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IS THE JOINT STRIKE FIGHTER RIGHT FOR AUSTRALIA?

PART 1 – F-35 V F/A-22

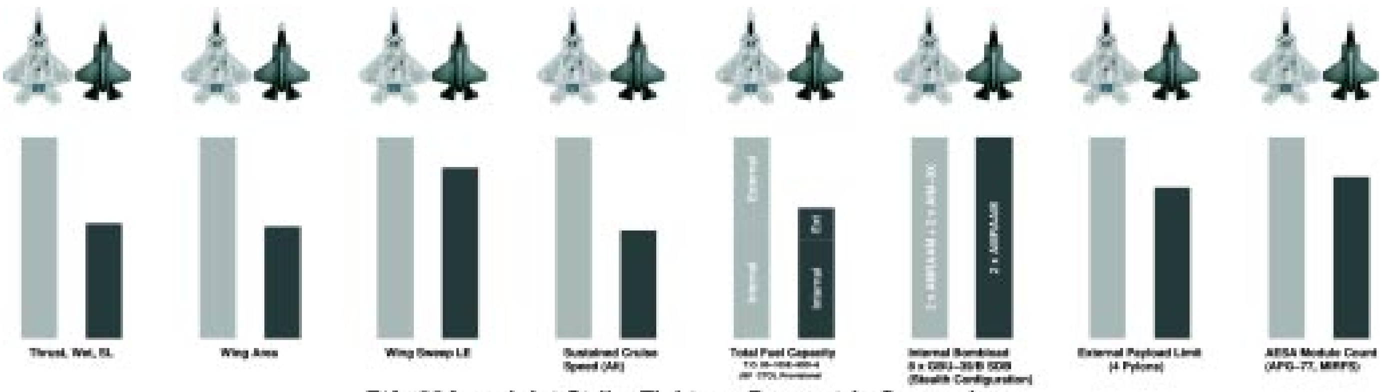
In recent testimony to the Joint Foreign Affairs, Defence and Trade Committee of Federal Parliament the Defence Department leadership asserted that the "the really big difference [between the F/A-22 and Joint Strike Fighter] is in cost". This remarkable statement, and others of a similar ilk, explains much of the enthusiasm surrounding the Joint Strike Fighter in Defence leadership circles – the Joint Strike Fighter is effectively perceived to be a single engine F/A-22. Given the design aims, development histories and characteristics of these aircraft, this belief is not supportable by available evidence.

This two part analysis will delve deeper into the differences between the JSF and its more capable sibling, the F/A-22A Raptor, and explore recent developments in the JSF program.

Both the F-35 JSF and F/A-22A reflect a process of strategic and technological evolution which began during the 1980s. This was a period during which the Soviet empire reached the peak of its military power before its economic and political collapse, a period during which the high performance Sukhoi Su-27 and Mikoyan MiG-29 entered large scale production, and massive Soviet tank armies presented the benchmark of land power worldwide.

During this period the US Air Force relied upon its fleet of F-15A/C Eagle air superiority fighters, supported by the smaller but highly agile F-16A/C, as the means of breaking the back of Warpac air forces in the pivotal Central European theatre. Soviet land forces were to be broken by a mix of F-111, A-7D, A-10A and later, F-16C strike aircraft.

The F-15A was primarily aimed at air superiority, although the weapon system supported a range of modes for dumb bomb delivery, used extensively by the Israelis in combat. The enhanced F-15C gained Conformal Fuel Tanks (CFT) to push internal fuel up from 6110kg (13,455lb) to 10,535kg (23,200lb), and avionics and engine enhancements. The F-16A was, like the F-15A, aimed at air superiority, but limited by radar to mostly day VFR combat. While exceptionally agile, the F-16A's 3085kg (6800lb) internal fuel



F/A–22A vs Joint Strike Fighter – Parametric Comparison

(Provisional Data)

capacity severely limited it.

