Japan's F-35 Acquisition and the Arms Race in the Western Pacific: Strategic Game Changer or Epic Boondoggle?

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Summary

The F-35 is a game-changing American fighter jet developed to penetrate present day air defences by evading radar detection. In the face of a resurgent China and assertive Russia, Japan is in the process of acquiring the largest fleet of this jet outside of the United States, thrusting it into a position in which it is able to compete with its regional rivals for military supremacy. Despite its technological capabilities, the F-35 has been plagued by a series of technical glitches, resulting in a 2019 crash of a Japanese-assembled F-35. Detractors of the F-35 have attributed this recent crash to fundamental flaws in the plane, ignoring the fact that fighter aircraft programmes tend to undergo a three-decade long development period, marked by significant technical challenges. The F-35 raises significant questions about the next stages in a costly and accelerating arms race involving Japan, China, Russia and the United States.

Keywords F-35 fighter jet, Stealth, Networked Warfare, Expeditionary Capability, Game-changing

Introduction

In the face of a resurgent China, many perceive Japan as a spent force. Its military is stretched, relying heavily on increasingly obsolete American equipment in the face of assertive neighbours[1]. The Japan Air Self-Defence Force (JASDF) is one of the busiest air forces in the world, its fighters scrambling virtually daily to intercept multiple aircraft (mostly Russian and Chinese combat aircraft) penetrating Japan's Air Defense Identification Zone (ADIZ)[2]; Japan's ADIZ extends to the Senkaku Islands in the East China Sea[3]. This trajectory is most apparent in the realm of strategic affairs where China is assiduously building up its military might with significant advances in high-tech weapon systems such as the Chengdu J-20 stealth fighter. China's J-20 while not in the same league as America's **F-35 Lightning II**[4] or F-22 stealth fighters, is rated as equal to the very best fourth-generation fighter aircraft fielded by the West[5].

Fourth-generation planes fielded by Western forces would refer to the F-16 Fighting Falcon or the F-15 Strike Eagle which have designs dating back to the 1970s. Their fifth-generation successors, which Japan is keen to secure, would include the F-35 or F-22 which rely on low-observable features (i.e. stealth) and cutting-edge sensors. Besides the obvious benefits of stealth, the other game-changing feature in fifth-generation aircraft such as the F-35 is its cutting-edge avionics which affords American forces an unprecedented level of battlefield situational awareness (a "God's Eye View") and increasing integration with other weapon systems (for example, MQ-9 reaper drones, Arleigh Burke-class naval destroyers, the M142 High Mobility Artillery Rocket System (HIMARS) and existing fourth generation jets such as the F-15s/F-16s). This contributes to the process of bolstering its operational capabilities to a point where it exceeds strategic rivals (i.e. China and Russia)

by orders of magnitude (seizing pole position in a new era of networked warfare).

Japan's F-35

Currently, Japan is planning to purchase up to 147 F-35 planes (105 F-35As, 42 F-35Bs), which would make it the largest operator of the stealth fighter in the world outside of the United States. At US$89.2-US$115.5 million per plane, this acquisition is expected to cost over US$10 billion[6]. The country is also retrofitting two of its Izumo class helicopter carriers to accommodate the F-35B, the **short take-off and vertical landing (STOVL)**[7] variant of the stealth fighter; a critical first step would be the reinforcement of the carrier decks to withstand the extreme heat from the F-35's engines. Once this weapon system achieves operational readiness, Japan would be able to project this considerable airpower far beyond its shores. For starters, the **low observable[8] F-35** (its radar blip is the size of a golf ball) would easily penetrate Chinese and Russian airspace (at least for now) until radar systems advance to the point of acting as effective countermeasures[9]. Even if Chinese and Russian systems manage to locate the F-35, they would face considerable difficulty in tracking and targeting the stealth fighter. Further, by the time of detection, the F-35 would have deployed its onboard weapon system, delivering a crucial first strike advantage on strategic targets such as enemy air defences.

China claims that its J-20 stealth fighter, which has attained initial operational capability, would be capable of countering the F-35 challenge. However, this is highly unlikely as the J-20 still lags the F-35 in terms of battlefield situational awareness[10] and jet propulsion systems, two factors that provide the jet with the critical combat operational edge[11]. In the world of aerial combat, the aircraft that is capable of "the first lock, first shot and first kill" would invariably emerge the victor. Further, the Pratt and Whitney F135 engine that powers the F-35 is capable of supersonic speeds without engaging afterburners. The WS-15 engines powering the J-20 do not have this capability[12].

Moreover, the single crystal turbine blades of the WS-15 engine is unable to manage the extreme heat generated by the high-performance J-20 and some of these engines exploded during testing in 2015. In addition, the Chinese have thus not been able to produce the WS-15 engine on a sufficient scale, often relying on the less sophisticated WS-10B engine to power the J-20[13]. Jet engine production, even today, remains a Chinese weakness, with Chinese engineers struggling to rectify this crucial gap. Given the F-35's superiority over its J-20 rival (in terms of situational awareness and jet engines), Japan with its projected fleet of over 100 F-35s would possess significant air superiority over the People's Liberation Army Air Force (PLAAF). The United States has thus far refused to sell the superior F-22 (with stealth technology and kinematics surpassing the F-35) to Japan, which would give the JASDF total air superiority in the region.

Despite the promised technological brilliance of the F-35, it has been plagued by persistent technical glitches (e.g. bugs resulting in

inaccurate cannons and system shutdowns), significant cost overruns (making it the most expensive weapons system in history) and delays in operational readiness. All these unresolved issues have caused many analysts to label the F-35 a boondoggle[14]; the late US Senator, John McCain, once lambasted the F-35 programme, stating that it "has been both a scandal and a tragedy with respect to cost, schedule, and performance"[15]. The embarrassing crash of Japan's newly acquired F-35A on April 9, 2019, and the subsequent grounding of the entire F-35 fleet also raises serious doubts about the operational readiness of this supposed game-changing weapon system. This article examines the strategic capabilities, potential and weaknesses of the F-35 and, more importantly, how this cutting-edge technological breakthrough could position Japan in an era marked by the escalating strategic rivalry between supposedly pacifist Japan, rising China and an assertive Russia.

