The F-35 Deal: An Enlightened Purchase?

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In August 2010, Defense Minister Ehud Barak announced his decision to accept the IDF's recommendation to purchase the F-35 Lightning II[1] as the future fighter plane of the air force.[2] An agreement in principle on this issue was signed in October 2010 by the director general of the Defense Ministry during his visit to Washington. The deal has long been controversial, and the debates about it have been underway for several years, both between Israel and the United States and within the Israeli defense establishment. It was recently announced that the state comptroller also intends to review the decision making processes.

The purchase of the plane has aroused debate not only in Israel. Similar discussions are taking place in the media and in legislative bodies in other countries participating in the project. In all the countries that have expressed a desire to purchase the aircraft, questions are asked about price vs. performance, its ability to cope with future threats, possible alternative systems, the benefit to local industry, and decision making processes.

This article describes Israel's role in the project and highlights the salient points in the decision making process regarding the purchase. Technical data about the plane and the disputes that the project has sparked in countries that have made a commitment to purchase the plane appear in an appendix to this article.

Israel and the JFS Project

The concept behind the development of fifth generation combat aircraft lies in the aircraft of the previous generation.[3] The idea was to procure

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a small number of air superiority combat aircraft: large, expensive, and with cutting edge technology. They would be complemented by a large number of multi-role combat aircraft, less capable but smaller and more affordable. During the 1970s this approach led to the development of the large F-15, and the smaller and cheaper F-16. By the late 1980s and early 1990s two projects were initiated: the Advanced Tactical Fighter (ATF), which eventually produced the F-22A, and the Joint Strike Fighter (JSF), which was meant to be the "affordable" aircraft, to be procured in large numbers.

From its inception the JSF project was unique. It was meant to be used by three branches of the US military: the US Air Force (USAF), the Navy, and the Marine corps (USMC). Traditionally these three branches have very different requirements, and apart from some rare exceptions (most notably the F-4 Phantom) these three branches have operated different types of aircraft throughout their history. Because of the different requirements, the JSF was to be designed with three different versions with a high percentage of shared features.

In addition, from its early stages, the project was opened to allies. The project managers defined three levels of participation, and participants were required to invest funds in accordance with their levels of participation. Eventually eight countries participated: United Kingdom, Canada, Denmark, Netherlands, Norway, Italy, and Turkey. Participants could influence – in accordance with their investment – the design requirements and secure chunks of the orders for their national defense industries. In later stages two states, Israel and Singapore, received a status of observer (without the power to influence the design requirements).

Israel thus began its romance with fifth generation planes at the end of the previous decade. Anyone familiar with the history of security cooperation between Israel and the United States could be sure that Israel would rush to purchase the most advanced models of the US-made fighter planes well before any other country in the Middle East. In the early years of the twenty-first century, it was the F-22 — then at an advanced stage of development — that was discussed. Israel expressed its desire to purchase it, and President Bill Clinton, notwithstanding Congress's decision in 1997 to forbid export of the plane, promised Israel in the last days of his term in office that it could purchase the plane.

In parallel, the possibility was raised that Israel would join the Joint Strike Fighter (JSF) project.[4] Ultimately, however, Israel was not included in the project at this point, both because of its decision not to invest in the project and because of American reservations about Israel's participation — mainly fears of technology leaks — and the reluctance to meet Israel's special demands concerning the model it would purchase. However, Israel was included with a special status of observer, without permission to be involved or influence the configuration of the plane. For their part, the heads of the defense establishment in Israel expressed their confidence that in any case Israel would be among the first to receive the plane upon its completion.

