Strategic Study of China's Fighter Aircraft Development

Fighter Aircraft Development Validation Group, March 2003

Original credit attributed to: Academician Gu Songfen, and relevant Chinese aerospace industry and People's Liberation Army service branch inputs

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With assistance from others

Foreword from the translator:

"Strategic Study" is a Chinese language document written sometime in the late 1990s to early 2000s period, that provides one of the most comprehensive and definitive glimpses into the development of the Chinese 5th-generation fighter project that would end up becoming J-20.

As a non-classified document, readers should note that sensitive technically or operationally revealing details are likely representational (such as radar cross section targets) or wholesale omitted (such as future fleet size requirements). Furthermore, while this document likely was part of the developmental journey resulting in the J-20 5th-generation fighter, it must be noted that specific requirements, projections, and technical targets are almost certainly to have undergone revision and progression from the initial baselines described in this study. Readers are advised to keep both of these factors in mind when assessing the paper.

This document was translated to keep the meaning, formatting and spirit, as close to the original Chinese language paper as possible. A few deliberate modifications were made by the translator, including converting 2nd, 3rd, 4th and 5th generation designations used in Chinese nomenclature for fighter aircraft, to the equivalent foreign and international 3rd, 4th, 5th and 6th generations, so as to mitigate misinterpretation.

A full assessment and commentary of this study written by the translator, can be found in full, published on The Diplomat. However, this full translated document is provided free of charge, as a gesture of good faith to the community. A copy of the original Chinese language document is included afterwards, for purposes of comparison.

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8. Main Conclusions and Recommendations

Introduction:
With the goal of implementing instructions from the Central Military Commission and the General Armaments Department to carefully carry out studies, under the auspices and guidance of the General Armaments Department's Science and Technology Committee and business organs, using the General Armaments Department's aircraft general technology professional group as the basis, a group was assembled, composed of navy, air force, aviation, electronics and other departments and units as well as a number of academicians and experts, forming the Fighter Aircraft Development Validation Group. Based on the aviation science and research and technological results from the 8th-Five-Year Plan, this study, "Strategic Study of China's Fighter Aircraft Development" is produced, which examines the necessity and feasibility of the development of Chinese fighter aircraft as well as other issues. The main research findings are reported below.

1. The Military/Combat Environment Faced by China around 2020
The international situation of the first 20 years of the 21st century is likely to remain generally peaceful, with localized conflicts, overall de-escalation, local tensions, general local turmoil, and new manifestations of hegemonism and power politics, which will produce a number of real and potential threats to the security of China and China's periphery. The situation of China's aerial military struggle is very complex, and also face serious challenges.

The first is with regard to anti-China forces in the West led by a certain nation, who do not wish to see the rise of China, who will continue to promote westernization of China, seek to divide and conquer, intensify infiltration of Central Asia, and increase military cooperation with our neighbouring countries and regions, with clear intent to militarily and politically contain our country. There are also disputes over sovereignty, territory, maritime rights and interests between China and some neighbouring countries, and the possibility of armed conflict or local war cannot be ruled out.

Secondly, the development of air power in major global nations and in our neighbourhood is accelerating. In order to ensure absolute global superiority, the US military is vigorously developing the F-22, F-35 and other fifth-generation fighter aircraft, which it plans to commission in 2005 and 2010 respectively, which will then proliferate to Japan and other Asia-Pacific countries and regions. Russia is working on a new generation of fighter aircraft (sometimes called the I-21) to surpass the US F-35 in terms of performance, and is projected to be commissioned and available for export around 2010. India will participate in the development of Russia's new generation of fighter aircraft and is actively preparing to build an airborne nuclear strike force. If the Taiwan issue is not resolved around 2015, the Taiwanese authorities may expend substantial finances to purchase F-35 fighters.

2. Necessity and urgency for China's development of fighter aircraft
President Jiang Zemin stated: "In the future, our contest with the enemy in the air may become a battle of decisive importance". In the face of severe competition in the domain of aerial warfare, in order to adapt to the needs of the new military revolution, the world is rapidly updating fighter aircraft equipment and technology, and the need to accelerate the development of China's fighter aircraft has become very apparent, as well as very urgent.

(2.1) The development of fighter aircraft is an urgent requirement to adapt to the revolution of military affairs

With the rapid development of high technology and its widespread application for military purposes, a new military revolution characterized by the informatization of weapons and equipment is flourishing worldwide. Weapons and equipment are accelerating in the direction of informatization, intelligence, precision, stealth and systematization. The emergence and development of fighter aircraft is an important part of this trend and a central reflection of it. In recent years, a number of high-tech local wars have demonstrated: airpower is the primary lead and enabler in the informatized war, is employed in multiple roles and domains, as it is used to seize air superiority and sea control, form the core of electronic warfare capabilities, and plays a pivotal role in joint warfare, to the extent that it can directly determine victory or defeat in a war. Fighter aircraft have always been the focus and backbone of air power, and is the embodiment of an air force's weapons capability, quality, and informatization. Global fighter aircraft developments show over the next 30-40 years, command of the aerial battlespace will be enabled aircraft with stealth, supercruise, informatized electronic warfare systems, and beyond-visual-range combat capabilities, all in one airframe most capable of realizing the informatized characteristics of a fifth-generation fighter. This type of fighter possesses significant firepower and manoeuvrability, as well as very strong information acquisition, communication, and domination capabilities, and will be especially relevant in future informatized warfare as a mobile network node and an aerial fires node, and will be better suited to the needs of joint operations. Therefore, the urgent development of China's fifth-generation fighter can advance our nation's aerial weapons and equipment and their overall level of information technology, and adapt to the development of the new military revolution needs.

(2.2) The development of fighter aircraft is an urgent requirement to defend national security and to transform the air force into an offensive and defensive force

Looking to the future operational environment, China faces a serious threat from the United States, Russia and the fifth-generation fighters that are being dispersed to our neighbouring countries and regions. The J-10 and the J-11 will gradually become the mainstay of our combat aircraft and play an increasingly important role in the future, and with continuous improvements and modifications, the capability of the J-10 and the J-11 will be substantially improved (Table 1).

The experience of fighter development reveals that it is impossible to achieve a "generational" leap through improvements and modifications to existing aircraft, which is the basic reason for the division and replacement of fighter jets. Therefore, no matter how much J-10 and J-11 are improved in the future, they will not compete with F-22, F-35 and other fifth-generation fighters.

Table 1. Comparison of the main features of the fourth and fifth generation fighters

	Fourth generation fighters	Fifth generation fighters
Representative fighter types	F-15, F-16, Su-27, Mig-29, J-10, J-11	F 22， F-35， Russian new generation fighter
Missions	Air superiority focused, secondary strike role	Multirole, strong air superiority and strike capabilities
Stealth characteristics	Radar cross section typically 10m2, improvements up to 2m2	High stealth, radar cross section 0.1-0.3m2
Manoeuvrability	Outstanding subsonic and transonic manoeuvrability	Excellent sub, trans and supersonic manoeuvrability and post-stall manoeuvrability
Methods of attack	Beyond-visual-range engagement	Strong beyond-visual-range, multi-target engagement capability
Weapons carriage	External weapons carriage	Internal and external weapons carriage
Engines	Turbofan, thrust to weight ratio of 8, supersonic speed with afterburner but high fuel consumption	Turbofan, thrust to weight ratio of 10, supersonic speed without afterburner and low fuel consumption
Avionics	Limited integration	Highly integrated and intelligent

In order to build China's modern air force, President Jiang Zemin has repeatedly requested in recent years that the air force should strengthen the development of offensive aerial combat forces and gradually transform from a homeland air defence mission to a force capable of offensive and defensive missions. The Air Force's current and in development improved third-generation fighters and fourth-generation fighters and their future modifications cannot conduct engagements that are long-range, stealthy and supersonic in nature, restricting the mission success rate and ability to enhance its own survivability, for this reason there is also a need to develop a new generation of fighters with greater offensive and defensive capabilities.

(2.3) The development of fighter aircraft is an urgent requirement to drive the development of China's aviation equipment development and innovation capability

After more than 50 years of development, our nation's aviation industry has attained significant achievements, but relative to equipment demands and requirements, there remains a large gap compared to other nations leading in military industry. This is primarily visible from the fact that development of our country's fourth-generation fighter jets did not experience a stockpiling of a full suite of technologies from pre-research, to development. Requirements and national policy were the main factors that led research and decision-making in the past. Meanwhile, development basically depended on foreign cooperation and imports. Thus, independent development and independent innovation have yet to be fully realized.

Research for our nation's fifth-generation fighter has been carried out over two Five-Year-Plans, and significant progress has been made on key technologies. We now possess better conditions to carry out development on the basis of independent pre-research, which will promote, achieve and improve our country's ability to independently develop advanced fighter jets, and greatly reduce the gap between China's military aviation technology level and global leaders. Fifth-generation fighter aircraft utilize a large number of the latest products in the domain of aviation equipment technology, from the perspective of integration and leadership. Simultaneously, advanced technologies of fifth-generation fighter can also provide reliable technical guarantees and necessary means for the subsequent improvement of fourth-generation fighter aircraft.