Growing Soviet airpower, especially the new Sukhoi Su-27 and Mikoyan MiG-29 fighters, provided the impetus for further air superiority fighter development. The US Air Force launched the Advanced Tactical Fighter (ATF) program aimed at replacing the F-15 with an aircraft providing an overwhelming capability margin over the Su-27 and MiG-29 – similar to that held by the F-15A over the MiG-21 and MiG-23. A key feature of the ATF was the addition of a supersonic cruise or 'supercruise' capability – the ability to remain supersonic on dry thrust as long as the fuel payload permitted.

Supercruise was intended to provide an unbeatable energy advantage over fighters with conventional propulsion which are limited to mere minutes in full afterburner before exhausting their fuel. A side benefit was the ability to transit from bases in Holland and the UK to the battlespace in half the time the F-15 required. Considerable R&D investment was made very early into the supercooled turbine engine technology required to support this regime of flight – stealth became a feature of the ATF program only after the F-117A proved to be viable.

The ATF flyoff saw the stealthier and faster Northrop/McDonnell Douglas YF-23A pitted against the Lockheed/Boeing/General Dynamics YF-22A, with Pratt & Whitney and General Electric bidding their respective YF119 and YF120 engines. By 1991, the respective winners were the Lockheed led team and P&W, in a large part due to their more conservative and thus lower risk designs.

The then F-22A ATF had evolved into the technological flagship of the 4th/5th generation fighter class – now embodied in the technologies in the F/A-22A and JSF. The aircraft has supersonic cruise engines, thrust vectoring, all aspect stealth, a large active phased array radar, and the innovative Pave Pillar avionics architecture, which shifted all signal and data processing into a group of centralised multiple processor chip computers.

With the Soviet empire's collapse the role of the F-22A evolved to encompass the 'deep strike' mission of the current F-117A (and earlier the F-111) – destroying heavily defended ground targets using smart bombs. The 250lb class GBU-39/B Small Diameter Bomb came into existence as a weapon to increase the firepower of the F-22, limited then to a pair of internal 1000lb GBU-32 JDAMs. The current F/A-22A is a genuine multirole fighter, with high resolution Synthetic Aperture Radar capability and will be tasked as much with air superiority as with killing SAM sites, radars, airfields, bunkers, command posts and other high value assets. The planned US Air Force Global Strike Task Force (GSTF) will comprise 48 F/A-22As and a dozen B-2As, and is intended to break the back of any opponent, globally.

Penetrating defences at 50,000ft and sustained supersonic speeds, the F/A-22A defeats most SAMs by kinematic performance alone – its stealth capability defeating the top tier S-300/S-400 series systems. The F/A-22A will remain the most survivable strike fighter in existence for decades to come – and the most lethal air superiority fighter.

The JSF evolved from a completely different set of needs and strategic pressures, and occupies a completely different niche in the US force structure. While the JSF program has its origins in the early 1990s, the philosophical thinking in many of its design features dates to a similar era to that of the ATF program.

The problem of breaking Soviet ground forces increased in difficulty during the 1980s. As the Soviets introduced night vision equipment on tanks and fielded the highly mobile SA-12 (S-300V), SA-11 (9K37), SA-15 (9K330) battlefield air defence weapons, it became evident that the existing fleet of A-10A and A-7D close air support and battlefield interdiction (CAS/BAI) aircraft would be hard pressed to survive, let alone provide the numbers to break the Soviets in the Fulda Gap. While the USAFE F-111E/F deep strike force was being supplemented with 200 of the new F-15E 'Beagle' Dual Role Fighter and the 60 F-117A stealth fighters, Tactical Air Command's close air support (CAS)/battlefield air interdiction (BAI) force was sorely in need of improvement.

A flyoff was started between an upgraded A-7D Corsair II, the YA-7F with the F-16's P&W F100 afterburning fan, and an enhanced F-16B variant. Concurrently, trials commenced with dual seat YA-10Bs fitted with the then new LANTIRN package of pods – one pod carrying a terrain following radar and 'look into turn' steered thermal imager, the other a laser/thermal imager pod most akin to a miniaturised Pave Tack.

