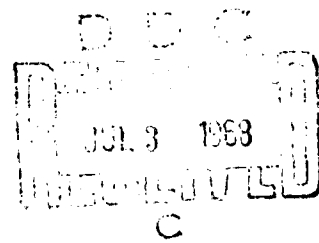


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COMPETITION IN THE PROCUREMENT OF MILITARY HARD GOODS

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I. INTRODUCTION

An unregulated market economy depends on competition as its primary guarantor of adequate economic performance. The history of economic policy in the United States demonstrates continuing efforts to strengthen and preserve market competition and to limit monopoly.

For many years the Congress has shown concern over competition -- or the lack thereof -- in defense procurement. Particular attention has been given to the salutary effects of competition on the prices paid for military goods and services. Other aspects have also received attention, such as the impact of competitive procurement on small business or on regional growth. The Congressional mandate arising out of this continuing concern can be simply stated: competition in defense procurement is highly desirable; therefore, maximize its use.

To levy a mandate is one thing, to carry it out quite another. There are severe economic, legal, and technological barriers that must be dealt with in order to increase competition in defense procurement. These barriers appear in various forms, including high R&D costs, high start-up costs for new prospective suppliers, private ownership of relevant production technology, and the difficulties of transferring technical data adequate to support competitive production.

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Portions of the first two sections of this paper were taken from R. E. Johnson and J. W. McKie, Competition in the Reprocurement Process, The RAND Corporation, RM-5657-PR, May 1968. For this and other valuable contributions, the authors wish to thank James W. McKie. Thanks are also due Ralph C. Nash, Jr. for comments and suggestions.

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If these barriers are to be overcome, it is important to gain improved understanding of the workings of defense markets and the degree they are influenced by the structure of defense industries and the peculiar features of defense products and market transactions. This Subcommittee, with its extensive background in investigations of market structure and competition, is in a position to render an important public service by exploring the relationship between procurement policy and the barriers to competition in markets for defense goods and services.

Various difficulties arise when the Government tries to obtain the benefits of competition in defense procurement. The success of the Government in creating, maintaining, or utilizing competition in defense supply markets has been variable. When it buys civilian goods and services or simple modifications of them, such as blankets, barracks, shoes, and paint, it can ordinarily buy under competitive conditions; the only peculiar element in such transactions is the sheer size of Government requirements. But when Government tries to secure the benefits of competition for weapon systems and other military supplies designed specifically for the defense mission, substantial barriers to competition are encountered. The more nearly unique an item is -- the more specialized, the more technologically advanced, the more innovative, the less fungible -- the less it resembles the competitive commodities of economic theory. Unfortunately, a sizeable and growing fraction of all procurements by the defense establishment have these characteristics in advanced degree.*

Competition in the procurement of military hard goods must be evaluated in terms of specific types of goods and services. Although each item the Department of Defense purchases has different competitive potentials and problems, it is useful to think of three general classes of military hard goods. At one extreme lie weapon systems and the initial provisioning of spare parts. Here the barriers to competition are huge. The Government has paid for most of the underlying R&D, the design

*The Services differ in consumption patterns and, therefore, in the importance of this category of purchases. Such products are particularly important for the Air Force, but all Services consume large amounts of them.

of production articles is unstable as a result of numerous engineering changes, and the R&D process generally spills over into production activities.

At the other extreme lie the non-specialized items, i.e., off-the-shelf commercial items procured for defense and items with close civilian counterparts. These items are characterized by privately funded R&D, stability of design, and low start-up costs for Government orders. Here there are few barriers to competition and the DOD has been generally successful in obtaining competition.*

A large fraction of defense products fall in the vast middle ground between these two extremes, involving the follow-on purchases of weapon system components, support equipment, and other specialized items. The Government has paid for most of the underlying R&D, designs are fairly stable by the time reprourement occurs, and there is a well-established production technology. The problem of getting competition in these cases is essentially the problem of providing access to existing manufacturing technology.

The differential role of price competition among various types of goods and services is illustrated by procurement statistics. Table 1 divides 1967 Air Force procurement by type of product and method of selecting the contractor. The procurement of complete weapon systems is separately identified. The class "other goods and services" corresponds roughly to the non-specialized items noted above. The class "other hard goods" involves primarily the reprourement of weapon system components, support equipment, and other specialized hard goods. While over half of the expenditures on the non-specialized items were competitive, less than one-third of the reprourements of specialized items and roughly one-sixth of the weapon system procurements involved price competition. The figures reflect the increasing difficulties encountered in obtaining competition when moving from commercial items or items with close civilian counterparts to highly specialized military hard goods.

* Of course, procurement difficulties are also encountered in purchasing non-specialized items. Generally speaking, however, considerable price competition has been obtained for the less specialized goods and services and the DOD, the General Accounting Office and the Congress have been effective in identifying and resolving the problems within the framework of the present procurement system.

Table 1
 AIR FORCE PROCUREMENT, FISCAL YEAR 1967^a
 (In \$ billion and %)

Contractor Selection Method	Research and Development		Procurement of Hard Goods				Other Goods and Services		Total	
			Complete Weapon Systems ^b		Other Hard Goods					
	\$	%	\$	%	\$	%	\$	%	\$	%
Price competition	.43	15.0	.41	17.2	.60	27.8	1.39	52.9	2.83	28.2
Design or technical competition	.71	24.7	--	--	.08	3.7	.07	2.7	.86	8.6
Single source after price competition	.03	1.0	.22	9.2	.07	3.2	.04	1.5	.36	3.6
Other	1.70	59.2	1.76	73.6	1.41	65.3	1.13	43.0	6.00	59.7
Total	2.87	100.0	2.39	100.0	2.16	100.0	2.63	100.0	10.05	100.0

^aCompiled from data submitted on DD Form 350, "Individual Procurement Action Report." Only procurement actions for \$10,000 or more with business firms in the United States are included. Detail does not always add to total because of rounding. The figures differ slightly from those in Directorate for Statistical Services, OSD, Military Prime Contract Awards and Subcontract Payments or Commitments, July 1966-June 1967, Office of the Secretary of Defense, Washington, D.C., p. 32, due to exclusions of non-business and overseas procurements.

^bIncludes complete aircraft, helicopters, missiles, spacecraft, complete aircraft engines, and major engine components.

In order to examine the problems of obtaining competition, we will continue to distinguish among the three classes of hard goods; i.e., weapon systems and the initial provisioning of spare parts, the reprourement of weapon system components and support equipment, and the procurement of commercial items or items with close civilian counterparts. The latter of these poses the fewest competitive problems and will be excluded from the discussion that follows. The next section will explore the problems of obtaining competition in the reprourement of specialized hard goods, and the section following it will take up the weapon system problem.

