aerospace
AIA
research center

AEROSPACE and the U.S. ECONOMY

Its Role, Contributions and Critical Problems

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

AEROSPACE and the U.S. ECONOMY

Its Role, Contributions and Critical Problems

A Publication of

AEROSPACE RESEARCH CENTER
AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.
1725 DE SALES STREET, N.W., WASHINGTON, D.C. 20036

NOVEMBER 1971

The mission of the Aerospace Research Center is to engage in research, analyses and advanced studies designed to bring perspective to the issues, problems and policies which affect the industry and, due to its broad involvement in our society, affect the nation itself. The objectives of the Center's studies are to improve understanding of complex subject matter, to contribute to the search for more effective government-industry relationships and to expand knowledge of aerospace capabilities that contribute to the social, technological and economic well being of the nation.

Contents

Graphs

Page

Graphs

Page

Introduction

1

The United States aerospace industry is today the focus of much attention by those concerned with the economic health of the nation. In this respect the industry is following a classic economic pattern. In the past, historically important U.S. industries such as railroads, shipbuilding, textiles and power have all emerged in different periods as healthy economic entities of crucial importance in world and U.S. commerce. While each contributed significantly to the well-being of the nation, each in time developed its own problems: depleted or displaced markets, specialized labor, and unwanted political and social side effects. Following this pattern, the U.S. aerospace industry is today undergoing crucial changes producing effects felt throughout the U.S. economy and has entered into its own period of major readjustment to changing conditions, priorities, and markets.

The point of this analogy is simply that in considering the relation of the U.S. aerospace industry to the total economy, it is clear that its problems constitute an economic and historic phenomenon of the first magnitude—not an ephemeral annoyance whose effects will subside as soon as the current economic uncertainties are clarified. The current situation and the outlook for the immediate future appear bleak, and if unchecked, this trend will result in a severe loss to the nation's output. In both tangible and intangible ways, the industry's problems have broad implications at both the federal and local levels. The proper perspective, therefore, is essential for those whose acts and decisions will affect the future role of this economic force in national affairs, determining whether the industry continues to contribute to its fullest capacity to the economic well-being or declines to the point where its potential cannot be realized.

This essential perspective is not easy to achieve. There are a host of misunderstandings and a lack of knowledge about the industry and its operations. Key to a better understanding is an objective perspective on the industry whose uniqueness among U.S. industries is established by these characteristics:

- Its product line is largely determined by Government needs and requirements which, during the past generation, have changed drastically and continually, and which appear likely to continue to change in unforeseen ways in response to developments in international and domestic relations.
- In virtually all its products, revolutionary advances in performance and capability are required, constantly forcing industry to work at the frontier of the technological "state-of-the-art" and to draw from virtually all of the scientific disciplines.
- It embodies a larger share of the nation's expenditures on R&D and technological advance than any other industry group, giving it an unmatched importance to long-term growth in productivity and national economic vigor.
- The scale of single programs that often run into billions of dollars each and with complexities requiring sophisticated systems management skills, is unparalleled in other industrial sectors.
- Major programs in many instances take more than ten years from concept to completion.
- With the exception of commercial aircraft, there is no present commercial or consumer marketplace for the preponderant share of its products.

In view of the present and potential role of this unique industry in economic growth, social progress, and national security, there exists in many policy circles concern over the current loss and potential long-term economic effects of aerospace decline. For several reasons, many informed persons believe that the economic viability of the nation, both domestically and internationally, depends in no small measure on a financially healthy and prosperous aerospace industry. At the same time, others are reacting to the current problems of the aerospace industry as if the national economic scene would be little affected by its demise.

The premise of this study is that the economic role of this industry at this point in U.S. history warrants most careful consideration. Its purpose, accordingly, is to provide some perspective on the industry for those whose actions and decisions will affect it. Such an objective understanding of the economic environment of the aerospace industry is particularly important now, when the general economic conditions of the country, downturns in market demand and shifting national priorities and political attitudes have depressed sales, profits, and other industry economic indicators. These trends, largely external to the industry itself, have contributed to the general public's misunderstanding of the economics of the industry and its relationship to the rest of the industrial economy of the U.S.

This study, therefore, examines the structure and problems of the aerospace industry in sufficient detail to relate an historically and economically objective point of view essential to rational policy-making in the years immediately ahead. It is basically diagnostic rather than prescriptive.

The complex inter-relationships of the material in this study are such that it was felt that inclusion of an Executive Summary for the busy reader would not adequately convey the perspective necessary for a full understanding. To assist the reader, however, the policy implications of the study will be found in the five chapters with the bulk of supporting details in the appendices.

The Aerospace Economic Profile

2

This chapter provides a summary of key factors presented in Appendix A, which is an analysis of the basic economic characteristics of the aerospace industry and its contribution to the nation's economy. These basic characteristics include the pattern of activity, employment, payroll, productivity, sales, exports, and financial items, and involve comparisons to related industries as well as levels and trends.

Industry Definition and Products

The aerospace industry consists of those industrial firms that produce aircraft, missiles, space vehicles, and their related engines, parts, and equipment. Approximately 70 such firms operate more than 1,300 establishments.[1]

Product lines in 1970 consisted of aircraft and electronic equipment for defense at home and abroad (47 percent); missiles, space vehicles, and related hardware (22 percent); commercial and private aircraft and equipment (20 percent), and other products and services (11 percent).[2] Within these product lines, much of the industry's output (20 percent) is in the form of technological inventions and innovations stemming from intensive research and development, and applied to the industry's complex products that are characterized by high unit-value, precision performance, and reliability.

Based on national input-output tables, about 30 strong aerospace inter-industrial linkages are identifiable. They represent an estimated $11 billion of productive activity generated in the other industries which supported the $14 billion of aerospace value-added in 1970.

---

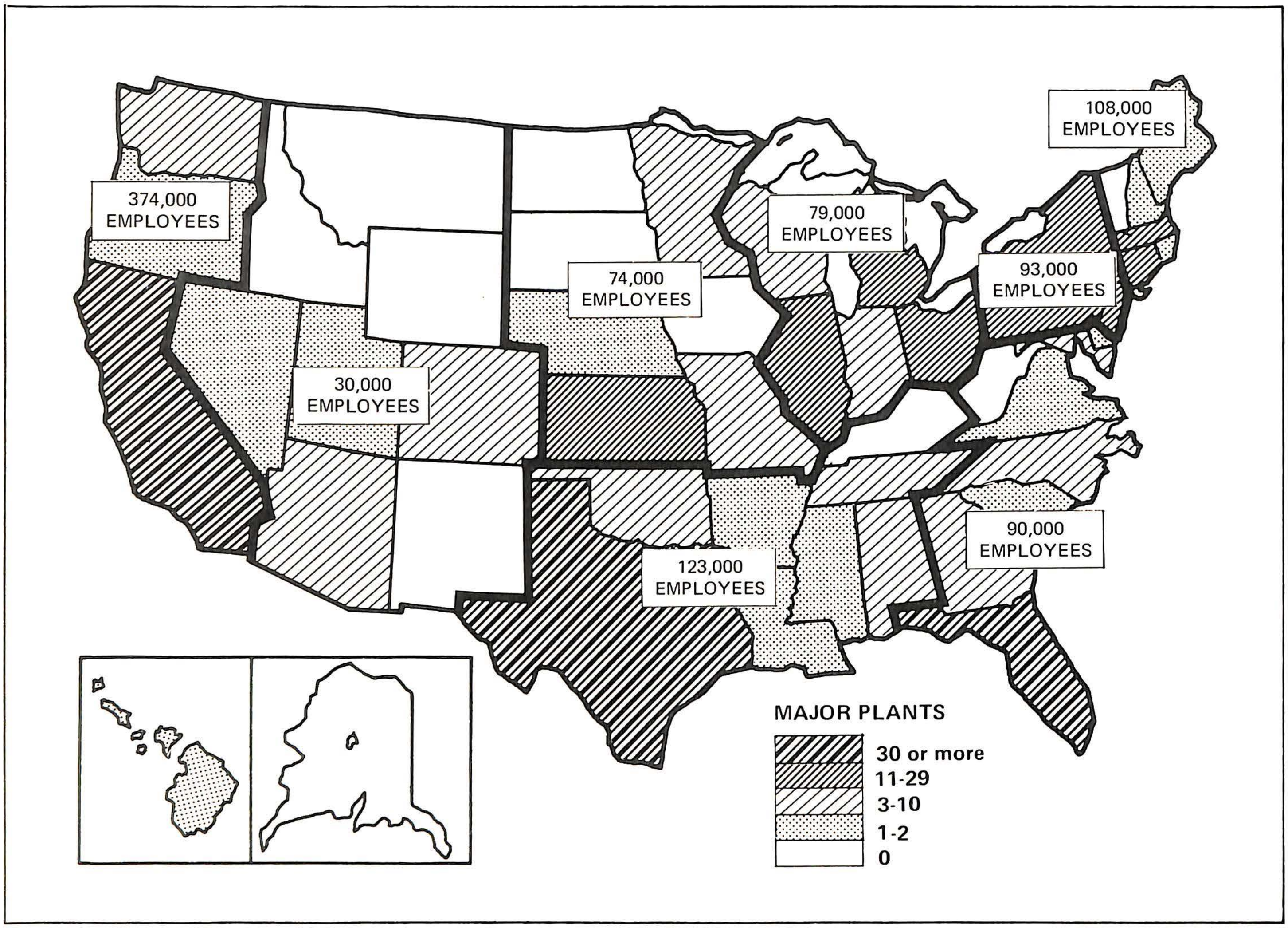
[1] *U.S. Industrial Outlook,* Dept. of Commerce, 1971, p. 387.

[2] Based on data from *Aerospace Facts and Figures*, AIA, 1971.

GRAPH 1

GEOGRAPHIC DISTRIBUTION OF MAJOR AEROSPACE ACTIVITY

Plants by State, Employment by Region



Plant Source: World Aviation Directory and AIA Estimates Employment Source: Based on data from BLS, Manpower Administration and AIA

Industry Location

A relatively small number of prime contractors subcontract extensively within the industry and also award lesser amounts to firms in related industries. Rising costs have accompanied an increase in subcontracting outside the industry, but these factors are not necessarily related. Industrial activity in aerospace (Graph 1) is widespread nationally, but locally and regionally concentrated in the far west (40 percent), north and south central states (27 percent), and the northeastern states (20 percent), because of climatological or agglomeration and technical advantages.

Sales

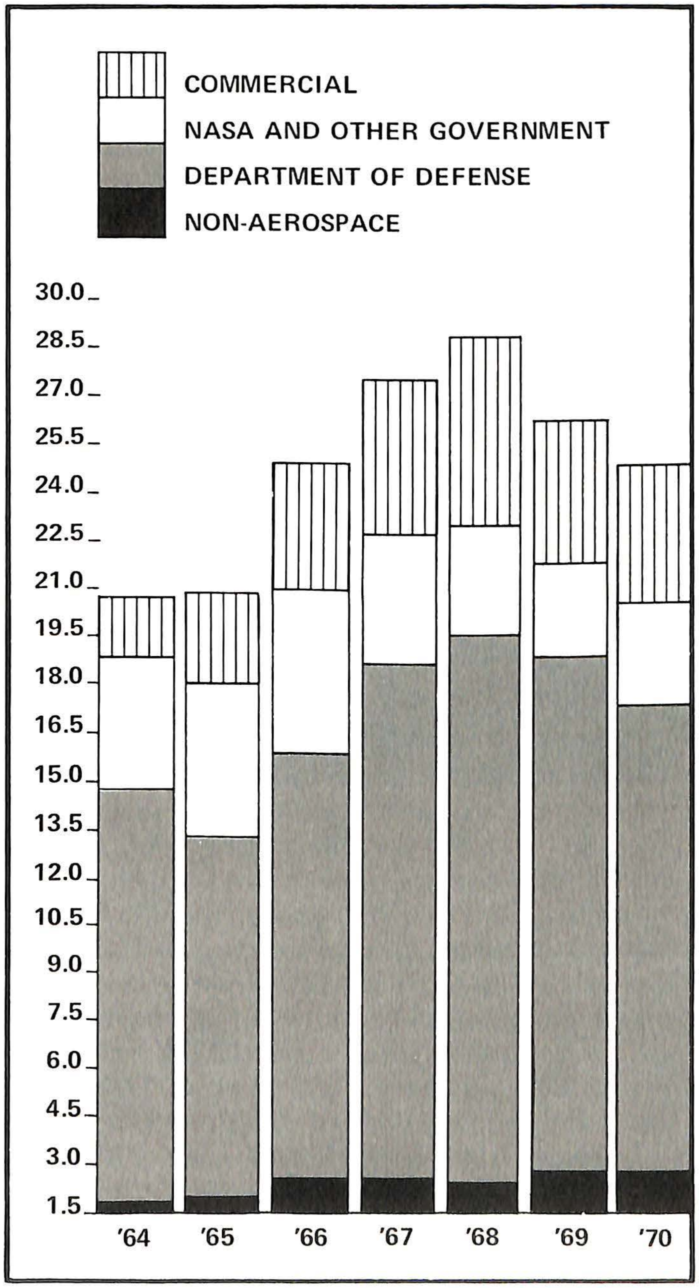
During the past decade, aerospace contributed 1.77 percent directly to the value of goods and services in GNP, plus an indirect contribution of 1.45 percent embodied in the output of sectors supplying aerospace. Aerospace sales in 1970 contributed 1.4 percent directly to GNP and about an additional 1.1 percent indirectly from the supporting output of other industries.

Sales by aerospace firms were 3.6 percent of manufacturers' sales and about 7 percent of durable goods output in 1970, despite a steady decline of more than $4 billion from the level of 1968 to the

GRAPH 2

AEROSPACE SALES

($ Billions)

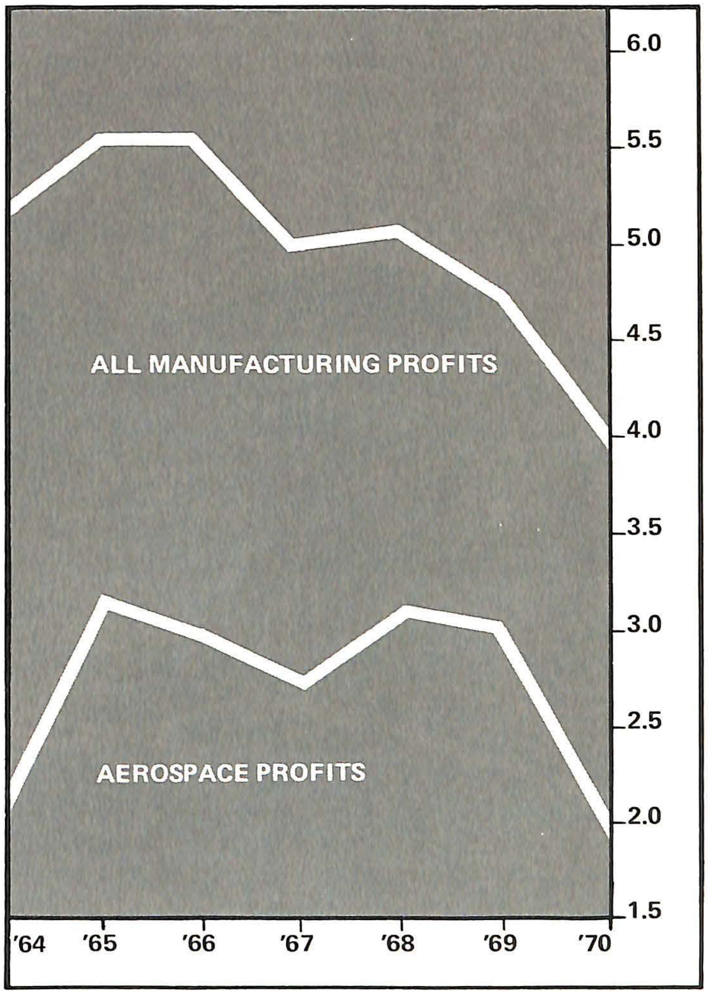


Source: Based on AIA and SEC-FTC Data

GRAPH 3

PROFIT SALES RATIO,
ALL MANUFACTURING AND AEROSPACE

After Tax Profit as Percentage of Sales



Source: Based on AIA and SEC-FTC Data

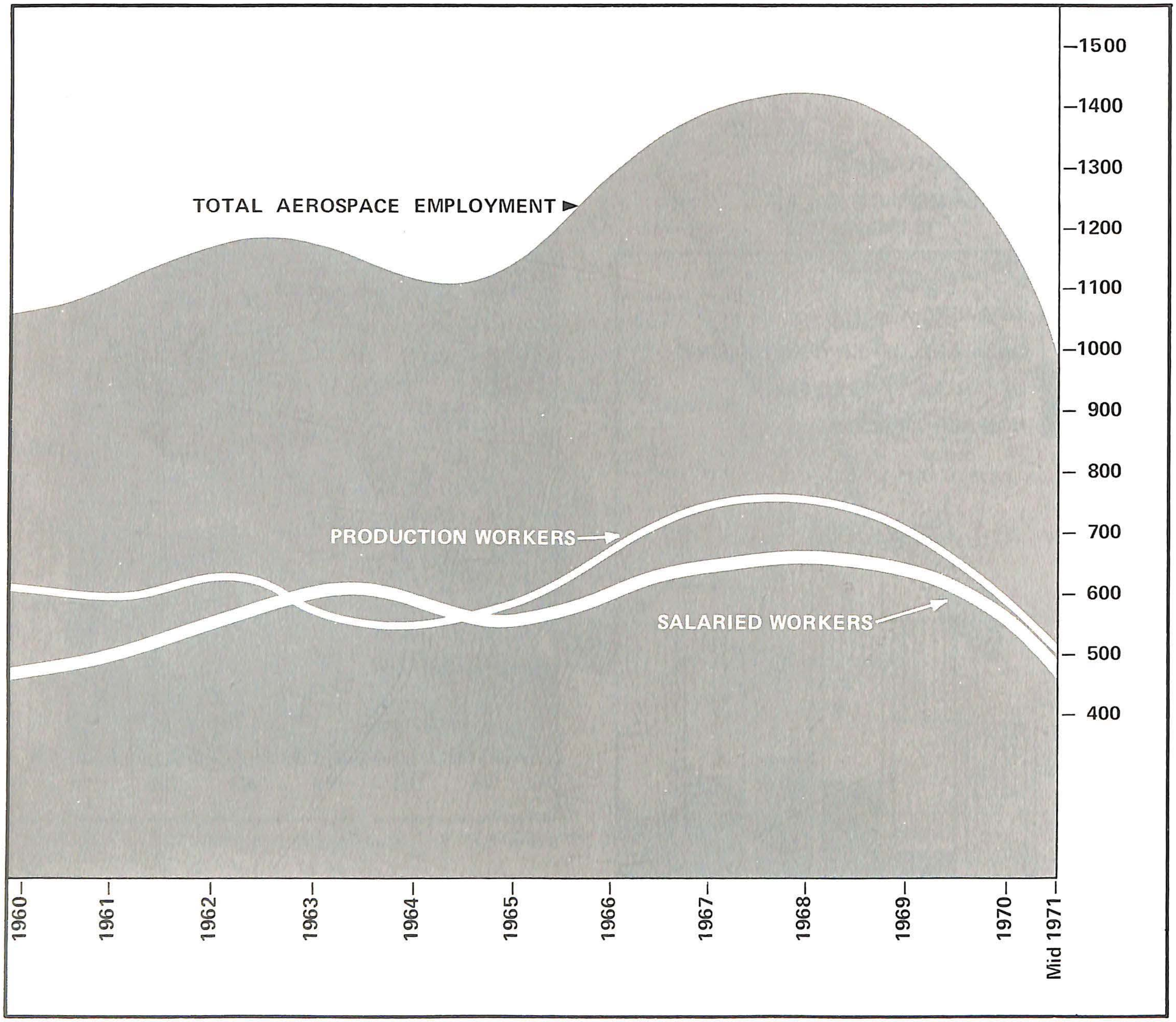
present level. Prior to the economic recession and the aerospace market contraction, the industry experienced a period of accelerated growth that lasted three years, during which time sales were about 3.4 percent of GNP and were substantially higher than in comparable industries. The trend in sales is shown in Graph 2.

Since 1968, the aerospace industry has felt the impact of reduced demand because of space program cutbacks, pressure for reduction in defense expenditures, the satisfaction of jet airliner demands prior to wide-body transport orders, and a reduction in the growth of air travel. As noted, these impacts have been experienced in the form of sharp reductions in

GRAPH 4

AEROSPACE ANNUAL AVERAGE EMPLOYMENT

(Thousands of Workers)



Source: Based on Aerospace Facts and Figures, 1971-72, AIA, Washington, D.C.

employment, reduced sales and fewer new orders, intensified competition for new government contracts, diminishing capital expenditures, and declines in aerospace's net income level and profit rate (Graph 3). The decline in general economic activity has amplified aerospace problems, and sales data indicate slow headway in diversification into non-aerospace products and markets. Moreover, the sharp cutback in aerospace activity has had resounding effects on other private sectors.

Employment

Aerospace is one of the largest manufacturing employers, and generates additional employment in its supporting industries at the rate of about 73 workers per 100 employees in aerospace.[3] Employment was 5.1 percent of the manufacturing labor force and 1.4 percent of total civilian employment in 1970. Although aerospace employment has exceeded one million workers in each year for the past decade (Graph 4), the recent decline in sales and orders has reduced employment since 1968 by about 450,000 in aerospace and more than 300,000 in other related industries through multiplier effects. Despite the contractions in the general economy and in aerospace market demand, the industry directly and indirectly accounts for about 1,700,000 jobs in all industries in 1971.

The aerospace industry is relatively labor intensive and employs as many salaried workers as it does production workers, the largest ratio among comparable industries, because of the great emphasis on R&D and systems management. Systems management requirements and intensive R&D efforts necessitate the employment of a greater number of scientists and engineers than in most industries (Graph 5). However, as of mid-1971, the three-year cutback in employment has affected at least 77,000 of the scientists and engineers who were the nucleus of highly technical research teams responsible for pioneering the innovations and inventions required in aerospace products. In addition, 80,000 other white collar workers and about 290,000 aerospace production workers lost their jobs since 1968. The rate of unemployment (about 16 percent from 1970 to 1971) representing these losses is greater than in other industries.

[3]Based on a BLS employment multiplier estimate, Dept. of Labor, *Bulletin* 1672, p. 125.

Payroll

Aerospace has one of the largest payrolls among comparable industries. But the decline in employment has meant a heavy loss in wages and salaries. A loss of about $3 billion in potential annual payrolls is associated with the decline in aerospace sales and employment when 1968 employment and 1971 wages are taken as base points. The accompanying effects on other industries result in an additional loss of about $2.5 billion in potential payrolls. Although the aerospace payroll was more than $12.8 billion in 1970 (8.1 percent of all manufacturing payrolls), the extent of the current decline can be visualized by the fact that the motor vehicles and equipment sector is now close to exceeding aerospace in payroll and employment. In contrast, aerospace payroll in 1968 was 9.5 percent of all manufacturing payrolls.