This ambitious plan for enhancing the CAS/BAI fleet collapsed with the Soviet Union, but important lessons were learned, all reflected now in the JSF program. The A-7F was found to have inadequate fuel capacity for the role though its mildly supersonic speed was suitable, while the A-10A's low speed remained a problem. The F-16 equipped with the LANTIRN system was found to be cumbersome – the pod set was designed for the 'deep strike' F-15E/F-16E (XL) and intended for strikes on prebriefed targets rather than searching for difficult to spot ground targets in proximity to friendly troops.

Perhaps the most significant technology then trailed on the F-16B was a head steered helmet visor projecting thermal imaging turret mounted in front of the windshield. This was found to be very effective, as the pilot could look around the aircraft, in any direction, to find targets and spot incoming SAMs and gunfire. In conventional low level close support work, fighters ended up orbiting the area of interest while ground Forward Air Controllers (FACs) relayed the enemy force position. Being able to look 'over the shoulder' to locate targets proved invaluable.

This experience was prominent in the minds of US force

F/A–22A vs Joint Strike Fighter – Parametric Comparison

(Provisional Data)

Both the F/A-22A and JSF use similar planform alignment and stealth shaping rules, reflecting a common design heritage. In the critical forward sector, the much more refined design of the F/A-22A is evident especially in the edge aligned inlet configuration and cleaner chining. The F/A-22A scatters into a smaller number of lobes over a much wider frequency band, reflecting its all aspect 'wideband' stealth requirement. (USAF & LM)

planners during the early 1990s, as the JSF was born, and LANTIRN equipped F-16CGs absorbed the role performed by the A-7D. The A-10A soldiered on, only recently acquiring Israeli built Litening II targeting pods.

During this period the US Air Force deep strike fleet retained the F-111F, the new F-15E and the stealthy F-117A, backed up by the B-52G/H and the new B-1B and B-2A heavy bombers. The then recent Desert Storm campaign illustrated that the key weakness in the force structure was the battlefield strike fleet – not only was the survivability of the slow A-10 a problem, but the range/endurance of the F-16C was inadequate even for the modest 400 to 600nm (740 to 1110km) radius needed. The US Navy and Marines experienced similar troubles with the F/A-18s, while the Marines' AV-8B Harriers suffered disproportionate losses to heatseeking SAMs.

As the JSF program materialised from the JAST technology demonstration effort, each of the respective US players brought their own wishlists to the table.

The US Air Force wanted a better CAS/BAI package than provided by the existing mix of F-16CGs and A-10As, one which absorbed all of the valuable lessons of the late 1980s and Desert Storm. This meant more fuel and weapon stations than the F-16C, stealth to beat radar guided battlefield SAMs and AAA, all round night vision to improve survivability against ground defences, and the ability to find immediate ground targets hidden from the view of a FAC.

The F-16 community insisted on good close-in air combat capability – a hedge against enemy fighters breaking through top cover CAP defences. While early proposals were devoid of an expensive radar, intended to rely on ground target coordinates provided by E-8 JSTARS, UAVs and satellites, the demand for air combat capability and more autonomy saw this idea die very quickly.

The politically vocal and influential US Marines wanted a replacement for their F/A-18s and AV-8Bs, which meant a V/STOL capability, but faster and more survivable than the Harrier. The Marines, like the F-16C community, insisted on close-in air combat capability, and wanted an all weather day night avionics package better than their two seat F/A-18D Night Attack fleet had. Tasked with close air support, the Marines needed an aircraft capable of surviving SAM and AAA defences at low level, and capable of autonomous target acquisition, absent capabilities like the E-8 JSTARS.

The US Navy at that time suffered significant losses in the budgetary game. The A-12A Avenger II ('Dorito') died at the hands of Defense Secretary Cheney, in an acrimonious dispute over performance and price, leaving them without a replacement for the 'deep strike' A-6E Intruder fleet. With much investment in the collapsed A-6F upgrade and the A-12A avionics suite, the Navy wanted a bomber which could absorb as much as possible of the capability planned for the A-12A.