(2.4) The development of fighter aircraft is a rare opportunity to narrow the gap with foreign advancements and achieve leapfrog development

China's development of fourth-generation fighters, in both technical capabilities and entry to service, were 20-25 years behind the world's advanced level (see Table 2). US fifth-generation fighters F-22 and F-35 will be commissioned around 2005 and 2010, and Russia's new generation of fighter aircraft will also be commissioned after 2010. China's fifth-generation fighter project will commence between 2005-2007, and is expected to enter service around 2020, shortening the gap between China and foreign advanced levels to 10-15 years, which is a significant advancement for our aerial warfare equipment and our aviation industry. From the current situation, the United States and Russia are still initially exploring the successor to the fifth-generation fighter, and for the immediate future, it is difficult to form a clear technical concept and program vision not to mention the launch of new development programmes, so at present we can focus on solving the technical gap of the fifth generation of fighters, which provides a rare opportunity for China's fighters to catch up with the world's advancement level.

Table 2.US, Soviet/Russian, and Chinese fourth-generation fighter introduction year

Nation	US military	Soviet/Russian military	Chinese military
Fighter type	F-15 / F-16	Su-27 /Mig-29	J-10
Introduction year	1975/ 1978	1986/1983	2003

3. The status, role, and mission of fighter aircraft in the aerial warfare hardware ecosystem

Our nation's fighter aircraft will be developed based on national conditions, military conditions, and enter service around 2020, by which time our air force would have developed its own J-10, J-11 and the service of Su-27, Su-30 and other fourth-generation fighters would have reached a considerable scale, along with a certain number of improved third-generation fighters (such as J-8F, J-7E variants, etc.), so before 2020, the air force will form a fifth-generation fighter as its backbone, with the fourth-generation fighter as the main body, and complemented by improved third-generation fighters, to form a high/low mix for a system of complementary systems.

Given the fifth-generation fighter will form the backbone of the aerial combat system, it must possess a strong dual mission capability composed of air superiority and air-to-surface strike. Its primary aerial opponent will be fifth-generation fighters, and its primary combat mission will be to carry out long distance aerial engagements, long-range stealthy penetration precision strike missions, with capability to lead third and fourth-generation fighters to perform aerial combat and air-to-surface (including maritime) missions in the area of operations.

The specific combat tasks of this fighter aircraft includes: utilizing air-to-air weapons to engage and destroy opposing combat aircraft, as well as cruise missiles, unmanned combat aircraft and other aerial weapons to seize air superiority for a campaign; to equip infrared, television, laser, radar and other precision guided munitions, to strike at targets on the ground, targets underground, targets at sea, and targets below water, and, when necessary, can carry special weapons to destroy high value enemy operational and tactical targets; utilizing general or special airborne electronic warfare weapons, to suppress enemy early warning, guidance and fire control radars, and cover other aircraft inside and outside the formation to perform informatized combat missions, to prevent enemy informatized attacks; to assist airborne early warning aircraft and ground control in achieving far-penetrating early warning, to provide targeting instructions and objective assignments, and to lead and protect other aircraft during missions.

4. The main capabilities required of China's fighter aircraft

Based on the aforementioned missions of our fighter aircraft, in order to be capable of competing with the F-22 and to hold a clear advantage over the F-35, our fighter should possess the following key capabilities.

(4.1) Possessing stealth capability comparable to the F-22

A strong stealth capability can significantly reduce the distance at which combat aircraft can be detected and significantly improve the effectiveness of one's aircraft in air combat. In a calculation of combat effectiveness between two opposing fighters, consider an enemy fighter with a forward radar cross-sectional area (RCS) of 2m2, intercepted by one of our fighters of equal RCS, and consider the difference in combat effectiveness when the RCS of our fighter is reduced to 0.1m. The aerial combat effectiveness will be increased by 4 times, as shown in Figure 1.

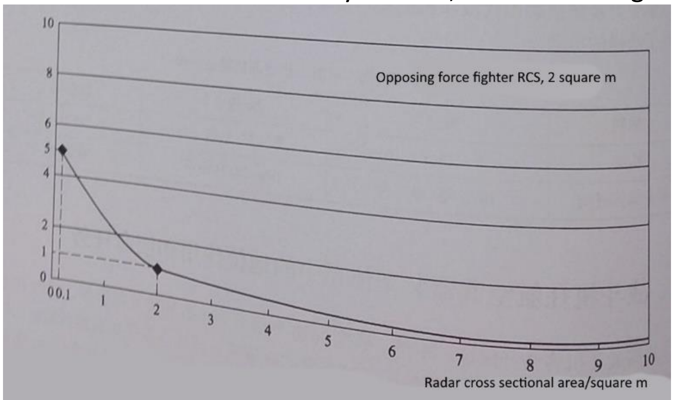

Figure 1. Simulation of the effect of changing the radar cross-sectional area and its result on the effectiveness of beyond visual range aerial combat

The use of stealth technology in combat aircraft can enhance the surprise of an air-to-surface (maritime) strike, significantly enhancing the survivability of the aircraft. Figure 2 compares a fourth-generation fighter conducting a JDAM strike mission against a surface to air missile system, to that of a fifth-generation fighter. At launch range of the JDAM, the non-stealth fourth-generation fighter would be within the effective range of the SAM system, thus posing great threat to its survival. By contrast, the fifth-generation fighter would remain outside of the SAM system's effective range when launching its JDAM, providing it with significantly better prospects of safely disengaging.

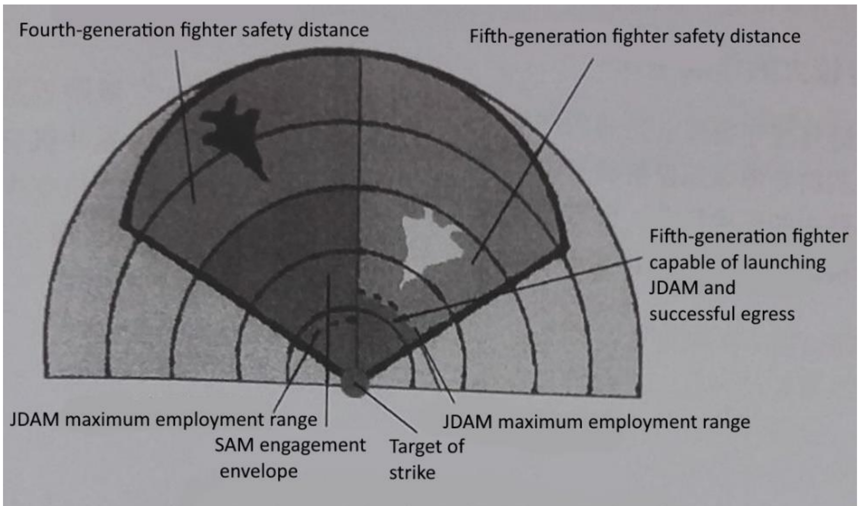

Figure 2. Illustration of survivability of a stealth strike mission by a fighter aircraft

(4.2) Possessing engines capable of supercruise without afterburner

Supersonic flight can increase the kinetic energy of a fighter's aerial missiles during initial launch, effectively expanding the missile's engagement envelope. Fourth-generation fighters generally operate at subsonic speeds and egress at supersonic speeds, while fifth-generation fighters have the ability to cruise at supersonic speeds without utilizing afterburner, and can operate at both subsonic and supersonic speeds, resulting in significantly improved aerial combat effectiveness, as shown in Figure 3. Figure 3 displays the combat effectiveness ratio of a friendly aircraft against a hostile aircraft at different airspeeds. Assuming the hostile aircraft maintains Mach 0.9, the graph shows that as the friendly aircraft increases its airspeed to Mach 1.7, its relative combat effectiveness vis a vis the hostile aircraft triples. Supercruise also greatly decreases transit time of friendly assets and enhances the ability to penetrate defences.

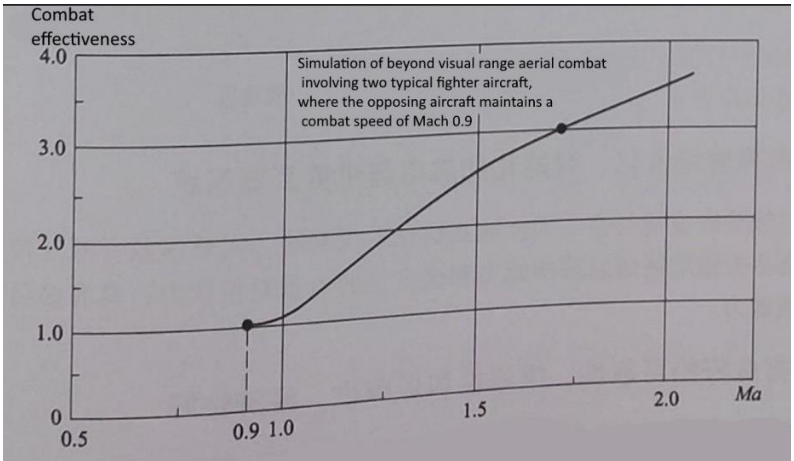

Figure 3. Effect of altering combat speed on combat effectiveness during an air-to-air engagement

(4.3) Possessing superior manoeuvrability

Subsonic manoeuvring can enhance the close combat capability of fighter aircraft in aerial combat. The fifth-generation fighter should possess a subsonic manoeuvring capability that is no less than that of fourth-generation fighters. Supersonic manoeuvring can enhance the beyond visual range combat capability of a fighter aircraft, as well as significantly reduce the enemy's missile engagement envelope and increase egress capability, and is an important measure for fifth-generation fighter fighters to enhance their operational effectiveness.