II. COMPETITION IN THE REPROCUREMENT PROCESS

BENEFITS OF COMPETITION

Before examining possible methods of increasing competition, let us consider why we might want more competition. Of course, there is a general consensus that business competition is a desirable social condition. This consensus is reflected, inter alia, in antitrust laws, procurement statutes and regulations, and in a variety of other public laws and policies. Apart from its general social merits, competition is also believed to yield lower prices to the purchaser. There is persuasive evidence that this is true for military procurements.

In this connection the GAO exhibits presented at many Congressional hearings are relevant. They show savings on the order of 25 percent or more when an item is bought competitively after a previous sole-source procurement. Based on GAO evidence and on studies conducted within the Department of Defense, Secretary McNamara has used the 25-percent estimate for determining savings in shifts to competition when reporting to Congress on his Cost Reduction Program.*

RAND studies have also probed into the cost-savings of competitive reprocurments. Table 2 shows the results of examining variations in the offer prices submitted by firms in competitive situations. The center column shows the results of nearly 2,000 cases of formal advertising in the procurement of aircraft accessories and electrical and electronic components; the third column lists the results of price competition on some of the major C-141 subcontracts let by the prime contractor, Lockheed Aircraft Corporation.

* Secretary McNamara's 1965 report goes into this subject in some detail. See U.S. Congress, Joint Economic Committee, Subcommittee on Federal Procurement and Regulation, Hearings on Economic Impact of Federal Procurement, 89th Cong., 1st Sess., U.S. Government Printing Office, Washington, D.C., 1965, pp. 12-14. Some relevant GAO reports are contained in U.S. Congress, Joint Economic Committee, Subcommittee on Federal Procurement and Regulation, Background Material on Economic Impact of Federal Procurement - 1966, 89th Cong., 2d Sess., U.S. Government Printing Office, Washington, D.C., 1966.

The important feature is the range of offer prices. The statistic denoted "d" is computed by taking the mean bid and subtracting the lowest offer price from an acceptable firm and dividing this by the low bid. Note that in roughly one-third of the cases involving formal advertising the mean bid was 50 percent or more above the low acceptable bid.

Table 2

RELATIONSHIP BETWEEN WINNING BIDS & MEAN BIDS

$$d = \left[\frac{\bar{x} - x_{\min}}{x_{\min}} \right] 100$$

d-Value (%)	Formal Advertising Situations ^a	C-141 Subcontracts ^b
0-10	416	1
10-20	308	3
20-30	279	3
30-40	210	5
40-50	142	3
50-60	127	2
60-80	183	5
90-100	79	1
>100	224	6
Total	1968	29

^aBased on data contained in S. S. Handel and R. M. Paulson, A Study of Formally Advertised Procurement, The RAND Corporation, RM-4984-PR, June 1966.

^bBased on data summarized in R. E. Johnson and G. R. Hall, Public Policy Toward Subcontracting, The RAND Corporation, RM-4570-PR, May 1965.

Keep in mind that for the most part these variations in bids occurred on contracts for standard commercial items or items common to a number of military systems.

The C-141 subcontracts are particularly interesting since product differentiation was more of a factor. About half of the cases showed a mean bid 50 percent or more above the low bid from a technically acceptable supplier. In 20 percent of the cases, the mean bid was more

than twice as great as the low bid. Although not shown in Table 2, the high bids typically exceeded low bids by a factor of 2 or 3 for the C-141 subcontracts.

The point is that one would be surprised not to observe savings of at least 25 percent on average when a supplier is chosen on the basis of price rather than some nonprice criterion, especially if the contractor knew he was in a "lock-in" or noncompetitive situation. In this connection it is important to bear in mind that the wide variation in bids shown in Table 2 occurred when firms knew they were competing against rivals; therefore, some or all of the price quotations may have been lower than they would have been under some other selection method.

PRESENT METHODS OF OBTAINING COMPETITION

Given that there will likely be substantial cost-savings from more price competition, let us examine how competition is obtained in the procurement of specialized military items. There are three major barriers that often hamper the entry of new firms into the production of specialized parts, components, or similar hard goods. One is an economic barrier created by high start-up costs. These costs are often so high that new potential manufacturers are uninterested in competing for an individual contract. The second barrier is legal. It results from the possession by the original developer of patents or proprietary rights to technical information.* The third barrier is technological and relates to the difficulty that competitive suppliers may have in producing exactly what is wanted, and to the difficulty of communicating to them technical data good enough to support competitive production. Without such technological rights and information, new firms may be unable to produce at an attractive cost, if at all.

The Government has attempted to overcome these barriers in several ways. To attack the start-up cost barrier, the DOD has been using a

* A general discussion of this problem and the policy background is contained in J. W. McKie, Proprietary Rights and Competition in Procurement, The RAND Corporation, RM-5038-PR, June 1966.

technique called multi-year procurement. In essence, it lets long-term requirement contracts that serve to assure the winner of a source-selection competition that he will have a large volume of business over which to spread costs of entry. This approach has had salutary effects, but its application is limited by the inherent uncertainty of forecasting future military purchase quantities. It also does not deal with the legal and technological barriers to entry.

There are two main techniques now in use to overcome these latter barriers. One is the establishment of standard military specifications for products or the procurement to performance or form-fit-and-function specifications rather than specific configuration or design specifications. Most competition in reprocurement is now obtained in this way. There are inherent limitations, however, on the use of this technique. One limitation is that it can result in the military having to stock a number of items that meet the same form-fit-and-function specifications but which have different physical characteristics and, therefore, require different replacement parts and maintenance procedures. Logistics costs can easily exceed the competitive benefits. Another limitation is that the establishment of standard military specifications is only practical with items having high and recurring demand and well-established physical attributes. In other words, for highly specialized or differentiated items, establishing general specifications can be infeasible or very expensive.

A second approach, which the Government has emphasized in recent years, is to try to develop competition for articles of identical design by acquiring the developer's technical data and then furnishing it to prospective suppliers when the Government decides to reprocure the item. The information or technical data is collected in a "data package" consisting chiefly or entirely of engineering drawings and associated specifications. The Government has struggled to secure data adequate for this purpose with varying success. The impact of this procedure during 1966 is suggested by a sample of Air Force purchases, the results of which are summarized in Table 3.

The total value of contracts covered in the sample was \$172 million. About one-third of this total involved price competition, which is

approximately the same as the overall experience of the Air Force Logistics Command during that year. Each of the procurements was screened to determine its competitive potential and the availability of suitable packages of technical data. Turning first to those procurements that were competitive, note that over half of them (in dollar volume) were procured to standard military specifications or to the form-fit-and-function specifications. Of more interest, it is noteworthy that less than \$14 million, or about 20 percent, of total competitive procurements could have resulted from the availability of complete data packages. In all other cases the data packages were either incomplete or simply not used.

