AIR TRANSPORTATION IMPLICATIONS OF HIGH TECHNOLOGY ECONOMIC DEVELOPMENT

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ABSTRACT

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In a climate permeated with a growing number of governmental and private endeavors to increase the pace of high technology development in the United States, state and local governments are competing fiercely in the hope for economic growth potentially provided by high technology development. However, as some areas with existing high technology development are experiencing an increasing strain on the local utility infrastructure, especially the transportation system, it is imperative to document the requirements and transportation usage patterns of technology-based firms to provide a sound basis for planning efforts aimed at supporting such development. In particular, special requirements exist in terms of air transportation for both passengers and freight.

The demand for air travel by professionals employed in technology-based firms is predicated by the need for direct personal communication and the high value of time of these tripmakers. Air freight service has not generally been perceived as a determining factor in the location of high technology firms because of its widespread availability to many communities. However, sustained growth and concentration requires planning for the adequate provision of essential air freight service, including not only the airlines carrying the loads, but also appropriate airport facilities to efficiently handle pick-up, delivery, and storage requirements, and good highway access.

This study of the use of air transportation in high technology industries is an effort to obtain basic data related to the relationship between high technology development and travel patterns in terms of air passengers and freight. By documenting these freight and passenger travel patterns, a better understanding of the relationship between air transportation and the evolution of high technology industries can be gained and information provided for future planning activities and transportation policy decisions. This study is an effort to explain the nature of air transportation use within high technology firms. It is based on a survey of a wide range of high technology firms in Austin, Texas. The results of the survey show that Austin is a national high technology center with a strong regional role, based on the reported origin and destination patterns. In attempting to relate a firm's characteristics to its use of air transportation, it was determined that size, in terms of employment, is not a determining factor in explaining air transportation use. Ranges of per employee air trip rates were developed for planning purposes. In

addition, the relative shares of air freight and special delivery services in terms of number of shipments as well as tonnage, were documented, revealing a very strong degree of dependence on these services by technology-based industries.

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Chapter 1

Introduction

1.1 Motivation

1.1.1 Changing Industrial Base

The dynamic nature of the U.S. economy involves the birth, growth, maturation and decline of various industrial sectors. Much of that change is the result of changes in the current state of technology. In the past two decades, the definition of technology has shifted from an industrial manufacturing technology to automation and information technologies. These new technologies are collectively referred to as "high technology" or "high-tech". The term, high technology industries, is most commonly used to denote a group of knowledge-intensive industries actively engaged in developing new products and processes.(1)

Today's high technology economy began in the mid 1960's and was fueled, in large part, by advances in electronics, aerospace and space technology. This was followed, beginning in about 1975, by extremely rapid growth as the developing technology came into widespread use. Except for a slowdown during a recent recession, this rapid growth has continued into the mid 1980's.(2)

As the overall American manufacturing economy has declined over the past fifteen years, the importance of high technology industries has increased. These firms are important not only because of their high growth records but because they develop and transmit new ideas, new capital, and new skills to other sectors of the economy.(3)

1.1.2 International Competitiveness and the Need for Strong Capacity for Technology Innovation

Since the industrial revolution, the leading sectors of the world economy have been the traditional heavy industries, such as coal, rail, steel, automobiles, rubber and machine tools. The nations, regions, and cities in which those industrial sectors were centered became most prosperous.

Over the last fifteen years, about 25 % of the total dollar amount of world trade in engineered products has been for high technology products, including aircraft, computers, nuclear reactors, microchips, machine tools, medical equipment, instruments, telecommunications equipment, office machines, and gas turbines. International competition has intensified because the goal is not just economic growth, in which there is considerable potential, but political stability and influence as well.(4)

Since the early 1970's, the position of the U.S. industry as a global leader in high technology has eroded. Corporate and federal investments in R&D have declined at a time of a stepping up of research efforts by other nations. There is however, a growing realization by public and private sectors that strong steps are needed to restore and maintain America's technological edge.

The major challenge comes from Japan, where the Ministry of International Trade and Industry (MITI) has organized and is subsidizing large multicompany R&D consortia in certain target industries, including steel, automobiles, microelectronics, TV, machine tools, satellites, biotechnology, and artificial intelligence. These consortia select a specific research objective (i.e., a 4 megabit memory chip) and assemble teams of top industrial scientists to develop generic technology. The member companies then develop their own commercial products from the basic prototype. As a result of this innovative approach to technology transfer, Japan has succeeded in obtaining large shares of several U.S. and world markets.

Japan's successes have put American industry on notice that it can no longer take the industrial innovation system for granted, and that it must increase the number of laboratory advances and transfer these advances into effective commercial technology more rapidly than it has in the past.(5)

1.1.3 Federal Government Initiatives

The Federal Government encourages R&D and technological innovation through two activities: funding R&D directly, and creating an economic environment conducive to private investment in R&D and innovation. Direct funding represents the most visible government role in encouraging R&D and innovation. In recent years the Federal Government has funded about half of the R&D conducted in the United States, most of it for public goods related to the missions of particular agencies. National defense is a common example of public good. Defense-related spending claims an increasingly large share of the Federal R&D budget - from 48 percent in 1980 to 70 percent in the fiscal year 1984 budget request, the highest defense share since 1962.

Direct funding of R&D also provides social returns in areas where private industry is likely to underinvest in long-term basic research in which the risks are high and the private returns are smaller than the social returns. Universities carry out over half the basic research conducted in the United States. Funding university research is an aspect of the Government's educational responsibilities.

In addition to direct funding, the Federal Government promotes innovation through policies that encourage increased private sector investment in R&D and new technologies. Fiscal, monetary, regulatory, procurement, and trade policies - all have indirect effects that, collectively, may have more influence on regional high technology development and technological innovation than programs that specifically target R&D.(6)

1.1.4 State and Local Initiatives

The "New Federalism" policy of the Reagan Administration is causing a major realignment of the flow of dollars between the Federal, State, and local levels of government. As the rate of increase in Federal aid is reduced, State and local governments are assuming a larger share of responsibility for providing services to their citizens and businesses. More and more State and local governments are turning to local development programs to accelerate local economic growth. These development programs often center around the high growth, high technology industries. The enhanced competition that has emerged among States and localities has a great potential to stimulate industrial innovation and technological change.(7)

Local governments are often influenced by the tremendous contributions that high technology companies have made to local economies of California's Silicon Valley and the Boston area. In an effort to accelerate local economic growth, or in many instances to slow down and offset losses in certain industrial sectors, many urban areas are targeting high technology and high growth industries such as telecommunications, semiconductors, microprocessors, medical and other precision instruments and related products. These industries are viewed as a necessary ingredient for economic growth and stability.(8)

State and local governments are using a number of initiatives to attract high technology growth, including R&D tax incentives, R&D grants, publicly initiated venture capital pools, business and technical assistance, industry-university joint ventures, and state science and technology policy councils.(9) An Office of Technology Assessment census, conducted in January 1983, identified 153 State government programs with at least some features directed towards high technology development. Of these, 38 were specifically dedicated to the creation, expansion, attraction, or retention of high technology firms.(10)

Examples of the intense inter-area competition for high technology development include the events leading to the June, 1983 choice of Austin, Texas, from a field of 57 cities, as the base location for the Microelectronics and Computer Technology Corporation (MCC), a private, for profit, R&D consortium and the November, 1984 choice of Carnegie-Mellon University in Pittsburgh, Pennsylvania as the location for a $115 million software engineering institute sponsored by the Defense Department.

MCC is a coalition of computer related companies formed in response to the Japanese initiative to develop a fifth-generation computer by 1990.(11) The firm does almost all of its research in-house and focuses on generic technology, the middle portion of the R&D spectrum between basic research and product development. By late summer, 1984, MCC had 18 corporate sponsors and an annual budget of more than $ 70 million.(12) The winning effort to attract MCC was a combination of incentives offered by the State of Texas, the City of Austin Chamber of Commerce, and the University of Texas.

The Defense Department's Software Research Institute will have the task of developing software standards and common languages from the more than 300 programming languages presently in use by the military. The institute will operate at least five years and will employ at least 250 full-time workers. Eight regions lobbied to have the institute located in their backyards, including the State of Texas whose 29 member congressional delegation had hoped to seal the state's reputation as the nation's top up-and-coming center of high technology. The Institute will be located in the economically depressed area of western Pennsylvania.(13)

The most fundamental initiatives are those that aim to quicken the flow of innovation itself. Since most basic research is still performed by universities, many of these initiatives focus on improving relations between universities and industry. Some, such as joint ventures and research consortia, involve formal, long-term collaboration between a university and one or more companies. Others, such as research centers and technical extension services, provide technical assistance or perform short-term research for local firms in exchange for fees or other support. Alumni groups have also become active in patenting and commercializing the results of university research.(14)

Local governments often seek to encourage high technology development through changes in land use and zoning, as well as the provision of public services and facilities. Research and science parks are the most common form of this type of initiative. These parks are parcels of land set aside for research-intensive firms and facilities, with varying tax incentives and eligibility requirements and are usually accompanied by improvements in local utilities, transportation systems, and other infrastructure. More than 150 research and science parks have been developed in the United States since the 1950's. The Stanford Research Park in California is often cited as the model for university science parks, as is the Research Triangle Park in North Carolina. Research Triangle was originally a State government initiative.(15)

An example of private initiative to attract high technology development is the Executive Air Park located in Austin, Texas. This former private grass aircraft landing strip was purchased in 1983 by a development corporation. This corporation plans to develop the property around the airstrip into an industrial park with the general aviation airport serving as an amenity. Plans call for the airstrip to be lengthened and widened to adequately accommodate executive type aircraft. Improved service facilities and a further upgrading of the runway and taxiway lighting is also proposed. The developers of the Executive Air Park are the first to apply for and receive federal development money for a private airport. The $ 1.6 Million in federal money was approved in October 1983. A second grant is now in application. Several inquires have been received from companies who would use the park to ship finished goods out of Austin and from companies with corporate aircraft.(16)

1.2 Objectives

The four principle objectives of this study are to

(a) demonstrate the importance of transportation in the evolution of high-tech industries, (b) provide information for future transportation policy decisions (planning tool), (c) contribute to a better understanding of the relationship between air transportation and the evolution of high technology industries, and (d) document air travel patterns of high technology professionals.

Transportation related measures have generally been overlooked in state and local initiatives to attract high technology development. Early efforts virtually ignored transportation as a factor in the location of high technology development. Over the past year however, there has been increasing interest in the possible role of transportation in high technology development. This is evident in the acknowledgment by the State of Tennessee that "easy access to interstate and commercial air transportation systems" is a factor which contributes to the success of research and technology parks, and the planning for a high technology industrial park to be located at Boston's Logan International Airport.(17) The industrial park would provide companies with space for research and development, manufacturing, warehousing and distribution of products. The easy access to air cargo and general aviation facilities would allow companies to reduce ground handling costs and further reduce loss and damage occurring in the interim. Another feature of the complex is its future designation as a "foreign trade zone" (FTZ) which would be exempt from normal duties, taxes, bonding costs and quotas to increase the competitiveness of the products in foreign markets.(18)

At this time however, there is virtually no information available to guide efforts to integrate transportation within comprehensive development guidelines. One reason for the tendency to overlook the transportation component of high technology development and its potentially far-reaching implications may be the perception that high technology industries are "footloose" or free to move about, that is, when choosing a location for a new plant , more weight can be given to factors such as prevailing wage rates, land costs, local taxes, and regional amenities and less weight needs to be given to the costs involved in transportation.(19) It is generally thought that access to raw materials, access to markets, and transportation are not major locational determinants for high technology industries. Regions that have good access to raw materials and markets, including an efficient transportation network, will not necessarily develop successful high technology centers.(20) The traditional perspective of economic theory is that industrial location is predicated upon the cost of access to production inputs and the cost of access to product markets. For high technology companies, transportation costs to markets, and materials costs tend to be low relative to expenses for research and development, and labor expenses.(21)

The interrelation between transportation and high technology development appears to be important in the planning of a comprehensive development program. Therefore, the involvement of local transportation agencies and professionals is required in local and state economic development strategic planning. To support the long-range planning needed to meet this objective, adequate quantitative tools are needed to predict the demand for the required services. A major part of this study includes the results of a survey designed to determine the demand for air transportation services associated with high technology development.

Chapter 1 of this study has presented a general overview of the present state of high technology development in the U.S. and has introduced the concept that transportation is an important factor in high technology development. The following chapters present a more detailed examination of the high technology industries, including a discussion of the growth process and how this process relates to the need for face to face communication among individuals in the high technology industries and the role of air transportation in this communication. This is followed by a brief review of the literature concerning transportation issues in high technology development.

The second half of this study is devoted to a survey of high technology industries in Austin, Texas. This survey was an attempt to collect data on the use of air transportation by a variety of high technology industries. The development of high technology and air transportation in Austin is discussed first. This is followed by the development and design of the survey and a presentation of the resulting information obtained from the survey. The next two chapters describe an analysis of the air passenger and air freight data respectively collected in the survey. Finally some conclusions drawn from the information in this study are presented along with recommendations for further study.

Chapter 2

Conceptual Background

2.1 Introduction

This chapter examines high technology industrial development from the perspective of its locational and transportation implications. The first part of the chapter begins by discussing several definitions of high technology and the difficulties encountered in attempting to classify industries as high technology. The process of innovation and the evolution of those industries generally considered as being high technology are presented next, followed by a discussion of plant location decisions in light of these innovation and evolutionary processes.

These location decisions often create a need for systems of contact or personal communication. These contact systems develop in response to the need for an exchange of information between professionals or scientists working in particular areas. These individuals are often located in widely separated regions of the country or even in different parts of the world. Related to the requirement for adequate contact systems is a parallel need for voice and data communications and for face to face communications. Telephone lines are commonly used for the exchange of information in the form of direct voice communication and data transmission between data sources. Equally essential are the face to face personal communications between two or more persons. Given the value of the time of the participants in such communications, travel to and from a destination will be primarily by air transportation.

Finally, air transportation for the movement of goods and products is related to the special characteristics of product development, assembly, and distribution. The chapter concludes with a statement concerning the importance of planning for access to air transportation facilities.

2.2 Definition of High Technology

Definitions of high technology firms are often vague due to the indefinite line that sometimes separates makers and users of high technology products and processes. The definition of high technology is complicated by the fact that high technology itself is constantly changing as new innovations render earlier advances obsolete. Many technologies considered advanced 20 years ago, such as plastics or aerospace, are now considered standard. The structure and needs of today's high technology industries are quite different from what they once were, and may also be different from those of the future high technology industries.

Efforts to define high technology firms usually rely on two principal characteristics: a large proportion of professional and technical employees and a significant percentage of sales revenues devoted to research and development. Both of these properties reflect an essential ingredient often called "knowledge intensity" which is necessary for continued innovation. Typically, 40-60 % of the high technology firm's employees have engineering and scientific degrees or are skilled technicians with two or more years of post high school education. Table 1 shows the distribution of occupations in Texas for both the high tech and standard industrial sectors. In general, these firms reinvest between 5% and 15% of their revenues in research and development. These percentages are two to five times higher than for non-high-technology companies.

