The F-35 Lightning II Potential Market 2007-2030

A specialist paper by the Royal Aeronautical Society

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The research into the prospective F-35 market and competition was sponsored by MBDA, but this paper is an independent analysis based on open source material conducted by the Head of Research at the Royal Aeronautical Society. The conclusions are the considered opinion of the author based on his judgement of a range of potential outcomes. The report and an attached summary should not be regarded as a definitive estimate of market performance or of likely customer behaviour.

The F-35 Lightning II Potential Market 2007-2030

A Specialist Paper prepared by

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EXECUTIVE SUMMARY

Market Overview

The world strike-fighter fleet comprises between 15,000 and 20,000 aircraft; conservatively there could be a market for at least 8,000 new aircraft up to 2025, over half of which will be from customers politically acceptable to western suppliers.

The F-35 Lightning II, which is currently under development, is only one of two genuinely 'fifth generation' programmes and the only aircraft available to world customers. While unmanned aerial strike platforms will mature over this period, the F-35, through anticipated upgrades, is conceived as a '100-year' design.

Programme Stability

Although subject to continual US domestic pressure over cost and relevance, support for the F-35 overall remains solid, bolstered by an international partnership, most of whom view the F-35 as a central feature of future capability needs.

Long-term Requirement

There is little evidence to suggest that the general need for conventional strike platforms will diminish over the next 20-25 years. Acquiring aircraft of the F-35 generation remains a prudent strategy in the face of strategic and political uncertainty. The key variables will be capability versus affordability.

Market Estimate

When the F-35 enters service, its technological superiority over even the so-called '4.5 generation' aircraft will become increasingly evident; as such it may be the only western fighter of choice left available to world customers. Conservatively, the world market for F-35 up to 2030 is estimated to be over 4,000 units.

Market Estimate Breakdown Summary

F-35 partner nations	9 members	2,600[1]
Observers	2	200
Others	29	1,300
Total		**4,100**

Even allowing for individual customer uncertainties, there is a potential base market in the region of 3,000 units for an aircraft that will increasingly have no conventional competitor at, or close to, its capability level.

Implications for Weapons and Ordnance Suppliers

With a few exceptions, most potential F-35 customers will be looking for between 15-40 units. Through-life and initial costs will be vital issues. Few, if any, will have individual weapons requirements. They will look for the best balance of capability and cost. There may be some who might wish to reduce direct dependence on the US for ordnance but generally most will buy off-the-shelf weapons. This underlines the importance to any weapons or ordnance supplier to be 'on the shelf' and available as an option to potential customers.

Given that the majority of the likely customers are already US weapons customers, non-US suppliers unless integrated into the platform from the outset will be at a severe competitive disadvantage.

[1]These are not confirmed orders and subject to change. The total estimate implies some reduction. This uncertainty is reflected in the detailed analysis found in the Attachment.

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PART ONE: THE STRIKE-FIGHTER CONTEXT

1.1 The Strike-Fighter Aircraft — the World's Airpower Workhorse

1. The jet strike fighter is the most ubiquitous fixed-wing combat aircraft serving in the world's airforces. Its centrality to modern warfare has been confirmed in every major conflict since 1945. This is undoubtedly true for high intensity engagements but the presence of effective airborne strike capability may also act as a deterrent and pacification force in modern peace enforcement exercises and as an immediate tactical response in support of ground forces.

2. Achieving air dominance is a central precept of US military doctrine, and tactical or theatre aircraft are a major component of US power projection and have played a prominent role in every US military operation since 1991. This is likely to continue, particularly in situations where the US hopes to limit or to avoid the commitment of ground forces. Even where is it evident that there is no alternative to extensive ground commitments (as in Iraq today), tactical airpower is still regarded as a key force multiplier in the face of insurgency.

3. As the US General Accountability Office (GAO) neatly summarises:

> *"(Tactical airforces) operate in the first days of a conflict to penetrate enemy airspace, defeat air defences, and achieve air dominance. This allows follow-on ground, air and naval forces freedom to manoeuvre and attack in the battle space. Once air dominance is established, tactical aircraft continue vigorously and persistently strike ground targets for the remainder of the conflict. Some tactical aircraft are also essential to protect the homeland against incoming missiles or enemy aircraft."*[2]

The modern strike-fighter is one of the most versatile and flexible weapons platforms; usually capable of both air-to-air combat and air-to-ground ordnance delivery, it may also have a reconnaissance and surveillance capability. Arguably, the manned fighter still has the most mission-adaptable and environmentally aware control system — the pilot; and as a manned vehicle best able to conform to current rules of engagement concerning weapons release.

1.2 The Strike-Fighter Market: Technology and Dynamics

4. Continuous technological innovation has steadily increased the performance of the modern strike-fighter in all areas - speed, agility, sensor awareness, and self-protection (passive and active) and in both the weight and precision of weapons delivery. It can operate from rough airfields including roads and aircraft carriers. The next generation of aircraft will offer a qualitative improvement in overall performance and role-flexibility. Optimal performance in any one mode will still require a degree of specialisation in design and weapons fit but the emerging generation of fighter platforms are close to providing a comprehensive single-platform full spectrum mission capability that will give the military maximum operational flexibility.

5. Developing this technology comes at a price. Increased sophistication has implied vastly more complex technology in every aspect of aircraft systems, pushing integration skills to the edge of the state-of-the-art, particularly in software development and verification. As a result, development times have increased to over a decade and unit costs have grown commensurately. Affordability has become an issue in the procurement of modern fighters leading to a difficult trade-off between numbers and enhanced capability. However, modern technology and design has improved the maintainability of the aircraft; open systems technology will anticipate continual upgrading and the move towards single-type fleets offers further savings in support and through life-cycle costs.

6. The global trend has generally been to replace one fleet generation with fewer successor aircraft. Combined with lengthening lifetimes, the market for new aircraft (and upgrades) is shrinking in scale, and each contest has inevitably become intensely competitive. Given the cost and development times for a modern aircraft, it follows that failure to win key contracts may lead to market exit. Even in the US, the effect of the last two major fighter competitions (for the F-22 and the F-35) has been to reduce US fighter prime contractors effectively to one player, Lockheed Martin. Boeing remains in the business only through continued production of the F-15 and F/A-18E/F Super Hornet. While states may be prepared to support a national (or regional) capability for strategic reasons, with each generation this becomes more burdensome, especially as other national priorities compete for resources. Technology may eventually create a fully satisfactory successor to the manned strike fighter in the form of relatively cheaper unmanned platforms (Unmanned Airborne Systems, UAS[3]). While this prospect is at least half a generation away, it may nevertheless deter continued investment in uncompetitive manned aircraft. As a result, fighter development is fast becoming a case of 'Last Man Standing', where the surviving manned platforms could dominate the market until the mid century.

1.3 The Strike-Fighter Generations

7. Fighter or tactical aircraft primarily engage in air-to-air or air-to-ground operations. Both classes usually have some capability in either role. Specialisation leads to particular design requirements, as does the likely combat environment envisaged for a type. The higher the threat environment, which includes the quality of the opposition air defences, ground and airborne, the more a contemporary fighter aircraft requires low-observability (stealth), the ability to detect and to engage an enemy at long distances or to deliver stand-off weapons. Increasingly, the demands of affordability and military flexibility have required multi-role or mid-mission adjustment (swing-role) capabilities. This necessarily requires compromise between functions, usually trading off pure air-to-air engagement capability. Similarly, differing basing modes (land or sea) also give rise to different performance requirements and design characteristics. In general, making use of a common aircraft for different missions and services is difficult if not impossible to satisfy all requirements. However, experience has shown that it is easier to adapt sea-based designs for land deployment than *vice versa*. This is why the F-35 programme does not aim to produce a common platform for three services but to develop a platform for three different basing modes with maximum commonality.[4]

[2]GAO, *Tactical Aircraft; DoD Needs a Joint and Integrated Investment Strategy*, April 2007 GAO-07-415.

[3]The acronym UAS is now commonly used instead of Unmanned Aerial Vehicle (UAV) to describe unmanned aircraft.

[4]See Bolkom, C. *Tactical Aircraft Modernization: Issues for Congress*, Congressional Research Service, 16 March 2006.

8. The evolution of the modern fighter/attack platform has gone through several generations since 1945. The first generation (1945-55) comprised the early jet powered fighter/attack aircraft; subsonic, often without radar and armed with dumb bombs, unguided rockets and cannon. Examples were F-86 Sabre and MiG-15, which engaged in air-to-air combat during the Korean Emergency. The second generation (1955-1960) were of a higher, often Mach 2 capable, equipped with the first miniaturised radars; guided air-to-air weapons began to replace guns. Examples included the US 'Century Series' of aircraft, the UK Lightning and the French Mirage III. The third generation (1960-70) were among the first to be designed for a multiple role in both air defence and ground attack. The most characteristic of this era was the F-4 Phantom which served in several airforces in both land and sea-based modes. Other examples were the Harrier and the MiG-25. The fourth generation (1970-1990) continued the trend towards multi-role aircraft and were equipped with increasingly sophisticated avionics and weapons. Many were highly manoeuvrable, controlled by fly-by-wire computer enabled systems. The F-16 is perhaps the most successful of this generation, but others included the F-14 and F-15, the F/A-18 Hornet, the Tornado, Mirage 2000 and the MiG-31. Most of these types are still in service and provide the bulk of the current world fleet of fighter-attack aircraft.

9. A four point five generation (1990 to 2000) describes a transition class of aircraft that owe much in concept to the fourth generation, but exploit more advanced technologies, primarily unstable aerodynamics, some stealth capability and weapons that enable precision stand-off attack and beyond visual range air-to-air engagement. This generation includes the F/A-18E/F Super Hornet, the Typhoon and Rafale. Most are still evolving and will be updated with technologies under development for the fifth generation types. These include AESA (active electronically scanned array) and some networking capabilities. Later versions of this class will offer genuine multi-role and swing-role (an ability to switch mission types *en route*).

10. The fifth generation (*circa* 2000–mid century) are currently still in development and only comprise two examples, the F-22 Raptor (just entering service) and the F-35 Lightning II. The key features of the fifth generation fighter are extended range, increased payload, advanced radar, sensors and communications. Super cruise (sustained supersonic flight) may also be a feature of performance. Fifth generation aircraft are stealthy, although all aspect stealth is perhaps less vital, certainly for strike missions once air dominance has been achieved. However, AESA radar is essential for both air-to-air and strike roles. Weapons comprise advanced standoff and air-to-air missiles and smart bombs guided by target designators, or with on-board navigation systems subject to continual data enhancement either by the platform or through networked external sources.

11. Weapons fit, therefore, must be fully integrated into the platform software. Fifth generation fighters are therefore genuine multi-role aircraft acting not only as air-superiority weapons and strike platforms, but also they have a surveillance, ECM and communications capability. Indeed, the network-enabled, multi-task capability is probably the fundamental difference between the fifth and four point five generation aircraft and is arguably the F-35's critical advantage over any other strike fighter in service or under development. The only expected competition for the fifth generation fighter is expected to be from unmanned systems — and these may not offer cheap solutions.

PART TWO: THE WORLD FIGHTER MARKET

2.1 Overview

12. There are some 15,000 strike-fighter aircraft in the world fleet.[5] The majority of this fleet is based on 'fourth generation' technology and a proportion of the current fleet is obsolescent or otherwise disabled. Dassault has a higher count of the world fleet (20,000) and estimates that between 8,000 and 10,000 will be taken out of service over the next eight years.[6] There are fewer than 100 'four point five' or 'fifth generation' aircraft in service but production of the early marques of this class is building up rapidly. Both the Typhoon and Rafale are operational. The F-35 flight test programme has picked up pace and, more important, all eight of the partnering nations have signed up to the next phase of development.[7] The FA-18E/F Super Hornet has won its first export order from Australia as an interim procurement before acquiring an all F-35 fleet.

13. The distribution of the future market is likely to reflect the historic breakdown of export (non-US) customers identified by the Teal Group:

- 26 customers for aircraft in the $25-35 million range (typically F-16, Mirage 2000, Gripen)
- nine customers for aircraft in the $36-45 million range (Super Hornet and notionally Su-27/30)
- three customers for $45 million plus aircraft (F-15, Tornado).

Overall the market has been dominated by the first category with some 450 aircraft sold over the past ten years. But the Teal Group warn that "straight-line extrapolations based on past market share would appear problematic."[8] Equally, not all of the potential market is 'open'. Specifically, on the supply side, export prohibitions (especially US) will block a number of potential sales; on the demand side, protection of a domestic aerospace industry will limit accessibility to outsiders, and other political factors will also determine the acceptability of suppliers. Finally, sales will also be affected by the degree of desperation on the part of the supplier and a willingness to sell at low, perhaps subsidised, prices.