Table 3
A SAMPLE OF AIR FORCE REPROCUREMENT EXPERIENCE^a
(In \$ million)

Reasons for Noncompetitive Procurements	
Data inadequate or incomplete	25.1
Proprietary data	5.9
Urgent procurement	35.6
Technical reasons other than data	20.2
Small dollar amounts (not screened)	21.5
Other	<u>1.5</u>
Total noncompetitive	109.8
Reasons for Competitive Procurements	
Data package complete	13.8
Procurement to military specifications or standards	37.8
All others	<u>10.8</u>
Total competitive	<u>62.4</u>
Total	172.2

^aCompiled from data furnished by Warner Robins Air Materiel Area for FY 1966. See Johnson and McKie, op. cit.

Turning to the noncompetitive procurements, it is noteworthy that the nonavailability of data packages accounted for only 25 percent of this total. In fact, the combination of reasons dealing with urgency, technical reasons other than data, and small dollar amounts accounted for the bulk of noncompetitive procurements.

Although improvement in the quality of data packages will permit some further increases in competition as time goes on, it is unlikely that the Government will be able to enlarge the sphere of competitive procurement of spare parts and components very much on the basis of the conventional data package. Especially with the more technically complex items, there seem to be some aspects of production know-how and engineering that simply cannot be transferred by means of engineering drawings and specifications. The modest amount of competition obtained through data transfer reflects the importance of complex parts and components in Air Force procurement. Of course, procurement officials recognize the need to supplement drawings and specifications with other information in order to support competitive manufacturing. Indeed, manufacturing support data is now defined to include operation sheets and machine instruction sheets; machine-loading control data; treatment data; tools, jigs, and fixture data; product, process or assembly data; and plant layout, machine tools, and work station data. As a matter of practice, however, data transfer is ordinarily limited to engineering drawings and specifications even though officials are authorized to procure supplemental data and data pertaining to items developed at private expense.

The bargaining problem in the procurement of supplemental data or data rights that may be needed to support competitive manufacturing is simply another form of the general problem of dealing with a firm on a sole-source basis. Unless all data requirements are anticipated at the outset of a program and price is established at that time, the question of price arises at a time when the developer has acquired monopoly power in the sense that he is the only possessor of all of the technology required to produce the item at an attractive cost. The firm is therefore in a position to extract monopoly rent regardless of whether the Government buys production articles or simply technology.

To sum up, it appears that engineering drawings and specifications and underlying data rights often fail to provide access to technology sufficient to support competitive manufacturing. The Government stands to gain little by procuring supplemental data and rights if it must do so after the developer has acquired monopoly power over the production of the item.

There are two basic issues. One concerns the embodiment of technology, i.e., the nature and form of the knowledge that must flow to a new supplier. The other concerns the techniques used to assure an orderly flow of knowledge. Fortunately, the arrangements and techniques used commercially for the transfer of production technology are instructive and contain implications for defense procurement policy.

INCREASING COMPETITION IN REPROCUREMENT

Improved access to aerospace production technology appears to be a prerequisite to any major increase in competition. There is at least one policy innovation that would provide better access to technology and supplement present technical data policies. This innovation involves provision for the licensing of production technology as a precondition of Government R&D contracts, under which the Government could designate a licensee at the reprocurement stage if transfer were deemed desirable. The nature and flow of technology would be patterned after commercial techniques and arrangements to the extent possible.

Commercial transfers of technology through licensing have grown by huge proportions during the past decade. The magnitude and growth of international licensing by U.S. firms are shown in Table 4. The table does not distinguish between license payments for patent rights and payments under "know-how" licenses. However, most of the increase in royalty payments over the past decade, and a substantial fraction of the royalty payments, appear to have resulted from licenses involving know-how.* Know-how licenses typically call for royalty payments of approximately 5 percent of the value of licensed production. While separate

*The distinction between patent licensing and know-how licensing is somewhat arbitrary because know-how licenses cover not only the technology but also any underlying patent and proprietary rights. In the case of know-how licensing, technology is viewed as a principal ingredient even though underlying rights to the technology are included. An examination of the content of 1205 foreign licenses of 55 U.S. Corporations showed that know-how was included in 515 cases. The licensing of patents or trademarks accounted for the remainder. For details, see J. N. Behrman and W. E. Schmidt, "New Data on Foreign Licensing," Patent, Trademark, Copyright Journal of Research, Education, Vol. 3, 1959, p. 370.

data on know-how licenses are not available, probably on the order of \$1 billion in royalties was paid to or by U.S. firms under these licenses during 1966 -- payments that resulted in roughly \$20 billion worth of licensed production. This amount of licensed production

Table 4
INTERNATIONAL RECEIPTS AND PAYMENTS OF ROYALTIES
BY U.S. CORPORATIONS, 1957-1966
(In \$ million)

Year	Receipts from Foreign Firms			Payments to Foreign Firms		
	Affiliated Firms	Other Firms	Total	Affiliated Firms	Other Firms	Total
1957	238	140	378	26	22	48
1958	246	168	414	26	25	51
1959	348	166	514	24	28	52
1960	403	247	650	27	40	67
1961	463	248	711	34	46	80
1962	580	257	837	57	43	100
1963	660	267	927	61	50	111
1964	756	301	1,057	67	60	127
1965	924	301	1,225	67	66	133
1966	1,045	271	1,316	64	73	137
Total	5,663	2,366	8,029	453	453	906

SOURCE: U.S. Department of Commerce, Office of Business Economics.

currently exceeds the total procurement of hard goods by the defense establishment.

U.S. aerospace firms have been particularly active in the field of know-how licensing. Literally thousands of airframes, aircraft engines, and accessories have been produced by firms not involved in R&D and initial production.* Methods by which technology is transferred between firms varies a great deal. However, in the transfer of

*Table 5 summarizes data on aircraft co-production programs.

production know-how for airframes and aircraft engines, a great deal of information on production techniques and processes is usually provided.* Tool design information (or actual tooling), production layout and process information, and technical or engineering assistance are almost always included in addition to engineering drawings. In a recent survey, officials of a number of aerospace firms were asked to describe policies and practices relating to transfers of manufacturing know-how under license.** One question that was raised concerned the role of technical assistance agreements used in conjunction with licensing. Almost without exception the responses indicated that various forms of engineering or technical assistance were customary whenever the technology dealt with a complex product. In short, the commercial experience indicates that manufacturing technology is embodied in a good deal more than drawings and specifications.

To sum up, U.S. aerospace firms have had vast experience in transferring production technology to firms that were not engaged in the original R&D efforts. In addition to engineering drawings and specifications -- the principal instruments of transfer used by the Government in the dissemination of procurement data -- commercial programs ordinarily call for the transfer of tool design information or actual tooling, production layout and process information, and engineering or technical assistance. These added elements in commercial transfers are generally considered essential in order to give the licensee proper access to the production technology.

Any substantial increase in competition in the procurement of weapon system components, accessories, support equipment and other specialized items will require improved access to the developer's technology by other prospective suppliers. It is particularly important to provide more complete information about production techniques and

* A discussion of techniques by which know-how was transferred between U.S. and Japanese firms in various co-production programs is provided in G. R. Hall and R. E. Johnson, Aircraft Co-Production and Procurement Strategy, The RAND Corporation, R-450-PR, May 1967.