Table 1
Distribution of Occupations (22)
(by Sector, in Texas)

	Industrial Sector	
Occupation	High Tech	Standard
Professional	27.0 %	14.5 %
Scientific	12.5 %	3.2 %
Technical	15.0 %	6.5 %
Production	30.0 %	44.0 %
Other	15.5 %	31.8 %

Two definitions of high technology industries, both based on three-digit Standard Industrial Classification (SIC) data, are included in Table 2. One is from the Federal government and the other is from the University of Texas. The Federal Department of Labor's Bureau of Labor Statistics (BLS) recognizes three broad categories: manufacturers of high technology products, such as computers; technology-intensive companies, such as chemical or turbine makers; and high technology services such as data processing and software companies. The University of Texas' Bureau of Business Research (BBR) takes a narrower approach, although it also recognizes three categories: electrical and electronic machinery (SIC 36), Instruments (SIC 38), and high tech services (SIC 73).

The lists consist only of SIC codes, not individual firms or establishments; while the industries on the lists share a relatively high reliance on research and development and on scientific, engineering and technical workers, they are far from homogeneous. The firms included in any particular SIC code can vary in size, structure, and in other characteristics that influence their role in and their use of the technological innovation process. Furthermore, the criteria are applied to industry averages, not firms. The lists reflect groups of firms that, while sharing a common

Table 2
Definitions of High-Technology Industry

SIC	Industry Classification	BLS	BBR	AUS
132	Natural gas liquids	X	-	-
281	Industrial inorganic chemicals	X	-	X
282	Plastic materials and synthetics	X	-	X
283	Drugs	X	X	X
284	Soaps, cleaners, and toilet preparations	X	-	-
285	Paints and allied products	X	-	-
286	Industrial organic chemicals	X	-	X
287	Agricultural chemicals	X	-	-
289	Misc. chemical products	X	-	-
291	Petroleum refining	X	-	-
344	Fabricated structural metal products	-	-	X
348	Ordinance and accessories	X	X	-
349	Misc. fabricated metal products	-	-	X
351	Engines and turbines	X	-	-
353	Const., mining, and material handling mach.	-	-	X
355	Special industry machinery	X	-	-
357	Office, computing and accounting mach.	X	X	X
361	Electric transmission and dist. equip.	X	X	X
364	Electric lighting and wiring equipment	-	X	X
365	Radio and TV receiving equipment	X	X	-
366	Communication equipment	X	X	X
367	Electronic components and accessories	X	X	X
369	Miscellaneous electrical machinery	X	X	X
372	Aircraft and parts	X	-	-
376	Guided missiles and space vehicles	X	X	-
379	Misc. transportation equipment	-	X	-
381	Eng., lab., scient., and research inst.	X	X	X
382	Measuring and controlling instruments	X	X	X
383	Optical instruments and lenses	X	X	X
384	Surgical, medical, and dental instruments	X	X	X
385	Ophthalmic goods	-	X	-
386	Photographic equipment and supplies	X	X	-
387	Watches and clocks	-	X	-
506	Wholesale trade, electrical goods	-	-	X
737	Computer & data processing services	X	X	X
739	Research & development laboratories	X	X	X
892	Noncommercial edu., scien., & research org.	-	-	X

BLS - U.S. Dept. of Labor, Bureau of Labor Statistics(23)
BBR - University of Texas, Bureau of Business Research(24)
AUS - Classifications used in this study

product and together satisfying certain criteria, can be quite different. Since the SIC codes are product-oriented, the lists are too. The narrower definitions exclude some industries whose products are not considered high-technology, and do not spend a lot on R&D relative to their sales, but which nevertheless rely heavily on high-technology processes or inputs.

Another important definitional issue concerns innovative or "high-technology" firms in the service sector. The production of computer software, for instance, is an innovative, high-growth, and technology-driven industry, yet it remains hidden in SIC 737, computer programming services.

Table 2 also includes a third column which represents SIC codes of companies or organizations contacted for information used in the preparation of this study. Several classifications used by either the Bureau of Labor Statistics or by the Bureau of Business Research, were not used in this study because there were no such companies in Austin at the time the survey was conducted. On the other hand, several classifications were included in this study which were not included on either of the other two lists. It was decided to include these classifications because the product or service represented by several of the firms in Austin was considered to be closely associated with high technology and exhibited many of the same characteristics of high technology firms in other SIC classifications.

2.3 The Innovation Process

The technological innovation process can usually be broken down into three stages. However, these stages are not necessarily clear-cut and our description is, of necessity, coarse and simplified. Nevertheless, a discussion of these stages does provide an overview of the high technology development process and a framework for an examination of transportation related to the development process.

The first stage, the innovation stage, corresponds to the discovery of ideas and techniques for possible future production and is almost exclusively within the realm of scientific and technological research and invention. These activities take place in technological universities, non-profit research institutes, industrial R&D laboratories and technology-driven firms in research parks. Communities with such resources are said to have a strong technology base and often have a visible concentration of high technology activities. As firms in this stage of development are located close to research and development facilities, travel is normally limited to research personnel who have a need to confer about highly technical matters with colleagues. The trips are usually to other high technology research centers, universities, or technical/professional meetings.

The next stage is that of early growth and involves bringing the commercial potential of a scientific discovery or idea to a point where the technology can be marketed. It is in this stage that the necessary financial backing is sought, potential markets or clients are identified and The product is introduced. During this stage, a firm's access to R&D and manufacturing can facilitate the early commercialization of a product. Access to technical support and expertise as well as access to innovation-oriented venture capitalists and a larger client base is easier when the firm is located within a concentration of high technology activities. California's Santa Clara County and Boston's Route 128 concentrations are prime examples of this phase. R&D and manufacturing are usually clustered at the same location in this phase, to facilitate the transfer from a research technology to a manufacturing technology. Trips made are usually for the purpose of finding financial backing and markets for a potential product and may be made to almost any destination.

A standardization phase follows in which production processes become standardized and the demand for the product expands. In this phase, production may shift to low-cost locations and factors such as land availability, taxes, quality of life, and availability and cost of labor become more important in the selection of new manufacturing locations(25,26). Because of this shift in location of production facilities to low cost locations, extensive travel by management and engineering personnel may be required. In some cases these plants are located as far away as Hong Kong, Korea, or Mexico and travel by air is the quickest and most cost-efficient mode of travel for the persons involved.

In contrast, traditional industries are normally located near the source of the raw materials needed in the production process and near major rail or surface transportation networks. Trips can be made for several purposes including, locating sites for new manufacturing facilities, investigating new manufacturing processes, or review of market characteristics. A look at some of the factors which influence the location decision of high technology firms follows in the next section.

2.4 Locational Influences

An illustration of the importance of air travel to the operations of firms engaged in technological innovation can be found in the agreement reached between the Microelectronics and Computer Technology Corporation (MCC) and the coalition of development promoters in the city of Austin. One of the "incentives" offered by local groups to MCC consisted of the free use of a private executive jet during the first two years of operation. The company subsequently cited that enticement as one that played an important role in their location decision.(27)

The early stages of development of a firm launching a technological innovation are such that its various functional activities, such as management, research and development, manufacturing, etc., usually take place at the same centralized location. This location is usually within an existing high technology conglomerate or "sci-tech" complex. With the maturation of a given product, and the standardization of the production processes, corporate control often becomes increasingly geographically separated from manufacturing and there is a definite trend towards allocating activities according to specialized regional clusters. These multilocational high technology firms increasingly select non-major areas for branch operations, particularly manufacturing. For example, Star Technologies, Inc., manufacturer of an array processor, has chosen a "distributed management" strategy in which the administrative offices are in Portland, Oregon, R&D is in Minneapolis, Minnesota, and production is located in Sterling, Virginia. This calls for a special mix of travel and communications between sites.(28)

2.5 Contact Systems

As technology and market conditions change more and more rapidly, the need to exchange information becomes more intense. High technology development activities are strongly dependent on this exchange of information, therefore informal "contact systems" tend to develop. These contact systems consist of various parties (engineers, scientists, managers, executives, financiers and others) with a need to exchange information. The exchange of information can take the form of face to face contacts, or via technical devices.(29) Personal face-to-face contacts are particularly important to technological innovation and development. Gibson's study of instrument manufacturing in the U.S.(30) points out that, although much research is done within the instrument industry, the nature of the industry's products requires frequent contact between the instrument manufacturer and both private research and development organizations and the research staffs of the end user firms, such as those producing aircraft or space systems, to insure proper design of the intricate and sophisticated instrument systems.

The need for direct personal communication is essential for a variety of reasons, including 1) the exchange of ideas and collaboration on challenging scientific and engineering problems, where the necessary expertise may be limited to a handfull of individuals, 2) implementation and monitoring of new processes at branch manufacturing plants, 3) securing needed financing for new high-risk high-payoff ventures from venture capital sources and 4) identifying appropriate national and international clients for one's products or processes.(31)

The above functions normally involve individuals with a high level of professional training, or individuals in the upper levels of management. In most cases they are highly paid individuals whose time is at a premium. To the extent that newer, smaller geographic concentrations are emerging, maintaining essential contacts and obtaining the required technical and scientific expertise requires frequent travel between these concentrations. Most of this intercity travel will take place using air transportation, given the distances involved and the high value of time of the tripmakers.(32)

A question frequently raised is whether trends in the development and use of electronic communication techniques might increasingly provide a substitute for air passenger travel. Little evidence is available to substantiate this possibility. An attempt was made in 1960 by the University of Michigan Survey Research Center to evaluate this possibility with respect to business travel.(33) It was learned that most business travelers either meet with a group of people or have several appointments. Few trips are made to talk to a single person. Thus the purposes of the trip could not be served by a system of communications designed for conversations between a limited number of persons. Also, it is unusual for the time spent at appointments of business trips to be short. Only a minority of business travelers spend less than six hours with their appointments. Most spend periods of 12 hours and over. Thus, according to Professor John B. Lansing, any new means of communication would have to be suitable for long periods of use in order to substitute for a business trip. He concludes that "business travel is not likely to be replaced by new methods of communication. An alternate possibility is that new methods of communication might complement rather than supplant business travel."(34)

2.6 Freight and Shipping

Overseas locations are of increasing importance to a high technology firm's network of facilities, suppliers and markets. Informal inspection of a terminal or personal computer made in California or Massachusetts, would reveal something of a who's who of international electronics. While assembled in the U.S., 80 to 90 percent of its components may come from overseas.(35)

Many semiconductor manufacturers will fabricate the integrated circuit dies to create wafers which constitute a number of individual integrated microchip circuits. These wafers are then shipped to a location in which labor is relatively inexpensive; Taiwan, Hong Kong, or Mexico for example. The individual microchips are assembled and then shipped back to the U.S. for final assembly and distribution. This procedure calls for fast, reliable freight transportation. This type of product is extremely time-sensitive, due to today's rapid rate of development.

Unlike conventional manufacturing, most goods transported in conjunction with high technology industries, both material inputs and finished products, are of relatively high value and low bulk. In addition, many of these items, such as precise instruments and electronic components, tend to be fragile and unable to withstand careless handling. The high value of the products often makes it preferable to minimize the time during which they are in transit, reducing the likelihood of loss and damage and releasing precious capital that would have otherwise been tied up unproductively (particularly given the fast-changing technologies and market conditions resulting in short commercial shelf lives of many of the products).(36) The transport of time-sensitive, high value, low bulk, fragile items is generally considered a prime candidate for freight service, the additional cost being typically traded-off against the greater speed and higher reliability relative to surface transportation.

There are basically three classes of demand for air freight service (37):

1. emergency demand, when unforeseen problems require highest delivery speed possible
2. regular demand of goods with limited life
3. planned demand, which is part of a firm's logistics strategy based upon an analysis of total distribution costs.

The first two classes are generally perceived to be tied to the air freight mode, while the third is the outcome of a rational choice process. While the first two do occur in conjunction with high technology products, perhaps with higher frequency than conventional manufacturing, it is really the third class that is worthy of note. The high value (per unit weight) and size characteristics of the products of interest lead, in many cases, to the use of air freight as the primary mode of goods transport and a major component of those firms logistics strategy. Reduced inventory strategies, such as just-in-time purchasing could accelerate planned demand for air freight traffic.(38)

Air freight service has not generally been perceived as a determining factor in the location of high technology firms because of its widespread availability to many communities (as evidenced by an examination of the network of

Federal Express and other courier service providers). However, sustained growth and concentration requires planning for the adequate provision of essential air freight service, including not only the airlines carrying the loads, but also appropriate airport facilities to efficiently handle pick-up, delivery, and storage requirements, and good highway access.(39)

An additional concern is the potential for major industrial development in the vicinity of airports. While this is often difficult around existing well-established older facilities, various opportunities exist for newer and contemplated facilities. A recent example is the high technology industrial park to be located at Boston's Logan International Airport described previously in this paper.

In the next chapter, various perspectives concerning high technology development and transportation characteristics of high technology are introduced. This is followed by the presentation of the study of high technology firms in Austin Texas. The information presented up to this point, will be related to the data obtained in the study from the survey of the Austin high tech firms.

Chapter 3

Literature Search

Very little has been written concerning the transportation aspects of high technology development. Most of the literature is concerned with either (1) industrial research as a whole with high technology as one of its components, (2) efforts to attract high technology development in order to strengthen the productivity and competitiveness of an overall regional economy or (3) specific factors as determinants of location and concentration of high technology industries.

In 1984, several articles appeared in a special issue of High Technology magazine.(40) These articles were an analysis of both the domestic and international aspects of the politics and economics of technology and national policy.

A 1984 congressional report, from the Office of Technology Assessment(41), analyzed the potential for local economic growth offered by high technology industries. The report outlines the types of programs used by State and local groups to encourage development of these industries and the implications of these programs for Federal policy. Along with an overview of high technology development, the report attempts to define the high technology industries and describes the roles of entrepreneurship and venture capital in high technology development.

The "Product-Cycle Model", i.e., the three distinct stages of product evolution, was described by Rees.(42) The three stages; the innovation stage, the growth stage, and the standardization phase; are used to explain the high "inter-regional mobility of capital within the United States during the 1970's" and inter-regional shifts in manufacturing in the late 1970's.(43)

In 1981, Graham(44) attempted to identify the factors or conditions "...which explain the pronounced variation in the distribution among geographical subdivisions of the U.S. of the formation of new and small technology-based firms". The results of his study show that the number of technology-intensive universities, non-profit research institutions, and industrial firms is the principal determinate of the formation of new and small technology based firms. Implications for economic policy development are outlined for efforts to stimulate regional economic development in the United States.

Hill and Naroff(45) also studied the factors affecting the location decisions of high technology firms by determining the relative importance of input costs, transfer costs (of inputs and outputs), and demand factors. They concluded that transportation costs are relatively unimportant in location decisions due to the low weight-to-volume ratio of high technology products. The influence of quality of life on the location of new firms was examined by Pennings(46), who studied 70 urban metropolitan areas. He concluded that economic and health/educational quality of life were found to have a positive impact and political and environmental quality of life to have a negative impact on the creation of new firms.

