CHAPTER 13: Space Business and JSC

Houston and the Texas of the 1980's became something different than they had been in the 1950's, in part because NASA and JSC gave them the opportunity to be different. Admittedly, many factors were involved, including unplanned events. Oil, cattle, cotton, real estate and the Port of Houston were never displaced in the public mind or in commercial realities by aerospace or related industries. At first from necessity but then with real enthusiasm, particularly when oil prices plummeted and land prices collapsed in the 1980's, Texas and Houston turned to space industries as a new opportunity. However, when oil prices quickened and the economy improved at the close of that decade, Owen Morris (a former JSC aerospace engineer and a cofounder of Eagle Engineering) recalled that Houston interest in space declined correspondingly.[1] Nevertheless, space and related industries established under the NASA/JSC stimulus created a more diversified technology and industrial base in Texas than previously existed.

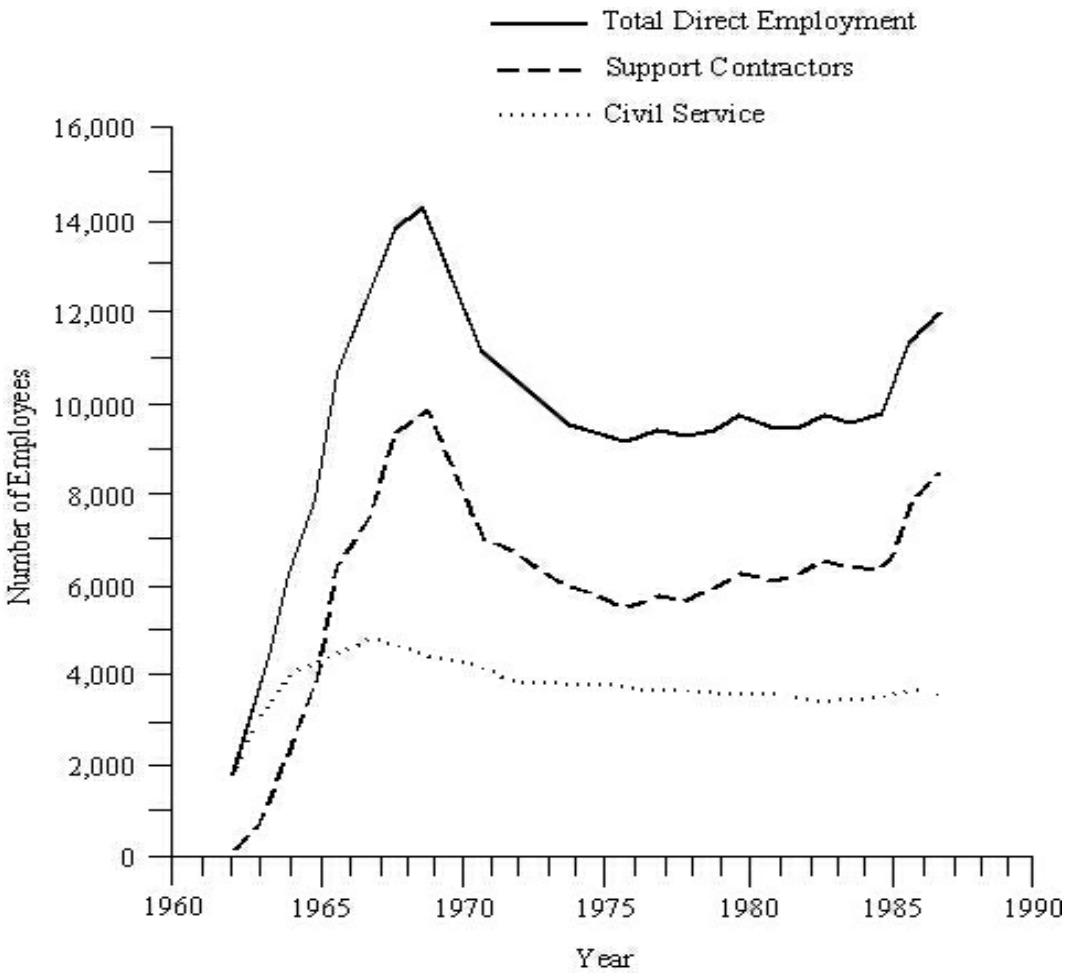
During President Richard M. Nixon's administration (1969-1974), the Republican Party's support of space programs, and specifically the Shuttle, was based on the premise that the Shuttle represented an economy measure and that, by providing a routine and economical access to near-Earth space, the Shuttle would support the commercialization of space. During President Jimmy Carter's administration, Democratic Party leaders, including former President John F. Kennedy's brother Senator Edward Kennedy and Vice President Walter Mondale, advised more funding for domestic programs and less for space. Upon assuming the presidency in 1981, Ronald Reagan promised to continue the space program, but reduced the NASA budget set by President Carter by $600 million.[2] Problems in the oil patch, privatization sentiments held by Republican administrations, affirmative action programs, and even the Shuttle's tightening budgets between 1970 and 1980 all contributed to the expansion of the private sector of space business, particularly in Texas.

Under the impetus of the marketplace and congressional programs seeking to stimulate minority and small businesses, many new small firms began to join the ranks of the giant aerospace corporations, such as Grumman, McDonnell Douglas, North American Rockwell, Ford Aerospace, RCA, Lockheed, Singer-Link, and IBM, as contractors and businesses which provided goods and services to NASA and to domestic and international aerospace consumers. Houston began to develop a space business complex and a new mind-set about modern technology.

From 1962 through September 1989, JSC disbursed $37.3 billion and most of that ($33 billion) to its contractors located throughout the United States for Research and Development work on the various space programs. Another $2.6 billion was spent in civil service salaries, $3.9 billion for research and program management, and $351 million for the construction of facilities. Most of these latter expenditures were made in the local economy.[3]

Through civil service and contractor-related employment, JSC was solely responsible for an average of 10,000 jobs in the Houston economic community after 1963. The average employee income exceeded that of the traditional petrochemical or agribusiness areas. A

history of civil service and contractor employment levels at JSC from 1963 through 1990 (figure 18) illustrates both fluctuation levels and peak employment levels associated with the Apollo lunar landing in 1969, and the increases 20 years later associated with Shuttle and Space Station development. Although not always obvious to the casual observer, by any measure JSC impacted significantly on the Houston and Texas economy.



