1. Amid reports of sixth-gen Chinese aircraft, what does 'generation' mean in the context of fighter jets?

Introduction

Unverified images of what is being termed as a Chinese sixth-generation fighter aircraft have gone viral on social media. This comes a month after China's Aviation Industry Corporation (AVIC) unveiled its Baidi White Emperor 'B Type' sixth generation fighter jet at the Zhuhai Airshow in November. But what does the concept of a "generation" mean in the context of fighter jets?

A relatively recent heuristic

Before getting into the weeds of what each generation entails, two points to be noted.

First, the notion of aircraft generations came up only in the 1990s. It has thus been retrospectively applied to fighter aircraft that came before this period. Notably, these generations only refer to jets and not the propeller-driven fighters that predated them.

Second, there is no standard definition of what constitutes a "generation". Some have even used terms such as "generation 3.5" or "generation 4.5". At the end of the day, the idea of generations is meant to act as a heuristic device and not the be-all, end-all determinant of an aircraft's capabilities. Not all aircraft in the same generation are equal, and the measure of a country's air capabilities does not rest solely on what generation of fighter jets it possesses.

So, how exactly are aircraft generations defined? Loosely put, a generational shift in fighter jets is said to occur when a certain technological innovation cannot be incorporated into an existing aircraft through upgrades and retrospective fit-outs — each new generation comes with a certain significant leap in technology.

The five generations (so far)

There are currently five generations of fighter jets which are (or were in the past) in active service, with sixth generation jets currently in development. Here is what each generation entails, according to the classification presented by aviation expert David Baker in Fifth Generation Fighters (2018).

First generation (1943 to 1955)

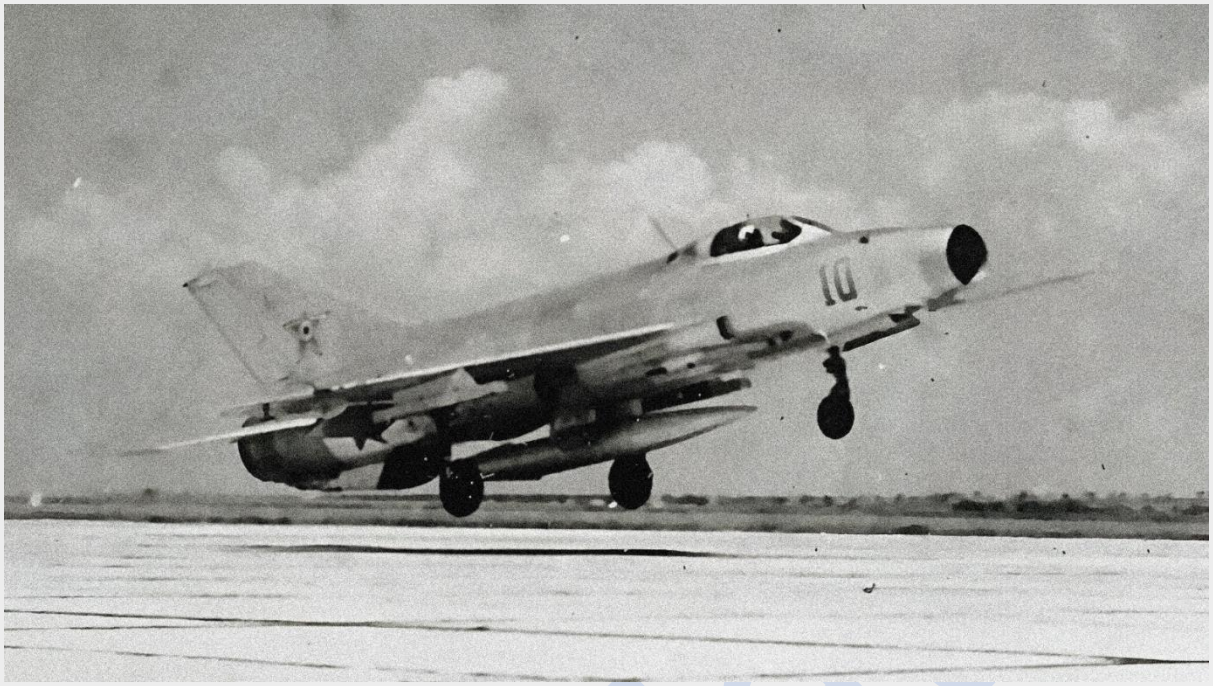
The Messerschmitt Me 262 Schwable, developed by Germany during World War II, is considered to be the world's first jet fighter. (USAF)

