OIDA Strategic Intelligence

OIDA Strategic Intelligence Case Study

Programme Analysis

JSF F-35 from Lockheed Martin

OIDA Strategic Intelligence - SASU au capital de 6.000 euros – n° SIRET 81989369400011
Porte de l'Arénas, Hall C – CS13326, 455 Promenade des Anglais – 06206 Nice Cedex 3 – France – Tel : 07.84.31.97.98

OVERVIEW

Referred to as the most expensive weapons programme in United States history, the $1.4 trillion Joint Strike Fighter programme[1], widely known as the F-35, has been arousing a fervency in defence circles in the U.S. and abroad. Yet, a dispassionate analysis of the programme is now more blatantly needed than ever before.

ANALYSIS

General Case

The unabated programme's ambitious objective was to provide U.S. and NATO air forces with a state of the art fighter jet capable of overriding any kind of air or land opposition, which would deny western forces air supremacy over a battlefield. Designed in the aftermath of the Cold War, the F-35 programme answers to a couple of priorities with its cutting-edge capabilities crafted under the guidance of Lockheed Martin (prime contractor), Pratt & Whitney (for the engines), and thousands of subcontractors.

The first priority is the optimisation of a wide array of new electronic potentialities to dramatically extend the range of its missions whilst reducing the probability of losses during engagement against a fair nuclear adversary. The stealth airframe purposefully allows F-35 pilots to sneak into enemy airspace and strike Surface-to-Air Missile (SAM) defences while constantly remaining out of reach to any air or ground retaliation thanks to its low radar signature and exceptionally wide missile range. Besides this, the F-35 also engages new century technologies by setting up an extended digitalisation of the battlefield. The pilot's understanding of the battle space is improved due to six optronic sensors placed at the edges of the aircraft, which collect 360° visuals displayed on the helmet to provide a sharper view of the battlefield. The connected helmet also offers enhancement of the squadron's operating efficiency by matching targets identified by one aircraft onto another's pilot's helmet display system. The Multifunction Advanced Data Link (MADL) system also allows the pilot to embrace an extended view of the battlefield aggregating data from allied planes, ships, or satellite devices. The battle space digital mapping tremendously enhances the interoperability of the fighter jet (theoretically with all 5th generation aircraft and NATO standard communication devices) and its combat capabilities, strengthening F-35 squadrons efficiency in completing missions.

The second developmental axis of the JSF programme, aims at obtaining an "all in one", omnirole fighter jet, designed to achieve a broad scope of missions from Close Air Support (CAS), homeland protection, battle space aerial supremacy, in-depth strikes on SAM defences to carrying nuclear missiles to ensure U.S. deterrence. These full scope aircraft capabilities and the operational leeway they represent for the U.S. Air Force (USAF) hastened the adoption of the F-35 to replace legacy fighters now deemed obsolete. In other words, the JSF programme was designed to retire the Air Force's F-16 and A-10, the Navy's F/A-18, and the Marine Corps Harriers to be replaced by three dedicated variants:

[1] http://nationalinterest.org/blog/the-buzz/the-f-35-14-trillion-dollar-national-disaster-19985?page=show

- F-35A: Designed for the sole use of the USAF and allied air forces, the A version is a conventional take-off and landing aircraft with extended range, speed, and weapon carrying capacity allowing it to more efficiently fulfil a broader range of missions. It is the only variant with an internal Gatling canon and the smallest of the three F-35 variants. The F-35A is by far the most common as 1,763 have been ordered by the USAF so far, not including multiple orders from foreign partners.
- F-35B: The short take-off and vertical landing variant aims at providing the Marine Corps with a stealth aircraft capable of operating from amphibious assault ships with a shorter deck than conventional carriers. Due to the high fuel consumption of its engines, the F-35B can carry fewer weapons and fly a shorter range than the other variants, limiting its tactical use to surgical strikes on ground targets. 340 F-35B's will equip the Marine Corps and 138 for the new United Kingdom aircraft carriers.
- F-35C: The version features larger wings with foldable wingtip sections, enhanced landing gear, and other modifications designed to match carrier requirements. 260 of this variant will replace the older F/A-18 equipping U.S. Navy carriers and 80 will be dedicated to the Marine Corps.

All F-35 variants. From left to right: F-35C, F-35B, F-35A (February 2014)

© Lockheed Martin

There was to be a high standardisation rate (around 80%) between the three variants to limit developmental, procurement, and overhauling costs and thus provide an affordable aircraft at a cost that would not have exceeded the price of the legacy fighters it was meant to replace.

U.S. international partners are ranked on a cooperation level scale depending on their financial and technical involvement in the programme. The U.K. is the sole level one partner, Italy and the Netherlands are level two, and Turkey, Canada, Australia, Denmark, and Norway are level three. These nations contributed funds for system development and all, but Canada and Denmark, have signed agreements to procure the aircraft. Although Lockheed Martin is the lead contractor, the programme heavily relies on subcontractors from these foreign partners, which has the advantage of tightening the links between all associated countries and deter any political turnabout. In addition,

Israel, Japan, and South Korea have signed on as foreign military sales (FMS) customers.[2] Procurement amounts for international partners and FMS are still subject to fluctuations, but the current estimation lays around 612 units (mostly F-35A's).

As for U.S. aircraft orders forecast, the 1996 programme totalled the F-35 order at 3,000 aircraft.[3] In 2001, the overall procurement programme amounted to 2,866 units,[4] but in 2012 it was reduced to 2,457 including 14 R&D aircraft and others dispatched to the three armies according to the above-mentioned figures.

