The JSF program has been intensely competitive since 1996. The present plan calls for one of the two firms currently flight testing demonstrator aircraft, Boeing and Lockheed Martin, to be eliminated in fall 2001. The winning firm will perform all further development and manufacturing of the JSF.

This winner-take-all prospect raises the following question: Should some kind of competitive posture be retained further into the program? If so, how should it be structured? In this chapter, we examine (1) some of the special conditions that exist in defense procurement, and the consequent balance of costs and benefits created when competition is introduced; and (2) the range of possible advantages and disadvantages the government might experience from sustaining competition through production.

Special Conditions in Defense Procurement
Defense procurement operates under a set of rules and constraints that differ from the classic free-market model. Here, we briefly discuss three aspects of those differences that have a direct bearing on how competition can be introduced into defense procurement.

Not a Perfect Market
The special nature of the environment for competition in defense procurement can be illustrated in comparison with the conditions usually assumed in the economist’s model of a perfectly competitive market. This comparison will help in understanding why there are inherent difficulties in introducing effective price competition into defense acqui-
sitions. This comparison also provides a key to understanding the va-
riety of competition-enhancing arrangements that have been developed
in defense procurement. Table 3.1 lists the characteristics assumed
for the perfect-market model next to the corresponding characteristics
of a typical defense system acquisition in which no special arrange-
ments have been made to introduce competition for achieving price
savings or other objectives.

The conventional wisdom is that when military acquisition pro-
grams experience difficulties, expenditure is the first constraint to be re-
laxed, and then schedule, but that performance goals are adhered to
quite rigorously. The result is frequently an increase in the unit price of
the product.

The data support this description of the way capability, schedule,
and price are traded off in defense acquisition (see, for example, Dews,
Smith, et al., 1979). However, it is not clear that focus on this increase
should be accepted as adverse criticism. The services’ emphasis on
high system capability is consistent with the long-established national
policy that relies on capability rather than quantity for defense—a
reliance that calls for the development and production of systems su-
perior to those fielded by possible opponents. Consequently, major sys-
tem acquisitions generally aim at a product that requires innovations in
design and the application of advanced technologies, with all the tech-
nical uncertainty that entails.

Phases in Buyer-Contractor Relationship
Another special feature of the acquisition process for major defense sys-
tems is that it comprises several separate and distinct steps, or phases,
as depicted in Figure 3.1. The buyer-contractor relationship thus in-
volves four phases—Concept Exploration, Program Definition and
Risk Reduction, Engineering and Manufacturing Development (EM D),
and Production. Each phase is triggered by a milestone decision made
in the Office of the Secretary of Defense (OSD).1

Concept Exploration. Milestone 0 approval begins the acquisition
process and authorizes entry into the Concept Exploration Phase. The

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1 The most recent of the DoD 5000 series directives introduces a somewhat different phasing and
nomenclature. Here, we have retained the definitions and nomenclature applied during the previous phases
of the JSF.
Milestone Decision Authority specifies the minimum set of alternatives to be examined, the lead organization, and exit criteria. In the Concept Exploration Phase, a statement of need is agreed upon. The focus of

