Cable Satellite Dist

The evolution of the cables-satellite distribution system.(Industry Overview)

From: **Journal of Broadcasting & Electronic Media** Date: **March 1, 2003** Author: **Parsons, Patrick**

The television industry began a dramatic transformation in the mid 1970s following the creation of the cable-satellite programming distribution system. This paper details the evolution of the cable-satellite link, from its conceptual roots in the 1960s, through pioneering efforts by Teleprompter Corp., to the eventual involvement of Home Box Office. It offers a narrative and analysis that fills a gap in the existing historical record and provides an illustration of several themes involving the social evolution of technology.

The introduction in 1975 of the cable-satellite programming distribution system led to a dramatic restructuring of the television industry in the United States. From an industry dominated by three national networks, television evolved into a multichannel environment in which viewers had access to dozens of highly specialized program choices. While NBC, CBS, and ABC remain the most heavily viewed television networks, their market share has steadily eroded since the introduction of the cable-satellite link and the cable programming industry that it spawned.

While this critical inflection point in television history is ritually noted in most textbooks, its evolution has never been substantively detailed. The typical treatment in the literature involves a note to the effect that in 1975 Home Box Office (HBO) inaugurated satellite-delivered programming, helping spark a revolution in television (See e.g., Dominick, Sherman, & Copeland, 1996, p. 70; Head, Sterling, & Schofield, 1994, p. 78; Gross, 1997, pp. 75-77; Parsons and Frieden, 1998, 52-54). Some broadcast and cable history texts offer a bit more detail (Fang, 1997, p. 201; Hilliard & Keith, 1997, p. 213, 216; Southwick, 1998; Sterling & Kittross, 2002, p. 412). Two pieces from the 1970s discuss then-future prospects for cable-satellite interconnection (Shapiro, 1972; Shapiro, Epstein, & Cass, 1975), and Winston (1986, p. 289) mentions early proposals for satellite-cable systems, but only in passing. None have provided the richer description that this key turning point in communications history arguably deserves. This paper is an effort to begin to fill that gap in the historical narrative. Its intent is to explore the development of the cable-satellite union.

The paper is also an effort to illustrate several broader theoretical points about the nature of technological development. It proceeds from the factual observation that the cable-satellite system had a substantial prehistory and the analytical position that technological change is, to a point, evolutionary. This review builds upon models of technological change that posit incremental and gradual, rather than radical and discontinuous, technical innovation (Basalla, 1988; Ziman, 2000). Analysis therefore focuses on the stages in the development of a given device or system. At the same time, this analysis breaks from much of the recent evolutionary literature to suggest that at some point a given idea, design, or device reaches a new phase in its technical development. Coming together, the constituent components offer a new functionality that opens the door to subsequent rapid social deployment. At the same time, appropriate social conditions must be in place to accommodate that deployment. This is a kind of quantum leap in the longer evolutionary path of the technology. Television itself is a classic example. Conceptually, the roots of television are almost timeless and technically they trace back to the discovery of selenium and the work of people such as Nipkow, Jenkins, Farnsworth, and Zworykin (Fisher & Fisher, 1996). The technical, political, economic, and social conditions were not in place for a viable system, however, until after World War II, when, with sufficient convergence of these elements, television took off with dramatic consequences. Therefore, analysis must be sensitive to both the slow accretion of ideas and activities that lead up to a socially operational system and to the subsequent rapid unfolding of that system.

The case of the cable-satellite distribution system also underscores the rather well established touchstone that analysis be sensitive to socio-economic context. Technology cannot be treated apart from its social conditions. Beginning with Marx and across the literature, from Hughes (1983) to Rogers and Shoemaker (1971) to Winston (1998), scholars repeatedly stress that technological change is shaped and constrained by the existing social, economic, and political fabric. A host of technical solutions may, therefore, be proposed for any particular communications problem but only those that comport, at least initially, with existing social structures will find fertile soil.

Early Discourse in Satellite Television

The cable-satellite distribution system built, of course, on existing technologies of cable and satellite communications, each with its own substantial history. It is not the intent of this paper to explore in any detail the full history of satellite or cable television, but rather to look at the particular events and forces surrounding their merger. At the same time, some background in satellite and cable development is useful.

The concept of satellite communications is classically traced to a seminal 1945 article by science fiction author and engineer Arthur C. Clarke (1945), in which he offered for the first time a published description of three strategically placed, manned space stations in geosynchronous earth orbit. Television and radio signals beamed from these platforms could, he noted, cover the globe. Twelve years later the Soviet Union launched the world's first artificial satellite, Sputnik I, setting off the Cold War's "space race," and leading eventually to passage of the Satellite Communications Act of 1962 and creation of the Communications Satellite Corporation (Comsat) in 1963. Comsat's mission was, in part, to be the exclusive state-sanctioned service provider for satellite communications facilities in the United States. It also helped form and manage a similar international body, INTELSAT, the International Telecommunications Satellite Organization.

Satellite technology itself was progressing with the launch of two passive communications satellites, SCORE in 1958 and Echo in 1960. SCORE simply transmitted a pre-recorded holiday message from President Eisenhower, while Echo was, in fact, a large metallic balloon that reflected radio signals back to earth. Courier, launched by the Defense Department in 1960, could actively relay limited voice and teletype communications but lasted only 17 days in space. The first communications satellite actually capable of electronically receiving and retransmitting voice and television signals was AT&T's Telstar, launched in July 1962. By 1963, Hughes Aircraft Corp., which would become a significant force in television-satellite development, provided the first geosynchronous communications satellite, Syncom-II (Syncom-I failed shortly after its launch earlier that year). Orbiting at

22,300 miles above the equator and traveling at 6,870 miles an hour, a geosynchronous satellite is stationary with respect to a spot on earth, giving it a stable coverage area and largely eliminating the need for expensive ground tracking. In 1965, Hughes launched the first true commercial communications satellite, Early Bird (Intelsat I).

The earliest satellites were designed and used in large part for the relay of telephone communications. Technically, however, satellite transponders can process either telephone or television signals, allowing for early experimentation with the latter. The first live television signal relayed by satellite was an image of the American flag waving in front of AT&T's ground station in Andover, Maine, on July 23, 1962. Telstar beamed that and other pictures to receiving sites in France and Great Britain, and brought signals from Europe back to the United States, opening the way for eventual commercial exploitation of the service. Within a few years, Early Bird and its successors were providing live feeds of important European news and cultural and sporting events, and offering Europeans similar coverage from the United States. The focus of this examination, then, is the harnessing of that emerging technology to the needs of a growing domestic cable television industry.

Futurists and policy makers in the 1960s discussed at length the possibilities, and potential dangers, of using satellites for purposes beyond the trans-Atlantic relay of specialty news and cultural events. These conversations, however, most typically revolved around the possibilities of direct-to-home (DTH) broadcasting. Studies on DTH were sponsored or conducted through the early 1960s by RCA (Bond, 1962), NASA, Hughes Research Laboratories, the Rand Corporation, General Electric, and TRW (Prochaska, 1974, pp. 17-24; Taylor, 1977, pp. 48-,53). The seductive image of instant, global television captured the popular imagination as well, leading to frequent commentary in the popular and trade press ("GE Engineer," 1962; Craven, 1962), and to serious policy debates, as early as 1958, over the control and social impact of such technology (U.S. Congress, 1958; Clarke, 1959; Smythe, 1960).

Contrasting sharply with the often enthusiastic rhetoric was the absence of any actual development of a DTH system. Beyond a set of direct-broadcast experiments by NASA in the early 1970s (the Applied Technology Satellite or ATS project), the economics and technology of the day militated strongly against adoption of the technology for this purpose. Satellite transponders were far too weak for true DTH service (President's Task Force, 1968) and there was little vested commercial interest in developing a DBS system that would directly threaten the powerful existing broadcasting networks, or AT&T, which profited handsomely from the common carriage of broadcast programming via terrestrial cable and microwave facilities.

Hughes, however, was seeking to expand its market for satellites and approached ABC with a proposal for a system that would use satellite technology to distribute network programming to ABC affiliates around the country. On September 21, 1965, ABC filed a proposal with the FCC. It was the first such request to come to the Commission and was novel in a number of aspects, including its plan to operate a satellite outside of the Comsat monopoly. The Commission returned the application, stating that it wanted to look more closely at the issues raised in the proposal (FCC, 1965a). The Commission then opened an inquiry into the question of private ownership of domestic communications satellites and their appropriate uses (FCC, 1965b). Sensing a general need for long-term planning in communications policy, President Lyndon Johnson commissioned in August 1967 a task force headed by Under Secretary of State Eugene Rostow to investigate the numerous intertwined issues, and the FCC indicated it would await the findings of the report before drawing its own conclusions on the matter.

Cable Networking: The Seeds of an Idea

DTH and broadcast television networking, in short, tended to dominate the television satellite agenda in the early and mid 1960s. The possibility that satellites could be used in connection with cable television was, at best, a marginal thought, but this was not surprising given the broader social context of that period. Started in the late 1940s and early 1950s as a simple television retransmission service, cable had expanded by the early 1960s, but was still a relatively small piece of the nation's television landscape. There were fewer than 1,600 systems in 1966, most of which served only a few hundred subscribers. Cable's national reach was only about 1.6 million of the nation's 53.8 million television homes, or about 3 percent. After a decade of benign neglect, the FCC was beginning to exert control over cable and place restrictions on its growth such that the prospects for its expansion beyond a well constrained supplementary television service were coming into doubt (LeDuc, 1973).

At the same time, the concept of cable networking, part of the seed that would grow into the cable-satellite system, had been a topic of industry conversation since at least 1959 (Merrill, 1991). Small-scale regional cable system interconnection via land-based microwave was common by the late 1950s. The possibility of extending such links and interconnecting cable systems, especially in order to create a larger audience for possible Pay-television programming, was a recurrent theme among cablecasters and broadcasters in the early 1960s, albeit one which the broadcasters naturally viewed with fear and loathing. The terrestrial technology that allowed for interconnection and the clear view that such regional systems might be expanded to a nationwide distribution platform were, therefore, steps along the incremental, evolutionary path toward today's industrial structure.

The idea that satellites might be a part of this interconnection concept was introduced and grew in the mid and late 1960s. Satellite technology itself was evolving during this period and, importantly, a new public rhetoric was springing up around the potential of cable television. The period saw a wave of utopian thinking sweep into the telecommunications field. Dubbed the "Blue Sky" era, it positioned cable television not as a simple broadcast retransmission service but as a broadband communications technology that could be used to bind local communities, deliver health and educational services, and foster democracy (Streeter, 1987). "Blue Sky" discourse also incorporated the idea of cable networking at about the same time that business and policy discussion about the potential for satellite television was heating up. The result was a confluence of concepts. A short time after ABC filed its satellite petition with the FCC in 1965, a long-time cable executive, Leon Papernow, wrote in Television Magazine that the near future would see satellites used to beam cable programming from New York and Los Angeles to cable systems across the country (Papernow, 1965).

From simple technical interconnection, the next conceptual step was the idea of exploiting a nationwide broadband system to provide multiple, specialty-programming networks. The Carnegie Commission Report on Educational Television published in January 1967 proposed interconnecting PBS stations via satellite, and a supplementary paper by MIT professor and Internet visionary J.C.R. Licklider outlined several future scenarios for television including one that foresaw a multiplicity of television networks aimed at serving the

p. 212). The means for delivering these networks, explained Licklider, would be interconnected CATV systems linked by terrestrial and satellite technologies.

In May 1967, Rand Corporation researcher Leland Johnson delivered an address to the annual meeting of the American Astronautical Society in which he detailed a similar proposal:

> The combination of CATVs with nationwide satellite hookups could provide the means whereby sufficiently large audiences could be accumulated to make more attractive than is now the case commercial sponsorship of programming that caters to 'minority' tastes. To be sure, such an arrangement would also make profitable additional mass-appeal, light entertainment as well. Moreover, the expansion of programming would tend to erode and fragment existing large audiences enjoyed by particular programs today (Johnson, 1967, p. 8).

In August of the same year, a pair of Johnson's Rand Corporation colleagues published a proposal for what they termed "wired city television" (Barnett & Greenberg, 1967). It called for a 20-channel coaxial system to carry all domestic television, replacing the existing broadcast system. The report noted almost offhandedly, citing Johnson, that national interconnection, by ground and satellite relay, would be a part of the scheme.

In the summers of 1967 and 1968, a project jointly sponsored by NASA and the National Academy of Sciences (The Summer Study on Space Applications) looked at the "Useful Applications of Earth-Oriented Satellites" (National Academy of Sciences, 1969). Panel number 10 reviewed the use of satellites in broadcasting and, among other recommendations, outlined a system of satellite networking for CATV. The panel visualized eight national cable-satellite networks, including the three existing broadcast networks, a public broadcasting channel, a world-wide United Nations channel, two additional educational channels and an eighth channel held in reserve for an unspecified "new service."

Capping the public policy examination was the widely publicized Rostow report, completed by December of 1968. The President's Task Force concluded that cable television, in contrast to direct broadcast satellites and even established television networks, offered the greatest promise for increasing diversity in the nation's television diet.

The Cable Industry Stirs

On the heels of the rising policy discussions about potential cable-satellite networks, the National Cable Television Association (NCTA), at its June 1969 convention, sponsored a General Management and Engineering session on "CATV Via Satellite" (NCTA, 1969). Among the presenters were representatives from Rand Corporation, Comsat, and perhaps most importantly, Irving Kahn, President of Teleprompter Corp., the cable industry's largest MSO. The panel was chaired by Frederick Ford, NCTA President and former Chairman of the FCC. Ford (NCTA, 1969, p. 668) indicated that he, along with others, had been considering the possibility of a national cable network for several years and that in early 1969 he had directed the NCTA staff to begin working on a plan for a multi-channel satellite system. Released at the 1969 convention, the scheme called for a six-channel service that included channels for PBS-type cultural fare, instructional television, medical and health programming, reruns of broadcast network (ABC, NBC, CBS) documentaries, 24-hour weather programming, and full-time coverage of Congress. (Entertainment programming was specifically excluded from the proposal as a result of an ongoing set of political negotiations with the NAB and FCC over developing cable regulations.)

The lure of new programming, even non-fiction programming, was especially important to cable operators at this time. Restrictive FCC regulations, the political and regulatory context in which cable had to operate at the time, had foreclosed to cable most of the nation's top 100 markets (LeDuc, 1973). Even without such regulatory shackles, however, cable had little product to offer in the nation's urban areas. In most large markets, consumers could receive adequate reception of all three networks, plus an independent or two, and were unwilling, in sufficient numbers, to subscribe to a cable service that offered only marginally better reception and perhaps an imported signal. Despite a 1969 FCC order requiring local origination for larger systems (FCC, 1969), individual cable operators were not in a financial position to create their own programming, at least not at a production level commensurate with existing broadcast fare. Pay television presented long-term potential, but again was expensive to produce and raised regulatory problems (Gershon, 1990).

The answer lay in national interconnection. Only by aggregating a national audience and spreading production costs across that audience could sufficient revenue be generated to make alternative programming possible. Cable operators needed to assemble a critical mass of subscribers and subscriber dollars sufficient to make national networking economically viable (see also, Markus, 1987). Construction of a dedicated terrestrial microwave system, despite the rhetoric of earlier years, was determined to be too expensive, as was use of the existing national television distribution system run by AT&T (See, e.g., Noll, Peck, & McGowan, 1973, pp. 246-250; Selden, 1972, p. 134). Those few cable operators who were discussing interconnection in the late 1960s, therefore, cast their eyes upward toward a satellite option.

Despite the high cost of building, launching, and operating a satellite, the economics of satellite communication were very attractive when contrasted with land-based networks (Parsons & Frieden, 1998, pp. 141-46). Satellite communication, for example, is economically distance-insensitive: once the capital investment is in place, the cost of transmission within the footprint of satellite is equal to all points. And the cost of adding additional receivers within the footprint is only the cost of the receiving equipment itself. Satellites, therefore, enjoy overpowering economies of scale in comparison to terrestrial networks. Additional benefits for cable included network externalities, the economic snowballing effect of system participation. Lower distribution costs would mean more and smaller systems could participate, increasing total and shared revenues, while keeping costs low and encouraging yet more participation. Satellite distribution also offered superior picture quality. Technically, therefore, there were several solutions to the distribution dilemma. The economic context of the time, however, favored and fostered only one--the satellite system.

Teleprompter

The concept of a cable-satellite distribution system providing multiple specialty programming services was well in place by the end of the 1960s. But while a satellite solution looked good on paper, the questions remained of how to bring it about and who to lead the way. The NCTA could encourage creation of satellite cable networks, but it required a company with substantial resources to make it real. The company that took the lead was Irving Kahn's Teleprompter. Kahn was one of the earliest and most vocal proponents of a satellite network and as head of the nation's largest cable company had the resources to initiate action (Kahn, 1987). Kahn assigned much of the job to his long-time partner Hubert Schlafly, an engineer and a cofounder of Teleprompter. In the late 1960s, Schlafly was working with Hughes Corp. on the development of a 12-channel, short-haul microwave distribution system (Amplitude Modulation Link or AML) to substitute for very expensive cable runs in Teleprompter's Manhattan, New York, franchise. The work brought Schlafly into regular contact with Hughes' satellite chief, Harold Rosen, and out of their conversations came the possibility of a Hughes-built satellite system for Teleprompter (Schlafly, 1998). (The AML project also led to a Hughes investment in Teleprompter and by 1970 Hughes owned 17 percent of the company). Following his appearance at the 1969 NCTA session, Kahn formally announced in October of that year Teleprompter's intention to create, with Hughes, a satellite distribution system.

Teleprompter was supported, at least in spirit, by other large cable operators. At a the NCTA convention in May 1970, "operators all but cheered at the suggestion that the only answer for the sale of national advertising.., must be a national interconnected CATV network" ("CATV headed for ad-supported network?" 1970). The NCTA issued a report that year analyzing the potential for growth in the industry, which was stagnating under the burden of FCC control, and pegged business revitalization in part to the promise of satellite interconnection. The report noted that if industry leader Teleprompter could interconnect all its systems, it would have a national subscriber base of 450,000 homes, sufficient to begin thinking about new program networks and accompanying advertising revenue (Lady, 1970, p. 4).

In December 1970, Hughes filed its proposal with the FCC. It called for two satellites, each capable of delivering 10 channels of video. Programming for the CATV service would consist of specialty channels for news, sports, music, public affairs, and minority interests. The material would be provided by Teleprompter and The Hughes Sports Network. The service would cost customers an extra 25 cents to $1 a month ("Hughes files for CATV satellite system," 1970).

It was not the only such plan presented to the Commission. Under the strong urging of the Nixon administration, the FCC in 1970 had finally proposed an "Open Skies" policy for communications satellites, one that would permit private companies to own and operate the system (FCC, 1970). In addition to Teleprompter, seven other companies filed applications to operate systems and most of the proposals included provisions for the distribution of programming specifically for cable. A Comsat proposal promised two channels for CATV use (and two for PBS) ("Comsat poised to file," 1970). MCI-Lockheed filed a plan said to be sufficiently flexible to meet the needs of the CATV industry, as did RCA Global Communications and Fairchild Industries? One of the most interesting filings, from an historical perspective, came from Western Tele-Communications, Inc., the microwave distribution arm of cable MSO, Telecommunications, Inc. (TCI). TCI had an early vision of a national microwave network for cable programming, and saw the advantage in developing its own material for delivery over that network. Its filing with the FCC in 1971 called for a $66 million, two-satellite, communication system designed in large part to interconnect cable operators (Shapiro, 1972).

An economic analysis of all the proposals concluded, in part, that TCI was unlikely to succeed in an open skies environment (Allen, Bossert, & Krause, 1971) and an FCC staff report (FCC, 1972a) recommended substantial revisions to the plan. By early 1973 the company had run into financial difficulties and was no longer actively seeking authorization, but the filing demonstrated the wider interest of the industry. Similarly, as part of the FCC review, three cable companies, including Teleprompter, sought permission to operate earth stations in conjunction with any potential cable-satellite network (FCC, 1972a). (2) The NCTA and cable operators such as Time, Inc. also weighed in on the debate, urging the FCC, no matter which applicants it approved, to make sure that facilities were provided for the interconnection of the nation's cable operators and to allow cable systems to own earth stations. ("Up in the air over satellites," 1971; Shapiro, 1972, p. 149).

By June 1972, the FCC had completed its inquiry and issued its "Open Skies" order (FCC 1972b). Western Union was the first company to earn FCC approval in January 1973, launching the nation's first commercial domestic communications satellite, Westar, in 1974 (FCC, 1973a). Satellite applications of five more companies, including Hughes and RCA, were approved in September 1973 (FCC, 1973b).

Cable, however, needed more than just FCC approval and transponder capacity. These were necessary but not sufficient conditions to bring about the technical quantum leap; additional key industrial components were still missing. Deployment of a satellite system required acceptance by the thousands of small systems that made up the bulk of the cable industry, and few of them were enthusiastic. The stumbling block was characterized at the time as "the chicken or the egg problem." Simply put, most cable operators were exceptionally hesitant to invest in satellite dishes without assurances of a steady stream of quality programming. Receiver prices were estimated at $75,000 to $250,000, and ownership, while now permitted, still required FCC approval which meant a lengthy and cumbersome application process. Alternatively, with exceptions such as Hughes and TCI, program producers were hesitant to spend the capital necessary to develop programming without some assurance there would be a sufficient number of receiving cable systems to recover their cost. It was an economic "vicious cycle."

It was Teleprompter's intent to break that cycle, in part by a physical demonstration of the satellite promise and in part through a plan to organize the industry. While the FCC pondered satellite applications, Teleprompter went to work in early 1973 to show the industry that satellite networking was more than just a pipe dream. Schlafly put out a request for proposals for an earth station capable of picking up a satellite television transmission but small enough to be transportable and priced under $100,000. As he recalled later, he received no response from the industry's major players, such as General Electric and Raytheon, but two men from a previously little known company approached him saying they could do the job (Schlafly, 1998). The company was Scientific Atlanta, headed by Sidney Topoi, who soon became a major proponent of the cable-satellite concept (Topoi, 1991). Schlafly had the Scientific Atlanta earth station hauled from Atlanta, Georgia, to Anaheim, California, for the National Cable Television Association's 1973 convention. There, on June 18, television history marked the first coast-to-coast satellite transmission of programming designed specifically for cable television. The United States had not yet launched a domestic satellite capable of transmitting the material and Teleprompter used the Canadian bird, ANIK II. The programming consisted of a morning feed featuring greetings from Speaker of the House, Democrat Carl Albert in Washington, D.C. That evening the satellite link beamed in a highly touted championship boxing match between Jimmy Ellis and Ernie Shavers from Madison Square Garden. The feature material was supplied by a pay television company called Home Box Office (HBO), through an arrangement initiated by Teleprompter.