Table 1: Overall U.S. Production Forecast Evolution

	1996	2001	2012
F-35A	2,036	1,763	1,763
F-35B	580	609	340
F-35C	380	480	360
Total Production Expected	**3,000**	**2,866**	**2,457**

Source: Annual Report, Company Website, Primary, and Secondary Research — OIDA Strategic Intelligence

The JSF programme was officially launched in October 2001 and the *concurrency* production phase was initiated in 2007 with the first two F-35A produced. Eight years later on July 31, 2015, the F-35B STOVL Initial Operational Capability (IOC) was declared for a squadron of 10 units, however the fighter jets were not trusted to be fully deployed in operational theatres and continued carrying out training missions just as they did before IOC. Indeed, this term falls more under political communication requirements than providing the aircraft with a real "battle proof" status. The F-35A declared IOC on August 2, 2016 for the Air Force's first squadron. The F-35C's IOC is indicated to be around 2018 according to a 2016 Congress Service Report. These new dates represent a delay of five to six years from the programme's initial baseline dates.

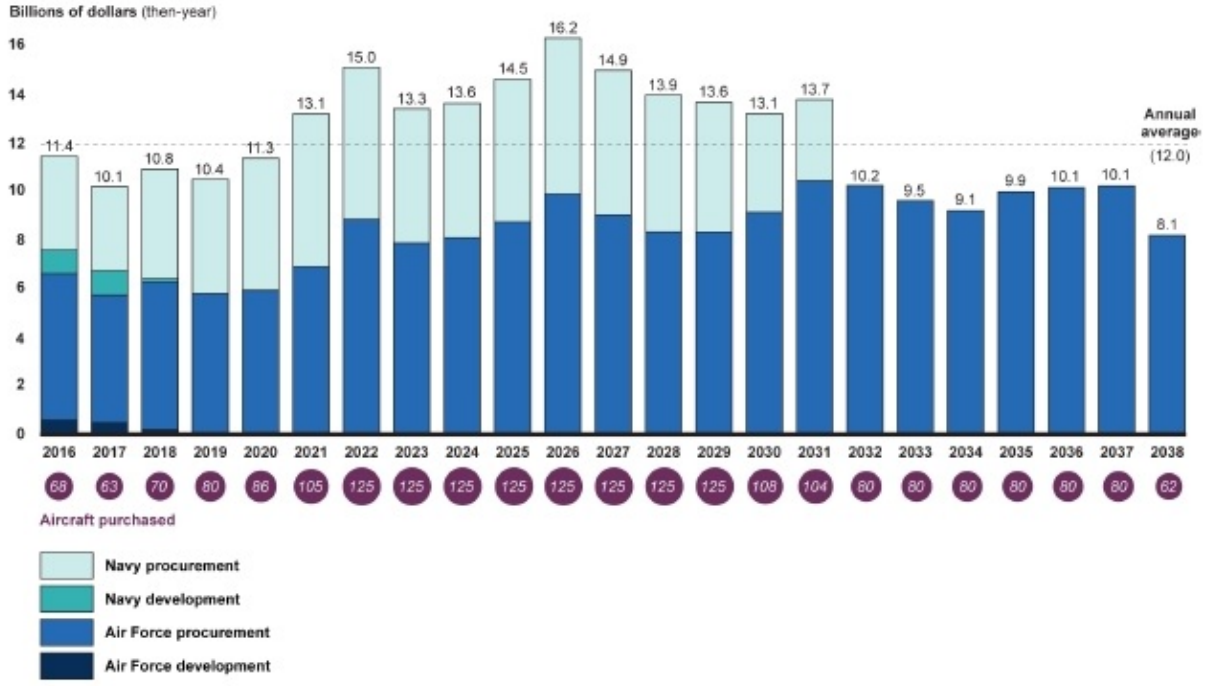
In a nutshell, the F-35 programme tackled head on two main challenges raised by the U.S. Department of Defense (DoD) - providing a mass produced, multipurpose, and multi-army fighter jet resolutely rooted in the digital era, and successfully broaching the pertaining tactical and operational specifications, which are deemed essential. However, paradoxically, the ambition of utilisation and technological improvements, which were its main assets, also represent the programme's stumbling blocks of how a programme initially targeting full rate production for 2015 would hardly manage to get through its testing phase by 2021.

Cost Overruns

Initially, during its rough outline setting in the 1990's, the JSF Programme was supposed to develop and field an affordable, highly common family of next generation strike aircraft for the U.S. Navy, Air Force, Marine Corps, and allies. However, while the first budget plan forecasts for the F-35 were estimated at $32.7 million each in 1994[5] ($53.75 million in 2017), the average price has now rose threefold and is far from alleviating concerns that affordability is an out of reach utopia.

[2] F-35 JOINT STRIKE FIGHTER, Continued Oversight Needed as Program Plans to Begin Development of New Capabilities, U.S. Government Accountability Office, N°GAO-16-390, 14 April 2016, p. 1;
[3] F-35 Joint Strike Fighter (JSF) Program: Background, Status and Issues, Congressional Research Service Report for Congress, 02 June 2006, p. 8-9;
[4] F-35, Selected Acquisition Report, 31 December 2010, p. 16;
[5] Medium estimate with 1994's affordability goals per aircraft. F-35 Joint Strike Fighter (JSF) Program: Background, Status and Issues, Congressional Research Service Report for Congress, 02 June 2006, p. 24;

Figure 1: F-35 Joint Strike Fighter Budgeted Development and Procurement Costs by Service