** This survey was conducted in 1967 under RAND auspices by Ralph C. Nash, Jr., Associate Dean, National Law Center, George Washington University.

processes that reflect the developer's accumulated learning. The adaptation of commercial licensing techniques to defense procurement under a policy of directed licensing is a promising way to improve access to technology.

As an instrument of defense procurement policy, directed licensing could be limited to situations in which the original producers were unable or unwilling to compete successfully for follow-on production contracts. Because a firm involved in R&D and early production possesses pricing and other advantages over other prospective suppliers, interfirm transfers of technology under directed licensing are unlikely in most situations. For the Government to obtain some of the benefits of competition, however, it would be unimportant whether production responsibility were actually transferred; the benefits would derive from the developer's awareness of the threat of competition for follow-on production contracts.

In addition to competitive benefits, directed licensing using commercial transfer techniques could offer other advantages. First, it would help reduce Government involvement with contractors, not only as a result of increased competition but also by reducing the Government's role as an intermediary in the transfer process. Technology transfer would be largely an interfirm matter governed by commercial practice and the law of contracts. It would also lessen or avoid many disputes over data rights -- the proprietary issue. Finally, some of the data-management and transfer costs of present data policies would be avoided, while others would not be incurred unless the buyer were able to realize savings from the transfer that were over and above the transfer costs.

In sum, policies that provide better access to existing production technology will create new opportunities for competition in the procurement of specialized hard goods. Because of the existence of relevant production technology, this method of obtaining competition should prove less costly than competition through the creation of substitute products. The latter method will often require the duplication of Government-funded R&D, the costs of which are likely to be large in relation to the costs of technology transfer.

III. COMPETITION IN WEAPON SYSTEM PROCUREMENT

THE MARKET FOR WEAPON SYSTEMS

A distinction was made previously among three classes of defense goods and services. For the first of these, the procurement of commercial items and items with close civilian counterparts, there is at present a high level of competition in defense markets and the competitive problems encountered are similar to those in most other commercial markets. In contrast, unusual barriers to competition are present with the other two classes of goods and much less competition is currently obtained.

The previous section was devoted to one of these classes -- procurements of specialized hard goods. Here the major barriers to competition occur because the Government must finance much of the R&D for specialized military items. Unless the Government is willing to incur duplicate R&D costs, it cannot obtain competition among substitute products. In the absence of close substitutes, competition can only result from two or more firms being in a position to produce items to a given design. After the R&D and initial production, it becomes necessary to provide new prospective suppliers with proper access to existing production technology if effective competition is to be obtained. As noted earlier, there are legal, economic, and technical barriers to this type of competition.

These same barriers apply to the third class of military products -- weapon systems and the initial provisioning of parts and support equipment -- with the addition of still other obstacles. Designs are far less stable as a result of numerous engineering changes, which limits the use of technology diffusion as a method of obtaining competition from new prospective suppliers.

Another important obstacle to competition in weapon system procurement arises from the way that weapons acquisition programs are organized, integrated, and coordinated. The difficulties inherent in trying to procure complex weapon systems, particularly when technology is changing rapidly, often have led the Government to use the same contractor

throughout an entire weapon system program. Ordinarily, one firm has prime-contractor responsibilities that span an entire weapon system program, from engineering development through final production. This procedure permits programs to be managed as a single unit so that decisions made for one part of the program can be related to those made in connection with other portions of the program. Moreover, using the same prime contractor throughout a program clarifies authority and relieves the Government from having to worry about transferring program responsibility and relevant technology among firms. Unfortunately, this procedure has the undesired and undesirable side effect of constraining the extent of competition in weapon system procurement.

This organization of acquisition programs produces an unusual form of vertical integration within the weapon system industry.* A weapon system acquisition program can be divided into a number of stages, with completion of each stage being a prerequisite to subsequent stages. The results of each stage become inputs for the next stage. The division of the stages depends on the points where important managerial decisions need to be made about the program, but a typical division would include R&D, production of the initial items that enter service inventories, and the manufacture of additional units of the system for replacing or increasing inventories. At various points in this chain there will be market transactions, i.e., the Government and a firm will sign a contract for some goods or services. Several contracts will be let and usually the same firm will be a party to all contracts. The program is under the responsibility of the same firm or firms from the start of engineering development until the last piece of hardware is delivered to the

*The term "weapon system industry" will be used here as a general classification of those firms that specialize in the development and production of complex military weapons. For more precise characterizations of this industry, see M. J. Peck and F. M. Scherer, The Weapons Acquisition Process: An Economic Analysis, Graduate School of Business Administration, Harvard University, Boston, Mass., 1962, pp. 98-159; and H. O. Stekler, The Structure and Performance of the Aerospace Industry, University of California Press, Berkeley and Los Angeles, Calif., 1965, pp. 25-41. We are primarily concerned with the subset of firms usually grouped together as the aerospace industry since this is the industry that receives most weapon system procurement dollars.

Government.*

The contractor for the system as a whole has been described as vertically integrated. By this is meant that his responsibilities extend all the way from R&D through successive stages of production; during the entire process the responsibility for a system seldom passes between firms. It seems appropriate to characterize this situation as vertical integration, but it differs from vertical integration in most other U.S. industries.

The extent of vertical integration in weapon system development and manufacture may not be unusual if integration is measured by the proportion of value added to sales of the firm selling the product to the final consumer. A large share of the price of a weapon system is accounted for by the activities of vendors and subcontractors of the prime contractor. However, this is precisely the point. For any specific weapon system, the product does not pass from firm to firm by means of market transactions with each "owner" of the system making a contribution to the value added. Instead, a single firm is the prime contractor for all stages, and other firms make their value-added contributions through providing goods and services to that firm as subcontractors or vendors.** It is this vertical control on responsibility

*An exception to this generalization should be noted. The prime contractor may be furnished material directly by the Government (GFAE), for example, engines. The firm that holds the contract for such items is responsible for that phase of the program, and the main prime contractor is responsible only for integrating the GFAE into the system as a whole.

**Semantic problems abound in the discussion of weapon systems acquisition programs. Most programs have had a single prime contractor endowed with extensive integration and control authority, and responsible to the Government for the entire system. All other participating firms have held subcontracts with the prime contractor. In some programs, however, there have been associate contractors; that is, several firms have held Government contracts and have shared the prime contractor responsibility. Also, the division of responsibility between the Government and the prime contractor has differed among programs.

These differences are not important here, however. We are not concerned with the division of responsibility at any single stage of a program, but rather with the phenomenon that the participants and their responsibilities at early stages in a program extend throughout the program. That is, this statement is concerned with the division of responsibility over time rather than the division of responsibility at any single part of a program.

for the weapon system that distinguishes the industrial organization of the weapon system industry from the usual manufacturing industry.