What is significant is that the US Navy had a large investment in air-to-ground radar technology. The capability for simultaneous Synthetic Aperture Radar (SAR) high resolution groundmapping and Ground Moving Target Indicator (GMTI) mobile target tracking had its origins in a Norden radar planned for the A-6, which later became the basis of the APG-76 radar fitted to Israeli F-4Es. This capability was to be absorbed in the A-12A's active phased array which was also cancelled. It has rematerialised now in the JSF's APG-81 radar system – the higher power rating of this radar against the F/A-18 radars reflecting the power-hungry GMTI mode.

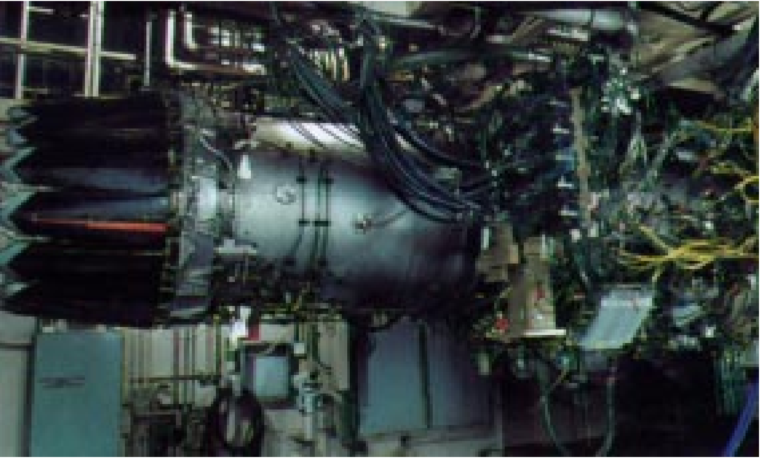
These diverse needs coalesced in the JSF program, which attempts to reconcile them with further and much broader aims. The stated service needs for the JSF, as per the JSF website, are thus:

- USN – 'first day of war, survivable strike fighter aircraft to complement F/A-18E/F' (This provides the stealth capability lost in the A-12A bomber, and the strike radius capability and the all weather strike avionics capabilities lost in the A-6/A-12A).
- USAF – 'multirole aircraft (primary air-to-ground) to replace the F-16 and A-10' (This absorbs the existing capabilities of the F-16CG and A-10A but incorporating the CAS/BAI avionics lessons of the late 1980s).
- USMC – 'STOVL aircraft to replace the AV-8B and F/A-18' (This replaces the capabilities in the basic and radar equipped AV-8B variants, the night strike F/A-18D and basic F/A-18C).

All three primary users plan to fly their JSFs with stealthy internal weapons during the initial phase of a conflict, shifting to larger payloads of non-stealthy external weapons once the primary radar directed air defences are broken.

Two other factors had a decisive influence on the JSF as we see it today. The first is that much of the avionics, stealth and engine technology first seen in the F-22A program was absorbed, but adapted for higher volume production and lower costs where achievable. The second was the adoption of a Cost As an Independent Variable (CAIV) design philosophy, intended to trade off capabilities and performance as required to achieve very ambitious cost aims - the simplest US Air Force model was originally to come in at $US38m flyaway each.

The common thread running through all of the US service roles is a primary strike optimisation, reflected in the JSF's avionics and airframe design. Single service roles have been clearly traded down to achieve commonality. The JSF will not provide the payload-radius of the Navy A-6/A-12A deep strike aircraft, nor will it provide the relative agility advantages of the Air Force F-16A against its original Soviet opponents. The aircraft has a more complex and expensive avionics suite than would be required for any of the single service roles, as it rolls all three requirements into one




While nominally both 'stealth fighters', there are important distinctions in stealth performance between the F-35 and F/A-22A. To save weight and costs, the JSF will use a 'narrowband' serrated circular engine nozzle (left), as compared to the highly stealthy 'wideband' edge aligned thrust vector nozzle used in the F/A-22A (right). This reflects the F/A-22A's roles of air superiority and penetration of heavy air defences, against the JSF's main role of battlefield interdiction and close air support. (LM)

package. The JSF's stealth capabilities are more narrowly optimised than those of the F-117A and F/A-22A, reflecting the need to survive mobile battlefield and littoral defences rather than penetrating an Integrated Air Defence System in depth.