The satellite demonstration was publicized in the trade press and featured in subsequent articles about HBO. Less heralded at the convention was a gathering of larger cable operators designed to initiate serious industry-wide discussion about satellites. More than a dozen companies attending the meeting indicated a willingness to contribute $5,000 each to fund a study ("Domsat show is high note," 1973), and at a subsequent meeting in July, the Cable Satellite Access Entity (CSAE) was formed. CSAE hired the consulting firm of Booze, Allen, and Hamilton to conduct a year-long study. In the meantime, Schlafly took his case for satellites, and his earth station, on the road.

The 1973 demonstration was a technical success, another incremental step in the evolution of the system, and was appropriately lauded in the trade press as a significant accomplishment for the industry. Despite the formation of the CSAE group, however, its reception on the floor of the convention center by rank-and-file operators was, at best, mild. Until operators could be convinced of the business case for the technology, promoters faced an uphill struggle. After the convention Schlafly took the earth station on a cross-country excursion, offering demonstrations to individual operators around the United States (Schlafly, 1998). But as a Teleprompter official explained in 1973, "The reactions [from cable operators] run the gamut from `we're too busy getting new subscribers' to `show us the numbers and when they figure up, we'll go'" ("How Teleprompter figures to weave a cable network," 1973).

Meanwhile, Teleprompter was running into serious business problems. In October 1971, Kahn was sentenced to 5 years in prison (eventually serving about 18 months) for bribing Johnstown, Pennsylvania, city council members to win the local franchise. A stockholder fight for control of the company followed, and in September 1973 the Securities and Exchange Commission suspended trading in Teleprompter stock amid rumors of accounting improprieties. The resulting tumult led to changes in management and corporate philosophy. Teleprompter's research and development activities were drastically reduced and the initiative for the satellite system evaporated. Schlafly soon left the company.

The period from late 1973 to mid 1975 was, in fact, a difficult one for the entire industry. Interest rates had risen and capital was hard to come by. Construction in the major cities had stagnated and companies such as Teleprompter and TCI were facing tough financial times. Grand schemes to build satellite systems were set aside. Beneath the troubled surface there was some movement. The CSAE/Booze, Allen and Hamilton report was finished in August 1974 ("Nothing to say," 1974). It concluded that a satellite system was technically feasible and a market existed for specialty programming. The real problem, according to the consulting firm, lay in the development and financing of the programming. It proposed a plan that included specialty channels aimed at children and women, along with various arts and entertainment material (Booze, Allen & Hamilton, 1974). The industry view, however, seemed to be that satellite distribution was a good idea, but one that was not yet ripe. Something was needed to move the project ahead. That something was to emerge from Time, Inc.'s Home Box Office.

Home Box Office

Chuck Dolan founded Sterling Communications in 1965 and obtained a franchise from New York City to wire lower Manhattan. Time Life, Inc., in the same year, purchased 20 percent of Dolan's company. The New York system was riddled with difficulties, however, and was losing money. In 1971, looking for new revenue sources, Dolan came up with the idea of creating a pay television service featuring movies and sports, initially dubbed the Green Channel and later renamed Home Box Office (Mair, 1988).

Time, Inc., as noted, had supported cable satellite use before the FCC and Dolan included it as a possibility when he presented his Green Channel idea to Time management (Winston, 1986, p. 289). Satellite distribution was only a distant possibility at the time, however, so HBO began service in November 1972 using microwave to feed its programming to a CATV system in Wilkes Barre, Pennsylvania (Gershon & Wirth, 1993). To help run the HBO project Dolan hired a young attorney named Gerald Levin, who had experience in contracting for televised films and sporting events (Whiteside, 1985, p. 61).

Levin had been at the 1973 Anaheim demonstration, having helped arrange the Madison Square Garden feed, and he was impressed with what he saw. But at the time, according to Levin, the plans for distributing HBO did not extend far beyond the use of regional microwave. Satellite distribution was a part of the long-term thinking, but not a part of the short-term reality. If the area network proved successful, explained Levin, the system would be extended one region at a time and "maybe, ultimately use satellite transmission to reach those parts of the country that wouldn't lend themselves to regional networking. There was no domestic satellite activity we could even plan for. It seemed very much a distant thing for us" ("HBO: Point man," 1977). Dolan left the company in March 1973; Levin took over as President, and in September, Time, Inc. completed its acquisition of the pay service. HBO was soon on 14 systems in New York and Pennsylvania, but the churn rate was exceptionally high. Subscribers would sample the service for a few weeks, get weary of seeing the same films, and then cancel. HBO was struggling and something had to be done.

By the end of 1974, Westar was in orbit and additional domestic satellites were in preparation. Scientific Atlanta's Sid Topol (1991), with dishes to sell, accelerated his lobbying for a cable-satellite network, as did Schlafly, now working as a private consultant. Levin, in fact, credits Topol with helping convince him of the feasibility of satellite distribution. RCA, readying its new Satcom I, was also looking for customers, and the head of its satellite division was Andrew Inglis, an old college classmate of Levin. This mix of business, technical, and interpersonal influences resolved in late 1974 and early 1975 in a new plan by Levine. Working with Inglis, he signed a contract for transponder time from RCA, $7.5 million for a five-year term. Levin also hired Schlafly as a consultant and cut a deal with Topol for a reduced price on bulk-order Scientific Atlanta dishes.

Levin next needed a cable operator to help him solve the "chicken or egg" dilemma. That operator turned out to be Robert Rosencrans, head of UA-Columbia Cablevision, Inc. Levin called him in early 1975 and the two met in New York (Rosencrans, 1998). Rosencrans said he was attracted to the concept for a number of reasons. UA-Columbia was already an HBO customer, taking the microwave feed at systems in Wayne, N.J., and Brookhaven, N.Y., and found the service so promising that he was looking for a means to expand. However, a plan to build a centralized microwave system in Florida, serving both UA-Columbia and unaffiliated systems, was plagued with potential problems. Rosencrans reported it would have been labor intensive, costly, time consuming, and would have relied on videotape shipped to the regional center. Satellite distribution solved those problems and offered a better quality picture than the tape-fed microwave. It also held the potential for live programming (Rosencrans, 1998).

Levin and Rosencrans announced their agreement to the press on April 10, 1975 ("Time, Inc. Unit to Use Satellites," 1975). A few days later, another large multiple system operator, ATC, joined the service. The cable satellite distribution system was inaugurated on September 30, 1975, with feeds to the UA-Columbia system in Ft. Pierce-Vero Beach, Florida, and an ATC system in Jackson, Mississippi. (The RCA satellite was not yet in service so the first programming was beamed via Westar). The programming consisted of speeches by FCC chairman Richard Wiley and Andrew Heiskell, of Time Inc.; two films, "Brother of the Wind" and "Alice Doesn't Live Here Anymore"; and the featured event, the championship boxing match between Muhammad Ali and Joe Frazier, beamed via satellite from the Philippines and known as the "Thrilla from Manila." The fight was a particularly shrewd marketing move because it demonstrated the power of the satellite system and it was a highly publicized sports event that was otherwise unavailable to television viewers in the United States.

In June 1975, Teleprompter, still the nation's largest cable operator, had reemerged from its financial problems to sign up for the HBO service. While historically this helped to realize Kahn's initial dream, more practically it added some 800,000 new subscribers to the HBO service, helping create the critical economic mass necessary for success. Additional cable companies were encouraged to sign on as Scientific Atlanta continued to offer deep discounts on its dishes and in some cases HBO helped cable operators buy the technology. Further, the FCC in late 1976 relaxed technical rules on earth stations, allowing operators to use smaller and cheaper dishes (FCC, 1977). The cost reduction, from about $100,000 for the larger dishes to less than $25,000 for the smaller ones, meant still more operators could afford the service. Finally, FCC regulations restricting pay television and limiting HBO's business opportunities were challenged by HBO and struck down by the courts in 1977 (Home Box Office v. FCC, 1977).

Expansion of the cable-satellite distribution platform was subsequently promoted by the addition of Ted Turner's "Superstation," WTCG, an Atlanta-based UHF independent (later renamed WTBS). Turner, like a few other independent television operators around the country, had been distributing his broadcast signal via microwave to regional cable systems. When he heard about HBO's initiative, he saw the possibilities for WTCG. In December 1976, Turner became the second satellite-delivered cable programmer. His channel was particularly appealing to operators and customers because, unlike HBO, it was an advertising-based service that could be offered to subscribers without additional charge (although operators paid 10-cents a subscriber for the feed).

Other programmers soon began flocking to the satellite. By 1980, some 2,500 systems were carrying such services as the Madison Square Garden channel, the Christian Broadcasting Network, C-SPAN, and Viacom's Showtime. By 1987 there were more than 70 cable networks. The industry was franchising the major cities and national penetration was on the rise. A new telecommunications infrastructure was evolving.

Conclusion

Development of the cable-satellite distribution system was, in summary, an evolutionary phenomenon, rather than a system that sprang forth from the ether, fully formed and implemented in 1975. Cable operators in the early 1960s and before were actively discussing cable system interconnection, and the rise of communication satellite technology in the mid and late 1960s offered a likely "next step" in realizing such interconnection. Pioneers such as Kahn helped promote the plan while engineers at Hughes, Scientific Atlanta, and similar firms worked on advancing the technology.

The idea of, and concrete proposals for, a satellite-cable system, in short, arose logically from prior technical, economic, and regulatory developments. Social structures in place at the time helped constrain and guide development. Costly terrestrial distribution options motivated cable operators and broadcasters to look to satellites, while changing FCC policy with regard to satellite ownership and smaller critical issues, such as allowable dish size, served to channel and regulate the pace of development. Within the given set of social and economic parameters, a multitude of players, such as Topol, Levine, and Schlafly, each with their own resources and agendas, engaged in a process of contestation and negotiation. Building from existing technologies and working within this context, the cable-satellite connection was finally established and the inauguration of the new system marked an inflection point, a quantum leap, in the longer-term trajectory of cable television development. The new system served as the foundation upon which were built scores of specialized cable programming services.

Understanding the evolution of the system requires a close examination of the small steps taken by the various actors in their social context as well as the examination of the often-substantial social impact of the technology at key developmental stages in the process. History shows us that technology does change, growing ever more powerful and complex. But the nature of that evolution is typically local and contingent; it is bound by existing social conditions. It is a fluid and dynamic social dance. The development of the cable-satellite link is important both in its real-world contribution to the development of our modern communications infrastructure and as a fascinating example of history, technology, and social change at work.

Notes

(1) Proposals limited CATV-dedicated transponders to a small number for several reasons. Transponder capacity in most of the plans was limited to 12 or 24, and demand from other potential users, especially telephone traffic, was high. Moreover, it was unclear whether the cable industry could or would use more than a few transponders at this point in its history, insofar as only Hughes, Teleprompter, and TCI had expressed serious interest in developing a cable network.

(2) Teleprompter asked for five ground station permits, as did LVO, a top-15 MSO, and Twin County Cable, a small but far-seeing company based in Northampton, Pennsylvania.

References

Allen, D.S., Bossert, J.L., & Krause, L.I. (1971). Economic viability of the proposed United States communications satellite systems, Final Report. Menlo Park, CA: Stanford Research Institute.

Barnett, H., & Greenberg, E. (1967). A proposal for wired city television. Santa Monica, CA: Rand Corp., Rand Doc. P-3668.

Basalla, B. (1988). The evolution of technology. New York: Cambridge University Press.

Bond, D. (1962, November 13-18). A system for direct television broadcasting using earth satellite repeaters: Five papers by members of the technical staff of the Radio Corporation of America. Paper presented at the 17th Annual Meeting and Space Flight Exposition of the American Rocket Society, Los Angeles, California.

Booze, Allen, & Hamilton. (1974, August 1). Final Report: Satellite Interconnection

Feasibility Study, Cable Satellite Access Entity. Norfolk, VA: NCTA.

Carnegie Commission on Educational Television. (1967). Public television: A program for action. New York: Bantam Books.

CATV headed for ad-supported network? (1970, May 4). Broadcasting, p. 23.

Clarke, A. (1945, October). Extra-terrestrial relays: Can rocket stations give world-wide radio coverage? Wireless World, pp. 305-308.

Clarke, A. (1959, September). Faces From the Sky. Holiday, pp. 48-49.

Comsat poised to file. (1970, March 1). Broadcasting p. 9.

Craven, T.A.M. (1962, June 25). Global TV unreal: Pursue practical uses. Advertising Age, p. 72.

Dominick, J., Sherman, B., & Copeland, G. (1996). Broadcasting/Cable and Beyond. 3rd ed. New York: McGraw-Hill, Inc. Domsat show is high note of NCTA's all-stops-out convention. (1973, June 25). Broadcasting. p. 25.

Fang, I. (1997). A history of mass communication: Six information revolutions. Boston: Focal Press.

Federal Communications Commission. (1965a). Non-acceptance of application by american broadcasting Cos., 2 FCC 2d 671.

Federal Communications Commission. (1965b). Notice of inquiry, establishment of domestic noncommon carrier communications satellites by non-governmental entities, 31 Fed. Reg. 3507. Docket no. 16495.

Federal Communications Commission. (1969). First report and order, 20 FCC 2d 201.

Federal Communications Commission. (1970). First report and order, in the matter of establishment of domestic communications satellite facilities by non-governmental entities, 22 FCC 2d 86. Docket no. 16495.

Federal Communications Commission. (1972a). Proposed second report and order on domestic communications satellite facilities, 34 FCC 2d 9. Docket no. 16495.

Federal Communications Commission. (1972b). Second report and order on domestic communications satellite facilities, 35 FCC 2d 844. Docket no. 16495.

Federal Communications Commission. (1973a, Jan. 4). FCC common carrier action, public notice No. 1000.

Federal Communications Commission. (1973b, Sept. 13). FCC common carrier action, public notice No. 1270.

Federal Communications Commission. (1977). In re: American Broadcasting Co., 62 FCC 2d 901.

Fisher, D., & Fisher, M. (1996). Tube: The invention of television. Washington, DC: Counterpoint. GE Engineer Envisions Space-to-Home TV. (1962, November 12). Broadcasting` p. 66.

Gershon, R. (1990). Pay cable television: A regulatory history. Communications and the Law, 12(2), 3-26.

Gershon, R., & Wirth, M. (1993). "Home Box Office," in Robert Picard (Ed.), The cable networks handbook (pp. 114-122). Riverside, CA: Carpelan Publishing.

Gross, L. (1997). Telecommunications: An introduction to electronic media. 6th ed. Madison, WI: Brown and Benchmark.

HBO: Point man for an industry makes it into the clear. (1977, October 17). Broadcasting` p. 51.

Head, S., Sterling, C., & Schofield, L. (1994). Broadcasting in America. 7th ed. Boston: Houghton Mifflin, Co.

Hilliard, R., & Keith, M. (1997). The broadcast century: A biography of American broadcasting. 2nd ed. Boston: Focal Press.

Home Box Office v. FCC. (1977). 567 F.2d 9.

How Teleprompter figures to weave a cable network. (1973, March 19). Broadcasting, p. 114.

Hughes files for CATV satellite system. (1970, December 28). Broadcasting, p. 9.

Hughes, T. (1983). Networks of power: Electrification in Western society. Baltimore: John Hopkins University Press.

Johnson, L. (1967, April). The impact of communications satellites on the television industry (Rand paper P-3572). Santa Monica, CA: The Rand Corp.

Kahn, I. (1987). Oral History. National Cable Television Center and Museum. Denver, CO: University of Denver.

Lady, J. (1970). Analysis of the potential growth of the CATV industry. NCTA Report.

Le Duc, D. (1973). Cable television and the FCC: A crisis in media control. Philadelphia: Temple University Press.

Licklider, L. (1967). Televistas: Looking ahead through side windows. In Public Television, A Program for Action (pp. 201-225). New York: Bantam Books.

Mair, G. (1988). Inside HBO. New York: Dodd, Mead & Co.

Markus, M.L. (1987). Toward a `critical mass' theory of interactive media. Communication Research, 14(5), 491-511.

Merrill, B. (1991). Oral History. National Cable Television Center and Museum. Denver, CO:

University of Denver.

Mr. Levin's giant step for pay TV. (1975, April 21). Broadcasting, p. 16.

National Academy of Sciences. (1969). Useful applications of earth-oriented satellites: Broadcasting, Report of Panel 10, Summer Study on Space Applications.

National Cable Television Association. (1969, June 22-25). 18th Annual NCTA convention, official transcript. Rx: Cable, prescription for the future. San Francisco Hilton, pp. 668-745.

Noll, R., Peck, M., & McGowen, J. (1973). Economic aspects of television regulation. Washington, DC: The Brookings Institution.

Nothing to say. (1974, August 5). Broadcasting; p. 5.

Papernow, L. (1965, December). One man's opinion. Television Magazine, pp. 30-31.

Parsons, P., & Frieden, R. (1998). The cable and satellite television industries. Boston: Allyn & Bacon.

President's Task Force on Communications Policy. (1968). Final report. (The Rostow Report). Washington, DC: Government Printing Office.

Prochaska, J. (1974). Key factors for domestic policy in the establishment of broadcast satellites for United States Television. D.B.A. thesis, George Washington University.

Rogers, E., & Shoemaker, F. (1971). Communication of Innovations, 2nd ed. New York: The Free Press.

Rosencrans, R. (1998, October 20). Telephone interview with author.

Schlafly, H. (1998, October 20). Telephone interview with author.

Seiden, M. (1972). Cable television U.S.A.: An analysis of government policy. New York: Praeger.

Shapiro, G., Epstein, G., & Cass, R. (1975). Cable-satellite networks: Structures and problems. Catholic University Law Review, 24, 692-718.

Shapiro, P. D. (1972, August). Networking in cable television: Analysis of present practices and future alternatives. Ph.D. Dissertation. Institute for Communication research, Stanford University.

Smythe, D. (1960, Summer). Space broadcasting: Threat or promise? Journal of Broadcasting, 4, 191-198.

Southwick, T. (1998). Distant signals. Overland Park, Ks: Primedia Intertec.

Sterling, C., & Kittross, J.M. (2002). Stay tuned: A history of American broadcasting. Mahwah, NJ: Erlbaum.

Streeter, T. (1987). The cable fable revisited: Discourse, policy, and the making of cable television. Critical Studies in Mass Communication, 4, 174-200.

Taylor, R. (1977). Satellite direct Broadcasting: The prospect for development. Ed.D.thesis. Columbia University.

Time Inc. unit to use satellites to deliver programs to UA-Columbia cable systems. (1975, April 11). Wall Street Journal, p. 21.

Topol, S. (1991, June 20). Oral History. National Cable Television Center and Museum, Denver, CO.

Up in the air over satellites. (1971, April 5). Broadcasting p. 71.

U.S. Congress. (1958). House Select Committee on Astronautics and Space Exploration. Summary of Hearings. April 15-May 12, 1958.

Whiteside, T. (1985, May 20). Onward and upward in the arts. New Yorker, p. 61.

Winston, B. (1986). Misunderstanding media. Cambridge, MA: Harvard University Press.

Ziman, J., ed. (2000). Technological innovation as an evolutionary process. New York: Cambridge University Press.

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SP-4217 Beyond the Ionosphere

Chapter 6

NASA Experimental Communications Satellites, 1958-1995

by Daniel R. Glover

[51] As the civilian agency exercising control over U.S. space activities, NASA has had a program of technology development for satellite communications since the agency was established in 1958. Part of this program has involved flying experimental communications satellites. NASA's first communications satellite project was Echo. Launched on 12 August 1960, Echo 1 was a passive satellite that reflected radio waves back to the ground.

Echo started out in 1956 as a National Advisory Committee for Aeronautics (NACA) experiment to probe the upper reaches of the atmosphere and the effects on large lightweight structures in orbit. John Robinson Pierce and Rudolf Kompfner of AT&T's Bell Telephone Laboratories had been working on ideas for communications satellites, including passive systems, for some time. They realized that the Echo sphere would provide an excellent test mirror and proposed a communications experiment. The National Academy of Sciences sponsored a meeting, held on 28 August 1958, to define the project.[1] In 1958, when NASA was created and NACA dissolved, Echo became a NASA project.

The Echo satellite was a 100-foot-diameter (thirty-one-meter-diameter) aluminized-polyester balloon that inflated after insertion into orbit. The G.T. Schjeldahl Company built the Echo 1 balloon, and Grumman built the dispenser, for NASA's Langley Research Center in Hampton, Virginia. Two-way voice links of "good" quality were set up between Bell Telephone Laboratories in Holmdel, New Jersey, and NASA's Jet Propulsion Laboratory facility at Goldstone, California. Some transmissions from the United States were received in England at Jodrell Bank.

Echo demonstrated satellite tracking and ground station technology that later applied to active satellite systems. Leonard Jaffe, director of the NASA satellite communications program at headquarters, wrote: "Echo [I] not only proved that microwave transmission to and from satellites in space was understood and there would be no surprises but it dramatically demonstrated the promise of communication[s] satellites. The success of Echo [I] had more to do with the motivations of following communications satellite research than any other single event."[2]

Echo 2, managed by NASA's Goddard Space Flight Center in Beltsville, Maryland, left the launch pad on 25 January 1964. It had a better inflation system, which improved the balloon's smoothness and sphericity. Echo 2 investigations were concerned less with

communications and more with the dynamics of large spacecraft. After Echo 2, NASA abandoned passive communications systems in favor of active satellites. The superior performance of the U.S. Department of Defense's SCORE (Signal Communication by Orbiting Relay Equipment) satellite, launched almost two years before Echo I, already had demonstrated the viability of the active approach.

