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Designing and Managing Successful International Joint Development Programs

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ACQUISITION RESEARCH PROGRAM
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Designing and Managing Successful International Joint Development Programs

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ABSTRACT: International joint development programs are important because of their potential to reduce costs and increase partnership benefits such as interoperability, economies of scale, and technical advancement. While all major development and acquisition programs are complex undertakings, international joint development programs introduce additional layers of complexity in the requirement for coordination with more than one government customer, supply chain and organizational complexities resulting from international industrial teaming, and technology control issues. The performance of international joint development programs varies greatly. This paper compares the best practices of international joint development and domestic development programs through case-study analysis to identify the key variables that contribute to a program's eventual success or failure and to understand the elements that are crucial to managing these programs.

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Executive Summary

This paper is intended to inform nations and organizations that are considering whether and how to engage in international joint development programs. It provides a framework of best practices, focused on major defense acquisition but with relevance beyond it, for the design and management of these programs. Nations often engage in international joint development out of necessity, because the military capabilities they require are too complex for their domestic industries to produce independently. The United States and allied partner nations, for instance, have chosen to enter into international joint development programs in order to improve interoperability, economies of scale, or relationships with partners and allies. Because of this, the question of whether to engage in international joint development may seem simple, but the question of how remains.

While international cooperation has the potential to provide allied nations with cost-effective and technologically superior end products, international programs face many challenges, which are distinct from those inherent in single-nation programs. International joint development is not a novel idea. However, approaches to the design and management of successful international joint development programs remain highly divergent. In a time where governments are simultaneously calling for greater international cooperation and implementing financial austerity, identifying solutions for international joint development programs' challenges is critical. This paper seeks to illuminate such solutions through the analysis of six case studies:

- NATO Alliance Ground Surveillance (AGS) program
- Joint Strike Fighter F-35 Lightning II (F-35) program
- Lightweight 155mm Howitzer (M777) program
- Standard Missile 3 Block IIA (SM-3 Block IIA) program
- Medium Extended Air Defense System (MEADS) program
- A400M Atlas program

The modern environment for international joint development started after World War II and was pursued frequently by European countries seeking to strengthen cooperation and overcome the limitations of a fragmented and often devastated industrial base. Countries strove, and continue to strive, to accomplish these goals through international cooperation because of theoretical benefits, which include shared R&D costs, shared risks, improved learning economies, greater economies of scale, lower unit cost of weapons procured, end-product superiority, and military interoperability.

Although the theoretical benefits of international cooperation are compelling, in practice, these programs exhibit a greater level of inherent organizational complexity that poses a range of obstacles. Evidence from past programs shows that international programs encourage participants to behave opportunistically, face collective tradeoffs that result in sub-optimal end products for individual nations, and experience competing factors within their structures. In some instances, the adverse effects on cost, schedule, and end-product outcomes are so significant that the desired benefits are either out of reach or not worth the additional work. Maintaining awareness of these risks, and utilizing best practices to mitigate them, is crucial for governments considering international cooperation in defense acquisition.

Characteristics of International Joint Development Programs

To investigate the practices that lead to success in international programs, this paper first asks:

1. What are the characteristics of international joint development programs that result in positive or negative cost, scheduling, and end-product outcomes, such as final product, interoperability, technical relevance, and development of existing defense industrial bases?¹

Through analysis of historical records, literature, and interviews with experts and program stakeholders, the study team identifies eight characteristics that are distinct from single-nation programs in their ability to impact the outcomes of international programs. Additionally, further analysis, through research and interviews, of these eight characteristics led the study team to identify two more characteristics—numbers 9 and 10 below, respectively. These final two characteristics were not included in the study survey, directly, but were nonetheless discussed during multiple interviews, sometimes when raised by the subjects and other times when introduced by the study team. The 10 characteristics are:

- | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> 1. Levels of integration between countries and industries 2. Number of participating countries 3. Nature of the needs driving decision making 4. Commitment mechanisms 5. Flexibility | <ol style="list-style-type: none"> 6. Alignment of operational needs 7. Tradeoff between leading-edge technology and cost 8. Workshare distribution 9. Technology transfer 10. Language, culture, and time zone differences |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The first characteristic, integration, is crucial to consider when designing and managing international programs, because a complication unique to international cooperation is the transnational partnership that must be made for governments and industries to work together. Deep layers of complexity exist as a result: between governments, government and industry, and industries.

The second characteristic is the number of participating countries. According to existing literature, having a higher number of partner nations in acquisition is associated with greater collaboration inefficiencies and additional layers of project complexity.

The nature of the needs driving decisions is covered by the third characteristic crucial to designing and managing international programs. This aspect contrasted decision making based on operational needs that could not be met by existing competing systems versus diplomatic or political needs. Major program decisions are often based on these conflicting sets of needs. The existing literature suggests that outcomes that are the result of making decisions based on operational requirements that competing systems cannot meet are more likely to achieve efficient cost and resource allocation, while those decisions passed on political or diplomatic demands are not as likely to do so although the study team found that this relationship was not so straightforward in practice.

Commitment is the fourth characteristic. For programs to achieve the theoretical cost benefits of international joint development, partner nations need to be committed to the program. Defection of a partner nation often leads to cost increases for the remaining partners and can result in the premature closure of a program.

¹ End-product outcomes are subjective to each case and successful end-product outcomes for each case will change depending on the purpose and goals of the program.

The fifth characteristic, the program's flexibility to change requirements in response to changing environments, merits program engineers' attention. The external environment that defense acquisition managers are responding to is growing increasingly complicated because of emerging and dynamic threats.

The extent to which the operational goals of the partner nations are complementary acts as the sixth characteristic, because multiple militaries working together can introduce varying operational goals. Nations need to have compatible goals when attempting cooperation so that they are equally invested in acquiring the end product.

The seventh characteristic, whether the program was based on demand for leading-edge technology or based on demand for economies of scale, is important because there is a tradeoff between achieving leading-edge technology and economies of scale. Since low-cost economies of scale are sometimes an incentive for pursuing international programs, it is important to ensure that goal can be reached. The more exquisite and expensive the system, however, the smaller is the number of countries that can afford and have a need for the capability, making economies of scale harder to achieve.

Workshare distribution, the eighth characteristic, is crucial because of the inefficiencies in collective action resulting from the conflicting interests of partner nations. While international programs present greater opportunities for countries to allocate resources based on comparative advantage, making allocation more efficient, costs are not always the sole incentive for nations to participate in international programs. Some participants may view strategic posture, trade policy, industrial gain, and technology transfer as spillover benefits that are more desirable than cost efficiency. How a program focuses workshare distribution will impact program outcomes and how countries work together.

During the interview process, the study team found that technology transfer issues were an additional characteristic that should be considered when making international programs. Inefficiencies, such as schedule delays and workshare distribution disappointment, are more likely in international programs because some nations have strict technology transfer and arms trade laws. Finally, language, culture, and time zone differences can affect communication, management processes, and program efficiency.

Hypotheses and Best Practices

For the next research question, the study team asks:

2. How are the best practices of international joint development programs in defense acquisition different from the best practices of single-nation acquisition programs?

From existing literature, the study team learned that both single-nation and international defense acquisition programs face organizational, environmental, and technical complexity (Drezner, 2009). The underlying difference is the high level of organizational complexity that's inherent in international cooperation. While modern single-nation programs face the complexities associated with integrating government and industry, international programs must also intermingle governments and international industries.

To explore this second research question, the study team posed four hypotheses developed in response to the initial review of the literature. The literature review suggested that organizational structure, security and political policies, a past history of cooperation, and working with countries, which have niche technological advantages despite smaller industrial bases, will contribute to achieving successful program outcomes. This paper examined the six case studies for evidence supporting or countering the hypotheses. The first hypothesis is:

1. The structure of cooperation in international joint development programs matters—international joint development programs with stakeholders that cooperate either only during the development or only during production will have less successful cost, scheduling, and end-product outcomes.

This hypothesis applies only to the six case studies indirectly because all of the case studies were originally intended to have both development and production components. In terms of development-only programs, standard practice is to have different agreements for different phases of the program. In a case like the MEADS air defense system, the choice not to proceed to the procurement phase reflects dissatisfaction with the outcome of development rather than a deliberate project design choice.

By comparison, a large portion of global arms transfers involves pure coproduction agreements. As a partial example, the Joint Strike Fighter (JSF) is also being sold via the Foreign Military Sales (FMS) process to countries that did not participate in its development. Multiple interviewees argued, however, that one of the major benefits of the development phase is that it forces early consideration of designing for exportability. Most partner nations in the JSF program could not directly change the design in early phases; however, interviewees on both the U.S. and partner nation side confirmed that their presence in the room helped ensure consideration of their interest. Among the interviewed experts, a regularly cited example of the risks of waiting until the production phase to cooperate is the United States' other fifth-generation fighter, the F-22. That platform was not exported in part because of the expense and legal restrictions of addressing technology transfer concerns in the production phase. The subsequent early closing of the F-22's production line despite interested international customers shows the costs of not including exportability considerations early on. This result does not necessarily extend beyond the United States, as the U.S. strategy of technological superiority and the size of the U.S. market means are both obstacles to prioritizing design for exportability concerns.

Second, the study team hypothesized:

2. International joint development projects that are more grounded in security policies rather than economic efficiency interests are more likely to result in negative cost, scheduling, or end-product outcomes.

While evidence garnered from research and interviews suggests that this hypothesis is indeed true, evidence also suggests that security policies are impossible to avoid in international joint development programs. While the most desirable cost and schedule outcomes are not a result of ensuring that political and security goals are met, security policies do yield other core program goals. The results of this hypothesis show the advantage of programs that are able to provide multiple categories of benefits, a finding discussed in greater detail in the conclusions later in this section.

Third, the study team hypothesized:

3. Countries that have cooperated in defense acquisition before have a higher chance of achieving positive cost, scheduling, and end-product outcomes.

While the F-35 and M777 programs confirm this hypothesis, the AGS program, which has the most notable history of previous cooperation, does not. In the case of the F-35 and M777 programs, it is likely that the historically close relationship between the United States and the United Kingdom contributed to their positive outcomes. In fact, overcoming the challenges associated with the U.S. acquisition process will likely enhance the ability of British defense company BAE System to work closely with the United States in the future. The AGS program, on the other hand, did not achieve the positive outcomes of a strong institutional memory because the NATO management office was not set up until the official

program memorandum of understanding (PMOU) was signed in 2009, 14 years after program inception. NATO's strong institutional history of cooperation between its member nations did not translate into starting the program in time for AGS to participate in NATO operations in Afghanistan or Libya.

The A400M program is a middle case. It was able to take advantage of the Airbus consortium for workshare distribution, but member countries overruled Airbus's judgment on key questions, such as who to use as an engine manufacturer. However, Airbus was granted more independence in order to handle the program's challenges, showing how cooperation can lead to cumulative changes that can benefit future projects.

Fourth, the study team hypothesized:

4. Countries that are uniquely capable of producing complex acquisition programs benefit from working with smaller countries or industries that may have comparative advantages in certain technologies, but do not have the capacity to produce complex acquisition programs on their own.

The NATO AGS program makes an interesting test of the advantages of such cooperation, because from the outset the United States had the intelligence, surveillance, and reconnaissance (ISR) capabilities that the AGS program provided. Nonetheless, the United States benefited from working with the various-sized countries of NATO, as it ensured that the United States would not be the sole provider of support for NATO operations requiring ISR capabilities in the future. Additionally, all nations benefited from international participation in the F-35 program because the leading-edge technology that the program achieved would not have been financially feasible for any of the partner nations other than the United States. Even for the United States, cost overruns might have resulted in the program's cancellation if not for the partners' intentions to proceed with production.

However, there are limits to the benefits of collaboration between countries that produce the full spectrum of advance defense systems and smaller countries that are more specialists in their approach. The partnership between the United States, Germany, and Italy for MEADS had far more varied results. While the development phase did advance cutting-edge technology, the United States decided not to proceed with the production phase. There may yet be spinoff or foreign military sales benefits from the program, but the United States intends to upgrade its existing Patriot systems instead. The MEADS experience shows that it is not enough for complex platform producers and more specialized smaller countries to work together. Instead, the program must be structured to take advantage of this dynamic, or at least have the flexibility to adapt to changing circumstances more quickly than MEADS did.

Best Practices

Drawing from the results of the research questions and hypotheses, the study team found that nations considering international cooperation in defense acquisition should critically question their incentives to do so, because while single-nation acquisition programs are hard, international joint acquisition is harder. Before pursuing an international program, countries should confirm that they are in a viable position to do so. To ensure that they are positioned to handle the resulting additional challenges, countries should use a high burden of proof when conducting both risk and cost/benefit analyses. Countries should then ask themselves if international cooperative programs, with their additional risks and costs, are a better option than FMS or pursuing the program indigenously. To assist in this effort, the study team has identified key questions drawn from the 10 characteristics that should aid evaluating the costs and benefits of international joint development.

1. Combining Operational and Political Considerations

When procuring a program with other militaries, a variety of wants and needs compete against each other. This also notably happens, as one interviewee reported in regards to a case study, among the military services of the United States, where inter-service consensus on common requirements can be just as difficult to achieve as international agreement. Countries that pursue international cooperation in defense acquisition face a variety of risks that threaten the successful acquisition of the intended, jointly developed capability. However, the variance in expert survey responses in classifying characteristics in each of our case studies shows that even experts disagree about the comparative importance of different priorities, such as fulfilling operational needs vs. diplomatic and political considerations or leading-edge technology versus economies of scale. What is clear is that successful international joint development programs should satisfy multiple categories of objectives, be they security, political, or economic, for each participant. These objectives need to have strong champions, who need to be capable of working with their international counterparts to overcome domestic constraints. Programs should also have comparatively few dedicated domestic opponents or they will face a magnified risk of breaking apart should major challenges arise.

As a result, some reasons for pursuing international joint development can serve as valuable secondary objectives but are insufficient to serve as primary objectives. Providing competition to existing indigenous systems through international joint development will likely face steady domestic opposition while having only mixed operational support, because the indigenous alternative is always available. Seeking to start up a cutting-edge domestic capacity through international joint development may stumble on the dual hurdles of insufficient domestic economic foundation and technology transfer limitations. Similarly, if multiple countries want the political and economic benefits of being the prime contractor, the organizational complexity and economic challenges of international joint development may easily undercut the advantages of working together.

Ensuring that a program serves multiple categories of objectives also mitigates against setting ambitious goals for operational capabilities, technology transfer, or industrial base development. Pushing too hard toward any one of these goals in isolation is likely to undercut other benefits for the project as a whole or for other participants. Thus, great ambitions in any one category typically come at the expense of the project's suitability for international joint development.

2. Component Compartmentalization

Another notable finding that should guide countries' consideration of whether or not to engage in an international joint development program is whether such a program can distribute development workshare as compartmentalized components across participants. Compartmentalized workshare distribution is dividing work into discrete, severable design elements that require a minimum of subsequent design integration—a practice exemplified in the SM-3 Block IIA case study and in the final, successful iteration of the NATO AGS program. This approach can optimize participants' cost/benefit ratios by minimizing integration complexity and risk from technology transfer limitations while also increasing economic benefits. In a best-case scenario, this ensures successful program outcomes while also optimizing individual country outcomes across a variety of objectives. However, this approach requires partners with the industrial capability to design and build major complex system elements.

3. Techniques for Mitigating Competing Objectives

Allocation as part of a larger portfolio of cooperative programs can constitute a best practice. A group of closely allied countries that collaborate often would benefit from practicing the prime-sub model of cooperation across all collaborative programs and also give different countries opportunities to lead as the prime contractor for each collaborative program. Looking at a wider portfolio makes this process easier.

Beyond the scope of this paper, there are also a range of other forms of international cooperation that could be considered, from off-the-shelf FMS to coproduction to international procurement of subcomponents. This bypasses the collective action issue that most collaborative programs face, in which partners attempt to maximize their benefits and deflate their costs.

Throughout the interview process, the study team discovered that some European partner nations have recognized the inefficiencies caused by competition between domestic security policies and efficient workshare allocation. To address this issue, the partner nations have decided to allocate workshare by considering their entire portfolio of projects rather than considering only each project individually. This allows trading prime contractor leadership in one program for a supporting role in another. For instance, while one country will take responsibility as prime contractor for the Euro Drone project, another country will take responsibility as prime contractor on a joint satellite. Instead of allocating workshare to meet various domestic needs for one program, partner nations allocate workshare differently for each program, ensuring that countries meet their independent goals over a variety of programs. This gives each individual program the opportunity to avoid inefficient workshare allocation and instead distribute industrial participation based on best value. Naturally, this approach is limited to countries that know that they will engage in cooperation repeatedly and simultaneously over long periods of time.

There are also approaches within individual projects that can aid in balancing competing objectives from participant nations. For example, the JSF workshare was distributed by giving participant countries the right to compete but not a guaranteed share. Countries were aware of the targeted price points for the basic variants and they could also choose to customize their own production units to a limited degree by using their own national funds. Thus, if an individual country prioritized industrial base development over their effective unit price it could subsidize development activities in its own industry to ensure they were price competitive. Because only national funds were used, this avoided cost growth that's detrimental to the program as a whole.

4. Joint Development as a Mechanism for Advancing Technological Capabilities

International cooperation in defense acquisition poses various hurdles associated with technology transfer laws. Countries that are global leaders in technology often implement demanding bureaucratic processes when participating in international armaments cooperation. Additionally, countries that seek international cooperation in armaments sometimes do so in hope of receiving industrial spillover benefits that result from technology and information sharing. Historically, countries engaging in international joint development to achieve these objectives often fail to achieve their anticipated spillover benefits due to restrictions mandated by partner country's technology security regime. Such a shortfall threatens the program because partner nations that fail to accrue their expected benefits from industrial spillovers are more likely to defect. This is one of many situations in which the study team noticed that placing too much priority on achieving a single objective in an international joint development program—in this case pursuing technology spillovers as a primary objective—can undermine the likelihood of overall success. When technology spillover benefits are one among several motivators, however, the study team found that countries that choose to participate as joint development partners from the outset are less likely to face high technology transfer hurdles through processes, such as the U.S. International Traffic in Arms Regulations (ITAR), compared to those simply pursuing FMS.²

² The ITAR enumerates requirements for the export and import of items and information (“defense articles” and “defense services”) found on the U.S. Munitions List. The U.S. Department of State Directorate of Defense Trade Controls is responsible for implementing ITAR through the issuing of export licenses.

Conclusion

International joint development programs, because of their complexity when compared to their domestic counterparts, present myriad challenges that can affect time, cost, and end-product performance. They additionally present many benefits that, from both a budget and a security perspective, merit consideration. To ensure the manifestation of these benefits, governments considering international cooperation need to carefully compare the potential program with their capacity to pursue the program in question indigenously, or through import. Integration levels, workshare distribution, number of participants, commitment, mutual warfighting demands, and technology sharing are all crucial aspects of a program and should be considered when deciding whether or not to develop jointly. This paper recommends setting a higher burden of proof for international joint development programs than for comparable single-nation programs or import when analyzing its costs and benefits; however, that does not mean that they should be ruled out. While this paper describes many of the complexities inherent in international joint development and pitfalls that can occur due to certain configurations of projects, future collaboration efforts designed after careful analysis of the characteristics and best practices presented in this paper are more likely to achieve successful outcomes.

1. Introduction

International cooperation on development projects can be beneficial in both the private and public spheres, as well as for both military and civil projects. International joint development projects in defense merit special attention because the barriers to cooperation in that sector are particularly high, even within alliances. Nonetheless, the theoretical benefits of joint development projects are considerable and include reduced costs, improved international cooperation, increased competition, and innovation. While unique combinations of these benefits drive each international program, most nations turn to international cooperation in defense acquisition to appease budget pressures and procure advanced programs that they cannot individually afford.

DoD recognizes the value of international joint development programs that include both research funding from, and technology development with, multiple countries. This is especially true in light of the Budget Control Act of 2011, which imposed caps on defense spending concurrent with European defense budget reductions. In reaction to a fiscally constrained environment, January 2012's Defense Strategic Guidance commits DoD, and the United States at large, to strengthening partnership and cooperation with the global community by emphasizing pooling, sharing, and specializing capabilities with partner nations (United States Department of Defense, 2012).

DoD's support for international joint development comes with policies that determine when international joint development is and is not appropriate. *The International Cooperation in Acquisition, Technology and Logistics Handbook* states that when considering participation in an international joint development program, the Milestone Decision Authority must consider whether a program executes "demonstrated best business practices, including a plan for effective, economical, and efficient management of the international cooperative program" (Office of the Undersecretary of Defense for Acquisition Technology and Logistics [AT&L], 2012). While the value of international joint development programs is recognized, the theoretical basis for best practices in these programs is a paucity (Office of the Undersecretary of Defense for Acquisition Technology and Logistics [AT&L], 2012).

