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April 2011
Approved for public release.
Distribution is unlimited
IDA Paper P-4678
Log: H 10-001291

INSTITUTE FOR DEFENSE ANALYSES
4850 Mark Center Drive
Alexandria, Virginia 22311-1882

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About This Publication
This work was conducted by the Institute for Defense Analyses (IDA) under contract DASW01-04-C-0003, Task AH-7-3186, "Value of Competition," for the Office of the Director, Industrial Policy. The views, opinions, and findings should not be construed as representing the official position of either the Department of Defense or the sponsoring organization.

Acknowledgments
Thomas G. Frazier, Stanley A. Horowitz, and Yevgeniy Kirpichevsky were the technical reviewers.

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Executive Summary

This study explains the mechanisms of competition for Department of Defense (DoD) acquisitions of major defense systems and examines the value of competition in that context. It also attempts to determine to what extent an active industrial base policy is necessary or desirable in obtaining value from competitive acquisitions. We draw on the previous conceptual and empirical analyses of competition for major DoD programs and sketches of cases that illustrate the main points made in the literature. This study does not attempt to go beyond the literature. It aims only to state in an understandable way the main things that are known about competition for major defense systems and to point to some areas in which our present understanding is incomplete.

The Main Cases

Competition for major defense systems cannot be usefully discussed in the abstract. Rather, it is necessary to specify some things about what is under consideration.

There are two main cases. The first of these, which we refer to as "Competition for a Weapon System Franchise," begins with "development" of the system, followed by serial production over a period than can continue for as long as 20 years. Typically, two (or very occasionally more) firms compete for an Engineering and Manufacturing Development (EMD) contract. The EMD process results in a detailed design of the system; design and production of the tooling and equipment, and sometimes facilities, needed to produce the system; and building of "production representative" units of the system for testing. Successive annual lots are then purchased using a series of separately negotiated contracts. Multi-year contracts (covering production of three to five annual lots) may be used in place of annual contracts once the system has reached maturity. These contracts ordinarily are firm fixed price and are typically placed with the firm that won the EMD contract on a sole-source basis. This is the most common case; it is typical, for example, of acquisition programs for aircraft, ships, tactical missiles, and combat vehicles.

One variant on the standard Weapon System Franchise case is "dual sourcing." As the label implies, in a dual source acquisition, DoD qualifies two or more firms to produce the system and then competes the annual production lots between the two or more firms. That is, annually each firm is invited to submit a bid to supply some or all of the units that the DoD wishes to buy that year. The low price bidder receives a larger quantity than the other firm and may, depending on the bidding structure, receive the

entire lot for the year. (Dual source bidding schemes can be quite complex.) Note that under the standard Weapon System Franchise model there is only one competition—for the EMD contract—while DoD may still be buying the system 20 years after EMD has been completed. Dual sourcing continues competition into the production phase.

The existence of a near-substitutable system also can provide competition during the production phase. There have been only a very few instances during roughly the past 25 years in which DoD has arranged a formal competition between two systems that had distinctly different capabilities but were similar enough for the two systems to be regarded as near substitutes. Much more common are implicit competitions that take place through the budget process. That is, if the price of System A becomes "too high," the purchasing Service may decide to buy more of substitute System B and fewer units of A or, in the extreme, cancel System A altogether.

The second basic case is one in which there is little or no contractual distinction between EMD of the system and its procurement. Rather, the entire acquisition process—both EMD and procurement—is done under a single prime contract. We refer to this case as a "Competition for a Single Development-Build Program." Such a contract may be the only real option if only a few units of the system are to be procured. This is typically (although not always) true of satellite programs. As in the Weapon System Franchise case, there is usually a competition involving two (rarely more) firms for the combined EMD/production contract. The contract type usually is cost-reimbursable with some incentive features.

Distinctive Properties of Competition for Defense Systems

The conceptual tools of industrial economics—supply and demand, competition, monopoly, oligopoly, among many others—are of use in analyzing defense markets, but they are not sufficient. Defense acquisition has some distinctive features that are not present in the standard textbook models.

The existing distinctive analysis of defense acquisition programs primarily concerns what this study calls the Weapon Systems Franchise case. A pivotal result of this analysis is that prices during the production phase remain high enough to provide the supplier of the system a return on invested capital greater than it could obtain in a similarly risky alternative employment. In economic jargon, the supplier obtains economic rents. This result stands in contrast to what is expected in a competitive commercial market, in which the process of competition is expected to drive price down to cost (where cost is defined as including a competitive return on the capital employed).

Viewed from one angle, there is nothing surprising about this result: the only competition in the Franchise case is for the EMD contract. That may well have occurred many years before the product lots are priced and those prices are the result of

negotiation with a sole-source supplier. It is also important to recognize that in no sense does the result represent inappropriate actions by either the defense contractor or the government. Rather, the rents are the result of the confluence of (1) incentives offered by the firm fixed price contracts typically used in rate production for the contractor to lower cost, (2) the contractor's efforts in response that do in fact reduce costs, and (3) lags in the adjustment of negotiated prices to reduced costs. Simply put, the contractor is allowed to retain the returns from cost reduction for a period of time and it is those returns that constitute the rents.

After the end of that period (typically one to two years), the cost reductions are "captured" by DoD. In a wider context that includes development and procurement, the rents also play an important and constructive role as incentives to the contractor to provide the system the government desires.

The nature of this role is suggested by the title of a seminal paper on this topic by William Rogerson, "Profit Regulation of Defense Contractors and Prizes for Innovation" (1989). The "prizes" Rogerson refers to are the rents identified above. He uses "innovation" in the title on the supposition (accurate at the time) that, in competitions for EMD contracts for major systems, DoD usually placed the heaviest weight on innovative capabilities. In Rogerson's analysis, however, "innovation" stands for "what DoD wants" which ordinarily is more multi faceted than only technological innovation. Hence, the point of the title is that the "prize" of potential returns above the competitive level in the production phase is a strong inducement of competitors to propose at the EMD down select and then deliver what DoD wants.

This point takes on significance from the enormous governance problems created by seeking to manage EMD for a complex weapon system. These problems fall into three main categories. First, DoD and the contractor understand key topics to different degrees. The contractor typically knows more about such matters as the relevant technologies, the main design options, and manufacturing issues. DoD, however, has better information about the threats the United States is facing, the capabilities that are desirable in the system, and the trade-offs that it is willing to make among various system attributes, cost, and schedule.

Second, the interests of the contractor and DoD diverge. DoD is chiefly interested in three programmatic goals: meeting technical performance metrics, achieving cost targets, and staying on schedule, although its priorities may vary from one program to another. The contractor's management has a fiduciary responsibility to its shareholders; responsibilities stated in the contract; and a general interest in performing well and being perceived as a reputable firm that plans to stay in the defense business. Corporate and government interests do not radically diverge, but neither are they wholly coincident.

Third, any EMD effort will be affected to some degree by unpredictable events—changes in the threat, unforeseen development issues, emergence of new technologies, or radical changes in input prices, for example—so no firm can wholly guarantee its performance.

Broadly, DoD has the choice of three governance mechanisms:

- The specific provisions of the contract;
- Direct DoD intervention that attempts to manage information asymmetries and divergences of interest, for example; and
- Alignment of the contractor's incentives with DoD's interests.

The first of these is of limited help, as a contract cannot be crafted to take account of the myriad contingences that may occur. Direct DoD management is expensive and experience suggests that it shares many of the limitations of the contract vehicle. It is reasonable to assume that alignment of contractor's interests with DoD's goals is, to the extent it is possible, the best course.

The rents available during the production phase provide an incentive that helps align the bidders' interests with DoD's. At the stage of the EMD competition, the rents provide incentives to bidders to put their best efforts into submitting what is judged to be the most attractive proposal. The incentive effect of the rents would end with the EMD contract if the winner were guaranteed the rents, but these rents are not guaranteed. The prize (that is, the stream of rents) is not awarded when the EMD contract is signed. Rather, the prize is obtained lot by lot during the production phase—the last of the prize is not awarded until the last unit has been delivered and fully paid for by DoD. As was noted above, the rents are at least to some degree typically at risk through several mechanisms—dual sourcing in a few cases, competition from substitute systems in more cases, and the normal operation of the DoD resource allocation process in which there is a tendency to buy less of a system judged to be relatively unsuccessful.

It would be going too far to say that the rents available during the production phase fully align the contractor's interests with DoD's. They do, however, provide the contractor with a strong profit incentive to see that the program meets DoD's definition of success.

There are many similarities between the Weapon System Franchise case and the Single Development-Build case. Both are subject to the Federal Acquisition Regulations (FAR) and the Defense FAR Supplement (DFARS)—the FAR requires that the fee in each case provide a "fair" return above cost to the firm; both almost always involve a competition for the award of the EMD contract, which is then negotiated with the winner; and both are subject to the same DoD regulations and Office of the Secretary of Defense acquisition process. The obvious, outstanding difference between the two is the use, in

the Weapon System Franchise case, of fixed price contracts to acquire successive annual lots of the system.

As noted above, the use of these fixed price contracts provides the winning contractor with a means for obtaining greater than competitive returns, and this possibility gives the prime contractor in the Weapon System Franchise case a strong incentive to be responsive to the service procuring the system. There are other mechanisms that help promote good performance during EMD:

- The contract itself and contract oversight and enforcement mechanisms,
- The desire of the prime contractor to maintain its reputation as a reliable supplier,
- The opportunities to profit from contract changes negotiated in the sole-source (post EMD contract award) environment, and
- The instinct to do a good job on a project of importance to national security.

These operate equally in both cases, but in the Weapon System Franchise case the prospect of the production franchise drives the entrepreneurial behavior to develop a product that the government will buy in large quantities. It would be expected on this basis that performance during the EMD phase tends to be better for the Weapon System Franchise case than it does in the Single Development-Build case.

What Dimensions of the Market are influenced by Competition?

The effect of competition (or its absence) affects many aspects of defense markets and there is no definitive list of which of these are most important. That said, both the theoretical literature and policy discussions point to the following:

- **Cost.** "Cost," in this context, is shorthand for a complex set of considerations. If DoD obtains a lesser capability at a lower budgetary expenditure it has not necessarily achieved an overall cost saving; it has simply spent less to get less, and if the lesser capability acquired proves ineffective, the net effect may well be a greater cost, all things considered. In this discussion, then, we assume that a given capability is to be obtained. Obtaining that capability at least cost requires at a minimum:
  - Identifying the firms with the capability of developing and producing a system with the desired capability,
  - Selecting the least cost firm, and
  - Providing incentives for that firm to develop and produce the system efficiently.

It is worth noting that "cost" in this context refers to the cost of the system over its entire life cycle and not only to acquisition cost.

- **Innovation.** The most dramatic example of the importance of innovation in weapon systems is the development of nuclear weapons during World War II, but there are many others. For at least the last 80 years innovation has been a primary—probably the primary—concern of the DoD acquisition program. The stated policy of the United States since at least the early Cold War years has been to maintain a clear technological edge over potential adversaries.
- **Responsiveness.** "Responsiveness" as used here refers to the willingness of the contractor to anticipate problems and proactively seek solutions, and to engage with the government to solve unanticipated problems as they emerge. A contract cannot provide a specification of responsibilities and deliverables that is both complete and sensible in the face of changes in, among others, threats that the nation faces, technologies, costs, priorities, and budgets. Rather, it probably is better to see a contract as a framework within which problems are identified and resolved, and how well or poorly that works depends to a large extent on the responsiveness of the prime contractor.
- **Industrial Base.** The United States requires an industrial base with sufficient capability and capacity to be able to satisfy the Department's military requirements. The availability of opportunities to compete for major defense programs shapes the size and composition of that industrial base. If firms do not see potential opportunities to compete for contracts, they will not invest in or retain the expertise necessary for them to effectively compete. In a similar manner, the structure of competitions matter; if a firm perceives that the risks are such that it will not be capable of earning an acceptable rate of return on its efforts, it will decline to enter the competition.

The Value of Competition

We turn now to what can be said, on the basis of the information reviewed in this study, about the value of competition. The most common and important form of direct competition in the acquisition of MDAPs is the down select (usually of one of two competing firms) for the award of the EMD contract. (Competition also is the norm at earlier stages of development, termed technology maturation or concept development.) It is commonly presumed that competition holds down the cost to the government of the EMD phase. In fact, this presumption is embedded in statutory direction favoring competitive awards of contracts for major defense acquisitions.

There is virtually no direct evidence of the validity of this presumption. There are two reasons for this. First, substantial growth in EMD costs from the Milestone B

baseline is the rule, not the exception. The cost growth occurs for several different reasons—an unrealistic initial estimate, as well as changes (at DoD's behest) in the program, to name two. Consequently, isolating the actual cost to the government of the EMD program as initially put on contract is a difficult and time-consuming process. Second, there are very few instances of an EMD contract for an MDAP that was awarded without competition. Thus, not enough "natural experiments" with sole-source placement of MDAPs exist to provide a solid basis for a straightforward evaluation of the effect of competition on the cost of EMD.

There is, however, indirect evidence that the equity market recognizes the worth of potential rents in a Franchise competition. On a broader basis, recent studies of the defense industrial base indicate that there is sufficient return on capital in most business with the DoD to ensure competition for new contracts.

This line of argument also bears on the effect on innovation in defense markets. Some part of the higher returns obtained by defense contractors are "recycled" into company funded research and development (R&D) and other investments that position them to win future contracts. Unfortunately, there seems to be no empirical work on how large an effect this recycling has on innovation in defense systems. In the limit, rents earned during the production phase may be entirely dissipated by investments in R&D equipment and facilities that defense producers make to improve their chances of being successful in future competitions.

In order to win a Weapon System Franchise competition, firms seek to present a solution that best satisfies the government's requirements. In many cases, such as the F-22 and F-35 aircraft, the government sought solutions that required novel designs and advanced technologies. The competing firms committed their best human capital (and, in the case of the F-22, considerable private capital) in developing innovative proposals that they believed would best satisfy the government's desires and thus obtain the Franchise. In contrast, our examination of the Single Development-Build method leads to a conclusion that, at least in the case of satellites, competitors tend to propose radical innovations and optimistic schedules that, in the end, prove to be unachievable.

Competitions for weapon systems, properly structured, are a critical tool in maintaining and shaping the industrial base. Losing firms in one competition may retain those critical skills necessary to enter the next competition. And, in the case of some second-source procurements, the Department makes a direct investment in the industrial base to train and qualify a firm to provide continuing competition in a market segment. However, the power of Franchise is of little use if firms perceive that there will be few, if any, opportunities for competition in the relatively near future. Such a dearth of opportunities at some point will cause firms to exit segments of defense markets in search of better business opportunities (military and non-military).

Finally, this study produces indirect evidence of the effect of competition in defense markets on responsiveness. As was noted above, Rogerson's analysis of "prizes" for innovation suggests that EMD programs will be executed more satisfactorily in the Weapon System Franchise case than in the Single Development-Build case. Our case studies tend to bear out this implication. The Weapon System Franchise holds future production contracts (the primary source of rents) at risk throughout the development and production cycle. This allows the Department to generate effective pressure on the contractor outside of the instant contract. In the case of the C-17, the threat was from a non-developmental alternative. In the case of the Joint Tactical Radio System, the source of competitive pressure was a privately developed alternative system, a system that some deemed sufficiently effective to serve as a substitute. In the Single Development-Build satellite cases, in contrast, the most likely rents were all embedded in a single contract. It seems, then, that the possibility—but not a guarantee —of earning rents in the production phase provides the firm selected a strong incentive to conduct a successful EMD program.

In summary, the evidence does not indicate that competition in defense markets over the past several decades has been sufficient to drive price to cost (including a competitive return to the capital employed), but it does seem to have had an important role in driving innovation in defense systems and in making prime contractors more responsive to DoD.

Contents

1. Introduction

This study examines the role of competition in defense acquisition. Competition is mandated by law, yet the law also allows for a number of exceptions. This somewhat flexible policy suggests that law and regulations assume that competition may impose costs as well as yield monetary and other benefits, and that the use of competitive bidding and contracting procedures may not always lead to the best outcome for the government. The aim of this study is to inform the reader of those considerations which help shape the outcomes of competitive processes for defense acquisition.

The focus of the study is primarily on the acquisition of systems, including both weapon systems and supporting systems such as communication, command and control, and information systems. Our inquiry does extend to the lower tier firms of the defense industrial base that help create major systems, but we do not discuss acquisition by the Department of Defense (DoD) of services and products that are largely commercial in character. While the arrangements through which these commercial products and services are purchased have features in common with the way DoD purchases systems that must first be developed, the differences are much greater than the similarities and purchase of services and commercial products present issues very different from those involved in competition, or its absence, for major systems.

A. Some Ways Defense Acquisition Differs from Commercial Market Behavior

In a market setting, the seller can conduct surveys or other market research to determine the product features that will appeal to most buyers, even if it is not ideal for any single buyer. In the defense sector, the desired features of a weapon system depend upon the perceived threats and capabilities of potential enemies. Changes in the threat or enemy can lead to changes in the type of weapon system needed, or make current systems obsolete. More important is the presence of just one buyer in the U.S. defense sector. When there are many buyers, even if buyers' preferences change over time, it is likely that some buyers will continue to purchase the product. Demand is not an either-or proposition. But the DoD acquisition agent—generally a military service, sometimes a defense agency—is the only buyer for a defense system. A cancelled program leaves a seller with no demand at all.[1] Added to this, the government cannot credibly commit to

[1] We ignore for the moment the possibility of foreign governments buying the system.

continue to purchase a system for the long term because the Congress must approve each year's defense program.

In a commercial market, the seller is not only responsible for deciding what to produce, but also for funding the development and production of the product. In the defense sector, the government usually funds the design and development stage of a weapon system. The size of the development expenditures required for weapon systems makes it unlikely that any individual firm would undertake to develop a weapon system on its own. Development costs can run into tens of billions of dollars. In their pioneering study of defense economics, Peck and Scherer (1962, 58) noted that of the three commercial products of the 1950s that came closest in scope to the development costs of weapon systems—nylon, color television, and the jet airliner—government funds were involved in the development of both color television and the jet airliner. Combined with the technological and demand uncertainties noted above, the size of the expenditures required to develop a weapon system would make private firms that attempt to do so unattractive to private investors (59).

There are two respects in which defense firms may be somewhat more sheltered than firms in commercial markets. First, in the defense sector, cost-plus contracts under all but fairly extreme situations guarantee the contractor reimbursement of his costs as well as a fee. The weighted guidelines in the Defense Federal Acquisition Regulation Supplement (DFARS) provide ranges of allowable fees depending on the contractor's degree of risk in completing the contract, the type of contract, and the capital investments employed in the contract. These regulations apply even to fixed price contracts (DFARS Section 215.404). Second, in the commercial market, sellers can face bankruptcy if they fail to find buyers or keep their cost of production competitive. When a large defense firm fails to meet its contract requirements (satisfy the buyer), the government may intervene to prevent bankruptcy (J. R. Fox 1974, 469).

The defense sector, however, is more highly regulated. Most of the regulations that apply to firms producing for the civilian market also apply to defense producers. In addition, the Federal Acquisition Regulation (FAR), together with DFARS, specifies how competition should be carried out for systems acquired by DoD. Those regulations set out the procedures for evaluating proposals, choosing the appropriate type of contract, and determining allowable contractor profit, among other details.

Table 1 provides a summary of these major differences between the defense sector and a competitive market.

Table 1. Comparison of Defense Sector and Commercial Markets

Competitive Market	Defense Sector
Price determined by supply and demand	Price is based on costs and determined through a series of negotiations
Buyers and sellers act independently	High levels of cooperation between buyer and sellers
Individual producers decide what to produce and finance the development	Buyer determines the requirements of the product and provides most of the development financing
Many suppliers and many buyers	One buyer and few sellers; frequently only one seller at the production stage
Demand is relatively stable as a function of disposable income	Demand is highly uncertain and is a function of available technology, estimates of potential enemies' capabilities, and political environment
Product is standardized and there are many choices within a category	Typically only one product, which is new and subject to design changes
Price is a dominant factor in product choice (substitutes are available)	Other factors such as schedule and quality are the dominant factors in choosing the product/ producer
Purchasing a product is a simple, one step process	Purchasing a weapon system is a multi-stage, multi-year process

Note: Properties adapted from those presented in Fox (1974, 39), and Arena and Birkler (2009, 5f).

Price is the focus of competition in the market for a commodity, with competition tending to drive price down to the minimum long-run cost of an efficient producer. The potential costs savings of competition are typically used to justify or encourage the use of competition in the defense sector. As the literature makes clear, however, competition in the defense sector cannot be relied on to produce this result.