Productivity

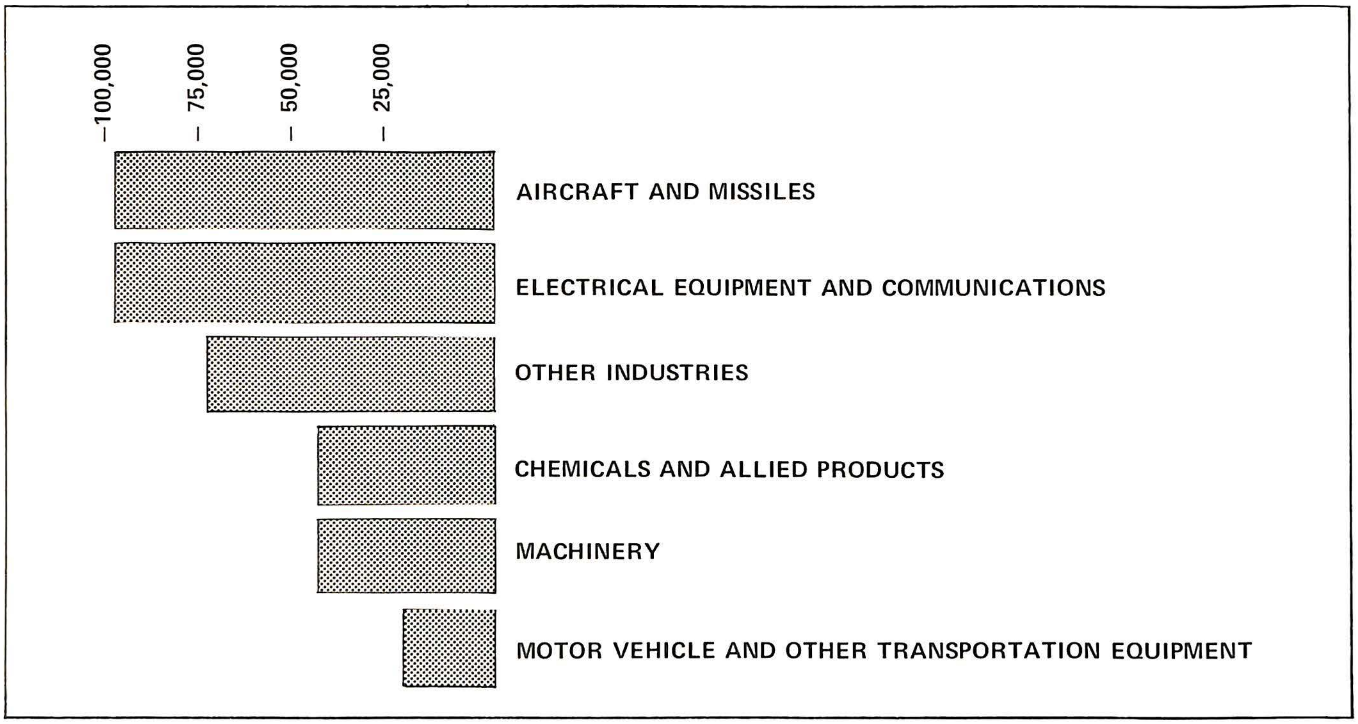
When productivity is based on shipments/worker or value-added/production worker, aerospace production workers are apparently the most productive in American industry, both in the level and rate of increase. Total value-added in the sector is second only to Motor Vehicles and Equipment, indicating a sizeable direct contribution by aerospace to GNP (Graph 6). Both the level and rate of increase in productivity are much above the average for manufacturing. Therefore, average salaries and wages of aerospace employees are also above other manufacturing industries in general. Trends indicate that the gap between aerospace and other manufacturing in value-added/production worker had widened until the recent decline in economic activity.

Fixed Capital Investment

Aerospace is relatively less intensive in fixed capital assets than all of its related industries, but its rate of expenditures in plant and equipment was second highest in recent years until overcapacity set in. In a given year, labor, material, and components costs are much greater than fixed capital expenditures. Inventories are also larger than in other industries due to the unit value of the products on hand and the lengthy time span between design and market dates (Table 14).

GRAPH 5

R & D EMPLOYMENT* OF SCIENTISTS AND ENGINEERS, 1968



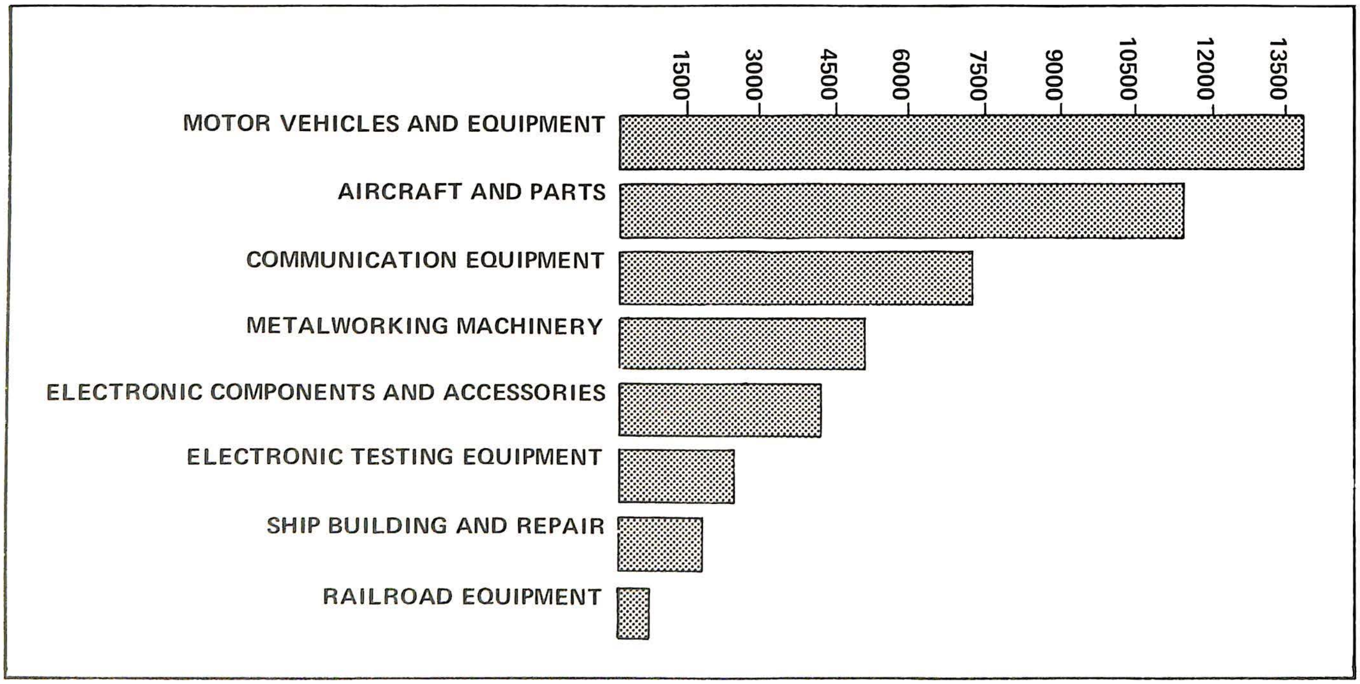
Source: National Science Foundation Annual Report, R & D in Industry.

*Full-time equivalents representing all those who were employed during the year. The actual number of scientists and engineers in aerospace, for example, was 235,000.

GRAPH 6

VALUE ADDED BY VARIOUS INDUSTRIES

($ Millions)

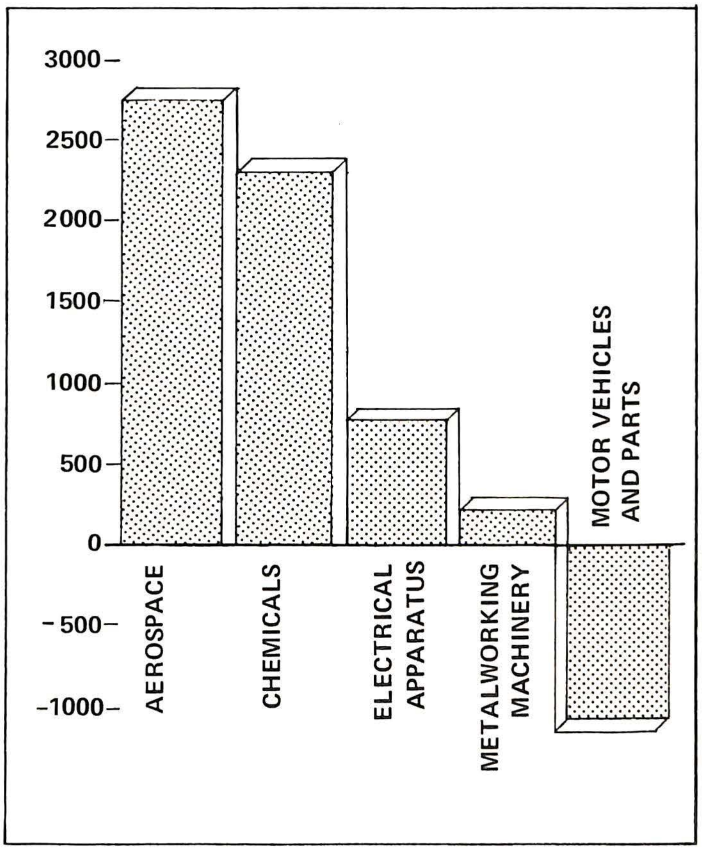


Source: Based on data from the Dept. of Commerce, Census of Manufacturers, 1967.

GRAPH 7

EXPORTS LESS IMPORTS FOR MAJOR U.S. INDUSTRIAL SECTORS,1969

($ Millions)



Source: Compiled from Dept. of Commerce, Bureau of International Commerce and Census data; and Aerospace Facts and Figures, AIA, Washington, D.C.

Balance of Trade

Because of world-wide demand for its reliable high-technology products developed through extensive research and development, the aerospace industry is the nation's largest net exporter (Graph 7). Most of the world's transport aircraft and equipment are made in the United States. Aerospace exports account for more than 12 percent of aerospace sales and 8 percent of all U.S. exports.

Until 1971, the effect of a large surplus in aerospace foreign trade has been: (a) a surplus in the total U.S. trade balance, (b) a deterrent to the erosion of the dollar on world markets, and (c) a postponement of government action to reduce imports of a variety of inexpensive foreign products.

A marked increase in aerospace exports during 1971 has been offset by the current domestic economic situation, little gain in other exports, and heavy importing; as a result, there is a strong possibility of a U.S. trade deficit in 1971. This deficit, however, would be even more severe without the rise in aerospace exports.

The Research and Development Component

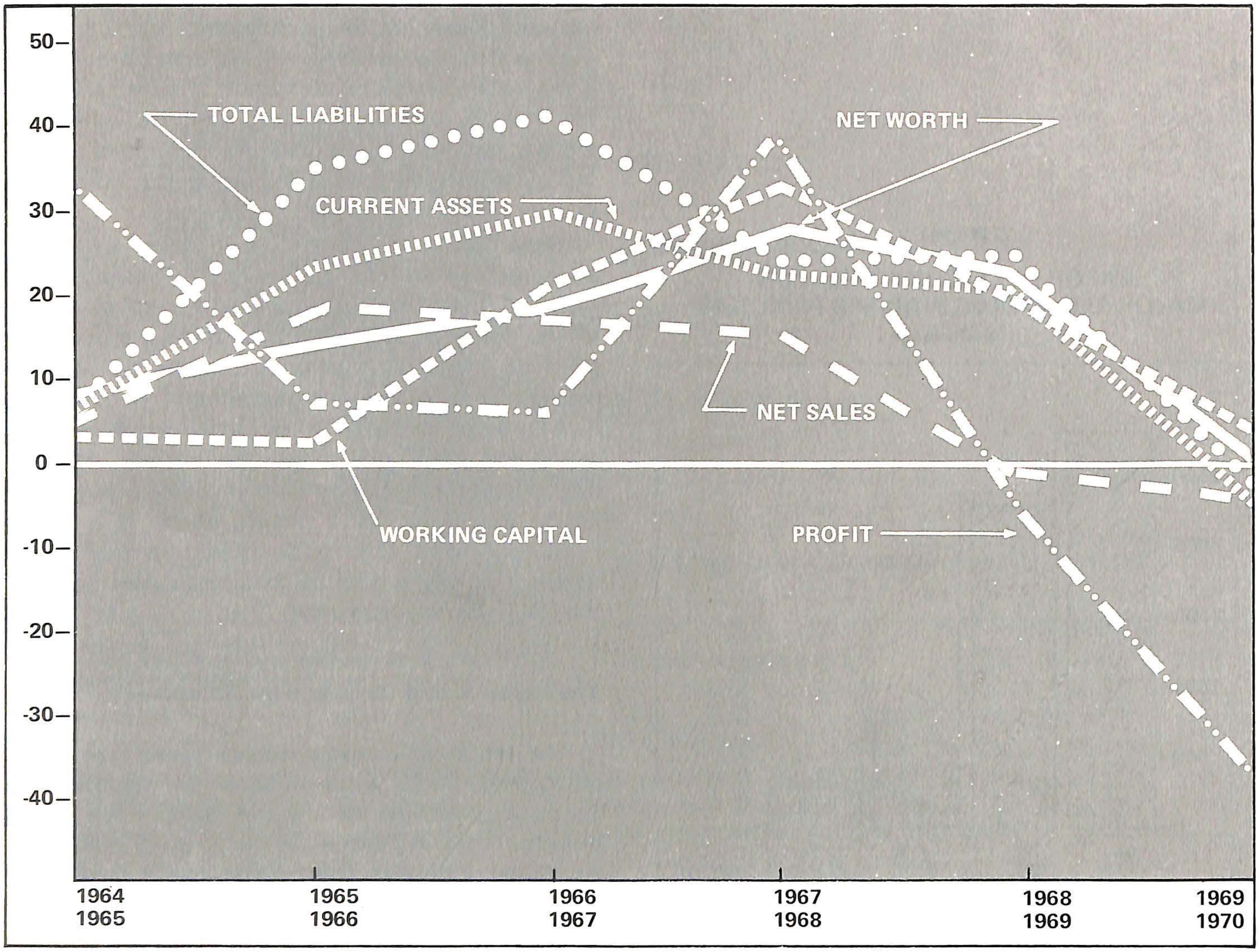
The aerospace industry receives more than half of all federal R&D funds directed to industry, and conducts one-third of all industrial R&D, ample evidence that aerospace conducts more R&D than any other industry. These R&D funds account for one-fifth of total aerospace revenues. The importance of R&D expenditures in the industry is illustrated by the large fraction of scientists and engineers employed, the technological inventions and innovations applied to produce reliable precision products, and the originality of these complex products demanded from the industry.

Defense and space goals dictate the bulk of these demands. But R&D in aerospace have also created a number of spillover effects that have influenced technology in metallurgy, computers, electronics, ceramics, fuels, and power equipment.

Contributions to economic activity and improved living standards stemming from aerospace R&D are in some respects immeasurable. Nonetheless, there is a correlation between economic prosperity and increased expenditures for R&D both in the U.S. and abroad. In any case, R&D expenditures are necessary

GRAPH 8

PERCENTAGE RATES OF CHANGE IN AEROSPACE FINANCIAL CHARACTERISTICS



Source: Based of Federal Trade Commission – Securities and Exchange Commission Data

to maintain U.S. leadership in aerospace exports and to make progress in defense and space programs (Tables 17 and 18).

Financial Characteristics

Because of the critical importance of financing in the aerospace industry, attention must be given to the behavior of financial characteristics.

Aerospace's total costs, inventories, and liabilities in the form of debt and progress payments have all increased steadily but at slower rates in recent years during which time profits, sales, and corporate taxes fell markedly. Liabilities, assets, inventories, fixed capital investment, and stockholders' equity have shown growth and shrinkage patterns similar to one another. Along with sales, taxes paid, and profits—the latter a distinct leading indicator—these characteristics have all turned down from 1969 to the present time, and further decline is indicated (Graph 8).

Progress payments by the Federal Government, gross inventories, and debt in aerospace are relatively greater than in related industries and other manufacturing in general. Net profit, fixed capital investment, stockholders' equity, and depreciation are all relatively smaller in aerospace than in aggregated manufacturing.

Financial performance ratios, when a comparison is made between aerospace and all manufacturing, are directly affected by the aforementioned trends, and aerospace is not as strong financially as other industrial sectors. The high leverage, Debt/Equity, in aerospace reflects potential risk to investors. In fact, when profit is measured on the basis of sales, equity, or fixed assets, it is lower than in comparable industries, and the margin between assets and liabilities (working capital) is thin in aerospace. Therefore, a weak financial position has developed within an industry that depends heavily on large-scale borrowing and prepayments to finance the R&D and manufacturing of complex new programs. Further, these new programs are now few in number and require extremely large amounts of financial resources to cover costs during long periods of development and production.

Almost every indicator illustrates a bleak picture concerning the financial aspects of the aerospace industry during the current period of economic stagnation, when it is viewed alone or in comparison to its related sectors and all manufacturing. In short, the aerospace industry is characterized by the highest debt and the lowest profits when compared to similar industries. The financial problem is directly tied to problems in contract terms, intense intra-industry competition, unforeseen technological difficulties, and the contraction in market demand.

The Role of Aerospace in the National Economy

3

The aerospace industry plays a unique and crucial role in the economic structure of the United States. More than any other industry it is tied to the requirements of national policy and the effects of international events. As the primary developer and producer of the nation's advanced weapon and space systems, the industry's size, structure, organization, skills and product lines are determined primarily by national requirements. As a major supplier to Government, it is subject to constraints and controls imposed through procurement policies and practices of the Federal Government which differ significantly from those in the commercial marketplace. At the same time the industry must compete in the commercial marketplace for economic and human resources under the same economic disciplines that affect all other industries.

As a result, the status and prospects of the industry have a direct and substantial influence on such national issues as taxes, employment, trade balances, and technological progress of the nation. The economic features of the industry, as they contribute to the national economy, are therefore a matter of interest to policy makers. Illuminating those features is the purpose of this chapter. It describes the industry's role and contributions to the economy from a national point of view and describes the major implications of the current decline in the industry.

The National Perspective

The aerospace industry today is a major economic entity and overshadows nearly all other comparable industries in several key respects. Among related groups of industries, aerospace has had the largest net trade balance in recent years ($3.09 billion in 1970), is one of the largest manufacturing employers, and conducts the most R&D—a major long-term determinant of economic growth. Individually, any of these is an economic contribution of considerable significance; combined, they are of vital importance to the economy.

During the decade 1960-1970, the aerospace industry's total sales were $247.7 billion, an annual average of 3.2 percent of GNP. By type, these sales were distributed as follows:

(1) More than $156.3 billion of these sales were to strengthen the national defense;

(2) More than $32.5 billion were directed toward advancing national achievements in space;

(3) Commercial sales during this period amounted to $35.3 billion; and

(4) Non-aerospace sales totaled $23.6 billion.

(R&D funds, which are included in the above sales distribution, amounted to $54.2 billion.)

Sales of aerospace products abroad amounted to more than $23.6 billion during this time period, while aerospace imported $2.2 billion, resulting in a favorable balance of trade of $21.4 billion for aerospace. Between 1965 and 1970, commercial aircraft exports amounted to $9.95 billion, substantially in excess of military aircraft products exported during the same time period.

During 1960-1970, the aerospace industry employed an average of 1,125,000 workers annually, whose aggregate payroll for the period was more than $123.7 billion, about 9 percent of total manufacturing payroll.

Between 1960 and 1970 aerospace paid nearly $4.6 billion in federal corporation income taxes, and its employees paid personal federal income taxes of $18.56 billion.

At its peak in 1968, the industry employed 1.4 million persons, and had sales of nearly $29 billion. These sales represented 3.4 percent of the goods and services enbodied in GNP and 8.8 percent of the sales of durable goods—second only to Motor Vehicles and Equipment, among related industries. The industry's workers constituted 7.2 percent of all manufacturing employment, 12.2 percent of the durable goods work force, and 26 percent of all U.S. scientists and engineers.

From the peak year of 1968, however, the industry has recorded sizeable economic losses. In 1970, its sales represented 2.5 percent of GNP, 3.6 percent of the sales of all manufacturing industries, and almost 7 percent of all durable goods sales. It employs 6 percent of manufacturing employees and 10.3 percent of the durable goods' employees. This sharp decline, occuring within three years, currently represents an aggregate annual loss to the American economy of more than 750,000 jobs, $5 billion in disposable income, and $800 million in personal income taxes.

Of equal importance to these questions of scale in comparison to the U.S. economy as a whole, are the relationships between aerospace and other U.S. industries. Perhaps the most important of these relationships is not shown by hard data: the technological demand-pull exerted by aerospace on other industries. That is, the aerospace enterprise has created and articulated demand for processes and products that are now considered essential to our industry and society, but which would probably not have been produced in the absence of the aerospace requirement. Examples of these goods abound in the fields of electronics, computers, metallurgy, communications, ceramics, and other areas.

Some further insight into the industry's economic role will be gained by briefly discussing data on its relations to its markets and to other industries.[4] First, aerospace buys quite heavily from within the industry. Of the industry's gross output, 19 percent goes to satisfy demands within the industry, as compared to 6 percent for the electronic components industry.

Despite this heavy dependence on intra-industry activity, the aerospace industry itself creates a significant number of jobs in other industries by virtue of its demands for goods and services. Specifically, it has been estimated that for every 100 jobs created in the aerospace industry, 73 additional jobs will be created in other industries.

Most important, however, the industry is dominated by the government as a customer. About 70 percent of aerospace's gross output sold to the ultimate users ("deliveries to final demand" in the terminology of input-output economic models) goes directly or indirectly to the Federal Government, while 20 percent goes to commercial and private customers. This contrasts sharply with other comparable

[4]This aspect of the industry is discussed at greater length in Appendix A. It should be noted that the discussion to follow is based on the latest industrial input-output data for aircraft and parts.

industries: motor vehicles and equipment, for example, sells only 5 percent of its end products to the government, 65 percent of total output directly to private customers, and 25 percent to commercial firms; radio and communications equipment sells 41 percent to the government, 22 percent to commercial firms, and 32 percent to customers. The high proportion of its gross output going to government reflects a most significant feature of the industry for the purposes of this study. Aerospace is strongly linked to national needs that cannot be filled by ordinary purchases in the commercial marketplace. Major growth of the industry is attributable to meeting requirements for defense and space exploration. It is accustomed to responding to needs that are articulated in the public sector rather than the private sector. The importance of this feature of the industry is related to the fact that acute public sector needs are now emerging with great force in many other areas of government operation.

National Implications of Aerospace Decline

The industry's strong links to national needs have occasioned much of the present concern about the aerospace industry. When an economic entity of this magnitude—whose products and processes and demand for inputs have so deeply influenced the products, productivity, and techniques of many other U.S. industries—enters such a decline, a careful examination of the causes, solutions, and implications, is a matter of national importance.

This decline takes on added significance when it is recalled that the aerospace industry is one of the few U.S. industries that has always enjoyed a foreign trade surplus. Aerospace represents one of our most important exports, not only because of the direct trade effects, but also because it creates fruitful ancillary dependencies and industrial relationships overseas.

Another reason for concern is that the aerospace industry is high in technology and research and development. The aerospace industry is engaged in more R&D effort than any other industry in the nation, accounting for 32 percent of all industrial R&D as recently as 1968. A substantially weakened capability by aerospace to supply this R&D will have severe long-term effects on U.S. industrial growth and productivity. In general, it has been noted by many observers that industries high in R&D and technological content are strongly growth-inducing. While much has been said and written recently in a descriptive sense about the relationship between the rate of economic growth and the level of expenditures for R&D and technological advance, precise values for this relationship are difficult to estimate. One of the most serious students of the problem, Edward F. Denison, has estimated that up to one-quarter of a one percent change in the measured growth of GNP can be imputed to "advance of knowledge" which, admittedly, includes both technological and "managerial" knowledge.[5] But even so, the relationship is clearly important. For if 25 percent were assigned to R&D and technology as a contribution to GNP, this would mean that in a $1 trillion GNP a rise of one percent would be $10 billion for which R&D and technological "advances in knowledge" would account for $2.5 billion. A relationship like this also embodies many of the less obvious effects that link R&D to general well-being. These linkages are subtle and barely perceptible in part because they may take years to produce a tangible effect. This phenomenon is described in more detail later.

With regard to productivity, a government staff analysis recently suggested that a strong relation exists between the amount of research and development invested in an industry and that industry's improvements in productivity, running to the order of a 1-percent productivity increase associated with a 3-percent increase in R&D. In the case of aerospace, an industry that has produced new materials, procedures, and techniques for a broad spectrum of the industrial community, expenditures on R&D have productivity effects in many other industries as well as in aerospace itself.

Most important, however, is a facet of the industry that will not be seen in the statistics of the input-output tables or international transactions. The industry as a whole bears a very subtle relationship to the U.S. economy and indeed to the society—a relationship whose severe disruption would not immediately affect economic indicators, although it would have important long-term consequences. This relationship is best presented by analogy.

---

[5] Edward F. Denison, *The Sources of Growth*, Committee for Economic Development, New York, 1962.

Imagine the effect on the economy of a community if its school system were discontinued. Since schools relate to the well-being of a city in a way that is extremely subtle, the effects of discontinuing these functions would not show up immediately in delivery of critical services or in reduction of the gross product of that community. But that is not to say that these services can be disregarded with impunity. The reason that effects are not readily seen is that their links to the functioning of the community are indirect and distant. They create the capacity to respond to unanticipated community needs. They build and conserve scarce intellectual resources that cannot be replaced overnight.

The aerospace industry plays a similar role in the economy of developed nations. It has come to be the source of essential intellectual and technological strengths which percolate over time through the entire industrial and economic framework, reaching the level of functional importance only over a long time period. And these impacts are quite sensitive to changes in the level of activity within high technology industries. It is very difficult to recover capability lost when this interaction between the economy and high technology is interrupted. This is because the lead times are long and the causal connections between the industry and the general economy are complex and subtle.

Moreover, in the decades ahead, the rate of change in the environmental and social factors to which the nation must respond can be expected to increase. This will call for the maintenance, if not the expansion, of the national capacity to provide needed services and to find technological solutions. The aerospace industry is a powerful potential source of those solutions, and its loss or serious decline would render them many times less likely.