Despite international joint development existing in its modern form since World War II, there is not yet a common framework on what the design and management of successful international joint development programs looks like. This report aims to alleviate this deficiency by utilizing the existing literature on best practices in both single-nation and international joint development programs to investigate whether best practices have been actualized and what characteristics in the design and management of such programs equate to different outcomes. Through evidence garnered from acquisition literature, the study team established characteristics that are crucial to program outcomes discussed in Section 3.5. To analyze how these characteristics affect international programs, the study team analyzed six cases of existing international joint development programs in defense acquisition. The six cases include:

- NATO Alliance Ground Surveillance (AGS) program
- Joint Strike Fighter F-35 Lightning II (F-35) program
- Lightweight 155mm Howitzer (M777) program
- Standard Missile 3 Block IIA (SM-3 Block IIA) program
- Medium Extended Air Defense System (MEADS) program
- A400M Atlas program

The results are then used to answer the study team's research questions and evaluate their hypotheses in order to more deeply understand what constitutes best practices in the design and management of international programs.

2. Methodology

2.1 Research Questions and Hypotheses

In order to investigate the best practices of designing and managing international joint development programs in defense acquisition, the study team focused on two overarching research questions:

1. What are the characteristics of international joint development programs that result in positive or negative cost, scheduling, and end-product outcomes, such as a final product, interoperability, technical relevance, and development of existing defense industrial bases?³
2. How are best practices of international joint development programs in defense acquisition different from best practices of single-nation acquisition programs?

Additionally, four hypotheses form a baseline for this analysis. These hypotheses were derived from a review of the existing literature on international joint development. They are:

1. The structure of cooperation in international joint development programs matters —international joint development programs with stakeholders that cooperate only during development or production phases will have less successful cost, scheduling, and end-product outcomes.
2. International joint development projects that are more grounded in security policies rather than economic efficiency interests are more likely to result in negative cost, scheduling, or end-product outcomes.
3. Countries that have cooperated in defense acquisition before have a higher chance of achieving positive cost, scheduling, and end-product outcomes.
4. Countries that are uniquely capable of producing complex acquisition programs benefit from working with smaller countries or industries that may have comparative advantages in certain technologies, but do not have the capacity to produce complex acquisition programs on their own.

2.2 Interviews with Program Stakeholders

The study team interviewed stakeholders from government and industry, as well as key leaders from research organizations, to augment the information gleaned from the literature. The interviews focused on investigating which characteristics, out of the eight described in Section 3.4, each case manifested. In addition, they addressed the research questions and hypotheses. The interviews were accompanied by a Likert-scale survey to determine which characteristics the cases demonstrated. Results of the survey will be discussed in Section 3.5.

3. Why International Joint Development?

3.1 History

Although collaboration on international projects, including in the military domain, has existed for centuries, this paper focuses on the cooperation between the United States and its allies in the modern international environment. In the modern era, the United States has participated in three general forms of international cooperation—reciprocal trade, cooperative production, and joint development—with three different types of partners: “first-tier industrialized countries, second-tier industrialized countries, and newly industrializing countries” (M. Lorell & Lowell, 1995). This paper focuses on joint development and that includes first-tier industrialized partners. The present-day environment for international joint development among U.S. allies and friends was initially formed during the period directly after World

³ End-product outcomes are subjective to each case and successful end-product outcomes for each case will change depending on the purpose and goals of the program.

War II. From the U.S. perspective, key policies on international joint development includes the Culver-Nunn (1977), Roth-Glenn-Nunn (1982), and Nunn-Warner (1986) amendments, the FY1990–1991 Defense Authorization Act, and policies introduced in Secretary William Perry’s administration (M. Lorell & Lowell, 1995).

International joint development found fertile soil in postwar Europe. The European Coal and Steel Community (ECSC), which was the predecessor of the EU, was one of the earliest navigators of modern globalization. Fear of further conflict between France and West Germany coupled with a devastated European economy fueled the ECSC as a way to ensure peace and more efficiently allocate coal, steel, and production (Eur-lex.europa.eu, 1951). Additionally, in 1954 the Western allies—through the newly developed NATO—allowed West Germany to rearm. West Germany, however, had demobilized its defense industrial base by then. Consequently, indigenous procurement was not an option, and this led to international collaboration in defense acquisition (De Vore, 2011). Furthermore, the growing tensions between the United States and the Soviet Union drove the two powers into a spiraling increase in defense and R&D spending that, firstly, European nation states could not keep up with, and secondly, inundated U.S. industrial base’s capacity (De Vore, 2011, p. 640). Therefore, because demand for military goods among NATO nations outpaced even the productive capacity of the U.S. industrial base, the United States participated with Western Europe in the international collaboration of defense acquisition following World War II.

In an article published by *Security Studies*, Marc R. De Vore categorizes international cooperation in defense acquisition since the end of WWII into three generations: first generation (1953–1962), second generation (1958–1969), and third generation (1968–present) (De Vore, 2011, p. 652, 646, 640). From De Vore’s timeline overview, one of the most notable characteristics of first-generation international cooperation was the awareness that navigating this type of cooperation was parallel to navigating uncharted waters. Accordingly, the first-generation time period saw to the creation of international bodies dedicated to managing these international projects. Furthermore, leaders of participating nation states recognized the complexity involved with incentivizing firms to provide competent products and efficient prices at the international level. These first-generation projects focused on this problem by defining a core and common requirement, employing competition, and creating management structures featuring defined responsibility chains where the prime contracting country had general leadership throughout the program (De Vore, 2011, p. 641).

Collaborative projects during this time included the Lightweight Strike and Reconnaissance (LWSR) Aircraft, Anti-Submarine Patrol Aircraft, Short Take Off and Landing (STOL) Fighter, NATO’s Mutual Weapons Development Program (MWDP), and the STOL Transport Aircraft. One key issue that permeated first-generation projects was the dissatisfaction non-prime participants felt from the unequal benefits distributed among the countries involved. De Vore explains that “[w]hile the winning firm and state could gain experience with systems integration and potentially monopolize critical technologies, losing firms and states risked relegation to a permanent position as subcontractors. Consequently, fears of losing capabilities and autonomy relative to partners provided powerful incentives for states to defect from projects they did not control” (De Vore 2011 p. 646). While direct leadership controlling a defined chain of command is necessary to manage the complexity associated with international programs, asymmetric costs and benefits also have to be accounted for. Second-generation programs took a stab at overcoming the latter.

Starting in 1958, what De Vore categorizes as second-generation international cooperation commenced. From 1958 to 1969, European countries could not independently support the rising costs of aerospace engineering. Additionally, European countries did not want to be dependent on FMS from the United

States. Therefore, European nations had to jointly develop and produce armaments in order to overcome rising technology costs and military dependence on the United States (De Vore, 2011, p. 646). Furthermore, second-generation programs sought to eliminate the characteristics of first-generation programs that incentivized countries to defect. To this end, countries participating in second-generation programs negotiated the share of development and production that would lead to international consortiums equally bolstered by the participating countries to act as the prime (De Vore, 2011, p. 647). Interestingly, second-generation programs recognized the direct relationship between number of participants and organizational complexity and, therefore, tended to have a lower total number of participating countries per project (De Vore, 2011, p. 647).

While second-generation programs' tendency to create international consortiums addressed first-generation issues of defection, the means to eliminating defection incentives reduced the ability for programs to be cost efficient, which was one of the main goals for international cooperation in the first place. Mark De Vore explains: "By awarding contracts on an uncompetitive basis and not establishing clear chains of corporate responsibility, these projects created few incentives for corporations to operate efficiently" (De Vore, 2011, p. 651). The competing factors of international cooperation highlighted by first- and second-generation programs continued to third-generation programs and pervades even modern-day programs. Second-generation programs include the C-160 Transall Transport Aircraft, the Anglo-French Variable Geometry (AFVG) Aircraft, the F-16, and the Jaguar.

De Vore calls the present environment the third generation of international development and pegs its start to 1968. The unique characteristic manifested by third-generation programs was to apply legal governance structures to international programs in an attempt to further improve international cooperation. These structures allowed opportunity for discussion so that all participants could voice their opinions and the most common and agreed-upon requirements were chosen. Third-generation programs also implemented complex voting systems in order to spread power multilaterally. Programs considered third generation include the Tornado, the Eurofighter, the FSX Fighter with Japan, and the case studies in this paper.

3.2 Reasons for International Collaboration and Issues Preventing Success

Why do countries embark on these organizationally complex international programs? What are their theoretical benefits, and how are they appealing enough to incentivize such ambitious and complicated goals? The recent push toward international collaboration is not novel but, instead, a recurring phenomenon. Maintaining a national competitive edge in the globalized economy, addressing monopolistic and oligopolistic market failures, collective action inefficiencies, financial needs, life-cycle costs, lack of competition, and alliance cohesion are among the many drivers pushing the pursuit of international joint development in defense acquisition (De Vore, 2011; Fitzgerald, Greenwalt, Grundman, Hasik, & Rumbaugh, 2014; M. Lorell & Lowell, 1995). Additionally, there are theoretical benefits from international cooperation that appeal to countries that experience the drivers listed above, which include shared R&D costs, shared risk, improved learning economies, greater economies of scale, lower unit cost of weapons procured, end-product superiority, and military interoperability (De Vore, 2011, p. 627, 625, 628).

While these hypothetical benefits merit support for international programs in defense acquisition, there are complications that exist in practice and often prevent international programs from achieving the benefits previously outlined. Evidence from past programs shows that international programs encourage participants to behave opportunistically, face collective tradeoffs that result in sub-optimal end products for individual nations, and experience competing factors within their structures. These phenomena

obstruct international programs from achieving their hypothetical benefits and knowledge of them is key to shaping best practices in the future.

International programs encourage participants to behave opportunistically for a variety of reasons. One is that decisionmakers have to be convinced that participating in an international program is in their country's best interests. Politicians are wary of allocating work and resources abroad that would otherwise be used to facilitate prosperity domestically. In a collection of recent work studying international cooperation in defense acquisition since the 2008 global financial crisis, it is reported that investing domestically in defense is associated with up to a 20 percent discount for resulting money flow and tax revenues (Fitzgerald et al., 2014, p. 6). Across the board, U.S. and allied nations are disinclined to spend their tax revenues on foreign products. As a result, countries have incentive to behave opportunistically in order to balance those who oppose offshoring. Additionally, individual states are aware of other states' incentives to obtain higher levels of benefits, and this rivalry prevents the participants from reaching a collectively efficient balance of workshare. In order to handle this, collaborative programs have to implement workshare mechanisms that proportionally allocate work to investments (M. Lorell & Lowell, 1995). De Vore argues that this tendency can cause inefficiencies so large that they cancel out the expected benefits from collaboration (De Vore, 2011, p. 635).

Furthermore, instead of using international cooperation to build and enhance specializations, countries typically prefer to build and sustain an industrial base that can build a range of platforms. Thus, they opportunistically seize cooperation as a chance to learn how to develop and procure technologies that they would never have been able to fund independently, even if this learning does not enhance industrial sectors where the country has a comparative advantage. Lorell and Lowell (1995) ascertain that, as a result, "the efficient use of resources is of second-order concern. For both advanced and less advanced economies, therefore, cost savings from collaborative as opposed to purely national programs may be insignificant." This eliminates the chance for the theoretical benefits in collaborative programs because "few collaborative programs achieve a rational division of work, economic specialization, or the elimination of R&D redundancy. Typically, participating governments seek work in areas in which their national industries have little experience. They wish to acquire new technologies and production capabilities rather than build on existing national comparative advantage" (M. Lorell & Lowell, 1995). Each participant faces competing incentives. While the benefits of collaboration are clear and incentivize countries to agree to international collaboration in the first place, it seems impossible for participating countries to achieve them because they cannot avoid behaving opportunistically. As a result, the benefits that international programs present are not achieved, and it's often better for nations to pursue these programs independently.

When designing an international program, it is critical to ensure that collaborative requirements meet each individual nation's needs. However, simply meeting every country's needs can also be a problem. If a participating country agrees to high cost or technically challenging requirements that they do not value, the resulting end product may be inferior to what that country could have produced independently. In the latter scenario, countries are more likely to defect from the program (De Vore, 2011, p. 634; M. Lorell & Lowell, 1995).

Evidently, it is crucial for countries participating in collaborative programs to do so only if the programs' requirements meet each country's capability needs in order to achieve the benefits presented from international cooperation in the first place. Additionally, programs in the past have invited as many participating countries as possible in order to help pay for the program. This increases the likelihood of both opportunistic behavior and dissatisfaction with the common end product (Grundman & Hasik, 2014).

These competing factors, which prevent international programs from achieving their theoretical benefits, are both more concretely and pessimistically defined by De Vore. De Vore defines the issues previously explained into two categories. The principal-agent dynamics exist where market inefficiencies cause industry (agents) and governments (principals) to allocate resources poorly. Asymmetric information and lack of competition allow both firms and governments to act inefficiently. Collective-action problems are those defined by opportunistic behavior and an inability to allocate workshare efficiently between participating countries. De Vore claims that these issues are irrevocable because by solving one, the other just persists more strongly (De Vore, 2011, p. 658).

International cooperation in defense acquisition has the potential to provide allied nations with cost-effective and technologically superior armaments. These programs face many challenges, which are well defined in both historical evidence and extensive literature, yet the solutions to them are missing. The next section will dive deeper into what issues inherently face defense acquisition to further identify how single-nation programs differ from international ones and how the challenges of international cooperation can be overcome.

3.3 Costs of International Acquisition

Because defense acquisition is a business transaction at its core, an economic approach should be applied when targeting best practices. However, existing economic theory literature regarding defense acquisition shows that regular, single-nation defense acquisition faces inherent barriers to reaching economic efficiency. Defense acquisition economic concepts will be presented here as a prefatory to developing best practices for the special case of designing and managing international joint development programs.

The first important concept that challenges policymakers in single-nation defense acquisition, and increasingly in alliances, is that defense is a public good. In *The Political Economy of NATO Past, Present and into the 21st Century*, Todd Sandler and Keith Hartley discuss the concept of defense as a public good in great detail. Public goods are basic market failures in maximizing economic efficiency because “public goods are nonexcludable and nonrival and markets fail to function efficiently for nonexcludable goods because there is an incentive to *free ride* on the efforts of others, so that a suboptimal amount of the good is anticipated” (Sandler and Hartley 1999, p. 17). The problem with *free riding* is that some market participants benefit at the expense of others. This causes a sub-optimal level of output, in which costs for one stakeholder are greater than what costs could be if shared by all. In single-nation defense acquisition, this problem is accounted for by government intervention. The government is the sole demand for defense products and is supported by its taxpayers, that is, DoD. While the public-good concept is generally not a problem for the single-nation defense market, an alliance model is different: an efficient solution for international programs has yet to be reached. The governance models of alliances, such as NATO, do not have the same supranational powers that single-nation country governance models do. Thus, the ability to account for the negative consequences of public goods is much more complicated. This directly relates to the next concept: burden sharing.

Burden sharing poses economic threats to large defense-producing countries, such as the United States, during times of tight budgets and dynamic international threats. For instance, the United States made the decision in 2012 to rebalance its strategic focus with less emphasis on Europe and greater emphasis on Asia. This decision was made, on the one hand, because some of the initial threats supporting the United States’ military presence in Europe had subsided, and on the other hand, because the budget could not continue bolstering a forceful presence in both Europe and Asia due to pressure. This rebalance to Asia could arguably be a result of the United States no longer wanting free-riding in international security by the EU. In an analysis of the U.S. rebalance to Asia, Carnegie Europe argues, “The real lesson here is that Europe needs to invest in its instruments because it needs to be both more self-sufficient and more useful

as a partner for the United States” (Techau, 2013). The article also argues that the U.S. rebalance to Asia is a compliment to the EU, in that the United States trusts that the EU has the capacity to enforce a foreign policy on its own that will both maintain the peace and stability in its region and support its neighboring regions (Techau, 2013). Now, three years later, this trust will be put to test with the rise of threats from Europe’s eastern and southern neighbor-regions.

Burden sharing also disrupts economic efficiency in alliances, especially when alliance members pursue external goals. Sandler and Hartley explain this idea through what they call the exploitation hypothesis: “if the ‘optimal’ amount of defense for the rich ally (where an ally’s marginal benefits equal its marginal costs) is \$300 billion while the optimal amount for the poor ally is \$10 billion, then the defense outlay of the rich ally may satisfy the poor ally’s defense needs without any spending on the latter’s part” (Keith Hartley & Sandler, 1999, p. 31). The *exploitation hypothesis* can occur only if the defense output of the rich ally is substitutable for the defense needs of the poor ally. Thus, if the United States’ defense output is expected to largely support the defense needs of the smaller countries in NATO, then the United States cannot use these same resources to pursue other foreign policy goals, because their defense output would no longer be substitutable for its smaller allies in Europe. Since the United States is pursuing goals outside of the NATO sphere, and since the United States cannot expand its budget, the countries in Europe that depend on the United States must now find ways to support themselves. International joint development may be an economically efficient and secure solution for these countries, as they will increasingly have to support themselves in security.

In addition to the problem with the inefficiency seen in burden sharing, policymakers in defense acquisition are also challenged by public choice issues. The core theory behind public choice presumes that decisionmakers are rational and make decisions in the pursuit of economic efficiency. If this was true, decisions would be made on the margin, in which the costs and benefits of every choice are always determinants of the decision and benefits would always be chosen over costs. In the reality of politics, costs and benefits are subjective and associated with many characteristics, as well as monetary value. Sandler and Hartley argue that because voters, political parties, governments, bureaucracies, and other interest groups are all participants in policy formation and have unique interests, “The bureaucracies within this complex will aim to maximize their budgets and they will do so by overestimating the benefits of their preferred policies and underestimating the costs of these policies. As a result, a budget-maximizing bureaucracy will be inefficient, providing too large an output which will be justified as an optimum by exaggerating demand and underestimating costs” (p. 125). Another assumption made in the analysis of efficiency in public choice is that to reach an efficient outcome, information sharing must be both abundant and accurate. In defense acquisition, however, this rarely exists. Companies have a natural tendency to delay the sharing of information, especially when acknowledging cost growth. This effect is exacerbated in the international joint development environment, where there are additional incentives for international partners to delay sharing negative information. Furthermore, international joint development programs face even greater risks associated with information sharing, because the tendency for information to be asymmetric will be multiplied over different governments and across international industries.

The costs of asymmetric information sharing in single-nation defense acquisition negatively impact the consumer (i.e., DoD), while the same in international defense acquisition can negatively impact both the consumer and the supplier. Derek Braddon—in a piece from *Defense and Peace Economics*—explains that the suppliers take advantage of information withholding and sell their products at a higher price than one equal to the cost of the product. Braddon says, “In such a market situation, consumers (governments) are at a continual disadvantage as only the supplier really possesses full knowledge about product costs

and performance. . . . In such circumstances, real costs will always be difficult to gauge” (Braddon, p. 502). Furthermore, in joint development and complex systems acquisition, the intellectual property of suppliers could be at risk because of its arduous, bureaucratic governance processes (Archer, 2013). Therefore, the development of best practices in international defense acquisition should consider asymmetric information and investigate which governance models are most likely to minimize this threat.

Another characteristic that causes asymmetric information sharing in the defense market, and introduces an additional market failure, is the monopoly/monopsony dynamic of defense acquisition. This dynamic reinforces the problems caused by asymmetric information sharing: preferential purchasing policies, high barriers to entry, price discrimination, and an absence of competition. Therefore, it is difficult to produce an efficient quantity of defense in a given market. Sandler and Hartley argue that preferential purchasing policies, such as the Buy America Act⁴ or support for national champions, produce “costly equipment, cost escalation, delays in delivery, gold plating, inadequate performance and unreliability of weapons, poor labor productivity, labor hoarding, project cancellations and excessive profits” (Luckey, 2012; Hartley & Sandler, 2012). Sandler and Hartley also emphasize that because the government is a monopsony and the only regulator in the defense market, it is impossible for it to ignore political factors when making decisions (Keith Hartley & Sandler, 2012). This causes asymmetric information and high barriers to entry, which can lead to inefficient outcomes. Sandler and Hartley support the idea that NATO could improve these market inefficiencies by creating “a NATO free trade area for weapons, where entry barriers into national markets would be abolished for firms from member states and defense contracts would be awarded on the basis of competition reflecting a nation’s comparative advantage” (199, 120). Additionally, Braddon argues that because monopolistic defense market private contractors have the capacity to control both output and prices, they benefit from high profits at the expense of the buyers. If best practices are applied, the hypothetical benefits of international joint programs, such as increased competition and a reduction in barriers to entry, could improve the state of defense acquisition.