B. Competition in Government Markets Defined

The term "competition" can be defined in a number of different ways. For purchases by the Federal government, competition is defined in statute. "Full and open competition" is defined as follows:

> ...the term full and open competition, when used with respect to a procurement, means that "all responsible sources are permitted to submit sealed bids or competitive proposals on the procurement." (Manuel 2009, 7)

The statute and the FAR define several other types of competition, including categories such as "free and open competition after limitation of sources."

In an economic context, competition takes place in markets, with sellers attempting to attract favorable bids from buyers for their products, and buyers attempting to be offered goods or services at favorable prices. These actions are voluntary, and the

competition itself serves to provide important information to markets: information about prices and about the goods and services themselves.

In this paper, we will use the term "competition" to mean an effective contest between two or more firms to develop and build a weapon system for the Department. It is a central premise of this paper that any benefits from competition can only be gained if at least two capable bidders stand willing to enter the contest and vigorously compete. A competition that meets the legal definition of "full and open competition," but that involves only one realistic bidder, should not be considered to be an effective competition.

C. The Main Institutional Settings of Competition for Defense Systems

The acquisition strategy for a major military system typically involves a structured process that reflects both DoD policies (notably DoD Directive (DoDD) 5000.01 "The Defense Acquisition System" and DoD Instruction (DoDI) 5000.02 "Operation of the Defense Acquisition System") and acquisition law (as described in the FAR and DFARS).

The acquisition of a new system occurs in a number of phases. While those phases' titles have changed with different revisions of DoDD 5000.01 and DoDI 5000.02, the concepts have remained similar over time. The first two phases—currently labeled "Material Solution Analysis" and "Technology Development"—are designed to set the stage by identifying the requirements for a new weapon system, and if necessary, developing the required technologies and materials needed to satisfy the requirements. As an example, before any stealth aircraft could be developed, the basic principles of using both design and materials to achieve stealth had to be worked out in the laboratory and tested in the field. Technology Development may also include Concept Development, in which potential contractors set out their approach to creating the new system.

The third phase—and the first phase of system acquisition—is "Engineering and Manufacturing Development" (EMD). EMD is the transformation of the concept into an actual product, complete with full engineering and design specifications, performance requirements, manufacturing processes, and test procedures. The final phase of system acquisition is "Production and Support," in which the system is acquired, typically as a series of annual lots that are purchased as separate contract actions, and sometimes in part through a multiyear contract spanning three to five years of production.

The evolution of the competitive environment for defense firms since the end of the Cold War has been marked by progressive waves of consolidation. Once there were several competing defense firms in every major market segment—aircraft, ships, vehicles, missiles, radars and other electronic systems, and others. At one point in the 1950s, for example, the United States Air Force alone was funding eight jet fighter

research and development (R&D) programs and seven bomber R&D programs (Birkler, Bower, et al. 2003, 1). In 1960, there were 11 American firms capable of producing fixed-wing combat aircraft. By the late 1990s, those 11 firms had been reduced to three: Boeing, Northrop Grumman, and Lockheed Martin.

The story is similar for shipyards. In 1972, eleven shipyards (with nine different owners) were building, or had recently built, major ships for the U.S. Navy (Gansler 1980, 185). Today, there are only six active shipyards producing major naval vessels, and only two firms—General Dynamics and Northrop Grumman—control all six (Arnold, Bronson and Tyson 2008, 7).

Another significant development is the emergence of foreign firms as owners of U.S.-based defense production facilities. The most notable acquirer of late has been BAE Systems. BAE Land and Armaments Group's U.S. Combat Systems Division is now the U.S. producer of Bradley Fighting Vehicles as well as other tracked and wheeled vehicles, including the Paladin self-propelled howitzer and the Mine Resistant Ambush Protected (MRAP) vehicle. Another major British firm is Cobham plc, which has aggressively sought to acquire many DoD suppliers of components and subassemblies. A third British firm, Ultra Holdings plc, owns one of the two U.S.-based firms producing sonobuoys for the U.S. Navy.

The U.S. defense market has increasingly seen the aggressive pursuit of contracts by foreign firms, with the help of U.S. partners. Most recently, attention has focused on the tanker competition, in which European Aerospace and Defence Systems (EADS) partnered with Northrop Grumman to win an award to produce the next-generation U.S. Air Force tanker. That award was subsequently set aside as a result of a Boeing protest, and the contract is being re-competed yet again. While Northrop Grumman has announced it will not bid this time, EADS has submitted a bid through its U.S.-based subsidiary.

The tanker contract is certainly the most visible instance of a foreign competitor trying to win a U.S. contract for a new major system, but it is hardly the only recent example. BAE Systems was a leading contender to win a contract for the Future Combat System before the vehicle portion of that program was cancelled by Secretary Gates. The British/Italian team of AgustaWestland produces the EH-101 helicopter, which provided the platform for the recent VH-71 VIP aircraft program. Again, that program was cancelled in 2009 by Secretary Gates because of cost overruns and schedule delays.

Another fact facing U.S. defense firms today is the sheer lack of programs for which they might compete. In the 1950s, each Service was responsible for developing its own equipment. The U.S. Air Force might have been developing one or two fighters as replacements for those currently in production, while the U.S. Navy was developing several designs for its own wings as well as a fighter for the U.S. Marine Corps to

operate. A similar situation characterized rotary-wing aircraft producers during the Vietnam era, when the Army and the Marine Corps were both fielding attack helicopters in large numbers, while they, as well as the other services, needed utility helicopters for transport of troops and supplies, anti-ship and anti-submarine operations for the Navy, and search and rescue for the Navy and the Air Force. In this environment, losing a competition was less serious for the firm than it would be today because there were more competitive opportunities.

Today, the program menu is dramatically compressed. First, individual service programs have been replaced by joint programs. In 1975, for example, when Northrop Corporation, with its YF-17 design, lost the competition for the Air Force's tactical fighter to General Dynamics' F-16 design, it partnered with McDonnell Douglas to compete for the Navy's Air Combat Fighter program and won that award with the F/A-18 design. But that option is no longer open. In the nine years since October 2001, when the Boeing team lost the competition for the F-35 contract to the Lockheed Martin team, no subsequent fighter development contract has been awarded.

In addition, the downsizing of the military has reduced quantitative program requirements. Tanks are a good example. The Army once maintained a tank fleet exceeding 12,000 vehicles. With a 20 year life, this meant an average of 600 new tanks being bought every year just for the U.S. Army, and a total production run of well over 12,000 for each new generation tank including U.S. Marine Corps and foreign military sales requirements.

Compare this to the current situation. The Army bought its last new M1 Abrams tank in 1997. That year, it procured 62 tanks. Since then it has been buying lighter, wheeled vehicles (Strykers) and developing the Future Combat System (since cancelled). Similarly the Navy, with some 300 major surface combatants, needs to buy about ten ships a year versus the 20 to 30 it bought during the Cold War. Annual Air Force purchases of tactical aircraft also are much lower than they were during the 1970s and 1980s.

D. Plan of the Study

Competition for major defense systems cannot be usefully discussed in the abstract. Rather, it is necessary to specify some things about what is under consideration. We begin with the standard acquisition process, consisting of engineering and manufacturing development of the system followed by production (as described in the previous section).

There are two main cases. The first of these is serial production over a period that can continue for as long as 20 years. At least until the system has reached maturity, a separate contract is negotiated each year to purchase a specified number of the system (that is, an annual lot). These contracts are typically placed with the firm that won the

EMD contract. For that reason we refer to this case as "Competition for a Weapon System Franchise." This is the most common case; it is typical, for example, of acquisition programs for aircraft, ships, tactical missiles, and tanks and tracked vehicles. We discuss this case in Chapter 2.

One variant on the standard Weapon System Franchise case is "dual sourcing." As the label implies, in a dual source acquisition, DoD qualifies two firms to produce the system and then competes the annual production lots between the two firms. That is, annually each firm is invited to submit a bid to supply some or all of the units that the DoD wishes to buy that year. The low price bidder receives a larger quantity than the other firm and may, depending on the bidding structure, receive the entire lot for the year. (Dual source bidding schemes can be quite complex.) Note that under the standard Weapon System Franchise model there is only one competition—for the EMD contract—while DoD may still be buying the system 20 years after EMD has been completed. Dual sourcing continues competition into the production phase. We discuss this variant in Chapter 3.

The existence of a near-substitutable system also can provide competition during the production phase. There have been only a very few instances during roughly the past 25 years in which DoD has arranged a formal competition between two systems that had distinctly different capabilities but were similar enough for the two systems to be regarded as near substitutes. Much more common are implicit competitions that take place through the program approval and budgeting process. That is, if the price of System A becomes "too high," the purchasing Service may decide to buy more units of near substitute System B and fewer units of A or, in the limit, cancel that program. We examine near-substitute competitions in Chapter 4.

The second basic case is one in which there is no major contractual distinction between EMD of the systems and its procurement. Rather, the entire acquisition—both EMD and procurement—is performed under a single contract. Consequently, we refer to this case as a "Competition for a Single Development-Build Program." A Development-Build approach may be the only real option if only a few units of the system are to be procured. This is typically (although not always) true of satellite programs. As in the Weapon System Franchise case, there characteristically is a competition involving two (rarely more) firms for the EMD/production contract. The contract awarded usually is cost-reimbursable with some incentive features. Development-Build programs are the subject of Chapter 5.

The remaining chapters provide insight into other aspects of competition. Chapter 6 examines competition at the subcontractor and lower tiers. An understanding of competition at this level is important, because the majority of economic activity occurs here, rather than with the prime contractor. Chapter 7 discusses how firms seek to position themselves to compete for future major defense programs. The final chapter

presents our conclusions on the benefits of competition and identifies areas where additional research could strengthen our understanding of defense competition.

2. Competition for a Weapon System Franchise

This chapter considers the case we labeled on page 7 as "Competition for a Weapon System Franchise." In this case it is common for there to be explicit competition at the technology development phase. Contracts for concept development will usually be awarded competitively, with multiple awards to several firms deemed capable of undertaking the task of EMD, if their design is selected. The EMD contract itself will almost always be competitively awarded if multiple bidders were present in the concept development stage.

Once the engineering design is complete, the production and support or procurement phase begins. Because only one firm has developed the chosen system, procurement contracts usually are awarded annually on a sole-source basis. Typically, the initial lots are acquired for a relatively limited quantity, because the system usually has not completed operational test and evaluation. Once that hurdle is passed successfully, full-rate production begins.

A. Examples of Franchise Competitions

To motivate the analysis of franchise competition, we review a series of competitions in three weapon systems sectors: tactical aircraft, surface combatant ships, and tactical radios. In all cases there appears to be competition for a franchise, although in the Navy's case, a closer examination reveals that they are not using a franchise model at all. A key element of these competitions is the contractors' deployment of private capital. Though the evidence for the amount of investment is limited, we clearly have anecdotal indications that it was spent. This provides some proof that franchise competition motivates contractors to innovate and develop a product concept that the government will buy in large quantities. This also provides justification for thinking about this competition as an "all-pay" auction, which is a common framework for studying innovation (Nitzan 1994; Anderson, Goeree and Holt 1998).

1. Aircraft Competitions

First we look at recent aircraft franchise competitions, such as those for the F-22 and the F-35 Joint Strike Fighter (JSF). The F-22 started as the advanced tactical fighter (ATF) competition. This competition began in 1985 with seven contractor teams presenting proposals. They are reported to have spent about $100 million each of internal

capital developing proposals that were submitted about one year after the Request for Proposal (RFP) was released (Warwick 1986). The competition then narrowed to the top two submissions from among those received. The government awarded fixed price contracts for about $700 million each to Lockheed and Northrop to build ATF prototypes. At the end of the competition, the Lockheed team was chosen over the Northrop team (Gertler 2009). It is conceivable that the winner was able to recoup its investment through its R&D expense in overhead. Northrop wrote its costs off as they were incurred and reported a loss on its financial statements as a result of losing the competition (Warwick 1986).[2]

The ATF competition appears to have motivated all of the aircraft sector companies to invest their own funds in competing for the design contract with their respective prototype aircraft. When it came time to compete for the JSF, however, the government did not appear to expect the contractors to commit substantial internal funds. Instead the government planned and funded a concept demonstration phase to which it expected the contract teams to scale their activities. The result of this phase was to be two experimental aircraft that demonstrated technical concepts that would be key to meeting the program requirements. The goal was not to minimize the demonstration budget, but rather to limit the scale and scope of new technology that was introduced into the program.

The JSF competition started its initial concept exploration phase in the early 1990s between five aircraft manufacturers and two engine contractors. Three of the contractors—McDonnell Douglas, Grumman, and Northrop—formed one team. The other two competitors were Boeing and Lockheed. The three competitors each selected Pratt & Whitney's F135 derivative of the F119 engine. The final competition was between the Boeing and Lockheed teams (which had been created for this phase of the competition). As part of the proposal development, the teams were to compete on concept demonstration prototypes with limited completion criteria such as: the potential for commonality and modularity to reduce cost across the three different variants of the aircraft; successful short take off, vertical landing, hover, and transition; and low speed carrier approach flying.

Each team was awarded a cost plus fixed fee contract to develop a demonstration prototype. Additionally, Pratt & Whitney was awarded a sole-source cost plus award fee contract to develop the F135 engine and support its integration into each of the

[2] As long as the expenses incurred in the competition were not due to contract requirements, the contractors could conceivably capitalize the expenses associated with the content developed, to the extent that they can be used towards the F-22 in the future and amortized over later contract periods. Northrop, as the loser would not be in this position and would have to write the asset off—as it did in 1989 and 1990. Northrop reported write-offs of $73 million and $66 million in 1989 and 1990, respectively (Securities and Exchange Commission 1993).

demonstrators. Clearly the JSF program sought competition between two teams; however, the government sought to capture more of the contractors' expertise than their capital. Since the F-35 is one of the largest acquisitions ever undertaken by the United States, the bidders had a strong incentive to get their proposals right; hence, the competitors most likely spent their private funds towards this goal.[3]

The government sought for the two contractor teams to deploy their best employees towards the concept demonstration phase of the JSF. The cost of these employees was recoverable, but the cost recovered may possibly be less than the opportunity cost of having them work on the JSF proposal in lieu of another program. If the DoD conducts competitions for MDAP franchises like it did with the JSF, where it provides all of the development capital, the remaining contractor lever is to put their best, most proven resources on the task of preparing the necessary bid materials. By limiting the proposal cost to a fixed amount and specific scope, the contractors will focus on demonstrating or validating those elements they feel are required to win the franchise. Given the prize structure of the competition and the penchant for the DoD to seek advanced technologies, competitors will be driven towards technically innovative proposals.

2. Ships: Problems of Industrial Base Management

Like the aircraft sector, the ship sector is highly concentrated in two main firms: Northrop Grumman and General Dynamics. In contrast with tactical aircraft, the surface Navy avoids all-or-nothing acquisitions and overtly manages the work flow to the shipyards, keeping them sufficiently busy to remain open. The Navy achieves some degree of competition at certain points in the life of a ship product. In particular, the Navy allows the shipyards to compete for the lead ship design. These competitions, however, are not aimed at yielding the same level of technology innovation as in the aircraft competitions. Once the lead ship has been selected, the Navy sometimes allows multiple shipyards to compete for production contracts and sometimes these contracts appear to be allocated to keep the key yards utilized (Schank, et al. 2006; The United States Department of Defense, Office of the Assistant Secretary of Defense (Public Affairs) 2002).

For example, Bath Iron Works (BIW and now part of General Dynamics) won the lead ship design for the DDG-51. Subsequently, BIW and Ingalls (now Northrop Grumman Ship Systems (NGSS)) competed for annual DDG-51 production based on the cost of the bid. In 1994, the Navy began allocating DDG-51 units to each yard in order to balance the work. Some competitive forces were kept alive through the use of the Profit

[3] It appears as though some internal capital was deployed, as Boeing reported a $46 million write-off associated with JSF at year end 2001 (Boeing Corporation, December 31, 2001 Form 10-K filed with the SEC March 8, 2002).

Relative to Offer (PRO) pricing system which rewarded the lower cost bid with a higher fee (Schank, et al. 2006).

When the shipyards competed for the LPD-17, they formed teams that accounted in some way for all prime shipyards (there were six independent yards at the time). Newport News teamed with Ingalls while BIW teamed with Avondale. The initial production plan was to award the entire planned acquisition to the winning team. If the Newport News/Ingalls team won, the two shipyards would each build half-ships and then integrate them together. If the Avondale/BIW team won, the two shipyards would alternate building entire ships. Ultimately, however, the Navy decided to build the entire ship class at Avondale and Ingalls, because Litton had recently purchased both yards.[4] The Navy at the same time allocated an equally valued block of DDG-51 ships to BIW.

The DDG-1000 program was to initially follow the DDG-51 path with a competition for the lead ship followed by competitions for production. However, the Navy ended up structuring the acquisition around a team arrangement between BIW and NGSS that broadly followed the same strategy as the initial LPD-17 plan (Schank, et al. 2006). The lead team member, Ingalls, produced half while BIW produced the other half, and each yard alternated integrating the halves into a whole.[5] The production phase was truncated to three units, however, and the Navy again stepped in to manage production by putting all three units at one yard, BIW, while offsetting the work shortfall at Ingalls with a block of DDG-51s.

The littoral combat ship (LCS) plan deviates somewhat from the other ship programs in that the Navy has seen new firms enter into the competition. Lockheed has been drawn into the sector with its LCS design, which it developed with teammate Marionette, a "second tier" yard. Similarly BIW (now part of General Dynamics) has teamed with Austal for its LCS catamaran entrant. At the end of 2010, the government decided to award production contracts to both teams—and, hence, two designs—for 10 ships each.

Do these competitions for lead ship designs act to motivate contractors to commit company capital and human resources? There is evidence that the contractors are investing internal capital in the development of design proposals. For example, BIW and Avondale's R&D/Bid and Proposal expenses increased dramatically in the years before the DDG-51 lead ship award. It appears, however, that these costs were recovered through overhead cost reimbursement (Cloos, et al. 1996). Even though the DDG-1000 used other transactions authority to fund the pre-development projects, we cannot

[4] Litton bought Ingalls and Avondale in 1999 and Northrop Grumman bought Litton and Newport News in 2002.

[5] This is also the strategy used by Electric Boat and Newport News in the production of the Virginia Class submarine.

determine if these costs were recovered. Furthermore, while Other Transaction Authority (OTA)-funded projects often require that at least a third of the funds come from outside the Federal government, it is not strictly required when the content is militarily unique.

3. Radios

A final case, the Joint Tactical Radio System (JTRS), demonstrates how potent the value of the franchise incentive can be. Two teams competed for the Airborne, Maritime/Fixed Station variant of the radio in 2005. The Lockheed team won the competition; however, Harris, on the losing team, continued to develop its radio based on the JTRS software communications architecture using its own capital. The result is the Falcon III radio, which the Army and Marines are buying in large numbers.

The popularity of the Harris alternative is actually threatening the viability of the JTRS franchise, as it may not be able to generate enough sales to justify the development expense. The Falcon III does not have all of the functionality as the planned JTRS, but it has enough capability for some applications, and it is available now.

The goal of this example is to illustrate two points: (1) that the value of winning the franchise can compel a firm to invest its own resources towards that end; and (2) that the franchise won at the EMD down select could still be contestable by the highly motivated competitor.

4. Summary

The government frequently holds competitions for weapon systems franchises. The prize that drives competition is the substantial profits available in the production phase, as discussed in the next section. However, these profits are a large enough incentive to, in some cases, motivate contractors to put their own private capital at risk in order to get the results sought by the government. This even appears to be the case when the government has sought to curb contractor investment, as in the concept demonstration phase of the F-35. There are also ways that the contractor can invest without incurring tangible costs on or off the contract that can be very valuable to the government. For example, the contractor can allocate its best engineering and design staff to the project, thereby incurring an opportunity cost that exceeds the concept demonstration contract value.

The Navy uses competition for surface combatants but usually does not allow the winning firm the sole-source franchise. Instead the government has switched between holding competition for each year's production to allocating blocks of units to level out workflow between the two main firms. In effect, the Navy forgoes the same degree of franchise competition as the aircraft sector in order to preserve the business viability of its industrial base.

Finally, the tactical radio case illustrates the contestability of the franchise if the entry barriers are low enough. Harris saw that they could usurp some of the profits intended for the planned JTRS units and rushed their radio to market to take advantage of the urgent needs created by Operation Iraqi Freedom (OIF)/Operation Enduring Freedom (OEF). The government effectively lowered the barrier to entry by developing and distributing to industry its software communication architecture. Furthermore, Harris is already an established designer and manufacturer of tactical radios and had been part of a losing team for one of the JTRS programs. It is conceivable that other franchise programs are contestable by sufficiently near substitutes.

