuously strengthening support and exploration to open up the commercial aerospace market and enhance product competitiveness. In 2025, CASC launched the Commercial Aerospace Excellent Supply Platform in Hangzhou, and in-depth implemented the "3+1" Excellent Product Plan centered on excellent product development, excellent supply chain construction, excellent supply platform construction, and excellent talents, accelerating the construction of a unique commercial aerospace product system. The flexible pulse production line for commercial satellites of CASC in Tianjin has an annual production capacity of over 200 commercial satellites.

3. Analysis of Main Constraints on Improving the Competitiveness of Commercial Aerospace Products

In the development process of aerospace products, when technical or management problems occur, the "5M1E" method is often used for traceability analysis, that is, starting from six aspects: Man (personnel), Machine (equipment), Material (materials), Method (methods), Environment (environment), and Measurement (measurement), to trace the source of problems and formulate countermeasures. Take the "national team" in the design and manufacturing of commercial satellite-related products into analyze at the three main aerospace product levels of system-level products, single-machine-level products, and AIT processes^{[5]-[8]}.

3.1 Main Problems at the System-Level Product Level

(1) Man: The "national team" sets excessively high standards for personnel in terms of capabilities, qualifications, educational background, and work experience, while paying insufficient attention to practical experience in production sites. This leads to misallocation and redundancy of human resources, resulting in high costs.

(2) Machine: Testing, experimentation equipment, and tooling are developed to meet specific task requirements, resulting in poor versatility and low localization rates, which in turn lead to high costs.

(3) Material: The standards for materials used in satellites are overly strict. There is insufficient research on the feasibility and risk assessment of applying civilian-grade or consumer-grade products in satellites, leading to narrow supply channels and high costs.

(4) Method: The traditional satellite design concept is based on the fundamental thinking of "quality first, technology-led", pursuing "perfect success" and "technological breakthroughs", and treating satellites as scientific research prototypes. This leads to each satellite being a unique, flawless masterpiece, with costs increasing exponentially. This mindset cannot meet the fundamental needs of the commercial aerospace market, where satellites are regarded as market-oriented commodities and off-the-shelf products, requiring high efficiency, low cost, rapid technological iteration, and market share expansion.

(5) Environment: There is insufficient analysis and evaluation of the production and manufacturing environmental conditions required for commercial satellites from the design basis. There are few trial productions of satellites under different environmental conditions, resulting in insufficient baseline data and the lack of established environmental standards that meet the needs of commercial satellites.

(6) Measurement: The requirements for supporting guarantees in satellite development are "comprehensive and all-inclusive", based on the idea of building an aerospace city with full professional coverage, complete functions, and all test conditions. Essentially, this stems from a lack of market research and analysis, failure to make full use of rich AIT resources within the country, province, or even the group, leading to repeated investments.

3.2 Single-Machine Product Level

(1) Man: Core talents and teams with high technical proficiency and mastery of core technologies and development experience in the research and development of professional payloads such as optics, communications, and navigation are key resources pursued by various enterprises. Currently, the "national team" still has insufficient training and incentives for core talents, facing the risk of talent poaching.

(2) Machine: The core capabilities for independent implementation of key components and key processes in single-machine production and manufacturing are still inadequate. In the process of outsourcing and external procurement, there is insufficient development and cultivation of the supply chain, resulting in production schedules being restricted by the supply chain's production capacity.

(3) Material: High-precision, high-standard components are expensive and difficult to purchase. There is insufficient research, trial implementation, and determination in promoting domestic substitution and equivalent substitution of supplies.

(4) Method: The problem is the same as at the system level: the product-oriented and market-oriented thinking has not been implemented.

(5) Environment: The problem is the same as at the system level.

(6) Measurement: The testing methods and standards for single-machine payloads supporting commercial satellites are incomplete, and they still follow military product testing processes, resulting in high costs.

3.3 AIT Process Level

(1) Man: Highly skilled talents and "national craftsmen" who can take charge independently are scarce and expensive. At the same time, there is a shortage of skilled industrial workers with average skills sufficient to complete tasks, making it difficult to form efficient, collaborative, and flexibly allocated work teams, leading to low overall work efficiency.

(2) Machine: The level of automation and intelligence in the assembly, testing, and experimentation processes is low, and the ideal state of "human-machine collaboration, with machines as the main body and humans as assistants" is far from being achieved.

(3) Material: Materials used in the AIT process mainly include direct components, fasteners, and on-satellite materials. Some of these materials have not yet been centrally purchased or processed by the assembly factory, resulting in high overall costs and long supply chains.

(4) Method: The assembly process adheres to the concept of "quality first, no room for error", with excessive protection and over-protection operations, leading to low work efficiency and difficulty in reducing the weight of the entire satellite.

(5) Environment: The problem is the same as at the system level.

(6) Measurement: The problem is the same as at the system level.

3.4 In-Depth Analysis of Constraints

By organizing the above problems, we can further discuss the main constraints on improving the competitiveness of commercial aerospace products from two aspects: objective factors and human cognition.

3.4.1 Objective Influencing Factors

Objectively, due to the strong inertial constraints of successful engineering technology and project management experience accumulated over decades, the "national team" lacks effective countermeasures to meet the current commercial aerospace market's high requirements for cost and efficiency. This has led to a series of technical and management problems, such as inappropriate design, inefficient verification, inaccurate supply, and inadequate market response.

In product design, there is insufficient research and exploration of truly customer-oriented, market-oriented, and demand-oriented design paths. Instead, experiences and technical paths from military models and major engineering projects are applied, resulting in cost and efficiency black holes such as redundant design and excessive reliability.

