

Analysis of High-Cost Long-Term Defense Programs: A Case Study of the Joint Strike Fighter

Análisis de los Programas de Defensa a Largo Plazo y de Alto Costo: Un estudio de caso del Joint Strike Fighter

Abstract: The present paper discusses the decision-making process in defense acquisition and budgeting. While the budget for defense services and for defense in general usually presents itself as stable, the same is not true for specific programs. Certain programs reveal the political turmoil that underlies defense acquisition. This paper investigates why programs differ in terms of budget volatility and what are the main factors that drive it. To attain this purpose, our first topic is a theoretical debate about decision-making, its main actors, and the budgeting process. This is followed by a description of the United States budgeting process. The case of the Joint Strike Fighter is then studied. Complemented by literature on innovation processes, our last topic is dedicated to the following hypothesis: since the F-35 program presents itself as essentially stable in acquisition and budgeting terms, it is argued that what distinguishes it from volatile programs is its elite consensus and a suitable Defense Industrial Base. This model intends to shed light on high-cost, long-term defense programs and their volatility.

Keywords: Defense. Acquisition. Decision-Making. Budget. F-35.

Resumen: Este artículo discute el proceso de toma de decisiones en la adquisición y presupuestación de la defensa. Si bien el presupuesto para los servicios de defensa y para la defensa en general suele presentarse como estable, no ocurre lo mismo con los programas específicos. Ciertos programas revelan la confusión política subyacente a la adquisición de la defensa. Este artículo investiga por qué los programas difieren en términos de volatilidad presupuestaria y cuáles son los principales factores que la impulsan. Para lograr este propósito, nuestro primer tema es un debate teórico sobre la toma de decisiones, sus principales actores y el proceso presupuestario. A continuación se describe el proceso de presupuestación de los Estados Unidos. Posteriormente, se estudia el caso del *Joint Strike Fighter*. Complementado por la literatura de Innovación, el último tema de este trabajo está dedicado a las siguientes hipótesis: dado que el programa F-35 se presenta como esencialmente estable en términos de adquisición y presupuestación, se argumenta que lo que lo distingue de los programas volátiles es su consenso de élite y una Base Industrial de Defensa adecuada. Este modelo pretende aclarar los programas de defensa a largo plazo de alto costo y su volatilidad.

Palabras clave: Defensa. Adquisición. Toma de decisiones. Presupuesto. F-35.

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The victories and defeats, the compromises and the bargains, the realms of agreement and the spheres of conflict in regard to the role of national government in our society all appear in the budget. In the most integral sense the budget lies at the heart of the political process (Wildavsky, 1964. p. 5).

1 Introduction

This paper's general theme is decision-making in defense; more specifically, in the underlying process of defense acquisition programs. The geographical scope of the paper is the United States, with a specific focus on post-Cold War programs. Its main goal is to understand volatility and stability in these projects – i.e., how and why these characteristics vary from program to program. Why are some programs volatile and others stable? What are the main variables influencing the defense budgeting, procurement and acquisition process? What are the roles of the different actors involved in the decision-making of the acquisition process? Acquisition is a complex process that depends on the interaction of multiple actors whose relationships have a bearing on the final result. In any case, the hypothesis of this paper is that *elite consensus* and the qualities of the Defense Industry are key variables for the understanding of volatility.

This paper also seeks to explain the budgeting, procurement and acquisition process for concrete defense programs. To this end, it discusses the specific case of the Joint Strike Fighter program. Defense budget in the United States is highly important because of its scope, supported by the jobs and taxes of millions. It is also extremely important for the country's economy. The defense budget and its distribution across different programs is the material core of the country's geopolitical strategy. It has powerful military consequences, as it can determine who lives and who dies. The decision to cut spending on radars, for example, may cost lives.

The methodology employed here is a combination of literature review, data analysis and case study. The F-35 case study will be approached from a *process-tracing* perspective¹. Although single-case studies have weaknesses in regards to their potential for generalization, details revealed by the process-tracing methodology can bring up good insights for further research, hypothesis testing and theory building.

In order to accomplish the paper's objectives and address its main research problems, this article starts by reviewing the state-of-the-art in research on the budgeting processes and actors involved in defense decision-making. The second section corresponds to the case study, exploring and analyzing the F-35 program, its evolution, and issues. Finally, the final section aims to combine insights from the

¹ The case-Study and process-tracing methodologies used in this paper are based on the works of Levy (2007); Gerring (2004); Silva e Cunha (2017).

theoretical debate with collected data, so as to explain the phenomena of volatility and stability in defense programs.

2 Budget Process-Tracing

The purpose of this section is to investigate the Budget Process underlying defense acquisition and appropriation in the United States. These are extremely important and complex budgetary components, and their implications range from ensuring jobs to political constituencies to the achievement of overarching strategic goals. In the first part, we discuss some theories and authors concerned with defense decision-making in general. The state-of-the-art research provides meaningful insights about decisive actors of the budget, appropriation and acquisition process. In the second part, this process will be described focusing mainly on program acquisitions, the scope of this article. This descriptive work will be complemented by some problematic questions, in order to advance this paper's objective.

2.1 Some Considerations on Incrementalism

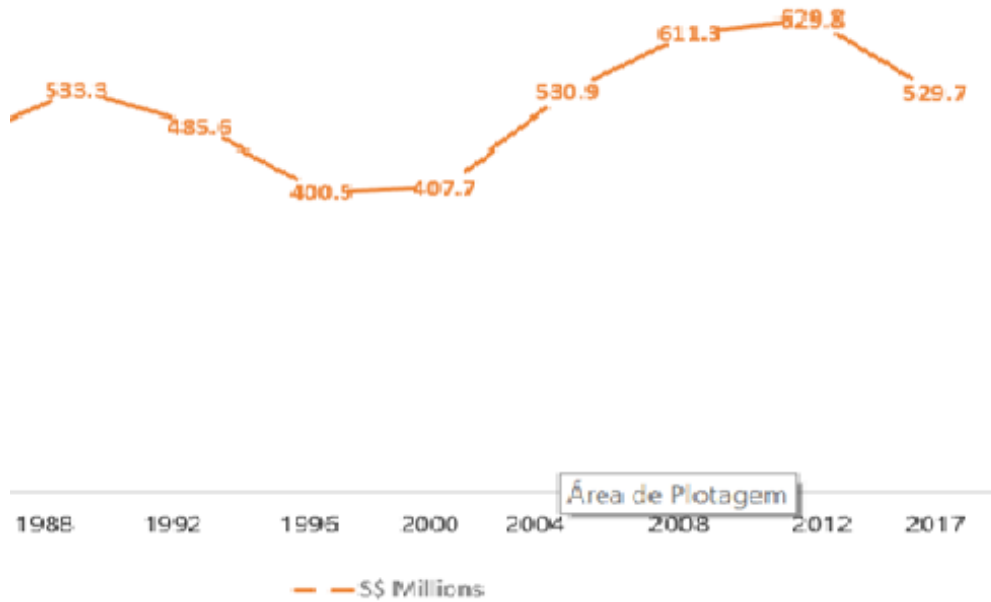
The predominant theory in budgeting is the Incremental Theory, put forward by Aaron Wildavsky (1964). According to this theory, one year's budget is always very similar to that of the previous Fiscal Year (FY), small upward or downward adjustments notwithstanding. For the author, this is a typical feature of wealthy nations, with their stable economies and considerable fiscal power. The main argument supporting Wildavsky's and Dempster's work with Incremental Theory² is that relative budget stability stems from the fact that individuals face hard trade-offs in the decision-making process. Budgetary decision-makers must rely on last year's budget, as management and administration processes allow no time for the budget-building process to begin all over again, every year, with all possible alternatives being reconsidered. This results in a kind of bureaucratic inertia. In the 1980s, decrementalism, a notion put forward by Allen Schick, supplemented Incremental Theory, arguing that budget cuts would generate great instability and conflict. Completing these theoretical insights, Herbert Simon's (1945) "boundedly rational" analysis demonstrated that decision-makers take shortcuts and simply cannot act in a strictly rational manner (i.e., in a manner that takes into account all possible outcomes of a decision).