A study by the Joint Economic Committee of The Congress of the United States(47) also identified factors influencing the location decisions of high technology firms. The study identified the most important factors to be labor skills and availability, labor costs and State and local taxes. The study also predicted a significant increase in the portion of the country's high technology firms locating in the Midwest, Southeast, Southwest, and the Mountain and Plains states. The "footloose" nature of high technology development was also mentioned in conjunction with the statement that, "Transportation costs seem not to figure highly in a high technology firm's decision on placement of a new facility."(48)

The relationship between high technology development and employment growth was studied by Glasmeir, Hall, and

Markusen(49) in 1983. They also attempted to isolate the most important variables affecting location decisions. Airport access, they determined, has a, "...very consistent incidence of positive association with high-tech plant growth..."(50) They concluded that, "High-tech industries are not a homogeneous group and that they are highly diverse in their rates of growth (or decline), their potential for plant or job growth, and their patterns of location."(51)

An analysis of contact (communication) systems and their effects on regional development was published by B. Thorngren(52) who reported on theoretical and empirical studies of contact systems. The analysis strived to determine how a knowledge of contact systems could be used to control the course of development by planning bodies at various levels and discussed how contact systems which bring together different activities and regions could effect changes in the structure of regional development. The locational importance of technical information contacts and contrasts between British and American instrument manufacturing firms were noted by R. P. Oakey.(53)

Gibson(54) described instrument manufacture as a high technology industry which is little influenced by transportation costs, i.e., it is footloose. The industry was characterized as "an industry producing sophisticated devices for a sophisticated market where a product's success often depends more upon the scientific and engineering abilities of its originators than on the promotional capabilities of its marketers".(55) Gibson also described the role of agglomeration economies, the tendency for individual firms to cluster, in an industry's geographic pattern.(56)

An early study of the relationship between industry and air transportation took place in June of 1967 when a group of air transportation experts from industry, government, and the academic community were asked to join in a transportation workshop.(57) An ad hoc group was formed whose general purpose was to make a systems-oriented study of the national air transportation system and its interfacing modes, with special emphasis on the future. The Workshop was organized to look at the entire air transportation system. Among the panels formed from this group were a socioeconomics panel, which addressed itself to outlining the socioeconomic environment in which the air transportation industry would be operating in the late 1970's; and a government panel to spell out the government policy climate which might be anticipated. The report from the Workshop contains some interesting projections of trends in both air passenger and air freight transportation.

Toft and Mahmassani(58,59) have studied transportation issues related to high technology development in a series of papers prepared as part of a larger study concerning major transportation issues including high technology trade and domestic and international transportation investment strategies. They conclude that, "The examination of air freight mode shares for identical high technology commodities in comparable cities can be useful in developing a competitive strategy for high technology development"(60), and that while transportation (in general) may not be the key determinant in the selection of a location for a given high tech activity, it is a necessary ingredient of an area's overall capacity to sustain growth and development of high technology-oriented activities."(61)

This brief review has indicated the existing gap in the current literature concerning transportation issues in high technology development. It is essential to include the dynamic nature of high technology growth and development in any model of the high technology processes and it is important to realize that transportation controls and investments are more likely to be effective during certain key stages of the evolution of a high technology system in a given area. However, no planning tools and no data for planning purposes are available to effectively integrate planning for high technology development and transportation systems management.

Chapter 4

Austin Survey

4.1 Overview

To obtain information not available in published literature, a survey of existing high technology companies was conducted to collect data on the specific use of air transportation by these firms. This chapter describes the development of the questionnaire distributed to the firms and introduces the data obtained from the firms responding to the survey, while chapters 5 and 6 present an analysis of that data. However, the development of high technology and of air transportation in the Austin, Texas study area will be described first

4.2 High Technology Development and Air Transportation in Austin, Texas

The first firms that today would be considered as high technology came to Austin in the late 1940's and in the 1950's. These early firms were primarily manufacturers of electrical filters and other electrical components and of

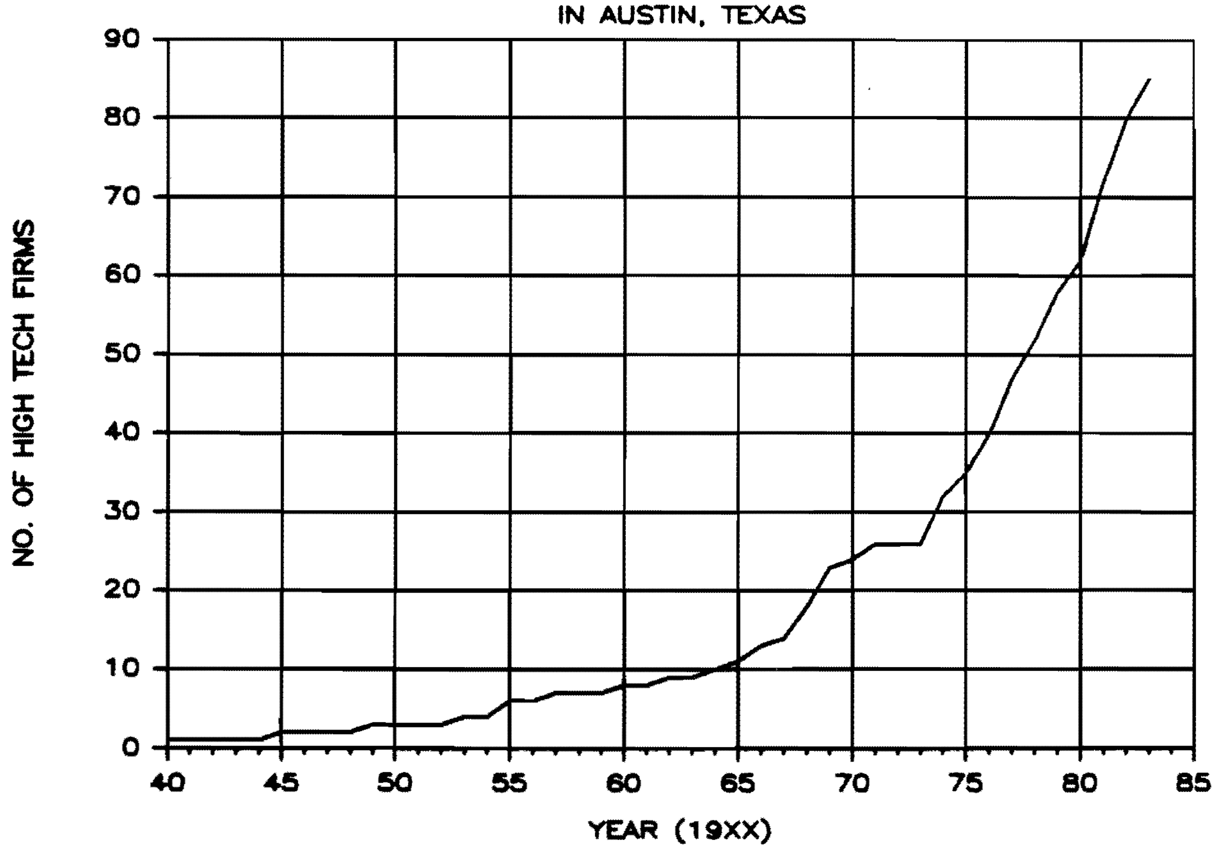
Table 3
Growth of High Technology in Austin

2-digit SIC	Number of Firms 1945	1955	1965	1975	1984
28 Chemicals	0	1	2	2	5
29 Petroleum Refining & Related	0	1	1	1	1
34 Metal Products	0	0	0	1	1
35 Machinery	0	0	0	2	13
36 Elect./Electronic Machinery	0	2	4	14	34
37 Transportation Equip.	0	0	0	0	1
38 Meas.& Analysis Equip.	2	2	4	13	22
39 Misc. Manufacturing	0	0	0	2	2
50 Wholesale Electrical	0	0	0	0	1
73 Computer/Data Proc. & R&D	0	0	0	0	6
TOTAL	2	6	12	35	86

electrical measuring instruments. The field of high technology firms grew quickly in the 1960's and even more rapidly in the 1970's and 80's. Table 3 shows the two-digit SIC codes for the firms contacted in the survey and the number of respective firms located in Austin every ten years from 1945 to 1984. The "Machinery, Including Selected Electrical & Electronic Machinery" category (two-digit SIC 35) experienced the fastest rate of growth in this time period, expanding from 2 firms in 1975 to 13 firms in 1984. This category includes computers, calculating machines, and office machines. The "Electrical, Electronic Machinery, Equipment, and Supplies" (two-digit SIC 36) category experienced the greatest total growth during this time period, from 2 firms in 1955 to 34 firms in 1984. This category includes electronic components and communications equipment.

Figure 1 is a graphic representation of the rapid

Figure 1 — GROWTH OF HIGH TECH
IN AUSTIN, TEXAS



growth of high technology development in Austin. The oldest firm responding to the survey, having located in Austin in 1945, was the Rainhart Company, a firm manufacturing measuring and controlling devices (SIC 3829). This firm had a 1983 employment total of approximately 20. The newest firm responding to the survey was the Microelectronics and Computer Technology Corporation, a research and development organization (SIC 7391). This firm had a total of 150 employees shortly after establishing itself in Austin in 1983 and had grown to 260 employees by the first quarter of 1985. (See Chapter 1 for additional information about this firm.) Figures 2,3, and 4 illustrate the spatial distribution of the high technology firms in the Austin area in 1965, in 1975, and in 1984 respectively.

Figure 5 summarizes the growth of the air passenger traffic at Austin's Robert Mueller Airport. The total number of passengers enplaned and deplaned for each year from 1979 through 1984 is presented. In a similar manner, figure 6 summarizes the total pounds of air freight enplaned and deplaned in the same period. Both figures 5 and 6 are based on data obtained from the Aviation Department of the City of Austin. Robert Mueller Airport is a city-owned municipal airport located 3.5 miles from the central business district. The airport covers 910 acres and has 120,000 square yards of paved ramp space. All airline operations are housed in a 116,000 square foot terminal building. The airport averaged a