Strategic reasons behind Japan's F-35 acquisition

Japan, bound by the pacifist principles inscribed in its constitution, has not maximized the potential of the Japan Self-Defence Forces (JSDF). As evidenced in Table 1, Japan, in 2012, spent US$44.6 billion on defence and this grew to US$46.6 billion by 2018 (a marginal compound annual growth rate (CAGR) of 0.8%; throughout these six years, Japan's military expenditure never exceeded 1% of its GDP. From 2019 to 2024, Japan is expected to spend US$245 billion (US$49 billion annually) on defence; for this forthcoming period, Japan's estimated US$49 billion annual defence expenditure is still only about 1% of its GDP[16]. China's military expenditure grew by a much larger CAGR of 7.6% in the same period, increasing from US$161.4 billion in 2012 to nearly US$250 billion in 2018. From 2012 to 2018, China spent nearly 2% of its GDP annually on defence[17]. China's rapidly rising expenditure and increasing flexing of its muscles worries Japan[18].

Throughout the postwar years, Japan has spent no more than 1% of its GDP on defence (see Table 1), continue to rely above all on the United States for protection. Even today, there are still 54,000 troops stationed in Japan[19]. This significant force includes personnel from the US Seventh Fleet (based in Yokosuka), which operates an aircraft carrier, destroyers, minehunters and large amphibious assault ships (capable of carrying F-35Bs)[20]. However, under the current Trump administration, Japan is under pressure to raise its military expenditure. President Trump has repeatedly stressed that allies such as Japan should bear the cost of their own defence. The US$10 billion plus acquisition of the F-35s could be viewed not just as a means of meeting the rising Chinese military challenge but also addressing the Trump administration's incessant demands for Japan to bear greater responsibility for its own defence. Moreover, this significant acquisition is expected to please an administration that has consistently prided itself on its robust job creation prowess[21]; the F-35 programme is a considerable 'job creation machine' as it provides 194,000 jobs in America both directly and indirectly and this figure is expected to increase further as overseas orders increase[22].

Table 1: Defense spending of China and Japan

Year	2012	2013	2014	2015	2016	2017	2018	CAGR
China's military expenditure (US$ million)	161441	176476	191627	204202	215718	227829	249997	7.6%
China's GDP (US$ million)	8560547	9607224	10482372	11064666	11190993	12237700	13407000	7.8%
China's military expenditure as a % of GDP	1.9%	1.8%	1.8%	1.8%	1.9%	1.9%	1.9%	
Japan's military expenditure (US$ million)	44552	44363	44836	45627	45351	45387	46618	0.8%
Japan's GDP (US$ million)	6203213	5155717	4850414	4394978	4949273	4872415	4971930	(3.6%)
Japan's military expenditure as a % of GDP	0.7%	0.9%	0.9%	1.0%	0.9%	0.9%	0.9%	

Sources: World Bank, IMF, Stockholm International Peace Research Institute (SIPRI)

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Concurrently, Japan faces considerable challenges from its other strategic rival, Russia, which has yet to sign a permanent peace treaty since the conclusion of the Second World War. The biggest obstacle to the peace treaty is that both countries claim ownership over four islands (Habomai, Shikotan, Etorofu and Kunashiri) north of Hokkaido, known to Japan as the Northern Territories and Russia as the southern Kuril islands[23]. In March 2018, the Russian Air Force, for the first time, sent two Su-35s fighters to Etorofu (known as Iturup in Russia), the largest and northernmost island in the Northern Territories. This provoked a reaction from Japan, which urged Russia to reduce its military presence in the disputed territories. Further, in February 2019, Japan scrambled fighters to intercept four nuclear-capable Russian Tupolev Tu-95MS strategic bombers escorted by four Sukhoi Su-35s fighter jets over Japan's east and west coasts[24]. The Su-35 is a highly-manoeuvrable, heavily-armed fourth-generation multirole air superiority fighter, regarded by industry analysts as the finest fourth-generation fighter in service today (see Table 2 for specifications)[25]. In a move that would invariably exert pressure on Japan, Russia sold and delivered 24 Su-35s to the People's Liberation Army Air Force (PLAAF). To contend with regional rivals, both armed with the sophisticated Su-35[26], the JSDF procured a sizeable fleet of fifth-generation F-35s; despite its considerable manoeuvrability and firepower, the Su-35 does not have advanced fifth-generation stealth features (unlike America's F-22/F-35 and China's J-20) and the cutting-edge avionics/sensors available in the F-35[27].

J-20, China's mighty dragon

China's J-20 also presents a serious challenge to Japan's air defences, as the fighter, with its speed, range and stealth is designed to penetrate deep into heavily defended territories[28]. In terms of speed and raw power, the J-20 is superior to Japan's F-35 and comparable to the F-35's "older brother", the F-22 (see Table 2); America's F-22 is arguably the finest air-superiority fighter of this era[29] but the country's 1997 Obey Amendment prohibits overseas sales even to its closest allies (including Japan). However, in the era of fifth generation aerial combat survivability (in the form of stealth) supersedes raw speed and power. After all, no existing fighter with an average speed of Mach 2 would be able to outrun surface-to-air missiles (SAMs), which easily exceed Mach 3 in velocity. Even a service ceiling in excess of 60,000 feet does not provide a safe zone for modern fighters, as relatively inexpensive SAMs could easily down targets around 100,000 feet; one Russian made S-300 missile costs around US$1 million[30] vis-à-vis the US$100 million price-tag for the F-35. In terms of sustainable flight performance, the relatively slower F-35 (vis-à-vis the J-20) could sustain a speed of Mach 1.2 for about 150 miles without using gas guzzling afterburners (see Table 2). This is superior to many fourth-generation planes, which operate at transonic (around Mach 1) speeds[31]. It is questionable whether the J-20's WS-10B engines could deliver comparable performance, even though its prima facie top speed of Mach 2 plus is somewhat higher[32].

Further, the remarkably small cross-section of the F-35 of 0.001 square metres (surpassed only by the F-22's impossibly miniscule 0.0001 square metres) (see Table 2)[33] would enable Japanese forces to penetrate Chinese-defended airspace in the South China Sea, populated by scores of SAM batteries[34]; if the F-35 were to engage its relatively more advanced electronic warfare suite, it could be stealthier than the F-22[35]. In essence, you can't kill what you can't see. By the time the F-35 is detected, it would

have achieved its strategic objectives of **suppressing enemy air defences (i.e. destroying area denial SAMs)**, allowing the next wave of heavily armed B-2 bombers and fourth-generation F-15 fighters (acting as bomb trucks and missile haulers respectively) to gain air superiority with impunity. The Chinese have undeniably made significant strides in stealth technology, as indicated by the J-20's estimated radar cross section of 0.025 square metres (See Table 2). This level of stealth while impressive, however, is still a far cry from the radar-evasiveness of the F-35. The J-20's level of stealth is at best comparable to America's earlier stealth fighter, the F-117 which was used extensively and with considerable success in the Persian Gulf Wars[36]. Given the F-35's revolutionary radar-evading technology, Japan's expected forthcoming acquisition of 147 F-35s would enable the country to provide a robust deterrence against increasingly assertive regional rivals, China and Russia[37].