Source: GAO Analysis of Department of Defense Data / GAO-16-390

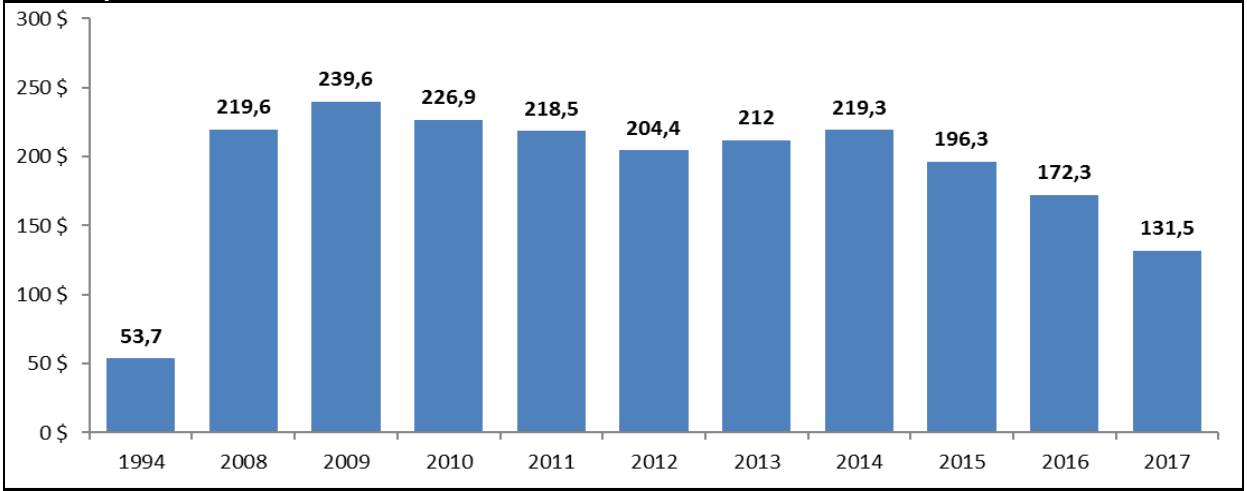
The number of aircraft displayed by this GAO chart has to be taken cautiously as the number of procured aircraft significantly varies over the years (please refer to our table on F-35 units by batch). With regards to cost, if we only focus on the procurement amounts for USAF, it is interesting to see that procurement budgets progress following an increasing trend over the 2021-2031 period and stabilising around $10 billion per year by 2037. A similar trend can be seen regarding the Navy's procurement budget. Assuming by the GAO's chart that the F-35 was deemed able to enter Full Range Production (FRP) from 2021 with a stabilised yearly production estimated at 60 units, it is surprising to notice such a rise in procurement whereas the ordered unit number stays put. Hence the prudence of many analysts regarding the JSF programme heads pious hope on long-term savings. While the procurement budget withstands these cost overruns, fighter jet development does not remain untouched.

F-35 first air-air AIM-120 missile launch (October 30th, 2013)

© Lockheed Martin

On March 20, 2010, only three years after production was launched, the DoD formally announced that the JSF programme had exceeded the cost increase limits specified in the Nunn-McCurdy cost containment law (25% breach), as average procurement unit costs in FY2002 dollars had grown 57% to 89% over the original programme baseline. Therefore, to avoid the programme from coming to a halt, the DoD had to provide Congress with convincing elements to convince it of the utmost necessity of the JSF programme for U.S. security. Exceeding costs are mostly due to unforeseen technology and component issues, however the initially fixed timeline proved to be overambitious and contributed to runaway costs.[6]

Figure 2: F-35 (All Variants) Procurement Unit Cost (Annual Procurement Costs Only, in $ million)



Source: *FY 2008-2017 "Programme Acquisition Costs By Weapons Systems",* Office of the Undersecretary of Defense (Comptroller). FY 1994 numbers from the *"F-35 Joint Strike Fighter (JSF) Programme: Background, Status, and Issues"* 06/02/2006 expressed in 2017 $. 2017 values are estimated from DoD FY budget request.

Even though a cutting-edge technological asset like the F-35 has a price, no one expected this price to be such an enormous financial burden for the U.S. and its allies with unitary cost overruns exceeding three times the initial unit price in 2016. As shown in the chart above, the average yearly cost for a single, generic F-35 even reached a paramount drifting of 346% in 2009 and still represents in 2016 an over-pricing of 220.8%.

High Prices Explanation

A Low Rate Initial Production (LRIP) exists in every DoD project and stands for the first years of a programme's production phase. The LRIP takes place straight after the first developmental phase after which the programme is approved and production launched. Here however, development was not conducted beforehand but merged with the production phase (this is called a *concurrency* programme pattern). Then, a further battery of tests is still to be conducted to fix the residual or newly discovered issues on the few jets produced.

The LRIP and the tests thereof, aim at reaching as fast as possible the Full Range Production (FRP) stage in which the development of the aircraft is over and its production line can be automated to increase significantly the volume of production and reduce the per unit procurement price for clients due to production improvements. For Joint Strike office heads, it was initially meant to begin in 2015.

[6] F-35 Joint Strike Fighter (JSF) Program, Congressional Research Service Report for Congress, 18 July 2016, p. 9;

Table 2: U.S. Procurement Book											
	Fiscal Years	Lot	Version	F-35A		F-35B		F-35C		Total	
				N°	Tot	N°	Tot	N°	Tot	N°	Tot
Historicals	FY-2007	LRIP 1		2	2	-	-	-	-	2	2
	FY-2008	LRIP 2	Block-1A	6	8	6	6	-	-	12	14
	FY-2009	LRIP 3	Block-1B	7	15	7	13	-	-	14	28
	FY-2010	LRIP 4	Block-2A	10	25	16	29	4	4	30	58
	FY-2011	LRIP 5	Block-2A	22	47	3	32	7	11	32	90
	FY-2012	LRIP 6	Block-3i	18	65	6	38	7	18	31	121
	FY-2013	LRIP 7	Block-3i	19	84	6	44	4	22	29	150
	FY-2014	LRIP 8	Block-3i	19	103	6	50	4	26	29	179
	FY-2015	LRIP 9	Block-3F	28	141	4	54	2	28	34	227[7]
	FY-2016	LRIP 10	Block-3F	44	185	9	63	2	30	55	283[8] [9]
Forecasts	FY-2017	LRIP 11	Block-3F	43[10]	228	16	79	4	34	63	346
	FY-2018	LRIP 12[11] [12]	Block-3F	44	272	20	99	6	40	70	416
	FY-2019 (requested)	LRIP 13	Block-3F	48	320	20	119	12	52	80	496
	FY-2020	LRIP 14	Block-4	48	368	20	139	18	70	86	582
	FY-2021	FRP	Block-4	60	428	21	160	24	94	105	687
Source: Annual Report, Company Website, Primary, and Secondary Research OIDA Strategic Intelligence											