Figure 2 - Spatial Locations of High-Tech Industries in Austin 1965

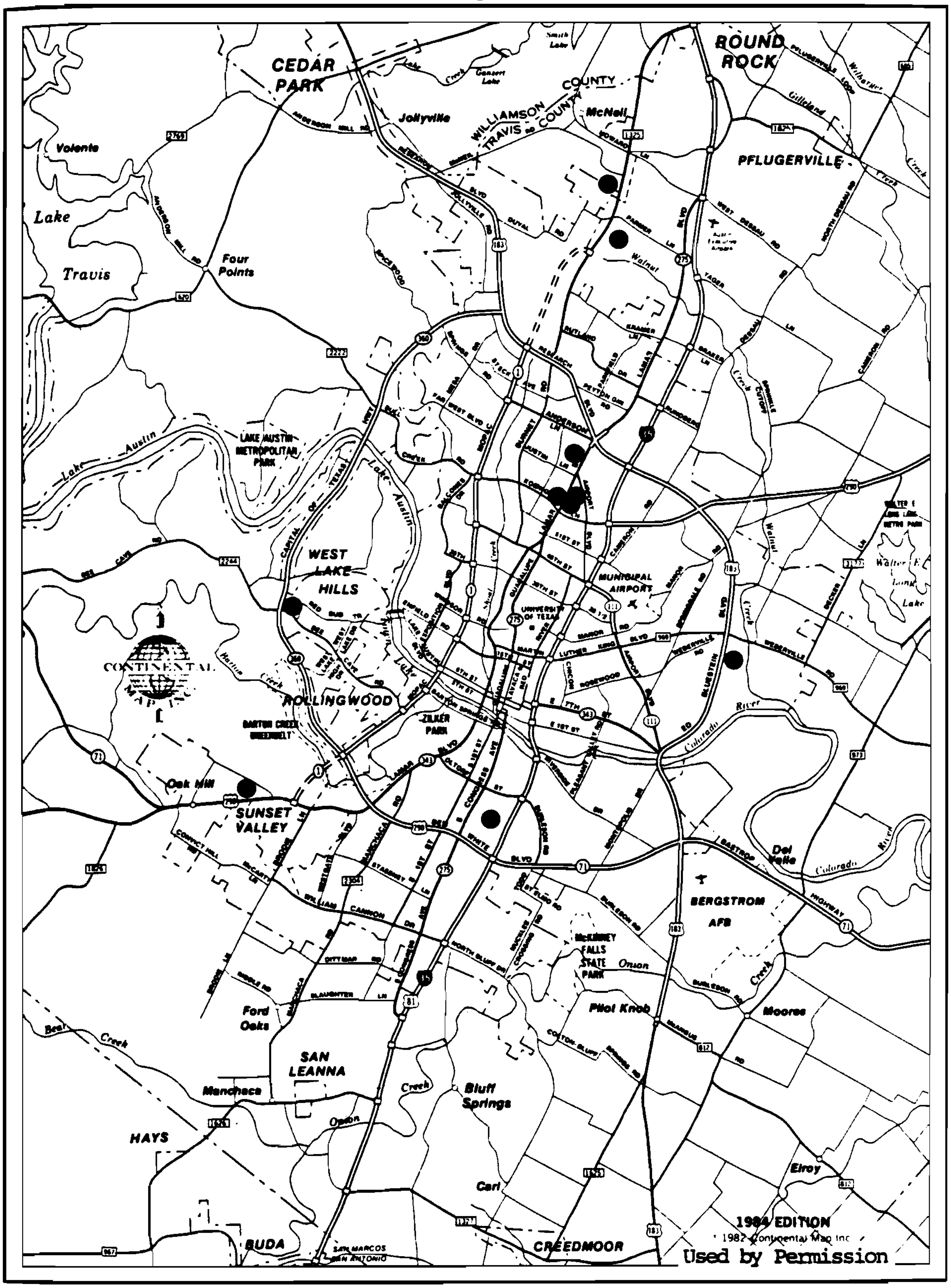


Figure 3 - Spatial Locations of High-Tech Industries in Austin 1975

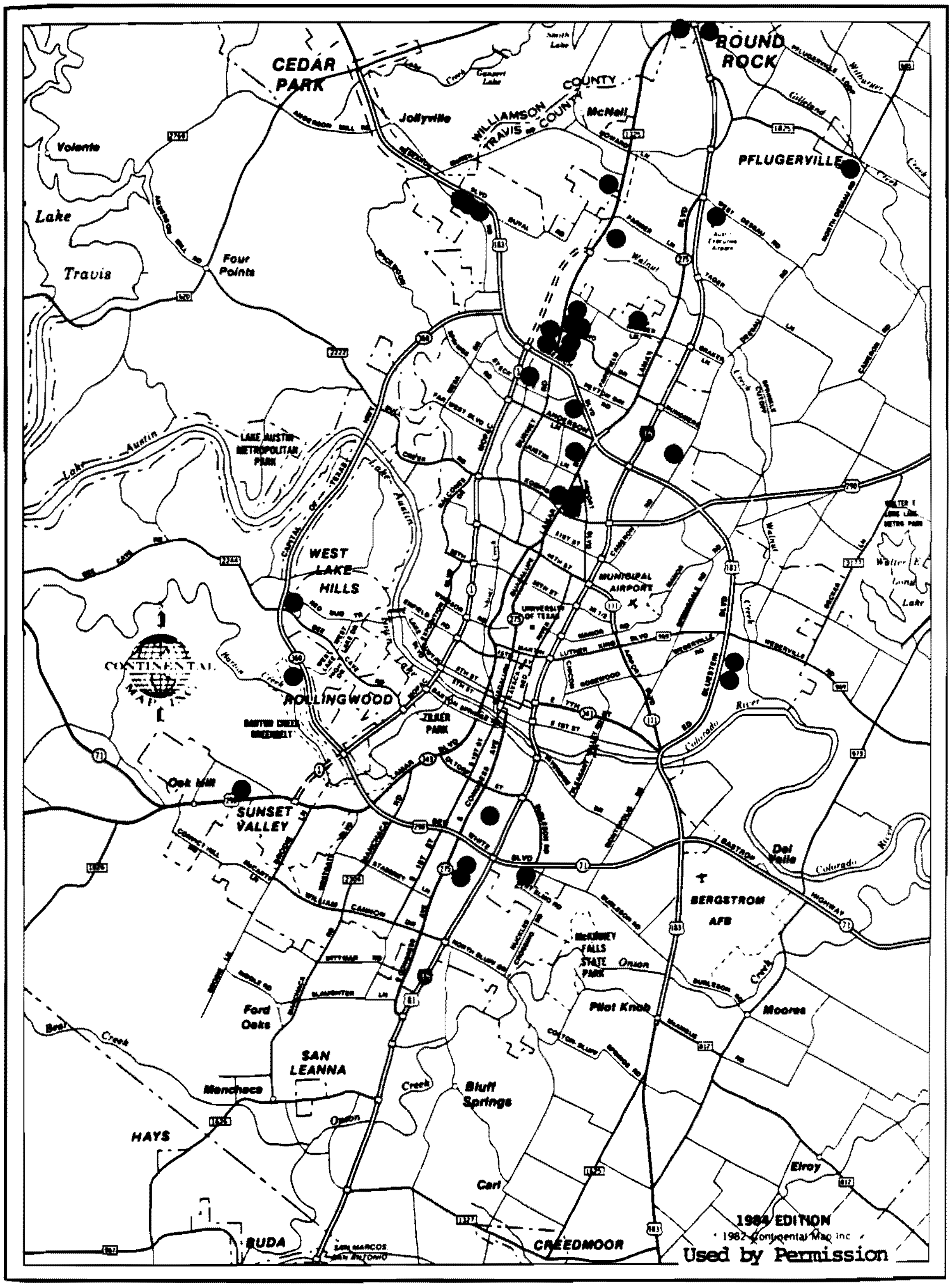


Figure 4 - Spatial Locations of High-Tech Industries in Austin 1984

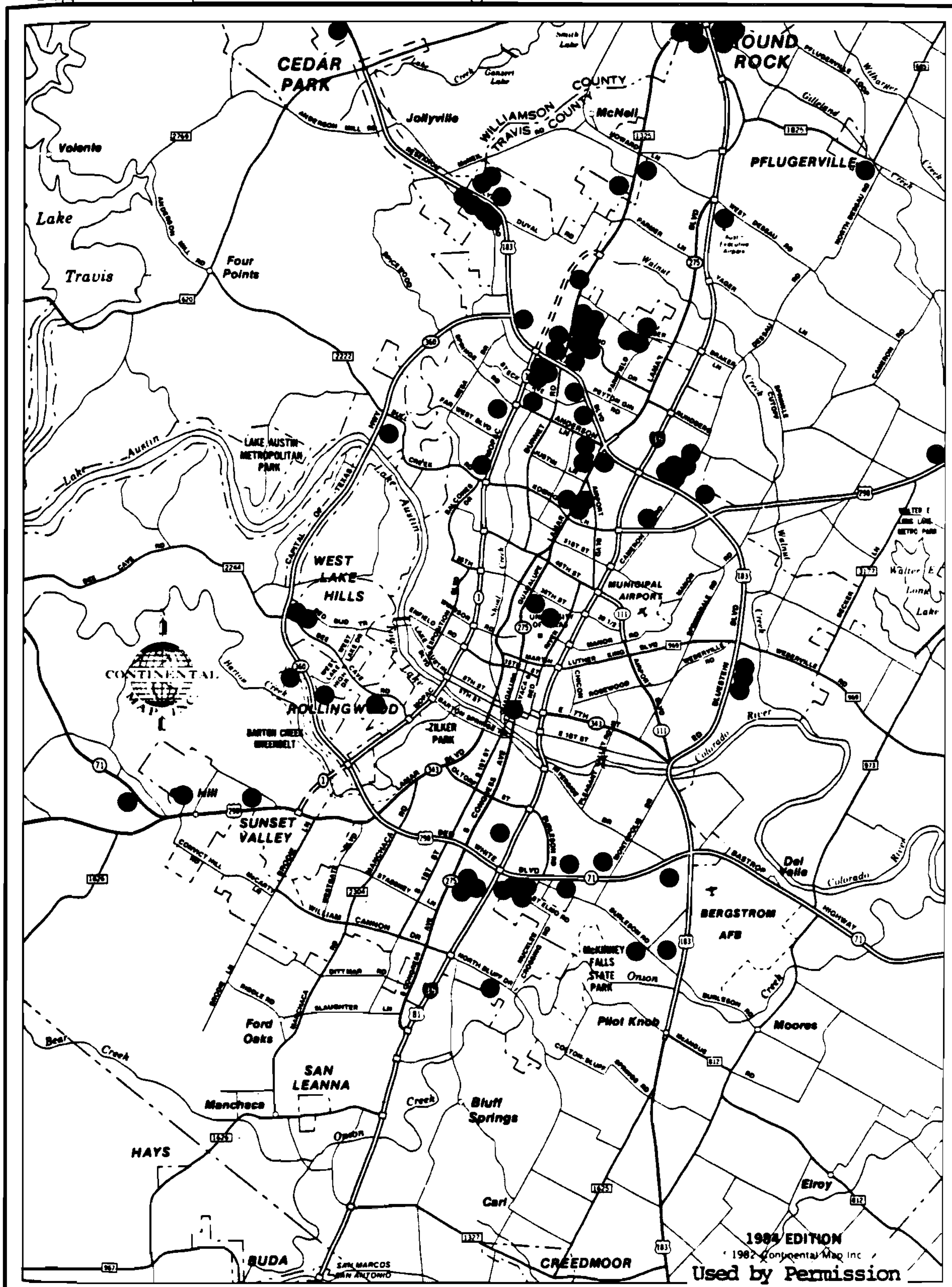
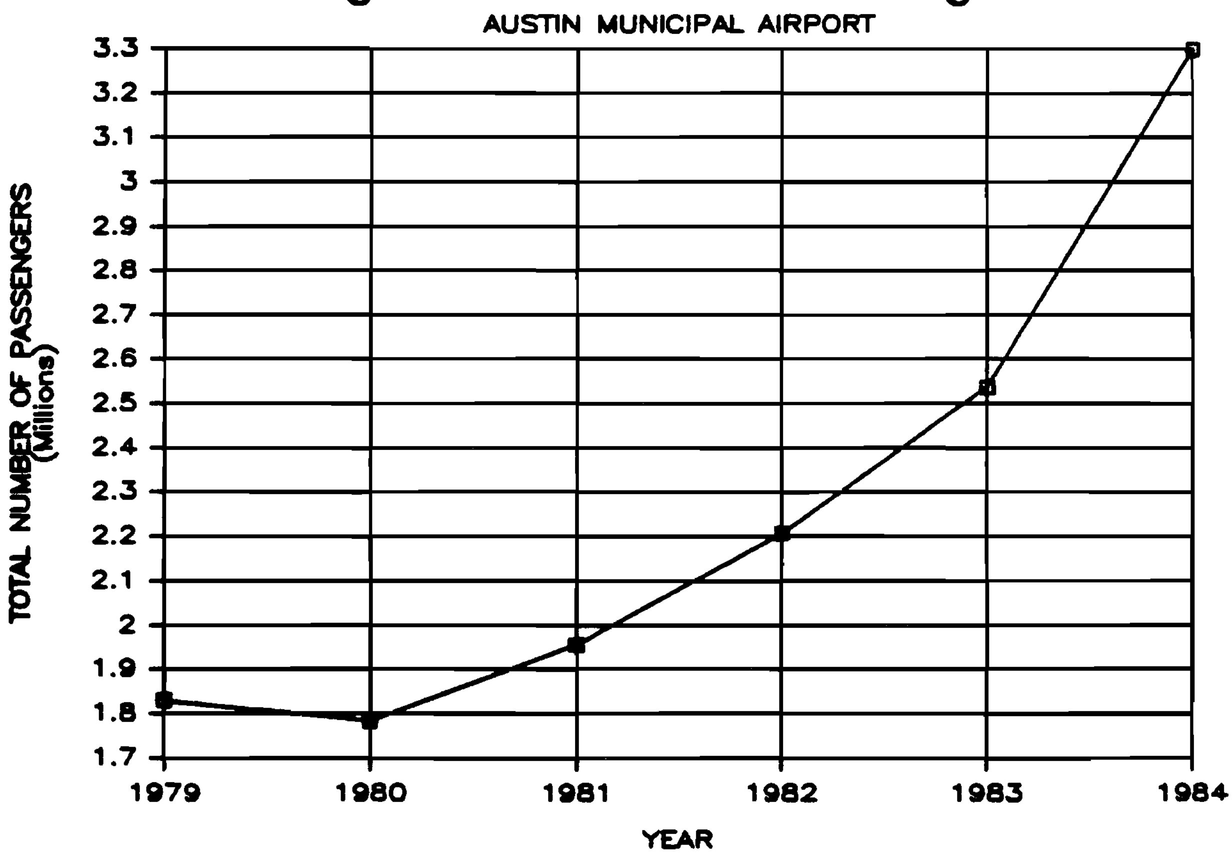


Figure 5 — Air Passengers



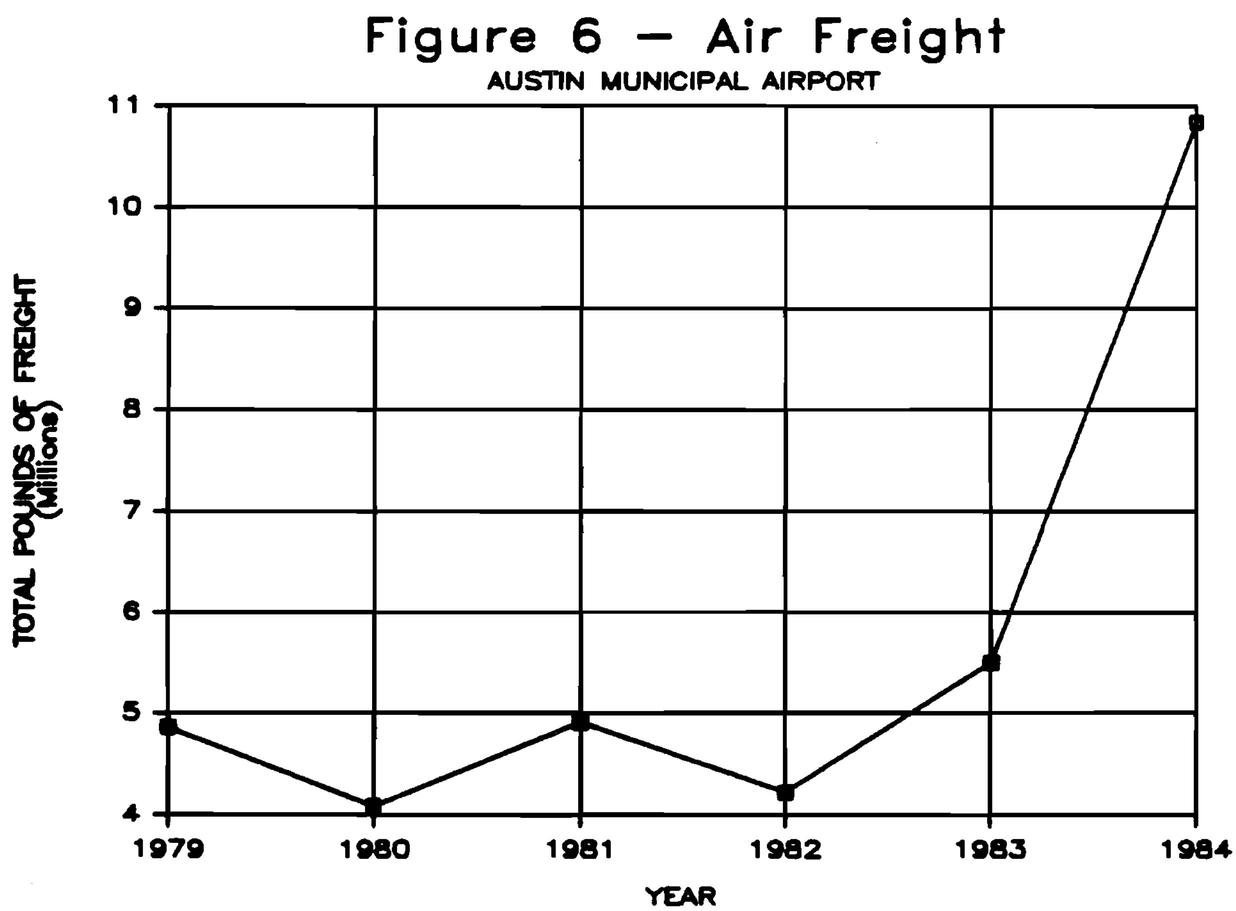


Figure 6 — Air Freight
AUSTIN MUNICIPAL AIRPORT
TOTAL POUNDS OF FREIGHT (Millions)
11
10
9
8
7
6
5
4
1979
1980
1981
1982
1983
1984
YEAR

take-off or landing every 3.1 minutes in 1983. A total of 60,000 square feet of hangar space is provided with facilities for tie-down of 234 private or executive type aircraft. No landing fee is charged for private or executive type aircraft.

The future of this airport is presently in question. There is some doubt as to whether or not the airport, in its present form and as currently operated, can adequately accommodate future growth in air passenger and freight traffic. At issue is whether to expand the airport at its present convenient location or to construct an entirely new airport facility on a larger remote suburban site. A glance at the growth rates presented in this section demonstrates the critical nature of this issue.

4.3 Survey Form

Each of the firms surveyed is located in the Austin area and is categorized by one of the SIC codes listed in Table 1, in Chapter 1, under the column labeled "AUS". The information requested was designed to provide data on the character and quantity of tripmaking in the high technology industries. Specifically, it was desired to determine the destination(s) for each trip made, the mode of air transport (commercial or private aircraft), the duration of each trip and stopover, the type of person (occupation) making the trip, the trip purpose, and information on advance planning of the trip.

The purpose of the survey was to document the travel patterns of the high technology industries, and attempt to relate these travel patterns to certain characteristics of the firm. It was anticipated that a comparison of the characteristics of high technology firms and characteristics of high technology air transportation use would provide useful information for exploring the impact of high technology development on the local, regional, and national air transportation system. Moreover, it was anticipated that analysis of this information would provide some insight into the role played by air transportation in the location decisions of high technology firms.