In 2003, the United States agreed to upgrade Israel's status on the project to security cooperation participant, and Israel agreed to invest a sum of some $50 million in the project (for the purpose of comparison, Britain invested $2.7 billion).[5] Once again, the question arose of customizing the plane for Israel's unique needs. The first controversial issue concerned the possibility of a two-seat model. The Israel Air Force prefers to use two-seater planes and divide the operating load of the plane between the pilot and the navigator/systems operator. The F-35 was planned as a single-seat plane, and its designers believed that its advanced systems would make the additional crew member unnecessary. The second controversial issue concerned installation of Israeli systems on the plane, including:

a. Weapon systems, such as the Python-5 and Derby missiles. From a technical point of view, this is the easiest aspect to carry out, and the demand that is easiest to comply with.
b. Installation of Israeli electronics systems. In particular, Israel is very interested in installing Israeli-made electronic warfare systems. Israel considers these systems as especially suitable to the needs of the arena, much more than the original systems in the plane.
c. The possibility of replacing the plane's radar with Israeli-made radar.
d. Access to the plane's software source code. This was a difficult demand for the planners,

The success of the F-35 project, one of the US defense establishment's largest projects, is important to the administration. Israel's purchase of the plane will undoubtedly be seen as encouragement to other countries to purchase the plane, and a clear boost for the project.

but such access is essential for installing Israeli systems on the plane that are integrated into the plane's software system.

Even at the initial stages, the cost of the plane, which initially was estimated at some $50-60 million per unit, raised many eyebrows. However, despite the concern and the misgivings, as early as 2007 an official decision was made in Israel to purchase the plane. The formal request was submitted to the United States in August 2008, and the following month a request was submitted for approval by Congress. The request was for the initial sale of twenty-five planes of the conventional model (CTOL – F-35A), with an option for another fifty of the conventional model or the vertical landing model (CTOVL – F-35B).[6]

Although at that time the plane's price was estimated at $78 million per unit, the estimated value of the deal — assuming that all the options were realized — was $15.5 billion (a total cost of $206 million per unit, a package that included the various components, such as building the infrastructure, establishing maintenance infrastructure, spare parts parts, and more).

After approval of the request the real negotiations began, and as expected, there were disagreements concerning Israel's special requests. The American side refused to approve the installation of Israeli equipment, and they also opposed Israeli access to the classified source code. Instead, it was suggested that Israel submit its particular demands to the manufacturer. Interestingly, these snags were not unique to Israel. Britain too threatened at a certain stage to withdraw from the project over the questions of access to the source code. And in the meantime, delays in the plane's development also affected the deal. The target date for the beginning of serial production of the plane was postponed four years, from delivery in 2010 to delivery in 2014, and with it, the price per unit rose.

The details of the deal announced in August 2010 have not yet become clear, and in particular, which of Israel's demands have been met and which demands Israel has decided to forego. Recent reports are that the target date for the F-35A and F-35C models to become operational has been postponed again until 2016. This change will undoubtedly affect the date of delivery of the planes to Israel.

The Merits of the Deal

Israel has always seen its qualitative advantage as a crucial component of its security, and the United States has also affirmed its commitment to maintain Israel's qualitative edge. More than in any other branch this advantage is expressed in the air force, and Israel has always been equipped with the most up-to-date planes. As such, the purchase of the F-35 was an obvious move. Nonetheless, the rationale of the purchase merits careful consideration.

Threats

An assessment of an air force and specifically its fighter planes must consider the regional arena and the threats it holds for fighter planes and their operation, today and in the future (since the planes purchased today will have to cope with threats in the arena in another twenty or even thirty years).

Air forces in the region. A number of countries in the Middle East operate Western fighter planes that are among the most advanced in existence. Egypt, Jordan, and Turkey are equipped with a large number of F-16C/Ds; the UAE has F-16E/Fs (a model that was developed especially for them, which is comparable to the Israeli F-16I); and Saudi Arabia purchased the European Typhoon and operates a large number of F-15s of various models (the purchase of eighty-four additional F-15s, of a more advanced model, was recently approved). Today none of these countries is seen as a threat to Israel. They are all allies of the United States; Jordan and Egypt have peace treaties with Israel; and the Gulf states, including Saudi Arabia, are considered de facto partners in the Israeli struggle against the Iranian threat. However, this does not obviate the concern that in the longer term any country operating advanced Western weapons may become an enemy of Israel.