In general, the competition for the franchise does not necessarily stop once the EMD down select has been determined. The contractor must still compete at the budget level to keep the government interested in buying units.

B. Economics of Competition for a Weapon System Franchise

The examples suggest that prices during the production phase remain high enough to provide the supplier of the system a return on invested capital greater than it could obtain in a similarly risky alternative employment. In economic jargon, the supplier obtains economic rents. This is a result that has been confirmed in several studies over the past 25 years (Arnold, et al. 2009). It stands in sharp contrast to what is expected in a competitive commercial market, however, in which over time the process of competition is expected to drive price down to cost (where cost is defined as including a competitive return to the capital employed). The first task of the economic analysis of the Weapon System Franchise case, then, is to explain the source of the rents apparent in the production phase.

1. Rents in the Production Phase

The path towards an explanation is suggested by the commonplace observation that stretching production of a major defense acquisition increases cost by flattening the learning curve.[6] This comment points to cost-reducing investments made by the firm and this, in turn, points back to pricing of firm fixed price (FFP) contracts typically used when a system is in full rate production and the incentives those contracts create.

The mechanisms sketched in what follows have long been understood in broad terms by the acquisition community and defense hardware contractors. They were first stated in analytical terms by Rogerson (1994). David Lee (1997) provided a more formal and general development of the mechanism. Bronson (2009) provided a simulation model based on the theory using parameter values characteristic of major weapon systems.

[6] A learning curve is the relationship between the number of units produced and the decrease in per unit cost.

The case under examination at this point is the one in which the FFP contracts for successive annual lots are awarded sole-source to the firm that won the EMD completion. The FFP contract for the first production lot will be negotiated on the basis of a proposal submitted by the contractor. This proposal includes extensive information on target cost, which is subject to review and challenge by the government. At this point the contractor and the government ordinarily know the actual costs incurred in building test articles during the EMD phase and probably have some information about the costs of lots built during Low Rate Initial Production. Fee is also negotiated and ordinarily stated as a percentage of target cost, but is paid as a dollar amount regardless of realized cost.

In a cost reimbursable contract with an incentive fee, the government pays costs actually incurred, at least up to a point. If cost exceeds target cost, fee is reduced according to terms specified in the contract; conversely, if actual costs are less than target cost, the underruns are shared between the contractor and the government on a predetermined basis. In an FFP there is no sharing of cost overruns and underruns; these flow entirely to the firm's profit (or loss).

Some cost overruns or underruns are simply fortuitous (for example, those caused by changes in material prices). The point of the comments above is that a single FFP contract provides the firm an incentive to make investments to reduce cost. This is the primary mechanism behind the familiar learning curve, a notional example of which is shown in Figure 1.

Suppose that early in the term of an FFP contract a firm does make cost-reducing investments and that these investments are successful in the sense that that they reduce the cost of producing the weapon system by more than the cost of the investment. Laying aside for the moment effects on future contracts, the firm gets to keep (as profit) the net return from the investment. The incremental profit is in addition to that provided by the negotiated fee and is a rent if the negotiated fee provided at least the firm's cost of capital.

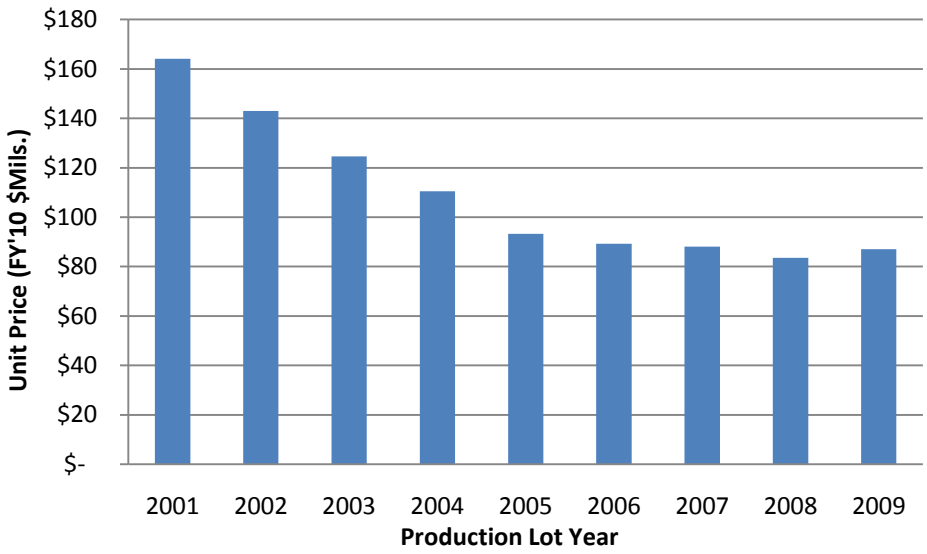

Figure 1. Example of a Unit Price Learning Curve

The comments just offered are the nub of the explanation of how rents arise during the production phase in the Weapon System Franchise case. To complete the argument, however, it is necessary to look at how prices are adjusted on successive FFP production contracts.

We return to the F-22 case to do this. The first F-22 full rate production contract (Lot 5), for 24 aircraft, was awarded in 2004 for fiscal year (FY) 2005.[7] The contract for Lot 6 (24 aircraft) was awarded in 2005 and covered FY 2006. Like the contract for Lot 5, the contract for Lot 6 was negotiated on the basis of a proposal submitted by the prime contractor (Lockheed Martin). It is important to note that these negotiations are subject to the Truth in Negotiations Act and use contractor cost and pricing data that is certified to be current, accurate, and complete on the date of the final negotiated price (Rogerson 1994).[8] This means that Lockheed risks criminal prosecution if it were to knowingly pad the cost estimate. At the time of the Lot 6 negotiation, the government and the contractor presumably had some information on the cost of Low Rate Initial Production (LRIP) lots that had not been available when the Lot 5 contract had been negotiated. Actual costs of Lot 5 were not available, however. Tactical aircraft—and the F-22 was not an exception to this rule—typically require two to three years to build. Hence, it was not until about FY 2007 or FY 2008 that the actual cost of the F-22 Lot 5 was known.

[7] For the F-22, as is typical of the major systems DoD buys, each lot is "fully funded;" that is, the Congress appropriates the full amount the contract obligates the government to pay. The amount appropriated is obligated to the contract but is actually paid out to the contractor as the work proceeds, which usually is over several years.

[8] That is, we are not assuming the contractor is violating the Truth in Negotiations Act.

On this basis, we would expect the actual costs of Lot 5 to be reflected in the prices negotiated for Lot 7 or perhaps Lot 8. At that point, the government would "capture" benefits of the producer's successful cost reduction efforts in a lower negotiated price. The interim—assumed to be two or three years in this instance—is referred to in the literature as the "regulatory lag." The regulatory lag is the period for which the producer keeps, as additional profit, the net reduction in cost due to cost-reducing investments.

Figure 2 is a highly simplified notional summary of the consequences of the mechanism sketched above. The example assumes a regulatory lag of two years. The magnitudes of the cost reductions are exaggerated to make the figure easier to follow. The example also assumes that the same number of systems is procured in each of the three lots and, finally, assumes there is no cost information accumulated prior to the Lot 5 negotiation (that is, no EMD articles or LRIP lots). Hence, Lot 5 and Lot 6 have the same price. The firm makes cost-reducing investments early in Lot 5 and gets to keep the net reduction (as profit) for two years. The actual cost of Lot 5 is known when Lot 7 is negotiated and target cost for Lot 7 falls to the actual price of Lot 5 (and the dollar amount of the target fee is somewhat reduced from the Lot 5 level because target price is lower). At Lot 8, the actual cost of Lot 6 is known, and so on through the remaining lots.

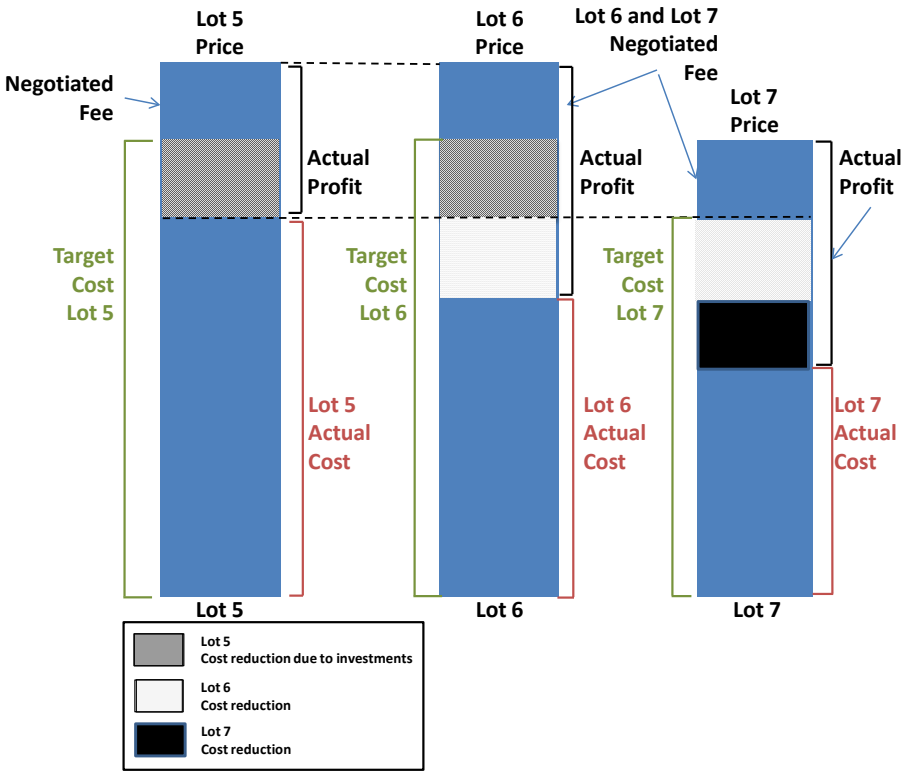

Figure 2. Regulatory Lag and the Incentive for Cost-Reducing Investments

A nearsighted producer would look only to the net gains he gets until the lower costs are captured by the government in lower prices. A more farsighted producer would also recognize that cost-reducing investments reduce the profit that can be negotiated on future lots, when actual costs are known. The farsighted decision rule is to press cost-reducing investments to the point at which (in net present value terms) the cost reductions are just equal to the cost of the investment and the foregone future profits.

The logic of the mechanism just sketched does not guarantee the existence of investment opportunities that pass the test just stated. Whether they exist is an empirical matter and one that cannot be directly resolved with the data available in the standard reports on acquisition programs. On this point it is possible to offer the following:

- Firms with FFP production contracts for major systems routinely make cost-saving investments.
- Learning curves usually (although not always or without some odd features) have the expected shape.
- It is the conventional wisdom that the decreases in cost captured in learning (or better, cost progress) curves largely reflect cost-reducing investments.
- Simulations using realistic parameters yield learning curves that are similar to those observed.

On this basis, it is reasonable to conclude that the mechanism sketched above is the core explanation of the existence of rents that are available in the production phase to the firm winning the franchise.

2. What Becomes of the Rents?

This concludes the discussion of why there are rents in the production phase. It is not at all unusual to observe rents in a competitive market. In some broad sense, competition is about rent seeking. The expectation, however, is that over a sufficiently long period, the operation of competition tends to eliminate rents. The next question, then, is whether this is true of the Weapon System Franchise case.

One possible avenue for the elimination of rents is pointed out by the examples offered above—investments of their own funds by the firms competing for an EMD award. To the extent that it makes these investments, the firm expects to lose money on the development phase of the work and to recoup it from profits on the production phase. Assuming reasonably that firms gauge their investments by their assessment of the probability of their winning the EMD contract, the winning firm presumably would obtain rents on the program as a whole (on a present value basis). The losing firm or firms would take losses, but overall the losses of the losing firms and the profit of the winning firm lead, in theory, to dissipation of the rent.

A process along these lines has worked in some major weapon system competitions in the past. Its use was discouraged by statute in 1988, only to be reinstated in 2007.

A variant of this is the assignment by a firm of its best people, intellectual capital, and physical assets to an EMD competition that it is particularly intent on winning. This might not have a tangible effect on the cost of the firm's efforts on the contract in question but might instead increase costs (or reduce revenue) elsewhere in the firm. The net effect would be to incur tangible and intangible costs on the development work (in order to win the EMD contract) in excess of what the firm is paid to do the work.

Both of these mechanisms work in advance of the award of the EMD contract. Another and less speculative mechanism has to do with the use the firm makes of rents that it obtains as the production phase proceeds. These rents show up on the firm's books as part of profit. The firm's after-tax profits are either returned to shareholders (via dividends or stock repurchases) or reinvested in the firm. One of the main objects of investments is development of technologies, materials, and production processes that position the firm to win future EMD contracts. Laying aside the question of the extent to which DoD benefits from these investments, they clearly count as absorption of rents in the competitive process.

Overall, the evidence of what happens to rents from the production phases of major acquisitions that involve serial production is far from clear. On the one hand, as noted earlier, successive studies have shown that primes (across their whole defense portfolios) apparently obtain returns on invested capital somewhat above what could be obtained on competitive alternatives of comparable risk. On the other hand, some of these returns are retained and invested in activities designed to position the firm to win additional defense business.

3. Contestability of Rents and Government Oversight

Oversight of EMD for a complex weapon system presents DoD with an enormous governance problem. This problem stems from three main sources. First, DoD and the contractor understand key topics to different degrees. The contractor typically knows more about such matters as the relevant technologies, the main design options, and manufacturing issues, and its ability to achieve efficiencies. DoD, however, has better information about the threats the United States is facing, the capabilities that are desirable in the system, and the trade-offs that it is willing to make among various system attributes, cost, and schedule.

Second, the interests of the contractor and DoD are not wholly coincident. DoD is chiefly interested in three programmatic goals: meeting technical performance metrics, achieving cost targets, and staying on schedule, although its priorities may vary from one program to another. The contractor's management has a fiduciary responsibility to its

shareholders, responsibilities stated in the contract, and a general interest in performing well and being perceived as a reputable firm that plans to stay in the defense business.

Third, any EMD effort will be affected to some degree by unpredictable events—changes in the threat, unforeseen development issues, emergence of new technologies, or radical changes in input prices, for example. So no firm can wholly guarantee its performance.

Broadly, DoD has the choice of three governance mechanisms:

- The specific provisions of the contract;
- Direct DoD intervention that attempts to manage information asymmetries and divergences of interest, for example; and
- Alignment of the contractor's incentives with DoD's interests.

The first of these is of limited help, as a contract cannot be crafted to take account of the myriad contingences that may occur. Direct DoD management is expensive and experience suggests that it shares many of the limitations of the contract vehicle. It is reasonable to assume that alignment of the contractor's interests with DoD's goals is, to the extent it is possible, the best course.

The rents available during the production phase provide an incentive that helps align the bidders' interests with DoD's. At the stage of the EMD competition, the rents provide incentives to bidders to put their best efforts into submitting what is judged to be the most attractive proposal. The incentive effect of the rents would end with the EMD contract if the winner were guaranteed the rents; however, there is no guarantee. The prize (that is, the stream of rents) is not awarded when the EMD contract is signed. Rather, the prize is obtained lot by lot during the production phase; the last of the prize is not awarded until the last unit has been delivered and fully paid for by DoD. The prize is only achieved through continued, lot by lot, investment in cost-saving actions.

Occasionally the threat to the rents of the production phase is provided by a formal competition—dual sourcing, which can recur over several years, or a single competition for the "franchise" with a near-substitutable system. Rents available during the production phase also are implicitly at risk to some degree during the budget process. DoD can choose to buy fewer units of a system whose performance or cost has proven to be less than satisfactory. In this case the implicit threat may be from a near substitutable system, a new start, or a decision to accept risk against the threat the system was designed against or counter it with a different capability.

C. Value of Competition in the Weapon System Franchise Case

The discussion to this point has been about the mechanisms of competition in the Weapon System Franchise case. We now turn to what can be said, in the light of that analysis, about the value of that competition.

The opposite of competition during the development phase is sole-source placement of the development contracts. A fundamental problem with this type of contract award is that the government is not able to tell which contractor is efficient and, hence, the efficient contractor will seek roughly the same price as the inefficient firm. However, the efficient firm will produce at a lower cost than the inefficient firm and earn the difference in costs as rent. The government will learn about the higher rents ex post when it observes a steeper than normal learning curve.

Under competition, however, the efficient firm is subject to the same informational disadvantage as the government relative to knowing the efficiency of other firms. This informational disadvantage forces the efficient contractor to bid a price that is lower than the sole-source price. This is potentially one basic advantage of competitive sourcing over sole-source awards.

The second conclusion that stems from the analysis is that competition during the development process, including the EMD down select, does not exhaust the rents available during the production phase. The examples offered earlier, broader studies of the rates of return on invested capital earned by defense hardware contractors, and the economic analysis all agree on this point.

Third, to at least a significant extent, the rents obtained during the production phase by the firm that wins the EMD contract are expended in ways that tend to reduce future development costs and/or push out the frontiers of the technologies available to DoD. On their own, a profit maximizing firm should be willing to invest in a project to the point that its expected net present value is zero. In that case the expected rents from production might be largely expended before they are earned. In practice, however, there are limits to the extent to which firms are allowed to pay with their own funds for Research, Development, Test & Evaluation (RDT&E) done for DoD. Consequently, the bulk of the expenditures probably is made by firms to position themselves to win future large EMD contracts and the production opportunities that come with them.

The fourth conclusion from the analysis is that the competition during the development phase in the Weapon System Franchise case does promote innovation. The central point is captured in the title of one of Rogerson's key papers—"Prizes for Innovation." The prize" is the rents available during the production phase. To win this prize, DoD must conclude that the firm's proposal is the most attractive and that the firm can development and manufacture the system. Rogerson argues that over the past several

decades usually the "most attractive" proposal has been the one likely to provide the largest increment in capability, that is, the most innovative.[9]

The fifth and last conclusion that emerges from the analysis is that the rents available during the production phase reduce the difficulty of the task that DoD faces in overseeing the development and production of a complex weapon system. As was noted above, the rents available during the production phase provide an incentive that helps align the bidders' interests with DoD's. Some degree of threat to the rents available during the production phase is unavoidable, since there always is some implicit competition through the budget process between weapons programs. It would be going too far to say that the rents available during the production phase fully align the contractor's interests with DoD's. They do, however, provide the contractor with a strong profit incentive to see that the program succeeds, in DoD's terms.

The last of these conclusions has strong implications for the balance between competition and active DoD regulation of contracts for major system acquisitions. As the analysis sketched here shows, the two are, at a broad level, substitutes for one another. To the extent that declines in the number of firms in the defense industrial base reduces the ability of DoD to have real competitions during the development phase and at the downselect at EMD, and enough possibility of competition to hold the rents available during the production phase at risk, the Department will have to engage in more intensive active management than would otherwise be necessary.

[9] Down select criteria usually include performance, cost, schedule, and management (and possibly others). Rogerson's discussion, but not his formal theory, puts the emphasis on performance. In more general terms, the "prize" is awarded for what DoD judges to be the best proposal in terms of the criteria specified in the solicitation.

3. Dual Source Competition

Dual sourcing occurs when the government chooses two firms to produce the same (or a functionally equivalent) system. There are a number of rationales for dual sourcing. One common reason is to maintain the industrial base, i.e., to retain two producers who are capable of producing both the current and future versions of the weapon system. Another reason is to use the pressure of annual competitions to keep the price of the system from escalating. Dual sourcing may also contribute to technological competition in which firms compete in innovation to win future contracts.

There are a number of variants to dual sourcing. In leader-follower dual sourcing, one company is responsible for developing the system, and another company is brought on to produce a similar product. The follower is typically given a noncompetitive contract for two years or so of "directed buys" to provide an opportunity for the follower to learn how to produce the system according to the leader's technical data package. Depending on the product and its underlying technologies, the government may specify that the second company will build a system as close to the original as possible (build-to-print) or may accept a product with the same functionality (i.e., a form, fit, and function alternative).

Under dual sourcing, the annual production competition can take a variety of forms. Typically, the competition is a split buy, with the lowest bidder receiving a majority of the work, while the other firm receives enough work to justify keeping its production line open. As the system's production approaches the end of the production run, the final production contract may be winner-take-all for the remaining quantity.

