In a fight between two aircraft, each representing the peak of its generation of jet fighter technology, the final outcome depended on such variables as surprise, position, numbers, and altitude. These same concepts, true through the first four generations of jet fighters, explain how nations with vastly different resources often managed to produce highly competitive aircraft. The Meteor offset the Me-262; the Sabre matched the MiG-15; the Mystere compared with the North American F-100; the MiG-21 countered the McDonnell Douglas F-4; and the Rafale battles the Sukhoi Su-27. The fifth generation of fighters, the Lockheed Martin F-22 and F-35, fundamentally changes the concept of operations for combat. A review of the first four generations of fighter aircraft around the world shows why. The First Generation: Early Jets <br />The first generation of jets included experimental aircraft not intended for combat. Germany was the first country to enter the jet age with the first flight of the Heinkel He-178. Flown on 27 August 1939, the He 178 was powered by an engine developed by Dr. Hans von Ohain and built by a special department of the Heinkel aircraft company. Earlier in Great Britain, Frank Whittle had begun work on the jet engine but failed to receive sufficient government support to complete his design before the flight of the He-178. Once government support became available, Whittle's engine powered the flight of the first Allied jet, the Gloster E. 28/39 on 15 May 1941. While both early flights furthered jet aviation, the first flight of a third experimental aircraft received credit for being the first jet flight. This aircraft, Italy's Caproni-Campini CC-2, was first flown on 27 August 1940. A hybrid, it used a 900hp Isotta Fraschini L.121/R.C.40 internal combustion engine to drive a compressor with a primitive afterburner fitted aft of the compressor. The Caproni-Campini flight was recognized as the first jet to fly by the F��ation A�onautique Internationale, the international aviation record sanctioning body, as the first flight date of the He-178, made in secret, was not known until after World War II. The first true jet fighter was the twin-engine Heinkel He-280, first flown 30 March 1941. The He-280 featured such advances as a tricycle landing gear and a compressed-air ejection seat, but its airframe belonged to the piston-engine era. It was distinguished only by its HeS 8A centrifugal flow turbojets, replaced in later aircraft by the Junkers Jumo 004. Although the He-280 handily defeated a Focke-Wulf Fw-190 in mock combat, the Luftwaffe cancelled the program to proceed with the world's first operational jet aircraft, the more capable Messerschmitt Me-262 Schwalbe (Swallow). The Me-262 was originally designed as a straight-wing aircraft with the engines mounted through the wing, much like those of the Gloster Meteor. When the engine diameter grew, the engines had to be placed in nacelles mounted under the wing. The weight and balance problem resulting from that redesign was resolved by sweeping the wings back twenty-three degrees. This engineering fix gave the aircraft a modern look as well as an aerodynamic advantage. The Me-262, with its 540-mph top speed and heavy armament of four 30 mm cannons, could easily have made it the best combat fighter in World War II. But slow delivery of the Junkers Jumo 004 jet engine and other factors delayed the Me-262's combat entrance until late summer 1944. Of the 1,300 or so Me-262s built, only about 300 ever saw combat. As a result, the Me-262 had little effect on the outcome of the war. Great Britain's first operational jet fighter, the Gloster Meteor, had its first flight on 5 March 1943. The prototype was powered by de Havilland Halford H.1 turbojets, but production aircraft used the Rolls-Royce version of the Whittle W.2 design. The Meteor engaged in the first jet-versus-jet combat when it battled an unpiloted Fiesler Fi-103 "V-1" Buzz Bomb. To the disappointment of historians, the Meteor and the Me-262 never met in combat. In 1942, the US Army Air Corps forfeited a chance to participate in the earliest rounds of the jet age by rejecting a Lockheed proposal for the L-133. A Kelly Johnson design,

the L-133 featured a blended wing and body, canard-surfaced jet fighter powered by two axial flow turbojet engines. Instead of the L-133, the first American jet fighter was the less-than-lethal Bell XP-59A Airacomet. The Bell design was flown for the first time 1 October 1942. Powered by two General Electric Type 1A turbojets, developed from Whittle's work, the aircraft's poor performance relegated it to training duties only. The Army Air Corps did turn to Lockheed for its first production jet fighter, the P-80. The first product of Skunk Works, the XP-80 took its maiden flight on 8 January 1944. While three P-80s arrived in Europe before the war ended, none saw action. Korea presented action aplenty, however, where the P-80 Shooting Star, re-designated F-80 in 1948, distinguished itself in ground attack and reconnaissance roles. The basic design then extended to include the T-33 trainer and F-94 Starfire interceptor aircraft. The Next Generations<br />Even before World War II ended, designers sought to maximize fighter performance by tailoring the airframe to the potential of the jet engine. The most important new development of the second-generation jet fighter was true swept wings specifically designed to delay the onset of drag associated with high Mach numbers. Such aircraft as the F-86, MiG-15, Saab J-29, Hawker Hunter, and Grumman F9F Panther and Cougar were optimized for transonic speeds. These