(4.4) Possessing a large operational radius

The first island chain is a choke point and strategic barrier to our maritime traffic, and the sea and airspace of island chain are potential positions where the US military may launch long-range precision strike weapons such as cruise missiles against our nation. Our fifth-generation fighters should be capable of supporting our navy’s future operations within the island chain, but also capable of carrying out operations and conducting air strikes independently in the island chain. Our fighters should be capable of operating over most of the surrounding countries' capitals and other important targets without aerial refuelling, and should possess the range to operate over the entirety of Japan’s islands after one refuelling, see Figure 4.

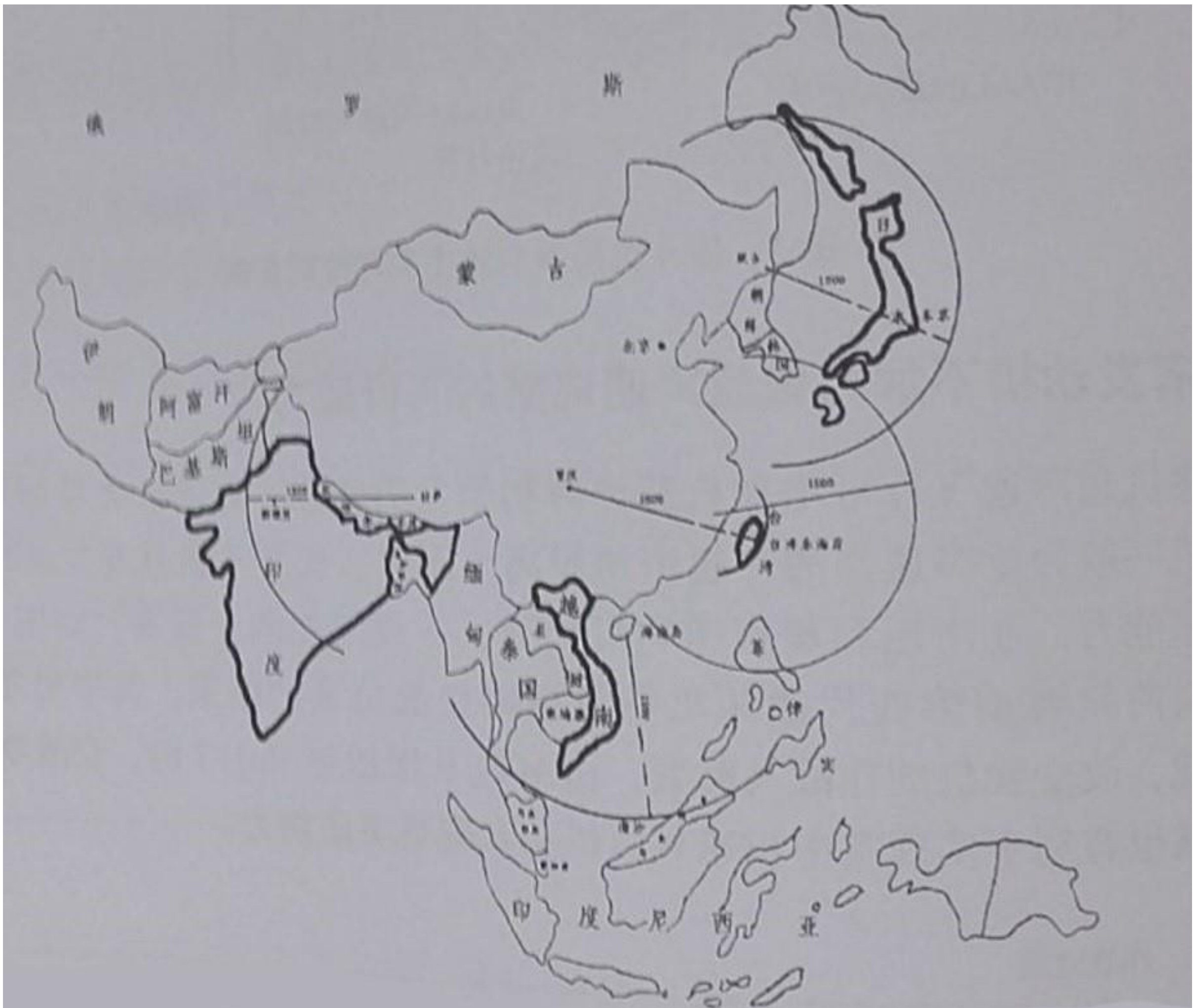

Figure 4. Areas of operations our nation’s fifth-generation fighter can operate over

(4.5) Possessing a highly integrated, intelligent avionics and airborne weapons system

The fifth-generation fighter must be capable of networking with air, space and ground-based information systems to achieve mutual transmission and sharing of information resources, capable of conducting combat in a joint manner; possess multi-directional sensor and information capabilities over the battlefield and comprehensive electronic countermeasures; it must possess multi-target engagement and multi-aircraft cooperative combat capabilities.

(4.6) Possessing good reliability, maintainability and security, good economy

Our fighter should possess short mission preparation times, and possess low operational maintenance costs. Efforts should be made to reduce support equipment to improve mobile deployment capabilities. Attention should be paid to the full life cycle of the aircraft, to make the acquisition and use of the aircraft economically affordable.

5. Development of China's fighter aircraft

(5.1) Guiding Principles

(1) Based on independent innovation, independent development, according to national conditions, actively carry out advanced technology cooperation with foreign countries, to achieve leapfrog development.

(2) Insist on pre-research first, reduce technical risks, and take the road of independent development from pre-research to model development.

(3) Strictly control development funds and production costs, and strive to achieve an aircraft that is “affordable as well as useable".

(4) Seek to develop one aircraft, with multiple roles, multiple models, that is adaptable to different combat responsibilities.

(5.2) Overall Ideas

Through the innovative design and development of a comprehensive aerodynamic layout and the development of a turbofan engine with a thrust to weight ratio of 10, the aircraft will achieve radar stealth, be equipped with supersonic cruise capability, and be capable of post stall manoeuvring and performance.

Through a sensor configuration including microwave, infrared, and visible light modalities with active phased array radar as the primary sensor will achieve an integrated and multifunctional sensor capability, the aircraft will attain a highly integrated avionics architecture, and with the development of associated weapons systems, the aircraft will be equipped with strong within-visual-range engagement, beyond visual range engagement, and multi-target engagement capabilities, as well as electronic countermeasures capabilities.

By inheriting mature electromechanical systems technologies and material technologies, using digital design and manufacturing technologies, shortening the development cycle, and reducing development risks, reducing development costs, a fighter aircraft will be developed for our nation to meet future operational needs.

(5.3) Preliminary programme concept

Through pre-research of key technologies for fifth-generation fighters conducted since the 8th-Five-Year Plan, and by comprehensively considering the current situation of our nation’s aviation, electronics and other industries and the possible development levels in the next few years, it is envisaged that the preliminary plans of our country's fifth-generation fighters are as follows.

(1) Employ an advanced overall aerodynamic layout with high lift, low drag and high stealth. Based on results of current pre-research, the maximum lift coefficient of the scheme can reach 2, which is about 30% higher than that of fourth-generation fighters. The zero-lift drag coefficient of

supersonic cruise is below 0.035, which is about 15% lower than that of fourth-generation fighters, the forward aspect (+/-45 degrees) radar cross-sectional area is under 0.3m2, which is about 2 orders of magnitude smaller than fourth-generation fighters.

(2) Employ two low bypass ratio afterburning turbofan engines each with a thrust-to-weight ratio of 10. The full power afterburning test bench thrust of each engine will be in the 15000kgf level, with a bypass ratio of about 0.25, and overall pressure ratio of 25-26. Pre-turbine temperature is 1800K. Primary technological targets will be qualitatively higher than those of the Su-27's powerplant, Al-31.

(3) Increase the use of lightweight structural materials such as titanium alloys and composite materials. The body structure should utilize about 25% advanced composite materials, about 25% titanium alloy, 10%-15% for aluminium-lithium alloy, and 30%-35% for other materials (ultra-high-strength steel, high-strength and high-toughness aluminium alloy). This allows the structural weight of the airframe to be about 10% lower than that of a fourth-generation fighter.

(4) Be equipped with an active phased array radar and an open-structure avionics system. The target tracking range should be 200km and can track 20 targets simultaneously, and can simultaneously engage multiple targets. Compared to a fourth-generation fighter, the detection range will be doubled. The radar combines with multiple sensors of the avionics system to achieve and manage sensor fusion, and provide pilots with battlefield situation awareness, stealthy communication capabilities, and the capability to provide intelligent combat support. The use of integrated electronic warfare systems can significantly improve the operational effectiveness and survivability of the aircraft.