The fact that the decline of an industry that relates in these ways to the U.S. economy will have a damaging impact on the economy is self-evident. Less evident is the degree of impact. For example, the aerospace industry does not presume to claim that it alone is the seed-bed of all national R&D or technological advancement. Obviously, this is not the case, as even nodding acquaintance with current research on power generation and energy sources, electronics, underseas explorations, materials, foods and fibres, chemicals, and medicine will indicate. However, an open-minded perspective is one of balance and proportion, of seeing both the gains and the losses, of weighing the actual benefits achieved against other benefits foregone. The following chapter is intended to help form that perspective by examining in greater detail the economic nature of some of the critical problems the aerospace industry confronts as it seeks to find a logical and productive place in the U.S. economy of the 70's.

Critical Economic Problems of the Aerospace Industry

4

Like any asset, national or otherwise, the value of the aerospace industrial establishment rises and falls in response to a number of factors. In this chapter a number of such factors will be examined to form a clearer picture of the industry in the operational national economic context and to focus on a number of general and specific problems that emerge from that operational context.

From the foregoing chapters has emerged a description of the aerospace industry that denotes a unique set of characteristics:

- A product line dominated by the government customer and subject to severe and abrupt shifts in requirements and program levels.
- A product line that is continually pressing the frontier of the technological state-of-the-art and which carries with it unusual levels of technological uncertainty and risk.
- Single programs of unusually high funding levels, high unit value items, and relatively small production runs.
- Exceptionally long leadtimes in bringing products and programs to eventual completion, in many cases running to more than ten years.
- Except for some aircraft models, lack of a commercial market for most of the industry's products.

For the most part these characteristics reflect the industry's response to national demands represented principally through the Federal Government's programs in defense and space and, to a lesser degree, demands from the commercial airlines for passenger and cargo aircraft. In general, the sheer size of these demands means that the industry's problems of adjustment and adaptation to changing economic conditions take on a degree of difficulty that is well beyond the ordinary.

As with all of America today, the aerospace industry finds itself sharing national concern over a reordering of social and economic priorities. The current controversy concerning the appropriate role of America in international political affairs, the unresolved will about further space exploration, the prevalent skepticism about technology's values, the confusion about the role and level of the defense establishment in the wind-down of the war in Vietnam, and the persistence of general inflation and unemployment throughout the national economic scene all mean that aerospace confronts a number of particularly critical problems as it seeks to find a viable and useful role to play in the social and economic scene that is unfolding.

This chapter addresses problems of the aerospace industry in two principal viewpoints. One set of problems may be thought of as those arising from the nature of the industry as it seeks to function in an economic and social environment that the industry by itself has little or no power to affect in any significant way.

Another set of problems arises because of characteristics of the industry that are, in a way of speaking, internal. That is, these problems would exist for the industry almost regardless of conditions in the general economic and social external environment. They are problems more sharply derivative of the industry's structure and form than its operational context.

Aerospace Problems in the General Economic Setting

Aerospace Concentration

The aerospace industry has developed and expanded in response to the special requirements of its government and commercial customers. Beginning with World War II, the need was for large quantities of varied weapons systems—basically bomber, transport, and fighter aircraft as well as light planes for training and observation. The aerospace industry had to begin to concentrate capital, labor, and facilities to maximize output to meet the nation's defense requirements. Most of the large aerospace firms of today trace their beginning to this period or to the commercial aircraft development period of the 1930's.

The problems of aerospace retrenchment at the end of World War II were significantly different from those of today because the total labor force was much smaller and the technology of aerospace much less specialized and scientific than at present. Much of the wartime employment in aerospace consisted of production workers who were only temporarily in the labor force—housewives, elderly people, etc.—and they simply dropped out of the market. Much of the facilities and equipment was government-owned and the corporations did not need to worry about dismantling or disposing of them. Wartime skills were somewhat transferrable to peacetime industries, whose pent-up consumer demands more than absorbed the resources released from wartime production.

After World War II, aerospace was engaged primarily in commercial aircraft production plus some government aircraft programs beginning to develop in the late 1940's and early 1950's. The Korean War also stimulated some growth during this period as jet aircraft developed. This was followed by the growth of air travel and private flying, and the commercial aircraft market began to expand rapidly. Then came the need for a more sophisticated defense industry and the post-Sputnik space race. The aerospace industry responded readily and well. However, this response posture has been at the core of many of the current industry problems.

The defense, space, and commercial transport programs were large by any development and production standards. Huge labor forces had to be recruited and trained. Giant facilities had to be constructed or refurbished. Capital had to be accumulated in large amounts in order to finance the expansion. Thus, an industry emerged that was regionally concentrated and with highly specialized management, labor force, and systems management capabilities. It had a limited line of products as well as a very narrow market in terms of the number of customers. The number of large firms in the aerospace industry was limited due to the few programs, but they were supplemented by many medium and small sized companies who served as suppliers and subcontractors to the large firms or played roles in the smaller defense and space programs.

This system operated smoothly during the early and middle 1960's with healthy corporations and robust economies in the regions where the aerospace firms tended to locate. Climate, trained labor forces, and agglomoration economies all combined to generate a specialization advantage of notable proportions. These benefits would probably exist today except for the economic downturn of the late 1960's and the social and political pressures to change our national goals and priorities.

Decline in Traditional Markets

The events of the last three years have had a profound effect on the aerospace industry. Its commercial customers have suffered downturns, new orders have diminished or almost ceased, and options and even firm orders in some cases have been canceled. The government also has canceled or curtailed major programs and replacement programs are limited. Thus, the aerospace industry, which was fostered by large government military and space efforts, as well as by rapid growth in airline and private aircraft travel, finds itself with a large labor force, major facilities, and large financial commitments without the continuing business to fully sustain them.

In contrast to other manufacturing industries, the aerospace industry finds itself with few if any alternative courses of action. The commercial aircraft market appears likely to suffer from a continuing low level of value for the next few years and from growing foreign competition. There are a limited number of large military programs on the horizon beyond those now in operation or in the development stage. Space emphasis is switching from lunar exploration to orbiting stations, with an attendant low activity level during their development. As a large prime contractor company experiences a sharp decline in sales, the reverberations are felt throughout the several tiers of subcontractors. Each of the prime contractors heavily influences the activity of many smaller companies and, as the number of aerospace programs is reduced, not all can maintain a stable level of operations.

Other Market Opportunities

A further complication is the degree to which the aerospace companies are specialized in terms of experience and facilities. In addition to the difficulties of career transferability, which will be discussed later, there is insufficient corporate mobility to other non-aerospace product areas. Many of the larger firms have not yet been able to diversify adequately into other lines as the aerospace market has declined. Acquisitions and mergers have been accomplished, but frequently these are into other phases of aerospace or else in compatible areas, such as shipyards or surface transportation, which today are also relatively depressed or underfunded industries.

Competing on a large scale in existing commercial manufacturing markets is very difficult. The market would have to be so big in order to absorb this aerospace capacity that only a few, such as steel or automobiles, have the relevant scale. And even these are practically closed to entry; the capital and facility requirements to establish a firm capable of challenging any of the large manufacturers would be difficult indeed for any company to achieve. Marketing channels would be completely new compared to aerospace; this too is a major drawback to such diversification.

The aerospace sales volume, which has declined by more than $4 billion recently, cannot be readily replaced in new fields. The alleviation of problems in waste disposal, mass transportation, oceanography, education, and ecology are all receiving much attention and undoubtedly will be growing rapidly in the next few years. However, current funds are not available in the large and concentrated quantities needed to offset the declines in traditional aerospace business, though such fields hold promise for technological solutions.

The Problems of Regional Dependence

Large aerospace programs have led to a concentration of aerospace firms in the regions of the country where the major prime contractors are located. The regional benefits from these corporate business location decisions worked well during prosperous times. However, when such programs are canceled or lost, there are severe economic consequences to the people of the region.

Many of the larger firms tend to dominate their regions economically. As a result, cutbacks in aerospace are multiplied throughout the region and the unemployment rate can be two to three times the national average.

The Problems of Labor Specialization

As shown in the industry profile, aerospace companies employ about one-fifth of all scientists and engineers in the U.S. These people are not generalists; they are highly specialized in aerospace work and their skills in many cases are not readily transferable to other industries. Thus, even if there were other local labor requirements, which often is not true, the aerospace worker's skill gives him very little if any advantage. In addition, the aerospace scientist's or engineer's salary requirements may well exceed the value of his specialized talents in another industry. Thus, if he does find another position, he is often underemployed.

A further complication is the geographic immobility of aerospace workers. They are unemployed in an industry that is unlikely to have job openings in any other localities. If the national economy generally and the regional economy in particular are in a state of recession, personal assets may be difficult to dispose of or liquidate. This further delays any potential relocation.

The unemployed aerospace worker therefore faces a series of problems that as a group are unique to industry. In turn, the industry problem leads to a loss to the nation as well, in that a pool of highly skilled labor is "locked in" and cannot be readily put to work in its own or another industry and cannot be easily moved to a location where it can be utilized.

The Problems of Intra-industry Transfer of Assets

Even within the aerospace industry itself the problem of product specialization limits the transferability of facilities, equipment, and skills between programs. The equipment in aerospace manufacturing is often so specialized that it is custom-produced for a single program or program type and any different program will require completely new equipment and a write-off of the existing plant and machinery.

Thus, again, the problem is one of transferability of special talents and capacity because of a dearth of companion programs and little ability to utilize talents and capacity in other incompatible programs. An airframe manufacturer cannot easily compete in the engine market. The missile division of a company cannot easily produce airframes. Rotary wing specialists cannot easily build space vehicles.

The effect of these industry specialization characteristics in the current economic environment is to make inordinately difficult the industry's own task of adjustment and diversification. Due to its principal dependence on the government customer and the heavy tailoring of its economic structure to meet his needs, the industry is severely limited in its power and capacity to enter other markets. All businesses learn the art of dealing with changing market demands. But the sheer scale of major program changes in the aerospace industry, both for the government and commercial customers, means that the concentrated effects go far beyond those of industries whose economic structure is more stable, balanced, and diffused.

Effects of Inflation

The pronounced inflation that the country has experienced during the last three of four years obviously has different meanings to different elements in the economy. For the government it represents a challenge upon its monetary and fiscal policies designed to affect aggregate levels of consumption and investment spending levels. For individual citizens it represents a problem of trying to sustain a level of real income by seeking wage increases either through union or other pressures, by changing employers, or by re-directing expenditures. For individual industries and firms within them, inflation represents difficulties on the cost side in respect to wages, materials, and finance and on the sales side in respect to the prices to be charged actual or potential customers. If an industry's products are characterized by relatively small production runs; if, relative to the gross value of sales, the products have small proportions of R&D directly invested in them; and if the firms produce and sell high volumes of low-value products; then, unanticipated inflation of factor prices and materials can more readily be incorporated in price adjustments than where contrary conditions prevail. Obviously, a manufacturer of electrical toasters can more easily adjust his production and prices to reflect inflationary effects on factors and supplies than can a manufacturer of, say, precision testing equipment.

The aerospace industry is particularly vulnerable to inflation because of four main factors:

(1) long R&D and production phases;

(2) heavy dependence on a few principal customers;
(3) a small number of high unit value product items; and
(4) a high working capital/total capital ratio, reflecting the large labor and materials cost shares of final product value.

These will be examined separately.[6]

Long R&D and Production Phases

It is characteristic of the aerospace industry that its principal products require a substantial investment in R&D both prior to and during the formal production process. For instance, R&D in aerospace currently runs to something around 19 to 20 percent of sales, compared with approximately 4 to 5 percent for all manufacturing. While most of the aerospace R&D activity is funded by the Federal Government, the substantial uncertainty of dealing with many product and system unknowns makes accurate determination of costs and product characteristics difficult. This uncertainty by itself carries many difficulties in a period of changing prices.

The R&D period is the important prelude to a production phase. And the two phases combined can typically take something like 7 to 10 years and even longer for major defense systems. Under these conditions, predicting the way in which general price effects impact on detailed inputs (such as wages or components and materials) is extremely difficult. Recent experience illustrates these difficulties. Up to 1968 the overall rate of price level change was 3 percent annually; however, since 1968, the annual rate of increase has roughly doubled. It is hard under these conditions to quote a price for a major aerospace system to be delivered, say, five years from now. The error in estimation could be substantial since compounding is involved. For example, at 3 percent per year compounded a dollar in costs will increase over five years to $1.16; at 6 percent per year the dollar would have risen to $1.34, a *difference* of $.18 on the dollar.

How serious the influence of this factor can be is indicated in the recently released GAO Report presenting causes of cost growth for 61 major Department of Defense weapon systems.[7] That study disclosed that approximately 17 percent of the identified cost growth was due to "economic factors," meaning principally inflation. Quantity changes, engineering changes, estimating errors, and other factors also contributed to the total cost growths that together now average out to about a 40 percent increase over original planning estimates. This would mean that for an original planning estimate of $100 for a system, it would be expected to show cost growth of $40 through the program completion. If inflation of 3 percent per year accounts for 17 percent (i.e., $6.80) of the $40 increase, then a 6 percent per year price rise would have caused better than $13 of the increase assuming the other influences remained unchanged.

How difficult it is to estimate accurately which rate of price change to use is obvious. It is interesting to note that current DOD guidance for price level changes in weapon systems cost estimates stipulate a 17.5 percent increase for a five-year projection, or roughly 3 percent per year. This means, then, that if prices and costs rise faster than approximately 3 percent per year for these items, DOD cost estimates seeking to use this price change factor themselves will be erroneous. How to obtain realism for both buyer and seller under such conditions is difficult and not immediately clear.

Heavy Dependence on a Few Principal Buyers

The implications of material and other price changes in long leadtimes intensify to the extent the seller is principally dependent on one or a few buyers. More buyers obviously could mean more opportunities to adjust final product prices to reflect factors such as those noted above, even under conditions of large R&D expenditures and long leadtimes. As noted earlier, the aerospace industry's current output is heavily tied to the Federal Government, which buys about 80 percent of its production. Even in the non-government portion of

[6]Identification of these four factors is not meant to imply that others (such as Federal Budget shifts, cancellations, renegotiations, technological uncertainties, cost estimates) are not equally serious for industry operation. These four, however, are judged to be particularly relevant here.

[7]*Acquisition of Major Weapon Systems*, Government Accounting Office, 1971.

its market, essentially commercial aircraft, engines, and parts, the buyers are few in number and generally homogenous in attitude and outlook. This heavy dependence on one (the government) or a few (the airlines) buyers by the aerospace industry leads to less resilience by the producers in altering pricing behavior in the face of rapidly changing costs. If, by contrast, the products are sold in large numbers of relatively low unit value to many buyers, product price changes can be effected more smoothly than in the case with one or very few buyers. The often erratic nature of funding decisions by single buyers, whether government or commercial, produces more intense effects on producers than in cases where more buyers are involved.

In a period of inflation, heavy dependence on government programs combined with funding variations, places excessive strain on the producer's financial capital resources. Inflation is ordinarily a condition of scarce or high-priced money. So if funding variations force producers into the money market for additional support, particularly for working capital, the result is simply another addition to the cost growths. A period of inflation typically will stimulate efforts to curtail government expenditures as a normal part of fiscal policy, and this may well add another element to the normally difficult-to-predict funding behavior.

A Small Number of High Unit Value Product Items

The aerospace industry had about $24 billion in sales in 1970. By comparison, the motor vehicle industry for the same year reported approximately $23 billion in shipments of cars, truck and bus chassis, bodies, and trailers, disregarding additional sales of automotive parts and accessories. For the motor vehicle industry, this $23 billion of shipments represented something around 8 to 9 million units, at an average unit value in the range between $2,500 and $2,800.

For the aerospace industry, it is a little more difficult to visualize an acceptable or comparable "unit" to summarize its $24 billion in shipments. But a useful impression can be formed in this manner: In 1968 the Department of Defense estimated that the cost of 4,400 military aircraft produced was $4.5 billion or approximately $1 million per aircraft system.[8] Current orders for jet transport aircraft are $9.3 billion for 634 units, or approximately $14 million per unit. Missile and space systems and space exploration vehicles are somewhat harder to categorize but they account for about $9 billion of the 1970 estimated aerospace industry's sales, and this implies a high unit value akin to those for aircraft systems. In any case, the point is clear: that aerospace products come in small volumes and high unit values. Because of this, cost change effects are more penetrating and direct and the impact is heavier on the single or relatively few customers or on the manufacturer, whichever bears it.

With a production contract under way and cost changes experienced, the normal government and airline reaction is to "stretch out" the production run and to reduce the quantity ordered. The C5A and F-111 are current examples from military procurement experience. But reduced orders for Boeing 747's and less-than-anticipated orders for other wide-bodied transports tell the same story. The producer's heavy commitment to the largely unique and specialized physical and human capital involved in the production, his ability to absorb the change by redirecting or redeploying his capital resources is very limited.

A High Working Capital/Total Capital Ratio

An additional factor that makes the aerospace industry vulnerable to inflation is its high working capital/total capital ratio. As pointed out in *Aerospace Profits Vs. Risks*[9], the all-manufacturing industry ratio of working to total capital is 0.4, while for aerospace it is 0.6. Government-furnished working capital represents about half the industry total (in the form of prepayments and advances), and this admittedly helps bear some of the industry's heavy liquid asset requirements or burden. Much of this burden arises from the relatively high proportion that labor and material costs bear to total value of output in aerospace products, better than 17 percent higher in the aerospace case than for all manufacturing, as shown in Graph 9. And this results in approximately $0.20 more working capital per dollar of sales in aerospace than the all-manufacturing average in 1970.

---

[8] *Aerospace Facts and Figures*, 1971, pp. 32-33.

[9] AIA, 1971, p. 6.

As noted, these variable cost items are more likely to rise quickly during inflationary conditions. But at the same time, if conditions force principal buyers to curtail spending, the high short-term interest costs associated with this large liquid asset burden, plus the already high level of debt financing, will strike aerospace heavily.

If these principal factors are taken together, then, it seems clear that the aerospace industry stands at a special disadvantage compared with other industries during a period of inflation. Accordingly, the risks that it bears are especially high. Its ability to "protect itself" against these inflation-borne risks is quite limited and thus contributes substantially to the financial problems and poor rate-of-return record in recent years.

Together, then aerospace industry's necessary specialization and concentration in both manufacturing structure and location, along with its special production and product technological characteristics make it particularly vulnerable to large changes occurring in its external economic environment. Declines in orders from its few principal customers accompanied by general conditions of inflation mean that substantial adjustment reactions are called for. But the basic high technology factor that drives so much of its manufacturing process precludes prompt and effective responses by the industry.

Particular Aerospace Problems

There are a number of specific industry problems largely independent of any particular level or aberration in the general economic environment.

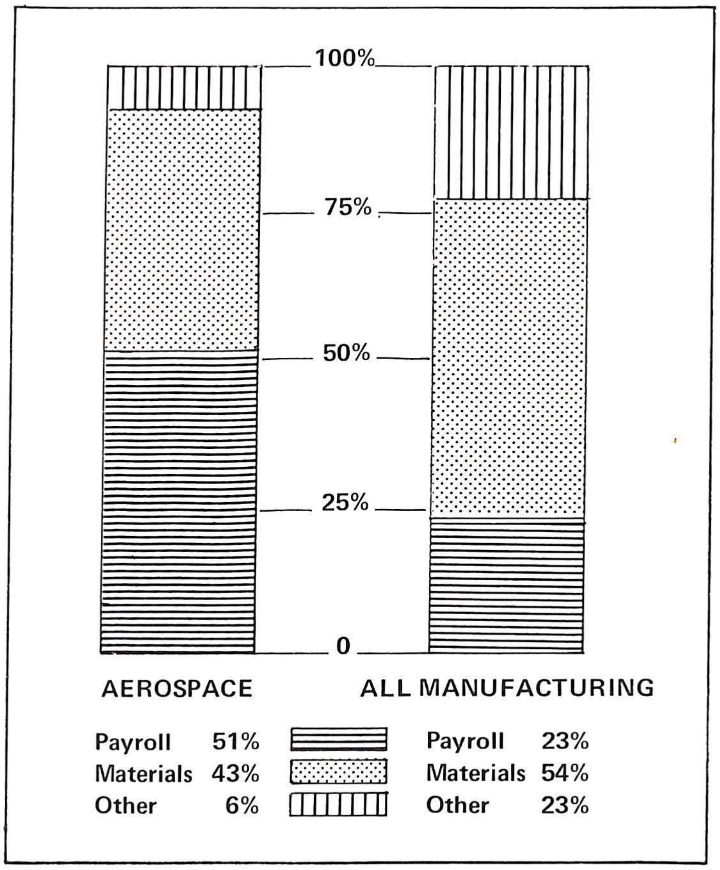
Research and Development Problems

The correlation between R&D expenditures and growth of both the industry and the U.S. GNP for the last two decades is apparent. Secretary of Commerce Maurice H. Stans and Assistant Secretary of the Treasury Murray L. Weidenbaum, in testimony before the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics both noted this relationship.[10]

[10] Secretary Stans in a statement of July 27, 1971, and Assistant Secretary Weidenbaum on July 29, 1971.

GRAPH 9

PAYROLL AND MATERIALS COSTS AS A PERCENTAGE OF VALUE OF SHIPMENTS (1963-1968)



Source: Industry Profiles, 1958-1968, Bureau of Domestic Commerce, U.S. Department of Commerce, Washington, D.C., 1970.

Secretary Stans pointed out the strong relation between the technological content of goods exported and the foreign trade balance experienced by the U.S. since 1964. Assistant Secretary Weidenbaum noted that the level of R&D expenditures is closely related to economic growth in general and to productivity in particular.

In addition, a 1967 study by RAND and the Brookings Institution noted that, "technological knowledge (is) the key determinant of the rate of production and general economic progress."[11] As the nation's leading R&D industry, performing one-third of all industrial R&D in 1968, aerospace is peculiarly sensitive to the effects stemming from these important relationships.

[11] Nelson, R. R., et. al., *Technology, Economic Growth and Public Policy*, The Brookings Institution, Washington, D.C., 1967.

R&D Trends

Currently, about 16 percent of Federal Government outlays for goods and services are for R&D. Aerospace receives about 30 percent of this, or just under $5 billion. The annual growth rate of federal R&D expenditures has been slowing appreciably in the last few years, however, from 14 percent per year in the 1950's to less than 5 percent in the late 60's. Discounting for inflationary effects, this rate becomes about 0.3 percent per year in the last five years as compared with 11 percent in the 1950's, and 7 percent in the early 60's.[12] Both the Department of Defense and NASA expenditures reveal an absolute decline after 1967-1968. While total government-funded R&D shows a modest increase from 1970, most of this has been in non-aerospace categories and reflects some reordering of national priorities.

R&D is a vital source of technological resources for the aerospace industry. Its importance is reflected in numerous ways. First, the ratio of R&D funds to sales revenues was higher for the aerospace industry than for any other industry. At its peak in 1964 the aerospace industry experienced 28.9 percent of its sales as R&D funds, compared with an average of 4.6 percent for all industries and 9.8 percent for the electrical equipment and communications industry. Indeed, 31 percent of the products expected to be sold in 1974 were not in the product line in 1970.[13] Comparable percentages for other industries are 23 percent for instruments and 31 percent for autos, trucks, and parts.[14] Moreover, a higher percentage of total employment is scientists and engineers in the aerospace industry than in any other industry (about (about 20 percent of the total number of engineers and scientists in all U.S. industry).

For these reasons, the general decline in productivity and performance attending a cutback in R&D expenditures has hit the aerospace industry harder than other industries. Processes vital to production in the industry are more sensitive to improvements wrought by R&D, and more vulnerable to problems that arise which R&D could solve. Thus, productivity, schedules, and long-term profitability are all affected by a decline in the R&D component of the industry.

A high proportion of applied R&D expenditures entails another problem less immediately evident. Deliveries in the industry of a new product are necessarily more distant in time from orders than in other industries. This provides more than normal opportunity for inflationary effects and other intervening events to undermine the original justification of prices and bids.

R&D/Export Relationships

Another aspect of the industry's performance that is highly sensitive to R&D levels is its contribution to the U.S. import-export balance. Of course, the overall U.S. world trade position is influenced by a great many factors, many of which are beyond the control of U.S. industry or government—differential inflation rates, material costs, wage differences, foreign exchange rates, and the like. However, a decline in the general level of technological development in industry can exert a decisive influence on balance of trade in the long run and, of more immediate concern to this study, directly on the imports and exports of the aerospace industry.

The U.S. economy has in recent years imported low technology items, such as raw or refined materials, and exported high technology items, such as air transports. Since 1960 the imports of low technology items have grown from less than $1.0 billion to almost $7.0 billion, while the surplus in high technology items above has remained rather stable at between $3.0 and $5.0 billion. But from 1965, little real growth occurred in sales of these latter items (inflationary factors would appear to completely offset any gains).