[52] Telstar

In the fall of 1960, as Echo 1 was achieving its first successes, AT&T began developing an active communications satellite system called Telstar. Although some observers felt that AT&T's early interest in communications satellites was part of a defensive maneuver to protect its commitment to cable technology, the company was investing large quantities of its own capital to create and launch its own communications satellite program.[3] Initially, the operational system was to consist of fifty to 120 active satellites in orbits approximately 7,000 miles (about 9,310 kilometers) high. Using the large launch vehicles then in development, Pierce envisioned that "a dozen or more of these satellites could be placed in orbit in a single launching." With the satellites in random orbits, Bell Telephone Laboratories figured that a "system of 40 satellites in polar orbits and 15 in equatorial orbits would provide service 99.9 per cent [sic] of the time between any two points on earth." As Pierce explained, "AT&T has proposed that the system contain about 25 ground stations so placed as to provide global coverage."[4]

The cost of such a system would be high. In 1961, Pierce estimated the expense at $500 million, but that high price tag was not a detriment from AT&T's standpoint. As a telecommunications monopoly, AT&T's rates were regulated, and those rates included an amount that allowed AT&T to recover its costs as well as to make a profit. Thus, the cost of the proposed Telstar satellite system would be passed on to consumers, just as the high costs of undersea cables were, so AT&T found the system attractive.

Bell Telephone Laboratories designed and built the Telstar spacecraft with corporate funds. The first Telstars were prototypes intended to prove various concepts behind the large constellation of orbiting satellites. Moreover, of the six Telstar spacecraft built, only two were launched. NASA's contribution to the project was limited to launch services, as well as some tracking and telemetry duties. AT&T reimbursed NASA $6 million for those services. NASA was able to negotiate such an excellent deal with AT&T, even though Telstar was not really a NASA project, because NASA held the monopoly for launch services. Moreover, NASA claimed Telstar as a NASA-supported project and even published the results of the communications experiments, originally issued as articles in the Bell Telephone technical journal, as a NASA publication (NASA Special Publication [SP]-32). In addition, NASA obtained the rights to any patentable inventions arising from the experiments.

On 10 July 1962, a Delta launcher placed the first Telstar spacecraft into orbit. The faceted 171-pound (about seventy-seven-kilogram) sphere had a diameter of a little more than thirty-four inches (about one meter). Telstar was the first satellite to use a traveling-wave-tube amplifier; transistor technology at the time was not capable of the three watts of power output at the required microwave frequencies.[5] Bell Telephone Laboratories also developed much of the technology required for satellite communication, including transistors, solar cells, and traveling-wave-tube amplifiers. To handle Telstar communications, AT&T built ground stations at Andover, Maine; Pleumeur-Bodou, France; and Goonhilly Downs, Britain. These were similar to, but larger than, the ground station used for project Echo. The French station used a duplicate of the AT&T Holmdel horn antenna, while the British antenna was a parabolic dish.

[53] Telstar was a tremendous technical success, and the international reaction was spectacular. A U.S. Information Agency (USIA) poll showed that Telstar was better known in Great Britain than Sputnik had been in 1957. Rather than launching a useless bauble, the Americans had put into orbit a satellite that promised to tie together the ears and eyes of the world. Interestingly, the world saw Telstar as an undertaking of the U.S. government (the USIA publicity may have helped). President Kennedy hailed Telstar as "our American communications satellite" and "this outstanding symbol of America's space achievements."[6]

Regarding Telstar, Jaffe, head of communications satellite programs at NASA, wrote in 1966: "Although not the first communications satellite, Telstar is the best known of all and is probably considered by most observers to have ushered in the era of satellite communications."[7] This impression resulted from the tremendous public impact of the first transmission of live television across the Atlantic Ocean from the United States to France by Telstar I on 10 July 1962, the very same day it was launched. In addition to television broadcasts, Telstar relayed telephone calls, data transmissions, and picture facsimiles.

Telstar was AT&T's major move into satellite communications. That move failed to extend AT&T's monopoly of terrestrial communications into space, however; changing telecommunications policy from one presidential administration to the next, and a government desire to avert a monopoly of satellite communications, kept AT&T's monopolistic aspirations in check. At the same time, NASA contracted its communications satellite work to firms other than AT&T.

When AT&T began working on Telstar, the Eisenhower administration seemed willing to allow it to extend its monopoly into space. A statement by President Eisenhower in December 1960, in which he presented his administration's policy on space communications, stressed the traditional U.S. policy of placing telecommunications in the hands of private enterprise subject to governmental licensing and regulation and the achievement of "communications facilities second to none among the nations of the world." The role of NASA was "to take the lead within the executive branch both to advance the needed research and development and to encourage private industry to apply its resources toward the earliest practicable utilization of space technology for commercial civil communication requirements."[8]

The election of President Kennedy ushered in a new policy on satellite communications that was openly antagonistic to monopolies, particularly to the extension of AT&T's monopoly in terrestrial communications to space communications. President Kennedy released a policy statement on 24 July 1961 that favored private ownership of satellite systems, but with regulatory and other features aimed at avoiding a monopoly.[9]

AT&T's preeminent position as the largest U.S. common carrier and sole international telephone carrier, together with its willingness and ability to commit large sums of money to the development of communications satellites, convincingly suggested that commercial satellite utilization would very likely become AT&T utilization. Concern over the possibility of an AT&T monopoly in space was one factor that prompted a later reorientation of the direction that commercialization seemed to be following.[10]

[54] On 31 August 1962, President Kennedy signed the Communications Satellite Act. The government assigned the monopoly of international satellite communications to a new corporation called Comsat. AT&T went ahead with Telstar

2, completing its experimental program. Of the six flightworthy spacecraft built by AT&T with corporate funds, only two were launched, but Telstar's publicity served AT&T very well. Nonetheless, between the success of Telstar 1 and the launch of Telstar 2 on 7 May 1963, AT&T lost its chance to control commercial satellite communications.

NASA's role in communications satellites was changing, too. A 1958 agreement between NASA and the Department of Defense gave responsibility for the development of active communications satellites to the military, leaving NASA with the development of passive satellites. In August 1960, however, NASA decided to pursue active satellite research, but not synchronous satellites. The military already had an active synchronous satellite, Project Advent, in place. NASA began developing medium-altitude satellite systems and issued a request for proposals on 4 January 1961 for an experimental communications satellite to be known as Relay. Both AT&T and Hughes approached NASA with their design concepts, but in May 1961, NASA selected RCA to build the two Relay spacecraft, instead of AT&T or Hughes. The Goddard Space Flight Center oversaw the project.

Project Relay

Although AT&T did not win the contract to build them, the Relay satellites used the same primary ground stations as those used by Bell Telephone Laboratories' Telstar 1 satellite. These were located in the United States (in Maine, New Jersey, and California) and overseas (in West Germany, Italy, Brazil, and Japan). Relay was an experimental satellite program; however, the satellites transmitted television signals between the United States and Europe and Japan. The Tokyo 1964 Olympics, however, were passed from Tokyo to the United States, and then on to Europe via Relay.

NASA launched Relay 1 on 13 December 1962 into an elliptical orbit with an apogee of 4,012 nautical miles (about seven kilometers). The orbit took Relay through the Earth's inner radiation belt, so that the spacecraft could measure the levels of radiation and study its effects on satellite electronics. Relay taught many lessons in communications spacecraft design. The idea of flying experimental communications spacecraft is to try new things and to determine whether they work. Failures are expected and provide the learning experience necessary for technology advancement. Relay was no exception.

While in orbit, the power supply for Relay 1's primary transponder failed, and the spacecraft had to switch to its backup transponder, which performed well. Another problem was spurious commands. The satellite recorded 401 anomalies (errors) during its first year. Ground stations observed anomalies when the satellite was in view, which was during only 15 percent of its orbit. The main culprit was interference from the wideband subsystem. Consequently, as a corrective measure, Relay 2 carried a filter on the command receiver's transmission line and had improved circuitry to better differentiate between noise and command signals. As a result, Relay 2 recorded only sixty-two command anomalies.

Among the other problems faced by the first Relay experimental satellite was the failure of the charge controller for one of three battery packs after about three months. Yet another was the long time required for the traveling-wave tube to warm up. Normally, the tube took three minutes to warm up, but the malfunctioning tube could take as long as sixteen minutes. This delay reduced the time the satellite was usable, as Relay 1's orbit placed it in any particular ground station's view for only about thirty minutes. Relay 2, launched 21 January 1964, had increased radiation resistance plus measures that **[55]** improved reliability. Finally, Relay 1 had a design life of one year, but when its turnoff switch failed, it continued to operate for a second year.

Syncom

The objective of the Syncom satellite project was to demonstrate synchronous-orbit communications satellite technology. In the early 1960s, achieving a synchronous orbit was a challenge. According to Lawrence Lessing, an observer at the time (1962):

> *Nearly everyone agrees that for a short-range, experimental first venture, the medium altitude active repeater satellite, such as Telstar or Relay, is the best bet . . . . Lockheed . . . is confident that before the complex problems of operating 50 or more satellites at lower altitudes are solved . . . the U.S. will be able to put up a full-powered, simpler, high-altitude system. Other experts, however, say that the synchronous high-altitude satellite is still some order of magnitude beyond present technology.*[11]

A synchronous orbit is one in which a satellite makes one orbit per day, the same period as the Earth's rotation around its axis. As a result, the satellite hovers over the same area of the Earth's surface continuously. The altitude of a synchronous orbit is 22,235 miles (19,322 nautical miles or 35,784 kilometers). At lower altitudes, satellites orbit the Earth more than once per day. For example, the Space Shuttle, at a nominal altitude of 180 miles (290 kilometers), orbits the Earth in an hour and a half. The Moon, on the other hand, at a distance of around 240,000 miles (nearly 390,000 kilometers), takes a month to orbit the Earth.

A key advantage of a synchronous satellite is that ground stations have a much easier job of tracking the satellite and pointing the transmitting and receiving antennas at it, because the satellite is always in view. With spacecraft in lower orbits, tracking stations must acquire the satellite as it comes into view above one horizon, then track it across the sky as the antenna slews completely to the opposite horizon, where the satellite disappears until its next pass. For continuous coverage, a ground station might need two antennas to acquire the first satellite, then connect with the next satellite passing overhead. In addition, continuous coverage requires the placement of ground stations distributed around the globe, so that any given satellite is rising over the viewing horizon of one ground station, while it is setting in relation to another station.

The chief communications advantage of the geosynchronous satellite, however, is its wide coverage of the Earth's surface. About 42 percent of the Earth's surface is visible from a synchronous orbit. Three properly placed satellites can provide coverage for the entire globe. Although Arthur C. Clarke published the first idea of a synchronous communications satellite in 1945, the first such synchronous-orbit spacecraft, Syncom 1, was not launched until 14 February 1963. However, when the motor for circularizing the orbit fired, the spacecraft fell silent. To demonstrate attitude control for antenna pointing and station keeping, Syncom had two separate attitude control-jet propellants: nitrogen and hydrogen peroxide. The most likely cause was a failure of the high-pressure nitrogen tank.[1] [2]

[56] Syncom 2 addressed these critical problems from the first attempt at making a geosynchronous communications satellite. Launched on 26 July 1963, after improvements in the nitrogen tank design, Syncom 2 successfully achieved synchronous orbit and transmitted data, telephone, facsimile, and video signals. Its successor, Syncom 3, launched 19 August 1964, had the addition of a wideband channel for television and provided coverage of the 1964 Tokyo Olympics. Syncom 3 was different from its predecessor in other ways, notably in its orbital pattern. A particular type of synchronous orbit is the geostationary orbit--namely, a synchronous orbit around the equator. Geostationary satellites seem to be stationary over a point on the surface, as distinguished from an area of the surface. Syncom 3 had a geostationary orbit, while the orbit of Syncom 2 was inclined thirty-three degrees to the equator, so that over a twenty-four-hour period, it appeared to move thirty-three degrees north and thirty-three degrees south in a "figure 8" pattern as observed from the ground.

Figure 12. Television image transmitted from Japan to the United States of the 1964 Olympic Games in Tokyo via the Relay experimental communications satellite launched in 1962. (Courtesy of NASA).

In addition to communications experiments, the Syncom satellites contributed to a determination of the Earth's gravitational field. They were capable of measuring range at synchronous altitude to an accuracy of less than fifty meters. The high altitude of their orbits minimized perturbations arising from local topology changes on the Earth's surface.

The Applications Technology Satellite Program

The Syncom spacecraft, built by Hughes for NASA's Goddard Space Flight Center, marked the end of NASA's experimental satellites of the early 1960s. NASA turned both Syncom satellites over to the Department of Defense in April 1965, and they were turned off in April 1969. As a continuation of its successful program of experimental communications satellites, NASA inaugurated the Applications Technology Satellite (ATS) series. These spacecraft demonstrated communications technologies and conducted weather observations and space research in response to congressional pressure. NASA and Hughes had hoped to continue the success of the Syncom project with an advanced Syncom satellite. Some members of Congress, however, feared that NASA was developing technology for the benefit of a single private company--namely, Comsat. Therefore, the advanced Syncom's objectives were broadened to include meteorology and other experiments, and the program became the ATS series.

The five first-generation ATS satellites, built by Hughes for Goddard, tested a range of new communications electronics in the Earth's orbit, as well as technology for gravity-gradient stabilization (on ATS-2, ATS-4, and ATS-5) and for medium-altitude orbits (ATS-2) on behalf of the Department of Defense. All of these first-generation ATS spacecraft were capable of carrying more signal traffic than any of their predecessors.

The first of these ATS satellites, launched 7 December 1966, carried out an impressive array of communications experiments and collected weather data. ATS-1 was the first **[57]** satellite to take independently uplinked signals and convert them for downlink on a single carrier. This technique, called "frequency division multiple access," conserves uplink spectrum and also provides efficient power utilization on the downlink. ATS-1 also carried a black-and-white weather camera, which transmitted the first full-disk Earth images from geosynchronous orbit. The communications hardware functioned for another two decades until 1985, when the spacecraft failed to respond to commands.

The second of these ATS satellites, in addition to communications experiments and space environment research, was to conduct technological testing of gravity-gradient stabilization for the Department of Defense. Launched 5 April 1967 atop an Atlas-Agena D rocket, ATS-2 never achieved circular orbit, because the Agena upper stage malfunctioned. Only a few experiments were able to return data. ATS-2 reentered the atmosphere on 2 September 1968.

The following ATS is the oldest active communications satellite by a wide margin. Launched in November 1967, it is still in service more than 28 years later. Among its widest known achievements are the first full-disk, color Earth images transmitted from a satellite. Its imaging capability has served during disaster situations, from the Mexico earthquake to the Mount St. Helens eruption. ATS-3 experiments included VHF and C-band communications, a color spin-scan camera, an image dissector camera, a mechanically despun antenna, resistojet thrusters, hydrazine propulsion, optical surface experiments, and the measurement of the electron content of the ionosphere and magnetosphere. Because of failures in the hydrogen peroxide systems on ATS-1, ATS-3 was equipped with a hydrazine propulsion system. Its success led to its incorporation on ATS-4 and ATS-5 as the sole propulsion system.[13]

The ATS-4 and ATS-5 satellites, because of the unsuccessful ATS-2 mission, again attempted to test technology for gravity-gradient stabilization for the Department of Defense--a key objective of the first generation of the ATS series. Gravity-gradient stabilization was chosen to maintain satellite stability, because it uses low levels of onboard power and propellant. The real goal, however, was to move away from spin-stabilized spacecraft to three-axis stabilization. Spin stabilization has the advantage of simplifying the method of keeping a spacecraft pointed in a given direction. A spinning spacecraft resists perturbing forces, similar to a gyroscope or a top. In space, forces that slow the rate of spin are very small, so that once the spacecraft is set spinning, it keeps going.

Spin stabilization, however, is inherently inefficient. Only some of the satellite's solar cells are illuminated at any one instant. Also, because the radio energy from the nondirectional antennas radiates in all directions, only a fraction of that energy is directed toward the Earth. Three-axis stabilization allows the solar panels to be always pointed at the Sun and enables the use of a directional antenna that not only remains pointed toward the Earth, but concentrates the radio energy into a beam, rather than a scattering pattern.

How, then, does one achieve three-axis stabilization? Gravity-gradient stabilization uses the Earth's gravitational field to keep the spacecraft aligned in the desired orientation. The spacecraft is designed so that one end is closer to the Earth than the other. The spacecraft end farther from the Earth is in a slightly weaker gravity field than the end closer to the Earth. Although this technique had been used in low orbit before the advent of the ATS program, the question to be addressed was whether or not the difference in gravity fields (the gradient) was too weak to be useful at higher altitudes. That was the objective of both ATS-4 and ATS-5.

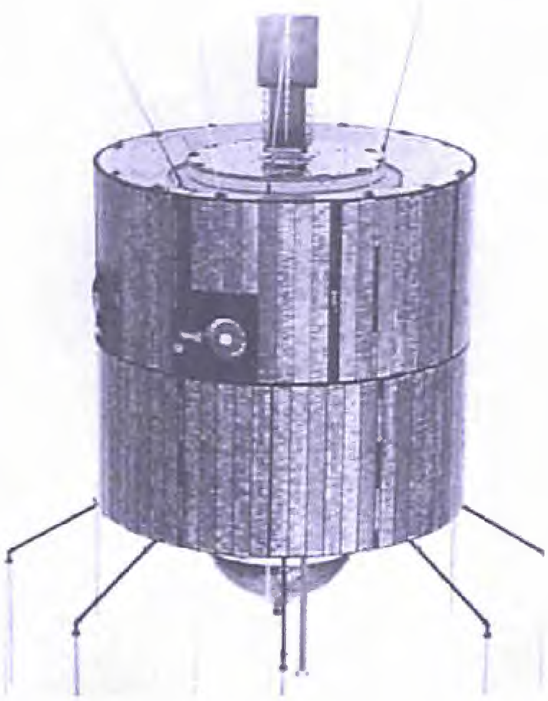

Figure 13. ATS-3, the third in NASA's Applications Technology Satellite (ATS) series of experimental communications satellites. Launched in November 1967, ATS-3 is still in service today. Among its most acclaimed successes is the first full-disk, color image of the Earth transmitted from a satellite. (Courtesy of NASA, photo no. 67-HC-612)

[**59**] ATS-4 was launched 10 August 1968 atop a powerful Atlas-Centaur rocket, but it reentered the atmosphere on 17 October 1968 because the Centaur upper stage failed to re-ignite. The ATS-5, then, was the final attempt at a synchronous gravity-gradient spacecraft. Launched 12 August 1969 on an Atlas-Centaur rocket, ATS-5 developed problems in its parking orbit and expended large amounts of propellant to stabilize itself. To try to salvage the mission, NASA injected the satellite into its final orbit ahead of schedule.

Although ATS-5 was to be a gravity-gradient stabilized satellite, spin stabilization was used during orbit insertion (a common practice). The spacecraft carried a device to remove the spin after it reached its final orbit. The device deployed booms to slow the spin, which is very similar to spinning figure skaters who extend their arms to slow down. Thus, ATS-5 successfully achieved a synchronous orbit, but the spacecraft's spin was in the wrong direction for this device to work. As a consequence, the gravity-gradient stabilization experiment was useless. The communications experiments were severely handicapped because the antennas were spinning with the spacecraft and could only work as a lighthouse beacon, rather than as a spotlight. Some communications experiments were later carried out in a pulse mode, and some secondary experiments were conducted as late as 1977.[14] Among those experiments were an L-band aeronautical communications package, an ion engine, a charge neutralizer, solar cell tests, and research on particles, electric and magnetic fields, and solar radio waves.

Applications Technology Satellites: The Next Generation?

The first of the second generation of the ATS program, known as ATS-6, also was the last ATS mission. Congress canceled the program in 1973 as a budget-cutting measure and to allow the commercial communications satellite industry to underwrite its own research and development. In 1974, NASA unsuccessfully attempted to reinstate the ATS program. Thus, the impressive ATS-6 spacecraft, launched 30 May 1974, marked the end of an era and the beginning of a dry spell for NASA experimental communications satellites.

Built by Fairchild Space and Electronics Company for Goddard, the ATS-6 spacecraft was much larger than its predecessors, weighing 1,336 kilograms (compared with 431 kilograms for ATS-5) and standing just over eight and a half meters tall and sixteen meters across its booms (ATS-5 was 1.8 meters tall and 1.4 meters in diameter). In addition to being the largest geosynchronous communications satellite launched to date, it was the first three-axis stabilized communications satellite. ATS-6 incorporated many significant design firsts, such as a 9.14-meter parabolic reflector, a digital computer for attitude control, solid-state high-power radio frequency transmitters, a primary structure made of graphite composite material, heat pipes for primary thermal control, monopulse tracking for attitude control, and a radio frequency interferometer for attitude determination and control.[15]

Equally significant was the demonstration of technology for tracking and data relay satellites that led to the Tracking and Data Relay Satellite System (TDRSS) program. In the TDRSS, a tracking and data relay satellite uses the geosynchronous orbital vantage point to look down on low-altitude satellites. Data are relayed from the low-altitude **[60]** satellite to a ground station through the geosynchronous satellite. Without this space relay capability, NASA needed ground stations all over the globe to collect data from satellites as they passed overhead. Because a low-altitude satellite orbits the Earth in a matter of a few hours, it is only in view of a single ground station for typically 20 minutes at a time. ATS-6 tracked the Nimbus 5 and 6 and the GEOS 3 (Geodynamics Experimental Ocean Satellite) satellites with a roll-and-pitch accuracy of better than 0.2 degree.

The nine-meter antenna enabled small ground receivers to pick up a good quality signal. A demonstration in India, in 1975, relayed television signals from a six-gigahertz uplink through the ATS-6 spacecraft and back to Earth at 860 megahertz, directly to three-meter antennas installed in approximately 2,000 villages. The large deployable antenna required tight pointing by the spacecraft, which is why it used three-axis stabilization.

ATS-6 carried out radio-wave propagation studies at frequencies up to thirty gigahertz; it also established L-band (1,550 to 1,650 megahertz) relay links to aircraft and demonstrated multiple aircraft tracking.

ATS-6 experienced a failure of three of its four orbit control jets in May 1979. That failure led to the decision to power down the spacecraft on 3 August 1979. Subsequently, its telemetry system was activated between November 1979 and February 1980 to collect particle data for correlation with similar data being collected by other satellites.[16]

NASA Quits

Although the launch of the ATS-6 spacecraft in 1974 marked the end of NASA's program of experimental communications satellites, the space agency also participated at the same time in a Canadian satellite venture known initially as "Cooperative Applications Satellite C" and renamed Hermes. This joint effort involved NASA and the Canadian Department of Communications. NASA's Lewis Research Center provided the satellite's high-power communications payload. Canada designed and built the spacecraft; NASA tested, launched, and operated it. Also, the European Space Agency provided one of the low-power traveling-wave tubes and other equipment.[17] Hermes was launched 17 January 1976 and operated until October 1979.