The more hostile countries are actually not capable of threatening Israel in the air. Syria has an outdated air force; its newest planes are MiG-29s purchased before the collapse of the Soviet Union. Lebanon has no combat aircraft and is not expected to have any in the near future. The Iranian air force is outdated, and because of Iran's distance does not constitute a serious threat.

In the realm of technology, the F-35 must be able to confront upgraded Western planes, many of which will have similar capabilities to its own,

such as the F-15s or F-16s equipped with AESA radar. Another threat is the new generation of Russian-made fighter planes, led by the Su-35S, which entered service over the past year in Russia, and two models of future planes made by Sukhoi (T-50) and Mikoyan, which will be full-fledged fifth generation fighter planes. Indeed, the advanced models of the Su-35 were developed with the threats from the fifth generation American planes, like the F-22, in mind. Thus, for example, this plane is equipped with secondary VHF air-to-air radar (a wave-band in which the radar cross section of the F-35 and the F-22 is not reduced).

Air Defense. As in the air-to-air realm, Egypt, Jordan, Saudi Arabia, and the Gulf states have air defense forces based on American systems, mainly the improved Hawk (which is outdated) and various models of the Patriot. Syria has thick, but outdated, Soviet-made surface-to-air missile force. In Lebanon and from Gaza, the main threat is from shoulder launched missiles, some of them among the most advanced Russian models.

In the distant future, sophisticated Russian-made air defense systems are expected to be introduced into the arena, as well as Chinese imitations of these systems: the S-300PMU-2 and the S-400. Again, advanced models of these systems have already been built with the threat of fifth generation fighter planes in mind, and therefore they have means of overcoming the stealth capabilities (such as use of radar in the VHF range).

High Trajectory Weapons. A serious threat to all future Israel air force activity is in the realm of high trajectory weapons: missiles and rockets that already can reach almost any point in Israel from Lebanese territory. The greater the accuracy of these weapon systems, the greater the chance that they will be used with precision against military and strategic targets. If today the main threat to air force bases is the threat of a missile salvo across the area of the base, in the future, the threat is likely to be precise firing on a facility within the base – the control tower, a runway junction, or a particular hangar.

Missions

Air Superiority. The first mission of the air force is to protect the country's skies, and planes such as the F-15A/C have been purchased for this purpose. The F-35 is not designed for this task. It carries air-to-air missiles and its stealth capability is likely to give it an advantage in

an air battle beyond visual range (BVR), but it has no advantage in close air combats (in which it is apparently inferior to the F-16, for example) or in its capability to perform sustained patrolling, and of course it is not intended for offensive escort missions and deep interdiction.

Combat air support. In a future war the IAF needs the capability to launch precise attacks in highly dynamic battlefields that will apparently be protected by surface-to-air missiles, such as with the operations during the Second Lebanon War and Operation Cast Lead. The F-35's big advantage is in its stealth and the integration of navigation and targeting systems: radar that is capable of accurate ground surveillance while jamming the adversary's defenses, and various electro-optical systems.

However, many of these capabilities already exist as external additions or enhancements in planes of the previous generation. Thus, for example, the F-35's capabilities in the realm of navigation, and targeting (embodied in its EOTS system) are based, in fact, on the LANTIRN-ER and Sniper-XR systems, which exist as external pods that can be carried by an F-15 or an F-16. Israel itself developed the advanced versions of the LITENING pod. Likewise, it is possible to install advanced AESA radar on F-16s, either American-made or Israeli-made, and to achieve most of the advantages the F-35 has in this realm.

As for the plane's stealth capability, this will undoubtedly give it an advantage, especially in the first stages of an attack in well protected areas. It is true that today, Syria's air defense forces are outdated, and in Lebanon, Hizbollah is equipped mainly with shoulder missiles, but this situation could certainly become a more serious threat. Nonetheless, the stealth capability must be taken with a grain of salt, since the plane is limited to carrying weapons in internal bomb compartments only. Hanging munitions on underwing hard points would compromise its stealth capacity.