14. Customers will inevitably seek to buy the best aircraft at affordable prices and will use their bargaining power to secure the best deal on price and on industrial participation or offset (the former is now usually seen as the more attractive option to build up national industrial assets). Export success carries a 'halo effect' for other equipment and weapons systems. US fighter clients in the future will probably continue to ally their defence industries with US companies and acquire a package of US products to fit their platforms. In this sense, "the F-35 can almost be regarded as an industry policy."[9] An inspection of the current world fleet suggests that, from a US perspective, over 53% of the world market (given current political conditions) in theory should be open to US suppliers. A further 20% would be more questionable on political grounds but feasible targets (this

[5]Derived from the 2006 *Flight International* world airforces survey. This does not include strike/trainer platforms.
[6]Dassault's estimate may include strike-trainers, which would add at least 5,000 units to the estimate.
[7]'Fighting Talk', *Flight International*, 5-11 May 2007.
[8] Teal Group 2002 cited Defense Industry Daily, 16 June 2005.
[9]'F-35's Potential Looms Over Global Fighter Market'. *Aviation Week*, 24 February 2003.

category includes India) given shifts in US foreign policy. Alternatively, only some 25% of the world market would appear to be currently closed to non-American suppliers.

15. The view shifts, of course, from other national perspectives. Bluntly, some 25% of the world market, the US, is largely closed to all but American companies (as primes, not necessarily as sub contractors). As the dominant supplier to the world market, all things being equal, the US is well placed to meet replacement needs. Based on a one for two-replacement rate Dassault predicts a (upper range estimate) market for 4-5,000 units, with about half open to non-US suppliers. A key market slot will comprise nations that want to avoid dependence on the US. Dassault believes that about 25% of the world market falls into this category. Competition for these available markets will be increasingly fierce and will almost always have to compete against American scale economics which, for any given level of capability, pushes down the export price of US equipment.[10] Again, association with a US platform immediately affords a clear and powerful competitive advantage for partners and sub contractors. This will be even more brutally applicable in the latest generation of platforms where initial aircraft-weapons integration is a central feature, with retrospective integration costly, perhaps prohibitively.

2.2 The Fourth Generation

Boeing F-15K

16. The Boeing (ex-McDonnell Douglas) F-15E Strike Eagle is a modern United States all-weather strike fighter, designed for long-range interdiction of enemy ground targets deep behind enemy lines. A derivative of the F-15 Eagle air superiority fighter, the Strike Eagle proved its worth in Desert Storm. The F-15K has many advanced features such as an AAS-42 IRST (Infrared Search & Track), JHMCS (Joint Helmet Mounted Cueing System), and advanced AN/APG-63(V)1 MSA radar. AESA Radar (Active Electronically Scanned Array) is also available as an option. In addition, the F-15K can launch many advanced weapons such as AGM-84K SLAM-ER ATA and AGM-84H Harpoon. The original F-15 was one of the first fourth generation heavy fighter/attack aircraft. The current Singapore and Korean orders will keep the production line open for the next two to three years but the F-15 may struggle to stay in the market beyond this date.

Dassault Mirage 2000

17. The Mirage 2000 is a French-built multi-role fighter jet manufactured by Dassault Aviation. Originally developed as a competitor to the F-16, the aircraft went into French operational service in 1984. The latest and most advanced version is the Mirage 2000-5 Mark 2, which is an enhanced, fully multi-role version of the Mirage 2000-5. This has upgraded avionics and can be equipped with a wide range of modern weapons including the Storm Shadow/SCALP-EG. This variant forms the basis of the export version and is a useful contender as a cheap interim solution especially for existing Dassault customers but Dassault will prefer to promote the Rafale wherever possible.

Lockheed Martin F-16

18. The F-16 Fighting Falcon is the classic multi-role jet fighter aircraft developed by General Dynamics and subsequently by Lockheed Martin for the United States Air Force. Designed as a lightweight fighter, it evolved into a successful multi-role aircraft. The Falcon's versatility is a paramount reason it was a success on the export market, serving 24 countries. The F-16 is the largest Western fighter programme with over 4,000 aircraft built since production started in 1976. Though no longer produced for the US Air Force, it is still produced for export.

19. The Latest Block 60 aircraft is based on the F-16C/D, and features conformal fuel tanks and improved radar and avionics. A major difference from previous Blocks is the Northrop Grumman AN/APG-80 Active Electronically Scanned Array (AESA) radar. Block 60 allows the carriage of all Block 50/52 aircraft-compatible weaponry as well as ASRAAM and the AGM-84E Standoff Land Attack Missile (SLAM).

20. Although the F-16 is still a potent aircraft, it is falling behind the four point five generation in overall performance but will contine to challenge at the lower end of the market. The F-16 customer base is a primary target for F-35 sales.

2.2 The Four Point Five Generation

Boeing F/A-18E/F Super Hornet

21. The Boeing (formally MacDonnel Douglas) F/A-18E/F Super Hornet is a modern all-weather carrier-capable strike fighter jet, designed to attack both ground and aerial targets. Designed in the 1970s for service with the US Navy and US Marine Corps, and is also used by the air forces of several other nations. The F/A-18E/F Super Hornet is a distinct, evolutionary upgrade to the F/A-18 designed to serve a complementary role with Hornets in the US Navy. The Super Hornet has a new, 25% larger airframe, more powerful GE F414 engines based on the F/A-18's F404, and upgraded avionics suite. It is not regarded as especially stealthy, but Boeing is developing further upgraded versions including an advanced radar and avionics that will keep the Super Hornet in the market for the decade. This will facilitate a high level of network enabling. The US Navy is considering further purchases to offset delays in the F-35C.

22. Although the F-18E/F Super Hornet is not seen as a competitor to the JSF, it can do a substantial part of the JSF mission. While not an all-aspect stealthy aircraft, the Navy regards it as a 'first day' asset. The USN plans to fly its F-18 Super Hornets until 2025 or even 2030 in a mixed fleet with the F-35C. US production alone is guaranteed to 2011 and unit costs are expected to fall to $53.8 million by 2010. Boeing is reportedly offering the USN a $49.9 flyaway unit price for 170 aircraft — double the Navy's stated commitment. Boeing has targeted India, Japan, Switzerland, Malaysia and Kuwait as key markets. The Super Hornet is arguably the 'best buy' of the current generation of fighter strike aircraft and given delays in F-35 development, could undermine predicted market share, especially if states are prepared to await more advanced UAV solutions. It may also be viewed as a useful interim buy before the F-35 becomes more widely available.

Dassault Rafale

23. The Dassault Rafale is a French twin-engined delta-wing highly agile multi-role fighter aircraft designed and built by Dassault Aviation. Dassault uses 'Omni Role' as a marketing term in an effort to differentiate the aircraft from other 'multi-role' fighters that have primary and secondary roles. Dassault also uses the term to indicate the Rafale's ability to switch from one role to another during a single sortie, although the term is mostly meant to encapsulate the fact that the Rafale is replacing seven specialised planes. The Rafale is being produced both for land-based use with the French Air Force and for carrier-based naval

[10]Boeing's offer of a price cut to the USN in return for a multi-year order of Super Hornets is likely to translate into an export unit cost of $49.9 million, a $4 million saving on current list prices. This would represent a tempting price for existing F-18 operators (Japan and Switzerland) and for other potential customers such as India. 'F/A-18E/F Suitors May Profit from USN Deal', *Defense News*, 25 June 2007.

operations with the French Navy. It has also been marketed for export and, while there are no foreign sales yet, several countries have expressed interest. The French forces were once expected to order 292 Rafales: 232 for the Air Force and 60 for the Navy. Reductions are now widely predicted and only 120 Rafales have been officially ordered to date.

24. The marine version has priority since the aircraft it is replacing are much older, especially the Vought F-8 Crusader fighter which is a 50-year-old design. Service deliveries began in 2001 and the type 'entered service' on 4 December 2000. The first naval squadron embarked on the *Charles de Gaulle* in 2002, becoming fully operational on 25 June 2004.

25. The Rafale B for the Air Force until recently was still optimistically scheduled for September 2006 but slipped back to mid-2007, when the type should be fully operational as an omni-role fighter/fighter-bomber with MICA air-to-air missiles, SCALP EG cruise missiles, GPS-guided bombs and laser-guided bombs (LGBs). It is regarded as a semi-stealthy aircraft, with a low radar cross-section and electronic counter measures.

26. To date, the Rafale has no orders outside of the French armed services and is one of the most costly French defence programmes. It is, however, being marketed very heavily and exports may well be heavily subsidised by the French Government.

Eurofighter Typhoon

27. The Eurofighter Typhoon is a twin-engine multi-role super cruise strike-fighter aircraft, designed and built by a consortium of European aerospace manufacturers through Eurofighter GmbH. The consortium comprises BAE Systems, Alenia-Finmeccanica and EADS. After a protracted and often politically difficult gestation, series production of the Eurofighter Typhoon is now underway and the aircraft has formally entered service. The cost of the Eurofighter project has increased considerably from original estimates. The cost of the UK's aircraft has increased from $14 billion to $36 billion and the in-service date (2003; defined as the date of delivery of the first aircraft to the RAF) was 54 months late.

28. Designed originally as an air superiority fighter with some attack capabilty, post-Cold War needs have forced changes to the balance of requirements. Officially the Typhoon is now described as a 'swing-role' aircraft, able to change from various modes during a mission. Like the Rafale, it is not a true stealth fighter, but electronics and some design features give it a low radar cross-section. The Typhoon's combat performance, particularly compared to the F-22A Raptor, the F-35 fighter and the Rafale, has been the subject of much speculation. While making a reliable assessment is impossible with available information, a study by the UK's DERA in the mid 1990s comparing the Typhoon to other contemporary fighters put the Typhoon second only to the F-22 in combat performance.[11]

29. The four Eurofighter consortium members comprise the bulk of the Typhoon sales base. Saudi Arabia has been negotiating its purchase for some years; while an outline agreement was signed in December 2005, public controversy in the UK over commission payments and a decision to end criminal investigation continue to cast uncertainty over the deal. A sale to Austria was reconsidered by an incoming Austrian Government on cost grounds but, in the face of possible cancellation charges, the deal held, albeit in reduced numbers. An earlier sale to Greece was terminated due to public spending pressures following the Athens Olympics. Norway has also signed an industrial co-operation agreement but this is part of a strategy to maintain several options on its future fighter aircraft requirement.

30. Production is divided into three 'tranches' with an incremental increase in capability coming with each tranche. Tranches are further divided up into batches and blocks, e.g. the RAF's Tranche one twin-seaters are batch 1 T1s and batch 2 T1As. In November 2006 BAE Systems commenced an upgrade programme to bring 43 tranche 1 RAF Typhoons up to a common standard. In March 2007, the Eurofighter nations confirmed an enhanced software capability programme worth $1.6 billion that including a much-improved air-to-ground performance for 236 Tranche 2 aircraft. This will deliver a true multi-role platform. The partners are also considering a 30-year technology roadmap programme that will take account of differing national requirements and schedules. While not officially linked to negotiations over Tranche 3, the roadmap may help to shape detailed requirements. The Tranche 3 specification will deliver a clearly defined multi-role platform with scope for further technology insertion — including electronically scanned radars, new generation electro-optics and networked capability.

31. Detailed commitments to Tranche 3 production have still to be finalised. The UK is debating the exact configuration of its order and is known to favour reduced orders of Tranche 2 aircraft while waiting Tranche 3 aircraft and to reduce its overall commitment. Cancellation of the British Tranche 3 order is also a possibility as budgetary problems are predicted; this, combined with an overlap with F-35, threatens to undermine the rationale for Tranche 3 procurement. The Saudi deal has been seen as an opportunity for the UK to reduce its commitment. This is being challenged by the other Eurofighter members who have threatened the UK with substantial cancellation charges in the event of changes to British procurement. However, given the uncertainties that perennially affect German and Italian defence procurement, their commitment to Tranche 3 cannot be taken for granted either. Final decision on Tranche 3 is expected in 2009 and will be dependent on the Eurofighter team delivering substantial improvements in production efficiency.

32. However, delays in the F-35 programme and predicted shortfall in the UK defence budget are likely to bolster the case for maintaining the UK's commitment to the Typhoon. A protracted F-35 will similarly extend the market opportunities of latter marques of the Typhoon. However, competition with other four point five aircraft will be intense and in the market it will have a unit cost disadvantage over the Super Hornet.

Saab Gripen

33. The Saab JAS 39 Gripen is a multi-role fighter with a sophisticated avionics suite and a very good rough field capability. The Gripen is in operational service with the Swedish Air Force which has ordered 204 aircraft.

34. In 1995, Saab Military Aircraft and British Aerospace (now BAE Systems) formed a joint venture company Saab-BAe Gripen AB, with the goal of adapting, manufacturing, marketing and supporting Gripen internationally. The deal was to take advantage of BAe's global marketing experience. BAe designed an improved wing which they manufactured, producing approximately 45% of export airframes. BAe also saw the Gripen as a complementary product to its existing aircraft, fitting between its Hawk light attack/trainer and the larger Tornado and

[11]A more recent Australian analysis suggests that, while the Typhoon still has a clear advantage over current F-18 generation aircraft, its edge against new versions of the Su-30 or even upgraded F-15s over an extended range flight profile is less evident. *Air Power Australia*, 29 May 2007. It is nevertheless regarded as the best of its class. www.ausairpower.net/typhoon.html

Typhoon fighters. This co-operation was extended in 2001 with the formation of Gripen International for the same purpose. In December 2004, SAAB and BAE Systems agreed that from January 2005 SAAB would take full responsibility for selling the Gripen in light of SAAB's increased export marketing capabilities.

