A number of photos and drawings of the J-10 appeared on the Internet over the past few years. Some of the earlier images included here turned out to be fake. Usually these were retouched photos of the 'Lavi'. This might have been a deliberate attempt to promote the belief that the J-10 was a derivative of 'Lavi'.

A J-10 "1013" makes a "dirty" pass with lowered undercarriage, three external fuel tanks and two dummy AAMs.

The same J-10 "1013" without the missiles or the fuel tanks.

China's Fighters - Chengdu J-10

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in PDF format

China did a good job keeping the lid on the J-10 development. Until very recently little was made public about this project. What one could find in aviation directories about the J-10 was limited to the fact that the aircraft's design was based on the *Lavi* - Israel's half-hearted and eventually canned attempt to develop its own "F-16." Approximate performance characteristics and physical data were extrapolated from *Lavi* and similar aircraft but this was about the extent of the available analysis.

The J-10 is much more than just a development of the Lavi. The new Chengdu fighter has a potential of becoming one of the most significant fighters for the next few decades. The J-10 may very well be the next MiG-21 or F-16 in terms of its potential on the international market. I find it rather surprising that the J-10 attracted relatively little attention from aerospace publications worldwide.

Aerodynamic considerations

Initial development of what later was to become the J-10 project was started in October of 1988 by the Research Institute No. 611. Initially the aircraft was to be an air superiority fighter. The 1980s saw a number of similar aircraft designs featuring a main delta-wing and canards. Some of the designs, like the Rafale, Typhoon, Kfir, and Gripen made it to active service in the past decade, while others like the Lavi only made it to flying prototypes. Some designs, like the original Russian design for the Sukhoi S-37 (not to be confused with a later forward-swept wing S-37/Su-47 'Berkut') featured what is called a compound delta-wing.

What is a delta-wing and what advantages does it offer? Simply put, a delta-wing is a triangular wing planform. The most common delta-wing combat aircraft are the Dassault Mirage fighters. The delta-wing design was first implemented by Alexander Lippich - an engineer for the Zeppelin company in Germany since 1918 - who launched his first motorized delta-wing design in 1931.

Delta-wing configuration offers two important aerodynamic qualities to a combat aircraft. The swept leading edge of a delta-wing stays ahead of the shock wave generated by the nose of the aircraft during supersonic flight making delta-wing a very efficient aerodynamic wing shape for supersonic flight. The leading edge of delta-wing also generates a massive vortex that attaches itself to the upper surface of the wing during high angle-of-attack (AOA) maneuvers resulting in very high stall points. The angle-of-attack term refers to the angle between the aircraft's velocity vector and the

Another view of the "1013" prototype

Another view of the "1013" prototype on the ground

A photo of what may be a pre-production J-10 being refueled before a test flight

wing plane.

While ideal for high-altitude supersonic flight delta-wing causes increased drag at lower speeds negatively impacting aircraft's fuel efficiency and low-speed maneuverability. Originally delta-wing aircraft were designed as high-speed interceptors and bombers. As development of the delta-wing concept progressed a compound delta-wing was introduced. In this configuration a small highly swept delta wing is added in front of the main wing for reduced drag at low speeds.

In modern fighter aircraft an element of a further development of the compound wing is known as LEX - leading edge extensions. These small "wings" at the root of the leading edge of the main wing (not necessarily a delta wing anymore) remain out of airflow in cruise flight and are used during high AOA maneuvers to generate a high-speed vortex that stays attached to the top of the main wing (Bernoulli principle). This maintains low pressure zone over the upper surface of the wing generating lift beyond what would have been the stall point for a single delta-wing.

		
Foreplane canards of the Eurofighter Typhoon	The Su-35 features a tri-plane wing configuration that features canards, the main wing and the tailplane.	The early Sukhoi S-37 configuration featuring canards and a compound delta wing

Modern fighter aircraft feature various combinations of canards, tailplanes and compound wings. Modern Russian aircraft like the Su-35 have a tri-plane configuration with all three of these elements present. Others, like the MiG MFI have a classic delta wing with the canards. The canard surface, unlike a conventional tailplane which it replaces in delta wing designs, generates positive lift. During high AOA maneuvers the canard surfaces stalls first. This causes the nose of the aircraft to pitch down and prevents the main wing from stalling - a very valuable feature for a fighter aircraft.