Canada also created a telecommunications policy that the United States would emulate, and this would lead to the end of NASA's communications satellite research and development program. In late 1969, Canada announced that any financially qualified organization could apply for, and expect to be granted, authority to operate a domestic satellite system. As a result, in November 1972, that country put into orbit the world's first domestic satellite. In addition, the Canadian government abandoned sponsored research in the hope of motivating competition in the development of satellite technology. This Canadian "Open Skies" policy represented a striking contrast to past U.S. policy,[18] but it was in tune with the Nixon administration's advocacy of competition.

[61] Subsequently, in January 1973, budget pressures caused NASA essentially to eliminate its communications satellite research and development program, much of which was carried out at the Goddard Space Flight Center, although the Lewis Research Center was working on advances in traveling-wave tube design and was participating in the Canadian Hermes project. Goddard had been responsible for most NASA experimental (as well as operational) communications satellites, including the ATS series.

Meanwhile, the danger of foreign competition, especially from Japan and Europe, loomed large. The Japanese launched the first commercial Ka-band operational satellite, called Sakura 2a, on 4 February 1983. Built by Ford (now Loral) and Mitsubishi, and launched on a Japanese N2 rocket, Sakura 2a also was Japan's first commercial communications satellite. It was replaced by Sakura 3a, which was launched 19 February 1988. In the 1990s, Loral also built the Superbird and N-Star satellites for Japan, and with Japanese contractors led by Toshiba, Japan's National Space Development Agency designed and built the ETS 6 (Kiku 6) spacecraft.[19]

At the same time, the Europeans were catching up. The Olympus satellite began development in 1979 as L-Sat and was built by European aerospace companies, of which British Aerospace was the prime contractor. Launched on 12 July 1989 on an Ariane 3 rocket, Olympus was a large multipurpose satellite demonstrating and promoting new applications in television broadcasting, intercity telephone routing, and the use of the Ka-band for videoconferencing and low-rate data transfer for business communication.[20]

Foreign competition provided NASA a strong argument for reinstating its commercial satellite development program. The question was: what technology ought to be developed? Market studies conducted during the 1970s revealed the crowding of synchronous orbits. The obvious solution to overcrowding was to use higher frequency Ka-band communications satellites.

A compelling synergy exists among the use of Ka-band frequencies, spot beams, and onboard processors. In general, higher frequencies produce smaller beam widths with a given antenna, and so it is easier to make antennas that produce spot beams at Ka-band frequencies. A spot beam covers a smaller area, such as a major metropolitan area, compared to typical beams covering the entire country. These spot beams improve the problem of rain fade at Ka-band by concentrating the signal strength to punch through clouds. Once there are spot beams, it is a natural extension to switch signals between various spot coverage areas (such as routing one signal from New York to Chicago and another from New York to Los Angeles) aboard the spacecraft.

Despite the virtual shutdown of the NASA communications satellite research and development program, NASA systems engineers throughout the mid-1970s sought ways to revive their canceled program. Work continued on satellites that were still operating in space, as well as on projects that were too far along to stop. Both the Lewis Research Center and the Goddard Space Flight Center advocated reviving the space communications programs, but along very different lines. Goddard championed public service satellites directly in competition with industry. The technology development program at Lewis supported U.S. industry, although some companies saw the Lewis approach as subsidizing competitors. The Nixon administration's advocacy of competition thus favored the Lewis approach.

The question of federal funding of communications satellite technology development by NASA came before the National Research Council, whose Committee on Satellite [**62**] Communications released a report on the subject in 1977. The committee considered several options and recommended funding a NASA experimental communications satellite technology flight program and an experimental public service communications satellite system. The committee opposed creating an operational public service system on the grounds that it was "inappropriate for NASA."[21]

In 1978, five years after budget pressures forced NASA to eliminate its commercial communications satellite research and development program, the space agency reentered the field.[22] The Lewis Research Center, not the Goddard Space Flight Center, acted as the lead center, in light of the program's emphasis on technology. Lewis worked on the next NASA experimental communications satellite and began a $45 million program of technology development using duplicate contracts, to have the new designs needed for a radically new spacecraft. NASA involved the five major builders of communications satellites--TRW, Hughes, Ford, General Electric, and RCA--by awarding each a study contract. These contracts ranged in cost from $264,000 (RCA) to $1,213,000 (TRW), and all were completed in the summer of 1981.

Joe Sivo, chief of the communications division at Lewis, brought U.S. communications carriers--the users of the technology--into the program to develop a consensus on advanced technology requirements. Between November 1979 and May 1983, the Carrier Working Group, formed by Sivo, met nine times to define flight system requirements and experiments and to review spacecraft designs as they became available from the study contractors. The Carrier Working Group consisted of representatives from American Satellite, AT&T Long Lines, Bell Telephone Laboratories, Comsat, GTE Satellite, Hughes Communications, ITT, RCA, Satellite Business Systems (MCI), Southern Pacific, and Western Union.

The Advanced Communications Technology Satellite

The efforts of the Carrier Working Group and the industry study contracts led directly to the design and construction of the next NASA experimental communications satellite, known as the Advanced Communications Technology Satellite (ACTS). Its unique feature is that it acts as a "switchboard in the sky." The communications payload incorporates steerable, spot-beam antennas and onboard switching that allows signals to be routed aboard the spacecraft. The Ka-band frequencies used by the ACTS (thirty gigahertz for the uplink and twenty gigahertz for the downlink) were new capabilities for U.S. communications satellites, but the Japanese already had used them on their own satellite. NASA makes the satellite available for experiments by industry, universities, and other government agencies, as well as for tests of new service applications.

Launched 12 September 1993, the ACTS has been perhaps the most successful of NASA's communications satellites. To date, it has operated for two years without failures and has conducted more than 100 experiments and tests. Furthermore, several commercial systems have proposed using ACTS technologies. For example, Motorola, which built the satellite's baseband processor, is incorporating onboard switching in its Iridium system, while Hughes is working on Spaceway, a Ka-band system with spot beams. Despite **[63]** these technical and commercial successes, the ACTS had a long and tortuous existence during the 1980s, as Congress and the White House debated the philosophy of having NASA develop technology for the U.S. communications satellite industry. While the satellite was still in the design phase, for example, the Reagan administration deleted the satellite from its budget, only to have Congress reinstate the project.

Conclusion

NASA's commercial communications satellite program has produced many significant results over the past 35 years. Although some critics have argued that NASA has overstated its contribution to satellite communications,[23] one can contend that the program has returned far more to the industry than its cost.

One often overlooked key to understanding the value of NASA's experimental communications satellite program is the concept of risk in space design. The high cost of launching spacecraft, coupled with the current impossibility of repairing hardware in synchronous orbit, means that the design of space hardware is driven by the risk of failure. As a result, space hardware designs have been very conservative, using old technology, because of the perceived risk associated with using anything new. Even if a new item can produce greater capability at lower cost, if it increases the risk of failure, it will not be used. For a new technology to fly, its benefits must be overwhelming, thereby precluding incremental improvements in space technology. As a result, space hardware can lag behind the state of the art by more than a decade.

A high risk of failure overshadowed the early years of satellite communications. NASA's launch record in the early 1960s reflected the state of rocket science at the time--namely, rockets failed quite often. Also, the space environment was not well known. The period was a critical time for NASA's involvement in the development of communications satellites. Without NASA, Hughes's Syncom would never have gotten off the ground, and Hughes would not be the world's largest communications satellite maker today.

Despite the benefits that NASA's experimental communications satellite program has brought industry, industry does not look kindly on NASA's development of spacecraft or technology that might undermine a firm's competitive advantage. In other words, a NASA spacecraft must develop new technology that all U.S. companies can use, but the space agency must avoid the construction of spacecraft that might seem to compete with any company. Hughes benefited enormously from NASA's involvement in the early days of communications satellites. Today, as a result, Hughes is the largest builder of commercial communications satellites. In the 1995 Space News "Top 50" list of space companies, Hughes was ranked second.[24]

The 1973 cancellation of NASA's commercial communications satellite research and development program, in retrospect, benefited the space agency. It forced a complete rethinking of the program. To be reinstated in 1978, NASA had to justify the program from scratch and transform it from a public service demonstration into a technology development program. The public service satellite program looked too much like competition to industry, even though the services NASA provided would not have been affordable to public service users.

[**64**] NASA currently is reorganizing its commercial communications program to prepare for the next generation of research and development following the ACTS, although a need for a followup project is not perceived at the moment. Therefore, NASA plans to develop long-term technology improvements and work on both spectrum management and issues of interoperability between satellite systems. NASA has benefited from the Satellite Industry Task Force, an industry advisory committee chaired by Hughes's Thomas Brackey. At a presentation of its findings on 12 September 1995, attended by Vice President Al Gore, the task force expressed support for the ACTS, but it did not call for NASA undertaking another satellite project.

END NOTES

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1. Leonard Jaffe, Communications in Space (New York: Holt, Rinehart and Winston, 1966), p. 67.

2. Ibid., p. 80.

3. Delbert D. Smith, Communication ~~Via Satellite: A Vision in Retrospect~~ (Boston: A.W. Sijthoff, 1976), p. 71.

4. John Robinson Pierce, "Communication Satellites," Scientific American 205 (October 1961): 101.

5. Telstar I, 3 vols. (Washington, DC: NASA SP-32, Goddard Space Flight Center, June 1963). Also published as A.C. Dickieson, et al., "Telstar I," Bell System Technical Journal 42 (July 1963). In December 1965, Goddard issued volume four of NASA SP-32, which related Goddard Telstar experiments. The four-volume set of NASA SP-32 consequently provides a useful compendium of Telstar information.

6. Typed manuscript, Peter Cunniffe, "Misreading History: Government Intervention in the Development of Commercial Communications Satellites," Report no. 24, Program in Science and Technology for International Security, Massachusetts Institute of Technology, May 1991, p. 29, ACTS Project Office, NASA Lewis Research Center, Cleveland, OH.

7. Jaffe, Communications in Space, p. 107.

8. Cited in Lloyd D. Musolf, ed., Communications Satellites in Political Orbit (San

Francisco: Chandler, 1968), pp. 17-18.

9. John F. Kennedy, Public Papers of the Presidents of the United States (Washington, DC: Office of the Federal Register, National Archives and Records Service, 1961), p. 530.

10. Smith, Communication Via Satellite, p. 74.

11. Lawrence Lessing, "Launching a Communications System in Space," in The Editors of Fortune, eds., The Space Industry: America's Newest Giant (Englewood Cliffs, NJ: Prentice-Hall, 1962), pp. 140-41.

12. Richard M. Bentley and Albert T. Owens, "SYNCOM Satellite Program," Journal of Spacecraft and Rockets 1 (July-August 1964): 395.

13. Paul J. McCeney, "Applications Technology Satellite Program," Acta Astronautica 5 (1978): 299-325.

14. Ibid., p. 324.

15. Robert O. Wales, ed., ATS-6 Final Engineering Performance Report (Washington, DC: NASA Research Publication [RP]-1080, 1981).

16. In 1985, the ATS program was transferred from Goddard to the Lewis Research Center in Cleveland to consolidate NASA's communications program. ATS-3 is still operational. Michael A. Cauley, "ATS-3: Celebrating 25 Years of Service in Space," unpublished manuscript, no date, p. 1, ACTS Project Office, NASA Lewis Research Center.

17. Harold R. Raine, "The Communications Technology Satellite Flight Performance," Acta Astronautica 5 (1978): 343-368.

18. A.D. Wheelon, "Von Karman Lecture: The Rocky Road to Communication Satellites," in AIAA 24th Aerospace Sciences Meeting: January 6-9, 1986, Reno, Nevada, Paper No. AIAA-86-0293, Vol. 4 (New York: American Institute of Aeronautics and Astronautics, 1986), p. 21.

19. Andrew Wilson, ed., Jayne's Space Directory 1993-1994 (Surrey: Jayne's, 1993), pp. 66, 359-60.

20. Ibid., pp. 330-32.

21. Committee on Satellite Communications, Space Applications Board, Assembly of Engineering, National Research Council, Federal Research and Development for

Satellite Communications (Washington, DC: National Academy of Sciences, 1977), p. 30.

22. Robert R. Lovell, "The Status of NASA's Communications Program," Pacific Telecommunications Conference, January 1982, p. 4, preprint copy supplied by author.

23. See, for instance, Cunniffe, "Misreading History," passim.

24. Laura K. Browning, "The Top 50 Space Companies," Space News 6 (24-30 July 1995): 8.

INDEX PAGE

REGULATORY DIRECTIONS FOR SATELLITE COMMUNICATIONS IN EUROPE

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INTELSAT SUMMIT

London

2/3/1995

Open skies in the 1980's clearly helped push EU policy

I INTRODUCTION

The G7 meeting in Brussels last weekend has consecrated the concept of the Information Society at a world level. Satellite communications are an integral - and essential - part of the new global information highway. Intelsat, of course, and the other International Satellite Organisations continue to be the backbone of this development.

At the same time, new satellite technologies are emerging. The Low Earth Orbit satellite consortia are setting themselves up to offer world-wide satellite-based communications by the end of the decade. It seems that satellite communications are moving world-wide into a new phase of development.

This new phase of development is posing major challenges for competition rules and regulatory policies world-wide - particularly for the European Union. This is why the definition of the future regulatory directions for satellite communications is both required and timely.

II BACKGROUND

The future regulation of the market for satellite communication services in

Europe was first contemplated in the Commission Green Paper of 20 November 1990 "Towards Europe-wide systems and services - Green Paper on a common approach in the field of satellite communications in the European Community". Basic regulatory directions were set at that time :

- full liberalisation of the earth segment, including the abolition of all exclusive or special rights in this area ;
- free (unrestricted) access to space segment capacity ;
- full commercial freedom for space segment providers ;
- harmonisation measures as far as is required to enable the provision and use of Europe-wide services.

The Commission's proposal to extend the scope of the 1988 and 1990 Directives concerning respectively telecommunications terminal equipment and telecommunications services, to include satellite communications, was welcomed by the EU-Council of Ministers, initially in Resolution 92/C8/01 of 19 December 1991 on the development of the common market for satellite communications services and equipment, and again in its Resolution of 22 July 1993 on the review of the situation in the telecommunications sector and the need for further development in that

WHAT'S NEW

MAIL-BOX

SEARCH

market. The Council considered this extension to be a major and immediate goal for the Community's telecommunications policy. In its Resolution of 18 January 1993 on the Hoppenstedt report, the European Parliament also expressed its strong support for such an extension.

The Council Resolution of 1993 also committed the EU-Member States to the opening of public voice telephony to competition by 1 January 1998. In November 1994 the Council agreed to the Commission's proposal to extend 1998 liberalisation to include the lifting of restrictions on infrastructure for the provision of telecoms services. This has led to the current broad consultation on the future regulatory framework for telecommunications and cable-TV networks in the EU; The consultations are based on the Infrastructure Green Paper which was issued in January.

In parallel, in the field of satellite communications, some first implementation steps were taken. In October 1993, an EU- Council Directive relating to mutual recognition of type approval for satellite terminals was adopted. In January 1994, the Commission submitted a proposal for the mutual recognition of licences for the provision of satellite networks and services in the European Union.

III LIBERALISATION : THE SATELLITE DIRECTIVE

Where competition in markets is restricted or distorted by government regulation allowing special or exclusive rights to particular bodies, and where such regulation can no longer be justified as being necessary in the interests of public service, then the European Commission's responsibility as guardian of the Treaty is to seek to abolish such rights. Article 90 of the Treaty allows us to act under these circumstances. When such a distortion of competition (without justification) occurs in a number of Member States at the same time, paragraph 3 of Article 90 gives the Commission the practical option of issuing a general directive to all Member States. This allows to give clear guidance to all Member States and to achieve an equal implementation of Community law throughout the Union.

This was the aim in 1988 with the adoption of the telecoms Terminal Equipment Directive and in 1990 with the adoption of the Services Directive. These Directives, adopted under Article 90(3), direct Member States to lift the existing restrictions and to open up these markets to competition, while allowing them to establish the necessary safeguards. The latter includes, in particular, to maintain, during a transitional period (up to 1st January 1998, as now decided) exclusive rights for the public.

In the satellite field, on 13 October 1994, the Commission adopted Directive 94/46/EC, the Satellite Liberalisation Directive. This requires the abolition of all exclusive rights granted for the provision of satellite services and equipment, and the abolition of all special rights to provide any telecommunications service covered by the Directive. The Directive, in fact, extends the 1988 Terminal Directive to include satellite earth station equipment and extends the 1990 Services Directive to include satellite communications services.

The aim is to stimulate without delay the greater use of satellite communications in the EU. Our studies anticipate that the liberalisation of markets in earth and space station and hardware and satellite services will lead to their rapid expansion in Europe. Growth is estimated to be, at least, threefold in the short term. This is particularly important given the widening gap between the delayed development of EU business satellite communications and that in the other major trading areas, particularly the United States.

The Directive does not affect still existing restrictions on the offering of voice telephony for the public via satellite network. However, this should not imply technical restrictions. Whilst it is recognised in the directive that "commercial provision [of voice] for the public in general can take place only when the satellite earth station network is connected to the public switched network", this is merely a guide as to what is normally the case. It certainly does not imply that such connections necessarily constitute the reserved service. In fact, the provision of voice for closed user groups (which is not reserved) will often involve connections with the public switched network, since some members of such groups will not be connected to the network via satellite stations.

The fact that public voice telephony is not liberalised until 1st January 1998 should therefore not be understood as a "carte blanche" to allowing technical restrictions to protect the monopoly.

Like voice telephony, the status of broadcasting services is unaffected by the satellite directive. However, one has to distinguish between the provision of programming content of broadcasting and the provision of the technical means to carry and distribute such services. The provision of the satellite network services for the conveyance of radio and television programmes is, by its very nature, a telecommunications service and there is therefore no justification for treating it differently from any other telecommunications service. The Directive, thus, makes a clear distinction between:

- the services provided by the carrier (transmission, switching and other activities) necessary for the *conveyance* of the signals, which are telecommunications services liberalised under the Directive, and
- the activities of those bodies which produce and control the *contents* of the messages to be broadcasted, which are broadcasting activities falling outside the scope of this Directive.

Services which are now liberalised under this Directive therefore include services provided over telecommunications operator's feeder links from studios/events to uplink sites, as well as uplink services for point to point, point to multipoint, direct-to-home (DTH) satellite broadcast services and services to cable-head ends.

The Satellite Directive is directly applicable as of the date of its entry into force - that is November 8 1994. However, it gives the Member States nine months - i.e. up to August of this year - to inform the Commission of the measures taken to transpose the Directive into national law, in particular those for the establishment of licensing regimes where Member States wish to do so.

The Commission will, in assessing these measures, take account of the particular situation of Member States in which the terrestrial network is not yet sufficiently developed. It may agree additional transition periods in this context up to 1st January 1996. There must, however, be a justification by the relevant Member States within the time period provided for the communication of the implementation measures of the Directive, i.e. before 8 August 1995.

IV ACCESS TO SPACE SEGMENT

Member States are required by the Directive to abolish all restrictions on the offer of space-segment capacity on their territory.

This means, in particular, that governments must ensure that:

- any regulatory prohibition or restrictions on the offer of space segment capacity to any authorised satellite earth station network operator are abolished, and that
- any space segment supplier is authorized, within its territory, to verify that the satellite earth station network for use in connection with its space capacity conforms to the published standards

A Commission Communication on access to space segment was published by the Commission in June 1994 and the Council adopted a Resolution in response to it at its November Council. The Communication addresses, among other things, the problem of the need to reform the traditional signatory / client relationship of the International Satellite Organisations, including the right to negotiate direct contracts instead of being obliged to deal through the Telecommunications Organisations who may also be a competitor. The Commission's conclusion, supported by the Member State Telecoms Ministers last November, is that the procedures of International Satellite Organisations should be adjusted to be in line with the overall European telecoms environment.

The Communication makes it clear that, in order to ensure direct access to space segment, the Commission intends to make full use of EU-Treaty provisions, particularly the competition rules, to remove existing restrictions.

This means that access to satellite capacity of the International Satellite Organisations must, in particular be non-discriminatory, i.e. all services providers and users should have access to capacity on an equal basis and differences in treatment must be justified by objective and transparent criteria.

The Communication further urges joint management in the future of the space segment as a common resource in the European Union.

V REQUIREMENTS ON THE INTERNATIONAL SATELLITE ORGANISATIONS

The new obligations in the Satellite Directive related to access to space segment do not directly affect the position of the Telecommunications Organizations as signatories of international organisations. The Member States are obliged, however, to ensure that there are no restrictive provisions in their national regulations which would have the effect of preventing the offer of space segment capacity in their territory by either another signatory or by independent systems. Member States must also abolish restrictions which prevent space segment capacity, already leased from the International Satellite Organisation by a licensed operator in one Member State, from being freely accessed by users from their own national territory. The main aim is to achieve maximum commercial flexibility for all concerned parties within the context of the current regulations.

The Directive emphasises that measures relating to International Satellite Organisations must comply with the competition rules of the EU-Treaty. It requires Member States to communicate to the Commission any information which might prejudice such compliance.

An example of such could be the coupling of investment obligations and utilisation if this effectively dissuades signatories to market space segment due to the threat of having to bear an increased investment share. Since international satellite organisations are operating in increasingly competitive markets, the current investment requirements may have to be assessed under the competition rules.

VI NEW PARTNERSHIPS AND ALLIANCES

With the prospect of a liberalised market for the provision of satellite services across the European Union, and the ability to shop around for the signatory offering the best deal on space access, significant opportunities are created for new projects, partnerships and alliances in the field. A major example in this rapidly developing market, has been the recent setting up of International Private Satellite Partners, or, as they are more commonly known "Orion". The partnership is made up of nine companies including one national telecoms operator.

The joint venture was notified to the Commission, who, according to the provisions of Article 85 of the EU treaty, found that there were no grounds for action under the EU competition rules. It was, thus, passed without further conditions. The Decision was published in December.

In fact the IPSP partnership represents a prime example of the current transformations in the global satellite communications sector. It also demonstrates the future rule of EU competition rules in this area. Projects of this kind tend to address the growing need of multinational companies for advanced end-to-end communications between their geographically dispersed locations around the world and, also, between themselves and their customers and suppliers. This segment of the telecoms market is the one with the biggest potential for growth in the years to come, taking full advantage of both liberalisation and technological developments.

