STRATEGIES FOR DIVERSIFICATION OF DEFENSE/SPACE COMPANIES

By
Murray L. Weidenbaum
Professor of Economics
Washington University

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PREFACE

This study is designed to help foster, in a modest way, the utilization of space and related defense technology in other public sector and in commercial fields. The specific approach taken is to provide a planning strategy for space and defense contractors who attempt to utilize their specialized capability in these other fields.

A substantial appendix to the report describes the diversification experiences of large space and defense contractors.

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ABSTRACT: This study develops specific guidelines for defense/space companies desiring to utilize their specialized capabilities in other markets. The positive approach presented consists of a blend of the lessons from past defense/space marketing and diversification experiences and the concepts and methodology of modern business planning. Five areas of potential market diversification are examined: surface transportation, hydrography or water systems, communication systems, atmospheric research and control, and area development. An enumeration is made of the specific factors to be analyzed in selecting one or more of these fields for defense/space industry diversification.

ABOUT THE AUTHOR: Murray L. Weidenbaum is Chairman of the Department of Economics and Director of the NASA Economic Research Program at Washington University, St. Louis, Missouri. He has previously served as the Corporate Economist for the Boeing Company and Executive Secretary of the President's Committee on the Economic Impact of Defense and Disarmament.

Mr. Weidenbaum has authored various studies on defense and space marketing, including The Military Market in the United States, published by the American Marketing Association in 1963. He received his Ph. D. from Princeton University. This research was supported by NASA Grant NsG-342 to Washington University.

STRATEGIES FOR DIVERSIFICATION OF DEFENSE/SPACE COMPANIES

The purpose of this paper is to offer specific guidelines for defense/space contractors that wish to utilize their specialized capabilities to diversify into other markets. From the viewpoint of the country as a whole, such diversification seems highly desirable. It would represent a major method of accomplishing the transfer of space and defense technology to the commercial and non-defense economy, which is so highly desired as a matter of national policy.[1]

From the viewpoint of the individual company, such diversification also could be extremely beneficial. It would broaden the customer base, thus reducing dependence on two fairly closely related government markets -- defense and space. Also, it would introduce a different set of uncertainties -- the private sector business cycle in addition to the public sector budget cycle. Although not necessarily, the fluctuations in these two market areas might at times offset each other. Finally, by using the by-products of the basic defense/space product lines, the companies may be getting an added return on an investment which already has been made and written off.

Of course, those familiar with the actual diversification experiences of the leading defense and space companies know, on the basis of very sad experience, the gap between the ideal and the reality. Analyses to date conclude that the major successes in market diversification on the part of the large defense/space contractors have been within the aerospace market itself -- that is, horizontal not lateral diversification. However, some of the most dismal business failures also occurred in this same area -- the 202 and 404 piston transports, the Electra turboprop, and the 880 and 990 jets, among others.

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[1] For an example of accomplishments and future lines of endeavor, see Richard L. Lesher and George J. Howick, Assessing Technology Transfer, Washington, D. C., U. S. Government Printing Office, 1967, 121 pp.

Almost all of the smaller diversification efforts fall within one of the following categories: (1) they have been abandoned, (2) they have been cut back and are providing rather marginal returns, (3) they are so recent that the returns are not yet in, and (4) perhaps the most popular condition, management has not yet faced the decision to go beyond the initial study and exploratory development stage.[2] Despite all of this, efforts to utilize defense and space capabilities in other markets still continue.

A key assumption underlying this study is that such efforts at market diversification will continue to be made. Hence, it should be useful to see what objective assistance can be given to such attempts. The positive approach presented here consists of a blend of two elements, (1) the lessons from defense/space marketing and diversification experiences of the past, coupled with (2) the concepts and methodology of modern business planning.

This analysis is built upon a simplified five-step model of the business planning process:[3] (1) external orientation, setting forth -- assuming or forecasting -- the external environment in which the business enterprise will be operating during the planning period, (2) targeting, establishing long-term goals and objectives for the enterprise, (3) internal orientation, analyzing the capability of and resources available to the enterprise, (4) development, choosing the key programs and major undertakings on which the company will embark, and (5) evaluation, closing the loop by checking the adequacy of the development programs to meet the goals and objectives in the anticipated environment.

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[2]Murray L. Weidenbaum, "Adjusting to a Defense Cutback: Government Policy Toward Business", Quarterly Review of Economics and Business, Vol. 4, No. 1, Spring 1964, pp. 7-14.

[3]This model is based upon M. L. Weidenbaum, The Role of Economics in Long Range Planning for an Aerospace Company, Washington University, Department of Economics, January 1967, 33pp.

Each of these five steps will be taken up in turn to see how they are necessary for formulating diversification strategies.

EXTERNAL ORIENTATION

The analysis of the external environment is the area in which most analysts have erred in the past -- either planning for catastrophe (or disarmament) or for Valhalla, where the military budget rises each year at an accelerating rate. The most sensible course of action may be to assume, with Adam Smith, that the cost of defense "grows gradually more and more expensive, as the society advances in civilization".[4] Specifically, it may be assumed that the basic Communist objective of world domination will continue. Although the nature of the threat may change, and the American response to it, the underlying demand for security systems to counter that threat will persist.

More specifically, it may be useful to rely on a statement by a distinguished member of the staff of the U. S. Bureau of the Budget:

> "Outlays for defense and international purposes ... have been stimulated by a number of unforeseen shocks and have exhibited an erratic steplike upward growth in the post-World War II period in response to Soviet challenges ... This steplike movement may well be the pattern over the long-run future, as long as the cold war remains with us, but there need not be upward steps every year."[5]

With regard to the space program, the present is truly a period of decision. Already the resources devoted to Apollo are beginning to diminish, even though the expected lunar landing is several years away. Total employment on Apollo, including both NASA and company personnel, is estimated to decline from a peak of 300,000 in 1966 to 240,000 in 1968, a drop of 20 percent.[6] The major uncertainty

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[4]Adam Smith, The Wealth of Nations, New York, The Modern Library, 1937, p. 668.

[5]Samuel M. Cohn, "Problems in Estimating Federal Government Expenditures", Journal of the American Statistical Association, Vol. 54, No. 288, December 1959, p. 719.

[6]Abraham Hyatt, "Beyond Apollo", International Science and Technology, March 1967, p. 32.

here, from a business planning viewpoint, is the nature of post-Apollo applications.