To accomplish this objective, the survey asked for details about the firm, including:

1. Name and address of company
2. Name and position of person completing the survey
3. Classification of operation of the plant or office
4. Address of parent company
5. Year of incorporation
6. Major business activities of the company
7. Major product (service) lines of the company
8. Product or service market
9. Change in geographical markets
10. Breakdown of number of employees at plant or office
11. Corporation revenues
12. Number of plants or offices
13. Location of other plants or offices

and information related to the travel patterns of the firm, including:

14. Air passenger travel information
15. Private aircraft information
16. departure schedule
17. planning schedule

18. Visitors to plant or office
19. Air freight information

The sample in this study was selected with the aid of the 1983 Directory of Austin Area Manufacturers(62). The directory includes the size of the firm, length of time in Austin, marketing areas, type of organization and chief products of the firm including SIC code for each product. The sample selected represents a mix of large and small firms and a mix of high technology manufacturing, research, and service firms. A total of 86 firms were contacted for information and replies were received from 33 of these firms. A complete list of firms contacted for information appears in Appendix A

Each of the 86 firms chosen was contacted initially in person or by mail and was requested to complete a questionnaire identical to the one shown in Appendix B. Completed questionnaires were received from 13 firms. The form had been pretested through several in-person interviews. However, given the low response rate, it was decided to sacrifice some detail in the interest of obtaining a greater representation. A new questionnaire, shown in Appendix C, was developed. This form was then mailed out to all firms not replying to the first survey. The second questionnaire did not include as many of the questions concerning the details of the company itself and asked for estimates only instead of actual figures.

A total of 20 completed forms were returned from the second survey. The return for the overall survey was 33 replies out of a population of 86 for a return rate of 38.4%. Questionnaire distribution statistics are summarized in Table 4. Of the 33 questionnaires returned in the survey, 27 firms responded with air passenger data, 19 responded with air freight data, and 17 responded to both sections on the questionnaire.

In order to determine if there were any systematic sources of non-response, the list of firms for which no reply was received was informally analyzed using multiple sort techniques. The list of replying firms was analyzed in the same manner. In the multiple sort method used, the lists were sorted by various categories and sub-categories using a

Table 4
Questionnaire Distribution and Response Data

	Long Form	Short Form	Total
No. Questionnaires Distributed	86	69	157
No. Firms Responding	15	23	38
No. Completed Forms Received	13	20	33
Response Rate (Completed Forms)	15.1%	29.0%	38.4%

NOTE: Several firms responded but indicated either that the information requested was proprietary or that the information was unavailable.

Response Rate (Total) = Total Number of Completed Forms Received / Total Number of Firms Contacted different set of categories for each sort. The categories included SIC code, years located in Austin, and number of employees. The results of this analysis did not suggest any systematic difference between those who responded to the survey and those who did not respond. The sample of responses will thus be considered adequately representative of the population of high technology firms in Austin for the purpose of this study.

A list of the firms replying to the survey appears in table 5. The firms, sorted by SIC code, appear in table 6 along with the number of employees, and the year the plant/office was established in Austin. This table illustrates the range of industries included in this study. The firms represent manufacturing as well as research and service industries and are represented by established industries which have been located in Austin for 40 years as well as recent (1983) arrivals. The number of employees for each firm is listed as of the first quarter of 1984. The size of the represented firms ranges from small shops with 4 employees to international corporations employing well over a thousand people.

4.4 Air Passengers

The bulk of the information received in this survey consisted of data on the air passenger and air freight

Table 5
Responding Firms

SIC CODE	INDUSTRY	PASS. INFO	FRT. INFO
2869	Industrial organic chemicals	X	X
3572	Typewriters & parts	X	X
3573	Electronic computing equipment	X	X
3573	Electronic computing equipment	X	X
3613	Switch gear & switchboard apparatus	X	X
3616	Electric transmission and dist. equip.	X	X
3621	Motors & generators	X	X
3622	Industrial controls	X	X
3677	Electronic inductors	X	X
3679	Electronic components, nec	X	X
3679	Electronic components, nec	X	X
3693	X-ray apparatus & tubes	X	X
3811	Eng., lab., sci., & research inst.	X	X
3811	Eng., lab., sci., & research inst.	X	X
3811	Eng., lab., sci., & research inst.	X	X
3825	Electronic measuring instruments	X	X
5065	Wholesale trade, electrical goods	X	X
3674	Semiconductors & related devices	X	-
3674	Semiconductors & related devices	X	-
7391	Research & development laboratories	X	-
2821	Plastics materials	X	-
3823	Industrial meas. & cont. instruments	X	-
2819	Industrial inorganic chemicals	X	-
7391	Research & development laboratories	X	-
3662	Radio & TV communication equipment	X	-
3662	Radio & TV communication equipment	X	-
3670	Electronic components & accessories	X	-
3829	Measuring & controlling devices, nec	-	X
3573	Electronic computing equipment	-	-
3662	Radio & TV communication equipment	-	-
3679	Electronic components, nec	-	-

Summary	PASSENGER DATA	FREIGHT DATA	BOTH
Number of Firms Providing Data	27	19	17

Table 6
Characteristics of Responding Firms

SIC CODE	INDUSTRY	YEAR EST. IN AUSTIN	NO. OF EMPL.
2819	Industrial inorganic chemicals	1960	11
2821	Plastics materials	1978	4
2869	Industrial organic chemicals	1949	200
3572	Typewriters & parts	1977	89
3573	Electronic computing equipment	1967	7000
3573	Electronic computing equipment	1979	40
3573	Electronic computing equipment	1981	190
3613	Switch gear & switchboard apparatus	1979	85
3616	Electric transmission and dist. equip.	1981	155
3621	Motors & generators	1878	1500
3622	Industrial controls	1970	30
3662	Radio & TV communication equipment	1955	1500
3662	Radio & TV communication equipment	1962	160
3662	Radio & TV communication equipment	1982	1500
3670	Electronic components & accessories	1982	50
3674	Semiconductors & related devices	1978	450
3674	Semiconductors & related devices	1979	10
3677	Electronic inductors	1953	35
3679	Electronic components, nec	1974	39
3679	Electronic components, nec	1976	55
3679	Electronic components, nec	1978	16
3693	X-ray apparatus & tubes	1969	130
3811	Eng., lab., sci., & research inst.	1968	10
3811	Eng., lab., sci., & research inst.	1971	5
3811	Eng., lab., sci., & research inst.	1977	7
3823	Industrial meas. & cont. instruments	1957	20
3825	Electronic measuring instruments	1976	20
3829	Measuring & controlling devices, nec	1945	20
5065	Wholesale trade, electrical goods	1981	12
7391	Research & development laboratories	1983	45
7391	Research & development laboratories	1983	150

characteristics of the sampled high-tech firms. The air passenger destination data on trips originating in Austin, was usually returned in the form of trips per region as listed on the second questionnaire. For the purposes of this study, one "trip" was considered as having an origin in Austin and a destination in a defined region. Return trips to Austin were not counted as separate trips but trips with multiple destinations, having an initial origin in Austin, were counted as multiple trips.

A number of firms were able to supply more comprehensive data on their intermediate air stops, the title or department of the person making the trip, the length of stay and the purpose of the trip. The data for one such company is presented in Appendix D as an example of the travel characteristics of a typical high technology corporation. All of the air passenger destination data was broken down into regions to facilitate comparison and analysis. Air passenger destination data is shown in Tables 7 and 8.

The two-letter codes used to distinguish regions for both passenger trips and freight shipments are defined as follows:

NE = New England - Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont

ME = Mideast - Delaware, Washington D.C., Maryland, New Jersey, New York, Pennsylvania, and Virginia

MW = Midwest - Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin

Table 7
HIGH TECHNOLOGY AIR PASSENGER
DESTINATIONS BY REGION (U.S.)
(1983 Trips per Month)

FIRM CODE	NE	ME	MW	SO	SW	MP	FW	DOMESTIC TOTALS
	REGION(*)							
2819	1	0	3	1	0	0	1	6
2821	0	24	0	0	24	0	12	60
2869	14	28	25	23	26	13	16	145
3572	564	1,440	1,668	8,100	3,564	1,896	1,272	18,504
3572	0	1	1	2	2	0	0	6
3573	12	0	0	0	0	0	180	192
3613	12	12	0	0	12	0	12	48
3616	24	24	48	144	12	144	48	444
3622	0	0	0	0	12	0	0	12
3662	0	0	38	0	157	2	1	198
3662	24	24	12	24	12	12	36	144
3670	0	60	0	0	60	0	72	192
3674	5	3	0	1	4	0	5	18
3674	0	0	0	0	8	0	120	128
3677	0	2	3	0	0	1	0	6
3679	192	60	168	36	372	48	168	1,044
3679	1	3	3	1	5	11	4	28
3679	0	0	0	0	190	0	0	190
3693	0	2	0	0	1	0	1	4
3811	0	0	0	0	0	0	1	1
3811	0	12	12	12	0	0	24	60
3811	0	1	0	2	6	0	3	12
3825	0	2	0	0	4	0	1	7
3825	3	2	5	5	5	2	3	25
3825	4	22	32	6	42	6	66	178
5065	0	0	0	0	24	0	12	36
7391	12	12	84	12	60	0	24	204
TOT.	868	1,734	2,102	8,369	4,602	2,135	2,082	21,892

(*) REGION - See text, section 4.4 for definition.

Table 8
HIGH TECHNOLOGY AIR PASSENGER
DESTINATIONS BY REGION (Foreign)
(1983 Trips per Month)

FIRM CODE	REGION(*) CA	EU	LA	SA	AS	OT	FOREIGN TOTALS	TOTAL DOM+FOR
2819	0	0	0	0	0	0	0	6
2821	0	0	0	0	0	0	0	60
2869	2	0	0	0	0	2	4	149
3572	108	336	0	0	180	84	708	19,212
3572	0	0	0	0	0	0	0	6
3573	0	1	0	0	0	0	1	193
3613	0	0	0	0	0	0	0	48
3616	0	12	0	0	0	0	12	456
3622	0	0	0	0	0	0	0	12
3662	0	0	0	0	0	0	0	198
3662	6	2	0	0	0	0	8	152
3670	0	24	0	0	0	0	24	216
3674	0	0	0	0	0	0	0	18
3674	0	0	0	0	0	0	0	128
3677	0	1	0	0	0	0	1	7
3679	12	0	0	0	0	0	12	1,056
3679	0	0	0	0	0	0	0	28
3679	0	0	0	0	0	0	0	190
3693	1	2	2	0	0	4	9	13
3811	0	0	0	0	0	0	0	1
3811	12	0	0	12	0	0	24	84
3811	1	2	0	0	1	0	4	16
3825	0	1	0	0	2	0	3	10
3825	3	0	0	0	0	2	5	30
3825	0	5	0	0	2	2	9	187
5065	0	0	0	0	0	0	0	36
7391	0	0	0	0	0	0	0	204
	145	386	2	185	94	824	824	22,716

(*) REGION - See text, section 4.4 for definition.

SO = South - Alabama, Arkansas, Florida, Georgia, Kentucky, Lousiana, Mississippi, North Carolina, South Carolina, Tennessee, and West Virginia

SW = Southwest - Arizona, New Mexico, Oklahoma, and Texas

MP = Mountain and Plains - Colorado, Idaho, Iowa, Kansas, Missouri, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming

FW = Far West - California, Nevada, Oregon, Washington, Alaska, and Hawaii

CA = Canada

EU = Europe

LA = Latin America (Central America)
SA = South America

AS = Asia

OT = Other

Further analysis of this data is presented in Chapter 5.

4.5 Air Freight

Air freight data was somewhat more difficult to define. Multiple attributes including weight, size and value of each shipment were requested, as well as origin and destination information. The air freight data from individual firms was often incomplete. However, taken as an aggregate, the data can still provide some useful information. Air freight data obtained in the survey is exhibited in Tables 9 and 10.

The term "Parcel" in the MODE column in these tables reflects companies offering a high level of service quality in terms of speed, reliability, and care in handling, such as UPS, AirBorn, Emery, Federal Express, etc. This mode of shipment depends heavily on air transportation as evidenced by the number of parcel delivery firms having their own fleet of aircraft exclusively for the transport of freight. The freight data is analyzed in Chapter 6.

Table 9
AIR FREIGHT DATA (1983)
INBOUND FREIGHT

SIC CODE	SIZE	VALUE	FREQ.	ORIGIN	MODE
3679			15/mo	SW	Parcel
			10/mo	FW	Parcel
3616			10/mo	NE	Air
			10/mo	ME	Air
			50/mo	MW	Air
			10/mo	SO	Air
			5/mo	SW	Air
			100/mo	MP	Air
			10/mo	FW	Air
			2/mo	CA	Air
			1/mo	EU	Air
3825	2-3#	$4-$6000	5-6/day		Air
3572			7/mo	NE	Truck
			16/mo	ME	Truck
			18/mo	MW	Truck
			16/mo	SO	Truck
			14/mo	SW	Truck
			7/mo	FW	Truck
			14/mo	MP	Truck
3679	5#/12ci		8/yr		Parcel
	8#/12ci		26/yr		Parcel
	20-25#/2.25cf		12/yr		Hand
	2#/3cf		12/yr		Parcel
	14#/432ci		26/yr		Parcel
	18#/648ci		14/yr		Hand
	1#/8ci		3/yr		Parcel
	3#/6cf		40/yr		Hand
	75#/1cf		14/yr		Hand
	25#/1.5cf		8/yr		Parcel
	170#/1 pallet		6/yr		Parcel
	25#/1.5cf		18/yr		Hand
	2#/192ci		8/yr		Parcel
	110#/12cf		5/yr		Air
	5#/192ci		10/yr		Parcel
	35#/1cf		3/yr		Parcel
	15#/.67cf		8/yr		Parcel
	23#/1.13cf		6/yr		Parcel

Table 9 (Cont.) - INBOUND FREIGHT

SIC CODE	SIZE	VALUE	FREQ.	ORIGIN	MODE
3613			5/mo	ME	Parcel
			5/mo	FW	Parcel
			10/mo	SO	Parcel
			5/mo	SW	Parcel
3811			6/mo	NE	Air
			1/mo	ME	Air
			1/mo	MW	Air
			1/mo	SO	Air
			25/mo	SW	Air
			1/mo	MP	Air
			4/mo	FW	Air
			1/mo	CA	Air
			4/mo	EU	Air
3622			2/mo	ME	Air
			1/mo	MW	Air
			4/mo	SW	Air
			1/mo	FW	Air
3573			1/mo	NE	Parcel
			1/mo	ME	Parcel
			1/mo	MW	Parcel
			3/mo	SO	Parcel
			3/mo	SE	Parcel
			1/mo	MP	Parcel
			50/mo	FW	Parcel
			2/mo	AS	Parcel
5065			20/mo	SO	Air
			3/mo	MP	Air
			4/mo	FW	Air
3811			1/mo	NE	Air
			.5/mo	ME	Air
			1/mo	MW	Air
			10/mo	SW	Air
			.5/mo	FW	Air
3677	5#/lcf	$500	800/yr	DOM	Parcel