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Strategic Attack Operations. Strategic attack operations involve deep penetration into the rear of enemy territory. Here the F-35's stealth offers a supreme advantage, but this is offset by the limited amount of munitions that it can carry in a stealth mission (two bombs of one ton each), and its

limited range. Therefore, even when the F-35 is in service, the F-15I and F-16I will likely be the preferred planes for such missions.

Self Defense. The Israel Air Force places special emphasis on aircraft self defense capability, particularly electronic countermeasures (ECMs) to defend against enemy radar (ground based or airborne), missiles, and electronic warfare. The F-35 has several unique advantages in this realm, beginning with its AESA radar, which is also capable of jamming ground radar while scanning for ground or aerial targets, and including its unique warning system (DAS), which grants the pilot warnings about threats in every possible sector. However, the Israeli electronic and anti-electronic warfare systems are considered preferable to every foreign-made system, and furthermore, they are uniquely tailored to threats in the Israeli arena. For this reason, Israel has conducted prolonged negotiations on installation of Israeli-made electronic warfare systems in the planes, although it is not clear if ultimately Israel achieved this requirement.

*Ability to Operate from Temporary Airports***.** Given the severe threat of high trajectory weapons, Israel requested the option of purchasing a certain number of F-35Bs. This model is capable of taking off from very short runways and landing vertically. It was developed for the operational requirement of the USMC, where this capability is especially important. These planes would allow the air force to operate from improvised airports, even when its main bases are under missile attack. However, this model is more expensive than the conventional model, although its aerodynamic performance is inferior. For these reasons, Israel has for now forgone this option.

The Role of the Israeli Defense Industries

A significant asset in the F-35 deal is the benefit for the Israeli defense industry, given the possibilities of customizing and installing Israeli electronic warfare systems and Israeli-made weapon systems on the planes − though this depends on American approval and access to the plane's original source codes. A second benefit concerns "offset" deals[7] that are common in the world's weapons market. As part of the purchase deal, the Israeli defense industry hopes to receive a share of the development and manufacture of F-35 parts for the world market, as subcontractors for Lockheed Martin (manufacturer of the plane),

Northrup Grumman (manufacturer of the radar), and Pratt and Whitney (manufacturer of the engine). With manufacturers predicting a future market of over 4,000 units, there are prospects for very large sales.

Along with the economic advantage, joining the project will allow the defense industry access to the most advanced technologies, such as technologies for materials to reduce the plane's signature. However, this will also obligate the industry to make large investments in infrastructure, staff training, and receipt of licenses from the US authorities. The participation of the Israeli companies in the manufacture of the planes intended for Israel only will not justify such investments.

The Israeli defense industry has vast experience and unique capabilities, especially in several niche areas, but with the F-35 project it is in tough competition with national defense industries in all the participating countries. There is no question that countries that have already invested hundreds of millions of dollars in the project from the early years will demand to receive a return on their investment in the form of orders by the plane's manufacturers. Israel, which joined the project at a late stage and with a relatively small investment, is necessarily in a poor opening position.

Israel's Reputation

An important point in Israel's favor in the negotiations for purchase of the plane is the special reputation of the IDF, and the air force in particular, in the global advanced weapons market. Even after operations that were seen as a failure, such as the Second Lebanon War, the IDF is recognized internationally as a sophisticated user of advanced weapon systems. The IDF's purchase of a weapon system is considered an indication of the superiority of that system over competing systems. There is no question that the American manufacturer (and the US defense establishment) were interested in selling the F-35 to Israel, sooner rather than later, especially since the project is facing technical and financial difficulties and several of the participating countries have already hinted that perhaps they will not purchase the plane, or will purchase a smaller number than they had originally intended. Moreover, the price of the plane (the price per unit) depends directly on the number of planes ordered.