The JSF is thus a radically different aircraft to the F/A-22A, in its primary design aims, capabilities and performance. Against its mid 1990s role definitions, the JSF is a very good fit, but with the evolution since 2001 toward persistent battlefield strike tactics, the JSF falls short in both fuel capacity and weapon payload. Were the JSF defined and sized today, the CTOL/CV variants would be larger twin engine fighters closer in size to the F-111 – the only viable commonality with the VSTOL roles would be in avionics and engine cores.

While the CTOL/CV JSF carries an 8170kg (18,000lb) class internal fuel load and the F/A-22A 9375kg (20,650lb), the 11,800 to 13,620kg (26,500 to 30,000lb) class empty weight JSF employs a single engine rated in the 40,000lb (178kN) wet thrust class, against the F/A-22A's pair of 35,000lb (157kN) wet thrust class engines. This results in an enormous difference in achievable thrust/weight ratio, both dry and wet, as the larger and heavier F/A-22A has almost twice the engine thrust available. Engine optimisations are also quite different, as the JSF's F135 uses a larger low(er) altitude optimised fan, compared to the high altitude optimised fan of the F/A-22A's F119-PW-100. The JSF trades away high altitude supersonic engine performance to achieve better cruise and loiter burn, and extract as much thrust as possible at lower altitudes, essential for it primary design role of battlefield strike.

The design optimisations of the 42.8m^2 (460sq ft) (CTOL/STOVL) and 57.7m^2 (620sq ft) (CV) JSF wings and the 77.2m^2 (830sq ft) class F/A-22A wing also differ radically. The JSF wing, with a sweep of around 34 degrees, falls in between the F-16's and F/A-18's, and is nearly identical to the battlefield strike optimised A-7D/E series. The F-16, F/A-18 and JSF however use vortex lift to further enhance low speed high alpha turning performance in subsonic engagements. The F/A-22A's wing, at around 40 degrees sweep, is closer in concept to the F-15 and Su-27/30 series – a tradeoff between supersonic drag and turning performance. Unlike the F/A-22A wing, which is designed around 9G supersonic agility, the JSF wing trades away supersonic performance to maximise subsonic cruise/loiter efficiency – an optimisation for subsonic manoeuvre and maximising subsonic cruise performance.

The basic aerodynamic and propulsion optimisations of the JSF against the F/A-22A reflect their original airframe design aims – the F/A-22A to kill other fighters and penetrate air defences at supersonic speeds, the JSF to hunt battlefield ground targets, and evade missiles and fighters. Like the F-15, the F/A-22A can be swung to strike roles without sacrificing its supersonic performance, but the JSF's wing and engine optimisations preclude it from ever achieving high supersonic performance, vital for running down supersonic opponents like the Su-27/30 – or supersonic cruise missiles.

The stealth design optimisations of the F/A-22A and JSF also differ markedly. The deep penetration and air dominance roles of the F/A-22A dictated all aspect capability, resulting in the expensive edge-aligned thrust vector nozzle design, which provides good 'wideband' frequency capability. The JSF is optimised for best stealth in the forward sector, sharing general airframe shaping rules common to the F/A-22A. The notable difference is in the serrated edge circular nozzle of the JSF, which is clearly optimised for best performance in the X and Ku-bands, typical of fighter radars, SAM/AAA tracking systems and missile seekers.

To achieve lower costs the JSF accepts notable aft sector stealth limitations, especially when tackling deep or layered air defences with fighter threats – an acceptable tradeoff for 'shallow' littoral and FEBA area battlefield strikes against predominantly short range mobile air defence systems. The aim in the JSF is to use newer materials technology than the F/A-22A does to reduce stealth costs, although we are likely to see this technology migrate across to the F/A-22A in later blocks.

