



THE SST PROGRAM
AND RELATED
NATIONAL BENEFITS

THE **BOEING** COMPANY COMMERCIAL AIRPLANE GROUP
SUPERSONIC TRANSPORT DIVISION

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February 17, 1969

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SUMMARY

SUMMARY

The aerospace industry stands at the leading edge of our nation's advance in science and technology. It is a leading employer and a high-quality employer. It provides a significant portion of our country's export sales of industrial products.

Commercial aircraft development and manufacture constitute a major and increasingly important portion of the activities of this industry. For several years the industry has been the predominant supplier of transport equipment to the airlines of the world, despite intense competition from European industry, some of it government-owned and an instrument of national policy. America's only means of attaining and holding this position is to offer constantly more advanced transport vehicles that excel in efficiency, safety, and attractiveness to the traveling public. Each such advance has stimulated a further growth in the total aircraft market.

Other factors, including economic and population growth, have combined to increase the size and importance of the world air transport market, and this growth continues. There is general agreement among traffic forecasters that revenue passenger miles in the free world will increase at least sixfold between 1968 and 1990. To carry this traffic, \$125 billion worth of new commercial aircraft will be required in the two decades ahead.

It is clear that the next major step in air transport progress will be the move to supersonic operation, because of the timely coincidence of technical readiness and market opportunity. Supersonic transports will constitute a significant part of the above-mentioned \$125 billion market. Comprehensive analyses of operational economics, competing equipment, and appropriateness to various routes—eliminating supersonic operation over populated land areas to avoid sonic boom effects—indicate that the SST market will total \$25 billion by 1990.

Supersonic transports will be built somewhere in the world to fill this market, and will gradually move into the position of prime equipment on the major international routes. The only question is whether they will be built in the United States or elsewhere.

The United States now has a design sufficiently superior in speed, passenger capacity, operating economics, and overall utility that timely implementation of its construction will put the United States in position to obtain at least \$20 billion of this \$25 billion market through the sale of an estimated 500 SST's, 270 of them to foreign airlines.

This projection of market penetration, on which U.S. program plans are based, not only confines the contemplated supersonic operation to routes over water and unpopulated areas, but also takes into account the continued operation of subsonic aircraft in numbers appropriate to their competitive capability. It is to be expected that intercontinental traffic will flow via the newer and much faster equipment—namely the SST's—as was the case when jet airplanes began replacing piston equipment. The experience at that time was that passenger demand produced such high load factors (percentage of seats occupied) in the period following introduction that equipment purchase costs were promptly recovered by the airlines. A few

percentage points difference in load factor became highly significant in operating profitability ratios—more so even than direct operating costs. But the U.S. SST is projected to have direct operating costs comparable to present 707/DC-8 class equipment, with room for further improvement as typically occurs during the development and early operational stages of a new model. Moreover, the market stimulation effect of the tripling of present speeds in the case of the U.S. SST can be even more pronounced than the jet introduction, which doubled previous speeds.

Looking at the effect of the program—prototype plus resulting production—the prospective direct employment will involve approximately 50,000 persons at peak production. This means a figure in excess of 150,000 if secondary employment effects, including trades, professions, and services supporting the original 50,000, are considered. Those directly employed will be at a high average wage; they will include many at the top levels of skill and technical competence, so important to the continuance of our nation's overall capability; they will also include substantial numbers in semiskilled and unskilled categories. The aircraft industry has a strong record of equal opportunity employment and is currently contributing to the solution of the nation's "hard core" unemployment problems by providing training, in conjunction with the government, and assimilating such individuals into the work force, including appreciable numbers from the minority groups.

Because of widespread subcontracting, the distribution of employment will be nationwide. It is constructive employment on a commercially useful activity contributing to the objectives of peace through improved communication and contact between the peoples of the world.

The dollar impact of the SST program on the U.S. economy is even more striking than the employment effect. Quite in contrast to the type of government-supported program that involves expenditure without direct return to the government, the SST program is devised to permit government recovery in amounts substantially greater than the original outlay:

- On a direct business venture basis, the government will be paid royalties on the sale of production airplanes in an amount returning the original investment by approximately the 300th airplane and producing \$1 billion in excess of investment by the 500th delivery.
- The production program is of such scope that personal and corporate income taxes of those directly involved will produce a return to the government more than double its prototype expenditure, and potentially five and one-half times that expenditure if the federal, state, and local taxes paid by those indirectly employed through the "multiplier" effect in the economy are included.
- Owing to the high percentage of export business included in the makeup of the program, the international balance-of-trade effect is truly substantial. If the loss of foreign sales from U.S. nonentry into the competition is combined with the consequent additional purchase of foreign-built SST's by U.S. airlines, the negative effect on the aircraft account in the U.S. balance of trade could reach \$16 billion by 1990. Conversely, the successful execution of a U.S. SST program of the dimension described will add appreciably to the strength of the dollar and America's monetary position.

- The stimulative effect of the advance into supersonic transportation will bolster the economy generally, because of the increased ease of transportation and the technological benefits deriving from the program. To the extent that gross national product growth is generated thereby, further income will be returned to the government through various revenue sources.

The technological benefits are impressive enough in themselves to provide strong justification for the SST prototype development, quite apart from the commercial revenues already discussed. Many advances already in process and to be completed for the SST will apply to the whole of air transportation and to the military side. These include: major safety advances stemming from automatic flight control equipment, internal systems reliability, and fireproof structure improvements; flight efficiency improvements stemming from advances in structures, propulsion, aerodynamics, and lightweight components; manufacturing advances, particularly in the realm of titanium structures applicable to other equipment, and finally, flight operations advancements that will permit the efficient handling of increased air traffic and relieve the congestion constraints that are hampering transportation growth generally.

In effect, the SST's requirement for these various advances serves as a forcing function to bring them expediently into existence. Without the SST program, they might require a number of additional years, and their beneficial effects—as applied to the rest of the air transportation system as well as possible other related systems—would thus be delayed. The existence of an SST prototype program in which the government is an interested participant provides the needed present mechanism to bring these developments forward.

Not only will the technological advances apply beneficially to the transportation system but, as has already been seen, numerous developments in materials, manufacturing techniques, electronics, and other important fields will find free application in industry generally, and undoubtedly throughout the consumer economy.

The total impact of the planned SST program extends beyond the many specific effects cited above. It can best be described in the dimension of overall national strength. Our position internationally, our ability to continue to lead industrially, our national security, our economic health, our technical capability, our prestige in terms of meaningful leadership in important lines of progress—all are components of our relative national strength and position. Each of these can be strongly affected by the SST endeavor. It is a project of the scope and character that gives it major national importance. It is the only development program in the large supersonic airplane field, military or commercial, under way in the United States at the present time. In its technology and its contribution to future mobility, the SST has an important bearing on our national defense capability. It must be viewed in the light that three other nations—the Soviet Union, Britain, and France—have already embarked on SST projects, thereby acquiring this capability and the benefits derived therefrom. The Soviet Union's general technology advance is especially impressive. That country prides itself on being the first to fly an SST.

The risk of overall loss resulting from nonparticipation in the SST competition would be serious in the aggregate. The increased risks associated with permitting competing sources too great a time lead over the U.S. product are likewise serious. Allowance has been made in program planning for substantial sales of the Anglo-French Concorde over routes on which this smaller vehicle is appropriate. However, the additional speed, size, and economic advantages of the U.S. SST are counted on to win the trunk route markets, assuming the production airplane will be available with no greater lag behind the competition than would be entailed by a prompt 1969 go-ahead on prototype construction. Increased delay could permit the Concorde to advance to a model more comparable to the U.S. airplane by the time the latter is available.

It is understood that the U.S. program is undertaken with the normal business risks associated with the attainment of ultimate commercial orders and the realization of air traveler patronage in the volume that would provide these planned orders. However, it must be remembered that European SST's will already be flying, and the factors of marketability and passenger demand will be much better known by the time of a go-ahead decision on American production quantities. If, at the time of airline introduction of the Concorde, the expected passenger approval and demand are demonstrated and there is no U.S. SST prototype in existence, it will then be too late to retrieve the desired U.S. position. Therefore, it appears that the real business risk of not going ahead with the prototype at this time is considerably greater from a national standpoint than the risk of proceeding according to plan.

AIRCRAFT INDUSTRY

AIRCRAFT INDUSTRY

In this chapter recent contributions of the aircraft industry are discussed in terms of economic and technological benefits.

Backlog of Business and Sales

The backlog of orders for commercial jet transports committed to the U.S. aircraft industry amounts to an important factor in the nation's financial stability. Currently, this industry has a 997-airplane backlog amounting to \$11.1 billion. This backlog supports a level of business that has not been exceeded since World War II. Figure 1-A displays the growth in dollar value of aircraft of deliveries from \$813 million in 1964 to more than \$3.5 billion in 1968. Figure 1-B shows the corresponding number of deliveries during this period.

Total Jobs in the Aircraft Industry

The aerospace industry in the United States is the largest single production element of our total economy. Of a total national work force (excluding agricultural workers) of almost 69 million workers, the aerospace industry contributes 1,415,000 employees. This is even greater than the auto industry's 880,000 workers. The aircraft industry share of the aerospace total is 848,000 workers. This is more than one and one-half times greater than the steel industry's 523,800 employees. Table 1-I displays historical data for comparison.

Average Wage

The average wage of the nation's aerospace employees is among the highest in industry. The relatively highly skilled work force currently commands an average hourly wage of about \$3.66 per hour. The aircraft production worker's average hourly wage is almost as great, being \$3.63 per hour. This compares to an average wage of \$3.01 per hour for all U.S. production and nonsupervisory employees. Recent data are given in Table 1-II.

Annual Payroll

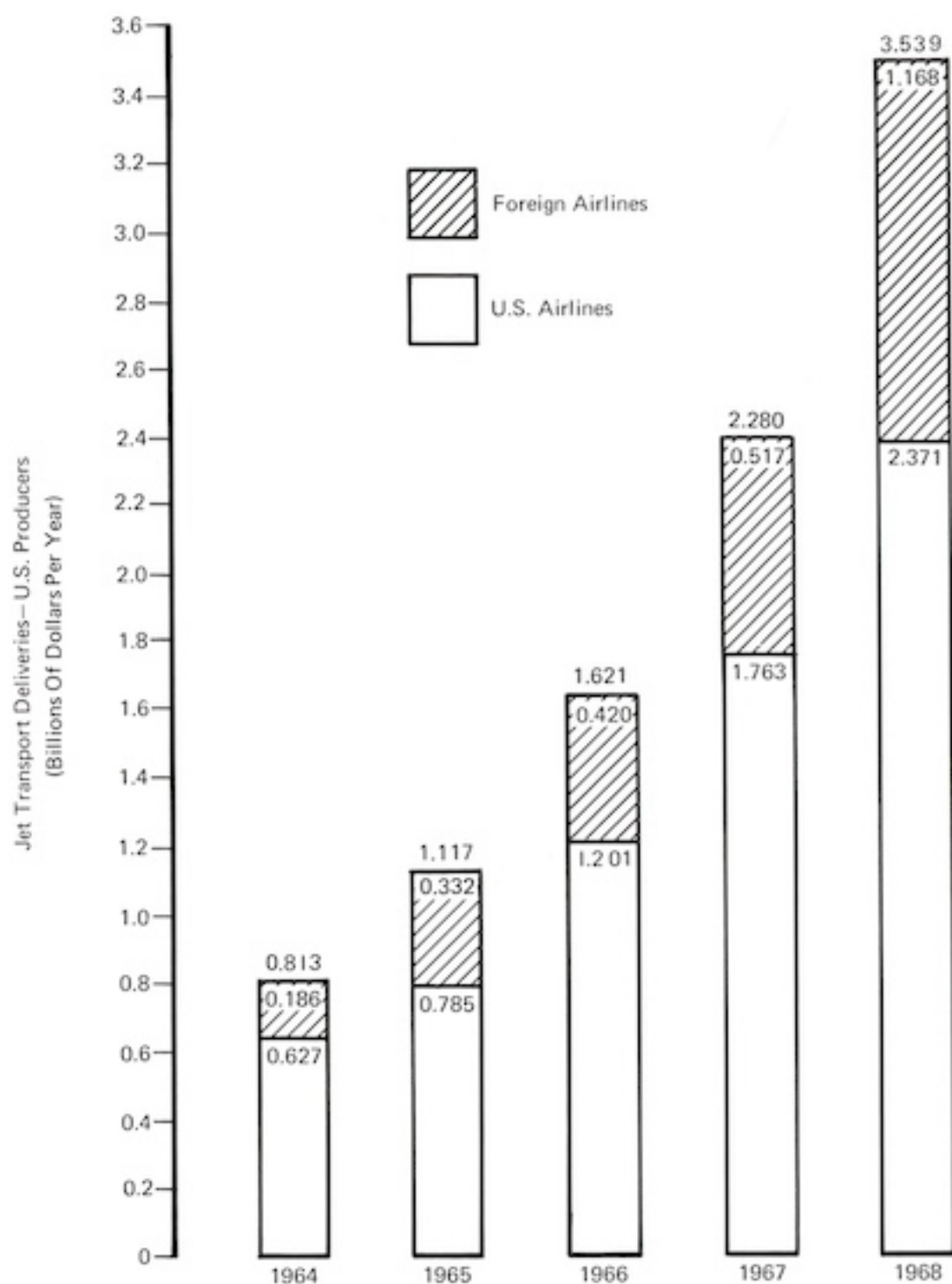
It is apparent that the aerospace industry is a large contributor to the maintenance of our nation's economic growth. In labor costs alone, the U.S. aerospace industry paid out \$12.3 billion in 1966 and \$12.9 billion in 1967. The product of a relatively high average labor rate and a high proportion of the nation's total work force results in a significant contribution to the overall national labor income.

Technological Benefits

The technological development required in the aircraft industry has led to innovations in materials structural techniques and systems design and manufacture.

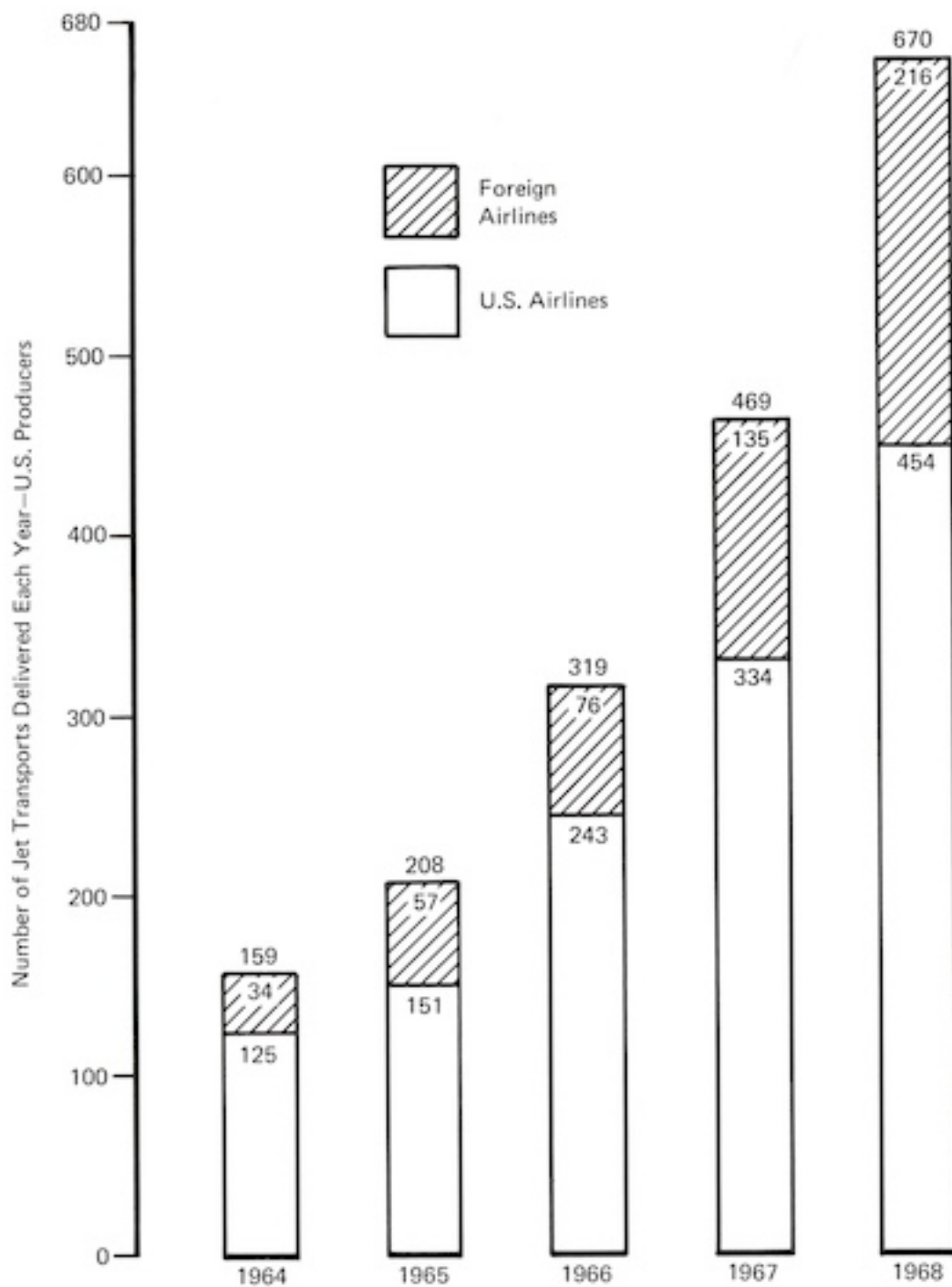
Innovations developed by the aircraft industry are applied to the *direct* benefit of the industry and its products and, more importantly, are transferred by the so-called *spin-off* process into the products of other companies in other industries.

A few of the more important examples of aircraft technical developments that have



Source: The Boeing Company

Figure 1-A. Dollar Value of U.S. Commercial Transport Deliveries



Source: The Boeing Company

Figure 1-B. Number of U.S. Commercial Transport Deliveries

Year	Employees on Nonagricultural Payrolls, U.S. (1)	Total Aerospace Industry (2)	Aircraft & Parts (SIC 372) (3)		Motor Vehicles & Equipment (SIC 371) (3)		Blast Furnaces & Steel Mills (SIC 3312) (3)	
	All Employees	All Employees	All Employees	Production Workers	All Employees	Production Workers	All Employees	Production Workers
1960	54234.0	----	627.9	369.6	724.1	563.3	577.1	470.5
1961	54042.0	----	609.7	347.7	632.3	479.1	526.5	424.7
1962	55596.0	----	638.4	349.1	691.7	534.0	522.3	421.4
1963	56702.0	----	639.2	350.8	741.3	573.6	520.0	424.6
1964	58332.0	1117.0	605.4	338.6	752.9	579.2	556.7	458.4
1965	60832.0	1133.0	624.2	356.3	842.7	658.9	580.2	477.4
1966	64034.0	1298.0	750.5	444.7	859.2	668.4	571.3	467.2
1967	66033.0	1392.0	812.5*	490.5*	826.9*	640.7*	550.5*	444.2*
1968	68927.0**	1415.0	848.4**	500.4**	888.8**	696.6**	523.8**	414.0**

Source: (1) Employment and Earnings and Monthly Report on the Labor Force, Volume 15, No. 5, November 1968, U.S. Department of Labor—Bureau of Labor Statistics
(**) September 1968
(2) Aerospace Industries Release, 69-9 Series 6-1 & 69-11 Series 8-1 of January 29, 1969
(3) Employment and Earnings Statistics for the U.S., 1909-67, issued October 1967, Bulletin No. 1312-5, U.S. Department of Labor—Bureau of Labor Statistics
(*) May 1967

Table 1-I. Total Job Comparison, Thousands of Employees

Year	Total Industry (1)	Total Aerospace (2)	Total Aircraft (2)
1968	\$3.01	\$3.66 (11 months)	\$3.63
1967	2.83	3.52	3.49
1966	2.72	3.39	3.34
1965	2.61	3.25	3.15
1964	\$2.53	\$3.13	\$3.00

Source: (1) Bureau of Labor statistics—gross average hourly earnings of production or nonsupervisory labor on private manufacturing; nonagricultural
(2) Aerospace Industries Association data

Table 1-II. Average Hourly Wage of Production Workers

laid the foundation for whole new industries or made large contributions to growth of existing industries are:

- Aluminum has moved from a lightweight high-priced novelty item in the lab into an inexpensive, extremely useful high-production metal that finds myriads of uses in many companies' products.
- Titanium is now finding more uses in aircraft design. Under the impetus of the SST program there will be further reduction in costs and greater utilization.
- Plastics and their application have undergone considerable development within the industry and found application in consumer goods industries. The SST promises further development and use of plastics.
- Using aluminum, titanium, and plastics singly or collectively, the industry has developed lightweight, high-strength assemblies that have been adopted in railway-car and automobile design, to name just two examples. The SST will force innovation in this area, especially in bonded and honeycomb structure.

Other examples include:

- Stronger and higher quality welding, fastening, and joining, which have been applied to all kinds of parts and assemblies, including pipe, storage tanks, cars, etc.
- Faster, cheaper, and more accurate metal forming and removal (especially using numerically controlled machine tools and chemical milling).
- Greatly improved manufacturing inspection and testing techniques, especially nondestructive testing.
- Higher-performance, compact, and more dependable environmental control systems, which have led to better heating and air conditioning systems for residential and commercial buildings and automobiles.
- High-performance, compact, and reliable communications and navigation systems, which have been applied to other modes of transportation.

More examples could be cited, but those selected serve to illustrate the benefits derived by this nation from the development and manufacture of aircraft. The SST's technical and economic performance will require technical development that will provide a continuation of comparable future benefit.

Balance of Trade

The United States leads the world in the export of goods; 4 percent of our gross national product is the result of this export business. The aircraft manufacturing industry has been able to produce exports to the extent that although the net U.S. balance of trade (exports less imports) has been declining, that portion for aircraft, parts, and accessories has continued to increase over the past 5 years. Table 1-III displays this information.

The civilian/commercial aircraft, parts, and accessories portion of this total aircraft, parts, and accessories balance has increased from 52 percent in 1963 to the current 72 percent.

World Recognition

The U.S. aircraft industry is recognized throughout the world as favorably reflecting the technological capability and production quality that our economic system encourages. Of the 104 major IATA free-world airlines, 89 use United States-built equipment. Of 135 major national capital cities in the world, 110 are on scheduled stops by United States-built air transports and 71 are served by U.S. airlines.