At the same time the canard surface creates a downwash which degrade the main wing's performance. Canards also make it very difficult to apply flaps: normally, extending flaps causes a downward movement of the nose, which is compensated by the tailplane. However, most airframe design involving canards do not have a tailplane and have thing to compensate for the effect of the flaps. Therefore, many designs involving canards have no flaps. There are some exceptions like the late-model Su-27-family fighters that have canards and the tailplane.

The delta-wing has another quality significant for a fighter aircraft: this wing profile offers increased survivability by having increased structural and airflow stability. From a financial point of view, a delta-wing is also cheaper to manufacture, which is not the last reason why you see this type of a wing on export-oriented aircraft like Typhoon, Rafale, and Gripen.

Eurofighter Typhoon

Saab JAS 39B Gripen

IAI Lavi

Dassault Rafale

Dassault Mirage 2000

IAI Kfir

MiG 1.41

Dassault Mirage III

Dassault Mirage IV-P

Table 1: Modern augmented delta-wing fighters

Category	J-10A	Rafale C	Gripen A	Typhoon DA1/9829	Lavi	Mirage 2000C
Country	China	France	Sweden	Germany/ UK/ France/Italy/ Spain	Israel	France
Number of engines	1	2	1	2	1	1
First prototype flight	1996 (1998)	1986	1988	1994	1986	1978
Max. total dry thrust	79.43 kN	97.4 kN	54 kN	120 kN	55.6 kN	64.3 kN
Max total augmented thrust	122.6 kN	145.8 kN	80.5 kN	180 kN	82.7 kN	95.1 kN
Dimensions						
Wing span	8.78 m	10.80 m	8.40 m	10.95 m	8.78 m	9.13 m
Wing aspect ratio		2.6		2.4		2
Length overall	14.57 m	15.27 m	14.10 m	15.96 m	14.57 m	14.36 m
Height overall	4.78 m	5.34 m	4.50 m	5.28 m	4.78 m	5.14 m
Gross wing area	33.1 m2	45.70 m2		50.0 m2	33.05 m2	41.0 m2
Weights and loadings						
Basic weight empty, equipped	9,750 kg	10,460 kg	6,622 kg	11,150 kg	9,990 kg	7,500 kg
Normal load on external stores (including fuel)		6,000 kg		6,500 kg		
Max. load on external stores (including fuel)	4,500 kg	9,500 kg		7,500 kg	7,257 kg	6,200 kg
Max. internal fuel	4,500 kg	4,500 kg	2,268 kg	4,500 kg	2,624 kg	3,160 kg
Conformal fuel		1,850 kg				
Underwing fuel		7,500 kg			4,164 kg	4,140 kg
Max T-O weight	18,500 kg	22,500 kg	12,500 kg	21,000 kg	18,370 kg	17,000 kg
Max. landing weight		22,500 kg				16,700 kg
Max. wing loading		426.7 kg/m2		470.0 kg/m2	555.6 kg/m2	414.6 kg/m2
Max. power loading		134 kg/kN		130 kg/kNß		179 kg/kN
Performance						
Max level speed at altitude	M1.85	M1.8		M2.0	M1.85	M2.2
Max level speed at sea level	M1.2	1,390 km/h			1,106 km/h	M1.2
Max rate of climb at sea level		18,290 m/min				17,060 m/min
Roll rate		270 deg/sec			300 deg/sec	
Service ceiling	18,000 m	16,765 m		16,765 m		16,460 m
T-O run in air-to-air configuration	350 m	400 m		300 m	305 m	
T-O run in air-to-ground configuration		600 m			1,112 km	
Landing roll		450 m			460 m	
Radius of action in air-to-air configuration with external fuel	1,850 km	1,759 km	~800 km	1,389 km	1853 km	1,852 km

Radius of action in air-to-ground configuration with external fuel	1110 km	1,055 km	~800 km	1,150 km	1,205 km

An artist's rendering of a J-10 in which it more closely resembled Israeli 'Lavi'

Another artist's rendering of a J-10 in which it more closely resembled Israeli 'Lavi'

As it turned out the J-10 we see today has little in common with the Israeli 'Lavi'. The form of the delta wing has changed, the air intake is different, the shape of the nose section is different, the different shape and position of the canards, etc. The J-10 features a simple delta wing with relatively large movable canards. The nose section, the canards and the air intake look similar to those of MiG 1.41.

The J-10 has a substantially more powerful engine than any other modern delta wing fighter in service. While the combined thrust of two-engine fighters like Rafale and Typhoon exceed that of a single Al-31FN, the J-10 is lighter and should have an excellent thrust-to-weight ratio.

In the recently-released photos of the J-10 the aircraft is seen with three external fuel tanks with at least 4,000kg total external fuel capacity.