A. Rationale for Dual Sourcing

DoD can choose dual sourcing to promote a variety of goals:

- **A lower price.** Dual sourcing is unlikely to result in lower costs in cases of steep learning curves, high nonrecurring costs, and low or uncertain quantity. This has been discussed in the literature section.
- **Improved quality and greater innovation.** One of the theoretical benefits of multiple companies is competition not just on the basis of price but also of quality and innovation. The government may want to keep two producers active to encourage them to compete in developing new, better products. However, dual sourcing may actually decrease the incentives to innovate. Rogerson's

(1989) work—as discussed in the previous chapter—views the succession of production contracts as the reward for innovation. When production is split between two firms, the reward to each producer is smaller, reducing the incentive to innovate.

- **Contractor responsiveness.** This was the motivation for some of the engine aircraft competitions. Keeping two producers increases the government's leverage over the contractor. It also provides the government with options in case of a strike, hurricane, or other catastrophic event in one location.
- **Maintenance of design and production base.** Dual sourcing has an impact not just on the immediate program but also on future programs. A firm that has experience in a past system has a huge advantage over a company that has no such experience or whose experience is generations old. Once a competitor exits the marketplace, it can be difficult to get them back. Some companies may be able to use their commercial experience as a way of keeping current with the technology. Where there is no commercial counterpart to the defense system, this opportunity is not available. To the extent that maintaining the industrial base is an explicit goal, acquisition decision makers need to consider the impact of these choices on the availability of future systems (Smallwood and Kovacic 1994).
- **Surge capacity.** This is a strategic consideration—sometimes a need, sometimes a justification for dual sourcing. In peacetime, planned quantity for major systems more typically goes down than up. However, U.S. military operations in the Middle East have increased the demand for some systems, most visibly the MRAP vehicle.

Sometimes dual sourcing is not the government's choice but is required by the Congress. The leadership of DoD has proposed canceling the JSF alternate engine program, but has been prevented from doing so by legislation. Shipbuilding is another market segment in which there is considerable congressional participation in dual sourcing. In addition to the potential advantages cited above, dual sourcing offers both the opportunity to preserve the industrial base and the politically attractive feature of spreading production across multiple legislative districts.

B. Some Examples of Dual Sourcing

1. Fighter Engine Competitions

Fighter engines represent a commodity that is often characterized by dual sourcing. Competition is facilitated by two factors: (1) engines are commonly contracted for by the Air Force and Navy separately from the aircraft they power; and (2) engines, as a

removable and replaceable item, are only required to be similar in form, fit, and function, not identical in every respect.

There have long been two sources for such engines—General Electric and Pratt & Whitney. These actors have participated in two dual source procurements—the Great Engine War of 1984 (involving the engines that powered the F-15 and F-16) and the F/A-18 engine competition—and are currently engaged in developing engines for a third aircraft, the JSF.

a. The Great Engine War of 1984

Leader Pratt & Whitney (who developed the F100 engine to power the F-15 aircraft) was challenged by follower General Electric (who developed the F110 engine as a derivative of the F101 engine that powered the B-1 bomber). The competition was prompted by the Air Force's dissatisfaction with the reliability of the Pratt & Whitney engine. The Air Force achieved its goals of obtaining more reliable engines with better warranties from both producers.[10] The fact that the General Electric entry was a modification of an earlier product helped reduce the cost of establishing the competition. The benefits have been attributed in part to the government's management of the competition. The Air Force demanded that the contractors provide six years of cost projections, and the Air Force held the contractors to those projections through firm fixed price or not-to-exceed contracts from the first production lot (Gertler 2010).

b. The F/A-18 Engine Competition

In the dual sourcing of the engine for the F/A-18 aircraft, the leader General Electric (with its F404 engine) was challenged by Pratt & Whitney during four years of dual production. The design and development were not dual sourced—only production. Under this "build-to-print" arrangement, Pratt & Whitney received contracts for three sole-source educational buys. Competition did not begin until Lot 10, and General Electric had little incentive to provide detailed instructions to Pratt & Whitney on how to build the engine. Net cost savings were relatively low. In a study of Navy procurement during the 1980s, the percentage net savings for this competition were the second lowest of 12 systems examined (Flynn and Herrin 1990).

[10] Testimony presented at a 1984 hearing suggested that the dual sourcing benefited DoD in areas such as "better contract terms and conditions, better warranties to ensure engine quality, consistency, and long term stability of support." U.S. Congress, House Committee on Armed Services, Air Force Alternative Fighter Engine, Hearings before the Subcommittee on Procurement and Military Nuclear Systems, 98th Cong. 2nd Sess., March 8, 1984 (Gertler 2010).

2. Tactical Missile Competitions

In the 1980s and 1990s, a number of tactical missile programs were dual sourced. The competing firms were usually Raytheon, Hughes, and General Dynamics. The missile programs include the Sidewinder (AIM-9), the Sparrow (AIM-7), and the Advanced Medium-Range Air-to-Air Missile (AMRAAM) (AIM-120). As with aircraft engines, the desire for cost savings was not always the exclusive reason for dual sourcing. Competition also emphasized such factors as missile reliability and maintainability.

3. Ship Competitions

As noted in the introduction, in the 1970s, at least nine shipyards were involved in building major ships for the U.S. Navy, and it was not uncommon for two yards to compete to produce cruisers, destroyers, and submarines, with a multi-ship buy split between them. Today, the U.S. naval ship industry comprises two firms—General Dynamics and Northrop Grumman—and between them there are six active yards (Arnold, Bronson and Tyson 2008). Newport News Shipbuilding Company (a Northrop Grumman subsidiary) and Electric Boat (General Dynamics) share—rather than compete for—the production of the SSN-774 nuclear attack submarine. The Navy has not yet determined a dual sourcing strategy for the LCS program. The Navy will own most of the technical data package and rights to the ship design.

It is interesting to note that these examples are drawn largely from the 1970s and 1980s. More recently, quantities purchased have decreased, making split buys more difficult. As we will see, large buys favor dual sourcing. The sole exception appears to be ships, where limited production is split across two yards without competition.

C. Considerations for the Use of Dual Sourcing

Whether dual sourcing is chosen by DoD or mandated, the government has a variety of policy levers. The tools available to DoD are different in development and procurement.

1. Considerations for the Development Phase

If dual sourcing is planned, it is essential to set requirements that are within the technical grasp of more than one company. The government must be prepared to invest in development, or it will be impossible for both contractors to produce the system successfully. An investment in competitive prototyping can motivate contractors to provide concrete information about their design early in the process. If the competition will be leader-follower, it will be necessary to secure data rights from the lead contractor and arrange for technical assistance from the initial source to the second source. If dual sourcing is not possible, the government may consider awarding small design efforts to

losing competitors to keep design capability fresh. Engineering design teams are assets that need an experience base to maintain and grow their skills.

2. Considerations for the Procurement Phase

The winner-loser split is an important policy lever. The more lopsided the split (for example, 65/35 vs. 55/45), the greater the incentive for the producers to engage in price competition. To preclude gaming the competition, the government will need to provide a credible possibility that a contractor will receive no award in a year in which its bid is prohibitively high.

Towards the end of procurement, the government may choose a multiyear winner-take-all buy. Recent theoretical and experimental work provides support for the notion that such a buyout can be beneficial from a cost standpoint (Lewis and Yildirim 2002).

Work on modifications and upgrades to the original system can be used as leverage on the contractors.

D. Assessments of Dual Sourcing

In 1990, Anton and Yao (1990) reviewed the empirical literature on competition for weapon system production contracts. The studies they reviewed evaluated cost savings on a program by program basis using learning curves. It is generally accepted that the unit cost of a weapon system decreases as the number produced increases and the producer gains experience.

In a learning curve study, cost savings are measured by comparing a predicted unit price to the observed competitive unit price. The predicted unit price is an estimate—using a learning curve—of the price that a sole-source supplier would have charged. All but one of the studies reviewed showed that competition during the production phase resulted in substantial unit cost savings.

However, the studies did not account for startup costs. Startup costs may include the incremental costs of funding two developers, costs of transferring technology from one producer to the other, the costs of educational buys, and added administrative costs of running the competition. Anton and Yao concluded that it is not clear from the literature if savings would still exist if the startup costs were fully accounted for. Washington (1997), in a similar literature review, also found that estimated savings due to competition fail to account for startup costs. He argued that once those costs are included, savings due to competition disappear.

Anton and Yao suggested that—even though competed programs do not show overall savings once the startup costs are considered—the threat of competition may still act as a brake on costs in sole-source procurements. Two of the studies they reviewed (Beltramo 1983 and Hampton 1984) noted that the estimated relationship between

production quantity and unit price is a poor predictor of final sole-source prices just before a competition. The final sole-source unit price is typically below the predicted price. This suggests that costs may be strategically determined, and that the threat of competition pushes defense firms to lower their costs. Thus, despite the lack of definitive evidence of savings in specific programs, competition may have a beneficial effect on overall prices in the defense sector.

Experimental work by Lewis & Yildirim (2002) on the effects of learning curves on competition supports this possibility. In their experiment, when suppliers win a round of the competition, their unit costs in the next round are lower. Suppliers want to win the current round of competition because doing so lowers their costs and puts them in a better position to win the next round. This pushes suppliers to lower their bids aggressively in the current round and allows the buyer to reduce the cost of current and future acquisitions by strategically managing the competition. The buyer can maintain the aggressive competition by rotating purchases among the suppliers to prevent a single supplier from gaining a large cost advantage. The buyer could increase his savings on the current round by awarding it to the winner of the last round. But, by giving up some of the current savings through rotating the awards, the buyer maintains competition and prevents future cost increases by a monopolist supplier, resulting in higher total savings over time (792).

Arena and Birkler (2009) examined multiple studies and concluded that two leader-follower missile programs of the 1970s, the Sparrow AIM-7F and the Sidewinder AIM-9L, had the greatest cost savings. In the Sparrow AIM-7F case, it appeared that the leader was keeping prices artificially high in the non-competitive phase and reducing them only under pressure from the follower. In the Sidewinder AIM-9L, the leader reduced prices sharply in the first two years of competition, and the follower cut prices enough to win the third year.

A study by Flynn and Herrin (1990) examined 12 Navy dual-source programs and used identical methods to estimate the percentage cost savings from each. Savings were measured as recurring cost savings over the projected sole-source cost, less the second source startup cost. They found the highest net cost savings, 16 percent or more, in the following programs:

- **The ship classes CG-47 and LSD-41.** In the 1980s, shipyards bid aggressively due to an almost total absence of commercial business.
- **The Tomahawk strategic missile.** In this procurement, General Dynamics and McDonnell Douglas alternated as winners from year to year, exhibiting behavior similar to that described in Lewis and Yildirim.
- **The Standard Missile 2 rocket motor.** In this program, the follower, Atlantic Research Corporation, gave the government an extraordinarily low price on

directed-buy units, prompting Morton Thiokol to reduce its price sharply in response.

In a more recent assessment, Arena and Birkler (2009) summarize the conditions under which dual sourcing appears to pay for itself through reduced procurement cost. There are three main conditions:

- **A Relatively Flat Learning Curve.** Learning is a phenomenon observed in weapon systems in which unit production costs decrease as the cumulative number of units produced increases.[11] Dual sourcing results in loss of learning, since quantity is split among the two producers. If the learning curve is relatively flat (i.e., the cost reduction on each additional unit is small), learning results in relatively little cost improvement, and these losses are smaller.
- **Relatively Low Nonrecurring Costs** (compared to the cost of the first production unit). Other things being equal, low nonrecurring costs are more easily amortized among the split production units.
- **Large Procurement Quantity.** A larger quantity makes it easier to recoup the additional investment costs such as duplicate tooling and facilities.

E. Conclusions

DoD influences the supplier base (particularly the number of companies and their skills) through its programs, funding levels, and acquisition strategies. Dual sourcing can be a useful tool to ensure a healthy industrial base that has design capability for future systems.

The literature does a thorough job of evaluating whether a given dual-sourced system cost less than a franchise system would have. Despite initial methodological oversights, particularly a failure to capture the full cost of establishing the second source, methods for considering the potential cost savings of a prospective dual-sourced program are now reasonably well developed.[12]

In another sense, the analytic state of the art is unsatisfactory. Some studies acknowledge the fact that low cost is not DoD's only goal. Some discuss the impact of dual-sourcing on innovation and contractor responsiveness. Some consider the preservation of the industrial base in the near term as a benefit. However, comprehensive analysis of all these factors does not occur.

[11] The slope of the cost improvement curve is given as a percentage. A 90 percent slope means that unit production cost decreases by 10 percent when production quantity doubles. A slope of 100 percent indicates a completely flat learning curve—e.g., unit cost remains the same when production quantity doubles.

[12] Clear discussions of methods and tools are contained in recent evaluations of the JSF alternate engine program (Woolsey 2007; Birkler, Graser, et al. 2001).

Moreover, the literature largely evaluates competition program by program. Analytic studies fail to account for the fact that DoD and the major prime contractors have continuing relationships. They ignore cross-program effects and the longer-term impact of dual-sourcing on the industrial base.

4. Competition among Near-Substitutable Systems

This chapter looks at competition among near-substitutable systems. Near-substitutes present an interesting case for competition; their competitive threat is often manifested early in the concept development stage of the acquisition life-cycle, but can also put competitive pressure on an existing franchise, holding production phase rents at risk.

A. Definition of Near-Substitutable Systems

The definition of near-substitutable systems is the following: systems that have overlapping capabilities, but are substantially different in some dimensions. It is easiest to start with an example of what they are not. To achieve a military objective, it is sometimes possible to choose between systems that have no meaningful overlapping capabilities. An example would be the use of tactical jamming devices to penetrate enemy airspace, instead of designing stealth features into the aircraft platform. Yet a third way to achieve the same ends might be the use of long-range standoff weapons on conventional aircraft platforms. This mode of competition between non-overlapping alternatives clearly falls outside of our definition.

Thus we will limit the case of near-substitutes to be competitions among items of the same commodity class; e.g., aircraft versus aircraft, missile vs. missile. What then separates near-substitutes from perfect substitutes, i.e., the dual-sourcing case discussed in the previous chapter? In bounding the definition in this direction we limit the near-substitute case to instances where systems were not originally designed to fulfill the same military requirement. Given this, a near-substitute may often be a non-developmental item that can be modified or repurposed to fill a military need.

This leads naturally to the question of where competition between near-substitutes fits within the overall acquisition process. We would expect this competition to begin in the early portions of the acquisition cycle, and continue at least though the performance of the initial Analysis of Alternatives (AoA).[13] However, it would be rare (although not unprecedented) for competition between near-substitutes to occur as a result of an RFP

[13] The problem of competition for the next MDAP has parallel characteristics (firms position themselves to fill a capability gap where the requirement for a material solution has not been fully defined); however, the definition of near-substitutes is meant to be more restrictive regarding the possible material solution.

leading to direct competition for a franchise or in a dual-sourcing environment. Near-substitutes, however, can provide competitive pressure on incumbent or quasi-incumbent (heir-apparent) systems throughout the acquisition cycle.[14] Decision makers can set up the competition between near-substitutes such that the incumbent is threatened with the loss of its franchise. AoAs or other cost/effectiveness analyses can prove pivotal in bringing attention to near-substitute systems; the role of cost/effectiveness analysis is an important topic in the case studies.

B. Literature on Competition among Near-Substitutes

Although we have found no analytic discussion specific to the near-substitute competition case, it is useful to relate its unique attributes to the broader literature. In Rogerson's (1994) survey article on the economics of defense procurement, he interprets the subject as a government regulatory problem with several distinguishing characteristics:

- The importance of research and development,
- Uncertainty,
- Economies of scale in production, and
- The role of government as a sole purchaser.

Although all of these characteristics have some relevance to competition, we will concentrate on the first and third points. Due to the high costs of carrying multiple firms through EMD, competition is usually only feasible through the conceptual design and prototyping phases—the down select at this point establishes a franchise for a single winner. In our framework for competition between near-substitutes, the limitations imposed by high development costs are less relevant: a near-substitute may already exist. This is an enormous advantage for the near-substitute as compared with an item yet to be developed.

C. Case Studies

We chose three case studies to help explore issues associated with competition between near-substitutes. More detail and documentation is provided in Appendix B.

1. C-17 versus Commercial Cargo Aircraft

In the late 1980s and early 1990s the C-17 program encountered substantial difficulties in terms of performance shortfalls, cost overruns, and schedule delays. In

[14] This is consistent with DoDD 5000.1 that states "Acquisition managers shall take all necessary actions to promote a competitive environment, including the consideration of alternative systems to meet stated mission needs."

1993 a Cost and Operational Effectiveness Analysis (COEA) of strategic airlift alternatives was performed by the Institute for Defense Analyses (IDA); alternatives to the full 120 C-17 program included the procurement of 747-400F freighter aircraft manufactured by the Boeing Corporation. The 747-400F clearly fits into our definition of a near-substitute relative to the C-17. The COEA found the 747-400F to be an effective complement to the existing U.S. Air Force airlift fleet.

The December 1993 Defense Acquisition Board (DAB) review resulted in several actions. An RFP for a Non-Developmental Airlift Aircraft (NDAA) was released; Boeing responded with the C-33 model based on the 747-400F. The C-17 was put on probation for two years with the fate of the remaining 80 aircraft to be determined at the end of 1995. The C-33 provided DoD with a clear alternative if C-17 program improvements were not forthcoming, while placing competitive pressure on McDonnell Douglas. With the NDAA program, decision makers created a direct threat to the C-17 franchise.

By the end of 1995 the C-17 program had satisfied the DAB with its progress and an 80-aircraft multi-year procurement was approved. The NDAA program was shelved. The general view was that the two-year probationary period was a success. Comparisons of actual C-17 procurement costs with those presented in the 1993 COEA show the actual cost for the final 100 aircraft of the originally planned 120 aircraft—$21.8 billion in fiscal year 1993 dollars—was substantially below the IDA independent estimate of $26.3 billion, and slightly below the Air Force estimate of $22.9 billion.

2. Joint Air-to-Surface Standoff Missile and Standoff Land Attack Missile-Expanded Response

The Joint Air-to-Surface Standoff Missile (JASSM) program was initiated in September 1995 as a joint Navy/Air Force program. The JASSM is a low observable standoff cruise missile designed to be launched from a number of tactical fighter and strategic bomber aircraft. The Navy's Standoff Land Attack Missile-Expanded Response (SLAM-ER) was a major modification of the SLAM (which in turn was an adaptation of the Harpoon anti-ship missile) intended to give the Navy a standoff capability against land as well as ship targets. The SLAM-ER had approximately a two-year head start on JASSM. The JASSM and SLAM-ER share many capabilities, but with some important differences.

The JASSM was subject to two COEAs prior to the November 1998 Milestone II decision, with the second COEA a direct comparison between the JASSM and SLAM-ER. Also, as a fallout of JASSM program's pricing strategy, IDA performed an "independent market research" analysis in support of the JASSM's 2004 Milestone III full rate production decision. In this analysis the SLAM-ER was one of the missiles with the lowest price-effective metrics relative to JASSM.

It was never likely that the Air Force would buy the SLAM-ER. However, there was a possibility that the Navy would procure fewer SLAM-ERs in favor of JASSM (with quantities up to 700 JASSMs contemplated). In the end the Navy did not significantly change their SLAM-ER inventory goal, although they did buy out their requirement substantially faster than originally planned. The Navy formally withdrew from the JASSM program in February 2005.

The SLAM-ER and JASSM exerted competitive pressure on one another throughout their acquisition cycles. However, following Milestone II, decision makers never set up a "do or die" moment for either system, as was the case for the C-17/NDAA. It is not clear whether program outcomes were materially affected. The JASSM program's ambitious unit price goals may have been partially prompted by competitive pressure from the SLAM-ER; the lower JASSM price estimates were an important advantage in the cost-effectiveness analyses. However, in the course of program execution, JASSM average procurement unit prices almost doubled, eliminating any cost advantage for that missile.

3. The KC-X Competition

The KC-X tanker aircraft program, an important instance where near-substitutable systems were part of a formal direct competition, was meant to replace the aging KC-135 fleet of air-refueling tankers. This program also has a unique back-story. The Air Force originally proposed to lease Boeing KC-767 aircraft for use as tankers under a commercial operating lease. Due to shortcomings in that program, the DoD Inspector General recommended that a new acquisition program be implemented that complied with all requirements for a major acquisition program, including the performance of an AoA. The AoA found that new medium- to large-sized wide-body (767-747) commercial aircraft-based tankers were the best solution for tanker recapitalization. The AoA's cost analyses did not have sufficient fidelity to determine a specific solution and an open competition was recommended.