1987-1988 increase in support contractor MYEs primarily due to increases occurring in Space Station and Shuttle operations.

1988-1989 increase in support contractor MYEs primarily due to increases occurring in Space Station and Shuttle operations.

1989-1990 increase in support contractor MYEs primarily due to increases occurring in Space Station.

MYE: Man year equivalent

Source: Administration Directorate, JSC, Houston, Texas [1990].

FIGURE 18. Civil Service and Support Contractor Employment History

Moreover, as time passed, more and more of JSC's expenditures, including those to contractors for research and development work, were made to Texas-based firms. JSC estimated that its impact on the local economy rose from slightly less than $400 million per year to approximately $1 billion between 1979 and 1989.[4] That increase in local spending reflected the growth of a supporting industrial and technological base in the Houston area and in Texas. Much of that growth occurred during the Shuttle era rather than during the Apollo program.

Most of the contract spending in the Houston area through the 1960's and 1970's had been for construction work and for services provided by major aerospace firms which, by the mid-1960's, had begun to locate corporate installations and branches in proximity to JSC. As mentioned in earlier chapters, Congressman Olin E. Teague in his role as Representative from the Sixth Congressional District (stretching to but not through the Houston and Dallas metropolitan areas) and as Chairman of the NASA Oversight Subcommittee of the House Committee on Science and Astronautics, kept careful surveillance of NASA spending in Texas. His records include the distribution of contract funding within Texas by city and by firm. The 11 Texas cities receiving the largest cumulative total of NASA contracts from 1958 to 1968 are indicated on table 11.[5]

Texas firms produced relatively little domestic industrial technology useful to the space program in the 1960's. Most of the firms that had particularly relevant expertise were located in the Dallas metropolitan area and included LTV (Ling-Temco-Vought) Aerospace

TABLE 11. Total NASA Awards to Business and Nonprofit Institutions in Texas by City to 1968

City	$/Thousands
Amarillo	$813
Austin	7,846
College Station	2,563
Dallas	151,721
Denton	545
El Paso	1,128
Fort Worth	7,496
Houston	643,545
Richardson	45,363
San Antonio	2,210
South Houston	2,039

Note: In Amarillo, Union Carbide received the $813,000 in NASA contracts. The University of Texas accounts for all but a few hundred thousand dollars of the work in Austin, and Texas A&M University was the sole recipient of the $2.5 million in College Station. In Dallas, LTV Aerospace received most of the $151.7 NASA contract dollars. Texas Instruments and the Southwest Center for Advanced Studies accounted for about $20 million. In El Paso, the University of Texas-El Paso and Globe Exploration held contracts totaling about $850,000. General Dynamics received the lion's share of the contracts in Fort Worth. Most of the contract dollars going to Houston before 1968 were awards to divisions of national aerospace and technology companies such as General Electric ($135.5 million), IBM ($112.4 million), Philco Ford ($118.5 million), TRW ($62.7 million), and Lockheed Aircraft ($51.3 million). Brown and Root, a local construction firm, in a joint venture with Northrop Aviation received a total of $25.7 million by 1968. Other major Texas recipients included Southwestern Bell Telephone ($6.3 million) and Rice University ($13.6 million-primarily land sales).
Source: Olin E. Teague Papers, Texas A&M University Archives, College Station, Texas.

Corporation, Collins Radio, and Texas Instruments. By 1963, *Houston* magazine estimated that 103 national space-related corporations had opened 137 offices (including some with multiple division offices) near Houston. Philco, Lockheed Aircraft, Goodyear Tire and Rubber, and Hayes International Corporation were mentioned as some of the early arrivals. Dave W. Lang, Chief of JSC's Procurement and Contracts Division, told the Houston Chamber of Commerce in 1964 that the center had become a catalyst for a "NASA boom." Friendswood Development Corporation had begun Clear Lake City, a 15,000-acre, $500 million, residential-research-industrial and commercial complex. Five new shopping centers, two motels, ten office buildings, three banks, a savings and loan association, and five service stations were already under construction. The older established villages, such as Webster and Seabrook, began to stir or be stirred from their somnolence.[6]

Houston Mayor Louie Welch was elected in 1963, assumed his office on January 2, 1964, and served as mayor through the NASA boom, until January 2, 1974. He was born in the small community of Lockney and attended public schools in Slaton, Texas, before completing studies in history (magna cum laude) at Abilene Christian University. He became a realtor in Houston and served several terms on the city council before making his successful bid for mayor. He attributed the decision to locate JSC near Houston largely to the work of Albert Thomas and George Brown and to Rice University.[7]

Houston had a very good relationship with Dr. Robert Gilruth and the center, Welch recalled, but during the 1960's there was considerable confusion and conflict involved in the rapid growth of the south Houston area. Houston was somewhat hesitant to annex the Clear Lake area because it was then some distance from the city, and because annexation involved an enormous expense for utilities, roads, and public services. Understandably, the city wanted the tax revenues and utility income from the growth areas. So did the neighboring incorporated communities of Pasadena and Webster. There was also some question in the minds of many as to whether JSC and the supporting space community were "here to stay." In short, the City of Houston's posture at first really was more of a wait-and-see attitude. Houston, Mayor Welch said, did not want to annex the area, but neither did it want anyone else to do so. The result was politically very confusing as city boundary disputes, suits, and legislative bills stymied any final boundary and utility decisions until about 1968-1969.[8] By this time, Houston and Texas were on the edge of the "oil boom" caused by the OPEC embargo, and Houston's fascination with space business, as was true with the rest of the United States, began to diminish somewhat.