The F-35 project is one of the US defense establishment's largest projects, especially since production of the F-22 was stopped. The success

of the project is important to the administration. Israel's purchase of the plane will undoubtedly be seen as encouragement to other countries to purchase the plane, and a clear boost for the project. Perhaps the proposal to deliver another twenty planes to Israel without compensation stemmed in no small part from these considerations.

Conclusion

For many years, preserving Israel's qualitative advantage has been a main element of Israel's security concept. For this reason alone, it has been clear since the beginning of the JSF project that when the time came, Israel would be interested in purchasing the aircraft. However, for the very same reason it was also clear from the early days of the Advanced Tactical Fighter project that Israel would want to purchase the F-22, the plane that would be developed as part of that project. This purchase was prevented mainly by the project's closure at an earlier stage than planned, and because Congress forbade its sale. In fact, if Israel had a choice between the two, it would almost certainly have preferred to purchase a small number of F-22s rather than a large number of F-35s. (In the end, the price of the F-35, which was supposed to be inexpensive, is close to that of the F-22.)

The analysis above shows that despite the plane's advantages, it will not be the panacea for Israel's problems and most of its tasks can be performed with similar effectiveness through existing planes with one type of upgrade or another. The high price of the F-35, which will allow the purchase of only a small number of aircraft, will in any case require the air force to retain a large number of F-16s for many years. Furthermore, the plane cannot be a substitute for the F-15s, which are used today for both air superiority missions and long term attack missions. As such, these planes are also expected to stay in the order of battle for many years, again, with upgrades of one kind or another.

Therefore, if the consideration for purchasing the plane was tactical only, the deal, under the current price conditions, is not justified. However, the picture is more complicated. The plane is not being paid for with money from Israeli taxpayers, but with American aid. The choice is not between guns or butter, but between various American-made weapon systems — fighter planes or ships, tanks, and cannons. The dependence on purchasing American-made systems and the strategic relationship

with the United States also rule out examining other options, such as purchasing European planes (the Typhoon or the French Rafale) or even the Russian Su-35S or its future replacement.

There are additional considerations as well: the advantages the F-35 deal will provide to the Israeli defense industry, and the deal's contribution to Israel's complex relations with the United States, which for its own reasons is interested in Israel's purchasing the plane. Thus given these considerations, the purchase indeed has an additional logic, which gives considerable weight to the considerations of those who support the purchase of the planes.

Notes

1 Although the plane is called "Lightning" by the US Air Force, the plane will *not* be called "Barak" in Israel, since the air force already uses this name for the F-16C/D.

2 Anshel Pfeffer, "Barak Approves Huge Deal to Purchase 20 F-35s," *Haaretz*, August 16, 2010.

3 The term "generation" refers to jet powered combat aircraft in use since the end of WWII. The first generation: combat aircraft of the 1950s were the first operational jet powered combat aircraft. They were subsonic, armed with machine guns and cannons. Typical models in the Middle East were the MiG-15 and the Mystere IV. The second generation, from the late 1950s until the early 1960s, were supersonic combat aircraft – up to Mach-2. They carried early versions of air-to-air missiles and early versions of radars. Typical models in the Middle East were Mirage 3 and MiG-21. The third generation, from the late 1960s though the mid 1970s, saw multi-role combat aircraft with better radars and better avionics. The main armaments were heat seeking air-to-air missiles, radar guided missiles, and early types of guided air-to-ground munitions. The typical model in the Middle East was the F-4E Phantom. The fourth generation appeared in the late 1970s and 1980s. It involved multi-role combat aircraft with much advanced aerodynamic performance (thrust to weight ratio around 1:1 and better). It sported radars with ground surveillance capabilities, battle management airborne computers, digital avionics, different types of precision guided munitions (PGMs), and electro-optical sensors. Typical models are the F-15 and the F-16. 4.5 generation is a term used for recent models or upgraded fourth generation aircraft, with some fifth generation capabilities like AESA radars and net-centric capabilities.

4 "Israel Foresees No Barriers to Early JSF Acquisition," *Defense Daily*, November 14, 2001.

