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A Comparative Study of Global Fighter Development Timelines

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This policy brief provides a summary of trends in the research, development, and acquisition (RDA) practices of fighter aircraft programs from the 1970s to modern times. This paper expands the evolving practice of RDA analysis by incorporating timeline analysis to compare the length of time the United States, Russia, China, and India take to design, produce, test, and field military fighters. The research suggests that while the United States remains the leader in fighter designs and advanced technology development, countries such as China are able to rapidly bridge the gap by copying foreign designs and building on the experience of collaborative partners. The brief lays the foundation for additional comparative studies that will focus on technology development and the ability of technology followers to emulate sophisticated capabilities for the next generation of fighter aircraft.

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METHODOLOGY

The goal of timeline analysis, as part of the RDA analytic framework, is to capture and categorize activities over the life of select programs. This study examines the development timelines of 14 fighter programs while focusing on the United States, Russia, China, and India to compare the RDA processes for fourth- and fifth-generation fighters. Documenting past practices may help to bring greater certainty when predicting future trends by identifying indicators that might signal the start and progression of a sixth-generation fighter program.

The stages of a defense RDA process include milestones for S&T studies, requirement and concept development, technical and systems development, testing, production, and delivery of military equipment. Earlier studies of defense RDA systems suggest a similar basic defense development structure, defined as the generic RDA process. The literature describes the use of timelines as an analytic tool to manage large amounts of information through the use of key terms to narrow the research field during the data mining process. The generic RDA process framework provides a structure to cluster key data points for comparative timeline analysis. For this study, the indicators detailed in Table 1 were used to categorize information and to track the length of time between fourth- and fifth-generation fighter program milestones.

The RDA process framework provides a way to organize, diagram, and present data that can later be transferred to a timeline graphic to indicate key observable events. RDA signposts are plotted and updated as new information becomes available, highlighting changes in the length of time between milestones from program to program. It often is difficult to obtain exact dates for R&D, therefore this brief uses the most widely accepted milestones available.

JET FIGHTER DEVELOPMENT

Leaders in jet fighter development can trace their origin to the late 1940s with advances in technologies and capabilities leading to the Cold War era quest for military advantage between the United States and the Soviet Union. The end of the Korean War is seen as the advent of the aviation technology arms race as the countries faced off for air superiority. These early-generation fighters laid a foundation for the most enduring and technologically advanced fighters that still inspire imitation in developing defense industrial bases such as China and India.

Fourth-Generation Fighters

The 1991 Gulf War air campaign demonstrated the technical prowess of the United States. Within 10 years of the production of US F-15 and F-16 and the Russian Su-27 and Mig-29 fighters, other design and development teams emulated these programs with their own fourth-generation variants.

Analysis of the development milestones for select fourth-generation fighter programs suggests that the United States and Russia took an

Table 1. Key indicators for timeline analysis of fighter aircraft development

Pre-Program	Requirements	Research and Design	Development and Demonstration	Production	Operations and Maintenance
Fourth, fifth-generation fighter Technology research program Technology study programs Reconfigured Follow-on	Air Force requirements Acquisition plan Requirements or system specifications/ operational concepts/threats System capability requirements/ capability gap Feasibility study/ project scope Project definition/request for proposals or information Budget	Research, demonstration, and validation Acquisition strategy Develop concept performance objectives Project analysis Systems/technology integration plan Risk assessments Contract completion Contract award Delivery projection Life cycle costs Technology development	Systems integration Preliminary and final design Model simulation Develop prototypes and pilot models Prototype testing and evaluation Design modifications Performance criteria Final approval and validation Low rate/initial production	Production approval Production strategy Production rates established Full-scale production Acceptance testing Final production Delivery/fielding	Rollout Service acceptance Maintenance plans Technology gaps Modifications/ upgrades recommended Retired