beefed-up airframes required new types of boosted controls, improved ejection seats, better cockpit pressurization, and the refinement of aerodynamics so that the fighter provided a stable gun platform at high speeds and high-g loads. The Saab J-29 Tunnan ("Flying Barrel") built by Sweden was the first swept wing fighter to enter service in Western Europe. It was flown for the first time on 1 September 1948. Saab built some 660 J-29s, which illustrates that a small country can field a first-line jet fighter with performance comparable to the best of its era. The third-generation of jet fighters heralded a proliferation of new designs and capabilities: supersonic speeds, sophisticated missiles, and high-output turbojet or early turbo-fan engines. This third generation also included the remarkable Century series, which began with the first operational American supersonic fighter, the North American F-100. Within six years (from 1951 through 1956), fighter and engine design took a giant leap the world over. In that time, at least eleven world-class fighters debuted: the F-100, Convair F-102 and F-106, Lockheed F-104, McDonnell F-101, MiG-17 and -19, Dassault Etendard and Mirage III, Saab Draken, and the English Electric Lightning. This sudden flowering of jet design incorporated many advances: delta wings, more highly swept wings, more powerful yet more fuel-efficient engines, sophisticated fire control and navigation systems, and in-flight refuelling. Later aircraft of this generation were far more sophisticated and possessed much greater capability. The Republic F-105, MiG-21 and -25, McDonnell F-4, and the Saab Viggen belong in this generation. Even as speed, altitude, and firepower increased, jet fighters still faced hard combat lessons in Vietnam and in the Middle East. Vietnam War politics restrained US forces and enabled a relatively few older MiG-17s and -19s along with the newer MiG-21s to dictate terms of combat. The result was a discouraging victory ratio for US forces that ranged from a low of one victory to two losses to a high of four victories to one loss. These wartime lessons meshed with the emerging computer age as digital electronics were incorporated into the design and production process as well as into the new aircraft designs. What resulted was a tidal wave of technological advances in fourth-generation jet fighters: the General Dynamics (now Lockheed Martin) F-16, Grumman F-14, McDonnell Douglas F-15 and F/A-18, Dassault Rafale, Eurofighter Typhoon, MiG-23 and -29, Saab Gripen, and Sukhoi Su-27. These vastly superior aircraft generally possessed high-output turbo-fan engines, infinitely more capable and reliable electronics, fly-by-wire control systems,

zero-altitude ejection capability, improved ordnance, and an ever-increasing number of on-board computers. Another development was that companies and even countries teamed to reduce research and development risk and enhance fighter capabilities. The Lockheed F-104 pioneered these efforts during the 1950s; the F-16 cemented international cooperation in the 1970s. The increased cost of these latest fighters strained military budgets everywhere and dictated the aircraft be adapted to both air-to-air and ground attack roles. Among these fourth-generation aircraft, the F-15 and F-16 emerged earlier than their foreign equivalents and established a reputation for air dominance unchallenged for years. As foreign-built fourth-generation contenders emerged, their US counterparts maintained their lead with significant advances in radar and engine performance as well as improved air-to-ground capabilities, including night, all-weather, and precision attack. Even with these improvements, fourth-generation fighters fielded by the United States and its allies face serious competition by such aircraft as the Su-27, MiG-29, and MiG-35. For example, the advantages of US F-15 fighters were put in question by highly motivated, well-trained Su-30K pilots of the Indian Air Force during Cope India exercises in 2004. Fourth-generation fighters also face more advanced ground threats in the form of "double-digit" (e.g., SA-14) surface-to-air missiles. On the Eastern front, China is rapidly moving toward an indigenous air-and-space capability suitable for a superpower. It is plausible that China will build aircraft and missiles in numbers compatible with its population and growing wealth and will create training programs to produce pilots with skills to match their Western and Indian counterparts. The Fifth Generation<br />The overriding characteristic of fifth-generation fighters is integrated very low observable, or VLO, stealth. Stealth relies on shape, materials, and internal weapon carriage. The result is a very low radar cross section even when fully configured for combat. The fifth-generation fighter takes advantage of the previous generations of stealth technology developed and matured for the B-2 bomber and AGM-129 Advanced Cruise Missile to become more than just a fighter generational evolution. This combination of near-invisibility to an enemy along with fighter manoeuvrability establishes fifth-generation platforms as more a part of a revolution than an evolution. A particularly important advance of fifth-generation stealth is its ease of maintenance. Stealth maintenance on the early F-117As required fifty man-hours per flight hour; at maturity, stealth maintenance on the fifth-generation aircraft will require minutes of maintenance per flying hour. Fifth-generation fighters combine stealth with huge improvements in integrated avionics and supportability. Stealth, agility, performance, fused-information, improved