The Air Force released an RFP in January 2007 for EMD and initial procurement. The offerors were Boeing, with the KC-767, and Northrop Grumman, with the KC-45 (an evolution of the EADS/Airbus A330 Multi-role Tanker Transport). Both competitors had sold precursor aircraft to foreign customers in limited quantities, but both competitors would need to perform additional development to meet U.S. Air Force requirements.

The KC-45 is a substantially larger aircraft than the KC-767. The metric in the RFP most relevant to size was fuel offload/range performance; the offerors were expected to meet or exceed KC-135 performance—the so-called KC-135 key performance parameter (KPP). However, the RFP did not indicate that any consideration would be given to *how*

much it was exceeded. Another RFP metric relevant to size was the integrated fleet aerial refueling assessment (IFARA) factor.[15]

The Air Force selection board chose the Northrop Grumman/EADS KC-45. Boeing protested the selection and the protest was sustained on a variety of counts. The most important was the use of performance above the KC-135 KPP as a discriminator in violation of the RFP instructions.

The problems with the KC-X program demonstrate the complications associated with a direct competition between near-substitutes. In the course of direct competition, the weighting of discriminators that flow from divergent attributes will be critical. The use of modeling and simulation tools that can aggregate over different attributes to form discriminators in a single dimension is a possible response. Although the IFARA factor was consistent with this approach, it was given minimal weight in the original competition. However, for the selection criteria included in the new KC-X RFP, the IFARA factor was more central, as it was included as an adjustment factor on the offerors' pricing data. Boeing was declared the winner of the second competition. Although the ultimate success of the KC-X program has yet to be determined, it is likely that the prices originally established as part of the sole-source lease will be improved upon.[16]

D. Conclusions

In general, the purpose of competition between near-substitutes has not been to gain lower prices, but has focused on capability and quality issues. Direct competition where the offered price is the key metric has been the exception. Almost by definition the up-front investment for competition between near-substitutes is relatively small as the systems/platforms will likely already exist in some form (this was the case for all of our case studies). The primary benefit is to provide decision makers with multiple ways to fill capability gaps. The best way (and perhaps the only valid way) to determine the relative value of near-substitutes is by employing cost-effectiveness analyses that portray the different interactions of the near-substitutes with complementary military force structure and physical infrastructure. This clearly is a difficult proposition in the case of direct competition, although the second KC-X RFP attempted to implement this.

In terms of the industrial base, near-substitutes provide the opportunity to expand the base of suppliers. This can be seen in the example of Boeing commercial in the C-17/NDAA case and EADS/Airbus in the KC-X case. It is interesting to note that the acquisition of McDonnell Douglas by Boeing would now hamper the participation of

[15] See Appendix B for a discussion of this modeling and simulation tool.

[16] Unit price data associated with Boeing's winning bid has not been released.

Boeing commercial as an alternative supplier of airlift aircraft given the C-17's incumbent status.

E. Policy Levers

How might the consideration of near-substitute systems to meet military requirements be encouraged? The requirement for an AoA is certainly a good starting place. However, in current acquisition policy, an AoA or a similar cost-effectiveness analysis is not required after Milestone B (formerly Milestone II). In the C-17/NDAA example a post-Milestone B cost-effectiveness analysis was undertaken because of pressures from the Congress and DoD leadership. In the JASSM/SLAM-ER case no follow-on comparative cost-effectiveness analysis was performed even though the pre-Milestone II COEA reflected relative pricing assumptions that changed substantially as the program progressed. One way to encourage competition would be through a "rolling cost-effective analysis" process, where the original AoAs would be updated as material changes become evident in the program or potential near-substitutes. As a program office itself may be in a de facto advocacy position, any action encouraging competition from a near-substitutable system may need to be initiated by an outside authority.

5. Competition for a Single Development-Build Program

A Single Development-Build program is one in which a Department of Defense service or agency selects a firm to both develop and produce a new weapon system of novel design. In the Weapon System Franchise case discussed in Chapter 2, the development effort for a system is separate from the procurement phase. In that case, the acquiring DoD component contracts for the development of a new system, and on completion of the design effort, contracts for the building of units, almost always with the firm that developed it. By contrast, the Single Development-Build approach requires the DoD component to sign a production contract even before the system has been developed.

In this chapter we will define the meaning of a Single Development-Build program in the context of competition, reference applicable literature, present relevant case studies and summarize findings, particularly as they relate to the key elements addressed by this study as a whole.

A. Academic Literature

In their landmark 1962 study, Peck and Scherer assert that weapons acquisition programs are characterized by high levels of uncertainty. They identify three components of this uncertainty: quality, or technological performance; development time; and cost. Integrating the development and build stages of an acquisition program into one contract ensures that the program is subject to significant risk along all of these dimensions. We will focus especially on the technological and time uncertainties. These are interlinked, because unforeseen challenges in technological development will cause time delays in the final delivery of the product.

As discussed in Chapter 2, Rogerson (1989) argued that defense contractors innovate at the design stage in order to win additional profits at the production stage, when large numbers of the new weapon system will be ordered. The incentive is then for contractors to produce an innovative and, crucially, working system before the production phase. Contractors receive “prizes for innovation.” Rogerson did not discuss the single Development-Build case, and we have found no treatment of it in the economic literature.

However, it is clear that the strategy of innovating at the design stage to gain profits at the production phase will not be available in the Development-Build case. Essentially

the system that emerges from the EMD phase is the final product. There will be no future production runs in which to derive additional profits. We will argue that the absence of this strategy has some bearing on the success or failure of these programs.

B. Reports and Case Studies

Examples of Single Development-Build programs abound among DoD space systems. In a 2003 report, the Defense Science Board (DSB) (2003) argued that technical performance should be given much greater weight relative to cost-minimization, given that "the space environment is unforgiving" and "a single engineering flaw or workmanship error" could lead to "mission failure." The board concluded that the focus on cost-minimization resulted from unrealistically low estimated costs on the part of the competitor(s) seeking to enter the market. Costs were driving award decisions, and non-incumbents were more "optimistic" about the complexity, risk, and cost of their proposals than the established producer. The board concluded that competition for these systems was not an unalloyed good, and that "national security space programs" should be competed "only when clearly in the best interests of the government."

The DSB report noted that, in recent years, follow-on contracts had mostly been awarded to firms other than those responsible for the previous system. Scearce (2007) investigated this issue of non-incumbent success in satellite acquisition competitions, and concluded that it stemmed from three sources. The first is *"optimistic" bidding* by the non-incumbent, as noted by the DSB. Incumbents are constrained to base their cost estimates upon experience with the actual systems, while non-incumbents are free to pick and choose appropriate analogy programs upon which to base their cost estimates. However, Scearce also saw positive benefits to competition manifested in the dominance of non-incumbents. Their second source of non-incumbent success is *innovation*. New competitions are held because requirements have outgrown the incumbent system. Incumbent contractors tend to propose evolutionary improvements to the existing technology, while outside firms develop radical alternatives that offer leaps in performance. The third factor in outsider success is *quality of management*. Incumbent management teams become risk-averse and focused on maintaining a status quo. "The core team that won the contract disperses over time" and an incumbent firm will put a "B-Team" in charge of the mature program. By contrast, the outside bidder assigns top talent and is willing to "push the risk boundaries" of the technology. We should note here that, in the light of the literature already discussed, the last point is not unambiguously to the good.

We chose two DoD space system case studies to help explore issues associated with competition for a Single Development-Build program. By way of contrast, we also examine one civilian space project.

1. Mobile User Objective System (MUOS)

MUOS is a tactical narrowband satellite communication system. It is to provide communication between ships, aircraft, vehicles, and handheld radios using wireless telephone technology. MUOS is intended to replace the Ultra-High Frequency Follow-On system (UFO), which was fielded between 1993 and 2003. Launch of the first satellite was scheduled for 2008, with the full constellation in place by 2013.

The incumbent UFO contractor was Boeing Space Systems. Its performance on the UFO system was considered an outstanding success. Based on rather limited evidence, Scearce concludes that Boeing's bid for MUOS was based on a refinement of the existing technology. DoD's goal in replacing UFO with MUOS was to increase capacity by a factor of ten. Boeing was eliminated in the first round of competition. The second round of competition pitted a Lockheed Martin/General Dynamics team against a Raytheon/Loral team. Lockheed Martin won the competition with a radical new approach that applies commercial 3G mobile phone technology to military satellites.

The development of the satellites encountered technical difficulties, and the first launch has now been slipped to December 2011. The capabilities of the existing UFO system are degrading, and are expected to fall below requirements in January 2011. DoD is attempting to fill this gap by leasing space on foreign and commercial satellites.

Additionally, the development of the next-generation field radios (JTRS) that can take advantage of MUOS's full capabilities has lagged the satellite development. DoD estimates that less than 20 percent of JTRS terminals will be available in December 2011, and only 32 percent will be available in 2014, when MUOS is fully fielded.

2. Space-Based Infrared System (SBIRS)-High

SBIRS-High is a satellite system for detecting ballistic missile launches that is intended to replace and improve upon the Defense Support Program (DSP) system originally fielded in the 1970s. The program was initiated in 1995, with the launch of the first of four geosynchronous orbiting satellites scheduled for 2002.

The incumbent was TRW, a firm that had produced and supported the DSP system continuously following its inception in the 1970s. In 1996, Lockheed Martin was chosen over TRW to build the SBIRS-High system. The Defense Science Board concluded that the acquisition decision for SBIRS-High had been based on costs, and that the contractor's cost estimate was highly "optimistic" (2003).

The program encountered severe issues with software development, and the launch date has slipped multiple times. The first launch is now scheduled for 2011. DoD was sufficiently concerned about maintaining capability that in 2008 it initiated a parallel program to design an alternative system, the Third Generation Infrared Surveillance system. The Department plans to cancel that effort in 2011.

The Government Accountability Office (GAO) has commented that "Key among the problems is the [SBIRS-High] program's history of moving forward without sufficient knowledge to ensure that the product design is stable and meets performance requirements and that adequate resources are available" (2008). The Defense Science Board (2003) commented that "it could be a case study of how not to execute a space program."

3. Iridium

Iridium was a commercial effort initiated by Motorola in 1990 to provide global mobile telephone service using a constellation of satellites in low earth orbit. The system was originally designed for a total of 77 satellites; service began in 1998 with 72 satellites in orbit. Lockheed Martin, the satellite contractor, achieved unprecedented efficiencies by adopting an assembly line approach that produced a complete satellite in 28 days (Christensen and Beard 2001).

Despite these impressive technical achievements, Iridium was a commercial failure. Far fewer users subscribed than had been expected, and those who did complained of poor service quality. Iridium LLC, the corporation established to build and manage the constellation, quickly entered bankruptcy protection. While Iridium was a commercial failure, it survived as a niche DoD service provider in the government market under a new owner.

C. Economic Analysis

A common theme emerges from the case studies: DoD orders systems built on a fixed timetable using as yet undeveloped technology, and holdups in the process of technological development scuttle construction and prevent deployment on schedule. This risk is unavoidable, because technological development is somewhat unpredictable by nature. The DoD systems were designed to replace and improve upon existing systems that were coming to the end of their lifespan. In both cases, uncertainties in technological progress and development times were understated at the time of the contract award; in both cases, the systems did not meet their delivery schedules. This placed the existing capability at risk.

The impressive achievement of Iridium in building and fielding so many satellites so quickly seems to have been based in part on the manufacturing economies of scale in producing many units. The smaller size of DoD satellite purchases makes this an imperfect comparison. Nevertheless, it is notable that while the lead contractor in all three case studies is the same, the outcomes are vastly different.

Rogerson's model of "prizes for innovation" may shed some further light on the situation. In the Single Development-Build case, contractors are not competing for a

series of production lots that will follow a prototype, but for construction of a single unit or relatively few units that are both the first units produced and final products. The incentive is not to innovate successfully in the production of a system, but to innovate at the proposal stage in order to win the contract to design and build. Once the contract is won, incentives to "get it right" are diminished. Insufficient resources may be devoted to solving the technical challenges associated with producing the promised product.

The Iridium program may provide a counter example of a satellite program with a bone fide production phase. The prospect of making additional profits by achieving efficiencies in the production of 76 additional satellites provided an incentive to produce a correctly-working model in the development stage.

It is clear that the Single Development-Build approach presents significant risks. There are two alternatives to this approach. First, DoD could field a system using existing technology, or technology that is only incrementally improved from the prior system. This approach obviously presents the least risk in production, but may be insufficient to meet increased warfighter demands. Second, DoD could separate development and build contracts and field a next-generation system only if next-generation technology has been delivered on-time. If this option is feasible, it will always be preferable to the Single Development-Build contract. It follows that Development-Build should be undertaken only when separating the development and build functions is impractical—for example, when development involves building the actual components that will go into a small system such as a satellite.

The inherent uncertainty in technological development cannot be overcome completely, but it is likely that increasing the resources applied to a technical challenge will increase the chance that it will be overcome in a timely manner. Consequently, DoD faces a trade-off when soliciting a Single Development-Build system: additional resources devoted to the development effort will reduce the chance of failure. Or, increases in project expenditures will increase the chance of success; therefore, DoD can trade off cost for outcome. If the consequences of a loss of capability are very large, DoD should be less concerned with minimizing the cost of the project than in avoiding the possibility of failure. The Defense Science Board (2003) concluded that "mission success" rather than cost should be "the guiding principle" in acquisition."

Thus there are both costs and benefits to competing Single Development-Build programs. Competition leads to the adoption of radical innovations as opposed to incremental ones, allowing for leaps in capacity to meet growing warfighter needs. However, the proposals for such radical departures may suffer from optimistic assessments of the time and costs required to develop the new technologies. Sole-source procurement from an ongoing contractor will allow for more accurate budgeting and reduce the risk of failure due to technological unknowns. It will do so at the cost of reducing innovation.

6. Competition below the Prime Contractor

Is competition at the subcontract tiers necessary for effective competition at the prime contract level? The government can complete a competitive acquisition process for a system, but the benefits of that competition will be eroded if competition cannot flow downward into the supplier base. If all competing firms are forced to rely on a single supplier to satisfy a requirement, that supplier is in a position to extract all of the rents from the transaction, thus raising the cost to the government for the program, regardless of which prime wins the competition. The existence of a single source also limits the incentive for innovative solutions to a requirement. Furthermore, the reliance on a single source also subjects the prime contractor, and the government, to a hold-up problem, wherein the subcontractor demands changes in contract terms knowing the prime contractor has little leverage to counteract the demand. The reliance on a single source also increases the risk of the program to disruption due to supplier failure, withdrawal from a market segment, or natural disaster, and may prevent any attempts to surge production.

A. The Sub-Prime Tiers from the Viewpoint of the Prime Contractor

Although most of the discussion about defense procurement concentrates on actions at the prime contract level, much of the economic activity occurs at hundreds of firms below the prime contractor. Some of these firms provide major components or large structural segments, other provide commodity components or raw materials. The development and management of a network of partners and suppliers is essential to the successful production of an end item, yet decisions about the allocation of work within a contract are generally the responsibility of the prime contractor, and the government often has limited visibility into these decisions. And, as we shall see, their interests are not necessarily aligned.

In preparing to bid for, and fulfill, a contract, the prime contractor must make decisions about how to create or obtain all of the sometimes tens of thousands of individual components and services required to develop and assemble the completed product. The development and management of this “supply chain” is critical to the success of the program, and therefore commands a significant amount of management attention. The prime contractor must first determine whether to make a component in-house or to contract it out (the “make-or-buy” analysis). If the decision is to procure the goods or services from another firm, the prime must then identify a source (competitively or sole-source), and negotiate and manage a contractual instrument.

The analytic tool of Transaction Cost Economics (TCE) recognizes that firms are governance structures and must, first and foremost, organize in a way to protect themselves from market failures.[17] TCE recognizes a continuum of possible market interactions, from total reliance on open markets at one extreme to total internalization of production at the other. Between these extremes "contracts between the buyer and seller are used with varying levels of reliance on markets, negotiators, courts, and formalized contract administration and control mechanisms" (Templin 1994).

Transactions themselves can be characterized on three dimensions that help to identify the appropriate form of governance. These dimensions are:

- **Asset specificity.** The extent to which one party to the transaction must make investments in specialized tools, facilities, and skills in order to fulfill a transaction. Specialized tools and equipment are those that would lose value if shifted to the next best use.[18]
- **Uncertainty/Complexity.** The extent to which the parties to a transaction can, in advance, agree on specifically what is to be accomplished, and the time and effort required to accomplish it.
- **Frequency.** Recurrent transactions provide an economic basis for investing in specialized equipment and skills, and offer the potential to reduce production cost through learning and amortization of an initial investment. Recurrent transactions also offer the opportunity to build a reputation.

TCE posits that the more complex and uncertain the object of a transaction is, the more difficult it is to establish a long-term governance structure that is acceptable to both parties. A requirement to invest in highly specific assets raises barriers to entry to any firm other than the original firm. This leads to "hold-up" problems, where one party to the transaction is able to increase its profits at the expense of the other party. For example, the supplier may demand increased profits on later deliveries because it knows that no other firm is willing to invest in the specific assets needed to enter the market. Likewise, the buyer may attempt to lower the payment, knowing that the supplier must continue to earn some positive return on specific assets and thus cannot walk away from the transaction. Therefore, transactions with highly specific asset requirements and that are complex or uncertain require more complicated (and costly) governance structures. In an attempt to minimize total transaction costs, firms will tend to retain highly complex

[17] For discussions of Transactions Cost Economics, see Williamson 1979 and Franck and Malese 2008.

[18] Different authors have used various methods to further identify asset specificity. For example, Franck and Malese (2008) describe the following: physical asset specificity, human asset specificity, site specificity, dedicated asset specificity, brand-name specificity, and temporal specificity.

transactions with high asset specificity in-house, and use market transactions for recurring, low complexity transactions which require no specific assets.

A number of studies have been conducted to apply TCE to various industries and to attempt to explicitly measure the costs of individual transactions. Masten applied the principles of TCE to a case study of the aerospace industry (1984). Masten, Meehan and Snyder evaluated the shipbuilding industry (1991), and Adler and Scherer examined the effects of contract types on TCE dimensions (1999).

King and Driessnack used TCE as a basis for analysis of the industrial base for the F-22 aircraft (2007). The F-22 had over 1,100 suppliers. The prime contractor, Lockheed Martin, had a formal corporate policy that make-or-buy decisions would be based on "best value" and not provide preference to Lockheed Martin business units. King and Driessnack's analysis demonstrates that Lockheed Martin utilizes competition for general materials, where complexity and uncertainty are lower and multiple suppliers exist. Single-source suppliers provide more complicated components; many of these were competitively selected at the outset of the program and represented suppliers with whom Lockheed Martin had established relationships.[19] Much of the 25 percent of the effort Lockheed Martin retained in-house concentrated on what it considered to be core competencies such as the manufacture of major structural components and the application of stealth technologies.

While TCE provides a powerful framework to understand make-or-buy determinations, it is not sufficient, as factors other than transaction costs may impact the decision. These factors, which generally represent corporate rather than program-specific considerations, include:

- **Capacity utilization.** If a firm has unutilized or underutilized capacity, it may decide to perform work within the firm in order to absorb some or all of that excess capacity. While at a component (and contract) level this may be more expensive than a market transaction, it may benefit the firm by absorbing costs otherwise charged to overhead.
- **Overhead allocation.** A firm with multiple contracts allocates its overhead costs over those multiple contracts. Overhead is usually allocated on the basis of direct labor hours. As Rogerson (1992) has demonstrated, it may be in the interest of the firm to perform work in-house to increase the base for the allocation of overhead.

[19] One can view these relationships as extensions of the franchise discussed in Chapter 2. Just as the prime contractor receives a series of production contracts from the government, some of these fall through to the major subcontractors. The major subcontractors are able to earn rents through regulatory lag and through their superior information about the cost structure of the product. However, the structure of the relationship should serve to align the interests of the prime and subcontractor.

- **Development of new capabilities.** A firm may decide to build a component within the firm in order to create a new facility and build an experience base for a new technology, to allow entry into new market segments.[20]

These factors may have a positive or negative effect on the Department's cost as a whole, and must be evaluated from that perspective. For example, increasing capacity utilization may lower the Department's cost on other contracts held by a firm. But retaining work in-house may preclude the establishment or enhancement of other potential vendors and therefore impact future DoD programs.

