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Research, Development, and Acquisition in China's Aviation Industry: The J-10 Fighter and Pterodactyl UAV

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Thanks in part to a revolution in research, development, and acquisition (RDA), China's long-lagging military aviation industry is finally producing modern products. Fifteen years after the J-10's successful debut flight, new literature is unveiling the project's genesis and helping to elucidate its RDA process and that of other Chinese military aircraft such as the Pterodactyl unmanned aerial vehicle (UAV). Comparing the modern RDA model with the Maoist-modern hybrid RDA model used in the J-10 elucidates changing Chinese political, organizational, and technical changes over time, as well as the J-10's transitional role in catalyzing development of China's modern military aviation RDA process. Today hard and soft innovation factors give China creative adaptation capabilities. In addition to successful development and deployment of multiple J-10 variants, one of the greatest signs of new Chinese orientation and capabilities is an emphasis on marketing the Pterodactyl, as well as a J-10 variant, for export. Such advances draw in part on progress in other fields. One source of China's recent UAV progress has been concurrent development of related support systems, such as Beidou satellites and high-speed data links.

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The J-10 fighter and Pterodactyl (Wing Loong/Yilong/Yi Long) UAV represent two major new Chinese military aviation industry products. Examining their RDA process suggests that China's indigenous systems pipeline is closing part of the gap with Russian and even U.S. systems. Development of China's industrial supply base, and consequent improvement of Chinese products, is fueled in part by foreign military sales.

The J-10, originally envisioned to be a third-generation air force fighter, is now evolving into a multi-role fourth- or fourth plus-generation fighter—a spiral development approach. Initial operational capability was declared on April 13, 2004, following completion of flight testing in December 2003; variants are in the production and maintenance phases. Multiple versions of the J-10's six variants are fielded, with first PLA Navy deliveries in 2010. Numbers per squadron are currently growing. The Pterodactyl Medium-Altitude Long-Endurance UAV has passed multiple tests since its first flight in 2007. Like a variant of the J-10, it is export-approved.

J-10 CASE STUDY

As with other defense sectors, China's military aircraft RDA system was under the "Mandatory Plan" during China's planned economy era. The state would "command" that a design task be performed, designate a department to implement, and allocate funding directly. Not until the late 1980s did China begin embracing modern defense acquisition concepts. The command to develop China's third-generation fighter (J-10) came in the early 1980s; the project was formed in the mid-1980s. While following many "Mandatory Plan" features, it was also China's first aircraft program to incorporate modern RDA approaches and indigenous efforts. The J-10's development course challenged traditional risk aversion, linked end-user needs more closely to existing design and manufacturing capabilities, and introduced design competition. The J-10 thus bridged the Mao-era and modern RDA processes.

China's military aircraft design process is divided into five stages: feasibility study, design proposal, development and engineering, design finalization, and production finalization. To this should be added production and maintenance. The General Armament Department (GAD), established in 1998, plays an important role, especially in the early stages; yet it was not in existence during the J-10 project's planning stages. Instead, the J-10 project had different early planning stages with different designated organizing and managing departments.

Another distinguishing feature of the modern RDA process is the close relationship between supplier and end-user. The technical and tactical requirements are proposed and controlled by the customer at all times, and the supplier is also directly responsible to military end-users. In the command model, by contrast, the supplier would only be responsible to the designated management agency, rather to the customer directly. This caused many problems, including products failing to meet end-users' needs, and unrealistic technical demands imposed by the designated agency.

J-10 RDA Timeline

The request to develop China's third-generation fighter came from the PLA Air Force in 1981: PLAAF Commander Zhang Tingfa proposed the idea to Deng Xiaoping, estimating that 500 million yuan would be required.In late 1981, after Central Military Commission (CMC) discussions, Deng issued the "central command." Implementation responsibility was subsequently delegated to the Defense Industry Office (DIO) and Ministry of Aviation Industry (MAI). In a sign of emerging defense industrial competition, China's three main aircraft design institutes proposed designs, albeit based on existing foreign fighter aerodynamics samples. The 601 Institute (Shenyang Aircraft Design and Research Institute) proposed a design based on the J-13 plan with an F-16-like strake-wing layout. The 320 Factory (Hongdu Machinery Factory) proposed a design with a MiG-23 and Su-24-like variable-sweep wing layout. The 611 Institute (Chengdu Aircraft Design and Research Institute, or CADRI) proposed an unconventional SAAB-37 Viggen fighter-like design based on the J-9 double-canard layout. Based on the three proposals, plan evaluations and engine proposals were implemented consecutively.

J-10 RDA Process: Innovation Capabilities

As the first fighter that China developed indigenously with limited foreign involvement, the J-10's success relied primarily on the soft innovation capabilities. Funding, technological foundation, R&D facilities, and other hard indicators remained weak.