Share of Free-World Market

Since the introduction of jet commercial transports by the air carriers of the world, the United States has captured almost nine-tenths of the available free-world market. Table 1-IV gives historical statistics in this regard.

Year	U.S. Balance of Trade— Total (\$ Billion)	U.S. Balance of Trade— All Aircraft, Parts, and Accessories (\$ Billion)	% of U.S. Balance of Trade— Civil & Commercial Aircraft, Parts & Accessories (%)	U.S. Balance of Trade— Civil & Commercial Aircraft, Parts & Accessories (\$ Billion)
		(a)	(b)	(a) x (b)
1963	5.287	0.726	52	0.378
1964	7.006	0.791	54	0.427
1965	5.334	0.997	58	0.577
1966	3.837	0.824	72	0.593
1967	4.126	1.270	72	0.914
1968	0.726	1.585 (est)	72 (est)	1.140
Source: U.S. Dept of Commerce Bulletin: Overseas Business Report of May 1968 U.S. Dept of Commerce Series FT 410 and Series FT 135 of January 1969. The Seattle Times of January 3, 1969.				

Table 1-III. Balance-of-Trade Comparisons

Calendar Year	Percent of Total World Dollar Sales
1960	88.4
1961	86.9
1962	83.3
1963	85.6
1964	83.2
1965	81.7
1966	85.8
1967	93.9
1968	95.0 (est)
Source: The Boeing Company	

Table 1-IV. U.S. Producers' Share of Free-World Commercial Transport Airplane Market

AIR TRANSPORTATION GROWTH

AIR TRANSPORTATION GROWTH

AIR TRANSPORTATION GROWTH

The air transport business is one of the outstanding growth industries in the world. Since 1950, air transportation has realized an average worldwide growth rate of 15 percent per year. Many studies have been undertaken to identify factors causing this growth in order to develop analytical methods for forecasting. These studies have indicated that air traffic growth correlates significantly with:

- Growth in the traveling age group (25 to 59 years)
- Growth in GNP per capita or personal income per capita in this group
- Decrease in fares

At this time there are insufficient historical data available to precisely predict the beneficial effect of reduced trip times on air traffic growth. However, airline managements in general regard this factor as significant. Analyses indicate that by 1990, 10 to 15 percent of the traffic could be attributable to the shorter trip times offered by SST's.

The Institute for Defense Analysis (IDA) developed an analytical model for the Federal Aviation Administration in 1966 as part of an overall economic evaluation of the SST program. The traffic forecast produced by this study is shown in Figure 2-A. In addition, the actual data are included up to 1968, and the current Boeing forecast used in business planning is also included. Note that the forecast underestimates by 30 percent the traffic just 2 years after it was made. Note also that the higher traffic volume in 1968 occurred in spite of the substantial air traffic congestion that occurred in many large airports of the world.

The substantial underestimate of the 1968 traffic by the IDA group does not invalidate the equations which they developed. The difference between actual and assumed growth in income would account for some of the difference in traffic. The increased international travel associated with the Vietnam war and other international unrest would account for substantially the rest of it.

Based upon airline and aircraft industry forecasts, the IDA air traffic model appears to produce reasonable estimates in the 1980-1990 time period, and it was used as the basis for the analysis results to be discussed in the remainder of this chapter and in the following chapter. The air traffic projection envisions an average growth rate to 1990 of about 8½ percent a year, substantially below the 15 percent average mentioned previously. At this rate, 1990 traffic will be six times that of 1968.

Recognizing that there is a serious question of the desirability of supersonic flight over land, it has been decided to make the economic feasibility studies under the assumption that supersonic flight over populated areas would not be allowed. This assumption results in application of supersonics primarily to routes where slight deviations from the great circle (shortest distance) would bypass populated land areas and where subsonic flying for short distances at the beginning and end of the trip would be economically feasible. In addition, some longer subsonic flying over populated areas was assumed in order to connect up airline route systems. The aircraft is designed to accommodate these options at practical costs. Under this assumption, about 30 percent of the total air traffic could possibly be served by

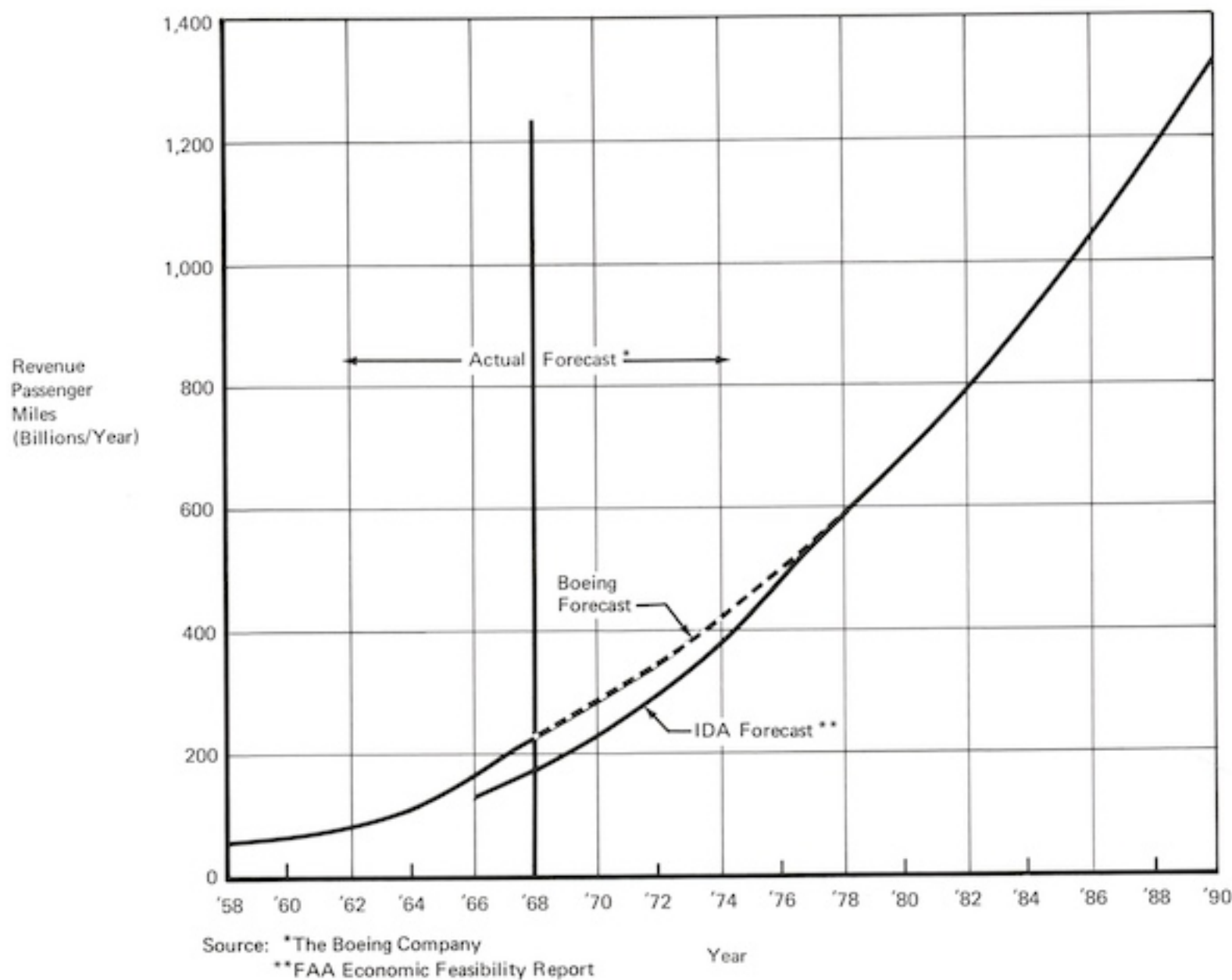


Figure 2-A. Free-World Traffic Forecast

supersonics. Figure 2-B shows a breakdown of the total market, and Figure 2-C shows typical supersonic aircraft routes.

The striking fact of the analysis today is that even under this restriction, the SST can compete for a future market nearly twice as large as the total of free-world air travel in 1968. The amount the U.S. SST would actually capture would depend upon its appeal to the traveling public and upon its relative earning ability for the airlines.

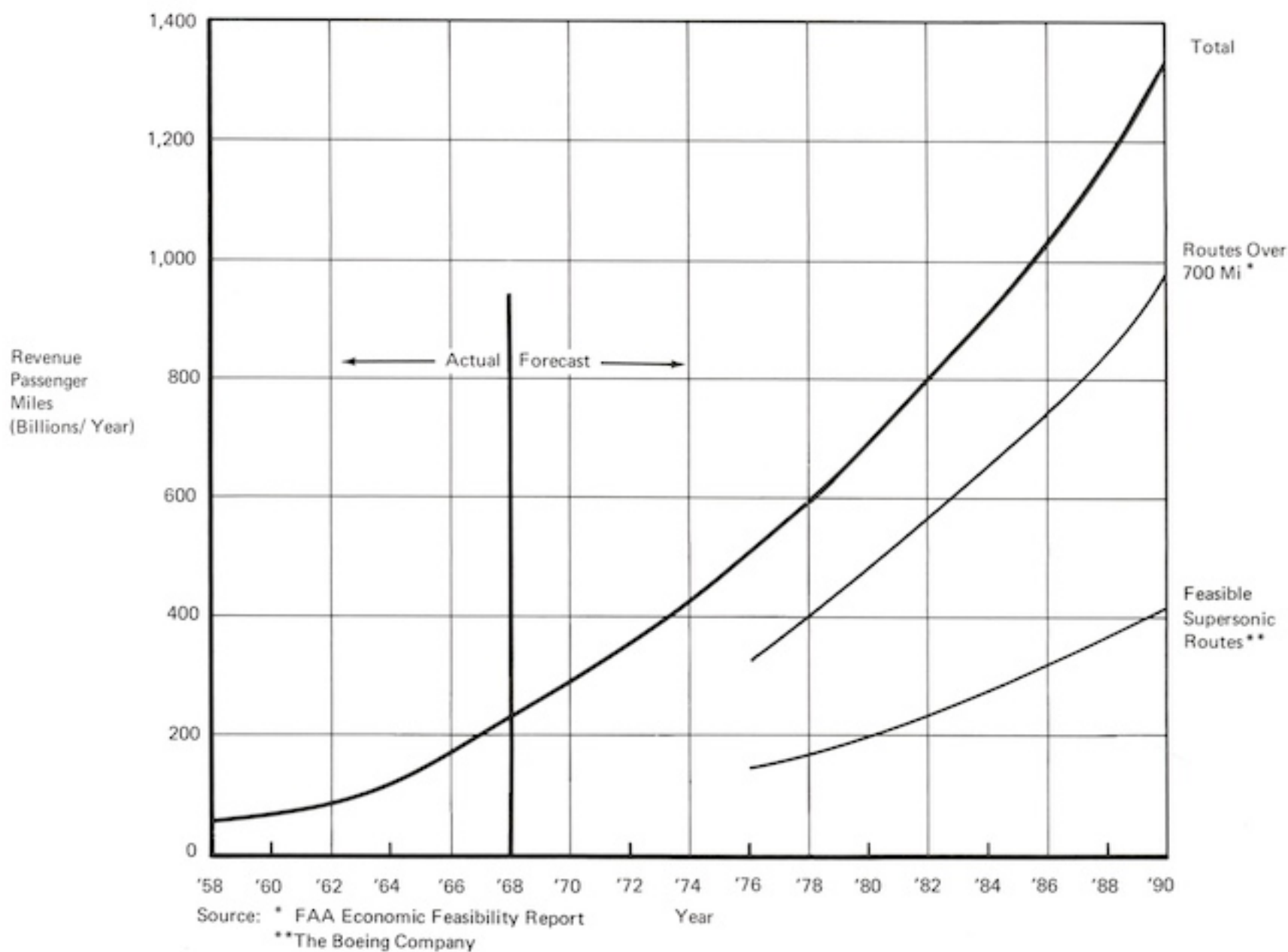
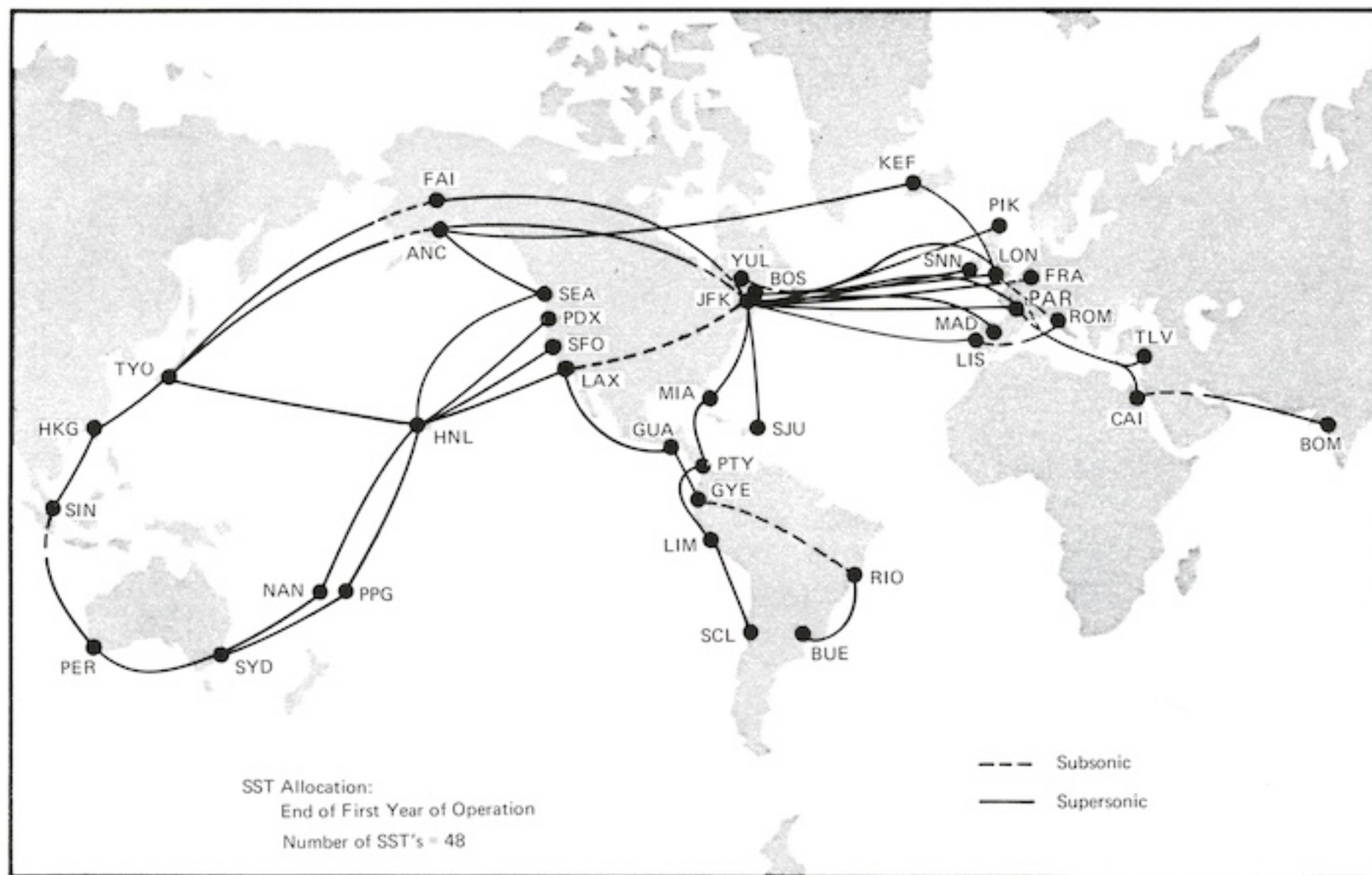


Figure 2-B. Free-World Traffic Forecast (by Market Area)



Source: The Boeing Company

Figure 2-C. International Air Traffic—10 Percent Penetration of SST Feasible Routes

ECONOMIC STUDIES

ECONOMIC STUDIES

The U.S. supersonic prototype is the forerunner of a family of transport airplanes just as the original Boeing jet transport prototype Dash 80 was the forerunner of the nearly 2,000 jet transports now flying. A key to successful SST penetration of the market is its relative economics. Figure 3-A shows a comparison of total operating costs of a production version of the SST with the 707 Intercontinental and with the wide-body 747. At equal load factors the total operating cost per seat mile is higher for the SST than the 747. However, a modest load factor advantage to the SST would eliminate this difference. There is historical justification for assuming that popular demand will generate the load factor difference. The right side of Figure 3-A shows the load factors on the subsonic jets during the period when the subsonic jets captured nearly all of the traffic on the prime long-haul routes.

Analyses show that both lower fares and shorter trip times generate additional traffic. However, it is evident that a large segment of travelers would consider trading one for the other. Analysis of these trades leads to the conclusion that people's choice will be related to their incomes. It is also evident that their choices will be influenced by the specific fare possibilities—first-class subsonic versus tourist SST, for example. Moreover, the choice will be related to the traveler's perception of the advantage gained by the faster speed. In this regard, scheduling studies have been done and trip time comparisons have been made. Trip time savings of 3 to 4 hours are typical. For examples, see Figure 3-B. Moreover, additional departures can be scheduled at convenient times for travelers. (See Figure 3-C.) The better departure schedules and shorter trip times would generate additional use of the SST. Projecting U.S. and foreign incomes out in time, it is estimated that if a fare difference of 20 percent or less is charged, then between 60 percent and 100 percent of the travelers would choose to fly supersonics by 1990.

Combining all of these factors results in an estimate of the total supersonic demand. It appears now that this demand will be about 20 percent of the total air traffic by 1990, or *slightly more than total free-world traffic generated by all aircraft on all routes in 1968*. The distribution of the long-haul traffic with range and the 20 percent supersonic share is shown in Figure 3-D. The split of this traffic between a U.S. SST and the Concorde will be a function of the relative economics of the two airplanes and of the relative introductory timing. At present, it is envisioned that the Concorde will be introduced in 1973 and that the U.S. SST would be introduced in 1976. Moreover, it is estimated that the smaller, slower Concorde has a higher seat-mile cost than the U.S. SST (Figure 3-E). Current projections, based upon the IDA forecasting model, are for a total U.S. SST market of 500 airplanes and a Concorde market of 120 airplanes under the assumption that no supersonic flight over populated areas is allowed.

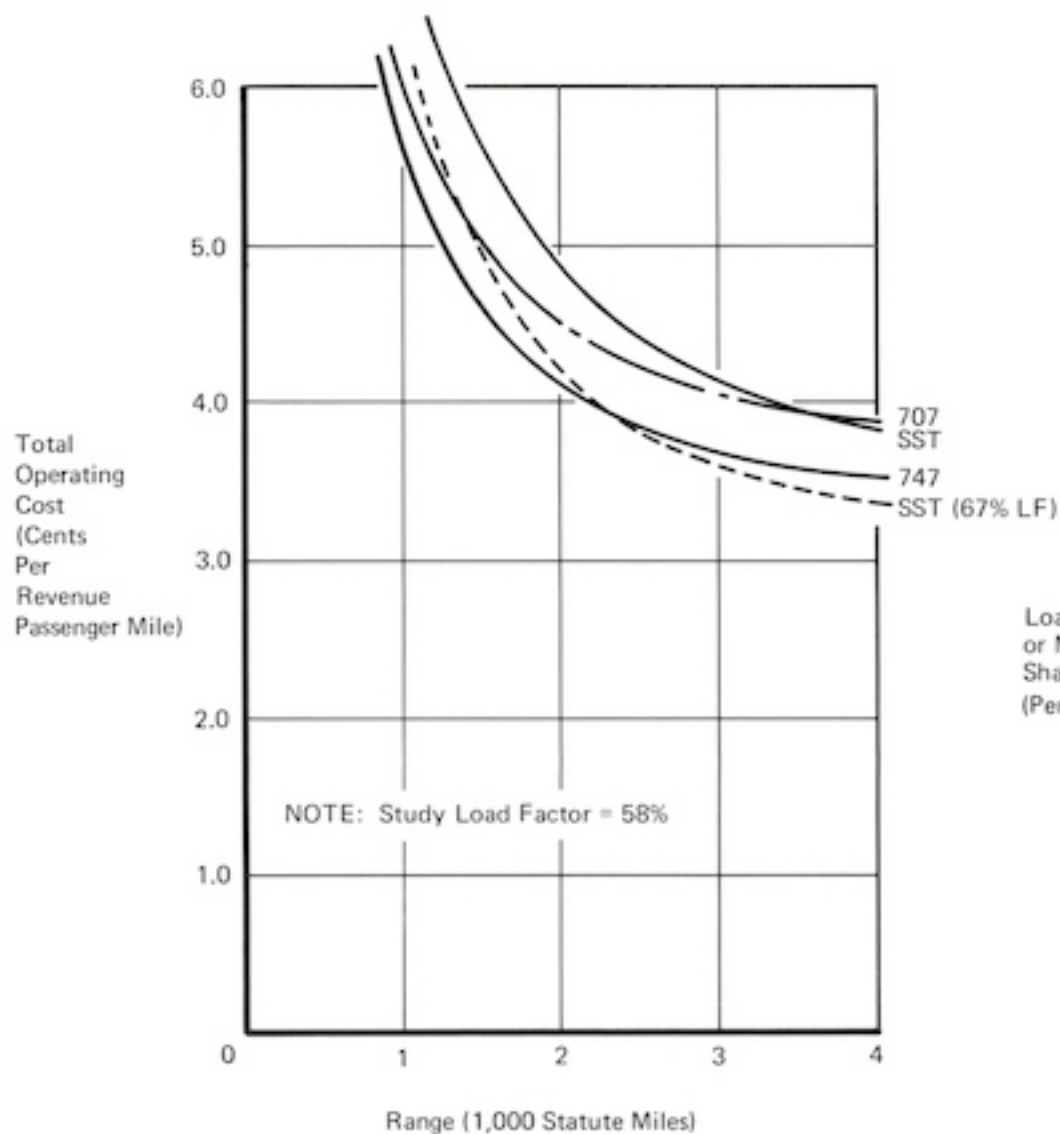
However, if the U.S. SST is not built, the less economical Concorde would capture a portion of the supersonic market. It is projected that 600 of these airplanes would be sold by 1990.