Table 2: F-35 specifications versus that of the F-22, J-20 and Su-35

Aircraft	F-35	F-22	J-20	Su-35
Speed (Mach)	1.6	2.25 (Estimated)	2-2.2 (Estimated)	2.25
Powerplant	F-135 (Pratt & Whitney, Single)	F-119 (Pratt & Whitney, Twin)	WS-10B (Shenyang Liming, Twin) WS-15 (Shenyang Liming, limited operational status at best)	Saturn AL-41F1S turbofan engines (NPO Saturn, Twin)
Thrust (pounds)	28,000	26,000 (Single)	25,000 (Single)	19,400 (Single)
Thrust with afterburner (pounds)	43,000	>35,000 (Single)	32,000 (Single)	32,000 (Single)
Thrust to Weight Ratio	1.07 (50% fuel)	1.25 (50% fuel)	1 (Estimated)	1.3 (Estimated)
Service Ceiling (Feet)	50,000+	60,000+	60,000 (Estimated)	60,000
Range in nautical miles (internal fuel)	F-35A >1200 F-35B > 900 F-35C >1200	>1,600	1,200-2,000	1,943
Radar Cross Section[38] (square metres)	0.001 (size of a golf ball)	0.0001 (size of a marble)	0.025 (roughly equivalent to F-117A)	1-3
Supercruise	Limited (achieve a speed of Mach 1.2 for 150 miles without afterburner)	Yes (achieve Mach 1.8 without afterburner)	No (with WS-10 engine) Yes (Mach 1.8, with WS-15 engine)	Limited (achieved a speed of Mach 1.1 at maximum setting of its Saturn AL-41F1S turbofan engines).
Internal weapons load (suggested configurations)	Two AMRAAM AIM-120 air-to-air missiles and two 2000-pound GBU-31 **Joint Direct Attack Munitions (JDAMs)**[39]. F-35A has a 25mm gun.	Six AMRAAM AIM-120 air-to-air missiles or two AMRAAM and two 1,000lb GBU-32 JDAMs. Has a 20mm gun.	Four PL-15 medium-to-long-range air-to-air missiles, with possibly two PL-10 missiles.	Twelve to fourteen K-77M radar-guided missiles. Could carry up to 8,000 kg of air-to-ground munition. Has a 30mm gun.
Price (US$ million)	89.2-115.5	150	100-110	85

Sources: Lockheed Martin, Global Security, David Goldfein, Minnie Chan, AIN Online, The Diplomat, Real Clear Defense

(See footnotes [38] and [39])

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The F-35's STVOL edge

An estimated 40 of the 147 F-35s which Japan is interested in acquiring would be the STOVL F-35B variant; Japan has reassured the United States of its commitment to acquire 42 of the F-35Bs despite the recent crash of the Japanese-assembled F-35A[40]. The F-35B would not only greatly augment the capabilities of the Izumo class carriers from which it is intended to be deployed but also significantly reduce relatively land scarce Japan's need for conventional terrestrial runways. Why does the STOVL capability of the F-35B give it a significant edge over potential adversaries? Once the F-35B has suppressed enemy defences, it could take off on short, makeshift runways of about 168 metres (most conventional fighters require runways of at least 1.5 kilometres) and land vertically, enabling Japanese forces to launch incessant waves of combat sorties to fulfil close air support missions for advancing forces, all the time moving closer to enemy territory in amphibious operations[41]. If this strategy works out as planned, it is a terrifying prospect for Chinese forces in the event of a conflict.

The potentially opposing PLA force, its J-20, does not possess the STOVL capability of the F-35B. However this STOVL capability is not without its trade-offs, as it requires the installation of a lift fan and thrust vectoring system which reduces the internal weapons storage facility of the F-35B; the F-35 has to store its weapons internally to maintain maximum stealth. Nonetheless, once enemy air defences have been suppressed, a JSDF F-35B would shed its stealth mode and shift into its so-called 'beast mode', which allows it to carry about 22,000 pounds of internal and external ordinance. In this heavily armed configuration, the JSDF F-35B leveraging on its STOVL capability would pound enemy targets relentlessly with overwhelming firepower (e.g. the 2000-pound GBU-31 JDAM), from positions that are extremely close to opposition coastlines and bases. This capability would significantly increase the firepower of F-35B

supported amphibious operations.

Currently, Japanese military planners intend to deploy the F-35B on its islands along the edge of the East China Sea and South China Sea. This is evidenced by the JSDF's retrofitting of its Izumo-class carriers for amphibious operations, with the STOVL-capable F-35Bs onboard[42]. The JSDF's strategy is modelled on the light carrier model already deployed by the United States; American amphibious assault ships such as the 40,000 ton USS Wasp, which carries at least 10 F-35Bs onboard, have been deployed in the South China Sea[43].

Game-changing sensor suite and networked warfare

However, the game-changing nature of the F-35 extends far beyond low observability and STOVL. It is a force multiplier, as its sensor suite and avionics are able to work in conjunction with other weapon systems, in the process significantly raising the lethality of one's armed forces. For instance, a JASDF F-35 would be able to network with surrounding fighter jets, drones, gunships and naval destroyers, and deploy their firepower with maximum effect. Additionally, "Hellfire" missiles (basically anti-armour missiles) could be deployed from nearby drones to engage advancing tanks, without the F-35 firing a single shot. In late 2017, the US Marine Corp also successfully linked its F-35B to the HIMARs rocket launcher; the F-35B fed target location data to the HIMARS onboard the amphibious transport dock Anchorage which proceeded to destroy a target on land 70 kilometres away[44]. This unique feature would also compensate for the relatively limited firepower (typically two air-to-air missiles and two JDAMs in internal carriage) inside the F-35 when it is operating in maximum stealth mode.