History of Development

By 1993 the Chinese designers have constructed the first all-metal mockup of the J-10. Wind tunnel testing revealed potential problems with low-speed performance and less-than-expected maximum AOA at subsonic speeds. At the same time the main trend in fighter aircraft development was a transition from single-purpose fighters such as high-speed interceptor or low-altitude dogfighters to multirole aircraft combining good subsonic and supersonic air-to-air performance with extensive air-to-ground capabilities. Added requirements for air-to-ground operations called for an in-depth redesign of the J-10 to accommodate terrain-following radar, more and sturdier hardpoints, an entirely new targeting, flight control and navigation systems.

At the end of 1995 Russian involvement in the J-10 program was confirmed when it was announced that a first J-10 flight is expected in early 1996 with Russian-made Al-31FN turbofan engine. Runway tests took longer than expected while the designers tweaked the control systems of the first J-10 "1001" prototype. The first "official" flight took place on March 28, 1998, and was largely successful. However, the first actual flight of the J-10 might have taken place two years earlier - in mid-1996 - but suffered from an engine malfunction with unknown consequences. In late 1997 the second flying J-10 "1002" prototype was lost in a crash which also killed the chief test pilot. Nevertheless, the J-10 program continued as scheduled and two more prototypes - the "1003" and "1004" - were completed by the end of 1998. The same year the aircraft received its official service designation "J-10".

The J-10 manufacturing, flight testing and service evaluation programs continued at a pace not seen in the world of combat aviation since the end of the Cold War. By mid-1999 China already had six prototypes: four of them used for flight testing two were used for static tests. By late 2000 nine J-10 prototypes were produced and the flying models accumulated over 140 flight hours. The first flight of the pre-production model took place on June 28, 2002, by which time China already had at least 10 of these aircraft. In early 2003 ten J-10s were deployed to Nanjing Military Region for training and operational evaluation. A photo released in 2003 shows a pair of J-10s in flight with numbers "1015" and "1016" indicating that at least 16 J-10s were built so far.

Also in 2003 China begun construction of two two-seat versions of the J-10 for training and air-to-ground roles. At the same time Chengdu (CAC) and the Research Institute No. 611 completed preliminary designs for two new versions of the J-10 featuring a single and twin engines and LO geometry. The new designs also feature a nose section angled downward for improved air-to-ground performance of the aircraft.

These latest additions in the J-10 design - the construction of the two-seater versions and the study of a stealthy version with angled nose section - indicate that China is interested in expanded air-to-ground capability for its future J-10 fleet, thus moving from the original concept of a tactical air defense fighter to a multirole fighter-bomber with LO features and, perhaps, to a dedicated ground attack variant. Latest Chinese

A three-way diagram of the J-10 depicting a compound delta wing

This photo was claimed to be of a nose section of a J-10. However, this is the nose section from MiG 1.41

One of the first photos of the J-10 program - a model.

The J-10 and its pilot following the first (official) flight in 1998.

reports refer to the J-10 as "Qian Shi-10" ("Attack 10") as opposed to the original name "Jian-10" ("Fighter 10"). The transition of the J-10 program from a dedicated fighter to a ground attack aircraft coincided with China's co-production of the J-11 (locally-produced Su-27), thus making the J-10 a likely replacement for the J-7/Q-5 attack planes rather than competition to the J-11.

Radar

Extent of Russian involvement in the J-10 program is significant. In addition to providing the J-10 with the Al-31FN turbojet Russia also offered advanced multifunction radars, navigation and targeting systems, ECM suite, and missile warning and defense systems. Russian avionics manufacturer Phazotron offered China three different radars for the J-10 project. These include the N010 "Zhuk" ("Beetle") and the RP-35 "Zhemchug" ("Pearls"). The "Zhuk" radar ("Zhuk-8-II") has been selected by China for the F-8IIM upgrade program. Over a hundred of these radars were recently sold to China.