The primary reason for this stagnation is that the rest of the world—particularly Europe and Japan—is catching up. Foreign firms are benefiting from relatively higher expenditures in these countries for civilian R&D and capital equipment. In 1968 the U.S. spent 1.5 percent of its GNP on civilian R&D, compared with Germany's 2.6 percent and Japan's 2.0 percent.[15] Government support of commercial aircraft development has been firmly established in England, France, West Germany, and Japan, and

[12] Stans, *op. cit.*

[13] *Civil Aviation Research and Development Policy Study*, March 1971, Department of Transportation and NASA, pp. 4-6.

[14] McGraw-Hill, Economics Department Report from DMS, "Business Plans for R&D Expenditures, 1971-1974," May 20, 1971.

[15] Stans, *op. cit.*

consortiums are active. Moreover, wage rates are lower in these countries so more R&D labor can be purchased on the average for a given investment than can be purchased in the U.S. Perhaps most important, the leader in this race must necessarily spend more to achieve the inventions and innovations needed to stay ahead.

R&D Risks

The most tangible payoff for aerospace R&D is the high technology embodied in its products and processes. Aerospace technology has come to represent the high point in the development of man's skill as a maker of complex mechanical and electronic systems that reliably perform difficult tasks in remote places. Yet this same characteristic is the source of some of the industry's most intractable problems, since these are inherent in the very nature of the aerospace enterprise.

Aerospace employs high-skilled labor, intellectual resources, and large sums of money to solve problems in developing new processes and materials which are then applied to a very specialized task or piece of equipment. The outcome of much of the research is highly uncertain, yet the final product must perform with unusual reliability under severe conditions. Thus, technological risk is great, and the intellectual and skill content of the aerospace product is high.

This is a combination that produces a peculiar situation: costs of the unit product are necessarily spectacular when compared with the unit costs of other products. Yet while the *costs* are simple to state and highly visible to the untutored eye, the *value* represented by that cost is obscure except to those expert in the complexities of exotic materials, super-reliability, high-precision manufacturing, and difficult scientific research. And this makes comparisons with other social demands both difficult and profound. From this difficulty has arisen a skeptical attitude toward technology's values that contributes to an erosion of the industry's and the nation's technological base. The time required to restore this base can be considerable and may well approximate the period between Sputnik and the 1968 peak of R&D expenditures by the Federal Government.

Perhaps the most serious of the problems imposed by the technological character of the industry is what has been called "technological surprise": those unpredictable problems that inevitably occur when new systems are designed for new operating regimes or environments. Weight problems, for example, have required the use of new and more costly materials; and interactions between two sub-systems, discernible only when they are finally operated together, sometimes create destructive instabilities. Such contingencies, more likely to arise as the complexity of systems increases, inevitably affect schedules, cost and systems performance—the three elements on which the industry is judged.

Technological sophistication, of course, is necessarily accompanied by risk and uncertainty, and requires high expenditures on research and development. And in this regard the aerospace industry is unusual: generally, the industry draws relatively little from independent technological advances outside itself. Titanium-working techniques had to be developed within the industry, as did heat-resistant ablative materials, beryllium brake linings, and any number of applications of microwave communications, and microminiaturization. Although it obviously creates demands on other sectors, internal problem-solving has required aerospace to take on a tremendous burden in research and development expenditures—one factor that has helped to depress profit rates below that of other industries.

The technological level of the industry also has contributed to its peculiar skill content: more than 50 percent scientists, engineers, technicians, and other salaried workers, and about 50 percent production workers. This skill mix reflects the large amount of planning, design, and prototype testing in the various stages of product development that are inherent in a high-technology industry. Not only does this necessarily add to the cost of the end product, but it creates a labor force whose value as a resource to its current industrial employer is considerably higher than its value to an alternative industry.

R&D's Critical Role

The aerospace industry's heavy dependence on R&D and its translation of R&D into high-technology products and services give it a critical role in the nation's striving for peace and material security. As in all departments of social and economic life, aerospace

R&D must compete with alternative uses of society's resources in order to further technological advances. The industry has been among the first to bear the brunt of slowing rates of R&D growth. But, as Mr. Charles A. Anderson, President of Stanford Research Institute recently observed (*N.Y. Times*, August 22, 1971), "The United States must soon face the fact that it is living on its research and development capital and the account is beginning to run low."

The critical importance of avoiding rapid and large declines in R&D funding levels is therefore clear. The cost of dismantling—only at some later time to have to re-assemble—highly trained teams of engineers and scientists is substantial. Major firms in the industry confront this dilemma in business plans when they seek to maintain their design and engineering capability to respond to the next technological demand that will be placed on them. Without this capability the firm cannot contribute to the industry's technical achievements. If this industry problem—which is equally society's problem—is not solved soon, its repercussion will be felt throughout the rest of the U.S. economy and indeed, the rest of the world.

Aerospace Contractual Problems: The Cost/Risk/Profit Environment

The aerospace industry in the last decade has been forced into an untenable position with regard to its contractual relationships with its government customers. As markets have declined, competition has become even more fierce. Major government policies have been completely reversed over just a few years. New contractual experiments have been imposed on the industry and most have not worked well. In addition, the inherent monopsonistic leverage of the government to make such changes has become stronger. The result is that the impact on the aerospace position has been extremely detrimental.

Congress is aware of these trends and in 1969 appointed a Commission on Government Procurement to report and make recommendations bearing on solutions to the procurement process. Books have been and more could be written on the subject. However, the discussion here is limited to the major aspects having the most direct impact economically on the industry.

Shift of Risks

Aerospace industry risks can be categorized into two types—technical and economic. The technical risks emanate from the problems of uncertainty in developing and producing an advanced technology product that is completely new and whose performance cannot be completely predicated. These unknown problems of innovation compound the already difficult task of estimating costs.

The economic or business risks center around the fact that the dominant customer for defense and space products is the Federal Government. This principle buyer has extraordinary technical requirements but also carries especially strong powers to regulate and bring pressure upon its aerospace suppliers. The trend in recent years toward a decrease in absolute number of major programs but increased unit value of major systems has heightened the importance of individual contracts and hence the competitive nature of the aerospace business. Aerospace firms must take more risks in their bidding, including prices, in order to gain program awards and this tends to increase the instability of the industry.

Both of these types of risks impact directly on profits. Bids are made in which estimated costs cut the profit rate to a minimum. This is coupled with the technical risk of not being able to meet the program specifications and therefore suffering the penalities impinging therefrom.

Disallowed Costs

A major contractual problem is that of disallowed costs. Regulatory changes have increased many times in size and have established rigid, detailed rules for *disallowance* rather than providing a philosophy of guidance for *allowable* costs. The result is that many normal costs of doing business are disallowed, even though the government pays them in its normal procurement of commercial "off-the-shelf" products. The government has thus dictated a position of preferential customer for itself in its defense and space program procurement. The impact has quadrupled in 8 years to the point that disallowed costs of the aerospace industry comprise 30 percent of the net profit before taxes.

Contract Types

One example of a complete failure in government contracting procedure is the total package procurement policy. The contractor was given a single contract covering development, testing, and production of a particular product. This completely ignored the realities of the development process and failed to recognize the inevitability of encountering unknowns. The contractor had little freedom to innovate or to adapt to changing conditions. This contracting philosophy has harmed both government and industry and the repercussions will continue to be felt for some time.

Another contract that has not been successful for complex development work is the fixed-price type. As with the total package procurement, this type fails to make any allowance for problems encountered that reach or surpass the bounds of current technology. This type of procurement is still being utilized for some development programs in spite of its known defects.

Proliferation of Regulations

In the past few years, an astounding and steady growth in contracting regulations has occurred. These regulations are now so numerous and complex that their review and simplification is a major task of the Commission on Government Procurement. In 1969, the estimated cost for contract management systems alone was $4.4 billion, or almost 1 out of every 7 procurement dollars.[16]

The effect of these complex regulations and related procedures has been a loss of flexibility for management. Virtually every step is dictated and too few opportunities to exercise judgment or ingenuity are permitted. The number of overhead personnel has multiplied and profits have been reduced. Another outgrowth of the multiplicity of regulations is the necessity to completely separate government and commercial work in order not to mix costs and procedures. This leads to decreased efficiency as well as increased costs.

[16]DoD Blue Ribbon Defense Panel Final Report, Appendix E., 1970.

Conclusion

All of these contractual factors (as well as others such as the failure of the government to recognize proprietary rights to patents and technical data), clearly point toward a serious impediment in government-industry bidding and contractual relationships, and directly effect product costs and profit levels. If the aerospace industry is to be restored to anything resembling its former position of technological leadership, these imperfections and deficiencies demand a restoration of the balance between risk assumption and profit potential in government contracting. A major key to this restoration is a review and revision of the cost disallowance regulations that are completely counter to normal business policy and procedures. Disallowing a cost does not make it disappear, and many of the currently disallowed costs in the aerospace industry are truly necessary to the efficient operation of any competitive business.

The Financial Problem

The profile analysis has outlined the economic characteristics of the aerospace industry. Sharp declines in sales and backlog of new orders have caused sizeable layoffs of workers, particularly in certain geographic areas, such as the Pacific and Northeastern states.

A decrease in profits and an increase in liabilities—progress payments, short- and long-term debt—combined with technological risks within the industry, has placed the industry in a relatively weak position for further borrowing. Limited availability of funds on the money market and the financial attractiveness of some other industries add to the aerospace problems. The industry's net working capital/long-term debt ratio, and its debt/stockholders' equity ratio exemplify its weak credit position. In addition, regulatory cost disallowances have eroded before tax profits by 30 percent; inventories have grown, and profits are deferred. Large cash holdings needed for payrolls in a labor-intensive industry, and assets heavy in inventories add to the precarious financial conditions.

The burden of unforeseen research and developments and inflationary costs and long leadtimes requiring heavy financial support, along with the factors previously mentioned, have placed many aerospace firms in critical financial situations. Intense contract competition in a shrinking sales market has been accompanied by optimistic bidding, difficult contract terms, changes in government specifications, cost overruns, and the technological risks encountered in developing sophisticated, technologically complex products.

In addition to the paring of DoD expenditures for aerospace products, a further contributing factor is that important aerospace customers such as the commercial airlines have collectively been faced with their own declining markets, increasing costs, and attendant financial difficulties.

The overall results of cost pressures, market contraction, and lower profits have not been conducive to obtaining funds from major low-interest lending sources (at average short-term rates of about 8 percent interest rate and between 8 and 11 percent for long-term, or from floating additional capital stock in a period of economic contraction. Instead, aerospace firms have had to borrow from an extensive network of banks at rates that narrow the margin between the costs of borrowing and the rate of return on investment. Program financing necessarily requires the availability of large amounts of capital, whereas commercial and federal prepayments have approached the limit on funds available.

With an already high level of debt financing, substantial working capital requirements, and a profit rate well below all other manufacturing industries, the aerospace industry has encountered logical resistance to further financial support from traditional lending sources. Perhaps abetted by bad publicity, bankers and financiers are resisting further commitment of funds to the industry during a period of relatively tight money. As stated, debenture and equity capital sales to the public are equally poor sources in the face of relatively unfavorable profits and earnings records.

This confronts the industry with a solemn paradox. Its heavy investment in fixed assets used to produce defense and space systems cannot be fully utilized for new programs necessary to the industry. In addition, large amounts of financial resources are needed continuously for the industry to develop and maintain the R&D that will enable it to compete for and conduct programs in traditional as well as new markets.

Summary and Perspective

5

Eight years ago, in a comprehensive study of the aerospace industry and its governmental relationships, Stanford Research Institute observed that "the tests of maturity for the industry are far from over. . . ."[17] Through those intervening years the aerospace industry has now reached a crucial phase of its maturity. In a series of ups and downs and major market changes, it has now come to a point at which its future relationship to the national economic and social setting is under searching examination and extreme duress. Its maturity is being severely tested in the determination of how it will deal with the vexing and difficult problems facing it during the 70's. This study has attempted to delineate the role of the industry in the national economy, to lay out its contributions and essential economic structure, and to examine a number of critical problems it faces today.

Aerospace and the National Economy

Throughout this study the word "unique" has been used a number of times. It is true, admittedly, that at some very low level of detail every industry differs from all others. But in the generic sense in which the aerospace industry has been analyzed in this study, the industry truly deserves the description "unique." It has been the first, and still is the major bearer of the private market's contribution to the largest government-industry nexus: defense and space. Nearly one-fifth of the Federal Government's purchases of goods and services in 1970 were supplied by the aerospace industry, an amount equivalent to

[17] *The Industry-Government Aerospace Relationship*, Stanford Research Institute, Vol. 1, 1963, p. 41.

about two-thirds of the entire budget of Great Britain. Its sales represented about 3.4 percent of the near-trillion dollar GNP during the last five years. Its exports of almost $3.5 billion represented a very significant part of all U.S. exports in 1970 and substantially helped support a declining U.S. trade balance surplus in recent years. Even in 1971, the industry's own trade balance is easily the largest of any American industry.

On the strength of its combined domestic and foreign sales, the industry's employment until this year has exceeded one million workers every year for the past decade. The industry, nevertheless, still accounts directly and indirectly for about 1.7 million jobs nationwide; for every 100 jobs created within aerospace, 73 others arise in other industries. Since its peak year of 1968, however, industry sales have declined by more than $4 billion and employment reduced by about 450,000, producing serious national effects in unemployment and incomes, while seriously eroding the financial strength and technological health of the industry. The repercussions are resounding throughout the entire U.S. economy and the end is not yet in sight.

Critical Industry Problems

Largely because of its substantial participation with the government in the public functions of defense, international sales, and space exploration, the aerospace industry bears a number of quite special characteristics: a highly restricted marketplace; a very narrow product line; long leadtimes and high technological content products with generally short production runs and high unit values; and a range of exceptionally high risks associated with dependence on a principal customer and advanced technological demands.

Like all business enterprises, aerospace firms have made conventional responses to declining commercial markets and changes in government R&D and procurement levels. Because of the industry's uniqueness, however, conventional responses have not been adequate and the industry now suffers a number of both general and specific problems of substantial magnitude:

- The industry's technological, organizational, and geographical specialization and concentration that are logical and desirable during a period of rising demand have severe negative effects during a period of weak or falling markets. This necessary specialization creates a serious barrier to diversification and market broadening as viable industry strategies.
- The economic structure of the industry puts it at a serious and particular disadvantage during inflationary periods. The technological uncertainty under which it labors and the strong government-dominated competitive forces bring pressures for cost and price limiting behaviors that frequently are unrealistic. These pressures are much greater than those of industries with different products and broader customer base.
- The industry's technological and market evolution has brought it to a financial situation that borders on crisis levels. Low profits and abnormal debt/equity ratios signal caution to financial interests. Private sources of financing are not forthcoming in the amounts judged necessary. The ability to finance future large-scale projects is dubious.
- Aerospace labors under an unusually high burden of procurement rules and regulations because of its deep involvement in the Federal Government's service. The cumulative details of the current "system" (which is really a non-system, inasmuch as it was not consciously designed to take the form and dimensions it presently holds) is considered by many to comprise serious over-regulation and contain many elements of concern to the industry's well-being. Key among them is the failure to identify many risk factors tied to government sales and the adversary attitudes under which cost and profit factors are allowed.
- The aerospace industry bears a special relationship to national R&D and technological progress through its own historical development, as well as sharing today many of the burdens of a reordering of priorities about R&D and technology. The lessons of the industry's history are that high-technology content products that "work" necessarily require a relatively long and stable R&D prelude. This R&D outlay is in the nature of a capital investment whose returns are rarely immediate and that typically take years for their realization. Some inkling of the losses due to this relative reduction in aerospace R&D and technological investment is given in the

dramatic increase in high technology exports from nations that hitherto depended on American export items.

While this list of critical aerospace industry problems is not long, it is most serious and compelling. Within its capacities the industry has been and is attempting to make rational and reasonable adjustments to the economic and social facts of life. At the same time, it is clear that some of the problems go far beyond what an individual firm or even its industry can do. Yet, a national interest is present here not only because of the extensive role that aerospace plays in assisting and supporting the government in discharge of key public functions, but due to the widespread implications for the national economy as well.

The National Interest

In the ordinary function of the business marketplace, dollar expenditures by customers continually signal firms and industries their value and importance. In the case of public needs for international security, space, technology, or foreign trade, the marketplace values are much less distinct or even absent. There, judgment about the value and importance of the private supplier of these public benefits are more difficult to reach. Ultimately, of course, the decision is made by the collective citizenry through its representatives and is manifest in budgetary allocations representing priorities. The valuation process is not easy, however, since the eventual purposes for which the government procures the goods and services are difficult to measure and are more matters of judgment than precise evaluation. National interests represented by security strength, technological advancement, international competition and general economic development will not readily yield to strict benefit/loss computations. Nevertheless, judgments on these points must and will be made. And because of its dominant role in meeting public requirements, the aerospace industry today is acutely conscious of the need for, as well as the difficulty of, making proper judgments by concensus about such national purposes.

As the principal contributor from the private sector in meeting national objectives to sustain America's world leadership in so many areas of national purpose, the aerospace industry's unique skills in complex systems management and deep-grounded experience in government-industry relationships necessary to solve complex problems are an unparalleled national asset. However, recent events have contributed to serious erosion of these aerospace assets. While the exact loss cannot be calculated, it is possible to form a reasonable judgment of the relevant dimensions by way of some recent comparative historical experience, particularly in the area of R&D, for which aerospace, admittedly, has a particular concern.

Without laboring heavily in statistics it seems self-evident that the dramatic technological achievements in advanced defense systems and dramatic space explorations of the late 1960's were in large measure the direct result of the substantial increase in R&D expenditures during prior years, an increase that saw R&D expenditures rise from 2 percent of U.S. GNP in 1955 to peaks of 3.5 in 1961 and 3.4 percent in 1968.

But the reverse is also true. And the decline in R&D's share of the nation's investment to just over 2.5 percent today presages a correlating loss in technological advantage. This is clearly illustrated by the degree to which America has been losing ground in the international marketplace to Japan and Western Europe in respect to high technology exports. These countries have been devoting increasing shares of their national resources to R&D and this explains in significant part why in the period 1965-69 Western Europe's productivity grew at an annual rate of 4.5 percent and Japan's at better than 10 percent, while the United States' rate was only 1.7 percent.

Corrective Action

In calling attention to the seeming lack of public concern and governmental action regarding a number of its critical problems, the aerospace industry obviously finds itself in an area of fundamental and delicate policy issues. Clearly, a large degree of the industry's own viability is at stake, for which it must naturally have a particular interest. But over and beyond that, the industry sees a high public risk involved in leaving policy to drift, either by inattention or misunderstanding, and feels a strong obligation for increasing public awareness that such a drift is taking place.

Although it has a substantial relationship with the government in fulfilling a number of vital public functions, the industry cannot by itself effectuate policy change; that function is necessarily and properly reserved to the government. But out of its understanding and experience the industry can logically call for cogent and positive policy engagement by the Federal Government as a first step toward countering trends that it believes portend significant and substantial national losses. This study has tried to give scope and dimension to the importance and urgency of the issues involved.

Measured against the magnitude of the nation's economic and technological needs, now is clearly the time for development and implementation of strong, effective, and innovative policies designed to avoid the further threatened loss of aerospace industrial capability and to regain some of the ground that has already been forfeited. This responsibility basically rests with the leadership of the Federal Government. The aerospace industry, however, convinced that its strength and productive capabilities are essential to meeting changing public needs, would welcome the challenge and opportunity to support such efforts.

The corrective measures required will be difficult but the benefits will be immense. The successful resolution of the complex public and private policy issues that surround the problems presented here are critical to the retention of world leadership and solution of domestic problems, and development of dynamic industry-government relationships that will help attain them.

These pressing policy issues will be the subject of a forthcoming companion study.

Appendix A: Economic Profile of the Aerospace Industry

The U.S. aerospace industry cannot be said to have emerged at any single point in history or with any single event. But, for analytic purposes, the industry can be said to begin when consistent data on its constituent parts began to be collected on a regular basis.

Using this criterion, the industry began to appear as a significant analyzable entity just after the second World War. This period, the late '40's and early '50's, also coincides with the emergence of national programs in high-performance aircraft for civilian and military use, and an awareness in certain quarters of the implications of the missile and crude space programs begun by Germany in the closing days of the war. At that time, the industry employed about 250,000 persons and had sales of about $1.5 billion. It was still primarily an aircraft industry. By 1959 it was heavily engaged in producing missiles as well as aircraft, and its sales had climbed to $16 billion with over one million employees.

For working purposes, the aerospace industry today can be thought of as comprising those firms involved in producing aircraft and their related parts and equipment, aircraft engines and parts, and missiles and space vehicles. While some gray areas (such as data processing equipment and electronics) make fine and clear definitions impossible, in broad terms the 1970 industry denoted this way represents about 70 different firms containing more than 1,300 producing establishments employing slightly over one million people, delivering just about $24.85 billion in product sales overall, of which $3.4 billion are in export sales. The bulk of the industry's final-product sales (59 percent) was to the Department of Defense, with non-government sales (20 percent), NASA and other government procurement (10 percent), and non-aerospace sales (11 percent) accounting for smaller proportions. The bulk of the industry's work, both for government and in the commercial market, is handled by a relatively small number of prime contractors, although substantial amounts of intra-industry subcontracting to smaller firms occur. It is well known that the industry's products are high value, low-volume items of a technologically complex nature requiring systems management capability and heavy emphasis on time and funds for R&D. This has given the industry an economic structure that is unique in comparison with most other industries in the manufacturing sector of the economy.

To analyze both an industry's problems and its contribution to the nation's economy, the levels and trends of basic characteristics such as employment, payroll, revenue, productivity, value-added, and net exports must be taken into account. In addition, the geographic distribution of activity generated and key interindustrial linkages should be delineated. It is also necessary to compare the industry to its related industries as a benchmark and to link it to Gross National Product. Finally, the financial characteristics of the industry can be assessed to determine its performance with respect to investment, profitability, and debt.

To obtain an intensive analysis and to draw from this a firmer understanding of its key problems in the 1970's, more than a general outline of the aerospace industry is needed. Accordingly, the industry is appraised in terms of a number of basic characteristics: concentration; industrial linkages; employment, wages and salaries; productivity, sales and backlog; financial characteristics; and exports and imports. Each of these categories will be discussed in this appendix.

Concentration

Upon examination of data on the 1,000 largest firms in the U.S. during 1970, approximately 55 of these firms were determined to be major producers of goods and services in the American aerospace industry. The Bureau of Census bases most of its aerospace data on 55 firms. Almost all of these firms are diversified into additional product lines that are closely related to aerospace and military applications. Despite the fact that relatively few (aside from those producing a full line of products under SIC Code 372—producers of all aircraft and related components) obtain more than half their revenue strictly from aerospace product sales, their revenues come from closely related products.

The total number of establishments in the industry varies according to how the aerospace classification is defined. For example, under SIC Codes 1925, 3721, 3722, 3723, and 3729,[1] which envelop all the main products and services of the industry, there were 1,340 establishments in 1970, a smaller number than in most sectors related to aerospace. Under SIC Code 1925 and all firms under SIC 372, there were 1,945 establishments in 1967. In comparison, the motor vehicles and equipment sector consisted of 2,652 establishments, there were 2,008 in shipbuilding and repair, 2,456 in electronic components, 2,535 in screw machine products, 2,702 in metal stamping, and 10,165 in fabricated metals.

Mergers and acquisitions in the number of firms and establishments also cause variations. Notable examples of past mergers and/or acquisitions are: Boeing with Vertol; LTV including Vought; McDonnell and Douglas; North American with Rockwell Standard and Aero Commander; Textron and Bell; Martin and Marietta; Teledyne and Ryan; and Fairchild with Hiller and Republic. Many of these mergers were obviously within rather than outside aerospace product lines, which is typical for the industry. However, the LTV conglomerate, the entry of Textron, Rockwell Standard, and Marietta are four major exceptions.

Some aerospace companies shifted from airframes to electronics, missiles, rockets, and space vehicles as the opportunities arose; and many are involved to some extent in all of these aerospace product lines. However, most of the American military and commercial aerospace product manufacturing in recent years is associated with the activity of about a dozen major design, fabrication, assembly, and power equipment corporations. Extensive subcontracting takes place (as much as 60 percent of the prime contract value), and the nature of the network results in much of the subcontract work being done by other smaller aerospace firms. Products are made for relatively few

[1] The Standard Industrial Classification (SIC) codes referred to here are: 3721 aircraft; 3722 aircraft engines and engine parts; 3723 and 3729 aircraft parts and related equipment, not otherwise classified; 1925 guided missiles and space vehicles complete.

customers but differ significantly from one another in design, components, and purpose.

Aerospace productivity is regionally concentrated on the basis of climatological, technical, or agglomeration amenities in the Pacific Coastal states (approximately 40 percent), the Northeast (20 percent), North Central (17 percent), and South Central regions (11 percent). Because the large prime contractors operate relatively few programs involving large-scale employment of labor and capital regionally, the income and employment multiplier effects are large in comparison to some other industries. This industrial structure is susceptible to cyclical prosperity and recession.