Further, it would be nearly impossible to surprise an F-35, as its onboard "Distributed Aperture System" or "DAS" (supported by six strategically mounted cameras), gives the pilot the earlier mentioned 360-degree "God's Eye View". The pilot is literally able to look through the plane and see everything beneath and around him. In addition, the "DAS" warns the pilot of any incoming missile or threat. Moreover, the F-35 has an "Electro-Targeting Optical System" ("EOTS") which blends forward-looking infrared and infrared search and track sensor technology, enabling it to find and track adversaries before engaging them with a choice of laser and GPS-guided precision weapons. In such a situation, the fight between the F-35 and any adversary becomes greatly skewed in favour of the F-35. The F-35 pilot is virtually "invisible" to opposing fighter jets through its low observability while concurrently, he is able to locate, track and destroy these adversaries. The technological advantages afforded by the F-35 do not end here, as it also incorporates "mission data files" (the "brains" of the aircraft) which compiles mission critical information on geography, air space and potential threats (e.g. enemy aircraft) in areas where the jet is being deployed. The cutting-edge capabilities of the F-35 have been borne out in America's intensive "Red Flag" air combat exercises where pilots are pitted against simulated Russian/Chinese adversaries and integrated air defence systems (i.e. SAMs). In such air combat exercises, the F-35s are able to achieve "20 to 1" kill ratios against capable fourth-generation jets such as the F-15s and F-16s; this means that for every downed F-35, it managed to destroy 20 simulated enemy fighter jets. Even newly-minted F-35 pilots are sometimes able to overcome experienced combat pilots (e.g. 3,000 flight hours) in capable, fourth generation fighter jets[45]. The JSDF, armed with 147 of these cutting-edge jets, would not only dominate the South China Sea but also become the preeminent air force in Asia, second only to the United States. Japan's sizeable F-35 acquisition makes it one of the few nations capable of networked warfare in the region.

This is, however, a perilous path, as it has catalysed an arms race that is rapidly unfolding in Asia, with China, Australia, South Korea and Singapore all bulking up their military might with the acquisition of state-of-the-art stealth fighters.

The world's most expensive boondoggle?

Despite the game-changing technologies packed onboard the F-35, there remain several questions regarding its operational readiness and capabilities, with some detractors labelling it a boondoggle[46]. The F-35 programme has become the most expensive weapon system in history, having spent over well over US$400 billion (to date) over a two-decade development period. Over the lifetime of this weapons programme, it is expected to involve an investment in excess of US$1.5 trillion[47]. In spite of this significant investment, the F-35 continues to be plagued with software bugs which affect the integrity of its weapons systems. For instance, software issues affect the verification of target coordinates that have been entered into a JDAM, thus increasing the possibility of friendly fire situations[48] in which troops are hurt or killed by their own weapons systems[49]. Further, the F-35A's internally mounted 25mm gun has accuracy issues, according to a recent 2018 report by the US Office of Operational Testing and Evaluation. The F-35B, which relies on an externally mounted gun pod, does not have such a problem but the externally mounted gun would invariably compromise the plane's stealth and performance to a limited degree[50].

Critics of the F-35's gun system argue that modern fighter jets today rarely rely on guns to engage their adversaries and aerial combat is all about beyond-visual-range engagements using high-tech sensors and radar[51]. These critics have clearly forgotten the lessons of the Vietnam War. The developers of the F-4 Phantom, the premier US fighter of the Vietnam War, initially decided against equipping the F-4 with a gun. Their argument was that the gun was an antiquated weapon system, ill-suited for the age of supersonic fighter jets[52]. This omission left the F-4 vulnerable to the more manoeuvrable Mig-21, which was able to sneak in close enough to take out the former in significant numbers[53].

Despite the lessons drawn from aerial engagements since the Vietnam War, the developers of the Chinese J-20 strangely decided to omit the gun, choosing to rely on missiles for aerial and other combat engagements[54]. In spite of the significant advances made in the ensuing decades since the Vietnam War, air-to-air missile lethality is still far from perfect. A close study of "probability of kill" statistics regarding America's high-tech AIM120 missile reveals an effectiveness of approximately 50 percent in actual combat situations (i.e. Desert Storm, Operation Iraqi Freedom)[55]. Thus, in short range aerial engagements of less than 5km, the F-35's gun could give the JASDF the decisive edge against opposing J-20s, who have survived the initial missile onslaught. The absence of a gun onboard the J-20 would render it highly vulnerable to the gun-equipped F-35 in such short-range dogfights.

Some critics have directed their aim at the F-35's much vaunted stealth status. They argue that low frequency radars operating in the VHF and UHF bands could detect and track stealth aircraft such as the F- 35 or even the F-22[56]. They also argue that the extreme heat generated by the F-35's powerful, single F-135 engine (capable of delivering 43,000 pounds of thrust) could also compromise its stealth. The downing of the F-117 stealth fighter by Serbian forces in 1999 is often cited to prove that stealth technology is no "cloak of invisibility"[57].

However, stealth technology has come a long way since 1999. The F-35's radar cross section is significantly smaller than the F-117's (see Table 2). By the time the F-35 is spotted, it

could be too late for opposing forces. The Chinese J-20 supposedly has a radar cross section comparable to the relatively mature F-117. This would place the stealth capabilities of the PLA, a generation behind that of the JASDF, which would operate the largest fleet of F-35s outside the United States.

Another common criticism of the F-35 is its limited dogfighting capability. In 2015, the F-35 engaged its predecessor, the F-16 in a controversial dogfight which saw the older fighter outclassing its stealthy upstart, despite carrying two external fuel tanks. The argument is that many earlier F-35 pilots were trained on legacy systems such as the F-15 and F-16, and they would tend to fly the F-35 in a similar manner. The first lieutenants who are trained in the F-35 right from the start, however, do not have this problem and are able to exploit the full capabilities of the aircraft, as evidenced by the ability of some of them in trumping experienced pilots operating legacy jets in recent "Red Flag" exercises[58]. In addition, many critics fail to mention that developmental restrictions on the F-35s manoeuvrability are still in place, thus curbing the jet's full dogfighting potential; the F-35A is well capable of pulling **9Gs**[59], a feat rivalling the F-16, which is known to be one of the most manoeuvrable fighters in the world[60].

The JASDF is relatively new to the F-35 and it can be expected to draw upon the accumulated experience of US pilots who have greater exposure to this new plane. Japan has already deployed a team of F-35 pilots at Misawa Air Base in the north of Japan's main island of Honshu. Before their deployment at Misawa, these F-35 pilots, along with their maintenance crew trained for 18 months at the Luke Air Force Base in Arizona[61]. Once the Izumo-class carriers (Izumo and Kaga) have been retrofitted, they would be able to deploy these trained F-35 pilots, allowing Japan to have an expeditionary capability that would tilt the balance of power in the region.

Conclusion

Critics of the F-35 programme ignore the fact that all new weapons systems face teething problems in their introductory phase. Even the fabled F-16, officially launched in 1978, was confronted with a series of technical problems in its early days. Pilots complained about its light weight and weak brakes which resulted in lacklustre landings, burnt out tyres and prompted resentment from ground maintenance crew. They also expressed reservations about the F-16's fixed sidestick. The F-16's problems mounted in the 1980s with some F-16 pilots crashing owing to electrical problems with the jet's flight control system. Nonetheless, the F-16 surmounted these challenges and emerged as possibly the most successful fighter aircraft programme in the world, with over 4,500 F-16s having being produced[62]. The complexity of today's F-35 far surpasses that of the F-16 of the 1970s. Given the technical complexity of the F-35, it would probably take another decade (after the first two decades of development) to resolve the host of issues surrounding this remarkably complex aircraft.