Analysts of the NASA program generally concur that any major space effort for the next 25 years will probably be based upon one or more of the following five objectives: (1) continuation of the unmanned scientific exploration of space, including near earth space, the near planets, the sun, the outer planets, and the space between, (2) continuation of programs for satellites that have practical benefits, such as communication and meteorology, (3) manned orbiting research and engineering laboratories, (4) continued exploration of the moon, following the initial Apollo landing, and (5) a manned exploration of one of the near planets, probably Mars.[7]

It is generally agreed that these are the alternative directions the space program can go. What is not generally agreed are the priorities that should be given each of these objectives, particularly in competition with other non-defense programs, such as anti-poverty, urban transportation, environmental control, education, and oceanographic research and development. This is an uncertainty which cannot readily be resolved by any amount of objective analysis. Summing this combination of assumptions and uncertainties yields the following results:

1. The most prudent course of action for a company or division of a large conglomerate corporation which now is primarily oriented to the military, space, and related government markets is to count on the continued existence of a large aggregate volume of business in this field for the foreseeable future.

2. In conjunction with this belief in the relative permanency of this governmental market for high-technology products and services, there should be the deep understanding of the inherent volatility, the abrupt shifts, the peak

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[7] Ibid., pp. 32-33.

and valley nature of this market and, even more particularly, of the analyses which are made of the short-term outlook of this market area.

3. Along with its volatility, there is the secular expansion in the range of products being purchased in this government market. Aside from the arsenals which themselves are in the public sector, until recently it has been primarily the aircraft industry which was the branch of the private sector devoting the bulk of its efforts to the government market. With the rise of missile, space, and related requirements, the governmental product mix was broadened to cover electronics, propulsion, and instrument companies or divisions, as well as small R and D companies themselves. Hence, plotting the number of companies and industries which are primarily oriented to the government market as a function of time results in a positively sloping trend line. Thus, the third basic finding for defense/space companies is the belief that their market will continue to widen, the SST and oceanographic efforts being the most recent cases in point.

Some statistical perspective may be obtained by examining the market and product shifts experienced by the members of the Aerospace Industries Association. This group of companies may be taken as a fairly good proxy for the defense/space industry, as the membership includes the suppliers of major aircraft, missile, and space systems, as well as leading producers of propulsion, electronics, and instrumentation subsystems.

As seen in Table 1, commercial sales of the aerospace industry have risen from $3.8 billion in 1960 to an estimated $6.7 billion in 1967. This 76 percentage growth compares quite favorably to the 46 percentage rise in the total sales of the industry, although the year-to-year trend has been far more volatile. Non-aerospace sales of $2.7 billion projected for the current year now represent a very respectable market segment.

Table 2 presents information on the product breakdown of aerospace industry sales. The 76 percentage growth in non-aerospace sales for the period 1960 to

TABLE 1

AEROSPACE INDUSTRY SALES BY CUSTOMER

Calendar Years 1960 - 1967
(Millions of Dollars)

Customer	1960	1961	1962	1963	1964	1965	1966	1967
Department of Defense	13,196	13,871	14,331	14,191	13,218	11,396	13,110	14,150
NASA and AEC	363	630	1,334	2,628	3,635	4,490	4,840	4,400
Commercial Aerospace Sales	2,208	1,876	1,772	1,485	2,020	2,816	3,400	4,000
Non-Aerospace	1,559	1,620	1,725	1,830	1,721	1,968	2,450	2,700
Total	17,326	17,997	19,162	20,134	20,594	20,670	23,800	25,250

Source: Aerospace Industries Association

TABLE 2

AEROSPACE INDUSTRY SALES, BY PRODUCT GROUP

Calendar Years 1960 - 1967
(Millions of Dollars)

Product	1960	1961	1962	1963	1964	1965	1966	1967
Aircraft	9,126	8,847	8,944	8,527	8,911	9,747	11,750	13,350
Missiles	5,762	6,266	6,311	6,003	5,242	3,626	3,820	3,850
Space Vehicles	878	1,264	2,182	3,774	4,720	5,329	5,780	5,350
Non-Aerospace	1,559	1,620	1,725	1,830	1,721	1,968	2,450	2,700
Total	17,325	17,997	19,162	20,134	20,594	20,670	23,800	25,250

Source: Aerospace Industries Association

1967 compares with a 33 percentage decline in missile sales and a 46 percentage increase in total aircraft sales. However, the largest growth has been in space vehicles, primarily to NASA. In a sense, this has been the major and most successful product and market diversification of the industry during the 1960's and, it should be noted, in an area closely related to its basic pre-NASA product line.

TARGETING

The second phase of the business planning process is setting the company's long-term goals and objectives. Mention should be made of the often repeated desires of defense/space companies to increase their civilian shares of sales or profits to 50 percent or some other such nice sounding figure. For reasons to be mentioned shortly, this may be a fruitless task. However, it should be acknowledged that this ratio can be achieved. A few companies have neglected their defense/space work sufficiently so that the volume declined to 50 percent or even less of their total sales.

The basic reason for opposing such rules of thumb is that, more often than not, they run counter to the more fundamental profit-maximizing concern of the shareholders. The choice between competing for a military or space or other order should be governed primarily by the expected profit, rather than merely hoping to contribute to some arbitrary sales allocation target. Although it may at times be forgotten in the excitement of product development and marketing, profitability is the basic purpose of business enterprise.

Hence, maximization of the return on the stockholders investment can be taken as the basic goal and objective of the firm. This general goal may take such specific forms as maintaining the growth rate of the past decade in total

profits or earnings per share or return on net worth. At times a more ambitious goal can be set, in terms of a rising return.

INTERNAL ORIENTATION

The third step in the business planning process is analyzing the capabilities and resources of the enterprise as a guide to the kinds of things that it can do. The following list is suggested, not as exhaustive but as indicative of the characteristics of the typical defense/space firm:

1. Strong engineering design and development capability.
2. Strong manufacturing capability for exotic materials and close tolerances.
3. Detailed knowledge of military/space markets and contractual procedures.
4. Unique systems management capability.
5. Ability to bring together and work with a multitude of firms in a wide variety of industries.

Some negative characteristics of defense and space companies also need to be noted:

1. Lack of broad marketing and distribution capability.
2. Lack of experience on mass production (an automobile market measured in millions of automobiles versus sales of a few hundred jet transports a year).
3. Relatively low capitalization in relation to sales.
4. Lack of experience in designing, producing, and servicing consumer and industrial products.
5. Highly limited and specialized equipment.

After such a frank evaluation of a company's true assets and liabilities, the business planner can proceed to the development stage. It should be noted that the assets and liabilities are relative to the tasks to be undertaken. The seller's lack of a vast distribution network is of little concern to the

military customer which maintains a substantial system of supply depots of its own. The lack of mass production experience is of little interest to a civilian space agency oriented to the design and development of relatively few numbers of new systems. Rather the absence of these unneeded capabilities may tend to keep overhead down and to orient the company to uniquely meeting the needs of its governmental customers.