Table 10
AIR FREIGHT DATA (1983)
OUTBOUND FREIGHT

SIC CODE	SIZE	VALUE	FREQ.	DEST.	MODE
3679			10/mo	SW	Parcel
			10/mo	FW	Parcel
3572		$2.00-$40.00	4/mo	ME	Air
			3/mo	MW	Air
			6/mo	SO	Air
3825	40#/24cf	$5000.00	5/yr	AS	Air
			3/yr	EU	Air
			2/yr	EU	Air
			3/yr	EU	Ship
			2/yr	EU	Air
			1/yr	EU	Air
3616			20/mo	NE	Air
			20/mo	ME	Air
			50/mo	MW	Air
			200/mo	SO	Air
			20/mo	SW	Air
			20/mo	MP	Air
			20/mo	FW	Air
			4/mo	CA	Air
			4/mo	EU	Air
3825	2-3#		5-10/wk	SW	Air
	2-3#		5-10/day	SW	Parcel
	8-32# up to 100#		100/day	SW	Parcel
3572			8/mo	NE	Truck
			17/mo	ME	Truck
			18/mo	MW	Truck
			16/mo	SO	Truck
			14/mo	SW	Truck
			14/mo	MP	Truck
			7/mo	FW	Truck
			10/mo	CA	Truck
			36/mo	EU	Truck
			1/mo	LA	Truck
			3/mo	SA	Truck
			2/mo	AS	Truck

Table 10 (Cont.) - OUTBOUND FREIGHT

SIC CODE	SIZE	VALUE	FREQ.	DEST.	MODE
3679	1#/54ci		250/yr	FW	Parcel
	8#/192ci		6/yr	SW	Parcel
	4#/192ci		3/yr	FW	Parcel
	1#/54ci		5/yr		Parcel
	35#/1.5cf		8/yr	FW	Parcel
	3#/192ci		3/yr		Parcel
	25#/1.5cf		2/yr	SW	Parcel
	5#/512ci		5/yr	FW	Parcel
	4#/192ci		8/yr	MP	Parcel
	15#/1cf		3/yr	FW	Parcel
	4#/192ci		2/yr	FW	Parcel
	20#/3.38cf		1/yr	FW	Parcel
	20#/1cf		1/yr	MW	Parcel
	2#/192ci		4/yr	SW	Parcel
	5#/5cf		18/yr		Parcel
3613	40#/8cf	$20K - $60K	5/mo	ME	Air
			5/mo	ME	Air
			5/mo	FW	Air
			5/mo	FW	Air
3811			1/mo	NE	Air
			3/mo	ME	Air
			5/mo	MW	Air
			25/mo	SO	Air
			5/mo	SW	Air
			2/mo	MP	Air
			6/mo	FW	Air
			12/mo	CA	Air
			12/mo	EU	Air
			1/mo	LA	Air
			1/mo	SA	Air
			0.33/mo	AS	Air
3829	8600#		1 time	AS	Air
	6500#		1 time	AS	Air
3811			10/mo	NE	Parcel
			80/mo	ME	Parcel
			85/mo	MW	Parcel
			35/mo	SO	Parcel
			25/mo	SW	Parcel
			15/mo	MP	Parcel
			50/mo	FW	Parcel

Table 10 (Cont.) - OUTBOUND FREIGHT

SIC CODE	SIZE	VALUE	FREQ.	DEST.	MODE
3622		$150.00/board	6/mo	SW	Truck
3573		$2300.00 (Avg.)	5/mo	NE	Air
			10/mo	ME	Air
			5/mo	MW	Air
			2/mo	SO	Air
			2/mo	SW	Air
			1/mo	MP	Air
			50/mo	FW	Air
			2/mo	CA	Air
			5/mo	EU	Air
			1/mo	SA	Air
			3/mo	AS	Air
2869			17/mo	NE	Parcel
			51/mo	ME	Parcel
			54/mo	MW	Parcel
			17/mo	SO	Parcel
			13/mo	SW	Parcel
			13/mo	MP	Parcel
			16/mo	FW	Parcel
			1/mo	CA	Parcel
			5/mo	EU	Parcel
			0.5/mo	LA	Parcel
			0.3/mo	SA	Parcel
			2.3/mo	AS	Parcel
			0.7/mo	OT	Parcel
3693	5K#/1000cf	$65K	7/yr	DOM	Truck
	20#/1cf	$5K	20/yr	DOM	Truck
	20#/1cf	$5K	10/yr	INT	Air
	20#/1cf	$5K	20/yr	INT	Truck
	30#/3cf	$2.5K	90/yr	DOM	Truck
	170#/3cf	$4K	90/yr	DOM	Truck
	170#/3cf	$4K	12/yr	INT	Air
	700#/6cf	$20K	20/yr	DOM	Truck
	100#/6cf	$5K	70/yr	DOM	Truck
	200#/3cf	$5K	300/yr	DOM	Truck
	200#/3cf	$5K	100/yr	INT	Air
	230#/3cf	$10K	20/yr	DOM	Truck
	50#/3cf	$15K	15/yr	DOM	Air
	50#/3cf	$15K	5/yr	INT	Air
	50#/3cf	$25K	50/yr	DOM	Air
	50#/3cf	$18K	60/yr	INT	Air

Table 10 (Cont.) - OUTBOUND FREIGHT

SIC CODE	SIZE	VALUE	FREQ.	DEST.	MODE
3693	var/1000cf	$150K	12/yr	DOM	Truck
	20#/3cf	$450.00	550/yr	INT	Air
	4#/1.5cf	$900.00	730/yr	INT	Air
5065			2/mo	NE	Air
			3/mo	ME	Air
			2/mo	MW	Air
			4/mo	SO	Air
			5/mo	SW	Air
			2/mo	MP	Air
			6/mo	FW	Air
			3/mo	CA	Air
3811			1/mo	FW/ME	Air
3677	25#/2.4cf	$2000.00	800/yr	DOM	Air

Chapter 5

Air Passenger Data Analysis

5.1 Introduction

The general hypothesis tested by this study is that it is possible to identify the characteristics of air passenger and air freight usage by type of high technology firm. Specifically, the study attempts to determine the demand for air transportation services associated with high technology development and to develop ways to predict the impact of high technology development on the air transportation network. This chapter will concentrate on air passengers while chapter 6 is concerned with freight.

Characteristics of the firms included in this study and analyzed in this chapter, include SIC code, number of employees, number of professional or technical employees, length of time established in Austin, and the air passenger and air freight data collected in the survey. Comparisons were made using the various characteristics and conclusions were drawn from these comparisons.

5.2 Data Characteristics

The 28 firms responding to the survey exhibited a range in size from 4 employees to over 7,000 employees. Because of this wide range in the number of employees, the air passenger trip data in tables 7 and 8 is biased towards the trips taken by the larger firms. To overcome this size effect, the number of trips for each firm to each region was divided by the number of employees in that firm. The result, the number of monthly trips per employee, or trip rate, is shown in tables 11 and 12 for domestic and foreign regions respectively and by SIC codes.

Because one of the large firms reported a number of trips that exceeded the number of trips reported by any other firm by more than a factor of ten, figures for that firm were excluded from summaries based on total trips. This firm was, however, included in the analysis when per employee trip rates were used.

5.3 Regional Destinations

As shown in Figure 7, the region to which the greatest number of trips were reported (excluding the above firm's trips) was the Southwest. A total of 1,038 trips per month, or 30.6% of the total number of domestic trips reported, were made to this region. The second most reported

Table 11
HIGH TECHNOLOGY AIR PASSENGER
DESTINATIONS BY REGION PER TOTAL NUMBER OF FIRM EMPLOYEES
(Domestic Monthly Trip Rates)

SIC CODE	NO. EMPL.	NE	ME	MW	SO	SW	MP	FW	DOMESTIC TOTALS
		---------- REGIONAL TRIPS ----------							
2819	11	0.09	0.00	0.27	0.09	0.00	0.00	0.09	0.55
2821	4	0.00	6.00	0.00	0.00	6.00	0.00	3.00	15.00
2869	200	0.07	0.14	0.13	0.12	0.13	0.07	0.08	0.73
3572	89	0.00	0.01	0.01	0.02	0.02	0.00	0.00	0.07
3572	7,000	0.08	0.21	0.24	1.16	0.51	0.27	0.18	2.64
3573	190	0.06	0.00	0.00	0.00	0.00	0.00	0.95	1.01
3613	85	0.14	0.14	0.00	0.00	0.14	0.00	0.14	0.56
3616	155	0.15	0.15	0.31	0.93	0.08	0.93	0.31	2.86
3622	30	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.40
3662	160	0.15	0.15	0.08	0.15	0.08	0.08	0.23	0.90
3662	1,500	0.00	0.00	0.03	0.00	0.10	0.00	0.00	0.13
3670	50	0.00	1.20	0.00	0.00	1.20	0.00	1.44	3.84
3674	450	0.00	0.00	0.00	0.00	0.02	0.00	0.27	0.28
3674	10	0.50	0.30	0.00	0.10	0.40	0.00	0.50	1.80
3677	35	0.00	0.06	0.09	0.00	0.00	0.03	0.00	0.17
3679	16	0.00	0.00	0.00	0.00	11.88	0.00	0.00	11.88
3679	55	0.02	0.05	0.05	0.02	0.09	0.20	0.07	0.51
3679	39	4.92	1.54	4.31	0.92	9.54	1.23	4.31	26.77
3693	130	0.00	0.02	0.00	0.00	0.01	0.00	0.01	0.03
3811	10	0.00	0.10	0.00	0.20	0.60	0.00	0.30	1.20
3811	7	0.00	1.71	1.71	1.71	0.00	0.00	3.43	8.57
3811	5	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20
3823	20	0.15	0.10	0.25	0.25	0.25	0.10	0.15	1.25
3825	380	0.01	0.06	0.08	0.02	0.11	0.02	0.17	0.47
3825	20	0.00	0.10	0.00	0.00	0.20	0.00	0.05	0.35
5065	12	0.00	0.00	0.00	0.00	2.00	0.00	1.00	3.00
7391	150	0.11	0.03	0.09	0.02	0.21	0.03	0.09	0.58
7391	45	0.27	0.27	1.87	0.27	1.33	0.00	0.53	4.53
TOT.	10,858								
AVG.	387.79	0.24	0.44	0.34	0.21	1.26	0.11	0.63	3.22
STD.	1,303.56	0.91	1.16	0.89	0.42	2.88	0.28	1.09	5.78
MIN.	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
MAX.	7,000.00	4.92	6.00	4.31	1.71	11.88	1.23	4.31	26.77

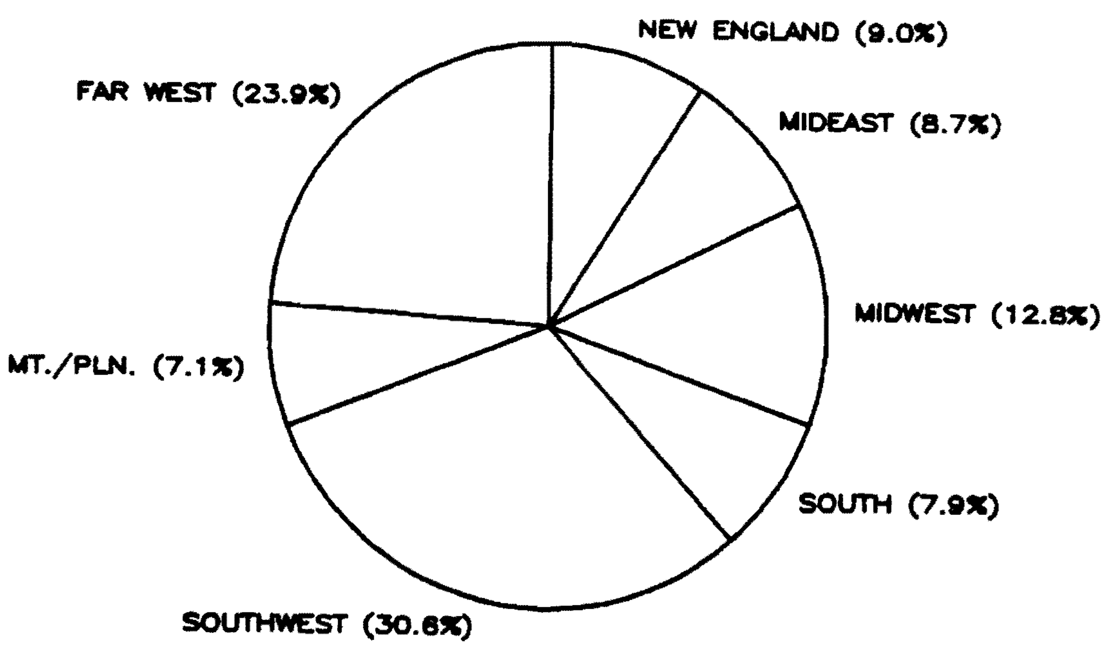
TOT = Total AVG = Average STD = Standard Deviation
MIN = Minimum MAX = Maximum

Table 12
HIGH TECHNOLOGY AIR PASSENGER
DESTINATIONS BY REGION PER TOTAL NUMBER OF FIRM EMPLOYEES
(Foreign Monthly Trip Rates)

SIC CODE	NO. EMPL.	CA	EU	LA	SA	AS	OT	FOREIGN TOTALS	TOTAL ALL
		------- REGIONAL TRIPS -------							
2819	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
2821	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00
2869	200	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.75
3572	89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
3572	7000	0.02	0.05	0.00	0.00	0.03	0.01	0.10	2.74
3573	190	0.00	0.01	0.00	0.00	0.00	0.00	0.01	1.02
3613	85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
3616	155	0.00	0.08	0.00	0.00	0.00	0.00	0.08	2.94
3622	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
3662	160	0.04	0.01	0.00	0.00	0.00	0.00	0.05	0.95
3662	1500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
3670	50	0.00	0.48	0.00	0.00	0.00	0.00	0.48	4.32
3674	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80
3674	450	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
3677	35	0.00	0.03	0.00	0.00	0.00	0.00	0.03	0.20
3679	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.88
3679	39	0.31	0.00	0.00	0.00	0.00	0.00	0.31	27.08
3679	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
3693	130	0.01	0.02	0.02	0.00	0.00	0.03	0.07	0.10
3811	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
3811	7	1.71	0.00	0.00	1.71	0.00	0.00	3.43	12.00
3811	10	0.10	0.20	0.00	0.00	0.10	0.00	0.40	1.60
3823	20	0.15	0.00	0.00	0.00	0.00	0.10	0.25	1.50
3825	20	0.00	0.05	0.00	0.00	0.10	0.00	0.15	0.50
3825	380	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.49
5065	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
7391	45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.53
7391	150	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.59
TOT.	10,858								
AVG.	387.79	0.08	0.03	0.00	0.06	0.01	0.01	0.19	3.42
STD.	1,303.56	0.32	0.09	0.00	0.32	0.03	0.02	0.64	5.96
MIN.	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
MAX.	7,000.00	1.71	0.48	0.02	1.71	0.10	0.10	3.43	27.08

Figure 7 — Air Passenger Trips

DOMESTIC TRIP TOTAL = 3592/MO.