This industrial organization has a number of impacts on the characteristics of the firms and on Government procurement policy. One result is that the firms must be able to perform a wide range of functions. A weapon system producer must stand ready to sell to the Government research, development, manufactured hardware, integrative and management services, as well as other goods and services. On the Government side, this type of buyer-seller relationship means that for contracts let after a firm has been designated as the prime contractor for the program, the Government must negotiate in an environment in which it has no readily available alternative sources of supply. This environment makes competitive forces of little help in determining the proper price for the system or in stimulating efficiency during production.

It is important to emphasize that competition in weapon system procurement should be studied in terms of the way acquisition programs are organized and that this approach differs from the customary methods of analyzing competitive problems. Traditionally, competition is studied by examining the structural characteristics of markets; i.e., demand characteristics, the number of firms, their relative sizes (concentration), and the entry conditions. Factors such as economies of scale, capital requirements, degree of product differentiation, and the role of advertising usually determine the barriers to the entry of new firms.

For weapon systems, the structural conditions necessary for workable competition are generally present. On the demand side, the Government buyers are professionally trained and purchases are based largely on technical or economic criteria. Therefore, many of the competitive problems encountered in civilian markets where merchandising and advertising are important weapons of rivalry are of small importance.* As to the number of suppliers, about as many firms are technically and

*"Brochuremanship" and "gold-plating" in defense project proposals are significant problems. However, they represent a different style of product differentiation than is found in many civilian consumer markets.

managerially capable of manufacturing a given article as are usually encountered in most industrial markets. Likewise, the level of concentration in major defense markets is about the same or slightly lower than the average nondefense industrial market.* As to the barriers of entry, these appear low. Economies of scale are not a major consideration. Capital requirements are unusually low, in part because of Government progress payments and public policies with respect to reimbursing investment and furnishing facilities and equipment. Moreover, product differentiation, at least of the usual type, does not enter the picture since the Government buys to physical characteristics and specifications rather than slogans.

In short, the usual indicators of market structure suggest market performance quite different from that actually observed in weapon system production. Certainly one would expect substantially more competitive source selections than are shown in Table 1. Recall that less than one-sixth of the Air Force's weapon system procurement dollars were spent in an environment of price competition.

The explanation of this apparent inconsistency between industry structure and competitive performance is simple. Weapon system production is unlike most manufacturing industries in that competitive problems do not stem from too few firms, too much concentration, large capital requirements and similar market-structure imperfections. Instead, the difficulties arise because the developer's responsibility for a weapon system often extends throughout a program, including stages to be contracted for later. The recipient of the initial R&D contract in effect possesses a product distinct from those of all other firms. Upon receipt of the first contract in a program he becomes the only

*After a thorough statistical examination of Air Force procurements, Weidenbaum found that seller concentration was somewhat lower in Air Force markets than in United States manufacturing generally. He also concluded that: "On balance, statements so frequently made concerning the larger degree of concentration and monopoly in military and related government procurement do not appear to be supported by the data publicly available." See M. L. Weidenbaum, "Competition in High Technology Markets," Working Paper 6713, Department of Economics, Washington University, St. Louis, Missouri, 1967, pp. 18-19.

relevant source for subsequent purchases related to the programs. He has acquired a differentiated product in the sense that if the Government wants to buy that system or its related hard goods it must go to him, and competitive difficulties stem from this unique form of product differentiation.

ALTERNATIVE POLICIES

There are two basic routes by which the amount of competition in weapon system procurement might be increased. One route is to generate a number of competing systems within the existing weapon system acquisition procedures. In terms of the cost-effectiveness of meeting a specified military requirement, these systems would be reasonably close substitutes. Thus, if the system were an aircraft to be used as a fleet interceptor, the Navy might try to insure that another airframe contractor had available a satisfactory alternative fleet interceptor. In bargaining with the company producing one of the systems, the Navy would always be in the position of having a satisfactory -- though maybe not preferred -- alternative product in the event that a satisfactory contract for a particular aircraft proved unobtainable.

In the past this form of product competition in weapon systems may have been an important influence on the performance of the weapon system industry. In recent years, however, the extremely high R&D costs required to develop a military system, high production start-up costs, and the added operating costs of supporting additional systems, have led military policymakers to judge this approach to be prohibitively expensive. Indeed, recent DOD management emphasis has been strong in the opposite direction. To achieve economy, the DOD has attempted to insure that new weapons demonstrate their cost-effectiveness advantage over existing weapons and that the minimum number of systems are developed to fill the same or similar requirements.

In short, obtaining more competition through the availability of alternative systems appears unlikely in the present environment.* This

* It may be possible to get some of the advantages of substitute systems through competing development programs where only one system enters production. Such a strategy, to be discussed later, would avoid duplication of production start-up and subsequent operating costs.

implies that if competition is to be increased it will be necessary to obtain alternative suppliers for the same system. There are several procurement strategies that permit this.

Weapon system acquisition strategies differ in the way various stages of activities are related through contracts and in the source-of-supply options available at various points in a program.* Figure 1 is a schematic representation of six acquisition strategies.** Solid horizontal lines represent points where a choice among alternative prime contractors is possible. Points where new contracts are let are indicated by breaks in the vertical lines. A simple three-stage division of activities is shown consisting of development, initial production and follow-on production.

A very significant point in any program is the end of the contract definition period. This point is shown in Figure 1 as the first important source-selection opportunity, i.e., the initial branching of the vertical lines. The contract definition phase is intended to verify preliminary design and engineering studies and to plan the management and contracting arrangements for the program.*** Before the contract definition stage, a number of contractors may be involved in relevant studies, research, and concept formulation. With the start of the contract definition stage, a few contractors address themselves to concrete planning. Contract definition ends with the Government's conditional decision to proceed with the program and its selection of a prime contractor.

The end of the contract definition phase is shown as a shaded band, to indicate that contract definition is an imprecise concept and it may end at a time when there is still considerable uncertainty about the

* Weapon system acquisition strategies are discussed in more detail in Hall and Johnson, op. cit. For background on competition in weapon system procurement, see Peck and Scherer, op. cit., and Weidenbaum, op. cit.

** Professor Ralph C. Nash, Jr. suggested this diagram to us.

*** For more on contract definition see R. G. Alexander, "Concept Formulation and Contract Definition," Defense Industry Bulletin, Vol. 3, Oct. 1967, pp. 1-4.