DEVELOPMENT

The fourth step is the heart of the matter, choosing among the many different things that a company can or should attempt to do in the future. In the most general terms, the two key questions are: What do you choose? And how do you choose? Perhaps the second question should come first. On the basis of the second step of the planning process -- quantifying the company's goals and objectives -- the choice among alternatives should be made on the basis of their relative expected profitability in relation to the company's investment in them.

The selection of products, of course, depends on the immediately preceeding step -- the analysis of the capabilities and limitations of the enterprise. As one defense industry executive commented after viewing a staff diversification analysis, "I don't care if corn flakes are a growth industry, they're not for us".[8]

Viewing the long series of unsuccessful performances at commercial diversification, many defense/space companies have thrown up their hands at any further attempts. It is not surprising that company managements are reluctant to move from fields they have mastered, and feel at home in, to lines of business quite alien to them. Their lack of knowledge of non-defense/space markets is

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[8] See M. L. Weidenbaum and A. B. Rozet, Potential Industrial Adjustments to Shifts in Defense Spending, Menlo Park, California, Stanford Research Institute, 1963, 74 pp.

pervasive -- covering products, production methods, advertising and distribution, financial arrangements, funding of research and development, contracting forms, and the very nature of the customer's demand.[9]

The real strength of these companies is their technical capabilities. The strong and often unique characteristics of the defense/space corporations are engineering accomplishment, technical systems management, meeting major national requirements, and serving governmental markets. How to mate these capabilities with the requirements of non-defense business is both the challenge and the problem.

It may be that the limitations of defense/space companies are not controlling in some carefully selected segments of the civilian economy. This may be the case for new product and market areas involving advanced technology, rather than in established fields, where the competition is with well-entrenched firms. There are many persons who believe that, at least in the long run, there must be a useful commercial return on the large national investment in defense/space research and development. The most frequently cited examples of such potential applications are in five areas:[10]

1. Improvements in surface forms of transportation. The alternatives here include mass urban transportation systems, integration of existing surface transportation systems, highway safety and traffic control systems, modernizing the merchant marine, and developing an alternative to the passenger automobile for personal transportation. In some of these cases the most difficult barriers may not be technological but political, social, and institutional obstacles to change.

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[9] Ibid.

[10] For an earlier analysis along these lines, see M. L. Weidenbaum "Defense Cutbacks and the Aerospace Industry", Astronautics and Aeronautics, Vol. 2, No. 6, June 1964, pp. 60-64 (reprinted in John S. Gilmore and Dean C. Coddington, Defense Industry Diversification, Washington, D. C., U. S. Government Printing Office, 1966, pp. 309-313).

2. Intensive development of hydrography or water systems. The suggestions that have been made in this category vary from mining of the ocean floor to sea farming to salt and brackish water conversion on a commercial scale to effective water pollution control systems for entire watershed areas. In many instances there are important questions of benefit-cost analysis to be answered, particularly the allocation of the benefits and costs to particular groups and industries. Such may be the case where the cost of pollution controls is expected to be borne entirely by industries upstream on a river where the benefits entirely accrue to residents in downstream localities. These are not simple questions nor are the solutions readily available. They may require key public policy decisions of a very subtle nature.

3. Communications systems. Numerous specialized applications come to mind, such as custom-designed communications enabling the individual schools in a given school district to utilize a single set of specialty teachers or linking the outlying branch offices and divisions of a large, diversified corporation. A worldwide satellite relay system is another possibility and would be an outgrowth of the existing Comsat spin-off. Still another possibility is the establishment of a truly effective communication system for a single large institutions, such as a hospital or a prison -- cases where improved information may lead directly to improved decision-making capability. A variety of potential customers is apparent here, including state, local, and foreign governments as well as non-defense corporations.

4. Atmospheric research and control. Examples of suggestions which have been made in this area include air pollution control devices, improved weather forecasting, and upper atmosphere research. Some of these alternatives may become operational in the near future, while others will remain in the exploratory investigation stage for some time to come.

5. Applying the systems approach to area development. The possibilities here vary from technical assistance to developing nations overseas to urban renewal and redevelopment in our own major metropolitan areas to conceptually as well as geographically new housing and community development projects, such as "New Towns" and "Satellite Cities". Other alternatives include application of the industry-operated Job Corps and Peace Corps camps concept to other educational and training problems.

As shown in Table 3, it seems relatively clear that defense/space companies in general possess much of the requisite technology and systems management capabilities to work in the public sector areas just enumerated. However, a fundamental distinction must be made -- between potential future demand and existing business markets. In many of these cases, there is still the lack of an identifiable customer with ready cash. Hence, the need exists, at least in some of these cases, to create new markets.

Some suggest that this is a task for the Federal Government. Others would rely on private initiative and also point to the desire to postpone new government spending programs until the end of the Vietnam War. The solution may lie with the defense/space companies themselves. The supersonic transport program may be an example of what can be done, as well as an indication of the problems that arise. In that case, aerospace companies exercised much of the entrepreneurial and risk-taking function at the outset. They invest very significant sums of private capital in R and D prior to the establishment of any government requirement or other firm indication of an assured market for the end product.

The time may be appropriate for defense/space companies to mount similar efforts in one of the areas enumerated above. It should not be expected that a company will be willing to invest significant sums on the basis of present knowledge of these areas. Such investment would have to be preceded by enough

Table 3

POTENTIAL DIVERSIFICATION OPPORTUNITIES FOR DEFENSE/SPACE COMPANIES

Potential Areas for Diversification	Defense/Space Industry Capabilities High				Defense/Space Industry Capabilities Limited			
	Systems Management	High Engineering Skills	Government Marketing Experience	Use of Exotic Materials	Commercial Marketing Experience	Low Unit-Cost Manufacturing	Mass Production Requirements	Heavy Financial Requirements
SURFACE TRANSPORTATION								
Mass urban transportation	X	X	X					X
Highway safety								
Integration of transportation systems								
HYDROGRAPHY								
Water pollution control	X	X	X	X				
Desalinization								
Oceanography								
Sea farming								
COMMUNICATIONS								
Satellite relay systems	X	X	X		X	X	X	
Branch office systems								
Educational services								
Internal communications								
ATMOSPHERIC CONTROL								
Air pollution devices	X	X	X	X				
Improved weather forecasting								
Upper atmosphere work								
AREA DEVELOPMENT								
Urban renewal	X		X			X	X	
Community development								
Underdeveloped area work								
Training installations								

X = IMPORTANT FACTOR

research and analysis to provide the individual company with a detailed understanding of a variety of matters. The key areas to be covered by such diversification business planning include the following:

1. The future potentials of the particular field.
   a. Historical growth and future projections.
   b. Types of government funding and other aid available.
   c. Current and potential competition.
2. The distinctive contribution that a defense/space company can make.
   a. Its technology, as well as its corporate image, for scientific and engineering achievement.
   b. Systems management and government marketing capability.
3. Alternative methods of entry.
   a. Merger or acquisition.
   b. Internal product development.
   c. Joint venture.
   d. Licensing.
4. Investment requirements.
   a. Financial risk and liabilities.
   b. Potential profitability (sales margins and return on investment).
   c. Length of payout period.
5. Obstacles and problems.
   a. Major technical problems likely to be encountered.
   b. New marketing requirements.
   c. Additional facilities and other capital assets needed.
   d. Competition with existing company programs.
   e. Organizational and managerial changes.

