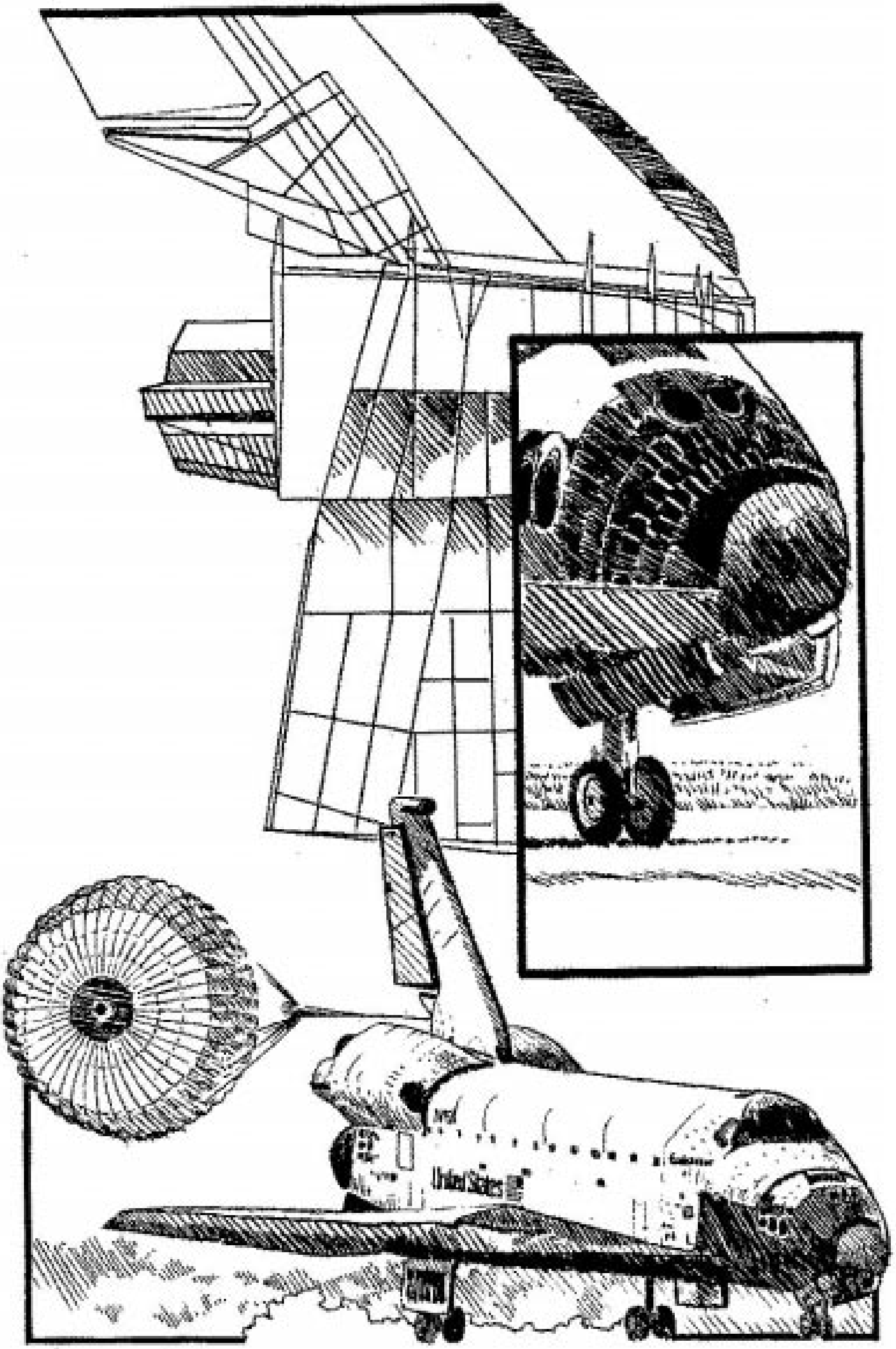

United States

CHAPTER 16: New Initiatives

The 32 months between the fiery destruction of *Challenger* and its crew and the return to flight marked an intense "downtime" for NASA and especially for the Johnson Space Center. Individuals coped as best they could with their own grief and sense of responsibility. The organization was traumatized. Despite an initial outburst of public support and confidence in NASA, media coverage became more critical and hostile. NASA's old self-confidence and "can-do" attitude seemed to erode. Administrative changes at Headquarters and within the centers, made to compensate for perceived weaknesses, contributed to a sense of insecurity. Relations between the centers, and particularly between JSC and Marshall Space Flight Center, deteriorated as each became more territorial. Relations between JSC and Headquarters became increasingly strained.[1]

The downtime involved several phases. In the aftermath of *Challenger* came trauma, characterized by personal grief and indecision within NASA. Almost every person at JSC had a personal or professional relationship with one or more of the astronauts. Public opinion samples by private pollsters indicated an initial show of public support for the agency and spaceflight. Administrative reactions, already described, included the internal NASA investigation of the causes for the disaster and the Presidential Rogers Commission inquiry. But events continued to unfold. A National Commission on Space headed by Thomas Paine had begun its work prior to the *Challenger* accident. Its report encompassed *Challenger* but focused on the next 50 years of *Pioneering the Space Frontier*. The report, published in May 1986 and dedicated to the crew of the Space Shuttle *Challenger*, now somewhat incongruously offered "an exciting vision of our next 50 years in space." NASA launched a special leadership and management review—a response both to *Challenger* and to the report of the National Commission on Space. Newspapers, magazines, and television conducted an almost uninterrupted debate of the causes of the disaster and the reasons for spaceflight. "The task of understanding the accident," commented one NASA historian, "became confused with the excitement of assigning blame . . ."[2] NASA survived as an agency, but with credibility tarnished, confidence shaken, morale low and leadership completely displaced.

The loss or disruption of leadership at almost every level of the NASA organization affected the style of management in place at the time of the *Challenger* disaster, and almost certainly impeded recovery. In a 12-month period surrounding the *Challenger* accident, NASA lost or replaced almost every top manager. Many retired, some went to business, others simply changed from one program to another, as, for example, from shuttle work to space station work. A sizable and relatively successful program in remote sensing at JSC was phased out between 1984 and 1985 because of costs. Glynn S. Lunney, manager of the National Space Transportation System Program Office and an experienced flight director, announced his resignation from NASA/JSC in April 1985. Gerald Griffin, who headed the center since 1982 and had spent most of his professional career with JSC, retired from NASA to become director of the Houston Chamber of Commerce on January 14, only weeks before the *Challenger* launch. It was, Griffin thought, an opportune time for a career change. The Shuttle was going great! The space station program had been approved. JSC had been designated the lead center for the space station. It was a good time for a change!" Griffin wanted to do something different, "something I didn't know a damn thing about."[3] Griffin left JSC when morale and optimism were at their highest. There had, in fact, been a considerable turnover of top NASA administrators in 1985 before the *Challenger* launch. Even more resignations and administrative changes followed the *Challenger* accident.