Jones and Baumgartner (2005) argue that Incremental Theory is usually precise, although in cases of dramatic changes – due to political instability or external events, for instance – its explanatory power can leave something to be desired. In the case of defense politics, this argument is empirically verifiable: threat-driven wars, innovation and emulation processes tend to disrupt budgetary inertia. There are scarce studies specifically dedicated to analyzing the defense budget in these terms³, so this issue is discussed below.

2 For insightful critiques of incrementalism in budgeting, see Wanat (1974), and LeLoup (1978).

3 See, for example, Kanter (1975), Schick (1983), and Korb (1977).

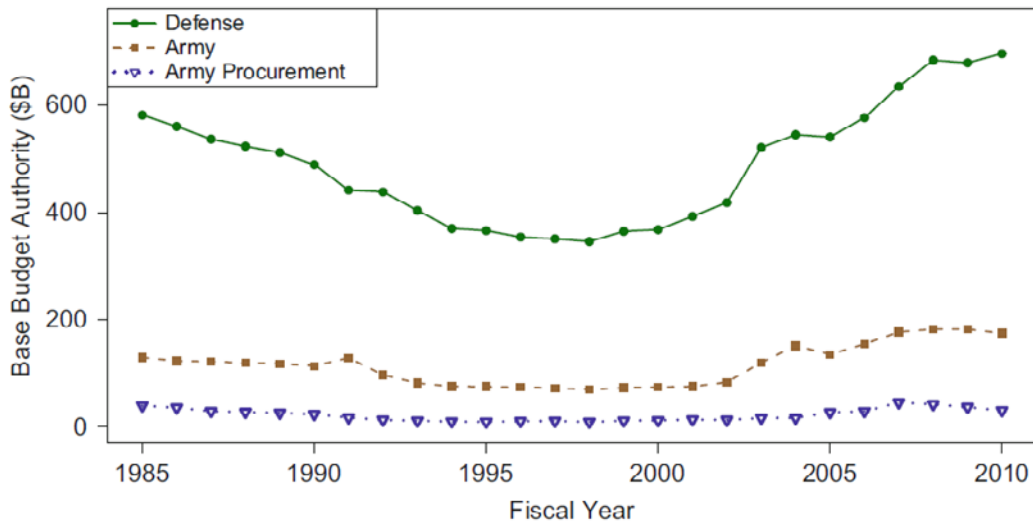
Graph 1 – Variation in Military Expenditure (1988-2017) Constant 2009 (US\$)



Source: Stockholm International Peace Research Institute (2018).

Graph 2 – Incremental Theory

Stability in Aggregate Defense Budgeting, 1985-2010



Source: Demarest (2017, p. 75).

As both graphs indicate, Incremental Theory is right when it comes to the overall, service-level, and procurement fractions of the defense budget. Jones and Baumgartner (2005) are also correct, since both the War on Terror and Reagan’s anti-Soviet military build-up in the 1980s effectively interrupted Incremental budgetary modifications.

Demarest (2017) argues that while aggregate budgets, defense budgets and service budgets are all incremental, *program funding is not*. Since this paper is concerned with long-term programs, this theory will be further explored in our discussion of the Joint Strike Fighter program, even though Demarest (2017) has already collected evidence to strongly substantiate this statement. Other authors, such as the proponents of the Military-Industrial-Complex approach, identify determinant actors in budgetary fluctuation and outcome. The next section will explore the literature regarding the main actors that can influence acquisition, budget and appropriation.

2.1.1 *The main actors*

One issue of foreign policy decision-making theories is that each author identifies different main variables as decision determinants. Valerie Hudson (2014, p. 11), for example, sorts out three main variables defining foreign policy: the actor's interests; domestic institutions and the distribution of information between actors. Hellen Milner, Alex Mintz and Karl de Rouen, on the other hand, have overlapping, but distinct defining variables for decision-making⁴. Although all these variables may be important, this study focuses on the ones we regard as most directly linked to defense program acquisition and budgeting.

The literature identifies some main actors who have a bearing on foreign policy and defense decision-making processes in general, and specifically on budgeting. These are: the President; the National Security Establishment; Bureaucracy; Congress; and the Defense Industry. This section briefly discusses some of the literature's insights in order to scrutinize some of its conclusions.

Hilsman (1987) argues that the President does in fact have great power. The author claims that this figure's power is derived from constitutional authority, from the right to participate in the legislative process, and from its distinguished role in foreign policy and defense as the protector of the sovereign nation-state. Reputation and prestige as well as media attention are also great sources of power for the presidency. But Hilsman cautions that the person of the president, his political skills and uniqueness may be decisive when dealing with a strong opposition. Sarkesien, Williams and Cimbala (2013, p. 128-129) also investigate the powers of the presidential person and office, as well as the National Security Establishment. Their conclusion, however, is more nuanced. The President, in order to succeed, has to have a skillfully established and understanding relationship with both the National Security Establishment and Congress. This would depend on a number of factors, such as the president's personality and leadership style. To stay in power and achieve National Security Goals, the president has to deal a number of constraints. Fichel (2017, p. 45-47) studies the National Security policy community, such as the National Security Council (NSC). He argues that there is a complex policy-implementation structure in service of the executive branch, which is enabled and constrained by legislation, bureaucratic structure and by the degree of resources allowed by Congress.

4 For Hellen Milner (2015) The President is constrained by: a) public opinion; b) governmental agencies; c) Congress; d) interest groups; e) partisanship opposition. Alex Mintz and Karl de Rouen (2010, p. 130) identify five determinants for foreign policy: a) the economic environment; b) economic interests; c) public opinion; d) electoral cycles; e) two-level games.

As for bureaucracy, Hilsman (1987, p. 179) argues that bureaucrats are power centers⁵. Their power is based on division of labor and regulations. They are quite independent, and act as legislators and innovators. Bureaucrats have long-term careers in the Department of Defense, the Central Intelligence Agency, Congress and other niches of power. Some are appointed by the President, so, in Hilsman's view, they share a portion of overall power as a middle ground in the structure of decision-making. Disagreeing with some authors, Hilsman (1987, p. 178) points out that congressional power is limited, since it is only effective if shared with the Presidency and the bureaucratic establishment. The author does recognize, however, that the United States Congress is more powerful than its counterparts in other democracies, since it truly legislates.

The Defense Industry is a more controversial actor. Proponents of the Military-Industrial-Complex approach (MILLS, 2010; GHOLZ, SAPOLSKY, 2006) argue that the behemoth military industries of today have a tremendous amount of power over decision-making. Other authors like Demerast (2017) argue that funding volatility is insensitive to contractors' needs. In any case, we must acknowledge that, in the US and worldwide, defense industry companies are some of the biggest and most profitable enterprises. We must not overvalue or undervalue their influence.

The purpose of this section was to discuss some of the main actors influencing decision-making processes and defense politics in their interaction with the budget cycle. This discussion will be revisited further along in the article, as our analysis develops.

2.2 The US Defense Budget Cycle

As mentioned above, the US budget process is tremendously complex, involving multiple actors and affecting the lives of millions of people. The defense budget is even more difficult to analyze: besides being the source of the lion's share of defense agencies' funding, it has the unique characteristic of being discussed during six-year plans elaborated ahead of schedule by the Pentagon. This is because large procurement programs are complex and hard to develop, both from a technical and political standpoint.