Although space began to lose its importance as a centerpiece of business activity, NASA research and fellowship funding to Texas universities, as well as contract dollars going to large firms operating in Texas, particularly the aerospace firms located in Houston, represented an investment in future technology that began to bear dividends of a different kind. New domestic, space, and technology business enterprises appeared in increasing numbers in the 1970's. By the 1980's, Houston, Fort Worth, San Antonio, and Austin, with Dallas, offered a considerably larger commercial and industrial complex that could and did exploit space-age technology. One of the NASA/JSC spin-offs of the past few decades involved a change both in the state-of-mind and in the state of Texas business.

Paradoxically, federal budget constraints for space programs contributed to the surge of space-related business development in the Houston economic community. NASA's

budget problems had to do with continuing fiscal pressures on the federal government caused (among other things) by the Vietnam War, the OPEC oil embargo, double-digit inflation, and rising federal deficits. Fresh reductions in personnel levels at JSC were implemented between 1978 and 1980. Again, as in the early seventies, young engineers at JSC tended to be the first dismissed. But, in addition, many older personnel nearing retirement age were offered incentives for early retirement in theory to help preserve places for the younger employees. As a result, NASA and JSC experienced a sudden loss of expertise at two critical levels. One cadre lost were those relatively young, but now experienced engineers who had been with NASA for 6 to 8 years and were now qualified to assume positions as subsystem managers and intermediate program directors. Because most NASA engineers came on board during the expansive sixties and few were hired during the doldrums of the seventies, NASA had few young or mid-career civil servants. The experienced older hands with 20 or more years of NASA longevity, who had matured through the entire NASA experience were beginning to retire. Thus, the mid-level technical managers left at JSC as the decade of the eighties began (the era of Shuttle operations) were left without the supporting technical infrastructure at the bottom of the system and at the top.[9]

This deficiency, particularly that of top-level engineering expertise, was ameliorated somewhat by the formation of private Houston-based consulting and contracting firms such as Eagle Engineering, Barrios, Inc., and Hernandez Engineering, Inc., among others. These firms often provided some of the basic engineering services enabling NASA engineers to concentrate on program and project management. Many former NASA engineers, in effect, continued to work for NASA, but as contractors. Finally, the threat of government RIFs and a cap on salaries stimulated a flow of employees from the government sector into the private sector under early retirement incentives. In addition, as major aerospace contractors such as Lockheed, Grumman, McDonnell Douglas, and North American Rockwell in the Houston/JSC economy reduced employee levels throughout the seventies, many of these people, rather than leave the Houston area where they had worked for the past 10 to 15 years, moved to smaller service-oriented firms that became independent NASA contractors or subcontractors to the major aerospace firms.[10]

Others moved into positions in the then burgeoning petroleum and petrochemical industries. These people began to apply the knowledge learned in the space business to the petrochemical, communications and electronics, and medical industries and thus aided in the transfer of space technology. The petrochemical industry particularly benefited from NASA experience with systems engineering and electronic and computer applications. Communications industries drew heavily on NASA expertise. Mayor Louie Welch was particularly struck, he recalled, when President Nixon dialed extension 713 (the Houston area code) from the White House to reach the astronauts on the Moon. And he credited space technology with many of the advances in medicine and pointed to the Texas Medical Center in Houston as a special beneficiary of that new technology.[11]

In the Shuttle era, the business of space tended to become more fractured and more broadly based both as a product of the marketplace and as a result of congressional policies providing small-business and minority-owned business incentives. This meant, in part, that while JSC lost many of its younger apprentice managers and some of its older tenured and tested engineers in the late seventies, it could still draw upon that expertise within the

Houston/JSC economic community (and elsewhere) through the consulting, contract, and subcontract systems. Thus, former NASA/JSC employees such as Owen Morris, Miguel A. Hernandez, Jr., Emyre Barrios Robinson, Max Faget, Jerry Hammack, Deke Slayton, and many others helped establish a commercial sector that not only began to provide technical support to NASA, but also created a broader Texas-based private commercial space and technology sector. For example, Eagle Engineering and Barrios Technology, Inc. both began in the Houston area in 1980 and became successful multimillion dollar space and engineering firms. Both drew heavily on the expertise of retired or separated JSC or JSC contractor employees. But each began for markedly different reasons and each offered a different, but complementary expertise.

Eagle Engineering began one Sunday afternoon in 1978 in Owen Morris' home in Clear Lake City, Texas, when he and his wife with Hubert P. and Mary Davis, Carl Petersen, John Hanaway, R.E. Johnson, and William A. Bland met to discuss a plan for a private consulting business initially developed by Davis and an attorney friend, Art Dula. Davis recalled that when he added up the numbers on his Hewlett Packard HP57 pocket calculator, the early-out retirement opportunity that had to be elected prior to December 31, 1979, simply meant that a large number of civil service employees such as himself had been given a very strong incentive to leave government employment. He submitted his papers in September for retirement to be effective on December 7, 1979. His options, he said, were to take a lower level position with a local contractor, seek an equivalent position with a major aerospace firm out of state, go to the "oil patch" as many elected to do, or become an independent consultant. Being a native of San Antonio and a graduate of Texas A&M University, he wanted to remain in Texas and elected consulting work. He was able to obtain two personal consulting contracts, but as he became involved in setting up his office and putting the numbers back into his calculator for overhead expenses, he began to realize that this would not be a highly profitable venture. But there were also many, he knew, who shared the same predicament. The problem was to band these people together to achieve economies of scale—i.e. shared office spaces, secretaries, telephones, attorney fees and such. A corporate consulting entity, he thought, needed someone with a "higher profile" than himself to head it, and this led him to Owen Morris.[12]