(5) The electromechanical system should seek to utilize equipment that is mature or proven on fourth-generation aircraft, with emphasis on miniaturization, integrated management, reducing the extent of equipment requiring improvement, to reduce costs and reduce the risk of flight tests. The initial concept implements a centralized management system as the core feature, and utilize redundant general processors for advanced comprehensive management of power, hydraulics, fuel, environmental control, and life support systems.

(6) Be equipped with medium and long-range fire and forget missiles, and within-visual-range air-to-air missiles with high off boresight with high G loading. Air-to-air missiles will be mounted internally, while ground-attack weapons will be primarily mounted externally.

(5.4) Estimated development schedule and costs

Based on the Air Force's urgent requirements for fighter aircraft, in conjunction with the state of progress of pre-research of key technologies in the 10th-Five-Year Plan, after some assessment, if the fifth-generation fighter project can be established in 2006-2007, it can optimistically be commissioned into service around 2019-2020. A hypothetical development schedule is shown in Figure 5.

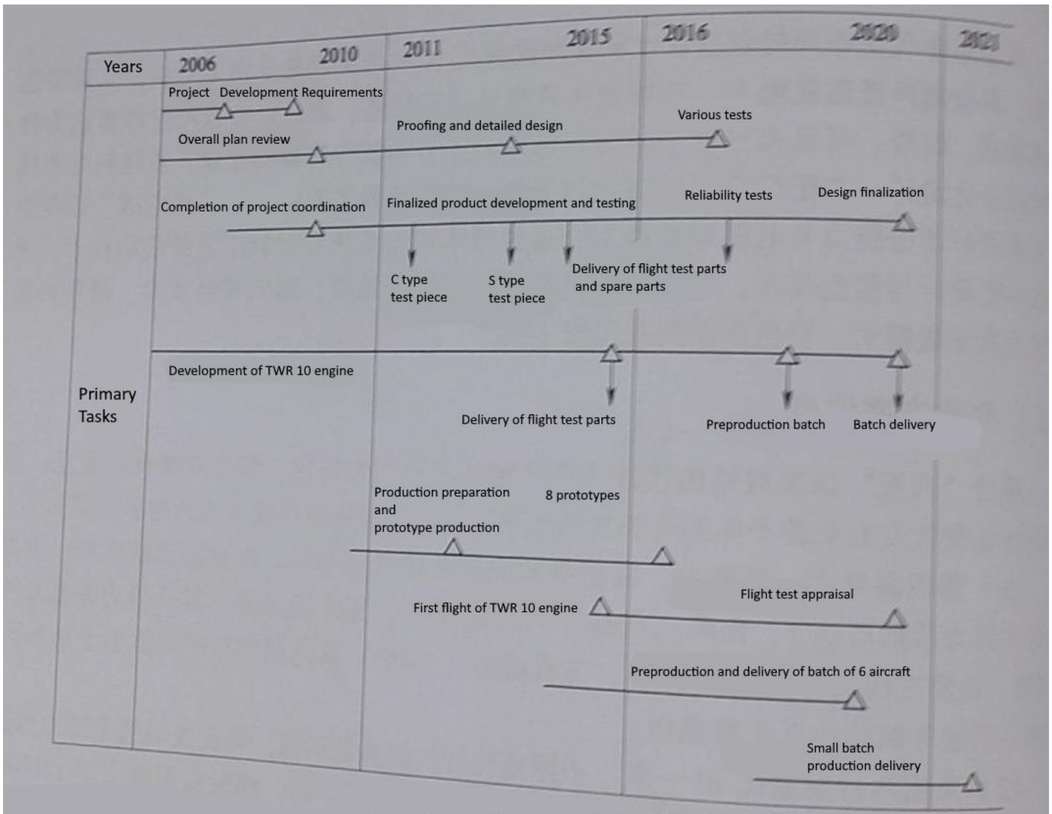

Figure 5. Projected Development Schedule

Based on the analysis of China's future airpower requirements for large-scale operations and funding availability, the Air Force will initially need xxx fifth-generation fighter jets by 2040.

Using the J-10 and J-11 program costs as a baseline, the preliminary estates of the cost of a fifth-gen fighter program amounts to 37.1 billion yuan including the manufacture of eight prototypes and six pre-production airframes, in 2002 yuan.

Among them, aircraft body development costs are about 20-billion-yuan, engine development costs are about 6-billion-yuan, airborne electronic equipment development costs are about 7.5-billion-yuan, and airborne weapons development costs are about 3.6 billion yuan.

This cost is roughly equivalent to the sum of the development and introduction costs of the fourth generation J-10 and J-11 fighters. The aircraft’s unit price is estimated at 450-500 million yuan, slightly higher than the 35 million U.S. dollars of the Su-27.

Considering the significant improvement of technical integration in fifth-generation fighters, the aircraft’s combat effectiveness is superior to that of fourth-generation fighters.

6. Technical feasibility of developing a fighter aircraft

Since the 8th-Five-Year Plan, China has carried out background research and development of fifth-generation fighter aircraft, started pre-research of the engine with a thrust to weight ratio of 10, concurrently proceeded on necessary cooperation with Russia, as well as made essential breakthroughs in many important key technologies, and intensified preliminary research during the period of the 10th-Five-Year Plan, all of which have laid a good foundation for the development of the fifth-generation fighter aircraft.

(6.1) Airframe Design Technology

The design of the airframe should ensure a good platform for the fifth-generation fighter's long-term development. The fifth-generation fighter will possess a life cycle of 40-50 years, and its engines, airborne equipment and weapons will retain great potential for upgrades. However, the fuselage holds less capacity for improvement due to the innate characteristics of the airframe. Therefore, during the period of the 8th-Five-Year-Plan heavy focus was placed to advance the key problem of the technology and design for the fuselage. Through the comparison of dozens of proposals and the study and refinement of a multitude of options, we conducted a large number of aerodynamic wind tunnel tests and microwave anechoic chamber stealth tests, thus meeting our design requirements. Through the above research, we have mastered the comprehensive design technology for the general layout of the fifth-generation fighter, with the ability to design an airframe structure with high stealth, low supersonic drag, high subsonic lift and a significantly lower weight coefficient compared to fourth-generation fighters. After further detailed research work during the 10th-Five-Year Plan, we can provide a number of configurations for the fifth-generation fighter that feature the required capabilities of supersonic cruise, stealth and high manoeuvrability for project selection.

(6.2) Engine technology

Through the development of the "Taihang" engine for J-10 and J-11, China has basically mastered the technological development of turbofan engines with a thrust-to-weight ratio of 8, and from the 9th-Five-Year Plan period, began to conduct pre-research for engines with a thrust-to-weight ratio of 10 for the fifth-generation fighter, of which the most crucial point of focus was technology for the core engine. Technical design of the engine core has already been completed and its high-pressure compressor performance has been tested and verified, basically meeting design specifications, while the main combustion chamber and high temperature turbine are currently in testing, and the development of the core engine is expected to meet qualifications before the end of the 10th-Five-Year Plan. If development continues as planned, it is expected that the engine will be available for test flight verification for the fifth-generation fighter around 2015. Prior to this, the aircraft platform can be validated by using the mature "Taihang" engine in order to reduce risks that would be present when flight testing new airframes and new engines simultaneously.

(6.3) Avionics Systems

After the development and production of fourth-generation-fighter aircraft, we have basically mastered technology of integrated avionics systems. Throughout the period of the 8th-Five-Year Plan, we have focused on key technologies such as avionics system structure, phased array radar, high-speed fibre optic bus, integrated data processor, multi-target engagement, data fusion, and liquid crystal displays, etc. By the end of the 10th-Five-Year Plan period, we can provide avionics systems that fulfil requirements for fifth-generation fighters, which will continue to be improved upon, based on future technological advancements, to enhance performance.

(6.4) Flight Control Systems

Through years of pre-research on active flight control technology and the development of the J-10 aircraft, we have fully mastered the design and manufacturing technology of advanced flyby-wire flight control systems, which can meet the design needs of the fifth-generation fighter's flight control system. The pre-research conducted during the period of the 10th-Five-Year Plan, have adequately prepared us for the design of a fifth-generation fighter's flight control system that integrates firepower, flight and thrust.

(6.5) Electromechanical Systems

Mature technology and completed products developed for fourth-generation fighters will be used as the basis for work for integration and miniaturisation.

(6.6) Air-to-air missiles

The proposed design of the PL-12 advanced medium-range air-to-air missile, and the demonstration design of the fifth-generation within-visual-range air-to-air missile and long-range air-to-air missile, can proceed, ahead of the development of the fifth-generation fighter's development schedule. This will provide a medium-range air-to-air missile and fifth-generation within-visual-range air-to-air missile that can be readily available.

In summary, by the end of the 10th-Five-Year Plan, the fighter's pre-research work will have made major breakthroughs. Therefore, from a comprehensive technical point of view, initiating the project development of the fifth-generation-fighter aircraft in the 11th-Five-Year Plan is entirely feasible. The domains of development schedule that carry a degree of risks include the thrust-to-weight ratio 10 engine, and the active phased array radar. Although there has been consideration for a step-by-step implementation and risk reduction plan, overall, this does not seriously affect the development of the fifth-generation fighter. If we can increase our efforts to tackle these two key technologies as soon as possible, the development of the fifth-generation fighter will be smoother.