The present section discusses the acquisition, budget and appropriation process within Defense planning and execution. To fulfill this task, we rely on the work by Demarest (2017), as well as supplementary authors and data, to try to summarize and simplify this process. In the Army alone, around 300 hundred programs are evaluated every single year by the Pentagon and by the Congress (DEMAREST, 2017). To understand how a single project is developed in the long run, this section first approaches the process that begins with conceptualization and ends with delivery (military use) of the program in the Pentagon. Subsequently, we seek to understand the budget cycle in the context of the Congress. This section is mainly descriptive, but may provide fruitful insights for further investigations.

5 Graham Allison and Philip Zelikow (1999) propose a theory of decision-making based on an understanding of bureaucracy.

2.2.1 The Pentagon Acquisition process

The Pentagon acquisition process is inherently protracted and complex. The institutions involved in this work are highly regulated, and military certification requirements are heavily audited. From start to finish, the delivery of a single program can take an average of 8 to 12 years. The long duration of this cycle is a matter for debate. The Pentagon's task is to translate the president's National Security Strategy (NSS)⁶ to a highly detailed and cost-effective spending strategy, with all expenditures being tactically and technically justified. However, as argued by Demarest (2017, p. 32) "translating text like 'promoting a just and sustainable international order' into a specific number of Javelin missiles is very hard, and subject to interpretation."

Funding categories include: operations and maintenance (OMA), military personnel, procurement, research, development, testing and evaluation (RDTE), and military construction. This article will focus mostly on procurement and RDTE, with some considerations on OMA, since it directly pertains the Joint Strike Fighter program and other similar large-scale programs. This categorical division, however, entails an empirical obstacle for the analysis of single programs, since most data are organized according to the abovementioned categories, rarely delving into individual program spending.

Until the end of World War II, each of the Armed Forces services had almost complete control of the acquisition process. In 1947, however, the National Security Act attempted to transfer the coordination of all acquisition activities and services to the Department of Defense. It was not until 1971 that Deputy Secretary of Defense David Packard restructured the system, so as to prevent corruption and abuse. Most defense acquisition policies still reflect Packard's original principles (FERRARA, 1996, p. 113-115).

There are four main steps in the defense acquisition process: Material Development Decision, followed by Milestones A, B, and C. The first step is the genesis of a program, providing the military with the authority to investigate current capability and initiate acquisition activities⁷. A small group of companies are then called in to propose ideas, in order to encourage competition (DEMAREST, 2017, p. 40). However, the program is only effectively initiated after Milestone B is reached. In this step, preliminary tests are held by the military and closely watched by Congress and the Defense Industry. If these tests are successful, the program reaches solid status. By Milestone C, the

6 The National Security Strategies are available from: <http://nssarchive.us/>. Access: Jan. 1, 2019.

7 Demarest (2017, p. 38) explains that "programs belong to one of three Department of Defense acquisition categories (ACAT), mostly based on dollar value. ACAT I programs are classified as major defense acquisition programs, and typically include large, expensive equipment like the M1 Abrams tank and the Stryker, or programs requiring sophisticated information technology."

program is no longer entirely within RDTE; procurement begins as well as a low-rate initial production. If, after these steps, the program is approved by Congress and by the Secretary of Defense, it can finally enter the full-rate production and deployment phase, which leads to final delivery.

The Pentagon's acquisition process is overlapped by the annual process of *budgeting*. The Pentagon is expected to deliver a Budget Request to be signed by the president and then sent to Congress by the first Monday of February of every FY. This procedure is guided by the Planning, Programming, Budgeting, and Execution System (PPBE), developed by Secretary of Defense Robert McNamara in 1961 (ADAMS; WILLIAMS, 2010; MCCAFFERY; JONES, 2004; SAPOLSKY; GHOLZ; TALMADGE, 2009).

Several important actors are involved in the PPBE process, which will be explored in greater detail later. *Planning*, for instance, is essentially the translation of the President's National Security Strategy into military language by the Joint Chief of Staff (JCS). The result is the National Military Strategy, a more in-depth strategic military document. Meanwhile, the Defense Planning and Programming Guidance (DPPG), issued by the Secretary of Defense, establishes the topline for each service, as an amount of the budget's ceiling (DEMAREST, 2017, p. 2017).

In the *Programming* phase, the Army, Navy and Air Force prepare their budget requests and submit them to the Secretary of Defense. This happens in August of each FY⁸. The proposals are analyzed by the JCS and by the Secretary of Defense, who make recommendations. Afterwards, the Deputy Secretary of Defense tries to contemplate these recommendations, and prepares the Program Decision Memorandum by approximately November of the FY. During the *budgeting phase*, this document is altered to conform to requests by the Office of Management and Budget, and then incorporated to the President's federal budget request. The *Execution* phase was instituted by Secretary of Defense Donald Rumsfeld in 2003, obligating the Pentagon to monitor spending and return unspent money to the Treasury.

2.2.2 Congressional appropriation disputes

The Congress' FY budgeting and appropriation cycle overlaps with the Pentagon's acquisition and budgeting process. The relationship between the two is dynamic, intense and usually conflictive. Some variables that can influence the process are constituency, partisanship, lobbying and the actions of key members of the committees who hold the most influent in Capitol Hill politics.

8 A service's budget request is called a Program Objective Memorandum, or POM. The POM includes funding of up to six years for every program the service believes necessary to provide a capability for countering the threats enumerated in the planning documents (DEMAREST, 2017, p. 52).

Chart 1 – The Defense FY Budget Process

DoD	Execution	Execution/ DASC's Paredes	Execution	Execution
DoD (Simultaneously)	<i>Planning</i>	<i>Planning</i>	<i>Programming</i>	<i>Budgeting</i>
Congress	Budget Arrives on Capitol Hill	<i>HASC/SASC</i>	<i>HAD-D/SAC-D CDA</i>	Congress votes Bill
FY	Jan Feb Mar	Apr. May Jun	Jul Aug Sep	Oct Nov Dec

Source: The Author (2019).

Chart 1 illustrates, in a very schematic manner, the process overlaps between Congressional and Department of Defense (DoD) FY activities regarding budgeting, acquisition and appropriation. The President's budget arrives on Capitol Hill on the first Monday of every February, every FY.

The first committees to analyze the proposal are the House Armed Services Committee (HASC) and the Senate Armed Services Committee (SASC). The professional staff of the HASC reviews the budget in order to make adjustments. By May, their work is usually complete. The HASC has about 40 professional staff members. The SASC has to make do with only 13. It delivers its remarks in June. Both committees are functionally authoritative, and they prepare a document known as the "National Defense Authorization Act." These bodies are responsible for reviewing and discussing the budget, and are in constant contact with members of Congress for advising them and preparing them for hearings on significant budgetary items (DEMAREST, 2017). The Congressional Budget Office (CBO), meanwhile, also has an important role in this process. Every FY, it prepares detailed analyses of the military's long-term plans, in form of published documents⁹ entitled "The Long-Term Implications of Current Defense Plans."

While the HASC and SASC are elaborating their remarks and the National Defense Authorization Act, the Pentagon, through its Department of the Army Systems Coordinators, or DASCs – which directly represent the program manager inside the Pentagon – remain in constant contact with the committee's members, answering to their questions and presenting their arguments. Other important actors in the process within the Pentagon are the G-3, the G-8 and the ASA(ALT), as explained by Demarest (2017, p. 61):

⁹ These documents are available from: <https://www.cbo.gov/topics/defense-and-national-security/defense-budget>. Access: 1 Jan. 2018.