Although some smaller aerospace firms are specialized, subcontractors may be more flexible at a point in time than larger prime firms mainly because the smaller firms can both conduct piecemeal subcontract work and focus on new markets, while the complexity and scale of large aerospace programs require the prime contractor firms to apply almost all of their facilities and resources in a concentrated effort.

The Geographic Distribution of Aerospace Activity

Because DoD procurement contract awards consist of a substantial and mixed amount of orders for ordnance in the form of arms, munitions, and sophisticated electronic and ground forces equipment in addition to aerospace products, the activity centers in which aerospace products are made cannot be readily singled out from production areas for the former products.

One of the most reliable sources from which to trace aerospace activity, aside from the "Place of Performance" statistics for NASA procurement, is the AIA tabulations of geographic employment in aerospace. These figures should indicate aerospace contract work in direct proportion to the number of employees in a particular location (Table 1).

In June of 1971, aerospace firms in the Pacific Coastal states employed 37 percent of all aerospace workers. Firms in South Atlantic states employed 18 percent, the Middle Atlantic states accounted for 12 percent, New England 9 percent, Northwest Central 7 percent, and the South Central and Northeast Central 6 percent each. These data indicate that the aerospace industry is widely dispersed, despite the observation that its firms are locally concentrated.

California is by far the state in which most aerospace workers are employed (29.1 percent in 1968 equivalent to about 282,000 workers).[2] It is also the state in which the greatest reductions in employment have recently occurred (about 200,000 from 1967 to mid-1971).

Washington (10.3 percent), Connecticut (8.65 percent), Texas (7.3 percent), New York (5.9 percent), Ohio, Missouri, Kansas, Florida, and Georgia are the nine states, along with California, in which aerospace employment was highest during recent years. These states also experienced sizeable unemployment problems since 1968, when both aerospace and general economic activity declined.

State aerospace employment trends show that California's relative share has declined steadily since 1964 from 34.5 percent of the aerospace work force to 29.1 percent in 1970. Since 1968, Washington also registered a relative decrease in its share of aerospace employment, Connecticut's and New York's percentage were relatively stable, and Texas showed an increase. The top five states employed about 60 percent of the aerospace work force, and the top ten states accounted for over 80 percent of aerospace jobs in 1968.

The following Standard Metropolitan Statistical Areas (SMSA's) are the major activity centers for aerospace work:

- California—Los Angeles-Long Beach, San Diego, San Jose, Anaheim-Santa Ana-Garden Grove, Sacramento, Santa Barbara, and San Francisco-Oakland;
- Washington—Seattle-Everett;
- Connecticut—Hartford-New Britain, Bridgeport-Norwalk-Stamford;
- Texas—Houston, Dallas, Fort Worth;
- New York—New York (including Bethpage);
- Ohio—Cincinnati, Cleveland, Columbus;
- Missouri—St. Louis, Kansas City;
- Kansas—Wichita;
- Florida—Tampa-St. Petersburg, West Palm Beach, Orlando;
- Georgia—Atlanta.

New Orleans, Huntsville, Denver, District of Co-

[2]United Bank of California's definition of aerospace employment takes in twice the number of workers that AIA data considers. AIA and federal government data are examined here, and these data make a more specific distinction in the type of products made by workers in all phases of electronics.

lumbia, Baltimore, Boston, and Philadelphia also have important aerospace production facilities, along with several SMSA's in Massachusetts and New Jersey, and supporting firms in Indianapolis and Miami. Supporting activity would include many other cities and towns in states not mentioned here. All of these localities have experienced severe cutbacks in the past three years.

NASA Contract Awards

California has been the location of most NASA procurement activity throughout the past decade, but awards declined from 50 percent in 1963 to only 30 percent in 1970, the decrease in activity being reflected in state employment and income. Along with California, Florida, Texas, New York, Alabama, Maryland, Louisiana, and Massachusetts have firms that were contracted for over $100 million of NASA procurement in each of these states during 1970. The share of contract awards in dollars secured by firms in Texas, Maryland, and New York have increased steadily in recent years, declined in Alabama, Louisiana, and Massachusetts while several states registered growth and decline similar to overall NASA awards.

Geographic patterns of NASA procurement are very similar to the employment patterns for all aerospace activity. The Far West region received the largest share of awards in 1970, as it did in previous years, but a steadily declining trend is obvious beyond 1965. The aggregations of firms in the Mid-eastern and Southeastern regions received a major part of NASA awards, which are also declining in these regions.

Awards to firms in the Southwest, Great Lakes, and Plains regions are on the increase. Firms in New England received a declining share of awards but the level in this region still exceeds that of the Great Lakes and Plains regions.

Distribution of Prime DoD Contract Awards to Major Aerospace Firms by Region and Type of Product

In military aircraft production, firms in the South Central states secured the greatest share of prime contract awards, measured in dollar value, followed by firms in the South Atlantic (15.2 percent), Mid-Atlantic (14.1 percent), and New England areas (13.7 percent) during 1970.

For missile and space system products, DoD procurement was greatest in the Pacific states (51.8 percent), with establishments in the Mid-Atlantic states (12.8 percent) and New England (12.0 percent) a distant second and third.

Establishments in the Pacific states (23.4 percent) and the Middle Atlantic region (22.7 percent) supplied the largest share of DoD requirements in electronics and communication equipment. Firms in the Atlantic states (17.7 percent) and New England (12.6 percent) also furnished sizeable shares.

Commercial Transport Production

For 1970, a review of prime contractors producing commercial transport production indicates that firms in the Seattle SMSA accounted for 60 percent of output, Los Angeles-Long Beach for 30 percent, and Atlanta for 10 percent. Firms in Cincinnati and Hartford account for jet engine production.

The Linkages Between Aerospace and Other Economic Sectors

Each industrial sector in the American economy supplies intermediate output to other sectors and/or products and services to final demand.[3] The national input-output tables illustrate these interindustry linkages. From these data, the principal contributions of aircraft and parts (SIC Code 372) to other industries and final customers can be traced as output products. Similarly, services purchased by the aircraft and parts industry as inputs from other industrial sectors can be illustrated.

Tables 2 and 3 indicate the principal relationships only. Data are based on the 1958 national input-output coefficients that are the latest detailed linkages published. The ordnance sector SIC 19 cannot be analyzed because SIC 1925, rockets and space capsules, cannot be separated from other ordnance products. The relationships are somewhat outdated, but they have not changed radically since the coefficients were computed.

From the national table of direct input-output relationships, aircraft and parts in 1958 supplied

[3]Final demand includes goods and services purchased by consumers, government at all levels, and output going to fixed capital replacements and additions, and exports.

about 4.4 percent of its total output to other industries as intermediate requirements chiefly to other aircraft firms, or as R&D and ordnance. Therefore 56 percent of total output went to final demand.[4] However, for total output sold, by aircraft and parts, 5 percent went to private fixed capital, 6 percent went to exports, 4 percent to personal consumption, and 87 percent to the Federal Government, while net inventories decreased 2.5 percent. In comparison to related industries, this latter group is much more consumer-oriented than aerospace.

The major intermediate direct inputs from aircraft and parts to other sectors appear in Table 2. It is obvious that the defined sectors research and development (29¢), ordnance and accessories (21¢), and aircraft and parts (19¢) each purchased a major part of their inputs per dollar of gross output from aircraft and parts. Other industrial sectors purchased relatively few inputs from aircraft and parts.

The multiplier values indicate the direct and indirect effects of one sector's activity on other sectors. These effects are of course greater than direct requirements and, in the case of aircraft and parts, the same sectors named above exert a strong effect in the form of both "direct" and "direct and indirect" requirements. In nine of the sixteen sectors listed, direct and indirect requirements from aircraft and parts are greater than one cent per dollar of final demand of each purchasing sector.

Conversely, Table 3 illustrates the requirements of aircraft and parts from other sectors. To produce each dollar's worth of gross output, relatively large amounts of input products were *directly* purchased by aircraft and parts from: ordnance (5.15¢), primary iron and steel (3.18¢), primary nonferrous metals (2.82¢), radio and communications equipment (2.7¢), stamping and screw machines (1.93¢), scientific and controlling instruments (1.54¢), wholesale and retail (1.85¢), machine shops (1.00¢), and metal working machinery (1.93¢). Other sectors from which substantial requirements were purchased also appear in Table 3.

Projections to 1980 indicate a similar pattern, but several changes are projected in the relative value of aircraft input requirements from the major supplying sectors. Rubber and miscellaneous plastic products used as inputs increase from .62¢ to 1.53¢ per dollar of gross output in aircraft and parts. Primary iron and steel requirements drop from 3.18¢ to 1.49¢. Nonferrous metals drop from 2.82¢ to 2.23¢ per dollar of gross output; stamping and screw machines supplied to aircraft and parts, fall from 1.93¢ to 1.63¢ per dollar of output. Communications equipment inputs rise from 2.7¢ to 3.9¢ and electronic components increase from .6¢ to 1.6¢. The value of inputs from among aircraft and parts firms to other firms in the industry falls from 19.15¢ to 14.90¢ and business services per dollar of gross output in aircraft and parts rise from .34¢ to 6.08¢. Imported components also increase significantly.

The overall pattern indicates that firms in aircraft and parts, taken as an industry, purchase over half of their intermediate input requirements outside of the firm, and about 30 percent outside the industry. However, almost half (47 percent) of the necessary inputs, which are largely labor services, originate inside the sector. These are classified as value-added.

The principal direct and indirect input requirements of aircraft and parts per dollar of its output to final demand are listed in Table 3. Those sectors listed in Table 3 supply directly and indirectly about one-third of all the needed products and services which enable aircraft and parts to meet final demands for its products.

Once again, it is projected that in 1980 intensive direct and indirect interdependence will continue to exist between aircraft and parts and these supplying sectors:

- ordnance and accessories (6.8¢/$1. final demand)
- primary iron and steel (8.6¢/$1. final demand)
- primary nonferrous metals (7.6¢/$1. final demand)
- radio, t.v., and communication equipment (4.1¢/$1. final demand)
- stamping and screw machines (3.2¢/$1. final demand)
- metalworking machinery and equipment (3.1¢/$1. final demand)
- transportation and warehousing (3.6¢/$1. final demand)
- wholesale and retail trade (5.1¢/$1. final demand)

These ratios indicate the value of economic activity generated in major supplying sectors by a dollar in

[4]This percentage has risen to about 60 percent in recent years when the total aerospace industry is considered as a sector.

sales to final demand by aircraft and parts. The values for other major suppliers are given in the table. Overall, one dollar in sales by aircraft and parts generate $2.15 of intermediate activity to produce "non-finished" goods and services in the industrial economy.

In general, aircraft and parts has intensive inter-industrial linkages with the supplying sectors mentioned above and sells a substantial part of its total products directly to final demand.[5] The remainder goes mainly to other aerospace firms, and ordnances for further production, or to R&D. These relationships illustrate the aerospace interindustrial linkages in the structure of the American economy. The aerospace sector is not nearly as consumer-oriented as the durable applicances or non-durable goods sectors, but it directly generates sizeable activity in at least 30 out of 85 other economic sectors, mainly as a purchaser of intermediate goods from these sectors and by its sales to the Federal Government and commercial aviation. The industry's sales in 1971 will generate economic activity valued at more than $10 billion in other industrial sectors of the economy.

Employment

Employment in an industrial sector is often used as an important measure of its contribution to the national economy. With some workers employed by aerospace firms engaged in related services and products, total employment in the aerospace industry at mid-year of 1971 was 968,000, 5.1 percent of the manufacturing labor force. This figure compares to 4.8 percent for motor vehicles and equipment, 2.3 percent for communications equipment, 1.7 percent for electronic components, and 1.4 percent for metal working machines.[6]

Among four-digit industries in 1968, the aerospace sectors ranked fourth, tenth, thirteenth, and fifteenth, and all together outranked each of the sectors named above. Much of aerospace activity generated the employment in its supporting sectors previously named. How much employment is generated in these sectors depends on their sales to aerospace, and a multiplier estimate[7] is 1.73, which is equivalent to about 730,000 jobs in all sectors supporting aerospace during 1971. By the same principle, the decline in aerospace activity and employment has a profound effect on these other sectors' employment and income potential.

From mid-1970 to mid-1971 a decrease in employment of 24 percent was recorded in aerospace. In no other related sector did overall employment decrease as much during the past year. Only in metal working machinery was the rate of decline in employment as great as in aerospace, although employment decreased in all sectors closely allied to aerospace.

The employment of salaried workers increased each year after 1960, with exceptions between 1963 and 1965 and after 1968 (Table 4). On the other hand, employment of production workers grew between 1961 and 1962 and between 1965 and 1968.

In 1967 and 1968, aerospace employment accounted for 1.87 percent of the total employed civilian work force. As an indicator that aerospace has experienced a greater decline in employment than the rest of the economy, this percentage fell to 1.26 to 1971. This latter percentage can be translated into the unemployment of approximately 450,000 aerospace workers—a decrease of 64,000 between the 1968 and 1969 average levels, an additional 285,000 persons laid off in aerospace from the average level in 1969 to the end of 1970, and 100,000 more from the beginning of 1971 and mid-year 1971.

The growth in complexity of aerospace R&D and production is indicated in Table 4. The data reveal that during the decade 1959-1970 there was a net increase of 126,000 salaried workers and a net decrease of 95,000 production workers. The explanation appears to be in systems management requirements having a large amount of contract competition, proposal writing, negotiation, planning, design, monitoring, and supervision which have increased at the same time that production processes were being mechanized and made more effective. Before the sharp contraction of activity occurred in 1969, the rate of staff increases was slowing and reversing at a higher rate for production workers than for salaried workers (Graph 4).

---

[5]The remainder goes to other aerospace firms and ordnance, or is embodied in R&D activities.

[6]AIA data combined with data from *Employment and Earnings*, Department of Labor, B.L.S., Volume 18, No. 2, August 1971.

[7]The B.L.S. employment linkage estimates, *Patterns of Economic Growth*, U.S. Department of Labor, Bulletin 1672, page 125. The estimated multiplier does not count feedback effects.

Based on the NSF definition, the percentage of scientists and engineers in aerospace relative to all aerospace employment increased throughout the decade until 1968, although small fluctuations were recorded in other years (Table 5).[8] The aerospace industry appears to be more labor intensive than manufacturing in general, requiring a large salaried worker staff in support of production workers. This phenomenon is associated with intensive planning, monitoring, and surveillance of complex production, research and development. The approximate ratio of salaried to production workers is 1:1, and in 1963, 1964, 1970, and 1971, the number of salaried workers has exceeded the number of production workers. Because of the widespread employment cutbacks, highly trained and technologically sophisticated research teams cannot be maintained to provide a strong R&D capability.[9] Graph 5 illustrates the equivalent number of full-time scientists and engineers employed annually in various industries. But for aerospace in 1971, the number of equivalent man-years will be about 6,600 associated with 158,000 scientific and engineering personnel.

Income

From 1959 until 1969, industry payrolls increased by $6,723,000,000 with increases occurring in almost every year. The average income per salaried worker rose from $8,114/year in 1959 to $13,194/year in 1970, compared to $5,550/year in 1959 and $8,941/year in 1970 for production workers.

A comparison can also be made between aerospace and the rest of the economy on the basis of personal income. In 1968, personal income in aerospace made up 2.00 percent of total civilian personal income. This percentage fell to 1.89 in 1969 and 1.60 in 1970. By 1971, aerospace payroll declined about $3 billion in comparison to its 1968 share of total personal income. The impact is even greater when additional multiplier effects on payrolls (a loss of about $2.5 billion) and employment (estimated to be a loss of 300,000 jobs) in the rest of the economy are included.

Average weekly earnings in aerospace increased by $10.85, a little more than the average amount for all manufacturing ($10.10) between 1970 and 1971. Among related sectors, only motor vehicle equipment increased by a greater amount ($16.94) and this sector also exhibited the highest average weekly earnings level ($200.55) compared to $181.64 for aerospace. The average weekly earnings level for all manufacturing was $155.04.

Considering the size of total sector payroll, aerospace and motor vehicles lead their allied sectors: communication equipment, metal working machinery, electronic components, general industrial machinery, metal stampings, and screw machine products.

Productivity

Productivity measures are used to demonstrate effectiveness (output/input) in an industrial sector's production. Productivity is difficult to compare on an equitable basis between industries. When output products differ, productivity must be based on value-added or sales to make reasonable comparisons. National income tables provide value-added data that can be matched with employment. When this is done for 1968, aerospace is second only to motor vehicles on a value-added/worker basis, but it is far ahead of all related sectors in value-added/production worker. Motor vehicles, nonelectrical machinery, and electrical machinery sectors have a lower value-added/production worker.

A large value-added/worker ratio for aerospace is due mainly to the high unit-value of aerospace products, whereas the large value-added/production worker is associated with the 1:1 ratio of salaried workers to production workers, which is higher than in most other industries.

Total value-added is greatest in the motor vehicles and equipment sector among related industries. Aerospace is second, substantially ahead of communications equipment, metal working machinery, and electronic components (Graph 6).

The productivity of aerospace workers rose steadily through the 1960's until it peaked in 1968, whether it is measured using value of shipments or

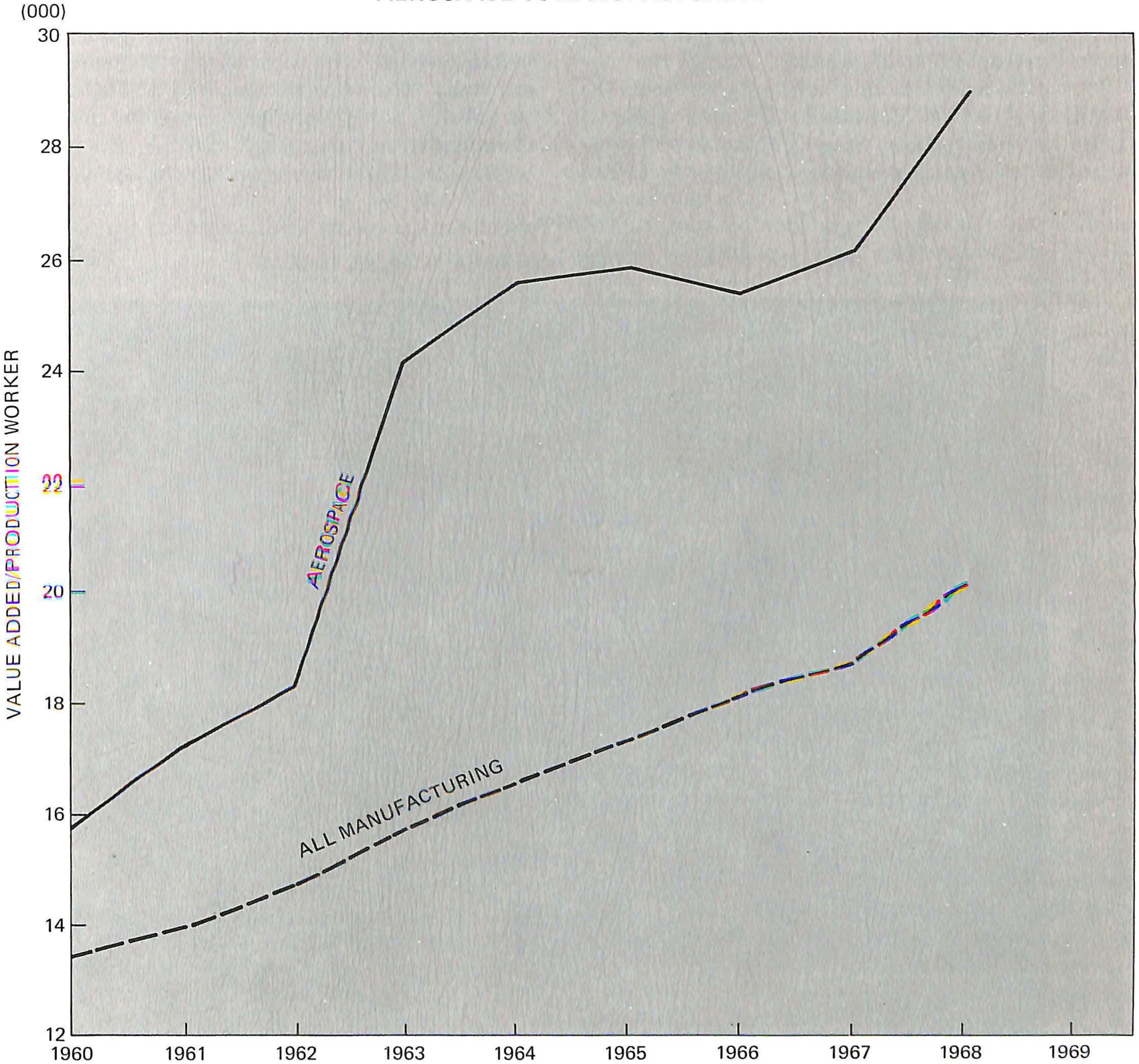
---

[8] AIA data indicate that the employment of scientists, engineers, and technicians in aerospace declined by 77,000 from 1968 to 1971, with further reductions forecast, based on a 1968 level of employment of 235,000. Jobs eliminated will affect future employment opportunities in aerospace.

[9] In 1970, industry employment consisted of 48 percent production workers, 29 percent managerial and clerical, 17 percent scientists and engineers, and 6 percent technicians.

GRAPH 10

VALUE ADDED PER PRODUCTION WORKER
AEROSPACE VS MANUFACTURING



Source: Department of Commerce, B.D.C., *Industry Profiles, 1958-68;* November 1970.

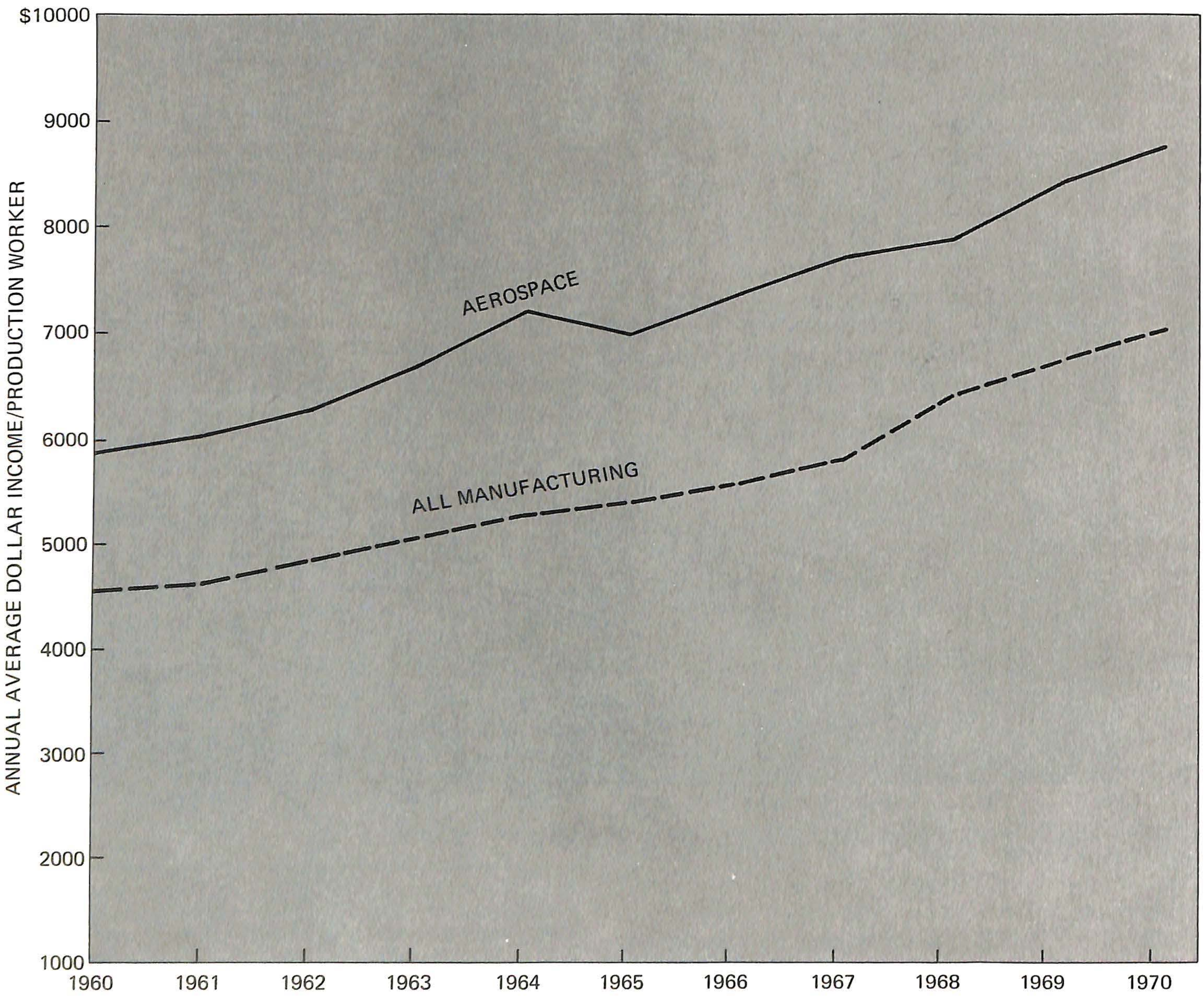
value-added vs. all employees or production workers alone (Tables 6, 7, 8 and 9).