B. The Sub-Prime Tiers from the Viewpoint of the Government

While the prime contractor will use competitive acquisition procedures when it is to its best advantage in assembling and managing its supply chain, the government may prefer a broader use of competitive contracts at the sub-prime tiers to promote a broader and deeper industrial base. Although the government is not a party to the subcontracts that a prime contractor may award, it has the authority to require that a contractor seek approval of its make-or-buy program. And, if necessary, the government can require that the contracting officer consent to subcontract actions specified in the contract. This requirement can be utilized in those cases where the contracting officer deems it necessary in order to "protect the Government adequately because of the subcontract type, complexity, or value, or because the subcontract needs special surveillance."[21] Among the items subject to review is whether adequate price competition was obtained or its absence properly justified.

While these interventions may prove useful for selected subcontracts or selected commodities, they do not appear to be widely utilized. In a recent GAO review (2010), contracting officers cited as a primary reason for playing only a limited role in subcontracting matters the fear that such actions may have implications for government liability.[22] Program officials rely instead on information exchanges with the prime contractors on supplier issues that may impact the cost or schedule of a program.

There are, however, other techniques that the government may employ to seek increased competition at the sub-prime tiers. For example, the government may identify through market research commercially available components that will satisfy certain

[20] See Perrons (1997) for a discussion of the desire of some in Lockheed Martin to keep production of composite wing spars for the F-22 in-house.

[21] FAR 44.201.

[22] Note, however, that the Defense Contract Audit Agency, according to the GAO review, finds the requirement of a make-or-buy plan useful in obtaining the information required to determine price reasonableness.

system requirements. The contract specifications can then be adjusted to allow the prime contractor to use these commercially available items in the system.

The government may also procure components directly and provide them to the contractor as government-furnished equipment (GFE). This allows the government to conduct competitive acquisitions of its own design. This is commonly done, for example, with aircraft engines. Opportunities to break out components for direct procurement may be limited early in the life of a program, prior to design stabilization. However, as the design stabilizes and the technology matures, the government may choose to break out components for competition to reduce costs, seek quality improvements, or enhance the industrial base (if necessary, by utilizing the dual-source strategies described in Chapter 3). In evaluating direct procurement opportunities, however, one must recognize that it will cause the government to absorb certain transaction costs (such as awarding and administering contracts) previously performed by the prime contractor. The government may also absorb liabilities (such as quality deficiencies and integration responsibilities) previously carried by the prime contractor. Therefore, the costs and benefits of direct procurement must be carefully weighed before this strategy is attempted.

C. Conclusions

Management of the sub-prime tiers is a critical challenge for a prime contractor. The prime contractor bases its sourcing decisions on a complex set of criteria, designed to successfully produce the desired product while maximizing the value of the firm. In making these decisions, the interests of the prime contractor may not always align with the interests of the government. For example, a prime contractor may decide to develop and produce a component in-house in order to build expertise in a technology area, while the government would prefer that the component be competitively sourced in order to maintain or expand a segment of the industrial base. While the government does have tools to monitor and intervene in these decisions, the magnitude and complexity of the sourcing process, coupled with a reluctance by contracting officers to intervene in prime contractor decision-making, suggests that the government should focus its efforts on the early identification and resolution of potential issues on a program-by-program basis.

7. Winning the Competition for the Next Major Defense Acquisition Program

Previous chapters have established that effective competition can further DoD's goals for weapon system development, including (1) achieving a given capability at an *affordable* price; (2) *innovating* to meet military requirements for dominance in the battlefield; (3) assuring that the contractor is *responsive* to government needs; and (4) maintaining an adequate *industrial base* of prime contractors and suppliers/ subcontractors. This chapter looks at how firms seek to position themselves to be effective competitors for major defense programs, and whether the steps they take in fact promote government goals.

Today, the defense business environment is about as difficult for a firm to navigate as it has ever been since before the onset of World War II. Notwithstanding the fact that the defense budget is at historic highs, opportunities for firms to compete for the right to produce our nation's next-generation weapon systems are relatively scarce. And the competition to win those contracts is fierce. This chapter looks at some of the forces at work as firms position themselves to win the competition to build the next major defense acquisition program.

The first section looks at alternative strategies that firms may adopt to win the competition. The second section examines some recent competitions. And the final section considers appropriate policies that DoD's acquisition managers may choose to best regulate the competition and channel the energies and resources firms spend on winning it toward enhancing the usefulness of the final product.

A. Strategies for Securing the Contract for the Next Major Defense Program

Defense firms need to be careful as they jockey for position in the race to win the next MDAP. The stakes are higher than they have ever been, and the penalties for not getting there are higher, given the competitive environment. How do firm compete for the next MDAP? This section looks at some of the competitive strategies they adopt.

1. Be There First: Produce the Current Generation Weapon System

Historically, the firm or firms who hold the contract for producing the current version of a weapon system have had the advantage in the competition for the next one. The major reasons why this is so are:

- They may hold the patents for many of the key enabling technologies,
- They employ most of the people who really know how to manufacture the product (Ekelund Jr. and Saba 1980),
- They are familiar faces to the acquisition officials who will make the award,
- Officials may fear that choosing a new contractor will interrupt and delay the progress of the acquisition program (Grasso 2009), and
- Politicians will favor an award to the incumbent to keep jobs in their districts.

For these reasons, it typically will be difficult to dislodge an incumbent producer. Nor is it clear that DoD has an interest in doing so. As long as acquisition officials and military commanders are satisfied with the performance and price of the product and the responsiveness of the contractor, the requirement to compete the next generation of the equipment may pose a threat to producer and customer alike. In these circumstances, all parties may prefer a program of system upgrades to a whole new system. Civilian leadership may need to intervene to ensure that the opportunity to compete is maintained for other firms not involved in producing the current generation of the system.

2. Buy Your Way In

Faced with the power of an incumbent, how can a new firm become a contender for the next MDAP? A common strategy is to buy your way in. This strategy is illustrated by BAE Systems. Members of the BAE Systems family are experienced producers of combat vehicles, having produced the Challenger tank and Warrior infantry fighting vehicle for the British Army. But they likely would not have been a serious contender for the Army's Future Combat System award if they had not purchased United Defense, the U.S. producer of the Bradley Fighting Vehicle as well as other vehicles and self-propelled howitzers. Acquiring United Defense gave BAE Systems several key assets: a portfolio of existing contracts for modification and repair of deployed systems, key production facilities, a skilled U.S. labor force, a marketing team that was familiar with the client's acquisition processes and staffs, and political allies who would work to ensure their constituents kept their jobs by supporting a "domestic" producer.

While BAE Systems may have been the leading acquirer of U.S. defense firms over the past decade, it is hardly the only one. With U.S. defense spending representing nearly

one-half of worldwide defense spending,[23] many foreign defense companies have been pursuing the American option (Neuman 2009). The British firms Cobham and Ultra have acquired U.S. firms. In addition, the British electronics giant Smiths has made several key acquisitions in the United States. Indeed, of the overall $29 billion spent in both 2006 and 2007 on international mergers and acquisitions in the aerospace and defense market, 68 percent in 2006 and 73 percent in 2007 was spent buying U.S. firms (Neuman 2009). As of mid-Summer 2010, EADS, the largest defense firm in Europe, had not made a major acquisition of a U.S. firm, but the chief executive of its U.S. subsidiary had announced its intent to do so in the future (Shalal-Esa 2010).

Buying one's way in is not without its problems. For one, it takes a lot of money. British and European firms have been advantaged by the high value of the pound and the euro in the past five years. If the dollar strengthens against the euro and the pound, the rush to acquire U.S. firms may abate. Certainly, assimilating a company with a different corporate culture, benefits structure, and—for some European firms—language presents a host of difficulties.

Setting aside the politics of the issue, it is not clear that the acquisition of a U.S. firm by a foreign corporation, or for that matter, by a U.S. firm that has not been a defense competitor in the past, has any negative implications for the U.S. industrial base. Indeed, the combination may strengthen the base by bringing with it new technologies, new industrial processes, or new capital investments. We assume that the firm is based in a country strongly aligned with U.S. interests and that the transfer does not present risks of adverse technology leakage or weapons proliferation.

3. Buying Your Competitor

One classic way to improve your chances of winning the contract for the next MDAP is by acquiring a potential rival. This is perhaps the riskiest strategy, because the acquisition of a rival who is in the same market segment will almost certainly raise anticompetitive issues with the regulatory agencies. Only when officials have given their blessing to consolidation, as occurred in the Clinton Administration, will one find many examples of such combinations.

The acquisition of a rival may present complications, especially with regard to existing business arrangements. For example, when Raytheon acquired Solipsys Corporation, a small firm that had developed a new approach to networking sensors, Raytheon had to commit to offer the product to any legitimate customer. Often, firms may be committed as partners on rival teams seeking a contract award. If those firms combine, they may have to establish internal firewalls to keep information from the rival

[23] In 2009, U.S. spending was 43 percent of the total (Stockholm International Peace Research Institute 2010).

group, so that members of their staffs can still support their respective teams without a conflict of interest.

Obviously, acquisition of one's rival does not promote competition. It reduces the independent sources of new technologies, eliminates a potential competitor for new contracts, and may lead to a diminution in the industrial base if duplicate facilities are closed and staff positions eliminated; thus, DoD normally would oppose such a move. The consolidation of the 1990s was the recent exception to this policy. In that instance, DoD leaders felt that consolidation of the base was necessary to eliminate excess capacity and resulting overhead costs.

4. Earn Your Way In

Finally, firms could adopt a strategy we call "Earn Your Way In." Under this strategy, a firm would assemble all the elements required to compete for the next major defense program. And they would do so the hard way: by building facilities, engaging in research and development of relevant technologies, hiring and training a skilled workforce, and developing appropriate relationships with the stakeholders: military requirements communities, acquisition officials, and regulatory officials.

Simply to list what needs to be done makes clear why this usually is not a preferred strategy today for entering established defense markets. However it is still an option, especially in emerging defense markets, such as information technology, biometrics and other security devices, and high-technology aerospace and defense niche markets. Such start-up firms may play important roles as members of a team seeking the next major defense program.

Earning your way in is completely compatible with DoD competition goals. It brings a new entrant into competition with established producers, augments the industrial base, and is likely to increase the responsiveness of industry to government concerns and issues.

B. Case Studies of Competitions

This section presents some examples of competitions in which the strategies discussed above are displayed. For each example, we summarize the system being competed, the competitors, the strategies each employed, and the outcome of the competition.

1. Family of Medium Tactical Vehicles (FMTV)

The FMTV competition in 2009 presents a classic example of a buy-in strategy that failed. The Army's FMTV is a group of vehicles based on a common chassis, which vary by payload and mission requirements. The Light Medium Tactical Vehicle (LMTV) has a

2.5-ton capacity (cargo and van models). The Medium Tactical Vehicle (MTV) has a 5-ton capacity (cargo and long-wheelbase cargo with and without material handling equipment, tractor, van, wrecker, and dump truck models). Three truck variants and two companion trailers, with the same cube and payload capacity as their prime movers, are capable of being air dropped.

The original contract to build the FMTV systems was won by Stewart & Stevenson, a Texas builder of oil field equipment, in 1991. Stewart & Stevenson built a plant in Sealy, Texas to manufacture the light and medium trucks and trailers specified in the contract. The Stewart & Stevenson facility has manufactured over 56,000 trucks and trailers for the U.S. Army.

In May of 2006, Armor Holdings Inc., a Jacksonville, Florida manufacturer of defense equipment including body armor, acquired Stewart & Stevenson for a price of $36.75 a share. Barely a year later, Armor Holdings was itself acquired by BAE Systems, a global defense firm headquartered in London, England. BAE Systems absorbed the assets of Armor Holdings into its Land and Armaments division of BAE Systems Inc., their U.S. subsidiary. BAE's acquisition represented an example of the strategy of buying one's way into the competition for a major defense program.

In February of 2009, the U.S. Army issued an RFP for a new contract covering five years of FMTV production. Three firms—BAE Systems, Navistar (an Illinois manufacturer of trucks), and Oshkosh Corporation (a Wisconsin firm)—responded to the RFP. All three firms were experienced—in addition to its commercial truck business, Navistar makes MRAPs for the U.S. Army and for export; Oshkosh Corporation has made trucks for the Army since World War II.

BAE Systems's strategy was straightforward: in July of 2007, it bought and became the incumbent producer of the vehicles in the FMTV family. To acquire this position, it paid $88 a share or a total of $4.532 billion for Armor Holdings Inc. This represented a considerable premium over net asset value: Armor Holdings had net income of $132 million or $3.80 per share in 2006, the last fiscal year for which it presented an annual report.

In contrast, Oshkosh Corporation and Navistar relied on their experience as truck producers. Their position was improved by the fact that 60 percent of the basic vehicle's parts and components by value are government furnished equipment. Thus the task is basically to be the lowest cost assembler of vehicles.

In August of 2009, the U.S. Army awarded the contract to Oshkosh Corporation, primarily on the basis of its lower bid price. The losing competitors protested the decision to the GAO, which upheld their protest on certain grounds and ordered the Army to reconsider its decision. The Army announced on February 12, 2010 that it would uphold the award to Oshkosh Corporation. On February 15, 2010, BAE Systems indicated to its

investors that it would write down goodwill and other intangible assets by £592 million ($924 million).[24]

2. The Air Force Tanker Competition

The Air Force is seeking to replace its fleet of nearly 500 KC-135 aircraft with a new model tanker aircraft. The KC-135 fleet was originally acquired at the peak of the Cold War. Most of the aircraft are 50 years old. While originally supporting the Air Force's nuclear strike mission, more recently they support the Air Force's commitment to global strike and global mobility for conventional U.S. forces.

The Boeing Corporation has built multi-engine aircraft for the Air Force since the 1930s. The Air Force's original plan was to lease KC-767 tanker aircraft rather than purchase them. The lease arrangement was viewed by the Air Force as an economical alternative that deferred the cost of recapitalization and also avoided the lengthy and laborious process of getting a new major acquisition program through DoD, congressional, and contracting hurdles.

Following the failure of the leasing proposal, the Air Force, in January 2007, released an RFP for EMD and procurement of a new tanker aircraft, the KC-X. The two responders were Boeing, with the KC-767, and Northrop Grumman (in cooperation with EADS) with the KC-45, an evolution of the EADS A330 Multi-role Tanker Transport aircraft. Versions of both aircraft had been built in limited quantities for foreign customers. EADS and their Airbus subsidiary have many years of experience producing commercial and military aircraft. Northrop Grumman is an experienced system integrator well prepared to incorporate the Air Force-specific elements—chiefly avionics and communications gear—into the new tanker, and familiar as well with the military's acquisition and accounting practices.

Boeing's strategy was straightforward. As the traditional supplier of multi-engine aircraft to the Air Force, Boeing first hoped to avoid competition altogether through the lease proposal. Once that strategy failed, Boeing sought to win the competition through its knowledge of the Air Force's requirements and acquisition processes.

The EADS/Northrop Grumman team faced a larger challenge. First, it had to overcome "Buy American" considerations by emphasizing the Northrop Grumman role and by committing to assembling the aircraft in Alabama. Second, it had to deal with claims that Airbus is subsidized by European governments.

In February of 2008, the Air Force announced it was awarding the contract to the EADS/Northrop Grumman team. Boeing immediately lodged a formal protest, and its Capital Hill allies raised a ruckus about giving such a contract to a "foreign" producer.

[24] See http://production.investis.com/baeir/rns/rnsitem?id=1266228367nRSO1409Ha.

The GAO upheld the protest in June 2008, and Secretary Gates decided in September that the decision should be made by the new Administration. The Air Force released a considerably expanded draft RFP in September 2009, and a final version in February of 2010. Northrop Grumman announced it would not participate in the new competition, but EADS submitted a bid on its own. On February 24, 2011, the Air Force awarded the contract to Boeing.

This experience illustrates how difficult it is for a foreign competitor to enter a major defense acquisition competition, even with U.S. teammates.

C. Possible DoD Regulatory Responses to the New Acquisition Environment

DoD merger and acquisition regulators have some choices as they seek to deal with the new climate for weapons acquisition. DoD's goals are to maintain competition in defense acquisition, to maintain a healthy and responsive industrial base, and to treat responsible competitors fairly and equally. To pursue these goals, they can continue current policies, or they can seek to take a more proactive approach.

1. Laissez Faire Policy

DoD's current approach to merger and acquisition follows the antitrust laws of the United States. Direct combinations of firms currently serving a market segment will generally be opposed because they reduce competition. The only exceptions in the recent record were during the Clinton Administration when DoD actively promoted combinations as a way of reducing excess capacity and rationalizing production during a period of much diminished procurement spending.

In cases where a larger firm is acquiring a smaller one in order to enter a market segment, however, DoD normally raises no objection. This seems to be true even if the firm is a foreign-controlled one, as long as it is viewed as a reliable ally (North Atlantic Treaty Organization (NATO) or Australia, New Zealand, United States Security Treaty (ANZUS) countries, Israel, etc.). Concerns have been raised when firms from countries that may not adhere to our technology control or patent protection policies seek to buy U.S. firms.

The advantages of a laissez faire policy are that it treats firms equally and it promotes the economic goals of seeing that capital and labor resources are efficiently managed by the most successful entities. However, in the current DoD acquisition environment, it may tend to concentrate power in fewer and fewer prime contractors. And the growth of foreign ownership of U.S. defense facilities is clearly viewed negatively by at least some in the Congress.

2. Nurturing New Competitors

DoD could explicitly seek to bring new firms into the defense industry. They could do so by (1) limiting technology development efforts to smaller firms not related to the traditional large system integrators and by (2) requiring prime contractors to allocate a portion of their subcontracts to smaller firms without substantial defense business. Doing this would require changes to the DFARS and might require changes to law as well.

The advantage of these policies is that they would promote the growth of competition at some levels of defense acquisition. It would also put a stop to the acquisition of small firms by the giant system integrators, because in doing so, they would be taking the firm out of the running for many contracts. The disadvantage would be that acquisition (and the resulting stock buyout) is often the prize sought by the leadership of emerging companies, and preventing that outcome might reduce the incentives to innovate. The solution to this might be to permit acquisition, but not by firms actively competing for DoD contracts. This might create what one might call the "Carlisle Group" approach, in which larger firms would collect portfolios of smaller firms, without themselves actively serving in a prime contractor role.

3. Organizing the Competitors

A final approach might be for DoD to take a more active role in determining the outcome of the competition. An example of this is the call by some in the Congress for DoD to adopt a split-buy approach to the KC-X tanker competition. A split buy would have many attractions for policy leaders in the Pentagon and on the Hill: it would promote jobs in both competitors' home states, it would resolve a question that is creating bitter divisions both domestically and with our European allies, and it might promote a robust industrial base by creating two sets of subcontractors and suppliers for this product. It would achieve all these goals at a price, however. See Chapter 3 for a discussion of whether or not dual-sourcing costs or saves money in most cases.

Another approach to organizing the competition is illustrated by the Missile Defense Agency's (MDA) Targets Program. MDA requires a variety of targets to conduct its tests of the various systems it is developing to protect ourselves, our forces, and our allies from ballistic missile attacks. These targets consist of a missile and a warhead. MDA's component agencies were acquiring these targets in various ways: some were off-the-shelf missiles and warheads developed for other purposes, some were bought from other countries, and some were developed to mimic the threats presented by missiles in the hands of unfriendly governments.

MDA chose to bring order to this situation by developing a family of target missiles. They chose Lockheed Martin Space Systems to serve as the system integrator that would develop a plan and implement it by managing the firms producing the missiles. The results have been unsatisfactory. The Targets Program is woefully behind schedule, has

abandoned many of its developmental goals, and has resulted in increased costs to the customer (the test agencies) even for off-the-shelf missiles that were being bought previously. This experience suggests that DoD components should proceed very cautiously and make sure they understand what they are getting into before they intervene directly to organize the market segment that supports their activities.

D. Conclusions

The lure of the potential rents to be earned on MDAPs provides a strong incentive for incumbent firms to maintain a position in the defense market, and for firms outside that market to position themselves to be in a position to compete for future program opportunities. Often, however, the barriers to entry are high—management of major defense programs require specific technological and management skills often not resident in commercial firms. In addition, a deep knowledge of the customer and its requirements is essential to successfully competing for these programs. These competencies cannot be assembled overnight, in an ad hoc manner, but require the development and execution of a long-term corporate strategy. The government has only a limited ability to directly influence the structure of the defense market (through actions such as the approval of mergers and acquisitions). It does, however, have the ability to shape firms' perception of future opportunities for business, through such actions as emphasizing competitive prototyping (allowing firms to maintain design and development teams), initiating second sources for selected programs, and by limiting the length of franchises by recompeting programs.