35. A useful and value for money four point five generation aircraft but export sales will be constrained by Sweden's highly restrictive arms export policy. A good prospect in any Scandinavian market as an interim for F-35 sales.

Russian Contenders

36. Starved of R&D and production orders from the Russian armed services, Russian fighter exports currently depend upon continued sales of Su-27 upgrades, Su-30 and Su-35s. Sukhoi hopes to rollout a new fifth generation fighter in 2008 with a performance nearer to the F-35. Similarly, the latest version of the MiG-35 will be equipped with AESA radar. Currently, exports represent some 59% of Sukhoi revenues, 91% for Irkut and 99% for MiG. With 1,600 in service through out the world, a key market will be MiG-29 upgrades.[12]

37. To date, Sukhoi's main customers have been former Soviet allies (including China) and 'fringe markets' such as Venezuela, Indonesia and Malaysia. One traditional market for Russian fighters, India, may be turning to US equipment. Russian competition can never be dismissed, especially where price is a major issue and, as in the case of Indonesia, when governments may be concerned about the possibility of a US arms embargo. But the Su-30 lacks the all-round capability of the latest western fighters and is clearly outmatched by the F-22 and F-35. This may change in the longer term, with recent commitments by President Putin to revitalise Russian military aviation which may include development of 'fifth generation' aircraft.

2.4 The Fifth Generation

Lockheed Martin F-22 Raptor

38. The Lockheed F-22 Raptor is the only fifth generation fighter in service and is commonly regarded as in a class of its own among the world's combat aircraft. It was originally envisioned as an air superiority fighter for use against the Soviet Air Force but is also equipped for ground attack, electronic warfare and signals intelligence roles. The first of a planned (82) aircraft formally entered United States Air Force service in December 2005 as the F-22A. The USAF had originally planned to acquire 648 aircraft but this was steadily whittled down by Congress with inevitable affects on unit costs. Developed at a total cost of $28 billion, each F-22 will cost the USAF $361 million.

39. Its maximum speed is estimated to be Mach 1.72 in supercruise mode and without external weapons; with afterburners, it is "greater than Mach 2.0" (2,120km/h). The F-22 is highly manoeuvrable, at both supersonic and subsonic speeds. The AN/APG-77 AESA (active electronically scanned array) radar, designed for air-superiority and strike operations, features a low-observable, active-aperture, electronically-scanned array that can track multiple targets in all kinds of weather. The F-22 is capable of functioning as a 'mini-AWACS'.

40. The Raptor is designed to carry air-to-air missiles in internal bays to avoid disrupting its stealth capability. The plane can also carry bombs such as the Joint Direct Attack Munition (JDAM) and the new Small-Diameter Bomb (SDB). It can carry weapons on four external hardpoints, but this vastly decreases the aitcraft's stealthiness, manoeuvrability, speed and range. The Raptor carries a 20mm rotary cannon in the right wing root.

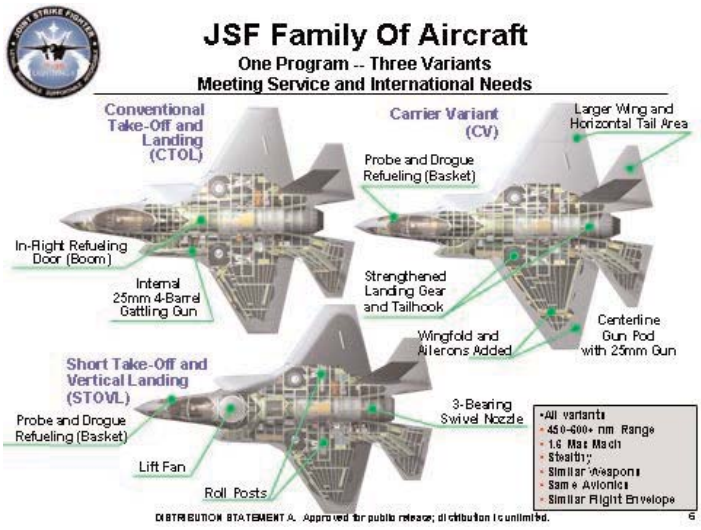

Figure 1.

41. Lockheed has proposed a dedicated strike version, the FB-22 and an export version with deliberately degraded stealth capabilities is under consideration. However, F-22 exports are subject to the 1997 Obey Amendment whereby any foreign sale will require Congressional authorisation. Unlike the F-35, the Raptor was not designed with protection for sensitive technologies and international industrial participation. With a notional unit price for additional aircraft in the region of $120 million, the F-22 is the most expensive of the new generation of fighters. The only customer to date is the USAF, although Israel, Japan and Australia are credible potential customers as both politically acceptable and able to afford the cost of procurement.

Lockheed Martin F-35 Lightning II

42. The F-35 is an international collaborative programme led by Lockheed Martin. Along with the F-22 Raptor, and possibly a Russian programme, the F-35 is likely to be the last conventional manned fighter strike aircraft to be developed over the next 25 years. The F-35 programme comprises three distinct variants with an 80% commonality — the F-35A conventional take-off and landing, the F-35B, STOVL and the F-35C conventional carrier take-off and landing. (See Figure 1) Spiral development and anticipated modification and upgrade programmes should maintain operational effectiveness of the aircraft well into the second half of this century. As of 2007, the US plans to buy 2,443 F-35s in all three versions (this represents a cut of over 500 units on 1996 programme assumption). However, this is still close to the USAF's planned intention to replace its A-10/F-16 fleet on a one-for-one basis.

43. The F-35 will be produced in three versions offering between 70% and 90% commonality in terms of production costs. The savings over three different projects to meet the respective service requirements is claimed to be at least $15 billion.[13]

- The F-35A is the basic USAF version and is expected to be the predominant export type. Its main difference is an integral 25mm cannon. It will replace the USAF A-10 and F-16 fleet.

[12]'Russian Industry Awaits New Fighter', *Defense News*, 18 June 2007.

[13]CRS Report for Congress, *F-35 Joint Strike Fighter Program: Background, Status and Issues*, 2 June 2006, p 4.

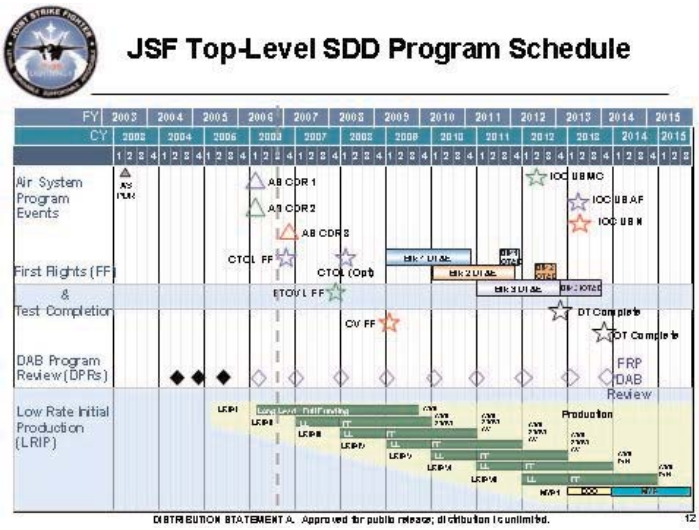

Figure 2.

- The F-35B STOVL designed to meet US Marine Corps and UK joint air and navy force requirement for carrier and forward deployment and will replace the AV-8B/Harrier II and other countries (such as Italy) with a small carrier or an 'expeditionary' requirement. It has the least range of the three versions and loses some internal bomb load and some structural strength (which will reduce its manoeuvring capability). It will be the most complex of the three to develop and will be the most costly.
- The F-35C is destined for the US Navy, has larger wings and stabiliser and the necessary strengthening for carrier operations. It has the longest range of the three versions and will be expected to act as the Navy's primary air superiority and attack aircraft. Few if any export customers are likely.

44. Additionally, like the F-22 Raptor, the F-35 has a powerful reconnaissance and electronic surveillance capability afforded by an AESA phased array radar and extensive integral passive sensors. This capability also enables the aircraft to act as a secure, high-bandwidth communication node. Overall capability will be enhanced by the combination of on-board and external data processing capacity. In short, both the Raptor and the F-35 will be fully network centric platforms. In keeping with the principle of spiral development, full capability will be achieved through a succession of initial variants; successive updates and opportunities for technology insertion are also envisaged over a projected 40-year lifetime. Finally, the design incorporates features designed to simplify maintenance and to keep life-cycle costs down. All F-35 variants will have two engine options, although the GE-Rolls-Royce alternative has been retained only by Congressional intervention and cancellation remains an obvious saving on development (if not through-life) costs. Currently the multinational team led by Lockheed Martin comprises:

- Level 1: the US and the UK (with a $2 billion commitment)
- Level 2: Italy ($1 billion) and The Netherlands ($800 million)
- Level 3: Turkey ($175 million) Australia ($150 million) Canada ($150 million) and Norway and Denmark ($125 million each)
- Observer status: Israel ($50 million) and Singapore ($50 million)

45. Team Lockheed Martin comprises Northrop Grumman and BAE Systems (UK and North America). The UK's standing as a Level 1 partner has led to substantial industrial benefits (the future of the second engine notwithstanding) generating a workshare for the development phase exceeding 20%.

The estimated JSF Air Vehicle procurement quantities of the participants

Participant	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18
Australia	0	0	0	2	6	14	15	15	15	15	15	3
Canada	0	0	0	0	0	0	0	10	10	10	10	10
Denmark	0	0	0	0	0	0	0	8	8	8	8	8
Italy	0	0	0	0	0	6	6	14	14	14	14	14
Netherlands	0	0	1	2	0	6	10	12	12	12	12	18
Norway	0	0	0	0	0	0	0	8	12	12	12	4
Turkey	0	0	0	0	0	10	10	10	12	12	10	10
UK	0	0	2	3	8	3	2	9	9	12	12	12
USA	5	16	47	56	64	103	135	153	160	160	160	160
Total	5	16	50	63	78	142	178	243	252	255	253	239

Participant	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	Total	% of Total
Australia	0	0	0	0	0	0	0	0	0	100	3.2%
Canada	10	10	10	0	0	0	0	0	0	80	2.5%
Denmark	8	0	0	0	0	0	0	0	0	48	1.5%
Italy	12	12	12	12	1	0	0	0	0	131	4.1%
Netherlands	0	0	0	0	0	0	0	0	0	85	2.7%
Norway	0	0	0	0	0	0	0	0	0	48	1.5%
Turkey	10	10	6	0	0	0	0	0	0	100	3.2%
UK	12	12	12	12	12	6	0	0	0	138	4.3%
USA	160	160	160	153	148	118	110	110	101	2,443	77.0%
Total	212	204	200	177	161	124	110	110	101	3,173	100.0%

Figure 3. *Source: JSF PSFD MoU.*

46. The development schedule currently expects Low Rate Production (LRIP) to begin in 2008 with US in-service dates beginning in 2012. Delivery dates for the other partners is planned to start in 2011 (see Figures 2 and 3).

47. Current Congressional authorisation is for two F-35A in LRIP Lot 1 and long lead funding for six F-35As and six F-35B in LRIP Lot 2. Congressional funding authorisation has been slower than expected and has led to increased development costs. However, Congress has been affected by a series of critiques from the GAO suggesting that the F-35 programme, as originally scheduled, was taking too many risks with technological maturity. So far, overall programme costs have risen by 8.5% with the combined development and production phase now expected to cost $300 billion. These increased costs have so far not been passed on pro rata to the international partnership.

48. While there will be a market for cheaper, less capable aircraft, such is the combat edge promised by the F-35 (particularly in terms of network-enabled capability and the flexibility provided a fully comprehensive multi-role design) the F-35 is perhaps the most marketable of the current and planned strike fighters. However, the future of the F-35 is not assured and is subject to a number of critical issues.

PART THREE: F-35 MARKET ANALYSIS

3.1 The United States

49. The debate about the future mix of US tactical aviation has been intense. The future cost of replacing the US fleet represents a large proportion of planned procurement. The US is about half way through a 40-year modernisation exercise that will be completed with the final F-35 deliveries. Collectively three new programmes, F-22, F-35 and F/A-18E/F Super Hornet, are expected to cost some $400 billion for 3,200 aircraft. Around 75% of these costs have still to be spent (see Figure 4). As a result of increased costs, extended development times and general budget pressures, the planned fleet will be reduced by 1,500 aircraft.[14] The three current fixed-wing tactical aircraft will absorb some 40% of the cost of developing the top 20 US equipment programmes over the next decade (F-35 – 16.5%, F-22 – 14.5% and F/A-18E/F Super Hornet – 11%).