6. Long-term benefits to the corporation.
   a. Financial--possible favorable reaction by financial community.
   b. Technical--extension of engineering capabilities.
   c. Organizational--broadening of the base of the company to withstand fluctuations in individual market or product areas.
7. Timing of action required.
   a. General commitment (go-ahead).
   b. Funding.
   c. Technical and managerial effort.
   d. Organizational changes.

If there is any single basic assumption, or conclusion, underlying this analysis it is that forming a diversification strategy for a defense/space company is essentially a variation of a comprehensive business planning activity. The fifth and last step of the business planning model is the evaluation process.

EVALUATION

How adequate are the projected developmental programs in meeting the company's stated goals and objectives in the anticipated environment? In all probability, the result is the almost inevitable "planner's gap". That is, if the projection is far enough into the future, the most optimistic sales line begins to sag and to fall behind the postulated targets. On the other hand, mechanically adding up all the possible systems and products which are recommended by the various divisions results in a major share of the future growth of the nation's GNP being absorbed by company X.

This last phase of the business planning process involves closing the loop. The reasonableness of the goals and targets set earlier can themselves now be checked against the likely accomplishments of the enterprise in view of its resources and capabilities. Necessary modifications may then be made in the goals and targets as well as in the programs to accomplish them.

SUMMARY AND CONCLUSIONS

On the basis of the foregoing analysis, the following guidelines are suggested for developing diversification strategies for defense/space companies.

1. Put first things first -- devote the bulk of the firm's resources and energies to the basic defense/space product lines. Perhaps this guideline should be rephrased to read, "do not try to diversify unless the top management is convinced that it really has to". The past history of defense/space industry commercial diversification is surely littered with a vast array of failures. Diversification, if anything, is exploration into the relatively unknown, a risky and reluctantly undertaken, although often rewarding, activity.

2. Plan and act on diversification plans when the company is "fat and happy". Hence, engage in this venture when the corporation is in the strongest position to bear the risk and additional investment required. Traditionally, bursts of enthusiasm for diversification occur when a defense cutback is already upon the industry or when an individual company loses a major competition. A recent exception to the trend should be noted (perhaps a new trend). McDonnell acquired Douglas as it was approaching the peak of its sales and earning power, not when it already faced a plateau or decline. It is, of course, too early to evaluate the success of this break with tradition, but the expectations are high.

3. Do not be a dilettante -- either make a major effort at diversification or none at all. So many defense/space companies do exploratory work on a variety of commercial possibilities, because they can afford to. Perhaps it also soothes the concerns of shareholders who are distressed over the narrow product and market base of the company. However, in so many cases management later backs off from making the major commitment of development funds on the basis of factors it was well aware of before the initial effort ever started. This is an expensive type of corporate games-playing or wheel-spinning.

4. Concentrate on applications and extensions of the company's basic capabilities. The successive moves from aircraft to missiles to space represented, in retrospect, fairly clear extensions of the basic capabilities of aircraft and electronics companies. Nuclear energy and oceanographic efforts seem to follow in that tradition. Educational systems, new towns, and foreign economic development just do not, at least at present, seem to possess that clear and close connection to the basic strengths and capabilities of defense and space companies.

5. Do not expect too much too soon. Few defense/space companies win as much as one out of every three major competitions they enter. Yet, these same firms often expect their first diversification effort to be a success. There may be a learning curve here too; diversification may be something that a company has to learn after many trials and errors. Characteristically, defense/space companies are farsighted in planning and development efforts in their basic product lines, expecting many years of exploratory research, development, and marketing effort to precede a successful competition. In contrast, the time span set for evaluation of commercial diversification is often far shorter. Upon reflection, the penetration of a new market would be expected to be a more rather than less time-consuming process than product development in the company's basic markets.

As a concluding note, it might be appropriate to make proper mention of the patron saint of business planning, whose spirit no doubt is present at all discussions of defense/space industry diversification. It may not be generally known, but the patron saint of business planning is the famous Scottish poet, the late Robert Burns. Of course, his claim to this position is based on a single line of his poetry which can be translated into contemporary English as "the best laid plans of mice and men still can get fouled up".

Appendix

REPRESENTATIVE COMPANIES THAT HAVE UTILIZED SPACE OR DEFENSE TECHNOLOGY IN OTHER FIELDS

Aerojet-General Corporation

Aerojet primarily supplies the propulsion portion of missile and space systems. It also produces torpedos, nuclear equipment, and oceanographic research vessels. It has attempted a great number of non-defense and space diversification efforts requiring its engineering force. Its Atlantic Division performs systems engineering work for several clients. These have included designing and installing a parcel sorting system for the U. S. Post Office in Miami, Florida, and a mail sack sorter system for the railway terminal in Texarkana, Arkansas.

The Aetron Division, an architectural-engineering-construction organization, does work for both government and commercial clients. It was formed specifically to apply system engineering skills to mechanized material and package handling problems in commerce, industry, and non-military government agencies. Examples of the latter include a food distribution center in Fresno, California, and an automated synthetic rubber plant in Odessa, Texas, and both a mail sack sorter and a package sorting system in St. Louis, Missouri.

Aerojet also has gone the joint venture route. It entered into a joint effort with Oude Delft, and Dutch optic firm, to develop and market optical and x-ray equipment and cameras. The company also has relied on internal product development. One such example is its microwelder, used for performing weld assembly of miniature electronic products. This was terminated in 1964 after a loss of several hundred thousand dollars.

The International Technical Assistance and Development Company (ITADCO) is a division of Aerojet. It is trying to provide a start-to-finish service for foreign countries, by surveying their needs for plants and other facilities,

helping to arrange financing, designing and constructing the plant, and then training local personnel to manage and operate the facility.

Aerojet also received two of the four California state contracts for exploring the civilian applications of military technology--the ones for waste disposal and crime and control of criminals.