From time to time studies have been made of the effect of design mach number on the economics of the SST. These studies show relatively small differences in the operating cost with mach number between mach 2.2 and 2.7. In some studies lower

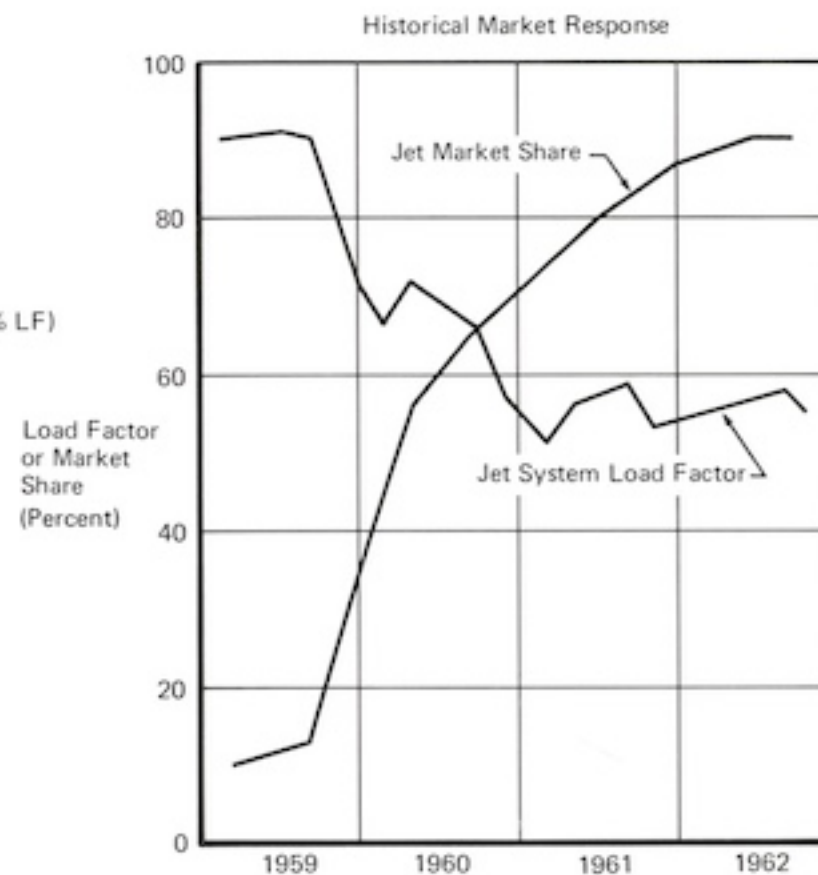
costs occurred at the lower mach number, and in some they occurred at the higher. The outcomes have been dependent upon small differences in assumptions and ground rules.

The significant factor in design mach number selection between 2.2 and 2.7 relates to the choice of a structural material. At low mach numbers, aluminum structures would be feasible. Even here, however, while aluminum is less of a production risk, titanium has superior potential.

In summary, air travel will be enjoyed by more and more of the world's people. To satisfy this growing demand, the airlines will buy an additional \$125 billion worth of aircraft and parts between 1970 and 1990. The U.S. SST can compete for about \$45 billion of these sales even assuming that supersonic overflights of populated areas are not allowed; and, as currently envisioned, it is expected to capture \$20 billion of the market.



Source: The Boeing Company



Source: Air Transport Association

Figure 3-A. Operating Cost—U.S. SST and Subsonic Competition

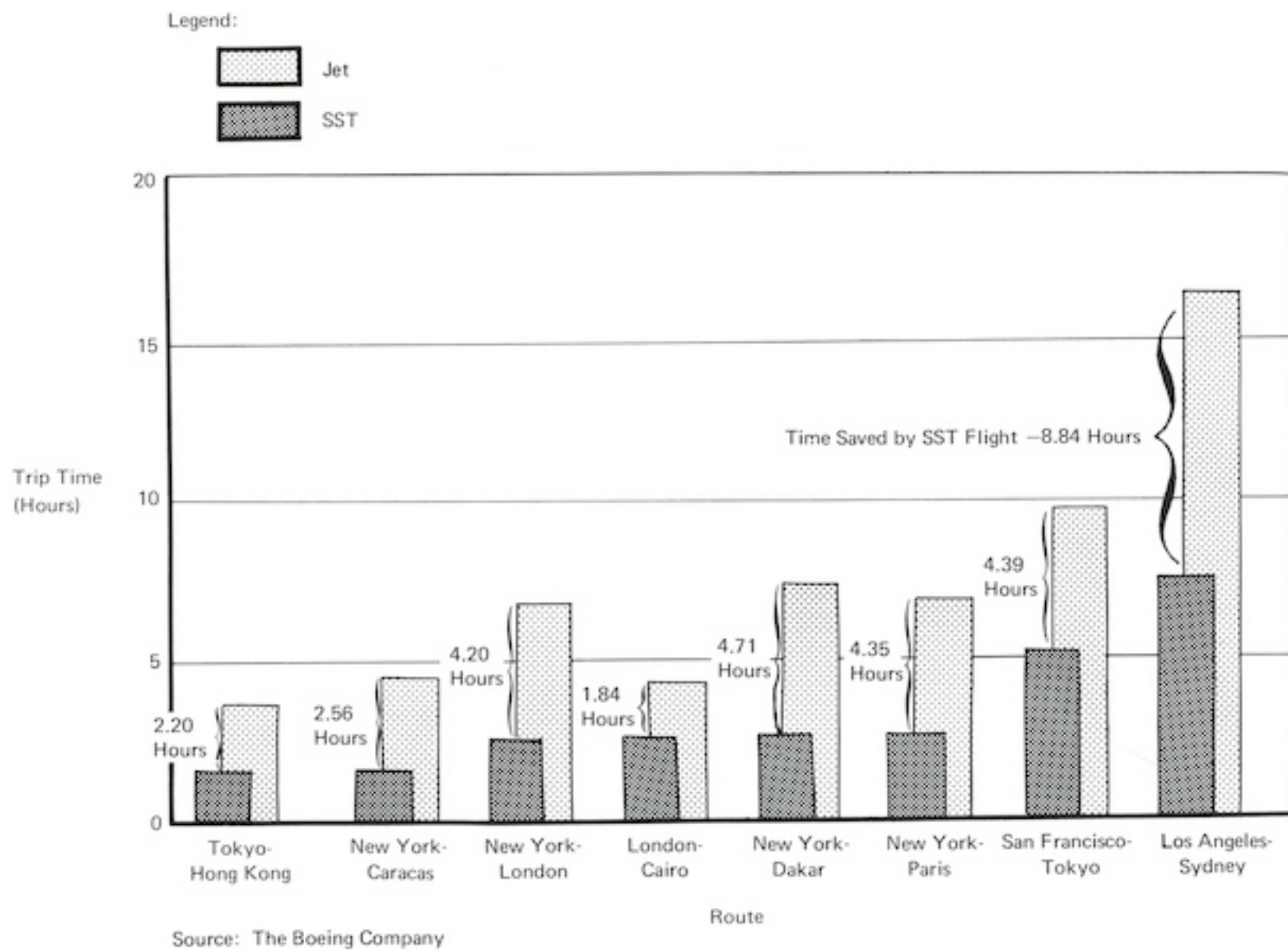
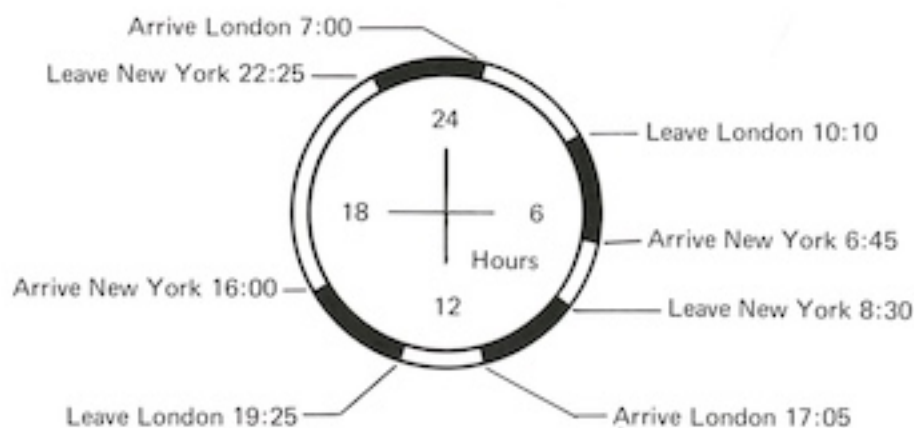
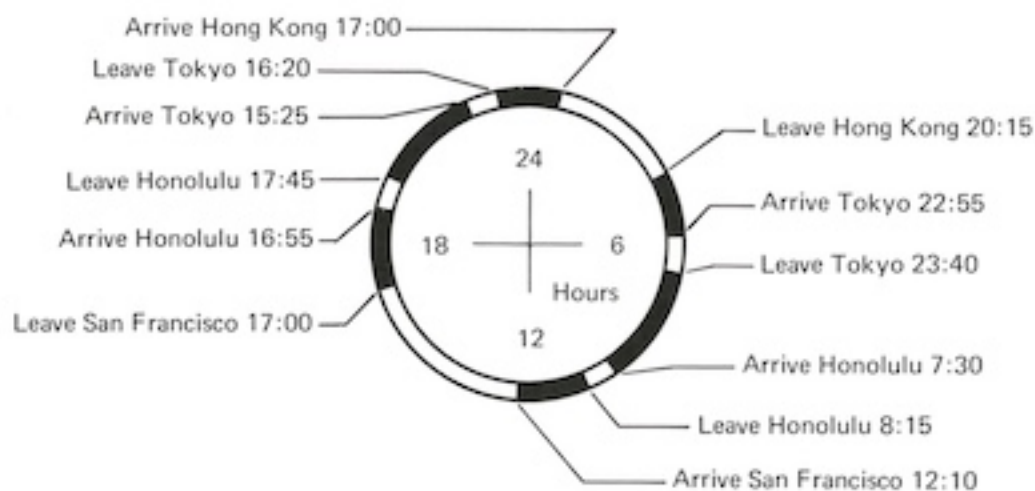


Figure 3-B. Trip-Time Comparison



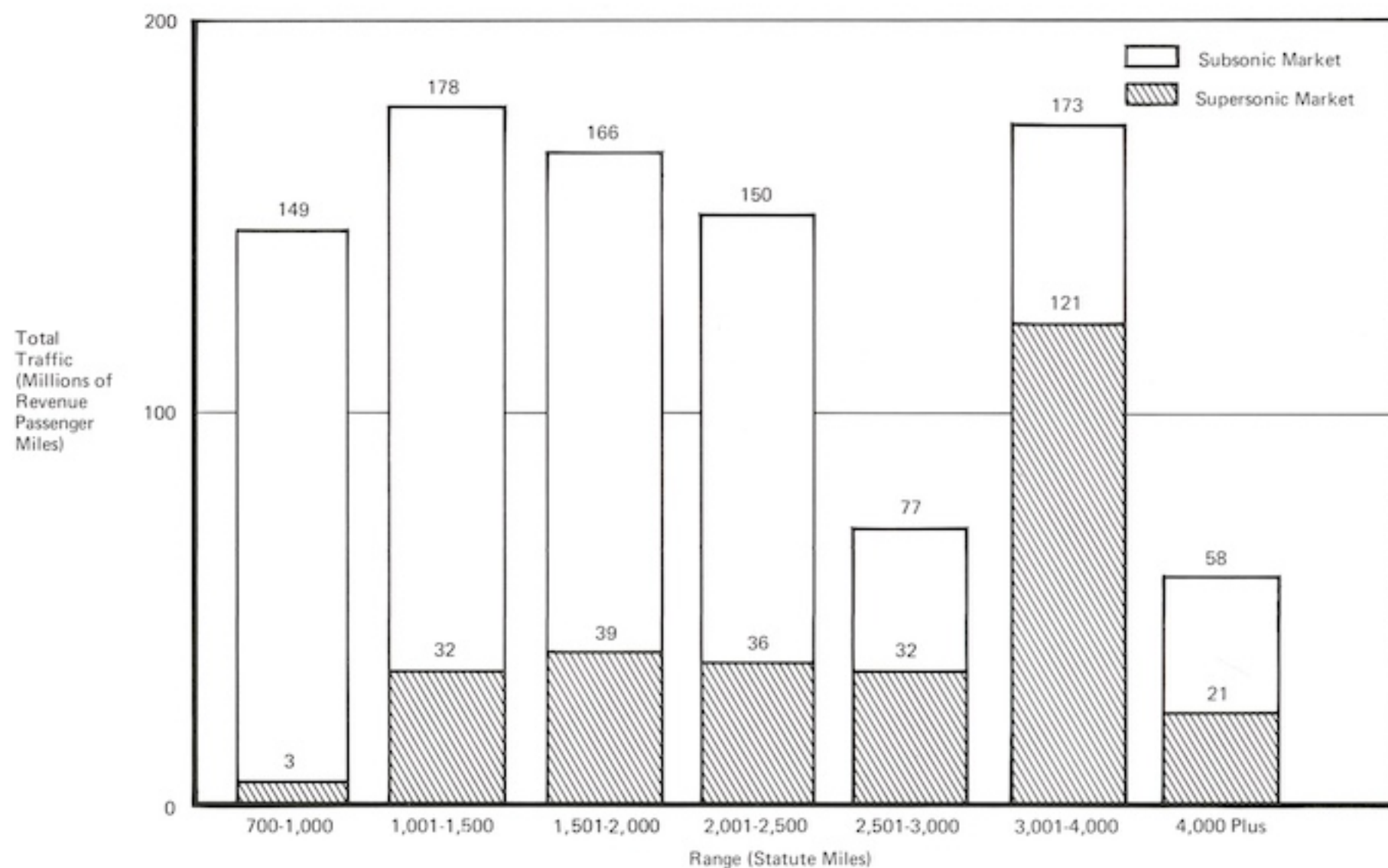
Airplane Day New York-London



Airplane Day San Francisco-Honolulu-Tokyo-Hong Kong

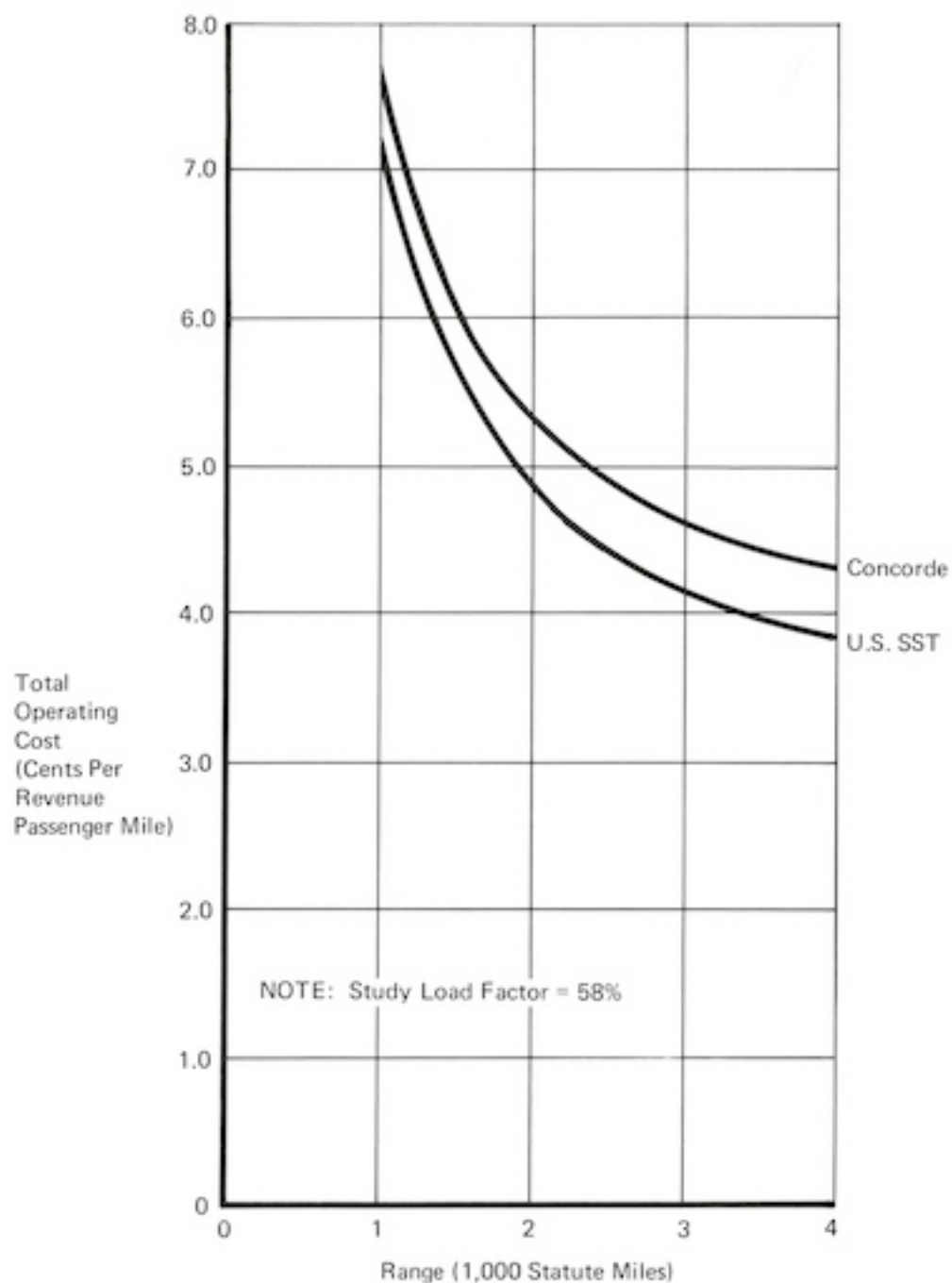
Source: The Boeing Company

Figure 3-C. Schedule Flexibility



Source: The Boeing Company

Figure 3-D. Estimated Market Penetration—1990



Source: The Boeing Company

Figure 3-E. Operating Cost—U.S. SST and Concorde Competition

JOB OPPORTUNITIES

JOB OPPORTUNITIES

The U.S. labor force will increase by approximately 1.5 million persons per year for the next decade. The structure of the labor force will change because of a large influx of younger workers, many of whom will be highly educated and trained. The skill requirements, number of jobs, and geographic distribution of jobs provided by the SST program appear to match the labor force changes.

The fundamental reasons for pursuing the program are its soundness as an economic venture and its importance in international aircraft markets. The discussion below is intended to indicate that, in addition to its economic soundness, the SST program is probably also a key element in achieving a desired use of our restructured labor force.

There is general agreement among the various forecasts of the size of the labor force that the United States will require a net addition of approximately 1.5 million new jobs per year for the next decade. The SST program has relevance to this requirement for new jobs in two respects:

- The relative magnitude of employment provided by an SST program and the new job requirements of the labor force
- The relationship between the types of jobs offered by the SST program and the changes anticipated in the structure of the labor force and, consequently, in the specific demands for jobs

During the design and prototype phases of the SST program, peak employment is projected to be approximately 20,000 prime and subcontractor people. An effort of this magnitude has significance with respect to near-term job requirements. The production program, with a projected direct peak employment of approximately 50,000 and total employment (including multiplier effects) in excess of 150,000, is large enough and of sufficiently long duration to be considered a meaningful element in the task of meeting the new job requirements.

The primary significance of the SST program with respect to the labor force appears to lie in the relationship of its skill requirements to the changing structure anticipated for the labor force, and to the major government programs aimed at upgrading and increasing the "utilization" of the labor force. Perhaps the most crucial single issue will be the manner in which young people just entering the labor force are absorbed into the ranks of the employed. First, the rate of absorption will have to be considerably higher than it has been in recent years. Secondly, a significant portion of the younger entrants to the labor force will be highly educated and trained in the managerial, technical, and skilled areas relative to their predecessors. Thirdly, those entering the job market with little or no skill will find diminishing opportunities. In these respects, successful prosecution of the SST program appears particularly important.

To illustrate, the United States has developed a very large base of technical, managerial, and industrial competence during the successful completion of very large, technically sophisticated programs. We are increasing the size of this base daily. If the U.S. SST program is not pursued and the supersonic technology is

pursued in other countries, we will lose jobs from the U.S. economic base, jobs for which our own technical, managerial, and industrial people are advantageously suited. The recent experience of other countries where large-scale, technically sophisticated programs were not brought to completion argues persuasively for this point. The loss would tend to place a ceiling on the upward mobility of both the highly trained new entrants to the labor force and on experienced workers. In turn, absorption of the less skilled new entrants would be more difficult.

The SST program has sufficient managerial, technical, and industrial content to use much of the base we have already developed, stimulating upward mobility in other segments of the labor force and thereby making the absorption of new entrants easier in all of our major industries and at all skill levels.

It is important to note that the ill effects of not pursuing the SST program would be felt not only in the U.S. aircraft industry, but in almost all our major industries and at all skill levels as a result of a lack of "multiplier-effect" jobs.

Table 4-I shows the expected changes in the structure of the labor force by age group through 1980. The two main points of interest are the indicated increase of approximately 1½ million per year between 1970 and 1980 and the projected large increases in the 25-34-year-old age group.

Table 4-II shows the expected increase in the labor force by major geographic regions, related to the currently available data on prospective subcontractor effort for the prototype and production programs. The distribution of SST employment by region is based on the distribution of subcontractor dollar effort by region. Supporting Table 4-II are detailed tabulations (Table 4-III) of the percentage change between 1970 and 1980 by region, and a distribution of the prospective subcontractor companies and dollar subcontracting effort by state for both the prototype and production programs (See tables 5-IV to 5-VII). Current prospects are that the largest portion of subcontract effort will be in the western states, which are projected to experience the highest rate of labor force increase through 1980.

Table 4-IV shows the jobs that would be created in the industrial sector, and which would in turn be created in the consumer sector, as a result of the SST program at peak rate.

Table 4-V displays the probably structure of the SST related industrial employment in terms of typical education levels, skill levels, ages, and salaries.

Tables 4-VI through 4-XV display the anticipated structure of the aerospace industry and engine portions of the SST labor force. There are several points of interest: First, a very large proportion of the jobs are expected to be available to the people in the fastest growing age group. The lowest anticipated manufacturing wage range of approximately \$6,000 per year in terms of current dollars is about equal to the present national average for manufacturing workers. There are a substantial number of jobs involving management, skilled workers, and technical functions, which are expected to be very well paid relative to the average for the labor force.

Approximately 50 percent of the total payroll will be in the unskilled and semiskilled categories on a headcount basis. Approximately 70 percent of the effort will be outside the professional and technical categories.