50. Concern about the expense of this programme has already led Congress to cap F-22 numbers and to enforce a stretch-out of F-35 development, even at the cost of actual or potential increases in unit costs. Similarly, and of particular relevance to the F-35 'triad', savings might also be achieved through adopting a more integrated approach to operations - in the case of the USN and USMC, one estimate has suggested savings of up to $35 billion could be achieved through better integration of carrier-based tactical airpower.[15]

51. The GAO has considered at length the status of US tactical aircraft fleet modernisation in general and the progress of individual programmes, notably the F-22 and F-35.[16] It has been uniformly critical of the management of both aircraft procurements and has questioned the affordability of the tactical aircraft modernisation programme. Only the F/A-18 E/F Super Hornet is regarded as meeting procurement best practice criteria. Delays in delivering new systems are also likely to increase the overall cost of force modernisation by requiring expensive life extension programmes for existing aircraft.

52. As the largest single procurement programme in US history, the F-35 has inevitably attracted considerable controversy. With the F-22 and F/A-18E/F procurement due to be completed over the next five years, the F-35, about half way through its development, inevitably will be the focus of future attention as 72% of expected investment and 85% of planned procurement quantities are in the future: "With most of its programme still ahead, its sheer size, and its tri-service impact, the JSF is, in many ways, the linchpin of the DoD's tactical aircraft future."[17] Already subject to substantial cost escalation — a 29% cost increase since 2001 — the GAO is not convinced that the programme will escape further substantial increases in cost. In the GAO's view, although commended for overcoming major design problems, the particularly aggressive procurement strategy with a heavy emphasis on concurrent development and production, the F-35 is a very high-risk enterprise.[18] Moreover, as the DoD assumes a very high level of annual funding (an average of $14 billion) between 2012 and 2023, it will be increasingly exposed to predicted

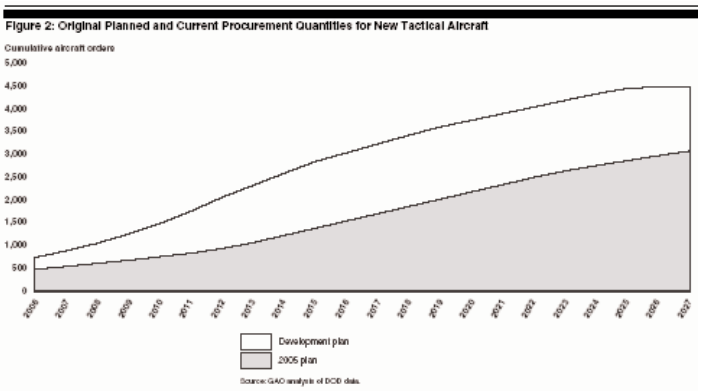

Figure 4. *Source GAO.*

budgetary pressures arising from a combination of other large DoD programmes, continuing operational burdens and wider demands on Federal discretionary spending. This is already affecting F-35 procurement quantities, with a planned reduction of initial deliveries from 160 a year to 115, a 28% decrease.

53. Further rises in cost would further undermine the F-35's affordability. As programme costs are vulnerable to variations in US annual funding and production, the F-35 could encounter the same dynamic that contributed to the F-22's rapid escalation in unit costs. Significantly, the F-35 team is exploring ways of capturing the multi-year funding common to many of the international partners. This stream would bolster the planned levels of F-35 production maintaining a predictable production cadence and keeping costs under control.[19]

54. A more insidious threat is from competing US programmes. The USAF has supported the F-22 as its 'crown jewel' platform and has resisted (largely unsuccessfully) Congressional cuts in procurement numbers. Some elements within the USAF have encouraged consideration of Lockheed's proposal for an FB-22 development that would substantially augment the Raptor's strike capabilities, albeit at a significantly high premium. This is considered an unlikely option. A more serious problem could stem from the growing need to extend the life of existing aircraft to cover delays in the F-35 programme, as well as any further substantial escalation in development costs. The former includes the annual cost of keeping an ageing fleet operational and to maintain levels of readiness. The US Navy and Marine Corps is especially exposed to this problem, with the latter's Harrier force affected by a high annual attrition rate. A one-year short fall in JSF In-service Date (ISD) increases the Marine Corps' short fall of capacity after 2011 by about three aircraft a year. Overall, the DoD is now predicting that in 2025 only 60% of the US tactical airforce will comprise new systems as opposed to a 100% originally planned. This will reflect the substantial cuts in F-22 procurement and the reduced annual buys of F-35s. A conservative estimate of the additional cost of keeping the legacy systems in service is over $2 billion for the F/A-18E/F alone.

55. The F-35B has also been subject to pressure from the Navy. Tension between the Navy and the Marine Corps over close air support has a long history and the Navy has argued that the F-35C could satisfy most of the Marines' requirement (aside from the immediacy offered by STOVL in the field). Most recently, the Navy has raised operational objections to STOVL operation in a carrier context — dismissed as spurious by the Marines. Abandoning the more complex and expensive STOVL version would of course

[14]GAO, April 2007.
[15]Bolkom, op cit, p 10.
[16]GAO, April 2007 and GAO *Joint Strike Fighter*, March 2007, GAO-07-360.
[17]GAO, April 2007,p 7.
[18]GAO, March 2007. The Super Hornet, in contrast, is commended for its conservative and largely successful procurement. The EA-18G Growler, however, is also considered to be a high risk procurement with a number of immature technologies at a late stage in development.

[19]"USA will offer JSF partners price deal", *Flight International*, 13 March 2007.

represent a massive saving overall in F-35 development. However, as the F-35B is central to UK and, to a lesser extent, Italian requirements, international politics affords it some protection. Nevertheless, the US has a track record in unilateral procurement decision-making and the Congress may be less concerned with the international ramifications of cancellation — a position that may of course apply to the programme as a whole. The case for the STOVL version is closely linked to other partner requirements and the Pentagon has closely monitored the UK carrier programme, less perhaps to do with concern for UK naval capability than to check on continuing UK commitment to the F-35B.[20]

56. On the other hand, the Super Hornet has been subject to stories criticising its performance, suggesting it had a design flaw and casting doubts on its reliability. These were attributed to the US Marines trying to head off cuts to F-35B procurement and a forced purchase of Super Hornets. The Marines are the only US service committed to pushing the pace of F-35 procurement with a total dependence on STOVL for close, amphibious support. The existing AV-8B fleet is ageing too fast and delays in the F-35B could leave the Marines without a platform. The Marines are also concerned that the Congress also lacks a sense of urgency about meeting their requirement.[21]

57. The long-term impact on the US defence industry of cancellation affords the whole programme some protection. The F-35 is widely perceived in the US as the "last major aircraft procurement." Whether consciously part of a deliberate 'industrial strategy' or not, the F-35 is likely to stymie any future European fighter programme beyond the Rafale and Typhoon.[22] If the aircraft does sweep up the F-16 market, on the most optimistic market forecasts it could win over 4,000 export orders through its lifetime.[23] While the Super Hornet and a revived F-15 have begun to attract some orders, in the absence of an alternative US product to match the new generation of European models, US defence aerospace export supremacy would be threatened. In this respect, even an export-authorised F-22 will have few customers at the price. The economic as well as the strategic implications posed by this scenario should help to protect the F-35 from all but its most implacable Congressional and other critics.

3.2 The International Partnership

58. With all nine partners signed up to F-35 System Development and Demonstration (SDD) phase, the key battle will be to keep all of the team on board. The next milestone — around 2008-9 — will be agreeing on production stage participation and signing up to initial purchase commitments. Delays to the F-35 are already opening windows for interim purchases and in some cases raising the total cost of new fighter procurement. Norway, for example, is keeping its options open with industrial partnership agreements with Gripen and Typhoon. Norway needs to replace its F-16s by 2015 and this drives its reluctance to sign up to F-35 production, as well as some success in driving a hard bargain on industrial participation and technology transfer. Holland's participation in the F-35 — described as a risky option — was an issue in the 2006 national election.

59. These pressures have led to significant modification of LMC's initial determination to sub contract on the basis of a 'best athlete' competition. This led to problems with several of the partner states. LMC has now adopted a 'strategic best value' approach. Equally, the other members of Team LM are examining second source supplier options as part of a strategic sourcing approach. BAE Systems are looking to Canada, Australia and Denmark for sub contractors, while Northrop is focusing on Norway, The Netherlands as well as Australia. The shift in emphasis was enough to keep the Norwegians happy at least for the moment. Other 'strategic' sourcing opportunities are likely to be derived from the F-35 'global sustainment' plan to support the aircraft in service.

The United Kingdom

60. Despite being the only Level One partner, the UK has encountered major problems in securing high-level technology access and transfers. As a Level One partner, British expectations in this respect are bound to be higher than the other partners. Release has been based on a succession of 'need-to-know' technology transfer agreements (TAA). The latest round included access to source coding and other technological data to enable the UK to maintain and upgrade the F-35. This included the ability to integrate its own weapons. The UK only received 'assurances' on future access to ensure operational sovereignty after considerable political pressure, accompanied by threats to withdraw from the programme, with assertion that a 'Plan B' alternative was feasible.[24]

61. The original in service targets threatened a clear overlap with Tranche 3 Typhoon. Slippage has widened the gap between the two aircraft. Indeed, even though the carrier programme has also moved to the right, there is a strong probability that the first year or so of carrier deployment will use Harrier GR9s, extending their life beyond the planned 2015 OSD. Confirmation of the carrier programme in August 2007 has increased confidence in the UK commitment to the F-35B, but budgetary issues might add three more years, with an ISD of 2017 now possible. This would require a further life extension programme for the Harrier.[25] Generally the RAF sees the Typhoon Tranche 3 as capable as the F-35 in most basic missions but the latter, with its stealth capability, is a 'day one' strike aeroplane as well as being a networked surveillance and reconnaissance platform. The F-35 is designed to meet the manned element of the UK's Deep and Persistent Offensive Capability requirement.

62. The rising costs of the F-35 is a cause for concern, not just on general grounds of aircraft affordability but because of implications for the UK specific requirement for weapons integration. This will come at an additional price. The current UK requirement is for MBDA's ASRAAM, Brimstone and Storm Shadow, Raytheon's Paveway IV and AMRAAM and, finally, the 'SPEAR' solution. So far this does not include the MBDA Meteor BVRAAM under development for the Typhoon, Rafale and Gripen, but this is understood to be now under consideration for the UK F-35 downstream. So far, the UK MoD does not see these requirements as a target for cost cutting. Weapons integration is vital to MBDA as it provides access to the F-35 export market, with integration costs absorbed by the UK order.[26]

Italy

63. Italy is a Level Two partner in the F-35 and the second most important international partner. Italy has a likely order for 131 aircraft (109 F-35As for the airforce as Tornado replacements and

[20]'US Navy Debates STOVL JSF Future', *Defense News*, 30 April 2007.
[21]'Protecting JSF, Marines Fire at F/A-18E/F', *Defense News*, 18 June 2007.
[22]Ethan Kapstein, 'Capturing Fortress Europe: International Collaboration and the Joint Strike Fighter'. *Survival*, 2004, **46**, (3).
[23]See Attachment for more considered analysis of F-35 market.
[24]This could have been either the Rafale, a navalised Typhoon or the Super Hornet. But given the cost and political difficulties with several of the options, Plan B was almost certainly blustering. *Financial Times*, 13 December 2006.
[25]*Financial Times*, 15 June 2007.
[26]'UK Delays JSF', *Aviation Week*, 11 June 2007.

22 F-35Bs for the navy — Harrier carrier-based aircraft replacements). The airforce may also want a number of F-35Bs for forward deployment, but the navy must have the STOVL version for operation on its small carrier, the *Garibaldi* and its replacement the *Cavour*, but the exact division of the order may well depend upon a future re-organisation of the Italian armed forces. There are also logistical advantages in focusing as in the UK on one variant. Finmeccanica and Lockheed have also agreed to locate a second Final Assembly and Check-Out (FACO) facility in Italy to build Dutch and Italian aircraft. This is still subject to US government approval. The exact size of the Italian order will depend upon future defence budgets; confirmation of 131 F-35s could lead to cuts in Typhoon Tranche 3.

64. Italian defence policy is in the process of modernisation. This includes conversion to an all-professional armed forces and a slow, but accelerating commitment to network centric concepts. Since the end of the Cold War, Italian security has become increasingly focused on the Balkans and the Eastern Mediterranean. In recent years, the Italian armed forces have been deployed abroad in an expeditionary mode. Italian industrial interests and commitment to European defence co-operation have heavily influenced Italian defence procurement. This has led Italy into the Tornado and Eurofighter partnerships. Budgetary uncertainties and annual funding have combined to create periodic crises in Italian procurement but last minute deals and compromises have usually seen Italy meet various international funding milestones.

65. The guiding principles of Italian procurement are defined by the 'country system' to meet Italian requirements "in terms of security and defence, to safeguard and to develop the intellectual, technological and production heritage of the national armaments industry, to promote presence on the export market and to develop international co-operation related to operational requirements, standardisation of procurement rules and harmonisation of the legislative framework for armaments export."[27] International co-operation and collaboration is explicit and hardwired in Italy, especially in the area of R&D and, like the UK, split between Europe and the US.[28] The Italian armed services have bought from world markets. However, in both cases there is an expectation of industrial participation and technology transfer for both security of supply and for wider industrial and economic objectives. In stressing the "valorisation and growth of technological capabilities and national production excellence areas, the preservation of job activities, the import-export balance and the international role of Italy in foreign and security policy," the 'country system' would appear to place Italian industrial interests firmly at the centre of procurement decisions.[29] The Industry Ministry is, for example, more directly involved in funding defence programmes than is the UK DTI.