Hans Mark left his post as NASA Deputy Administrator in September 1985 to become Chancellor of the University of Texas. William Graham came to NASA from private industry as the new deputy administrator in November 1985. On December 2, a federal grand jury indicted General Dynamics Corporation and three of its former executives—one of whom happened to be NASA Administrator James Beggs—for fraud relating to a Defense Department contract on an antiaircraft gun. On December 4, Administrator Beggs took an indefinite leave of absence. President Reagan appointed Graham, who now had 8 days of NASA work experience, as acting administrator. Graham then appointed NASA's experienced associate administrator Phil Culbertson to serve as "general manager." Culbertson was a 20-year NASA veteran and headed the Office of Space Station at Headquarters. Beggs was later fully exonerated and received a letter of apology from the Attorney General. The impact of his untimely indictment and departure from NASA will ever be debated.[4]

When Gerald Griffin left JSC, Robert C. Goetz, formerly with Langley Research Center who came to JSC as deputy director in 1983, succeeded Griffin as acting director. On January 23, just days before the scheduled launch of *Challenger* on January 28, Jesse W. Moore, Associate Administrator for Space Flight, was named Director of JSC. He joined the Headquarters staff in 1978 as Deputy Director of the Solar Terrestrial Division in the Office of Space Science and became Director of the Space Flight and Earth and Planetary Exploration Division, before moving in 1983 to the Office of Space Flight were he served variously as deputy associate administrator, acting associate administrator and then associate administrator, from August 1984 until January 1985. Goetz, who had, on his own initiative and in the context of JSC's role as lead center for the Shuttle, implemented NASA's accident contingency plan when the new acting administrator declined to do so without higher authorization, concentrated on internal reviews and investigations. Concurrently, Jesse Moore made what came to be a rather transient move to JSC. By October of that year Moore was back in Washington D.C. and JSC had yet another director.[5]

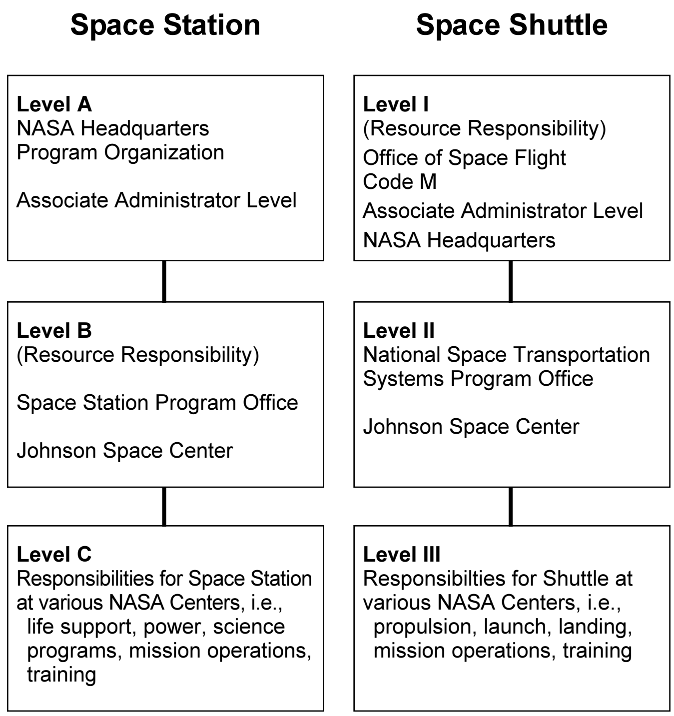
Shuttle management became entangled not only in the abnormal rate of personnel changes but also in the spill-out from the *Challenger* accident. It became increasingly clear outside of NASA that the Shuttle was one of the most complex machines ever built. It required "the world's largest pit crew"—tens of thousands of highly skilled workers from a dozen NASA facilities, thousands more from large companies such as Lockheed and Rockwell, and yet more from small subcontractors scattered throughout the country. Its payloads involved the work of still more scientists and technicians, including often the work of those in other nations.[6] Neither fish nor fowl, the Shuttle was not truly an experimental device, nor was it—contrary to its early portrayal by NASA—a wholly operational spacecraft or "shuttle" that could routinely fly people and cargo into space and return to Earth.

Its prime purpose was not national defense, nor was it science. Other than for the placement of communications satellites into orbit, opportunities for profitable business ventures seemed esoteric and distant. Neither was the Shuttle essentially a research and development tool. The Shuttle could carry the American flag and American astronauts into space—but not to the Moon—and the latter had already been done. Mistakenly compared to expendable launch vehicles, the Shuttle was unique in its ability to return from space and in being reusable. The American public, however, was not sure just what the Shuttle was, or should do. Inasmuch as JSC was most closely associated in the public mind with Shuttle flights, the center lost stature because of the *Challenger* accident and the declining reputation of the Shuttle. Moreover, the Shuttle's various constituents, such as space-related businesses and contractors, scientists, engineers, national defense interests, and diverse governmental agencies held often conflicting purposes.

The Shuttle seemed somehow emasculated from a broadly conceived space program or policy. It seemed to be an interim device filling the void between the program that had been (Apollo) and that which was to be (the space station). But what was to be was not yet fully known. The purposefulness and clarity of vision for the space program suffered, consensus waned, and confusion persisted.[7]

Indecision, change, and confusion extended to JSC's role in the space station program. At NASA Headquarters, John Hodge, regarded by some as a "controversial figure with respect to his relationship with the Johnson Space Center" became acting associate administrator for the space station in December 1985. In 1969, while Manager of the Manned Spacecraft Center's Advanced Missions Program, Hodge presented an overview and justification for the development of a large space station in Earth orbit coupled with a low-cost Earth-to-orbit transportation system to the House (Committee on Science and Astronautics) Subcommittee on Manned Space Flight. That presentation reflected then current NASA and MSC thought about post-Apollo programs. Later, Hodge directed the initial space station task force planning group and favored centralizing space station (Level B) management at the Headquarters level. Following the *Challenger* accident, Hodge (with the concurrence of Acting Administrator Graham) asked General Samuel Phillips to head a special committee to study the space station program management system.[8]

The existing three-tiered space station management plan provided that Level A Headquarters would establish policy and guidelines and protect Level B JSC Program Office from "the political environment and allow them to do the technical job," while Level C would comprise the space station project offices located at the various centers which managed the specific contracts related to the space station (figure 19). As the space station management study began in Washington, D.C., Neil Hutchinson, a former JSC flight director who headed the program office of the space station at JSC and managed the developmental (Level B) phase of the space station, stepped down as program manager in February 1986. John Aaron, formerly special assistant to the Director of JSC, replaced Neil Hutchinson as Acting Manager of the Space Station Program Office at JSC for the remaining months of JSC's Level B lead center role. Finally, in March of that year, James C. Fletcher, who held the position between 1971 and 1977, reassumed the post of NASA Administrator, replacing William R. Graham.[9]



Space Station Phased Development as of 1986

Block I:

Phase A	Concept definition
Phase B	Definition (Specifications for hardware, etc.)
Phases C & D	Construction and launches—for initial capacity

Block II:

Advanced capacity and technology development

FIGURE 19. Shuttle and Space Station Compared

Within the 12-months surrounding *Challenger,* NASA had three administrators (Beggs, Graham [acting], and Fletcher). During calendar year 1986, JSC had four directors (Gerald Griffin, Robert Goetz [acting], Jesse W. Moore, and Aaron Cohen). The space station had a new associate administrator at Headquarters and two different program managers at JSC. Aaron Cohen described the post-*Challenger* era as a time "worse than chaos." JSC had no spokesman and NASA no leadership. Morale was low, it was imperative that there be a return to flight, and the space station was "upon us."[10] The leadership changes created uncertainty and confusion, delayed an effective response to the *Challenger* accident, and contributed to a realignment of the space station program.