8. Summary and Conclusions

Federal government policy requires that competition be used to the maximum extent possible in the procurement of goods and services by federal agencies. Competition has shown itself to be an effective tool for reducing the acquisition costs of commercially available products. This paper has attempted to assess the impact of competition on the acquisition of major defense systems. The evidence supports a conclusion that competition can contribute to desired program outcomes if the objectives of a competitive acquisition strategy are well understood, and if the competition is properly structured to achieve those goals. However, competition is not a cure-all that will compensate for flaws in the structure or management of programs, and the use of competition is no guarantee of a successful and cost-effective program outcome.

A. What Drives Decisions on Acquisition Strategy?

In developing an acquisition strategy, program managers usually begin with a statement of the requirements the system must meet. Normally, that requirements statement has been developed by a military service or, for a joint program, an inter-service product team. For a major system, it must be approved by the Joint Requirements Oversight Council (JROC), chaired by the Vice Chairman of the Joint Chiefs of Staff. It is the job of the program manager to come up with a system that meets those requirements.

A number of program characteristics will shape the strategy for acquiring the system:

- How complex are the technical challenges that must be overcome to field the system?
- What will be the likely cost of the system?
- What number of units must be acquired?
- What will be the system lifetime?
- How will the system be supported and maintained?
- Over what period of time will procurement of the system be conducted?
- Are there qualified producers at all stages of the industrial base, or must suppliers be developed?

Normally, these questions are addressed early in the acquisition process, and certainly answers should be known before Milestone B, approval to begin development of the system. There are times, however, when acquisition decisions must be revisited later in the acquisition process, either because of an emerging issue or simply because a program has experienced cost growth that moves into the category of an MDAP. So the stage of the product life-cycle can be a consideration for program planners.

Given an understanding of the system and its requirements, acquisition planners will decide within what competitive regime the system falls. For a system that involves the creation of production facilities and the production of many units, the franchise model is normally the one selected. If the challenges are highly technical, but few units are required, the Development-Build model may be appropriate. The analysis of alternatives (AoA) should identify non-developmental alternatives that can be pursued if the AoA indicates that they offer a less expensive way to meet system requirements.

Programs can be tailored with options that increase the competitive nature of the exercise. Either complete systems or major components such as engines may be dual-sourced, if the industrial base has adequate numbers of competitors. Alternatively, a second source can be developed either initially or at a later stage of production.

B. Competition for a Franchise

The franchise model achieves most of what we expect competition to bring to the defense acquisition process. A properly structured competition for a franchise provides significant incentives for bidders to invest financial and human capital in developing weapon system designs that meet customer requirements, and in providing incentives for innovation. The value of the potential prize, a series of sole-source contracts for development and production of the system, is a powerful incentive, as it offers the winning bidder the potential to earn rents, and it positions the firm to capitalize on future work, such as system improvements and foreign sales. If the cost to enter into the competition is too high, however, the process may push potential competitors away, either by deterring them from entering in the first place, or by causing losing bidders to suffer losses large enough to cause them to exit the market segment.

1. Dual-Sourcing and Recompetition

Dual-sourcing and recompetition under the franchise model are problematic. A plan to dual-source the production phase reduces the potential rents to any one party obtainable from “winning” the competition, and therefore dilutes the incentives to the contractor to invest in winning the development contract. So dual-sourcing is only appropriate where technologies are mature and price is the dominant consideration.

The evidence that dual-sourcing or recompetition reduces acquisition cost is less clear. In cases where the government conducts a recompetition of a mature product, such as the Family of Medium Tactical Vehicles, the savings can be measured. However, most major systems do not fall into this category, and therefore we must look at other evidence.

Studies of dual-source competitions suggest that savings can be achieved under certain conditions. Dual-sourcing puts in place incentives to reduce costs in order to capture or maintain the largest possible market share. However, utilizing multiple production sources for complex systems usually requires duplicative capital investment, and slows the achievement of cost reductions through learning. Therefore, while a dual-source competition may reduce the prices bid for a product, it will only result in savings once all of the relevant costs are taken into account. Therefore, acquisition cost savings will most likely occur in programs with relatively flat learning curves, low capital investment requirements, and relatively large production runs.

2. Quality and Responsiveness

Competition can translate into improved contractor responsiveness. The results of the Great Engine War led to improvements in the reliability of the F-16 aircraft engines from both of the producers. Establishment of dual production sources provides the government the ability to surge production, if necessary, or to maintain production in cases of business disruption or natural disaster. Improved quality and assured production capacity are difficult to translate into direct dollar benefits, but they are key benefits to be derived from competition.

3. Industrial Base

Competition can affect the industrial base in a positive or a negative manner. As noted above, costly bid preparation may serve to drive firms losing a competition out of certain defense markets. Competitions that are subsidized by the government, on the other hand, provide incentives for firms to retain core design teams; these design teams provide the cadre upon which a firm can build a full development and production team should it win a competition. Likewise, dual-sourcing has a positive impact on the industrial base by qualifying additional producers in a market segment, often at government expense.

4. Near-Substitutable Systems

Examination of near-substitute systems can provide decision makers with information about alternatives at the start of a program, or it can be used to test the feasibility of moving to alternative solutions if a program encounters problems. On one hand, the mere existence of a near substitute, and the knowledge that a substitute is being

considered, will provide a level of competitive uncertainty to the managers of a program, and can thus be expected to provide some incentive to improve price, quality, and capability. On the other hand, to the extent that this knowledge increases the perceived risk that the program will be cancelled prematurely, it may lower the expected value of the franchise "prize" and thereby reduce the incentive to pursue it.

C. Single Development-Build Contracts

Single Development-Build contracts are an alternative to the franchise model that are appropriate when the number of systems and the resulting length of the production contract are small, as compared with the development effort. It is useful to think about the polar design/build case, in which only one functioning system (say a unique defense surveillance satellite, or perhaps a prototype unpiloted aerial vehicle) is the result of the contract effort. How do contractor incentives—and, therefore, contractor behavior—change in the design/build case?

IDA examined the acquisition of space systems, because so many of them use the Single Development-Build approach. Hence, our conclusions may not hold over all Single Development-Build contracts. Space systems are characterized by two key elements: an unforgiving operating environment in which repair may not be possible, and expectations for rapid technical progress. These two goals are in conflict, which may explain why so many systems experience developmental problems.

1. Quality and Responsiveness

The case studies we examined show that competition did succeed in providing incentives for firms to develop proposals for innovative solutions. However, cost growth after contractor award can only be described as excessive. In these cases, the competitions served to provide incentives to firms to base their bids on radical innovation, but these radical innovations proved very difficult to transfer to production.

Studies suggest that new entrants are liable to "out-promise" incumbent producers of space systems in an effort to win contracts. If they do win, they then experience predictable problems meeting promised schedules and keeping costs within target. The contract type—typically cost plus incentive fee—contributes to the lack of appropriate incentives. In this instance, competition does not seem to be leading to positive outcomes for the government.

2. Near-Substitutable Systems

Dual-sourcing is clearly not an issue for design/build contracts. The existence of near-substitutable systems, however, is a major consideration. Often, the new system is designed as a replacement for an aging system. Upgrades to the old system are often a

viable alternative to designing a new one. And indeed, developmental delays in the new system may force the DoD service or agency to field upgrades as an interim measure.

D. Competition below the Prime Contractor

Prime contractors must rely on hundreds of team members, subcontractors, and vendors in order to design and build a modern military system. The benefits to be gained from competition among prime contractors will be diluted if the industrial base does not possess sufficient depth to allow the prime contractors to reap these same benefits in assembling their contract teams. However, management of the sub-prime tiers represents a significant, and time-consuming, management challenge, as the achievement of the prime contractor's goals depends to a significant degree on the performance of the sub-prime tiers. To ensure that the interests of the prime contractor and subcontractors are appropriately aligned, the prime contractors tend to create franchise-like arrangements with subcontractors providing technologically-complex components or components requiring a high degree of specific investment. Recurring competition at the sub-prime tiers should only be expected for commodity or commercial-type items, where suitable goods are available from a number of qualified vendors.

E. Implications for the Defense Industrial Base

Competition for a commercial product would be expected to drive price to cost, but the evidence does not support this outcome in competitions for MDAPs. Rather, the evidence is that defense firms earn positive rents. But, as our analysis has shown, the existence of these rents provides the appropriate incentives for defense firms to align their interests with those of the DoD, and to provide the responsiveness and technological innovation that are valued in the development and manufacture of defense systems.

The incentive effect of these rents, however, holds only if the rents are contestable. The franchise form of competition for MDAPs provides a mechanism to put these potential rents at risk by the use of annual production contracts. Should the government determine that the incumbent firm's cost, schedule or quality performance, or responsiveness are deficient, the franchise can be recompeted, a second source can be established, or the size of the franchise can be reduced in favor of a near substitutable product. These threats to the rents to be earned over the full extent of the franchise provide a continuing incentive to maintain performance in a manner acceptable to the government.

The ability of the government to contest rents under the franchise form of competition, however, depends on the presence of viable competitors in the industrial base. If effective competitors are not extant in the relevant sector of the defense industrial base, a firm rightfully views the risk to its long term rents as lower than if competitors exist, and may choose to act accordingly. In the extreme, the option left to the

government is to cancel the program, but the cost of such action in terms of lost capability may be too large to accept.

This argues for an active role for the government in assuring that viable competitors exist throughout the life of a program. Actions to create or preserve potential competitors provide the government with a level of protection against program disruptions caused by changes in market conditions or natural disasters. But, more importantly, it maintains a continuing, credible ability to contest the rents created in a franchise competition, and thereby preserves the incentive effects created by these rents.

The government lacks this same ability to contest rents for programs structured as Single Development-Build programs. For these programs, the only effective contractual option the government has is to terminate the program and start over, a difficult choice to make because it delays the fielding of needed capabilities. In circumstances where a Single Development-Build contract is appropriate (i.e., a technologically complex system with low end item quantities), the use of a competitive or sole-source contract instrument appears to be of less importance to eventual program success than the management of the program post-award.

F. Unanswered Questions

Although there is a considerable body of research on the value of competition, much of the research was conducted when the industrial base and the annual defense procurement portfolio were considerably different than they are today. Today's environment of a few large firms vying for fewer, more technologically complex systems may be affectingg the fundamentals of competition in the defense market in ways that are not readily apparent. There are a number of questions that we cannot answer, and that would benefit from further research:

- Does the present defense industrial base still offer opportunities to achieve cost savings through dual-sourcing of systems or major components?
- Has technical progress in the defense sector fallen behind that of the commercial sector where the two sectors can be usefully compared, such as information technology and radio communications?
- Has the acquisition process changed as a result of the passage of the Goldwater-Nichols legislation? What changes result from the Weapon System Acquisition Reform Act of 2009? Have those changes increased or decreased the opportunity for effective competition in major systems acquisition?

- Producers in a number of sectors have been complaining of problems in maintaining qualified sources of supply for specialized parts and subassemblies. What is happening to this part of the industrial base? Are the changes related to competition policy? Can the Department do anything to improve the situation?

Appendix A.
Auction Theory of Rent-Seeking Behavior

This appendix provides a review of the auction theory used to model firms seeking economic rents, or prizes, through research and development (R&D) competitions. The basic premise is that firms will spend their own funds to seek knowledge that allows them to better compete in an auction for a production contract. The firms are not under contract to perform R&D; however, the model assumes that the quality or value of their bid is directly proportional to the amount spent towards that end. This application of the model will be deemed efficient since it creates a competitive framework for an acquisition for which there is no formal market. However, other applications of the model may not be as beneficial. For example, the same model has been used to model political lobbying—presumably to sustain a market (Nitzan 1994).

Competition for prizes is an important method for funding innovation. Rent-seeking firms compete to capture the prize. Even though a competitive market may not exist for the type of innovation the buyer seeks and the successful seller will gain economic rent, this can be efficient if the rent is dissipated through the costs incurred by the firms competing for the award. Industrial organization theorists have modeled this problem using an "all-pay" auction where all bidders must pay their bid to the seller. This is in contrast to a standard auction where the only the winner pays. (Only the auction winner captures the prize in either case.)

To illustrate this idea, consider an example relating to the MDAP franchise. The buyer employs a two-stage auction mechanism for an MDAP where each bidder spends internal funds in amount b on research to gain improved knowledge of the production cost, which is ultimately stochastic, of the item to be acquired. The winner negotiates the actual prize at the beginning of the development contract in the second stage. The bidders offer to sell the item in bid proposals based on their research efforts. Only the bidders know their R&D expense and their production cost estimate, i.e., their "cost type." The bidder reveals its cost type in its bid, which is the basis for the principal's selection criteria for the winner. The winning bidder is given a contract to develop the item which is then procured through a series of production contracts. Seller i's bid b_i maximizes its expected value of winning the auction:

$$\pi_i(b_i,v_i)=[v_i-b_i][F(b_i)]^{n-1}$$

Here v_i is the value of the franchise. This expectation is mainly taken with respect to the potential bids of the other n-1 sellers. The distribution function $F(b_i)$ is the cumulative probability of winning the auction with a bid of b_i. In the case where F is uniform for all firms, competing firms will bid prices evenly on the interval $[\underline{b}, \overline{b}]$.

There is no pure strategy equilibrium for this auction; rather, equilibrium is achieved through a mixed strategy, which could be reached through stochastic bids from a fixed interval of the distribution. Alternatively, if all bids are equal due to a common prize valuation, the seller can choose a bidder at random (Hillman and Samet 1987).

If the bidders are risk neutral and the minimum bid is 0 or greater, their expected revenue will be equal to the buyer's expected cost. For there to be an equilibrium state, the bidders must expect to have profit of at least zero. Only the winning bidder, i.e., the one with the lowest cost type, will actually receive the prize v, while the losing bidders will still have paid their R&D expense. Note that the buyer must pay the sum of all the bidders' R&D expenses in the form of rent to the winner (G. Tan 1989). This is due to the symmetry of the expectation between the seller's expected cost and the bidders' expected profit. Bidder's profit expectation is composed of R&D investment b and rent v associated with winning the auction. Assume that all n bidders invest the same amount b, which implies that all bids are the same. If F(b) is the distribution of bids, then the expected bid, b (i.e., the expected R&D outlay) is,

$$E[b] = \int_0^v b dF(b)\ v/n \text{ or } v=nE[b]^1$$

For example, there are 100 bidders who each value the price at 100. If F is uniform and the buyer picks a bid at random, there is a 1 percent chance of winning. Bidders will invest no more than K, but the buyer will expect to pay at least 100 to the winner bidder. Thus the buyer expects to pay all of the active bidders' R&D expense. This is how the all-pay auction model of competition for the franchise is a competitive allocation in that the rent is dissipated over the bidders as a group.[2]

This model has a number of ramifications as we move away from the ideal case where there is free entry and bidders are risk neutral. Generally the R&D expense can be decomposed into fixed and variable parts. While the fixed element of R&D cost is sunk for bidders who made the investment, it represents an entry barrier for potential bidders. If all the R&D cost is variable, bidders will freely enter the competition.

1 From Hillman and Samet (1987), let $F(b) = [b/v]^{1/(n-1)}$, thus $E[b]=\int bdF=\int bd(b/v)^{1/(n-1)}$, which, with limits of integration of 0 to v equals v/n – where n is the number of bidders.

2 This is a version of Posner's (1975, 807-828) rent dissipation postulate: In equilibrium, the total expenditures of rent-seekers equal the value of the prize.

As bidders enter, however, their investment in variable R&D decreases reflecting the lower probability of winning the bid. As the number of bidders increases without limit, their likely investment amount goes to zero. Production cost will decrease as more bidders enter, however if not enough R&D is expended this may not be practical.

Many auctions have a reserve price that keeps the buyer from paying more than its opportunity cost. For an MDAP, this might be an independent cost estimate or the cost of an alternative weapon system. The reserve price, r, is related to the opportunity cost of the buyer, v_0, through the formula v_0-F(r)/f(r), where f(r) is the probability density. The inverse hazard ratio of r, F(r)/f(r), represents the rent of the winning bid. The point of the reserve price is to force a winning bid, b, to be higher than it otherwise would (McAfee and McMillan 1987).[3] The higher the bid, b, the lower the cost type.

A more realistic auction structure that better approximates the competition for the franchise would have minimum, as well as reserve, bids and risk adverse bidders. The minimum bids arise due to the complexities of developing minimally acceptable bids for modern weapon systems. Bidders would possess R&D assets that would effectively prevent free-entry. Under these conditions, however, the equilibrium bids and investments are smaller and the rents are not completely dissipated. The incentive for competition still exists; however, the procurement is not economically efficient in that the prize winner will extract rent from the government.

In actual franchise auctions the uncertainty surrounding the firm's payoff causes them to under-invest relative to the level described above. This is during the pre-contract phase when several factors can keep the potential bidder from investing either at a level or technical specificity at a socially optimal level. Part of the bidder's concern is that the buyer will renege on the auction mechanism should it observe signals on the actual level of the production cost of the item to be procured. The bidder may also expect that the value of its investment will be lower once it is in negotiation with the buyer—for example, private investments made before the contract negotiation are sunk costs.

The risk of underinvestment can possibly be mitigated if the buyer can commit to the ultimate auction mechanism. If this is not possible, a long term contract for production signed prior to the firm's investment could encourage the appropriate level of investment. The contract would need to have cost incentives either explicitly or implicitly embedded that keep the buyer from extracting too much rent. Other mechanisms include ensuring that repeated procurements are viewed as fair, i.e., not expropriating the firm's investment, and encouraging the firm to engage in commercial activities. This last

[3] Note that if the buyer were the winning bidder, the reserve price would force him to pay more than he would have in the absence of the reserve.

mechanism is double-edged since less specific investments give the firms bargaining power.[4]

What should the government hope to achieve through a franchise auction, or competition, in lieu of simply granting it to a favored sole-source vendor? The basic benefit the government could anticipate through its effort to compete a Major Defense Acquisition Program (MDAP) would be lower rent paid to the contractor for the same amount of innovation effort put forth. Assume that the government had a choice between an auction and selection of a contractor using another approach that was not competitive. Also assume that the government estimates that the cost of the item it seeks is about $100. In theory, to motivate the efficient contractor to innovate will require rent in proportion to the cost difference between the first and the next best efficient contractor to perform the same innovation. For example, the inefficient contractor A, with cost type $\overline{b}$, requires an actual cost of $100 to perform a task which contractor B, cost type $\underline{b}$, could perform for $90. However, B will require to be paid $100 for the task just as A would charge because the government will not be able to determine *ex ante* whether B is efficient.[5]

If the government buyer can make the two contractors bid on the task, however, B would not be able to determine whether A is efficient. If, for example, there was an equal chance that A is efficient, too, B's expected rent would drop from $10 to $5 assuming the same informational asymmetry between the government and bidders on which cost type they are, as in the noncompetitive case. Increasing the number of bidders and cost types (still between $[\underline{b}, \overline{b}]$) can reduce the efficient bidder's rent even further. In this way, competition among bidders can reduce the rent created by the informational asymmetry between the government and industry. Thus, in the absence of competitive markets, there is a clear benefit to the government to use competitive auctions where multiple bidders exist.

However, MDAP franchise competitions compete on more than one dimension; for example, cost and quality. Quality, technical innovation, is another attribute sought by the government in MDAP procurements. Two problems emerge with auctions based on scoring multiple attributes. The first relates to the underinvestment problem already addressed. If the buyer may not ultimately be committed to the scoring rule, bidders may be distorting their decisions away from what is socially optimal. Another problem relates to how the production contracts will ultimately be priced and the distortive effect on bids of fees based on cost. This fee policy effectively subsidizes higher cost producers. This is not such a problem in that efficient producers will be forced to lower their bids to

[4] J.J. Laffont and J. Tirole, *A Theory of Incentives in Procurement and Regulation* (Cambridge, MA: MIT Press, 1993), 99–103.

[5] Ibid., 53–128 and 307–340.

compete. However, if the low cost producer has the option of producing at a higher quality level, given that it won out on the cost element of the auction, it has an incentive to offer more quality than is socially optimal to achieve higher rent. This property has been compared to the Averich-Johnson effect seen in regulated utilities (Che, Buy-in and Gold Plating Under Defense Profit Policy 1994; Che, Design Competition through Multidimensional Auctions 1993).

Government program officials must recognize whether the contractor's drive to beat the other bidders in the competition for the engineering and manufacturing development (EMD) contract could manifest in different program attributes that will ultimately dominate the development of a production weapon system. For example, a technologically advanced concept that puts a contractor ahead during the competition could be exceptionally hard to develop and produce. Tan and Piccione find that general welfare increases when technologies whose procurement cost can increase with higher R&D investment are more efficiently acquired without competition; while competition improves outcomes with technologies that only become more efficient with R&D (Tan and Piccione 1996, 663-685). Once in development, a technologically difficult to produce concept is probably good for a contractor's profit potential. Ultimately, it provides an opportunity for the contractor to extract rent from the government by developing a high cost system using low risk designs that can be improved once in production.