The IPSP project also demonstrates the possibilities of the new market environment. Orion Atlantic and its partners had already been working hard for several years to obtain authority to provide services over International Satellite Organisation space segment in order to build up a business base for the new Orion-1 satellite. In a majority of Member States it seems they have faced significant barriers to providing services. In some Member States they were granted only very short term licences, in others they were obliged to work through the TO under unfavourable conditions, and in the worst cases Orion devoted years of effort without obtaining the requested operating authority.

IPSP is now in a position to provide space segment and satellite services on a pan-European basis using their first Orion-1 satellite. This case also shows the new challenges for the International Satellite Organisations vis a vis competition for end customers. The latter are in a position to exploit this introduction of competition and should push the International Satellite Organisations and their signatories to reform and streamline their operations in order to face the new competitive environment.

This is really more a question of corporate philosophy than anything else. International Satellite Organisations will need to start acting more like companies and less like cosy conventions if they are to stay in the game in the longer term. Both satellite services and space segment are becoming an open market.

This development will be substantially accelerated with the advent of the satellite-based personal communications systems. In anticipation of this, the EU-Council of Ministers has adopted a resolution, confirming an EU position vis-B-vis the introduction of satellite personal communications in Europe. It aims to assist European industry in their endeavours to participate in provision of PCS by assuring that the necessary and appropriate regulatory and policy frameworks are developed.

The Commission's November Communication on the results of the consultations on the EU Mobile Green Paper has proposed the launching of EU-wide allocation of licences for such systems by 1st January 1996 at the latest. This time schedule is confirmed by the recent issuing of LEO licences in the United States.

The Commission is also working closely in this field with the European Committee for Regulatory Affairs (ECTRA, the committee of European regulatory authorities in the field of telecommunications) and its newly created European Telecommunications Office (ETO).

VII THE AGENDA FOR THE IMMEDIATE FUTURE - MAKING

LIBERALISATION WORK

In the immediate future, the Commission will focus on three inherently related areas, as far as satellite communications are concerned :

i implementation of the Satellite Services Directive ;

ii access to the space segment :

iii promoting reform of the International Satellite Organisations

L Implementation of the Directive

As I mentioned earlier Member States must inform us of measures taken to implement the Satellite Directive by August of this year. Since a number of Member States have limited experience of procedures and drafting provisions concerned with authorizations for new satellite entrants we anticipate the need for a certain amount of contact and discussions with Member State authorities before this time. I would also emphasise that individual complaints regarding non-implementation of the Directive's provisions are legitimate as of last November when the Directive was published. Indeed, we have already been alerted to problems in some Member States by market players who recognise that the situation may now represent legitimate grounds for complaint.

L Improving access to the space segment

The major part of space segment continues to be offered by the International Satellite Organisations. A major element of the improvement of access must therefore be the reform of the rules governing access to this part of the space segment.

We recognise that efforts have been made, but more has to be done. This is not only in the interests of new service entrants and their users, but in the interests of the International Satellite Organisations themselves. It is increasingly realised that the latter must transform themselves into sleeker, more commercially minded operations if they are to compete with new rivals in the form of private satellite systems.

We are well aware that Intelsat is sympathetic to such reform movements and has begun streamlining its operations in order to meet the new challenges.

L future reform process in the International Satellite Organisations

The Commission's June 1994 Communication on space access spells out the main objectives of joint action by the Member States in the broad reform of the International Satellite Organisations.

In the Communication, the Commission sets as major goals the working out of common positions guided by the following principles :

- > strict separation of all regulatory and operational aspects also within the International Satellite Organisations to enable moves towards a more commercial environment ;
- > separation of user and shareholder interests in the International Satellite Organisations through, inter alia, a separation in the linkage of investment share and usage, including adjustment and strengthening of the financial base and opening participation to new shareholders ;
- > within the International Satellite Organisations, structural separation of space segment provision on the one hand, and the provision of satellite communication services on the other ;
- > the marketing and selling of the International Satellite Organisations' space segment by either the organisation directly, or by agents (brokers) for whom conflicts of interest do not exist.

While we recognise this to be an ambitious programme, it also seems to be the only way of ensuring compatibility with a competitive market environment - and with the competition rules which must govern such an environment - in the longer term.

VII CONCLUSIONS

looking to open skies otherwise falling - behind

The current liberalisation of the satellite markets, the transformation of the International Satellite Organisations and the emergence of completely new private competitors initiate a new - and exciting - stage of the development of the world's satellite sector.

The EU Satellite Liberalisation Directive, together with the EU's Communication and Resolution on access to space segment equip Europe to face this new satellite age. Before the year 2000, liberalisation should result in up to tenfold increases in significant segments of the satellite communications market.

US de-regulation (the 'Open Skies' policy) greatly stimulated the satellite market in North America during the 80s.

L We expect substantial benefits in the EU market :

- ***Reduction of costs*** of deploying and operating satellite networks which will be translated into lower prices for the consumer: Competition and liberalisation will mean lower charges for licensing, terminal type-approvals (which will become 'one-stop') and space segment access.
- ***Pan-European networks***: The harmonised regulatory environment will facilitate the establishment of pan-European satellite networks which has been frequently recognised as a key requirement for market growth. This will be critical to the development of trans-European communications networks.
- The rapid deployment, especially in less developed or remote areas of ***multimedia applications*** and ***access*** to the ***information highway.***
- ***Removal of prohibitions*** on service provision and interconnection and ***Simplification*** of operations such as licensing, equipment registration and installation and, most importantly, increased ***confidence*** of users, operators and investors in satellite solutions for Europe

L We have, of course, some way to go to match US developments in this market :

In Europe, due to tardy liberalisation and therefore of development of the market, we start from a point of disadvantage because our costs for equipment, hub stations and access to space segment are higher and we still face the cost of low utilisation of expensive hub stations.

There are still not enough European products in key parts of the ground equipment market. There was no commercially significant market in Europe for small satellite terminals until beginning of this decade.

Finally, liberalisation in the US has led to a proliferation of satellites and substantial falls in transponder access prices. Europe still has some of the highest access prices of any region.

However, we believe that the right regulatory directions are now set down. The lights are switching from red to green for the European satellite communications market.

▲

[Speeches and articles 1995]

Questia :: Journal Article

The Evolution of the Cables-Satellite Distribution System

Journal article by Patrick Parsons; Journal of Broadcasting & Electronic Media, Vol. 47, 2003

Journal Article Excerpt

The evolution of the cables-satellite distribution system.

by Patrick Parsons

The television industry began a dramatic transformation in the mid 1970s following the creation of the cable-satellite programming distribution system. This paper details the evolution of the cable-satellite link, from its conceptual roots in the 1960s, through pioneering efforts by Teleprompter Corp., to the eventual involvement of Home Box Office. It offers a narrative and analysis that fills a gap in the existing historical record and provides an illustration of several themes involving the social evolution of technology.

The introduction in 1975 of the cable-satellite programming distribution system led to a dramatic restructuring of the television industry in the United States. From an industry dominated by three national networks, television evolved into a multichannel environment in which viewers had access to dozens of highly specialized program choices. While NBC, CBS, and ABC remain the most heavily viewed television networks, their market share has steadily eroded since the introduction of the cable-satellite link and the cable programming industry that it spawned.

While this critical inflection point in television history is ritually noted in most textbooks, its evolution has never been substantively detailed. The typical treatment in the literature involves a note to the effect that in 1975 Home Box Office (HBO) inaugurated satellite-delivered programming, helping spark a revolution in television (See e.g., Dominick, Sherman, & Copeland, 1996, p. 70; Head, Sterling, & Schofield, 1994, p. 78; Gross, 1997, pp. 75-77; Parsons and Frieden, 1998, 52-54). Some broadcast and cable history texts offer a bit more detail (Fang, 1997, p. 201; Hilliard & Keith, 1997, p. 213, 216; Southwick, 1998; Sterling & Kittross, 2002, p. 412). Two pieces from the 1970s discuss then-future prospects for cable-satellite interconnection (Shapiro, 1972; Shapiro, Epstein, & Cass, 1975), and Winston (1986, p. 289) mentions early proposals for satellite-cable systems, but only in passing. None have provided the richer description that this key turning point in communications history arguably deserves. This paper is an effort to begin to fill that gap in the historical narrative. Its intent is to explore the development of the cable-satellite union.

The paper is also an effort to illustrate several broader theoretical points about the nature of technological development. It proceeds from the factual observation that the cable-satellite system had a substantial prehistory and the analytical position that technological change is, to a point,...

restructuring cable industry

End of free preview...

NASA

The Space Review
essays and commentary about the final frontier

Can the International Space Station be converted into a platform that can be used for future human exploration beyond Earth orbit? (credit: NASA)

Can NASA go back to the Moon, or anywhere else?

by Taylor Dinerman
Monday, November 10, 2003

Editor's Note: Taylor Dinerman's "Monday Analysis" column, previously on SpaceEquity.com, will now be appearing on The Space Review.

Can NASA be reformed? As an institution, it has been given any number of chances to reform itself and, until recently, it has failed—not through lack of trying. Dan Goldin did everything but transform himself into a Klingon prison guard to try and push the agency into fixing itself. He made some marginal progress with the basic "Faster, Better, Cheaper" (FBC) idea. NASA now sends a wide variety of small and medium-sized spacecraft on missions as different as mapping the Earth's ice fields, or out to the asteroids and Mars. FBC may not have worked perfectly, but it did shake the agency out of the mindset of doing only billion-dollar science missions.

In fact, the Space Science and the Earth Science enterprises at NASA are in fairly good shape. Sean O'Keefe has been trying equally hard, though without the emotional intensity, to change the way the agency does business. He has made some minor progress in bringing some of their management practices into the 21st century, but no one doubts that there are still big problems to overcome.

It is the Spaceflight enterprise—essentially the space shuttle and space station programs—that have caused even the best-intentioned NASA supporters to sometimes despair. The CAIB report is particularly damning of the culture that developed inside the agency's human spaceflight program. It was not that safety was ignored, but that it was not made an overwhelming priority.

Even going beyond the CAIB report, one must begin to question all of the bureaucratic impedimenta that a government-run space exploration program must carry with it when it tries to venture off the surface of the Earth. It is difficult to simultaneously convince the US House and Senate that NASA needs more money and more freedom from normal regulations while it has so far failed even to convince the Congress that it has a reasonable plan to replace the shuttle and to begin serious human exploration beyond earth orbit.

> **Many of NASA's worst problems can be laid at the feet of those in the Nixon and Clinton administrations who were unwilling to cancel human spaceflight outright but were equally unwilling to put a coherent program together.**

Many of NASA's worst problems can be laid at the feet of those in the Nixon and Clinton administrations who were unwilling to cancel human spaceflight outright but were equally unwilling to spend the time, money, or mental effort needed to put a coherent program together. In the Nixon administration, they ordered the shuttle developed on a shoestring budget. Most of the system's problems can be traced back to its having been starved while still in the womb.

For the ISS, its lack of usefulness as a base for lunar exploration is due to the fact that it is in the wrong orbit. In order to make the station accessible from both Cape Canaveral and Baikonur, it is in a skewed orbit, suitable for doing useful earth observation but not for much else. The Clinton administration saw it as a symbol of US-Russian friendship and for keeping the large aerospace contractors happy, but that was about it.

Luckily, a set of circumstances has developed that might allow the ISS to be moved into an equatorial orbit, thus allowing it to be used as the departure point for manned lunar missions. First, the European and Russians have agreed to build a Soyuz launch pad in Kourou that will allow them to launch reach the ISS if it were in such an orbit. Second, the technology to move the ISS using an electromagnetic tether is within reach. Third, the US Congress is interested in finding a way to have the US human spaceflight program actually go somewhere, instead of simply going around in circles.

Instead of putting together yet another commission, as Senator Hollings recommends, the President could simply say that we are going to find a way to move the ISS into an orbit from which it can be used to launch missions to the moon. It might take more than three or four years to begin such a move, but by then the new pad in Kourou would be ready and the station itself could begin to be configured as a base for such operations. Also, NASA should come up with either a credible way to get into and out of low earth orbit, frequently and safely, or a way to buy the passenger service from some US entity (commercial or otherwise) that will.

In 1989, on the 20th anniversary of the Apollo 11 moon landing, President George H.W. Bush proposed to go back to the Moon and then to Mars. After a short study, NASA presented both him and the Congress with a price tag of more than 450 billion dollars. The sticker shock alone, leaving aside any questions of technological capacity, killed the idea. Since then, the US has spent about 100 billion dollars on the shuttle and the ISS, and we are only a tiny bit closer to those objectives than we were fourteen years ago.

By using the ISS as a base, and perhaps also creatively using the existing shuttle infrastructure, the President and NASA can take a meaningful step into interplanetary space.

By using the ISS as a base, and perhaps also creatively using the existing shuttle infrastructure, the President and NASA can take a meaningful step into interplanetary space. Only a step-by-step process, with clearly defined milestones with the ultimate goal of a permanent human settlement on Mars, will satisfy America's need for a visionary space program and an affordable way to accomplish it.

The alternatives would represent years of more wasted or nearly wasted effort and increasingly bitter political arguments. There is a embryonic consensus building in the Congress that the US human space program needs an objective. To start a lunar and Martian program from nothing, as some have proposed, would be to waste the huge sums already invested in the Shuttle and the ISS. Making ISS the base from which lunar exploration can depart, and changing the way we use the shuttle's infrastructure, can be one way to move forward without breaking the bank.

Eventually, the shuttle system will have to be replaced, but the current NASA plan, based on the Integrated Space Transportation Plan of November 2002, is being firmly rejected by both houses of Congress. The space agency had better rethink its program or it will be in even deeper trouble than it is now.

■

Taylor Dinerman is editor and publisher of SpaceEquity.com.

Home

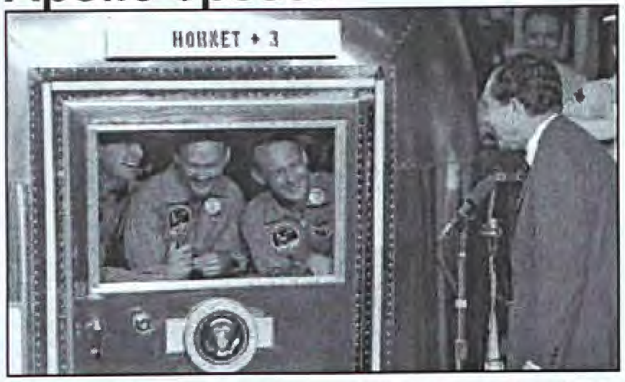
Front Page
World
UK
UK Politics
Business
Sci/Tech
Health
Education
Sport
Entertainment
Talking Point
In Depth
On Air
Archive

Feedback
Low Graphics
Help

Saturday, July 10, 1999 Published at 13:39 GMT 14:39 UK

Sci/Tech

Full text: Nixon's unused Apollo speech



In the event Nixon personally welcomed the astronauts back home

Recently discovered documents detail the steps Nasa and the Nixon administration would have taken had the Apollo XI astronauts Neil Armstrong and Edwin "Buzz" Aldrin been unable to return from the moon.

The following is the full text of the unused speech, ominously entitled "In the event of moon disaster", which President Nixon would have given as the astronauts lived out their final hours:

A lonely view of a distant home

Fate has ordained that the men who went to the moon to explore in peace will stay on the moon to rest in peace.

These brave men, Neil Armstrong and Edwin Aldrin, know that there is no hope for their recovery. But they also know that there is hope for mankind in their sacrifice.

These two men are laying down their lives in mankind's most noble goal: the search for truth and understanding.

They will be mourned by their families and friends; they will be mourned by their nation; they will be mourned by the people of the world; they will be mourned by a

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Mother Earth that dared send two of her sons into the unknown.

No-one knew whether the module would successfully launch from the moon

In their exploration, they stirred the people of the world to feel as one; in their sacrifice, they bind more tightly the brotherhood of man.

In ancient days, men looked at stars and saw their heroes in the constellations.

In modern times, we do much the same, but our heroes are epic men of flesh and blood.

Others will follow, and surely find their way home. Man's search will not be denied.

But these men were the first, and they will remain the foremost in our hearts.

For every human being who looks up at the moon in the nights to come will know that there is some corner of another world that is forever mankind.

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transmission of gravity-perception information within both plants and animals; 3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration) on the development of metabolism of organisms; 4) use gravity to study the normal nature and properties of living organisms; and 5) extend the limits of knowledge about plant and animal growth and metabolism to provide for long-term survival and multigeneration reproduction of life in space. This program provides basic ground-based information in support of future space flight experiments and life support systems environment. This includes assurances that physical welfare and performance is preserved and that adequate treatment of inflight illness or injuries is provided.

Exobiology is the study of the origin, evolution, and distribution of life and life-related molecules on Earth and beyond. Sophisticated analyses of life as we know it, its chemical precursors and its origin, coupled with extrapolation to extraterrestrial environments, affords a unique opportunity to address a most fundamental question regarding the existence of such processes beyond the Earth. Theories about chemical evolution and the origin of life are being refined to reflect results from the most recent planetary and astronomical explorations. The current research program also is uncovering an intimate association between the origin and evolution of life on Earth and the processes that shaped the evolution of the solar system itself. These discoveries have highlighted gaps in our knowledge which, when completed as the program expands, will ultimately allow tests of the concept of universality of biological processes.

It may be useful to describe one additional space science program that has now been significantly cut back, **because this cutback has ramifications for future international cooperation in space applications.**

The international solar polar mission (ISPM) was a joint NASA and European Space Agency mission designed to obtain the first view of the solar system from a new perspective—a view from far above and far below the plane in which the planets orbit the Sun's equator, i.e., over the poles of the Sun. The two spacecraft would have aided in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, and hence might have allowed us to gain insight into the possible effects of solar activity on the Earth's weather and climate. The objective of the international solar polar mission was to conduct an exploration of those regions of the heliosphere above and below the equatorial plane of the Sun. Observations in the extreme, high-latitude regions of the sun have not been made before, and evidence indicates that this region of space is greatly different from the region in which the Earth is located.

The U.S. spacecraft for ISPM was canceled on account of budget constraints. The issues raised by its cancellation are discussed in chapter 7.

PUBLIC ATTITUDES ON SPACE

Democratic government is based on the premise that there should be some linkage between public attitudes and political choice, not only in general but also with respect to specific issues on the public agenda. This linkage is not a one-way path, of course; public officials are leaders, teachers, and molders of public attitudes and opinion as well as representatives of the public in the political process. Thus, the following account of public attitudes about the space program needs to be interpreted with the understanding that general public opinion is only one determinant of public policy, and that its influence is rarely direct. Public opinion more frequently acts as a general constraint, setting boundaries within which political leaders are free to chose, or as an indirect shaping influence on the attitudes of elites inside and outside of government; most often, it is these attitudes that are closely correlated with specific policy choices.

From this analysis it follows that:

1. During the early years of the U.S. space program, the general public was willing to accept the interpretation of society's leaders as to the significance of space activities. This made it possible for the United States to first adopt a moderate response to Soviet space achievement, then to reverse policy and to enter into competition with the Soviets, even though public attitudes seemed to be opposed to such competition.
2. More recently, public understanding of the space program, and a supportive public attitude toward that program, have increased to the point where they may have political impact. Although an official's position on space-related issues may not be a crucial determinant of electoral success, prospace attitudes, and particularly, groups organized to reflect them, appear to be having some impact in influencing public policy with respect to the U.S. space program.

It is important, however, even if the second of these propositions is accepted, to recognize that "while it has considerable intellectual interest and entertainment value, space exploration is not a daily concern of the general public. . . . The levels of interest and information in this area are especially low."[5] Thus it is likely that public attitudes will provide the background, but not much more, against which national space policy will continue to be formulated.

Public Opinion and Space Policy: 1965-80

A striking example of a leadership decision not being constrained by apparent public opinion is the U.S. commitment to a manned lunar landing. In the very month that President John F. Kennedy announced that he was setting as a national goal a lunar expedition before 1970, the Gallup Poll reported that the public was opposed by a 58 to 33 percent margin to spending the up to $40 billion such an enterprise would require, Until very recently, only once since 1965 has the percentage of U.S. adults calling for the United States to do more in space exceeded the portion believing that the Government should do less. Figure 9 compares this division of opinion for the period

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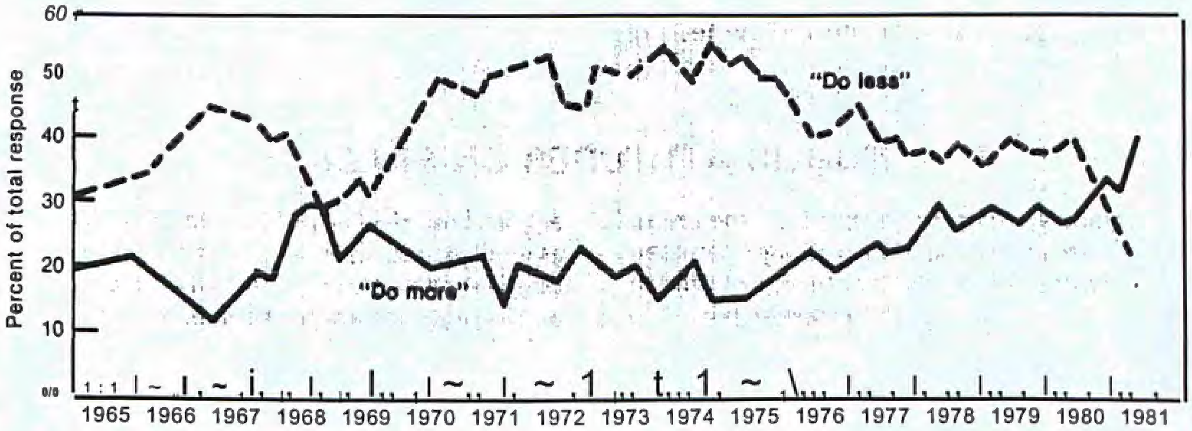
[5] National Science Board, *Science Indicators, 1980*, p. 169.

Figure 9.–Long-Term Trend Polling Results of U.S. Public Opinion on the Federal Space Effort



NOTE: Responses to question of whether government should "do more" or "do less" in support of space exploration, 1965-1981.