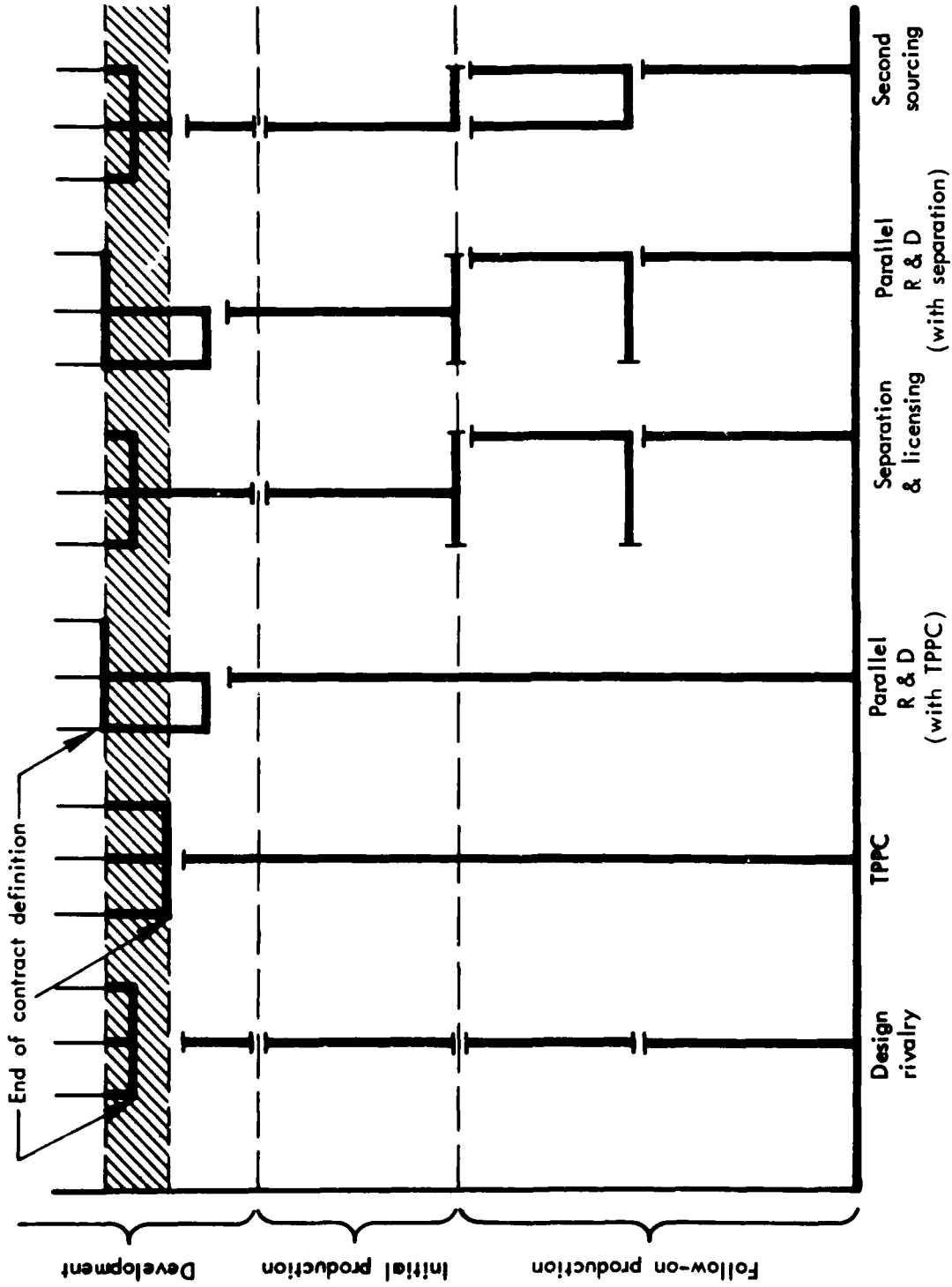


Figure 1—Acquisition strategies

nature of the system to be developed and other aspects of the program. Procurement strategies may differ in the amount of effort and time devoted to resolving product and program uncertainties before the selection of a prime contractor.

THE CONVENTIONAL STRATEGY - DESIGN AND TECHNICAL RIVALRY

Most weapon system source selections during the past two decades have been made on the basis of so-called design and technical rivalry. This designation is something of a misnomer in that solutions to meeting operational requirements or solving technological problems are not usually supported by demonstration hardware or other convincing physical evidence. The important aspect of the conventional strategy is that on the basis of relatively little precise information the Government selects a contractor for an entire acquisition program. While a contract definition phase is now being employed in conjunction with this strategy, an early conclusion of the phase is shown in Figure 1 to indicate that this acquisition strategy can accommodate considerable uncertainty at the time a prime contractor is selected.

The initial contract, the one for which the Government has source-of-supply options, ordinarily covers only part of the program envisioned. On the basis of technological and strategic developments as the program progresses, other contracts for different parts of the program are let. These may involve more R&D, initial production of end items and spare parts, and perhaps follow-on production. All the contracts, however, go to the contractor selected after the contract definition phase. They are all follow-on, single-source contracts awarded without any new source-selection competitions.

The design rivalry strategy has the advantage that it does not legally obligate the Government for expenditures beyond those covered in the contract for the immediate part of the program authorized. This permits the Government to be flexible with respect to uncertainties. On the other hand, since the developer knows he will receive any production contracts, expenditures can be made early in a program in anticipation of later needs. Tooling, for example, can be constructed at the R&D phase with an eye to later quantity production.

Another advantage to the Government is that because the entire program is under the cognizance and control of the same prime contractor, he can insure that technological knowledge gained during one stage is transferred to those units within his firm responsible for later stages. The Government need not be concerned about insuring that knowledge and information acquired in one part of the program is transferred to parties involved in other parts of the program.

There are three difficulties with this strategy. First, in selecting the recipient of the initial development contract, the Government cannot merely choose the best development organization. Instead, it must keep in mind manufacturing as well and select the firm with the best overall capability. The strategy works against firm specialization.

Second, with this strategy R&D is not viewed as an end in itself but as the prelude to more lucrative manufacturing contracts.* This situation creates intangible pressures that make it difficult to terminate less useful projects. Also, since early in the program the contractor begins preparation for production, cancellation of the program or changes in the configuration of the system frequently lead to the scrapping of tooling, plans and so forth. This can prove extremely expensive.

Third, with this strategy most procurement dollars are spent under follow-on contracts without even technical rivalry. If cost-saving benefits from competition in weapon systems are anything like those in the reprourement area, this results in a substantial increase in weapon system costs.

The uncertainty inherent in weapon system development presents the DOD with three options. The first is to regard competition as infeasible or uneconomic at all stages of a program, let the initial contract be a design rivalry, and let all other contracts (accounting for most of the expenditures) as noncompetitive follow-ons. The second option is to attempt to resolve the uncertainties early enough in the program to permit effective price competition at the R&D stage. The third option is

* For an exposition of this point by an aerospace industry spokesman, see M. Meyerson, "Price of Admission into the Defense Business," Harvard Business Review, July and August 1967, pp. 111-123.

to regard uncertainty resolution at the R&D stage as infeasible or uneconomic but to attempt to generate competition later in the program.

The DOD has chosen the first option for most programs since World War II. For some programs, however, the other approaches have been used. Some of the strategies shown in Figure 1 permit competition at the development stages, while others facilitate competition at later stages in programs. They will be briefly described here.