In summary, the all-pay auction can be used as a model for government procurement through a competitive MDAP franchise. Generally the government buyer benefits from the R&D performed by bidders prior to the actual auction, though it ultimately must pay all of these costs back to the winning bidder in the form of economic rent. The clearest benefit of the auction mechanism to the seller is that it is extracting some of the rents it would otherwise have to pay to the contractor if selected through non-competitive means. The government may also extract additional rents through the use of a reserve ceiling price. It is less clear that social welfare increases when quality is a co-basis for determining the winning bidder since the government's fee policy provides incentives to the contractor to "gold plate" the item and thereby extract further rent.

Appendix B.
Case Studies for Near-Substitutable Systems

A. Near-Substitutable Systems

We chose three case studies to help explore issues associated with competition between near-substitutes. The cases are presented in chronological order.

1. C-17 and 747-400F/Non Developmental Airlift Aircraft (NDAA)

In the late 1980s and early 1990s the C-17 program encountered substantial difficulties in terms of performance shortfalls, cost overruns, and schedule delays. Because of these difficulties the Congress directed DoD as part of its FY 1993–1994 Defense Authorization Act to conduct a Defense Acquisition Board (DAB) review of the program; included were an examination of C-17 requirements and affordability as well as the results from a new cost-effectiveness analysis (then referred to as a Cost and Operational Effectiveness Analysis, or COEA). At the time, the Air Force had planned to buy 120 C-17s, with 20 already funded.[1]

The COEA was performed by IDA; alternatives to the full 120 C-17 program included the procurement of Boeing 747-400F freighters (Boeing had yet to acquire McDonnell Douglas, the C-17 prime contractor at the time). Important characteristics of the C-17 and 747-400F are included in Table B-1.

Table B-1. Comparison of C-17 and 747-400F Characteristics

Characteristic	C-17	747-400F
Average payload (tons)	48.3	73.7
Surge utilization rate (hrs/day)	15.2	12.5
Block speed (knots)	423	445
Million-ton-miles/day (MTM/D)	.146	.191
Maximum on ground (MOG),[a] robust conditions	26	15
MOG, constrained conditions	16.5	5.0

Source: W. L. Greer, J. N. Bexfield, J. R. Nelson, et al., "Cost and Operational Effectiveness Analysis of the C-17 Program," Institute for Defense Analyses, December 1993.

[a] Maximum number of aircraft on ground simultaneously in theater for the Major Regional Contingency-East scenario.

[1] United States General Accounting Office, "C-17 Settlement Is Not a Good Deal," April 15, 1994.

The 747-400F has advantages in payload/range performance while the C-17 has substantially better Maximum on Ground (MOG) metrics, can deliver outsized cargo (primarily large armored vehicles) and performs military-specific missions such as air-drop and combat delivery. The 747-400F clearly fits into our definition of a near-substitute relative to the C-17 (the incumbent in this case).

The COEA posited alternative fleets with the same MTM/D as the planned fleet with 120 C-17s. While MTM/D is a static measure, the effectiveness modeling took into account dynamic effects, including the impact of limited airfield space in theater. The overall results were that a mixed fleet of C-17s and 747-400Fs (along with other aircraft in the planned force) had approximately equal cost-effectiveness when compared with the case with 120 C-17s. The COEA found significant synergies between the 747-400Fs and aircraft carrying outsize cargo (C-17s and C-5s); the additional oversize and bulk carrying capacity of the 747-400Fs freed up space in the aircraft capable of carrying outsized cargo.

The December 1993 DAB review resulted in several actions. An RFP for an NDAA was released; the NDAA could be a new commercial freighter or refurbished/modified used aircraft. Boeing was the only respondent, with its C-33 (the military designation for the 747-400F). Parallel actions for the C-17 included directing management and manufacturing process improvements, as well as the approval of procurement through the 40th aircraft. The C-17 was put on probation for two years with the fate of the remaining 80 aircraft to be determined at the end of 1995. The C-33 provided DoD with a clear alternative if C-17 program improvements were not forthcoming, while placing competitive pressure on McDonnell Douglas.

By the end of 1995 the C-17 program had satisfied the DAB with its progress and an 80-aircraft multi-year procurement (MYP) was approved. The NDAA program was shelved. The general view was that the two-year probationary period was a success.[2] Comparisons of actual C-17 procurement cost with those presented in the 1993 COEA show the actual cost for the final 100 of the originally planned 120 aircraft substantially below that estimated by IDA, and slightly below the more optimistic Air Force estimate ($21.8 billion versus $26.3 billion and $22.9 billion, respectively, in FY 1993 dollars for aircraft 21-120).

2. Joint Air-to-Surface Standoff Missile (JASSM) and Standoff Land Attack Missile-Expanded Response (SLAM-ER)

In 1994 the Tri-Service Standoff Attack Missile (TSSAM) was cancelled because of cost overruns. However, the services' requirement for a standoff precision weapon to

[2] Christopher Bolkcom, "Military Airlift: C-17 Aircraft Program" (Washington, DC: Congressional Research Service, January 2007).

attack well-defended high-value targets did not go away. The JASSM program was initiated (Milestone 0) in September 1995 as a joint Navy/Air Force program; the approach was to take the lessons learned from the TSSAM program and apply acquisition reform initiatives in order to produce an affordable missile with capabilities similar to those of the TSSAM.

The Navy's SLAM-ER was a major modification of the SLAM (which in turn was an adaptation of the Harpoon anti-ship missile) intended to give the Navy a standoff capability against land as well as ship targets. Like the Harpoon and SLAM, the SLAM-ER's prime contractor was McDonnell Douglas (later bought by Boeing). An EMD contract was awarded in March 1995, giving the SLAM-ER a substantial head start on the JASSM. The SLAM-ER had a new airframe/wing design to increase range, a warhead with increased lethality, as well as avionics/software/mission planning upgrades to improve accuracy and make employment easier. As an upgrade to a small number of existing missiles, the SLAM-ER was not subject to the standard acquisition milestone process.

The JASSM and SLAM-ER share many capabilities, but with some important differences. Characteristics of the two missiles are included in Table B-2.

Table B-2. Comparison of JASSM and SLAM-ER Characteristics

Characteristic	JASSM	SLAM-ER
Length (ft)	14.0	14.3
Diameter (inches)	18.0	12.5
Total weight (lbs)	2,250	1,388
Warhead weight (lbs)	990	488
Maximum range (nmi)	180–200	150

Source: Forecast International.

The JASSM is heavier, has longer range, and carries a larger penetrating warhead. Guidance systems are similar, with Global Position System (GPS) bringing the missiles close to their targets while imaging infrared sensors are used in the terminal phase. Both missiles use the same Williams turbojet engine. A distinguishing attribute of the SLAM-ER is its two-way data-link with man-in-the-loop functionality. This gives the SLAM-ER the capability to attack moving targets such as ships, as well as providing additional tactical flexibility. The JASSM's "fire and forget" capability is meant only for stationary targets; a similar capability was included in the SLAM-ER as a retrofit in the FY 1999 production lot. The JASSM is also distinguished by its stealth capabilities.

The JASSM program was required to complete an AoA-like activity prior to Milestone I and the start of the Program Definition and Risk Reduction (PDRR) phase.

COEA I compared potential JASSM capabilities and associated technologies to those achievable through modification of existing systems. It was not clear from available documentation whether SLAM-ER was included in COEA I. COEA I found JSSAM the preferred alternative. Milestone I occurred in June 1996, with Lockheed Martin and McDonnell Douglas chosen to design and build prototype missiles. Prior to Milestone II and the beginning of EMD an updated COEA (COEA II) was required, where the two candidate systems from the PDRR phase were compared directly to the SLAM-ER.[3] COEA II also found the JASSM to be the preferred system. Milestone II occurred in November 1998, with Lockheed Martin chosen as the prime contractor.

JASSM acquisition initiatives included adoption of commercial practices, minimization of military specifications and data reporting, and cost as an independent variable (CAIV). The general approach was to give the contractors maximum flexibility in making trade-offs within the constraints of high-level key performance parameters (KPPs) and a unit cost goal of $400,000–$700,000 in FY 1995 dollars. Another aspect of the acquisition strategy was the use of price-based acquisition (PBA). This meant the inclusion of fixed price options for the first five production lots (accounting for 1,146 of the 2,400 Milestone II requirements) as part of the EMD contract and the elimination of cost reporting for those lots. This resulted in concessionary prices on the part of Lockheed Martin for those lots along with a high risk that subsequent lots would increase in price and with the government left with limited information for use in negotiation and program planning. This problem opened-up another opportunity for contrasting JASSM against SLAM-ER.

As a fallout of the PBA strategy, IDA performed an "independent market survey" analysis in support of the JASSM's 2004 Milestone III full rate production decision (Woolsey, Frazier, et al. 2004). A unique aspect of this was the use of effectiveness analysis to help determine fair prices for the JASSM in relation to the prices and capabilities of other standoff missiles including the SLAM-ER. The campaign model used did not force the one-for-one substitution of the competitive missiles for JASSMs; instead, platform/weapon/target assignments were determined by an optimization model where Blue (friendly) losses were minimized. From this a utility measure was specified, $U_k=Q_{jassm}/Q_k$, where U_k was the utility for the kth competitive missile, Q_{jassm} was the quantity of JASSMs planned at Milestone III,[4] and Q_k was the quantity of the kth competitive missile required for Blue attrition and campaign length to equal those for the JASSM quantities. The utility measure provided a basis for comparing near-substitutable systems. Target prices for the JASSM in relation to the competitors were then defined as $P^*_{jassm} = P_k/U_k$; for the JASSM to be a "good deal" relative to competitors, its purchase

[3] "Joint Air-To-Surface Standoff Missile (JASSM) Single Acquisition Management Plan (SAMP) For Milestone II, Revision 1," December 1997.

[4] At this point the planned quantity had increased to 4,250.

price would need to be equal to or below P^*_{jassm}. In practice P_k/U_k varied over a range, depending on effectiveness modeling assumptions and pricing ground rules for the competitive missiles. In the analyses, the missiles resulting in the lowest P_k/U_k metrics were the SLAM-ER and the Storm Shadow, a France/UK joint venture.

It was never likely that the Air Force would buy the SLAM-ER.[5] However, there was a possibility that the Navy would procure fewer SLAM-ERs in favor of JASSM. It should be noted that although the Navy was a participant in the JASSM program, its contributions to RDT&E were minimal and no procurement was funded (although quantities up to around 700 were considered). In the end the Navy did not significantly change their SLAM-ER inventory goal (which varied between 400 and 600), although they did buy out their requirement substantially faster than originally planned. The Navy formally pulled out of the JASSM program in February 2005; they were satisfied with the SLAM-ER for their standoff missile requirements (Fein 2005).

The JASSM was subject to a Nunn-McCurdy breach in April 2007, primarily because of increases in procurement unit costs. The program was not recertified until one year later; the delay was mainly because of concerns regarding reliability. During this period the Air Force released a Request for Information (RFI) for alternative missiles; we do not know from available documentation whether Boeing responded with the SLAM-ER (Putrich 2008).

It is clear that SLAM-ER and JASSM exerted competitive pressure on one another throughout their acquisition cycles. What is less clear is whether program outcomes were materially affected. The JASSM program's ambitious unit price goals may have been partially prompted by competitive pressure from the SLAM-ER; the lower JASSM price estimates were an important advantage in the Milestone II AoA.[6] However, in the course of program execution, JASSM average procurement unit prices almost doubled ($720K versus $400K FY 1995 dollars); SLAM-ER prices changed little. In terms of missile capabilities, the upgrade paths of the missiles showed convergence in some objective capabilities. Already mentioned is the upgrade of SLAM-ER with automatic target recognition; there are plans for JASSM to add a two-way data link and maritime attack capabilities. JASSM and SLAM-ER compete with one another for foreign sales, although the additional capabilities of JASSM mean that it is available to fewer nations. A notable

[5] The Navy had offered 40-50 SLAM-ERs to the Air Force for use on B-52s against Yugoslavia, with the Air Force refusing the offer; reports indicated that the Air Force viewed the SLAM-ER as a threat to JASSM procurement. "Air Force Won't Use Navy Missile In Kosovo," *Navy News & Undersea Technology*, April 12, 1999.

[6] "Joint Air-to-Surface Standoff Missile (JASSM) Analysis of Alternatives, Appendix G Cost Analyses (U)," September 1998.

direct competition was to equip Australia's F/A-18s, where the JASSM was chosen over the SLAM-ER.[7]

3. KC-X: KC-767 and KC-45

The KC-X program was meant to recapitalize the aging KC-135 air-refueling tanker fleet. The KC-X case is an important exception, where near-substitutable systems were part of a formal direct competition. This program also has a unique back-story, where KC-135 recapitalization was originally to be accomplished through a commercial operating lease of KC-767 aircraft (a derivative of Boeing 767 commercial aircraft). This solution would have side-stepped the normal acquisition process, where no AoA or formal competition was included, minimal pricing and cost data were available, and the normal requirements process was not followed. Due to these and other shortcomings in the program, the DoD Inspector General recommended that a new acquisition program be implemented, including the performance of an AoA.[8]

The AoA was performed by RAND and found that new medium- to large-sized wide-body commercial aircraft-based tankers (767-747) were the best solution for KC-135 recapitalization. Although cost-effectiveness analyses were performed on individual aircraft models within this category, RAND did not think that the cost analyses had sufficient fidelity to determine a specific solution. The price of the "green" aircraft (the commercial aircraft prior to modification to tanker configuration) was cited as an important source of uncertainty. Given this, RAND recommended on open competition to determine the best alternative (Kennedy 2006).

The Air Force released a request for proposals in January 2007 for EMD and procurement of up to 80 aircraft; a total of up to 179 could be procured over a 15-20 year period. The offerors were Boeing, with the KC-767, and Northrop Grumman, with the KC-45, an evolution of the EADS/Airbus A330 Multi-Role Tanker Transport (MRTT). Both tanker aircraft had precursors sold to foreign customers, although the Boeing entrant would require substantially more additional development.

Table B-3 presents characteristics for the KC-X aircraft along with the KC-135.

[7] "ADF Weapons: Was JASSM the right choice?," *Australian Defence Magazine*, August, 2007.

[8] Department of Defense Office of the Inspector General, "Acquisition of the Boeing KC-767A Tanker Aircraft (D-2004-064)," March 29, 2004.

Table B-3. Comparison of KC-135, KC-767, and A330 MRTT Characteristics

Characteristic	KC-135R	KC-767	A330 MRTT
Length (ft)	136	159	193
Wing Span (ft)	130	156	198
Maximum Fuel Weight (Klbs)	200	202	245
Max. Gross Take-off Wgt. (Klbs)	323	395	514

Sources: U.S. Air Force, Boeing, and EADS North America.

The KC-45 was substantially larger than both the KC-767 and KC-135. Total fuel carried is an important driver of tanker aircraft capabilities. The KPP in the RFP most relevant to size was KC-135 fuel offload/range performance. The offerors were expected to meet or exceed KC-135 performance, but with no consideration given to how much the KPP was exceeded.

Another RFP metric relevant to size was the Integrated Fleet Aerial Refueling Assessment (IFARA) factor. The IFARA factor was derived using a modeling and simulation tool applied to various scenarios; the factor is the inverse of the quantity of an offeror's aircraft that would be required in order to perform the scenarios divided by the number of KC-135R aircraft needed. This is similar to the type of analysis used in the RAND AoA. The IFARA metric should be positively correlated to maximum fuel weight, but would also take into account other constraints on employing tankers, many of which would advantage a smaller aircraft. The IFARA factor was 1.90 for the KC-45 and 1.72 for the KC-767. Although the IFARA factor could be used as a discriminator, its weighting was low relative to other categories.

The winner of the competition was Northrop Grumman. Boeing protested and the protest was sustained on a variety of counts, the most important of which, to us, was the use of the KC-135 performance KPP as a discriminator in violation of the RFP instructions.[9]

The problems with the KC-X program demonstrated the complications associated with a direct competition between near-substitutes. By definition, near-substitutes will have substantial differences in attributes across at least some dimensions. Thus, in the course of direct competition, the weighting of discriminators that flow from divergent attributes will be critical. The use of modeling and simulation tools that can aggregate over different attributes to form discriminators in a single dimension is a possible response. Although the IFARA factor was consistent with this approach, it was given minimal weight in the original competition. However, for the selection criteria included

[9] Gary L. Kepplinger, General Counsel, General Accountability Office, *Decision, Matter of The Boeing Company, File: B-311344, et al.*, June 18, 2008.

in the new KC-X RFP, the IFARA factor is more central, as it is included as an adjustment factor on the offerors' pricing data.[10]

[10] Department of the Air Force, Air Force Materiel Command, *KC-X Tanker Modernization Program, Solicitation Number: FA8625-10-R-6600,* February 24, 2010.

Illustrations

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Abbreviations

AMRAAM	Advanced Medium-Range Air-to-Air Missile
ANZUS	Australian, New Zealand, and United States Security Treaty
AoA	Analysis of Alternatives
ATF	Advanced Tactical Fighter
BIW	Bath Iron Works
CAIV	Cost As an Independent Variable
COEA	Cost and Operational Effectiveness Analysis
DAB	Defense Acquisition Board
DFARS	Defense Federal Acquisition Regulation Supplement
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DSB	Defense Science Board
DSP	Defense Support Program
EADS	European Aerospace and Defence Systems
EMD	Engineering and Manufacturing Development
FAR	Federal Acquisition Regulation
FFP	Firm Fixed Price
FMTV	Family of Medium Tactical Vehicles
FY	Fiscal Year
GAO	Government Accountability Office
GFE	Government-Furnished Equipment
GPS	Global Positioning System
IDA	Institute for Defense Analyses
IFARA	Integrated Fleet Aerial Refueling Assessment
IG	Inspector General
JASSM	Joint Air-to-Surface Standoff Missile
JROC	Joint Requirements Oversight Council
JSF	Joint Strike Fighter
JTRS	Joint Tactical Radio System
KPP	Key Performance Parameter

LCS	Littoral Combat Ship
LMTV	Light Medium Tactical Vehicle
LRIP	Low Rate Initial Production
MDA	Missile Defense Agency
MDAP	Major Defense Acquisition Program
MOG	Maximum on Ground
MRAP	Mine Resistant Ambush Protected
MRTT	Multi-Role Tanker Transport
MTM/D	Million-ton-miles/day
MTV	Medium Tactical Vehicle
MUOS	Mobile User Objective System
MYP	Multi-Year Procurement
NATO	North Atlantic Treaty Organization
NDAA	Non-Developmental Airlift Aircraft
NGSS	Northrop Grumman Ship Systems
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OTA	Other Transaction Authority
PBA	Price-Based Acquisition
PDRR	Program Definition and Risk Reduction
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
RFI	Request for Information
RFP	Request for Proposal
SBIRS	Space-Based Infrared System
SLAM-ER	Standoff Land Attack Missile-Extended Response
TCE	Transaction Cost Economics
TSSAM	Tri-Service Standoff Attack Missile
UFO	Ultra-High Frequency Follow-On
VIP	Very Important Person

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
xx-04-2011	Final	Jan 2010 - Jan 2011

4. TITLE AND SUBTITLE

The Mechanisms and Value of Competition for Major Weapon Systems

5a. CONTRACT NUMBER

DASW01-04-C-0003

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

AH-7-3186

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

IDA Paper P-4678

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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Office of the Director, Industrial Policy
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Washington, DC 20301

10. SPONSOR/MONITOR'S ACRONYM(S)

Dir, IP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The purpose of this study is to evaluate the impact of competition on the acquisition of Major Defense Acquisition Programs. The assessment is based on case studies and previous analytic studies of the impact of competitive acquisition processes on the acquisition of major weapon systems. The paper identifies the goals of a competitive acquisition strategy, and the competition regimes available to acquisition officials. Each of the competition regimes is evaluated based upon its ability to achieve the stated goals. The study also evaluates the interaction between competitive procurements and the state of the industrial base, to include firms at the sub-prime level. The study utilizes these findings to offer a construct for developing a competitive acquisition strategy, and offers recommendations for further research.

15. SUBJECT TERMS

Weapon System, Competition, Industrial Base, Defense Market, Major Defense Acquisition Program, MDAP

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Vehmeier, Dawn
Unclassified	Unclassified	Unclassified	Same as Report	100	19b. TELEPHONE NUMBER *(Include area code)* (571) 372-6247

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