5 Dror Marom, "Joining JSF Project will Cost Israel Only $50m," *Globes Israel's Business Arena*, February 16, 2003.

6 Defense Security Cooperation Agency (DSCA), "Israel – F-35 Joint Strike Fighter Aircraft," Transmittal No. 08-83, September 29, 2008, DSCA officia website, http://www.dsca.osd.mil/PressReleases/36-b/2008/Israel_08-83.pdf.

7 Offset deals are deals in which in exchange for signing a government weapons purchase contract, the manufacturer of the weapon system makes a commitment to invest in the market of the country making the purchase. Such deals are usually (but not always) connected to the main weapons deal (such as purchase of services and accompanying products for the weapon system in the local market). In very competitive markets, the scope of the offset deals is liable to be 100 percent of the weapons deal, if not more.

Appendix: The JSF Project and the F-35

Aircraft Features[1]

The F-35 Lightning II is a single-seat, single-engine fighter jet. The plane comes in three versions:

a. The F-35A – the CTOL (conventional take-off and landing) version – is a plane that takes off and lands in a conventional manner, using paved airfields, meeting the requirements of the USAF.
b. The F-35B – the STOVL (short take-off vertical landing) version – is a plane capable of taking off from extremely short runways and landing vertically, for use by the USMC (and the Royal Navy).
c. The F-35C – also known as the CV version – is intended for taking off and landing on aircraft carriers in the US Navy.

In all its versions, the F-35 has some unique features that when combined, mark it as a true fifth generation fighter jet:

Low observability. This is usually called "stealth" capability. The combination of careful body design, especially the parts returning strong radar echoes, and housing of munitions in internal bomb bays has significantly reduced the plane's radar cross section.[2]

Engine. The F-35 is a single-engine plane, like the F-16. Pratt & Whitney developed the new F-135 engine for it. The engine provides maximal thrust of some 40,000 lbs (with a burner; the number is approximate, as detailed data has not been published).

Multi-task radar. The heart of the F-35 is the plane's AN/APG-81 AESA radar system by Northrop Grumman.[3] It is based on the F-22's AN/APG-77 radar system (and both radar systems share many hardware and

software components), but it is smaller and its air-to-surface capabilities are more pronounced. Its precise capabilities have not been made public, but it is known that it can track a large number of targets while continuing to scan the skies and seek new targets. It is even capable of scanning the ground and providing a high resolution picture of the ground by day or night, in every type of weather. It is capable of identifying ground targets automatically, and its smart identifying software allows it to focus on land or sea targets and identify them. In addition, the radar is capable of jamming hostile radar systems in the air and on the ground.

EOTS.[4] The plane has an internal electro-optical system to scan the ground both by visible light and in the infrared spectrum for navigating, targeting, and illuminating with a laser beam. It is based on the Sniper-X and LANTIRN-ER systems already operational in planes of the current generation, but according to the manufacturer, with improved performance, both in terms of its range of detection and in its resolution and precision.

DAS.[5] The plane's self defense system consists of a set of six infrared sensors installed on different spots on the plane's body, providing coverage of a full sphere for passive electro-optical identification of aerial threats, aircraft or missiles, by day and night.

Cockpit. The display in the cockpit includes a multi-functional 20x50 cm screen with projecting capabilities in every type of lighting, by day or by night, and picture processing and memory capabilities that are among the best in the world. The pilot can operate the screen by using a cursor, by touch, or by vocal commands. In addition, the pilot is equipped with a helmet mounted display: data is projected directly on the helmet's visor and is positioned correctly no matter the direction in which s/he turns his/her head.

Weapon systems integration. The plane can be modified to use the entire range of weapons – air-to-air or air-to surface – available to the United States and the program member states. It is designed to carry weapons – both air-to-air missiles and bombs or air-to-surface weapons – in internal bomb bays. At the same time, it also has seven external hard points for suspending a wide range of armaments. (Of course if these stations are used, the plane's stealth capabilities are compromised.)