The next issue of major importance is whether the aircraft and related industries have established the policies, administrative practices, and relationships with suppliers that will encourage movement in the desired direction within the labor force. There is every reason for confidence in this respect. The aircraft industry has traditionally attracted and utilized the most competent technical, managerial, industrial, and production people available in the conduct of major, technically rich programs. In addition, because of its long association with military contracting and the equal opportunity endeavors entered into jointly by the industry and government, the management philosophies and practices that foster equal opportunity and upward mobility of the labor force are well established in the industry. Because of the technology changes and the obvious requirement for quality and reliability in our products, we have long experience in training and upgrading the skills of our workers.

In addition, the SST contractors, prospective subcontractors, and suppliers for the prototype program indicate that they currently have approximately 1,150 "hard-core unemployable" trainees. Prospective subcontractors and suppliers for the production program indicate that they currently have approximately 2,350 hard-core trainees. All have stated their intention to continue with the programs.

Tables 4-XVI and 4-XVII portray the current statistics of major contractor employment status with respect to equal opportunity employment.

Age	Number Change 1970-1980	Percent Change		
		1950-1960	1960-1970	1970-1980
16 +	15,325	12.9	17.4	18.1
16 to 24	3,633	2.2	48.8	19.2
25 to 44	9,965	8.9	4.9	29.8
25 to 34	7,980	-0.3	12.3	47.1
35 to 44	1,985	18.8	-1.8	12.0
45 +	1,727	24.1	17.3	5.4
45 to 64	1,490	26.2	20.4	5.1
65 +	237	11.3	-5.3	7.4

Source: Manpower Report to the President, U.S. Department of Labor, April 1968

Table 4-I. Changes in the Total Labor Force (Both Sexes) by Age—1950 through 1980

Region	Prototype (2)			Production (2)			Increase in Labor Force 1970-1980 (Millions)(1)	Potential Distribution of Jobs Attributable to SST at Peak (Thousands)(3)
	Suppliers	\$Millions	%	Suppliers	\$Millions	%		
West	398	211	35	2048	4710	44	3.9	77
South	103	51	8	238	941	9	4.9	16
North Central	1364	194	32	2888	2410	22	4.0	38
North Eastern	536	149	25	1365	2694	25	2.6	44
Total	2401	605	100	6539	10,755	100	15.4	175

Sources: 1. "Labor Force Projections by State" Special Labor Force Report No. 74, October 1966, Exhibits 2, 3, and 7
2. See tables 5-IV to 5-VII
3. See table 4-IV

Table 4-II. Geographic Distribution of Increase in Labor Force and Employment Attributable to the SST Program at Peak

Region	Labor Force 1970 (Thousands)	Labor Force 1980 (Thousands)	Percent Change 1970-1980
Total United States	85,257	100,670	18.1
Northeast	21,150	23,762	12.3
North Central	23,399	27,362	16.9
South	25,569	30,514	19.3
West	15,139	19,032	25.7
Source: "Labor Force Projections by State," Special Labor Force Report No. 74, October 1966, U.S. Department of Labor			

Table 4-III. Percent Change in Labor Force by Region—Projected 1970 and 1980
(Excluding Armed Forces Overseas)

		Industrial Employment	Consumer & Services Employment	Total
1.	Agricultural, Forestry, and Fisheries	282	8,327	8,609
2.	Mining	350	515	865
3.	New Construction	—	—	—
4.	Maintenance Repair Construction	365	2,084	2,449
5.	Food and Kindred Products	94	3,935	4,029
6.	Textile Goods and Apparel	232	4,902	5,134
7.	Furniture and Wood Products	393	1,243	1,636
8.	Paper and Paperboard	294	1,267	1,561
9.	Chemicals, Rubber and Plastics	856	2,102	2,958
10.	Petroleum Industry (Refining)	44	266	310
11.	Other Manufacturing	392	10,064	10,456
12.	Iron and Steel	1,681	708	2,389
13.	Nonferrous Metal	1,250	286	1,536
14.	Fabricated Metal Products	2,773	1,338	4,111
15.	Machinery, Except Electrical	2,227	544	2,771
16.	Electrical Machinery	2,625	1,174	3,799
17.	Motor Vehicles	196	1,083	1,279
18.	Aircraft and Parts	36,664	35	36,699
19.	Other Transportation Equipment	43	242	285
20.	Other Manufacturing Durables	1,618	2,106	3,724
21.	Communications	403	1,325	1,728
22.	Wholesale and Retail Trade	2,354	30,615	32,969
23.	Services, Education, and Medical	2,881	35,883	38,764
24.	Government Enterprises	510	2,077	2,587
25-28	Transportation and Warehousing	1,290	3,896	5,186
	Total	59,817	116,017	175,834

Source: Projections 1970—
Interindustry Relationships,
Bureau of Labor Statistics

Table 4-IV. Employment Provided by SST Program at Peak

Function	Type of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Avg. Age	Average Annual Salary (dollars)	Number of Employees	Avg. Age	Average Annual Salary (dollars)	
Research, Design, and Development	Systems Analysis and Engineering Design and Drafting Test Engineering Technical Analysis Materials and Processes	3400	35-45	(000) 10-16	8000	35-40	(000) 10-14	A, B, C, HS
Sales and Service	Sales Representatives Technical Sales Support Contract Administration Advertising and Sales Promotion	600	35-45	10-13	1500	35-40	10-12	A, B, C, HS
Assembly and Fabrication	Tool Design and Fabrication Assembly and Installation Service Stores Fabrication and Processing	10,800	35-40	8-10	27,500	35-40	7-8	A, B, HS, TS
Material Procurement	Raw Material Procurement Purchased Systems and Subsystems Outside Production and Subcontracting Receiving and Stores	600	35-40	9-11	1500	35-40	8-10	A, B, HS, TS
Facilities Service	Buildings, Ground, and Equipment Engineering Maintenance Construction and Installation Transportation	1000	40-50	8-9	2500	35-45	7-8	B, C, HS, TS
Personnel Services	Employment Training and Development Personnel Relations Wage and Salary Administration Safety	400	30-35	9-10	750	25-35	8-10	A, B, C, HS
Finance	Cost Estimating Accounting Payroll Credit and Collection Audit	400	35-40	9-11	750	30-35	9-10	A, B, C, HS
Computing	Programming Data Processing Computer Operation Equipment Operation	600	25-35	9-11	1700	25-30	9-11	A, B, HS
Quality	Quality Planning and Control Inspection Reliability	1600	40-45	8-9	3800	35-45	8-9	B, HS, TS
General Services	Libraries/Files Reproduction and Printing Systems and Procedures	600	30-35	7-91	2000	25-35	7-9	B, HS, TS
Total		20,000			50,000			

(1) A - Advanced Degree
B - Bachelor's Degree
C - Some College

HS - High School
TS - Trade School

Source: The Boeing Company

NOTE: All Dollars Constant 1968

Table 4-V. Statistical Distribution of SST Labor Force (Total Employees)

Function	Type of Jobs	Number of Employees	Prototype Program		Number of Employees	Production Program		Typical Education Levels (1)
			Average Age	Average Annual Salary (dollars)		Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Systems Analysis and Engineering Design and Drafting Test Engineering Technical Analysis Materials and Processes	1,510	41	15,200	3,155	40	13,800	A,B,C,HS
Sales and Service	Sales Representatives Technical Sales Support Contract Administration Advertising and Sales Promotion	180	41	12,200	395	40	11,400	A,B,C,HS
Assembly and Fabrication	Tool Design and Fabrication Assembly and Installation Service Stores Fabrication and Processing	5,330	39	8,200	11,125	36	7,500	A,B,HS,TS
Material Procurement	Raw Material Procurement Purchased Systems and Subsystems Outside Production and Subcontracting Receiving and Stores	290	40	9,400	580	38	8,900	A,B,HS,TS
Facilities Service	Buildings, Grounds, and Equipment Engineering Maintenance Construction and Installation Transportation	630	46	8,200	1,295	44	7,900	B,C,HS,TS
Personnel Services	Employment Training and Development Personnel Relations Wage and Salary Administration Safety	110	30	10,000	220	28	9,900	A,B,C,HS
Finance	Cost Estimating Accounting Payroll Credit and Collection Audit	120	35	9,600	245	34	9,400	A,B,C,HS
Computing	Programming Data Processing Computer Operation Equipment Operation	360	27	10,400	735	27	10,300	A,B,C,HS
Quality	Quality Planning and Control Inspection Reliability	610	42	8,600	1,305	41	8,100	A,B,HS
General Services	Libraries/Files Reproduction and Printing Systems and Procedures	460	31	7,200	945	31	7,000	B,HS,TS
	Total	9,600	---	-----	20,000	---	----	-----

(1) A - Advanced Degree HS - High School
 B - Bachelor's Degree TS - Trade School
 C - Some College

Source: The Boeing Company

NOTE: All Dollars Constant 1968

Table 4-VI. Statistical Distribution of Boeing SST Labor Force (Total Employees)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Structures Design Stress Analysis Configuration Management Control Systems Design	1,220	42	17,100	2,580	38	15,100	A,B,C
Sales and Service	Customer Engineering Route Analysis Contract Administration Advertising	100	42	16,000	195	42	16,000	A,B,C
Assembly and Fabrication	Production and Tool Planning Tool Design Production Control Production Work Measurement	740	42	13,800	1,320	42	11,900	A,B,HS,TS
Material Procurement	Procurement Analysis Purchasing Subcontract Management Traffic Control	100	43	14,000	195	43	13,300	A,B,HS
Facilities Service	Equipment Engineering Facilities Planning	70	43	13,300	120	43	13,300	B,HS
Personnel Services	Wage and Salary Administration Safety Engineering Personnel Representatives	70	40	11,500	140	40	11,500	A,B
Finance	Cost Estimating Cost Accounting Cash Management	35	41	12,900	70	39	12,900	A,B
Computing	Digital Computer Programming Design and Development of Special Equipment Applied Mathematics	275	30	11,200	560	30	11,200	A,B
Quality	Statistical Quality Engineering Quality Planning	120	42	12,200	220	44	12,200	A,B,HS
General Services	Business Planning Technical Information	90	38	10,900	160	38	10,900	B,HS
Total		2,820	—	—	5,560	—	—	—

(1) A - Advanced Degree HS - High School
 B - Bachelor's Degree TS - Trade School
 C - Some College

Source: The Boeing Company

NOTE: All Dollars Constant 1968

Table 4-VII. Statistical Distribution of Boeing SST Labor Force
 (Professional/Technical and Management)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Test Engineering Aide Training Aide Laboratory Technical Technical Information Aide	210	38	9,200	375	38	8,600	B,HS
Sales and Service	Market Research Assistant Contract Administration Assistant Lease and Contract Coordinator Service Instructor	35	41	9,200	65	41	8,300	B,HS
Assembly and Fabrication	Industrial Engineer—Schedule Planner Method Analyst Setup Man—Drill Presses Welder Experimental	1,420	41	8,900	2,390	39	8,000	B,HS,TS
Material Procurement	Freight Accounting Clerk Subcontract Estimator Material Rejection Investigator Material Change Analyst	50	40	9,700	85	40	8,900	B,HS
Facilities Services	Contract Construction Engineering Assistant Facilities Accountability Coordinator Facilities Requirement Forecaster Outside Properties Investigator	220	48	9,200	390	48	9,200	HS,TS,ST
Personnel Services	Magnetic Tape Coder Operator Office Assistant—Training Industrial Hygiene Safety Investigator	30	29	7,900	55	29	7,900	B,HS
Finance	Design Progress Estimator Billing Accountant Cost Accounting Investigator Cash or Overhead Forecaster	50	37	9,300	90	37	9,300	B,HS
Computing	Data Processor Analog Computing System Technician Hybrid Computing System Specialist	45	30	8,000	85	30	8,000	B,HS
Quality	Procedures Technician Programmer Systems Analyst	170	45	9,400	285	44	9,400	HS
General Services	Documentation Equipment Operator Audio-Visual Coordinator Communications Systems Coordinator	120	31	7,800	205	31	7,800	HS,TS
Total		2,350	---	---	4,025	---	---	---

- (1) A—Advanced Degree
B—Bachelor's Degree
C—Some College

TS - Trade School
ST - Specialized Training

Source: The Boeing Company

NOTE: All Dollars Constant 1968

Table 4-VIII. Statistical Distribution of Boeing SST Labor Force (Skilled)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Technical Library Assistant Shop Liaison Man—Engineering Engineering Aide—Technical Information Engineering Weight Computer	80	36	6,200	200	35	6,200	HS
Sales and Service	Office Services Coordinator—Spares Shipping Methods and Procedures Planner Spares Parts Coding Analyst Spares Production List Compiler	25	39	7,000	70	38	7,000	HS
Assembly and Fabrication	Small Tools Coordinator Tool Order Writer Grinder Operator Welder	2,430	39	6,700	5,870	36	6,700	HS, TS, ST
Material Procurement	PCR Ledger Accountant Reconciliation Clerk Order Control Records Clerk Material Usage Investigator	75	38	6,500	170	36	6,500	HS
Facilities Services	Plant Inventory Records Coordinator Transportation Handling Equipment Coordinator Plant Planner Automotive Mechanic	185	46	6,800	465	45	6,800	HS, TS, ST
Personnel Services	Personnel Records Clerk Suggestions Analyst Wage and Salary Clerk Personnel Assistant	10	27	5,900	25	26	5,900	HS
Finance	Payroll Control Clerk Time Card Checker Travel Assistant Statistician	25	35	6,900	65	34	6,900	HS
Computing	Engineering Aide Computer Data Processor EDP Exception Analyst Computer Program Servicer	35	25	7,000	80	25	7,000	HS, TS
Quality	Quality Requirements Investigator Shipping Inspector Material Receiving Inspector	315	42	6,900	785	41	6,900	HS
General Services	Copy Camera Operator Office Service Center Representative Offset Press Operator	110	28	5,900	285	28	5,900	HS, TS, ST
Total		3,290	---	---	8,015	---	---	---

(1) HS - High School ST - Specialized Training
TS - Trade School

Source: The Boeing Company

NOTE: All Dollars Constant 1968

Table 4-IX. Statistical Distribution of Boeing SST Labor Force
(Semiskilled)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development		0			0			
Sales and Service	Order Control Records Clerk Correspondence Clerk Packing and Crating Clerk Typist Clerk	20	37	5,300	65	35	5,300	HS
Assembly and Fabrication	PCR Ledger Clerk Expediter Assembler Mechanic and Assembler Helper Installer Interior Assemblies	740	25	6,000	1,545	25	6,000	HS, TS, ST
Material Procurement	Accountability Clerk PCR Ledger Clerk Stores Clerk Warehouseman	65	25	5,600	130	25	5,600	HS
Facilities Service	Custodial Services Material Preparer Building and Grounds Maintenance Carpenter—Welder	155	44	5,900	320	42	5,900	HS, TS, ST
Personnel Services		0			0			
Finance	Timekeeper Payroll Clerk Typist Keypunch Operator	10	33	6,000	20	31	6,000	HS
Computing	Clerk Typist	5	22	6,000	10	22	6,000	HS, TS
Quality	Typist Shop Clerk Clerk, Statistics	5	30	6,100	15	25	6,100	HS
General Services	Keypunch Operator Blueprint Cutter and Folder Mail Room Clerk	140	22	5,300	295	22	5,300	HS, TS, ST
Total		1,140	---	---	2,400	---	---	---

(1) HS - High School
TS - Trade School
ST - Specialized Training

Source: The Boeing Company

NOTE: All Dollars Constant 1968

Table 4-X. Statistical Distribution of Boeing SST Labor Force
(Unskilled)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Systems Analysis and Engineering Design and Drafting Test Engineering Technical Analysis Materials and Processes	520	38	11,900	1300	36	11,200	A, B, C, HS
Sales and Service	Sales Representatives Technical Sales Support Contract Administration Product Support	130	38	11,500	340	35	10,600	A, B, C, HS
Assembly and Fabrication	Tool Design and Fabrication Assembly Value Engineering Parts Manufacturing	1210	39	9,500	4350	38	7,900	A, B, HS, TS
Material Procurement	Raw Material and Parts Procurement Subcontract Management Contract Administration Traffic Control	91	40	10,200	265	38	9,300	A, B, HS, TS
Facilities Service	Plant Engineering Maintenance Construction and Installation Transportation	90	41	8,000	299	39	7,500	B, C, HS, TS
Personnel Services	Employment Training and Development Personnel Relations Wage and Salary Administration Safety Engineering	57	33	9,400	173	31	8,600	A, B, C, HS
Finance	Cost Accounting and Estimating Payroll Disbursement Auditing	71	36	10,200	197	34	9,400	A, B, C, HS
Computing	Programming Engineering Applications Computer Operation Equipment Operation	68	32	9,800	198	30	9,000	A, B, C, HS
Quality	Quality Planning and Control Inspection Quality Laboratory	228	41	8,800	752	39	8,300	A, B, HS
General Services	Office Services	35	31	8,700	126	29	7,400	B, HS, TS
Total		2500			8000			

(1) A - Advanced Degree HS - High School
B - Bachelor's Degree TS - Trade School
C - Some College

Source: General Electric

Note: All Dollars Constant 1968

Table 4-X1 Statistical Distribution of General Electric Labor Force (Total Employees)

Function	Type of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Noise Control Systems Analysis Mechanical and Aero Design Configuration Management Test Engineering	378	38	13,300	820	36	13,000	A, B, C
Sales and Service	Product Support Customer Engineering Sales Representatives Contract Administration Technical Publications	88	40	14,000	195	38	14,000	A, B, C
Assembly and Fabrication	Production and Tool Planning Tool and Equipment Design Production Control Parts Manufacturing and Assembly	188	42	11,900	436	42	11,900	A, B, HS, TS
Material Procurement	Contract Administration Materials and Parts Purchasing Subcontract Management Traffic Control	43	43	12,900	95	42	12,500	A, B, HS
Facilities Service	Plant Engineering Facilities Planning Maintenance and Construction	23	41	11,500	51	40	11,000	B, HS
Personnel Services	Wage and Salary Administration Safety Engineering Personnel Representatives Security	19	41	13,600	42	40	13,000	A, B
Finance	Payroll Cost Accounting and Estimating General and Sales Accounting	47	40	12,400	105	38	12,000	A, B
Computing	Computer Operation Computer Techniques Engineering Applications Information Systems	37	35	12,000	82	35	12,000	A, B
Quality	Material Quality Manufacturing Quality	67	42	12,300	150	42	12,000	A, B, HS
General Services	Business Planning Technical Information Legal	11	39	15,200	24	38	15,000	A, B,
Total		901			2000			

(1) A – Advanced Degree
B – Bachelor's Degree
C – Some College

HS – High School
TS – Trade School

Source: General Electric

Note: All Dollars Constant 1968

Table 4-XII. Statistical Distribution of General Electric Labor Force (Professional, Technical and Management)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Testing Technical Laboratory Technical Mechanical Design Tech. Electrical Design Tech.	70	39	8,800	270	37	8,500	B, HS
Sales and Service	Customer Service Clerk Spare Parts Planner	2	38	7,700	10	36	7,500	B, HS
Assembly and Fabrication	Scheduler Planner Development Assembler Machinist	367	42	8,400	1,450	40	8,000	B, HS
Material Procurement	Purchasing Clerk	25	41	8,000	83	39	7,800	B, HS
Facilities Services	Auto Mechanic Painter Carpenter	30	45	7,600	110	43	7,500	HS, TS
Personnel Services	Eye Protection Technical Testing Technical	1	36	8,800	5	35	8,500	B, HS
Finance	Accounting Clerk	2	37	9,000	10	36	9,000	B, HS
Computing	Computer Programmer Digital Computer Operator	8	31	8,100	30	31	8,000	B, HS
Quality	Tool & Gage Inspector Fault Analysis Clerk X-Ray Technical	32	43	9,100	120	42	9,100	HS
General Services	Photographer Commercial Artist Technical Writer	3	38	9,000	12	37	8,500	HS, TS
TOTAL		540			2,100			

(1) A – Advanced Degree
B – Bachelor's Degree
C – Some College

HS – High School
TS – Trade School

Source: General Electric

Note: All Dollars Constant 1968

Table 4-XIII Statistical Distribution of General Electric Labor Force (Skilled)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Technical Librarian Engine Des. Support Tech. Weight Control Calculator Design Change Writer	72	37	7,500	210	35	7,500	HS, TS, ST
Sales and Service	Marketing Clerk	13	36	6,500	50	34	6,500	HS, ST
Assembly and Fabrication	Lathe Operator Assembler-Engine Dispatcher Milling Machine Operator	497	39	7,400	1,864	37	7,400	HS, TS, ST
Material Procurement	Expediter Order Control Clerk	20	36	7,700	75	35	7,700	HS
Facilities Services	Fuel Field Maintenance Locksmith Boiler Plant Oper.	17	40	6,800	63	38	6,800	HS, TS, ST
Personnel Services	Nurse Personnel Clerk Employment Interviewer	30	31	7,800	100	30	7,800	HS
Finance	Payroll Clerk Cost Clerk Insurance Clerk	15	30	6,500	56	29	6,500	HS
Computing	Accounting Mach. Oper. Computer Trainee	22	28	6,900	82	27	6,900	HS, ST
Quality	Receiving Inspector Process Inspector Line Inspector	126	40	7,000	470	38	7,000	HS
General Services	Offset Press Operator Office Service Clerk Telephone Operator	8	35	6,000	30	33	6,000	HS, TS, ST
Total		820			3,000			

(1) A - Advanced Degree
B - Bachelor's Degree
C - Some College

HS - High School
TS - Trade School

Source: General Electric

Note: All Dollars Constant 1968

Table 4-XIV Statistical Distribution of General Electric Labor Force (Semi-Skilled)