The F-35, however, has been subjected to testing under the harshest battle conditions by the world's premier fighting force, the Israel Defence Forces (IDF). The Israeli Air Force, has modified the F-35 to suit its unique needs. The Israeli version of the F-35, known as the Adir ("Mighty One") has been customised to carry major Israeli-developed weapons systems in its internal weapons bay which would include the Python-5 short-range heat-seeking air-to-air missile. Its internal payload would also encompass the Spice family of glide bombs, which combine electro-optical and satellite configurations for enhanced targeting versatility and have an effective range of 60 miles. The Israel Air Force has deployed the F-35 in the penetration of Syrian airspace to engage Iranian antiaircraft batteries. The JSDF and other F-35 user nations such as Singapore

and South Korea (the so-called **"F-35 friends' circle"**[63]) would undoubtedly learn from Israel's battle hardened experience.

Moreover the more conventional (i.e. runway dependent) F-35A would be customised to carry two of the Kongsberg 'Joint Strike Missile' (JSM), a long-range sea and land target missile (capable of engaging targets beyond 500km) in its internal carriage for maximum stealth, greatly augmenting the plane's destructive reach. Leveraging the JSM's range, the JSDF would also customise the STVOL-capable F-35B for marine expeditionary operations, greatly expanding the ability of Japanese forces to project power in the hotly contested South China Sea; with its considerable range, the JSM would be a significant deterrent to Chinese warships. However the JSDF's STVOL-capable F-35B is only able to carry the 'JSM' in an external configuration, in the process compromising some degree of stealth (the F-35 has to carry all its weapons internally to achieve maximum stealth)[64]. The 'JSM'-armed F-35B deployed by the JSDF (mounted on its Izumo-class carriers) is not only a highly effective means to counter China's increasingly assertive naval forces in the region but would also allow Japan to project power far beyond its shores. The Japanese F-35B, in this configuration, has effectively become a cruise missile launching platform, capable of devastating far away land-based targets. With China already moving to equip its fighters with cruise missiles capable of engaging targets 600km away[65], this new Japanese capability is indicative of the new stage of an arms race in the Western Pacific and beyond.

The highly networked F-35 leapfrogs Japan into an era of networked warfare, enabling it to access and concurrently deploy a host of weapon systems (from multiple launch rocket systems to Naval destroyers) to engage other nations on its periphery and in the East China and South China sea. To date, game-changing networked warfare is an area in which the US alone has achieved significant progress. The networked warfare model allows once disparate weapon systems to fight as an integrated 'force of one', significantly increasing response time, accuracy and firepower.

Despite technical glitches, the F-35 has demonstrated its innovative networked warfare capabilities in 'Red Flag' exercises conducted by US pilots where it has repeatedly overwhelmed rivals, although only in simulated tests[66]. However, this network-centric approach to warfare also renders F-35-dependent Japan more exposed to well-orchestrated cyberwarfare tactics targeting the aircraft's highly-interlinked computer systems. It is no surprise that the PLA has developed world-class capabilities in cyberwarfare in the form of a crack team of hackers known as PLA Unit 61398. Having developed these cyberwarfare teams to counter the US' far superior conventional forces, the PLA has successfully hacked into the systems of US military contractors (e.g. Boeing, Lockheed Martin) to secure valuable information on the Aegis ballistic missile defence system, the multi-mission Littoral Combat Ship, the F/A-18 fighter jet, the V-22 Osprey vertical take-off aircraft and even the F-35[67].

Once the kinks in the F-35 weapon system have been eliminated over the coming decade, Japan would have in its possession the most technologically advanced and capable air force in the world, trailing only the US and battle-hardened Israel. The technology harvested from the F-35 would also accelerate Japan's efforts to develop its own high-tech stealth fighter. The JASDF's recently crashed F-35A was assembled in Nagoya, Japan by Mitsubishi Heavy Industries. What is certain is that the possession of a significant F-35 fleet (positioned on Izumo class carriers) heralds Japan's potential return as a regional military power with expeditionary capability, and a new stage in the accelerating arms race in the

Western Pacific.

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Notes

[1] Japan's 1950s-era design F-4 Phantom jet is only recently being retired. Michael Peck, The National Interest (https://nationalinterest.org/blog/buzz/japan-dumping-f-4-phantom-f-35-and-it%E2%80%99s-big-deal-38447), December 11 2018.

[2] The ADIZ is the airspace designated over and often extending beyond a country's borders in which any unknown approaching aircraft is asked to identify itself. If the aircraft is deemed hostile, it would be asked to leave or risk being destroyed. Peter Layton, War on the Rocks (https://warontherocks.com/2019/04/japans-air-force-steps-up-its-scrambles-what-are-the-risks