In addition to the complexity that single-nation programs face, joint international programs have unique levels of complexity. Technical complexity is not inherent in international joint development programs, but organizational complexity poses one of the largest threats to successful outcomes of international programs. Additionally, technical complexity in defense acquisition programs is more common now than ever before. The external environment that acquisition programs are responding to is exceedingly complex. The separation of complexity into three dimensions—technical, organizational, and environmental—was done by Jeffrey A. Drezner (Drezner, 2009, p. 32). The concept of complexity in defense acquisition is often difficult to pin down, and this paper uses Drezner’s three distinctions because they clarify the concept.

Drezner states that “*Organizational* complexity addresses the structures and interactions of the government and industry organizations responsible for system design, development, production, and support” (Drezner 2009, p. 32). Organizational complexity is inherent to international joint development programs because of the different governments, different industries, and different military services involved with such programs. The largest problem facing international joint development programs is an inability to achieve their theoretical benefits. The current literature shows that best practices of complex acquisition programs such as international joint development depend on the organizational structure, approach, and governance attributes of those programs.

⁴ The Buy America Act requires that direct government purchases over \$3,000 must be produced in the United States on the condition that the purchased products are reasonable in cost, and that they are for use in the United States.

When identifying the best practices in designing and managing international joint development programs, organizational complexity directly affects how programs are designed and managed and, therefore, will be this paper's focus when analyzing best practices for designing and managing international joint development programs.

3.4 Benefits of International Acquisition

As discussed above, the single-nation defense market inherently experiences obstacles to reaching efficient outcomes, and this also happens to international cooperation in defense acquisition. However, international cooperation also presents opportunities to increase efficiency. These opportunities include gains from trade and competition, innovation, and scaled economies, as well as reduction of duplication within industrial bases (K. Hartley, 2006, p. 473). This section will discuss the economic features of defense industries and the hypothetical benefits from pursuing international joint development programs in defense acquisition.

One interpretation of economic efficiency in the defense market is the buyer getting the most value with public purse. This means acquiring the largest number of highest-quality defense products and services with respect to the budget constraints determined by the government. This concept of efficient procurement is complicated by emerging and dynamic threats that introduce additional considerations. High-quality defense products and services must be ready, reliable, technologically advanced, and increasingly adaptable to unanticipated or rapidly evolving threats. Simultaneously, economic efficiency for private companies that produce defense products means making profits. Put simply, this means producing products where the marginal benefit of producing one unit of a certain good is greater than the marginal costs of producing that unit. To achieve the best scenario for both consumers (DoD) and suppliers (industry) of defense, defense markets must consider the costs associated with defense acquisition: research and development (R&D), quantity, production, life-cycle costs, scheduling costs, and transaction costs.

Defense products require a variety of expenditures throughout their lifecycle, including R&D, production, and operations and maintenance. These costs add up to create the life-cycle cost of a product. International joint development programs present opportunities to increase efficiency through reducing this cost. In an article published by *Defence and Peace Economics* in 2004, David L. I. Kirkpatrick explains, "It has been shown that equipment with high performance and a correspondingly high unit production cost generally has a high unit life cycle cost: hence, the growth in the unit production costs of defense equipment is associated with similar growth in unit life cycle costs" (Kirkpatrick, 2004). Additionally, Kirkpatrick determines that there is a tradeoff between average fixed costs and life-cycle costs. This means that producing a large quantity will push down the average fixed costs while simultaneously pushing up total life-cycle costs, or vice versa (Kirkpatrick, 2003).

International joint development programs present opportunities for a solution to the tradeoff identified by Kirkpatrick (2003). While increasing the number of participants in a joint program increases its total costs, it also decreases the costs that each country would incur in comparison to what that country would incur in isolation. One rule of thumb for measuring the benefits of international cooperation, established by scholars of international cooperation in armaments, is that "the development cost of a collaborative project should exceed that of a national project by a factor equal to the square root of the number of partners" (De Vore, 2011).⁵ While there is a lack of empirical evidence supporting this rule, it is clear that

⁵ Thus, compared to a single-nation project a two-partner program should have 41 percent more funding and a three-partner program should have 72 percent more.

a great deal of literature claims that shared R&D costs are a theoretical benefit of high-enough value that it outweighs the costs associated with international programs. For instance, R&D costs are increasingly higher due to technological demands. Joint programs could help ease the burden of fixed R&D costs in two respects. First, joint programs increase the opportunity for spreading costs over many payers, which reduces the average costs for each participant. Sharing R&D costs, which are synonymous with investments, also distributes the investment risks over the participants, thus reducing the risk any one nation incurs. Second, joint programs present the opportunity for higher output levels, which reduce average costs because as quantity levels rise, the opportunity for economies of scale increases which lowers average production costs. In today's financial environment, both shared risk and R&D are crucial to both the United States and partner countries wanting to maintain a competitive and effective industrial base.

As R&D matures and turns into production, international collaboration presents new benefits, associated with learning curves and economies of scale, for participating nations. More efficient learning curves and large economies of scale result in lower per-unit costs and more efficient allocations of resources. This type of dynamic tends to create learning economies, which occur when production efficiency increases. When more time and effort is spent on a project, the efficiency of producing that project typically grows. De Vore argues that collaboration results in higher cumulative output in production lines, which further translates into increased ability to achieve the most efficient processes (De Vore, 2011, p. 627). Programs that include multiple countries will automatically produce more end products than a single-nation program, thus resulting in higher output and theoretically, via economies of scale, lower average and per-unit costs.

Compared to single-nation programs, the end-product superiority of international programs should exist because of comparative advantage. Economic theory suggests that resources are allocated most efficiently when different actors, be they firms or countries, specialize in different products and then trade with each other. When countries have the opportunity to focus on and perfect a single specialty, combining them afterwards into one final platform, the product will acquire high technical quality at a more efficient cost than if one country was responsible for developing and producing the entire program (De Vore, 2011, p. 628). Additionally, when allied countries contribute their specialized components to acquire a common end product, their effectiveness as a military force is enhanced: "States equipped with the same weapons can support, reinforce, repair, and resupply each other's armed forces without advanced warning" (De Vore, 2011, p. 628). Consequently, countries both independently and collaboratively benefit from joint cooperation in defense acquisition.

International joint development approaches may have enhanced utility during times of significant budget constraints. In an opinion piece in *Acquisition Review Quarterly*, former Deputy Secretary of Defense John Deutch looks back at the post-Cold War drawdown and argues that both government and industry had to reduce their defense assets in order to maintain a healthy industrial base (Deutch, 2001, p. 138). During this period, the defense industry confronted the simultaneous impact of budget pressures and external threat uncertainty. As the peak of the Reagan defense buildup gave way rapidly to the post-Cold War peace dividend, DoD encouraged consolidation to reduce the size of the defense industrial base in order to prevent an unguided raveling of the industry. Deutch claims that without consolidation during that time, unit costs would have increased while profit margins went down, harming both DoD and industry. As a result, "defense aerospace companies essential to a strong defense infrastructure would be in trouble, and this was not in the interest of the nation, DoD, or stockholders" (Deutch, 2001, p. 138).

Today, budgets are again tight and maintaining financial success for defense industries is necessary for the current U.S. strategy. The further consolidation of the defense industry during the most recent defense

drawdown has led to concern on the part of Under Secretary of Defense for Acquisition, Technology and Logistics Frank Kendall, concerning the “diversity and spirit of innovation that have been central to the health and strength of our unique, strategic defense industrial base” (Mehta, 2016). Further consolidation of defense industries may run afoul of antitrust laws and, consequently, threaten the necessary economic incentives that antitrust laws aim to protect, such as efficient prices, innovation, and competition, which are all important when maintaining a healthy industrial base. However, international joint development programs could serve to alter the trajectory of defense consolidation. Instead of merging, separate industries—potentially from separate countries—can work together to develop and produce acquisition programs. In this scenario, unit costs would decrease and resources could be focused on producing one product instead of multiple variations of the same product in different partner nations.

In addition to the complicating effects of consolidation during the post–Cold War drawdown, organizational complexity confronting industry rose due to the increasing demand for technically complex systems that involved subsystems and participation from multiple industries. Industry consolidation chiefly responded to protecting industries from market uncertainty, and it also introduced opportunities for better management of programs. While discussing the industry consolidation during the 1990s, Drezner concludes that “the top-tier defense firms have restructured to better address technical, organizational, and environmental complexity . . . these integrated defense business units also position the firms to better address interdependency and interoperability across system types, a challenge driven at least in part by technical, organizational, and environmental complexity” (Drezner, 2009, p. 40). Again, since consolidation in today’s defense industrial base is not always helpful, international joint development programs could be viewed as an alternative. Instead of consolidating industrial firms within countries to better address technical, organizational, and environmental complexity, the firms working on a program could build partnerships from the international pool of industries. While this might produce additional organizational complexity, it can also help solve issues associated with both technical and environmental complexity by reducing costs, increasing interoperability, and pooling intellectual and tangible resources.

While classic economic theory’s assumptions call for efficiency are not met in the defense marketplace, the concept of international joint development offers some potential solutions to the underlying problems of cost, efficiency, innovation, and competition compared to single-nation defense acquisition in the current state of budget cuts and dynamic international threats. The theoretical benefits of international joint development programs merit an investigation of what constitutes successful design and management of such programs. Before investigating how each of the cases in this study were designed and managed, it is important to first understand the already-defined best practices (or lack thereof) for comparison.

3.5 Characteristics

Characteristics are discussed in the first research question:

1. What are the characteristics of international joint development programs that result in positive or negative cost, scheduling, and end-product outcomes such as a final product, interoperability, technical relevance, and development of existing defense industrial bases?⁶

Through analysis of historical records, existing literature, and interviews with experts and program stakeholders, the study team identifies eight characteristics that are unique from single-nation programs in

⁶ End-product outcomes are subjective to each case and successful end-product outcomes for each case will change depending on the purpose and goals of the program.

their ability to impact outcomes of international programs. Additionally, further analysis of these eight characteristics led the study team to identify two more characteristics, numbers nine and ten below, respectively. The 10 total characteristics are:

- | | |
|-----------------------------------------------------------|------------------------------------------------------|
| 1. Levels of integration between countries and industries | 6. Alignment of operational needs |
| 2. Number of participating countries | 7. Tradeoff between leading-edge technology and cost |
| 3. Nature of the needs driving decisionmaking | 8. Workshare distribution |
| 4. Commitment mechanisms | 9. Technology transfer |
| 5. Flexibility | 10. Language, culture, and time zone differences |

The first characteristic is integration. As Drezner recognizes, organizational complexity is inherent in modern acquisition programs. Drezner states that “*Organizational* complexity addresses the structures and interactions of the government and industry organizations responsible for system design, development, production, and support” (Drezner, 2009, p. 32). One complex aspect unique to international cooperation is the transnational partnerships that must be made for governments and industry to work together. Consequently, deeper layers of complexity exist: first, between governments; second, between government and industry; and third, between industries. In 2003, the U.S. Government Accountability Office (GAO) published a report that argues, “the collaborative relationship between the customer and the product developer is essential to driving down operating and support costs” (United States Government Accountability Office, 2003). This study decided to focus on transnational relationships by analyzing the level of integration between the players involved.

The second characteristic is the number of participating countries. In 2012, Keith Hartley claimed that the number of partner nations in acquisition programs is associated with collaboration inefficiencies. Furthermore, the number of partner nations, as previously discussed, adds additional layers of complexity.

The third characteristic is how dependent decisionmaking was on operational needs that could not be met by competing systems, versus how dependent decisionmaking was on diplomatic or political needs. Major program decisions, such as those on requirements or contracting, are based on either the operational needs or political and diplomatic needs. The literature suggests that making decisions based on requirements that competing systems cannot meet is more likely to achieve efficient costs and resource allocation than decisions based on political or diplomatic demands (Keith Hartley, 2012, p. 20).

The fourth characteristic is commitment. For programs to achieve the theoretical cost benefits of international joint development, partner nations need to be committed to the program. If a country defects, costs for the remaining countries will rise. If too many nations defect, the program will die.

The fifth characteristic is the program’s flexibility when it comes to adjusting requirements in response to changing environments. The external environment that defense acquisition managers respond to is increasingly complicated by emerging and dynamic threats. Flexibility is an inherent requirement for success in single-nation programs due to the complex nature of modern acquisition programs. This is made even worse by the increased complexity that multination programs experience; joint programs have to simultaneously respond to emerging and dynamic threats, and also handle increased program complexity.

The sixth characteristic is the extent to which the partner nations’ operational goals are complementary. Multiple militaries working together can introduce varying operational goals. In order to produce a

successful end product, partner nations need to have reciprocal goals so that the program stays focused and those involved are equally invested in acquiring the end product.

The seventh characteristic is whether the program was based on demand for leading-edge technology or economies of scale. Achieving either one requires tradeoffs with the other. R&D in modern defense acquisition has an inherent, exceptionally high cost when procuring technologically advanced capabilities. The more exquisite and expensive the system, however, the smaller the number of countries that can both afford it and have a need for the capability, which makes economies of scale more difficult to achieve. Economies of scale exist when the scale of output increases to a point where the per-unit costs of production begins to decrease. International cooperation in defense acquisition increases the likelihood of achieving economies of scale, because, compared to single-nation procurement, more output will be ordered. Therefore, the per-unit cost will decrease and there will be a higher return on the initial investments made for R&D. Economies of scale, however, are achieved only after an operable system has been established, and it is difficult to determine if it will be achieved at the outset of a program. If a program decides to procure a system from scratch, it is not certain that the outcome will be successful enough to make a return on the initial investments made during R&D.

The eighth characteristic captures how the program distributed workshare. To achieve cost-efficient outcomes, international programs present increased opportunity for competition based on comparative advantage. Allocating workshare based on comparative advantage through competition is critical for achieving cost-efficiency, because when there are many substitutable choices for consumers to choose from, suppliers will be forced to produce at the lowest cost possible, as consumers usually choose to buy the product at a lower cost. The international marketplace presents greater opportunity for competition among industries, which in turn capitalizes on different comparative advantages and supply procurement at a lower cost to the buyer. The international marketplace, however, also introduces greater political and industrial-base variables into the equation. Costs are not always the sole incentive for nations to participate in international cooperation in defense acquisition. Countries view strategic posture, trade policy, industrial gain, and technology transfer as spillover benefits that are, in some cases, considered more important than cost-efficiency. Focusing on spillover benefits to a greater extent than cost-efficiency will affect program outcomes and how countries work together. Consequently, the last characteristic crucial and unique to impacting outcomes of international joint programs is whether the distribution of workshare was based on participating countries' comparative advantage or on political or industrial-base goals.

4. Cases

Section 4 introduces the six case studies used for this paper's analysis. Each case is introduced and summarized to highlight both the programs' requirements and the programs' international characteristics. This background is important for the analysis because each case has unique approaches to international cooperation. Additionally, some of the cases possess similar characteristics that are key to the analysis of program outcomes in relation to best practices for designing and managing international programs.

4.1 The Joint Strike Fighter F-35 Program

The FY2000 Director, Operational Test and Evaluation (DOTE) Annual Report describes the Joint Strike Fighter (F-35) program's purpose as to "develop and deploy a family of strike aircraft by capitalizing on commonality and modularity to maximize affordability while addressing the needs of the Air Force, Navy, Marine Corps and United Kingdom Royal Navy and Royal Air Force." The report further emphasizes the affordability factor by saying, "the focus of the program is affordability: reducing the development, production, and ownership costs of the JSF family of aircraft" (*Director Operational Test and Evaluation Annual Report FY2000*, 2001). Two years after Lockheed Martin was awarded the prime

contract for the F-35 program, GAO succinctly reiterated the purpose of the F-35 program: “the JSF program goals are to develop and field a family of stealthy, strike fighter aircraft for the Navy, Air Force, Marine Corps, and U.S. allies, with maximum commonality to minimize life-cycle costs” (Walker, 2003). These program goals have manifested in the suite of advanced abilities that the F-35 brings to bear, including cutting-edge sensors, stealth technology, and networked interoperability (Sullivan, 2016). Additionally, while the F-35 program’s primary focus was on achieving the appropriate operational capabilities to become the next-generation strike fighter in respect to the many technical requirements defined at the outset, the program also emphasized affordability. Furthermore, some of the international partner nations joined this program not only to reap the operational and monetary benefits, but to develop a stronger relationship with the United States and to play a role in future strategic and military collaboration.

A crucial component of the F-35 has been the utilization of partner nations throughout the design, development, and production of the program. Initially, the F-35 program⁷ was established to replace U.S. attack fighters, specifically the A-12 program, which was originally meant to replace the A-6 carrier-based attack planes, and the Multi-Role Fighter program, which was originally meant to replace F-16s. Additionally, the Joint Advanced Strike Technology (JAST) program sought to develop a cutting-edge STOVL aircraft (Gertler, 2014). These goals appealed to the U.S. Air Force, U.S. Navy, U.S. Marine Corps, and the United Kingdom, who were the initial interested parties in developing this program when it became the JSF program. After JAST transitioned to the JSF program, the requirements in the aircraft were expanded to address capability gaps between allied air forces and the United States that had been noted in the then-current U.S. National Security Strategy. In 2001, the United States invited Australia, Canada, Denmark, Italy, the Netherlands, Norway, Turkey, and the United Kingdom to officially join the program after the prime contract was awarded to Lockheed Martin’s F-35 model (“The F-35: A New Era of International Cooperation,” 2015). From 2011 to 2015, 154 aircraft were delivered to DoD and the JSF international partners (Sullivan, 2016) out of a planned output of 3,025 aircraft, with 582 aircraft designated for international partners (Lockheed Martin, 2015). Additionally, Japan, Israel, and South Korea joined the program as FMS partners in 2014 and 2015. These nations have thus far ordered 16, 33, and 40 aircraft, respectively, while Japan and Israel have the option to purchase additional aircraft moving forward (Office of the Under Secretary of Defense for Acquisition Technology and Logistics, 2015).

According to a 2015 GAO review of the program, the F-35 currently faces “significant affordability challenges” (United States Government Accountability Office, 2015a). While cost baselines, schedule projections, and technical capabilities have consistently not been met, the program has made new baselines⁸ and recently shows progress in punctuality (*F-35 Joint Strike Fighter Assessment Needed to Address Affordability Challenge*, 2015). For instance, according to the 2015 DOTE report, the number of 2015 actual test flights⁹ was only 88 behind schedule, which is a 7.4 percent difference from what had been planned. Compared to 2012, when only 34 percent of the planned flight tests had actually been executed, a 7.4 percentage point difference is a large improvement (Office of the Under Secretary of Defense for Acquisition Technology and Logistics, 2012).

Since the system development and demonstration (SDD) phase went into effect, the program has not met cost or schedule goals. Instead, it has been re-baselined three times¹⁰ and faced a few existential crises

⁷ At inception, the program was called the Joint Advanced Strike Technology.

⁸ The F-35 program was restructured in 2003, 2007, and 2012.

⁹ As of November 2015.

¹⁰ December 2003, March 2007, March 2012.

and a series of smaller obstacles (*F-35 Joint Strike Fighter Assessment Needed to Address Affordability Challenges*, 2015). However, many of these challenges can be attributed to the risks and challenges inherent to technologically leading-edge acquisition programs. The challenges unique to the international aspect of the program seem to have been less of an existential threat to the program. Another characteristic crucial to the international cooperation side of the F-35 is how decisionmaking was made based on operational or diplomatic and political needs.

4.2 The NATO Alliance Ground Surveillance Program

The roots of the AGS program started growing in the early 1990s when NATO's Defense Capabilities Initiative (DCI) called for both higher standardization and interoperability of NATO alliance equipment, and using cooperative development and production to realize the theoretical economic and technological benefits cooperation presents. Additionally, the U.S. use of the Joint Surveillance Target Attack Radar System (JSTARS)¹¹ during Operation Desert Storm in 1991 accentuated the paramount importance that intelligence, surveillance, and reconnaissance (ISR) capabilities played in next-generation warfare of that time (Chao, 2004, p. 6). Responding to this capability demand, the inception of the AGS program occurred in November 1995 by the Conference of National Armaments Directors (CNAD) (*The New Cross-Border Business Relationships: Case Study Findings and Proposed Future Research from Going Global?: U.S. Government Policy and the Defense Aerospace Industry on JSTOR*, 2002, p.151). The original proposal for the AGS program was a "NATO-owned and operated core AGS capability, supplemented by interoperable national assets" (Chao, 2004, p. 5). Furthermore, program stakeholders from both government and industry emphasized that when making decisions throughout the program, decisionmakers needed to ensure that there was a European face on the project and that it was an alliance program. From the beginning, the AGS program wanted to include as many nations as possible while staying cost effective and maintaining operational requirements.