<table>
<thead>
<tr>
<th>“Perfect market” characteristics</th>
<th>Major defense system market characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many buyers and producers, none being dominant; each buyer has a choice of many producers. To a close approximation, price (a firm fixed price) is determined by the “hidden hand” of the market.</td>
<td>Only one buyer. Usually only one producer—the prime contractor who developed the system. Production prices (seldom truly firm fixed prices) are determined by a series of negotiations in a sole-source environment.</td>
</tr>
<tr>
<td>Product is an existing, standardized item, the same for each producer—“homogeneous”—and its characteristics are stable over time.</td>
<td>Product is a newly developed item, usually without close substitutes and with a design that is periodically upgraded during much of the production phase, often even afterward.</td>
</tr>
<tr>
<td>Competition focuses on price alone.</td>
<td>Prospective producers compete early in the development phase through “design rivalry.” Buyer is concerned with product quality (especially performance), delivery schedule, and other nonprice factors. Price is not the dominant consideration in selecting the producer; quality of the product is normally given priority.</td>
</tr>
<tr>
<td>No producer has an advantage in production technology or economies of scale.</td>
<td>Production technology is dynamic and may differ among prime contractors and their subcontractors. Economies of scale, including cost improvement over time (“learning curve”) and production-rate effects, significantly influence producer costs. A superior developer is not necessarily a more efficient producer.</td>
</tr>
<tr>
<td>The market is easy for new producers to enter.</td>
<td>New prime contractors seldom enter the defense sector; entrance is inhibited by the high capital investment required, the proprietary rights of others, and the administrative and contractual burdens of a highly regulated industry.</td>
</tr>
<tr>
<td>Buying the product is a simple, quickly completed, one-step transaction between the buyer and the producer, and is independent of other purchases from the same or other producers.</td>
<td>Acquiring a major system is a multiyear, multistep, complex process, involving scores of successive, usually interdependent, contract negotiations between buyer and producer.</td>
</tr>
<tr>
<td>The market is characterized by perfect intelligence and absence of uncertainty. Information about product price, standards of quality, number of items purchased, and delivery schedule is freely available to all concerned.</td>
<td>Uncertainty is a dominant, and largely unavoidable, feature. Among the market uncertainties are the</td>
</tr>
<tr>
<td>• threat the system will face</td>
<td></td>
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<tr>
<td>• most suitable system capabilities</td>
<td></td>
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<tr>
<td>• best design approach</td>
<td></td>
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<tr>
<td>• feasibility of development</td>
<td></td>
</tr>
<tr>
<td>• time and other resources required to complete development and make the transition to production</td>
<td></td>
</tr>
<tr>
<td>• deficiencies that may be revealed by operational testing.</td>
<td></td>
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</tbody>
</table>
this phase is to define and evaluate the feasibility of alternative concepts and to provide a basis for assessing the relative merits of these concepts at the next milestone decision.

**Program Definition and Risk Reduction.** After a go-ahead decision has been made at Milestone I, the Program Definition and Risk Reduction Phase (Phase I) begins.² At this point, the acquisition strategy and concept baseline are approved. Exit criteria that must be accomplished during Phase I are established.

Phase I is characterized by measures designed to reduce the risk of incorporating new and emerging technologies. Contractors put forward designs and their feasibility is assessed; prototypes may be built and compared—“fly before buy”; preliminary estimates are made of system performance, schedule, and costs; and the trade-offs among these three variables are considered. Emphasis is on ensuring the feasibility

² Before Milestone I, some prospective prime contractors may have been informally consulted, performed special studies under contract, or submitted unsolicited proposals.
of system design and the capabilities it promises, and on reducing any inherent risks to levels deemed appropriate for moving to the next phase.

**Engineering and Manufacturing Development.** The next step—Engineering and Manufacturing Development—begins with a go-ahead decision at Milestone II. Proposals for EMD are requested from several contractors—almost always from the fairly small number of “primes” that participated in Phase I. Especially if prototypes have been built and tested, these proposals describe rival designs and their estimated capabilities in much more specific detail, and provide more-refined estimates of schedule and costs. In most cases, the high cost of EMD means that only a single prime is chosen in the source-selection process. The task of the EMD contractor or contractors is to bring development to the point at which transition to production can begin. EMD contracts usually call for some initial output of fully production-configured units at low production rates, which enables manufacturing and production processes to be validated. There is a heavy emphasis on testing to ensure that specifications are met and that the system is operationally effective and operationally suitable.

In EMD contractor selection, cost receives substantially more attention than it does in earlier phases. For example, although design-to-production cost goals may have been established in the request for proposals, the contractor’s cost estimates for EMD and production are recognized as still being subject to much revision—typically upward. The choice of the prime contractor or contractors for EMD is normally weighted in favor of expected system capability; cost is an important but still secondary consideration.

**Production.** The fourth phase in this description of the buyer-contractor relationship begins with a favorable Milestone III decision to proceed to full-rate production of the system. A production contract is then negotiated, and, if there has been only a single prime contractor in the EMD phase, the negotiation is conducted in a sole-source environment. This phase often overlaps Phase II, especially when a low rate of initial production (LRIP) is a part of the program acquisition strategy. The system is produced and delivered (along with support infrastructure) to the field for operational use. To assess performance and
quality, compatibility, and interoperability, Follow-on Operational Test and Evaluation may be conducted. System status is monitored to ensure that the system continues to meet the user’s needs. During deployment and throughout operational support, the potential for modifications to the fielded system continues.

At the end of a system’s useful life, it must be demilitarized and disposed of. During this portion of the system life cycle, the project manager must ensure the materiel requiring demilitarization is controlled. The project manager must also ensure that disposal minimizes DoD liability related to environmental, safety, security, and health issues.