Function	Types of Jobs	Prototype Program			Production Program			Typical Education Levels (1)
		Number of Employees	Average Age	Average Annual Salary (dollars)	Number of Employees	Average Age	Average Annual Salary (dollars)	
Research, Design, and Development	Structures Design Stress Analysis Configuration Management Control Systems Design	27						
Sales and Service	Customer Engineering Route Analysis Contract Administration Advertising	27	30	5700	85	28	5700	HS
Assembly and Fabrication	Production and Tool Planning Tool Design Production Control Production Work Measurement	158	38	6500	600	36	6500	HS, TS, ST
Material Procurement	Procurement Analysis Purchasing Subcontract Management Traffic Control	3	25	5000	12	25	5000	HS
Facilities Service	Equipment Engineering Facilities Planning	20	37	5600	75	35	5600	HS, TS, ST
Personnel Services	Wage and Salary Administration Safety Engineering Personnel Representatives	7	21	4800	26	21	4800	HS
Finance	Cost Estimating Cost Accounting Cash Management	7	25	5500	26	25	5500	HS
Computing	Digital Computer Programming Design and Development of Special Equipment Applied Mathematics	1	21	5000	4	21	5000	HS, TS
Quality	Statistical Quality Engineering Quality Planning	3	22	5200	12	22	5200	HS
General Services	Business Planning Technical Information	13	21	4800	60	21	4800	HS, TS, ST
Total		239			900			

(1) A – Advanced Degree
B – Bachelor's Degree
C – Some College

HS – High School
TS – Trade School

Source: General Electric

NOTE: All Dollars Constants 1968

Table 4-XV. Statistical Distribution of General Electric Labor Force
(Unskilled)

Occupation	Negro	Oriental	American Indian	Spanish American	Total
Officials & Managers	51	101	9	29	12,841
Professionals	114	792	11	58	16,305
Technical	157	289	22	51	12,255
Office & Clerical	493	316	30	81	18,683
Craftsman, Skilled	923	335	85	207	24,465
Operatives, Semiskilled	1,231	197	84	138	13,634
Laborers, Unskilled	9	—	—	1	74
Service Workers	115	26	7	7	1,104
Total	3,093	2,056	248	572	99,361

Minority ratio: 6.0 percent

Source: The Boeing Company

Table 4-XVI. Statistical Summary of Boeing's Puget Sound Employment by Job Category and Race (September 1968)

Race	Applications	Hires	Promotions	Training	
				On-Shift	Off-Shift
Negro	7,771	1,080	1,248	2,405	277
American Indian	406	89	110	198	20
Oriental	1,121	418	513	1,083	364
Spanish-American	834	172	267	462	89
Others	145,619	16,387	28,941	70,339	12,972
Total	155,751	18,146	31,079	74,487	13,722

Ratio of minority hires: 9.7%

Source: The Boeing Company

Table 4-XVII. Statistical Summary by Race of Boeing Applications, Hires, Promotions, and Training in the Puget Sound Area (January 1 to September 30, 1968)

DOLLAR IMPACT

DOLLAR IMPACT

The economic impact of the SST program will be in several areas. At home, investment expenditures will raise employment levels, consumption, and tax revenues. This investment also means that U.S. workers will produce an airplane that would otherwise have to be purchased abroad by U.S. carriers. Sales of U.S. SST's abroad will provide substantial further benefit for the U.S. balance of payments. This section discusses the following areas:

- *The extent to which the SST program will impact the U.S. balance of payments*
- *The recovery of government investment in the SST prototype through royalty payments*
- *The time-phased expenditures for the SST program and the derived impact of this investment on the personal income, personal taxes, and personal consumption of the nation*
- *The extent to which subcontractors throughout the nation will be involved in production of the SST*
- *The impact of the SST program on tax revenue*

Balance of Trade (Aircraft Account)

One of the primary objectives of U.S. economic policy is to maintain worldwide confidence in the dollar. The positive side of the U.S. international financial position has been derived in large part from the surplus of commodity exports over imports. Without net merchandise exports, deficits in U.S. international payments that result from military spending overseas, foreign aid, private capital outflow, and foreign travel expenditures would become a substantial burden. Thus, the need for a high volume of U.S. exports is of paramount importance.

Foreign travel, both business and tourist, is going to grow regardless of whether it is carried on United States or foreign-built equipment. It should grow faster with more attractive equipment; but in any event, it will grow. Travel by Americans overseas exceeds travel by foreigners to the United States, with a consequent net dollar outflow. The sale of U.S. equipment to foreign operators is a significant and appropriate means of offsetting this particular outflow—certainly more so than restriction of travel abroad, which would be unpopular politically and undesirable from the standpoint of international relations and cultural and business objectives. The U.S. SST program is a key to the continuance of our successful export business in the future.

Historically, capital goods have been a major factor in our export business—the result of technological expertise, production knowhow, and risk capital. In 1967, *the largest single contributor to the export business in the capital goods account was commercial airplanes*, amounting to \$914 million or 8.4 percent of the \$10.9 billion of capital goods sold abroad. Put another way, this \$914 million of commercial airplane exports constitutes 22.3 percent of the total \$4.1 billion merchandise trade surplus in 1967.

Of the market estimate of 500 U.S. SST's by 1990, 270 aircraft would be exported to foreign airlines. The export of the aircraft and spares would account for a total of \$13 billion of export business over the 1975-1990 period. Under this case, imports of 60 Concorde are envisioned. These imports would amount to \$1.1 billion when spares are included. The balance of trade would be a favorable \$11.9 billion. In addition, future markets for follow-on aircraft would be enhanced, and the growth of a competitive U.S. manufacturing industry strengthened.

However, if the United States is without a timely SST program, a major portion of the U.S. domestic market for aircraft would be open to the Concorde. United States carriers will demand supersonics in order to be able to compete for international and domestic passengers. The U.S. carriers would import 300 Concorde by 1990. Purchase of these aircraft and spares would result in a cash outflow of \$5.6 billion. The swing on the SST balance of payments is \$17.5 billion or an average of \$1.17 billion per year. Offsetting this is an estimated \$1.3 billion of additional subsonic exports without the U.S. SST for a net swing of \$16.2 billion. (See Fig. 5-A.)

In addition, there is a risk that foreign manufacturers could not assure timely delivery of required foreign-made SST's, because of either lack of capacity or preferential treatment to foreign airlines. Availability of foreign-produced aircraft is not under U.S. control. If, for example, U.S. carriers could get only 75 percent of their aircraft when they needed them, they would lose their ability to compete for many international passengers. This would mean reduced airline payrolls, taxes, and purchase of goods and services in the United States. The loss of U.S. citizen travelers to foreign airlines, combined with the failure to get foreign citizens on board our aircraft, could result in a net loss of \$5 billion in balance of payments over the 15-year period. This loss, combined with the loss in exports of a U.S. SST and the import of a lesser quantity of foreign-made SST's, could total \$21 billion over this period.

Government Prototype Investment Recovery

The total cumulative program cost through Phase III is estimated to be \$1.45 billion; approximately \$1.2 billion of this total will have been invested by the government. The contracts between the government and Boeing and General Electric provide specifically for Boeing and General Electric to make royalty payments at a rate that will return all invested funds to the government by the delivery of about the 300th airplane.

After the investment has been repaid, additional royalty payments will be made on the sale of additional aircraft to allow the government a return on its investment. With the sale of 500 aircraft, the government will be repaid its \$1.2 billion investment plus an additional return of approximately \$1.0 billion.

Impact of SST Program on Personal Income and Consumption

Table 5-I displays the estimated annual expenditures for the prototype and production phases of the SST program. These amounts represent income to

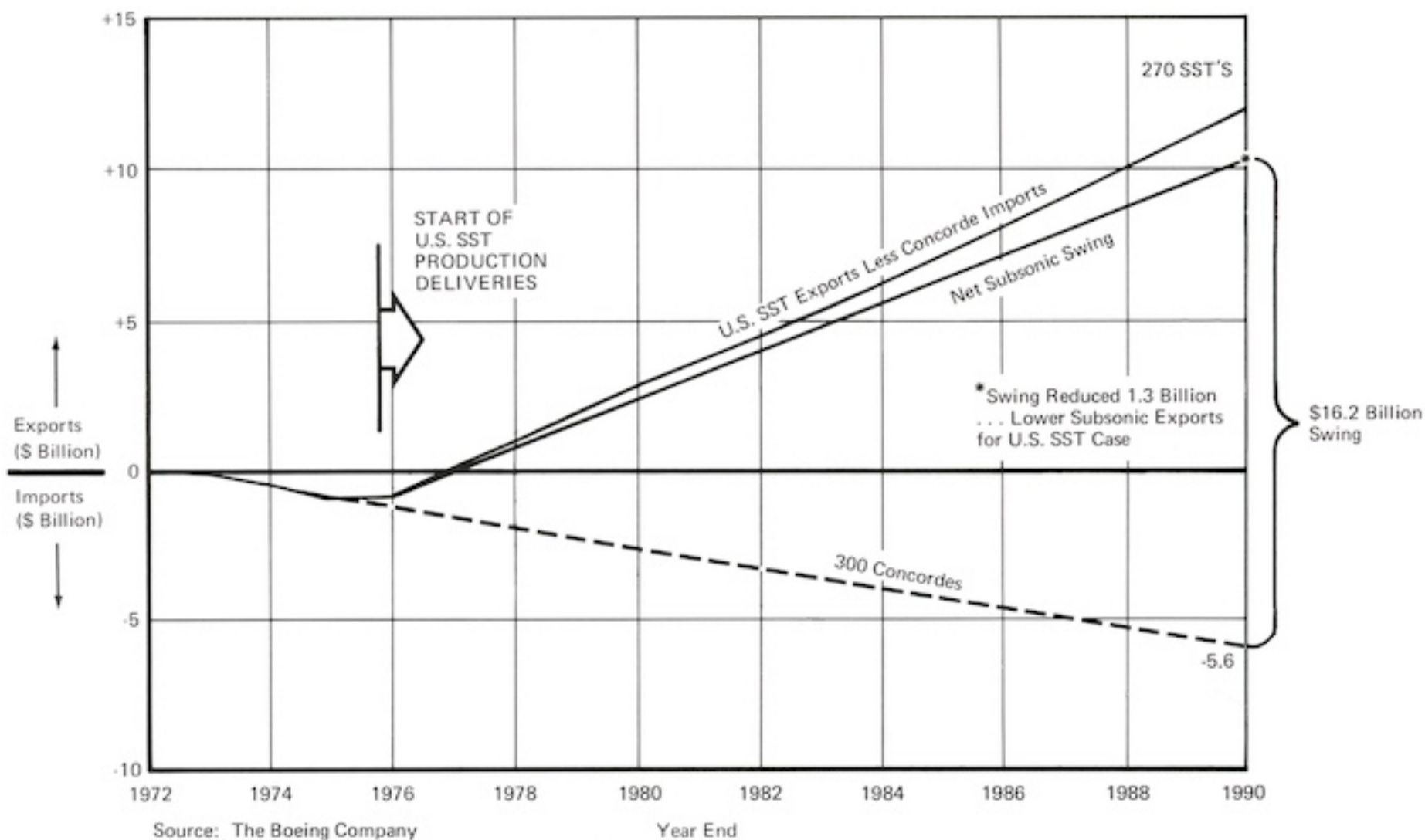


Figure 5-A. Balance of Trade (Cumulative Exports and Imports)

Year	Prototype (\$ Million)				Production (\$ Million)			
	Salaries & Wages	Material & Other	Facilities	Total	Salaries & Wages	Material & Other	Facilities	Total
1967	33.4	11.6	13.5	58.5				
1968	45.2	23.1	8.0	76.3				
1969	72.8	58.8	3.6	135.2				
1970	117.2	168.4	8.9	294.5				
1971	75.2	93.2	1.6	170.0	4.0	14.0	—	18.0
1972	12.0	19.6	0.2	31.8	113.0	456.0	10.5	579.5
1973					126.0	482.0	12.8	620.8
1974					132.0	470.0	22.1	624.1
1975					143.0	588.0	20.0	751.0
1976					146.0	812.0	17.0	975.0
1977					109.0	835.0	15.0	959.0
1978					115.0	757.0	12.0	884.0
1979					120.0	758.0	10.0	888.0
1980					122.0	758.0	8.0	888.0
1981					128.0	820.0	7.0	955.0
1982					124.0	817.0	7.0	948.0
1983					124.0	817.0	6.0	947.0
1984					124.0	817.0	5.0	946.0
1985					124.0	814.0	5.0	943.0
1986					120.0	810.0	4.0	934.0
1987					115.0	780.0	4.0	899.0
1988					110.0	750.0	3.0	863.0
1989					110.0	740.0	2.0	852.0
1990					100.0	480.0	2.0	582.0
TOTAL	355.8	374.7	35.8	766.3	2,309.0	13,575.0	172.4	16,056.4

Source: The Boeing Company

Table 5-1. Boeing SST Expenditures for Prototype (Phase III) and Production (Phases IV & V)

employees, suppliers, and the various governmental bodies. In addition, it is generally recognized that there is a multiplier effect resulting from these investment expenditures, because the income provided stimulates further consumer spending. Economists differ as to the precise effect; however, this multiplier can exceed three, depending upon combinations of industry characteristics and specific prevailing economic conditions. It is recognized that under conditions approximating full employment the multiplier could be minimal. However, as indicated in Table 5-I, the significant effect on employment and income will occur in the period beyond 1971 when, as pointed out in the preceding section, a substantial requirement for additional jobs will undoubtedly exist. Under such circumstances, the full multiplier effect should be achieved. For purposes of this analysis, a relatively conservative multiplier of two has been utilized.

Tables 5-II and 5-III indicate the disposition of personal income and distribution of personal consumption, assuming (1) that each dollar of SST expenditure results in \$2 of personal income and (2) that such income is distributed in the same proportions as in 1967, per Department of Commerce statistics.

The attached tables show some interesting data, including the following highlights:

- Expenditures (Table 5-I) build up to a peak of approximately \$1 billion per year and total \$16.8 billion.
- Personal income peaks at roughly \$2 billion and totals in excess of \$33 billion.
- Personal taxes total \$4.7 billion, roughly four times the original government investment in the SST prototype.
- Consumer demand is generated for durable goods of over \$4 billion, of which \$1.8 billion is represented by automobiles and parts and \$1.7 billion by furniture and household equipment.
- The overall impact on personal consumption is projected to exceed \$26 billion.

Extent of Subcontractor Participation

In support of the SST, manufacturers will buy a variety of products and services from companies throughout the United States. This procurement will include all basic materials, electronic components, and actuation and control devices, as well as a large percentage of the required supplies and minor parts and assemblies. In addition, approximately 50 percent of the main structural and assembly effort will be procured from other U.S. aerospace industries. In total, the subcontracting effort in support of the manufacture of the prototype airplane is estimated to involve the expenditure of approximately \$275 million, excluding capital facility investment. The subcontracting effort in support of the SST production program will involve an additional \$6.5 billion, excluding capital facility investment.

For the prototype program, some 550 companies will be involved in airframe production, and approximately 2,350 companies will be engaged in the manufacture of the aircraft engines. Based on the utilization of industry sources in current transport aircraft programs, some 2,500 companies will be involved in the airframe production program and approximately 4,040 companies will support the engine

(\$ Million)	1967	1968	1969	1970	1971	1972	TOTAL
Personal Income	117.0	152.6	270.4	589.0	340.0	63.6	1,532.6
Less: Personal Taxes	16.5	21.5	38.1	83.0	47.9	9.0	216.0
Consumers' Interest	2.3	3.1	5.4	11.8	6.8	1.3	30.7
Foreign Transfers	0.1	0.2	0.3	0.6	0.3	0.1	1.6
Personal Savings	6.9	9.0	16.0	34.8	20.1	3.8	90.6
Personal Consumption							
Durable Goods:							
Automobiles & Parts	6.2	8.1	14.3	31.2	18.0	3.4	81.2
Furniture & Household Equip	5.8	7.6	13.5	29.4	17.0	3.2	76.5
Other	2.1	2.7	4.9	10.6	6.1	1.1	27.5
Total:	14.2	18.5	32.7	71.3	41.1	7.7	185.5
Nondurable Goods:							
Foods & Beverages	19.9	25.9	46.0	100.1	57.8	10.8	260.5
Clothing & Shoes	7.8	10.2	18.1	39.5	22.8	4.3	102.7
Gasoline & Oil	3.4	4.4	7.8	17.1	9.9	1.8	44.4
Other	8.2	10.7	18.9	41.2	23.8	4.5	107.3
Total: Nondurable Goods	39.3	51.3	90.9	197.9	114.2	21.4	515.0
Services:							
Housing	13.0	16.9	30.0	65.4	37.7	7.1	170.1
Household Operation	5.3	6.9	12.2	26.5	15.3	2.9	69.1
Transportation	2.8	3.7	6.5	14.1	8.2	1.5	36.8
Other	16.6	21.7	38.4	83.6	48.3	9.0	217.6
Total:	37.7	49.1	87.1	189.7	109.5	20.5	493.6
Total: Personal Consumption	91.1	118.9	210.6	458.8	264.9	49.5	1,193.8

Source: The Boeing Company

Table 5-II. Impact of SST Prototype Expenditures on Personal Income and Personal Consumption—Phase III

(\$ Million)	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Totals
Personal Income	0	0	0	0	36.0	1159.0	1241.6	1248.2	1502.0	1950.0	1918.0	1768.0	1776.0	1776.0	1910.0	1896.0	1894.0	1892.0	1886.0	1868.0	1796.0	1726.0	1704.0	1164.0	32,110.8
Less: Personal Taxes	0	0	0	0	5.1	163.4	175.1	176.0	211.8	274.9	270.4	249.3	250.4	250.4	269.3	267.3	267.1	266.8	265.9	263.4	253.2	243.4	240.3	164.1	4,527.6
Consumers' Interest	0	0	0	0	0.7	23.2	24.8	25.0	30.0	39.0	38.4	35.4	35.5	35.5	38.2	37.9	37.9	37.8	37.7	37.4	35.9	34.5	34.1	23.3	642.2
Foreign Transfers	0	0	0	0	0.0	1.2	1.2	1.2	1.5	1.9	1.9	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.7	1.2	32.1
Personal Savings	0	0	0	0	2.1	68.4	73.3	73.6	88.6	115.0	113.2	104.3	104.8	104.8	112.7	111.9	111.7	111.6	111.3	110.2	106.0	101.8	100.5	68.7	1,894.5
Personal Consumption																									
Durable Goods:																									
Automobiles & Parts	0	0	0	0	1.9	61.4	65.8	66.2	79.6	103.3	101.7	93.7	94.1	94.1	101.2	100.5	100.4	100.3	100.0	99.0	95.2	91.5	90.3	61.7	1,701.9
Furniture & Household Equip.	0	0	0	0	1.8	57.9	62.1	62.4	75.1	97.5	95.9	88.4	88.8	88.8	95.5	94.8	94.7	94.6	94.3	93.4	89.8	86.3	85.2	58.2	1,605.5
Other	0	0	0	0	0.6	20.9	22.3	22.5	27.0	35.1	34.5	31.8	32.0	32.0	34.4	34.1	34.1	34.1	33.9	33.6	32.3	31.1	30.7	21.0	578.0
Total: Durable Goods	0	0	0	0	4.4	140.2	150.2	151.0	181.7	235.9	232.1	213.9	214.9	214.9	231.1	229.4	229.2	228.9	228.2	226.0	217.3	208.8	206.2	140.8	3,885.1
Nondurable Goods:																									
Foods & Beverages	0	0	0	0	6.1	197.0	211.1	212.2	255.3	331.5	326.1	300.6	301.9	301.9	324.7	322.3	322.0	321.6	320.6	317.6	305.3	293.4	289.7	197.9	5,458.8
Clothing & Shoes	0	0	0	0	2.4	77.7	83.2	83.6	100.6	130.6	128.5	118.5	119.0	119.0	128.0	127.0	126.9	126.8	126.4	125.2	120.3	115.6	114.2	78.0	2,151.5
Gasoline & Oil	0	0	0	0	1.0	33.6	36.0	36.2	43.6	56.5	55.6	51.3	51.5	51.5	55.4	55.0	54.9	54.9	54.7	54.2	52.1	50.1	49.4	33.8	931.3
Other	0	0	0	0	2.5	81.1	86.9	87.4	105.1	136.5	134.3	123.8	124.3	124.3	133.7	132.7	132.6	132.4	132.0	130.8	125.7	120.8	119.3	81.5	2,247.7
Total: Nondurable Goods	0	0	0	0	12.1	389.4	417.2	419.4	504.7	655.2	644.4	594.0	596.7	596.7	641.8	637.1	636.4	635.7	633.7	627.6	603.5	579.9	572.5	391.1	10,789.1
Services:																									
Housing	0	0	0	0	4.0	128.6	137.8	138.6	166.7	216.4	212.9	196.2	197.1	197.1	212.0	210.5	210.2	210.0	209.3	207.3	199.4	191.6	189.1	129.2	3,564.0
Household Operation	0	0	0	0	1.6	52.2	55.9	56.2	67.6	87.7	86.3	79.6	79.9	79.9	85.9	85.3	85.2	85.1	84.9	84.1	80.8	77.7	76.7	52.4	1,445.0
Transportation	0	0	0	0	0.9	27.8	29.8	30.0	36.0	46.8	46.0	42.4	42.6	42.6	45.8	45.5	45.5	45.4	45.3	44.8	43.1	41.4	40.9	27.9	770.5
Other	0	0	0	0	5.1	164.6	176.3	177.2	213.3	276.9	272.4	251.1	252.2	252.2	271.2	269.2	268.9	268.7	267.8	265.3	255.0	245.1	242.0	165.3	4,559.8
Total: Services	0	0	0	0	11.6	373.2	399.8	401.9	483.6	627.9	617.6	569.3	571.9	571.9	615.0	610.5	609.9	609.2	607.3	601.5	578.3	555.8	548.7	374.8	10,339.7
Total Personal Consumption	0	0	0	0	28.0	902.9	967.2	972.3	1170.1	1519.0	1494.1	1377.3	1383.5	1383.5	1487.9	1477.0	1475.4	1473.9	1469.2	1455.2	1399.1	1344.6	1327.4	906.8	25,014.4

Source: The Boeing Company

Table 5-III. Impact of SST Production Expenditures on Personal Income and Personal Consumption—Phases IV and V

production program. Tables 5-IV through 5-VII portray a geographical distribution of these supplier bases and show an approximate value of the subcontracts for which the source base will compete.

Taxes

It can be seen below that the SST program makes a highly significant impact on federal, state, and local tax revenues, totaling (over the period through 1990) \$7.1 billion or approximately five and one-half times the original government investment of \$1.2 billion in the prototype:

	\$ Million
Federal Income	5,400
State and Local	1,275
Total	6,675

Corporate income tax portion hereof based upon an assumed 10% profit.

Illustrative of the impact of tax revenues at the state and local levels is the tax effect on the State of Washington. (See Table 5-VIII.)