A top-down decision-making process and vertical management hierarchy were established and applied throughout the entire RDA process. At the top level, Deng Xiaoping and the CMC were the primary decision-makers. In 1986, the CMC and State Council jointly approved the project. At the operational level, DIO, which later became the Commission for Science, Technology and Industry for National Defense (COSTIND), together with MAI, played the central role in project implementation. At the design proposal stage, they hosted major meetings to determine the aircraft and component design and engine selection. COSTIND and MAI played an active role in approving nominations and major development actions. While the two departments were at the same horizontal level in the decision-making hierarchy, the working office was in DIO, whose major responsibilities were to organize, implement, coordinate, and supervise weapon research, design, and production. A group of consultative agencies were organized at the design and proposal stage, including the PLAAF, PLA Navy, and aviation experts from various design institutes and factories who attended the evaluation meetings and gave tactical and technical inputs.

The selection process focused on Shenyang and Chengdu's models. Shenyang was then China's foremost, largest fighter design unit. Before the J-10 project was planned, Shenyang had been conducting preparatory research on the J-13, which it regarded as China's next-generation fighter. It was confident that the J-13 would be chosen as the model for China's third-generation fighter.

Chengdu was established in the "Third Line" period in which defense facilities were relocated to China's remote interior to reduce risk of foreign attack. Shenyang's J-9 design team, later renamed the 611 Institute, was thereby transferred to Chengdu in May 1970. Many members, though young, had participated in the J-7 and J-8 projects. However, the team's main knowledge accumulation came from preparatory research on the J-9 fighter, in which it used the double-canard design ultimately used in the J-10 layout.

Though both Shenyang and Chengdu had conducted pre-research on the J-13 and J-9 projects, political and technical problems stymied their advance. Yet this preparation still played an important role in the J-10 project, serving as a preparatory research stage then unknown in China's RDA process. The resulting technological foundations enabled the project to be established in only three years.

Many Chinese publications discuss competition between Shenyang and Chengdu during the J-10, and later the J-20, projects. It was the first time that competitive mechanisms were introduced into the military aircraft design system; previously models were simply assigned to specific institutes.

From the perspective of Chengdu, Shenyang, given its authoritative position, was initially assigned to design the new J-10 fighter, while Chengdu was called in to present its design at the first evaluation meeting. Chengdu maintained that its victory stemmed from using a nontraditional design that offered superior operational parameters and avoided limitations inherent in Shenyang's conservative design. From Shenyang's perspective, its failure stemmed from frequent technical problems in the J-8 program, which damaged its reputation.

Competition over the J-10 project catalyzed Chengdu's rise as a latecomer in China's aviation industry. Competition between Chengdu and Shenyang persists today regarding China's fourth-generation fighter. It has improved China's state-owned centrally planned aviation industry by injecting new ideas and stimulating design improvements through competition. On the defense RDA side, it underscores that only by clearly knowing and fulfilling the customer's needs can a supplier be successful in winning a project. This, in turn, helped implant a feasibility study stage in the contemporary RDA process.

Clearly based on adaptation of the existing designs, the J-10's similarity to Israel's Lavi has also raised suspicions of Israel involvement in its development. The memoirs of Gu Songfen, one of the J-10's designers, indirectly imply Israeli contributions.

PTERODACTYL UAV CASE STUDY

As with the J-10, China's UAV design and manufacturing system has evolved to include competition within the design system and increased linkages of end-user requirements to existing design and manufacturing capabilities. Thus far, and unlike the J-10, Chinese UAV designs are not yet challenging traditional attitudes toward risk in that they are still strongly imitative, drawing on established UAV models. The Pterodactyl UAV—likely one of China's first UAVs to be exported—illustrates each of these points. However, Beijing's ability and wherewithal to call upon existing expertise within the military aircraft design and manufacturing industry as well as in the historically civilian UAV industry has almost certainly expedited Chinese UAV development. The industries' overlap will facilitates accelerated pursuit of more innovative UAV designs.

Chinese UAV RDA Establishment, Motivation, and Successes

Since at least the early 2000s, China has prioritized UAV research and development (R&D)—consistent with Beijing's goal of military force "informatization"—with significant resulting models displayed at recent air shows. Around 2000, the General Staff Department (GSD) allegedly focused on synthesizing information warfare and the unmanned battlefield, stressing that unmanned battlefield weapons development should be prioritized. GSD's instruction was implemented by 2003, when the 863, 973, and other state technology programs listed UAV R&D as important aviation projects. This overarching organizational structure apparently persists, with GSD and GAD the national-level authorities for UAV mission requirement and policy development. Beijing by 2005 had adopted a licensing system that allows the private sector to compete for defense projects, probably in part because civilian experts in China were responsible for all known, albeit limited, UAV development between the early 1960s and late 1990s and harbored the resulting industry expertise. The state retains ultimate control over the process, however.