Morris, a native of Shawnee, Oklahoma, who graduated from the University of Oklahoma in 1948 with an undergraduate and master's degree in aeronautical engineering, took his first job with NACA at Langley, Virginia, in 1948. His first assignment was to help design a large supersonic wind tunnel at Langley, and when the tunnel was built he had charge of the calibration of the tunnel as it began operations. Most of his work after that focused on stability and control problems of the new jet fighter series, such as the North American F-100, McDonnell 101, or Republic F-103 (which never became operational). He was working on the Atlas and Redstone missile development and doing research on hypersonic heating when he asked to transfer to MSC closer to home.[13]

Upon arrival in Houston in January 1962, Morris joined the Apollo Project Office under Bob Piland. Over the next 10 years he directed the Reliability and Assurance Division, became Chief Engineer on the lunar module, Project Manager of the lunar module after Apollo 11, and Apollo Program Manager for Apollo 17. He worked briefly for Aaron Cohen as deputy manager in the Shuttle orbiter office, and then moved to the Shuttle

Program Office to manage the Systems Engineering and Integration Division. Morris made important contributions to the Apollo program and to the design and inception of the Shuttle.[14]

Morris' NASA association with the Shuttle ended upon his retirement, but continued at least tangentially through his work as a NASA contractor. By the time Morris retired, Hugh Davis and Carl Petersen had opened an office for Eagle Engineering (the name was derived from the Apollo LM) on January 1, 1980, in a 600-square foot office on El Camino Real near JSC. Within a short time, Eagle became an association of approximately 30 of the 275 NASA engineers who had elected early retirement. The consultants comprised a pool of technical expertise from which individuals or a special mix of individuals could be recruited to accomplish a particular task. The firm offered special competency in systems engineering, production management, contract proposal review and preparation, and computer programming and "debugging." Most of the associates had 30 or more years of technical aerospace experience. They wanted to do something different, at their own choice and time, and to remain current and active in their fields. In addition, Eagle wanted to create a comfortable environment ("as comfortable as an old shoe") so that retirement would be easy. For example, the company paid cash advances to people traveling at government rates, as had been done by NASA. And the social aspects of their previous government work were also duplicated.[15]

A break came when Sun Oil Company recruited Eagle Engineering to work on its computer software systems. Soon other petrochemical companies, such as Exxon and Champlin Oil, began drawing upon Eagle expertise. Martin Marietta used Eagle engineers as subcontractors on a NASA project, but almost 5 years passed before Eagle embarked upon a direct contract for a NASA project. The reason for this delay was in part (JSC Assistant Director Joseph P. Loftus commented) that the center and NASA sensed an image problem (accusations of a brother-in-law deal) if NASA awarded contracts to Eagle Engineering and similar start-up firms that were developing in Houston and in proximity to other NASA centers. And in fact, Owen Morris and Hugh Davis, who were the primary shareholders in Eagle Engineering, went out of their way to pursue nonspace contracts.[16]

Within a relatively few years, Eagle began to experience growing pains as its work expanded to include systems engineering and consulting projects throughout the United States and in England. Within 5 years, its clients included Marathon Le Tourneau, Plessy Radar Ltd., RCA, Superior Oil, Tenneco, General Electric, and the U.S. Food and Drug Administration, among others. Within a few years of its organization, Max Faget retired as head of JSC's Engineering and Development Directorate and joined Eagle as a technical vice president. Other technical vice presidents included Robert E. Johnson (formerly the chief of JSC's Structures and Mechanics Division), Thomas Chambers (formerly chief of the Guidance and Navigation Division), and Burnell Bennett (former head of the Facilities Development Department of the Exxon Baytown [Texas] Refinery).[17]

Eagle accommodated its first decade of rapid growth by hiring a large staff of full-time young engineers and office personnel, expanding its list of associates to include several hundred people, and reorganizing under a parent umbrella company called Eagle Aerospace and a number of subsidiaries that provided more sharply defined services. Eagle Engineering focused on concepts, management, and marketing. Eagle Technical Services provided

mainstream but cost-effective engineering services to a broad clientele and to Eagle Engineering. After a period of tension between Morris and Davis over administrative control of the firm, Davis withdrew from active participation and organized his own independent consulting firm, Davis Aerospace, which he runs from his Texas hill country home.[18] Eagle Engineering, also in the process of growth, helped create and spin-off yet other independent technical enterprises.

One of these was Space Industries, Inc. which Max Faget organized in 1982 in cooperation with Eagle, and with the support of Westinghouse, Boeing, and Lockheed, for the purpose of developing an industrial space facility—a permanent workplace in space for private enterprise and profit. Space Industries completed the design of the facility in 1988, and in 1989 won NASA payload contracts providing the space agency a "bridge" facility for its work and experiments during the construction and deployment of Space Station *Freedom.* The 35-foot-long industrial space facility was designed to maintain a permanent orbit, operate in conjunction with the Shuttle, and accommodate removable auxiliary modules to give it greater flexibility. The $30 million investment in the venture by 1990 represented a very serious step in the "privatization" of space. But by then, Space Industries was only one of many private American and foreign firms which, as the firm's slogan professed, sought to bring "the promise of space down to Earth."[19]

Barrios Technology, Inc., founded by Emyre Barrios Robinson and conceived in the same month of 1979 as Eagle Engineering, began providing basic engineering services to NASA, its contractors and other firms requiring cost-efficient technical services. Emyre Barrios was born in El Paso, Texas. Her father practiced medicine. She and her two brothers were reared in a traditional Mexican home and because she did not speak English, she "flunked kindergarten." She completed elementary and high school in El Paso, attended the University of California-Los Angeles for 2 years, married, had three children, divorced, and married Donald M. (Mack) Robinson (a Rockwell International engineer). They had one child, and after her family began to leave home, Emyre went back to school and completed a degree at the University of Houston in 1971 with a major in Spanish and a minor in business. She entered the business world for the first time in 1973 as an Associate Editor for Kentron International, a firm providing technical support services to JSC under contract. She became Manager of Data Services and then Business Manager for Kentron in 1978.[20]