The core avionics systems of the JSF and F/A-22A share a common architectural model – sensors are 'dumbed down' and signal/data processing is performed on software running on general purpose high performance computer processors in central processing boxes, rather than specialised hardware. This very powerful model permits rapid evolution in signal and data processing techniques, within the limitations imposed by the sensors used to gather information. Both the F/A-22A and JSF are to now use cheaper commercial processing chips and optical bus technology. The distinctions in onboard computing power between both types will be given by the immediate block upgrade configuration at that time – both using multiple commercial PowerPC chips.

The sensor suites of both fighters differ strongly, reflecting their different roles. The F/A-22A's APG-77 active array radar with 1500 modules of higher power rating than the 1200 module APG-81 radar of the JSF achieves significantly better detection range against airborne targets, and by default greater standoff range in synthetic aperture groundmapping – and any growth GMTI/MMTI modes.

The APG-77 also has growth provisions for sidelooking cheek arrays. The JSF radar is conversely designed around simultaneous SAR/GMTI strike capability, but providing air-to-air detection capabilities much better than the F/A-18A-F and F-16C. The fundamental differences between the radar packages lie not only in the F/A-22A's much superior air-air range performance, but also in their long term growth potential. While radio-frequency modifications and software growth permit the APG-77 to acquire the capabilities in the JSF APG-81, the JSF's nose size, power generation capacity and cooling capacity will set limits on the achievable air-to-air and air-to-ground range growth in the JSF.

Recent reports indicate that a second generation F/A-22A antenna, using common modules to the JSF but of higher power rating, will be phased into later block production.

The passive electronic detection suites in both aircraft differ, although few details have been disclosed. The JSF system is claimed to incorporate a passive emitter location capability (passive rangefinding of threat radars), effectively absorbing the role of the F-16CJ. Given the F/A-22A's demand for higher operating altitudes and threat radar geolocation for deep penetration, we can safely assume that its passive detection system will be much more sensitive – the radar horizon at 50,000ft is much further away than at 25,000ft.

The F/A-22A was to have been fitted with the Advanced Infra-Red Search and Track (AIRST) system, provisioned for in the avionics. This has not materialised as yet for funding reasons. The JSF on the other hand will be equipped from day one with two optical systems – the Electro-Optical Targeting System (EOTS) and the DAS (Distributed Aperture [InfraRed] System). The EOTS is a repackaged growth derivative of the latest Lockheed Martin Sniper XR laser/TV/thermal imaging pod, fitted inside a faceted sapphire window chin fairing. It will provide TV and midwave infrared imaging with multiple fields of view, and increased range laser designation, spot tracking and ranging capability over most existing podded systems.

The JSF's DAS is a radically new idea, using six fixed thermal imagers to provide spherical coverage around the aircraft, and digital processing to provide not only missile threat warning, but also a 'look anywhere' Helmet Mounted Display System (HMDS) capability for the pilot. The DAS combines the ideas trialled in F-16 head steered FLIRs for battlefield strike, with an all aspect IR Missile Approach Warning System (MAWS) capability – the latter reflecting ongoing losses of A-10s and AV-8Bs to low level infrared manportable and mobile SAMs. While an EOTS equivalent for the F/A-22A has been repeatedly discussed in the US press, it is unlikely to be added until later blocks due to existing cost caps.

The JSF cockpit is newer technology to that of the F/A-22A, using a single panel redundant projector rather than individual active matrix liquid crystal display panels. Production cost pressures may see the JSF display technology absorbed in later blocks of the F/A-22A. Integrated capabilities for networking with other platforms are similar for both, driven by the need for intra-type, and intra and inter service interoperability – with the caveat that the larger sensor footprint of the F/A-22A makes it a very much better 'information gatherer' compared to the JSF.

The weapons capabilities of the F/A-22A and JSF are similar, but the JSF is designed to carry larger 2000lb JDAMs internally, compared to the F/A-22A's 1000lb JDAMs. Both carry eight GBU-39/B Small Diameter Bombs internally – an equal payload of the 'standard' new smart bomb. With eight internal GBU-39/Bs each, the F/A-22A carries two AMRAAMs and two AIM-9Xs, while the JSF is limited to two internal AMRAAMs.