The G-3, G-8, and ASA(ALT) are the Army's three primary decision-making organizations on questions of funding priorities in the Army's budget. The G-3, or operations directorate, manages requirements. Remember, a capability cannot be developed by the acquisition system without first meeting a valid requirement. The G-3 vets requirements from units and adjudicates their validity. The G-8, or resource management directorate, is responsible for prioritizing resources [...] ASA(ALT), or the office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology, is primarily responsible for the acquisition cycle. The triduum is exceptionally important in the Army's internal budget process, but can also affect congressional funding decisions. Occasionally, representatives from each of the three organizations will brief congressional staffers on particular programs. If the Army's position is not uniform, the congressional staffer will easily detect incongruence and the program becomes more susceptible to shifts in funding.

The authorization issued by the SASC and the HASC is not mandatory for the appropriation process or for budgeting, but their remarks are taken very seriously by the appropriators, the House Appropriation Subcommittee for Defense (HAC-D), and the Senate Appropriation Subcommittee for Defense (SAC-D). These members of Congress have one of the most prestigious tasks in all public policy. The HAC-D has 14 professional staffers, while the SAC-D has 12 (DEMAREST, 2017, p. 57). Richard Fenno (1973, p. 2) argues that the Appropriations Committee is the most powerful and most important of all committees. But they are not all powerful, nor strictly what George Tsebelis (2002) would refer as "veto players." There are twelve separate subcommittees which have to reconcile for an appropriation to happen. The HAC-D and the SAC-D publish their remarks between July and August, which, according to Demarest (2017, p. 58), results in changes to over 40 percent of the Pentagon's programs, usually through earmarks¹⁰ in the final conference on the Defense Appropriations Act, held in August or September. The Bill is finally voted by Congress before the new FY in October 1st, and sent to the White House to be signed by the President.

As expected, the DoD is highly active during this process. Through presentations, hearings, and constant bargaining and discussion, the Pentagon lobbies Congress mainly through its Chief Legislative Liaison (OCLL), the program's manager, or its Senior Army Leaders. The OCLL is headed by a two-star general and lobbies the Appropriation Committee through the Budget Liaison Office (SAFM-BUL), which employs eight officers. The legislative liaison officers are expected to provide interface between the committee's staff and the Armed Forces. When Congress asks for information regarding programs, they are expected to provide it. The program managers are expected to know detailed information regarding a program and are in close interaction with the respective contractor companies. As for Senior Defense Leaders, in the case of the Army, for example:

¹⁰ Earmarks are provisions inserted into a discretionary spending appropriations bill that directs funds to a specific recipient.

Senior Army leaders include four-star general officers and civilians of equivalent rank in the Army headquarters. These individuals often engage directly with members of Congress and professional committee staffs. “If the Vice Chief of Staff of the Army cares enough to leave his office and go up to the Hill to deliver a message, they’ll listen,” explained one liaison officer (DEMAREST, 2017, p. 60).

As we have previously mentioned, other actors can be highly influential throughout this process. The most obvious is the Defense Industry, who relies on profits that stem mainly from governmental acquisition contracts. These companies engage in anticipated and fierce competition to develop technology and meet the requirements of the DoD. Their professional lobbyists are stationed in Washington to provide members of Congress with information about projects and capabilities¹¹. The media, through papers and specialized “think tanks,” can have a considerable influence over the Congress, since they mobilize public opinion and provide information to decision-makers.

The purpose of this section was to describe the acquisition, budgeting and appropriation process within and between the Pentagon and Congress. Other actors were also seen to be influential. In the next topic, the paper will analyze the Joint Strike Fighter program, from its origins and conceptualization to its testing and delivery.

3 The Joint Strike Fighter Program: Conception, Development and Procurement

This section discusses the Joint Strike Fighter Program (JSF), understood as a case study of what we have discussed so far. To this end, we investigate the technical needs and political motivations that gave birth to the JSF. Afterwards, we briefly analyze the F-35, the JSF final product, its costs and technical and tactical justifications. Finally, we discuss the turmoil generated by concerns from important political actors regarding the program. As technological details are outside the scope of this paper, greater attention will be given to the political process.

3.1 The origins of the Joint Strike Fighter

The Joint Strike Fighter Program was conceived as an affordable fifth-generation aircraft for the Air Force and the Navy^{12,13}. The Program was mandated by Congress to

11 For a significant collection of defense industry information and discussion of the difficulties of soliciting information from defense contractors, see Adams (1981).

12 Strike fighters are dual-role tactical aircraft capable of both air-to-ground (strike) and air-to-air (fighter) combat operations.

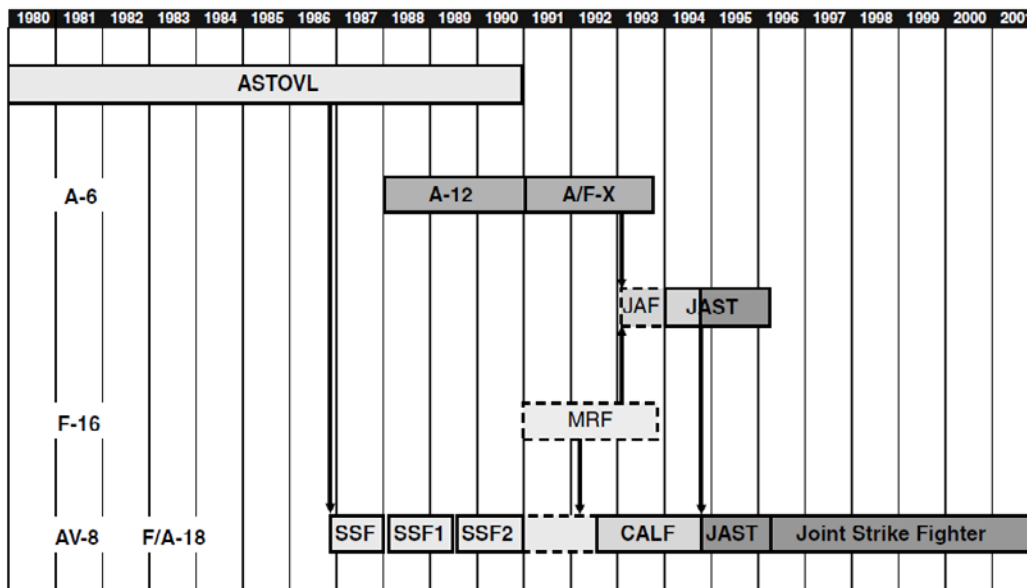
13 “Fifth-generation” aircraft incorporate the most modern technology, and are generally considered to be more capable than earlier-generation aircraft. Fifth-generation fighters combine new developments such as thrust vectoring, composite materials, stealth technology, advanced radar and sensors, and integrated avionics to greatly improve pilot situational awareness. Among fighters currently in service or in regular production, only the Air Force F-22 air superiority fighter and the F-35 are considered fifth-generation aircraft. Russia and China have flown prototype fifth-generation fighters with the ability to go supersonic for short periods, as well as advanced stealth characteristics (GERTLER, 2018, p. 1).

spearhead the Marine Corp’s effort to replace its AV-8B Harrier. This would avoid greater development and defense-budget procurement costs. A brief history of the program’s origins is presented below.

The origins of the JSF can be traced back to the Cold War. Knowing that fourth-generation fighters (Air Force F-16 Falcon, U.S. Marine Corps AV-8B Harrier, and U.S. Navy F/A-18 Hornet) would have to be replaced, each of the services began developing programs for a fifth-generation replacement aircraft. Budget constraints meant that there was not enough money to fund three separate programs. At the time, the technical challenge of developing a supersonic, vertical takeoff and landing (VTOL) aircraft was also a huge constraint.