She and her supervisor, Ray Perkins, became aware of an opportunity to bid on a NASA support contract designated as a "small business set aside" which precluded Kentron from bidding. The contract involved training nonengineering personnel to do the repetitive engineering tasks required to generate flight design data. Perkins decided to stay with Kentron, but encouraged Emyre to pursue the opportunity. She recruited Gary Zoerner to assemble a technical team that could meet the contract specifications. The team wrote the proposal between October and December of 1979, received notification of the $1.8 million 2-year contract award in May 1980, incorporated Barrios Technology, Inc. that month, and began work on July 1 with 15 employees.[21]

Within 10 years Barrios grew from its JSC dependency to become a regional and national aerospace services firm with 1989-90 business receipts of $22 million and 525 employees. It became one of the Nation's largest Hispanic-owned businesses, and with 51 percent of the stock, Emyre was one of the few female chief executive officers in an

aerospace firm. But by the end of the decade, Barrios had reached that awkward stage: "neither small, and really not big." To help make that leap to the midsize arena and enter the international scene and also to better diversify into commercial services, in 1990 Emyre Robinson sold a controlling interest in the company to H. Ray Barrett and investors Charles Whynot and Lyle Anderson. Barrett, previously President of Hi-Port Industries, became the chief executive officer of Barrios Technology, Inc. Emyre continued as president of Barrios and a "space activist." She accepted an appointment to the Governor's Texas Space Commission which was charged to develop a strategy to establish the State as an industrial, academic and scientific leader in space. The commission elected her its chairman. It is imperative, she believes, that Texas and the Nation become firmly committed to space. "If we let this go we will become a Third World nation."[22]

Miguel (Mike) A. Hernandez, Jr., a refugee from one of those Third World nations, founded one of Houston's NASA/JSC spin-off space firms in 1983. Hernandez fled Fidel Castro's regime in Cuba in 1960 and settled in Florida. He graduated from the University of Florida in 1966 and accepted a job with JSC, in part because he was promised the opportunity to locate with the Apollo program flight crew training group stationed at Kennedy Space Center. "We were something of a JSC island in the midst of Kennedy," he recalled, "but we worked very closely with our Link contractors and with Kennedy personnel." When Apollo ended, that segment of astronaut training was transferred to Houston and the training branch was relocated there. Hernandez recalls some difficulty in selling his home near Cape Canaveral. Contractor and NASA personnel layoffs, beginning in 1969, severely depressed the housing market in and around the Kennedy Space Center. He finally sold his house in 1972 when people from northern states migrated into Florida to Cocoa Beach because of the bargains in the housing market. His Cuban origins and the United States embargo did create some personal problems for Hernandez. For one thing, he was grounded from commercial flying by NASA because of the threat of being hijacked to Cuba.[23]

One of the last Apollo training episodes, he recalls, was during a simulated training mission for Apollo 16. Astronaut Charles M. Duke, who was the LM pilot, failed to make the session. John Young, the commander for Apollo 16, asked Mike Hernandez to handle the LM controls for the simulation exercise. Edward Mitchell, the CAPCOM in charge of the exercise, was unaware of the substitution of Hernandez for Duke. When the communication checks began, Young responded, and then Mitchell called for a response by the LM pilot. What he got was a distinctly Latin accent on the communications network, rather than the Carolina drawl of Charles Duke. There was silence on the entire communications system. Finally, John Young broke in and reported to Mitchell: "Houston, this is Apollo 16. We've been hijacked to Cuba."[24]

Hernandez decided to leave NASA in 1980, just before Shuttle flights began, when he was recruited by Scott Science and Technology, Inc. to work on Air Force astronaut training programs. That company was itself a NASA/JSC spin-off. David R. Scott was among the third group of astronauts recruited by NASA (1963) and piloted Gemini 8 and Apollo 9. He commanded the Apollo 15 lunar mission and was the seventh man to walk on the Moon. He became special assistant for Mission Operations during the Apollo-Soyuz flight, and then in 1975 was appointed Director, Dryden Flight Research Center in Edwards, California. In 1977 he resigned to establish the company that became Scott Science and Technology, Inc.,

based in Los Angeles.[25] After only 2 years with Scott, Mike Hernandez decided to establish his own company and pursue opportunities elsewhere.

He and Scott Millican organized Hernandez Engineering in 1983, and opened their office in Houston with "two and one-half" employees—including himself and Millican. He began with a consulting job overseas. The European Space Agency (comprising members of the European Economic Community) had been organized and Hernandez saw an opportunity to provide training, payload integration expertise, and control center operation experience. The company won a small consulting contract with a German space company located in Bonn. Hernandez then won contracts with General Electric providing them support on Shuttle payload integration. At the same time they added another engineer. Next an engineer was hired to remain permanently stationed in Germany to work on the expanding European business.[26]

After 1985 the company's business grew rapidly. Jerome B. Hammack retired from JSC as Safety and Reliability officer on August 1, 1987, and began similar duties with Hernandez on August 3. The firm won contracts at Goddard and NASA Headquarters. William R. Holmberg, an engineer from the University of Texas with a graduate degree in fine arts, had taught for a few years before joining McDonnell Douglas and becoming one of the first contract (as opposed to civil service) mission control front room leaders at JSC. He joined Hernandez in September 1987 as manager of Operations and Logistics. Millican left the firm and Hernandez spun off his overseas operation as an independent subsidiary incorporated in Germany. Hernandez then doubled the size of the company adding over 200 new employees, with the assumption of a technical information and public affairs support services contract with JSC in 1989—his first with the center.[27]

Unlike most space firms, Hernandez Engineering began its business as an international operation and then later developed activities within the United States. Mike Hernandez believes that space exploration and space business for the foreseeable future are inextricably tied, wherever it is, to government programs and government funding. Unlike the aircraft industry, it does not yet have an independent private sector. But the aircraft industry did not truly become an industry until would-be airplane manufacturers began to receive orders for military aircraft and would-be airlines began to receive mail delivery contracts.[28] Space, international business, and doing business with governments are individually difficult spheres in which to operate. To do all three requires a very special business expertise.