situational awareness, and network-enabled operations all combine to create advantages never seen before in previous fighter evolutions. Other critical factors include an emphasis on reliability, maintainability, and sustainability  the capability to fight day after day without extensive maintenance. Fifth-generation maintenance requirements will be one-third the maintenance requirements of the legacy aircraft they replace. They also have the ability to deploy more rapidly. The fifth generation, therefore, is really defined by two fighters, the F-22 Raptor and the F-35 Lightning II. By fielding a fifth generation of jet fighters, the United States establishes a true generation gap unapproachable by a single power or a combination of powers. The F-22 and F-35 offer obvious complementary advantages. Both have all the features that define fifth-generation fighters, but the F-22 adds the unique features of high-altitude super-cruise and extraordinary agility. These attributes allow it to more efficiently secure immediate air dominance in any environment. Among all fighters current as well as future, including the F-35the F-22's ability to super cruise (fly at greater than Mach 1.5

without the use of afterburner) adds to the kinetic energy imparted to its missiles at launch while simultaneously denying the enemy time in which to respond. Super-cruise also allows for increased supersonic persistence and decreased adversary reaction times. In combat, the integrated avionics system gives a God's eye view of the combat scene to every pilot in a data-linked flight of F-22s, raising the concept of situational awareness to a universal level. This universal situational awareness enables Raptor pilots to concentrate on tactics. They don't have to spend time integrating separate data inputs from multiple sensors. The F-22 enables pilots to see and destroy enemy fighters and missile sites before either is aware of the Raptor's presence. If a threat gets within dogfighting range, the incredible agility of the thrust-vectored Raptor ensures close-in success. A less-obvious relationship between the F-22 and the F-35 is their unprecedented exchange of technology. Lessons learned on the F-22 are built into the F-35, while advances from the F-35 can be retrofitted into the Raptor fleet. The extraordinary performance of the two aircraft is dependent upon their powerplants, and these are inextricably linked. The F-22 is powered by two Pratt & Whitney F119 engines with about 35,000 pounds of thrust each. The core section of the F119 was used to develop the P&W F135 for the F-35. The F-35 adds its own unique features that focus on basing flexibility, as its three versions are individually designed to operate from carriers, conventional runways, or extremely short austere strips. With both good-range and high-payload capacity in non-stealth mode, the F-35 will be able to secure immediate strike dominance. The F-35A is optimized for the US Air Force; the F-35B offers short take-off and vertical landing for the US Marine Corps and Allied countries; and the F-35C operates off large aircraft carriers. The F-35B is the world's first stealthy, supersonic, STOVL strike fighter. The design of the F-35 incorporates advances in electronics not immediately available to the F-22. These advances &#65533; fourth-generation active electronically scanned array radar with half the weight, half the cost, and twice the reliability of the third-generation F-22 AESA &#65533; will be retrofitted to later-block F-22s. The active and passive capabilities of the F-35's radar exceed any previous radar and can generate long-range, high-resolution synthetic aperture radar maps of unprecedented size. Other advances featured in the F-35 include a distributed aperture system, which acts as an infrared sensor and provides a protective sphere around the aircraft to alert the pilot to any threat; an internally mounted electro-optical targeting system that provides long-range, high-resolution target recognition; an integrated communications, navigation, and identification avionics suite, which provides lethal beyond-visual-range recognition and intra-flight data exchange; an advanced electronic warfare and countermeasures system; and a helmet-mounted display with the most advanced head-tracking system available. These systems combine to optimize fighter tactics through the OODA loop &#65533; observe, orient, detect, and act &#65533; as defined by fighter tactics guru John Boyd. These systems depend on the aircraft's integrated core processor, which presents all incoming information to the pilot in an optimized form. There is also an X factor. Ingenious future aviators will use the capability of these aircraft beyond the standard air-to-air and air-to-ground regimes. Examples could include intelligence, surveillance and reconnaissance, and advanced electronic attack, both of which show promise to radically change the use of tactical aircraft. The F-22 and the F-35 will stand alone for decades to come. No other fifth-generation fighters exist and none appear on the horizon. The fifth generation will be with us for decades, and one can only speculate about the advances to be found in the sixth generation and beyond. Weapons will change over time, with directed energy coming to the fore, along with satellite-linked missiles. And, as much as pilots may hate the idea, a generation of stealthy, agile, and

lethal unmanned fighters may someday be flying under the control of pilots in sixty-year-old F-22s and forty-year-old F-35s.  Source : Lockheed Martin Corporation (NYSE: LMT)