All elements of our social structure receive benefits from the SST tax dollar. This includes state and local governments, public safety, health, and hospitals. The SST program will also generate tax revenues at state and local levels to support programs which might otherwise require federal aid. Examples, as illustrated by Table 5-VIII, are educational, transportation, and correctional and rehabilitation programs.

Summary

The principal total dollar benefits to the United States through 1990 by reason of having a U.S. SST program may be summarized as follows:

	\$ Billion
Balance of Trade (Aircraft Account) Payments . . .	16.2 to 21
Recovery of government investment in prototype:	
Through royalties	2.2 (\$1 billion in excess of \$1.2 billion investment)
Through taxes	5.4

In addition, state and local governments would receive \$1.3 billion in tax revenues.

Airframe Manufacturer		
State	Number of Potential SST Suppliers*	Potential SST Dollars
Alaska	—	—
Alabama	1	345,000
Arizona	5	21,029,000
Arkansas	3	180,000
California	202	146,020,000
Colorado	4	60,000
Connecticut	13	13,017,000
Delaware	1	50,000
Florida	10	1,500,000
Georgia	1	20,000
Hawaii	—	—
Idaho	—	—
Illinois	20	13,824,000
Indiana	8	2,000,000
Iowa	2	2,500,000
Kansas	4	80,000
Kentucky	2	15,000
Louisiana	—	—
Maine	—	—
Maryland	9	4,252,000
Massachusetts	16	2,109,000
Michigan	19	8,600,000
Minnesota	6	3,009,000
Mississippi	—	—
Missouri	8	990,000
Montana	—	—
Nebraska	—	—
Nevada	—	—
New Hampshire	2	50,000
New Jersey	20	6,825,000
New Mexico	—	—
New York	38	44,735,000
N. Carolina	2	10,000
N. Dakota	—	—
Ohio	37	24,805,000
Oklahoma	2	57,000
Oregon	6	1,650,000
Pennsylvania	21	3,255,000
Rhode Island	1	25,000
S. Carolina	1	10,000
S. Dakota	—	—
Tennessee	1	14,091,000
Texas	15	24,700,000
Utah	—	—
Vermont	2	75,000
Virginia	3	2,334,000
Washington	54	1,821,000
W. Virginia	1	10,000
Wisconsin	7	5,050,000
Wyoming	—	—

*Tabulation represents qualified suppliers, not selection of probable sources

Source: The Boeing Company

Table 5-IV. Potential SST Supplier Support—Prototype

Airframe Manufacturer		
State	Number of Potential SST Suppliers*	Potential SST Dollars
Alaska	-	-
Alabama	3	6,963,000
Arizona	11	550,371,000
Arkansas	3	850,000
California	804	3,857,392,000
Colorado	6	449,000
Connecticut	65	343,369,000
Delaware	2	782,000
Florida	11	1,121,000
Georgia	1	1,011,000
Hawaii	-	-
Idaho	-	-
Illinois	88	401,419,000
Indiana	24	58,400,000
Iowa	3	17,941,000
Kansas	20	673,000
Kentucky	4	725,000
Louisiana	-	-
Maine	-	-
Maryland	14	124,535,000
Massachusetts	50	74,315,000
Michigan	46	173,577,000
Minnesota	15	107,142,000
Mississippi	-	-
Missouri	18	16,167,000
Montana	-	-
Nebraska	3	811,000
Nevada	-	-
New Hampshire	2	449,000
New Jersey	69	261,412,000
New Mexico	1	423,000
New York	145	1,333,496,000
North Carolina	2	870,000
North Dakota	-	-
Ohio	86	617,035,000
Oklahoma	6	887,000
Oregon	32	35,243,000
Pennsylvania	66	109,407,000
Rhode Island	5	449,000
South Carolina	1	405,000
South Dakota	2	810,000
Tennessee	3	348,514,000
Texas	21	495,420,000
Utah	-	-
Vermont	2	449,000
Virginia	5	32,491,000
Washington	839	26,788,000
West Virginia	2	916,000
Wisconsin	16	218,471,000
Wyoming	-	-

*Tabulation represents qualified suppliers, not selection of probable sources

Source: The Boeing Company

Table 5-V. Potential SST Supplier Support—Production

Engine Manufacturer		
State	Number of Potential SST Suppliers *	Potential SST Dollars
Alaska	—	—
Alabama	4	577,000
Arizona	1	3,721,000
Arkansas	—	—
California	115	35,329,000
Colorado	4	82,000
Connecticut	68	25,690,000
Delaware	1	158,000
Florida	9	1,946,000
Georgia	1	3,000
Hawaii	—	—
Idaho	—	—
Illinois	115	13,589,000
Indiana	69	12,980,000
Iowa	1	8,000
Kansas	—	—
Kentucky	20	3,044,000
Louisiana	1	3,000
Maine	—	—
Maryland	11	300,000
Massachusetts	58	17,920,000
Michigan	143	29,720,000
Minnesota	12	11,842,000
Mississippi	—	—
Missouri	13	237,000
Montana	—	—
Nebraska	1	33,000
Nevada	2	110,000
New Hampshire	7	43,000
New Jersey	63	7,124,000
New Mexico	—	—
New York	126	15,063,000
N. Carolina	2	262,000
N. Dakota	—	—
Ohio	880	63,226,000
Oklahoma	4	442,000
Oregon	4	611,000
Pennsylvania	69	8,596,000
Rhode Island	5	68,000
S. Carolina	—	—
S. Dakota	—	—
Tennessee	8	1,141,000
Texas	9	874,000
Utah	—	—
Vermont	4	377,000
Virginia	—	—
Washington	1	30,000
W. Virginia	3	61,000
Wisconsin	19,	1,714,000
Wyoming	—	—
Washington, D.C.	1	62,000

*Tabulation represents qualified suppliers, not selection of probable sources

Source: General Electric

Table 5-VI. Potential SST Engine Supplier Support—Prototype

Engine Manufacturer		
State	Number of Potential SST Suppliers *	Potential SST Dollars
Alaska	—	—
Alabama	7	3,462,000
Arizona	7	22,277,000
Arkansas	—	—
California	309	211,497,000
Colorado	16	492,000
Connecticut	132	153,788,000
Delaware	3	954,000
Florida	24	11,646,000
Georgia	11	15,000
Hawaii	—	—
Idaho	—	—
Illinois	214	81,356,000
Indiana	127	77,709,000
Iowa	7	46,000
Kansas	1	2,000
Kentucky	50	18,231,000
Louisiana	2	15,000
Maine	3	3,692,000
Maryland	18	1,800,000
Massachusetts	185	107,279,000
Michigan	249	177,912,000
Minnesota	35	70,894,000
Mississippi	—	—
Missouri	27	1,415,000
Montana	—	—
Nebraska	4	200,000
Nevada	3	662,000
New Hampshire	10	261,000
New Jersey	145	42,647,000
New Mexico	4	1,000
New York	251	90,171,000
N. Carolina	8	1,569,000
N. Dakota	—	—
Ohio	1858	378,502,000
Oklahoma	9	2,646,000
Oregon	8	3,662,000
Pennsylvania	168	551,463,000
Rhode Island	16	415,000
S. Carolina	—	—
S. Dakota	—	—
Tennessee	17	6,831,000
Texas	31	5,231,000
Utah	1	307,000
Vermont	8	2,261,000
Virginia	12	1,385,000
Washington	7	185,000
W. Virginia	5	369,000
Wisconsin	45	10,262,000
Wyoming	—	—
Washington, D.C.	6	369,000

*Tabulation represents qualified suppliers, not selection of probable sources
Source: General Electric

Table 5-VII. Potential SST Engine Supplier Support—Production

Distribution	Phase III— Prototype (\$ Million)*	Phases IV & V— Production (\$ Million)*
Education	11.7	55.6
Public Welfare	1.7	11.4
State & Local Governments	5.1	18.9
Roads & Port Authority	1.8	7.0
Health & Hospitals	0.1	1.6
Correctional Institutions	0.1	0.9
Agriculture	0.1	0.5
Fire, Safety & Flood Control	0.4	1.6
Total	21.0	97.5

*Does not include tax revenue generated by subcontractors
and suppliers

Source: The Boeing Company

Table 5-VIII. Distribution of SST-Generated Tax Revenue to State and Local Governments
(Washington State)

AERONAUTICAL TECHNOLOGY

AERONAUTICAL TECHNOLOGY

The SST is the only advanced-technology high-performance supersonic airplane under development (either civil or military) in the United States at this time. The SST design objective of a cruise speed of 1,780 mph (mach 2.7) above 60,000 feet altitude for distances up to 4,000 statute miles has never before been achieved with commercial transportation standards of safety, reliability, and economy. Its achievement will occur only through the synthesis, development, test, and perfection of thousands of components that have never been built before. Past experience has shown that once these new components (and inventions) are developed, they will eventually be modified and applied widely. The SST program is an opportunity to organize and focus this activity to stimulate a rapid and practical development of these many new components. Although the new components stemming from the SST program will have wide application in other fields, it is apparent that the field of civil aviation will be a major beneficiary in the areas discussed below.

Summary

Safety

The automatic flight control system being developed for the SST is applicable to all aircraft. It has the ability to relieve the pilot workload in congested traffic, to provide smooth and safe flight in extremely rough air, to permit tight air traffic control, and to make safe zero-visibility landings. This system will virtually eliminate accidents associated with pilot errors in interpreting instrumentation and will permit more than a threefold increase in airspace utilization.

The SST will be built of titanium to withstand the high temperatures caused by aerodynamic heating. This titanium structure automatically provides a safety advantage relative to today's aluminum structure, because of its much greater resistance to external fire damage during crash conditions. The stimulus of the SST program will hasten the day when all future aircraft will utilize titanium structure for both cost efficiency and safety reasons.

Flight Efficiency

The SST has a very great work capacity for its size because of its tremendous flight speed. It is therefore necessary to minimize the weight of aircraft structure and systems for maximum operating efficiency. Titanium was chosen as the basic structural material because it is 25 percent stronger than aluminum for the same weight and maintains its strength to much higher operating temperature. Structural concepts which capitalize on these advantages have only recently been identified. These concepts planned for the SST are applicable to all future aircraft and to many nonaircraft developments. Titanium structure has seen only limited application on subsonic aircraft because of problems of availability, producibility, and cost. The SST program will go a long way toward solving these problems through practical design and manufacturing concepts and developments. The impact of successful titanium development in the 1970's is expected to approach the impact of the aluminum development in the 1930's. The advanced and lightweight systems developments that are under way for the SST will also provide benefits for all future aircraft.

The engine development stimulated by the needs of the SST, if applied to present or future airplanes, will greatly improve the operating economics and substantially reduce community noise. The following engine developments have immediate applicability to both subsonic and supersonic aircraft:

- New high-temperature high-strength alloys
- Hollow compressor blades and rims
- Turbine blade cooling for long life
- Lightweight components

Manufacturing

The SST requirements for the use of new, highly efficient materials and components are stimulating the development of new manufacturing techniques and processes that are applicable to many industrial operations not related to the SST program. The development of efficient manufacturing techniques for the titanium structure for the SST will result in manufacturing cost reductions for future widespread applications of these lightweight structures. The SST program is stimulating progress in the following basic titanium fabrication areas:

- Machining—Cutters, drills, and coolants have produced a tenfold improvement in machining rates.
- Tooling—The techniques of forming titanium have evolved from the use of large heated dies and cumbersome equipment, to local part heating and conventional dies.
- Fasteners—Electromagnetic riveting.
- Welding—Automated resistance and fusion welding.
- Rolling—High-quality, large-capacity facility development.

Flight Operations

The combination of the SST automatic flight control capability with automatic ground control will permit closer spacing of aircraft to improve the use of the airspace and runways. The development of such technology is necessary in the immediate future to relieve the airport congestion problem. Since the SST's will cruise between 60,000 and 70,000 feet of altitude while the subsonic jets cruise below 40,000 feet of altitude, the addition of the SST's will actually result in a reduction of the congestion on intercontinental airway routes for a given level of passenger traffic. Therefore the SST will offer some relief to a growing subsonic operational problem.

The massive effort involved in reducing engine noise associated with the SST will produce concepts and techniques applicable to all jet-powered aircraft; the expected result is a significant reduction in community noise from any aircraft employing that technology.

Applicability

The SST program will result in technology advances across a broad front in a number of engineering and manufacturing disciplines. The dividends that will accrue from this progress will have applicability in many fields. Specifically, in the aeronautical field these advances can be expected to contribute directly to the following future programs:

- Future subsonic commercial aircraft
- Advanced manned strategic aircraft (AMSA)
- Advanced military transport aircraft
- Air-superiority fighter aircraft
- High-speed mass transit (ground)
- Advanced supersonic commercial transport aircraft

The following sections present a brief discussion of some of the most significant and far reaching technical developments underway on the United States SST program.

Safety

Automatic Flight Management

Development of automatic flight was started early in the SST program to reduce pilot workload during short flight times with numerous events demanding attention. Such automation puts the pilot in better command of the airplane; i.e., he has more time to assess the general situation and to check operation of the airplane systems. The automatic system also provides the pilot very realistic displays on his instrument board, free from errors in interpretation, as contrasted to the current airplane dial and scale indications.

It has become obvious that such an automatic system could considerably improve safety of all airplanes, particularly during poor visibility. A significant number of accidents have resulted from navigational errors involving either visual flight under poor conditions or misreading the altimeter or accidents due to faulty cockpit procedures and misunderstanding of warnings. These types of accidents could be largely prevented by improvements in airplane controls and displays, integrated with improved ground navigational aids into a unified system. However, because of the complications and lack of reliability, the application of these improved systems has been progressing slowly. The engineering problem of achieving a reliable and cost-effective advancement such as this can only be overcome by a comprehensive program such as is planned for the SST. Progress to date is impressive and indicates eventual success.

The development of a combined airplane/ground automated system has been discussed with many agencies including:

- DOT – Dr. Frank Lehan, Assistant Secretary for R&T during 1968
- FAA – Washington, D.C., and NAFEC, Atlantic City
- NASA – Ames Laboratory, Moffet Field, California
Electronic Research Center, Cambridge, Massachusetts
Headquarters, Washington, D.C.
- USAF – Flight Dynamics Laboratory, Wright-Patterson AFB
- MIT – Dr. C. S. Draper, Instrument Laboratory, Cambridge, Massachusetts
Apollo Guidance Program

The laboratory and flight test work to date is illustrated in Figs. 6-A and 6-B. The electronics industry has participated in this work and has contributed much of the equipment shown in the photographs. These companies include:

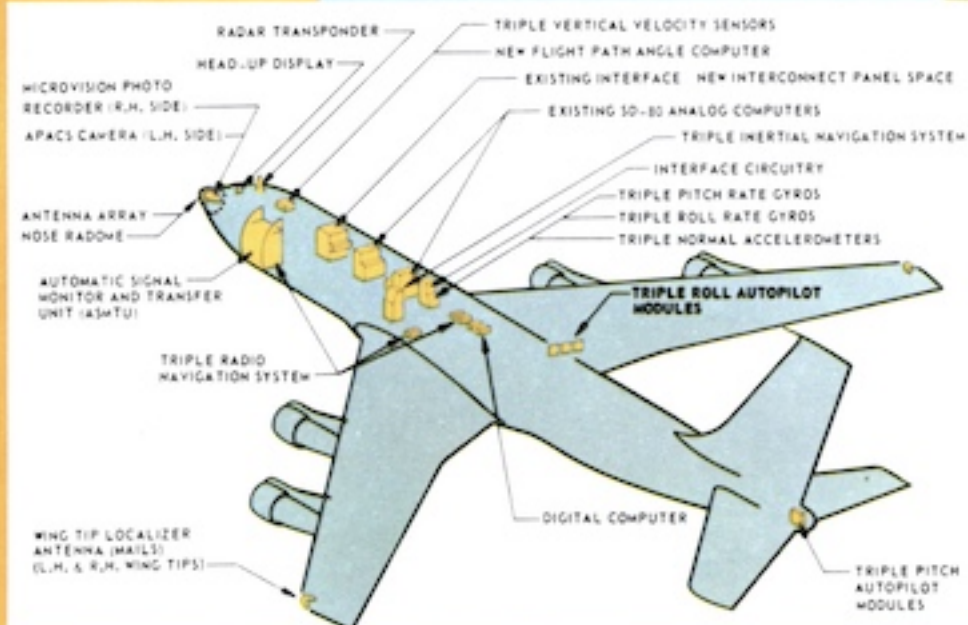
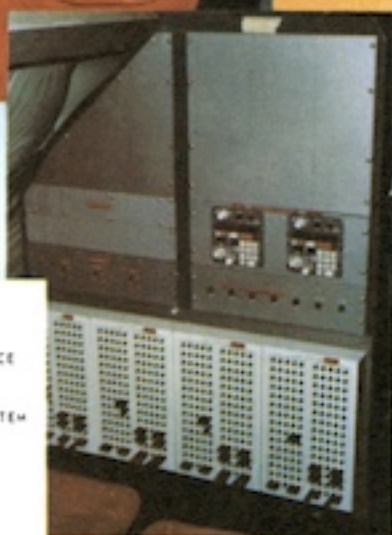
- | | |
|----------------|------------------|
| AC Electronics | General Electric |
| Litton | Lear Siegler |
| Bendix | Norden |
| Sperry Rand | Collins Radio |

Full development of this effort will constitute a large part of the SST program and will be applicable to all airplane types.



MOBILE RESEARCH LABORATORY

Computers, radio nav/aids, and inertial equipment to develop the basic precision navigation/automatic path guidance techniques for accident prevention and increased ATC capacity.



FLIGHT DEMONSTRATIONS 367-80 AIRPLANE

Extensions of the mobile bus research in developing more accurate navigation guidance systems that will permit higher traffic density with greater safety. Fail-operative automatic landing system currently being tested.

Figure 6-A. Mobile Research Laboratory and Flight Demonstration of 367-80 Airplane

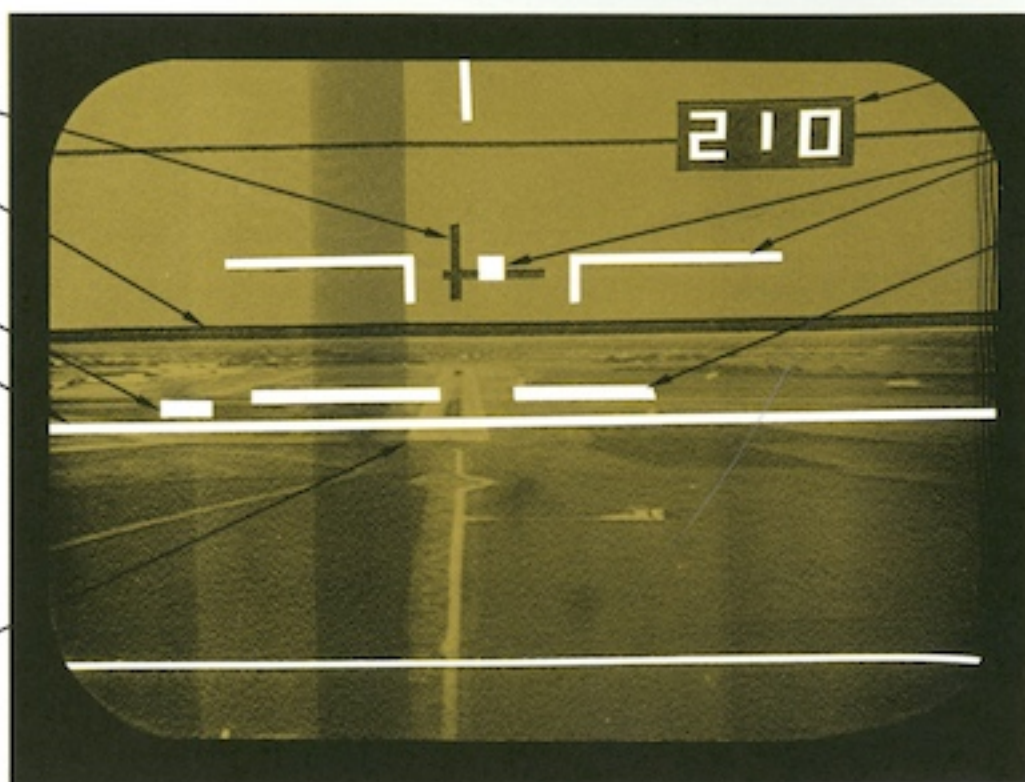
COMPUTED
STEERING
COMMANDS

ARTIFICIAL
HORIZON

ENGINE
THRUST
MANAGEMENT
SYMBOL

DESIRED
GLIDE PATH

TELEVISED
RUNWAY
IMAGE

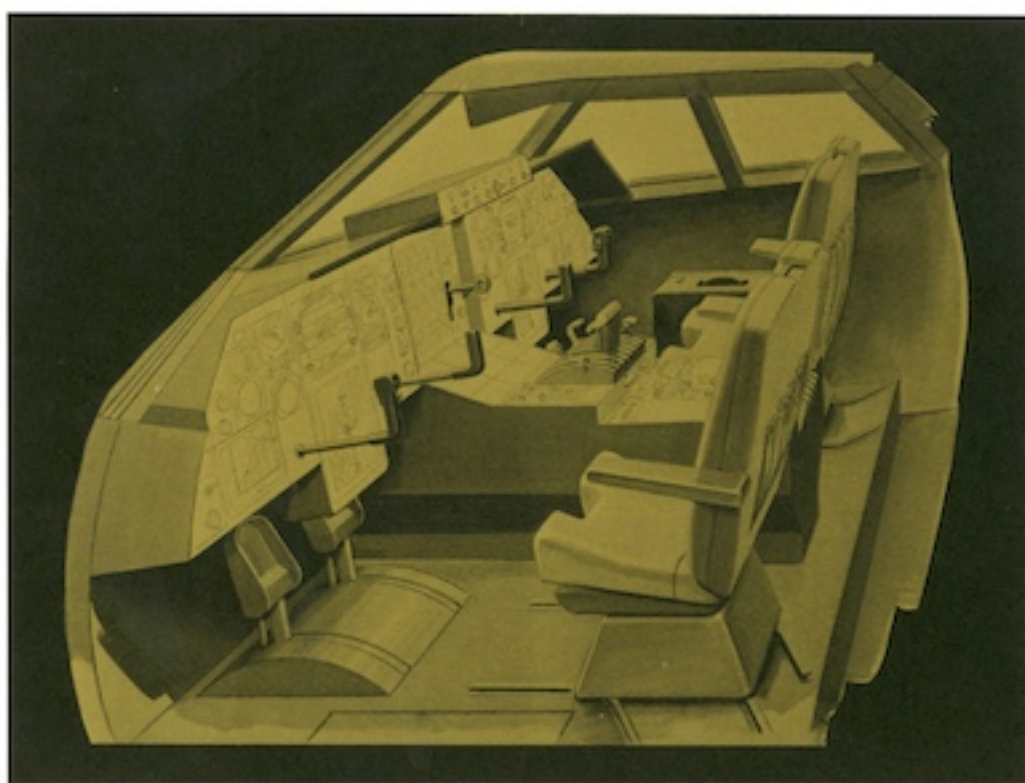


RADIO
ALTITUDE

AIRPLANE
REFERENCE

ACTUAL
GLIDE PATH

(Electronic attitude director being flight tested in the Boeing 707 provides the pilot with precise attitude, command, and situation information. The superimposed external television image enhances the quality and safety of landing operations, day and night.)