Programs in the 1970s were unsuccessful in developing supersonic fighter jets. VTOL aircrafts like the AV-8 tested by the Navy in the 1980s had no supersonic capabilities. Lockheed Martin’s SkunkWorks was already involved in the process. Working with NASA and the Defense Advanced Research Projects Agency (DARPA), the company tried to meet the challenge of developing an aircraft whose engine could provide enough vertical thrust for short takeoffs and vertical landings while remaining small enough to avoid excessive supersonic drag (BEVILAQUA, 2009, p. 1826-1827). They came up with the dual-cycle operation propulsion system, which would become the cornerstone of the future F-35.

Figure 1 – The History of the Joint Strike Fighter



Source: Bevilaqua (2009, p. 1833).

The concept of the new propulsion system was developed by SkunkWorks and DARPA throughout the late 1980s. These two organizations continuously briefed both the Pentagon and the U.S Congressional budget committees in order

to secure funding for the program. At first glance, the Air force appeared to lack interest in the ASTOVL, as it was developing its own aircraft, a conventional takeoff and landing (CTOL) MultiRole Fighter (MRF). DARPA lobbied high officials in the Pentagon and in 1992 convinced it to begin a STOVL/ CTOL Strike Fighter Program (JAST), with an initial appropriation of US\$ 65 million by the Congress (BEVILAQUA, 2009, p. 1833).

In March 1994, the Congress appropriated US\$ 6 million for the development of the STOVL and cruise project, followed by an additional US\$ 10 million in the next year. Boeing entered the competition by matching the money with its own resources. The program was still incipient, but its prospects were great as the results of the President Clinton's Bottom-up Review Strategy

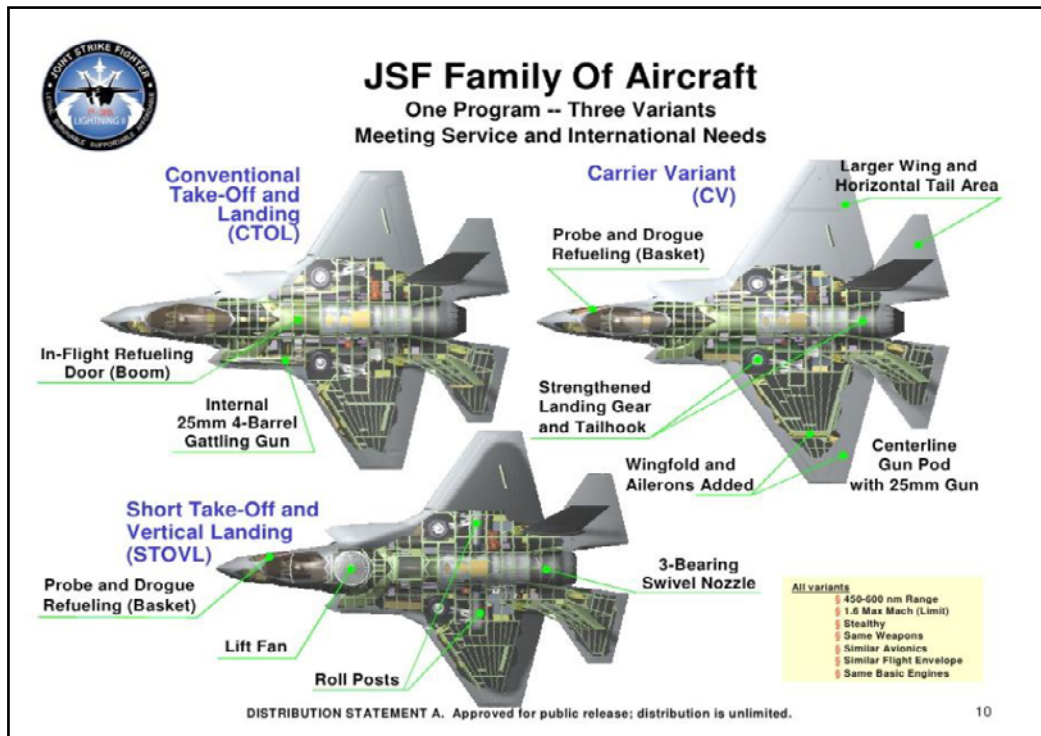
... were announced in September 1993. It was decided to cancel the MRF and A/F-X programs and to develop technologies for a Joint Attack Fighter that would replace the AV-8, F-16, and F-18 when they were retired beginning in 2010 .. Undersecretary of Defense for Acquisition and Technology Paul Kaminski changed the program to an acquisition category 1D program and renamed it the Joint Strike Fighter program, reflecting the greater scope and cost of the next phase of development and making it clear to U.S. Congress that JSF was an aircraft development program. In November 1996, Boeing and Lockheed Martin were selected to build concept demonstrator aircraft (BEVILAQUA, 2009, p. 1833).

The proposals were submitted in February 2001, and in October 2001, the JSF Program Office announced Lockheed Martin as the winner of the competition. The JSF program entered the system development and demonstration (SDD) phase, with SDD contracts awarded to Lockheed Martin for building the aircraft and to Pratt and Whitney for building the aircraft's engine (GERTLER, 2018, p. 11). By February 2006, the first Air Force F-35-A (named by Lockheed within its F-35 Lightning II Program) was rolled out of the factory; it was flown in December 2006. The STOVL F-35-B made its first flight in 2008. According to Bevilaqua (2009, p. 1836), the JSF "will achieve significant saving in aircraft production and life cycle costs ... All of the JSF variants have essentially the same airframe, engine, avionics and subsystems."

3.2 The F-35

The F-35 is the result of the Joint Strike Fighter program. As a multi-service jet, it has three versions: The F-35-A, a conventional takeoff and landing (CTOL) version for the Air Force; the F-35-B, a short take-off and vertical landing version (STOVL); and the F-35-C, a carrier-suitable CTOL version.

Figure 2- The Joint Strike Fighter's aircrafts



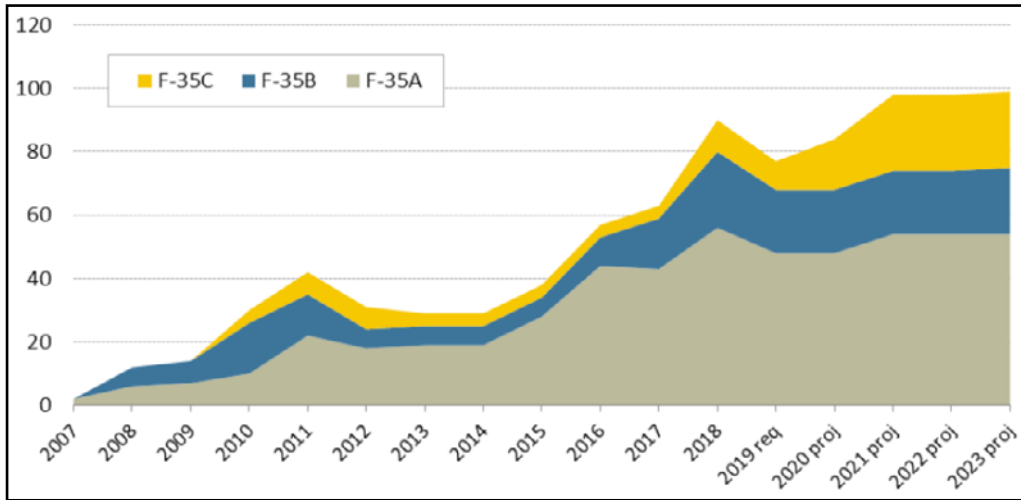
Source: Gertler (2018, p. 2).