TOTAL PACKAGE PROCUREMENT*

One way to obtain competition at the development stage is to use the total package procurement concept (TPPC) recently applied to the procurement of the C-5 transport aircraft. This strategy requires elaborate product definition such that uncertainties can be sufficiently resolved to permit a single contract for the entire program to be let with price competition. This is indicated in Figure 1 by the source selection at the end of contract definition. With TPPC, all procurement dollars after contract definition are spent in a competitive environment. Follow-on contracts are eliminated. Also, a single contractor has coordination and integration responsibility for the entire program. Transfer of technology among stages is an interfirm matter.

The main problem with applying TPPC is that technological and strategic uncertainties must be largely resolved before the package contract is let. Even for relatively "certain" projects, such as the C-5, this can prove quite expensive. For more advanced systems with greater technical uncertainty, or in situations where there is considerable strategic uncertainty, resolving uncertainties might be impossible or at least prohibitively expensive.

A possible complication is that TPPC requires the Government to adopt a "hands off" policy towards the system once the contract is let.

*The concept is described in R. H. Charles, "Effective Competition: A Key to Government Procurement," Defense Industry Bulletin, Vol. 1, October 1965, pp. 3-4; R. E. Lee, "Total Package Procurement Concept," Defense Industry Bulletin, Vol. 2, August 1966, pp. 11-12, 20; and Office of the Assistant Secretary of the Air Force (Installations and Logistics), "Total Package Procurement Concept," May 10, 1966.

The contractor has a competitively priced contract for a tightly specified system and revisions have to be authorized and funded by change orders. With extensive changes, to be priced separately by negotiation, the Government will find itself back in the position of negotiating with a single source -- the position it attempted to avoid by using TPPC. Of course, for a system without much uncertainty, changes should be few and it is desirable to minimize the Government's involvement with the production. If changes are inevitable, however, either TPPC complicates the process of making them or the changes dilute the usefulness of TPPC.

In short, TPPC is an extremely effective way to achieve competition in weapon system projects with relatively little uncertainty. For projects with a high degree of uncertainty, however, it could be infeasible or expensive to apply.

PARALLEL DEVELOPMENT WITH TPPC

Another approach to generating competition at the development stage is the parallel development strategy.* In a sense, this strategy is an attempt to gain some of the advantages of competing systems without the costs of actually having a number of similar operational systems in Service inventories.

The basic concept involves supporting two or more prospective suppliers through the development stage until demonstration hardware has been produced. One possible form of parallel development would be to combine it with TPPC; this strategy is the third shown in Figure 1.

Demonstration hardware would presumably resolve enough technical uncertainty to permit accurate cost-effectiveness evaluation of the competing systems. The winner of the cost-effectiveness competition would be awarded a package contract for the remainder of the program along the lines of TPPC. Combining parallel development with TPPC would appear to permit obtaining competition for important parts of a program even in the face of substantial uncertainty.

* The case for a parallel development strategy is developed in B. H. Klein, W. H. Meckling and E. G. Mesthene, Military Research and Development Policies, The RAND Corporation, R-333, December 1958.

The principal obstacle to parallel development is that it adds to the total cost because of the duplicated R&D activities. At least this seems to be the main reason why this approach has not been used in recent years. The costs and benefits of parallel development and other prototype approaches have received relatively little study, although there are reasons to think that the cost might be lower and the benefits higher than commonly believed.

The TPPC and parallel development, either applied separately or in combination, attempt to generate competition in weapon system procurements by reducing uncertainty at the R&D stage. There are other strategies that take an alternative route and attempt to generate competition later in the program during the production stage.

SEPARATION AND LICENSING

One possibility for generating competition in weapon system manufacturing is separation and licensing.* The idea is to open a program to competition at one or more points during the production stage, aided by technology licensing of the sort previously discussed in connection with the reprocurement problem. Technology licensing has been an important feature in various co-production programs under which aircraft and missiles have been produced by firms that were not involved in the underlying R&D. Provisions that might permit licensed production were also written into the contract for the Phoenix missile system intended for the Navy version of the F-111.**

Separation and licensing represents one polar approach to competition in weapon system procurement and TPPC represents the other. With the conventional procurement strategy there are a number of contracts but only one source selection. TPPC deals with the problem by collapsing the many contracts into a single contract, for which there is only one

* In Hall and Johnson, op. cit., this strategy is described in more detail and evidence about its costs and benefits is provided.

** This contract clause is described in R. C. Nash, Jr. and I. Kayton, Patents and Technical Data, Government Contracts Program, George Washington University, Washington, D.C., n.d., pp. 45-46.

competitive source selection. With separation and licensing there may be several contracts, and therefore several opportunities for competitive source selection.

The separation and licensing strategy could be tied to a conventional R&D effort or to some other development strategy. A clause in the development contract would give the Government the right to designate another firm as the developer's licensee for production of the system. Contract negotiations would include fees for licenses of patents, proprietary rights, know-how, and any other technology a new manufacturer might require. Provisions for technical assistance would also be included.

After the system was developed and produced in at least limited quantities, a source selection would be conducted for a follow-on production contract. If some firm other than the developer were selected, the developer would receive royalties and assistance payments for his contribution.

In Figure 1 this strategy is depicted as a single line, to indicate that only one firm is involved at any point in the production phase of the program. Points at which competition might occur for follow-on production are indicated by horizontal lines.

This strategy has four attractive features. First, there is competition for most of the production program. Second, the Government need not be involved closely with technology transfer; this is an interfirm matter covered by law and by conventional technology licensing procedures. Third, quantity production commitments and source-of-supply decisions can be postponed until late in an acquisition program. Fourth, only one system need be developed and most of the duplication of tooling required by second sourcing is avoided.

On the adverse side, interfirm technology transfers incur added costs and impose administrative burdens. Also, the contracts must be carefully written to insure the flow of technology between firms and to give the developer adequate incentive to transfer his know-how.

There has been relatively little licensed production in domestic military programs for major weapon systems, but it is a common practice in the international market. Aerospace firms have become experts in

exporting know-how and establishing other firms in the business of manufacturing systems the former have designed. Table 5 presents figures on international licensing of complete aircraft systems. It shows that more than 10,000 aircraft have been produced by firms not involved in the underlying R&D work. These aircraft have a total value of over \$5 billion. Case studies indicate that the costs of transferring the technology have not been prohibitively high,* implying that this could be a way to generate more competition in weapon systems at an attractive cost.