Table 3: International Procurement Book										
Fiscal Year	**2008**	**2009**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Total**
LRIP N°	**LRIP 3**	**LRIP 4**	**LRIP 5**	**LRIP 6**	**LRIP 7**	**LRIP 8**	**LRIP 9**	**LRIP 10[13]**	**LRIP 11**	
Australia	-	-	-	2 F-35A	-	-	-	8 F-35A	-	**10**
Israel	-	-	-	-	-	2 F-35A	7 F-35A	6 F-35A	-	**15**
Italy	-	-	-	3 F-35A	3 F-35A	2 F-35A	-	-	-	**8**
Japan	-	-	-	-	-	4 F-35A	2 F-35A	4 F-35A	-	**10**
Netherlands	1 F-35A	1 F-35A	-	-	-	-	-	-	-	**2**
Norway	-	-	-		2 F-35A	2 F-35A	6 F-35A	6 F-35A	-	**16**
South Korea	-	-	-	-	-	-	-	6 F-35A	-	**6**
Turkey	-	-	-	-	-	-	-	2 F-35A	-	**2**
United Kingdom	2 F-35B	1 F-35B	-		1 F-35B	4 F-35B	6 F-35B	3 F-35B	-	**17**
Total	**3**	**2**	**-**	**5**	**6**	**14**	**21**	**35**	**-**	**66**
Source: Annual Report, Company Website, Primary, and Secondary Research OIDA Strategic Intelligence										

Regarding the first three LRIP unit price, it is quite uniform to get a high-cost given the low number of aircraft produced and the setting up of early production lines. But still, it represented anything but a bright future promise for the programme already bogged down in the aftermath of the 2008 financial crisis and threatened by the Damocles sword of the government shutdown later illustrated in 2013.

The conjunction of external negative contingencies and early programme cost flares precipitated the major 2012 cut in U.S. production quantities. The USAF's fleet was slashed by 15%, the commander of the Navy's air forces said that budget pressures may cause the Navy to reduce its planned 20 per year acquisition to as few as 12 per year, and the end of the testing phase was postponed up to 2021. The reduction of total FRP amounting to 120 units including 100 for sole U.S. service,[14] propped up the unit cost to over $200 million each for three years, annihilating the 2010-2012 first forerunning signs of a feeble cost curve decrease.

However, it is quite paradoxical to note that in FY 2016, the F-35 programme was already at its LRIP 10, 15 years after the programme's implementation and expecting to wait for LRIP 14 before FRP.

[7] http://www.businessinsider.fr/us/lrip-9-f35-jet-2016-12/
[8] http://www.defensenews.com/articles/pentagon-lockheed-sign-f-35-contract-for-90-jets
[9] http://www.janes.com/article/65741/dod-awards-lot-10-production-contract-for-f-35
[10] F-35 Joint Strike Fighter (JSF) Program, Congressional Research Service Report for Congress, 18 July 2016, p. 5;
[11] Statement of Lt General C. Bogdan F-35 Program Executive Officer Before the Tactical Air and Land Subcommittee of the House Armed Services Cmmittee on F-35 Program Review, 16 February 2017, p. 20;
[12] USAF's, Marines' and Navy's Under Secretary of Defense Justification Books, February 2016;

[13] http://www.defensenews.com/articles/pentagon-lockheed-sign-f-35-contract-for-90-jets
[14] F-35 Joint Strike Fighter (JSF) Program, Congressional Research Service Report for Congress, 18 July 2016, p. 5;

Even though it is not a scarce habit for the DoD, it is putting strain on the scale saving objectives that were dramatically needed both for Congress and foreign buyers' public budgets. Testing phase management particularly highlighted the overlap between testing and production in the JSF programme. While the LRIP 1 was started in 2007 with the first two aircraft under production, the programme only completed 1% of the flight tests. This may not have raised concern if the expected units produced before developmental testing was complete (around 2020) were not sitting at 582. According to GAO reports, a *concurrency* development and acquisition programme is a considerable risk weighing heavily on the government's shoulders to declare operationally capable hundreds of immature aircraft with the risk of a cruel battle space disillusion.[15]

Furthermore, the high production pace with simultaneous development does not allow production operators to adhere to standardisation as the equipment is constantly modified. Perhaps the hallmark of a diverse array of technical issues does not suggest a quick shift towards a more standardised and affordable production process. Reasons for an increase in the already high unit cost is becoming clear. As shown by the DoD's reports on F-35 testing, a remarkable number of significant F-35 components (including the airframe) have had serious issues requiring redesign. That means the F-35 design has always been in flux. Paying for changes in mid-assembly is proving to cost more than whatever efficiencies might be achieved elsewhere. So long as the F-35 configuration continues to change, there can be no meaningful learning curve.

Besides this, the high volume of "experimental" F-35 delivered during the testing phase places strain on the final unitary cost as the aircraft designed to fly over 60 years will require costly retrofits to repair inherent issues and adapt to evolving requirements. These expenses are scarcely mentioned in budget estimates and are likely to inflate even more the already out of control overall programme cost.

At the very beginning, the LRIP was expected to last from 2001 to 2015 and deliver 465 aircraft according to the SAR (Selected Acquisition Report).[16] In fact, in 2015 the LRIP was rescheduled to last up to 2019 (now estimation even reaches 2021) and was tremendously below the delivery objective with only 154 operational aircraft (every version included).[17] This helps on the one hand to broach the production and development disaster, which besides mismanaging the defence budget is dangerously harming U.S. operational capabilities. These production delays and the seldom mentioned low rates of availability, raises the issue of a strategic gap between the legacy fighters expected retirement and the F-35's expected maturity. As reported under the DOT&E,[18] only half of 2016's so-called operational F-35 was able to fly due to a need to retrofit previous LRIP's aircraft. Amongst these fighter jets, those deemed fully mission capable were estimated to only stand at 30% of the overall fleet.