Despite the variety of diversification efforts, about 99 percent of Aerojet's sales is to defense and space (almost 80 percent defense and almost 20 percent space). The relatively small utilization of engineering staff on commercial projects is about proportional to the one percent of its sales going to commercial customers.

American Machine and Foundry Company

AMF's major participation in space and defense work is as a supplier of mechanical ground support equipment (GSE) for missile and space systems. Its Government Products Group also produces nuclear reactors and fuel elements. To a substantial extent, its military and space activity represents the successful transfer of its civilian material handling equipment capability. Hence, the flow of engineers between its commercial and government work may have been far more frequent and simpler than for the larger, more specialized defense/space producers.

AVCO Corporation

AVCO makes a variety of space and defense products, including Lycoming engines, missile nose cones, structural and assembly subcontract work on aircraft, missiles, and space vehicles, ammunition and other ordnance, nuclear and space instrumentation, and military and space communications systems and equipment.

Its Aerospace Structures Division has also been producing metal office furniture for Globe-Wernicke Company and gas and electric ranges for Western Auto Supply. It also has done subcontract work on the Convair 880 and 990 (empennage

and wing sections). AVCO's Research and Advanced Development Division, through its Industrial Products Subdivision, has produced and marketed a few products for sale to industrial markets. One example is the plasmagun system, which provides an economical means of coating many common materials, extending their useful applications and increasing their durability. Another example is a series of shock test machines, originally developed as part of the Titan missile program, which have been sold to aircraft companies to simulate and check landing shocks for commercial aircraft production.

It appears that during most of the post-World War II period AVCO has attempted as company policy to expand its commercial work. Major corporate impetus appears to have been present during periods of slack military business.

AVCO is in a state of transition. In 1963, 76 percent of its sales and 60 percent of its profits came from government work. In 1966, about 70 percent of earnings are expected to come from commercial operations. In part, this shift represents a number of acquisitions involving little if any transfer of personnel from government to commercial work at least at the present time. For example, since 1964 it acquired the Bay State Abrasive Products Company, the Delta Acceptance Corporation, radio stations WWDC, AM and FM, television station WOAI, and the Iowa Finance Company. It also formed a new corporation, Meredith-Avco, Inc., to engage in the community antenna television field.

Boeing Company

Boeing is a producer of long-range bombers (B-52's, now modification work), military and commercial jet transports, ICBM's space boosters, gas turbines, and navy hydrofoil vessels. Its major diversification effort has been the 707 - 720 - 727 - 737 line of commercial jets. This was derived from the same company-financed prototype--the so-called dash 80--on which the KC-135 military tanker was based and drew on the company's extensive experience with large military jet aircraft

(B-47's and B-52's). The 707 family represents the major commercial utilization of Boeing engineers.

A much smaller effort was the line of gas turbines, which is now being phased out. Originally developed for the Navy as auxiliary power for minesweepers, these small gas turbine engines also were used on fire engines and light aircraft, but sold in disappointing numbers.

Boeing Associated Products attempt to market a great number of by products of the basic aerospace product line, including medical devices (such as electrocardiographs, respiration meters, thermometers, and electroencephalographs), a fluidized bed furnace, and thickness gages. However, this division of the company went the licensing route and utilized perhaps a handful of engineers for product evaluation and marketing efforts.

The commercial share of Boeing's sales has risen from an insignificant portion in 1958 to about 50 percent in 1965 and exceeded that in 1966. The 707 program was designed and developed as an integral part of Boeing operations. Hence, the flow of personnel back-and-forth between commercial aircraft and military work was both continuous and commonplace.

Curtiss-Wright Corporation

The company manufactures rocket motor cases, propellers, simulators and other components for aerospace and industrial products. Curtiss-Wright is the unfortunate example of a major defense company that tried so hard to diversify that it lost most of its military business but also was unable to make a success of its commercial ventures. Most of the latter were acquisitions, many of which have been sold off.

Most of Curtiss-Wright's transfer of technology and employees from government to commercial work results from its subcontracting position in the aircraft industry. For example, its Electronics Division in East Paterson, New Jersey, produces simulation systems for both military and commercial jet aircraft.

Douglas Aircraft Company

Douglas is a major producer of military and commercial aircraft, which also has designed and sold missiles and space systems. Its major commercial diversification effort is similar to that of Boeing--large commercial airline transports, particularly the DC-8 and the DC-9.

All of its other commercial activities have been on a much smaller scale. One of the more ambitious undertakings is that of the Aircomb Division, which produces and markets a honeycombed construction material based on airplane technology. Aircomb is a honeycomb structure of paper impregnated with a phenolic type resin and sandwiches between faces of a thin material such as aluminum, plywood, stainless steel or magnesium. Aircomb was originally developed by Douglas for the first NIKE program.

Smaller commercial efforts have been made for several medical instruments originally developed for missile/space programs, including an electronic cancer thermometer and an electronic stethoscope. In conjunction with a non-defense company, Douglas has contracted to operate the Atomic Energy Commission's reactor and fuel fabrication facilities at Hanford, Washington.

A major share of Douglas' employment and sales now comes from its commercial aircraft work--about 30 percent in 1963 and probably one-half or more in 1965. In April, 1967, the Douglas Aircraft Company was merged into the McDonnell-Douglas Corporation as a major division.

Garrett Corporation

Garrett is primarily a subcontractor to large aircraft companies producing gas turbine engines, starters, control systems, space life support systems, instruments, etc. It also operates aircraft supply and modification facilities. Two noteworthy efforts to utilize its defense technology are the turbocharger developed by its industrial division and the Total Energy Package developed by

Airresearch Manufacturing division. TEP provides the total power requirement for an office building, manufacturing plant or shopping center. It uses the Model 831 Gas Turbine which was originally developed for powering helicopters and light fixed wing aircraft.

The military portion of Garrett's sales has declined from 90 percent in 1954 to 65 percent in 1963.

General Dynamics Corporation

General Dynamics is a rather diversified corporation, the bulk of whose activities is in the aerospace industry. It has produced military and commercial aircraft, missiles, space boosters, nuclear submarines, telephone and electronics equipment, chemicals, and building supplies. Its major transfer of personnel from military to commercial work has been similar to that of Boeing and Douglas, the 880 and 990 commercial jet transports. Although these were commercial failures for the company, they did involve the large-scale utilization of resources previously assigned to military or space projects, primarily in the San Diego division.

Like the other major aerospace companies, General Dynamics also has engaged in smaller commercial diversification projects. For example, it has sold over 5,000 Shock Masters to private industry. This is a low-cost mechanical device that positively indicates with a bright red signal when predetermined shock levels have been exceeded.