When aerospace is compared to all manufacturing, value added/employee in aerospace is much larger. Only when SIC 372 (aircraft manufacturing) alone is compared to all manufacturing in the early 1960's does manufacturing have a higher ratio. The addition of SIC 1925 (missiles and space capsules) raises aerospace above manufacturing in all other years. This aerospace margin was expanded to $1,563 annually in 1968, indicating a distinct trend to increase through time.

When production workers in aerospace and all manufacturing are substituted for all employees as a base on which to judge productivity, the aerospace industry held an even larger edge of $3,395 in 1958, and steadily increases its margin to $8,785 by 1968 (Graph 10), a 101.7 percent increase for the decade compared to manufacturing's 66.6 percent increase. Value-added data beyond 1968 are not yet avail-

GRAPH 11

PRODUCTION WORKERS' AVERAGE ANNUAL INCOME



Source: Department of Commerce, B.D.C., *Industry Profiles, 1958-68;* November 1970.

able. In any case, aerospace workers appear to be among the most productive in the economy on the basis of dollar value of national income originating within the aerospace sector.

When a comparison is made between aerospace and all manufacturing in Table 8 on the basis of value of shipments/production worker, aerospace again prevails after 1963. In 1970, the aerospace industry was well ahead by $7,555. Once more, aerospace workers appear more productive on the basis of dollar-value of total output. Both the level of and the gain in aerospace worker productivity exceed manufacturing in general.

Throughout the decade, aerospace's value of shipments/production worker increased by 70 percent, compared to 52 percent for all manufacturing. In general, aerospace was ahead of aggregated manufacturing in most categories of performance. Trend comparisons of the rates of increase in economic measures are made in Table 9.

In addition to being ahead in the defined productivity categories, aerospace also exhibited a relatively greater increase in production worker's average annual income, which reinforces the productivity observations. At the start of the decade, aerospace production workers were about 20 percent more productive than all manufacturing workers and received commensurate wages. By 1968, productivity had increased relative to manufacturing. Therefore, when annual average income per employee is compared, aerospace workers on the average received an annual income about 1-1/3 that of manufacturing employees. The rate of increase in average income was about equal for the decade, 51.7 percent for aerospace and 48.3 percent for manufacturing. Nonetheless, aerospace production workers received about 1-1/4 as much in average annual income as manufacturing production workers (Graph 11). Payroll/value-added, although the difference is decreasing, is much larger in the aerospace industry, reflecting its larger salaries and larger labor input.

From Table 8, it is evident that aerospace is more labor intensive than manufacturing, in general, since labor costs are between 42 and 48 percent of total labor, material, plant, and equipment expenditures per year, compared to about 28 or 29 percent for all manufacturing.

Fixed Capital Assets

In 1970, total fixed capital assets in the form of plant and equipment, net of depreciation, were valued at about $5.4 billion in aerospace[10] compared to approximately $21 billion in transportation equipment, $15 billion in motor vehicles and equipment, $16 billion in other industrial machinery, $15 billion in electrical machinery, $7.8 billion in other fabricated metal products, and $225.5 million in all manufacturing. These data indicate that aerospace is much lighter than the other sectors in fixed assets, which were about 1.7 percent of total fixed assets in all manufacturing.

Put another way, much larger expenditures are made in aerospace for (a) materials or components (16.5 times capital costs), and (b) labor, which were 13 times fixed capital expenditures. For motor vehicles and equipment comparable expenditures for materials and components were 40 times capital costs, and for labor were 9 times capital costs. Therefore, materials and parts are the major type of expenditure for the motor vehicles industry, while labor is the major expense item in aerospace.

However, the level of annual expenditures (about $740 million) for plant and equipment in aerospace in recent years ranked just behind motor vehicles and equipment and are much higher than in other related sectors, giving aerospace a sizeable rate of annual increase in fixed capital expenditures and, hence, capacity up until 1970.

In general, fixed capital per production worker is larger in manufacturing, showing a greater need for fixed assets per worker; but the decade rate of growth is much larger for aerospace (195.6 percent compared to 89.6 percent increase in manufacturing) because it is accumulating fixed capital on a smaller base.

Inventory values in relation to shipments are about 11 to 15 percent greater in the aerospace industry for any year during the decade indicating longer lead-times to complete high unit-value products in process. This reflects the need for high financing of programs and the long time horizons involved in covering the costs for labor, materials, and components.

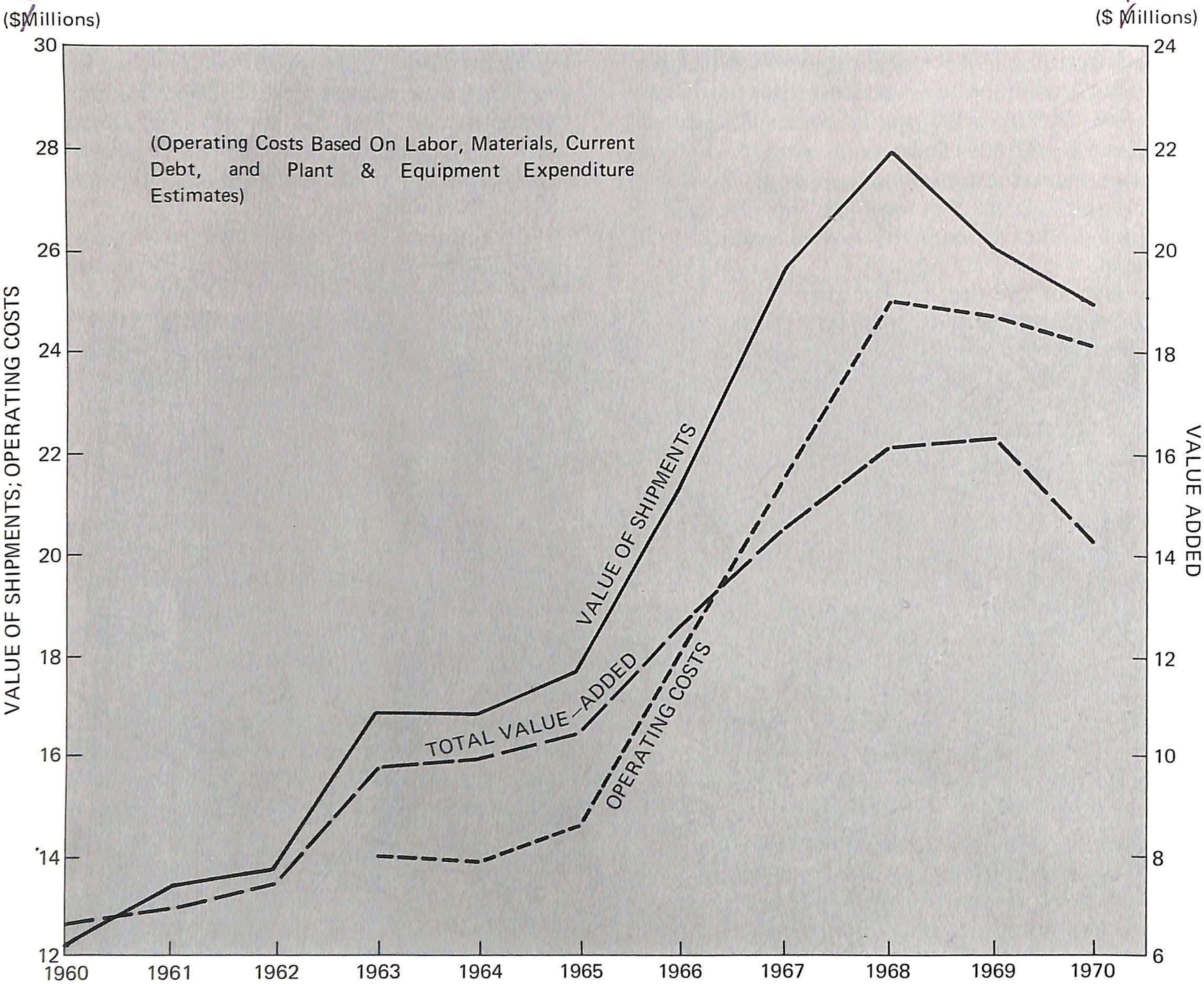
Sales

Although sales figures contain the value-added of other manufacturing industries contributing to aerospace, they are a representative criterion on which to base an industry's contribution to GNP, because sales

[10] This figure includes facilities owned by the Federal Government in aerospace, depreciated.

GRAPH 12

AEROSPACE INDUSTRY'S ANNUAL SALES AND COSTS LEVELS



Sources: Combined data from *Industry Profiles 1958-68*, Department of Commerce; and *Aerospace Facts and Figures*, AIA, Washington, D.C.

comparisons measure the relative total activity generated by industries in the economy.

In 1968, the four aerospace sectors, taken at the 4 digit SIC level, were all among the top 21 manufacturing sectors in sales. Motor vehicles (1st), radio and TV communication equipment (6th), metal stampings (9th), and electronic components (19th) were the only related industries among the top-ranked sectors, which included aircraft (5th), aircraft engines and parts (12th), guided missiles (13th), and aircraft equipment (21st).

When the four aerospace sectors are grouped, they rank second in sales to motor vehicles and parts among manufacturing industries. Aerospace sales contributed 3.6 percent of all sales by manufacturers in 1970, down from a high of 5 percent in 1967. Aerospace industry sales plummeted steeply (14 percent) from 1968 to the end of 1970. And with a loss of $4 billion in sales, it is also discussed elsewhere that profits and employment declined sharply during the same period. The accompanying Graph 12 illustrates that operating costs have also increased relative to sales since 1968. Previous to 1968, both sales and costs were rising sharply, but preliminary estimates indicate the gap between them has recently narrowed. This phenomenon is a reflection of inflationary increases in costs.

On the same graph, it is important to note that total value-added failed to increase as fast as the value of shipments since 1965 and that costs rose faster than value-added after 1965. The implication is that there was an increase in subcontracting outside the industry and costs to aerospace arising from outside the industry increased faster than expenditures for internal resources.

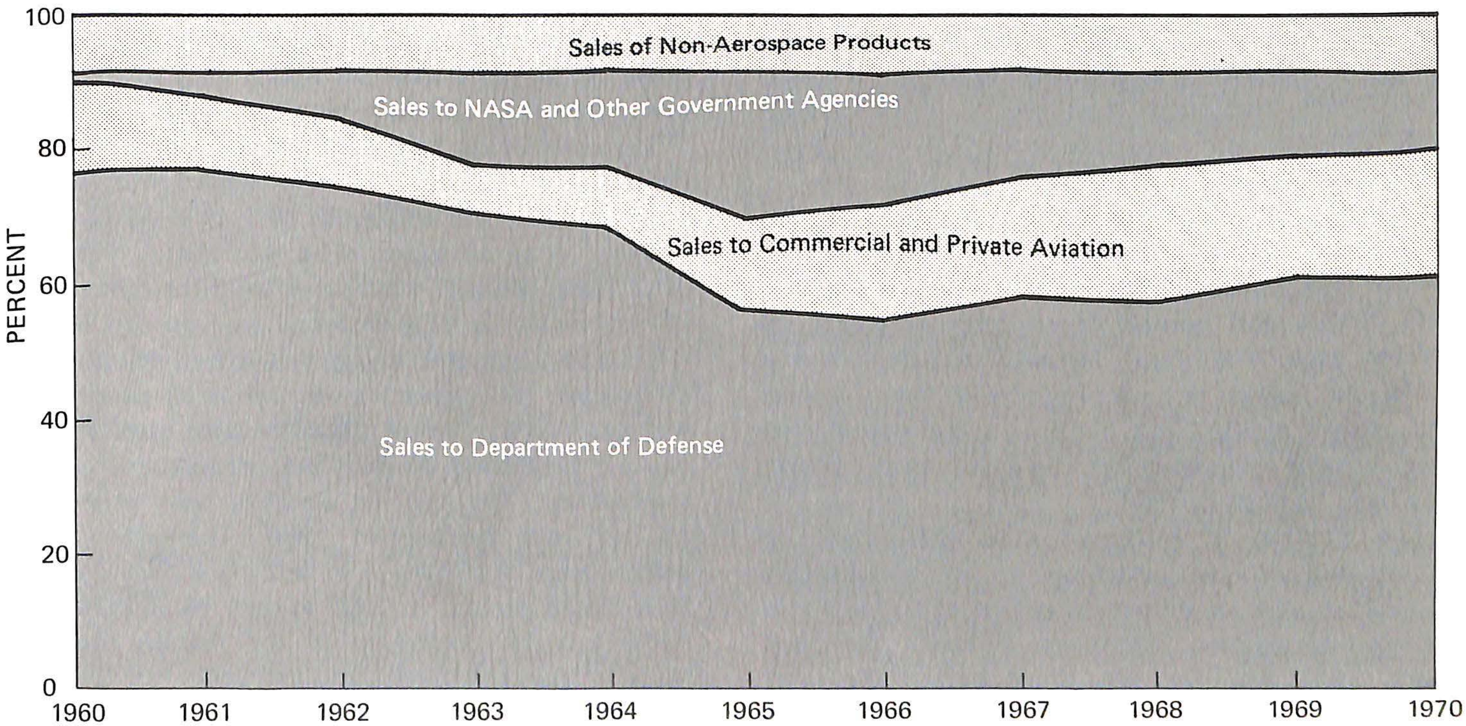
Sales trends, by customer and for products, are plotted on Graphs 13 and 14. Aerospace industry sales increased by about 50 percent from 1959 to 1970 (Table 10). Among changes in sales to customers, the relative share of defense purchases declined steadily from 75 to 60 percent (but increased absolutely) until 1967 and fluctuated in relative importance each year thereafter. The absolute peak in sales to the DoD occurred in 1968, which coincided with the peak year in aerospace sales to private and commercial aviation. Since that time, the growth rate in demand for military products has declined. Private and commercial aviation sales increased relative to other categories since 1966 and their percentage of total sales was 18.42 in 1970. The growth in passenger traffic in the mid-1960's prompted airlines to exercise optional purchases of jet aircraft during the last half of the decade.

Aerospace sales to NASA and other federal agencies increased rapidly in a relative sense until 1965 but declined steadily after 1966 in both absolute and relative terms up to the present time because of the Apollo space program maturation. The only new major space programs in recent years, were Skylab and the Space Shuttle which have been given a modest start. Program activity for Skylab and the Space Shuttle is due to increase by 1972 and 1974 respectively.

The sales trend of non-aerospace products in-

GRAPH 13

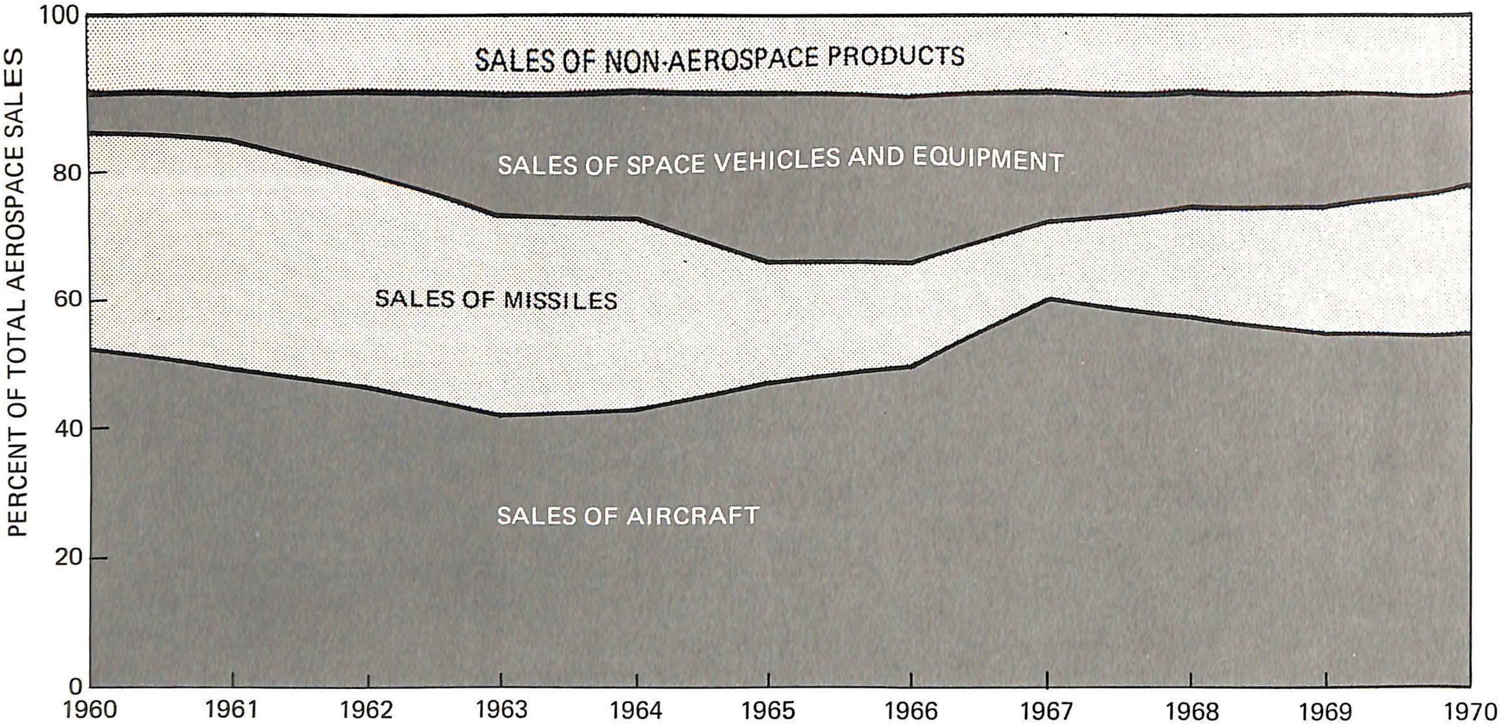
SALES PERCENTAGES, BY CUSTOMER



Source: *Aerospace Facts & Figures*, AIA. Washington, D.C.

GRAPH 14

SALES PERCENTAGES, BY PRODUCT



Source: *Aerospace Facts and Figures,* AIA, Washington, D.C.

dicated a fairly slow relative increase but a rather sharp jump in absolute sales during 1966, a level at which sales have since stabilized in revenue terms indicating that non-aerospace product diversification has been apparently limited.

In general, defense-related aerospace sales still account for about 60 percent of aerospace output, private and commercial aviation about 20 percent, with NASA and non-aerospace sales at about 10 percent each. The trends indicate that defense and space sales appear to have peaked with regard to past and present activity, but the private and commercial aviation sales trend appears to be declining at a slower rate from its peak in 1968.

The fraction of aerospace sales attributable to aircraft indicates two peaks, one in 1957 and another in 1968, a year of numerous deliveries to DoD and commercial aviation customers. Between the peak years, 1963 was the low point before the large build-up in military aircraft for Vietnam. Aircraft sales rose from 1964 to 1968, whereas sales declined from 1958 to 1963 and after 1968 when military and civil aviation demand fell. Aircraft sales accounted for a low of 42 percent of aerospace sales in 1963, 57 percent in 1968, and 53 percent in 1970.

Missile sales do not show a single trend but were lower during the mid-1960's in general. Missile sales were sizeable in the 1950's, peaked in 1962 at 35 percent of all aerospace sales, but declined sharply until 1968, increasing thereafter until the dollar value of missile sales in 1970 exceeded the level of 1964.

Space vehicles and equipment sales have changed by roughly the opposite trend in missile sales. Space vehicles, as a fraction of aerospace sales, grew steadily beyond 1958 until the relative peak (percentage) was reached in 1965 and the absolute peak sales level (dollars) was reached in 1966. Thereafter, space vehicle sales as a fraction of aerospace sales declined from 25.78 percent in 1965 to only 14.35 percent in 1970 toward completion of the Apollo program. Sales of non-aerospace products produced by aerospace firms (chiefly electronics apparatus, and complex mechanical devices) as stated, increased steadily from $1.5 billion in 1959 to $2.6 billion in 1966, a level near which it remains in 1970, showing little gain in diversification, particularly when inflation is discounted.

In summary, aircraft continued to be the dominant aerospace product, accounting for more than half of all sales. Missile sales comprise about 20 percent of all aerospace sales, with space vehicles registering about 15 percent and non-aerospace products about 10 percent of aerospace sales. Avionics has become a more important aspect of most aerospace products.

Backlog

Aerospace backlog grew rapidly from 1964 to 1967. Backlog, of course, depends on new orders. The cylce shows that the ratio of sales/backlog rose from 1960 to 1962, fell until 1966, and increased until 1970. In a growth period, sales/backlog decline because sales will be larger in subsequent years and are based on previous years' backlog. The stronger the growth in demand, the more likely the ratio will decline below 1:1 (Table 11).

Although U.S. federal procurement orders grew strongly between 1964 and 1967, commercial and private demand in the form of new orders grew at a much larger rate of increase, particularly in aircraft and engines.

Missiles and space hardware orders show rapid fluctuations during the R&D and testing period in the Apollo program. Other aerospace-related electronic tracking, communication, and guidance system orders indicate continual increases at a slow rate, roughly similar to non-aerospace products.

What is more critical, however, are the sharp declines in backlog under virtually every category beginning in 1968, but most strongly during 1969 and 1970, causing the sales/backlog ratio to climb once again, and acting as a leading indicator of slow growth in sales during the next few years. Sales competition among aerospace firms is therefore likely to intensity further as the market contracts.

Sales in Relation to GNP, Manufacturing, and Durable Goods

Aerospace sales, as a percentage of GNP, reflect the industry's contribution to the total economy, and remained fairly stable (about 3.4 percent) from 1960 to 1968, but declined sharply in 1969 to 2.8 percent and in 1970 to 2.5 percent. As a percentage of total manufacturing industries' sales, aerospace sales were low in 1965 (4.2) and high (5.0) in 1965. In 1970, this ratio had fallen sharply to 3.6, one percent below its median for the decade (4.7). As a part of total durable goods sales, aerospace products have maintained a declining share through most of the decade, but in 1970 the industry continued to account for a sizeable share (6.9 percent) of all durable goods sales.

In 1966 and 1967 the aerospace share of total output showed an increase before activity declined throughout the economy. Major aerospace growth years were 1966 and 1967 in each category followed by a sharp decline since 1968, particularly as a share of durable goods (Graph 15).

It is notable that aerospace contributes a greater share of GNP (2.5 percent in 1970) than it employs (1.47 percent of labor force in 1970) workers because its sales are relatively greater per worker than sales per labor utilized in most other industries, and its productivity is relatively greater than in other sectors.