It was not until 2009 that 15 NATO partners signed the PMOU agreeing to the legal and budgetary framework for AGS, as well as to the organization of how the AGS program would be executed ("NATO's Allied Ground Surveillance Programme Signature Finalised," 2009). During the 14 years it took for the program to go from inception in 1995 to a PMOU in 2009, drivers from various sources influenced the course of the program and ultimately caused such a lengthy process. JSTARS was the original consideration for AGS given its operational ISR capabilities. In this scenario, the United States would have been responsible for the air component and Germany would have been responsible for leading the procurement of the ground component. The European partners, however, disliked this route for two reasons. For one, JSTARS was too expensive. Additionally, the European partners wanted to play a greater role in the procurement of the program (Johnson, 1998, p. 1, 2). There was concern that if the United States were to supply JSTARS as the air component, there would be no opportunity for radar technology sharing. The European partner nations did not see any spillover benefits of industrial participation or information technology advancement and as a result, JSTARS was rejected by NATO as a candidate for the AGS program (Chao, 2004, p. 6).

After the partner nations voted against JSTARS, the CNAD initiated the NATO Transatlantic Advanced Radar Program (NATAR) through a concept definition study aiming to utilize Radar Technology Insertion Program (RTIP) technology in AGS (M. A. Lorell et al., 2002, p. 151).¹² Concerns over U.S. technology transfer laws and using a United States-centric acquisition approach limited European interest

¹¹ Northrop Grumman's E-8 JSTARS was an aircraft designed to conduct ground surveillance, command and control, and battle management.

¹² RTIP consists of an advanced active electronically scanned array (AESA) radar and associated electronics.

in NATAR. Consequently, in 1998, France, Germany, Italy, the Netherlands, and Spain jointly cooperated to develop the Standoff Surveillance and Target Acquisition Radar (SOSTAR-X) technology demonstration program (M. A. Lorell et al., 2002, p. 157). A 2002 RAND report found that some of the nations participating in the SOSTAR concept definition study viewed the SOSTAR program as partially intended to create more bargaining power for the European partners to use in leveraging terms of entry into NATAR (M. A. Lorell et al., 2002, p. 157). In 2001, Northrop Grumman (NG) worked with Daimler/Chrysler Aerospace to propose a transatlantic approach to rekindle the stonewalled program by signing an MOU that proposed combining the RTIP-based NATAR program with the SOSTAR program (M. A. Lorell et al., 2002, p. 158). In 2002, the United States, France, Germany, Italy, Spain, and the Netherlands signed the “Statement of Intent to Assess a Cooperative Radar Development” at NATO’s summit in Prague. This officially merged the NATAR and SOSTAR programs into the Transatlantic Cooperative AGS Radar (TCAR) program (Chao, 2004, p. 5).

In 2004, the AGS program—still in its TCAR stage—became a mixed fleet consisting of both manned and unmanned systems. TCAR radars would be mounted on Airbus A321 aircraft and Northrop Grumman RQ-4 Global Hawk unmanned aerial vehicles (UAVs) mutually augmented by a ground segment (“Alliance Ground Surveillance (AGS),” 2016). In 2007, financial circumstances put pressure on defense budgets in Europe and forced NATO to drop the mixed-fleet approach. Instead of A321s and RQ-4s with TCAR radars, the program decided to buy off-the-shelf Block 40 RQ-4s equipped with MP-RTIP radars. The composition of the ground segment would remain largely the same and be developed and procured by the European and Canadian partners (“Alliance Ground Surveillance (AGS),” 2016). In 2009, the NATO AGS PMOU was signed and serves as the official contractual agreement binding the various partner nations to procuring AGS. NATO’s 2010 Lisbon Summit reinforced its commitment to “collective defence, crisis management and cooperative security,” reinforcing the DCI’s statement 20 years earlier that called for both higher standardization and interoperability of NATO alliance equipment (“Lisbon Summit Declaration,” 2010).

In its current state, AGS is composed of 5 Block 40 RQ-4s complemented by 22 mobile general ground stations (MGGs) and a support segment (Kington, 2016). AGS completed its first test flight (Seligman, 2015) and also saw the delivery of the first of its MGGs in late 2015 (“Airbus Defence and Space completes first mobile general ground station for NATO’s Alliance Ground Surveillance,” 2015). All AGS aircraft are scheduled to be completed and delivered to AGS’s base in Sigonella, Italy, by 2017 (Kington, 2016).

4.3 The Lightweight 155mm Howitzer M777 Program

The Request for Proposal (RFP) for the M777 was released April 10, 1996. The M777 would replace the M-198 howitzer previously used by both the Marine Corps and the Army introducing a lighter machine capable of higher fire speed and accuracy rates.¹³ The RFP stated that the platforms competing for the contract would first be presented at Yuma Proving Ground on April 25, 1996, and that the companies able to provide a platform that met the operational requirements detailed within the RFP would receive a shoot-off contract. The RFP requirements centered on weight, safety, transportability, and traverse and elevation requirements, while the engineering, manufacturing, and development EMD contract was to be awarded based on technical merit, short- and long-term costs, and a past performance risk assessment.

¹³ The Army incarnation uses the abbreviation Lightweight 155 or LW155. This paper uses M777 for both the Marine and Army version for simplicity.

The final contract would be awarded based on best overall value (United States Marine Corps and United States Army, 1999).

Textron Marine and Land Systems teamed with Vickers Shipbuilding and Engineering, LTD. (VSEL), United Defense Limited Partnership with Royal Ordnance, and Lockheed Martin competed in the shoot-off phase to award the contract. The team of Textron and VSEL won the EMD contract March 1997. A year later, Textron dropped out leaving the contract to VSEL due to internal management difficulties at their production facility in New Orleans. Following that announcement, VSEL declared that 70 percent of its M777 manufacturing and assembly work would be conducted in the United States by an American subcontractor, despite VSEL's status as a British company (United States Marine Corps and United States Army, 1999). VSEL made significant progress in development of M777 during its time as the system's prime contractor and made extensive use of American arsenals in its development and production of M777. VSEL experienced some challenges in adapting to the American systems engineering process. This led to an initial delay as VSEL restructured preproduction systems engineering tasks, and led to a program cost growth of \$43 million. This restructuring also generated a 21-month program delay, from December 1999 to September 2001 (United States Government Accountability Office, 2000, p. 7, 8).

In 1999, BAE Systems acquired VSEL, making it the new M777 prime contractor. This transition was accompanied by a contract overhaul, which shifted the contract to a cost-plus-incentive fee contract and included various schedule shifts. BAE quickly began to encounter manufacturing challenges with M777, many of which were driven by problems with welding the titanium parts in M777.

In the initial conceptualization of M777, it was planned that the Marine Corps and Army would be the only groups to acquire the platform. However, in the past decade the United States has utilized FMS to provide M777 to allies across the globe following M777's successful deployment in Afghanistan and Iraq. Australia ordered 35 M777s in 2009 and ordered an additional 19 three years later, Canada acquired 12 howitzers between 2005 and 2008 and acquired more 25 in 2009, and Saudi Arabia purchased 36 M777s in 2011 ("\$118 Million in New Orders for BAE Systems' M777," 2009; "19 New Howitzer Guns for the Army," 2012; "M777 155mm Ultralightweight Field Howitzer, United Kingdom," n.d.). Additionally, India recently finalized the acquisition of 145 M777s in February 2016. BAE and its Indian partners agreed that the deal would include an offset worth 30 percent of the agreed value of the contract, that BAE would move its M777 assembly, integration, and test facilities to India, and that 40 Indian defense companies would participate in production of M777 as well as maintenance and repair (Grevatt, 2015).

4.4 The Medium Extended Air Defense System (MEADS)

The Medium Extended Air Defense System (MEADS) is a jointly developed ground-based mobile air missile defense (AMD) system designed to replace the Patriot, Hawk, and Nike AMD systems in the United States, Germany, and Italy. MEADS provides a key defensive capability against tactical ballistic missiles, cruise missiles, air-to-surface missiles, antiradiation missiles, and unmanned aerial vehicles (Office of the Under Secretary of Defense for Acquisition Technology and Logistics, 2014), and fills a critical operational gap in defense of maneuvering forces (Under Secretary of Defense (Comptroller), 2000). It is marked by enhanced in-theater mobility, strategic deployability, and networked interoperability (Under Secretary of Defense (Comptroller), 2000). The program is managed by the NATO MEADS Management Agency (NAMEADSMA) on behalf of the nations involved in the platform's development, production, and acquisition (*Fiscal Year 2013 United States Army Annual Financial Report*, 2013), while the contractor in charge of MEADS is a tri-nation venture consisting of MBDA Italia, MBDA Deutschland, and Lockheed Martin under the umbrella of MEADS International ("About MEADS," n.d.).

The MEADS program commenced in 1989 following the Army's recognition that it needed to replace older air defense systems such as the Homing All-the-Way to Kill (HAWK) missile. This replacement would work in concert with existing and planned systems, such as the Patriot Advanced Capability 3, while providing new capabilities not present in competing systems. However, the then-under secretary of defense for acquisition and technology stated that he would allow development of a new air defense system only if the Army found partner nations to cooperate with in the program. As MEADS approached its initial formal approval in the mid-1990s, then-Deputy Secretary for Defense Bill Perry enforced a push for international cooperation in defense acquisition. Perry encouraged nations to work together for cooperative programs throughout the 90s. Germany was the first nation invited to join the program, and out of desire to make the program a U.S.-European cooperative acquisition, Germany invited Italy and France to join as well. In February 1995, the four nations signed a multilateral statement of intent to design a platform capable of filling the capability gaps of all four nations, which led to the MEADS program. However, France dropped out of the program due to budgetary concerns before the program's MOU was signed in May 1996 (United States Government Accountability Office, 1998).

The MEADS's acquisition schedule consisted of three phases: Project Definition and Validation (PD/V), D&D, and Production (Missile Defense Agency, 2004). The MEADS PD/V MOU signed in 1996 allocated the cost shares for the PD/V phase as the United States, Germany, and Italy taking responsibility for 60, 25, and 15 percent, respectively. Additionally, it stated that the participating nations would create new MOUs at each stage of the program in order to provide an opportunity for the participants to renegotiate cost shares or drop out of the program altogether. After the MOU was signed, a GAO report on MEADS noted, "DOD believes the MEADS program represents a new and innovative approach to the acquisition system" because it "reflects the missions needs of all countries, involves technology from all countries, and requires competition between two transatlantic contractor teams" (United States Government Accountability Office, 1998). MEADS program plans from the 1990s scheduled a production target for 2007 (Office of the Secretary of Defense, 2014).

While the program had originally aimed to transition from the PD/V phase to the D&D phase in FY 1999 (The Office of the Director of Operational Test and Evaluation, 2001), the program restructure in 2001 added a three-year Risk Reduction Effort (RRE) (The Office of the Director of Operational Test and Evaluation, 2001). The aim of the RRE phase was to "(1) demonstrate an integrated MEADS system concept incorporating the [PATRIOT Missile System's] PAC-3 missile, (2) reduce the overall program's technical, schedule, and cost risk, and (3) develop the international cost and schedule consensus for the MEADS program" (Missile Defense Agency, 2004). The effort was first advocated for by Germany, which wanted to reduce its development costs. A major part of the RRE was a three-year, \$216 million contract, of which the United States paid 55 percent, Germany 28 percent, and Italy 17 percent, that was awarded to MEADS International (Shuey, 2001).

The plan to incorporate the PATRIOT's PAC-3 missile into MEADS was designated as the PATRIOT/MEADS Combined Aggregate Program (CAP) (Office of the Director of Operational Test and Evaluation, 2005). At the time of the program restructuring, MEADS's Milestone B was scheduled for 2Q FY2004, Milestone C was scheduled for FY 2009, and full rate production was scheduled for FY 2012, which moved the full-rate production decision back five years from its 1990s target (Office of the Director Operational Test and Evaluation, 2001).

By 2004, MEADS's Major End Items (MEIs)¹⁴ received a successful Milestone B decision, thus moving the program's MEIs into low-rate initial production (LRIP) (Office of the Under Secretary of Defense for Acquisition Technology and Logistics, 2014). However, MEADS's targeted full-rate production start slipped another two years to 2014 (Office of the Secretary of Defense, 2014). On the international stage, the United States and Italy both signed the MEADS D&D MOU in late September 2004, and NAMEADSMA awarded MEADS's \$3.4 billion D&D contract to MEADS International on May 31, 2005 (Under Secretary of Defense (Comptroller), 2012a).

By 2011, the Office of the Secretary of Defense (OSD) responded to mounting concerns about MEADS's high level of risk and rising costs by proposing that the United States cease participation in the program. A 2011 OSD evaluation of MEADS noted, "[MEADS] has been unable to meet schedule and cost targets," pointing to MEADS's seven-year delay in production commencement and a necessary program restructuring that would extend the program an additional 30 months and cost \$947 million over five years. The proposed restructuring would move MEADS production date to 2018, placing the program 14 years behind schedule.

OSD laid out reasons supporting the defection of the United States from the program in its 2011 evaluation. Beyond the overall concern with the cost growths and schedule delays of the program, OSD stated that the United States would not be able to upgrade its previously existing Patriot missile defense systems and purchase MEADS simultaneously due to budget restraints. If DoD decided to acquire MEADS, it would be forced to invest in MEADS while simultaneously sustaining and modernizing its Patriot system until MEADS reached operational capacity (United States Government Accountability Office, 2012). On the other hand, OSD resisted calls for the outright cancellation of the program prior to the completion of the current phase. Instead, OSD recommended that the program utilize the rest of its D&D funding, as laid out by the D&D MOU with the express aim of "implement[ing] a 'proof of concept' effort . . . [to] provide a meaningful capability for Germany and Italy and a possible future option for the United States." This "proof of concept" phase would end in 2014, and would allow the nations involved in the program to repurpose technological advancements while also providing the United States an avenue by which to exit the program (United States Government Accountability Office, 2012).

Indeed, in 2011, the United States formally withdrew from the program by ceasing to fund MEADS beyond its 2013 obligations. By that time, DoD had spent \$1.5 billion on the program, and had pledged another \$804 million to see the program through completion of D&D (Stewart & Shalal-Esa, 2011). However, the departure of the United States from the program has not ended the program entirely. Poland and Turkey both expressed interest in acquiring MEADS to bolster their respective air defense capabilities this year (Forrester, 2016). Members of the Turkish government suggested that they preferred to develop a missile defense capability indigenously, but rising regional threats and the long timeline inherent to such a project may nevertheless force Turkey to acquire a missile defense system internationally instead (Kaplan, 2016). Additionally, Germany has announced that it will partner with Lockheed Martin and MBDA Deutschland to adapt MEADS to serve as the foundation for Germany's Taktisches Luftverteidigungssystem (TVLS) next-generation air defense system ("Germany Announces MEADS Selection for Future Air and Missile Defense System," 2015).

¹⁴ MEADS's Major End Items (MEIs) include surveillance radars, fire control radars, battle management command, control, communications, computers and intelligence (BMC4I) tactical operations centers, lightweight launcher, and launcher reloaders.

4.5 The Standard Missile-3 Block IIA

The relationship between the United States and Japan critically bolsters U.S. presence in Asia. The security relationship is grounded in mutual concerns centered around an expansionist China and a belligerent North Korea. Increased tensions between Japan and China, as well as advancements in North Korea's nuclear program, have led to increased military cooperation between the United States and Japan. Throughout the past decade, the alliance has worked toward promoting military interoperability in various areas: maritime operations, counter-piracy, ballistic missile defense (BMD), and ISR (Chanlett-Avery, Manyin, Rinehart, Nelson, & Williams, 2015). This increased cooperation culminated in the 2015 release of the new Guidelines for Japan-U.S. Defense Cooperation. These guidelines created an Alliance Coordination Mechanism to promote bilateral security and defense cooperation, emphasized bilateral planning for joint operations, and encouraged further bilateral enterprise through joint acquisition for defense equipment and technology (Japan Ministry of Defense, 2015).

In regards to acquisition, the central piece of this enhanced cooperation has been the Standard Missile-3 Block IIA (SM-3 Block IIA). SM-3 Block IIA is the latest missile developed under the umbrella of the Aegis Ballistic Missile Defense (BMD) forward-deployed ballistic missile detection and interceptor system (Under Secretary of Defense (Comptroller), 2012b). The Standard Missile 3 (SM-3) is the component of the Aegis system that acts as an interceptor missile (O'Rourke, 2016), and SM-3 Block IIA is the third iteration of SM-3, possessing greater velocity, range, and accuracy than its predecessors (United States Government Accountability Office, 2013). SM-3 Block IIA is unique among the programs analyzed in this study in that it takes a previously existing, American-developed system and upgrades it with additional support from an ally, in this case Japan. Raytheon and Mitsubishi Heavy Industries (MHI) are the prime contractors for the United States and Japan, respectively (Standard Missile-3 IIA Completes Critical Design Review: U.S.-Japan Co-Development Program On Track For 2015 Flight Testing, 2013).

Cooperative BMD technology R&D began in the 1980s with the commencement of the Western Pacific (WESTPAC) Missile Defense Architecture Study, which was conducted by Japanese and U.S. industry. This study examined opportunities for U.S.-Japan cooperation in BMD technology (Kallender-Umezu & Pekkanen, 2010). In 1998 the government-to-government MOU for Joint Cooperative Research (JCR) for SM-3 was signed. This MOU made it easier for Japanese and U.S. industry to engage in technology transfer (Cronin, 2002). Japan and the United States began actual joint development in 2006 by commencing the SM-3 Cooperative Development (SCD) project. As part of SM-3 Block IIA's development, Raytheon and Mitsubishi opened liaison offices in each other's SM-3 development sites that led to more effective coordination between the two firms.

SM-3 Block IIA's MOU (O'Rourke, 2016) notes that the United States and Japan are responsible for funding their respective portions of SM-3 Block IIA development and testing, and therefore Japan and the United States will not transfer actual funds to each other. Under the MOU, Japan is responsible for the SM-3 Block IIA nosecone, as well as the second- and third-stage components, the United States is responsible for the kinetic warhead, missile guidance systems, and Aegis integration, and all testing and evaluation is conducted jointly (Under Secretary of Defense (Comptroller), 2015).

SCD's development and testing has been broken up into three phases. The first phase took the program from its conception up to System Design Review (SDR), which occurred in FY 2009. Phase II, which consisted of work done from SM-3 Block IIA's SDR up to and including SM-3 Block IIA's Critical Design Review (CDR), concluded in FY 2014. As part of Phase II, Japan and the United States designed, manufactured, tested, and assessed their corresponding parts of SM-3 Block IIA. The ongoing third phase of the program includes all work between completion of the SDR and completion of SM-3 Block IIA's testing schedule. SM-3 Block IIA's acquisition strategy is a performance-based approach, linking testing success to key program decisions (Under Secretary of Defense (Comptroller), 2015). SM-3 Block IIA was allowed to begin testing only after it achieved full design maturity by its CDR—this maturity was

demonstrated by SM-3 Block IIA's 100 percent completion of its design drawings and lack of major design defects in FY 2014 (United States Government Accountability Office, 2015b), (Under Secretary of Defense (Comptroller), 2015). The initial production decision for SM-3 Block IIA is planned for 3QFY 2017 (United States Government Accountability Office, 2015b).

4.6 A400M

Conceptually the A400M was to become “a flagship European collaborative procurement project . . . represent[ing] . . . the new beginning to European defence and security” (Mawdsley, 2013). By using European collaboration and a new management structure, the A400M would theoretically avoid many of the cost and schedule challenges resulting from political backlash that were encountered during one of Europe's previous collaborative projects, the Eurofighter. Central to this procurement approach was the Organisation Conjointe de Coopération en matière d'Armement (OCCAR), a new cooperative defense management agency established by France, Germany, Italy, and the United Kingdom in 1996 to prevent political friction and domestic interests from impeding A400M's development (Mawdsley, 2013).