7. Consideration of Several Important Issues

(7.1) The relationship between China's fourth-generation fighters and fifth-generation fighters

In addition to introducing the Su-27 and Su-30 aircraft, China's development and production of the fourth-generation fighters includes plans to finalize the design of the J-10 this year, while the Su-27 production line has been completed and has begun mass production, and the fully indigenized J-xxx is under development. Considering the service life of a standard fighter aircraft is 30 years, by 2020 when China's fifth-generation fighter enters service, the first production airframes of J-10, J-11 and other fourth-generation fighters will have served for at least 10 years. Those airframes produced later will still have nearly 30 years of service life. Therefore, over the next 20-40 years, fifth-generation fighters will be used in conjunction with fourth-generation fighters. This mix of high and low is fully consistent with our national and military situation, and also with the development of military aircraft. At the same time, it should be pointed out that the development concept of using improved fourth-generation fighters as a substitute for fifth-generation fighters is not technically optimistic nor economical, and in the long run will delay the construction of airpower, and delay the advancement of aerospace technology.

(7.2) The relationship between fighter aircraft and unmanned combat aircraft

Unmanned combat aircraft are a product of scientific and technological developments of the information age, and have become one of the current hot spots in the field of military aviation research. The United States' X-45A and X-47A research aircraft have begun test flights. According to their research plans, after 2010, there may be clear prospects for the use of mixed formations of unmanned combat aircraft and fifth-generation fighters. Our nation has also set up a project in the "National Security Major Fundamental Projects" plan to carry out research on the basic technology of unmanned combat aircraft systems. However, it must be noted that the actual use of unmanned combat aircraft must be supported by a relatively complete integrated information network, and the current unmanned combat aircraft under active development are not considered to be sixth-generation fighters. Therefore, prematurely pursuing development of unmanned combat aircraft as a substitute for fifth-generation fighters is an unrealistic prospect. On the contrary, such a pursuit will not only make us unable to realize leapfrog development against our competitors, but will also delay our development.

(7.3) Regarding the question of engines

After preliminary analysis, the pre-research and development schedule of the thrust-to-weight ratio 10 class engine may lag behind the airframe platform. It is anticipated that an engine transition plan will be necessary, to use what will be by then a relatively mature "Taihang" engine or its improved version. That is to say, the fifth-generation fighter power system needs to take a two-step approach; the first step would be to utilize and integrate "Taihang" or its improved version to verify the performance of the aircraft platform and its systems: the second step would be to commission the fifth-generation fighter after the thrust-to-weight ratio 10 engine is finalized.

(7.4) Consideration of heavyweight versus lightweight fighters

Fighter development practice has demonstrated that when using the same propulsion unit, the payload capacity of twin-engine heavyweight fighters as well as its ability to perform combat tasks will be superior to single-engine lightweight fighters, but will entail higher unit costs than that of lightweight fighters. We believe our nation should first focus on the development of a heavyweight fighter aircraft. This is based on air force requirements for the fifth-generation fighter to possess strong air superiority and long-range precision strike capabilities, which is capable of competing with F-22 and possess obvious advantages over F-35, which will require a heavyweight fighter to achieve. Furthermore, key pre-research of aircraft technologies carried out during the period from the 8th-Five-Year Plan to the 10th-Five-Year Plan were all been conducted based on twin-engine heavyweight fighter configurations, possessing more favourable circumstances for development.

8. Main Conclusions and Recommendations

The development of our nation’s fifth-generation fighter aircraft is a requirement of national security and military competition, a requirement for responding to military changes, and a requirement for achieving leapfrog development of Air Force equipment and our aviation industry. The fifth-generation fighter aircraft occupies an important position and role in China's future aviation weaponry system. The fifth-generation fighter and the fourth-generation fighter will possess a high-low relationship, and will complement each other with unmanned combat aircraft in the future. The fifth-generation fighter should be able to compete with the F-22 and possess notable advantages over the F-35. It should possess long-range, stealth penetration and precision attack capabilities, good supersonic performance, strong capabilities in beyond-visual-range air combat, close air combat, electronic warfare, and the ability to perform multiple missions. Based on pre-research during the period from the 8th-Five-Year Plan to the 10th-Five-Year Plan, our nation has achieved the basic conditions for developing the fifth-generation fighter jets.

It is recommended that the fifth-generation fighter should be developed at the beginning of the 11th-Five-Year Plan, and strive to finalize the design by 2020.

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我国战斗机发展研究

（战斗机发展专题论证组，2003 年 3 月）

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为贯彻落实中央军委和总装备部首长关于要认真开展我国战斗机发展论证的指示精神，在总装科技委及业务主管机关的主持和指导下，以总装备部飞机总体技术专业组为依托，组成了有海军、空军、航空、电子等部门和单位的多位院士、专家参加的战斗机专题论证组，在《我国战斗机发展战略研究》及“八五”以来航空科技预先研究成果的基础上，就发展我国战斗机的必要性和可行性等问题进行了深入研究。现将主要研究意见报告如下。

一、2020年前后面临的作战环境

21世纪前20年，国际形势仍是总体和平、局部战乱，总体缓和、局部紧张，总体稳定、局部动荡，霸权主义和强权政治有新的表现，影响我国周边安全的现实威胁和潜在因素依然存在，我国空中军事斗争形势十分复杂，也面临严峻挑战。

一是以某国为首的西方反华势力不愿看到中国崛起，将继续对我推行西化、分化战略，加紧对中亚地区的渗透，增强与我国周边国家和地区的军事合作，政治上和军事上防范我国的意图明显。我国与周边一些国家和地区还存在主权、领土或海洋权益争议，爆发武装冲突甚至发生局部战争的危险性不能排除。

二是世界主要国家和我国周边地区空中力量正在加速发展。美军为确保全球绝对优势，大力发展F-22、F-35等第四代战斗机，计划分别从2005和2010年起装备其本国军队，并将扩散到日本等亚太国家和地区。俄罗斯正抓紧研制其新一代战斗机（有称Ⅰ-21），力求在性能上超越美国的F-35，计划2010年前后全面换装并外销。印度将参与俄罗斯新一代战斗机研制，并积极筹建空中核打击力量。如果在2015年前后，台湾问题尚未解决，台湾当局有可能斥巨资购买F-35战斗机。

二、我国发展战斗机的必要性和紧迫性

江泽民主席指出：“未来我与敌人在空中的较量，可能成为具有决定意义的较量。”面对严峻的空中军事斗争形势，为适应发展中的新军事变革需要，世界战斗机领域的装备与技术正在快速更新，当前加快发展我国战斗机的需要已变得非常明显，也十分紧迫。

（一）发展战斗机是适应新军事革命的迫切需要

随着高新技术的飞速发展以及在军事领域的广泛应用，一场以武器装备信息化为代表的新军事革命正在全球蓬勃兴起。武器装备正向着信息化、智能化、精确化、隐身化、系统化的方向加速发展。战斗机的出现和发展是这一趋势的重要组成部分，也是其集中反映。近几年来的多次高技术局部战争表明：在信息化战争中，空中力量首当其冲，全程使用，是夺取制空权、制海权、制电磁权的核心力量，在联合作战中具有举足轻重甚至直接制约战争胜负的作用。战斗机历来是空中力量的重点和中坚，也是一个国家空军武器装备能力、水平和信息化程度的集中体现。世界战斗机发展表明，

在未来30~40年内，主导战场天空的将是集隐身、超声速巡航、智能化航电系统和超视距攻击于一身，最能体现信息化兵器特征的第四代战斗机。这种战斗机有很强的火力和机动性，也有很强的信息获取、传递和支配能力，将是未来信息化战争的机动网络节点和空中火力点，能更好地适应联合作战的需要。所以，抓紧发展我国的第四代战斗机，能带动我军航空武器装备整体信息化水平的提高，是适应新军事革命发展的需要。

（二）发展战斗机是保卫国家安全和实现空军向攻防兼备转型的迫切需要

综观未来的作战环境，我国面临着美国、俄罗斯及其向我周边国家和地区扩散的第四代战斗机的严重威胁。我自主发展的歼10和引进并国产化的歼11等第三代战斗机将逐渐成为我军的主力机种，发挥越来越大的作用，而且随着不断改进改型，其作战能力还会有较大幅度的提高。但歼10和歼11毕竟是第三代战斗机，其主要特征与第四代战斗机有着质的差异（见表1）。

战斗机发展的经验揭示，战斗机不可能通过改进、改型实现“代”的飞跃，这也正是战斗机分代和换代的基本缘由。所以，不管未来歼10和歼11如何改进、发展，仍不足以与F-22、F-35等第四代战斗机相抗衡。

表1　第三代与第四代战斗机的主要特征对比

	第三代战斗机	第四代战斗机
典型机型	F-15、F-16、苏-27、米格-29、歼10、歼11	F-22、F-35、俄新一代战斗机
使命任务	空战为主，兼顾对地	多功能，空战及对地攻击能力均强
隐身	雷达截面积一般在$10m^2$，通过隐身改进可到$2m^2$	高隐身能力，雷达截面积为$0.1\sim0.3m^2$
机动性	突出亚、跨声速机动能力	优越的亚、跨、超声速机动能力和过失速机动能力
攻击方式	有超视距攻击能力	有强的超视距、多目标攻击能力
武器携带	靠外挂增大武器装载量	武器以内埋式为主，也可外挂
发动机	推重比8一级涡扇发动机，开加力能超声速飞行，油耗高	推重比10一级涡扇发动机，不加力可超声速巡航，油耗低
航空电子	初步综合	高度综合化、智能化