/), April 4 2019.
[3] Japan's ADIZ encompasses the Senkaku Islands. See Burke E.J. and Cevallos A.S. (2017) p5.
[4] The F-35 comes in three variants (A, B, C). The F-35A is designed to operate using conventional runways and is the only variant equipped with an internal cannon. As for the F-35B, it is the short-takeoff and vertical landing (STOVL) variant and was developed to operate from barebones military facilities with limited runways and vessels capable of hosting a small air wing (e.g. light carriers and destroyers) operating near combat zones. The F-35C was developed primarily for aircraft carrier operations. See here (https://www.f35.com/about/variants).
[5] China's J-20 and America's F-15 (America's premier fourth generation fighter) appear to be evenly matched. At longer ranges, the J-20 with its stealth, has the upper hand but at shorter ranges, the F-15 with its internal gun, superior thrust and greater manoeuvrability would emerge the victor. Kyle Mizokami, The National Interest (https://nationalinterest.org/feature/chinas-j-20-stealth-fighter-vs-japans-f-15-who-wins-14112), October 16 2015.
[6] The JSDF plans to acquire up to 147 F-35s, with the F-35B variant expected to equip its Izumo class carriers. See here (https://www.defensenews.com/air/2019/04/01/asia-allies-take-major-steps-forward-with-f-35-rollout/). The more technically complicated STOVL capable F-35B at US$115.5 million per plane costs more than the F-35A (US$89.2 million per plane) which is only capable of conventional landings. See here (https://www.f35.com/about/cost).
[7] **STOVL** capability enables jets to operate in harsh conditions and from remote locations where there are no conventional runways. Jets with STOVL capability are able to operate from makeshift runways and roadways. This capability is of significant value to expeditionary forces which often have to operate in difficult environments with no access to conventional airfields. See "Marines' F-35B Expeditionary Envelope Expands (https://navalaviationnews.navylive.dodlive.mil/2018/03/21/marines-f-35b-expeditionary-envelope-expands/)".
[8] Low observable technology (stealth technology) attempts to reduce the radar signatures emitted by vehicles. See "Camouflage at War: An illustrated Guide from 1914 to the Present Day" by Martin J. Dougherty, p158.
[9] See "What went wrong with the F-35, Lockheed Martin's Joint Strike Fighter? (https://theconversation.com/what-went-wrong-with-the-f-35-lockheed-martins-joint-strike-fighter-60905)" by Michael P. Hughes, The Conversation, June 14 2017.
[10] In a discussion with the author (Wilson Wong), Justin Bronk, Research Fellow with the Royal United Services Institute for Defence and Security Studies, indicated a similar view on the F-35's vastly superior sensor suite and internal software capabilities vis-à-vis the J-20. Bronk added that the F-35's sensor capabilities will continue to strengthen throughout the 2020s and further capabilities leveraging on the F-35's superior data-processing capabilities would be added, see Bronk (2019).
[11] See "Why an F-22 or F-35 Would Crush China's J-20 Stealth Fighter (https://nationalinterest.org/blog/buzz/why-f-22-or-f-35-would-crush-chinas-j-20-stealth-fighter-54857)" by Dave Majumdar, The National Interest, April 29 2019.
[12] See "Welcome to the Stealth Slaughter: China's J-20 Can't Beat An F-22 or F-35

(https://nationalinterest.org/blog/buzz/welcome-stealth-slaughter-chinas-j-20-cant-beat-f-22-or-f-35-56522)" by Zachary Keck, The National Interest, May 9 2019. China's fighter aircraft engine woes were also mentioned in an earlier Reuters article, "Not Top Gun yet: China struggles with warplane engine technology (https://www.reuters.com/article/us-china-military-engines/not-top-gun-yet-china-struggles-with-warplane-engine-technology-idUSKCN0V7083)" by Siva Govindasamy, Reuters, January 29 2016.

[13] The inability to produce capable and reliable fighter aircraft jet engines has been a perennial weakness for the PLA Air Force. See "Why China's first stealth fighter was rushed into service with inferior engines (https://www.scmp.com/news/china/diplomacy-defence/article/2130718/why-chinas-first-stealth-fighter-was-rushed-service)" by Minnie Chan, South China Morning Post, February 10 2018.

[14] Paul Waldman of the Washington Post, states that history's most expensive weapon system, the F-35, is both disaster-prone and a boondoggle. See "How the F-35 boondoggle shows that deficit hawkery is a sham (https://www.washingtonpost.com/blogs/plum-line/wp/2014/07/25/how-the-f-35-boondoggle-shows-that-deficit-hawkery-is-a-sham/?utm_term=.309c1aa2cf97)" by Paul Waldman, The Washington Post, July 25 2014.

[15] See "John McCain: F-35 is 'a scandal and a tragedy' (https://edition.cnn.com/2016/04/26/politics/f-35-delay-air-force/index.html)" by Ryan Browne, CNN, April 27 2016.

[16] See The Economist, Defending Japan, A new front, p23-24, April 20 2019.

[17] See SIPRI military expenditure database (https://www.sipri.org/databases/milex). GDP figures for China and Japan are obtained from the following World Bank and IMF websites (https://data.worldbank.org/country/china, https://data.worldbank.org/country/japan), China's GDP (https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/weorept.aspx?pr.x=41&pr.y=16&sy=2017&ey=2021&scsm=1&ssd=1&sort=country&ds=.&br=1&c=924&s=NGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC%2CPCPIPCH&grp=0&a=), Japan's GDP (https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/weorept.aspx?pr.x=45&pr.y=5&sy=2016&ey=2021&scsm=1&ssd=1&sort=country&ds=.&br=1&c=158&s=NGDP_RPCH%2CNGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC%2CPCPIPCH&grp=0&a=).

[18] See "Japan is worried about its alliance with America (https://www.economist.com/asia/2018/09/06/japan-is-worried-about-its-alliance-with-america)".

[19] See here (https://www.usfj.mil/About-USFJ/).

[20] See "The Navy and Marines Are Deploying a 'Lightning Carrier' to the Pacific (https://www.popularmechanics.com/military/aviation/a27347243/lightning-aircraft-carrier/)" by Kyle Mizokami, Popular Mechanics, May 2 2019.

[21] According to a White House fact sheet released on March 19, 2019, more than 2.6 million jobs were created in America in 2018 alone, owing to the economic boom the Trump administration created. Further the administration asserted that the number of job openings exceeded the number of unemployed workers for the first time. Additionally, it claimed that America's unemployment rate reached a 50-year low of 3.7% in September 2018. See "President Donald J. Trump's Economic Agenda is Working for All Americans

(https://www.whitehouse.gov/briefings-statements/president-donald-j-trumps-economic-agenda-working-americans/)".

[22] Lockheed Martin's CEO, Marillyn Hewson, stated that the F-35 programme creates 194,000 jobs both directly and indirectly in America, see " 'Made in America': Lockheed Martin adds jobs to boost F-35 production (https://www.foxbusiness.com/economy/made-in-america-lockheed-martin-adds-jobs-to-boost-f-35-production)" by Matthew Kazin, Fox Business, July 23 2018.

[23] See "77% of Russians oppose handover of disputed islands off Hokkaido to Japan (https://www.japantimes.co.jp/news/2019/01/30/national/77-russians-oppose-handover-disputed-islands-off-hokkaido-japan/#.XM6nWaQRVc8)".

[24] See "Air Self-Defense Force jets scrambled as Russian bombers and fighters skirt Japanese coasts (https://www.japantimes.co.jp/news/2019/02/16/national/air-self-defense-force-jets-scrambled-russian-bombers-fighters-skirt-japanese-coasts/#.XM6zAaQRVc9)" by Jesse Johnson, The Japan Times, February 16 2019.

[25] The Su-35 has a maximum speed of Mach 2.25, which is equal to the F-22 and superior to the F-35. It has 12 to 14 hardpoints for carrying missiles compared to just eight on the F-15, operated by the JASDF and the United States Air Force. On top of this considerable firepower, the Su-35 is also equipped with a 30mm autocannon (150 rounds of ammunition). Sebastien Roblin, The National Interest (https://nationalinterest.org/blog/why-russias-enemies-should-fear-the-su-35-fighter-16995?page=0%2C1), July 16 2016.