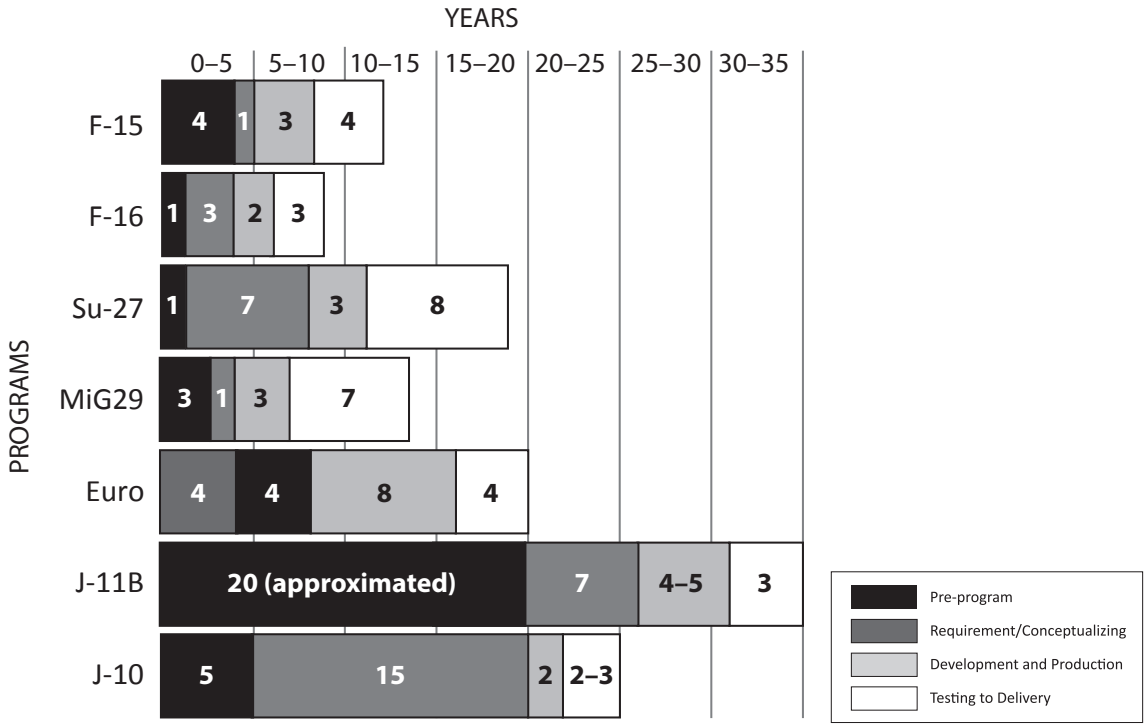

Figure 1. Overview of fourth-generation fighter timelines

average of 12 years from study to delivery of their fourth-generation systems. The Eurofighter joint development program took about 17 years from program initiation to delivery. China was able to cut corners when it replicated Russia's Su-27 designs to springboard its J-11B version some seven years later. The J-10, however, shows the weakness in China's technical skills and experience, leading to a much longer timeline of nearly 25 years to convert foreign designs and assistance to a fielded fighter (see Figure 1).

Technology Innovators

The fourth-generation capabilities of the United States are built on a history of incrementally improved technical levels. Russia has drawn from the Sukhoi and MiG fighter family for its fourth-generation capabilities. France and Sweden, too, built on predecessor designs for the Rafael and Gripen, taking a little more than 15 years from study to fielding their fourth-generation variants.

When countries that are still developing their defense industrial bases attempt to indigenously design and produce a fighter they often face longer development timelines because they are incapable of complete self-reliance. This is the case with India's Tejas program, which began with technical studies in the mid-1970s and has yet to be delivered to operational forces.

Joint Programs

Unable to individually develop a fourth-generation fighter, the United Kingdom and Germany in 1983 began plans to design and build the Eurofighter Typhoon collaborative fighter. The program drew heavily on previous research studies conducted by the United Kingdom, France, Spain, and Italy, with each committing to contribute designs and technologies from their own studies. Although on the surface this seemed to be the best bet for the partners to develop a multi-role fighter, management of the program was daunting. Eventually, France withdrew from the consortium and returned to developing its own fighter. It would take some 14 years for France to field its fourth-generation Rafael, just shy of the 17 years from program initiation to delivery of the Eurofighter.

Late Followers

Other country's designs have been influenced by the capabilities of U.S. and Russian fourth-generation fighters. China has successfully incorporated knowledge gained through its collaboration with Russia on the Su-27 licensed production to emulate an advanced program. India, on the other hand, continues its attempt to develop the Tejas fighter, although press coverage reports numerous delays because of funding, political battles over the program, lack of domestic technical capabilities, and a culture ill-prepared to implement a complex fighter program. Nearly 40 years after India committed to indigenous design and production of a fourth-generation fighter, it has yet to deliver.

China entered the era of fourth-generation fighters with its licensed production of Russia's Su-27SK. It is unclear when China began researching the technology to build its own version; however, the first kits from Russia arrived in China around 1999 and within a few years China cancelled its contract for future deliveries of kits. By 2002, China had announced that it had indigenized Russia's aircraft.

Some observers argue that the J-11B is sufficiently different from the Russian-provided variant, and China continues to tweak follow-on variants with improved technical capabilities. After investing nearly 20 years maintaining previously purchased Su-27 fighters and learning through the kit production process, China was able to deliver the first hybrid version of the Su-27/J-11B in about 14 years.

China moved further into production of fourth-generation fighters with its foreign-influenced J-10. Some reports suggest that the J-10 is a design drawn from the Israeli Lavi project, while other reports indicate that Chengdu Aircraft began to work with designs in the mid-1980s and was influenced by the U.S. F-16 and Russian MiG-29. By the mid-1980s, China's aviation group was able to draw from its domestic practice of copying and emulation to produce improved variants. It took China approximately 25 years from study to delivery of its first nearly-indigenously designed advanced fighter.

Fifth-Generation Fighters

By the 1990s, the United States, Russia, and China were studying new concepts in air superiority, including stealth technology, precision weapons, improved avionics, and the ability to operate in a networked environment. The complexity of these emerging capabilities has resulted in longer development timelines. At least eight fifth-generation fighters may be in development worldwide, with the U.S. F-22 design influencing concept development. Aviation experts continue to debate the existence of a breakaway capability that defines a fifth generation, with some claiming that it is more about marketing than about new capabilities.