Numerous Contract Negotiations
The complexity of the buyer-producer relationship is reflected in the large number of sequential contract negotiations that take place between the buyer and the prime during the course of the acquisition process. This large number of negotiations is the result of several interrelated factors (see Table 3.1), including the following:

- Very long program duration
- A widespread institutional preference for short-term, sequential decisions
- A product changing over time, with development continuing through—and usually beyond—the production phase.

For a single major acquisition, the contractual relationship between the government and the prime may continue over 20 years or more—beginning with (or even before) Phase I and ending with the last post-production upgrade or prime-contractor-handled spare-parts purchase. This decades-long buyer-contractor relationship is one reason for the numerous contract negotiations that occur.

Another reason is the widespread institutional preference on the buyer’s side for short-term, sequential decisionmaking. Congress has preferred to exercise control through annual appropriations, even when multiyear contracts are approved; and most major-system contracts (or contract amendments) are negotiated for a single year’s buy.

The services have compensated for uncertainties about the threat—and especially for uncertainties about future-year funding levels, allo-
cation decisions, and the timing of new starts—by generally preferring to retain programming flexibility, avoiding long-term contractual commitments.³

Contract administrators and auditors prefer short commitments, which enable them to close out contract files in a few years and avoid long and complex audit trails. Compared with longer-duration contracts, short-term, quickly completed contracts may also have financial benefits for the government. For example, by shortening the contract period, the contractor receives its profits sooner and resulting taxes become payable sooner.

During EMD and the early years of production, program managers want the contractual flexibility to make desirable design trade-offs, fund major design changes, and approve at least some of the many apparently well-justified engineering change orders that are almost inevitably proposed at this time. These actions require frequent contract renegotiations or the negotiation of contract amendments. Other, often separate, contract negotiations can involve such things as long-lead-time procurements, additional test items and test support, initial and other spares, data rights, special studies, foreign assistance, new subsystems, and retrofits.

The result is that the contractual relationship between the buyer and the seller is neither the one-step transaction of the perfectly competitive market nor the four-phase transaction implied by the OSD milestone decisions.

The Benefits and Drawbacks of Competition

In a government procurement, competition can have both benefits and drawbacks, some of which are depicted in Table 3.2. The measurement of past effects of competition has produced a variety of answers, some of them conflicting. We need to carefully examine each situation, assess the likely benefits and drawbacks, and reach a judgment on the expected balance between them.

³ However, some members of the armed services have argued for greater use of multiyear contracts as a means of "locking in" stable funding for favored acquisitions, even at the cost of decreasing the stability of other acquisitions.
Table 3.2
Primary Benefits and Drawbacks of Competition in Defense Acquisitions

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Drawbacks</th>
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<tbody>
<tr>
<td>Reduced prices</td>
<td>Additional front-end time and money needed</td>
</tr>
<tr>
<td>Staffed with best employees</td>
<td>Extra management complexity and effort required</td>
</tr>
<tr>
<td>Enhanced product quality through technology insertion and design refinement</td>
<td>Few, if any, near-term benefits</td>
</tr>
<tr>
<td>Strengthened industrial base</td>
<td>Outcome is uncertain</td>
</tr>
</tbody>
</table>

Benefits of Competition
Most observers argue that competition produces many significant benefits (Archibald et al., 1981). Compared with a noncompetitive environment, competition results in improved product quality and lowered unit costs. They say competition forces manufacturers to quickly learn about new technologies and production techniques, fostering greater technological progress and industrial productivity. Finally, competition allows for a more equitable process under which acquisition contracts are awarded.

We do not question the value of competition as a means of inducing a firm to reduce prices. When competition or the threat of competition is perceived as real, a firm can act in a number of ways to cut costs and prices. Managers often assign their best people to a competitive program, allocate corporate capital for equipment, and fund value-engineering studies (rather than expecting the customer to fund them). A company can transfer production from an area of high labor costs, such as California or Massachusetts, to locales where labor costs are lower.

Also, management can take measures to substitute capital for labor, accelerate cost-reduction schemes, and seek out alternative vendors. A firm may be able to operate at an economical rate by producing enough parts in a few months to satisfy the contractual requirement.
for an entire year, then assign the workers to other tasks for the remainder of the year. In addition, a company is often able to reduce the number of engineering and manufacturing support personnel assigned to a program. Noncompetitive programs tend to be heavy in such personnel, often because the customer wants to retain the services they provide.