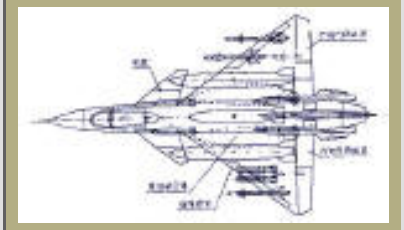
"Zhuk" is a large family of X-band (8 to 12.5 GHz) airborne multimode radars. The radar was originally developed for the MiG-29 tactical fighter but since then a multitude of versions have been produced for MiG-23, Su-27, F-8IIM and other aircraft. Later models of "Zhuk" offer look-up/look-down range-while-search and Track-While-Scan of 10 targets with simultaneous engagement of up to four (two targets for the "Zhuk-8-II"); vertical search; head-up display search; wide-angle search; boresight and automatic terrain avoidance for low-altitude combat operations; real beam ground-mapping; Doppler beam sharpening; synthetic aperture; display enlargement/freeze; TWS on four targets; ground target Moving Target Indicator (MTI)/tracker; air-to-surface ranging and navigation update. Weapons compatibility for "Zhuk" includes the Kh-31A, R-27R1, R-27T1, R-37E and RW-AE missiles. Later models of "Zhuk" such as the "Zhuk-F" offer detection range of up to 200km for a 5 m2 RCS targets with +/- 70 deg angular coverage and detection of 24 targets with simultaneous tracking of 8 targets. The radar weighs between 180 kg and 300 kg depending on the model.

The most likely candidate for the J-10's future radar is the Phazotron RP-35 "Zhemchug" which is an X-band radar with digital fire-control sensors and an electronically scanning phased-array antenna. The radar features a liquid-cooled traveling wave tube transmitter; an exciter; a three channel microwave receiver and programmable signal and data processors. All critical radar controls for "Zhemchug" are integrated into the aircraft's throttle grip and stick controller and radar data is displayed via the head-up and head-down displays allowing for one-man operation. This radar has an expanded air-to-ground capability and is compatible with a wide range of Russian air-to-air and air-to-ground munitions.

Another candidate is the Chinese version of the Israeli Elta EL/M-2035 multimode pulse Doppler fire control radar based on the original development by Elta Electronics Industries - a subsidiary of Israel Aircraft Industries Electronics Group. This radar is used on the South African Denel (Atlas) "Cheetah" fighter - a development of the Dassault "Mirage III". The Elta EL/M-2035 radar is based on the 2021B version used by the IAI Kfir-C2 fighter. The radar offers a range of 46km for a 5 m2 RCS target, five air-to-air modes (automatic target acquisition, boresight, look-down, look-up, and track-while-scan) and two air-to-ground modes (beam-sharpened ground mapping and terrain avoidance and sea-search). Originally the Elta EL/M-2035 was developed for the "Lavi" program and after the program's cancellation the radar was offered for export.

Engine

The Lyulka-Saturn Al-31 turbojet is the main Russian engine for modern fighter aircraft. Numerous modifications of the Al-31 have been produced, including the world's first supersonic jet engine with a thrust-vectoring nozzle. Various versions of this engine are used on Su-27, Su-27SK, Su-27UBK, Su-30MKK produced for China's PLAAF, Su-30MKI produced for the Indian Air Force and other fighter and fighter-bomber aircraft. The Al-31FN - a development of the Al-31F - was created in 1992-1994 and



A rough drawing of the J-10

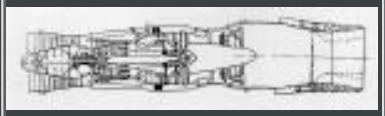
This is actually 'Lavi' with some retouching done in Photoshop

A recent photo of two J-10 numbers "1015" and "1016"

features increased thrust, fadec control with hydraulic fuel pressure-activated back-up and significantly improved fuel economy. The Al-31FN is used on Su-32 (Su-27IB), Su-27SM (Su-35) and Su-32FN permitting these aircraft to have a maximum range of well over 4,000 km on internal fuel. The initial delivery of Al-31FN engines to China took place in 2001-2002 and numbered some 54 non-thrust-vectoring engines. China's CEC is also believed to have successfully negotiated with Russia license production of Al-31 engines. Later models of the J-10 are likely to use the thrust-vectoring version of the Al-31FN.

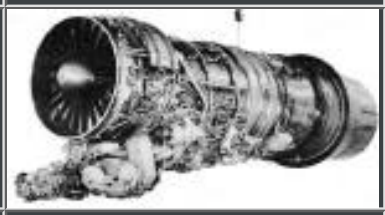
Al-31F with vector-controlled nozzle

Cutaway AL-31F



Longitudinal section through AL-31F (fixed nozzle)

AL-31FN for Chinese J-10



AL-31FN configured for J-10

AL-31F, without accessory gearbox

The new KND-924 fan will give added thrust to the Su-27 'Flankers' AL-31 F engine

Cutaway AL-31FP

AL-31F showing top-mounted aircraft accessory gearbox

A very nice and detailed photo of the J-10 "1013"