The earliest fighter jets appeared on the scene in the final years of World War II. They were faster than their piston-engined contemporaries, but otherwise not very different from existing fighter aircraft.

Notably, these jets still flew mostly at subsonic speeds. This was not only because of the capabilities of their engines — these were without afterburners, which provide a sudden boost of thrust — but also the design of their wings, which were more or less straight, and thus aerodynamically inefficient. Although later first generation aircraft did introduce swept wings which were angled backwards to the fuselage, which allowed for transonic flight during dives, pilots had minimal control at such speeds, which made them impractical.

First generation jets also had very basic avionic systems and no self-protection measures. Only the very final jets in this generation had rudimentary radar systems. They were armed with machine guns or cannons, and unguided bombs and rockets. These aircraft were deployed as interceptors, and could engage in combat within close visual range. Most such aircraft could also be operated only during the day. During this time, ground-attack aircraft continued to be powered by piston-engines and propellers.

Second generation (1955 to 1970)



A Romanian Mig-21F, the very first Mig-21 variant to be developed. (Govt of Romania)

Second generation fighters saw massive improvements in terms of speed, weaponry, and avionics. With the introduction of afterburners, and swept wings becoming the norm, these aircraft for the first time were capable of transonic and supersonic dashes during level flight. This new-found speed had a major influence on how dogfights would unfold, and air forces had to bring in major changes to their fighting doctrines.

Second generation fighters also boasted the very first fire control radars and semi-active guided missiles. Also came along radar warning receivers, which would eventually develop into aircraft being able to deploy active countermeasures. While the range of air-to-air engagement greatly increased, most combat was still within visual range albeit with pilots having much more accurate fire control systems.

Aircraft in this generation were classified as either interceptors or fighter-bombers for air superiority and ground attack roles respectively.

Third generation (1960-1970)

The Hawker Siddeley Harrier was the first jet to have vertical take-off and landing capabilities. (San Diego Air and Space Museum Archive)

There are four main points of demarcation between the second and third generations of fighter jets.

First, the design process of this generation of aircraft saw a major overhaul. Instead of designing an airframe upon which to hang an increasingly complex suite of systems and subsystems, there was a shift towards more integrated designs. The most important change in this regard came with the shift to an integrated engine and airframe assembly.

Second, this was the first generation of fighter jets designed to have multi-role capabilities. The traditional demarcation between fighter-bombers and interceptors started to become blurred — aircraft could now carry a far wider range of weapons, from air-to-ground missiles and laser-guided bombs, to air-to-air missiles and cannons.

Third, this generation of aircraft were the first with capabilities of beyond visual range air-to-air combat, aided by significantly improved fire control radars, guided missiles, and the first generation of tactical electronic warfare systems. Improved avionics included pulse-doppler radar, off-sight targeting and terrain-warning systems.

Fourth, the engines saw some major improvement as well, with better turbofans. Third generation fighters were thus capable of more sustained supersonic flight, far superior range and performance, and more maneuverability, with some aircraft also coming with vectored thrust.