In 1986 the space station received a new directive which removed the Level B program office from JSC and placed it at Headquarters. As Hodge anticipated, Phillips' group recommended that the lead center management system be abandoned for the space station and that Level B management be concentrated at the Headquarters level. In addition, the committee recommended that Marshall Space Flight Center assume project management for the life habitat module systems, JSC manage the truss or support structures, Goddard Space Flight Center manage the platforms and servicing facility, and Lewis Research Center supervise the power systems.[11]

As the incoming NASA Administrator, Fletcher accepted the Phillips committee recommendations and began reorganizing along the lines suggested. Concurrently, Jesse Moore left JSC to accept the position of Special Assistant to the General Manager at Headquarters without having communicated to JSC personnel the full content of the Phillips report or the organizational changes being made.[12]

As the space station reorganization developed, personnel at JSC, now somewhat adrift in the throes of management changes, viewed the elimination of the center's "lead" position both as punishment for the *Challenger* accident and the product of Machiavellian machinations at Headquarters. In addition, JSC engineers considered crew systems and flight capsules to be under their domain and wholly foreign to the expertise at Marshall Space Flight Center. Moreover, many believed that Headquarters lacked the technical depth, expertise, and experience to manage the space station Level B program. JSC engineers associated effective program and project management with hands-on engineering and in-house laboratory support systems. They believed that successes in the earlier Mercury, Gemini and Apollo programs derived in part from the fact that center engineers duplicated much of the developmental engineering work in their own shops and laboratories, and thus were better and more experienced contract and project managers.[13]

Leadership changes, the *Challenger* trauma, and reorganization combined to drop morale at JSC to a new low. With the space station reorganization an apparent *fait accompli,* Administrator Fletcher set about to restore order and direction to NASA and within JSC. He addressed the issue of order by creating a special task group headed by astronaut Dr. Sally K. Ride to report on NASA's status, review the long-term goals of the civilian space program, and consider the Agency's ability to meet those goals. The confusion and turbulence at JSC were met in part, and perhaps somewhat belatedly, by naming a new director to replace Jesse Moore. On October 12, 1986, Aaron Cohen became JSC's director.[14]

A Texan by birth, Cohen completed engineering studies at Texas A&M University and an advanced degree in applied mathematics at Stevens Institute of Technology. He served in the Army and had a brief stint as a microwave tube design engineer with RCA where he developed patents on a microwave tube and a color TV tube before joining General Dynamics as a senior research engineer. He joined the Apollo Program Office at MSC in Houston in 1962, managed the Command and Service Modules Offices of the Apollo spacecraft program from 1969 to 1972, and headed the Space Shuttle Orbiter Project Office from 1972 to 1982. Prior to his appointment as Director of JSC, Cohen managed the Engineering and Development Directorate. Cohen felt a deep sense of personal frustration at the seeming inability of NASA to resolve the Shuttle problems and wanted to get things moving.[15]

Cohen and others sensed that Headquarters and perhaps history were nudging JSC into the role of being exclusively an operations center. The Chris Kraft-Gerald Griffin/

Apollo-Shuttle era had imprinted a JSC operations mode into the collective mind of the general public and administrators at Headquarters. Other centers, such as Marshall Space Flight Center, might well have encouraged that trend as a way of allocating a greater share of research and development (R&D) or project management to those respective centers. From this point of view—that is, that JSC should be preeminently concerned with operations—it made perfectly good sense at Headquarters and at Marshall Space Flight Center that the major technical management contracts related to the space station go elsewhere than to JSC. Moreover, Marshall's experience as a "lead center" for Skylab seemed to point to its expertise in heading the space station's habitable modules. Cohen believed that the unique strength of JSC was in fact its technical project management expertise relating to the design and development of manned spacecraft and the integration of that expertise with flight operations.[16]

Since the days of Mercury, JSC's unique capability had in fact been the design, integration and technical management of manned space vehicles, astronaut training, and flight operations. Historically, among the manned spaceflight centers, JSC managed the spacecraft design, development, and use (including crew training and operations). Marshall's expertise was in propulsion and launch vehicles, Kennedy's in launch operations, and Goddard's in communications and data acquisition. Or so it seemed to those at JSC.

The traditional center roles were changing in response to space station planning. The "lead center" management style, always under some duress, became suspect after the *Challenger* accident. In addition, whereas the Mercury, Gemini, and Apollo programs each had a finite life, the long-term programs envisioned in the Shuttle, Space Station, and Space Telescope required that each center have more diverse capabilities but also that each interface more closely with the others in program development.[17] Thus Headquarters became more involved in program implementation as well as oversight, and centers increasingly began to overlap and compete with each other for the same projects. Although JSC actually concentrated most of its energies and personnel on the design and development of spacecraft, its public reputation derived from flight operations.

Cohen sought to reestablish engineering and technical management as the center's fulcrum. It was important, he thought, that JSC avoid becoming wholly an "operations" center, and that it preserve its unique "design, fly, and use" capability. JSC managers and planners began looking not only at the problem of returning the Shuttle to flight, but also at JSC's role under the new space station management plan. William Huffstetler, who began his space career with the Army Ballistic Missile Agency before joining NASA's Marshall Space Flight Center (from which he transferred to MSC in 1963), recalled "serious conversations" with Aaron Cohen beginning in 1986 that eventually led to the establishment of the center's New Initiatives Office. That office sought to maintain the center's technical diversity in research, development and operations, to institutionalize long-range planning, and specifically to respond to perceived challenges and competition from the Marshall Space Flight Center.[18]

Indeed, the New Initiatives Office, which Cohen appointed Huffstetler to head, unabashedly imitated the Program Development Directorate established years earlier at the Marshall Space Flight Center which was originally headed by Eberhard Rees. James Murphy currently headed the office which gave Marshall an edge in program planning and in organizing its resources for new projects—such as the space station. Huffstetler's New Initiatives Office assumed the functions of the Chief of Technical Planning (Joseph P.