AL-31FP showing vectoring nozzle	Al-35 with experimental two-dimensional nozzle flown on the Su-27LL-PS in 1989	AL-35 rectangular nozzle
		
AL-37FU	AL-41F with vectoring nozzle	AL-37FU with vectored nozzles on Su-30MK
		
AL-41F with vectoring nozzle		

The Al-31-series engines proved to be reliable, relatively simple to maintain and offering great performance. Design work on the Al-31 begun in 1963 and the first prototype of the engine was tested in 1974. In 1986 a P-42 (modified Su-27 prototype) powered by two Al-31F engines set 32 time-to-height records. Recent computer simulations conducted by the US Air Force and Boeing showed that an Al-31FP-equipped Su-30MK outperformed the F-15C in a diverse range of engagements. A basic comparison of the Al-31FN (developed in 1992-1994) and the F100-PW-232 (the ultimate version of the Pratt & Whitney F100 developed in 1999-2001 and designed to be retrofitted to the F-15 and F-16 fighter aircraft) reveals that the Russian engine provides near-identical performance while being more than 300 kg lighter (not to mention substantially less expensive). The next generation of Russian turbofan engines - the Al-41 - offers a dramatic increase in power and reliability. The Al-41 is currently being tested on Su-47, MiG MFI and Su-32FN. The Al-41F is planned as the future engine for the LFI project.

Table 2: Al-31FN and F100-PW-232 comparison

Category	Al-31FN (non-vectored)	F100-PW-232 (non-vectored)	Al-41F (vectored)
Overall diameter	1,180 mm	1,181 mm	1,180 mm
Length	5,000 mm	4,844 mm	5,000 mm
Dry Weight	1,538 kg	1,844 kg	1,850 kg
Max. augmented thrust	122.6 kN	142.0 kN	175 kN
Max. dry thrust	79.43 kN	79.18 kN	113.9 kN
Specific fuel consumption (dry)	19.97 mg/Ns	19.83 mg/Ns	19.18 mg/Ns
Specific fuel consumption (augmented)	53.23 mg/Ns	54.11 mg/Ns	?

Conclusion

The new Chinese fighter-bomber today represents little threat to the Russian share of the fighter market. Even in China the J-10 is unlikely to compete with the license-produced Su-27 or the imported Su-30MK. However, everything about the current version of the J-10 that we have seen says that it is a transitional model. Already Chengdu is moving toward a two-engine version that would incorporate LO geometry and expanded air-to-ground capability.

Looking at the striking progress of the J-10 (especially in comparison to Russia's own slow-paced development of the next-generation interceptor MFI and the attack aircraft LFS) it should be expected that the future development of the J-10 may be only 3-6 years away. And this will be the aircraft that may eventually encroach on Russia's

A nice rendering of the J-10 "1013"

traditional fighter export market and not just Russia's. This may happen sooner than many Russian and Western analysts believe today. For Russia the J-10 and its derivatives may be what the MiG-15 was for the West half-a-century ago: a rather unpleasant surprise.

"Russian components, American components: they are all made in Taiwan", said a Russian cosmonaut in the "Armageddon" sci-fi flick with Bruce Willis. Today China may be lacking in the avionics and engine departments but nothing prevents it from buying everything it needs from Russia, France and other eager suppliers of advanced aerospace components. You need an engine? Russia offers its best fighter turbofans at a very reasonable price. You need a radar or avionics? Russia, France and Israel will be more than happy to supply top-of-the-line equipment.

Russians had to reproduce a Rolls-Royce jet in secret and at great expense to put it on its MiG-15. Today there is no need for such extreme measures: all essential advanced components are readily available. What really matters is experience with integrating these systems to produce a fighter aircraft. The J-10 clearly shows that China is rapidly gaining this experience.

The new Chinese fighter-bomber will be a welcome addition to the PLAAF, considerably boosting the service's tactical offensive capabilities. Taiwan's Western technological edge is quickly melting away and China's military buildup inevitably leads to restoring the country's territorial integrity. The J-10 is a significant piece of this great wall being built around Taiwan.

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www.aeronautics.ru

P.S. I may update this article in the future when more information becomes available. So you may want to bookmark this page separately if you are interested in the J-10 progress.

Also, if you have any photos or other information about the J-10 not found on this page, please e-mail it to me.

Other J-10 resources
Various articles about J-10 in the media
Articles about the J-10 and technical aspects of the delta wing

This great photo showing five J-10s and the three photos above it was sent to me by Niels Hillebrand. Thanks.