About 80 percent of General Dynamics' sales are to defense/space programs. The remainder is made primarily by its commercial acquisitions, such as Liquid Carbonic and Material Services.

General Electric Company

GE is a large, diversified industrial corporation whose defense activities represent an important but minority portion of the company's resources. In a sense, defense work represents a diversification effort on its part. A major

transfer of defense technology and personnel to commercial work occurred with the sale of its jet engines to companies producing commercial aircraft, such as the Convair 880 and 990. This work was done at the jet engine division at Evandale, Ohio. GE is also engaged in the commercial as well as military development of atomic energy.

Seventeen percent of GE's sales in 1965 came from defense or space programs. This represented a decline from a high of 24 percent in 1964.

Grumman Aircraft Engineering Corporation

Grumman is a traditional supplier of Navy aircraft. Recently it also has been doing some NASA work, particularly the LEM portion of the Apollo project. Since the end of World War II, Grumman has designed and sold a line of aluminum and fiberglass canoes, cruisers, and sail boats. Since 1931, two years after its founding, the company has produced aluminum truck bodies widely used by trucking lines. It also has built hydrofoil vessels for the Navy and the U. S. Maritime Administration and executive aircraft (the Gulfstream) for the civilian market.

Less than 10 percent of Grumman's sales is derived from its commercial products. Similarly, a relatively small share of its engineering staff has been shifted to civilian work. Grumman's commercial work is performed by Grumman Allied Industries, Inc., a subsidiary located at sites away from the main aircraft plant.

Honeywell, Inc.

Honeywell is a major producer of industrial and military control and other electronic devices. It has drawn upon its military space technology for a variety of commercial products. One example is its Traffitrol vehicle detector, a vehicle counting or control device which employs infrared for detection purposes. Another example is the 1108 Visicorder which is an improvement or extension of

the writing oscillograph. Another example is the self-adaptive electronic autopilot. This is a direct transfer of technology from research on the X-15 and X-20 to light twin-engine aircraft.

The bulk of Honeywell's sales is derived from its commercial customers. Twenty-five percent in 1965 came from military and space business.

Hughes Aircraft Company

Hughes is a major supplier of fire control and other electronic subsystems for aircraft and missiles. It has made numerous attempts to commercialize its military technology. Hughes developed for its internal training program teaching aids called "videosonic systems", which can teach a housewife the basic skills of an electronics assembler in ten days. The system is also marketed commercially, Hughes also set up an organization modeled after Boeing Associated Products to commercialize the by products of its main product line. Apparently for lack of strong management support, the effort was terminated after a few years.

The great bulk of Hughes' work (well in excess of 75 percent) is done under defense/space contracts. Hence, very small portions of its work force have been exposed to commercial activities.

International Telephone and Telegraph Corporation

1. IT and T is a holding company of several medium sized producers of industrial, military, and space electronics and numerous telephone equipment producers and telephone system operators, the latter primarily overseas. The ITT Federal Laboratories at Hutley, New Jersey, have developed several commercial applications of its defense/space technology. High-powered communications transmitter (power range 10-15 KW; frequency range 2-8 kmc) were an outgrowth of ground station transmitters for communicating with satellites and spacecraft. This equipment is being used in nondefense long haul point-to-point telecommunication. The laboratories also developed a parametric amplifier based on low

noise amplification studies and newly available solid state diodes. It is used in high sensitivity communication receivers applied to point-to-point information transmission.

ITT's subsidiary, Federal Electric Corporation, operates the Job Corps Center at Camp Kilmer, New Jersey. Only about one-fifth of IT and I's sales are from defense or space programs. However, the bulk of its commercial revenues are from its telephone and other established nondefense functions, rather than representing the transfer of defense/space technology and engineering.

Lear-Siegler, Inc.

Lear-Siegler is a medium-size producer of electronic components and equipment to both industrial and military markets. As for many electronics companies of its size, it is difficult to disentangle its military/space activities from its commercial product development work. For example, its Electronic Instrumentation Division in Anahelm, California, produces an established line of commercial and military equipment with emphasis on video systems (close circuit TV for surveillance). The company reports that this equipment has been improved for NASA and DOD requirements and this more rugged equipment also has been used commercially. Lear-Siegler also produces jet aircraft, automatic landing systems and aircraft and rocket test stand instrumentation.

Ling-Temco-Vought, Inc.

LTV is the product of mergers involving Chance Vought Aircraft Corporation, Temco-Aircraft, and Ling Electronics. Prior to the merger, Chance Vought--a traditional supplier of Navy aircraft--had embarked on a series of commercial diversification efforts, most of which were via acquisition and unsuccessful. These included a line of mobile homes which subsequently were sold off. Ling, in contrast, was primarily oriented to commercial markets. The Ling Electronics Division in Anahelm, California, has sold for automotive research vibration test

equipment which originally was developed for testing the reliability of missile and space programs.

Chance Vought's diversification efforts were the direct result of the company's reaction to the loss of major military aircraft and missile contracts. Over 70 percent of LTV's sales are now made to DOD and NASA.

Litton Industries, Inc.

Litton is a highly diversified combination of electronics, shipbuilding, typewriter, office furniture, paper mill, motion picture camera and other similar operations. Most of these ventures resulted from the active acquisition program of its top management. Currently, Litton is extremely active in utilizing the systems management capability it acquired in defense and space programs in the area of education and governmental social welfare problems. It conducts broad economic studies; one covers the general economic planning for the U. S. Appalachia Commission; another is for the Greek Government. Indicating how best to develop the island of Crete and the Peloponnesus peninsula. Litton has been running training programs for the Job Corps and has set up three new small divisions: Educational Systems, Instructional Materials, and Educational Technology.

About 35 percent of Litton's revenues came from prime defense-space contracts, with additional amounts received under subcontracts.

Lockheed Aircraft Corporation

Lockheed is a diversified aerospace company, producing fighter and transport aircraft, missiles, vehicles, space vehicles, destroyers, electronics equipment, commercial aircraft. The largest internal commercial diversification efforts were the Electra turboprop airline transport and the Jet Star executive aircraft, which were business failures but represented a major utilization of the firm's defense-oriented engineering force. Lockheed's highly touted acquisition program

represents a surprisingly small portion of the company's activities. These include the Lockheed Propulsion Company which was originally the Grand Central Rocket Company, Lockheed Shipbuilding and Construction Company which was originally the Puget Sound Bridge and Drydock Company, and Lockheed Electronics Company which was a combination of Stavid Engineering and the company's own electronics division.

On a smaller scale, Lockheed also has tried to develop commercial versions of military products or adaptations of its unique manufacturing and systems skills. These efforts include its fuel oil register, a pilot plant to convert waste materials into economically useful gases and solid products, and a fully equipped oceangoing oceanographic research vessel.