Loftus) in the JSC director's office, and broadened that capability by providing a full project-level office and support system. As a project-level office (rather than a directorate) the New Initiatives Office avoided direct competition with the line offices or directorates at JSC. It could draw upon the resources of the directorates and provide a mechanism for coordinating planning activities and future programs.[19]

The New Initiatives Office sought to maintain JSC's leadership in spacecraft design and development, and to learn to package and market new ideas to potential space customers in accord with the Agency's growing emphasis on technology transfer and efforts to realize practical benefits for Earth from space exploration. By 1990 the office had become the incubus for six major "future" projects. One related to Shuttle middeck experiments in the life sciences. Personnel also managed the design of an assured crew return vehicle (ACRV) for the space station. Others worked on the development of LifeSat, an unmanned satellite for low-level biological studies. One division focused on the development of a commercial Shuttle (or space station) module designed to carry up to 75 experiments for paying customers. Another group worked on studies and projects related to space servicing for the maintenance and repair of vehicles in space. Another division concentrated on the design of human and robotic spacecraft for future missions—such as a Mars mission. The work focused on "touch and feel" engineering, that is, in studies of hardware and project management capabilities.[20]

The office also was charged with helping JSC establish ties to the regional academic community. Major universities had become a neglected resource for new ideas and new

Through their conceptions, artists have enabled the New Initiatives Office to learn to package and market new ideas such as the ACRV (left) and space station robotics (right).

initiatives. After Apollo, JSC concentrated its energies and its diminishing funding on building and flying the Shuttle. By 1986, the Shuttle absorbed 80 to 85 percent of the center's resources and dollars.[21] One fallout of the *Challenger* was that NASA and JSC were forced to look beyond the Shuttle.

Although JSC had a long informal association with Texas universities, programs involving those universities later tended to be underfunded, neglected, and sometimes simply cosmetic. Many JSC employees came from Texas universities, and in that sense the center was very dependent upon them. Because of this and the fact that space was a powerful stimulus, JSC had a profound impact upon higher education in Texas and upon the public's perception of education and technology. Space helped jar Texas and the Nation from its yesterdays into a new tomorrow.

One of the factors leading to the location of the MSC in Houston, Texas, had been the presence of strong educational institutions—prominently Rice University and the University of Houston within the city, and the University of Texas and Texas A&M University in Austin and College Station, respectively. In 1963, Center Director Robert R. Gilruth announced an Aerospace Summer Intern Program that would give 30 junior/senior or graduate students drawn from throughout the United States (20 from science and engineering and 10 from public and business administration) the opportunity to work as salaried interns at the center.[22] The internship program was an effective device both for tapping the intellectual resources of the university, and also for assisting in the transfer of technology from NASA to the private sector. The program generally flourished through the 1960's, declined due to budget problems in the 1970's, and was reinvigorated as a cooperative educational program in the 1980's.

The location of the space center in Houston particularly provided a stimulant to the University of Houston to accelerate its development as a major university. Under the leadership of President Philip G. Hoffman, the University of Houston upgraded its academic offerings, faculty, and facilities. The University of Houston received direct fellowship funding from MSC totaling $365,000 by 1965 which provided 20 graduate fellowships in business, and space-related science and technology fields. In 1969, the university established a graduate campus adjacent to MSC, which became the University of Houston-Clear Lake campus, offering upper-division undergraduate and graduate courses. Paul Purser was assigned by JSC's director to assist in the creation of a graduate center at the University of Houston-Clear Lake. In the 1970's, both the Clear Lake and main University of Houston campuses offered specially devised management programs to help NASA administrators cope with shrinking personnel and budgets.[23]

Texas A&M University, with relatively strong programs in engineering and sciences, proposed to establish an Activation Analysis Laboratory and Space Research Center in 1961, and did implement several NASA-related predoctoral traineeships as early as 1962. Although the Texas Engineering Experiment Station (TEES), administered under the authority of Texas A&M University, did establish a Space Technology Division in 1963, the proposed Space Research Center failed to materialize for several decades. By 1965 Texas A&M University offered 32 scholarships funded by $614,000 in NASA grants. The Dean of Engineering, Fred J. Benson, informed Congressman Olin E. Teague that by 1966, the university had received $2.9 million in NASA-funded grants, including almost $1 million for traineeship grants for graduate students, over $300,000 for independent interdisciplinary research designed to "support faculty ideas which are in the area of the space effort," and $1 million for a Space Research Center building grant. Despite progress, Benson thought that NASA had funded non-Texas schools more generously, and that NASA had handled a number of Texas A&M research proposals "badly," resulting in interminable delays in decisions, funding and real progress, all the while giving verbal encouragement that the university should continue its space-related research programs.[24]

NASA's "Sustaining University Program" included the predoctoral training grants, internships, research grants, and facility grants designed to help rapidly enlarge the production of scientists and engineers in space-related fields. Physical and life sciences, mathematics, physics, biology and developing fields of bioengineering were greatly stimulated by America's space programs.[25] Texas A&M University and the University of Texas, for example, having nationally recognized programs in mechanical and petroleum engineering, began a buildup of faculty and facilities in chemistry, mathematics, physics, and electrical and aerospace engineering under the "space-race" impetus. Generally, however, Texas universities at the beginning of the space era were teaching oriented rather than research oriented, and their expertise lay in practical applications of engineering, agriculture, business, and the sciences.

By the 1980's, those same universities had developed a much broader research base, a more diversified academic program, and in many cases, space-oriented research capabilities. The latter is exemplified by the belated establishment of a Space Research Center at Texas A&M University in 1985, and the Texas Space Grant Consortium organized in 1989, which included 21 state universities, 18 Texas companies, and 2 state agencies. Progress in the development of space programs at Texas universities had, however, been spasmodic and in part deflected by the strong resurgence of traditional emphasis on petroleum production and petrochemical development. The oil boom, in a sense, slowed Texas conversion to diversified industries and to space, but once that boom ended, universities, like businesses, sought new opportunities in space, medical, and computer technologies. There was, in the latter part of the decade of the eighties, a conscious attempt by universities and by JSC to "reach out" to each other, thus ending a long period when relations between the two had been rather quiescent.

The TEES, located at Texas A&M University, initiated an effort to develop more direct research contacts with JSC. David J. Norton, a professor of aerospace engineering and then Assistant Director for Research at TEES, and Oran Nicks, who had joined TEES as a research engineer in 1980 after 20 years of NASA experience ranging from Director of Lunar and Planetary programs to Associate Administrator of Advanced Research and Technology (1960-1970) and Deputy Director of the Langley Research Center (1970-1980), took the initiative in attempting to develop a more permanent relationship between the university and JSC. The two actively began to explore the possibilities with JSC managers.[26]

Conversations with Director Gerald Griffin in the fall of 1984 led to more intense discussions with Michael B. Duke, Chief of the Solar System Exploration Division in the Space and Life Sciences Directorate of the center. Meanwhile, there was within JSC a growing realization that "things were changing," and that the center should become more actively involved in Texas business and university interests and look beyond the Shuttle.