66. In short, the F-35 represents an important element in future Italian defence and aerospace industry policy, although the rationale behind its choice of a mixed fleet remains something of a mystery, subject to the vagaries of inter-service interests.

The Netherlands

67. The Dutch are the third largest contributor to the international partnership. As leading members of the original European F-16 co-production agreement, they might reasonably be regarded as a pivotal customer for the F-35. The Netherlands has been particularly sensitive to industrial participation and technology transfer issues. The Dutch have been linked with Italian interest in establishing a European FACO facility. In common with a number of other European states, Holland may begin to question the affordability and need for such a sophisticated strike aircraft. Nevertheless, as long as Dutch industrial interests can be satisfied, they are likely to remain committed to the programme.

Australia

68. As its largest ever-single procurement, the F-35 is subject to much debate in Australia. Australia has bought 24 Block II Super Hornets worth $4.9 billion as an interim replacement for its F-111 fleet with deliveries running from 2010-11. Officially, this contract is not regarded as a threat to the F-35 deal and Australia will retain the option of a mixed fleet of F-18E/F Super Hornets and F-35s, but official thinking still tends towards an all-F-35 force. Australia is committed to a network enabled defence infrastructure and a more extended oceanic-capable patrol and strike capability. With its existing force of F-111 bombers being phased out, the Super Hornet with its improved range and better sensor performance will fill the gap until the arrival of a full network capable F-35 force.

69. While the Australian request is for aircraft and support equipment only, the new block of Super Hornets may be fitted with the AIM-9X Sidewinder rather than Australia paying for the integration costs of the MBDA ASRAAM currently in service with the existing F/A-18A fleet. For the F-35, the AIM-9X and ASRAAM are options and studies will be made of the costs of integrating the ASRAAM with the F-35, exploiting commonality with the UK preference. Future air-to-ground will have to be consistent with a fully networked battlefield environment. Commonality and affordability will also be key criteria for selection.[30]

70. However, there have been several critical studies of the F-35 programme comparing it badly to the F-22 Raptor and suggesting that an F-22 purchase might be the more cost-effective and timely solution to Australian requirements. From an Australian perspective, British vacillations over the F-35 could also have serious ramifications for the eventual cost of an Australian procurement. Assuming that the US would allow an F-22 export to Australia (not unreasonable) and the resolution of technological transfer issues (less reasonable), F-35 critics have pointed out that the F-22 would offer Australia a more capable aircraft to meet regional threats posed by Su-30 class aircraft and radars capable of detecting F-35 levels of stealth.

71. In its existing form, the Raptor might also be a more than adequate strike aircraft to follow F-111 retirement. As an 'off-the-shelf' purchase, this would certainly be a less risky option but the price of the F-22 is unlikely to drop much below double that of the F-35. More radically, upgrades of existing aircraft with some of the technology under development for F-22 and F-35, particularly network enabling technology could be a cheaper alternative — an option that could be used to await developments in UAS platforms.[31]

72. However, even if the US allowed an F-22 procurement, a pure strike F-35 is still likely to be the more effective option. Participation in the F-35 is consistent with Australia's defence aerospace industry strategy document, which combines

[27]Italian Ministry of Defence, Defence Procurement in Italy, 2007.
[28]Although for the present, R&D co-operation tends to focus more on Europe.
[29]Italian Ministry of Defence, op cit, p 30.

[30]'RAAF examines options to evolve weapons capability', *Flight International*, 13 March 2007.
[31]Alex Tewes, The F-35 Project: progress and issues for Australia. Research Note 32, 2005-6, Library of the Parliament of Australia, 9 June 2006.

procurement of the best value equipment for the armed forces with benefits to the domestic economy through technology acquisition and export earning potential. Australian industry expects to earn some $9 billion over 30 years through participation in the F-35 programme. Some 20 Australian companies were involved in the SDD phase. The continued development of the domestic aerospace industry was also the subject of a government-industry action plan that referred to the success of the 'Team Australia' approach to the F-35. Significantly, pressure from the Australian Government secured important concessions from Team Lockheed to select sub contracts on the basis of strategic sourcing.

Canada

73. Like Australia, Canada is also positioning itself to obtain significant industrial benefits from the F-35 as well as meeting core defence requirements. Canada is likely to replace its existing CF-18 fleet with up to 80 F-35s, and participation in the F-35 development programme is helping to define more clearly its future fighter requirement. Canada has established an office to determine future fighter requirements with specific reference to an F-35 order. Canada is not due to decide on buying the F-35 until 2012 for a 2016 ISD. Its current CF-18 fleet will be phased out between 2017 and 2020. Over that time-span, other platforms and technology, including UAS might have matured sufficiently to affect F-35 numbers or even its suitability. As a member of the F-35 SDD phase, at a cost of $150 million, and the PSFD at a cost of $500 million spread over 45 years, Canada has a substantial stake in the F-35. The Canadian armed forces are also very keen, viewing it as the most cost-effective 30-year solution. Growing concerns over control of the Arctic may also fuel the requirement for the multi-role F-35, especially given its surveillance capability. Internal market forecasts also underline the commercial and industrial potential for Canadian firms, earning up some $5 billion over the lifetime of the programme (excluding sales outside the partnership). Return would shrink with any cut to Canada's commitment.[32]

Norway and Denmark

74. Both Norway and Denmark are members of the European 'F-16' group and have signed up to the next phase of F-35 partnership. Norway is keeping its long-term options open. In May 2007, it signed an industrial co-operation agreement with Sweden on the Gripen. This would keep Gripen in the $8 billion competition to supply new generation fighters to replace its F-16s starting in 2016. The Typhoon is a contender as well, also with a long-standing co-operation pact further reinforced in May 2007. A decision is expected in 2008. Norway's choice will depend heavily on the rate of return to Norwegian industry. Funding so far for all three programmes is modest and enables Norway to assess all three on equal terms. Northrop has already agreed to source advanced composite structures from Norwegian industry.

75. The other members of the 'Nordic Group', Sweden and Finland, have adopted different procurement strategies. Sweden naturally is focusing on the Gripen and Finland operates F-18 E/B Hornets, currently being upgraded in a programme that should extend the lifetime of the fleet until 2025-30.

Turkey

76. As a major regional power, in a highly unstable area, Turkey has a significant military capability. Turkey's location close to several areas of political tension in the Middle East and Central Eurasia underlines the need for advanced defence equipment. Continued tensions with Greece have also underpinned a high level of defence spending that has been used to acquire modern, mainly US equipment — and even given warmer relations between the two countries Turkey is unlikely to buy equipment with less capability than Greece. As a result, the Turkish defence budget is likely to remain at a high level for the foreseeable future.

77. Industrial participation will continue to be a key factor in defence aerospace procurement decisions. This has usually entailed significant levels of offset and in the case of the F-16, a full scale upgrading of the country's aerospace assembly capabilities.

78. Turkey as a major F-16 user is an important potential F-35 customer, a position underlined by the May 2007 F-16 Block 52 orders worth $1.5 billion. Despite its position as an F-35 international partner, Turkey is being wooed by Eurofighter to join in Tranche 3 development and is offering equal partnership rights with a $9 billion local workshare for a 120 aircraft deal. Turkey had considered a mixed procurement of F-35s and Typhoon but the Turkish military preferred the all-F-35 solution. Given Turkey's application to join the EU, there may be political pressure to 'buy European', but this might be assuaged by selection of European weapons for the F-35. Turkey's order for 100 F-35s is worth $10.7 billion over 15 years. Turkey is looking to replace some 300 older F-16s and F-4s by 2020. By then Turkey expects to field 130 fighter/strike aircraft, replacing numbers with greater capability.

Israel

79. Israel is an observer member of the F-35 programme. Unless there is a radical change to US policy, the country should be allowed to acquire the aircraft. Israel may also want access to the necessary technology to ensure 'operational sovereignty' and to integrate its own weapons. Israel has also reportedly approached the US about buying an F-22 export version to underpin its regional air superiority.

Singapore

80. Singapore's defence procurement plans are invariably shrouded in some secrecy but the country's geo-political position implies a need for long-range strike and surveillance capabilities. The economy is strong enough to support the acquisition of the F-35 and has a high degree of political acceptance. While Singapore in the past has sought industrial participation agreements, these might be satisfied by offset.

3.3 Other Potential Customers[33]

Austria

81. Austria is still slated to be the first export customer for the Typhoon albeit in reduced numbers. However, doubtful need for advanced strike fighters and general affordability issues makes Austria an unlikely F-35 customer in the short to medium term.

Germany

82. A key player in the Typhoon partnership, Germany has so far given no indication that it has a requirement for the F-35. Indeed,

[32]'New Office To Assess Canada's Fighter Needs', *Defense News*, 18 June 2007.

[33]For a more comprehensive customer analysis, see Attachment.

its existing commitment for Typhoon has been questioned on grounds of affordability and need. However, recent foreign deployment of Luftwaffe Tornados suggests that Germany is likely to play a more active role in future EU/NATO expeditionary missions. If this is the case, the Typhoon Tranche 3 or enhanced Tranche 2 will be regarded as the platform of choice.

Greece

83. Although Greece had originally bought the Typhoon, the cost of the Athens Olympics forced the Government to re-consider. The Greeks subsequently bought 30 Block 52 F-16s as an interim solution. The competition for 40 aircraft has been re-opened with Typhoon, Rafale, Gripen, Super Hornet and the Su-30 as contenders. The F-35 is also a possibility, especially given Turkish interest. However, affordability is likely to remain an issue.

India

84. India has one of the highest levels of defence spending in the developing world. It has regional power projection ambitions with long-range strike and carrier-borne air power. In addition to the long-standing tension with Pakistan, its strategic interests are also shaped by a rivalry with China. Matching capabilities with both of these states is a fundamental driver in Indian procurement policy. Indian security also requires a degree of hegemonic power in the Indian Ocean and South East Asia.

85. Indian procurement policy has also been shaped by a determination to develop its indigenous defence industry base. This has required licence production and local assembly wherever possible. Until recently, India has bought its weapons from European states, Israel and, most importantly, from the Soviet Union/Russia. Russia is still India's main source of defence equipment — some 70% of current inventory. With limited success, India has also sought to develop indigenous designs. The LCA fighter has been in development since the 1980s and has still to enter service. However, since 2005 and the signing of a civil nuclear deal with the US, India has begun to look to the US as relations generally between the two countries have warmed markedly. The US clearly views India as a regional balance *vis-à-vis* China and, as relations with Pakistan have become more problematic, India may also offer the US various back channel options in the Middle East. Currently, co-production of both the F-16 and the F-18 E/F Super Hornet are under consideration.

86. Indian procurement has been heavily affected by bureaucratic paralysis that has made it very difficult to conclude contracts. Procurement decision-making has also been affected by a series of corruption scandals. Reforms designed to improve and expedite the process were introduced in 2005. Earlier, in 2001 India moved to open up its defence industry to inward investment.[34]

87. India is looking to modernise its fighter fleet with advanced equipment, a need highlighted by Pakistan's recent contract to modernise its F-16 fleet. In particular India wants to replace its MiG-21 and Jaguar fleet. This will eventually entail local assembly with a final run of over 200 units. Contenders include the Rafale, Gripen, Super Hornet, Typhoon, F-16 and MiG-35. India expects up to 30% of the $12 billion cost to be offset. Boeing has already invested $100 million in a maintenance and overhaul facility that, while targeted at India's civil aviation industry, could be a precursor to defence investment. Boeing is considering using Israeli avionics for its F-18 Super Hornet submission to bypass US restrictions on the export of some F-18 equipment. Currently, India is assembling Su-30s and receiving its first MiG-29K carrier aircraft and has signed an $800 million contract with Dassault to upgrade its Mirage 2000, including Israeli avionics. On balance, India should not be regarded as a near-term F-35 customer, particularly as it is not regarded as especially secure in safeguarding sensitive technologies.

Japan

88. Japanese security policy is undergoing a significant change.[35] Since the end of the Cold War, it has begun to modify its long-standing 'Self Defence' criterion that constrained its armed forces to the defence of the Home Islands. Japan has steadily expanded its regional 'power projection' capabilities and has taken a more active role in peacekeeping activities and, albeit in a very limited way, some aspects of US-led coalition warfare. Its links with the US are still central to Japanese security policy and, for political and economic reasons, US-designed products have dominated procurement, though usually licence-built by Japanese companies. Acquisition of heavy fighters such as the F-15 was justified to defend Japanese airspace and *de facto* US bases against Soviet incursion. Over the past two decades, the Japanese have adopted air-to-air refuelling and increasingly more strike-capable aircraft. Japanese defence spending was set at no more than one per cent of GDP; while this has now been breached, defence spending still hovers at or just over the one per cent mark. Expenditure fell in real terms during the 1990s but has gradually increased since 1997. However, the sheer size of the Japanese economy ensures that Japan is the world second ranked military power in terms of expenditure. However, due to high personnel costs, procurement accounts for only around 19% of the total defence budget.