According to Gertler (2018, p. 3), the Air Force plans to acquire 1,763 F-35-As to replace their F-16 fighters, A-10 attack aircraft, and possibly their F-15 fighters. The F-35-A is not as stealthy or as capable in air-to-air combat as the F-22, but it is designed to be more capable in air-to-ground combat than the F-22, and stealthier than the F-16 (TRIMBLE, 2010). Stealthy aircrafts are designed with reduced radar signature, using special coatings and gap sealing. Stealth technology also reduces the aircraft's signature in other aspects, such as engine heat, electromagnetic emissions, and emissions from radars or communications. All these features compound to make it very difficult for the enemy to detect these aircraft.

Gertler (2018, p. 3-4) points out that the Marine Corps plans to procure 353 F-35-Bs, to replace their AV-8B Harrier vertical/short take-off and landing attack aircraft and their F/A-18A/B/C/D strike fighters, which are CTOL aircraft. The Marine Corp's purpose with these acquisitions is to support the Marine Air Ground Task Force. The Marines also plan to acquire 67 F35-Cs. As for the Navy, it plans to procure 273 F-35-Cs, to operate carrier air wings combining the F-35-Cs with the fourth-generation F/A-18E/Fs.

The F-35 engine is the Pratt & Whitney F135. It is produced in East Hartford, Middletown, CT. Another company involved is Rolls-Royce, which builds the vertical lift system for the F-35, subcontracting for Pratt & Whitey. The F35 is currently in low-rate initial production, with 280 aircraft delivered as of April 2018 (GERTLER, 2018, p. 5).

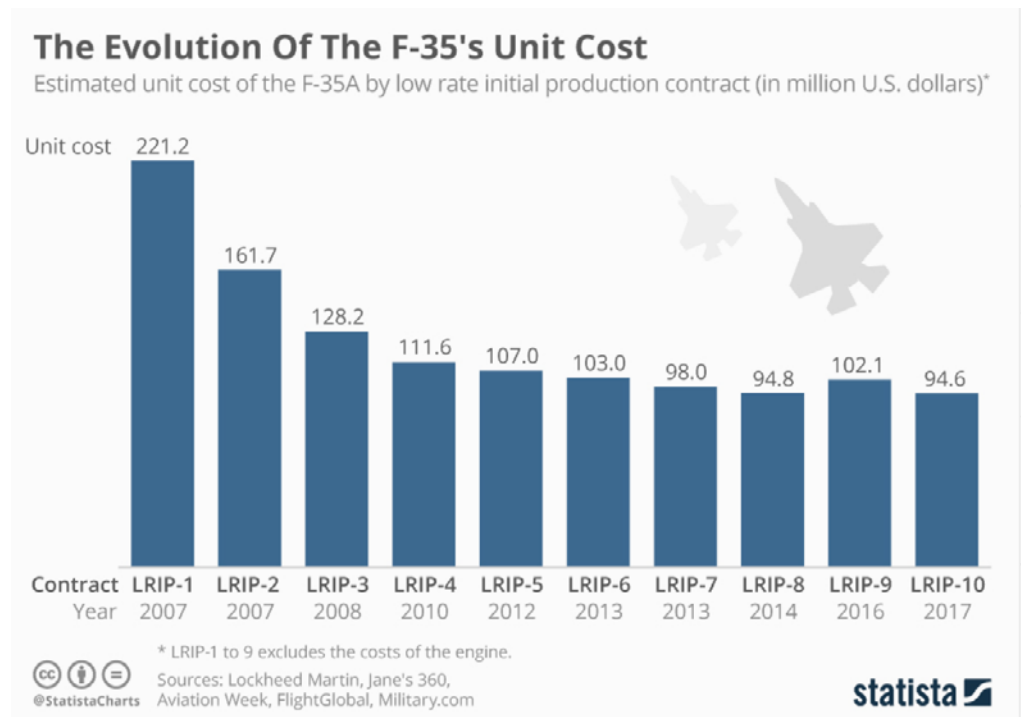
Graph 3 – Procurement Quantities



Source: Gertler (2018, p. 15).

In total, the procurement of 2,456 aircraft for the Air Force, Marines and the Navy is estimated. Among these, 13 are meant for research and development and 2,443 are production aircraft. The procurement began in FY 2007 (cf. UNITED STATES, 2018). Graph 3 shows the procurement quantities since then, and the projected procurement for the following FYs.

Graph 4 – F-35 Unit Cost



Source: McCarthy (2018).

As seen in Graph 4, the unit cost of the F-35 has experienced a dramatic decrease, with a subsequent stabilization. The decrease is expected, given production scale and productivity gains. Stabilization, however, demands more attention. The total estimated acquisition cost of the F-35 (in FY 2012 dollars) was about US\$ 325 billion (GERTLER, 2018, p. 21). The biggest cost concern is sustainment. The F-35 fleet's lifecycle sustainment costs have been estimated at more than US\$ 1 trillion (CAPACCIO, 2018). The cost of units, the program and its sustainment have been a matter of great intrigue between Lockheed Martin and the government, as we will see in the next section. Other issues regarding F-35-related political constraints are also relevant, and will be highlighted below.

3.3 Concerns and disputes regarding the program

Although the F-35 program appears unequivocally successful, it has not been immune to the political turmoil of budget and acquisition. Uncertainties regarding technical capabilities, costs, competition, possible block buys and contracts have been part of the F-35 program's trajectory so far. This section explores these disputes.

The first signs of problem arose in 2010. The DoD demanded a 13-month delay of the SDD phase, and withheld US\$ 614 million from contractors, arguing poor performance. On March, the DoD announced that the JSF had exceeded the cost specified in the Nunn-McCurdy cost containment law¹⁴. This required the Secretary of Defense to notify Congress of the breach and to "present a plan to correct the program and to certify that the program is essential to national security before it can continue" (GERTLER, 2018, p. 12). In 2012, other problems emerged as the F-35 procurement was stretched (Graph 3) beyond FY 2017. This process allowed the Treasury to save US\$ 15 billion.

Another issue that concerns the government are additional upgrades made by the contractor, since these can significantly increase final cost. The Government Accountability Office questioned the DoD's ability to sustain the F-35 program, given the required budgets. Even if it is already in production, the aircraft is still subject to testing and revision. These revisions might cause cost uptakes not included in the lot's negotiated price. Long-term sustainment conjectures must include inflation, labor costs, fuel costs and other factors outside the program's control. Conflict is almost inevitable.

An important congressional concern regards the development of the F-35 Block 4 software, part of an effort now known as Continuous Capability Development and Delivery (C2D2), expected to cost as much as US\$ 10.8 billion over the next six years (GERTLER, 2018, p. 31). For regulation purposes, Congress demands the program's upgrade from a traditional procurement program to a Major Defense Acquisition Program (MDAP) (INSINNA, 2016), which would entail much stricter auditing rules. Although the F-35 has evolved together with its budget, Congress remains unsure:

¹⁴ For a history of the Nunn-McCurdy law and a discussion on its future possibilities, see Schwartz and O'Connor (2016).

The F-35's cutting-edge capabilities are accompanied by significant costs. Some analysts have suggested that upgrading existing aircraft might offer sufficient capability at a lower cost, and that such an approach makes more sense in a budget-constrained environment. Others have produced or endorsed studies proposing a mix of F-35s and upgraded older platforms; yet others have called for terminating the F-35 program entirely. Congress has considered the requirement for F-35s on many occasions and has held hearings, revised funding, and added oversight language to defense bills (GERTLER, 2018, p. 30).

A major concern for Congress and for the United States in general reflects the manner in which defense contracts have been rewarded. Competition during the initial phases stimulated the development of the F-35 alternate engine program. Since there are few sources of supply available for high-technology systems, Congress is discussing maintaining competition while the procurements are still in progress. The F-35's high-cost sustainment issue, for example, could inspire Congress to open sustainment to competition. In the same direction, there are worries about Boeing losing its ability to continue its R&D programs after missing such a big contract, raising questions about the United States Defense Industrial Base. Since foreign companies are allowed¹⁵ to participate in the F-35 program, another issue regarding the industrial base are the impacts caused by this type of competition.