SOURCE: For 1965-1975, Herbert Krugman, "Public Attitudes toward the Apollo Program," Journal of Communications, vol. 27, No. 4 (1977), More recent data are derived from Trendex Polls taken for the General Electric Co.

from 1965 to 1981; the recent shift toward a markedly more prospace position is clear from this chart.

Table 10, which reports opinions for the 1973-**80 period,** is even more revealing, both in terms of the longer term trends and in terms of the current uprising in prospace opinion. Only in recent years have space "antagonists" comprised less than an absolute majority, and the explicitly prospace group grew only slowly, from **7.4** percent in 1973 to 11.6 percent in 1978. Most recently, however, the figure for those believing the United States is spending too little on space has jumped to 18 percent, and space antagonists are now only 39 percent of the total. The size of the "space neutral" segment has stayed constant, and thus the gain in support for expanded space spending appears to reflect a real shift in opinion. In 1980, for the first time, those of the opinion that space spending should not be lowered outnumbered those holding the opposite view, 53 percent to 39 percent.[6]

While prospace opinion appears ***to*** be increasing, the priority assigned to the space program has historically remained low. Tables 11 and 12 demonstrate this both for Government priorities in general (table 11) and for priorities within science and technology (table 12). What is most relevant in table 11 is that only the "military, armaments, and defense" category showed a greater increase in percentage in favor between 1977 and 1980 than did the "space exploration program," although this increase only moved space one rank up the priority scale. According to one analyst, "the increasing approval of space activities among Americans over the past several years is

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[6] Robert **D.** McWilliams, **"The Improving** Socio-Political **Situation of the American Space Program in the Early 1980' s," paper prepared for Fifth** Princeton/AIAA **Conference** *on* **Space Manufacturing, May 1981, p. 2.**

Table IO.—Distribution of Opinion Toward Federal Spending on the Space Program: 1973 Through 1980 (percentages)

	1973	1974	1975	1976	1977	1978	1980
Too little	7.4	7.7	7.4	9.1	10.1	11.6	18.0
About right	29.3	27.5	30.1	28.0	34.4	35.0	34.6
Too much	58.4	61.0	58.1	60.2	49.6	47.2	39.1
Don't know	4.7	3.6	4.4	2.5	5.9	6.5	8.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

SOURCE National Opinion Research Center Polls as reported in Robert D. McWilliams, "The Improving Socio-Political Situation of the American Space Program in the Early 1980s, " paper prepared for Fifth Princeton/AIAA Conference on Space Manufacturing, May 1981

Table 11.— Percentages of Americans Favoring Increased Funding, and Relative Priority Rankings, for 11 Areas of Federal Government Spending, 1977 and 1980

	1977 percent	1977 rank	1980 percent	1980 rank	Percent increase
Halting the rising crime rate	70.0	1	72.0	1	2.0
Dealing with drug addiction	59.5	2	64.5	2	5.0
Improving-protecting Nation's health	58.5	3	57.1	4	– 1.4
Improving-protecting the environment	51.2	4	50.8	6	– 0,4
Improving Nation's education system.	49.5	5	54.9	5	5.4
Solving problems of the big cities	46.9	6	45.8	7	-1.1
Improving conditions for blacks.	27.3	7	26.2	8	– 1.1
Military, armaments and defense	25.7	8	60.2	3	34.5
Welfare	13.0	9	14.0	10	1.0
Space exploration program	10.7	10	19.6	9	8.9
Foreign aid.	3.7	11	5.4	11	1.7

SOURCE' **Robert** D. McWilliams, "The Improving Socio-Political Situation of the American Space Program in the Early 1980s," paper prepared for Fifth Princeton/AIAA Conference on Space Manufacturing, May 1981

Table 12.—Public Priorities for Federal R&D Spending

Funding objective	Most preferred		Least preferred	
	Response	Rank	Response	Rank
Improving health care	815	1	60	12
Developing energy sources and conserving energy	754	2	40	14
Improving education	630	3	55	13
Reducing crime	587	4	82	11
Developing or improving methods for producing food	368	5	253	8
Reducing and controlling pollution	358	6	113	10
Developing or improving weapons for outer space	266	7	403	6
Preventing and treating drug addiction	259	8	195	9
Developing faster and safer public transportation	210	9	430	5
Improving the safety of automobiles	155	10	284	7
Finding better birth control methods	139	11	705	1,5
Discovering new basic knowledge about man and nature	135	12	577	4
Exploring outer space	99	13	705	1.5
Predicting and controlling the weather	60	14	592	3

SOURCE: Institute for Survey Research, Temple University, *National Survey of the Attitudes of the U.S. Public Toward Science and Technology*, submitted to National Science Foundation, May 1980, pp. 178–180. (This was a survey of 1,635 people over 18. Respondents were asked: "Which 3 areas . . . would you *most* like to receive science and technology funding from your tax money?" and "Which 3 areas . . . would you *least* like to have science and technology funding from your tax money?"

not a trend that is riding mainly on the coattails of militarism or growing faith in science and technology. Rather, it seems that Americans may be coming to view the space program as being conducive to the achievement of other types of goals of which they are in favor."[7]

One indication of what the public expects from space exploration is presented in table 13. A national survey taken for NSF asked adults to identify benefits they believed would result from exploring outer space. Listed in table 13 are those benefits mentioned either first or second by respondents. What is striking about the results is the high ranking given to an indirect benefit of the program ("improve other technologies") and the low rankings given to direct economic benefits ("find industrial use," "create jobs and other economic benefits"). Compared with other technology-related issues such as nuclear power or chemical food additives, a greater proportion of Americans see space exploration as producing substantially more benefits than potential harm.[8]

It is possible to construct a profile of those who most "support" and those who most "oppose" the U.S. space program, if "support" and "oppose" are defined as deviations of more than 10 percent from the average of all Americans. Table 14 contains such a profile, Those who support the space program tend to have one or more of the following characteristics: male, between 25 and 34, college-educated, professional or technical employment, working for government, income over $25,000/year,and living in the West. Opponents of the space program tend to be: female, over 65, black, less than a high school degree, laborers and service workers, and under $5,000 income. One more relevant characteristic that emerges from another opinion study is that those who support increased space spending are significantly more likely to vote than those who believe that too much is spent on space; over 72 percent of those who supported an increase in space budgets in 1980 voted in the 1976 Presidential election, while only 56 percent of those calling for reduced spending voted that year.[9]

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[7] Ibid., p. 8

[8] National Science Board, op. cit., p. 170.

[9] McWilliams, op. cit., p. 16.

Table 13.—Perceived Benefits From Space Exploration

Benefits	First or second mention
Improve other technologies (e.g., computers)	272
Find mineral or other wealth, other resources, sources of energy	200
Increase knowledge of universe and/or of man's origins	190
Find new areas for future habitation	134
Contact other civilizations, other forms of life	107
Improve rocketry and missile (military) technology.	43
Find industrial use for space	27
Find new kinds of food/places to raise more food products	26
Create jobs and other economic benefits.	16
Learn about weather and how to control it.	13

SOURCE: Institute of Survey Research, p. 164

Table 14.—Profile of Public Attitudes of Space Exploration: "In General, Do You Favor or Oppose the Exploration of Outer Space?"

Group characteristics	Percent favor	Percent oppose
All	60	31
Men.	71	22
Women	49	38
Age 25 t0 34	70	23
Age over 65	34	50
Black	38	49
O to 8 years of schooling	32	50
9 to 11 years of schooling	40	50
Some college, no degree	74	19
Bachelor' s degree	79	15
Graduate degree	85	10
Professional or technical job.	78	16
Operatives and laborers	43	43
Service workers	47	41
Work for government	76	17
Under $5,000 income	31	55
$25,000 to $49,999 income	76	17
Over $50,000 income	74	15
Live in West	74	20

[a]Only those characteristics that differ by more than 10 Percent 'rem overall opinion are included.

SOURCE: Institute for Survey Research, Vol *II, Detailed Findings*, p 170.

The demographic makeup of the "prospace" group appears to be undergoing some changes in recent years, although its general characteristics as profiled in table 11 have remained stable. Among those changes:

- recent increases in prospace attitude are much more marked among the most highly educated;
- formerly, "lower" and "working" classes were more antispace than were **"middle" and "upper" classes. Recently, however, the "middle" and "working" have become** more space positive than either "upper" or "lower" class respondents;
- prospace attitudes have increased substantially among whites and only negligibly among blacks; and
- support for space is increasing faster for divorcees than for any other marital class.[10]

There has been a suggestion that the shifts in space-positive attitudes with respect to variables of social class and education "provide a classic example of how social change tends to begin and develop in society. Innovations generally find their beginnings in the ideas and efforts of the more highly educated members of the upper-middle class and, if they survive and grow more prevalent in the upper strata, they then tend to catch on at the lower socioeconomic levels." The same analyst argues that "the resurgence of space-positivism in America since 1975 was spawned by the upper and middle social classes. The trend then began to spread throughout the general public with the classic pattern that has characterized other prominent American social movements such as the feminist and civil rights crusaders.'"[11]

One of the most striking recent developments in the space policy field is the emergence of a number of organized prospace groups. As the quotation just cited suggests, the aggregation of individual opinions into more-or-less broadly based interest groups with middle and working class roots is part of the traditional pattern by

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[10]McWilliams, op. cit., pp. 10-15.

[11] Ibid., p. 14.

which issues are given increased attention on the public agenda. perhaps this is what is happening with respect to space. The following section describes the recent emergence of a space interest group network.

Interest Groups and Space Policy

During the 1970's, interest groups organized around one or a few issues and claiming to represent broad sectors of the general population—so-called "public" interest groups—became an increasingly important influence on public policy. In part, the increased influence came at the expense of political parties as vehicles for articulating, influencing, and implementing the public's policy preferences.[12] Thus the rapid increase in space interest groups in recent years may be a development of political significance. A May 1980 survey of space interest groups identified 39 organizations with nationwide activities.Is In the past 2 years, and particularly with the transition in administrations, there have been a number of one-time efforts organized ad hoc to mobilize opinion on space policy; these groups have provided a base for such mobilization efforts.

There is an active "Coordinating Committee on Space" that attempts to identify areas of agreement and disagreement among the major prospace groups; its membership includes 11 of the most active organizations. There are two general types of prospace groups: 1) traditional professional groups, and 2) citizen support groups. Most prominent among the former are:

- ***American Institute of Aeronautics and Astronautics,*** the professional society for people in the aeronautics and astronautics field, with almost 30,000 members.
- ***American Astronautic/ Society,*** a group of individuals with professional interest in space. Current membership is about 1,000.
- ***Aerospace Industries Association,*** a consortium of major aerospace firms that functions as a trade association.
- ***National Space Club,*** a Washington-based group of business and government leaders in the space field.
- ***University Space Research Association,*** a consortium of universities active in space research that operates several facilities under NASA contract.

Among the most active and/or largest of the public interest or citizen support space groups are:

- ***Delta-Vee,*** a citizen-supported, nonprofit corporation that channels public contributions into the support of specific space activities, such as the continued operation of the Viking spacecraft on Mars and a U.S. Halley's Comet Mission.
- ***High Frontier,*** a group formulating a national strategy to make maximum use of space technology to counter the threat of Soviet military power, to replace current nuclear strategy with one based on space defense, and to promote the industrial and commercial potentials of space.
- ***Institute for the Social Science Study of Space,*** which sponsors research and publications related to the social science aspects of space exploration and development.
- ***L-5 Society,*** which emphasizes human settlement in space as a long-term goal. Founded in 1975 by Gerard K. O'Neill, it has broadened its scope to most aspects of space policy. Its membership is between 3,ooo and 4,ooo individuals.
- ***National Space Institute,*** the largest of the broadly based space groups, with over 10,000 members. Founded in 1975 by Wernher von Braun, its emphasis is on communication with general audiences.
- ***Planetary Society,*** which promotes awareness of and public involvement in planetary exploration and search for extraterrestrial life. Publishes newsletter, supports research, organizes meetings. Has grown to over 100,000 members in just over a year.

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[12] **Charles Chafer, "The Role of Public Interest Groups in Space Policy, " Jerry Grey and Christine Krop (eds.),** *Space Manufacturirrg III,* **Proceedings of the Fourth Princeton/AIAA Conference (New York: American Institute of Aeronautics and Astronautics, 1979), pp. 185-189.**

[13] **Trudy Bell, "Space Activists on the Rise, "** *Insight,* **August-September 1980, pp. 1, 3, 10, 13-15.**

- Space *Foundation,* a private foundation for support of space industrialization.
- *Space Studies Institute,* a research performing and supporting group with focus on use of nonterrestrial resources.
- *World Space Foundation,* a group supporting research projects to accelerate space exploration (e.g., solar sail).

The purposes of these and other space groups fall into three general categories:

1. educating and informing the public;
2. conducting research themselves; and
3. funding external research.

Recently added to the list are groups explicitly engaging in political activities. There were attempts to organize prospace Political Action Committees (PACS) for the 1980 election, and at least one prospace PAC remains in existence.

The influence of these various organizations and groups on space policy is difficult to estimate. Certainly, as the Reagan administration took office in January 1981 and as the proposed NASA budget was cut several times in the following year, there have been a number of attempts by one or a coalition of these groups to mobilize opinion in support of specific projects (e.g., a mission to Halley's Comet) or for the civilian space program in general. Whether the reductions in the NASA budget would have been even more severe, had not these groups been active, is a question difficult or impossible to answer.

Finally, note should be taken of the emergence of a Congressional Space Caucus, and a supporting Congressional Staff Space Group. This caucus is initially limited to the House of Representatives; its goal is to increase the awareness of Members and staff of the benefits of the Nation's space effort.

Space Achievement and Public Opinion: 1981

With two successful flights of the shuttle *Columbia* and the encounter of Voyager 2 with Saturn, 1981 was a year of spectacular space achievement for the United States. Several public opinion polls have confirmed that the citizens of the United States were quite supportive of these achievements.

- A May 1981 Harris survey, taken less than 1 month after the initial shuttle flight, found 76 percent of Americans calling the shuttle "a major breakthrough for U.S. technology and know-how' and a 63 to 33 percent majority favoring the expenditure of several billions of dollars over the next decade to develop the full potential of the shuttle. The Harris poll noted that "after the 1969 Moon landing, a 64 to 30 percent majority did not feel it was worthwhile to spend an additional $4 billion on the Apollo space program" and commented that "current support for spending on the space program is even more significant in view of the current overwhelming preference for cutting Federal spending. "
- An August 1981 Associated Press-NBC survey found that 60 percent of U.S. adults thought that the United States was not spending enough or was spending about the right amount on the space program, and 66 percent believed that the shuttle was a good investment for the United States.
- An October 1981 Associated Press-NBC poll confirmed the results of the earlier survey, finding that 60 percent of respondents think the shuttle program is a good investment, 30 percent do not, and 10 percent aren't sure.

A further examination of the results of the May Harris poll suggests both that support for the space program is not evenly distributed across all strata of U.S. society and that the reasons for the support differ substantially among respondents (see tables 15 and 16). The August poll found that 49 percent of respondents believed that the emphasis of the Nation's space program should be primarily on national defense, 32 percent cited scientific exploration, 10 percent cited both, and 9 percent were not sure. By October, these responses had shifted, with 43 percent in support of a defense emphasis and 40 percent favoring an emphasis on scientific exploration. In this latter poll, 46 percent of respondents believed that the United States should keep its space program

Table 15.—How Would You Rank the Importance of Various Uses of the Space Shuttle?

	Very important	Only somewhat important	Not very important at all	Not sure
	Percent	*Percent*	*Percent*	*Percent*
Doing experiments with new pharmaceutical products that can help cure disease	82	11	5	2
Developing a military capability in space beyond what the Russians are doing	68	20	10	2
Putting new communications satellites in space at a much lower cost	64	25	9	2
Doing scientific research on metals, chemicals, and living cells in space	55	27	16	2
Picking up other U.S. space satellites and repairing them in space	47	32	19	2

SOURCE: May 1981 Harris Survey.

Table 16.—"IS the Space Shuttle Program Worth Spending Several Billion Dollars Over the Next 10 Years to Develop its Full Potential?"

	Worth it	Not worth it	Not sure
	Percent	*Percent*	*Percent*
Total	63	33	4
College educated	71	26	3
Men	76	21	
Women	52	43	3
Blacks	45	53	2
Republicans	71	26	3
Democrats	57	39	4
Conservatives	66	30	4
Liberals	57	41	2

SOURCE: May 1981 Harris Survey.

separate from the programs of other nations, 32 percent favored a joint space program between the United States and the U. S. S. R., and 15 percent favored joint ventures with other countries, but not with the Soviet Union.

Opinion polls, taken singly, do not reveal fundamental views underlying the shifting tides of opinion. Thus, the facts that by 1981 the success of the shuttle and of the Voyager missions spurred public interest in the U.S. space program and that a clear majority of the public was found to favor the program do not in themselves prove that there is deep public support for space. But, viewed in the context of a quarter century of space activities, the recent upswing in opinion in favor of the space program appears significant.

First of all, current support is part of a long-term trend of increasing support. It cannot, therefore, be explained as the result only of shuttle and Voyager successes. Second, the trend of increasing support coincides with the proliferation and growth of citizens' support groups. As public education about space is perhaps the major overall goal of these groups, their efforts have been the effect, if not the cause, of continued rising interest in space. Third, the Space Caucus, arising as a "back bench" movement within Congress, rather than in response to the leadership, is evidence for a genuine space constituency, i.e., one whose real interests, economic, political, or scientific, are at stake. These three conditions suggest that public awareness of space issues is increasing and that official space policy may begin to receive more constant scrutiny among at least the attentive public. This would seem to bode well for those who believe that increased understanding of the benefits of U.S. activity in space will lead to continued and firmer public support for that activity.

National Aeronautics and Space Administration

Report of the Space Task Group, 1969

Editorial Headnote: Space Task Group, "The Post-Apollo Space Program: Directions for the Future," September 1969; available in NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C. Page references to original document in brackets.]

[i] Conclusions and Recommendations

The Space Task Group in its study of future directions in space, with recognition of the many achievements culminating in the successful flight of Apollo 11, views these achievements as only a beginning to the long-term exploration and use of space by man. We see a major role for this Nation in proceeding from the initial opening of this frontier to its exploitation for the benefit of mankind, and ultimately to the opening of new regions of space to access by man.

[ii] We have found increasing interest in the exploitation of our demonstrated space expertise and technology for the direct benefit of mankind in such areas as earth resources, communications, navigation, national security, science and technology, and international participation. We have concluded that the space program for the future must include increased emphasis upon space applications.

We have also found strong and wide-spread personal identification with the manned flight program, and with the outstanding men who have participated as astronauts in this program. We have concluded that a forward-looking space program for the future for this Nation should include continuation of manned space flight activity. Space will continue to provide new challenges to satisfy the innate desire of man to explore the limits of his reach.

We have surveyed the important national resource of skilled program managers, scientists, engineers, and workmen who have contributed so much to the success the space program has enjoyed. This resource together with industrial capabilities, government, and private facilities and growing expertise in space operations are the foundation upon which we can build.

We have found that this broad foundation has provided us with a wide variety of new and challenging opportunities from which to select our future directions. We have concluded that the Nation should seize these new opportunities, particularly to advance science and engineering, international relations, and enhance the prospects for peace.

We have found questions about national priorities, about the expense of manned flight operations, about new goals in space which could be interpreted as a "crash program." Principal concern in this area relates to decisions about a manned mission to Mars. We conclude that NASA has the demonstrated organizational competence and technology base, by virtue of the Apollo success and other achievements, to carry out a successful program to land man on Mars within 15 years. There are a number of precursor activities necessary before such a mission can be attempted. These activities can proceed without developments specific to a Manned Mars Mission-but for optimum benefit should be carried out with the Mars mission in mind. We conclude that a manned Mars mission should be accepted as a long-range goal for the space program. Acceptance of this goal would not give the manned Mars mission overriding priority relative to other program objectives, since options for decision on its specific date are inherent in a balanced program. Continuity of other unmanned exploration and applications efforts during periods of unusual budget constraints should be supported in all future plans.

We believe the Nation's future space program possesses potential for the following significant returns:

- new operational space applications to improve the quality of life on Earth.
- non-provocative enhancement of our national security
- scientific and technological returns from space investments of the past decade and expansion of our understanding of the universe.
- low-cost, flexible, long-lived, highly reliable, operational space systems with a high degree of commonality and reusability
- international involvement and participation on a broad basis

[iii] Therefore, we recommend -

That this Nation accept the basic goal of a balanced manned and unmanned space program conducted for the benefit of all mankind.

To achieve this goal, the United States should emphasize the following program objectives:

- increase utilization of space capabilities for services to man, through an expanded space applications program
- enhance the defense posture of the United States and thereby support the broader objective of peace and security for the world through a program which exploits space techniques for accomplishment of military missions
- increase man's knowledge of the universe by conduct of a continuing strong program of lunar and planetary exploration, astronomy, physics, the earth and life sciences
- develop new systems and technology for space operations with emphasis upon the critical factors of: (1) commonality, (2) reusability, and (3) economy, through a program directed initially toward development of a new space transportation capability and space station modules which utilize this new capability
- promote a sense of world community through a program which provides opportunity for broad international participation and cooperation

As a focus for the development of new capability, we recommend the United States accept the long-range option or goal of manned planetary exploration with a manned Mars mission before the end of this century as the first target.

[iv] In proceeding towards this goal, three phases of activities can be identified:

- initially, activity should concentrate upon the dual theme of exploitation of existing capability and development of new capability, maintaining program balance within available resources.
- second, an operational phase in which new capability and new systems would be utilized in earth-moon space with groups of men living and working in this environment for extended periods of time. Continued exploitation of science and applications would be emphasized, making greater use of man or man-attendance as a result of anticipated lowered costs for these operations.
- finally, manned exploration missions out of earth-moon space, building upon the experience of the earlier two phases.

Schedule and budgetary implications associated with these three phases are subject to Presidential choice and decision at this time with detailed program elements to be determined in a normal annual budget and program review process. Should it be decided to develop concurrently the space transportation system and the modular space station, a rise of annual expenditures to approximately $6 billion in 1976 is required. A lower level of approximately $4-5 billion could be met if the space station and the transportation system were developed in series rather than in parallel.

For the Department of Defense, the space activities should be subject to continuing review relative to the Nation's needs for national security. Such review and decision processes are well established. However, the planned expansion of the DoD space technology effort and its documented interest in the Space Transportation System demands continued authoritative coordination through the Aeronautics and Astronautics Coordinating Board to assure that the national interests are met.