From a 'bombing productivity' perspective, armed with the GBU-39/B, supercruise in the F/A-22A provides a unique advantage. At ranges where the transit time between runway and target dominates the sortie duration, the ability of the F/A-22A to cruise supersonic at around twice the subsonic cruise speed of the JSF permits it to perform more sorties – at some ranges this becomes twice as many sorties, effectively doubling the potential 'bombing productivity' of the F/A-22A vs the JSF.

Both aircraft are equipped with external wing pylons to carry external weapons and/or fuel in scenarios where stealth is no longer required, and both will suffer range penalties due to external stores cruise drag when carried. The F/A-22A has four jettisonable pylons with paired AMRAAM rail launchers, each rated to 2270kg (5000lb), the JSF four pylons, inboard at 2270kg (5000lb), outboard at 1135kg (2500lb), with further outboard auxiliary pylons rated at 135kg (300lb) for AAMs. An external stores pod was in development for the F/A-22A.

While the JSF is funded for external air-to-ground stores clearances, at this time the F/A-22A remains limited to external tanks and air-air missiles due to the funding cap. With similar subsonic cruise range performance given similar internal fuel, both types will require generous tanker support in stealthy air-to-air and strike regimes of operation. Neither can compete with the F-111 for payload radius.

In comparing the JSF and F/A-22A in air combat roles, the F/A-22A is vastly superior. In long range BVR combat the F/A-22A has major advantages in sustained energy performance, stealth, radar range and missile kinematic performance – an AMRAAM goes a lot further if launched from twice the altitude at supersonic speed. In close-in combat the F/A-22A's greater agility cannot be contested – on dry thrust the F/A-22A out climbs and out accelerates an afterburning F-15. The JSF is designed to achieve similar performance to the F-16C, itself inferior to the F-15. In any Combat Air Patrol scenario, supercruise permits the F/A-22A to cover four times the footprint of a JSF. It can engage and disengage opponents at will, unlike the slower and less stealthy JSF. The F/A-22A outclasses the JSF across the board and is several times as effective in most air combat regimes.

In comparing the JSF and F/A-22A in strike roles, the divergent deep strike optimisation of the F/A-22A and battlefield strike optimisation of the JSF are telling. The F/A-22A is much more survivable as it is stealthier and su-

Side by side the aerodynamic differences of the F/A-22A against the JSF are prominent, especially the larger wing area, larger tails, larger leading edge sweep angle, and high alpha inlet configuration. The F/A-22A is built for supersonic cruise and high G manoeuvre, distinct from the JSF which is built for subsonic cruise and supersonic dash only. The F/A-22A on dry thrust alone outperforms an afterburning F-15C, whereas the JSF is designed around the agility and manoeuvre envelopes of the 1970s era F-16 and F/A-18 – both inferior to the F-15 family (LM).

The new 285lb Boeing GBU-39/B is the weapon of choice for stealthy strikes on battlefield, urban or other smaller targets. The JSF carries eight weapons internally, with growth up to 20 – the F/A-22A also carries eight (depicted), with growth to 12 weapons.

percruising. However, the F/A-22A in its current configuration lacks the extensive electro-optical suite and radar modes of the JSF, required for battlefield interdiction and close air support. The JSF will have better loiter performance, especially at low altitudes, and carries a larger internal bomb payload. Yet on long range strike profiles, the F/A-22A achieves similar 'productivity' in bomb deliveries as the JSF as it can transit to and from targets twice as fast, both requiring generous tanking to achieve F-111 class strike radii or on station persistence.

In comparing the JSF and F/A-22A in Intelligence Surveillance Reconnaissance (ISR) roles, the F/A-22A does much better for a number of reasons. Both aircraft will have a respectable capability for high resolution SAR ground mapping and electronic intelligence gathering built in - adaptation for ISR requires an internal digital recorder and datalink transmit capability, neither expensive.