Integrating Competition

Beijing continues to rely on both state and private expertise to meet its UAV requirements, with UAVs researched and developed by institutes such as CADRI, under direct managment of the Aviation Industry Corporation of China (AVIC) and the Xi'an Northwest Polytechnic University ASN Technology Group Company (ASN). China is also working to integrate additional private expertise into military UAV research and development, with the results of nationwide design competitions announced at each Zhuhai Airshow, and with AVIC sponsoring a competition in late 2011 designed to solicit Chinese universities' input regarding how to use UAVs on aircraft carriers. Private industry winners of the competition, however, were from places such as ASN, which has a long record of UAV-related achievement and claims to hold 90 percent of China's UAV market.

In contrast, smaller, less-established private enterprises are unlikely to break into China's tight UAV market. China's "drone economy" works on two tiers: state-run companies, which benefit from their connections with government buyers and promoters to achieve higher domestic and international sales, and smaller private companies, which lack such connections.

Coordinating Military Requirements and RDA Capabilities

For at least several years, PLA services and UAV developers have also been coordinating organizations to facilitate cross-linkages. The PLAAF UAV Combat Lab, established in 2007, performs combat model R&D and operational training for new UAVs. The Committee on Planning for Aerial Vehicles (CPAV), established in 2006, operates with executive support from the Third Academy of China Aerospace Science and Industry Corporation (CASIC). CASIC Third Academy, China's main cruise missile research and design and manufacturing group, has been increasingly involved with UAV development since the early 1990s. CPAV includes administrative leaders and experts from the GAD, various PLA services, and numerous research institutions and institutions of higher education. This, together with prototypes unveiled at the 2012 Zhuhai Airshow, suggests that China may engage in architectural innovation by developing platforms that increasingly combine the characteristics of cruise missiles and UAVs.

Pterodactyl Market and RDA Timeline

The U.S. Predator likely inspired the Pterodactyl's visually similar design. Li Yidong, deputy CADRI chief designer, equated his organization's UAV and the Predator broadly, stating that both can conduct long-distance navigation, reconnaissance, and strike missions. The Pterodactyl is allegedly selling for $1 million USD, a quarter of the U.S. Predator's unit cost. Li claims his organization's UAV is competitive with the Predator's operating cost. CADRI also claims that the Pterodactyl is the only UAV freely being sold on the international market that can be used for both reconnaissance and strike.

The Pterodactyl, allegedly the first Chinese UAV marketed internationally, has allegedly been sold to the United Arab Emirates and Egypt. Uzbekistan is allegedly also considering a purchase. Huang Yun, previously responsible for Pterodactyl field testing and data collection, transferred departments to focus on foreign tests and air shows, indicating an export emphasis. A CADRI representative asserts that Beijing was working to exploit an opportunity created because the United States does not export a significant number of attack drones.

From the moment the project was launched in 2005 to its first publicly-reported international sale in 2011, the Pterodactyl's 5–6 year development timeline may have been expedited because of opportunity to imitate the U.S. Predator and because CADRI had already acquired significant relevant experience through J-10 RDA. Key milestones, such as the Pterodactyl's first flight in 2007, performance and payload testing in 2008, and weapons trials and achievement of export permits in 2009 likely occurred much faster than would transpire with a more innovative design or one built by an institution without CADRI's expertise. Significantly redesigned in 2010, the UAV still managed its first export sale in 2011.

CONCLUSIONS

- Leadership attention to a program can keep it focused; inattention can reduce focus and prolong development timelines. The J-10 program offers examples of both dynamics. It was initiated by the mid-1980s, but leadership attention faded in late 1980s, constraining funding. When leadership attention returned after Chinese leaders observed Operation Desert Storm technologies, the project was prioritized again and funded sufficiently.
- The J-10 benefitted from a lack of requirements creep. Technical requirements can be raised by leaders' unrealistic demands, producing serious failures and technological setbacks. This problem plagued China's aircraft industry from the late 1950s through the early 1970s.
- The J-10's basing on adaptation of existing designs signifies that adaptation requires understanding of design, and therefore increases in an industry's knowledge base. J-10 RDA helped adapt China's aviation industry supply base to developing indigenous capability.
- China's RDA process appears designed not only to bolster military aviation capabilities but also to solidify China's industrial supply base to make it

competitive with that of Russia and even the United States.

- China's efforts to engage in UAV and J-10/FC-20 foreign military sales suggests a strategic method for advancing industry supply base experience.
- Chinese organizational patterns and prototypes suggest emerging architectural innovation in combining UAV and cruise missile characteristics.

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