[v] The Space Task Group has had the opportunity to review the national space program at a particularly significant point in its evolution. We believe that the new directions we have identified can be both exciting and rewarding for this Nation. The environment in which the space program is viewed is a vibrant, changing one and the new opportunities that tomorrow will bring cannot be predicted with certainty. Our planning for the future should recognize this rapidly

changing nature of opportunities in space.

We recommend that the National Aeronautics and Space Council be utilized as a mechanism for continuing reassessment of the character and pace of the space program.

[1] THE POST-APOLLO SPACE PROGRAM: DIRECTIONS FOR THE FUTURE

I.INTRODUCTION

With the successful flight of Apollo 11, man took his first step on a heavenly body beyond his own planet. As we look into the distant future it seems clear that this is a milestone - a beginning - and not an end to the exploration and use of space.

Success of the Apollo program has been the capstone to a series of significant accomplishments for the United States in space in a broad spectrum of manned and unmanned exploration missions and in the application of space techniques for the benefit of man. In the short span of twelve years man has suddenly opened an entirely new dimension for his activity.

In addition, the national space program has made significant contributions to our national security, has been a political instrument of international value, has produced new science and technology, and has given us not only a national pride of accomplishment, but has offered a challenge and example for other national endeavors.

The Nation now has the demonstrated capability to move on to new goals and new achievements in space in all of the areas pioneered during the decade of the sixties. In each area of space exploration what seemed impossible yesterday has become today's accomplishment. Our horizons and our competence have expanded to the point that we can consider unmanned missions to any region in our solar system; manned bases in earth orbit, lunar orbit or on the surface of the Moon; manned missions to Mars; space transportation systems that carry their payloads into orbit and then return and land as a conventional jet aircraft; reusable nuclear-powered rockets for space operations; remotely controlled roving science vehicles on the Moon or on Mars; and application of space capability to a variety of services of benefit to man here on earth.

Our opportunities are great and we have a broad spectrum of choices available to us. It remains only to chart the course and to set the pace of progress in this new dimension for man.

The Space Task Group, established under the chairmanship and direction of the Vice President (Appendices A and B), has examined the spectrum of new opportunities available in space, values and benefits from space activities, casts and resource implications of future options, and international aspects of the space program. A great wealth of data has been made available to the Task Group, including reports from the National Aeronautics and Space Administration and the Department of Defense reflecting very extensive planning and review activities, a detailed report from the President's Science Advisory Committee, views from [2] members of Congress, the National Academy of Sciences Space Science Board, and the American Institute of Aeronautics and Astronautics. In addition, a series of individual reports from a special group of distinguished citizens who were asked for their personal recommendations on the future course of the space program were of considerable value to the Task Group. This broad range of material was considered and evaluated as part of the Task Group deliberations. This report presents in summary form the views of the Space Task Group on the Nation's future directions in space.

[3] II. BACKGROUND

Twelve years ago, when the first artificial Earth satellite was placed into orbit, most of the world's population was surprised and stunned by on achievement so new and foreign to human experience. Today people of all nations are familiar with satellites, orbits, the concept of zero `g', manned operations in space, and a host of other aspects characteristic of this new age - the age of space exploration.

The United States has carried out a diversified program during these early years in space, requiring innovation in many fields of science, technology, and the human and social sciences. The Nation's effort has been interdisciplinary, drawing successfully upon a synergistic combination of human knowledge, management experience, and production know-how to bring this National to a position of leadership in space.

Space activities have become a part of our national agenda.

We now have the benefit of twelve years of space activity and our leadership position as background for our examination of future directions in space.

National Priorities

By its very nature, the exploration and exploitation of space is a costly undertaking and must compete for funds with other national or individual enterprises. Now that the national goal of manned lunar landing has been achieved, discussion of future space goals has produced increasing pressures for reexamination of, and possible changes in, our national priorities.

Many believe that funds spent for the space program contribute less to our national economic growth and social well-being than funds allocated for other programs such as health, education urban affairs, or revenue sharing. Others believe that funds spent for space exploration will ultimately return great economic and social benefits not now foreseen. These divergent views will persist and must be recognized in making decisions on future space activities.

The Space Task Group has not attempted to reconcile these differences. Neither have we attempted to classify the space program in a heirarchy of national priorities. The Space Task Group has identified major technical and scientific challenges in space in the belief that returns will accrue to the society that takes up those challenges.

Values and Benefits

The magnitude of predicted great economic and social benefits from space activities cannot be precisely determined. Nevertheless, there should be a recognition that significant direct benefits have been realized as a result of space investments, particularly from applications programs, as a long-term result of space science activities, DOD space activities, and advancing technology. These direct benefits are only part of the total set of benefits from the space program, many of which are very difficult to quantify and therefore are not often given adequate consideration when costs and benefits from space activities are weighed or assessed in relation to other national programs.

[4] Benefits accrue in each of the following areas:

- economic - directly through applications of space systems to services for man, and indirectly through potential for increased productivity resulting from advancing technology; improvements in reliability, quality control techniques, application of solid state electronics, and computer technology resulting from demands of space systems; advances in understanding and use of exotic new materials and devices with broad applicability; refinement of systems engineering and management techniques for extremely complex developments.
- national security - directly through DOD space activities, and indirectly through enhancement of the national spirit and self-esteem; reinforcement of the image of the United States as a leader in advanced technology; strengthening of our international posture through demonstration that a free and democratic society can achieve a challenging, technologically sophisticated, long-term objective; maintenance of a broad base of highly skilled aerospace workers applicable to defense needs; and advancement of technology that may have relevance to defense use.
- science - directly through support for ground and space research programs, indirectly through ability to open to observation new portions of the electromagnetic spectrum; opportunity to search for life on other planets, to make measurements in situ at the planets or in other regions of space, and to utilize the unique environment of space (high vacuum, zero 'g') for experimental programs in the life sciences, physical sciences and engineering.
- exploration - the opening of new opportunities to investigate and acquire knowledge about man's environment - which now has expanded to include not only the Earth, but potentially the entire solar system.
- social - providing educational services through enhanced communications which improved treatment of social problems.
- international relations - providing opportunities for cooperation; the identification of foreign interests with U.S. space objectives and programs, and their results.

What is the value to be placed upon these benefits, and how should the space program be constituted to provide the greatest return in each of these areas for a selected level of public investment?

The answers to these questions cannot be stated in absolute terms - there is no dollar value associated with national self-esteem or with many of the other benefits listed above, and there is no fixed program of missions without which these benefits will not accrue. As with many programs, there is, however, a lower limit of activity below which the viability of the program is threatened and a reasonable upper limit which is imposed by technological capability and rate of growth of the program.

These limits are a key consideration in the options discussed later in this report.

[5]

National Resource

In the eleven years since its creation, NASA has provided the Nation with a broad capability for a wide variety of space activity, and has successfully completed a series of challenging tasks culminating in the first manned lunar landing. These accomplishments have involved rapid increases to peak annual expenditures of almost $6 billion and a peak civil service and contractor work force of 420,000 people. Expenditures for NASA have subsequently dropped over the last three years from this peak to the present level of about $4 billion and supporting manpower has dropped to about 190,000 people.

In addition to NASA space activity, the DOD has developed and operated space systems satisfying unique military requirements. Spending for military space grew rapidly in the early sixties and has increased gradually during the past few years to approximately $2 billion per year.

The Nation's space program has fostered the growth of a valuable reservoir of highly trained, competent engineers, managers, skilled workmen and scientists within government, industry and universities. The climactic achievenment of Apollo 11 is tribute to their capability.

This resource together with supporting facilities, technology and organizational entities capable of complex management tasks grew and matured during the 1960's largely in response to the stimulation of Apollo, and if it is to be maintained, needs a new focus for its future.

Manned Space Flight

There has been universal personal identification with the astronauts and a high degree of interest in manned space activities which reached a peak both nationally and internationally with Apollo. The manned flight program permits vicarious participation by the man-in-the-street in exciting, challenging, and dangerous activity. Sustained high interest, judged in the light of current experience, however, is related to availability of new tasks and new mission activity - new challenges for man in space. The presence of man in space, in addition to its effect upon public interest in space activity, can also contribute to mission success by enabling man to exercise his unique capabilities, and thereby enhance mission reliability, flexibility, ability to react to unpredicted conditions, and potential for exploration.

While accomplishments related to man in space have prompted the greatest acclaim for our Nation's space activities, there has been increasing public reaction over the large investments required to conduct the manned flight program. Scientists have been particularly vocal about these high costs and problems encountered in performing science experiments as part of Apollo, a highly engineering oriented program in its early phases.

Much of the negative reaction to manned space flight, therefore, will diminish if costs for placing and maintaining man in space are reduced and opportunities for challenging new missions with greater emphasis upon science return are provided.

[6]

Science and Applications

Although high public interest has resided with manned space flight, the Nation has also enjoyed a successful and highly productive science and applications program.

The list of more achievements in space science is great, ranging from our first exploratory orbital flights resulting in discoveries about the Earth and its environment to the most recent Mariner missions to the vicinity of Mars producing new data about our neighbor planet.

Both optical and radio astronomy have been stimulated by the opening of new regions of the electromagnetic spectrum and new fields of interest have been uncovered - notably in the high energy X-ray and gamma-ray regions. Astronomy is advancing rapidly at present, partly with the aid of observations from space, and a deeper understanding of the nature and structure of the universe is emerging. In planetary exploration, we have a unique opportunity to pursue a number of the major questions man has asked about his relation to the universe. What is the history of the formation and evolution of the solar system? Are there clues to the origin of life? Does life exist elsewhere in the solar system?

In the life sciences, questions about the effect of zero 'g' upon living systems, demands of long-duration space flight upon our understanding of man and his interaction or response to his environment, both physiologically and psychologically, promise new insights into the understanding of complex living systems.

These are only a few of the disciplines that have profited from the program of research in space. Space science is not divorced from science on the ground, but is rather an extension of science which builds and depends vitally upon a strong ground-based foundation.

Building upon the basic science on the ground and in space, and upon the growing capability in the design, construction and launch of satellites, the United States pioneered in the development of space applications - notably communications, meteorology and navigation. Operational systems have been placed into service in each of these areas, and the potential for the future appears bright - not only in these areas but also in new fields such as earth resource surveying and oceanography.

International Aspects

Achievement of the Apollo goal resulted in a new feeling of "oneness" among men everywhere. It inspired a common sense of victory that can provide the basis for new initiatives for international cooperation.

The U.S. and the USSR have widely been portrayed as in a "race to the Moon" or as vying over leadership in space. In a sense, this has been on accurate reflection of one of the several strong motivations for U.S. space program decisions over the previous decade.

[7] Now with the successes of Apollo, of the Mariner 6 and 7 Mars flybys, of communications and meteorology applicotions, the U.S. is at the peak of its prestige and accomplishments in space. For the short term, the race with the Soviets has been won. In reaching our present posirion, one of the grear strengths of the U.S. space program has been its open nature, and the broad front of solid achievement in science and applications that has accompanied the highly successful manned flight program.

The attitude of the American people has gradually been changing and public frustration over Soviet accomplishments in space, an important force in support of the Nation's acceptance of the lunar landing in 1961, is not now present. Today, new Soviet achievements are not likely to have the effect of those in the post. Nevertheless, the Soviets have continued development of capability for future achievements and dramatic missions of high political impact are possible. There is no sign of retrenchment or withdrawal by the Soviets from the public arena of space activity despite launch vehicle and spacecraft failures and the preemptive effect of Apollo 11.

The landing on the Moon has captured the imagination of the world. It is now abundantly clear to the man in the street, as well as to the political leaders of the world, that mankind now has at his service a new technological capability, an important characteristic of which is that its applicability transcends national boundaries. If we retain the identification of the world with our space program, we have on opportunity for significant political effects on nations and peoples and on their relationships to each other, which in the long run may be quite profound.

[9] III. GOALS AND OBJECTIVES

Goals

An important aspect in both popular acceptance of the space program and in the spirit, dedication and performance of those who ore directly involved in space activity is the conviction that such activity is worthwhile and contributes to the quality of life on Earth.

Public support for the space program con be related to understanding of the values derived from space activity and to understanding and acceptance of long-term goals and objectives which establish the framework for the program.

In the National Aeronautics and Space Act of 1958, the Congress declared "...it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind." This policy statement, which served effectively as a guide to the first decade in space, must now be translated into clearly enuncioted new long-range goals and program objectives for the post-Apollo space program.

We view the challenge of setting new goals, of providing a focus for our future space activities, of expanding the limits of man's reach and thereby demonstrating America's leadership in scientific and technological undertakings while maintaining the confidence of the people in the strength and purpose of our Nation, as the key to continued space leadership by the United States.

Facing this challenge, some would urge that our efforts should be restricted to exploitation of existing capability, pointing out, quite correctly, that exciting and challenging missions remain to be accomplished which con utilize the existing base. But such a course would risk loss of the foundation for future achievements - a foundation which depends largely on providing a new capability which challenges our technology.

One of the values of the lunar landing goal was that it carried a definite time for its accomplishment, which stressed our technology and served as basis for planning and for budget support. It was a national commitment, a demonstration of the will and determination of the American people and of our technological competence at a time when these attributes were being questioned by many.

The need for an expression of our strength and determination as a Nation has changed considerably since that time. Today the need is for guidance - for direction - to set before the people a vision of where we are going.

[10] Such a vision for the future should have a number of important qualities:

- it should have substantive values that are easily characterized and understood
- it should have a long-term goal, a beacon, an aim for our activities to act as a guide to both short-term and longer range decisions
- it should be sufficiently long-range to ensure that adequate opportunity exists for solid progress in a step-by-step fashion towards that long-term goal yet sufficiently within reach that each step draws measurably closer to that goal
- it should be challenging both for man's spirit of adventure and of exploration and for man's technological capability
- it should foster the simultaneous utilization of space capabilities for the welfare, security, and enlightenment of all people.

The Space Task Group has concluded that a balanced space program that exploits the great potential for automated and remotely-controlled spacecraft and at the some time maintains a vigorous manned flight program, can provide such a vision.

This balanced program would be based upon a framework in which the United States would:

- Accept, for the long term, the challenge of exploring the solar system, using both manned and unmanned expeditions.
- Develop on integrated and efficient space capability that will make Earth-Moon space easily and economically accessible for manned and unmanned systems.
- Maintain a steady return on space investments in applications, science, and technology.

- Use our space capability not only to extend the benefits of space to the rest of the world, but also to increase direct participation by the world community in both manned and unmanned exploration and use of space.

The balanced program for the future envisioned by the Task Group would possess several important characteristics:

- flexibility. The ability to see clearly the opportunities that lie ahead in this new field is limited at best. Some opportunities will fade as we approach them while others, not even discernible at this time, will blossom to the first magnitude. This program will permit the course and time scale to be flexible, to adjust to variations in funding, to shifting national and international conditions, while preserving a guidepost for the future.
- challenge. The space program has flourished under a set of goals that has demanded the highest standards of performance, and an incentive for excellence that has become characteristic of our space efforts. A balanced program of both challenging near-term objectives and long-range goals will enhance and preserve these attributes in the future.
- [11] opportunity. The Nation has in being significant capability for space activity. Abundant opportunities exist for further exploitation of this capability. A balanced progrom will permit adequate attention to applications and science while also creating new opportunities through development of new capability.

In its deliberations, the Space Task Group considerd a number of challenging new mission goals which were judged both technically feasible and achievable within a reasonable time, including establishment of a lunar orbit or surface base, a large 50-lOO man earth-orbiting space base, and manned exploration of the planets. The Space Task Group believes that manned exploration of the planets is the most challenging and most comprehensive of the many long-range goals available to the Nation at this time, with manned exploration of Mars as the next step toward this goal. Manned planetary exploration would be a goal, not an immediate program commitment; it would constitute on understanding that within the context of a balanced space program, we will plan and move forward as a Nation towards the objective of a manned Mars landing before the end of this century. Mars is chosen because it is most earth-like, is in fairly close proximity to the Earth, and has the highest probability of supporting extraterrestrial life of all of the other planets in the solar system.

What are the implications of accepting this long-range goal or option on the character of the space program in the immediate future?

In a technical sense, the selection of manned exploration of the planets as a long-term option for the United States space program would act to focus a wide range of precursor activities and would be reflected in many decisions, large and small, where potential future applicability to long-lived manned planetary systems design will have relevance. In a broader sense such a selection would tend to reinforce and reaffirm the basic commitment to a long-term continued leadership position by the United States in space.

The Space Task Group sees acceptance of the long-term goal of manned planetary exploration as an important part of the future agenda for this Nation in space. The time for decisions an the development of equipment peculiar to manned mission to Mars will depend upon the level of support, in a budget sense, that is committed to the space program.

NASA has outlined plans that would include a manned Mars mission in 1981 with the development decision on a Mars Excursion Module in FY 1974, if the Nation were to accept this commitment. Such a program would result in maximum stimulation of our technology and creation of new capability. There are many precursor activities that will be required before a manned Mars mission is attempted, such as detailed study of biomedical aspects, both physiological and psychological, of flights lasting 500-600 days, unmanned reconnaissance of the planets, creation of highly reliable life support systems, power supplies, and propulsion capability adequate for the rigors of such a voyage and reliable enough to support man. Decision to proceed with a 1981 mission would require early attention to these precursor activities.

While launch of a manned Mars exploration mission appears achievable as early as 1981, it can also be accomplished at any one of the roughly biennial launch opportunities following this date, provided essential precursor activities have been carried out.

[12] Thus, the understanding that we are ultimately going to explore the planets with man provides a shaping function for the post-Apollo space program. However, in a balanced program containing other goals and objectives, this focus should not assume over-riding priority and cause sacrifice of other important activity in times of severe budget constraints. Flexibility in program content and options for decision on the specific date for a manned Mars mission are inherent in this understanding.

The Space Task Group, in response to the President's request for a "Coordinated program and budget proposal," has therefore chosen this balanced program as that plan best calculated to meet the Nation's needs for direction of its future space activity. In reaching this conclusion we have considered international and domestic influences, weighed and placed in perspective science and engineering development, exploration and application of space, manned and unmanned approaches to space missions, and have appraised interagency influences. Discussion of the principal objectives which describe this balanced program follows.

Program Objectives

Elements of the balanced program recommended by the Space Task Group can be identified within the following set of program objectives which define major emphases for future space activity:

- Application of space technology to the direct benefit of mankind
- Operation of military space systems to enhance national defense
- Exploration of the solar system and beyond
- Development of new capabilities for operating in space
- International participation and cooperation

1. Application of space technology to the direct benefit of mankind.

Focus: To increase utilization of space capabilities for services to man. Programs directed toward the application of the Nation's space capabilities to a wide range of services, such as air and ocean traffic control, world-wide navigation systems, environmental monitoring and prediction (weather, pollution), earth resource survey (crops, water resources, geological structures, oceanography) and communications have great potential for improving the quality of life on this planet Earth. Significant direct economic and social benefits from such applications have been forecast. Major contributions to management of domestic problems and greater opportunities for international cooperation could result from an expanded space applications program.

2. Operation of military space systems to enhance national defense

Focus: Enhance the defense posture of the United States and thereby support the broader objective of peace and security for the world.

[13] The Department of Defense is presently using space capabilities in the support of communications, weather forecasting, navigation, surveillance and mapping, and for other functions. Such space activity has been not an end in itself, but a means for accomplishing functions in support of existing forces and missions. Military uses of space have proven effective and space systems are now contenders for specific applications and missions. Each military space mission should continue to be decided on a case-by-case basis in competition with ground, sea, and airborne systems and should reflect priority given to national defense with consideration of arms limitation agreements, and other U. S. policy reactions. Exploitation of the unique characteristics of space systems by the Department of Defense can provide increased confidence in the ability of this Nation to defend itself from any aggressor and assurance that space will be used for peaceful purposes by all nations.

3. Exploration of the solar system and beyond.

Focus: Increase man's knowledge of the universe.

Exploration of the solar system and observations beyond the solar system should be important continuing broad objectives of the Nation's space program. Many unanswered scientific questions remain about the planets, the interplanetary medium, the sun - both as a type of star and as a source of the earth's energy - and about a variety of celestial objects, such as pulsars, quasars, X-ray and gamma ray sources. Both ground-and space-based experiments and observational programs will contribute to the quest for answers to these questions. Space platforms provide several unique advantages - such as ability to observe across the range of wave lengths of the electromagnetic spectrum (rather than only through specific atmospheric "windows," which is the case from the ground); freedom from local environmental conditions; potential for continuous observations (no day-night cycle); ability to approach, orbit and land on extraterrestrial bodies - and also disadvantages - high cost, inaccessibility for easy repair and servicing, and long lead times for experiment modification. For these reasons a careful balance between investments in space and ground experiments should be maintained.

The major elements of such a program should be:

Planetary Exploration - Unmanned planetary exploration missions continuing throughout the decade, both for science returns and, in the case of Mars and Venus, as precursors to later manned missions. The program should include progressively more sophisticated missions to the near planets as well as multiple-planet flyby missions to the outer planets taking advantage of the favorable relative positions of the outer planets in the late 1970's. Early missions to the asteroid belt and to the vicinity of a comet should be planned.

Astronomy, Physics, the Earth and Life Sciences - In each of these disciplines, extension of existing or planned unmanned programs promises continued high science return. There are additional significant opportunities for experiments in connection with manned Earth orbital programs which should be exploited. Work in astronomy, physics and the life sciences, as well as work in the earth sciences and remote sensing, will form an essential part of the foundation for future applications benefits and will contribute to the broadening horizons of man as he acquires knowledge not only of his own planet but also about the rest of the universe.

[14] Lunar Exploration - Apollo-type manned missions to continue exploration of the Moon should proceed. The launch rate should permit maximum responsiveness to new discoveries while maintaining mission safety and efficient utilization of support personnel. Early upgrading of lunar exploration capability beyond the basic Apollo level including enhanced mobility capability, and lunar rovers, is important to safe and efficient realization of significant returns over the longer term. An orbiting lunar station, followed by a surface-base, building upon Earth orbital space station and space transportation system developments, could be deployed as early as the latter half of the decade. Extension of manned lunar activity beyond upgraded Apollo capability should include consideration of these options.

4. Development of new capabilities for operating in space.

Focus: Develop new systems for space operations with emphasis upon the critical factors of: commonality, (2) reusability, and (3) economy.