It is difficult to assess the effect of competition in the abstract. A contractor who needs business or is determined to increase market share acts differently than one who does not. Willis R. Greer, Jr., and Shu S. Liao (1993) discuss this “hungriness” factor; however, their capacity-utilization model uses industry-wide capacity as an input, rather than the capacity of an individual firm. Savings are contingent on speculation about what might have happened if a second contractor had not been brought into a program and assumptions about estimates of program cost without competition. If that estimate is too high, savings from competition or other causes would be easy to achieve. If it is too low, savings would be unlikely.

Improved quality assurance often is cited as a reason for second-sourcing. In some instances, the underlying reason has been a profound dissatisfaction with the initial contractor, which may be a good developer but an inefficient producer. The nature of defense procurement is such that, once a contractor is chosen to develop a major new system, the responsible military service is locked into a relationship with that contractor that could last 20 years or more. Bringing a second company into a program is an effective way to encourage greater cooperation from the initial firm.

**Drawbacks of Competition**

Competition also has its drawbacks and barriers. Observers note that competition requires additional time and money and entails extra management complexity and effort. Since most of the benefits of competition are long-term, not near-term, program managers have few incentives to implement competitive steps. Further, competition has uncertain and mixed results. In a risk-averse environment, this uncertainty reduces the program manager’s incentive to use competition.
In discussing each drawback, we attempt to distinguish among different problems that arise during discrete phases of the acquisition cycle.

**Additional Time and Money.** At almost every phase in the acquisition cycle and for almost every kind of competition, adding a second competitor initially costs more than the cost of a sole source. During the Concept Exploration Phase, such funds are fairly small in absolute terms, although large relative to the overall funds available in that budget category. But competition during the Concept Exploration Phase is a well-established tradition, so funding for multiple sources is somewhat easy for a manager to obtain.

When the program moves to EMD, the magnitude of the funding required for a second, competitive source becomes large in both relative and absolute terms. Furthermore, while general statements supporting competition occur at every level in the defense establishment, this verbal support does not mean that everyone concerned with a particular program would be willing to fund competition. When the funding required to support a second, competitive source reaches the level of tens or hundreds of millions of dollars, authorization will have to come from higher up in the decisionmaking structure. Many people will have to be “sold” on the competitive action. At every level in the organization, some will be sympathetic to the request for funds, and others will see themselves as competing for the same funds. Some groups will tend to underestimate the difficulty of developing a particular system or have an interest in fielding it very quickly, and will thus resist competition during full-scale development on the grounds that it is a waste of time and money. The situation is even more complex in multiservice programs, for which each of the services must agree to put up the extra money.

When substantial amounts of money are involved, the DoD and Congress must be sold on the competition as well. When there is no great pressure for competition and when other acquisition initiatives are being emphasized, DoD and Congress can be difficult to convince. Congress tends to dislike programs with heavy front-end cost, and other, less obvious, political problems sometimes intrude (Rich, 1976). Also, funding requests are reviewed by four different congressional
committees that do not automatically coordinate their decisions; so, each committee must be persuaded separately to fund a program.

Further, once funding for a competition is approved, there is no guarantee that it will be maintained. Money for competitive development programs is a prime target in a budget squeeze, and initial high-level support for competition may evaporate. Written policy supporting competition remains fairly consistent, but interest in competition changes with personnel. In the services and in the OSD, there are frequent changes in top-level personnel. When new people take over, they inevitably change priorities. The result is that it can be difficult to maintain all the funding necessary to conduct a competitive development program.

Competition can slow the program during EMD because of the time involved in testing and source selection or in qualifying a second contractor. Schedules also can lengthen because of the increased program complexity and increased bureaucratic involvement caused by competition. By lengthening schedules, competition carries the risk of increasing program costs. Moreover, the risk of increased program length also is a disincentive to competition because there is usually a strong desire to deploy the system as rapidly as possible.

During the production phase, the funding required to qualify a second, competitive source appears to pose less of a problem, at least for less-complex systems or components—perhaps because, by the time the program is in production, all major conceptual issues have long since been resolved. Attention is more easily focused on the task of efficiently producing the system. Furthermore, there is some evidence of financial benefit from competitive reprocurement.

Extra Management Effort. Competition increases the workload of the Program Office. This extra work stems from two sources: planning for the competition and ensuring fairness.

If a competition is to be beneficial, extensive planning for the competitive steps is necessary. The request for proposal (RFP) must be prepared and the source-selection process designed; the Program Office must comply with certain regulations designed to ensure the fairness of the competition, which involves special security to deal with competition-sensitive material, special reports, etc.
Competition introduces the possibility of lawsuits, disputes, and charges of unfairness by contractors who lose. So, the source selection must be carried out in a way that not only chooses the best design but also raises a minimum number of questions about fairness—not an easy task. The task is complicated particularly because little information or guidance can be drawn from the experience of other programs from lessons learned reports. For the most part, program managers must plan solely on the basis of their own experience. Some program managers need no more than their past experience; others' lack of experience with the additional burden complicates planning.