Table 5
INTERNATIONAL PRODUCTION OF AIRCRAFT UNDER LICENSE, 1950-1967^a
(In \$ million)

Location of Licensor	Location of Licensee	Bombers	Fighters	Other Military	Helicopters	Civilian Transports	Total
U.S.	Europe	--	(1,393) \$2,046	(100) \$3	(2,183) \$294	--	(3,676) \$2,343
U.S.	Other	--	(2,532) \$1,002	(568) \$241	(570) \$94	--	(3,670) \$1,337
Europe	U.S.	(403) \$484	--	--	--	(278) \$148	(681) \$632
Europe	Europe	--	(899) \$365	(699) \$109	--	--	(1,568) \$474
Europe	Other	(48) \$372	(699) \$109	--	(100) \$20	(44) \$66	(861) \$567
Total		(451) \$856	(5,493) \$3,522	(1,337) \$353	(2,853) \$408	(322) \$114	(10,456) \$5,353

NOTE: Numbers of aircraft shown in parentheses.

^aIndividual license agreements underlying these and other programs are listed in Johnson and McKie, op. cit., Appendix C.

*This seems to have been the experience for transfers to Japan of the manufacturing technology of the T-33A, F-86F, and F-104J. Hall and Johnson, op. cit., describes these programs and analyzes the transfer costs for the F-104J.

PARALLEL DEVELOPMENT WITH SEPARATION AND LICENSING

A combination of strategies that might have considerable competitive potential would be parallel development and separation and licensing. As Figure 1 indicates, after the initial production stage the procurement technique would be the same as just discussed for the separation and licensing strategy. Before initial production, however, there would be parallel development with at least two contractors carried beyond contract definition to a point of demonstration hardware.

This combination would be preferable to parallel development with TPPC in programs with extensive uncertainty. It is easy to imagine a system of such an advanced nature that it would be impossible to resolve uncertainties by means of contract definition sufficiently for a single package contract. In such a case, it might be advantageous to let competitively a contract covering only initial production and a small amount of development and later open up the program to further competition using the separation and licensing technique.

Parallel development with separation and licensing would have advantages over the simple separation and licensing strategy in cases where it appeared desirable to have competition during the R&D stage. Rather than having only one supply alternative after contract definition, the Government would have at least two potential suppliers through most of the remaining R&D period.

The main disadvantages of this combined strategy are those found in the two strategies when employed separately. Opponents of these strategies argue that the cost of generating the competitive opportunities would outweigh the benefits. There is some evidence that neither the prototyping nor separation is as costly as is commonly believed. More experimentation with the strategies is needed to establish a convincing case either way.

SECOND SOURCING

Another method for obtaining competition of the reprocurment level is "second sourcing." The Navy has successfully applied this technique to a variety of programs for small missiles, target drones, aircraft engines and torpedoes.* Usually the underlying R&D is performed by a single firm, although in some instances the Navy has designed the weapon in-house. The developer (if Navy-developed, the original producer), furnishes the Government with drawings, specifications and other technical information. The Government performs enough system engineering to validate the data and transfers at least portions of the technology to the new supplier.

During the initial production run or during follow-on production, or both, there is some form of competition. Sometimes this is negotiated price competition but there have even been advertised procurements. The new or second source sets up a production line. Production by the original and second source may overlap in time, two production lines may be maintained through much of the program, or the original source may drop out of the program with the award of the contract to the new supplier. The second sourcing example shown in Figure 1 assumes a privately developed system with only one producer during the initial production phase and two "hot" production lines during the early part of the reprocurment period.

This strategy has the advantage that only one development program takes place yet competition is obtained sometime during production. Also, the Government need not make long-term procurement commitments, but can procure on a year-to-year basis, generating competition through the dissemination of data packages.

There are two disadvantages. First, the Government must engage in extensive system engineering and technology control in order to warrant the design given the second source. This is expensive and requires a sizeable, skilled staff. Second, there is duplication of tooling and

*Some second-sourcing experience is discussed in Stekler, *op. cit.*, pp. 190-192.

other set-up costs. If production runs are large enough to absorb these costs, this may be a negligible consideration. With smaller production runs, such as are typical with ships and aircraft, such costs may be prohibitive.

INCREASING COMPETITION IN WEAPON SYSTEM PROCUREMENT

Increasing the extent of competition in weapon system manufacture is a more complex matter than increasing competition in the reprocurement area. For reprocurements, because designs are relatively fixed and at least one firm possesses the underlying manufacturing technology, the main requirement is dissemination of technology. Improved techniques for providing excess to technology might usefully supplement current practices of generating competition through dissemination of engineering drawings and specifications. Enlarging the sphere of competition would alter the way the Government does business, of course. Nonetheless, it would not necessitate major changes in proeurement policy.

It is a different matter with weapon systems. The number of opportunities for meaningful source-selection decisions and the times in the program at which they occur depend upon the particular weapon system acquisition strategy used. In other words, competition depends upon how the acquisition program is organized and managed. Applying the appropriate acquisition strategy is the key to maximizing the benefits of competition in weapon system procurement.

It follows that the usual instruments of antimonopoly policy in obtaining and maintaining competition in weapon system procurement will be of secondary importance. Antitrust and antimerger activity may have supporting roles in obtaining or maintaining competition in weapon system production; but since competition is not primarily a matter of industrial structure, such as the number and size of firms, the impact of the antitrust laws is necessarily marginal.

The Government's acquisition strategy or mix of strategies is a much more basic determinant of the degree of competition in the weapon system industry. Each of the alternatives to the conventional approach -- TPC, second sourcing, parallel development, and separation and licensing -- has special merits, limitations and conditions for application. No

single strategy is likely to increase competition in weapon system production greatly, but an effective mix of strategies could do so.

Determining the best mix will be difficult. Experience to date has been too limited to indicate the precise conditions under which each is preferred. Because obtaining more competition in weapon system production will require an assortment of techniques, it is vital to prevent any one procurement technique from acquiring the aura of orthodoxy. In sum, increasing the level of competition in defense procurement will require innovations in the way system acquisition programs are organized. Innovation is always challenging and particularly so when it involves organizations as large as the military Services and the leading defense contractors.

It was noted earlier that in defense procurement of commercial items or items with close civilian counterparts, competition is either readily available or else can be obtained at a small cost. This statement has focused on the problems of obtaining more competition in the procurement of the specialized military items. With these items, competition is not automatically forthcoming, and the costs of overcoming various economic, technical, and legal barriers to competition may be substantial.

Statistics presented earlier showed substantially less competition in the procurement of weapon systems than in the reprocurement of weapon system components, support equipment, and other specialized hard goods. This difference in the amount of competition obtained also reflects the relative difficulty and cost of generating competition in the two cases. Reprocurement occurs at a time when designs are relatively stable, established production technology is in existence, and the transfer of this technology to a new supplier may be accomplished at modest cost. For weapon systems, however, the generation of competition will likely require the duplication of certain R&D costs or the transfer of technology that is still evolving. Regardless of the techniques employed, the cost of generating competition in weapon system procurement will often be substantial -- considerably more than in reprocurements. Moreover, situations will arise where the costs of creating competition will exceed the competitive benefits. For each program, then, there should be an evaluation of the costs of obtaining competition in relation to the likely benefits in order to maximize the advantages of competition.