Space Services Inc. of America, founded by a group of Texas investors headed by Houston real estate developer David Hannah, Jr. and directed by Donald K. (Deke) Slayton, Director of Flight Crew Operations who retired from JSC in 1982, made the first commercially licensed rocket launch by an American firm on March 29, 1989. The Starfire rocket was lofted from the White Sands Missile Range in New Mexico on a contract with the University of Alabama for a suborbital flight to test medicines and materials in a weightless environment.[29] Despite congressional incentives, the fledgling space company encountered frequent difficulties with technical malfunctions, financing problems in the face of Texas banking woes, and competition for elusive federal space contracts.

Congress did, however, attempt to facilitate and encourage private ventures in space and other high-tech industries in a variety of stratagems throughout the 1980's. The Small Business Innovation Development Act of 1982 established contracting guidelines for all

federal agencies that spent $100 million or more annually on research. The program encouraged scientific and technical feasibility research projects by small businesses (having fewer than 500 employees) with $50,000 (Phase I) investigative grants. Phase II awards to successful investigators could qualify for funding of $100,000 to $500,000 per year for the development of prototypes of the project. In addition, Congress directed NASA to provide more specific support for space-related projects by small businesses in a 1984 amendment to the National Aeronautics and Space Act. The amendment directed NASA to "Seek and encourage to the maximum extent the commercial use of space."[30] The measures reinforced the public-oriented attitude and a procurement process that encouraged smaller subcontractors to provide goods and services to larger, primary contractors.

TABLE 12. Distribution of JSC Procurements

	Net Value of Obligations (Millions of Dollars)								
Fiscal Year	Business		Educational/ Non-Profit		Government Agencies		Outside U.S.		Total
1988	1708.2	(94.5)*	34.2	(1.9)	41.7	(2.3)	23.7	(1.3)	1807.8
1987	1540.3	(94.6)	34.2	(2.1)	42.4	(2.6)	11.8	(0.7)	1628.7
1986	1296.4	(95.0)	30.4	(2.2)	33.6	(2.5)	4.2	(0.3)	1364.6
1985	1651.1	(96.0)	30.8	(1.8)	28.9	(1.7)	9.2	(0.5)	1720.0
1984	1561.1	(96.0)	23.1	(1.4)	28.1	(1.7)	13.7	(0.9)	1626.0
1983	1664.0	(95.7)	23.9	(1.4)	32.8	(1.9)	17.7	(1.0)	1738.4
1982	1627.6	(96.3)	18.7	(1.1)	26.7	(1.6)	17.6	(1.0)	1690.6
1981	1567.7	(96.4)	20.0	(1.3)	21.8	(1.3)	16.7	(1.0)	1626.2
1980	1380.4	(96.6)	19.0	(1.3)	20.8	(1.4)	9.5	(0.7)	1429.7
1979	1154.9	(96.4)	16.2	(1.3)	22.4	(1.9)	4.6	(0.4)	1198.1
1978	980.9	(96.6)	17.6	(1.7)	17.4	(1.7)	.2	(<.1)	1016.1
1977	1083.4	(97.1)	16.8	(1.5)	15.4	(1.4)	<.1	(<.1)	1115.6
1976	991.7	(96.7)	16.9	(1.7)	16.3	(1.6)	<.1	(<.1)	1024.9
1975	801.1	(96.3)	17.5	(2.1)	13.3	(1.6)			831.9
1974	633.3	(93.6)	24.1	(3.5)	19.4	(2.9)			676.8
1973	449.9	(91.4)	24.9	(5.0)	17.6	(3.6)			492.4
1972	391.6	(87.1)	35.4	(7.9)	22.4	(5.0)			449.4
1971	542.0	(89.0)	45.1	(7.4)	21.9	(3.6)			609.0
1970	995.5	(94.0)	36.6	(3.5)	26.8	(2.5)			1058.9
1969	1101.4	(95.3)	28.9	(2.5)	25.8	(2.2)			1156.1
1968	1174.1	(95.2)	31.6	(2.6)	26.8	(2.2)			1232.5
1967	1408.4	(94.7)	26.6	(1.8)	51.9	(3.5)			1486.9
1966	1396.9	(90.3)	22.0	(1.4)	127.8	(8.3)			1546.7
1965	1280.5	(86.1)	21.5	(1.4)	185.4	(12.5)			1487.4
1964	1234.6	(85.2)	18.9	(1.3)	195.1	(13.5)			1448.6
1963	560.8	(76.1)	15.4	(2.1)	161.0	(21.8)			737.2
1962	169.2	(83.0)	3.1	(1.0)	32.2	(16.0)			204.5

**Numbers in parentheses are percentages.*
Source: JSC Annual Procurement Reports (FY 1963-1988).

The Technology and Commercial Projects Office at JSC under the New Initiatives Office, provided special assistance to small businesses. In the Administration Directorate, the Procurement Operations Branch of the Procurement Support Division actively assisted in the identification of small business subcontracting opportunities. A Small and Disadvantaged Business Office and an Industry Assistance Office offered special services to firms needing assistance in developing proposals or tailoring their firms to best fit NASA procurement requirements. In 1987, small and small disadvantaged businesses received $729.2 million in total direct NASA prime contract awards and approximately $815 million in subcontract awards. Of the total $4,807 million in contracts awarded by JSC in 1988, $92.1 million (or 5.4 percent) went to small businesses.[31] These efforts helped broaden both the space services and the space technology base within the Houston economic community and in Texas.