Subsequently, Space and Life Sciences Director Carolyn L. Huntoon approved a response to Texas A&M inquiries by which Duke offered to fund (for $25,000) a proposal for a Space Research Center which would both "define" such a center and identify at least 10 specific tasks related to space and the work of JSC that TEES and Texas A&M could accomplish. Moreover, Duke charged Norton and Nicks to support their proposals by finding specific advocates among relevant JSC engineers and scientists.[27]

While this work progressed, Norton, with the direction and assistance of W. Arthur Porter, Director of TEES, developed a more broadly constructed proposal that would develop within TEES a statewide structure for coordinating cooperative space-related research efforts by Texas universities and businesses. In November 1984, Norton authored "Space Technology Consortium: A Concept Paper," which began circulating within NASA and through Texas universities. In this document, TEES proposed to "provide for an industry-university partnership which would enhance the mission of each through the development of new technology."[28] Both the Texas A&M University-based Space Research Center idea and the statewide Space Technology Consortium developed proponents and critics.

Some faculty and administrators at Texas A&M particularly believed that a consortium of universities under the auspices of TEES might divert research funding from their university to other universities. Although it was in fact a state agency, Texas A&M held a proprietary interest in TEES. Other universities regarded TEES as a competitor rather than an independent state agency. There was also concern that the Space Research Center might deflect research funding from academic departments already involved in space-related research to other departments, duplicate work already being done by the Texas A&M University Research Foundation, or simply impose another intermediary agency between the faculty members and their research. In addition, there was some concern that contract research and an academic-business alignment might jeopardize the integrity of academic research.

Nevertheless, in January 1985, the Board of Regents of Texas A&M University approved the creation of the Space Research Center under the jurisdiction of TEES, and appointed Oran Nicks its director. Nicks discussed the Space Research Center concept with a number of department heads, particularly those in aerospace, electrical, nuclear, and chemical engineering, and held a general meeting of interested faculty and administrators to discuss programs and possibilities. Nicks stressed that the center would serve as a broker between the university and NASA and that it would focus on stimulating interdisciplinary research. Research was to be funded by grants rather than through contracts. There was an important distinction in that proposals were to emanate from the researcher and were not necessarily driven by formal requests from NASA. Thus, research would tend to be generic and preserve academic integrity. Nicks explained that the center sought to promote space-related research, encourage interdisciplinary projects within the university, help attract accomplished scholars and researchers to the campus, and train future scientists and engineers for space activities. Subsequently, the faculty developed 31 rather than the 10 specific research proposals requested by Mike Duke, and the Space Research Center forwarded all of those to NASA through its designated contact, Aaron Cohen, then Director of Research and Engineering at JSC. Nicks commented that the large list of proposals was intended to demonstrate to JSC Texas A&M's capability and relevance in space research.[29]

Gerald Griffin, representing JSC, and the new Dean of Engineering and Director of TEES at Texas A&M, Herbert H. Richardson, approved a Memorandum of Understanding in February 1985, for the announced purpose of "permitting beneficial contact between JSC and TEES, providing opportunities for dissemination of information concerning the activities of the National Aeronautics and Space Administration, and providing opportunities for the scientific community to participate in problem-solving endeavors concerning the space program." Next, JSC funded from the Director's "Discretionary Account" six of the research proposals submitted by the Space Research Center.[30]

Concurrently, a special Space Advisory Board established by the Texas A&M University System, whose members included Gerald Griffin and Aaron Cohen from JSC (both former students of Texas A&M), actively considered establishing a Space Technology Consortium and six NASA Commercial Centers of Excellence to handle proprietary industrial and public domain government research, including prospective Texas projects related to President Ronald Reagan's "Star Wars" or Strategic Defense Initiative, and other independent research initiatives. Norman R. Augustine, Vice President of Martin Marietta Aerospace and President of Denver Aerospace, was also included on this consultative body. (In July 1990, Vice President Dan Quayle appointed Augustine to chair an Advisory Committee on the Future of the U.S. Space Program.) W. Arthur Porter, past Director of TEES, participated as the new director of what became the Houston Advanced Research Center (HARC—a privately funded institution located in The Woodlands, Texas, adjacent to north Houston). George Jeffs, a Rockwell International vice president; Dr. W.H. Pickering, former Director of the Jet Propulsion Laboratory and president of a Pasadena-based research company; Edward "Pete" Aldrich, an Undersecretary and later Secretary of the Air Force; Dr. Lloyd Lauderdale with E-Systems in Dallas, Texas; C.H. McKinley, an LTV Aerospace vice president; and John Yardley, president of McDonnell Douglas Astronautics participated in discussions regarding new initiatives in university-business space technology. Texas A&M University Chancellor Arthur G. Hansen believed that in the future, government/industry/university collaboration would be vital to the state's economic health and well-being—particularly in light of the state's sharply declining oil revenues.[31] Economic misfortunes, coupled with NASA's own *Challenger* misfortune, compelled Texas businesses and universities to seek new research and funding opportunities on the one hand, and JSC to more actively reach out to these constituents on the other hand.

By early 1986, Houston had come to know the depths of recession resulting from the collapse of petroleum prices. Industry began looking for strategies to diversify. When Gerald Griffin assumed the position of President of the Houston Chamber of Commerce, he immediately established an Aerospace Task Force that might seek ways to better integrate JSC's "space economy" into the economy of the city. The task force, led by Walter Cunningham (a former astronaut), included Aaron Cohen, Richard Van Horn, President of the University of Houston, Richard Wainerdi, head of the Texas Medical Center, David Norton, Director of the Space Technology and Research Center of HARC, and Eleanor Aldridge, coordinator for the study. In addition, local business leaders founded a Space Foundation to promote research and private space ventures. It in turn stimulated the organization of a Space Business Roundtable which facilitated monthly discussions by bankers, entrepreneurs, engineers, accountants and business representatives of space business and opportunities. The Space Roundtable idea soon spread from Houston into seven major cities, including Washington, D.C.[32]

When he became Director of JSC, Aaron Cohen established a special $2 million research package to be allocated on the basis of grant applications to the major research institutions in Texas, including Rice University, Texas A&M University, the University of Texas, and the University of Houston. Meanwhile, Frank E. Vandiver, then President of Texas A&M University, proposed to the Space Advisory Board at its first meeting in 1985, that it support an effort to have Congress create national Space Grant universities, as it had already established and funded Land Grant and Sea Grant institutions. Subsequently, Senator Lloyd Bentsen of Texas sponsored legislation authorizing a National Space Grant College and Fellowship program to be administered by NASA. Congress approved the measure in 1987. Texas A&M University and the University of Texas received "Space Grant" status in 1989, bringing together a "Texas Space Grant Sonsortium" involving 21 Texas universities. The two universities, which historically worked in competition rather than in consort, joined in the formation of a broader Texas Space Grant Consortium operating under a Space Grant Program Office located on the University of Texas campus. Dr. Byron Tapley became program director, and Dr. Sallie Sheppard of Texas A&M University and Dr. Steven Nichols of the University of Texas became associate directors. Oran Nicks, with the Texas A&M Space Research Center, chaired the Space Grant Board of Directors, composed of university, industry, and state agency representatives.[33] The space consortium marked the development of a new relationship between Texas universities, and between those universities, JSC, and space industries.