[15] Medium estimate with 1994's affordability goals per aircraft. F-35 Joint Strike Fighter (JSF) Program: Background, Status and Issues, Congressional Research Service Report for Congress, 02 June 2006, p. 8;
[16] F-35 Joint Strike Fighter, Selected Acquisition Report, December 2015, p 65;
[17] F-35 Joint Strike Fighter (JSF) Program, Congressional Research Service Report for Congress, 18 July 2016, p. 26;
[18] F-35 Joint Strike Fighter Report to Congress, Director of Operational Test and Evaluation FY2017, 10 January 2017, p. 85-86;

F-35B vertical landing on USS Wasp (October 3rd, 2011)

© Lockheed Martin

Table 4: F-35 Availability for 12-month Period Ending October 2016 (1)

Operational Site	Average	Maximum	Minimum	Aircraft Assigned (2)
Whole Fleet	52%	55%	44%	178
Eglin F-35A	38%	49%	32%	25
Eglin F-35C	60%	71%	54%	21
Yuma F-35B	55%	62%	40%	19
Edwards F-35A	53%	74%	40%	8
Edwards F-35B	46%	64%	30%	7
Edwards F-35C (3)	27%	40%	4%	2
Nellis F-35A	50%	62%	42%	13
Luke F-35A	61%	68%	44%	44
Beaufort F-35B	43%	53%	33%	24
Hill F-35A	57%	80%	22%	15

(1) Data does not include SDD aircraft.

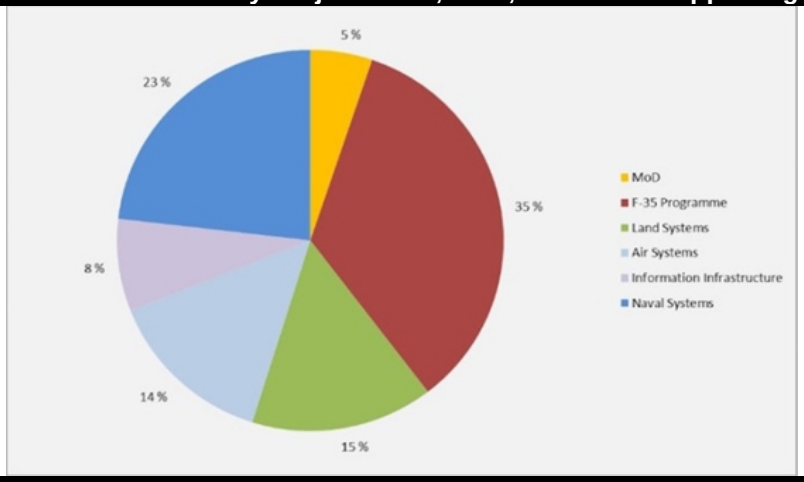
(2) Aircraft assigned at the end of October 2016.

(3) Edwards AFB F-35C operations began August 2016.

Source: F-35 Joint Strike Fighter Report to Congress, Director of Operational Test and Evaluation FY2017, 10 January 2017, p. 5-86

The preoccupying budgetary situation was highlighted in 2010 by former Pentagon Comptroller, the U.S. Undersecretary of Defense Robert Hale: “I think we are at the point in our budgetary situation where if there is unanticipated cost growth, we will have to accommodate it by reducing the buy.” If this is undertaken, a fleet volume reduction would provide the eagerly awaited fully operational F-35 on a bigger and earlier scale than is expected now, but it would have the tremendous downside of inflating the unitary cost and sending an all but positive sign to already hesitant foreign partners. On this point, Norway’s MoD, one of the second level programme partners with Kongsberg being a cornerstone subcontractor, has recently disclosed a Materiel Acquisition Report for the period 2017-2025 confirming the overwhelming place (35% weight) of the F-35 procurement in the national budget.

Figure 3: Acquisitions (% share) Broken Down by Programme During the Period 2017-2025. The MoD Allocates Funds for Preliminary Project Work, R&D, and Other Supporting Activities.



Source: Future Acquisitions for the Norwegian Defence Sector 2017-2025 (April 2017)

Therefore, a national defence budget severely stretched by the financial crisis could not bear the exhausting costs overrun. Norway is not an isolated case and the F-35 budget weighs heavily on other partner's shoulders as an increasingly hard-to-support burden that could encourage U.S. partners to be inspired by Canada's recent turnabout.

Besides this, the international career of the aircraft where foreign sales are expected by Lockheed Martin to eventually drive the worldwide fleet over 5,000 units would then be vowed to an inevitable failure.

Table 5: Official Per Unit Cost Estimate Including Procurement and R&D

(in million USD)	F-35A	F-35B	F-35C
FY-14 (LRIP 8) [19]	108	134	129
FY-15 (LRIP 9) [20]	102.1	131.6	132.2
FY-16 (LRIP 10)[21]	94.6	122.8	121.8
FY-17 (LRIP 11)[22]	113	142	241

Source: Selected Acquisition Reports and Press Releases

When it comes to per variant unitary costs, the situation is even more blurred and the facts are difficult to fully embrace when comparing the various JPO, GAO, Congress, and Comptroller figures. If all these institutions are involved in the F-35 programme to a different extent, they all provide conflicting reports where unit purchase price for each batch and variant suffers from numerous discrepancies. The table above lists the JSF's most referred to figures, figures that often appear in the media. Even if these numbers show an advantageous version of the previous years programme evolution with the achievement of the DoD's long-term objective of stepping down the F-35A from the $100 million threshold, the fact is that these numbers do not broach all the issues. The procurement costs listed above only refer to procurement and R&D, but neither are tackling the modifications, spare parts costs, nor development even though the data appears in the USAF's, Marine Corps, and Navy's Under Secretary of Defense justification books.