So far, this paper has discussed some of the literature's contributions to the understanding of the decision-making process underlying defense projects and budgeting. Specifically, the F-35 program was discussed, from the origins of the aircraft's concept to its procurement phase. Some issues regarding costs and other political constraints affecting the F-35 were also discussed. In the next topic, this study attempts to establish a relationship between theoretical debates on this subject and this article's case study of the Joint Strike Fighter. In order to do so, we will approach some variables and documents regarding the JSF as a whole. Finally, in the conclusion, we question whether high-cost long-term budgeting in defense projects is stable or volatile. To this end, we bring up other examples besides the F-35. Moreover, we attempt to identify what are the key variables that generate a stable or volatile long-term high-cost program.

4 Acquisition and Budget for long-term Procurement Defense Programs

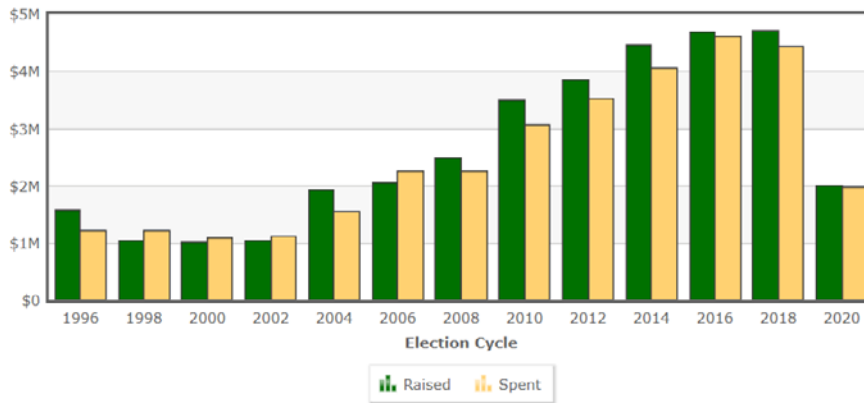
This last topic interconnects the previous two. It discusses the F-35 program in light of insights provided by the state-of-the-art research on the budgeting, acquisition and procurement process. In order to do so, we first discuss some key actors, using the F-35 case study to raise important issues regarding the main features of long-term budget defense programs.

¹⁵ The JSF is a joint effort of the United States with the United Kingdom, Italy, Netherlands, Canada, Denmark, Norway, Turkey, Israel and Singapore. Exports have been made to Japan and South Korea. This paper focuses only on the United States.

4.1 Defense Industry, Congress and the establishment of the long-term budget

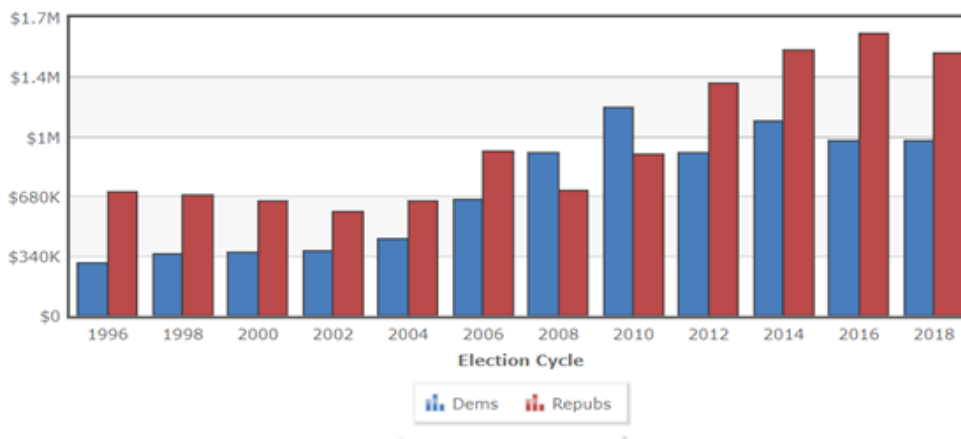
Lockheed Martin Corp. is the world’s largest defense company, with approximately 100 thousand employees and a total net worth of US\$ 100 billion (2018) (LOCKHEED MARTIN NET..., 2019). During its F-35 procurement years (2007–2019), the corporation reached a net nominal value of approximately US\$ 100 billion, from a previous US\$ 27 billion. A company this big, alongside its subcontractors, is certainly expected to have decisive influence on the state’s budgeting and procurement process. A key feature to understand long-term defense programs lies in Lockheed’s anticipation of DoD needs for a fifth-generation fighter. As previously pointed out, even decades before procurement, Lockheed was already investing in R&D for this kind of project. Only a highly profitable, big company would have the resources to take such a risk.

Graph 5 – Lockheed Martin’s donations for Congress elections (1996-2018)



Source: Lockheed Martin Summary (2019).

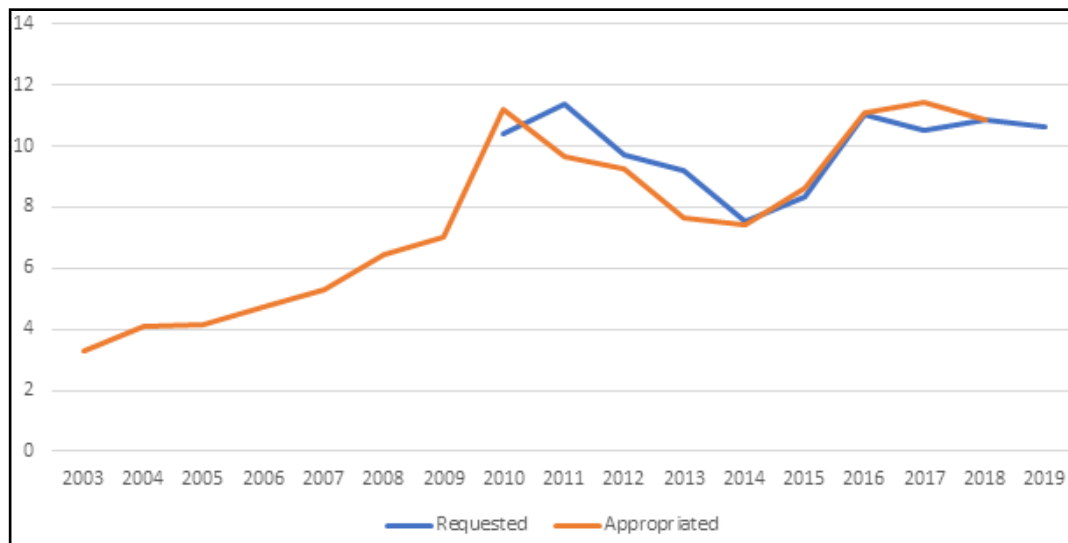
Graph 6 – Lockheed Martin’s donations for Congress Elections by Party (1996-2018)



Source: Lockheed Martin Summary (2019).

Lobbying data is hard to find, and even harder to correlate with government policy. Much of the company's effort to influence government depends on personal relations, i.e. informal conversations. Many former military servicemen are employed in the Defense Industry. And many Defense Industry former-top employees are appointed to government. These types of connection are meaningful. Graphics 5 and 6 show that Lockheed's lobbying efforts grew a significant amount after the start of the F-35 procurement cycle. Companies are strong actors, but they still have to meet the DoD requirements.

Graph 7 – Requested vs. Appropriated F-35 Budget (Current US\$ Billions)



Source: DoD Budget... (2014).