The F-22 was developed in response to a U.S. Air Force requirement to replace and/or improve the capabilities of the F-15 and F-16. The new fighter emerged after years of study and a rigorous five-year competition. From concept to operation, the program spanned more than 25 years. The program was costly, and in 2009 the U.S. Senate voted to end the program. By May 2012 the final F-22 was delivered.

The Joint Strike Fighter (JSF) F-35 is defined as "a fifth-generation fighter, combining advanced stealth with fighter speed and agility, fully fused sensor information, network-enabled operations, advanced sustainment, and lower operational and support costs." The multinational program, like that of the Eurofighter, has not run smoothly, in large part because of the high costs and risks associated with the integration of emergent technologies. The program is now in testing and evaluation and it could take the United States approximately 24 years to develop and field this complex fighter.

Some argue that Russia and China are unlikely to replicate the stealth capabilities of the F-22 or the improved radar and sensor powers of the F-35. Russia is developing the T-50 while China has begun testing of the J-20. Many experts suggest that these aircraft lack the technical parameters of a fifth-generation fighter and are more likely just incrementally improved fourth-generation fighters. India reportedly has a requirement for a medium multirole fighter, designated the MMRCA, to match the capabilities of the U.S. F-22 Raptor.

Russia is developing the Su-35S fighter, often described as a "4++ generation fighter using fifth-generation technology." The Su-35 program may have begun as early as 1993, drawing from the Su-27 family of designs. Sukhoi is promoting a fighter with new avionics, radar, and a reduced radar signature. The fighter began flight testing in 2007 and was in assembly as of 2011. Russia may export the completed fighter to China, although there are conflicting reports regarding a sale. Undoubtedly, China hopes to gain access to Russia's technology to bolster its domestic programs. It has taken more than 20 years to design and test the prototypes of this advanced program.

Russia continues to develop the long-awaited T-50 fighter; however, it has extended the projected full operational capability date to 2016. Russia could slip the date again if it is unable to overcome technical difficulties associated with the complex design. The T-50 received government endorsement and funding in 2002 as a joint Russia-India venture known as the PAK-FA aircraft. Press reports indicate that the final design was approved in 2010, although R&D likely began in the early 2000s. Blueprints were completed for prototype development and testing began in 2010; however, series production with India is not expected before 2022.

China's J-20 program remains a closely guarded secret despite a first flight in January 2011. Most aviation experts agree that the program has progressed at an accelerated pace, suggesting a higher degree of competency in the design and development stages. There is some debate regarding the design influence for the J-20, with some pointing to the U.S. F-22 and the Russian T-50. The J-20 has some similarities to the J-10 and it may incorporate some of the advanced features of the follow-on J-10B, creating questions about its designation as a fifth-generation fighter. Based on the limited known data regarding the development of the J-20, it probably has taken China at least 12 years to reach the point of testing an aircraft, and past practices

suggest it may take an additional five years to deliver a completed aircraft.

China is not content to have just one stealth aircraft program. Initial reports suggest that the developmental J-31 is smaller and lighter than the J-20; however, even fewer details are available on this aircraft. The J-31 first flew in November 2012 but additional analysis is needed to understand what a second stealth fighter means for China's defense industrial capabilities as well as its ability to bring two complex programs to the operational field in the coming 5–10 years.

What's Next?

It is difficult to discuss a sixth-generation fighter when most countries continue to develop fourth plus/fifth-generation fighters. However, given the common practice identified in the timeline analysis of creating early R&D study groups, it is highly likely that defense planners, including the United States, Russia, and China, are already exploring options for a future fighter aircraft. A study of the literature reveals any number of possible options for the future, but most articles suggest that the next generation of fighters will have increased speed, longer range, and even "self-healing structures and multi-spectral stealth." Since most fighters were influenced by previous variants, the same may hold true for the next-generation fighter. However, technical breakthroughs, including application of emerging technologies and concepts such as hypersonics, directed energy, new materials, advanced microelectronics, and the "stuff of science fiction," may lead to unexpected characteristics in future programs.

CONCLUSION

China's fighter development programs have lagged some 20 years behind western technology developments, but appear to be closing the gap in terms of aircraft capabilities and manufacturing know-how. The United States and Russia took an average of 12 years from study to delivery of their fourth-generation systems. The Chinese fourth-generation J-10, however, has taken 25 years to develop.

The timeline for fielding China's fifth-generation fighters appears to be more in line with other countries. It is likely that it will take most developers about 25 years to conceptualize and deliver a fifth-generation fighter because of the complexity of the technologies and components. It is important to remember that only the United States has actually produced and delivered a fifth-generation fighter, calling into question the ability of other countries to replicate U.S. technological advances.

China only recently entered the playing field and it is unclear what capabilities its purported fifth-generation fighter will display. China, however, has the benefit of watching the United States and Russia, which may help to shorten its development timelines.

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