为建设我国现代化的空军，近年来江泽民主席多次要求，空军要加强空中进攻作战力量建设，逐步实现由国土防空型向攻防兼备型转变。空军现役及在研的第二代改进型飞机和第三代战斗机及其今后的改型都不能实现远程、隐身和超声速攻击，制约

了突防成功率和自身生存力的进一步提高，为此也迫切需要发展攻防能力更强的第四代战斗机。

（三）发展战斗机是带动我国航空装备研制和创新能力发展的迫切需要

我国航空工业经过 50 多年的发展，取得了重大成就，但与空军装备建设的需求相比还有较大差距。主要表现在我国第三代战斗机的发展并未经历由预研到研制的充分技术储备过程，需求因素和国家政策因素是当年推动研制决策的主要因素，研制也基本采用对外合作或引进的方式，没有完全实现自主发展和自主创新。我国第四代战斗机预先研究已开展了两个五年计划，各项关键技术都取得了较大进展，现在我们有较好的条件在自主预研的基础上进行型号发展，推动并实现这样一个过程无疑将极大地提高我国自主研制先进战斗机的能力，大大缩小我国军用航空科技水平与世界先进水平的差距。第四代战斗机采用了大量目前世界航空装备技术领域的最新成果，起着集成和“龙头”的带动作用。同时，第四代战斗机的先进技术也可为第三代战斗机的继续改进提供可靠的技术保证和必要的技术手段。

（四）发展战斗机是缩小与国外先进水平差距和实现跨越式发展的难得机遇

我国在第三代战斗机研制方面，无论是技术能力还是装备时间都落后于世界先进水平 20 ~ 25 年（见表 2），美国第四代战斗机 F－22 和 F－35 将分别于 2005、2010 年前后装备部队，俄罗斯的新一代战斗机也将于 2010 年后装备部队。若我国的第四代战斗机在 2005—2007 年立项，则有望在 2020 年前后装备部队，那时我国与国外先进水平的差距将缩短为 10 ~ 15 年，这对我军航空武器装备和我国航空工业来说都是一个实实在在的跨越。从目前的情况看，美、俄对更长远的第四代战斗机后继机尚在探索，短时间内难以形成明确的技术概念和方案设想，更未启动新的研制安排，因此当前我们可以集中力量解决第四代战斗机的技术差距，这为我国战斗机迎头赶上世界先进水平提供了难得的机遇。

表 2　美、苏/俄、中第三代战斗机装备时间

国别	美空军	苏/俄空军	我空军
机型	F－15/F－16	苏－27/米格－29	歼 10
装备部队时间	1975 年/1978 年	1986 年/1983 年	2003 年

三、战斗机在航空武器装备体系中的地位作用和使命任务

我国战斗机将结合国情、军情，瞄准 2020 年前后的作战环境开展研制，届时我空军有自研的歼 10、歼 11 及引进的苏－27、苏－30 等第三代战斗机并达到相当规模，同时还有一定数量经过改进的第二代战斗机（如歼 8F、歼 7E 改等），因此在 2020 年前后的一个时期内，空军将形成以第四代战斗机为骨干、以第三代战斗机为主体、以改

进的第二代战斗机为补充的高低搭配、系统配套的装备体系。

鉴于第四代战斗机在航空武器装备体系中的骨干地位，必须具有较强的制空和制地双重任务能力。它的主要作战对手是敌第四代战斗机，主要作战使命是执行远程截击、远程隐身突防和精确打击等作战任务，能带领第二、第三代战斗机，在作战区域内遂行空战和对地（海）攻击任务。

战斗机的具体作战任务是：使用机载空战武器拦截和打击敌作战飞机、巡航导弹、无人作战飞机等空装兵器，夺取战役制空权；配挂红外、电视、激光、雷达等精确制导弹药，对地面、地下、海上、水下的目标实施攻击，必要时可携带特种武器摧毁敌重要战役、战术目标；使用通用或专用的机载电子战武器，压制敌预警、制导和火控雷达，掩护编队内外其他飞机遂行信息作战任务，防范敌信息武器攻击；辅助空中预警机、地面指挥机构实施探测预警、目标指示和任务分配，带领和保护其他飞机遂行作战任务。

四、我国战斗机主要能力要求

根据前面提到的我国战斗机使命任务，为能与 F－22 战斗机相抗衡，并对F－35 有明显优势，我战斗机应具有以下主要能力。

（一）具有与 F－22 相当的隐身能力

在制空作战中，较强的隐身能力可显著缩短作战飞机被发现的距离，大幅度提高飞机的空中作战效能。我们做过双机对抗的作战效能演算，设想敌一架前向雷达截面积（RCS）为 $2m^2$ 的战斗机，遭到我一架战斗机拦截，对我机的不同前向 RCS，分别进行超视距空战仿真，结果当我机 RCS 减小到 $0.1m^2$ 时，空战效能将提高 4 倍，如图 1 所示。

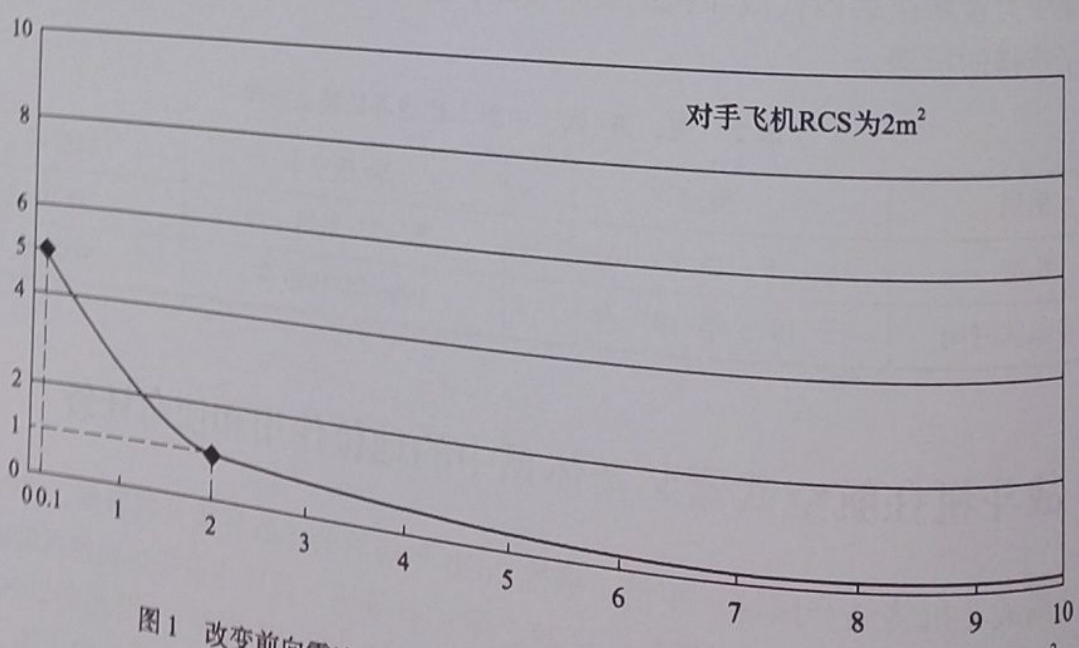

图 1　改变前向雷达截面积对超视距空战效能影响的仿真结果

作战飞机使用隐身技术，在对地（海）攻击中，可显著增强攻击的突然性，大幅度提高飞机战场的生存率。图 2 为两种战斗机对地攻击模拟示意图，表示的是要攻击一个防空导弹系统，若投放卫星制导炸弹（JDAM），用没有隐身能力的第三代战斗机则已进入对方防空导弹系统的杀伤区，飞机生存受到重大威胁。而第四代战斗机隐身性能好，可以逼近发射 JDAM，能实现有效攻击并安全脱离。