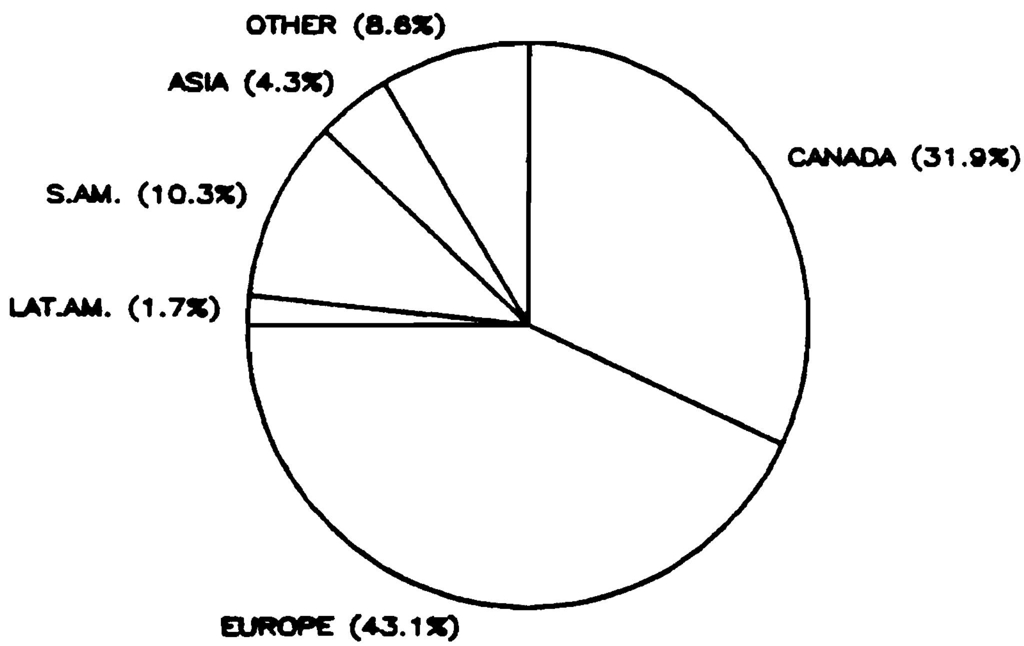
destination, the Far West, collected 23.9% of the reported trips. This region includes the high-technology-rich San Francisco/San Jose area of California as well as the high technology regions of Southern California and the Oregon Coast.

The Midwestern states collected the third largest share of the trips with 12.8% of the reported trips. This region, which contains relatively densely populated areas in the states of Illinois, Indiana, Michigan, and Ohio, is considered the second largest population area of the United States. The other four regions each collected between 7% and 9% of the reported trips. These results were not surprising considering the market potential and the growing potential for high technology development in the Southwestern region and the established high technology development in the Far West. The industrial Midwest area of the United States is a source for materials and components used in high technology manufacturing processes.

The largest fraction of foreign trips reported in the survey (43.1%), shown in Figure 8 (excluding trips from one particular firm) , were to Europe. Just under a third of the reported trips (31.9%) were to Canada. It seems logical that Europe and Canada would both have high percentages of the reported trips given the interrelation between the United States, Western European and Canadian economies. The potential markets in Europe and in Canada also serve to

Figure 8 — Air Passenger Trips

FOREIGN TRIP TOTAL = 116/MO.



increase the number of trips made to these regions. Tables 7 and 8 in the previous chapter present a breakdown of the total trips reported in the survey.

5.4 Trip Rates

For purposes herein, Trip Rate is defined as the number of trips per month made by a firm to a region divided by the number of employees in that firm. The trip rates for each firm and each regional destination are shown in tables 11 and 12. Average Trip Rates are given for each region as well as the standard deviation, minimum rates, and maximum rates per region. The Average Trip Rate in tables 11 and 12 is defined as the sum of the trip rates for a region divided by the total number of firms reporting trips to that region.

The highest domestic average trip rate is 1.26 trips per employee for the Southwestern region followed by 0.63 trips per employee for the Far West region of the U.S. Due to the low number of foreign trips reported, analysis by trip rate was inconclusive when compared by destination region.

In Table 13, trip Rates are compared based on two-digit SIC categories. These categories correspond to groups of similar industries. The average trip rates in table 13 are defined as the sum of total trip rates for the SIC category divided by the number of firms in the two-digit SIC category. The highest average trip rate in this analysis

Table 13
Air Passenger Trips per 2-Digit SIC Code

2 DIGIT SIC	NO. OF FIRMS	TRIP RATE MIN	TRIP RATE MAX	TRIP RATE AVG*	SIZE MIN	SIZE MAX	SIZE AVG
28	3	0.55	15.00	5.43	4.00	200.00	71.67
35	3	0.07	2.74	1.28	89.00	7,000.00	2426.33
36	13	0.10	27.08	3.93	10.00	1,500.00	208.85
38	6	0.20	12.00	2.72	5.00	380.00	73.67
50	1	3.00	3.00	3.00	12.00	12.00	12.00
73	2	0.59	4.53	2.56	45.00	150.00	97.50
ALL	28	0.07	27.08	3.42	4.00	7,000.00	387.79

$$\text{*AVG. Trip Rate} = \frac{\text{Sum of (No.of Trips/employee per firm)}}{\text{No. of firms}}$$

(5.43) was in SIC category 28; Chemical and Allied Products. The smallest average trip rate was 1.28 in SIC category 35; Machinery, including Selected Electrical and Electronic Machinery. Because of the difficulty in defining high technology industries by SIC category, as discussed earlier in chapter 2, these SIC categories can be misleading. For example, SIC category 35 includes garden tractors as well as computers.

Table 13 also includes the ranges of rates for each two-digit SIC category. These ranges are shown graphically in Figure 9. The largest range of trip rates was reported by firms in category 36; Electrical and Electronic Machinery, Equipment and Supplies. However, the range of trip rates for the SIC categories is, with one exception, directly related to the number of firms reporting in each category.

Figure 9 — Trip Rate Ranges

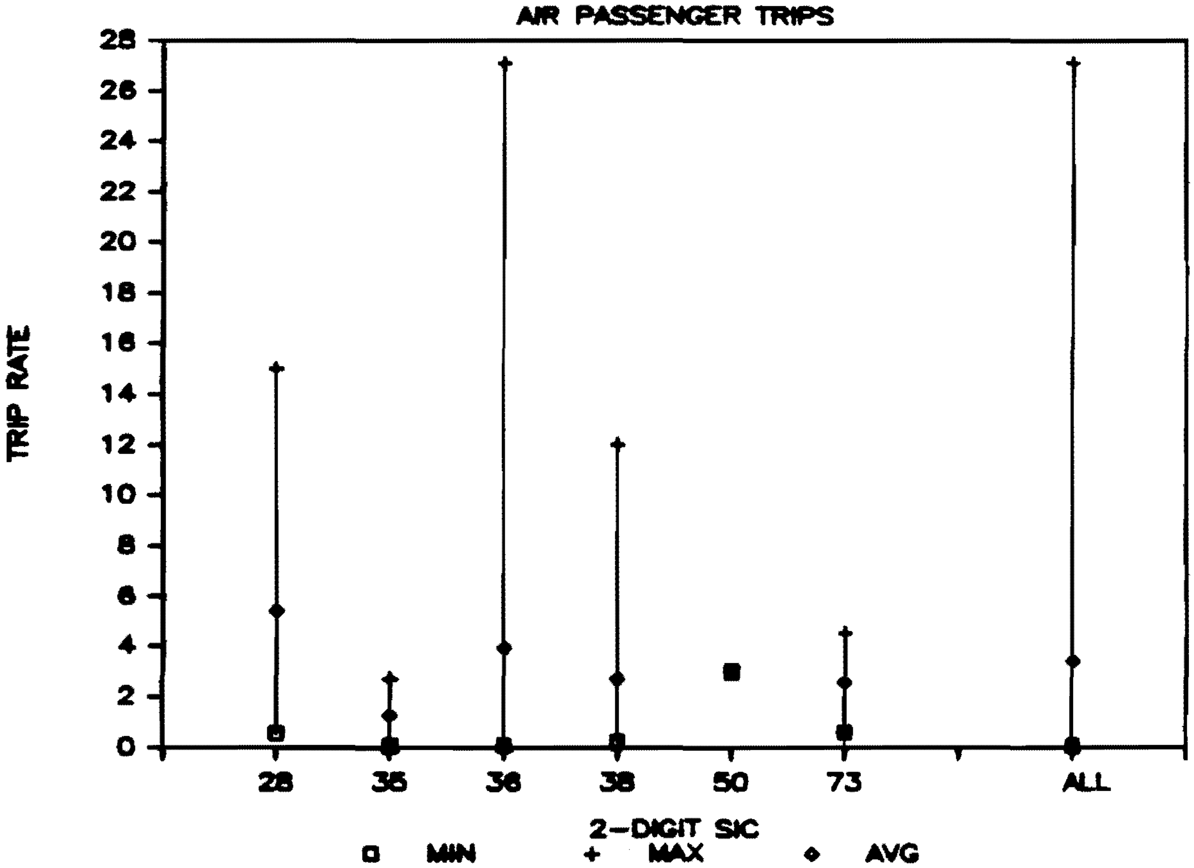


Table 14
DISTRIBUTION OF TRIP RATES

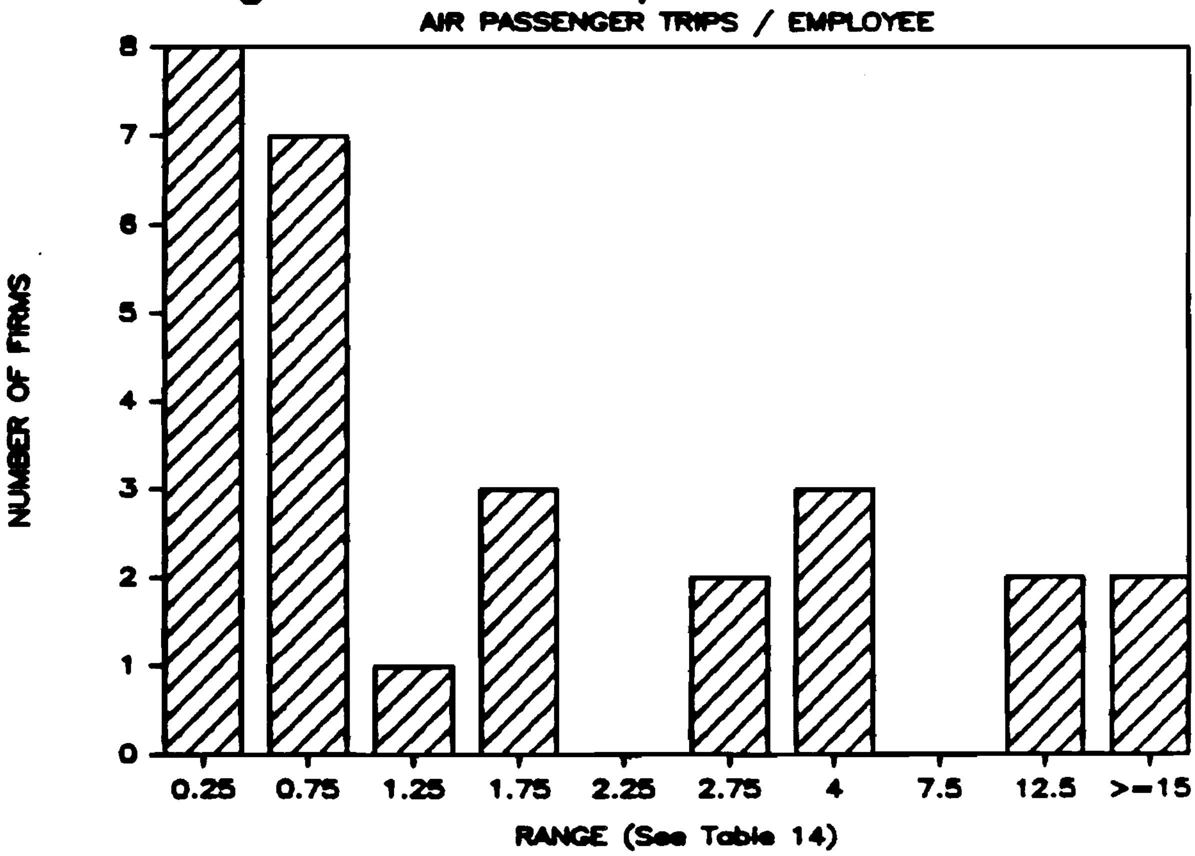
TRIP RATE RANGE	NUMBER OF FIRMS		
	DOMESTIC	FOREIGN	ALL TRIPS
0 - 0.49	9	27	8
0.5 - 0.99	6	0	7
1 - 1.49	3	0	1
1.5 - 1.99	1	0	3
2 - 2.49	0	0	0
2.5 - 2.99	2	0	2
3 - 4.99	3	1	3
5 - 9.99	1	0	0
10 - 14.99	1	0	2
> = 15	2	0	2

The next summary of the passenger trip data was in the form of a frequency distribution of the trip rates. Figure 10 shows the distribution of trip rates (also shown in tabular form in Table 14). The distribution shows that 68% of the firms reported between 0 and 1 trips per employee and 27% of the firms reported between 2 and 4 trips per employee.

5.5 Correlation Tests

The trip rates were then compared to the number of employees in each firm. The Spearman Rank Correlation Test(63) was used to determine if the trip rate was related to the size of the company. This non-parametric test is used to determine the correlation between two sets of ranked data, in this case the trip rates and the size of the firms. The correlation coefficient for this test can lie between +1 and -1 (corresponding to perfect positive and negative

Figure 10 — Trip Rate Distribution



correlation, respectively, between the two variables). The coefficient will lie near zero if there is no correlation. The Spearman rank coefficient for the data in Table 15 was -0.33, which results in the null hypothesis of "no correlation" being rejected with 95% confidence, but not 97.5% confidence. It is apparent that size may not be the only factor in explaining trip rates, although there is a significant relationship.

This test was again used to compare the trip rates to the percentage of engineering personnel in 8 of the firms contacted in the survey. Employee breakdowns were provided by 9 firms in the survey and are shown in Table 16. However, one of these firms provided no air passenger data. Due to the extremely small sample on which this test is based, caution should be exercised in the interpretation of this data. The result of the Spearman test for this data is shown in Table 17. A coefficient of -0.071 was determined for the data sets. Table 18 shows the correlation coefficient calculations using the percentage of administrative plus engineering personnel, No meaningful conclusions can be reached on the basis of these tests as they are based on an extremely small sample which does not allow proper testing of the many hypotheses regarding tripmaking by high technology firms.