As shown in Graph 4, the F-35 program is essentially stable. There is no significant difference between requested and effectively appropriated budgets. The main volatility can be seen in the period between 2010-2014, which is explained by the previously discussed conflicts. This does not mean that Congress and its committees are not powerful. Instead, it means that despite criticism and dispute, Congress and the military are essentially aligned to the program's objectives, even if partisanship variables are incorporated into the analysis.

4.2 Are high cost long-term budget defense programs volatile or stable?

After the review of the literature on budgeting and defense decision-making actors, and analyzing the F-35 case to illustrate its main points, this work is now in a position to return to its main question. Budgeting, acquisition and procurement are part of a complex process, as we have argued. There are innumerable variables and actors that have to be considered, such as: the role of Congress; the power of Congress committees; technical feasibility; the military's role; the Defense Industry; the innovation process; the

media; public opinion; the economy; the international environment and its perceived threats. This paper does not focus on international threats or environment variables, nor does it pretend to generalize its findings to all countries¹⁶.

As pointed out in the first section of the present paper, Incremental Theory is the prevailing budget analysis theory. We saw how incrementalism is empirically accurate while describing overall budget, the defense budget, and service (Army or Air force) budget. At a program level, however Demarest (2017) presents several examples to argue that the acquisition process is highly volatile. According to the author, no single factor can explain this finding. The funding volatility at the program level would be insensitive to vendors, jobs, elections, acts of engagement (by actors of the process), number of engagements, or engagement type. His explanation for volatility relies on engagement quality and subjective interrelationships between people (DEMAREST, 2017, p. 118). He suggests that, in the Army's case, an incremental strategy is the best alternative to prevent volatility:

The Army can best achieve its own funding objectives (stability, predictability, and appropriations closely approximating the President's budget request) by developing a consistent, coherent plan and incrementally shaping the budget request to achieve the plan over time (DEMAREST, 2017, p. 187).

Although Demarest's thesis and insights are highly detailed, they do not apply to our F-35 case study. This does not in any way disprove his findings, however, as the author recognizes that "major acquisition programs" like the F-35:

... are difficult to cancel ... If programs successfully navigate the obstacle course of reports, tests, and independent evaluations required by the acquisition process and answer a valid requirement, they are generally never terminated altogether. Programs develop constituencies, create jobs, and supply money to towns and businesses. While beginning a program is hard, ending one is usually much more difficult (DEMAREST, 2017, pp. 32-33).

The question remains: why are some programs canceled, or appear to be more volatile than others? The remainder of this section discusses this issue, comparing the Future Combat Systems programs with the F-35, as well as other examples.

Future Combat Systems (FCS) was a collection of Army programs that intended to face the challenge of modernizing combat. The FCS was developed in 2003 as a "system of systems," given its amalgamation of multiple programs. It was designed to contemplate the Army's organizational change into Brigade Combat Teams, each comprised of about 4,000 soldiers, which intended to accomplish rapid mobilization and tactical success, seen

¹⁶ For an analysis comparing domestic and international factors in defense decision-making, see: Posen (1984); Fortham (2012).

as more dynamic and modern tactics. Initially, the industry and Congress supported the program. No one disagreed, especially in the face of War on Terror, that the Army needed modernization. However, the program's process of acquisition remained highly volatile throughout the years, and it was finally cancelled by the Secretary of Defense in 2009 (DEMAREST, 2017, p. 164-168).

The FCS was necessary, but it lacked *elite consensus*. First of all, the contracting structure transferred all responsibility – including administrative duties – to the contractor, Boeing. The Pentagon could not oversee expenses in subcontracting, for instance. The Defense Industrial Base of the period was the same as of that of the F-35, but Boeing had difficulty proving it could handle major defense programs such as the eight Manned Ground Systems. Each program required a huge effort to develop and demonstrate.

FCS was complicated, and the Army could not provide Congress with a consistent narrative or convincingly demonstrate the return on billions of dollars appropriated for research and development. No matter how often Army officials discussed FCS with members or professional staffers, funding projections remained unstable (DEMAREST, 2017, p. 166).

Although large programs are rarely canceled when they have already reached a mature phase, the FCS was. This resulted from a lack of organic agreement between key members of the Army, members of Acquisition and Arms Procurement Committees, and the Industry. This increased cost projections on a regular basis (DEMAREST, 2017). Some degree of volatility due to cost issues and sustainment projections notwithstanding, the F-35, on the other hand, was much more stable. This was mainly because of an agreement between *elites*.

Two other examples are interesting. NASA's Apollo Program represented 20.8% of all R&D funding in 1966, while it employed 92,000 scientists and engineers, costing billions of dollars every year (ZEGVELD; ENZING, 1987, p. 29). The main actors of the system were tightly working together towards the goal of winning the space race. Although, at the time, the Defense Industry did not have the same technical capabilities, those could be developed in the medium term. Reagan's Strategic Defense Initiative was seen as technically impossible. Nevertheless, it received huge amounts of R&D funding in the 1980s. Political, Military and Industrial elites consented that the program was a top priority, and advantageous. Today, missile defense has reached acquisition stage.

This paper reinforces that long-term budgeting, procurement and acquisition are complex processes. Its variables influence are difficult to measure. Nevertheless, we can emphasize two variables that seem to have a strong volatility-diminishing impact on programs such as the ones we have discussed.

This paper proposes a preliminary model for explaining volatility in such programs. The variable identified as X1 (elite consensus) represents the compatibility of

objectives between key Defense Industry, Military and Congressional actors. The more closely in agreement these elites are, the more likely that the Acquisition Program will be stable. However, although necessary, this is not the only condition for success. The success or failure of a *High-Cost Long Term Defense Acquisition Program* depends on a Defense Industrial Base capable of developing the required projects for the elites. Thus, X2 (Defense Industrial Base) is also a necessary condition that, by itself, remains insufficient. Although further research is needed, this paper suggests that X1 and X2 put together have a strong bearing on explaining Y (*Volatility of High-Cost Long Term Defense Acquisition Program*). The Elite Consensus and Defense Industrial base conditions can be explored in a qualitative, *process-tracing* manner, although possible quantitative and comparative studies cannot be discarded as methods to explore these variables.

5 Concluding Remarks

The main objective of this paper was to analyze high-cost, long-term acquisition defense programs. More specifically, we intended to discuss predictability issues regarding their volatility or stability. Some programs are volatile, while others are stable. Large programs seem to be more stable, since they require tremendous efforts and their cancelation would contradict considerable interests. However, that is not always the case. Explaining that discrepancy was the objective of this study.

In order to do so, the first section was dedicated to a literature review and qualitative description. The paper reviewed the main-stream consensus on budgeting theory and theories regarding actors in the overall defense and foreign policy decision-making process. The first section also described the budgeting, procurement and acquisition process within the Pentagon and Congress fiscal years. As many actors are involved and influence this process, Demarest (2018) is correct to point out that, at the program level, incrementalism does not always apply.

Testing the application of this hypothesis to the F-35 case study, this paper revealed that, in this specific case, the program is satisfactorily explained by incrementalism. Although there some level of volatility and conflict was ascertained, the program was generally stable in terms of budget, procurement and acquisition. Finally, the third section was aimed at explaining the reasons for the program's stability. We noticed that the Military, Congress and Industry were aligned in their efforts to ensure the program's success.

The remainder of the third section compared the F-35 and the FCS programs. It was noted that a crucial variable for program success is elite cohesion and consensus regarding feasibility and strategy. Finally, based on these case studies, this paper proposed a model for understanding long-term high-cost acquisition programs in defense.

This research sustains some limitations that must be addressed. More case studies are needed, regarding different time periods and with different characteristics, so the pertinent variables can be isolated. Adding the international environment and threats as variables could also refine the model, making it more accurate. These are subjects for further research.

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