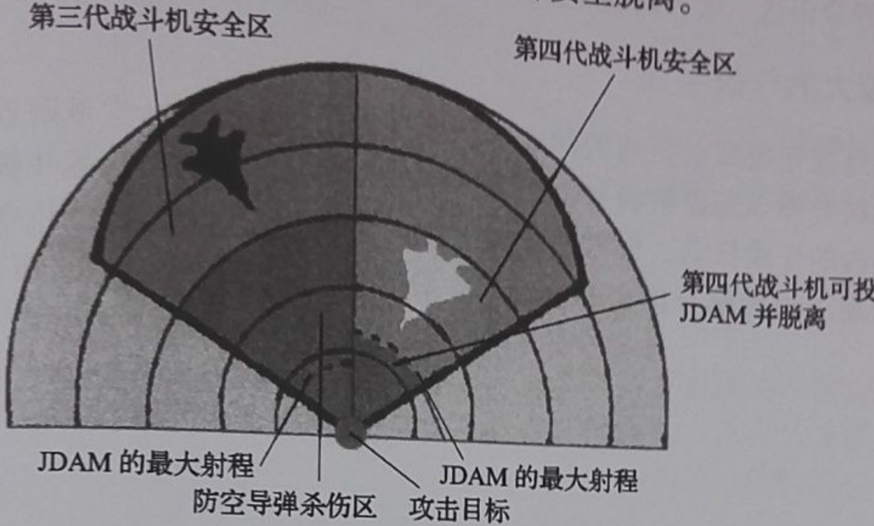

图 2 战斗机隐身对攻击生存性的影响

（二）具有发动机不加力做超声速巡航的飞行能力

作战飞机超声速飞行可增加机载导弹初始发射动能，有效扩大导弹攻击包线。第三代战斗机一般为亚声速作战、超声速脱离，而第四代战斗机具有发动机不开加力的超声速巡航能力，亚声速和超声速均可作战，空战效能明显提高，如图 3 所示。图 3 表示的是对两架典型第四代战斗机做超视距空战仿真的结果，其中对手飞机保持以 *Ma*0.9 作战，改变我机的作战马赫数，由 *Ma*0.9 增加到 *Ma*1.7 时，空战效能提高 2 倍。超声速巡航也有利于实现空中快速兵力机动和提高突防能力。

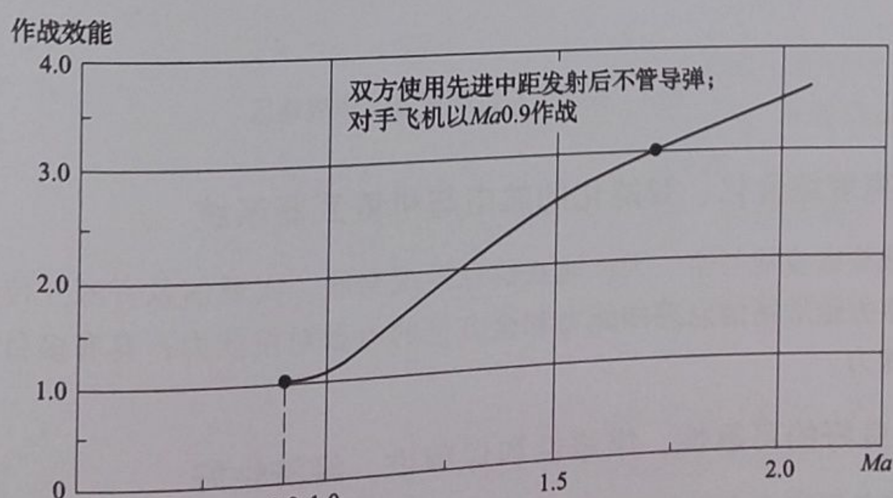

图 3 改变空战飞行速度对作战效能影响的仿真结果

（三）具有优越的机动性能

战斗机亚声速机动可有效提高飞机空战的近距格斗能力，第四代战斗机应具备不低于第三代战斗机的亚声速机动能力。超声速机动可有效提高飞机的超视距作战能力，可明显缩小敌导弹攻击区，增大我机摆脱距离，是第四代战斗机提高作战效能的重要措施。

（四）具有较大的作战半径

第一岛链是扼守我海上交通的咽喉和战略屏障，该岛链海、空域附近是美军可能对我空袭的巡航导弹等远程精确打击武器的发射阵位。我国第四代战斗机应能掩护海军未来在岛链内的作战行动，也可单独在岛链内实施空袭作战。战斗机空中不加油作战半径应可覆盖周边大部分国家的首都等重要目标，经一次加油应可覆盖日本全岛，见图4。

图4　我国战斗机能覆盖的作战地区

（五）具有高度综合化、智能化的航电与机载武器系统

第四代战斗机应能与空、天、地基信息系统交联，实现信息资源互传共享、联合作战；具有多方位战场信息感知能力和全方位的电子对抗能力；具有多目标攻击、多机协同作战能力。

（六）具有良好的可靠性、维修性和保障性，经济性好

战斗机应使再次出动准备时间短，使用维护费用低。要努力减少保障设备以提高机动作战能力。应注意全寿命成本控制，使飞机的购置和使用具有经济可承受性。

五、我国战斗机发展设想

（一）指导思想

（1）立足自主创新、自主研制，根据国情，积极开展与国外的先进技术合作，实现跨越式发展；

（2）坚持预研先行，减小技术风险，走从预研攻关到型号研制的自主发展道路；

（3）严格控制研制经费与生产成本，努力实现“买得起，用得起”；

（4）一机多用，一机多型，以适应不同作战任务。

（二）总体思路

通过总体气动布局的创新设计和新研推重比10一级的涡轮风扇发动机，实现雷达隐身，具备超声速巡航能力，兼顾过失速机动飞行性能；通过以有源相控阵雷达为核心的微波、红外、可见光三位一体的目标探测等多功能传感器的配置，实现航电系统高度综合化设计，并配套研制相关武器系统，使飞机具备很强的超视距空战、近距空战和多目标攻击能力与电子对抗能力；通过继承机电系统和材料工艺的成熟技术，采用数字化设计与制造技术，缩短研制周期，减小研制风险，降低研制成本，研制出能满足未来作战需求、特色鲜明的我国战斗机。

（三）初步方案设想

通过“八五”以来对第四代战斗机关键技术的预先研究，综合考虑我国航空、电子等行业现状及未来若干年的可能发展水平，设想我国第四代战斗机的初步方案如下。

（1）采用高升力、低阻力、高隐身的先进总体气动布局。按目前预研成果，方案的最大升力系数可达2，比第三代战斗机约高30%，超声速巡航的零升阻力系数小于0.035，比第三代战斗机约低15%，飞机前向（±45°）雷达截面积平均值小于0.3m²，比第三代战斗机约小2个数量级。

（2）采用两台推重比10一级、小涵道比加力涡扇发动机。每台发动机全加力台架推力为15000kgf级，涵道比为0.25左右，增压比为25～26，涡轮前温度大于1800K，主要技术指标比苏－27飞机的发动机АЛ－31Ф有质的提高。

（3）增大钛合金、复合材料等轻型结构材料的用量。机体结构上先进复合材料用量约为25%，钛合金用量约为25%，铝锂合金用量为10%～15%，其他材料（超高强度钢、高强高韧铝合金）用量为30%～35%。这可使机体结构重量占全机重量的比例比第三代战斗机低10%左右。

（4）配装有源相控阵雷达，采用开放式结构的航空电子系统。相控阵雷达的目标探测距离约为200km，可同时跟踪20个目标，并能实施多目标攻击，这比第三代战斗机雷达的探测距离高出近1倍。雷达结合航电系统中的多种传感器，实现多传感器数据融合和管理，为飞行员提供战场态势感知能力、静默通信能力和智能化辅助作战能

力。采用综合电子战系统可大幅度提高飞机作战效能和生存力。

（5）机电系统尽量沿用第三代飞机的成熟设备，强调小型化和综合化管理，减少量设备做必要改进，以降低成本和减小试飞风险。初步方案是以公共管理系统为核心，采用多余度通用处理机对供电、液压、燃油、环控、救生等系统进行综合管理。

（6）配装中、远程发射后不管空空导弹和大离轴发射、高过载的近距格斗导弹，空空武器采用内埋方式挂载，对地攻击武器则以外挂为主。

（四）研制进度设想和费用估计

根据空军对战斗机的迫切需求，结合“十五”预研技术攻关进展情况，经分析认为，如第四代战斗机能够在2006—2007年立项，可望在2019—2020年间装备部队。研制进度设想如图5所示。