[26] Russia is also developing its own fifth-generation fighter, the Su-57, which supposedly has stealth technology and supercruise capabilities. The Su-57 was initially expected to enter production in 2020 but its development has been seriously hampered by a paucity of funds and technical issues with its engines, see "What's Going on With Russia's New Stealth Fighter? (https://www.popularmechanics.com/military/aviation/a27510827/sukhoi-su-57/)" by Kyle Mizokami, Popular Mechanics, May 18 2019.

[27] In a discussion with the author (Wilson Wong), Justin Bronk, Research Fellow with the Royal United Services Institute for Defence and Security Studies, commented that the F-35 was far superior to the Su-35 owing to the superior situational awareness afforded by its cutting-edge sensor suite, see Bronk (2019). Lieutenant General David A. Deptula, USAF (Retired), Dean of the Mitchell Institute for Aerospace Studies, also commented in a similar discussion with the author, that the F-35 was significantly superior to the Su-35, see Deptula (2019).

[28] See "The real purpose behind China's mysterious J-20 combat jet (https://www.businessinsider.com/the-real-purpose-behind-chinas-mysterious-j-20-combat-jet-2017-1?r=UK&IR=T&_ga=2.217744853.292732007.1559275260-1319531691.1559275260)" by Alex Lockie, Business Insider, January 24 2017.

[29] See "Smiling Stealth: Is the F-22 Raptor Fighter Jet Too Good? (https://nationalinterest.org/blog/buzz/smiling-stealth-f-22-raptor-fighter-jet-too-good-49647)" by Robert Farley, The National Interest, March 29 2019.

[30] The S-300 missile is capable of engaging targets at approximately 27,000 metres (about 90,000 feet). See "How Dangerous is the S-300 Syria is About to Receive? (https://defense-update.com/20130518_how-dangerous-is-the-s-300.html)" by Tamir Eshel,

Defense Update, May 18 2013.

[31] Lockheed Martin, Vice President, Stephen O'Bryan states that the F-35 is capable of maintaining a speed of Mach 1.2 for 150 miles without using gas-guzzling afterburners. O'Bryan states that this is a good performance, as most fighters tend to operate at transonic speeds (close to Mach 1, which is just below the speed of sound). He was cited in "The F-35's Race Against Time (http://www.airforcemag.com/MagazineArchive/Pages/2012/November%202012/1112fighter.aspx)" by John A. Tirpak, Air Force Magazine, November 2012.

[32] The WS-15 engine that is slated to power the J-20 is still under development. Currently, the WS-10B engines powering the J-20, was meant for earlier J-10 and J-11 fighters and not the more sophisticated J-20 which would require higher thrust levels see "China reveals J-20 stealth fighter's missile carrying capability at Zhuhai air show (https://www.scmp.com/news/china/military/article/2172993/china-reveals-j-20-stealth-fighters-missile-carrying-capability)" by Minnie Chan, South China Morning Post, 14 November 2018.

[33] For the radar cross section of the F-35 and F-22, see "The F-35 vs. the Russian Su-35 and the PAK FA (https://www.realcleardefense.com/articles/2015/11/05/the_f-35_vs_the_russian_su-35_and_the_pak_fa_108649.html)" by Mark B. Schneider, Real Clear Defense, November 4, 2015. The radar cross sections of the F-35 and F-22 are 0.001 square metres and 0.0001 square metres, which are significantly smaller than conventional fighters such as the F-4 (6 square metres). This makes fighters such as the F-35 extremely hard to track and achieve a missile lock, see Radar Cross Section (RCS) (https://www.globalsecurity.org/military/world/stealth-aircraft-rcs.htm).

[34] In the South China Sea, China has constructed more than 3,200 acres of man-made islands dotted with numerous military facilities which are supported by high-tech sensors, airstrips for fighter aircraft, and long-range SAMs, see "The Japanese Air Force Needs an Upgrade (https://foreignpolicy.com/2019/03/18/the-japanese-air-force-needs-an-upgrade-f35-f22-china-fighter-jets-fifth-generation/)" by David A. Deptula, Foreign Policy, March 18 2019.

[35] The F-35's electronic warfare system is capable of jamming most known forms of radar and sensors, see "The F-35 Isn't Just 'Stealthy': Here's How Its Electronic Warfare System Gives It An Edge (https://www.forbes.com/sites/lorenthompson/2019/05/13/how-a-super-agile-electronic-warfare-system-makes-f-35-the-most-invincible-combat-aircraft-ever/#44b494304382)" by Loren Thompson, Forbes, May 13 2019.

[36] See comments by General David L. Goldfein (21st chief of staff of the USAF) on the J-20's RCS. Goldfein was cited in "The U.S. F-35 versus the PRC J-20 (https://www.realcleardefense.com/articles/2017/10/30/the_us_f-35_versus_the_prc_j-20_112550.html)" by Mark B. Schneider, Real Clear Defense, October 30, 2017.

[37] See "Japan reassures US on F-35 purchase despite crash (https://asia.nikkei.com/Politics/Japan-reassures-US-on-F-35-purchase-despite-crash2)" by Reiko Miki, Nikkei Asian Review, April 21 2019.

[38] Radar cross section measures the power dispersed in a given direction when radar illuminates a target. Basically, the smaller the radar cross section, the lower the detectability by radar, see Rajyalakshmi and Raju (2011).