In test verification, there is insufficient understanding of the objective conditions such as the space environment and electromagnetic environment that commercial aerospace products are exposed to, as well as insufficient research and analysis of the product's own performance characteristics. This makes it difficult to unify verification standards, leading to excessive increases in test items and higher test requirements, which are not conducive to cost reduction and efficiency improvement.

In terms of product supply chain construction, inaccurate grasp and delayed response to market demand, coupled with the lack of corresponding control measures, result in long product development cycles, rigid iteration strategies, and easily lead to inventory backlogs or supply bottlenecks.

In market response, the long-term thinking orientation of "focusing on vertical tasks and prioritizing research and development" has led to a lack of teams with keen market insight and a system of off-the-shelf products with strong market adaptability. This makes it difficult to quickly customize supporting solutions that meet user needs and have market competitiveness.

3.4.2 Issues with Human Cognition

As discussed earlier, the primary problem for the "national team" to enter the commercial aerospace industry is to, on the basis of fully investigating market demand, break away from the inherent thinking of spacecraft development and thoroughly rethink and reshape the future of the industry, development goals, and product frameworks. The experience of SpaceX in building Starlink, as well as the explorations of Galaxy Space and Spacety in the domestic market, all provide useful insights. Commercial activities must consider profits and losses, and innovative explorations should accept setbacks. Instead of aiming to develop "prestige satellites" or pursuing "perfection without any mistakes", we should quickly change our way of thinking and reconstruct the traditional satellite development process with a new development mindset centered on "free thinking, cutting-edge design, practical verification, and rapid iteration" in the Internet era. However, abandoning a proven successful path and re-exploring a commercialized and innovative development path that leads to the goal of economical and efficient development but is full of unknowns and challenges undoubtedly requires the "national team" from the leadership to the execution level to unite as one, have the determination to forge ahead, and embrace the market.

4. Basic Strategies for Improving the Competitiveness of Commercial Aerospace Products of the Aerospace "National Team"

4.1 Extreme Design

Fully promote customer-oriented design. Technical personnel and market personnel work together to carry out pre-sales consulting, fully understand customer needs, constantly iterate customer requirements, and select design schemes that meet customers' psychological expectations for price and performance. At the same time, cost control must be placed at the top of the design principles, sort out and optimize the entire process of product supporting development from an overall perspective, reduce costs, and gain market advantages. In addition, adhere to the learning and application of cutting-edge technologies, develop new design tools such as collaborative design AI, and further improve design effects.

4.2 Sufficient Verification

For the space environment and electromagnetic environment faced by commercial satellites, use existing resources, adhere to the identification thinking of high concurrency and strong traversal, conduct sufficient test verification in the early stage, drive the improvement chain of "familiarity - understanding - mastery - optimization" for the necessary test project schemes, and continuously iterate to simplify test processes and reduce identification items, thereby achieving equivalent test verification effects and reducing costs and construction periods simultaneously.

4.3 Flexible Supply

On the procurement side, refer to the practices of highly integrated and standardized industrial industries such as automobile manufacturing and mobile phone manufacturing, and promote the full implementation of the competitive VMI (Vendor Managed Inventory) procurement model based on qualified suppliers through communication and negotiation with suppliers, reducing inventory risks and improving supply chain health. On the production side, conduct sufficient pressure tests and risk countermeasure drills on the production line to ensure that the production line can stably achieve optimal efficiency output, reach peak production capacity output, and healthily achieve minimum guaranteed production capacity output, while achieving cost optimization under this production capacity strategy, so as to flexibly respond to rapid changes in market demand.

4.4 Continuous Improvement

Based on the Internet product iteration thinking and SpaceX product development thinking, promote the standardization, shelving, and consumerization of aerospace products, deconstruct commercial aerospace solutions into organic combinations of standard aerospace product modules, and promote oneself to grow into a comprehensive supplier providing a package of aerospace products including solutions, supporting products, after-sales services, and operation models. In addition, consider providing standardized DATASHEETS for the commercial aerospace market, facilitating customers to stimulate personalized and customized in-depth needs on the basis of standard solutions, and forming a positive feedback effect of mutual incentives between supply and demand parties.

4.5 Interest Convergence

Vigorously promote the integration of internal and external interests. For internal factories and institutes with market competition relations, require them to achieve technical cooperation and market segmentation through discussions and negotiations, reduce internal friction and repeated investments, find their own differentiated advantages, make up for the shortcomings of sister units, and form an interest convergence consortium in the commercial aerospace market. For external upstream and downstream suppliers and customers in the industrial chain, understand and identify

with them from the perspective of values, strengthen commercial mutual trust and risk sharing, and ultimately achieve win-win cooperation.

4.6 Team Building

In addition, sufficient attention should be paid to the construction of talent teams. The "national team" must emancipate the mind, break the shackles of "success-only theory" and "task-only theory" in the commercial aerospace field, reshape the commercial aerospace work model from the basic market characteristics of cost, efficiency, and benefit, and activate the market vitality of design, manufacturing, and management teams. Vigorously discover and cultivate dual-capable talents with both technical accumulation and market vision, provide them with platforms and space to exert their abilities and improve their skills, offer market-competitive salary packages, create a stable environment for talents to move forward without distractions, and shape simple, efficient work processes and mechanisms that avoid internal friction, so that this high-level team can exert its due high level in the commercial aerospace market.

5. Summary

The deep integration of the aerospace "national team" into the commercial aerospace market is not only an inevitable market demand but also a result of industry development. How to break the inherent disadvantages of high cost and low efficiency that have long plagued the "national team" is a key issue that we must thoroughly study and solve. Based on the concept of developing excellent commercial aerospace products of "extreme design, sufficient verification, flexible supply, continuous improvement, and interest convergence", it is expected that this paper's analysis and discussion will provide useful enlightenment for the subsequent improvement of work mechanisms and enhancement of market competitiveness of the aerospace "national team" in commercial aerospace.

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