[19] F-35 Lightning II Program Fact Sheet, Selected Acquisition Report 2015 Cost Data;
[20] http://www.businessinsider.fr/us/lrip-9-f35-jet-2016-12/
[21] F-35 Lightning II Program, Public Affairs Release, 02 March 2017;
[22] http://warisboring.com/the-official-f-35-price-tags-are-bogus/#.ji5ndr9v9

Table 6: OIDA Strategic Intelligence Actual Unit Price Estimate (procurement, aircraft modification, spare parts, and R&D)			
(in million USD)	**F-35A**	**F-35B**	**F-35C**
FY-15 (LRIP 9)	181.1 (including 172.8 for proc. and R&D)	351.1	356
FY-16 (LRIP 10)	144 (including 136.8 for proc. and R&D)	215	286
FY-17 (LRIP 11)	136.1 (including 129.9 for proc. and R&D)	189.7	565
Source: Annual Report, Company Website, Primary, and Secondary Research OIDA Strategic Intelligence			

OIDA Strategic Intelligence's figures are computed using data from the DoD, providing each feature related expenses for each F-35 variant and dividing the sum by the adjusted number of procured aircraft in the above-mentioned table. In this calculation, the USAF procurement amounts were adapted to those disclosed by the Defense Comptroller. This method could not be adopted with the Navy variants due to the blending of the two models in a single budget line. Indeed, F-35B and C unit price estimates use only DoD (underestimated data) figures and were adapted to the changes in procurement quantities.

The "Programme Acquisition Costs by Weapon System" data is only estimates, not independently audited, but that being so it remains the most accurate available military data on the programme.

The first table unit procurement estimate above displays only the data available from SAR reports, but when you broaden the picture with the Defense Comptroller report on *Programme Acquisition Costs by Weapons* for 2017 (same data in the Congress 07/18/16 report), which includes 2015 data, there is a $200 million difference between the two disclosed procurement budgets for the USAF with an unchanged number of birds. Besides the choice of not using all the pertaining data in the unit cost calculation, the origin of such discrepancies remains a strategic question. Furthermore, the data mismatch is not an isolated fact and numbers of aircraft types in batches or pertaining budget lines are constantly subjected to this blurry environment rendering the quest for reliable data unexpectedly difficult.

Regardless of the methodology debate, the aggregated unitary procurement data shows a tremendously high cost for each aircraft (all costs included) - way higher than what was disclosed in the media. Even if the recent trend bears witness to the obvious cost cut recession announced by Lieutenant General Bogdan, head of the F-35 programme, its alacrity is diminished by the fact that the beginning of the cost cut recession has to be mitigated by an extremely high unit cost. However, this positive tendency shift only concerns the F-35A and F-35B. The Navy version is harshly suffering from a wing design problem, hampering its development and production volume leading each unit price to keep progressing on an accrual basis up to the insanely high amounts of FY2017.

All these costs and development mismanagements, despite the positive cost downturn announcements made by the heads of the programme, keep raising concerns in the U.S. and abroad about programme sustainability and the unit costs high political sensitivity. Thus, several doors remain open to implement a "damage limitation plan".

Analysis and Advice

To counter these soaring cost tendencies and keep the programme afloat, one may wonder where all these issues are coming from. Firstly, is the component of the materiel costs that contribute to the overall unit price inflation.

Table 7: F-35 Projected Unit Recurring Flyaway Cost (includes hardware costs over the life of the programme and assumes 612 international sales)

(in million USD of 2012)	F-35A	F-35B	F-35C
Airframe	65.7	77.3	78.0
Engine	11.0	27.7	10.9
Total	76.7	105.0	88.9

Source: Office of the Secretary of Defense, Selected Acquisition Report (SAR): F-35 Joint strike Fighter Aircraft (F-35), March 21th 2016.

Table 8: Equipment Unit Costs by Type for FY 2015 ($ Million)

	F-35A	F-35B	F-35C
Airframe	72.786	83.045	98.049
Engine	13.793	32.493	13.747
Total	**102.1**	**131.6**	**132.2**

Source: USAF's, Marine Corps', and Navy's Under Secretary of Defense Justification Books, February 2016

When compared to 2012 data, the equipment cost figures bear witness of cost overruns, which increase along the LRIP notwithstanding the inversion of the procurement price curve for F-35A and B variants. As the leading contractor, Lockheed Martin had to pay fines for its production parts mismanagement, but other subcontractors are also at fault as is evident in Pratt and Whitney's engine unit cost growth, irrespective of the aircraft type over the 2012-2015 period. A factor that may also lead to at least some supply chain over sophistication and maybe some pertaining extra costs, is the internalisation of the subcontractors network with the versatile participation of every partner state. Some of them, Italy and Japan, even managed to obtain the installation of indigenous final assembly and check out chain in Nagoya (Japan) and Cameri (Italy), which rolled out on May 5th its 100 percent "made in Italy" STOLV aircraft[23]. Thus, the production facility and supply chain scattering may not lead to interesting affordability gains even though it has the merit of tightening the ties between international partners.

It is this idea of gaining in bargaining power over the supply chain that lies behind U.S. President Trump's political statement last November against the F-35 programme's management and Lockheed Martin's direction.

LRIP 10 amounted to an $8.2 billion overall price for a total of 90 aircraft both for the U.S. and foreign sales. Over what was the most quantum batch at the time, U.S. Secretary of Defence, James Mattis, in a recently disclosed memo, hinted that about $600 million was saved by the Trump Administration on the LRIP 10 negotiation process and that he would endeavour to lower the costs on the next batch in the FY2018 budget.[24] He also warned Lockheed Martin that its F-35 should not be entirely removed from any competition process and did not hide his desire to see advanced F-18 Super Hornets competing with the F-35C on Navy procurement forecasted to provide a competitive and cost-efficient

[23] http://www.defense-aerospace.com/cgi-bin/client/modele.pl?shop=dae&modele=release&prod=183472&cat=3
[24] http://www.cnbc.com/2017/02/03/trumps-claims-of-saving-millions-on-f-35-fighter-untrue-says-armed-services-committee-dem.html

alternative for U.S. carriers.[25] Yet, if most of this breakthrough was at the initiative of the former administration, it shows the new promising trend of close political involvement from the White House in the JSF programme aiming at reducing procurement costs by all means. On the political level alike, President Trump recently nominated Patrick Shanahan, the former head of Boeing's defence division, as the U.S. Deputy Defence Secretary, a determined signal sent to Lockheed Martin that its F-35 position could be questioned than secured in the near future and the programme restructured with the backup of a new Super Hornet order. Besides this, Shanahan was previously the head of the Boeing 787 Dreamliner's troublesome development programme and managed to bring it back afloat.