A400M's original designation was the Future Large Aircraft (FLA). FLA's RFP was issued on behalf of the United Kingdom, Italy, France, Belgium, Germany, Spain, and Turkey to Airbus in September 1997 (National Audit Office, 2015). Airbus Military Company was established two years later by BAE Systems, Daimler Chrysler, Aerospatiale Matra, and Casa to direct development and production of A400M. In 2001, Belgium, France, Germany, Luxembourg, Portugal, Spain, Turkey, and the United Kingdom announced an order of 196 A400Ms (Hepher & Siebold, 2010), and by May 2003, A400M's fixed price development and production contract was signed (House of Commons Defence Committee, 2011). A clause within the A400M contract noted that any nations involved in the program could exit and recoup their previous contributions to the program if the A400M's first flight was delayed by over 14 months. Additionally, the contract stated that a government could levy a payment penalty of 0.02 percent of the A400M's base cost for each day that the nation's aircraft was late for its delivery date, with a cap of 6 percent placed on the penalty (Gros-Verheyde, 2009). By late 2005, South Africa and Malaysia had also announced A400M orders, although South Africa would cancel its purchase four years later (Hepher & Siebold, 2010).

According to the legal framework behind the A400M, workshare distribution was allocated conscious of the fact that “juste retour,” where every participant received workshare equal to its individual financial contribution, is not financially efficient. Instead, the program aimed to reconcile the tendency for countries to seek industrial benefits at the cost of financial efficiency through its work allocation. To do this, the program relied on the consortium and prime contractor Airbus to handle the distribution of workshare across the major industry locations of the participating countries with aircraft component management teams (Sénat, n.d.).

The first completed A400M was assembled in Spain, June 2008 (National Audit Office, 2015). However, Airbus announced in 2009 that it needed to amend the A400M contract with its European partners to ensure additional funding and loans. Following that announcement, France declared a willingness to reconsider certain financial penalties within the contract, but Germany was unwilling to do so and the United Kingdom noted that it had begun considering an alternative platform to fill the A400M's capability gap (Gros-Verheyde, 2009). Leading up to negotiations for a new contract, Airbus Chief Executive Officer Tom Enders announced that Airbus was willing to walk away from the A400M given the program's exorbitant costs. He cited the European nations involved in the program when discussing causes for Airbus's spread of the project's workshare throughout Europe and acquisition of engines from an untested European consortium. Airbus had preferred established U.S. engine-maker Pratt and

Whitney(Wilson, 2010). After a year of contentious contract negotiations, additional funding was granted to Airbus (House of Commons Defence Committee, 2011).

A400M's test aircraft completed its first flight in late 2009, and completed more than 800 hours of test flights during the next year. However, the A400M was three years behind schedule by 2010 (House of Commons Defence Committee, 2011). According to a 2009 analysis of the A400M featured in *Europolitics*, a now-defunct magazine focused on European affairs, these delays can partially be attributed to differing cost, schedule, and capability interests among the partner nations involved in the program. These conflicting interests being: an overemphasis on innovation without a requisite schedule adjustment, a misunderstanding of the distinctions between military and civilian aircraft acquisition by Airbus, and a lack of direct dialogue between the partner nations and industry. For instance, there was a Contract Effectivity Date (CED) slippage from November 2001-October 2002 that increased costs by £149 million (Comptroller & Auditor General, 2005). Additionally, a 2003 German decision to reduce its future purchases caused a contract renegotiation and an additional £130 million in costs (Comptroller & Auditor General, 2004). The absence of an appointed nation in charge of directing the program, complemented by OCCAR's lack of decision authority, also led to significant program challenges (Gros-Verheyde, 2009). Enders noted that year, "... if stakes are high, national decision-making prevails and overrules European bodies," leaving European defense procurement "miles away from an efficient and effective [process]" (Hepher & Siebold, 2010).

The A400M experienced substantial hurdles in 2013, 2014, and 2015. Between 2013 and 2014, only half of the aircraft that were supposed to be delivered during those years were not completed due to unfinished components arriving at the final assembly line in Spain. Additionally, the program fell short of its November 2014 goal of achieving Standard Operating Capability 1.0, which would have signified the achievement of initial operating capability (IOC) with limited defensive aids subsystems. While failure to reach this benchmark on time triggered a clause within the A400M contract that allowed the European partners to leave the program, none did. In 2015, efforts to get the A400M program back on track were severely hampered by a crash in May during a test flight, which led to the grounding of all production-standard aircraft and left only three test aircraft operational. Subsequent investigations found that three of the crashed aircraft's engines failed to respond to commands from the crew (IHS Jane's 360, 2015).

2016 has been marked by continuing dissatisfaction over the direction of A400M. While Indonesia recently announced that it will purchase "a small number" of the aircraft, expanding A400M's foreign military sales to two recipients (Kapoor & Fabi, 2016), Germany has called for an additional risk assessment of the A400M to bring to light potential future delays or challenges within the program, and has even threatened to leave the program as a result of having received only three of the 53 planes ordered (Copley & Smith, 2016). While Airbus has claimed that its current delays stem from shortcomings with the A400M's engines" (Heller, Carrell, & Chambers, 2016), Germany has nevertheless decided to exercise its contractual ability to demand financial compensation from Airbus in response to the aircraft's delays. Additionally, Airbus recently announced that it was unsure if it would be able to hit its target of 20 delivered aircraft for 2016 (Heller et al., 2016). That said, one interviewee cited the experience of pilots using the A400M in demanding roles being impressed with the qualitative performance improvement over the prior system, in line with the original intent of the program.

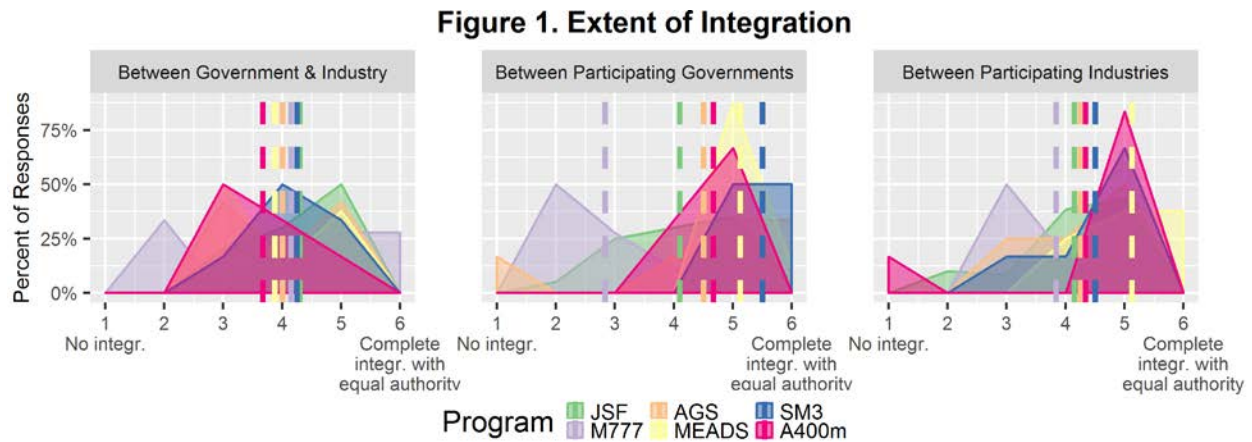
5. Survey Analysis

This section discusses the results from the aforementioned interviews with program stakeholders from government, industry, and academia. To reiterate, the interviews focused on investigating which characteristics, out of the 10 described in Section 3.4, each case manifested in addition to addressing the research questions and hypothesis. Each subsection goes over the exact survey question, the survey

results, and additional discussion relevant to this research effort. The results of the survey that the study team administered during these interviews are displayed in Figures 1 through 8. Figures 1, 2, 4, 5, and 6 display the percent of interviewees that voted for each response level. Figures 3, 7, and 8 report the percent of interviewees that voted for each response level for two related questions and those questions are indicated on the y and x axes.

5.1 Integration

For the integration characteristic, the study team asked the interviewees: On a scale of one to six, rate the level of integration between government and industry, governments, and industries for each program. The responses are reported in Figure 1.



5.1.1 Between Government and Industry

Across all six programs, the level of integration between government and industry was clustered around “decisionmaking” integration. At this level of integration, the government made all final decisions, but there was also collocation of employees from both government and industry where the two would consult before final decisions were made. This collocation increased during production.

For the F-35 program, the contract was more of a top-down relationship in terms of decisionmaking, where the government had the majority of decisionmaking power. The level of relationship between government and industry often depended on the company in question. One interviewee noted that integration with the government was highest with top-tier companies with those in the supply chain largely speaking to one another. The government and industry had an extremely close working relationship, but government still had the final say in program direction.

For AGS, the relationship between government and industry was strong and positive in some instances, but in other cases caused problems for the program. The most notable and positive relationship was between NATO and NG, which consulted regularly from the outset. For other companies, the integration between industry and government occurred domestically. Due to each country wanting to secure its own investments, issues arose, because it was difficult to create work for every country based solely on investment levels. Without higher levels of transnational integration, certain countries viewed that the level of their industries’ workshare was not worth the costs and defaulted from the program.

For the A400M program, the level of integration between government and industry evolved over the lifespan of the program thus far. The governments of the participating states are represented by OCCAR and OCCAR acts as the point of contact to industry for the participating governments. One notable aspect of the government-to-industry relationship was that the governments made fixed order contracts with the

industry that fixed the number of future orders. Due to the financial crisis, strains on defense budgets caused participating countries to demand fewer aircraft. Because of the fixed order contracts, countries had to work deep into the integration with the companies in order to make new deals. One interviewee argued that the general relationship between Airbus and governments was initially too closely defined. The program used the agency model of cooperation where all the companies worked together and made decisions on requirements that involved politically driven conflict. Different countries wanted different requirements but had equal share and power within Airbus, which caused tension. One instance where this caused adverse program outcomes was a 2008 contract renegotiation caused by German reduction in offtake. The result was an increase of £130 million (Comptroller & Auditor General, 2004).

The SM-3 Block IIA program is unique in that each country is responsible for implementing its own government-to-industry relationship. There is little cooperation between U.S. and Japanese industries, and each country's respective government and industries work together differently. The U.S. government hired Raytheon as the prime contractor for the U.S. portion of the program and Japan hired Mitsubishi Heavy Industries (MHI). The program is more of a government-to-government program. One interviewee emphasized that this integration mechanism has made engineering harder while also making budget and progress at the top level easier.

In the MEADS program, the participating governments always had the final say in the program. On the U.S. side, however, there was a perpetual dialogue with Lockheed Martin that happened in response to problems or just for updates.

5.1.2 Between Governments

Compared to integration between government and industry, integration between governments showed significant variability between programs, suggesting that while government-to-industry relationships may be fairly standardized, government-to-government approaches are not.

The most government-to-government integration was observed in the SM-3 Block IIA program, which executed government meetings at a relentless pace during the initial years of the program to keep Japan and the United States as equals as much as possible on the government side. This was continually pushed in order to efficiently work through the requirements for the program. The requirements, however, were less of an issue for this program because of the strong mutual demand for BMD systems as a key element for both countries at that time. This really helped the program because according to one interviewee, if the politics do not work, then nothing will. Additionally, both U.S. and Japan governments have worked in collocated facilities in both Japan and the United States.

The next tier of government-to-government integration programs—MEADS, A400m, and NATO AGS—each had a special purpose multinational agency. It was unique for the MEADS program to establish a NATO management agency because the program was not a part of NATO. There is evidence that this was established to help the European participants' governments feel that they would have a greater voice in the government side of the program instead of a U.S.-led project. Even though it was headquartered in the United States, MEADS operated primarily under NATO regulations and policies. For instance, the program's decisionmaking body functioned under consensus-based decisionmaking and equal representation from each partner nation. The program had a strong steering committee and the NAMEADSMO worked under consensus voting despite the differences in financial contribution made by each participant. One interviewee expressed regret when asked about whether or not putting the program under NATO was a good idea. The trilateral aspect of the program could have been a positive characteristic for MEADS that translated into success. Allocating organizational structure to NATO, however, retracted this positive potential. Even though the program was small, the NATO rules and

procedures did not give the program optimal flexibility. Additionally, NATO personnel procedures made it difficult to find the most efficient team to work on the program, which at one point caused delays in the program. Another interviewee noted that commonly, the United States and Germany would be on the same page for technical issues while Germany and Italy would stick together on the European wants and needs. Governments would at a minimum meet twice a year and one interviewee reported that the discussion on MEADS between the participating countries was near continuous.

For the NATO-operated AGS program, the survey responses for integration between governments were comparable to that of MEADS, as can be seen in Figure 1. NATO's historic establishment as an intergovernmental organization bolstered AGS's achievement of high integration between governments. Decisions made on the AGS program were consensus-based with equal voting power for each partner nation. The study team did find, however, that formal voting arrangements did not always translate into how decisionmaking worked in practice. In a consensus-based voting mechanism, notionally every nation comes to the table with an equal stake in achieving its goals. In reality, there are the leaders and the followers during decisionmaking. Typically, newly ascended or smaller partner nations fall into the latter category. When the larger contributing nations reached consensus, the other participating nations were generally quick to follow. Additionally, when there was disagreement between the larger players, delays could and did happen. Holdout partners could be outmaneuvered as long as the remaining nations all agreed, but escalation to direct contact between national leadership was sometimes necessary to resolve disagreement. While NATO as an organization has a strong institutional memory, during the first 15 years of the program there was not a standing office for joint acquisition. Instead, the designated NATO equivalents of a program office—the Board of Directors (BOD) and the NATO AGS Management Agency (NAGSMA)—were not created until the PMOU was signed in 2009. This late organization standup cost the program the benefits of institutional memory, because NAGSMA had not been present during the previous 14 years of the program.

One notable impact that the government-to-government characteristic of the AGS program had on its ultimate fate was the disparate incentives between the United States and the European participants. Although there have been previous instances where the United States participated in the consortium model and European countries have participated in the prime contractor model, the institutional culture between U.S. joint programs and EU joint programs differs, where the United States is more likely to pursue the prime contractor model while the EU prefers the joint-venture or consortium model. One interviewee argued that there was a complete mismatch between expectations and performance for U.S. and European partners during the AGS program and this is likely attributable to the disparate institutional culture between U.S. and EU joint programs.

For the F-35 program, the predominance of the United States resulted in lower government-to-government integration ratings than those projects with featuring more formal equality. The most frequently chosen level was “decisionmaking integration.” The partnership between the governments involved in the program was not legally binding but did implement obligations that represented formal commitments between the partners. The decisionmaking between the partner nations during both the SDD and PSFD phases of the program were made by consensus. At the outset of the partnership, countries determined what was on their “must-have” and “nice-to-have” lists. Despite the eventual exclusion of most “nice-to-have” items, there have thus far been minimal defections and one interviewee argued that most partner nations were satisfied with at least one F-35 variant on an operational level. In addition, there were instances where non-U.S. partner nations teamed up to push for an operational requirement not initially planned by the United States. The mechanism encouraged the U.S. military branches and the partner nations to each coordinate their opinions before facing one another.

For the M777 program, the United States established and built the program, and while the United States consulted with the other nations involved, the program was ultimately U.S.-led with unilateral decisions on requirements. As a result, M777 has the lowest government-to-government integration rating of the sample. International cooperation evolved when other nations decided that this program fulfilled their operational needs and joined the program. The partner-nation governments each had a representative collocated in the U.S.-based program office, but these foreign representatives were there for information gathering rather than for sharing leadership.

5.1.3 Between Industries

Integration between industries, as is shown in Figure 1, is clustered in a manner similar to integration between government and industry. The largest exception is MEADS, which stands out as the most integrated by a fair margin. The industries participating in the MEADS program were integrated through the joint venture, MEADS International. One interviewee suggested that there were no clear costs or benefits to MEADS International. The work division was clear-cut, where the European participants worked on one radar and the United States did the other. For the Europeans, the benefits of MEADS International might have been more highlighted because it made technology cooperation easier. One interesting comparison an interviewee made was that taking the joint-venture approach caused operational inefficiencies. The same interviewee also gave a clear preference for the prime contractor approach for industry contracting in international programs because the interviewee suspected that integration via joint venture more often results in inefficiencies similar to the ones experienced in MEADS.

For the integration between industries in the AGS program, the prime contractor (NG) controlled intra-industry relations. The AGS program was shaped by the *juste retour* concept where cost share equaled workshare. Some experts argue that this concept contributed to the drawn-out, 14-year process of choosing the platform and signing the PMOU. Since European industry wanted access to U.S. technology, it was less desirable for the European partner nations to choose a platform manufactured by the United States because of U.S. hesitancy to share technology. This meant that, with a U.S. platform, there was not a sufficient ratio between cost and workshare. However, from the outset of the program, NG wanted not only to become the prime contractor for the AGS program, but to build a stronger relationship with European industry. To do this, NG built personal and professional relationships through consultation with an emphasis on developing a stronger European relationship. Once the Global Hawk was chosen for the air segment of the program, NG held responsibility for the intra-industry relations. From a U.S. perspective, any arrangement of industry cooperation was acceptable, as long as it led to the best-value product.

For the F-35 program, the industry integration was reported by interviewees as higher than contractually obligated because of the already-established working relationships between Lockheed Martin, Pratt & Whitney, and BAE Systems. However, while the industries involved with the F-35 program had integrated decisionmaking processes and established relationships, commercial tension between industries existed because of external competition. Consequently, industries were less integrated during development and production. However, higher levels of integration during sustainment are anticipated, and tensions over competition appear likely to fade. One of the interviewees reported that governments were more inclined to share information and work together than the industry partners.

The industry integration for the A400M program has experienced a variety of hardships throughout the program thus far. Oftentimes, these have been a result of mismanagement or technological difficulties on

the supplier side. The industrial participants¹⁵ were referred to as aircraft component management teams and each team was led by the prime contractor associated with that team. For instance, the Airbus team included participation from France, Germany, and the UK for work on the fuselages, wings, and wing box. The management team for the engine, Europrop, was a consortium that included Spain, Germany, the UK, and Italy. Additionally, hardships facing the program can also be attributed to the impacts that the financial crisis had on the participating countries.

The industry collaboration of the SM-3 Block IIA program was more cooperative rather than codevelopment. The program was not integrated in the sense that U.S. and Japanese engineers were getting together to work on the platform. The equal authority on the industry side was limited by export control laws. For instance, while industry teams from both the United States and Japan had relationships with each other, there was no collocated program office and each industry team worked on its respective workshares independently. In other words, there was no formal relationship between MHI and Raytheon. In fact, when MHI would ask Raytheon for assistance, Raytheon legally could only tell MHI if the approach they were taking—for example, regarding the weight of their components—was right or wrong. They could not release any further information or guidance.

For industry integration during the M777 program, one interviewee marked the lowest value out of the six programs for this response. Interviewees, however, indicated that the prime contractor, BAE Systems, had regular consultation on decisions between the other industries involved. The prime and subcontractors were more integrated here because BAE Systems controlled contracting with the subcontractors. Regular consultations occurred between contractors when developing the system and throughout manufacturing. This was crucial for cutting-edge technologies. However, as the program matured, consultations happened less frequently.

5.2 Number of Participants

For the number of participating countries characteristic, the study team asked the interviewees: On a scale

Figure 2. Number of Participating Countries



of one to six, rate the extent to which the number of countries involved with the program impacted major decisions. The results are displayed in Figure 2 and show significant variation from program to program. The programs below are considered in two groups. The first group, AGS, JSF, and A400m, had between 6 and 15 participants. The second, MEADS, SM3 Block IIA, and M777, had only two to three participants by the time the MOU was signed. Note that the programs with fewer participants are clumped at both extremes of

the scale in terms of how often that number influenced program choices. SM3 Block IIA and MEADS are at the top while M777 is by far the least integrated. This shows that program structure is at least as important as breadth when determining the influence of the number of participants.

¹⁵ Airbus, EADS, TAI, and Flabel, which have 69.44 percent, 20.56 percent, 4.44 percent, and 5.56 percent of shares in the program.

The number of countries participating in the AGS program varied from inception, and today 15 countries officially participate in the program.¹⁶ In terms of participating countries, the AGS program has the highest number out of the cases analyzed for this study. Multiple interviewees discussed the program's core need to be a NATO alliance program with a European face. Furthermore, from the outset, the program wanted to include as many nations as possible while staying cost effective and maintaining operational requirements. Consequently, the number of nations involved always impacted the program, mirroring what the interviewees said. The core program characteristics of putting a European face on the program and including as many alliance member states as possible influenced many of the twists and turns the program took over its 20+ years of existence. Every decision made had to support inclusion and diversity at the same time that it satisfied each partner nation's investments and national interests. For instance, partner nations rejected the United States' original offer of JSTARS for the air segment of AGS. From there, the United States then offered to use JSTARS radar technology on an Airbus aircraft. This caused further problems with technology gains desired by the EU, was too expensive, and was ultimately an unsuccessful solution. Although the influence that the number of countries had on decisionmaking throughout the program presented challenges, the large number of participating nations also kept the program moving forward. One expert from government noted that if there had been fewer partner nations, the program would have been more likely to fall apart because it would have lacked the broad political support within NATO to push the program forward.