That impact is documented in part by analyses prepared by JSC and by the University of Houston-Clear Lake, Bureau of Research. The following tables denote the distribution of JSC procurement dollars since it began operations among business, educational, and government agencies and the percentage of distributions to small business and minority firms. Table 12 illustrates the severe contraction of space expenditures in fiscal years 1971 through 1974 and the expansion concurrent with Shuttle operations and space station program development in the 1980's. As indicated in table 15, NASA/JSC budgets for 1980 through 1987 generated an estimated 21,000 to 28,000 jobs in the Houston area and pumped some $560 to $859 million into the local economy. Although much more difficult to measure than dollars, the greater impact of JSC on Houston and Texas had to do with conversion from a dominantly agricultural and petroleum economy to a more diversified economy with a strong base in aerospace industries, communications, electronic and computer technology, and sophisticated medical technology. This had as much to do with a changing world-view by Texans and with new educational and employment opportunities and incentives, as it had to do with specific business developments or technology. Although JSC was by no means uniquely or singly responsible for the substantive transformation in the Texas economy, it was a catalyst in that change.

Hard times brought about by reductions in personnel and contract spending by JSC between 1971 and 1974 resulted in a considerable absorption of personnel and talent by the domestic petroleum industry, which was then enjoying boom times, and by academia. Subsequently, civil service retirements, start-up ventures by former NASA engineers and scientists, federal incentives to small businesses and minority business, and an overriding initiative to transfer much of the government's business to the private sector affected the transfer of space technology to the Texas economic order. Finally, during much of the 1980's, Texas capital and Texas business turned increasingly (and sometimes desperately) to space ventures and new technology, as petroleum and real estate entered into a severe recession. Thus, change in the Texas economy became much more pervasive and significant in the dawning Shuttle era than it had been during the previous several decades. The development, production, and experimental flights of the Shuttle were coterminous with the changing economic order.

During its first two decades, JSC became the home of human spaceflight and a significant contributor to the development of a new regional business culture that took space and

high technology in its stride, and that learned to do business not only with the federal government, but also with governments and businesses throughout the world. Particularly during 1972 through 1982, which witnessed the development and orbital test flights of the Space Shuttle, JSC became a conduit for the transfusion of people and their experiences and know-how into a changing Texas and national economy.

TABLE 13. Small Business and Minority Business Participation in JSC Procurement Activity

Fiscal Year	Small Business Value of Obligations (millions of dollars)	Minority Business Value of Obligations (millions of dollars)		Value of Obligations (millions of dollars)	
1988	1708.2	92.1	(5.4)*	24.1	(1.41)
1987	1540.3	89.3	(5.8)	27.5	(1.79)
1986	1296.4	79.3	(6.1)	23.7	(1.83)
1985	1651.1	74.4	(4.5)	20.4	(1.24)
1984	1561.1	58.9	(3.8)	15.3	(0.98)
1983	1664.0	57.1	(3.43)	13.5	(0.81)
1982	1627.6	49.5	(3.04)	16.4	(1.01)
1981	1567.7	40.7	(2.6)	10.0	(0.64)
1980	1380.4	33.4	(2.4)	2.1	(0.15)
1979	1154.9	28.2	(2.4)	2.4	(0.21)
1978	980.9	25.3	(2.6)	2.4	(0.25
1977	1083.4	25.1	(2.3)	2.7	(0.25)
1976	991.7	19.6	(2.0)	2.3	(0.23)
1975	801.1	22.1	(2.8)	1.78	(0.22)
1974	633.3	20.8	(3.3)	1.4	(0.22)
1973	449.9	19.8	(4.4)	0.431	(0.09)
1972	391.6	21.3	(5.4)	0.611	(0.16)
1971	542.0	29.3	(5.4)		
1970	995.5	27.8	(2.8)		
1969	1101.4	22.8	(2.1)		
1968	1174.1	27.3	(2.3)		
1967	1408.4	28.9	(2.1)		
1966	1396.9	17.2	(1.2)		
1965	1280.5	23.3	(2.0)		
1964	1234.6	21.5	(2.0)		
1963	560.8	11.6	(2.1)		

**Numbers in parentheses are percentages.*
Source: JSC Annual Procurement Reports (FY 1963-1988).

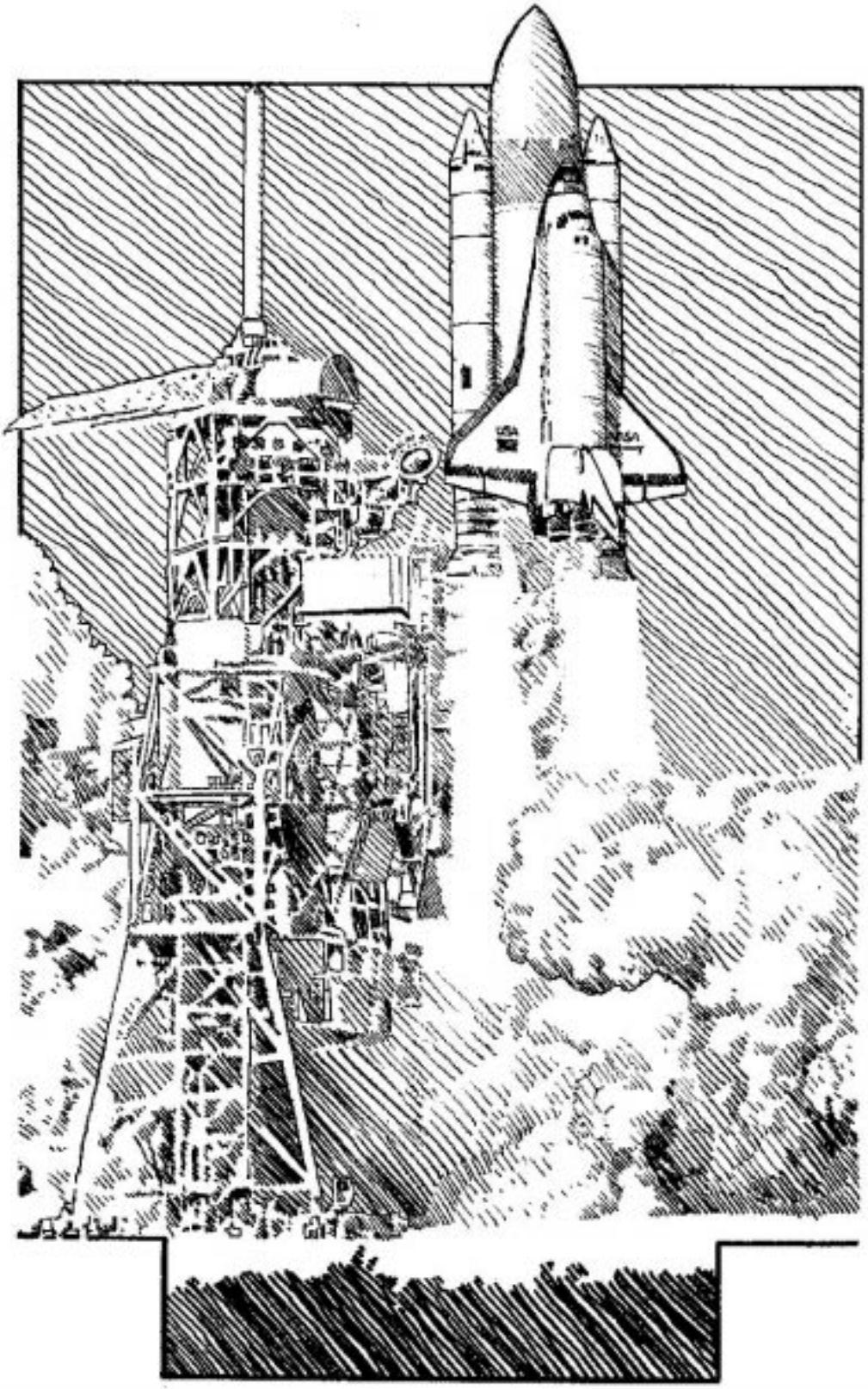
TABLE 14. Geographical Distribution of JSC Procurement Excluding Intragovernmental Actions (thousands of dollars)