F-35C displaying its hardpoints while taking off from USS Georges Washington (August 2016)

© Lockheed Martin

The second option that will have to be seriously considered is a wise and thorough restructuring of the F-35 programme. The DoD would be well advised to follow the 2016 CRS recommendation and to reduce the planned total procurement quantities and at the same time accelerate the production pace in order to reduce unitary costs by having wider batches to be delivered with operational aircraft in shorter terms.

Yet, this option has to be balanced with the ill-fated *concurrency* programme pattern, which did not give enough leeway to end the test phase and to dismiss most of the current technical issues. The level of pressure placed on the JSF timeline did not allow time to fix all of the existing problems, which

[25] http://www.defensenews.com/articles/mattis-orders-f-35-air-force-one-reviews-to-cut-cost-of-programs

is why the fighter jets budget already considers some modification costs even though it has just been produced. This haste for providing the U.S. with a brand new 5th generation fighter has paradoxically hampered the programme's efficiency over time because of the shortened array of OT&E that may have revealed all the issues that existing equipment instabilities could provoke. These forerunning signs give credit to the foresight that extra retrofits may lead to even sharper cost overruns, as the project will grow in age. As the JSF expected service life has recently be extended from 55 to 60 years, the cost of further modifications and spare parts are not to be overestimated.[26]

Instead, the soundest alternative may be to restructure production by blending the F-35 fleet with some upgraded and life-extended legacy fighters like the F/A Super Hornets or F-16V. The fleet reduction aims at reaching a level of only 853 F-35A (according to CRS numbers)[27] and to proportionally reduce the other variants numbers. The purpose of such a restructuration also aims at helping the DoD budget to face other strategic programmes such as the next generation bomber, which seems to be on a roll as Lockheed Martin just announced the life extension of several batches of F-16 from 8,000 to 12,000 hours. [28]

In the same restructuring option idea, the adoption of a block buy pattern is often evoked as a means to avoid annual LRIP procurement cost gains. Shifting from a contract negotiated on an annual basis to a three year contract would create approximately 10.3% of cost savings and provide stability to the supply chain to foster learning curves and counter delivery delays.[29] Indeed, in the aftermath of the F-35's journey across Europe, DoD contracts approved this Economic Order Quantities (EOQ) policy by granting Lockheed Martin with a substantial $1.4 billion acquisition contract advance, dedicated to a long lead materiel procurement regarding the LRIP 12, 13, and 14, that is to say an overall expected sum of 240 fighter jets for the U.S. armed forces, NATO ally stakeholders, and FMS clients.[30] This first and long awaited multi-lot order paves the way for further scale savings that are deemed able to reduce the procurement price to about $2 billion for the next 440 jets to be ordered, said Lt. Col. Bogdan. The sway of this EOQ plan shall even bring some further benefits until the end of the procurement phase scheduled in 2038. It is supported by the tightly involved Trump Administration and the GAO, which spiritedly backed the initiative in its last April report at the condition that the EOQ plan would be based on transparency and Congress approval.

To end our forecast of the F-35 programme's fate, one may acknowledge that such a cutting-edge materiel would be a must-have for the U.S. and NATO to assert they are a step ahead of competitors on any potential battlefield. In order to make this happen, the F-35 programme would require a thorough and in-depth audit to clarify the situation and if necessary to make a better trade-off possible between budgetary constraints, technical ambition, and operational requirements to promptly provide air forces with operational F-35 fleets.

[26] http://breakingdefense.com/2016/03/current-f-35-costs-drop-but-total-costs-go-up/
[27] F-35 Joint Strike Fighter (JSF) Program, Congressional Research Service Report for Congress, 18 July 2016, p. 26;
[28] http://news.lockheedmartin.com/2017-04-12-U-S-Air-Force-Authorizes-Extended-Service-Life-for-F-16
[29] F-35 JOINT STRIKE FIGHTER, Continued Oversight Needed as Program Plans to Begin Development of New Capabilities, U.S. Government Accountability Office, N°GAO-16-390, 14 April 2016, p. 23;
[30] DoD contract n° CR-082-17, 28 April 2017;