Fourth generation (1970 to 2000s)

The F-16 is the most popular fighter jet in the world, with almost 5,000 models produced till date. (Wikimedia Commons)

The fourth generation is the longest according to any classification, meaning that even within the generation one can find a rather extensive progression of technology. The earliest fourth gen fighters, like the Grumman F-14 Tomcat, made famous in the movie Top Gun (1986), are pretty much incomparable to the latest fighters of the generation (sometimes referred to as gen 4.5 as a result) such as the Dassault Rafale.

A few characteristic developments are nonetheless notable.

First, true multi-role aircraft emerged only with this generation. While the lines between interceptors and fighter-bombers had started to blur with the previous generation, it was now that fighters such as the F-14, and later the McDonnel Douglas F/A-18 'Superhornet' and Sukhoi Su-30 that one had fighters which were equally adept at either role.

Second, this was the first generation of aircraft to use fly-by-wire (FBW) control systems, which use computers to mediate between pilot's inputs and the eventual output on an aircraft's control surfaces (such as the rudder or the elevons). This provided pilots with improved control at high speeds, improved the performance and fuel efficiency of aircraft by replacing heavier control systems with 'wires', and allowed for more intentionally aerodynamically unstable aircraft designs to increase maneuverability.

Third, with advancements in computers and electronics seen elsewhere, fighter aircraft too became far more "high-tech", as per modern standards. This generation saw a wide-range of developments in avionics, including the introduction of "heads-up displays", and "improved electronic warfare systems".

Fourth, this was the first generation of fighter aircraft designed using some stealth principles. (Stealth here refers to the ability to be invisible to radar systems). Composite construction materials, radar absorbent paints, and stealth-designs make a debut with this generation.

EXAMPLES: Sukhoi Su-30, Mikoyan Gurevich MiG-29, Chengdu J-10, Sukhoi Su-35, Eurofighter Typhoon, Saab Gripen, HAL Tejas LCA, Dassault Rafale

Fifth generation (2000 onwards)

The F-22 Raptor is the most expensive fighter jet produced till date, with each unit costing upto $350 million. (USAF)

The most advanced fighter aircraft currently in operation, fifth generation aircraft have fully embraced stealth, advanced integrated avionics systems that provide the pilot with a complete picture of the battle space (literally allowing them to look through the airframe), and network capabilities (which allow aircraft to be in constant touch, and act in coordination — like a hive mind).

The Lockheed Martin F-22 Raptor was the first fifth generation aircraft to enter service (in 2005). Till date, its stealth and long-range combat capabilities remain unmatched — its radar cross-section is comparable to a small bird or insect, while its own suite of advanced avionics allows it to identify and locate enemy aircraft at great distances. This means that the Raptor can effectively shoot down an adversary before they even know of its presence.

A crucial aspect of a fifth generation fighter jets capabilities are its computers and onboard software, which help automate or semi-automate many functions, and process battlefield information at a very advanced level. However, these aircraft are also extremely expensive to develop and maintain, meaning that even among countries which operate them, they do not form the bulk of the fleet.

The Lockheed Martin F-35 Lightning was meant to address the cost issue by developing a single, all-purpose, universal aircraft which could be operated out of land or sea, for

interceptor, ground attack or electronic warfare roles, in all conditions. The F-35B even boasts short takeoff/vertical landing capability. But the aircraft has seen multiple cost overruns, and its performance has been debatable.

Currently, only the US (F-22 and F-35), Russia (Sukhoi Su-57), and China (Chengdu J-20) have developed operational fifth generation aircraft. India is currently developing its own fifth generation aircraft, although this is not even in the prototype stage.

Sixth generation: What the future looks like

Several countries such as the US, China, Russia, the UK-Japan-Italy, and France-Germany-Spain have announced the development of sixth-generation fighters even before fifth-generation ones become ubiquitous. So far, there is no clarity on what features these fighters might boast, apart from further improving on beyond-visual-range capabilities, stealth, computational power, and weaponry.

The Tempest, being jointly developed by the UK, Italy, and Japan will be a sixth generation fighter. This is an image of a mockup from 2019. (Wikimedia Commons)

Some possible features may include the following.