There were other symptoms of those changing relationships. W. Arthur (Skip) Porter, who had participated in the inception of the Space Consortium and Space Research Center, left Texas A&M University to head what became HARC. Created by Houston oilman George Mitchell (President of Mitchell Energy & Development Corporation) in 1984, HARC was a rather unique public-private endeavor (richly funded by George Mitchell) and with a yet undefined mission to stimulate research and technological development through university-business cooperative projects. HARC was yet another umbrella organization within which Texas universities—including Rice University, Texas A&M University, the University of Texas, and the University of Houston—could cooperate without forsaking their familiar turf. It provided for Porter an opportunity to develop the kind of cooperative enterprises he had sought to build through TEES, but in what he thought would be a more conducive and independent environment.[34] Although much of HARC's initial work related to locating a supercollider and supercomputer in Texas, one of HARC's first initiatives was to develop a space research component within HARC.

To do this, Porter recruited his former assistant director at TEES, Dr. David J. Norton, to head the Space Technology and Research Center at HARC. Norton now continued to build from the private sector that which he had worked to develop within the public sector—a liaison between industry and education for research on space-related projects—specifically directed to the needs of NASA and developing private space enterprises. One of the mechanisms for promoting this new liaison was Partners in Space, a nonprofit organization which emerged from the work of the Houston Aerospace Task Force and HARC. Partners in Space helped integrate NASA/JSC into the intellectual and economic fabric of Texas through education, conferences and other forums.[35]

Complementary developments occurred within individual universities and in collaborative efforts by business and civic organizations. NASA's Headquarters Office of Commercial Programs which had launched a program for the establishment of "Centers for the Commercial Development of Space," approved and provided funding, in cooperation with industry, for a Space Vacuum Epitaxy Center at the University of Houston in 1986 and a Center for Space Power at Texas A&M University in 1987. The Epitaxy Center began under the direction of Dr. Paul C.W. Chu, who had become famous for his work on superconductors. Epitaxy, "the atomically ordered growth of a thin film on a substrate in an atom-by-atom, layer-by-layer manner," if conducted in a vacuum such as space, provided the means for producing electronic, magnetic, and superconducting thin film materials of extremely high quality.[36] Like HARC in The Woodlands and the Space Research Center at Texas A&M University, the Epitaxy and Space Power Centers helped build a bridge between private business and NASA.

More directly to the point of the business-space-NASA connection, the University of Houston-Clear Lake, in cooperation with JSC, established a Space Business Research Center in 1986. The Clear Lake center offered library and data base information services relating to NASA and space industries, conducted educational seminars, and provided economic analyses and market forecasts.[37] In addition, beginning in 1987, The Space Foundation (a nonprofit Washington, D.C. organization), *Space Magazine*, and *Washington Technology* (a biweekly business newspaper) in cooperation with JSC, and area chambers of commerce and businesses, sponsored an annual Space Technology Commerce and Communications Conference and Exhibition at the George R. Brown Convention Center in Houston. People in the community and at JSC began serious discussions about building a large visitor center that might better explain what had been done in the past and could be done in the future.[38]

In this general context of public enthusiasm, concern, or even desperation, Texas business and political interests took a very dim view indeed of NASA Headquarters' plan to reduce JSC's participation in the space station program. As information regarding the Phillips report began to filter through JSC and its external support groups, a sense of alarm began to build. Congressman Jack Brooks and Gerald Griffin met in Washington with members of the "Texas delegation" and business leaders to discuss an appropriate response to the threatened program transfers. One immediate result was a telephone call from House Speaker Jim Wright (D-Texas) to Administrator James Fletcher suggesting that if NASA persisted in the planned reallocation of space station spending away from JSC "no future NASA funding legislation would ever be enacted."[39] NASA did begin to reevaluate the planned transfers, and Congressman Jack Brooks subsequently became a self-appointed watchdog to safeguard Texas (and JSC) interests. Vice Admiral Richard H. Truly, who succeeded James Fletcher in the Administrator's post in 1989, commented that Brooks was "one tough customer."[40] As a result, space station management and JSC participation in the program remained relatively unsettled through 1989, when NASA awarded its major space station contracts.

All of this meant, in part, that NASA and JSC had begun to take a different look at the world, and that conversely, the world outside, especially that in Texas, was beginning to change its role from being largely an observer to becoming an active participant in space and new technology. JSC had begun to move from its more narrowly defined role as a project manager, to incorporate a broader perspective of its role as an arbiter of changing technology in society. Nevertheless, the center was aware, as executive assistant Daniel A. Nebrig explained, that there are "some things we cannot do and should not do." Aaron Cohen added that JSC's leadership is best demonstrated by doing those things it can do well.[41] Whatever its intentions, over three decades, Texas society had clearly changed under the influence of space in general and JSC in particular. There had been not only a technology transfer, but also the development of a new attitude and perspective by people in business, education and government. Texans had taken one small step beyond the old frontiers of cattle, cotton, and oil, into the new frontier of space.

NASA too was adapting to change. In May 1986, the President's National Commission on Space charged to help formulate an "aggressive civilian space agenda to carry America into the 21st Century," submitted its report entitled *Pioneering the Space Frontier*. The report offered an "exciting vision of our next 50 years in space." Although predicting the future can be hazardous, the authors noted that Wernher von Braun and Chesley Bonestell predicted a reusable launch vehicle, a space telescope, and a rotating space station as early as 1951. Space technology, the commissioners concluded, "has freed humankind . . . from Earth . . . to expand to other worlds." They advised stimulating individual initiative and free enterprise in space, harnessing solar energy, creating a sustained space program using "a small but steady fraction of the national budget," and fostering international cooperation and American leadership in space (with a critical lead role by the U.S. Government).[42]

The commission recommended an aggressive space science program that first, stressed an understanding of the structure and evolution of the universe, the galaxy, the solar system and planet Earth; second, applied this understanding to forecast future phenomena "of critical significance to humanity"; and third, used space to study basic properties of matter and life. NASA should work on those projects related to sustaining human life in space, including robotic prospector missions, robotic and human exploration and surveying, and the establishment of human outposts in the inner solar system.[43]

The report recommended that NASA should encourage new space enterprises. The commissioners recommended that 6 percent, rather than 2 percent, of NASA's total budget be allocated for research and development in basic technologies, specifically those relating to aerospace plane propulsion and aerodynamics, advanced rocket vehicles, aerobraking for orbital transfer, long-duration closed ecosystems, electric launch and propulsion systems, nuclear-electric space power, and space tethers and artificial gravity.[44]

The commission advised that work on post-Shuttle transportation systems should include an economical cargo transport for low Earth orbit, a passenger transport to and from low Earth orbit, and a reusable round-trip multipurpose vehicle for destinations beyond Earth orbit. Technological milestones envisioned included the initial operation of a space station (projected for 1994), the initial operation of "dramatically lower cost transport vehicles to and from low Earth orbit," the establishment of spaceports in low Earth and lunar orbit, Mars orbital flights first by robotics and then by humans, and finally human exploration and prospecting on Mars. Because "the American public has become uncertain as to our national space objectives . . . We must strengthen and deepen public understanding of the challenges and significance the space frontier holds for 21st-century America . . ."[45] Although the report of the National Commission on Space did offer an "exciting vision," it tended to be ignored by the media and the public who were concentrating on the *Challenger* accident, economic and federal budgeting problems, and other domestic concerns. The report did, perhaps, help restore a sense of clarity and purpose to NASA's own vision for its future.