89. The rise of China, the threat posed by North Korea and the fear of regional instability is forcing the pace of reform in Japanese security policy. The perceived need to protect Japanese sea communications as well as concerns about being drawn into regional conflicts are increasingly important factors in setting procurement plans. There is also emerging tension between the traditional alliance with the US over relations with China, as well as the degree to which the country should be drawn into the 'War on Terror'. However, it is increasingly the case that Japan will seek to strengthen its ties with the US. This has already seen collaboration over BMD and improved co-operation generally in military technology.

90. Industrial and technology policy interests play a major (often decisive) role in procurement policy. In the aerospace sector, Japan has usually elected to build equipment under licence and, where possible, to install indigenous equipment. An attempt to develop an advanced indigenous fighter (the FSX) in the 1970s and 1980s led to tension with the US, seeing the FSX as a potential challenge to its own aerospace industry. In the event, with US aid, the Japanese built what was to all intents and purposes a more advanced version of the F-16, the F-2. Japan's determination to support its relatively small defence industrial base has led to higher unit costs. There are still strict restrictions on the export of Japanese weapons systems; these also add to procurement costs. Finally, the absence of genuine collaborative relations overseas companies has further limited Japanese ability to acquire technology or to defray development and procurement costs.

91. The Japanese military, though subject to tight civil control, are in favour of a more active security role. While constrained

[34]See Mohanty, D.R. *Changing Times? India's Defence Industry in the 21st Century*, BICC, Bonn 2004.

[35]See Hughes, C. *Japan's Re-mergence as a 'Normal' Military Power*, Adelphi Paper 368-9, IISS 2004.

defence budgets have led to cuts in equipment numbers, the Japanese military have continued to focus on quality with an emphasis on high technology and firepower. Japan is committed to force modernisation through network-centric concepts and to further extend the range of its power projection capabilities, including more advanced airborne weapons. This is also driven by the need to remain interoperable with the US. Japan may be moving to develop a STOVL capable carrier force. There is growing pressure to end the restrictions on arms exporting and to seek more equitable and beneficial forms of industrial co-operation; primarily aimed at deepening relations with the US.

92. Japan currently has a requirement to replace its F-4 Phantoms and is considering Typhoon, Rafale and Super Hornet. Singapore's revitalising order has also put the F-15 back in contention. However, Japan has its eye on more advanced aircraft to facilitate its transformation programme, including the F-22 Raptor if the US will allow transfer of stealth technology. The F-22 would certainly match any of Japan's neighbours and would satisfy both air defence and strike-reconnaissance requirements. Japan could be a beneficiary of the momentum building up in the USAF to sell the F-22 to trusted allies as a means of maintaining production and reducing unit costs generally. Upgraded F-15s would be a stopgap but the F-35 would be attractive for both budgetary reasons and for its superior performance, and its promise as a surveillance platform. The STOVL version would also give Japan a carrier option.

93. However, timing of the more advanced programmes, which includes the F-35, has created a need for 20-30 less expensive interim aircraft. The Japanese are also exploring licence-building Typhoon. Combined with the Meteor BVRAAM, this would be a major shift in Japanese procurement but would offer a better deal on technology transfer. However, it might equally be a ploy to press the US into a deal on the F-22 or F-35. The Japanese are looking to replace a total of nearly 300 F-4s and F-15s. Some US officials are also opposed to selling the F-22 to Japan fearing the affect on Sino-American relations. The Pentagon would prefer Japan to focus on the F-35 as a less controversial option.[36] Japan remains one of the few countries that could afford the $200 million list price for an F-22. The F-22 would better match Japan's F-4 replacement target of 2010.

94. Sale of the F-22 would be subject to close scrutiny by the US Government and Congress, but the Japanese may regard sale of the F-22 as a sign of good faith in US-Japanese relations and part of the renewed alliance relationship.[37] If, as is still the more likely outcome, the F-22 is not available, the F-35 programme remains an option, but Japan may want a significant degree of technology transfer which may be less easy to achieve as a late comer to the F-35 programme. Reports that Japan might be considering developing its own fifth-generation fighter have not been confirmed and would require some degree of technology transfer. Japan's past efforts to develop indigenous products has not been operationally successful and, as pure military requirements begin to dominate Japanese defence planning, satisfaction of industrial interests may play a diminishing role in procurement.

Korea

95. In the light of reports that Japan might be seeking F-22s, Korea may try to keep up and may also try to buy the F-22 or F-35. Up to this point, Korean ambitions centred on developing the indigenous KFX $13 billion fighter designed to be slightly stealthier than the Rafale and Typhoon. Korea currently plans to buy 120 KFX for delivery in 2018. Interim current requirements were to be satisfied by 20 more F-15Ks following the purchase of a previous batch of 40, although Eurofighter is still hoping to sell the Typhoon. While the Koreans have said they would like to open their market to non-US suppliers, political interests would tend to confirm Korea's US orientation. This order (with more from Saudi Arabia a possibility) should keep the F-15 in the market until at least 2015. Korea is unlikely to be an acceptable customer for the Raptor and the $45-65 million unit cost of the F-35 will be more affordable. Korea could reasonably expect some level of industrial participation in the F-35.

Malaysia

96. Malaysia has ordered 18 Sukhoi Su-30MKM aircraft but would like to acquire the Super Hornet. This has been a target for the Malaysian airforce for seven years but the Government chose the Russian aircraft on cost and political grounds. The airforce hopes to see funds for the F/A-18E/F included in the 2010-15 development plan. Malaysia already operates an old fleet of MiG-29s and the F/A-18D, but would like the Super Hornet for extended range operations.

Pakistan

97. Pakistan is struggling to replace its current fleet of F-16s with upgrades and possible purchase of the Chinese Chengdu FC-1. Pakistan (is seeking/got) authorisation for 18 new Block 52 F-16s as well as upgrading its existing fleet of 117 aircraft. Turkish Aerospace will conduct the updating programme. Given the deteriorating state of US-Pakistan relations and concerns over its political stability and technology security, sales of the most advanced US military equipment are unlikely.

Saudi Arabia and the Gulf States

98. Despite the controversy over bribery allegations in the UK, Saudi Arabia is going ahead with preparations to receive its first 24 Typhoons of a 72 order worth $40 billion. The second batch will be completed in country. At one stage, all of the western fifth generation aircraft were in contention, with the F-35 seen as a having an edge over the Typhoon. The Saudi Typhoons will have priority over RAF deliveries but, as these are Tranche 2 air superiority models, this will not necessarily detract from UK needs.

99. Several of the Gulf States are also likely to modernise their tactical airforces over the next decade and have few obvious affordability problems. However, as in the case of Saudi Arabia, the US might hesitate to supply F-35s while the threat to Israel remains high. This constraint would apply to other potential Middle Eastern customers such as Egypt and Jordan. There may also be concerns about regime instability — the Shah factor — where a change of government may leave US technology exposed to a potential adversary. Significantly, the US arms package to several Middle Eastern countries announced in the summer of 2007 focused on upgrading air defence capabilities.

Spain

100. Spain has steadily become a more active player in NATO but has not so far been prepared to embark on expeditionary engagements. The Typhoon is a major industrial and defence commitment. There may be a requirement for a Harrier replacement if Spain retains its small carrier capability.

[36]'F-22 Raptors to Japan?', *Defense Industry Daily*, 24 May 2007. 'Japan is urged to consider F-35 jets', *Financial Times*, 15 May 2007.
[37]'First Choice', *Aviation Week*, 23 April 2007.

PART FOUR: FACTORS SHAPING F-35 MARKET EVOLUTION

4.1 The Fifth Generation Debate

101. Current generation of air superiority and strike fighters were designed primarily to meet Cold War air superiority and strike requirements. The four point five and fifth generations had their genesis in the need to anticipate developments in Soviet capabilities. The Typhoon and F-22 were designed to counter Soviet heavy fighters and a layered Warsaw Pact defence system. This latter threat also drove the requirement for stealthy attack platforms such as the JSF (F-35) and the cancelled USN A-12.

102. However, just how much capability is needed to meet reasonable assessments of potential adversary capabilities remains moot. Recent experience of conflict has shown that current, or upgradable equipment may have the potential to meet most US or western needs for the foreseeable future. Pure air-to-air engagement has rarely figured in conflicts over the past 30 years. The US and its allies have so far found the current generation of aircraft more than adequate against even 'day one' targets. Stealth aircraft performed a tiny fraction of strikes in either Gulf Wars and standoff weapons were more than adequate to hit key initial targets. The survivability of current generation has proved to be very high (the use of Tornados at low-level in Gulf 1 excepted). The huge cost of developing fifth generation types could be used to defend a policy of trading sheer performance against cost, and the F-22 can only be justified against an adversary with similar equipment, unlikely given the state of development outside the US.

103. The most radical solution posed by some US analysts suggests that the current level of US technological dominance could enable a pause in the development of fighter/strike aircraft. This approach suggests skipping a technology generation to await the arrival of the fully capable unmanned combat airborne system (UCAV) and other long-range strike options. From this perspective, much of the advanced capability promised by the F-22 and F-35 could be both regarded as unnecessary. Critics of the F-22 have noted that, with the cancellation of the A-12, the US Navy appears able to perform its core missions without advanced stealth or 'super cruise'.

104. Affordability, especially as all fifth (and four and a half generation) fighters have tended to experience severe cost escalation during development, has added a critical dimension to the debate. In the US this has led to a capping of F-22 procurement and the implicit adoption of a 'silver bullet' approach with a limited number of F-22s available to ensure US air superiority against any likely threat over the next 20 years. However, advocates of the fifth generation fighter argue that the end of the Cold War may have mitigated the need for the most advanced air superiority/strike aircraft, the longevity of modern aircraft, with the prospect of continual technological upgrading will be an insurance against long term uncertainty. The proliferation of Russian military technology as well as western equipment to areas of potential conflict, and the growing military 'spin-in' from advanced civil technology, continue to justify the procurement of fifth generation types. According to this logic, although initially expensive, the F-35, with its multi-mission, mission adaptability, multi-basing options and full-networked capability, its high unit cost notwithstanding, may represent a long-term affordable solution to most future requirements. This assumes, however, that the absolute cost of developing and procuring the F-35 does not rise to the point that its affordability is questioned. This depends upon the development programme staying on track and amortising costs across a large base and export market.

4.2 Unmanned Alternatives

105. The UAS is fast becoming the platform of choice for the so-called 'dull dirty and dangerous' missions — although the technology for defence suppression, the most dangerous mission, is still evolving. Nevertheless, the speed at which UAS technology has entered the US inventory for persistent surveillance missions, as well as some armed engagements, is dramatic. UAS technology is also widely spread with over 39 countries having some form of UAS capability. The UAS is an innovative weapons system that reduces the human cost of failed operations. Through automation and persistence, it fulfils a range of missions more readily than a manned vehicle. However, the genuine Unmanned Combat Aerial Vehicle (UCAV) with high-speed performance, stealth characteristics and integrated weapons systems is still in the early stages of development.

106. However, developing a replacement for the fifth generation manned strike fighter will not come cheap. UCAVs will require stealth technology, advanced avionics and high performance engines just like manned combat aircraft. Under current configurations UASs have less flexibility and are more vulnerable under most combat conditions, compared with manned aircraft. More importantly, a UAS cannot yet analyse and respond autonomously to its environment to the same degree as a manned platform. Nor can UASs, especially the large, more sophisticated designs, be considered truly expendable; they are just more suitable for high-attrition missions where human casualties must be minimised. Technological limitations also constrain some of the missions they could undertake safely and reliably, especially if involving munitions. There are important technical issues, especially bandwidth constraints, to resolve and serious operational concerns, particularly in conforming to rules of engagement, will have to be addressed if even the current generation of UASs is to achieve its full combat potential.

107. Fully capable UCAVs are still at least a generation away from the more complex defence suppression and air-to-air operations. Artificial Intelligence may parallel some of the human functions but combat conditions may be too demanding to rely upon for dangerous, rapidly changing and ambiguous situations. Both may still face difficult weapons release problems if constrained by legal and ethical issues. Unless these issues are resolved, the UCAV may not achieve the level of intensity of strike on target delivered by the modern fighter-bomber force. Cruise missiles may also have more utility for many strike missions and, with the addition of a loitering capability, they may also be able to attack elusive or quick response targets.

108. Paradoxically, the very capabilities offered by UASs may hinder their marketability. Their characteristics alone render much of the technology highly sensitive, especially in the case of vehicles able to carry heavy payloads long distances. UASs are rightly included in the Missile Technology Control Regime (MTCR) as potential WMD delivery systems. As larger UAVs become more widely used in commercial applications, the threat from a disguised lethally armed UAS could increase. This might lead to demands for more stringent controls on the sale of UASs and the transfer of UAS technologies. These issues might constrain market growth and leave room for the conventional strike-fighter. On the other hand, as the core technologies become more widely known or derived from commercial sources, even more countries might enter the UAS market.