The Spearman test was also used to compare trip rates to 1983 Austin firm revenues. This data, shown in Table 19, varied from a low of $0.2 M. to a high of $400 M. Average

Table 15
Spearman Rank Correlation Test
Number of Employees vs. Monthly Trip Rate

SIC CODE	RANK Xn	NO. EMPL.	RANK Yn	TRIP RATE	X-Y	(X-Y)^2
2821	1	4	27	15.00	-26	676
3811	2	5	4	0.20	-2	4
3811	3	7	26	12.00	-23	529
3811	4.5	10	18	1.60	-13.5	182.25
3674	4.5	10	19	1.80	-14.5	210.25
2819	6	11	11	0.55	-5	25
5065	7	12	22	3.00	-15	225
3679	8	16	25	11.88	-17	289
3825	9.5	20	9	0.50	0.5	0.25
3823	9.5	20	17	1.50	-7.5	56.25
3622	11	30	7	0.40	4	16
3677	12	35	5	0.20	7	49
3679	13	39	28	27.08	-15	225
7391	14	45	24	4.53	-10	100
3670	15	50	23	4.32	-8	64
3679	16	55	10	0.51	6	36
3613	17	85	12	0.56	5	25
3574	18	89	1	0.07	17	289
3693	19	130	2	0.10	17	289
7391	20	150	13	0.59	7	49
3616	21	155	21	2.94	0	0
3662	22	160	15	0.95	7	49
3573	23	190	16	1.02	7	49
2869	24	200	14	0.75	10	100
3825	25	380	8	0.49	17	289
3674	26	450	6	0.28	20	400
3662	27	1,500	3	0.13	24	576
3572	28	7,000	20	2.74	8	64
			SUM. OF (Xn - Yn)^2		=	4866

$$r = 1 - \frac{6T}{n(n^2 - 1)} \qquad \text{where: } T = \text{SUM. of } (Xn - Yn)^2$$

$$r = 1 - ((6 * 4866) / (28 * (28^2 - 1)))$$

$$r = -0.33$$

Table 16
EMPLOYEE BREAKDOWN

SIC Code	No. of Employees Total	Admin.	Engr.	% Admin. + Engr.	% Engr.	Total Trips	Trip Rate
3674	10	1	8	90.0%	80.0%	18	1.80
3662	1500	300	600	60.0%	40.0%	198	0.13
3573	40	7	15	55.0%	37.5%	-	-
3613	85	21	21	49.4%	24.7%	48	0.56
3693	130	25	35	46.2%	26.9%	13	0.10
2819	11	3	1	36.4%	9.1%	6	0.55
3677	35	8	4	34.3%	11.4%	7	0.20
3825	20	4	2	30.0%	10.0%	10	0.50
3674	450	3	50	11.8%	11.1%	128	0.28
AVG.	253.4	41.3	81.8	48.6%	32.3%		

revenue, among the 21 firms reporting in this category, was $62.5 M. When compared to trip rates, a correlation coefficient of -0.612 was obtained which allows a rejection of the "no correlation" hypothesis with over 99.5% confidence. This indicates a rather strong negative correlation between revenues and trip rates. This test is shown in Table 20.

Responses were initially anticipated from each firm surveyed regarding the composition of their workforce, as well as the number of trips made by each occupational category, (such as, trips by engineers, by executives, etc.). This data would have allowed us to perform a multivariate analysis of the factors affecting tripmaking by high technology firms.

5.6 Other Air Passenger Data

Table 19 also shows information concerning the use of

Table 17
Correlation Test
Number of Engineering Personnel Vs. Trip Rate

SIC CODE	RANK Xn	% ENGR.	RANK Yn	TRIP RATE	X-Y	(X-Y)^2
2819	1	9.1	6	0.55	-5	25
3825	2	10.0	5	0.50	-3	9
3674	3	11.1	4	0.28	-1	1
3677	4	11.4	3	0.20	1	1
3613	5	24.7	7	0.56	-2	4
3693	6	26.9	1	0.10	5	25
3662	7	40.0	2	0.13	5	25
3674	8	80.0	8	1.80	0	0
						90

r = - 0.071

Table 18
Correlation Test
Number of Administrative and Engineering Personnel
vs. Trip Rate

SIC CODE	RANK Xn	% ADM&ENG	RANK Yn	TRIP RATE	X-Y	(X-Y)^2
3674	1	11.8	4	0.28	-3	9
3825	2	30.0	5	0.50	-3	9
3677	3	34.3	3	0.20	0	0
2819	4	36.4	6	0.55	-2	4
3693	5	46.2	1	0.10	4	16
3613	6	49.4	7	0.56	-1	1
3662	7	60.0	2	0.13	5	25
3674	8	90.0	8	1.80	0	0
						64

r = 0.238

Table 19
MISC. FIRM INFORMATION

SIC CODE	NO. EMPL.	USE OF PVT. AIRCRAFT	DEPART DAY OF OR DAY BEFORE MEETING	ADVANCE TRIP PLANNING TIME	1983 CORP. REVENUES ($ M)
2819	11	OWN	DAY	1-4 WK	4.0
2821	4		BEFORE		0.2
2869	200		BEFORE		
3572	89		BEFORE		
3572	7000		BEFORE		
3573	40			1-4 WK	1.0
3573	190		BEFORE		400.0
3613	85		BEFORE		2.4
3616	155		BEFORE		
3622	30		DAY		3.6
3662	160	RENT/PRIV	BEFORE		5.1
3662	1500	PRIV.	BEFORE	2-7 DAY	394.0
3670	50		DAY		
3674	10		BEFORE	2-7 DAY	0.6
3674	450		BEFORE	1-4 WK	358.0
3677	35		BEFORE	1-6 MO	1.5
3679	16		BEFORE		1.5
3679	39				1.0
3679	55		BEFORE		
3693	130		BEFORE	1-4 WK	10.0
3811	5			6-12 MO	
3811	7		BEFORE		2.0
3811	10		BEFORE		0.5
3823	20		DAY		1.0
3825	20		BEFORE	1-6 MO	1.0
3825	380				
3829	20				1.0
5065	12		BEFORE		0.5
7391	45	OWN	BEFORE		
7391	150	RENT	BEFORE		1.0

Table 20
Correlation Test
Corporate Revenues vs. Trip Rates

SIC CODE	NO. EMPL.	Revenue Rank Xn	1983 Corp. Revenue ($M)	Rate Rank Yn	Trip Rates	X-Y	(X-Y)^2
2821	4	1	0.2	18	15.05	-17	289
3811	10	2.5	0.5	13	1.60	-10.5	110.25
5065	12	2.5	0.5	15	3.00	-12.5	156.25
3674	10	4	0.6	14	1.80	-10	100
3679	39	6.5	1.0	19	27.08	-12.5	156.25
3823	20	6.5	1.0	12	1.50	-5.5	30.25
3825	20	6.5	1.0	6	0.50	0.5	0.25
7391	150	6.5	1.0	9	0.59	-2.5	6.25
3677	35	9.5	1.5	3	0.20	6.5	42.25
3679	16	9.5	1.5	16	11.88	-6.5	42.25
3811	7	11	2.0	17	12.00	-6	36
3613	85	12	2.4	8	0.56	4	16
3622	30	13	3.6	5	0.40	8	64
2819	11	14	4.0	7	0.55	7	49
3662	160	15	5.1	10	0.95	5	25
3693	130	16	10.0	1	0.10	15	225
3674	450	17	358.0	4	0.28	13	169
3662	1500	18	394.0	2	0.13	16	256
3573	190	19	400.0	11	1.02	8	64
	Avg Rev. =		$62.5 M				1837.25

r = - 0.612

private aircraft for high technology trips taken. Five firms reported that private aircraft were used. Two firms own their own aircraft, two said they used a rented aircraft. Two firms indicated the use of an aircraft privately owned by an employee of the firm. One of these firms commented that rental was paid for the use of the privately owned aircraft. All other firms responding to the survey indicated the use of commercially scheduled airlines for their trips.

The next column in Table 20 shows that 21 out of 25 firms usually left for a business trip on the day before a scheduled meeting rather than on the day of the meeting. This departure time is most likely related to the scheduled time of the meeting and the required travel distance to the destination. The trips were usually planned from 2 days before the day of departure to 12 months before the departure date. This wide range in advance planning time may be related to the trip purpose and/or to the urgency of the trip. Further study could be undertaken to confirm the extent of this relation.

5.7 Firm Specific Data

As a final analysis of passenger trips, a determination was made of the number of air trips made by various persons within the firm (SIC 3825) whose data is shown in Appendix D. As shown in Table 21, 23.1% of the total number of trips made during the six month period of data were made by

Table 21
No. of Trips by Dept./Title

Department/Title	No. of Trips /6 mo.	%
R&D	21	23.1%
Other	18	19.8%
Product Manager	10	11.0%
President	7	7.7%
Marketing	6	6.6%
Engineering Services	4	4.4%
Trade Show Coord.	4	4.4%
Software	3	3.3%
Vice Pres.	3	3.3%
Asst. to Comptroller	2	2.2%
Comptroller	2	2.2%
Engineering	2	2.2%
Purchasing	2	2.2%
Software Manager	2	2.2%
Data Processing	1	1.1%
Maintenance	1	1.1%
Sales Coordinator	1	1.1%
Service	1	1.1%
Service Manager	1	1.1%
	91	100.0%

Employment Category		
Scientific/Engineering	33	36.3%
Marketing	21	23.1%
Administration	16	17.6%
Maint./Service	3	3.3%
Other	18	19.7%
	91	100.0%

Research and Development personnel. The product manager made the second highest number of trips (11.0%) followed by the company president who made 7.7% of the trips. Also included in this table is a summary of trips made by various employee categories, such as engineering/scientific, administration, marketing, etc. This firm had a total employment of 380 in

1984. A breakdown of the number of people within the various employee categories, mentioned above, was not available for this firm.

Chapter 6

Air Freight Data Analysis

6.1 Introduction

In this section of the study, the freight data obtained with the survey was analyzed. Specifically, the analysis looked at the freight shipment modal split for each type of high technology firm (by two-digit SIC codes) to determine the transportation mode most often used to ship freight to each region. The origins and destinations were analyzed to determine which regions and firms shipped and received the most freight. Finally, the characteristics of the freight itself was analyzed to determine what transportation modes carried what kind of freight.

Of the 18 firms responding to the air freight portion of the survey, 12 provided information on inbound freight. Of these 12 firms, only 6 indicated any use of air freight for inbound shipments. In this study, air freight and parcel delivery services are considered as two separate categories even though the parcel delivery services make extensive use of air transportation themselves.

6.2 Freight Transportation Modes

Except for one shipment by "ship", all of the monthly outbound shipments could be broken down into one of three shipment mode categories; (1) parcel, which includes freight delivery services such as United Parcel Service, AirBorn, Federal Express, and Emery; (2) air, including commercial airlines such as American, Delta, etc.; and (3) Truck, or surface transportation. No firm reported any shipments by rail. For the purposes of this study, shipments reported by air freight were shipped by commercial airlines. A majority of the freight delivery services depend heavily on air transportation to move freight. Several of the freight delivery services employ their own fleet of aircraft which are used exclusively for the transport of freight. However, these services also use other transportation modes and the mode used is usually dependent upon the delivery time of a particular mode.

Table 22 is a summary of the number of outbound shipments per month reported by responding firms. Almost two-thirds or 61.2 % of the reported shipments were shipped by parcel delivery services, while 30.9% of the reported shipments were by air freight. Trucks carried 7.9% of the

Table 22
Outbound Shipments per Month by Mode

MODE	SIC CODE	TOTAL /MO.	AVG.	STD.	MIN.	MAX.
TRUCK	3572	146.00				
	3693	54.09				
	3622	6.00				
	3825	0.25				
	ALL SIC	206.34	51.59	58.38	0.25	146.00
PARCEL	3825	1,060.00				
	3811	300.00				
	2869	190.80				
	3679	46.76				
	ALL SIC	1,597.56	399.39	391.84	0.08	900.00
AIR	3616	358.00				
	3693	127.03				
	3573	86.00				
	3811	75.33				
	3677	67.00				
	3825	34.07				
	5065	27.00				
	3613	20.00				
	3572	13.00				
	ALL SIC	807.43	89.71	101.04	0.08	200.00
ALL MODES		2,611.33	870.44	569.71	0.08	900.00

freight. The actual percentage of freight carried by air is most likely much larger than 30.9% as much of the freight handled by the parcel companies is also transported by air. The actual fraction of shipments transported by air by these firms was not obtained.

6.3 Regional Mode Split

The number of shipments by each mode to and from each region are shown in Table 23 and in Figures 11 and 12. This table includes only shipments from those firms responding to the survey with information on freight modal split. Table 23 shows the percentage of shipments for each mode to or from each of the regions. The data indicates that air freight is the mode of transportation most often used for high technology freight into Austin from the Northeast, Midwest, South, and Mountain and Plains states. Parcel services are used most often for freight into Austin from the Southwest and Far West states, and Truck is the preferred mode from the Mideastern states. Inbound freight from Canada and Europe is transported exclusively by air while freight from Asia comes exclusively by parcel service. It is probable that inbound shipments from the Mideastern states are transported by truck because of the established network of trucking in that region of the U.S.

Outbound freight to the Northeast, Mountain and

Table 23
NUMBER OF REGIONAL SHIPMENTS PER MONTH

	INBOUND						
	AIR		PARCEL		TRUCK		
REGION	NO.	%	NO.	%	NO.	%	TOTAL
NE	17.0	68.0%	1.0	4.0%	7.0	28.0%	25.0
ME	13.5	38.0%	6.0	16.9%	16.0	45.1%	35.5
MW	53.0	73.6%	1.0	1.4%	18.0	25.0%	72.0
SO	31.0	51.7%	13.0	21.7%	16.0	26.7%	60.0
SW	34.0	39.5%	38.0	44.2%	14.0	16.3%	86.0
MP	104.0	87.4%	1.0	0.8%	14.0	11.8%	119.0
FW	19.5	21.3%	65.0	71.0%	7.0	7.7%	91.5
CA	3.0	100.0%	0.0	0.0%	0.0	0.0%	3.0
EU	5.0	100.0%	0.0	0.0%	0.0	0.0%	5.0
LA	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
SA	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
AS	0.0	0.0%	2.0	100.0%	0.0	0.0%	2.0
OT	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0
TOTAL	280.0	56.1%	127.0	25.5%	92.0	18.4%	499.0

	OUTBOUND						
	AIR		PARCEL		TRUCK		
REGION	NO.	%	NO.	%	NO.	%	TOTAL
NE	28.0	44.4%	27.0	42.9%	8.0	12.7%	63.0
ME	51.0	25.6%	131.0	65.8%	17.0	8.5%	199.0
MW	65.0	29.3%	139.0	62.6%	18.0	8.1%	222.0
SO	237.0	77.7%	52.0	17.0%	16.0	5.2%	305.0
SW	65.0	5.4%	1109.0	92.9%	20.0	1.7%	1194.0
MP	25.0	36.9%	28.7	42.4%	14.0	20.7%	67.7
FW	93.0	46.8%	98.8	49.7%	7.0	3.5%	198.8
CA	21.0	65.6%	1.0	3.1%	10.0	31.3%	32.0
EU	16.7	28.9%	5.0	8.7%	36.0	62.4%	57.7
LA	1.0	40.0%	0.5	20.0%	1.0	40.0%	2.5
SA	2.0	37.7%	0.3	5.7%	3.0	56.6%	5.3
AS	3.7	46.5%	2.3	28.6%	2.0	24.9%	8.0
OT	0.0	0.0%	0.7	100.0%	0.0	0.0%	0.7
TOTAL	608.4	25.8%	1595.3	67.7%	152.0	6.5%	2355.7