Civilian space goals needed to be carefully chosen and consistent with NASA's capabilities, that is, to be technically and financially feasible. The National Commission on Space offered a vision of new frontiers, while the report of the Rogers' Commission offered a very sobering view of that which was possible or desirable:

> . . . in the aftermath of the *Challenger* accident, reviews of our space program made its shortcomings starkly apparent. The United States' role as the leader of spacefaring nations came into serious question. The capabilities, the direction, and the future of the space program became subjects of public discussion and professional debate.[46]

Could NASA adopt a major, visionary goal or did the Shuttle and the space station already represent an overcommitment?

NASA attempted to confront the issues presented in resolving the futuristic goals of the National Commission on Space with the hard realities proffered by the Rogers Commission. A *Leadership* study, headed by astronaut Dr. Sally K. Ride and presented to Administrator Fletcher in August 1987, if it did nothing else, highlighted the complexity of civilian space program policy decisions—and it urged the institution of better long-range planning mechanisms. Somewhat reminiscent of the Sputnik scare and a reminder that the cold war had not ended, the study noted that unmanned Mariner and Viking missions visited Mars in the 1960's and 1970's, but none had done so since 1976, and the Soviets were beginning an extensive robotic exploration of the Martian surface in 1988. The American space station Skylab was last visited in 1974, whereas the Soviets' six space stations had been visited in orbit since the mid-1970's, and the Mir, launched in 1986, would give the Soviets a very long presence in space. The United States "has clearly lost leadership in these two areas and is in danger of being surpassed in many others during the next several years."[47]

The National Space Policy Act of 1982 obligated the United States to maintain "space leadership." And what constitutes leadership? Leadership is something that cannot be announced but must be earned. It involves the development of capabilities and the demonstration of those capabilities. It requires the ability to set and meet goals and achieve objectives. Space leadership requires the development and sustenance of strong programs in scientific research and technology development, and the demonstration of tangible accomplishments. Once achieved, leadership generates national pride and international prestige, and enhances "the human spirit's desire to discover, to explore and to understand."[48] How, then did one extrapolate leadership to the mundane world of NASA research, engineering, and contract development?

Very briefly, the *Leadership* report viewed NASA as the agency designated to implement national civilian policy in aeronautics and space. Those goals are to advance scientific knowledge of the Earth, the solar system, and the universe beyond; expand the human

Johnson Space Center, 1986

FIGURE 20. Organization as of March 1986.

Johnson Space Center, 1987

FIGURE 21. Organization as of April 1987

Johnson Space Center, 1988

Office of the Director (AA)

Aaron Cohen	Director
Paul J. Weitz	Deputy Director
Daniel A. Nebrig	Executive Assistant
Clifford E. Charlesworth	Special Assistant
John W. Young	Spec Asst for EO & S
Joseph P. Loftus	Assistant Dir (Plans)
John W. Aaron	Technical Assistant
George W. S. Abbey	Spec Asst (Programs)

NASA Inspector General Field Office

W. Preston Smith	Chief
Ned Eckerd	Deputy

Legal Office (AL)

Henry W. Flagg — Chief Counsel

Equal Opportunity Program Office (AL)

Joseph D. Atkinson — Chief

Human Resources (AH)

Jack R. Lister	Director
Harvey L. Hartman	Deputy

Public Affairs Office (AP)

Harold S. Stall	Chief
Douglas K. Ward	Deputy

Administration Directorate (BA)

William R. Kelly	Director
R. Wayne Young	Deputy

- Office of Director of Procurement
- Office of the Comptroller
- NSTS Program Control Office
- Orbiter and GFE Projects Control Ofc
- Management Analysis Office
- Space Station Projects Control Ofc

Orbiter & GFE Projects Office (VA)

Richard Colonna	Manager
Daniel M. Germany	Deputy
Gary A. Coultas	Asst Mgr
Robert V. Battey	Asst Mgr for Plans & Sch

- Orbiter Project Resident Office – Downey
- JSC Resident Office – KSC
- Flight Data and Evaluation Office
- Orbiter Avionics Systems Office
- Flight Support Equipment Office
- Orbiter Engineering Office

Space Station Projects Office (KA)

Clarke Covington	Manager
Carl B. Shelley	Deputy
Robert E. Bobola	Mgr for Dev
Jesse F. Goree	Mgr for Integ
W. E. Rice	Asst Mgr for Policy

- Information Systems Office
- Flight Elements Office
- Management Integration Office
- External Integration Office
- Manufacturing and Test Office
- Systems Engineering and Integration Office

Mission Support Directorate (EA)

Ronald L. Berry	Director
Elric N. McHenry	Deputy
John R. German	Asst to Dir
Samuel M. Keathley	Asst to Dir

- Data Processing Systems Div
- Mission Planning and Analysis Div
- Spacecraft Software Division
- Systems Development Division

Flight Crew Operations Directorate (KA)

Donald R. Puddy	Director
Henry W. Hartsfield	Deputy
Richard W. Nygren	Asst to Dir
Karol J. Bobko	Asst to Dir

- Vehicle Integration Test Office
- Aviation Safety, Chief
- Crew Integration Office
- Astronaut Office
- Aircraft Operations Division

Space & Life Sciences Directorate (KA)

Carolyn L. Huntoon	Director
Donald E. Robbins	Deputy
Lawrence F. Dietlein	Asst Dir for Life Sci

- Medical Science Division
- Life Sciences Project Division
- Solar System Exploration Div
- Man-Systems Division

Engineering Directorate (EA)

Henry O. Pohl	Director
Max Engert	Deputy

- Engineering Management Office
- Advanced Programs Office
- Program Engineering Office
- Crew and Thermal Systems Div
- Systems Development and Simulation Division
- Avionics Systems Division
- Tracking and Communications Div
- Propulsion and Power Division

Mission Operations Directorate (DA)

Eugene F. Kranz	Director
John W. O'Neill	Deputy
James D. Shannon	Asst to Dir

- Reconfiguration Management Ofc
- Administrative Office
- Flight Director Office
- Management Integration Office
- Flight Design and Dynamics Div
- Operations Division
- Systems Division
- Schedules and Flow Office
- Training Division
- Facility and Support Systems Div
- Space Station Mission Ops Ofc

Center Operations Directorate (JA)

Kenneth B. Gilbreath	Direcctor
Grady E. McCright	Deputy

- Logistics Division
- Security Division
- Management Services Division
- Photography and Television Technology Division
- Technical Services Division
- Plant Engineering Division
- Facilities Design Division

Safety, Reliability & Quality Assurance Office (NA)