Similarly, multiple interviewees from the F-35 program argued that the higher number of countries participating in the F-35 program prevented the program from being cancelled in the face of challenges. Unlike the AGS program, the experts interviewed responded differently from each other on the characteristic describing the number of participating countries in the program. The study team has concluded that the varied responses for this characteristic can be attributed to different perspectives from different partner nations. Unlike the NATO-driven AGS program, the F-35 program is United States-centric. The United States is harder to integrate with for many of the participating nations because of the size and technical edge of the U.S. defense industrial base as well as technology transfer laws. Historically, the United Kingdom, Canada, and Australia have an easier time with this because of the long-term relationship that they have had with the United States and information sharing. Consequently, some partner nations feel that the sheer number of participants influenced decisionmaking during the program, while other partner nations do not view the number of participants as a unique driver of decisionmaking. On the U.S.-side, experienced experts noted that having a larger number of partners meant that a nation had to craft its communications in a way it would not have had to do otherwise. OSD and service secretariats often had to be involved, which required more overhead as a result of that relationship maintenance.

Similar to the AGS program, the A400M program was specifically designed as an agency model¹⁷ because all countries had equal authority when coming together to decide requirements, making it a more integrated program. While the program knew that more participating nations would result in more opinions and decisionmaking complexity, a consensus-based approach was always feasible. Additionally, interviewees argued that having six motivated customers ensured a good supply of ideas and proposals to solve problems.

¹⁶ Bulgaria, Czech Republic, Denmark, Estonia, Germany, Italy, Latvia, Lithuania, Luxembourg, Norway, Poland, Romania, Slovak Republic, Slovenia, and the United States.

¹⁷ As opposed to lead-nation model or national model.

Turning to those programs with fewer member countries, the SM-3 Block IIA program included participation from both partners in all aspects of the decisionmaking processes. The small size of the SM-3 Block IIA program was important because the United States-Japan relationship faced large culture, time zone, and language hurdles throughout the life of the program. Having more than two partner nations would have made these hurdles exponentially higher. Additionally, from the outset, the program was only meant to include Japan and the United States. There were contractual restrictions on talking to third parties and the program never considered including more participants.

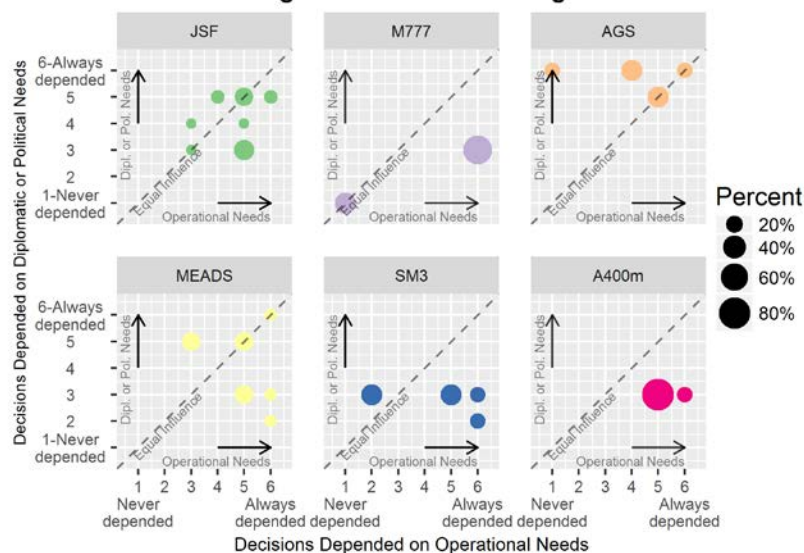
The tri-nation aspect of the MEADS program was more natural selection than intentional planning. More specifically, it was an expensive and big program that needed countries who were focused and dedicated to making the investments to acquire the capability and who had a fairly high level of sophistication in air missile defense. In fact, Poland tried to join the program at one point because it wanted to build its missile defense, but it could not get enough funding to join. All three countries always had an influence on decisionmaking, however—it was common that opinions would be divided between the United States and the European partners, Germany and Italy.

The interviewees for the M777 program unanimously chose “slight influence” for how the number of participants affected decisionmaking during the program. The small number of partner nations coupled with the United States-centric program left little room for the number of partners to cause complications. When speaking with FMS M777 customers, it was clear that the customers had to adhere to what the United States decided for ease of commonality and spare parts. Otherwise, they would face complicated licensing procedures that would only be worth the costs if a high number of units were being procured.

5.3 Decisionmaking

For the decisionmaking characteristic, the study team first asked the interviewees: On a scale of one to six, rate the extent to which decisions regarding the program were made depending on operational needs that could not be met by competing systems. Second, the study team asked: On a scale of one to six, rate the extent to which decisions regarding the program were made depending on diplomatic or political needs. The results are in Figure 3. One striking observation is that operational needs are highly contested. Five of the six cases are spread across at least four points of the scale, with the A400m the sole exception.

Figure 3. Decision Making



For the AGS program, one of the interviewees noted that decisionmaking depended on different factors that changed over the different stages of the program. Another interviewee noted that, for some nations,

decisionmaking depended on operational needs in some instances, but considered industrial-base needs other times. AGS directly responded to NATO's demand for both ISR capabilities and NATO alliance equipment standardization and interoperability in the early 1990s. However, political factors for the AGS program were typically rated higher, which is not surprising given the inclusive alliance goals discussed in Section 3.5.2. For some member states, acquiring the AGS system did not necessarily respond to their domestic strategic goals. Instead, these member states participated with the intention of either being good NATO partners or investing for the benefit of domestic industrial-base interests. For instance, governments that wanted their domestic constituent industries to benefit would be more likely to participate and contribute money. Additionally, the political and diplomatic pressures of periodic summits and major NATO events facilitated decisionmaking during the program. When examining the timing of major decisions throughout the program and major summits or events, there is clear alignment. For example, the AGS procurement contract was signed at NATO's 2012 Chicago Summit. These types of events accelerated key program milestones and decisions.

For the F-35 program, one interviewee was reluctant to rate "always depended" on operational needs even though at the outset the goals were to pursue, develop, and design based on the operational requirements of the predicted evolving security threats. A number of participants joined the program to participate in the development of a fifth-generation fighter, ensuring that they would then be able to acquire it. As the program developed, additional countries joined through scheduled FMS. FMS decisions were partially based on competing interests and best value rather than purely operational requirements.

The responses rating the extent to which decisionmaking depended on diplomatic or political needs for the F-35 program are more in the middle. One of the interviewees from a foreign government chose "depended more than occasionally," because that country chose to participate in the F-35 program not only to reap the operational capabilities, but also to strengthen their interoperability with the United States and allied nations in the future. During interviews, it was suggested that another foreign country participated in the program to advance its domestic industrial capabilities. One interviewee discussed how operational requirements concerns drove decisionmaking during the development stages of the program, while during and after the transition to follow-on development and production, political and diplomatic needs became more important. This could be attributed to the United Kingdom and United States cooperating from the outset, and as the program moved forward, other partner nations joined, which added political concerns, national sovereignty requirements, and diplomatic interests.

The responses for the M777 program on whether decisionmaking depended on operational needs that could not be met by competing systems conflict each other. While two interviewees rated decisionmaking depending on operational needs as a six, "always depended," one interviewee rated a one, "never depended." For the United States, there were no indigenously built competing systems at the time. Instead, the United Kingdom had a lightweight howitzer in the works. The Marine Corps and the Army jointly needed the lightweight and digitized firing system capabilities the M777 offered. The United Kingdom similarly had a demand for this technology because the Falklands War made it obvious that the UK's land munitions lacked M777's capabilities. The United Kingdom's large stakes in this operational requirement made it the dominating industry when competing for the contract.

The interviewees rated lower for the dependence of decisionmaking on diplomatic or political needs for the M777 program. The reason some of the survey respondents chose the third level, "depended occasionally," is that the United Kingdom had already been developing this type of capability in response to its operational gaps during the Falklands War. However, due to the United States Arsenal Act, the United States had to establish a domestic-dominated supply chain. In the end, 70 percent of the program

was made in the United States despite the United Kingdom's existing effort at establishing the capacity to do so.

When the European nations were considering pursuit of the A400M program, there was both a clear capability need and a consensus that age and size of the existing C-130 and C-17 were not sufficient to meet the capability requirement. While Lockheed Martin offered to update the C-130, the European partner nations seeking to fill their heavy transport aircraft capability gap decided that the C-130 was too small and a new aircraft was necessary. Consequently, they decided that the A400M would fulfill their unique strategic and tactical requirements that no existing aircraft had.

As the A400M program was executed under the agency model where all participants were equally integrated, all decisions had a political aspect to them. Furthermore, both research and interviews have shown that political and diplomatic needs are always part of the acquisition process in Europe. In some respects, political factors are what drove the decision to allocate engine development to a consortium consisting of companies that were less qualified than existing competitors. However, the interviewees ultimately disagreed with this characterization, consistently ranking A400m at the lower end of diplomatic and political concerns. This may come down to differing definitions of political needs that consider industrial base matters in a separate category.

For the SM-3 Block IIA program, competing systems were never considered. The program was focused on the SM-3 iterations. Both Japan and the United States demanded the same missile capability as a response to emerging missile threats in the East-Asian theater. Accordingly, they decided the joint development continuing the SM-3 missile would meet this demand. The Japan side did, however, have more of a political aspect to the program. Their expectation was that the program would be successful no matter what, and there was a more concrete expectation on how the program would proceed. On the political and diplomatic dimension, there were times when the joint nature and political ramifications of the program drove some decisions that may not have happened otherwise. As one interviewee put it, the program stemmed from operational needs, but political and diplomatic support had to be there to keep it moving.

The MEADS program did have a competing system: the Patriot missile defense system. While this did not affect the development of the program, it is one of the reasons that the United States decided not to participate in production and deployment of the program. The United States experienced internal disagreement throughout the entirety of the program on whether procuring MEADS was a better decision than upgrading Patriot. For Italy, however, there was no competing system. While Germany wanted MEADS, in retrospect, they also could have upgraded Patriot. Consequently, all three countries were in a different place as to whether MEADS would meet unmet operational needs, which was disruptive to the program. According to the information gleaned from the interviews, decisions were not made on political or domestic factors any more than the average international program.

5.4 Commitment

For the commitment characteristic, the study team asked the interviewees: On a scale of one to six, rate the extent to which commitments for the program stated in the contract or PMOU were binding. The responses rating the extent to which commitments are binding is displayed in Figure 4. One common point across multiple interviews is that the circumstance of the partnership and the larger bilateral relationships, which are key to commitment, often mattered more than the specific mechanisms in the PMOU or contract. That the MEADS program made it through development even though different departments throughout the U.S. government wanted to end the program attests to the fact that MEADS had strong commitment measures. Under the MEADS MOU, if the United States were to have withdrawn

before MEADS was able to complete key D&D tasks, the financial penalties stated in the MOU meant that the United States would have owed more money than it would have cost to complete that phase of the program. There was U.S. criticism for agreeing to enter into a program with such strong terms. One interviewee noted that the MEADS would not have come as far as it has today without the commitment measures in place. Additionally, one of the interviewees suggested that if the United States had defected from the program earlier, other Ministries of Defense might have retaliated by defunding other programs such as the F-35.

Responses to the commitment characteristic are also split for the F-35 program and AGS. When following up with the F-35 interviewees, the study team found that one point of view argued that there are limited explicit measures to prevent defection. For instance, direct PMOU commitments state that if a partner nation decides not to buy its planes, that nation will still have to pay for indirect costs such as production facilitation, logistics sustainment, and follow-on development. This situation acts as a measure to prevent defection but was not explicitly planned in the PMOU or contracts. Furthermore, countries that are benefiting from industrial spillovers have a disincentive to defect because exiting the program would most likely result in losing industrial benefits. Another interviewee concluded that instead of being contractually binding, countries have moral, ethical, and political commitments to the program that act as measures to prevent defection.

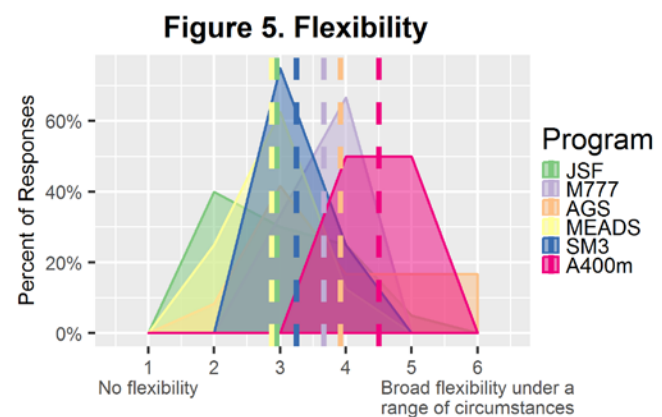
For AGS, there is evidence that these divergences can be explained by differences in point of views from government and industry. For the AGS program, one interviewee expressed that NATO worked hard to put in disincentives for partner nations to quit. At the same time, another interviewee emphasized the importance of having disincentives, but not to the point that nations only stay in the program because the consequences of defecting are too harsh. It was equally important for the partner nations to benefit from participation as it was to prevent defection.

Interviewees from the M777 program noted that for FMS countries, it was easy to defect from the MOU and not buy the scheduled howitzers, but it was harder to get out of the actual manufacturing contracts. Furthermore, manufacturing commitments were stronger with BAE Systems than with U.S. companies, which made it harder to defect from contracts with BAE Systems. For the main participating countries, the United States and the UK, these commitments were not as important because the two participants had such a strong, inherent demand for the capability. This supports the idea that programs whose participants have mutually compatible requirements create natural commitment mechanisms. Consequently, countries that have stronger similarities in demands for operational requirements will more likely follow through on a program.

The SM-3 Block IIA program did not contractually bind the countries to the program so either country could walk away at any point. Instead, the contracts were between each government and their respective industries. However, if one of the partners were to defect, the program would fall apart because the program was conceptually and financially dependent on cooperation. The system would work as intended only if the design elements produced by both partners were combined. As a result, there was more indirect pressure on the countries to remain.

5.5 Flexibility

For the flexibility characteristic, the study team asked the interviewees: On a scale of one to six, rate the level of flexibility the program had in being able to change requirements in response to program updates such as an



Flexibility to Change Requirements in Response to Program Updates

addition of participating countries or new developments. The results are displayed in Figure 5. While flexibility can be an advantage, multiple interviewees also argued that too much flexibility can lead to requirements creep and higher costs. With the exception of the A400M, most programs seemed aimed at a sweet spot between level 3, “changes under multiple circumstances with high hurdles,” and level 4, “changes were easy but only in limited cases.”

The A400M program had a high level of flexibility, which one interviewee reported was a large problem because participants tried to make so many changes that Airbus threatened to terminate the program in the event of any further change requests. A lot of these additional wishes and requirements were not well thought out and the engineering was always hard to execute. It took Airbus a few tries to realize how serious the resulting cost and schedule increases were. The program started as a fixed-price contract and as the requests for changes increased, Airbus quickly went from making money to losing money. Throughout the program Airbus had been transitioning to independence from the government and developed more decisionmaking autonomy. Consequently, they worked out a new contract and started to crack down on accepting change requests.

While the AGS program maintained its operational and political requirements made from the outset, the technical specifications on which these goals would be executed changed multiple times over 14 years of negotiation. These changes were made not necessarily because the program was flexible, but more so because the political nature of the program demanded it. To reiterate, the original mantra of the program was to include as many flags as possible. This level of complexity inherently faced political stalls, aggressive workshare negotiations, and affordability challenges. Whether or not these changes were “high hurdles” or “easy” depends on who is talking. Ultimately, the program had to be flexible, even if this meant 15 years of negotiations before the PMOU.

From the discussion with interviewees on the M777 program, there is evidence that the highest hurdles to flexibility existed between the services and not the international partners. Additionally, the study team found that the level of flexibility depended on whether there was a need to change a capability or to correct a problem. Little flexibility existed in the need for a capability change, but it was fairly easy to correct a problem.

The interviewees for the F-35 program emphasized that the number of partner nations and increasing cost pressures created high hurdles for change. Additionally, the flexibility throughout the program changed depending on the phase. In the earlier stages, only the United States and the United Kingdom could make changes. The program was set up to make changes difficult because they had invested so much time and work into the program where any change request by one partner makes it harder for everyone else. As a result of schedule delays, certain nations had to invest additional money to maintain their existing fleets on top of the money already invested in the F-35 program. These countries would have been more flexible and able to manage this situation if these risks were addressed from the outset. Daunting cost estimates were another barrier to flexibility. According to an interviewee, the vast majority of proposed changes were generally dropped after the proposing country saw the estimated cost increases that the requesting country would be responsible for. The program was set up so that if a country wanted the program to have a unique capability, that country would incur the entire financial burden of that individualized portion. This was a strong disincentive for participants to make changes. Additionally, bureaucracy imposed organizational constructs that controlled decisionmaking within cost, schedule, and performance and did not welcome change.

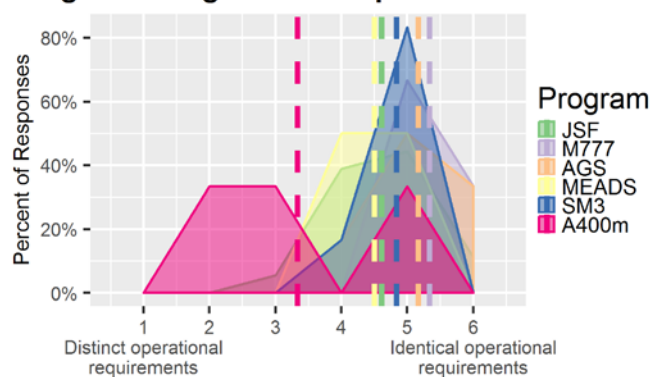
The MEADS program specifically tried to execute most of the requirements work up front to avoid the need or desire for changes later on. In the event of a change request, the NATO program office and the

industry team fought back to stick within the original program requirements because they understood that both cost and schedule slippage would be avoided. As previously discussed, the NATO-management style of the tri-nation program introduced more bureaucracy than necessary, which also prohibited flexibility. Consequently, the level of flexibility for the program was low.

5.6 Operational Mission

For the operational mission characteristic, the study team asked the interviewees: On a scale of one to six, rate the extent to which the countries involved with the program were compatible in operational requirements. The responses are displayed in Figure 6. Naturally, programs involving a small number of countries, for example, the M777 and SM3, are near the top. The program with the largest number of participants, NATO AGS, is near the top as well, but in that case it is because the program is buying a capacity for the NATO alliance and not for individual countries.

Figure 6. Alignment of Operational Needs



Extent of Compatible Operational Requirements Between Countries

global operations and operating the same systems—such as the M777—increases interoperability effectiveness. According to the interviews, there were just trivial differences in maintenance and sustainment, such as Canada’s dual-language laws. The interviewees noted that the United States, Australia, and Canada usually have similar operational needs, which benefited the FMS portion of the program.

For the SM-3 Block IIA program, operational needs of the two partners were always highly aligned. Both the United States and Japan were incentivized to pursue this program as a response to the threat from North Korea. The purpose of the project was to help Japan build a missile that it could use to defend itself. Cooperation was pursued because it would help finance the program, and Japan viewed collaboration with the United States as an opportunity for MHI to learn U.S. engineering processes and techniques. Interviewees from the SM-3 Block IIA program noted that the Japanese requirements are a subset of the U.S. requirements because, while Japan has its own command and control system, its ships’ systems parallel those of the United States. Additionally, the nature of missile defense is relatively straightforward, which contributed to program harmonization between the United States and Japan.

For the AGS program, the individual countries were less coherent on their individual operational demands. Since this was a NATO program, however, the countries participating all agreed that the alliance needed to satisfy the demand for ISR capabilities and greater interoperability and collaboration within NATO. The United States, for instance, already had access to this capability. Its interests were centered on helping NATO achieve this capability so that the United States would not be called upon as frequently to bolster alliance demands requiring ISR. Conversely, smaller nations could not achieve this capability on their own. Even if the need for leading-edge ISR capabilities is not in a nation’s core strategy, having a more public access to ISR technology through NATO benefits both their domestic and

The countries involved with the M777 program had similar operational needs for a lightweight howitzer, with even the FMS countries possessing the same level of operational needs. For instance, Canada’s existing howitzer, the M109, weighs 49,940 pounds and operated with obsolete technology. Accordingly, the 9,200-pound M777 improved Canada’s warfighting capabilities in the modern environment. Additionally, Canada, the United Kingdom, and the United States interoperate in various

international security. Consequently, the participating partner nations do not perfectly align with their domestic interests but as a whole, the AGS program supports a common demand.