Fiscal Year	Far West	Mountain States	Mid-West	Texas	Great Lakes States	Southeast	Mid-Atlantic	New England	Alaska	Hawaii	Outside U.S.
1988	817,100	22,586	21,453	746,552	5726	55,154	35,305	38,479	3	--	23,705
1987	758,582	21,941	5410	608,252	8313	82,698	50,730	38,561	1	--	11,767
1986	1,572,304	18,396	3585	608,252	7759	72,151	38,002	51,627	30	39	4179
1985	928,363	15,671	4148	513,797	5330	68,433	72,647	73,444	3	--	9199
1984	922,942	23,681	2074	453,315	3508	54,418	65,799	58,952	--	1	13,289
1983	1,060,422	30,553	2785	407,972	7861	58,131	52,704	67,446	1	--	17,715
1982	1,146,372	12,390	1955	344,822	5603	46,892	43,722	44,572	3	--	17,624
1981	1,144,176	23,471	2220	266,274	7726	35,159	68,204	40,443	--	10	16,663
1980	978,514	33,594	2536	246,268	4634	30,166	65,573	37,973	75	9	9543
1979	810,162	4341	1568	218,901	5002	23,631	56,719	50,852	<1	9	4568
1978	679,861	21,226	7948	197,161	4959	8932	51,602	26,807	10	36	211
1977	827,093	14,857	4350	182,124	4944	10,978	41,866	13,971	-(23)	7	47
1976	770,773	8766	2267	141,394	5500	10,958	61,527	7451	-(3)	<1	-(18)
1975	607,405	7252	7849	128,873	6001	11,661	42,328	7068	108	2	80
1974	433,411	15,945	13,041	109,159	5450	9101	58,218	12,971	30	1	132
1973	257,618	22,657	9682	103,945	10,370	5189	44,578	20,617	45	2	119
1972	140,366	28,971	17,495	116,605	26,357	3697	57,394	35,991	145	<1	12
1971	153,588	20,717	14,233	118,974	60,967	3717	154,992	59,420	192	33	287
1970	403,248	55,258	18,919	139,283	42,688	13,723	304,118	54,529	21	--	275
1969	494,057	14,411	17,801	83,403	49,790	53,330	375,966	40,613	422	--	443
1968	504,871	8143	27,395	84,240	71,204	40,309	433,867	35,265	103	--	278
1967	591,218	7666	16,714	74,681	98,342	27,832	578,907	39,367	--	--	348
1966	694,966	7368	58,795	50,566	134,649	24,862	405,612	41,785	89	--	--
1965	654,503	7261	177,478	30,360	76,624	23,998	295,982	38,375	--	--	--
1964	991,226	3046.6	654,659.3	19,158.5	55,810	209,133.3	79,535.9	--	--	--	--

Source: JSC Annual Procurement Reports (FY 1964 - 1988)

TABLE 15. Impact of the NASA Budget on JSC and Houston Area Economy

	Fiscal Year (dollars in millions)										
	1980	1981	1982	1983	1984	1985	1986	1987*	1988	1989	1990
Total NASA Budget	5,243	5,522	6,020	6,836	7,248	7,552	7,764	10,774	7,800	10,897	12,296
Total JSC Budget	1,557	1,702	1,789	1,745	1,662	1,617	1,445	2,909	1,445	1,935	2,505
JSC's Share of NASA Budget	29.7%	30.8%	29.7%	25.5%	22.9%	21.4%	18.6%	27.0%	18.5%	17.8%	20.4%
Dollars Spent in Houston	404	475	502	559	564	645	706	788	797	973	1,182
Houston's Share of JSC Budget	25.9%	27.9%	28.1%	32.0%	33.9%	39.9%	48.9%	27.1%	55.2%	50.3%	47.2%
Houston's Share of NASA Budget	7.7%	8.6%	8.3%	8.2%	7.8%	8.5%	9.1%	7.3%	10.2%	8.9%	9.6%

**In 1987, the NASA/JSC budget reflects a one-time appropriation for a replacement orbiter. Production of the new orbiter was primarily done in California.*

Source: JSC Almanac, "Economic Impact," 1991.