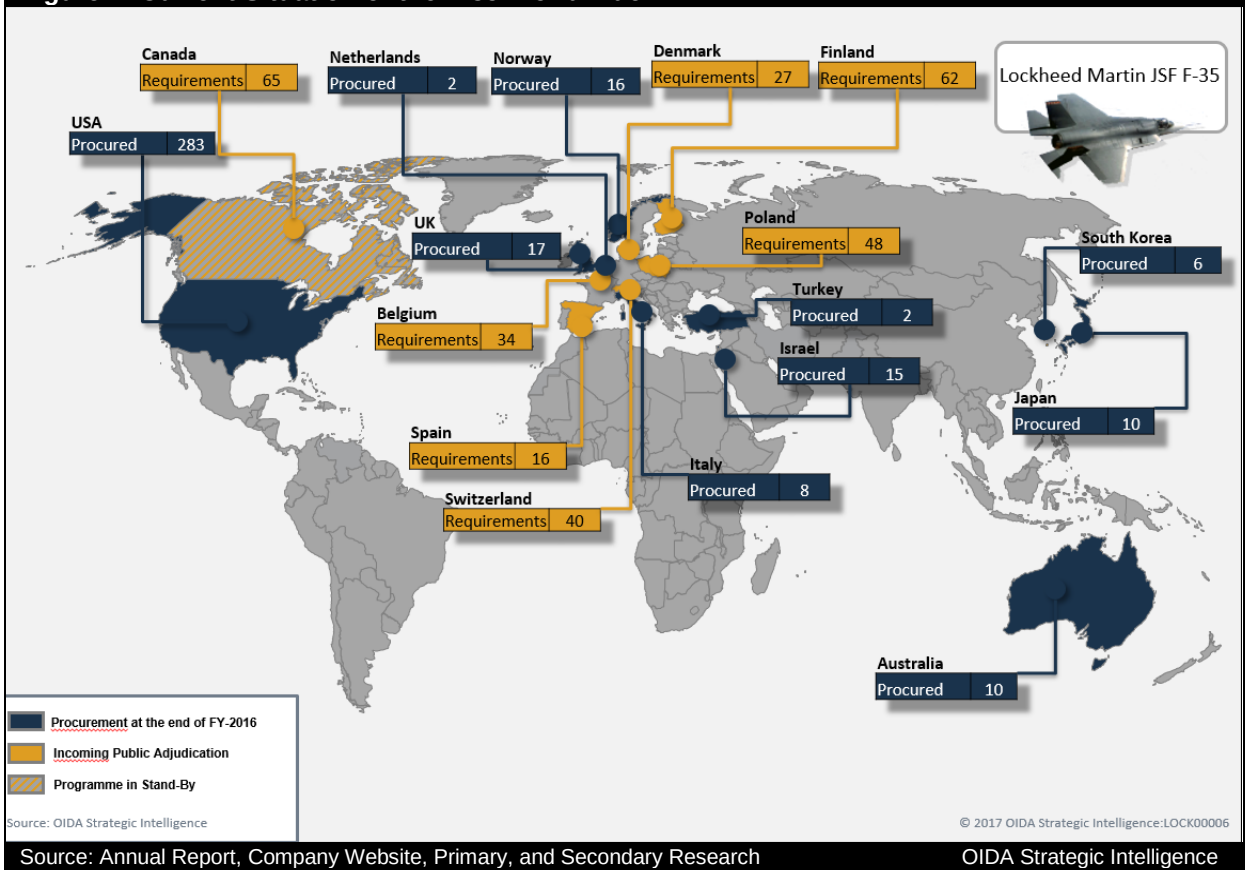
APPENDIX

Table 9: Procurement Evolution for non-DoD partners and FMS

	2005 Procurement Foresight	2016 Procurement Recorded	Total Current Expected Orders
Australia	100 F-35A	10 F-35A	72 F-35A
Canada	65 F-35A	None	Programme Renegotiation
Denmark	48 F-35A	None	27 (30) F-35A
Israel	75 F-35I	15 F-35I	50 F-35I
Italy	131 F-35A	8 F-35A	60 F-35A ; 30 F-35B
Japan	42 F-35A	10 F-35A	38 F-35A
Netherlands	85 F-35A	2 F-35A	37 F-35A
Norway	52 F-35A	16 F-35A	52 F-35A
South Korea	60 F-35A	6 F-35A	40 F-35A
Turkey	116 F-35A	2 F-35A	100 F-35A
UK	138 F-35B	17 F-35B	138 F-35B
Total	912 F-35	84 F-35	476 F-35A ; 168 F-35B

Source: Annual Report, Company Website, Primary and Secondary Research — OIDA Strategic Intelligence

Figure 4: Current Situation of the F-35 Worldwide



Source: Annual Report, Company Website, Primary, and Secondary Research — OIDA Strategic Intelligence

	Belgium	Looking to purchase 34 new aircraft with a public tender expected in 2018. Thanks to the new pilot formation cooperation programme with the U.S., the F-35 is well placed to win the competition against Rafale, Eurofighter, and Gripen.
	Finland	Air force shown interest for the F-35 to replace its aging F/A-18. During the incoming 2020 tender, the Lockheed Martin aircraft will be opposition to Gripen, F/A-18 Super Hornets, Eurofighters, and Rafale.
	Poland	The Russo-Ukrainian tensions propped up the willingness of the Polish Ministry of Defence to acquire additional aircraft following its 48 F-16 delivery and led to expectation of a 2022 tender announcement where the F-35 would have more of a chance. Yet, the tender forecast vanished with the new government election declaring that a F-16 modernisation programme would rather be considered.[31] Lately, Polish DoD has expressed its willingness to procure 32 fifth generation aircrafts at the horizon 2025. PZL Mielec is at the cornerstone of the local aerospace industry. Being a fully owned subsidiary of Lockheed Martin through Sikorsky, PZL Mielec might be involved in the JSF production if the F-35 is chosen as a probable heir of Polish Air Force F-16 and Mig-29.[32]
	Spain	Initially mentioned to replace Spanish Harriers in 2014, the F-35B procurement has been postponed, but has recently been placed on the table again as being the only fixed-wing aircraft capable of operating from Spain's single Amphibious Assault Ship, the Juan Carlos I. However, no official statement has been made in this direction to date.[33]
	Switzerland	After the disappointment of the initial Saab choice and dismissing the Gripen through a public vote in 2012, the Swiss Air Force is looking for a new aircraft and is likely to announce a new tender for a number between 30 and 50 jets in 2017. F-35 will be competing against Rafale, Eurofighter, Gripen, and F/A-18 Super Hornets.
	Turkey	The Turkish Navy is ambitiously looking to buy a squadron of F-35B to operate from its new Amphibious Assault Ships.

[31] https://theaviationist.com/2016/11/28/polish-air-force-further-postpones-procurement-of-5th-generation-fighters-to-replace-mig-29-and-su-22-jets/

[32] http://www.defensenews.com/articles/poland-to-buy-5th-gen-fighter-jets-around-2025

[33] http://www.defensenews.com/story/defense/naval/naval-aviation/2016/04/20/f-35b-may-spanish-navys-future/83270268/