Similar to the AGS program, the partner nations of the F-35 program did not have identical operational requirements, but because there are three variants of the program, major requirements for each country were met. The level of operational commonality between partner nations changes according to the country. Compared to the United States, the United Kingdom's level is more of a five or a six while Turkey's level is more a three or a four. Strategically, all partner nations are interested in interoperability, which acquiring the F-35 promotes. Interestingly, evidence suggests that in some instances, the participating nations were more persuaded that this fifth-generation fighter would meet their operational needs in the future. They were told that the program would be affordable, but because both the security and economic environments have changed so much since the program inception, the F-35 is significantly more expensive than originally estimated. When considering the operational needs of each country, it is important to keep in mind the high cost hurdles countries faced when demanding an alternative requirement. This disincentive might make it seem like the partners were more in sync with their operational requirements because they could not afford to change the program depending on their individual needs.

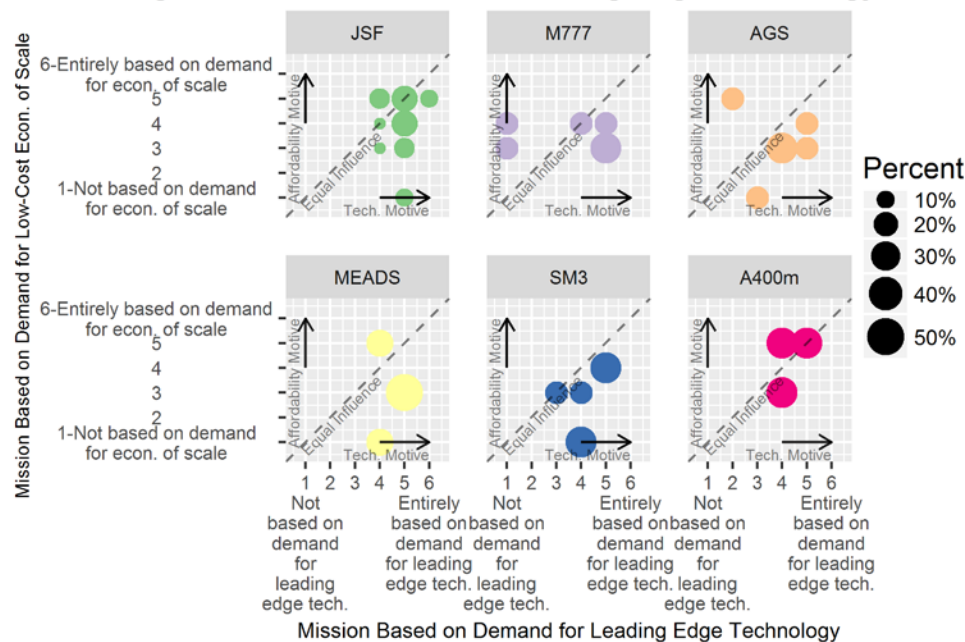
Generally speaking, the partners involved with the MEADS program agreed on compatible requirements with a slight overlap in operational needs. The operational requirements were pretty well coordinated, the U.S. Army drove them and the Italian and German partners agreed at the outset. One issue was communication on technology further into development. The United States brought a lot of the technology on board to bolster the capability of partners. Disclosures for these technologies took a long time and occasionally caused collaboration issues between Lockheed Martin and the German and Italian engineers.

The countries participating in the A400M program had the common need for a European strategic and tactical mobility. However, disputes on more specific requirements occurred. For instance, France wanted to have the ability for paratroopers to exit on the side by the wing while Germany wanted them to use the cargo door. In the end the program accommodated both countries; however, this required extra development work because exiting on the side in proximity to large propellers was not an easy feature to implement.

5.7 Program Mission

For the program mission characteristic, the study team first asked the interviewees: On a scale of one to six, evaluate the extent to which the mission of the program was based on the demand for leading-edge technology and a lower number of initial output. Second: Evaluate the extent to which the program was based on the demand for developing low-cost economies of scale. The results are displayed in Figure 7.

Figure 7. Tradeoff Between Leading-Edge Technology and Cost



The study team hypothesized that there is a tradeoff between these two underlying program goals. The survey responses, however, suggest that this is not the case. Or, rather, program directors did not consider them to be a tradeoff. Many of the answers from interviewees fall on or near the dashed line, meaning that their rating on economics of scale was within one point of their rating on leading-edge technology.

For the AGS program, NATO was acquiring a leading-edge technology, but not necessarily developing it. The ISR capability NATO wanted to acquire already existed (JSTARS), just not as a platform that was NATO owned and operated. The United States tried its best to preserve and expand upon the leading-edge technology it had already developed with JSTARS to meet AGS requirements, despite understanding that there were other political dimensions it had to simultaneously account for. The underlying tradeoff was between the cost of the program and the level of innovation in the technology for Europe. Before deciding on the Global Hawk RQ-4B Block 40 for the air segment, NG tried to work through the ITAR process and make the more leading-edge radar technologies exportable and deliverable to NATO. However, no new development solution was found that could satisfy export regulations, European participation requirements, or the affordability requirements, which is why compromises continually had to be made. Financial circumstances in the 2000s caused the program to procure the RQ-4B Block 40, which was an already-developed capability. Even after the PMOU in 2009, AGS on its own does not achieve economies of scale. The additional Air Force's procurement of RQ-4B Block 40, however, does create economies of scale, which helps AGS achieve higher cost efficiency.

What is notable about the responses for the F-35 program is that most respondents rated high levels for the program mission being based on both leading-edge technology and economies of scale. On the surface, the survey results reject the hypothesis that there is a tradeoff between leading-edge technology and low-cost economies of scale. The discussions with interviewees confirm, however, that this tradeoff still exists. Since the inception of JAST, which later became the F-35, the program was entirely based on acquiring a leading-edge fifth-generation fighter. One interviewee, however, did note that the extent to which leading-edge technology prioritized over affordability depended on the service or partner nation. For example, while the Air Force is buying the most F-35s and as a replacement fighter, the Navy is using the F-35 to augment their current capabilities. Consequently, the Air Force is more likely to rate the level

of demand for leading-edge technology as a five or a six while the Navy is more likely to rate it at a level four or five. Despite this difference, all the interviewees rated the program on the higher end of the scale of demand for leading-edge technology.

Affordability has been advertised from the outset of the F-35 program. Whether the program emphasized affordability to gloss the brochure sent to the then-potential partner nations, or as a primary focus, is unclear. Nothing about the leading-edge technology in the F-35 program is low cost. From the Nunn-McCurdy cost breach to the continuous LRIP, the program has consistently pushed prospects for economies of scale into the future. The program does, however, present opportunities for relatively low-cost production down the road if a global fleet in the four-digits is procured. With a large global fleet, low-cost sustainment will more likely be able to reap the benefits from global spare parts and supply chains, as well as economies of scale. Tagging affordability to this program from the outset was not realistic and could be considered a major source of the criticism the program has seen to date. One U.S. interviewee emphasized that the entire purpose of acquiring a fifth-generation fighter was technology. If the services wanted economies of scale, they could have procured more F-16s and F-18s for the Air Force and carrier versions, respectively. In the end, it was not necessarily a mistake to pursue both leading-edge technology and economies of scale, but pursuing both makes any program exceedingly challenging.

For the A400M program, interviewees discussed the inability of European countries to independently generate economies of scale because of the small size of the Europeans' respective industrial bases. Thus, affordability through economies of scale was not a high priority for the program. The program does, however, automatically increase likelihood for economies of scale by including multiple participants—a common trend in European acquisition due to the size of European defense budgets. Additionally, the A400M demanded leading-edge technology and this was principally in order to meet customer capability needs.

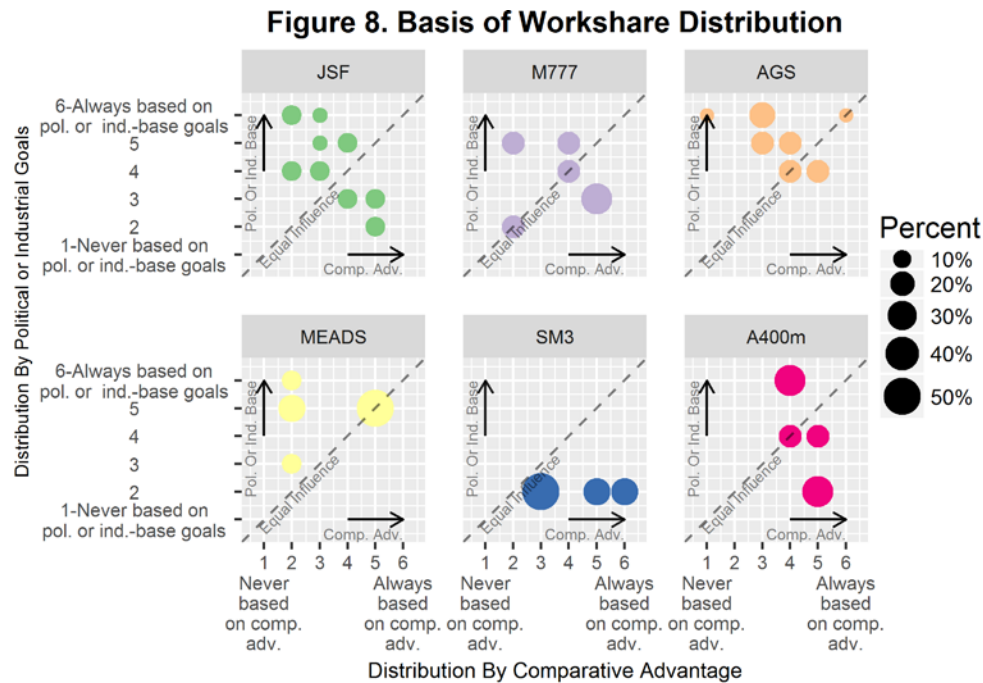
The SM-3 Block IIA program was an evolution of two previous U.S. development programs. Leading-edge technology was not as critical for this program because although SM-3 Block IIA is an advanced missile, the missile is made up largely of previously tested and utilized technology. The requirements of the missile were more designed to meet a threat instead of acquiring leading-edge technology. The United States handled most of the technology advances but they were more evolutionary than revolutionary. In other words, the program was more focused on upgrading the existing Standard Missile, rather than inventing a whole new technology. Additionally, the program was not driven by a demand for large economies of scale. From the outset, the program knew it was not going to get economies of scale because of the limited amount of missiles that it was going to produce. Instead, the program focused on addressing the security threat of North Korean aggression.

From the outset, the MEADS program was a high-technology program that never envisioned a production level conducive to economies of scale. Because of this high-technology content, there were foreign disclosure and information-transfer issues. The United States had some people concerned that if too much was shared, there was a chance that U.S. technology on missile defense programs as a whole would be lost. This issue was exacerbated by those who wanted to end MEADS and upgrade Patriot instead. Consequently, the program did not pursue absolute cutting-edge technology. The core problem was funding, and if the program could not allocate workshare because of technology-transfer issues, the program could not afford the highest leading-edge technology.

5.8 Workshare Distribution

For the workshare distribution characteristic, the study team first asked the interviewees: On a scale of one to six, rate the extent to which the distribution of workshare was based on participating countries'

comparative advantage. Second: rate the extent to which the distribution of workshare was based on political or industrial-base goals. The responses are displayed in Figure 8.



AGS and SM-3 Block IIA both merit special attention because of the way they divided workshare, namely splitting off a divisible section of the project to be separately administered. This paper refers to that practice as component compartmentalization. The responses for the AGS program reflect the program's blueprint. Interviewees rated the workshare level based on political or industrial-base goals generally higher than how they rated the workshare level based on comparative advantage. This is no surprise, given the political nature of the AGS program's core goals. With the ground segment, stations were already available from the United States; however, using the stations would have defeated the goal of high participation levels from the European partner nations. The program paid for a NATO ground station because it avoided technology transfer hurdles in development and ensured that it would be available for use in other European programs. While basing workshare distribution on comparative advantage is often more economically efficient, the program would not have been able to exist without politically based decisionmaking. Spain, for example, withdrew from the program after not receiving enough industry participation. Although distributing workshare based on comparative advantage presents opportunities for cost efficiency, political and industrial base factors can be equally crucial in order to sustain program participation.

The workshare distribution for the SM-3 Block IIA program was controlled by the United States and majorly dependent on technology transfer laws. There were certain technology aspects of the program that the United States did not want to share. As a result, the United States was allocated that workshare. Additionally, the two partners did joint technology research prior to the actual program start, which helped Japan acquire its share of the work. As a result, the countries are not financially dependent on each other, meaning that high cost increases for one partner would not financially affect the other partner. While this workshare mechanism avoids the complexities involved with programs whose costs are more integrated, this also eliminates the incentives for countries to pursue behavior that would reduce their partner's costs.

Nonetheless, organizational complexity is one of the leading contributors to the unique challenges of international joint development programs. By pursuing this approach of component compartmentalization, SM-3 was able to pursue an approach that consistently ranked the lowest in terms of complexity among all of the sample. That was not true for NATO AGS, which only pursued component compartmentalization in its third stage.

MEADS also changed during execution to engage in component compartmentalization for the missile units. That part of the program builds on PAC-3 technology and survived the U.S. withdraw as a separate program. For the MEADS Fire Unit, the workshare was for a large proportion based on the cost share. Countries were to receive work equivalent to their cost value. To get the Europeans on board, the United States had to adapt to their common *juste retour* system, where a country's workshare equals that country's financial contributions. This did not hinder the program to a large extent because both Germany and Italy had the ability to execute their workshares, as there was a sophisticated technology base in both Germany and Italy from the onset.

Countries participating in the F-35 program have a right to compete but not a right to contract. Although this is the case, countries ended up spending extra money to make themselves seem more competitive. There were factories built from scratch in Turkey where workforces were trained from ground zero. Historically, the European environment practices cost-share equal to workshare, while the U.S. environment prefers best-value workshare distribution. This could be attributable to European countries having been forced to participate in international cooperation more often than the United States has. As a result, European countries have had to appease individual partner nations' tendency to demand workshare equitable to investment contributions. Additional political factors influenced workshare distribution as well. For example, supplementary wing production opened in the state of Georgia because that facility was facing a crisis from lack of work, not because producing wings in Georgia was the most efficient allocation of resources. Without this work, the plant would incur increasingly high overhead costs. Some countries were disappointed from the low level of integration for technology transfer, as technology-transfer laws significantly influenced the distribution of workshare. As one interviewee explained, if a country writes a piece of software, that software is property of the country, not the program. Because of this, software-intensive production was automatically allocated to the United States.

The M777 program is a prime example of when political factors become more important than comparative advantage. Despite the United Kingdom having been developing the technology needed for this program, the Army and the Marine Corps were directed by the Senate and House Appropriations Subcommittees on Defense in 1999 to develop a plan to utilize Rock Island Arsenal in producing various portions of M777 (United States Marine Corps and United States Army, 1999). This is yet another example of how monetary costs and benefits are not the only ways to measure efficiency with international cooperation.

Due to the nature of Airbus, instead of workshare distribution in the A400M program being dependent on who buys the most airplanes, the workshare was distributed in accordance with the size of the air and space industry that went into Airbus when it was created. Consequently, although Spain did not buy as many planes as France or Germany, because of its participation in Airbus, Spain has a larger role than one would expect. The program had the advantage of Airbus's established history of procuring trans-European planes. There's an institutional history here for spreading the supply chain over Europe. Airbus made use of its established comparative advantages for the civilian parts of the plane. The study team found that OCCAR used their general application of the "Global Balance" approach to national work allocation. More specifically, Airbus was able to distribute the work allocation and because of its previous experience, there should be a rough balance already established. As a leading industry, Airbus should be

able to most effectively decide which country has the best advantage to take responsibility for which component.

6. Research Questions and Hypothesis Analysis

The eight characteristics that were previously discussed and analyzed for each program provide a comprehensive response and discussion to the first research question:

1. What are the characteristics of international joint development programs that result in positive or negative cost, scheduling, and end-product outcomes, such as final product, interoperability, technical relevance, and development of existing defense industrial bases?

Through research and discussion with program experts, the study team identified integration, number of participants, decisionmaking, commitment mechanisms, flexibility, alignment of operational needs, tradeoff between technology and cost, and workshare distribution as key elements crucial to program outcomes. Additionally, the study team added two more characteristics after further discussion with program experts and stakeholders.

First, technology transfer plays a key role in determining program outcomes because technology security is one of the prime drivers of complexity. Programs that transcend any one nation's borders inherently add industrial risks to the level of complexity that domestic acquisition programs already navigate. This added complexity is multifaceted. From a government standpoint, program leaders must consider defense product and service export laws such as those under the munitions list portion of the Arms Export Control Act of 1976. These will directly govern both the relations and exportability of any arms transfers between the United States and participating nations. Specific observations about tradeoffs that relate to technology security are covered in Section 7.1 in the next chapter.

Second, the study team learned through expert and stakeholder interviews that culture, language, and time zone differences have the potential to directly influence programs' challenges and their likelihood to achieve success. Discussion of this characteristic was primarily present when interviewing those involved with SM-3 Block IIA. Some other interviewees mentioned relevance in specific instances, but many interviewees viewed these cultural, language, and time zone differences as nonfactors.

The SM-3 Block IIA program was specifically affected by differences in culture. Japan, for instance, has an acquisition culture where a program is expected to be successful from the outset. No matter the costs or complications, Japanese partners expected to achieve success with SM-3 Block IIA. One interviewee discussed the tendency of "one-way conversations" in Japan, where high-level officials' commands could not be disputed, no matter the costs or complications. The interviewee contrasted this with a tendency in the United States that even low-level officials could deliver bad news in the presence of high-level officials from either country. As a result, there were conflicts between the way the United States does business and the way Japan does business.

Furthermore, one interviewee explained how language could cause program inefficiencies. While collocated English and Japanese program officers resided in both Japan and the United States on the government and industry side, there may have been times in which discussions occurred at meetings but communication did not. While specific circumstances were cited, however, language issues played a minimal role in most of the other case studies.

Finally, time zone differences were a hardship for the United States when working with Japan. The time zone difference, coupled with commuting mechanisms in Japan, required long telecommunications meetings at the end of the United States work day (around 6:00 pm) that would last until 10:00 or 11:00

pm. According to interviewees, Japanese public transportation to and from work made it hard for meetings to be held after the end of the business day. Meetings, therefore, had to be scheduled during their mornings and thus during United States evenings. Routine approaches for handling these challenges were developed by midway through the project history, but some inefficiencies may have occurred as a result, particularly at the start.

Next, the study team inquired:

2. How are the best practices of international joint development programs in defense acquisition different from the best practices of single-nation acquisition programs?

The study team found that today's single-nation and international defense acquisition programs face the different levels of complexities that Drezner (2009) recognized: organizational, environmental, and technical. The underlying difference between single-nation acquisition programs and international joint development programs is the high level of organizational complexity inherent in international cooperation. While modern single-nation defense programs face the complexities associated with integrating government and industry, international programs must also intermingle multiple governments and international industries. In Chapter 7, this paper discusses how to overcome both the environmental and technical complexities of modern programs and manage the inherent organizational complexities of international programs, drawing on characteristics that this paper has identified.

Next, the study team will discuss the proposed hypotheses and to what extent the research supports them. The first hypothesis of this study is:

1. The structure of cooperation in international joint development programs matters—international joint development programs with stakeholders that cooperate either only during the development or only during production phases will have less successful cost, scheduling, and end-product outcomes.

International joint development programs are often highly segmented, which complicates testing this hypothesis. Both the execution and the results of program outcomes during production were highly informed by the outcomes from the development and testing stages. Some programs operate through different phases, where each phase has a different MOU or alternative agreement and its execution depends on the level of success of the preceding phase. During transition periods from one phase to the next, participants decide on whether or how to enter production depending on the outcomes of the completed phases. Breaking up program phases effectively provides the opportunity for countries to renegotiate their participation in a program or even exit altogether. Moreover, opportunities for additional countries to participate can present themselves during transition periods between phases. During transition periods, the program could renegotiate number of purchases, requirements, financial obligations, and schedule. The severability of MOUs for each phase of a program creates higher program flexibility. In turn, programs are more likely to address issues and successfully continue notwithstanding various program changes.