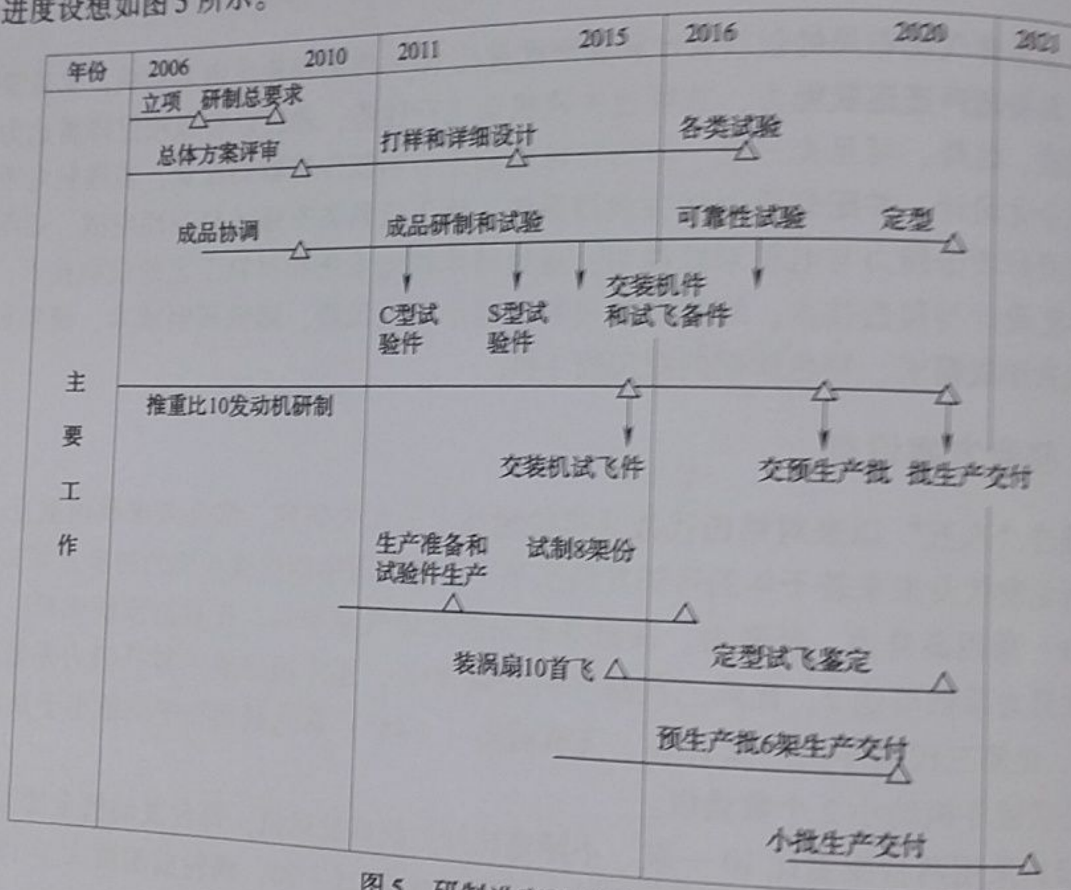

图5　研制进度设想图

通过对我未来空中力量规模、作战使用需求及经费可承受能力的分析，初步测算空军到2040年前需要第四代战斗机×××架。在此前提下，我们参照国内第三代战斗机歼10和歼11的研制费用及目前的单机价格，按2002年的币值，进行了匡算和分析，初步结果是总研制经费约需371亿元，包括制造试验试飞飞机8架及预生产型飞机6架。其中飞机机体研制费约200亿元，发动机研制费约60亿元，机载电子设备研制费约75亿元，机载武器研制费约36亿元。此费用与第三代战斗机歼10和歼11的发展和引进费用总和大致相当。单机价格4.5亿~5亿元，略高于引进苏-27的3500万美元。考虑第四代战斗机技术集成度的重大提高，飞机的作战效费比明显好于第三代战斗机。

六、研制战斗机的技术可行性

自“八五”期间以来，我国已经开展了第四代战斗机背景方案和推重比 10 一级发动机的预研攻关，同时进行了必要的对俄合作，突破了许多重要关键技术，并且在“十五”期间加大了预研的力度，为第四代战斗机的研制奠定了良好的基础。

（一）飞机机体设计技术

飞机机体设计应保证为第四代战斗机提供可长远发展的良好平台。第四代战斗机使用周期为 40～50 年，其发动机、机载设备、武器都有很大的改进余地，而机体由于飞机本身的特点，改进的余地较小，因此，自“八五”期间起我们着重对机体设计技术进行了攻关，通过几十种方案的对比和多种方案的细化研究，进行了大量的气动力风洞试验和隐身微波暗室测试试验，其结果已达到了设计要求。通过上述研究，我们已掌握了第四代战斗机总体布局的综合设计技术，具备了设计高隐身、低超声速阻力、高亚声速升力和机体结构重量系数明显低于第三代战斗机的能力。再经过“十五”期间深入细化的研究工作，可提供实现超声速巡航、隐身和高机动等战斗机的典型能力的多个第四代战斗机总体布局方案，供立项选用。

（二）发动机技术

通过配装歼 10 和歼 11 的“太行”发动机的研制，我国已基本掌握了推重比 8 一级涡扇发动机的研制技术，从“九五”期间开始预研用于第四代战斗机的推重比 10 的发动机技术，目前重点攻关内容是核心机技术，现已完成了核心机的技术设计，其高压压气机性能经试验证明基本达到了设计指标，主燃烧室和高温涡轮也在试验中，“十五”期间末期，核心机研制可望达标。继续按计划发展，进而在 2015 年前后可望提供第四代战斗机试飞验证用的发动机。在此之前飞机平台的验证可采用成熟的“太行”发动机先走一步，以减小飞机机体和发动机同时新研的试飞风险。

（三）航空电子系统

经过第三代战斗机的研制生产，我们已基本掌握了航电系统综合技术。“八五”期间以来，重点围绕航空电子系统结构、相控阵雷达、高速光纤总线、综合数据处理机、多目标攻击、数据融合、液晶显示等关键技术进行了攻关，“十五”期间末，可提供基本满足第四代战斗机需要的航空电子系统，并在以后根据技术的发展不断改进，以提高性能。

（四）飞控系统

通过多年航空主动控制技术的预研和歼 10 飞机的研制，我们已全面掌握了先进的电传操纵飞控系统的设计及制造技术，可以满足第四代战斗机飞控系统的设计需要。通过“十五”期间的预研攻关，可基本掌握火力、飞行、推力综合控制的设计技术。

（五）机电系统

将以第三代战斗机成熟技术和成品为基础，重点开展综合化、小型化工作。

（六）空空导弹

初步完成了“霹雳”12改先进中距空空导弹的方案设计、第四代格斗导弹和远程导弹的方案论证，可先于第四代战斗机的研制进度提供可用的中距空空导弹和近距格斗弹。

综上所述，到“十五”末期，战斗机的预研工作将取得重大突破，因此，从技术上综合来看，第四代战斗机在“十一五”初期立项研制是完全可行的。只是在推重比10发动机、有源相控阵雷达的研制进度方面尚存在着一定的风险，虽然已考虑了分步实施、减少风险的方案，总体上并不严重影响第四代战斗机的研制，但如能及早加大攻关力度，尽快拿下这两大关键技术，将使第四代战斗机发展更顺利。

七、对几个重要问题的认识

（一）关于我国第三代战斗机与第四代战斗机的关系问题

除直接引进的苏－27、苏－30飞机外，我国研制生产的第三代战斗机中，歼10计划今年设计定型，苏－27的生产线已建成并开始批量生产，全面国产化的歼×××正在研制中。按一般战斗机30年左右的日历寿命考虑，到2020年前后，我国第四代战斗机投入服役时，先期投产的歼10、歼11等第三代战斗机至少还有10年的服役寿命，后期生产的则还有近30年。因此，在未来的20～40年间，战斗机将与第三代战斗机构成搭配使用关系。这种高低搭配关系完全符合我们的国情、军情，也符合军用飞机的发展规律。同时应当指出，期望用第三代战斗机改进来代替第四代战斗机的发展设想在技术上是不乐观，也不经济的，从长远看将会迟滞空中力量建设，延误航空技术发展。

（二）关于战斗机与无人作战飞机的关系问题

无人作战飞机是科学技术发展到信息时代的产物，已成为当前军事航空研究领域的热点之一。美国的X－45A和X－47A研究机已开始试飞，按其研究计划，2010年后，实现无人作战飞机与第四代战斗机混合编队的使用前景已趋于明朗。我国也已在“国家安全重大基础项目”计划中立项开展无人作战飞机系统总体基础技术的研究。但必须注意，无人作战飞机的实战使用要有比较完善的一体化信息网络的支持，而且无人作战飞机的人工智能水平在相当长时期内也难以接近有人驾驶战斗机的水平。国外目前积极发展的无人作战飞机并不是第五代战斗机。因此，当前用研制无人作战飞机来取代第四代战斗机在安排上是不现实的。否则，不但不能实现跨越，反而会延误我们的发展。

（三）关于发动机问题

经初步分析，推重比 10 一级发动机的预研及研制进度可能要落后于机体平台，预先考虑一个发动机过渡方案是完全必要的，就是利用届时比较成熟的“太行”发动机或其改进型。也就是说，第四代战斗机动力系统需采取两步走的办法：第一步是先装“太行”或其改进型来验证飞机平台及其系统性能；第二步是待推重比 10 一级发动机定型后再配装第四代战斗机。

（四）关于重型与轻型问题

战斗机研制实践证明，在采用同一种动力装置的条件下，双发重型战斗机的性能、装载能力、执行作战任务的能力均将优于单发轻型战斗机，但单价比轻型战斗机高一些。我们认为，我国应先重点研制战斗机，理由是空军要求第四代战斗机具有很强的制空和远程精确对地攻击能力，能与 F－22 相抗衡，对 F－35 有明显优势，这显然只有重型战斗机能做到。此外，我国“八五”至“十五”期间的航空技术预研攻关的背景机也都是按双发重型安排的，进一步发展的条件较好。

八、主要结论和建议

发展我国第四代战斗机是国家安全和军事斗争形势需要，是应对军事变革的需要，也是实现空军装备和航空工业跨越式发展的需要。第四代战斗机在未来我航空武器装备体系中占有重要地位和作用。第四代战斗机与第三代战斗机是高低搭配关系，将来与无人作战飞机是相互补充关系。战斗机应能与 F－22 相抗衡，对 F－35 有明显优势。应具有远程、隐身突防和精确攻击能力，良好的超声速性能，很强的超视距空战、近距空战、电子战以及遂行多种任务的能力。经过“八五”到“十五”期间的预研，我国研制第四代战斗机的基本条件是具备的。

建议第四代战斗机于“十一五”初立项研制，力争 2020 年前设计定型。