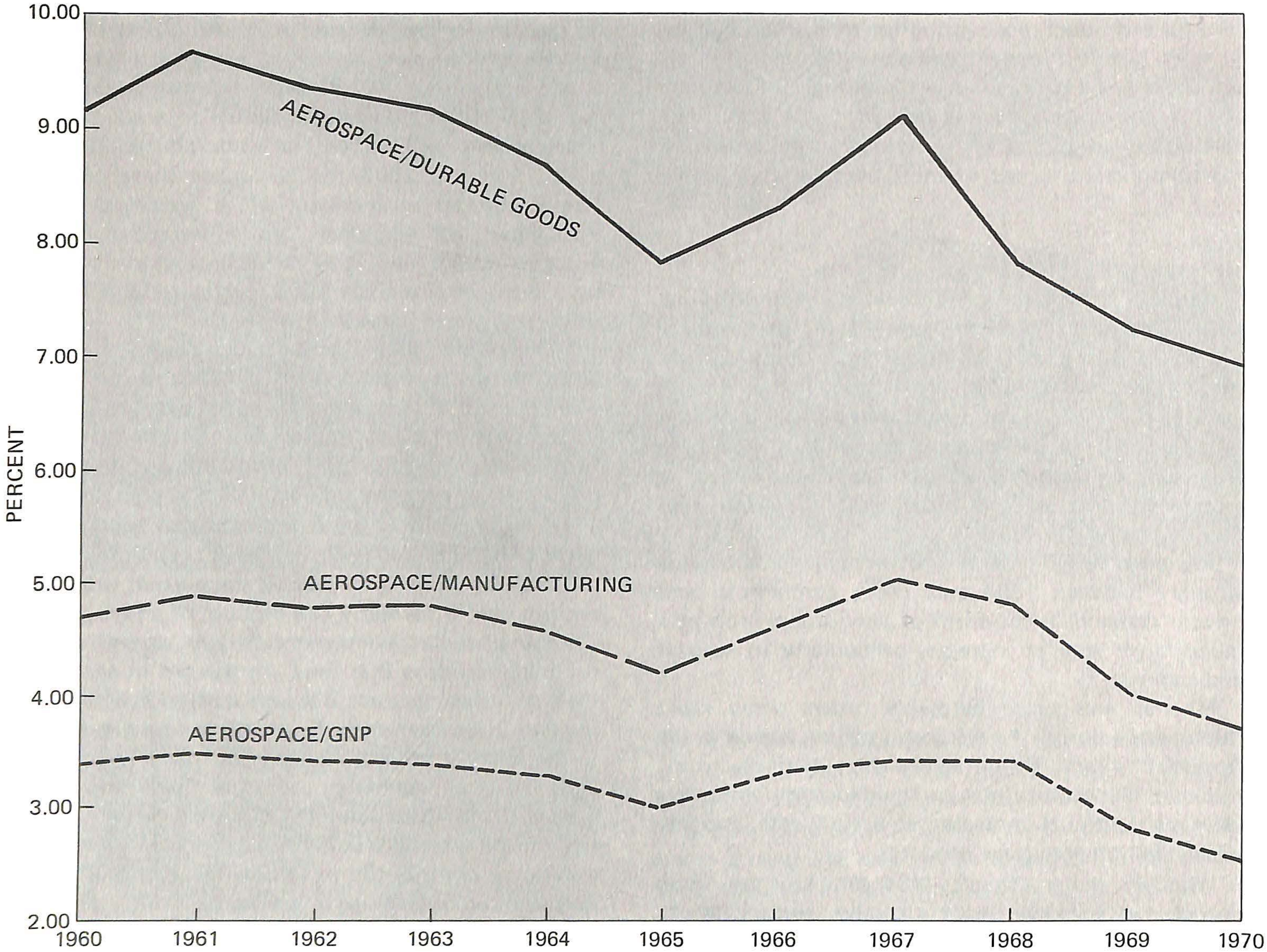
These trends (Table 12) indicate that aerospace is contributing less to GNP, federal taxes, and employment of the labor force during the current economic decline than it formerly did because of severe market contractions. An even more serious aspect of the declining trends is that they are sharper in aerospace than in other sectors. Because cutbacks within the industry have been more severe, there is a greater loss in the form of potential output of many sectors that adds to the inactivity, resulting from multiplier effects. Notwithstanding the current economic stagnation, the aerospace industry has been and remains a significant contributor to GNP in general and to the output of durable goods in particular.

Aerospace Balance of Trade

The aerospace industry is the largest net exporting sector. The only domestic industry that approaches aerospace as a net exporter is the group of major nonelectrical machinery sectors. Other industries that export a large amount of goods are virtually counterbalanced or outweighed by imports of similar goods. This situation does not exist in the American aerospace industry, and its balance of trade is easily the largest. One apparent reason that the aerospace sector is a strong exporter lies in the worldwide demand for its efficient high-technology products developed

GRAPH 15

AEROSPACE SALES AS PERCENTAGES OF GNP, ALL MANUFACTURING, AND DURABLE GOODS



Source: Based on data from Aerospace Facts & Figures, AIA, Washington, D.C.

through the extensive research and development conducted by the industry, in comparison to all other domestic and international industries. Perhaps most exemplary is the fact that the U.S. aerospace industry has built about 80 percent of the Free World's transport aircraft.

A number of distinct trends is indicated in U.S. aerospace exports and imports. Obviously, aerospace exports are a very significant part ($3.47 billion or about 8 percent) of total U.S. exports in 1970 and are estimated at an all-time high of $5 billion for 1971.[11] Aerospace exports are also a significant part (12 to 20 percent) of aerospace sales. Although U.S. civilian aerospace exports, as a share of total aerospace exports, accounted for only 45 percent in 1963, they increased steadily to 74 percent by 1970. Aircraft and parts comprise the largest part of civilian exports.

Military aerospace exports, which accounted for

[11] *The Economy at Mid-Year*, U.S. Department of Commerce, Washington, D.C., 1971.

about 26 percent of aerospace exports in 1970, have declined and increased in alternate years, showing a gradual trend toward increasing in value but declining in the number of units.

Exports by the industry have risen sharply in total value since 1966, particularly for transport aircraft and parts; and civil exports have comprised the major portion of this increase in exports (Graph 7 and Table 13). Aerospace imports increased during each year since 1966 and are valued at about one-tenth the value of aerospace exports; thus, they have a relatively small effect on the balance of trade. A declining but positive aerospace trade balance was experienced from 1963 to 1966. Beginning in 1967, however, the aerospace trade balance showed a strong increase up to the present time.

The United Kingdom, West Germany, France, Japan, Canada, Israel, Australia, New Zealand, South Africa, Brazil, Mexico, Switzerland, Belgium, the Netherlands, and Lebanon imported the major portion of U.S. aerospace exports, although several other nations purchased a number of American aerospace products.

The peak year for units exported in most aerospace categories was 1967, but the value of exports continues to increase. Since 1968, the aerospace trade balance has itself exceeded the U.S. trade margin and, alone, has provided enough margin to permit a U.S. trade surplus until 1971, when the latter declined severely. In addition to preventing a U.S. trade deficit, this favorable influence of aerospace exports has been vital in preventing the softening of the value of the U.S. dollar on world markets, and until recently, aerospace exports have indirectly aided American industry and consumers in obtaining relatively inexpensive imports of a variety of products.

Research and Development Expenditures by Aerospace Firms

The aerospace industry is characterized by the highest activity in research and development, when compared to other industries ($5.66 billion total R&D in 1968). The industry ranks first in federal funds and third in private industry funds, behind two larger industries—all electrical equipment and communication, and chemicals and allied products.

Aerospace R&D is one-third of all industrial R&D. Aerospace receives over half of the federal funds contracted to industrial R&D. R&D funds account for about one-fifth of total aerospace revenue. These figures illustrate the vital importance of R&D revenues in the aerospace industry, inasmuch as R&D funds account for no more than 5 percent of other industries' revenues, on the average. As a result of R&D requirements in the industry, aerospace employs the most scientists and engineers to develop an ever-changing line of sophisticated new products.

Trends in the Financial Characteristics of the Aerospace Industry

The behavior of an industry's financial characteristics is an indication of its general performance and economic health, and thus acts as a guide for capital investment decisions, loan activity, and stock transactions. The financial strength of industries can be compared as well as firms within an industry. The trends and ratios developed here are strictly based on averages for the aerospace industry.

Costs and inventory increases over the five-year period, 1964-1969, resulted in a sizeable rise in aerospace companies' current assets, that has reversed only in the past year. As a result, total assets almost tripled in five years before declining in 1970. The value of depreciated plant, property, and equipment in place also increased rapidly until 1970, as did the returns from other investments and leased properties. But total liabilities of aerospace companies grew threefold in five years, many of them in long-term debt, short-term loans, and program payments by the Federal Government.

Net worth (stockholders' equity) more than doubled in the five years beyond 1964 but declined in 1970. Net working capital, which is the surplus of current assets over current liabilities, more than doubled, although each component decreased in 1970. As stated, sales rose until 1968 but declined in 1969 and 1970, as did profits, dividends, and taxes paid. In fact, corporate taxes paid by aerospace companies combined in 1970 were only half of the taxes paid by these firms in 1968 because of the poor profit situation.

Almost uniformly, Table 14 and Graph 8 indicate negative trends in the financial characteristics of the aerospace industry after 1969. Most noticeable is the behavior of net income (net profits) as a leading indicator. In contrast, the behavior of working capital implies that it is a lagging characteristic. Since profits lead other financial characteristics, a continuation of financial problems in the aerospace industry for the near future might be illustrated by the continuation of the downward trend in net income from 1969 to 1970. If the current relationship between profits and other characteristics continues, there will be a further decline in these aerospace financial characteristics in 1971, placing the industry in a more vulnerable financial position. The data on which the graph was compiled as presented in Table 14.

Financial Comparisons between Aerospace and All Manufacturing

The comparison between aerospace and all manufacturing corporations is simplified in Table 15. The difference between the median percentage (3.88) for aerospace and the percentage registered by an aerospace financial item reflects the differences between aerospace and all manufacturing in the subsequent comparison of the financial ratios.

From this table, the total assets percentage, 3.88, represents the median percentage of an aerospace item as a share of total manufacturing. Since net profits are a small percentage of all manufacturing corporations' profit, it can be expected that federal corporate taxes for aerospace will be correspondingly low, and it is (1.72 percent). Greater fixed capital investment in all manufacturing is indicated by the relatively small share registered by aerospace (1.95 percent).

Clearly, progress payments from the U.S. Government to aerospace make up the largest part of all of these prepayments to manufacturing (66 percent). These necessary incremental payments, along with aerospace debt, directly raise current and total liabilities much above the levels of these items for other industries. Aerospace firms depend on these payments to float expensive programs involving a lengthy period between research and actual sales. Accordingly, gross inventories in aerospace are high compared to industry in general and the large labor force requires a sizeable amount of cash for payrolls. Therefore, current assets are high.

With these characteristics in mind, an analysis of financial ratios follows.

Financial Ratio Analysis

A number of financial ratios were calculated for the aerospace industry from 1964 to 1970. For comparison, these same ratios were calculated for all manufacturing in 1970. The ratios are of the type used for financial analyses of the business firm. They are used here as aggregate industry measures for a sample of 72 companies classified as the aerospace industry's since the ratios are weighted averages for the 72 companies.[12] An individual company's financial position, of course, may be above or below the computed industry ratio. Results are presented in Table 16.

Assets/Sales

Ratios that utilize sales are relative measures of the activity level of the industry. Assets to sales is used to measure the annual turnover of assets. The large increases in cash, inventories, and net plant compared to smaller increases in sales resulted in this aerospace ratio growing steadily; the aerospace ratio (.88) exceeded the ratio for all manufacturing (.39) in 1970, indicating that the latter's sales were able to cover assets 2.5 times in the given period of one year, whereas aerospace sales cover assets 1.14 times because of large payrolls and inventories.

Net Working Capital Ratio

The net working capital ratio is a measure of liquidity (current assets minus current liabilities). Because inventories are included in computing this ratio, it is viewed as having a time horizon of one year. A 2:1 ratio is usually considered as the accounting norm for the net working capital ratio. Current assets/current liabilities for aerospace declined from 1964 until 1967, then began to increase due to cash and inventories, but still remained below all manufacturing in 1970 (1.447 to 1.985) because of sizeable debt in aerospace. Since 1966, the aerospace industry has had financial pressure on its working capital, whereas the manufacturing ratio in 1970 is closer to the desired 2:1 ratio.

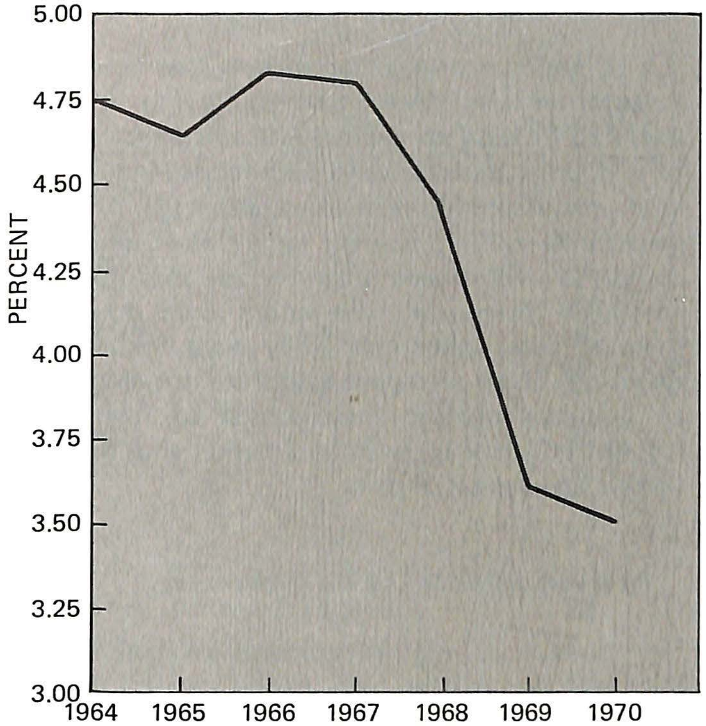
Acid-Test Ratio

A supplement to the working capital ratio is the

[12] Data are based on the *Quarterly Financial Report for Manufacturing Corporations*, Fourth Quarter, 1970, FTC of the SEC.

GRAPH 16

AEROSPACE INDUSTRY'S
NET SALES/NET WORTH



Source: Federal Trade Commission and Securities and Exchange Commission data.

acid-test ratio, also called the "quick current ratio." The acid-test ratio is defined as the ratio of cash and receivables to current liabilities. The acid-test ratio excludes inventories that are less liquid than cash and receivables. An acid-test ratio of at least 1:1 is usually regarded as desirable.

A low acid-test ratio is characteristic of the aerospace industry. From 1964 to 1971, the ratio only once (in 1965) exceeded .5. In 1970 the aerospace industry had an acid-test ratio of .38, while for all manufacturing the ratio was .9, showing that manufacturers' liquid assets could cover 90 percent of current liabilities, while aerospace could cover only 38 percent.

Net Sales/Net Worth

This again is a relative measure of business activity, in this case measuring sales to ownership equity. This ratio was stable for aerospace until 1969 when sales dropped off and lowered the ratio. But the aerospace ratio (3.52) was much higher than for all related industries[13] including all manufacturing (2.31) in 1970, reflecting relatively lower equity to sales in the aerospace industry than in most industries (Graph 16).

Net Sales/Fixed Assets

Fixed assets to sales is a point measure of the annual turnover of fixed assets. Because the revenue from aerospace products sold is high relative to most manufacturing industries and the level of the plant, equipment, and property value is low relative to its equivalent in all manufacturing, this ratio was higher for aerospace (5.62) than for all related industries (each was less than 4.75) even though the aerospace ratio decreased steadily in six of the last seven years with the build-up of assets. Sales in aerospace are 3.6 percent of manufacturing corporations' sales, whereas aerospace net plant, equipment, and property comprise only 2 percent of all manufacturing's net fixed capital. This explains the larger aerospace ratio—a larger relative sales volume and lower fixed capital intensity, when government—owned facilities are discounted.

The following three ratios are computed using net income (profits). These ratios measure the profitability or the rate of return of the industry based on sales, equity, and fixed assets.

Net Income/Net Sales

Profits/net sales provides an important comparison of the rate of return on revenue between aerospace and related industries and all manufacturing. Aerospace profits/sales has been lower than in manufacturing since World War II, and in 1970 the aerospace ratio was less than half that of all manufacturing (1.7 percent compared to 4 percent). All transportion equipment was second lowest, with a 2.61 percentage.

Net Income/Net Worth

The net profit/stockholders' equity ratio, which is the rate of return on capital stock has been declining

[13]Aerospace is represented by aircraft and parts; related industries include all transportation, motor vehicles and equipment, electrical machinery and equipment, metal working machines, and other fabricated metals.

sharply for aerospace since 1968. A 1970 comparison shows the aerospace ratio at .069 compared to a manufacturing ratio of .093. However, motor vehicles and equipment had a lower ratio (.0614) and, therefore, all transportation equipment also exhibited a low ratio of .0631. This result was affected from profits in aerospace contributing only 1.7 percent of all manufacturing profits throughout 1970, while stockholders' equity in aerospace was 2.4 percent of manufacturing equity during 1970. The resulting trend is an indicator of a substantial difference in aerospace's financial status based on equity, when compared to other industries.

Net Income/Fixed Assets

Net profits/net plant equipment and property, the return on fixed investment, is about 11 percent for aerospace and is low when compared to related industrial sectors, with the exception of motor vehicles and equipment, which has sizeable fixed capital assets. The same ratio in related industries exceeded 15 percent for electrical machinery and equipment and for metal working machinery. To explain the differences, profits in aerospace are only 1.7 percent of all manufacturing profits, whereas its fixed capital is 2 percent. Note that this ratio is falling; it must remain somewhat higher than the cost of borrowing if investment in fixed assets is to take place in the industry. The maintenance and growth of capacity depends largely on this ratio.

From these ratios, profitability in all manufacturing is greater than in aerospace, regardless of the measure on which the rate of return is based.

All Debt/Stockholders' Equity

This ratio measures leverage, or the risk of ownership. The larger the ratio the higher the risk. Aerospace has the highest ratio when it was compared to its related industries. These sectors had ratios near or below the average for all industries, motor vehicles and equipment exhibiting a ratio as low as .21.

The debt/equity ratio increased rapidly from .38 to .76 from 1964 to 1970 for aerospace and was almost twice as large as the ratio for all manufacturing (.445), indicating a weaker debt and credit position for aerospace. The increase in the ratio shows that the financial risk for holders of capital stock is increasing.

Gross Inventories/Sales

This ratio measures the turnover of inventories. Inventories sales have grown rapidly in aerospace, from .25 in 1964 to .44 in 1970, and greatly exceeds (it is double) inventories in each related industry and in all manufacturing relative to sales (.18). Aerospace inventories in 1970 was the largest asset item. When compared with inventories for all manufacturing, aerospace inventories were more than double the share of total assets than they were for all manufacturing. These aerospace assets are not always easy to liquidate because they consist of relative few high-priced items for a limited market and, therefore, involve an element of risk.

Progress Payments by U.S. Government/Sales

In aerospace, progress payments as a percentage of sales has always been high. Payments/sales increased from 11 percent in 1964 to 16.6 percent in 1970, overwhelming completely the less than 1 percent ratio in manufacturing during 1970. Aerospace progress payments accounted for fully two-thirds of all U.S. Government prepayments to manufacturing corporations in 1970. These progress payments are necessary to pay subcontractors, meet payrolls, and purchase materials and components throughout the various stages of the R&D and production phases.

Federal Taxes Paid/Profits before Taxes

Federal taxes paid/profits before taxes declined steadily in aerospace from 47 percent in 1964 to 43 percent in 1970, but still exceeded the percentage of profits paid by all manufacturing (40.6), indicating larger deferrals for the latter.

In summary, almost every indicator illustrates a bleak picture concerning the financial aspects of the aerospace industry, during the current period of economic stagnation, when it is reviewed alone or in comparison to its related sectors and all manufacturing. In short, the aerospace industry can be financially characterized by the highest debt and the lowest profits in comparison to similar industries.

Appendix B: Aerospace Profile Tables

TABLE 1

STATE EMPLOYMENT TRENDS FOR THE AEROSPACE INDUSTRY

State / Year	Midyear 1971 (thousands)	Percentages						
		1970	1969	1968	1967	1966	1965	1964
California	282	29.1	27.7	29.5	30.1	30.7	32.6	34.5
Washington	90	9.3	9.5	10.3	9.8	9.2	7.3	6.8
Connecticut	85	8.8	8.7	8.6	8.8	8.7	8.9	8.4
Texas	79	8.2	8.1	7.3	5.8	5.0	4.8	4.8
New York	56	5.8	5.8	5.9	5.8	5.9	5.9	6.0
Ohio	41	4.2	4.6	4.8	4.7	5.3	5.1	5.2
Kansas	33	3.4	3.4	3.7	4.3	4.3	4.0	4.2
Missouri	38	3.9	3.9	4.1	4.7	4.8	4.8	4.8
Florida	36	3.7	3.9	3.6	3.6	3.4	3.6	3.6
Georgia	32	3.3	3.2	2.5	2.5	2.5	2.6	2.4
Indiana	24	2.5	2.3	2.3	2.4	2.4	2.6	2.6
Pennsylvania	23	2.4	2.5	2.4	2.4	2.4	2.2	2.3
Oklahoma, Arkansas, Louisiana	23	2.4	2.5	2.2	2.2	2.5	2.8	2.3
Massachusetts	21	2.2	2.3	2.1	2.0	1.9	2.2	2.6
Maryland	16	1.7	1.8	1.6	1.9	1.9	1.9	2.2
Alabama	14	1.4	1.5	1.2	1.2	1.5	1.7	1.2
Arizona	12	1.3	1.5	1.3	1.1	1.0	1.0	.9
Montana, Idaho, Wyoming, Colorado, New Mexico, Nevada	12	1.3	1.5	1.3	1.1	1.1	1.4	.5
New Jersey	11	1.1	1.1	1.1	1.1	1.2	1.4	1.4
Michigan, Wisconsin	7	.7	.9	.8	1.0	.8	.9	.7
Illinois	7	.7	.8	.7	.8	.7	.7	.5
Tennessee, Kentucky, Mississippi	7	.7	.7	.7	.7	.7	.2	.1
Utah	6	.6	.7	.7	.7	.8	1.1	1.2
Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina	6	.6	.6	.6	.6	.5	.5	.4
Minnesota, Iowa, North Dakota South Dakota, Nebraska	3	.3	.4	.3	.2	.2	.2	.1
Maine, New Hampshire, Vermont, Rhode Island	2	.2	.2	.2	.3	.3	.2	.1
Oregon, Alaska, Hawaii	2	.2	.2	.2	.2	.2	.2	.2
TOTALS	968	100	100	100	100	100	100	100

TABLE 2

THE AIRCRAFT AND PARTS INDUSTRY
AS A SUPPLIER OF INTERMEDIATE PRODUCTS IN THE ECONOMY[a]

Major Purchasing Sectors of Aircraft and Parts Products[b]	Direct Inputs from Aircraft and Parts to Other Sectors Per Dollar of Their Gross Output: (In 1958 ¢ Value of Inputs Supplied)	Direct and Indirect Requirements of Other Sectors from Aircraft and Parts Per Dollar of Final Demand for These Sectors: (In 1958 ¢ Value of Inputs Supplied)
Engines and Turbines	1.0¢	1.9¢
Farm Machinery	.2	.7
Materials Handling Machinery and Equipment	.2	.6
Special Industry Machinery	.3	.8
General Industrial Machinery	1.7	2.5
Machine Shop Products	.3	.6
Computers and Business Machines	.7	1.1
Service Industry Machinery	.6	1.1
Radio, TV and Communication Equipment	.9	2.0
Aircraft and Parts	19.2	125.7
Other Transportation Equipment	.5	.9
Scientific and Control Instruments	1.6	3.1
Transportation and Warehousing	.5	.7
Research and Development	29.0	42.1
Ordnance and Accessories	20.6	26.7
Metalworking Machinery and Equipment	.5	.9
Totals	77.8	211.4

Notes: $2.11 is the approximate aggregate multiplier effect generated in the aircraft and parts industry by the intermediate input requirements of the other sectors listed in this table per dollar of their aggregated output to final demand. Final demand consists of those goods and services going to personal consumption, the government sectors, gross private investment, and exports.

a. National input-output relationships for 1958 are those currently available and in use.

b. Other minor purchasing sectors are omitted.

TABLE 3

THE AIRCRAFT AND PARTS INDUSTRY
AS A GENERATOR OF ECONOMIC ACTIVITY,
BASED ON 1958 INTERINDUSTRY LINKAGES

Direct Input Requirements from other Sectors by Aircraft and Parts per Dollar of its Gross Output				Industrial Sectors Supplying Inputs to Aircraft and Parts[a]	Direct and Indirect Requirements Per Dollar of Final Demand for Aircraft and Parts
Actual Total Requirement in $ Million for 1958	Percent of Supplier's Output in 1958	1958 Constant Cents In 1958 ¢ Actual	1958 Constant Cents In 1980 ¢ Estimated		1958 Linkages in 1958 ¢
$ 657	4.3%	5.15¢	5.13¢	Ordnance and Accessories	6.8¢
22	1.1	.17	.12	Furniture and Fixtures	1.0
16	.1	.12	—	Chemicals and Fertilizers	1.3
10	.6	.08	.10	Paint and Allied	.3
79	1.2	.62	1.53	Rubber and Miscellaneous Plastics	1.5
48	.6	.37	.37	Stone and Clay	1.1
405	2.1	3.18	1.49	Primary Iron and Steel	8.6
360	3.4	2.82	2.23	Primary and Nonferrous Metals	7.6
245	6.6	1.93	1.63	Stamping and Screw Machines, and Bolts	3.2
131	1.8	1.03	1.00	Other Fabricated Metals	2.3
20	.1	.16	.14	Engines and Turbines	.3
246	6.5	1.93	2.05	Metalworking Machinery and Equipment	3.1
138	3.3	1.08	1.04	General Industrial Machinery and Equipment	1.9
126	7.8	.99	1.15	Machine Shop Products	2.2
344	5.1	2.70	3.87	Radio, TV and Communication Equipment	4.1
76	2.8	.60	1.55	Electronic Components and Accessories	1.7
46	2.9	.36	.38	Miscellaneous Elec. Machinery, Equipment and Supplies	.6
2414	18.9	19.15	14.90	Aircraft and Parts	1.3
81	.2	.64	.64	Motor Vehicles and Equipment	1.8
197	4.4	1.54	1.57	Scientific and Control Instruments	2.4
113	.3	.89	.80	Transportation and Warehousing	3.6
26	1.6	.20	.19	Optical and Photographic Equipment	.3
236	.2	1.85	1.85	Wholesale and Retail	5.1
56	.6	.44	.51	Other Communications	1.0
72	.1	.57	.51	Real Estate and Rental	2.1
52	.8	.41	.30	Business, Travel, and Entertainment	1.4
10	.7	.08	.10	Office Supplies	.2
69	.3	.54	.86	Utilities	2.0
39	.1	.30	.29	Finance and Insurance	1.4
44	.2	.34	6.08	Business Services	1.9
43	.7	.34	.34	Electric Industrial Equipment	1.3
50	.4	.39	2.35	Imports	2.5
				Total, including sectors not listed above:	$2.15/$1.00[b]

Source: Based on Survey of Current Business Data, November 1964 and September 1965.

a. National input-output relationships for 1958 are those currently available and in use.

b. Other minor purchasing sectors are omitted.