The Lockheed Electronics Company, although one of the smallest divisions of the company, has developed numerous commercial products. For example, a variation of a modularized tape recorder originally developed for satellite use has been sold on the commercial market. Lockheed also was awarded one of the four California studies on possible civilian applications of defense technology. It studied the information flows and needs of state government.

Since the termination of the Electra program, commercial work has accounted for about 5 percent of total sales.

Martin-Marietta Corporation

The major diversification effort of this company was the merger of Martin with American Marietta, a supplier to construction and other industrial markets. Little flow of product technology or employees has occurred between these two major portions of the new company. The Martin Division has attempted various commercial and civilian efforts, but all on a scale much smaller than its unsuccessful line of commercial transport aircraft (202 and 404). Its Nuclear Division has produced radioisotope fueled generators, originally developed for the space program, for an automatic meteorological data transmitting radio station for the

AEC and Weather Bureau on Axel Heiberg island in the Arctic.

About 70 percent of the company's sales are to the Federal Government, mainly missiles and space boosters. The remaining 30 percent is in such commercial items as cement, lime, sand, aggregates, printing inks, and super-alloys.

McDonnell Aircraft Corporation

McDonnell is primarily a producer of fighter aircraft. The Mercury and Gemini programs have made it also an import NASA supplier. Several diversification attempts have been made in recent years. The McDonnell Automation Center provides data processing services to companies and government agencies. Its work ranges from the production of numerical control programs for manufacturing operations to the maintenance of inventory control records for a small candy company and a retail beverage firm. It has programmed student classroom assignments for junior colleges and has performed consulting and systems services for companies in banking, wholesaling, and retailing.

The company established an Electronic Equipment Division in 1961. More recently, it purchased the assets of Tridea Electronics, 55 percent of the common stock of Hycon Manufacturing, and 21 percent of the stock of Conductron Corporation. Most of the company's electronics work is done in conjunction with DOD or NASA programs.

Prior to the merger with Douglas, military aircraft accounted for about 75 percent of McDonnell's sales, and space about 20 percent. The remaining 5 percent came from the electronics and automation activities, of which the Automation Center accounted for 1-2 percent of total company sales.

The most important diversification effort by McDonnell was its successful attempt in the Spring of 1967 to acquire the Douglas Aircraft Company. Although basically a form of "stockholders' diversification" this move, it was generally expected, would provide Douglas with the managerial and financial strength of McDonnell and provide the latter with the commercial diversification it has long sought after.

North American Aviation Corporation

North American is a major aerospace company, with the most substantial industrial role in the Apollo project, the development of the RS-70 to its credit, and the supplier of electronics and propulsion on a variety of missile and space programs, including the minuteman ICBM. In 1957, it set up Navan Products, Inc., a wholly-owned subsidiary, to sell the by-products invented by its employees. Navan has six major product lines--industrial diamond products, Klimp fasteners, and other packaging products, cryogenic seals and other fluid components, drill presses and other machine tools, bags and covers impervious to water vapor, and various welding products.

Autonetics, the electronics division of North American, has developed several commercial products. Its RECOMP computer series, however, has been discontinued because of the very heavy competition in that field. The Los Angeles Division has done some explosive forming for industrial customers. One job, for the Braun Citrus Company, consisted of a stainless steel feed wheel for orange juice squeezing requiring very close tolerances.

North American was awarded the California state study to explore the applications of aerospace technology to the whole gamut of transportation programs.

About 97 percent of North American's sales are to the Federal Government, either directly or through subcontracts. About one-third of the sales are to NASA, the bulk of the remainder going to the Air Force. Hence, NAVAN and other commercial endeavors represent only 3 percent of the company's total effort.

Northrop Corporation

Northrop is a medium size aerospace company doing some work on its own, such as the F-5 Freedom Fighter, but relying heavily on electronic and structural subcontracts from the larger primes. Much of its limited commercial work is the result of mergers rather than internal product development. For example,

Northrop Architectural Systems, which manufactures aluminum extrusion products for use in building construction, is the result of combining two companies manufacturing structural products that Northrop acquired in recent years--Acme Metal Molding Company and Arcadia Metal Products Company. However, another acquisition--Page Communications--which is primarily oriented to the military and space markets--has used the knowhow it developed working on long-range military communications systems to design and install civilian national communications links for a foreign country.

Some of Northrop's subcontracting work is done in connection with commercial aircraft, such as manufacturing wing panels and fuselage sections for jet airliners.

Radio Corporation of America

RCA is a large, diversified electronics company with consumer, industrial, and defense (including space) products divisions. Because of its tendency to place its defense and space work at separate locations, the opportunities for transfer of personnel between commercial and government work is limited. An SRI study in 1963 revealed that there is little movement of scientists and engineers between defense and civilian-oriented operations in companies such as RCA. However, some of the more technically advanced products, such as computers, may have occasioned such movements of personnel.

Twenty-five percent of RCA's sales result from DOD and NASA work, a decline from 38 percent in 1960. The large commercial orientation should not be viewed as successful transfer of defense technology. If anything, there may have been more substantial movement in the other direction.

Raytheon Company

To a large extent, the situation at Raytheon, an important electronics systems supplier, with reference to the shift of defense engineers to commercial work is similar to that of RCA. About 60 percent of its sales come directly from prime DOD and NASA contracts. Some of the remainder comes indirectly from defense sources via subcontracts.

Rohr Corporation

Rohr is primarily a subcontractor to large aircraft companies, providing pod assemblies ("power packages") for multi-engine jet and turboprop aircraft, fabricating fuselage sections, and producing sound suppressors and thrust reversers. Its most publicized diversification effort in recent years has been the Rohr modular home, the construction of which utilized the company's capability to fabricate light metals. The Modular House, a prefabricated affair, consists of a steel frame structure with wall panels of polystyrene foam plastic. For a variety of reasons, including craft union difficulties and local building codes, Rohr recently terminated this venture. The bulk of its commercial work at present is producing components for jet airliners, which are fairly closely related to its military aircraft subcontract work.

Rohr's business is about 50 percent military and 50 percent commercial. About 80 percent of total sales comes from aircraft component manufacturing.

Ryan Aeronautical Company

Like Rohr, Ryan is primarily a supplier of structural components to large airframe primes. However, it also has produced some small military aircraft and target drones. Its commercial work, again, is similar to that of Rohr--components of jet airliners which are similar to the work performed under military aircraft subcontracts.