(Research on instruments, displays and controls is directed towards such a flight deck.)

Figure 6-B. Inflight View of Advanced Pilot Display Development—SST and Artist concept of Advanced Cockpit

Only a national program such as this can successfully carry out the development of such a large new system.

System Reliability

All aircraft are required to provide an extremely high degree of flight safety; on the present-day subsonic aircraft this has been achieved largely by using many nonintegrated elements such as cables, beams, power units, instruments, and two pilots cross-checking procedures. The SST, to achieve safety, will require automatic flight control systems and advanced cockpit displays. Achievement of safe and reliable automatic flight controls has stimulated the development of multiple control actuating systems with duplicated parallel electronic control channels devised to detect failure and automatically take the action required to continue normal flight.

Automatic flight controls will relieve the pilot in congested traffic, provide a smoother ride and safer flight through rough air, and permit automatic landings in extremely adverse visibility.

The development of reliable automatic flight controls and advanced cockpit displays can be applied to all present and future aircraft, and will materially improve the air transport industry's safety record.

Fireproof Structure

Contemporary aircraft use titanium extensively as a firewall material because of its superior resistance to penetration by fire. This material is used for the fuselage shell surrounding the passenger compartment of the SST and will provide excellent protection to passengers and crew from external burning.

Tests have been run to demonstrate this capability. A kerosene fire next to an aluminum fuselage burned through in about 2½ minutes. The aluminum was replaced with a titanium panel, and the fire was allowed to burn for 25 minutes without burn-through of the titanium. The test and the resulting panels are shown in Figs. 6-C, 6-D, and 6-E.

As a result of the development of a complete titanium fuselage for the SST, and the protection and additional safety this material offers to the passenger, titanium will find extensive use in the future on all advanced transportation systems involving the mass movement of people.

Flight Efficiency

Structural Efficiency

General

The desirable properties of titanium as an aircraft structural material—e.g., corrosion and fire resistance, toughness, thermal stability, stiffness, and light weight—have been recognized for years by industry. Titanium can carry a substantially higher load for a comparable weight than conventional aircraft materials such as aluminum and



Figure 6-C. External Fire Test



Figure 6-D. Aluminum Structure After Fire Test



Figure 6-E. Titanium Structure After Fire Test

alloy steels. Early attempts to use titanium with conventional design and processing methods, however, failed to exploit these desirable properties and resulted in very modest structural efficiency improvements at high cost.

Design

The decision to use titanium as the primary structural material for the SST was necessitated by the thermal environment in which the aircraft will operate. Conventional materials such as aluminum do not have adequate strength at the operating temperatures. The SST program has forced design research and technology improvements that will exploit the potential of titanium. New structural concepts in lieu of riveted skin-stringer construction were required to permit full use of titanium's strength. Titanium is twice as strong as aluminum; thus for a comparable load the skin gauge is one-half the gauge of similar aluminum structure. The use of conventional design methods was limited by panel flutter and stability under compression loading. The resulting designs developed for the SST, embodying the use of sandwich or face-stabilized structure, permit higher loading per unit weight than heretofore was possible. This improvement in structural efficiency was obtained by stabilizing the face sheets with core material so that they would not buckle under load. A proportionately greater percentage of the load-carrying material is in the cover or skin material, compared with conventional design; a greater torsional stiffness is thereby achieved for less weight. In addition, the basic structural system is exploited to perform the dual function of carrying load while providing adequate fuel tank insulation.

Processing

Concurrent with concept development, new processing methods were required for economical and practical fabrication of such structure. The use of resistance welding with thermal cycles to metallurgically diffusion-bond and join the sandwich core, honeycomb or corrugated, to the face sheets greatly simplifies the producibility of such parts when compared with the exacting and difficult brazing processes used on the B-70 steel structures. The SST structural fabrication processes permit economical realization of the weight-saving potential of titanium. Improvement in cost is achieved through substantial reduction in the number of detail parts, elimination of a substantial number of fasteners, and better utilization of the raw material. Further improvements in toughness, crack containment, damage resistance, lightning strike resistance, and fuel insulation are realized as a result of this effort.

Application

The application of titanium to the SST will make possible the wider application of titanium to future subsonic aircraft. The accumulation of basic titanium knowledge resulting from the SST development has fostered significant improvements in the strength, toughness, cost, and quality of the basic mill products through new rolling and forging methods.

The development of titanium technology for the SST is considered a major addition to aerospace industry technology. A correlation may be drawn between the current SST structural development effort and the aluminum structural development in the 1930's. As a result of a joint government/industry effort, basic aluminum material properties, structural methods, and analysis were established which became the basis for the structural design of the subsonic and initial supersonic aircraft flying today. This development spear-headed the transition from the wood, wire, and fabric airplanes of the early days to the all-metal aircraft of today, and allowed exploitation of aluminum in the commonest of commercial applications. In a like manner, the SST structural development program is developing a base for the transition to the titanium aircraft of the future. This transition has already begun in the Soviet Union with the advent of mach 3 titanium fighters.

An accumulated knowledge of design strength of basic titanium materials and components is applicable to all structures that can potentially use titanium. The concepts developed for utilizing the potential strength of titanium through proper design and technology are being applied to other metals such as aluminum and steels with corresponding gains in structural efficiency. Thus we will have a firm base on which to expand the use of titanium into many industrial, commercial, and military applications such as petrochemical, desalinization, and ground transportation and marine systems.

The basic technology has been developed in the SST program to use high-strength fiber-reinforced structures in a high-temperature matrix system for use on selective structural members such as floor beams and fuselage sheel stiffeners. These fibers, such as boron and graphite, are approximately six times stronger and stiffer than steel.

Other areas of technological progress having direct application to existing aircraft systems would include the following:

- Graphite brake discs, which can apply to all future vehicles that will benefit from high-energy-capacity lightweight brake systems.
- Radial-ply aircraft tires, which run cooler, wear longer, have low pressures and improved flotation. These apply to all military and civil aircraft.
- Lightweight high-temperature corrosion- and sonic-resistant biaxial load-carrying structures, such as honeycomb and corrugated core sandwich. These can benefit such widely diverse weight-critical structures as space vehicles, hydrofoils, submarine hulls, portable military bridges, aircraft runways, and air transportable equipment.
- High-temperature fuel tank sealants, adhesives, elastomers, and pressure seals. These apply to a variety of domestic and industrial areas: e.g., home appliances, power leads, air conditioning equipment, and nuclear power systems, as well as aerospace systems.

Some applications of titanium technology are shown in Figs. 6-F, 6-G, and 6-H.

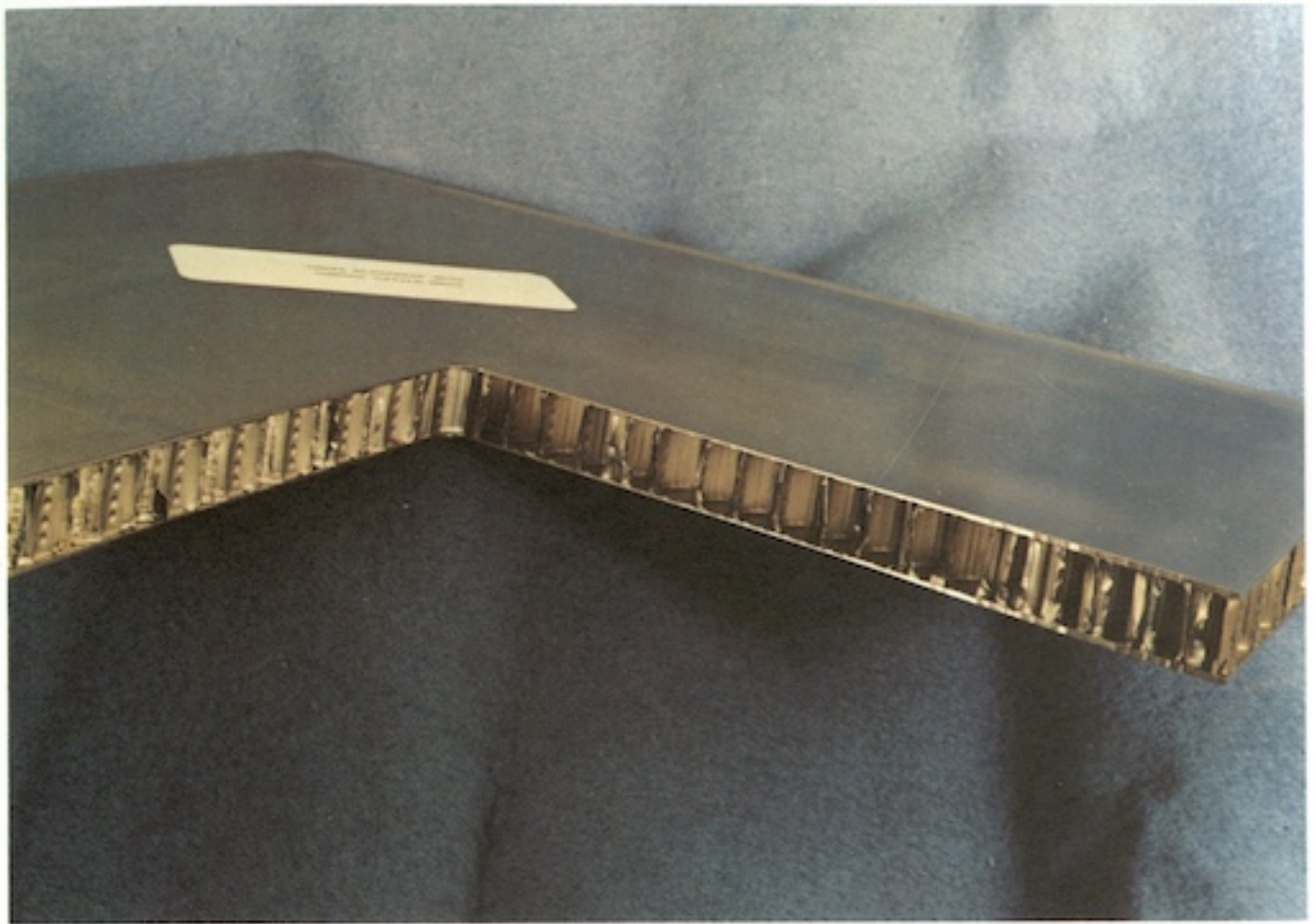


Figure 6-F. Tapered and Formed Welded Honeycomb Sandwich Panel

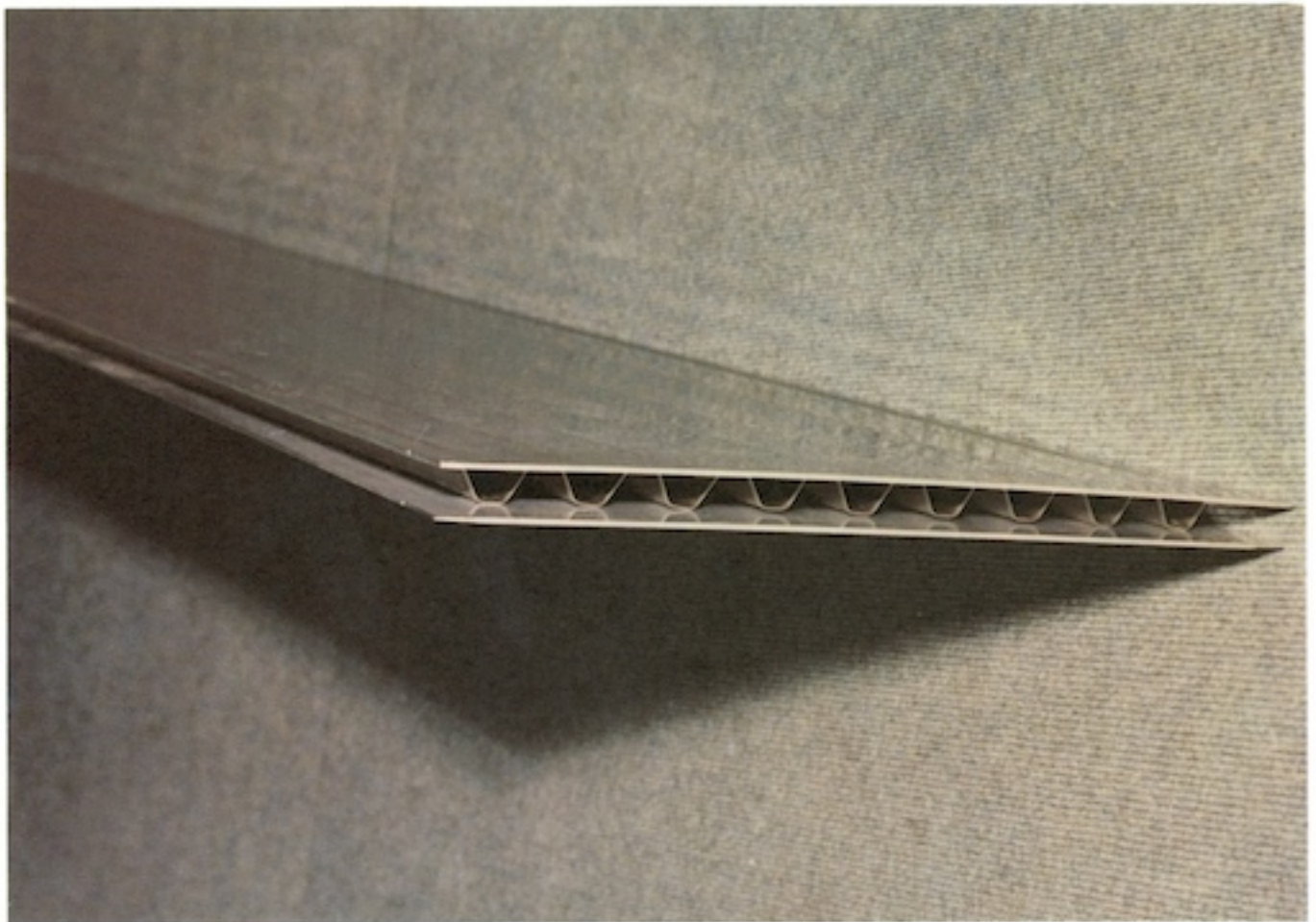


Figure 6-G. End View of 20-Foot Truss Core Panel

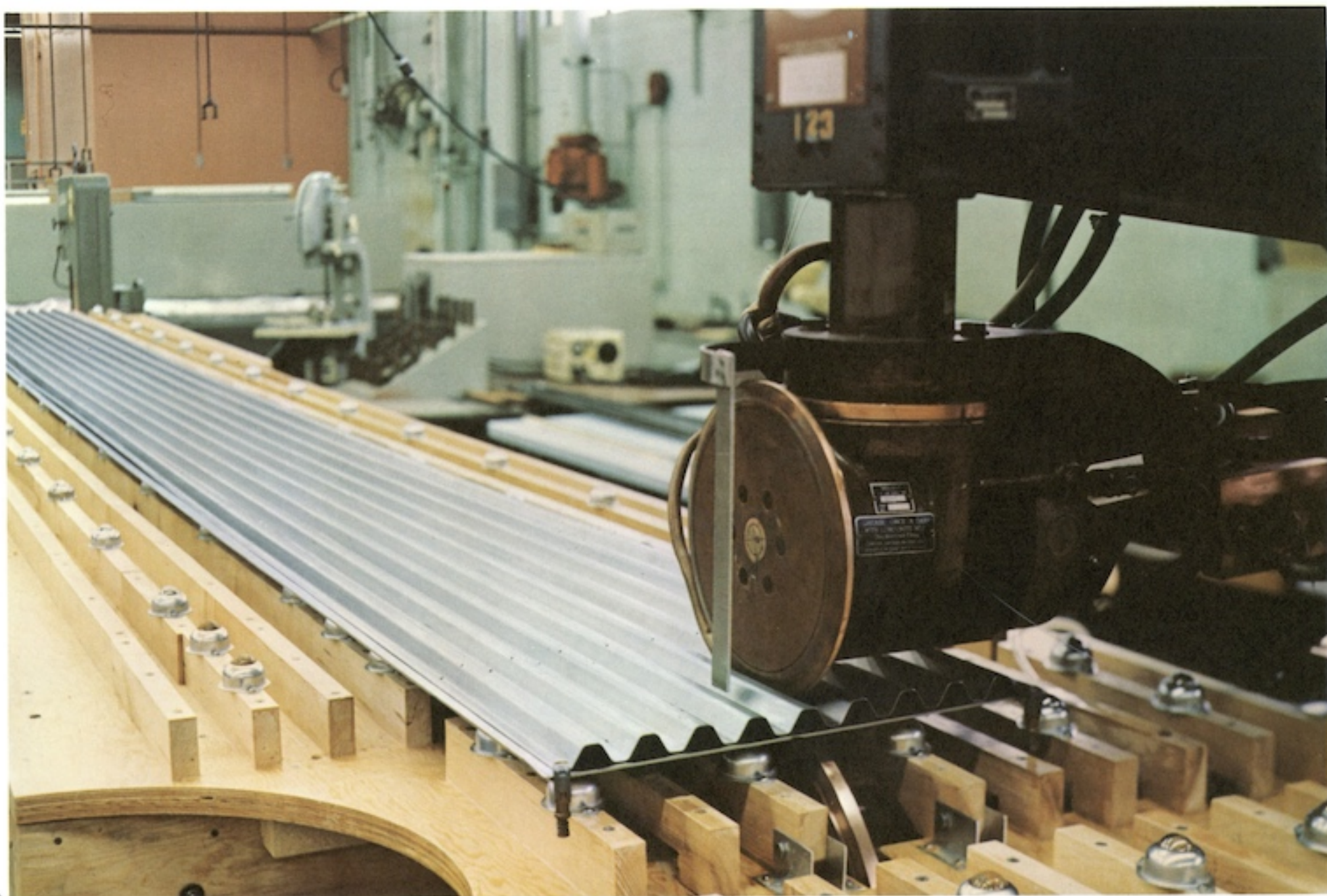


Figure 6-H. Continuous Roller Spotwelding of 20-Foot Truss Core Bottom Face Sheet

Propulsion Efficiency

The economics of the SST has forced the development of a propulsion system significantly more efficient with respect to fuel consumption and weight than any existing design capable of flying at mach 2.7. In addition, a propulsion system for commercial service requires a longer life and higher reliability than one designed for military service.

The new technology required for the SST propulsion system is directly applicable to improvements in subsonic airplane engines and their installation as well as to military airplanes. When applied to subsonic airplanes, the propulsion technology required for the extreme conditions of supersonic flight will result in new standards for engine life, reliability, operating costs, and airplane safety. The total result will be an increase in air transportation productivity accelerated beyond the present rate of design improvement.

Following is a brief description of SST propulsion system developments which are especially significant to other airplanes.

Engine

Metallurgical advances in component design in the engine are a primary source of high thrust/weight ratio. General Electric has developed three new nickel-base alloys for the G4 engine: A high-strength sheet/bar material that withstands 50°F higher temperature than current alloys and will have a life increase from 4,000 to 12,000 hours; a turbine blade/vane alloy with improved strength and corrosion resistance at 50°F higher temperatures; and a third alloy, for turbine and compressor rotors, offering a 50 percent increase in tensile and creep strength over the 718 Inconel currently used.

General Electric has also developed a new titanium alloy that offers a 200°F increase in temperature capability, up to 900°F. A high-temperature nickel-chrome sheet metal has been developed for afterburners and nozzles that has double the rupture strength, at 2,000°F, of previously used materials.

Hollow compressor blades and hollow rims in the compressor contribute to a marked reduction in weight. The augmentor incorporates a short-combustion-length flameholder design that provides a lightweight means of increasing the takeoff, climb, and acceleration thrust of the SST engine. The engine exhaust nozzle incorporates ejector nozzle principles, plus aerodynamically positioned flaps to further reduce weight.

The turbine provides efficient operation at high turbine temperatures. This, combined with a cooling technique that improves the effectiveness of the air used to cool the turbine, provides the extended life required for commercial operation. High levels of component performance, coupled with high turbine temperature at supersonic cruise, result in the SST engine being 10 to 15 percent more efficient

than existing engines for mach 2.7 flight. These developments in turbine cooling technology can be applied directly to subsonic fan engines, which also require high turbine temperatures for optimum cruise efficiency.

Manufacturing Processes

Several special joining, welding, and brazing techniques have been required for the new General Electric alloys: burn-through welds for titanium, inertia welds of U-700, diffusion bonding of titanium hollow blades. Electro-stream drilling is used for the cooling holes. Thin sheet-metal inserts are drilled by laser. All these processes are applicable to a wide range of industrial uses.

Air Intake

The air intake is critical in designing a supersonic propulsion system. The SST employs an axisymmetric external/internal compression inlet of lightweight design incorporating an advanced control system to permit operation at supersonic cruise at optimum performance levels. The intake will have higher efficiency and lower drag than have been achieved on any aircraft flying at supersonic speeds, equivalent to a 10 percent range advantage over present-day intakes.

Aerodynamic Efficiency

Electronic Pitch Damping

A pitch damper is being developed for the SST that permits balancing the airplane to center-of-gravity locations further aft than would be otherwise permitted. This system reduces weight and drag by permitting the use of smaller flight control surfaces and actuation systems. Noise produced by the aircraft on takeoff and landing is also reduced. The system is designed to have integrity equivalent to primary aircraft structure and, when developed, will benefit all future large aircraft.

Handling Qualities Criteria for Large Aircraft

Rational criteria for pilot handling qualities of large airplanes are needed for sizing control systems and design synthesis.