TABLE 4

TRENDS IN AEROSPACE EMPLOYMENT

	1959-1960	1960-1961	1961-1962	1962-1963	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970	1959-1970	Percent Change
All Employees, Change	-54000	+22000	+81000	-3000	-57000	+16000	+165000	+94000	+26000	-64000	-195000	+31000	
All Employees, Percent Change	- 4.8	+ 2.0	+ 7.4	.3	- 4.9	+ 1.4	+ 14.6	+ 7.2	+ 1.9	4.5	14.4	+ 7.9	
Salaried Workers, Change	+12000	+32000	+59000	+26000	-29000	- 3000	+ 50000	+33000	+19000	-7000	76000	+126000	
Production Workers, Change	-66000	-10000	+22000	-39000	28000	-19000	+115000	+61000	+ 7000	-57000	-119000	- 95000	
Payroll, $ millions, Change	- 110	+ 492	+ 1080	+ 213	-205	+ 605	+ 1892	+ 1265	+ 1089	+ 402	1316	5407	
Average per Salaried Worker, 1959-1970	8114	8212	8531	9041	9126	9427	9660	10163	10636	11639	12464	13194	+62.61
Average per Production Worker, 1959-1970	5550	5736	5950	6210	6347	6469	7133	7542	7736	7984	8552	8941	+61.60

Source: Aerospace Facts and Figures, AIA.

TABLE 5

TREND OF SCIENTISTS AND ENGINEERS MAN-YEARS

Year	Aircraft and Missiles: Scientists and Engineers*	Number of Aerospace Employees
1960	72,400	1,074,000
1961	78,500	1,096,000
1962	79,400	1,177,000
1963	90,700	1,174,000
1964	99,400	1,117,000
1965	97,400	1,133,000
1966	97,200	1,298,000
1967	98,800	1,392,000
1968	94,300	1,418,000
1969	93,600	1,354,000
1970	NA	1,159,000

*As classified by the National Science Foundation in man-years.

Note: Based on AIA and Federal Government data and definition, there were 235,000 individual scientists and engineers employed in aerospace at one time or another during 1968, which was 19.5 percent of all scientists and engineers.

In 1970, there were about 175,000 scientists and engineers in aerospace, and indications were that there would be a further reduction in employment.

TABLE 6

PROFILE DATA FOR SIC CODES 372 AND 1925 COMBINED: THE AEROSPACE INDUSTRIES[a]

	1960[b]	1961[b]	1962[b]	1963	1964	1965	1966	1967	1968	1969	1970
Total Employees (1,000's)[c]	756.1	762.0	803.7	811.8	771.0	779.3	912.7	990.7	1002.0	937.4	792.0
Production Workers (1,000's)[c]	418.1	403.2	407.1	406.2	392.2	407.1	501.3	556.7	557.5	509.0	512.1
Value Added ($ million)	6578.8	6956.6	7466.5	9828.2	10029.9	10521.4	12742.5	14570.9	15821.0	16310.0	14222.0
Cost of Materials ($ million)	5480.6	6483.9	6315.4	7056.6	6928.1	7397.2	9236.0	11267.5	12184.4	24713[d]	24197[d]
Value of Shipments ($ million)	12360.3	13373.7	13723.4	16905.9	16954.9	17833.5	21578.0	25789.4	28073.1	26126[f]	24848[f]
Capital Expenses ($ million)	179.2	226.4	291.4	343.0	332.6	356.1	784.2	903.5	739.9		
End of Year Inventories ($ million)	3425	3470	3580	3936	3833	4381	6323	8317	9593	11179[e]	10763[e]
Value Added/Shipments	.5323	.5202	.5441	.5813	.5916	.5900	.5905	.5650	.5757	.6243	.5724
Inventories/Shipments	.2598	.2326	.2371	.2226	.2206	.2212	.2607	.2999	.2858		
Payroll/Value Added	.702	.711	.714	.6720	.6626	.6531	.6470	.6349	.6035		
$ Value Shipments/ Production Worker	29560	33169	33710	41640.4	43230	43806	43044	46325.5	50355.3	51328	60296

a. Based on Industry Profiles (1958-1968), B.D.C., Department of Commerce, Washington, D.C., (for 1945 establishments in 1967).
b. Includes data from SIC Code 372 only, in every category.
c. Source: "Employment and Earnings, U.S. 1909-70," BLS Bulletin 1312-7, SIC 1925 and 372.
d. Estimates of all operating costs, including labor.
e. *Quarterly Financial Report for Manufacturing Corporations,* Fourth Quarter, 1970, FTC-SEC.
f. Estimates Sales of Aerospace Industries, based on Shipments of Commercial Aerospace Products (MQ376), DoD Expenditures and NASA Expenditures.

TABLE 7

PROFILE OF ALL MANUFACTURING

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Value Added/Shipments	.443	––	––	.457	.460	.461	.466	.470	.471
Inventories/Shipments	.145	––	––	.142	.141	.138	.144	.151	.147
Payroll/Value Added	.510	.509	.502	.486	.514	.503	.500	.472	.467
$ Value Shipments/Production Worker	30300	––	––	34400	36100	37700	39000	39900	42800

Source: Department of Commerce, *Industry Profiles* (1958-68), B.D.C., Washington, D.C.

TABLE 8

PROFILE CALCULATIONS FOR AEROSPACE AND ALL MANUFACTURING

	1960[b]	1961[b]	1962[b]	1963	1964	1965	1966	1967	1968	Percent Change 1958-68
$ Value Added/Employee, Aerospace	8701.0	9129.4	2990.2	12106.7	13008.9	13501.1	13961.3	14707.7	16128.4	+ 67.35
$ Value Added/Employee, All Manuf.	9783.6	10053.2	10693.7	11271.2	11919.2	12575.5	––	13554.6	14565.4	+ 64.95
$ Value Added/Production Worker, Aerospace	15735.0	17253.5	18340.7	24195.5	25574.4	25844.8	25418.9	26173.7	28987.8	+ 86.72
$ Value Added/Production Worker, All Manuf.	13429.5	13939.5	14780.7	15720.0	16568.5	17352.0	––	18759.0	20202.0	+ 66.56
Capital Expenses Shipments, Aerospace	.0145	.0169	.0212	.0203	.0196	.0200	.0363	.0350	.0264	+ 60.98
Capital Exp's./Shipments, All Manuf.	.0273	––	––	.0270	.0296	.0338	.0376	.0384	.0345	+ 24.55
Capital Exp's./Δ Shipments, Aerospace	.1549	.2234	.8333	.1078	6.7878	.4053	.2094	.2145	.3240	
Capital Exp's./Δ Shipments, All Manuf.	1.3512	––	––	––	.4830	.2652	.4355	1.1123	.4358	
$ Capital Expenses/Production Worker, Aerospace	437.93	566.99	725.60	766.99	809.05	826.79	1519.47	1622.67	1331.23	+195.64
$ Capital Expenses/Production Worker, All Manuf.	827.04	830.31	860.61	929.60	1069.26	1271.68	1465.15	1534.00	1477.67	+ 89.58
P+E Costs/Total Aerospace	––	––	––	.0245	.0239	.0243	.0429	.0422	.0326	
P+E Costs/Total All Manuf.	––	––	––	.0340	.0368	.0416	.0461	.0483	.0439	
Labor Costs/Σ Costs: Capital, labor, materials, Aerosopace	.4492	.4242	.4467	.4716	.4779	.4699	.4514	.4318	.4301	+ .21
Labor Costs/Σ Costs: Capital, labor, materials, All Manuf.	––	––	––	.2790	.2917	.2860	.2856	.2786	.2802	
Labor Cost/Material and Labor Costs, Aerospace	.4415	.4326	.4579	.4835	.4865	.4896	.4716	.4509	.4446	+ 1.55
Labor Cost/Material and Labor Costs, All Manuf.	––	––	––	.2888	.3029	.2984	.2993	.2927	.2930	
Annual Avg. Income/ Production Worker, Aero.[c]	5863.15	6042.32	6300.30	6718.25	7260.27	7073.83	7467.35	7831.90	8023.03	+ 47.56
Annual Avg. Income/ Production Worker, All Manuf.	4550.19	4649.54	4876.44	5076.32	5308.18	5465.76	5668.44	5831.03	6203.15	+ 45.91
Average Annual Income per Employee, Aerospace[c]	6802	7138	7458	7948	8330	8713	9015	9269	9559	+ 51.66
Average Annual Income per Employee, All Manuf.[c]	5181	5319	5560	5746	6141	6325	6580	6678	7106	+ 48.32
$ Wages/Production Worker Man-Hour, Aerospace	2.811	2.936	3.008	3.244	3.477	3.394	3.519	3.682	3.882	+ 46.32
$ Wages/Production Worker Man-Hour, All Manuf.	2.298	2.351	2.437	2.533	2.608	2.686	2.774	2.924	3.104	+ 41.93

a. Based on Industry Profiles (1958-1968), B.D.C., Department of Commerce Washington, D.C. for 1945 establishments.

b. Includes data from SIC Code 372 only, in every category.

c. Data based on Industry Profiles differs from AIA data but trends and relationships are not different.

TABLE 9

COMPARISON BETWEEN AEROSPACE AND ALL MANUFACTURING

Item	Percent Increases			
	1958 to 1968		1968 to 1970	
	Aerospace	All Manufacturing	Aerospace	All Manufacturing
Value of Shipments	82.0	85.7	-14.2	10.3
Value Added	100.1	102.0	NA	NA
Annual Capital Expenditures	193.3	130.2	-36.1	12.62
Value Added/Shipments	9.9	9.1	NA	NA
Value Shipments/Production Worker	69.9	52.4	11.9	10.6
Value Added/Employee	67.3	65.8	NA	NA
Value Added/Production Worker	86.7	66.3	NA	NA
Capital Expenses/Shipments	61.0	24.5	-25.6	2.13
Wages/Production Worker Man-Hour	46.3	41.9	13.0	16.0

Source: Computed by Resource Management Corp. Inc. from Department of Commerce data.

TABLE 10

AEROSPACE SALES PERCENTAGES
BY CUSTOMER AND BY PRODUCT

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Aerospace Goods and Services by Customer Type, DOD Percent	76.16	76.57	74.79	70.48	64.18	55.13	53.98	58.15	57.23	60.37	58.93
Aerospace Goods and Services by Customer Type, NASA Percent	2.10	3.50	6.96	13.05	17.65	21.72	20.42	15.41	13.54	12.69	11.88
Aerospace Goods and Services by Customer Type, Commercial %	12.74	10.42	9.25	7.38	9.81	13.62	14.88	16.99	20.43	16.62	18.42
Non-Aerospace Sales, Percent	9.00	9.00	9.00	9.09	8.36	9.52	10.72	9.46	8.80	10.33	10.77
Aerospace Goods and Services by Product Group, Aircraft Percent	52.67	49.16	46.68	42.35	43.27	47.16	48.56	59.94	57.25	53.96	53.25
Aerospace Goods and Services by Product Group, Missiles Percent	33.26	34.82	35.07	29.82	25.45	17.45	16.47	16.20	16.30	19.36	21.63
Aerospace Goods and Services by Product Group, Space Vehicles Percent	5.07	7.02	11.39	18.74	22.92	25.78	24.25	19.40	17.66	16.35	14.35
Aerospace Goods and Services by Product Group, Non-Aerospace Percent	9.00	9.00	9.00	9.09	8.36	9.52	10.72	9.46	8.80	10.33	10.77

Source: .Based on AIA data.

TABLE 11

CHANGES IN AEROSPACE BACKLOG

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total Sales ($ millions)	10977	14948	15972	16407	16686	17016	20227	23444	25592	24648	24976
Sales/Backlog	.8784	1.0737	1.2157	1.1800	1.0986	.8347	.7386	.7991	.8323	.8710	1.0083
Total Value Backlog ($ millions)	12496	13922	13138	13904	15188	20385	27385	29339	30749	28298	24770
Percent Change of Total for U.S. Government	—	—	- 4.0	+ 3.6	+ 6.0	+17.9	+14.4	+13.0	- 7.9	-12.5	- 8.5
Percent Change of Total (Other)	—	—	-11.6	+15.1	+19.7	+99.1	+77.9	+ 9.6	+11.1	- 2.8	-16.5
Percent Change of Aircraft and Engine for U.S. Government	—	- 5.6	- 3.1	+ .5	+ 7.3	+15.6	+43.5	+11.6	.3	-13.0	-15.1
Percent Change of Aircraft and Engine for Other Customers	—	-10.2	-21.7	+12.9	+33.3	+110.0	+84.0			- 2.5	-20.0
Percent Change of Missiles and Space	—	—	+ 5.7	+14.5	- 1.9	+20.3	-17.7	+26.5	-10.9	14.7	+ 3.6
Percent Change, Other Aerospace for U.S. Government	—	—	-28.7	-15.6	+ 9.1	+41.7	+22.7	+ 7.8	+ 8.1	+ 8.2	+ 1.4
Percent Change, Other Aerospace for (Other) Non-Government Customers	—	—	+25.1	- 6.1	+ 7.4	+14.2	+60.9	+ 1.4	+ 7.2	-10.5	-10.3
Percent Change, Non-Aerospace	—	-76.6	- 7.5	+11.8	+24.1	+16.2	+24.4	-14.8	+29.1	-16.8	- 6.9

TABLE 12

CHANGES IN THE RELATIVE SHARE OF AEROSPACE SALES AS A PART OF GNP, TOTAL MANUFACTURING, AND DURABLE GOODS

Year	Aerospace Sales as a Percent of			Annual Change in Percent of Shares of		
	GNP	Manufacturing Industry Sales	Durable Goods Sales	GNP	Manufacturing	Durable Goods
1960	3.4	4.7	9.1	—	—	—
1961	3.5	4.9	9.7	+.1	+.2	+ .6
1962	3.4	4.8	9.4	-.1	-.1	- .3
1963	3.4	4.8	9.2	0	0	- .2
1964	3.3	4.6	8.7	-.1	-.2	- .5
1965	3.0	4.2	7.8	-.3	-.4	- .9
1966	3.3	4.6	8.3	+.3	+.4	+ .5
1967	3.4	5.0	9.1	+.1	+.4	+ .8
1968	3.4	4.8	8.8	0	-.2	- .3
1969	2.8	4.0	7.2	-.6	-.8	-1.6
1970	2.5	3.7	6.9	-.3	-.3	- .3

Source: Based on AIA data.

TABLE 13

TRENDS IN AEROSPACE EXPORTS AND IMPORTS

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Aerospace Exports ($ millions)	1726	1653	1923	1627	1608	1618	1673	2248	2994	3138	3400
Aerospace Imports ($ millions)	60.901	151.667	128.204	95.290	90.062	158.837	303.264	286.968	333.469	306.625	308.469
Trade Balance Amount ($ millions)	1665	1501	1795	1532	1518	1459	1370	1961	2661	2831	3092
Trade Balance, (percent change)	—	-9.85	+19.59	-14.65	-.914	-3.89	-6.10	+43.14	+35.70	+6.39	+8.44
Civil Exports/All Aerospace Exports	.6309	.5312	.4732	.4499	.4751	.5278	.6187	.6139	.7645	.6460	.7377
Aerospace Exports as a Percent of Total U.S. Exports	8.5	8.0	9.4	7.1	6.1	6.0	5.6	7.2	8.8	8.4	8.0
(Exports-Imports) Aerospace/Total	.0961	.0834	.0937	.0761	.0737	.0706	.0557	.0719	.0919	.1084	.1224
Aerospace Trade Balance as a Percent of U.S. Trade Balance	31.0	24.6	34.7	25.3	20.1	24.9	30.3	44.4	234.9	219.6	114.6

Source: Based on AIA data.

TABLE 14

RATES OF CHANGE IN AEROSPACE FINANCIAL CHARACTERISTICS

Item \ Years	1964 to 1965	1965 to 1966	1966 to 1967	1967 to 1968	1968 to 1969	1969 to 1970
Total Current Assets	.0614	.2409	.3025	.2227	.2096	-.0387
Gross Inventories	.0444	.3471	.3846	.2274	.2063	-.0372
Total Net Plant	.0497	.2862	.3264	.2432	.2693	.0069
Total Liabilities	.0616	.3497	.4071	.2317	.2496	-.0128
Total Net Worth	.0680	.1506	.1882	.2785	.2112	-.0088
Net Income	.3266	.0916	.0664	.4049	-.0618	-.3769
Working Capital	.0416	.0355	.2106	.3324	.2025	.0397
Long Term Debt	-.0110	.3556	.7340	.4064	.3561	.1368
Net Sales	.0435	.1960	.1828	.1532	-.0171	-.0336

Source: Calculated from FTC and SEC data.

TABLE 15

AEROSPACE FINANCIAL ITEMS
AS A PERCENT OF THE SAME ITEMS FOR ALL MANUFACTURING CORPORATIONS
FOR THE LAST QUARTER OF 1970

Item	Aerospace as a Percentage of All Manufacturing Corporations
Total Assets	3.88
Net Sales	3.54
Working Capital	3.38
Current Assets	5.41
Total Liabilities	5.67
Current Liabilities	7.40
Net Profit after Taxes (Net Income)	1.53
Net Plant, Equipment, and Property (Fixed Assets)	1.95
Net Worth (Stockholders' Equity)	2.33
Debt (Borrowed Capital)	4.04
Long-Term Debt	4.01
Gross Inventories	8.11
Advance Payments from U.S. Government	65.91
Federal Corporation Income Taxes	1.72
Depreciation, Depletion, Accelerated Amoritz.	2.72
Median Value: 3.88 for Total Assets	

Source: Calculated from SEC and FTC data.

TABLE 16

FINANCIAL RATIO TRENDS FOR 72 AEROSPACE COMPANIES
BASED ON BALANCE SHEET DATA AGGREGATED

Ratio / Year	1964	1965	1966	1967	1968	1969	1970	Financial Ratios For All Manufacturing Industries Aggregated 1970
Assets/Sales	.5314	.5418	.5757	.6466	.6827	.8593	.8789	.3935
Current Assets/Current Liabilities	1.5296	1.5146	1.3959	1.3580	1.4031	1.3998	1.4470	1.9825
Cash and Receivables/Current Liabilities	.2896	.5153	.4205	.3625	.3694	.3751	.3815	.91
Net Sales/Net Worth	4.7628	4.6534	4.8374	4.8155	4.4479	3.6094	3.5189	2.3104
Net Sales/Fixed Assets	9.6813	9.6246	8.9497	7.9814	7.5810	5.8701	5.6340	3.1428
Net Income/Total Assets	.0483	.0602	.0517	.0415	.0467	.0355	.0223	.0536
Net Income/Net Sales (All Manufacturing)	.052	.056	.056	.050	.051	.048	.040	.0400
Net Income/Net Sales (Aerospace)	.026	.032	.030	.027	.032	.031	.01975	NA
Net Income/Net Worth	.1221	.1517	.1439	.1292	.1420	.1100	.0691	.0932
Net Income/Net Fixed Assets	.2483	.3138	.2663	.2141	.2420	.1788	.1107	.1267
Net Fixed Assets/Net Worth	.4920	.4835	.5405	.6034	.5867	.6149	.6246	.7351
Net Fixed Assets/Total Assets	.1944	.1918	.1941	.1938	.1932	.1983	.1985	.3975
Net Fixed Assets/Non Current Debt	1.8436	1.9108	1.7990	1.3677	1.2019	1.1156	.9784	1.8860
Net Fixed Assets/Current Assets	.2544	.2516	.2608	.2656	.2701	.2834	.2968	.8059
Net Working Capital/Long-Term Debt	2.6544	2.7955	2.1353	1.4908	1.4123	1.2523	1.1454	1.4202
Earned Surplus/Capital Stock	1.4152	1.6326	1.6707	1.6454	1.6783	1.9190	1.9097	1.9187
Gross Inventories/Net Sales	.2516	.2519	.2837	.3320	.3451	.4236	.4220	.1841
Federal Taxes/Profits before Taxes	.469	.467	.452	.445	.466	.435	.431	.406
Aerospace Taxes/All Corp. Taxes	.0149	.0181	.0157	.0144	.0261	.0172	.0103	NA
Progress Payments/Sales	.1120	.1162	.1272	.1574	.1608	.1946	.1663	.0095
Debt/Stockholders' Equity	.3840	.3448	.4592	.6438	.5909	.6751	.7722	.4454

NOTES:
1. Net Income is equivalent to Net Profits after Taxes.
2. Stockholders' Equity is equivalent to Net Worth.
3. Fixed Assets are equivalent to Net Plant, Property, and Equipment owned by firms in the industry and excludes Federal Government facilities.

Source: Based on FTC and SEC data.

TABLE 17
FEDERAL EXPENDITURES FOR RESEARCH AND DEVELOPMENT FISCAL YEARS 1960 to DATE
(Millions of Dollars)

Year Ending June 30	Total	Department of Defense	National Aeronautics and Space Administration	Atomic Energy Commission	Other
1960	7,738	5,654	401	986	697
1961	9,278	6,618	744	1,111	805
1962	10,373	6,812	1,251	1,284	1,026
1963	11,988	6,849	2,540	1,335	1,264
1964	14,694	7,517	4,171	1,505	1,501
1965	14,875	6,728	5,093	1,520	1,534
1966	16,002	6,735	5,933	1,462	1,872
1967	16,842	7,680	5,426	1,467	2,269
1968	16,865	8,148	4,724	1,593	2,400
1969	16,208	7,858	4,252	1,654	2,444
1970	15,632	7,568	3,753	1,616	2,695
1971[E]	15,960	7,706	3,369	1,619	3,266
1972[E]	16,258	7,887	3,152	1,523	3,696

Note: Includes military personnel, procurement, civil functions, and some other items not included in other tables. Includes R&D facilities and administrative operating costs.

[E]Estimate.

Source: "The Budget of the United States Government", (Annually).

TABLE 18
FUNDING FOR R&D PERFORMANCE BY SELECTED INDUSTRIES 1960-68
(Percentage of Net Sales)

Year	All Industries	Aerospace	Electrical Equipment & Communications	Instruments	Machinery	Chemicals	Motor Vehicles
Total Funding							
1960	4.2	23.2	11.2	6.3	4.7	4.5	3.0
1961	4.3	23.5	10.1	6.0	4.2	4.3	4.0
1962	4.3	23.8	9.9	6.3	4.0	4.2	3.5
1963	4.5	26.7	10.1	5.9	4.2	4.3	3.4
1964	4.6	28.9	9.8	6.1	4.3	4.5	3.6
1965	4.3	28.1	9.5	6.1	4.1	4.2	3.1
1966	4.2	25.3	8.6	5.6	3.9	4.2	3.2
1967	4.2	21.4	8.6	5.6	4.3	4.3	3.4
1968	4.1	19.3	8.3	5.9	4.4	4.0	3.2
Funded by Industry							
1960	1.8	2.4	3.8	3.4	2.7	3.7	2.3
1961	1.8	2.4	3.6	3.7	2.7	3.5	3.0
1962	1.9	2.7	3.5	4.1	2.9	3.4	2.5
1963	1.9	2.6	3.6	4.2	3.1	3.6	2.5
1964	2.0	2.5	3.6	4.3	3.2	3.8	2.6
1965	2.0	3.4	3.6	4.1	3.1	3.6	2.3
1966	2.0	3.5	3.4	3.8	3.0	3.7	2.4
1967	2.1	4.1	3.5	3.6	3.2	3.8	2.5
1968	2.1	3.9	3.7	3.8	3.2	3.5	2.3

Source: NSF 70-29, pp. 58-9

AIA

aerospace research center

1725 DE SALES STREET, N.W., WASHINGTON, D.C. 20036