Charles S. Harlan	Director
Gary W. Johnson	Deputy

- NSTS SR&QA Office
- Quality Assurance, Reliability, and Safety Office – Downey
- Quality Assurance, Reliability, and Safety Office – WSTF
- Reliability and Maintainability Div
- Safety Division

White Sands Test Facility (RA)

Rob R. Tillett — Manager

- Administration Office
- Propulsion Office
- Laboratories Office

New Initiatives Office (IA)

William J. Huffstetler — Manager

- Crew Emergency Return Vehicle (CERV) Office
- Advanced Projects Definition Ofc
- Technology and Commercial Projects Office
- Flight Projects Office
- Lunar and Mars Exploration Ofc

NSTS Operation Integartion Office

Richard A. Thorson — Manager

National Space Transportation Systems (GA)

Richard H. Kohrs	Mgr/Dep Dir
Jay F. Honeycutt	Deputy
Bryan D. O'Connor	Asst Mgr for Ops

- Management Integration Office
- NSTS Integration and Operations Office
- Space Station Integration Office
- Flight Production Management Ofc
- Mission Integration Office
- Cargo Engineering Integration Ofc
- Customer Integration Office
- NSTS Engineering Integration Ofc
- Project Integration Office
- Avionics Systems Office
- Systems Engineering Office

FIGURE 22. Organization as of May 1988.

presence beyond the Earth; and strengthen aeronautics research. Its immediate commitments were to return the Space Shuttle to flight status, develop advanced space transportation capabilities, and build the facilities and pursue the science and technology needed for the Nation's space program. In the process, NASA would promote the application of aerospace technologies to improve the quality of life on Earth, and conduct cooperative activities with other nations.[49] It seemed to be a reasonable and clearminded charge, attainable, and more practical than visionary. It was something that NASA and JSC could attack and Congress and the public could understand. The *Leadership* report, delivered to James Fletcher in August 1987, helped resolve doubts and uncertainties.

By the close of 1987, most of the reports, studies, and organizational changes relating to the space station and the Shuttle had been completed. Program management, both for the Shuttle and the space station, shifted to NASA Headquarters. Aaron Cohen revised JSC's administration by having each directorate report directly to the center director, rather than through a division head. Thus, whereas Flight Crew Operations, Mission Operations, and Mission Support had reported through C.E. Charlesworth to the director, now each reported directly (figures 20 through 22). JSC relinquished the National Space Transportation System Program Office to Headquarters. Arnold D. Aldrich became director and Richard H. Kohrs deputy director. Robert L. Crippen, one of the Air Force manned orbiting laboratory trainees who transferred to the astronaut corps in 1969, became deputy director of the Space Transportation System Operations Office stationed at Kennedy Space Center in Florida.[50] Administrative arrangements for the space station and the Shuttle, however, continued to change.

In addition to the regular line directorates, the three project offices at JSC included the New Initiatives Office, the Space Station Projects Office managed by Clarke Covington, and an STS Orbiter and GFE Projects Office under Richard A. Colonna.[51] The Space Station Projects Office concentrated on planning and designing the proposed station until 1989 when major development contracts were let. The Orbiter Office readied the three remaining Shuttles for flight, and, in July 1987, began to award contracts for a replacement vehicle for the *Challenger*.

The replacement vehicle (Orbiter 105) was to be markedly improved over the three existing Shuttles. Orbiter 105, Colonna said, "would have stronger

On August 2, 1991, STS-43 soared toward space to begin a 9-day mission to deploy a Tracking and Data Relay Satellite (TDRS-E) similar to that lost aboard Challenger. *The TDRS-E had waited more than 5 years while NASA investigated the* Challenger *accident and the Nation reassessed its space programs.*

wings, midbody, and tail, better brakes and tires on stronger axles, improved electronics, bigger and better computers, improved auxiliary power units, a safer heat exchanger, a parachute brake, fewer tiles, and new fuel disconnect valves." Rockwell, the Shuttle prime contractor, had major structural parts for a new Shuttle on hand which speeded construction by an estimated 2 years. Subcontractors such as Grumman (wings), Fairchild Republic (tail), and IBM (computers) manufactured their components in their own plants and delivered them for assimilation at the Rockwell plant in Downey, California, or for final assembly to a Rockwell hangar in Palmdale. The new Shuttle was scheduled for delivery in April 1991. In addition, the solid rocket booster joints had been completely redesigned under the supervision of Marshall Space Flight Center and Morton Thiokol engineers.[52]

The Orbiter Project Office also managed an extensive refurbishment of the existing Shuttle fleet. There were 210 modifications to the orbiters, including a rudimentary escape system, new pressure suits to be worn during launch (versus the old shirtsleeve uniform), inflatable life rafts and emergency signals, structural reinforcements in the wings and fuselage, better brakes, and enhanced computers. In January 1987, NASA selected a crew (Frederick Hauck, Richard Covey, George Nelson, Mike Lounge, and David Hilmers), a ship (*Discovery*), and a launch date (February 18, 1988) for the return to flight. That launch date slipped to September 29, when fuel tank tests, and then solid-fuel rocket booster test failures, leaky seals, and valve malfunctions caused delays.[53] NASA's response to *Challenger* and the Rogers Report was better engineering and enhanced safety and quality control checks.

But NASA now seemed to be plagued with problems that lay beyond engineering expertise and quality control. Moreover, problems of any sort in the post-*Challenger* era had become matters of public concern and alarm. Although it had long labored under the public eye, NASA's performance was now being viewed through a magnifying lens. In March 1987, a NASA Atlas-Centaur carrying a Navy communications satellite broke up after being struck by lightning only moments after launch. In June, three rockets being readied on the Wallops Island launch pad were struck by lightning and launched in premature and "hopeless" flight. In July, the upper stage of an Atlas-Centaur rocket on the launch pad at Kennedy Space Center was destroyed in an accident. In August, valve malfunctions on the orbiter and hydrogen leaks in the ground support equipment forced postponement of a *Discovery* launch. And in September a hurricane off the Texas coast threatened to disrupt operations in Mission Control and forced a delay in setting a firm launch date. Finally, the countdown began on September 25. An estimated one-half million people gathered at the Cape to view the launch. "After 2-1/2 years of anguish, resolve, and accomplishment," on September 29, 1988, *Discovery*—and the United States returned to space.[54] The downtime ended.

Out of this time of chaos came a reassessment of America's role in space. The results of these deliberations were remarkably consistent with visions and programs delineated in the 1950's and 1960's. A space shuttle, unmanned missions to the planets and beyond, a space station, and habitation by humans of other solar bodies still comprised the general plan for an American presence in space. The dream was still alive. There was now a new space station initiative, a better and safer Shuttle, and a "New Initiatives" management group at JSC. The structures for administering the Shuttle and the space station had changed and would continue to do so as the programs themselves changed and as the new styles of management were field-tested. There were new initiatives by NASA, JSC, universities, and businesses that would fabricate a new extension and a new permanence of space in the affairs of people on Earth, and particularly among those in that community associated with JSC.