• Sixth-generation aircraft may be optionally-manned, meaning that they may not require a human to sit in a cockpit to carry out their missions. So far, unmanned drones have been limited by various factors, including the tiny lag in the time it takes for aircraft to respond to commands sent from the control centre. The integration of Artificial Intelligence, and

improvements in computation and networking can change this, which would fundamentally revolutionise aerial warfare.

• This generation might even boast advanced dual cycle engines, allowing aircraft to potentially touch hypersonic speeds when required while still being able to cruise economically. Such high speeds may especially become viable if pilots do not need to sit in cockpits and endure the tremendous G-forces that such speeds would generate.

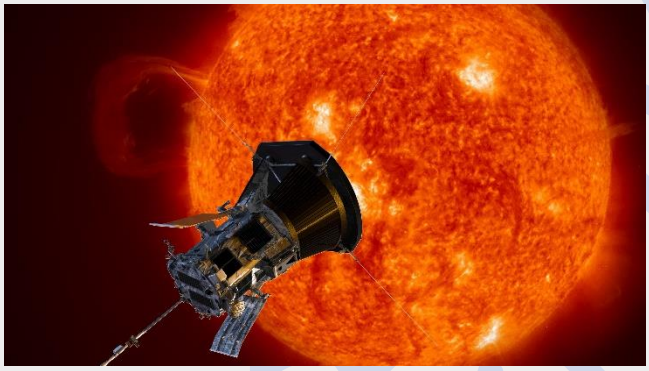
• These aircraft may see the potential use of directed-energy weapons such as a laser.

• Some speculate that sixth-generation fighters might also come with the ability for suborbital flight, meaning they could operate in low space for brief periods, allowing them to escape anti-aircraft systems, and significantly improve survivability.

Relevance: GS Prelims & Mains Paper III; Science & Technology
Source: Indian Express

2. Why Parker Solar Probe completing closest-ever approach to Sun is significant

Introduction



NASA scientists announced that the Parker Solar Probe survived the closest-ever approach to the Sun. The craft was operating normally after it passed just 6.1 million km from the solar surface.

This distance might not sound close but Dr Nicola Fox, head of science at NASA, told the BBC, "We are 93 million miles away from the Sun, so if I put the Sun and the Earth one metre apart, Parker Solar Probe is 4 cm from the Sun — so that's close."

What is the Parker Solar Probe?

Launched in 2018, the Parker Solar Probe was developed as part of NASA's Living With a Star program to explore aspects of the Sun-Earth system that directly affect life and society on Earth.

It is designed to make observations of the Sun's upper atmosphere, known as the corona, and carries four instrument suites.

The probe, which is the size of a small car, "also makes critical contributions to forecasting changes in the space environment that affect life and technology on Earth," according to a NASA report.

Over the years, it has completed 21 orbits around the Sun, with flybys of Venus gradually moving closer to our star.

How did it manage to come so close to the Sun?
The Parker Solar Probe is the closest any human-made object has ever come to the Sun.

Travelling at the speed of 6,92,000km/h, it endured temperatures up to 1,377 degree Celsius when it reached the closest to our star which occurred on December 24. The probe went out of contact during this but the scientists operating it received the signal on the night of December 26.

The craft was able to survive such high temperatures as it is protected by a 4.5-inch-thick (11.43 cm) carbon-composite shield.

"The spacecraft is outfitted with a cutting-edge heat shield made of a carbon composite foam sandwiched between two carbon plates. The heat shield is so good at its job that, even though the front side will receive the full brunt of the Sun's intense light, reaching 2,500°F (1,371 degree Celsius), the instruments behind it, in its shadow, will remain at a cosy 85°F (29.4 degree Celsius)," a different NASA report said.

The probe circulates a single gallon of water through its solar panels which helps it keep its cool — the water absorbs the heat, and then radiates it out into space.