[39] A JDAM is a formerly, unguided free-fall bomb that has been equipped with a guidance tail kit (comprising a navigational system and global positioning system), resulting in accurate and adverse weather "smart" munition. See here (https://www.military.com/equipment/joint-direct-attack-munition-jdam).
[40] Ibid.
[41] The F-35B's STOVL ability has also been tested under wet runway and 20 knot crosswind conditions. See here (https://www.f35.com/news/detail/f-35b-successfully-completes-wet-runway-and-crosswind-testing). Also see Heginbotham et al. (2015) p56 for details on conventional runways for fighters.
[42] See "Japan surges new weapons, military roles to meet China's rise (https://www.militarytimes.com/news/2019/01/15/japan-surges-new-weapons-military-roles-to-meet-chinas-rise/)" by Tara Copp, Military Times, January 15 2019.
[43] See "Navy Amphib Sails Through South China Sea with a Bunch of F-35s Aboard (https://www.military.com/daily-news/2019/04/05/navy-amphib-sails-through-south-china-sea-bunch-f-35s-aboard.html)" by Gina Harkins, Military.com, April 5 2019. The F-35B is also expected to be deployed onboard the United States Navy's larger Arleigh Burke guided-missile destroyers, See Majumdar (2018).
[44] See Schogol (2017).
[45] See Pickrell (2019).
[46] See "Congress Greases Flightpath for the F-35 Boondoggle (https://www.theamericanconservative.com/articles/congress-hypnotized-by-plane-that-cant-get-off-the-ground/)" by Dan Grazier, The American Conservative, July 17 2017.
[47] The F-35's expected overall programme costs of $1.5 trillion comprises servicing and maintenance costs over the jet's lifespan through 2070. See "US F-35 stealth fighters fly first-ever combat mission in Afghanistan (https://thedefensepost.com/2018/09/27/us-f-35-first-combat-mission-afghanistan/)".
[48] Friendly fire occurs when troops are fired upon by their own side in a war, resulting in harm and casualties. See "Friendly fire (https://www.collinsdictionary.com/dictionary/english/friendly-fire)".
[49] The F-35's software issues could prevent the verification of target coordinates in a weapon system. See "F-35: Still No Finish Line in Sight (https://www.pogo.org/investigation/2018/03/f-35-still-no-finish-line-in-sight/)" by Dan Grazier, Project on Government Oversight, March 19 2018.
[50] The accuracy of the F-35's gun has been detailed in the "FY 2018 report by the Office of the Director, Operational Test and Evaluation: FY18 DOD Programs, F-35 Joint Strike Fighter (https://www.dote.osd.mil/pub/reports/FY2018/pdf/dod/2018f35jsf.pdf)" p27. The presence of a gun pod does reduce the level of stealth in the F-35B, see "Air Force Presses Lockheed On F-35 Readiness: Lt. Gen. Bunch (https://breakingdefense.com/2019/02/air-force-presses-lockheed-on-f-35-lt-gen-bunch/)" by Colin Clark, Breaking Defense, February 1 2019.
[51] Justin Bronk, Research Fellow with the Royal United Services Institute for Defence and Security Studies, was cited in "Syria conflict: Why are air combat kills so rare? (https://www.bbc.com/news/world-40327934)" by David Molloy, BBC News, June 19 2017. Bronk argues that the era of the gun in modern aerial combat is over and the arbiter of

victory in such engagements would be high-tech sensors and missiles.
[52] See Lorell and Levaux (1998), p94 and 104 on the need to install guns on fighter aircraft.
[53] During the Korean War, the US Air Force destroyed between six and 10 enemy jets for every downed US aircraft in aerial engagements. But by the Vietnam War, the ratio was approximately two to one owing to the highly-manoeuvrable, gun-equipped MIGs, see "Why You Need to Respect the McDonnell Douglas F-4 Phantom II Fighter (https://nationalinterest.org/blog/buzz/why-you-need-respect-mcdonnell-douglas-f-4-phantom-ii-fighter-52862)" by Sebastien Roblin, The National Interest, April 17 2019. The F-4's weakness at short-ranges was overcome when subsequent versions of the F-4 started carrying the M-61 Vulcan Gatling gun (the F4E in August 1965), see Davies (2013) p12.
[54] See "Problem: China's J-20 Stealth Fighter Doesn't Have a Gun (https://nationalinterest.org/blog/buzz/problem-chinas-j-20-stealth-fighter-doesnt-have-gun-40402)" by David Axe, The National Interest, January 3 2019.
[55] See Majumdar (2017).
[56] See Kuschel (2002).
[57] An American F-117 was shot down by Serbian SAM operator, Zoltan Dani on 27 March 1999. See "Foes now friends: US stealth pilot and the Serb who shot him down (https://www.bbc.com/news/world-europe-20209770)" by Guy De Launey, BBC News, November 6 2012.
[58] See "Here's why the F-35 once lost to F-16s, and how it made a stunning comeback (https://www.businessinsider.com/f-35-vs-f-16-15-18-lost-beaten-flatley-comeback-2017-4)" by Alex Lockie, Business Insider, April 18 2017.
[59] G-force (gravitational forces) refers to the force impacting a body as a consequence of acceleration or gravity. 9G means nine times this gravitational force. Ali Venosa, Medical Daily (https://www.medicaldaily.com/breaking-point-whats-strongest-g-force-humans-can-tolerate-369246), January 14 2016. The F16 is capable of pulling negative 3Gs to positive 9Gs. See here (https://www.lockheedmartin.com/en-us/news/features/2018/the-thunderbirds-experience.html). Lockheed Martin states that its F-35 is a 9G capable fighter. See here (https://www.f35.com/about/variants/f35a).
[60] See Lockheed Martin (2019).
[61] See Yeo (2018).
[62] See Bjorkman (2014).
[63] The "F-35 friends' circle" is the label which China has given to its neighbours that have acquired the F-35 to counter its burgeoning airpower. This group includes Australia, Japan, South Korea and Singapore. See "Stealth Showdown: Could the F-35 Start a Deadly Arms Race in Asia? (https://nationalinterest.org/blog/buzz/stealth-showdown-could-f-35-start-deadly-arms-race-asia-42797)" by Charlie Gao, The National Interest, January 29 2019.
[64] The JASDF plans to equip its entire fleet of F-35As with the 'JSM', see "Kongsberg awarded contract to supply JSMs for Japanese F-35s (https://www.janes.com/article/87151/kongsberg-awarded-contract-to-supply-jsms-for-japanese-f-35s)" by Gabriel Dominguez, London and Kosuke Takahashi, Tokyo, Jane's Defence Weekly, March 12 2019. The 'JSM' has a range of 300 nautical miles (approximately 556 km),

see “Japan inks deal with Kongsberg for F-35 standoff missile (https://www.defensenews.com/air/2019/03/13/japan-inks-deal-with-kongsberg-for-f-35-standoff-missile/)” by Mike Yeo, Defense News, March 13 2019.

[65] China’s GB-6A subsonic stealth cruise missile, armed with a 500kg warhead, has a range of 500-600km and is effective against enemy bases and warships. See “Come look at China's coolest new missiles (https://www.popsci.com/chinas-new-missiles-zhuhai)” by Jeffrey Lin and P.W. Singer, Popular Science, November 6 2016.

[66] Red Flag exercises now include pilots from the UK, Australia, Italy, Saudi Arabia and Spain. See here (https://www.airforce-technology.com/news/us-uk-australia-exercise-red-flag-19-1/), here (https://theaviationist.com/2019/04/02/heres-what-three-italian-f-35-instructor-pilots-with-62nd-fs-have-to-say-about-their-first-red-flag-with-the-lightning-ii/) (David Cenciotti, The Aviationist, April 2 2019) and here (https://combataircraft.keypublishing.com/2017/03/07/spanish-eurofighters-on-red-flag/).

[67] See Jasper (2013), p43.