109. The UAS may not therefore be a truly disruptive technology rendering existing platforms obsolescent. There will be a demand for manned aircraft for the foreseeable future for a range of missions where the flexibility and adaptability of a human pilot will still be an advantage. Many countries, while prepared to invest in a limited number of specialist UASs, will not want the expense of creating a large additional support and logistical operation for a comprehensive fleet of unmanned systems. Manned aircraft will remain the cheaper and more widely applicable solution to a range of military operations. Nor will every current buyer of manned aircraft necessarily want to replace a proven technology with sophisticated UASs, or require the sophisticated network-based systems characteristic of US and European thinking. A one-for-one substitution of UASs for manned aircraft in the near-term is therefore unlikely even in the US. UASs are more than likely to represent a complementary capability in most military inventories, perhaps acting in conjunction with a manned aircraft controller to suppress defences or to maintain long duration surveillance and patrolling.

110. Nevertheless, as the Israeli armed services have shown and as operations in Iraq and Afghanistan demonstrate, UAS technology is an increasingly vital component in a defensive and offensive security system. The needs of expeditionary warfare will continue to encourage development of an even greater range of tactical and strategic UASs. Inevitably, therefore, UASs will continue to erode the total market for strike-fighter aircraft and the UCAV is likely to constitute a viable alternative to the conventional strike fighter over the lifetime of the F-35.[38]

4.3 US Technology Transfer Policy

111. Since the late 1990s, the US Government — or more accurately elements of the DoD and the White House (both with varying degrees of enthusiasm and commitment) — have sought to reform the regime governing technology transfer. These efforts have centred on proposals to liberalise the ITAR system administered by the State Department and overseen by Congress. Reformers have contended that the ITAR process is not only cumbersome but it also reflects an outmoded approach to the diffusion of defence critical technologies. In a world of increasingly globalised defence companies, global supply chains and advanced, security relevant technologies widely available in the civil market, over-strict controls on technology constrain the development of effective joint programmes and reduce the efficiency with which trans-national defence companies can do business. Latterly, US industry has also complained that foreign governments have deliberately sought to 'design out' US technology, thus causing a net loss to US trade. Those opposed to reform continue to stress the need to maintain the US lead in defence technology as a critical edge in a world of multiple threats. Improvements could and should be made in the implementation of the rules but the regime itself should stay in place — indeed, perhaps even strengthened.

112. The UK, with its large US industrial footprint, has looked for UK-specific changes in the US ITAR system. This has often included heads-of-government level negotiations, referring to Britain's role as the loyal member of US-led coalitions. Some seven years of negotiations have produced very little. The UK has retained a privileged and unique level of access in the government-to-government R&D sphere but the industrial restrictions remain as rigorous as ever. There are even signs that the implementation of the ITAR regime has worsened. The so-called Global Project Authorisation, one of the reforms introduced to expedite collaborative ventures, covers technology transfer associated with the F-35 international programme. However, this still requires a succession of release agreements on a 'need-to-know' basis. As we have noted earlier, as these begin to involve the most sensitive elements of the F-35 design — stealth and software integration — negotiating the relevant technology transfer agreements have become increasingly fraught.

113. During 2007, efforts were renewed to effect changes to the US system. The DoD Industrial Policy Office — long a champion of reform — commissioned a report from the Institute for Defence Analysis examining the affects of US export controls on the US defence industrial base. Although it concluded that there were no observable negative consequences for US industry, there was equally little logic and value in maintaining the regime in its present form. Similarly, even if there were no quantifiable effects, the cumulative impact on the US's ability to co-operate in defence procurement through teaming and joint ventures could be damaging.[39] At the same time US industry has begun to lobby for improvements in the administration of the control system. This has been given particular impetus by the emergence of new market opportunities in the Far East, particularly in India. In many respects the aims are modest and do not seek, as in the past, fundamentally to change the system. Care has been taken to address Congressional concerns. However, the signs are not promising, given the growing protectionist sentiments in Congress and a backlash to the globalisation of US procurement.[40]

114. The likelihood is that for the foreseeable future the US will maintain strict controls on the export of defence-sensitive and a wide range of dual technologies. This may run counter to both industrial and technological logic but the US political system has proven highly resistant to the application of economic or strategic logic. As such, these constraints will remain a given for either direct military exports or for joint ventures and collaborative programmes. Participation in US led, or US technology predominant, defence programmes will require adherence to US practice and would again imply an early integration of sub systems and equipment into US products. Delay or failure to achieve early access will inevitably entail costly insertion programmes and potentially difficulties in securing the necessary technology clearances. On the other hand, involvement with a US programme will entail acceptance of US general controls over export and subsequent exploitation of intellectual property. However, given the fragility of alternative markets, this may be a necessary requirement of commercial survival.

115. The UK Government has not abandoned its hopes of achieving a broader agreement with the US on a reformed technology transfer regime — an effort that dates from the 1999 Declaration of Principles. This has proven a hard and frustrating exercise, and despite the support of successive US Administrations, the DoD and US industry, usually blocked by Congressional opposition.[41] The MoD argues that progress on the JSF has led to improvements elsewhere in Anglo-US co-operation. It also has confidence in making progress during 2007, including measures designed to improve the position for UK-owned subsidiaries in the US. These efforts will centre on an Anglo-American Treaty that is planned to go to the Senate for approval before the end of 2007.

[38]Although it may also be the case that UASs, particularly in tactical situations, have created their own and different market.

[39]IDA, *Export Controls and the US Defense Industrial Base*, IDA D-3363, January 2007.

[40]'US seeks reform', *Flight International*, 29 May 2007.

[41]See Keith Hayward, *Friends and Rivals: Transatlantic Relations in Aerospace and Defence in the 21st Century*, Royal Aeronautical Society Discussion Paper, 2006.

116. In practice, irrespective of the state of US technology controls, the lure of the US market is likely to remain strong. UK industry in particular continues to expand its footprint in the US; as do US companies in the UK (GE's acquisition of Smiths Aerospace for example). For industry, it is, bluntly, a clear example of 'follow the money'; the US market is huge and still expanding; UK companies still have a privileged presence. At a political level, the two countries remain on a common defence doctrinal track. There are also signs that Italy is following a similar pattern of US investment, albeit with a stronger ideological commitment to the principle of European collaboration. The UK's growing distance from regional initiatives and industrial strategies will become a cause of further divergence and division rather than a symptom. In this respect, the JSF represents a clear watershed for European military aerospace.

4.4 European Defence Market Fragility

117. The attractions of forging deeper links with the US are underlined by the continuing fragility of the European defence market. European collaboration in the past has usually delivered a more egalitarian access to jointly developed technology and has underpinned the defence industrial capabilities of most of the leading European states. However, the gap between European security goals and military capabilities is widening, as is, and at a greater rate, the defence technology gap between Europe and the US. This is not entirely caused by the vast differential in spending, although this is substantial, it is also about the continuing duplication of effort and a failure to liberalise the European defence market. Despite the growth of transnational defence companies, national interests and barriers to the free movement of capital in the defence sector inhibits the development of an efficient and effective industrial base. Matters are further complicated by the demands of the smaller states for 'fair return' in collaborative programmes and an equal voice in EU policy formulation. The EU also struggles to make the best use of its investment in civil and dual technology in defence programmes.

118. The emergence of pan European defence agencies such as the EDA and OCCAR have led to some improvements in the delivery of European defence procurement and defence technology planning, but these continue to be affected by divergent national attitudes towards European defence integration. The UK does not have much confidence in the multilateral or pan-European level; while welcoming initiatives designed to improve the efficiency of European defence R&D such as the recent moves by the EDA to promote a series of pilot R&D programmes; the UK Government is still opposed to divert substantial resources to the effort.

119. Part of the problem is the absence until very recently of an active EU-led dialogue on these issues; the EU Commission's Green Paper on the European defence market and subsequent attempts to scope the range and depth of European defence industry capabilities are important developments. The EU is still working on a European DTIB policy and the EDA has recently announced a number of initiatives designed to improve the co-ordination of European technological collaboration as well as national budgetary cycles and to encourage closer links with European civil R&T programmes. These have also included the publication of capability objectives in areas such as UAS technology and Force Protection.[42] The European Commission is also pressing for the extension of European competition policy to the defence sector and a more restrictive application of the Article 296 prohibitions on EU involvement in defence issues.

120. However, the process through which specific policy measures might emerge is slow and torturous and, as with the EDA, must necessarily engage the smaller EU members. The interests of the 'Big 4', Britain, France, Germany and Italy, who constitute over 80% of total EU defence equipment spend are necessarily different and more immediate than the remaining members of the EU. More important, from a British perspective, that majority may be more interested in defending and promoting narrow national interests than efficient and effective procurement. But the fact remains that the UK is not prepared to see a major shift in defence spending to any European body and remains wedded to the belief that the EDA should be looking to improve European capabilities and not to run large-scale programmes.[43]

121. However, the major limitations in the European defence market stem directly from the paucity of new programmes beyond the competing Typhoon, Rafale and Gripen. While these in theory offer a 20-year market, none is likely to sell in large numbers and could be truncated by commercial failure and budgetary limitations. The prospects for a coherent European UCAV programme, with the promise of large production runs, are also poor. The F-35 and even the Super Hornet cast a large shadow over European prospects. Looking further ahead, US investment in advanced UAS technology (and the attractions of joining US-led programmes) will dwarf that of Europe.

4. 5 Changing Patterns of Threats and Capabilities

122. Predicting the likely pattern of global tension and conflict over the next 20-25 years is fraught with difficulty. For the major western powers this has become more problematic in the absence of Cold War certainties (the re-emergence of a confident and truculent Russia notwithstanding). The alternative has been to stress the essential variability of threat and its ubiquity — an approach underlined by the view that there is the prospect of an indefinite 'war against terror'. At the same time the nature of the threat ranges from asymmetric attacks against domestic civilian targets to rogue nuclear strikes. Nevertheless, the US and some European states argue that conventional military capabilities will also be required, including airpower in its various forms, and deployable in an expeditionary mode.

123. The Middle East shows little sign of stabilising and falls into the 'Crescent of Instability' that helps to define the world according to Pentagon planners. The volatile combination of religious, ethnic and resource driven tensions is likely to figure in any one's prediction of conflict and local arms races. A similar sense of inevitability determines views of Central Asia and the Sub Continent. The extra dimension is the triangular dynamic between India, Pakistan and China, with the bilateral relationship of China and India (reflecting economic growth rates and beliefs about regional status and power projection) potentially the source of a conventional and nuclear arms build up.

[42]'Europe sets out technology strategy', *Flight* website, 22 May 2007. In both of these capability areas there is still considerable duplication with several national programmes and in the case of Force Protection, a NATO effort.

[43]A further problem, at least as judged from publicly available documents, is that the UK may have difficulty in engaging directly with its main European partners on defence industry policy. The Swedes appear to be the only other major European defence industrial state systematically and openly to have investigated the impact of globalisation and network centric warfare on procurement and its national DTIB. France apparently has held a confidential review of these issues — but there has been little explicit and obvious activity elsewhere. Italy has also been exploring the development of a network approach to defence, although this is still largely at a conceptual level. More progress is expected through a number of industry-led initiatives.

124. China is also at the centre of the third most obvious threat/conflict dynamic in Asia. Japan and other regional powers (including Australia) are concerned at the rise of Chinese power projection and the threat of a military solution to the Taiwanese issue. The continued instability of Indonesia and an irrational North Korea add further complications to the Asian regional threat analysis. The US views the rise of China and its goals for regional influence and control as a key determinant of policy. The latest Pentagon assessment of Chinese military power refers to 'area denial' as a goal to obviate or deter US intervention in defence of Taiwan; there is a legitimate interest in regional power projection to defend Chinese economic interests. The China factor is already reaffirming the US–Japan alliance and may well lead to closer relations with India.

125. Europe — now extended to the Russian frontier and encompassing the Balkans and perhaps even the Turkish–Iran border poses the most interesting questions. Until recently (the Balkans excepted and excluding Turkish accession to the EU) there was a good case for viewing European security in terms of an enhanced gendarmerie capability; a more ambitious concept would also include a range (with an indeterminate upper limit) of expeditionary capabilities to enable power projection at least as far as the Eastern Mediterranean. This view would explain and justify flat or even declining defence expenditures as well as in many cases, national challenges to the procurement of sophisticated weapons systems including fifth generation fighters. The deterioration in relations with Russia, and its evident willingness to deploy resource power may also arrest the move towards a gendarmerie posture. Indeed, the apparent willingness of the Russian Government to re-vitalise its military capabilities and to adopt a more aggressive posture would further serve to justify expenditure on programmes like the F-35 as a long term insurance against security uncertainties. It would certainly encourage the more realistic military planners to continue with the procurement of another generation of weapons systems.

126. Finally, South America is the only region that is unlikely to generate the level of tension and local threat to justify high levels of expenditure on conventional weapons. The region in the past has shown some tendency towards regional arms racing — or at least prestige driven emulation. There may also be maverick governments that may seek to acquire new platforms for a variety of idiosyncratic motives. But overall, South America is unlikely to offer much of a market for advanced strike-fighters.