Avionics, communications, preparation. Special efforts were invested in the software in the plane's development phase. The central idea of the

software architecture is sensor fusion, i.e., integration of the information coming from all sensors into a unified information system. As the sensors themselves become "dumber," the "intelligence" from them is gathered into a single system. The plane also has an advanced communications suite, which includes satellite communications for communications beyond sight range. It has sophisticated data relays enabling information sharing among planes in formation and information exchanges with other planes and ground stations, both fixed and mobile.

Logistics. The F-35 project put a great deal of thought into developing maintenance capabilities with high operational and maintenance credibility, as well as a system of maintenance and assistance with high reaction speed: the computerized system combines operational data from the planes with configuration parameters specific to the plane, its history of parts, planned upgrades, and prognostics.

Where the Project Stands

The JSF project, like many other complex weapons development programs, has had significant setbacks in budgets and schedules. The project is one of the largest projects ever in the American defense establishment and it is expected to cost $238.6 billion. Between 2000 and 2009, the program exceeded its planned budget by about $100 billion and was a full year behind in systems development. In order to accelerate development, program leaders decided on LRIP, i.e., a low rate of initial production, even before all development stages are complete. Acquisitions of the plane began in the 2007 fiscal year.[6]

However, test flights are still in their early stages. While the first flights of the F-35A version began in early 2007, it was only in July 2010 that the AN/APG-81 radar was flown on the F-35.[7] In early 2010, project leaders announced that the first operational phase of the A and C versions has been postponed to 2016.

Criticism of the Technology

Criticism of the plane's technological aspects has focused on the following:

Stealth

a. The plane was planned to have a low signature vis-à-vis radars in the X-band and Ka/K/Ku-band, the frequencies used in most current

threats. This low signature is effective especially in a forward sector, but less so in other sectors. Its level of stealth is much lower against radar using lower frequencies (and the Russians are already developing such systems).

b. The stealth capability depends on carrying weapons in the internal bomb bays, which are limited in size. Hanging weapons externally is possible but compromises the stealth feature.

c. The F-35 is the first stealth plane offered for sale to non-American customers. Some countries participating in the project have expressed concern that the plane will be sold to them at a lower than maximal level of stealth.

The plane's software and hardware. The plane's software is integrative, transferring the intelligence from sensors and secondary systems to central computer systems. The software is highly complex and this complexity caused difficulties even at the development stages. Critics are worried that difficult problems are liable to surface later, when a large number of planes are already in operational service.[8]

Structure and propulsion. During the early stages, the program ran into problems of overweight. Because the ratio of thrust to weight is the most important component in the performance of a fighter jet, and because this is a single-engine plane, planners were forced to make every effort to reduce the weight at the expense of maneuverability (the ability to withstand large G-forces), the lifespan of the structure, the amount of internal fuel, and more. Critics outside the US have stressed that while decreasing performance is less critical to American customers (because of the assumption that some of the combat missions would be flown by the F-22), it is more critical to countries in which the F-35 would constitute the most advanced plane available. Other concerns have been raised about the F-135 engine. It is supposed to operate at higher temperatures than any other engine in existence, and critics have expressed concern that over time this would cause problems.

Integration of weapon systems. At the outset, the F-35 was supposed to be able to carry almost every kind of weapon − air-to-air and air-to-surface − in American military arsenals. However, the early production batches of the plane will be very limited in terms of the types of weapons they could carry. Because of development delays, the integration of many

weapon systems has been postponed to later production batches, after the first planes have already been delivered to customers.

Conflicts with Partners

The eight countries that partnered in the project have differences of opinion on distribution of labor and ownership of the technologies. All have expressed dissatisfaction with the type and scope of jobs they have been allotted and have threatened to minimize their participation or to cancel orders for the plane. The governments of Italy and Britain have lobbied for the establishment of assembly facilities on their soil.

Another concern is that the United States will withhold technologies from them. Indeed, in November 2009 the Pentagon announced that it would not be sharing some sensitive technologies with Britain, its senior partner. This of course had clear implications for the more junior partners.