What is the significance of this milestone?
Scientists are hoping that as the probe passed through the Sun's outer atmosphere – the corona – it would have collected data that can give clues about some long standing questions. For instance, researchers expect to solve the mystery around why the corona is so hot — temperatures regularly reach 1 million to 2 million degree Celsius there.

The data could also give an idea about the origins of solar winds, a continuous flow of material escaping the Sun. A better understanding of solar winds is crucial as it affects not only the space environment but also life on Earth.

Solar winds are usually deflected by Earth's magnetic field, which acts like a protective shield. Still, sometimes particles interact with atoms and molecules in the atmosphere to produce the phenomena of the northern and southern lights. However, a strong solar wind can disrupt power grids, satellites, and communication systems.

Speaking about the importance of the Parker Solar Probe's data, Dr Julia Stawarz of Northumbria University (UK) told The Guardian, "The measurements from Parker solar probe will help us to answer some of the most fundamental questions about how the sun and its extended atmosphere behave that we have had since the very beginning of the space age."

The probe is expected to send back detailed telemetry data on its status on January 1, according to a statement by NASA.

Relevance: GS Prelims; Science & Technology
Source: Indian Express

3. Manmohan Singh's last rites: What is a state funeral, what rules govern it

Introduction

The ashes of former prime minister Manmohan Singh were immersed in the Yamuna river near Majnu ka Tila Gurdwara on in New Delhi, by members of his family following Sikh rituals.

Singh was given a state funeral a day before, on December 28. He was cremated at the Nigambodh Ghat in New Delhi, in the presence of President Droupadi Murmu, Prime Minister Narendra Modi, Leader of Opposition Rahul Gandhi, and other senior leaders.

Singh's body, draped in the Indian flag, was carried through New Delhi on a flower-decked carriage pulled by a ceremonial army truck. Before his body was placed on the pyre, the flag was removed and the body covered with a saffron cloth, in accordance with the rules of a state funeral.

What is a 'state funeral'? Who is accorded this, and what are the rules?

What is a state funeral?

A 'state funeral' is when a person of importance is laid to rest in an elaborate ceremony following laid-down rules, involving members of the public in the mourning.

In India, according to government guidelines, a state funeral "will be accorded in the event of the death of the President, Prime Minister, a former President or a Governor. No State funeral will be accorded in the event of the death of any other dignitary, but in individual cases Central Government may order a State funeral."

Recent examples of this include industrialist Ratan Tata and singer Lata Mangeshkar, who were given state funerals.

"A State funeral will be attended by all the gazetted officers of Government who may be present in the station. Service personnel will wear dress as for State functions. Arrangements for the State funeral will be made by the Ministry of Defence on receipt of information from the Ministry of Home Affairs," the rules further say.

What is national mourning?

National mourning can also be declared by the Centre or state governments for political leaders and others who have made an exceptional contribution to the country. The National Flag in such cases is flown at half mast, following a set of rules.

"When State mourning is observed on the death of any dignitary, the flags will be half-masted throughout the period of mourning throughout India in the case of the Union dignitaries and throughout the State concerned in the case of a State dignitary," the rules say.

After Manmohan Singh's death, the government announced seven days of state mourning, from December 26 to January 1, during which period the "national flag will be flown at half mast throughout India where it is regularly flown."

Also, no official entertainments are held during national or state mourning, unless Republic Day, Independence Day or Mahatma Gandhi's birth anniversary fall during this period, in which case "the mourning shall be interrupted on such day and the unexpired period of mourning shall be observed immediately following the interruption."

In a state funeral, the dignitary's body can be draped in the national flag. However, Section 3.58 of the Flag Code of India, 2002, says: "On occasions of State/Military/Central Paramilitary Forces funerals, the flag shall be draped over the bier or coffin with the saffron towards the head of the bier or coffin. The Flag shall not be lowered into the grave or burnt in the pyre."

Relevance: GS Prelims; Governance
Source: Indian Express