Sperry-Rand Corporation

Sperry-Rand produces a wide variety of electronic and office equipment for consumer, industrial, and government customers. The Sperry Division (formerly Sperry Gyroscope) produces guidance equipment for aerospace systems. The former Remington Rand division make computers and other office equipment. There has been little publicity on any Sperry-Rand transfer of space or defense technology to commercial fields. Recently, the Sperry and Univac divisions combined forces

on a project to provide electronic control for New York City traffic. The system incorporates sensors, detectors, controllers, data processors, control consoles and displays, which are components of numerous defense and space systems that the company works on.

About 40 percent of Sperry Rand's sales revenue comes from its prime defense/space contracts. A portion of its commercial revenues results from subcontract work on jet airliners and from sales of computers to defense and space companies.

Sundstrand Corporation

Sundstrand is a producer of aircraft and missile components. It also manufactures machine tools and industrial hydraulic and hydrostatic equipment. Its Sundstrand-Denver division produces aircraft accessories such as constant speed drives, one-fourth of which currently are used for commercial aircraft. As the result of top management concern with reducing the Division's dependence on military work, Sundstrand-Denver designed and produced the Sundyne Process Water-Injection Pump which is used by heavy industry. This was an outgrowth of its water-injection pumps for jet aircraft and it drew upon the existing engineering and manufacturing capability of the division.

About 50 percent of Sundstrand's total sales are made to the defense market. Defense and commercial aircraft sales combined represent "the majority" of total revenue of the company.

Texas Instruments, Inc.

TI is a producer of a wide variety of electronic components; much of its growth resulted from the boom in transisters. Although the company has reported that it has had no direct transfer of defense/space technology to commercial work, it points out that the entire field of silicon transistors would be in a far less sophisticated state of development without the advanced application

to the missile/space market. In the early stages of their development, silicon transistors were used almost entirely in missile/space applications.

About one-fifth of TI's sales result from prime government contracts. However, most of its military and space work is performed under subcontract.

Textron, Inc.

Textron is a company which, like Litton, has expanded as the result of a series of mergers. One of these included the defense divisions of the former Bell Aircraft Corporation, which is a major producer of helicopters, primarily military. Textron's government work also includes inertical guidance systems, radar antenna, and electronic test equipment.

Its Defense Group (Bell Aerosystems, Bell Helicopter, Dalmo Victor, Hydraulic Research and Manufacturing, Accessory Products, and Nuclear Metals) account for about one-third of Textron's sales. Each of these operations is conducted at sites separate from the company's commercial business.

Thiokol Chemical Corporation

Thiokol is a major producer of solid and liquid engines for guided missiles and rocket engine fuel. One of its commercial efforts is the Trackmaster, which is capable of operating in snow, swamps, and mountainous terrain. This item is being produced and sold under an exclusive license from the Utah Scientific Research Foundation.

Defense and space work represents the major part of the company's business.

TRW, Inc.

TRW is the result of a merger between Thompson Products, a traditional producer of mechanical components to both military and industrial markets, and Ramo-Wooldridge, an important systems management organization for the Air Force bailistic missile programs. TRW spun off the systems management group as Aerospace Corporation; the former Ramo-Wooldridge organization, later Space Technology

Corporation, and now TRW Systems, has become a prime contractor on systems of its own. TRW also has attempted to utilize its defense/space skills in other areas, to a limited degree. It has developed what it claims to be the world's fastest camera, used in medical and laser research. It has contracts for applying systems and advanced technology concepts to hospital and other public sector fields, both in the United States and Canada. Defense and space work accounts for about 40 percent of TRW's total volume. The bulk of the remainder is to the automobile industry; 15 percent of total sales are components supplied to commercial aircraft engine manufacturers.

United Aircraft Corporation

United is the largest producer of jet engines in the United States. Other major activities include the Sikorski helicopters, the Hamilton-Standard aircraft propeller and accessories, the Norden guidance and electronics effort, and the United Technology rocket propulsion division. Much of the output of the corporation goes to commercial aircraft primes and is an integral part of its operations, rather than representing "diversification" or "transfer" of its technology. Undoubtedly, its developmental work on military engines and other subsystems has been of great value in its commercial work, and vice versa.

A specific diversification effort has been that of the Turbo-Power and Marine Department of the Pratt & Whitney Division. This department sells adaptations of Pratt & Whitney jet engines for industrial uses, such as gas transmission, power generation, marine and railroad use, and process applications such as in the chemical, metal and paper industries. Recently the U. S. Department of Commerce and the Canadian National Railways ordered a total of 7 Turbo-Trains from United. These vehicles, powered by Pratt & Whitney gas turbine engines, are being produced under subcontract by Pullman Standard.

As a result of the substantial decline of the propeller market, the Hamilton Standard Division has diversified into turbine engine fuel controls, jet engine starters, aircraft air conditioning and pressurization systems, and ground support equipment. Most of these items, however, are sold within the military market. Some of the Division's products are geared to industrial users, such as its electron-beam machine which cuts, mills, drills, and welds extremely hard materials to precise tolerances. This product is produced under license from the Zeiss Company in Germany. United has been working with hospitals to develop products for the remote, continuous monitering of various physiological conditions without wires and with less inconvenience to the patent.

As recently as 1963, sales to commercial aircraft primes accounted for 20 percent of United's total business. With the more recent expansion of jet airliner production, this ratio has expanded. A very small fraction of the company's sales comes from other commercial markets.

Westinghouse Electric Corporation

Like GE and RCA, Westinghouse is a large electrical and electronics producer which keeps its government work quite separate from its consumer and industrial product divisions and reports little movement of personnel from government to commercial work. For example, Westinghouse has installed numerous desalinization units in countries all over the world, but it is not clear how much of this can be attributable to the transfer of defense and space technology and personnel. More recently, the company has operated a training program for the Peace Corps.

Defense, space, and atomic energy sales represented 19 percent of Westinghouse's total volume in 1965, a decline from 25 percent in 1963. Of the remainder, one-third is consumer products and two-thirds general industrial.

Major Sources of Information

1. Annual Reports of Individual Companies.

2. Moody's Industrials and supplements.

3. Aerospace Industries Association, Aerospace, Fall 1965, pp. 10-14, "The Innovation Industry".

4. Denver Research Institute, The Commercial Application of Missile/Space Technology, September 1963.

5. Denver Research Institute, Defense Industry Diversification, January 1966.

6. Edmund K. Faltermayer, "The Rail Route to a More Mobile America", Fortune, July 1, 1966.

7. U. S. Senate, Committee on Labor and Public Welfare, Nation's Manpower Revolution, Part 9, 1964.

8. M. L. Weidenbaum and A. B. Rozet, Potential Industrial Adjustments to Shifts in Defense Spending, Stanford Research Institute, November 1963.

9. Files of the Washington University NASA Economic Research Program.