How Many Planes Will Be Bought

The customer cost of the F-35 will greatly depend on the number of planes manufactured. According to plans currently approved by Congress, the American Armed Forces will buy a total of 2,456 planes. On the basis of Congressional data there are two possible figures: the program acquisition unit cost (PAUC), representing the cost of the entire program divided by the number of planes. Currently, this stands at $133.6 million. The other cost is the average procurement unit cost (APUC), representing only the cost of acquisition, divided by the number of planes. Currently, this stands at $113.6 million.

At this stage, it is still unclear how many planes will be bought by external customers. Program leaders estimate that external sales will reach about 2,000-3,000 planes. Clearly, these sales will dramatically reduce the cost of the plane. Hence, the American interest in selling the plane to Israel is also clear.

Critics, however, worry that the number of planes that will actually be sold is much lower and that therefore the cost of the plane will be much higher. A report prepared by experts at the request of the Dutch parliament estimated that a reasonable assessment puts the total number of planes sold at no more than 2,500. The researchers estimated that the purchase by the American Armed Forces would in the end be somewhere

between 1,170 and 1,440 planes.[9] This low number affects the cost per unit and steeply increases the cost of future upgrades. At the same time, the chances for the local defense industries making a profit are much lower than calculated today. The report concluded that the cost of the entire life cycle of the plane would be double the current estimate.

Notes

1 The primary sources for this appendix are: www.globalsecurity.org; F. C. Spinney, "JSF: Another Card in the Cards Building," *US Naval Institute Proceedings,* August 2000; Jeremiah Gertler, "F-35 Joint Strike Fighter Program: Background and Issues for Congress," CRS Report RL30563, April 2, 2010 (this report is published annually under the same title; the most up-to-date version available was used for this article); Carlo Kopp, "Assessing the Joint Strike Fighter," at www.ausairpower.net. This website includes much information, as it is in part devoted to opposing the Australian Air Force plans to purchase the F-35; Carlo Kopp, "F-35 – JSF Program: Collapse is a 'when' question, not an 'if 'question," at www.ausairpower.net.

2 The radar surface cross section, or RCS, is determined by comparing the radar echo returned from the plane to the echo that would have been returned by a flat surface placed exactly perpendicular to the radar. On the basis of data made public, the F-22's RCS is between 0.0001-0.0002 sq m, or the size of a playing marble. The F-35 has anterior RCS of 0.0015 sq m – i.e., 10-15 times that of the F-22, but still only the size of a golf ball. For the sake of comparison, the RCS of the MiG-29 is 5 sq m.

3 AESA – Active Electronically Scanned Array. This type of radar system is constructed of a set of independent transmission and reception units. The radars of the phased array concentrate the radar beam by differentiations in the phases of the various units and thus a change in the pattern of spiraling between the transmissions of the units. It is also possible to divert the radar beam immediately (within nanoseconds) to every direction possible without using mobile parts (unlike radar systems of the previous generation in which the movement of the antenna was mechanical). Likewise, it is capable of simultaneously generating a number of radar projection beams in different directions and at different frequencies, depending on different missions. The AN/APG-81 has 1,200 independent transmission and reception units.

4 EOTS – Electro-Optical Targeting System.

5 DAS – Distributed Aperture System.

6 For 2010, 10 F-35As were budgeted for the Air Force, 16 F-35Bs for the Marines, and 7 F-35Cs for the Navy.

7 The radar has gained many flight hours since 2005, first on a Northrop Grumman flying lab (installed on a BAC-111) and later on a Lockheed Martin flying lab (installed on a Boeing 737); the same is true of other avionic systems.

8 An acute example of problems that are liable to crop up in such complex systems was an event that occurred in February 2007, when computer systems on board all the members of an F-22A formation crashed during the plane's first flight outside US. See http://www.defenseindustrydaily.com/f22-squadron-shot-down-by-the-international-date-line-03087/.

9 Johann Boeder, "Market Analysis for the JSF," www.CEOworld.biz, October 20, 2009.