Competition during production introduces still other management complications. Qualifying a second producer after production has begun can be a major effort. It is difficult and expensive to create a good technical data package (TDP) for the second contractor to use in starting production and even more difficult to persuade the first producer to pass along to a competitor the benefits of its manufacturing experience. Not all services have an in-house capability to evaluate a TDP. Without this capability, it is difficult to judge the adequacy of a TDP. Even with a good TDP, it frequently takes a major effort by the Program Office to help the second source through all its technical problems and into production.

Moreover, in developing a competitive source, the Program Office must work with both contractors on such things as quality control and configuration management. It is generally quite difficult to get two contractors to produce systems and components with interchangeable parts. If they do not do so, the Program Office faces additional problems in spare-parts procurement and logistics. Further, each added production line means an additional set of nonrecurring costs whenever there is an engineering change. Finally, if two production lines are created, the program manager must decide how hard to push each contractor in order to ensure the benefits of competition. A manager who pushes too hard runs the risk of driving one of the contractors out of the program.

As we have seen, one factor in program managers' reluctance to introduce competition is the perception that it will make management of their program more difficult and increase their workload. Since very
few program managers believe that they have enough well-qualified people to cover the work of monitoring one source, they are reluctant to take on even more work or to complicate matters.

It should be noted that, under special circumstances, competition can reduce the management workload of a Program Office. Under a fixed-price development program for which the prime contractor is obligated only to a “best effort,” the program manager can adopt a largely “hands-off” management style, with competition substituting for a host of conventional Program Office management controls over the contractors. This acquisition form is rarely used, because the services prefer to retain substantial control over contractor actions, even with the attendant management workload. Another possibility is for the prime contractor to act as the agent for the government in organizing competition for stipulated subsystems or components, thus relieving the Program Office of most of the burden of managing competition.

Few High-Confidence, Near-Term Benefits. Disincentives of the type described above tend to limit a manager’s enthusiasm for introducing competition. The costs of competition are short-term and clear; the benefits of competition are long-term and uncertain. The incentive structure is more likely to motivate the program manager to look for strategies that return short-term benefits. Apart from exhortations in policy documents and the conventional wisdom that competition is good for everyone, few direct incentives for introducing competitive practices exist. A program manager is unlikely to be rewarded merely for introducing competition. Real cost reductions are difficult to prove and can be masked by other factors, such as inflation. Moreover, given a typical tenure of only about three years, a program manager is unlikely to be around to receive the credit for any benefits that finally accrue.

In many cases, competition is seen as impractical. There may be few or no contractors qualified to participate in a competition, and many of them may not wish to compete. Contractors often find that the uncertainties about how a competition will come out and about the criteria to be used in the source selection are sufficient to deter them from entering a competition. Qualifying a second source can be seen as im-
practical, because the production run is too small, the tooling for the second production line is too expensive, or the design is too complex to be transferable.

**Uncertain Outcome.** Retrospective studies of second-source procurement programs have not been conclusive about the effects of competition, partly because their conclusions depend heavily on the analytic methods used. Archibald and colleagues' 1981 RAND study of the Shillelagh missile, for example, showed that analysts—by using different analytic procedures—could produce vastly different estimates of the effect that second-sourcing had on procurement costs. Those estimates ranged from a cost savings of 79 percent to a cost increase of 14 percent. Some uncertainty is inevitable: If two sources are used, one cannot know the cost that would have been incurred with only a single source. That cost must be estimated and compared with the actual cost incurred through second-source procurement.

A follow-on to the 1981 report (Birkler et al., 1990) describes five methods of estimating the cost benefits of second-sourcing. For each method, the research team estimated the hypothetical single-source cost for four air-to-air missile programs (AIM-7F, -7M, -9L, -9M). For none of these programs was any of the five analytic methods unanimous in indicating that a net cost savings accrued to the government through competition. However, three of the five methods did show a net savings for two programs (AIM-7F and AIM-9M), and four methods did show a cost increase for one procurement (the AIM-7M). In any case, it is exceedingly difficult to determine a distinct cost benefit for competition. The path not taken is always an educated guess. When the results are very sensitive to the assumptions made, one must be cautious in drawing any conclusions.