High quality optical and thermal imaging reconnaissance would require specialised payloads for both types – the JSF EOTS is not competitive against even current multi-Megapixel focal plane imagers, as would any F/A-22A growth equivalent. Payloads such as thermal imaging strip mappers, visible/IR digital framing cameras and hyperspectral imagers would have to be carried in the internal bays of these aircraft. In this respect the F/A-22A's Sidewinder bays are much better situated geometrically, compared to the JSF's main ventral bays, permitting oblique imaging without a stealth reducing faceted bay door bulge. In the ISR game, timeliness and survivability are top considerations, and the supercruising F/A-22A wins this game without question. Future ISR payloads are likely to evolve for both types as depot fit weapon bay payloads, with additional software added.

In comparing overall evolutionary growth potential, the F/A-22A wins decisively over the JSF. A plethora of historical case studies of multirole aircraft indicate that the two decisive drivers of evolution into alternative roles are size and raw aerodynamic performance. The F/A-22A with a larger airframe, wing, internal volume, radar bay, total engine/electrical power and better stealth design has an unassailable lead. This is true for a comparison of the basic F/A-22A vs the basic JSF. An unknown at this time is the proposed deep strike FB-22A – an 'F-111 like' deep strike optimised F/A-22A derivative. This paper aircraft uses an F/A-22A fuselage and tail section, with a large fuselage plug and a highly swept delta or cranked arrow wing planform. Designed for 1000nm (1850km) class radius supercruising strikes, the FB-22A is a 'new technology F-111' intended to fill exactly that niche, but with potential to be a long range/ endurance interceptor and deep escort for the B-2A.

Comparing unit flyaway costs of the F/A-22A and JSF is complex, insofar as technology migration from the high volume JSF into the lower volume F/A-22A could significantly impact next decade cost structures. Currently likely candidate technologies will be antenna modules, computer components, internal data networking, engine hot end components, stealth materials and production processes especially for composite parts. Build volumes for both types longer term remain unclear, as the US Air Force wants more F/A-22As more than it wants extra JSFs, while JSF numbers for the Navy, USMC and export may decline if current trends continue.

The current US Air Force contracted build for 287 to 332 F/A-22A Raptors is capped by political edict, while lobbying continues for an increase to 380 aircraft, and ultimately 500 plus. This follows the historical pattern seen with the F-15A-E. Unit flyaway costs at the end of the current build are expected to be in the $US80-90m bracket, with downstream technology insertion favouring the lower numbers. With follow-on builds, the numbers are likely to fall into the US$70m to 80m bracket. It is important not to misrepresent F/A-22A 'program' costs which include R&D expenses as 'unit flyaway' or FMS prices, as this results in grossly inflated and sensational numbers.

The JSF has seen a steady growth in its target costs over time. Early in its evolution is was to cost the same as an F-16C, but that soon crept up to $US38m for the cheapest basic (CTOL) model and by 2002 US reports indicated about $US50m. Now many US analysts predict a flyaway unit cost in the $US65m bracket. Where the cost of the JSF ends up will depend on a range of technological factors as well as total build numbers.

A mature production F/A-22A in the 2015 timeframe, one which has absorbed avionics, engines, materials and production technologies paid for by the JSF program, will incur its principal production cost differences against the JSF in additional structure, and an additional engine/nozzle. The order of magnitude difference in cost between F-35 and more mature JSFs and F/A-22As could be as little as $US10-15m flyaway – this estimate fitting very closely to cited flyaway numbers for F/A-22As post the current build number cap, vs the more conservative JSF estimates. If the then JSF comes in at 50 to 75 percent of the flyaway/FMS cost of the then F/A-22A, buying the much less capable JSF would be a folly.

Given what is known about both the JSF and F/A-22A, Department of Defence assertions claiming 'the really big difference is in cost' are little more than nonsense.

Next month's analysis will explore NACC and JSF program issues in closer detail.

Both the F/A-22A and the JSF are built to carry weapons internally and if required, externally. Internal carriage is used to achieve full stealth during the opening phase of an air campaign, once opposing defences are broken, larger and more diverse stores can be carried externally. While the JSF matches the internal GBU-39/B payload of the F/A-22A, it can carry only 75% of the F/A-22A's external payload. (US Air Force/LM)