Flight simulator studies on the SST have shown the airplane to be controllable under conditions previously considered unacceptable. This is possible because of improved flight displays for the pilot and because the airplane's size causes it to respond more slowly to disturbances. Understanding of handling qualities criteria is continuing, and studies will be continued during flight tests of the SST prototype.

Knowledge gained from the SST program will benefit future commercial and military aircraft by reducing flight control system and airplane balance requirements. These reductions will save weight and improve performance.

Development of Lightweight Components

Subsystems include the following: engine accessories, flight controls and displays, hydraulics, electrical, avionics, environment (cabin pressure and temperature) control, insulation, and furnishings.

These subsystems are all essential to the mission. They are required to provide higher levels of performance, safety, reliability, maintainability, and comfort than have been necessary for subsonic operation.

For the SST, the emphasis on least practical weight is far greater than for subsonic aircraft; this has resulted in the deliberate exploration, introduction, and exploitation of new technical developments to achieve all of the above-mentioned objectives. Among the subsystem technical developments to reduce weight are:

- Electric throttles for precise redundant thrust control
- Fly-by-wire primary flight control systems
- Full-time stability augmentation (to reduce size and weight of control surfaces)
- High-pressure (4,000 psi) hydraulic system, using fuel as a heat sink
- Titanium actuators (hydraulic)
- Improved packaging of electrical and avionic components
- Extensive use of "solid-state" electronic devices
- Lightweight electrical wire for high temperatures
- Improved thermal and acoustic insulation for high temperatures
- Sealants and lubricants for high temperatures
- Lighter weight seats, galleys, and lavatories
- Lightweight, flame-retardant, nontoxic cabin trim materials

In general, these developments differ from those thus far obtained from military programs because of the operational economics involved and because a commercial aircraft must be designed for a significantly longer flight life than a military aircraft.

The benefits of these new technical developments will be directly applicable to both commercial and military aircraft since:

- These subsystems are necessary to all aircraft.
- New lightweight technical developments are exploitable as soon as they are tested and proved and an industry-based design and production knowhow is developed.
- Every component is essentially designed, developed, and produced by an airframe industry vendor, supplier, or subcontractor, not by the prime contractor, even though the detail description of the need (and the financial support) comes from the prime contractor.

Manufacturing

Efficient Structure at Low Cost

The decision to use titanium as the basic structural material in the SST necessitated the development of significant technological advances in manufacturing processes of titanium. Conventional machining methods, forming techniques, tooling concepts, and material handling were inadequate for economical production of an SST. Through extensive efforts in manufacturing research, the complexity ratio of titanium processing to aluminum processing has been drastically reduced. (See Fig. 6-I.) This was accomplished through processing methods improvements, tooling concept changes, and identification and elimination (through proper design) of the most difficult operations.

For machining, research and development on cutters, drills, and coolants have produced a tenfold improvement in metal removal rates. This, combined with new equipment designed for titanium cutting, numerical control, and multispindle operations, has brought the cost of titanium machining down sufficiently to compare favorably with that of some aluminum and mild steels.

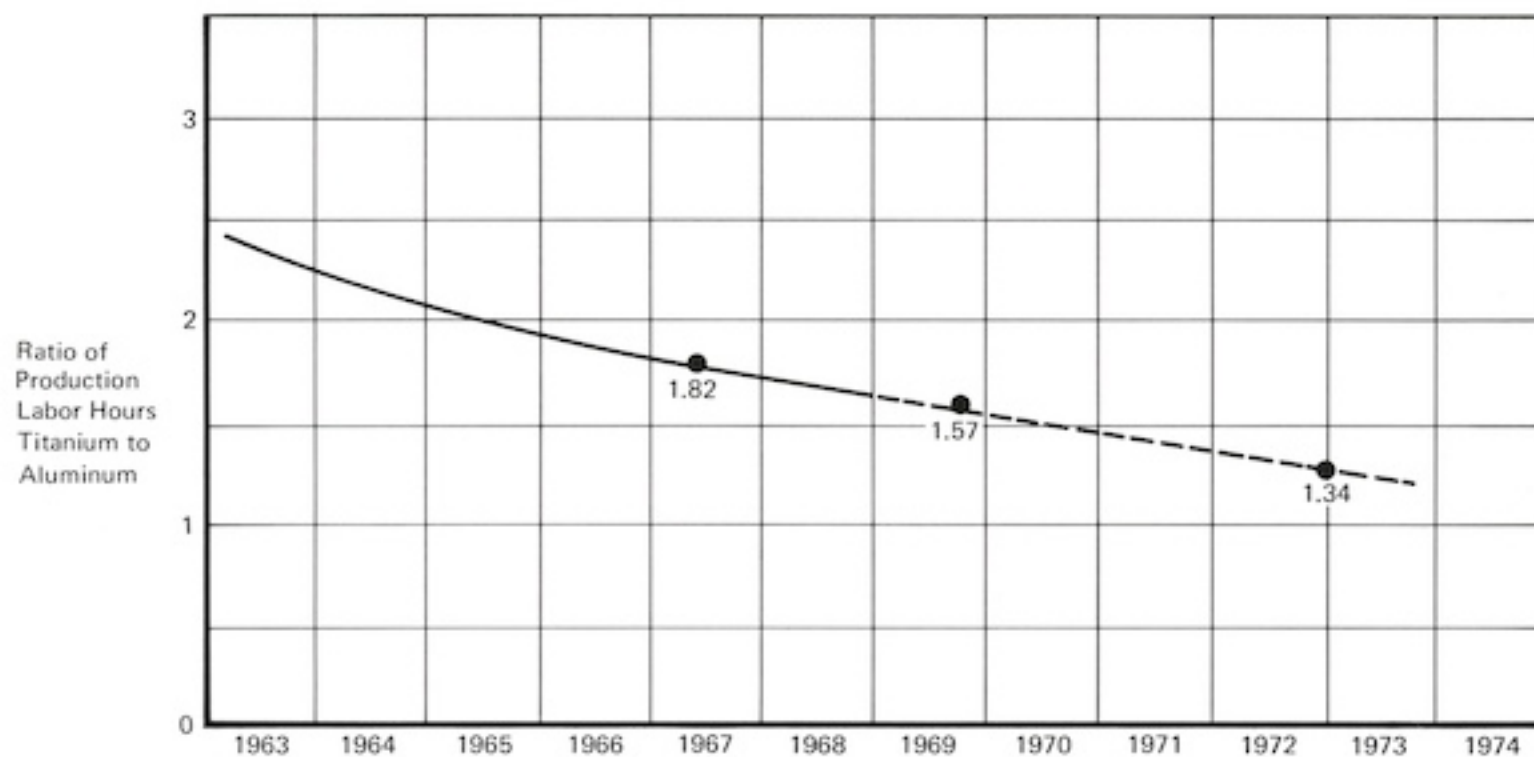
The techniques of forming titanium (Figs. 6-J and 6-K) have largely evolved from the use of large heated dies and cumbersome equipment to local part heating with conventional dies and die materials. This is accomplished through induction heating, resistance heating, and controlled radiant heating with automated elongation control. Local part heating greatly reduces tooling costs, fixed equipment requirements, and part contamination that result from long exposure at very high temperatures. For large, heavy, complex parts, the development of vacuum-creep forming has significantly improved the choice of forming applications available to the designer. This process also reduces significantly the facilities and tooling costs of large presses and massive matched-die tooling.

The development of electromagnetic riveting with light, portable equipment has reduced facilities and process costs and has improved product quality. This has made practical the manual driving of titanium alloy fasteners.

Development of automated resistance and fusion welding equipment for titanium has reduced fabrication costs by eliminating many detail parts, while providing improved structural efficiency by eliminating notches and material overlap.

Chemical processing has been developed as a complementary material removal system. This permits milling of large skins to tapered and pocketed configurations without a need for heavy, complex machine tools. Automated control of this process provides uniform metal removal and exact part reproduction.

Titanium mill products available were very limited until development of high-quality sheet and strip products became mandatory. The basic-metals industry responded to that requirement with large facility improvements in rolling equipment. As a result, titanium mill products are available equal in quality to those from the aluminum and



Source: The Boeing Company

Figure 6-1. Effect of SST Titanium Processing Improvements on Labor Hours

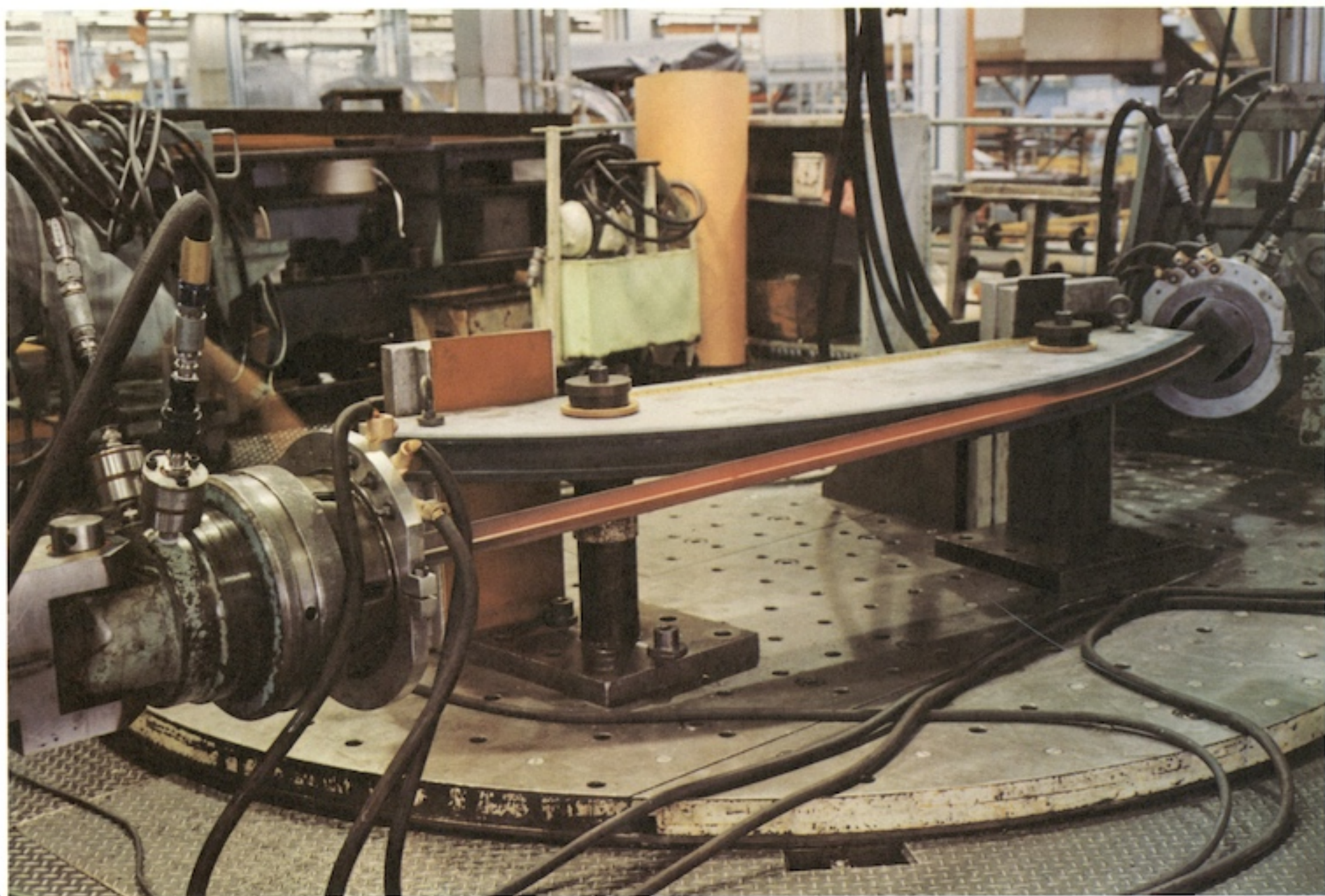


Figure 6-J. Contouring a T Section Using Resistance Heat and Ceramic-Coated Die

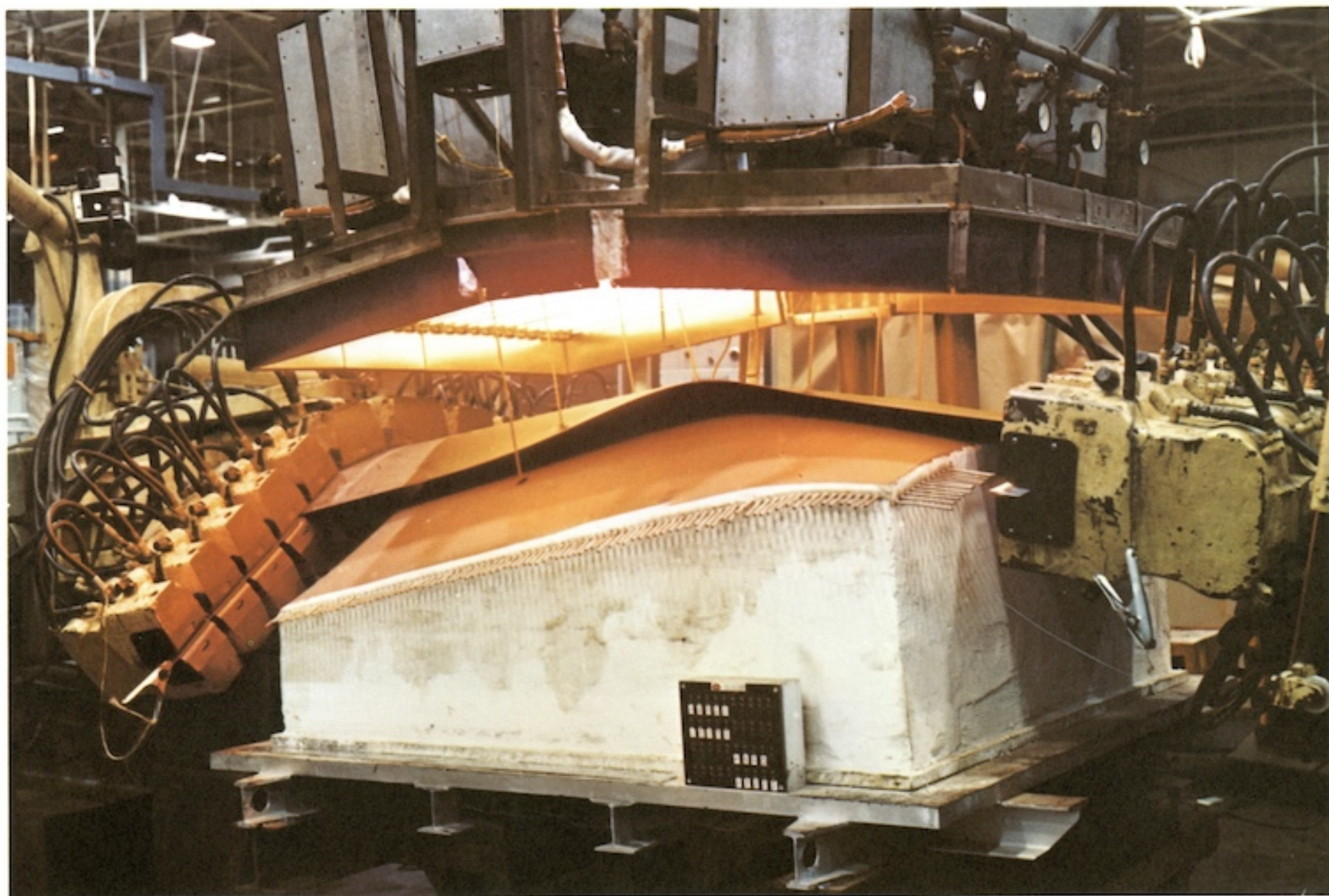


Figure 6-K. Stretch-Forming Contoured Skins

steel industries. This was accomplished in conjunction with significant reduction in costs through increased volume and production efficiency. Similar gains have been made in the production of extruded shapes, tubing, and forgings.

Applicability to Other Products

Improvements in titanium processing and manufacturing technology and mill products are available and usable on any metal structure system that uses titanium. The impact of the improved technology has reduced the cost of fabricating titanium, thus opening new potential applications for it. This increased usage will ultimately have a further impact on costs as a result of increased volume and a broader technology base.

The properties of titanium, combined with development of new processes, equipment, and manufacturing techniques for application, provide increased "spin-off" potential in the following representative areas:

- Petrochemical industry—Reaction vessels, high-temperature cracking units, absorption towers, pumps, and heat exchangers. (Titanium is highly corrosion resistant in chlorine gas, nitric acid, and sulphur atmospheres.)
- Food processing industry—Pressure vessels and piping systems where corrosion is a problem.
- Automobile industry—High-strength, lightweight body frames, doors, floor panels, and mufflers.
- Oceanography—Lightweight, high-strength submersible hulls; highly corrosion-resistant plumbing and instruments.
- Desalinization—All components exposed to sea water and elevated temperatures.
- Space exploration—Lightweight fuel and oxidizer containers, sandwich structure, and heat-resistant components.
- Airframe industry—Lightweight structure, heat-sensitive areas, and fatigue areas.

Flight Operations

Air Traffic Control

A significant economic advantage of an automatic airplane control, when designed in conjunction with an automatic ground air traffic control, is much greater utilization of the airspace and runways, with at least a threefold—and possible a tenfold—improvement. This is the major reason why such a development would be profitable to the airlines and to the government.

Increased Airspace

The SST will add 27,000 feet of vertical airspace to the 16,000 feet now available, with the result that today's levels of enroute airways traffic on international overwater routes can be maintained in the SST time period.

In 1966 there were approximately 270 daily scheduled airline transatlantic crossings. In the SST time period, these scheduled crossings will have increased to about 2,800 per day if all are by current jet airplane types, or 1,100 per day if all are by the new large 747-type jets.

If the world air transport transatlantic fleet is divided between SST's and large jets of the 747 type, there will be 300 daily crossings of the large jets and 900 crossings of the SST's. This combination increases the available cruise altitudes from 25,000 to 41,000 feet for the current jets to 25,000 to 72,000 feet for the combination mixed fleet of large jets and SST's. Since the speed of the SST is about three times that of subsonic jets, an SST will utilize the airspace only one-third as long as a subsonic jet. With a fixed distance separation system, a given airspace will accommodate three times as many SST's as subsonic jets in a given time.

Engine Noise Suppression

Development of methods to reduce engine noise is an essential element in the development of the SST as well as subsonic jet aircraft. Reduction of engine noise, however, is more difficult for the SST. Acceleration to supersonic speeds and efficient supersonic cruise require engines with high-temperature high-velocity jets. These engines are fundamentally noisier than the fan engines that are optimum for the subsonic jets.

For some years, The Boeing Company and General Electric have conducted extensive research and development programs to reduce engine noise levels. Much of this effort has recently been directed toward engines for the SST. This work will continue during the SST development program with the objective of obtaining up to 15 PNdB of noise reduction for the production SST. As part of this program the following will be developed:

- An improved understanding of the sources of engine noise and techniques for reducing the noise level.
- The ability to use high-temperature material such as columbium in the engine exhaust system.
- A jet noise suppressor capable of being retracted from the jet stream to eliminate any adverse effect on engine efficiency when its use is not required.
- Techniques for choking the engine air intake to prevent forward propagation of the compressor noise.

Although the specific noise suppression equipment to be developed for the SST will not be used on other aircraft, significant technology advances will be obtained from the development program. This technology will be directly applicable to reducing the noise of subsonic as well as other supersonic aircraft.

NATIONAL STRENGTH

NATIONAL STRENGTH

The most important fact about commercial supersonic transportation is that the SST era has already begun. The United States had no voice in determining whether this was timely; it will have no voice in determining whether other nations manufacture and operate SST's. The only real decision the United States can make regarding the SST is whether to compete. The benefits and spinoffs mentioned in the foregoing chapters, resulting from a U.S. SST program, will accrue to any nation that manufactures a commercially viable SST. The cumulative impact of these benefits will have a measurable effect on international, economic, military, and political relationships for the remainder of this century.

The U.S. decision to participate in the manufacture and sale of the U.S. SST rests largely on two primary considerations:

1. The benefits to the nation must be commensurate with the investment and risks.
2. The U.S. SST program must provide a competitive airplane with substantial inherent speed and performance growth potential.

The benefits discussed previously indicate strongly that a successful U.S. production program will provide a reasonable return on investment for all program participants. It is also important to consider program benefits as they relate to total national strength in the international arena. Viewed from this perspective, the economic and technological benefits from the program could more properly be called necessities.

Technology is generally regarded as a pivotal component of national strength, leading to the strengthening of other primary components. Aviation technology is a particularly significant factor in this respect in the 20th century.

The SST prototype program requirements necessitate technological advance in powerplants, materials, airframe structure, and systems. These developments will result in an airplane capable of carrying high payloads economically at sustained supersonic speed to nearly any intercontinental destination in half a day—a significant achievement in the progress of man. These developments will also contribute materially to other segments of the aviation industry and to other industries.

Translation of SST technology into a fleet of commercial airliners through the production program will directly impact the component of national strength that affects most Americans: the economy. The most evident effect will be the increase of employment related to the manufacture and operation of the SST fleets. Less noticeable, but important, will be the tangible increase in taxes paid to government at all levels. Dollar strength provided by these taxes will become increasingly important in view of the nation's efforts to resolve domestic problems.

Internationally, export sales of U.S.-built SST's will assist in improving this country's world trade position, which has recently been in serious decline. Anticipated export sales will substantially strengthen this trade position.

The existence of a viable U.S.-built SST operated by foreign airlines will also increase the probability of route and trade agreements favorable to the United States.

In the area of physical resources, the performance requirements of the U.S. SST will stimulate development of currently unrealized natural resource potential. Titanium, for example, is one of the most common metals in the earth's surface, but in spite of its remarkable physical qualities it has been rarely used in commercial or industrial products because of high processing costs. The SST requirements for production of titanium in large volume will significantly reduce cost, making the metal usable in a wide variety of industrial and commercial applications.

The U.S. SST contributions to national strength are more than commensurate with the investment and risks.

In competition with foreign airplanes in airline service, the American product will be strongly competitive. Its performance advantage will stem largely from the fact that it starts from a later and superior technological base. The Concorde and TU-144 are engineered near the upper limits of aluminum technology with respect to speed and structural efficiency. By contrast, the U.S. program, based on titanium technology, establishes a new developmental plateau that will be difficult for competitors immediately to attain. Thus, the United States, in its prototype program, is not only taking steps to unlock the whole supersonic technology for the benefit of our national economy, but is also entering at a level that will become a stepping stone to further growth and advancement in air transportation in the future.