Thus, when a program stops at a development phase, such as MEADS, that typically reflects program performance rather than a governance decision. By comparison, pure coproduction efforts are fairly common. Multiple interviewees, however, argued that one of the major benefits of the development phase is that it forces early consideration of designing for exportability. In the JSF program, most partner nations could not directly change the design in early phases, but interviewees on both the U.S. and partner nation side confirmed that their presence in the room helped ensure the consideration of their interest. By comparison, the United States' other fifth-generation fighter, the F-22, was not exported in part because

of the expense and legal restrictions of addressing technology transfer concerns in the production phase. This result does not necessarily extend beyond the United States, however, as the U.S. strategy of technological superiority and the size of the U.S. market means are both obstacles to prioritizing design for exportability concerns.

Second, the study team hypothesized:

2. International joint development projects that are more grounded in security policies rather than economic efficiency interests are more likely to result in negative cost, scheduling, or end-product outcomes.

The study team uses the three characteristics, decisionmaking, program mission, and workshare distribution, to analyze this hypothesis. And while the hypothesis may be technically correct, the study team also found that it may be impractical or actively counterproductive to seek to significantly prioritize economic efficiency concerns over other objectives. The program mission can indicate which financial incentives are likely to be most relevant. For those programs with a significant requirement for leading-edge technology, shared R&D costs and shared risks are likely to play a role. For those seeking economies of scale, complementary traits, such as improved learning economies and lower unit cost of weapons procured are likely also in play (De Vore, 2011, p. 625, 627; Fitzgerald et al., 2014). When it comes to judging whether the structure of a program takes economic factors into account, it's important to look at whether comparative advantage is emphasized in establishing workshare distribution. The problem that international programs face when seeking to achieve these benefits is the competition between cost efficiency and maintaining country participation. As previously discussed, the most efficient allocation of workshare often does not satisfy every countries' demand for spillover benefits, such as technology development or industrial participation. Therefore, participants will engage in counterproductive actions in order to receive workshare that could cause cost increases, delays, and end-product inefficiencies.

While evidence garnered from research and interviews suggests that the above is indeed true, it also suggests that security policies are impossible to avoid in these programs. The other main incentives to pursue international cooperation programs are end-product superiority compared to single-nation programs, and military interoperability (De Vore, 2011, p. 625, 627, 628). Both of these incentives require decisions to be made on political and security factors. Furthermore, the case-study analysis suggests that for some programs, these incentives are more important than financial efficiency. Reinforcing the importance of noneconomic factors, a review of the program mission characteristic shows that for a majority of interviewees across all projects, leading-edge technology is more important than achieving economies of scale. Seeking economies of scale does not necessarily mean that financial factors are outweighing security factors. Quantity, in and of itself, is important from a military perspective. However, the two cases that emphasize scale over leading-edge technology, the A400M and M777, are both examples in which technology security policy was comparatively less of an issue.

While meeting these political and security goals does not yield the most desirable cost and schedule outcomes, it does better achieve core program goals. The decisionmaking characteristic is relevant here for tracking what larger goals are important to the program. For instance, the AGS program often depended more on political or security needs than cost efficiency. In fact, multiple interviewees say that was always the case. On the one hand, this could have contributed to the long time it took for the program to reach a contract and PMOU. On the other hand, AGS is an alliance program, so political factors, such as including many NATO member states and having a European face for the program, were key objectives. Likewise, the European ground station, while neither cheaper nor more advanced than the

American equivalent, bypassed technology security concerns that may have accompanied the use of a U.S. ground station for the NATO-owned capability. The AGS program successfully achieved its alliance-based goals thanks to the ability to meet political factors reflecting different nations' security policies.

Another example in which noneconomic efficiency factors were unavoidable is the JSF program. Workshare distribution for the JSF program was, for the most part, based on best value. One interviewee noted, however, that it is not always possible to subcontract entirely to lowest-cost contractors. This is especially true in an international program with a large number of participants, because the prime contractors have to subcontract to a larger number of suppliers to meet program expectations. For the JSF program, it was important that the primes allocated industrial content in the participating countries. Countries would sometimes independently spend money and effort in order to make their industries more competitive and win contracts. While the costs incurred by a country employing subsidies to win competitions do not show up on the program's balance sheet, they are still costs associated with the program. A country that spends more to gain more industrial participation is making a tradeoff between its industrial base policies and economic efficiency. Future research may benefit from measuring costs and benefits for each individual country, in addition to overall program costs, because individual country goals often go well beyond cost, scheduling, and end-product outcomes. Likewise, with the approaches such as that of the F-35 program, participants may be making different tradeoffs between economic development and the effective unit cost that they pay as a result.

During the interview process, the study team learned that some European partner nations have recognized the inefficiencies caused by competition between domestic security policies and efficient workshare allocation. To address this issue, the partner nations have decided to allocate leadership and workshare based on trades across different programs. For instance, while one country's firm will take responsibility as prime contractor for the Euro Drone project, another country's firm will take responsibility as prime contractor of a joint satellite. Instead of allocating workshare to meet various domestic needs for one program, the partner nations will allocate workshare differently for each program, ensuring that countries meet their independent goals across the entire defense portfolio. This gives each individual program the opportunity to avoid inefficient workshare allocation, instead distributing industrial participation based on best value while still meeting overall political objectives.

Third, the study team hypothesized:

3. Countries that have cooperated in defense acquisition before have a higher chance of achieving positive cost, scheduling, and end-product outcomes.

As previously discussed, the number of participating countries is a notable characteristic that influences joint international program outcomes. While the study team has found that a higher number of partner nations supports a program's ability to move forward without cancellation, the number of countries involved often means that choices must be made in light of a diverse number of actors and while satisfying numerous investments, international interests, and domestic interests. Hypothesis 3 predicts more positive outcomes with the AGS program due to the countries involved having historically worked together before through NATO. Information gleaned from stakeholder interviews suggests that the office dedicated to integrating the program's government and industry partners, NAGSMA, did not achieve the positive outcomes of a strong institutional memory because the office was not set up until the official PMOU was signed in 2009, 14 years after program inception.

The A400M program also consisted of countries that have a long history of cooperation. As previously discussed, the A400M program used OCCAR to integrate the participating nations and industry with one

another. Additionally, the prime contractor (Airbus) is an integrated company that has business units in the participating nations: Germany, Spain, Turkey, and the United Kingdom. These two developed, and in the latter case experienced, mechanisms improved intra-program relations. Compared to AGS, another European-heavy program, the A400M more efficiently chose requirements and workshare distribution. Despite these advantages, Airbus's judgment was overruled on key questions, such as which engine manufacturer to employ. And yet, the greater independence Airbus gained during the acquisition process does provide the hypothesis with an example of how future programs can directly benefit from the hard experience of prior rounds.

Conversely, the F-35 program partially reaped benefits of having partner countries that have a history of cooperation in the past. Multiple interviewees noted how the United States, United Kingdom, Australia, and Canada were more fluidly integrated into the F-35 program because of their past experiences working together. The program ultimately had three tiers of partnership, with the greatest influence and most technology sharing being reserved for those countries with the strongest preexisting advanced platform cooperation with the United States. This approach may have contributed to JSF being rated in the middle of the case studies in terms of the extent of influence of the number of countries participating in the program. That said, the multiple tiers of JSF participation also complicate using the F-35 to evaluate this hypothesis.

Similar to the Anglo-American aspect of the F-35 program, cooperation in the M777 program was between the United States and the United Kingdom. Based on program outcomes, it is likely that the historically close relationship between the United States and the United Kingdom contributed to successful program outcomes. In fact, overcoming the challenges associated with the U.S. acquisition process will likely enhance BAE's ability to work closely with the United States in the future. The SM-3 Block IIA program additionally confirms this hypothesis, because the United States and Japan had relatively less experience cooperating in armaments development and faced considerable obstacles in regards to cultural, language, and time zone differences. For instance, Japanese corporate culture tends to discourage presenting information that contradicts statements by their own government. This tendency is reinforced in meetings with U.S. partner participants. In the United States, plenty of lower-level officers working closely with the program are willing to speak up. This added a certain form of inefficiency to the program.

Fourth, the study team hypothesized:

4. Countries that are uniquely capable of producing complex acquisition programs benefit from working with smaller countries or industries that may have comparative advantages in certain technologies, but do not have the capacity to produce complex acquisition programs on their own.

The research conducted supports the fourth hypothesis. The case studies also demonstrated that this cooperation is particularly effective there are components that can be compartmentalized and then managed by smaller partners. This holds for SM-3 Block IIA and for the ground station in NATO AGS. For the AGS program, the United States already possessed the ISR capabilities required by the program. However, the United States benefited from working with the various-sized countries of NATO, as it ensured that the United States would not be the sole provider of support for NATO operations requiring ISR capabilities.

Additionally, while key European partners did demand a European face for the program, the United States still benefited from shared maintenance and lifecycle costs. In a similar vein, all nations benefited from international participation in the F-35 program because a fifth-generation fighter available at a price affordable to a wider range of partners would not have been financially feasible for any one nation. The

benefits the United States gained from MEADS are less clear, though provisionally Germany at least does appear to be planning to reap benefits from the program. One of the reasons that MEADS did not go through to production in the United States was that splitting the program into compartments was not baked in from the start, and due in part to program inflexibility, a great deal of time was lost when the program was reconfigured to use an existing missile. Hypothesis 4 predicts a better outcome for MEADS than actually occurred; the more optimistic prediction was based on the differing sizes of participants and the advanced industrial bases of Germany and Italy. However, the mixed-at-best results indicate that for the hypothesis to hold true, it may also be necessary for the program to be structured from the start to effectively exploit the advantages of each of its participants. This would mean that countries uniquely capable of producing complex acquisition programs would benefit from working with smaller countries or industries.

7. Discussion and Framework for Future Programs

Internationalization of the defense market at the R&D stages of acquisition offers crucial benefits in light of budget pressures in the United States and allied partner nations. In order to reap these benefits, international joint development programs must follow best practices. This report has identified 10 characteristics critical to programs' ability to achieve desired cost, scheduling, and end-product outcomes. Additionally, through case-study analysis, this report has reached a variety of interesting conclusions regarding effective and successful pursuit of international joint development programs. To conclude this paper, a review of the key finding and potential practices for international joint development will be discussed, in addition to suggestions that the study team hopes will help shape future considerations of international joint development in defense acquisition.

The study team has found that these programs never seem quick or easy. Thus, evidence from this analysis suggests that nations considering international cooperation in defense acquisition should critically question their incentives to do so. Single-nation acquisition is hard, and international joint acquisition is harder. Therefore, countries considering joint cooperation should ensure that they are positioned to handle the additional challenges associated with international programs. Countries should use a high burden of proof when conducting both a risk and a cost/benefit analysis. They should then ask themselves if the additional risks and costs associated with international cooperative programs are a better option than FMS or pursuing the program indigenously. To assist in this effort, the study team has identified key questions that draw on the eight characteristics and that should aid evaluating the costs and benefits of international joint project development.

7.1 Operational and Political Considerations and Hard Choices

The challenges of international cooperation do not end with the increase in organizational complexity. Partner nations face various risks that threaten operational capabilities and proprietary information. When procuring a capability with other militaries, a variety of wants and needs for the program compete against each other. This even happens, as one interviewee reported, within the military services of the United States, where intra-service cooperation can be just as difficult as intra-country. The probability that compromises on requirements and operational capacity will have to be made is likely, and this probability increases as the number of countries involved with the program increases.

Consequently, when countries are negotiating whether or not to pursue an international program, they should determine if doing so will threaten attainment of their core requirements. However, as the discussion of competing characteristics has revealed, even experts disagree about the comparative importance of different priorities, such as unique operational needs versus diplomatic and political considerations, or leading-edge technology versus economies of scale. What is clear is that successful international joint development programs should serve multiple categories of objectives for each

participant. These core needs should have strong champions, who may need to work with their international counterparts to overcome challenges, and comparatively few dedicated opponents.

Making sure a program serves multiple categories of objectives also mitigates setting ambitious goals for operational capabilities, technology transfer, or industrial base development. Pushing too hard toward any one of these goals in isolation is likely to come at the expense of the project's suitability for international joint development. This is particularly true because partner nations often bring different sets of core needs to the project.

Interviewee comments on technology security issues further illuminate this point. Concerns over both intellectual property and coherence to domestic and international arms transfer laws complicate industry business models. Sorting through international supply chains while maintaining the security of classified work requires command of complex business management. Additionally, both lead nations and sub-partners seek maximum benefits, which complicates program workshare allocation. On the one hand, programs want to prevent partner defection. To do this, program management has to ensure that all countries are satisfied, which often requires industrial spillovers. Nations hope that by participating in international joint development programs, they will further develop their technological capabilities and industrial base. On the other hand, in order for programs to maintain efficiency, workshare should be wholly based on best value. Countries that seek technology development and industrial base growth usually do not offer this. Those that do offer best value have already developed the relevant technology and possess an industrial base with the capacity to execute procurement. Therefore, a balance must be made between satisfying countries enough so that they maintain participation and ensuring best value of workshare distribution. Satisfying participation requirements requires technology security awareness.

Compatible operational requirements are key, but it is also important to ensure that the other goals of critical participants are not actively in tension. Agreeing on requirements and goals is important not only to reduce incentives for countries to defect during development, but also benefit the entire lifetime of the program. Countries have less incentive to defect from a program that aligns with their core capability demands.

Additionally, international cooperation in defense acquisition poses various hurdles associated with technology transfer laws. Countries that are global leaders in technology often experience arduous bureaucratic processes when participating in international development and international supply chains, which are two unique aspects of international cooperation. Of course, this is prominent when countries partner with the United States. Furthermore, some countries that sign up for international programs seek the industrial spillover benefits that result from technology and information sharing. These countries are often disappointed, because the anticipated spillover benefits are often unachieved due to onerous bureaucratic and legal processes. This can be problematic for two reasons. First, countries that fail to receive their expected benefits have a higher cost-to-benefit ratio. If the expected benefits cannot be achieved by participating in an international program, then embarking on one might not yield results that would be worth the additional challenges that do not exist in single-nation programs. Second, if the risk of failure to accrue expected spillover benefits is high, countries will be more likely to defect from the program, which will impact all of the countries involved. Based on the actual achievements and disappointed expectations present in the case studies, countries considering participation in an international program should base cost-benefit analysis on incremental and cumulative expansions of trust and technology sharing arrangements, rather than dramatic breakthroughs.

There are reasons for pursuing international joint development that can serve as valuable secondary objectives but challenging primary ones. In theory, a country could use international joint development to

create a competitor to an indigenous system that lacks an alternative. However, in practice such a project will likely face steady opposition while having only mixed support. After all, the other option is always available. Likewise, a country seeking to start up a cutting-edge domestic capacity through international joint development will likely run afoul of economic logic and technology-transfer regulations, particularly when dealing with the United States. Similarly, if multiple countries want the political and economic benefits of being the prime contractor, the organizational complexity and economic challenges of split leadership may easily undercut the advantages of working together.

These are not hard-and-fast rules, but rather guides meant to aid in risk and cost-benefit assessments. The following section discusses ways to mitigate these hard choices and better achieve the theoretical benefits of international joint development.

7.2 Component Compartmentalization

One finding that should guide countries' decisionmaking is that international joint development programs that can distribute development workshare as compartmentalized components across its participants are more likely to achieve success. Distributing compartmentalized workshare better satisfies participants' cost/benefit ratios, which results in more successful program outcomes as well as individual country outcomes. In short, it mitigates many of the organizational complexity challenges inherent in international joint development.

In the SM-3 Block IIA program, for instance, Japan is independently responsible for developing the nosecone and the second-stage rocket motor. These two components are compartmentalized, in that Japan can use them on their own to develop indigenous capabilities. In this situation, both the separate financial and the workshare responsibilities of each country lowered the chance of risks and costs escalating as a result of collaboration. As a result, the program has achieved success in cost, scheduling, and end-product outcomes at the current stage of the program.

Similarly, the AGS program provides evidence that sharing work across compartmentalized components leads to successful outcomes. The AGS program took 15 years to reach a satisfactory procurement strategy agreement. This strategy is the acquisition of an air segment and a ground segment via the U.S. Global Hawk RQ-4B Block 40 and European ground capabilities for data exploitation and distribution, both of which are operable on their own and, when combined, create a system-of-systems capability. Before this agreement, the program spent a great deal of time (15 years' worth) and money trying to reach a procurement strategy that satisfied the 15 countries that operated under the NATO rules and regulations of unanimity. The two procurement strategies previously considered—the existing JSTARS platform and then the TCAR system on both manned and unmanned aircraft—failed because they did not satisfy the participants' wants and needs for participation and were too expensive, respectively. The third try, however, satisfied demands for both affordability and workshare participation. Furthermore, the third try allocated participation as compartmentalized components for a system-of-systems capability. That this solution proved successful for an international program suffering all associated risks and costs shows how valuable compartmentalized workshare allocation can be, and that it should be considered during program development.

7.3 Techniques for Mitigating Competing Objectives

Allocation based on portfolio sharing, like compartmentalized workshare distribution, can constitute a best practice. A group of countries that are close allies and collaborate often will benefit from practicing the prime-sub model of cooperation across all collaborative programs and allowing different countries opportunities to lead as prime contractor for each collaborative program. This eliminates the collective-action issue that most collaborative programs face, in which partners exaggerate and deflate their benefits

and costs, respectively. Countries do this to gain as much workshare as possible, which results in major program inefficiencies. If countries refrain from exaggeration and deflation, then programs can more effectively address the issues inherent to acquisition programs while ensuring that the participants will gain their desired industrial participation in other programs. European governments have recognized this best practice and plan on applying it to current and future inter-European collaboration in defense acquisition.

Of course, portfolio tradeoffs are a large scale, strategic approach, and they're outside of the reach of many of those seeking to design the best available joint development project. There are also specific approaches within projects that can allow for countries to weight priorities differently without adding tension to the project. For example, the F-35 had a principal pay to be different, which allowed any partner country to add a special requirement if they were willing to foot the bill. As previously discussed, programs that practice codevelopment sometimes allocate workshare to a country that is more willing to independently spend money on maintaining a competitive supply of parts. The extra finances spent independently by that country are not accounted for in total program costs.

7.4 Joint Development as a Means of Building Trust and Infrastructure in Technology Security

Once countries considering cooperation in defense acquisition have determined that they are in a viable situation to pursue an international program, proponents should provide evidence that codevelopment is a more beneficial option than FMS. If the risks and increased costs of joint development outweigh the expected benefits, countries are better off joining programs that catch their interest later on as an FMS partner.

Based on information gleaned from interviewing experts from the six case studies, the study team found that countries that do choose to participate from the outset as joint development partners are less likely to face high technology transfer hurdles, such as ITAR. Programs such as SM-3 Block IIA, F-35, and MEADS dealt with the risks associated with technology-transfer hurdles more effectively because they were anticipated and addressed at the outset of the program. Alternatively, the F-22¹⁸ program is an example of a single-nation approach, in which both owner-nation and allies could benefit from FMS but technology-transfer issues prevented such a scenario. Perhaps, if the F-22 had considered international participation from the outset, the program could have better navigated the FMS process.

The mechanism for better outcomes through development is not necessarily voting, as representation in other ways are also forms of formal input into a program. By placing representatives in the room where decisions are made, partner countries can explain their interests and influence decisions early in the process, which can make the system much more affordable. Likewise, for the lead country, joint development may prompt them to avoid choices that lock-in technology that they are uncomfortable exporting. If these considerations are not included early on, the only alternative may be major redesign or not exporting a system at all for affordability reasons. This dynamic may be the most important when the United States is the lead partner in a project, given the United States' stringent system of export control rules and strategic emphasis on technological superiority.

¹⁸ The F-22 Raptor is a fifth-generation fighter aircraft utilizing integrated avionics, thrust vectoring, and stealth technology. The United States currently maintains 187 operational F-22s. The F-22 has thus far been excluded from FMS as result of a provision within Department of Defense appropriations known as the Obey amendment, which prohibits the use of funds to sell the aircraft to other nations.

7.5 Closing Thoughts

International joint development programs present myriad challenges associated with added complexity that can affect time, cost, and end-product performance for countries that may be primarily motivated by economic efficiency. They additionally present many benefits that, from both a budget and security perspective, merit consideration. To ensure the manifestation of these benefits, governments considering international cooperation need to carefully compare their capacity to pursue the program in question indigenously, or through foreign military sales, to their international cooperative options. Levels of integration, workshare distribution, number of participants, commitment, mutual warfighting demands, and technology sharing are all crucial aspects of the program that bear consideration when making a decision. This paper recommends setting a higher burden of proof for international joint development programs when analyzing costs and benefits; however, this does not mean that international projects should be ruled out. Future collaboration efforts, designed after careful analysis of the characteristics and best practices presented in this paper, are more likely to achieve successful outcomes.

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