127. As the world's primary military power, while the exercise of air power may not entail a classic struggle to win air superiority, maintaining control of the aerial battlespace will remain a key requirement for the US. US doctrine and planning certainly demands an uncontested technological edge in this domain. Strike capabilities (with an emphasis on precision effects) — including the 'first day' ability to take on heavily defended targets also rank highly. The lessons of recent wars and conflicts have also underlined the value of persistence and an ability to hit highly illusive targets. Network capability and multi-functional platforms will be highly desirable as both force multipliers and as a means of reducing the overall lifetime cost of procuring a given capability. There is certainly a debate about which type of platform is best suited for these tasks and, over the next 20-25 years, unmanned platforms will undoubtedly assume a greater role than hitherto — but still perhaps to a lesser extent than some analysts predict.

128. In short, US technology, military requirements and doctrine will drive the world strike-fighter market. If the F-35 programme survives US procurement politics (and the balance of probability is still very much in its favour), it could dominate the market for a generation. A Russian (or even a Japanese) fifth generation platform may emerge over the next decade but unless the Rafale or Typhoon make a significant market breakthrough by 2010, production of the four point four generation will be running down by the time the F-35 enters service. It is highly unlikely that Europe will independently develop another manned strike-fighter. The Super Hornet may retain some competitive edge at the lower end of the market but the F-22 programme is likely to run its costly course. The F-35 will be the 'Last Man Standing', facing competition only from the still unproven fully capable, autonomous UCAV. And in any realistic view of future military operations, the future of air power is likely to hinge on a mixed force of F-35s, UCAVs and other UAVs. In this scenario, the most likely successor to the F-35 is likely to be another generation of upgraded and improved F-35s. It is not unreasonable to suggest that the F-35 could be the first planned '100-year' combat design.[44]

PART FIVE: SUMMARY

129. There is little evidence to suggest that the general need for conventional strike platforms will diminish over the next 20-25 years. The key variables will be capability versus affordability; or put more directly, just how much technological superiority do you want to pay for? If the threat is a full-scale conflict involving China in the late 20teens, the F-22 will provide the necessary air superiority edge and defence suppression will demand high levels of stealth and perhaps an expensive unmanned vehicle for the leading wave. A more modest, all round capability based on the FA-18 with additional leverage afforded by networking might suffice for many other circumstances. The F-35 presents a (significantly) more expensive option but with capability closer to the F-22 and a greater networking potential. It also has the greater potential for further technological insertion. The current generation of European and Russian fighter aircraft are likely to be squeezed between the F-35 and F-18 E/F Super Hornet. These products do offer significant capability advantages over the F-16 and the older versions of the F-18 but perhaps not at an affordable price. Timing may be important and delays in bringing the F-35 to market will influence some customers. However, the F-18E/F Super Hornet is not only an effective platform in its own right for a wide range of customers but it is also emerging as the more attractive interim purchase for states waiting to acquire the F-35.

130. Individual procurement decisions will be affected by wider factors. Avoidance of dependence on the US will continue to shape policy, as well as the willingness or otherwise of the US to sell advanced platforms to specific customers. The degree of offset, industrial participation and technology transfer will inevitably play a crucial role in procurement. Increasingly governments are less happy with offset agreements and want higher value returns, especially if they have a domestic aerospace industry of any note. Most of the European products have the flexibility and transfer regimes to facilitate some level of industrial participation.

[44]The B-52, first conceived in the late 1940s, will be in service until the middle of this century, but this will be a largely accidental centennial platform.

130. In some respects the F-35 is a Cold War legacy system that may be felt to offer an unnecessary increment in capability — in the case of the US already far superior to any likely adversary. Emerging threats could be countered by appropriate technological insertion and longer over the longer term by more radical solutions such as advanced UCAVs. On the other hand, given that the F-35 is planned for incremental development over some 20 years with opportunities for future enhancement, it is precisely the kind of flexible, adaptable platform needed to anticipate threats into mid century, providing a necessary bridge to a new generation of platforms still to be matured.[45] On balance, a prudent procurement strategy must assume there will be a need for a fifth generation strike-fighter: the issue is numerical — just how many to buy?

131. It is likely, however, assuming the F-35 does survive the US procurement process (and the balance of probability is still well in its favour), that this will be the most enduring strike fighter platform for the first half of this century. For any weapons supplier, early and affordable integration with this aircraft will be vital to ensure commercial survival.

[45]See CRS op cit. p12.

ATTACHMENT: F-35 LIGHTNING II POTENTIAL CUSTOMER ANALYSIS

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State	Fleet Size	F-16 User	F-35 Indicated[46]	Need	Acceptability	F-35 Order Banding	Probability	Comments
F-35 Partnership								
USA	2,958	Y	2,443	H	N/A	D	H	Order subject to budget issues and procurement politics — 2,500 not unreasonable estimate
Australia	81		100	H	H	D	H	Ideal aircraft for regional defence, possible budget issues
Canada	75		80	M	H	C	H	Growing strategic need, but budget issues might erode order
Denmark	49	Y	48	M/L	H	B	M/L	Vulnerable to other social priorities
Italy	196	Y	131	H	H	D	H	Budget pressures may affect order, but security context implies robustness of demand
Netherlands	103	Y	85	M	H	D/C	M	Eventual commitment could slip due to budget and strategic need issues
Norway	47	Y	48	M/L	H	B/A	L	Possible marginal candidate, industrial participation key to purchase, also questions about strategic need
Turkey	427	Y	100	H	H/M	D	H/M	Strong need if budget allows, vulnerable to shifts in US foreign policy
UK	297		138	H	H	D	H	Clear need but budget pressures may force reductions
F-35 Observers (SCP)								
Israel	631	Y		H	H/M	D	H	Clear need for regional air dominance, could be affected by US regional sensitivities;
Singapore	78	Y		H	H	B/C	M/H	Clear need in potentially unstable region.
Others								
Bahrain	29	Y		M	H	A	L/M	Gulf stability questions might drive need and no affordability issues
Belgium	60	Y		L	H	A	L	Low national commitment to defence, not a strong prospect
Chile	56	Y		L	M	A	L	Latin American region does not have relevant security drivers
Czech Rep	14			M	H	A	M	Affordability an issue, but strong commitment to NATO interoperability and possible coalition partner
Egypt	446	Y		H	L/M	C	L	Affordability and acceptability problematic
Finland	55			L/M	A	A	L	Sensitivities in respect of Russia could induce or stifle requirement
Germany	325			M	H	D	M/L	If need established, potentially big customer, but budgetary, national commitment to extended defence and late comer industrial participation could be issues

[46]These are not confirmed orders and are subject to change. This uncertainty is reflected in the detailed analysis.

Greece	282	Y	H/M	H	B	H/M	Affordability issues currently, but may improve and clear need to match Turkish capabilities
Hungary	29		L/M	H	A	L	Affordability issues in medium term and may be deterred by Russia political threats, keen to modernise air defence forces however.
India	580		H	M	D	M	Potentially major customer given regional power projection needs, depends on continuing warming of relations with US, satisfying industrial participation issues could be major difficulty and technological security concerns.
Indonesia	41	Y	H	L	A	L	Key regional player, affordability and political acceptability rule out market
Japan	319		H	H	D	H	Best likely prospect outside partnership. Strong national strategic requirement and US relationship a key factor in procurement.
Jordan	100	Y	H	L	C	L	Proximity to Israel would rule out market
Korea (S)	600	Y	H	H/M	D	M/H	Clear need, but US might want to curb local arms race would want high level of industry participation
Kuwait	28		H/M	H	A	H/M	Gulf stability issues, can afford F-35 and US may want to bolster ally
Malaysia	48		M/H	M	A/B	M	May want extended capability to cover regional threats. Relations with US improving
Morocco	97		L	H/M	A/B	L	Strong US ally, but distant from external threats in region and likely to prefer Rafale.
Oman	27	Y	H	H	A	L/M	Strong US ally
Pakistan	423	Y	H	L	B/D	L	Strong national need, but affordability questions and on wrong end of changing US foreign policy
Poland	120	Y	L/M	A	B	L/M	Keen to modernise armed services with western equipment. Affordability issues in medium time. Russian factor might limit acceptability
Portugal	20	Y	L	A	A	L	Need highly questionable
Romania	140		M/L	M/H	A/B	L	Need and affordability questions
Saudi Arabia	324		H	H/M	D	M	Always on a list of potential customers, but questions about future regime stability might deter US
Spain	141		M	H	C	M/L	Unclear strategic requirement unless an active 'coalition' player. Typhoon commitment more important industrially but a possible need for Harrier replacement
Sweden	126		H	H	C	L	But unlikely given continued commitment to national autonomy in major defence platforms
Switzerland	76		L	A	A/B	L	Too much capability for Swiss neutrality policy
Taiwan	348	Y	H	L/M	D	H/M	Clear need but one of most politically sensitive markets, depends on how US plays future relations with China
Thailand	97	Y	H/M	M/H	A/B	M/L	Affordability and possible acceptability issues as well as concerns over technology security.
UAE	71	Y	H/M	H	B/A	M	Gulf stability rationale and no affordability problems

Fleet Size: Current fighter/strike aircraft in national inventory (2006)
F-16: F-16 users key F-35 market
Need: Judgement of national strategic requirement and affordability (**H**igh, **M**edium, **L**ow)
Acceptability: To US as potential customer (**H**igh, **M**edium, **L**ow)
Banding: Size of possible F-35 purchase (**A** = 1-25, **B** = 26-50, **C** = 51-75, **D** = 0ver 75)
Probability: Judgement of purchase based on need (and affordability) & acceptability (**H**igh, **M**edium, **L**ow), where **L** = less than 30%, **M** = less than 60% **H** = 60% plus. Covers initial market up to 2020.

Analysis

Initial commitments from the nine F-35 partnership comprise 3,173 units; a 10% reduction in orders would still leave a base market of over 2,600; the SCP states could account for a further 150+ sales. Both of the SCPs, Israel and Singapore, would be rated as highly likely customers, easily counterbalancing Norway and Denmark who are rated as possible defectors from the partnership.

The market for F-35s outside the core partnership and observers, including all candidates, would suggest conservatively potential sales of over 1,300 units. This could change markedly as F-35 is fully perceived as the last of manned generation of combat aircraft and as competitors such as the F-18E/F Super Hornet and 4.5-generation aircraft fall by the wayside. The rate of UCAV technology evolution will itself be a key variable: F-35 sales might be eroded by the emergence of an affordable fully capable UCAV but affordability for an unmanned F-35 level of capability is likely to be questionable. Equally, the fully capable UCAV is likely to require a level of technological sophistication in networking and control systems that may not be possessed or required by several customers. Moreover, the US will probably be highly reluctant to transfer technology of this sensitivity. On the other hand, as the US and the core team upgrade the F-35 platform, it may be easier to sell earlier variants to a wider range of customers. Finally, there is a clutch of states, mainly new or candidate EU members, who, as their economies improve, may find the F-35 more affordable.

Inevitably, the Middle East has a number of potentially important customers, but only two large markets, Saudi and Egypt, and the latter has distinct affordability issues. Israel, as an observer member of the F-35 partnership is clearly a key client, but its requirement may pre-empt sales elsewhere in the region. Regime change and other political volatility could affect sales to any country in this region — the Shah effect?

Asia and the Far East contain several key targets. Taiwan, Korea and Japan are all Band D markets with clear requirements and few affordability issues. A key variable will be how US foreign policy evolves in respect of China. A more aggressive approach would reduce constraints on sales. Equally, regional perceptions of Japanese capabilities might also drive procurement elsewhere. It will be a question of whether the US takes an active role in controlling regional conventional proliferation. Finally, India would appear to be a very tempting prospect but one of the more problematic markets from a political point of view as well as presenting the challenge of reconciling what would be strict industrial participation requirements as well as concerns over technology security.

Summary

Partner nations	9 members	2,600
SCPs	2	200
Others	29	1,300
Total		**4,100**

The total represents a modestly optimistic estimate of the F-35 initial market (up to 2025). With 15 states in the wider market defined as Low or Low/Medium probability customers, at least 500 of the total must be classified as questionable. This still leaves a potential base market in the region of 3,000 units for an aircraft that will increasingly have no conventional competitor in, or close to, its capability level.

As a comparison, over 4,000 F-16s have been produced since its entry into service in 1976. This is already a 40-year production programme and still continuing. It would not be unreasonable to speculate that a comparable 40-year F-35 production programme might exceed 6,000 units.

Implications for Weapons and Ordnance Suppliers

With a few exceptions, most potential F-35 customers will be looking for between 15-40 units (median band A and B). Through-life and initial costs will be vital issues. Few, if any will have individual weapons requirements. They will look for the best balance of capability and cost. There may be few who might wish to reduce direct dependence on the US for ordnance but generally most will buy off-the-shelf weapons. This underlines the importance to any weapons or ordnance supplier to be 'on the shelf' and available as an option to potential customers.

Given that the majority of the likely Band D customers are already US weapons customers, non-US suppliers unless integrated into the platform from the outset will be at a severe competitive disadvantage.

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