Exploration and exploitation of space is costly with our current generation of expendable launch vehicles and spacecraft systems. This is particularly true for the manned flight program. Recovery and launch costs will become on even more significant factor when multiple re-visit and resupply missions to on Earth orbiting space station are contemplated. Future developments should emphasize:

Commonality - the use of a few major systems for a wide variety of missions.

Reusability - the use of the same system over a long period for a number of missions.

Economy - far example, the reduction in the number of "throw away" elements in any mission; the reduction in the number of new developments required; the development of new program principles that capitalize on such capabilities as man-tending of space facilities; and the commitment to simplification of space hardware.

An integrated set of major new elements which satisfy these criteria are:

a. A space station module that would be the basic element of future manned activities in Earth orbit, of continued manned exploration of the Moon, and of manned expeditions to the planets. The space station will be a permanent structure, operating continuously to support 6-12 occupants who could be replaced at regular intervals. Initially, the space station would be in a low altitude, inclined orbit; later stations would be established in polar and synchronous orbits. The same space station module would also provide a permanent manned station in lunar orbit from which expeditions could be sent to the surface.

By joining together space station modules, a space base could be created. Occupied by 50-100 men, this base would be a laboratory in space where a broad range of physical and biological experiments would be performed.

Finally, the space station module would be the prototype of a mission module for manned expeditions to the planets.

[15] Such an array of space station modules would be designed to utilize the space transportation system described below.

b. A space transportation system that will:

Provide a major improvement over the present way of doing business in terms of cost and operational capability.

Carry passengers, supplies, rocket fuel, other spacecraft, equipment, or additional rocket stages to and from orbit on a routine aircraft-like basis.

Be directed toward supporting a spectrum of both DoD and NASA missions.

Although the concept of such a space transportation capability is not new, advances in rocket engine technology, additional experience in design for reentry conditions, and improved guidance, navigation and automated check-out systems now permit initiation of on experimental effort for a Space Transportation System with technical, operational, and economic characteristics satisfying the needs of both NASA and DoD. An orderly, phased, step-by-step development program could then be implemented including as potential components:

A reusable chemically fueled shuttle operating between the surface of the Earth and low-earth orbit in an airline-type mode.

A chemically fueled reusable space tug or vehicle for moving men and equipment to different earth orbits. This some tug could also be used as a transfer vehicle between the lunar-orbit base and the lunar surface.

A reusable nuclear stage far transporting men, spacecraft and supplies between Earth orbit and lunar orbit and between low Earth orbit and geosynchronous orbit and for other deep space activities. The NERVA nuclear engine development program, presently underway and included in all of the options discussed later, provides the basis for this stage and represents a major advance in propulsion capability.

c. Advanced Technology Development - In addition to the major vehicle developments listed above, a continuing program of investigation and exploration of new technology that can serve as the foundation for next generation systems is on essential component of the DoD, NASA, and other agency programs. A broad and aggressive program to advance our capabilities to operate in space during the next decade and to set the stage for the decade to follow is needed.

We foresee future requirements for larger and more efficient power supplies utilizing a range of energy sources, particularly nuclear systems, for continuing propulsion system improvements - both in performance and reliability, for improved understanding of the complex interface between man and machine, for advances in technology and systems design that result in lower cost development of new spacecraft, and for achievement of new levels of reliability. In the advanced technology program, we should emphasize biomedical research, space power and propulsion technology, both nuclear and non-nuclear, remotely control led teleoperators, data management, multi-spectral sensors, communication and navigation technology, and experimental evaluation and demonstration of new concepts.

[5] 5. International participation and cooperation.

Focus: To promote a sense of world community; to optimize international scientific, technical, and economic participation; to apply space technology to mankind's needs; and to shore the benefit and cost of space research and exploration.

To these ends, our international interests will be served best by (1) projects which afford maximum opportunities for direct foreign participation, (2) projects which yield economic and social benefits for other countries as well as ourselves, and (3) activities in which further international agreement and coordination might usefully be employed.

The post decade has demonstrated that programs like Project Apollo are virtually unrivaled in their capacity to catch the world's imagination and interest, win extensive admiration and respect for American achievements, and generate a common human experience. The decade has demonstrated also that effective ways can be found to share the practical benefits of space with people everywhere, as in space meteorology and communications. Modest but significant levels of direct participation in space flight research and exploration have also been successfully achieved through cooperative projects. Future program plans must seek to continue and substantially extend this experience.

We should also devote special effort to meliorate, between the space powers and others, the increasing gap in technological capability and the gap in awareness and understanding of new opportunities and responsibilities evolving in the space age.

If international participation and cooperation are to be expanded in an important way, there will have to be (1) a substantial raising of sights, interest and investment in space activity by the other nations able to do so in order to establish a base for major contributions by them; and (2) creation of attractive international institutional arrangements to take full advantage of new technologies and new applications for peoples in developing as well as advanced countries.

The most dramatic form of foreign participation in our program will be the inclusion of foreign astronauts. This should be approached in the context of substantive foreign contributions to the programs involved.

The form of cooperation most sought after by advanced countries will be technical assistance to enable them to develop their own capabilities. We should move toward a liberalization of our policies affecting cooperation in space activities, should stand ready to provide launch services and share technology wherever possible, and should make arrangements to involve foreign experts in the detailed definition of future United States space programs and in the conceptual and design studies required to achieve them. We should consider three further steps:

The establishment of an international arrangement through which countries may be assured of launch services without being solely and directly dependent upon the United States.

A division of labor between ourselves and other advanced countries or regional space organizations permitting assumptions of primary or joint responsibility for certain scientific or applications tasks in space.

International sponsorship and support for planetary exploration such as that which was associated with the International Geophysical Year.

[17] The developing countries will be most attracted to (l) applications of space technology which serve their economic and social needs, and (2) the development of international institutional arrangements in which they can participate along with the advanced countries. Some examples are:

- Environmental studies and earth resource surveying via satellites;
- Direct broadcast via satellites of TV instructional and educational programs;
- Expanding arrangements to acquire and use meteorological data;
- Training opportunities in space applications and space-related disciplines.

To the extent that future practical space applications are achieved, there should be no significant technical obstacles to ensuring the sharing of benefits on a global basis. There will, however, be economic and political issues which require recognition and effective anticipation.

In the case of the USSR, experience over the past ten years makes clear that the central problem in developing space cooperation is political rather than technical or economic. Numerous specific technical opportunities for cooperation with the Soviet Union have been identified and are available. Indeed, many of them have been put to the Soviet Union in various forms through the years with little success. For example, we could formulate a series of graduated steps leading toward major cooperation. They would range from full and frank exchange of detailed space project results, at the lowest level, to prearranged complementary activities at the next level (e.g., mutual support of tracking requirements, coordinated satellite missions for specific tasks in space), and ultimately to fully integrated prejects in which sub-systems could be provided by each side to carry out a total space mission of agreed character. The following possibilities merit serious consideration:

In space research -- earth orbital investigation of atmospheric dynamics and Earth's magnetic field; astronomical observations from earth satellites or lunar stations; satellite observation of solar phenomena, and lunar and planetary exploration.

In practical applications -- coordination of a continuing network of satellites to provide data for world-wide weather prediction and early warning of natural disasters; the development of capabilities for earth resource surveying via satellites.

In manned flight -- bio-medical research, space rescue, coordination of experiments and flight parameters for Earth orbiting space stations, lunar exploration, and exchange of astronauts.

In tracking -- to supplement each other's networks.

In view of the heavy commitment of the Soviets, planetary exploration appears to offer unusual opportunities for complementary activities.

[19] IV. PROGRAM AND BUDGET OPTIONS

The Space Task Group was asked to provide "definitive recommendation on the direction the U. S. space program should take in the post-Apollo period," through preparation of a "coordinated program and budget proposal." In the Section "Goals and Objectives," the Space Task Group has outlined the elements of this coordinated program.

We have also pointed out that there are upper and lower bounds to the Funding which will support a viable, productive and well disciplined program. Between these bounds there are many options both in program content and in total funding required. In this section we will explore the range of these options and their resource implications.

Clearly, there are a number of factors outside the space program and the intrinsic merit of it; goals and objectives that must be considered in determining the allocation of resources to the program. Demands of other domestic programs, international conditions, and state of economic health of our Nation are only a few of the major influences upon the specific budget for space in a given fiscal year.

Despite the highly variable nature of these influences, which produces a corresponding increasing uncertainty in projections of resource availability, it is important far planning purposes to look into the future and forecast the general nature of funding required to support decisions on content and pace of the program. Two basic questions arise. Is the Nation to exploit its existing capabilities, to expand those capabilities or reduce its participation in space activity? Is funding for space generally to remain at present levels, to increase dramatically or to decrease significantly below present levels?

We stand at a crossroads, with many sets of missions and new developments open to us and with three main avenues for funding to pursue these opportunities.

To assist in answering these questions and to provide a basis for Task Group analyses, NASA and DOD were each requested to prepare a set of alternative proposals or options that would cover a range of future resource levels and be consistent with the goals and objectives recommended by the Task Group.

NASA Options

The range of resource levels considered by the Task Group for NASA is shown in Figure 1.

(Graphic--see hard copy)

[20] These include: (l) an upper bound, defined by a a program conducted at a maximum pace - limited, not by funds, but by technology; (2) options I, Il, and III which illustrate programs consistent with the Task Group recommendations, but conducted under varying degrees of funding restraints; and (3) a low level program constructed with an increased unmanned science and applications effort consistent with the Task Group recommendations but, because of the significantly lower budget levels, without a manned flight program after completion of Apollo and Apollo Applications.

A comparison of the timing of major mission accomplishments under the various programs is indicated in Table 1

(Graphic--see hard copy)

Although the program represented by the upper bound appears technically achievable, would provide maximum stimulation to our over-all capabilities, and is fully consistent with the Task Group recommendations, it represents on initial rate of growth of resources which cannot be realized because such budgetary requirements would substantially exceed predicted funding capabilities. This has therefore been rejected by the Space Task Group, and is presented only to demonstrate the upper bound of technological achievement.

We have therefore developed a set of options which falls within these limits to illustrate programs conducted at budget levels which appear possible during the next decade.

Option I is illustrative of a decision to increase funding dramatically and results in early accomplishment of the major manned and unmanned mission opportunities, including launch of a manned mission to Mars in the mid-1980's, establishment of an orbiting lunar station, a 50 man earth-orbit space base and a lunar surface base. Funding would rise from the present $4 billion level to $8-10 billion in 1980. Decision to proceed with development of the space station, earth-to-orbit shuttle and the space tug would be required in FY 1971. Firm decisions [21] on other major systems or missions would not be needed until later years; for example, a decision to develop the Mars excursion module for an initial manned Mars expedition would not be required before FY 1974.

Options II and Ill illustrate a decision to maintain funding initially at recent levels and then gradually increasing. These options are identical with the exception that Option Il includes a later decision to launch a manned planetary mission in 1986 and in Option III this decision is deferred. Both options demonstrate the effect of simultaneous development of the Space Transportation System and earth orbital space station module, each of which is expected to require peak expenditure rates of the order of $1 billion per year, and both options include a substantial increase in unmanned science and applications from present levels but less than that in Option I. Maintaining the unmanned program at the Option I levels would require several hundred million dollars in additional funding. Decision to develop both space station and earth-to-orbit shuttle would be in about FY 1972, resulting in initial availability of these systems in 1977. Similarly, other major milestones would occur later, with decision on tne Mars Excursion Module estimated for FY 1978. Funding for both options would remain approximately level at $4 billion for the next two fiscal years and then would rise to a peak of $5.7 billion in 1976 - this increase reflecting simultaneous peak resource requirements of space station and space shuttle developments. If these developments were conducted in series, lower funding levels ($4-5 billion) could be achieved. Option II would have a later peak of nearly $8 billion in the early 1980's resulting from the manned Mars landing program. . . .

[23] The lower bound chosen by the Space Task Group illustrates a program conducted at significantly reduced funding levels. It is our judgment that, in order to achieve these significantly reduced NASA budgets, it would be necessary to reduce manned space flight operations below a viable minimum level. Therefore, this program has been constructed assuming a hiatus in manned flight following completion of Apollo applications and follow-on Apollo lunar missions. It thus sacrifices, for the period of such reduced budgets, program objectives relating to development of new capability, and the contribution of continuing manned space flight to several of the other program objectives recommended by the Task Group. It does, however, include a vigorous and expanded unmanned program of solar system exploration, astronomy, space applications for the benefit of man and potential for international cooperation. Funding for such a program would reduce gradually to a sustaining level of $2-3 billion depending upon the depth of change assumed for the supporting NASA facilities and manpower base.

The Space Task Group is convinced that a decision to phase out manned space flight operations, although painful, is the only way to achieve significant reductions in NASA budgets over the long term. At any level of mission activity, a continuing program of manned space flight, following use of launch vehicles and spacecraft purchased as part of Apollo, would require continued production of hardware, continued operation of extensive test, launch support and mission control facilities, and the maintenance of highly skilled teams of engineers, technicians, managers, and support personnel. Stretch-out of mission or production schedules, which can initially reduce total annual costs, would result in higher unit costs. More importantly, very low-level operations are highly wasteful of the skilled manpower required to carry out these operations and would risk deterioration of safety and reliability throughout the manned program. At some low level of activity, the viability at the program is in question. It is our belief that the interests of this Nation would not be served by a manned space flight program conducted at such levels.

DOD Options

A similar set of DOD Options, A through C, was constructed to illustrate three basically different levels of military space activity.

Three options are presented, not only to provide funding and program options, but also to characterize the band of choices within which a rational program of military space activities will evolve. Options A and C are considered to be the upper and lower boundaries of probable military space activity, with Option B being an example of an intermediate level.

Option A presumes a future in which the threat to national security could evolve in an increasingly hostile manner, thereby leading to increased priorities for national defense and military space activities. This option also provides for contingency efforts designed to accommodate a high degree of uncertainty in future international conditions. Cost effectiveness, technology availability, growth rate of resource application, and national policy constraints were considered in establishing this upper option for a full military space capability.

[24] Option B includes those efforts necessary to counter the known and generally accepted projections of the threat. In addition, it provides limited developmental activities toward those capabilities needed if the threat increases. Option B is a prototype program which recognizes the need to minimize cost increases over the next few years, but reflects the expectation that military space activity will increase to provide the necessary support to our military forces and posture. This option is consistent with national and DOD policies and with Force Structure planning.

Option C is directly responsive to current national economic constraints, and assumes that a lessening of world tensions will result in reduced emphasis on national defense. It, therefore, includes a lower level of system deployment than the other two options. It still includes, however, the technology and support effort necessary for contingency planning, together with those programs now considered to be reasonable and predictable requirements. Option C is the lower boundary of military space activity that will meet existing national defense needs, although implied in this option is a higher degree of risk than that inherent in Options A and B. . . .

Program Flexibility

In the options submitted by NASA and DOD, resource requirements have been projected which represent a large number of decisions to be made in sequence over a number of years. Thus, the resource projections represent the upper envelope or sum of funds required to support these decisions. Many of these decisions are relatively independent - that is, an earth orbit space station module can be developed independently, without commitment to placing such a station in orbit around the moon, or sending such a module on a mission to Mars. In both of these examples, however, development of the space station module would [25] be the normal first step in achieving the lunar orbit station or Mars mission capability. An example of the set of major program elements and hence decision points inherent in the options described, based upon NASA Option II, is included as Figure 6. A diversity of specific programs with varying emphasis can be constructed by delaying or shifting initiation of funding for these major elements relative to other new developments.

There is, therefore, a great amount of flexibility inherent in each of these options and adjustments to funding constraints may be made on a yearly basis as part of the normal budget process. Of course, once initiated, a specific major system development profits from continuity in funding - stretchout or major fluctuations in funding for a particular project generally increase the total costs associated with it.

The levels of activity for the NASA and the DOD programs are essentially independent, that is, selection of Options I or II for NASA could be consistent with an Option A, B, or C level of activity for DOD, since the DOD space activity will continue to be responsive to national defense needs and will be determined on a case-by-case basis under the budget and program established annually for the Defense Department. It is important, however, that continued coordination of the NASA and DOD programs and the effect of each agency's activity on a common industrial and facility base receive authoritative attention.

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Encyclopedia Astronautica

Spiral 50-50

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topic index

space wire

Updated: Jan 29, 2003
Mars rover shows near-total panoramic view of its surroundings

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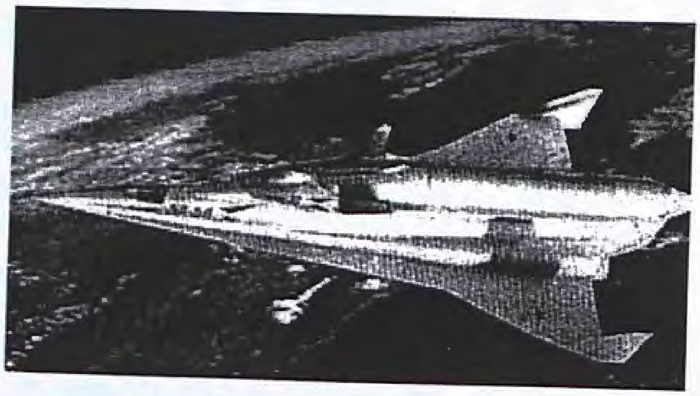

Spiral 50-50
Credit: © Mark Wade

Winged orbital launch vehicle. *Year*: 1965. Family: Winged. *Country*: Russia. *Status*: Developed 1965-1975. *Other Designations*: EPOS. *Manufacturer*: MiG.

Mikoyan GKAT OKB-155 began work in 1960 on the Spiral combination aerospace system. In 1965 the advanced project was approved, laying out an ambitious work plan leading to operation of a regular earth-orbit-earth reusable transportation system by the mid-1970's. Go-ahead to actually proceed with development of the manned orbital vehicle was given on 26 June 1966 and Lozino-Lozinsky was selected as project manager.

The Spiral system consisted of three main components:

- GSR reusable hypersonic air-breathing launch aircraft
- RB expendable two stage rocket
- OS orbital spaceplane

The project plan for Spiral was as follows:

- 1967 - Subsonic test flight of OS (article 105-11)
- 1968 - Hypersonic test flight of OS (article 105-12)
- 1970 - Unpiloted orbital flight of OS (Soyuz-launched - article 105-13)
- 1970 - Construction of GSR to begin
- 1972 - First rollout of LH2-propelled experimental GSR
- 1977 - First piloted orbital flight of complete system

Interest in the project at higher levels of the Soviet hierarchy was difficult to maintain, due to the massive funding requirements, technical difficulties, and multi-year development program which could not promise quick results. Underfunded from the beginning, the project was finally reoriented to a simple test of the analogue systems without using these as the basis for a flight system. This was now designated EPOS

Spiral 50-50 Chronology

1965 Jan 1 - Spiral development at MiG bureau authorised. Decree 'On plan of work on Spiral at OKB-155' was issued.

1965 July - Spiral cosmonaut team formed

In 1965 the advanced project of the Mikoyan Spiral aerospace system was approved. The ambitious work plan indicted operation of a regular earth-orbit-earth reusable transportation system by the mid-1970's. With Gherman Titov as its head, a Spiral cosmonaut training group was formed (Titov, Dobrovolskiy, Filipchenko, Kuklin, Matinchenko) to train to fly the spaceplane.

1965 Sep 2 - Spiral cosmonaut team changes The was team now consisted of Titov, Beregovoy, Filipchenko, Kuklin, and Shatalov.

1966 Jun 26 - Development of Spiral spaceplane authorised Lozino-Lozinsky was selected as project manager. The Spiral system consisted of three main components: the GSR reusable hypersonic air-breathing launch aircraft; RB expendable two stage rocket; and the OS orbital spaceplane.

1967 December - New Spiral cosmonaut team A new cosmonaut training group for the Spiral spaceplane was established: Titov, Kizim, Kozelskiy, Lyakhov, Malyshev, Petrushenko.

1976 Oct 11 - MiG 105-11 first flight The EPOS spaceplane made its first flight, taking off from an old dirt airstrip near Moscow, flying straight ahead to an altitude of 560 m, and landing at the Zhukovskii flight test center 19 km away. Pilot was A. G. Festovets.

1977 Nov 27 - MiG 105-11 first air-drop The first air-drop launch from a Tu-95K (used previously for Kh-20 air to surface missile tests) was made from an altitude of 5,000 m, with landing on skids on a beaten earth air strip.

1978 September - MiG 105-11 final flight

The eighth and final flight resulted in a hard landing and the write-off of the aircraft. First and last flights were made by test pilot A. G. Festovets. The eight flights were considered sufficient to characterize the spaceplane's subsonic aerodynamic characteristics and air breathing systems.

Bibliography:

- Matthews, Henry, *The Secret Story of the Soviet Space Shuttle*, X-Planes Book 1, Beirut, Lebanon, 1994.
- Pesavento, Peter, *Spaceflight*, "Russian Space Shuttle Projects 1957-1994", 1995, Volume 37, page 226.
- Belyakov, R A and Marmain, J, *MiG-Fifty Years of Secret Aircraft Design*, Airlife, England, 1994.
- Butowski, Piotr, *Air Forces Monthly Special, X-Planes*, "Black Reds", February 1998, p. 35.
- Lozinskiy, *Need title - Air space vehicles*,

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Chapter 5

U.S. CIVILIAN SPACE PROGRAM

Contents

LIST OF TABLES

LIST OF FIGURES

Chapter 5

U.S. CIVILIAN SPACE PROGRAM

OUR DEPENDENCE ON SPACE

The extent to which the modern world in general and the United States in particular have become dependent on space technology is not generally appreciated. If the United States were to cease using space systems, day-to-day life and business activities throughout society would be disrupted. National security would be jeopardized as well. This section outlines the effects of doing without space, first in the civilian sector, then in the military sector. Tables 3 and 4 list the major U.S. space systems.

In the civilian sector, long-distance ***communications*** would be perhaps hardest hit. Already over two-thirds of all overseas telephone traffic is carried over satellite links provided by the international Telecommunications Satellite Organization (INTELSAT) system. Not only would private citizens be unable to complete many of their calls, but the rates for those calls completed would have to rise in order to provide enough capital to lay additional transatlantic cable to replace the capacity lost from satellite circuits.

News reporting all over the world would be severely restricted and delayed. Global television reporting would be out of the question, so that news from the international wire services would be restricted to stories and photographs that could be taped or transmitted as they were before the space age, through uncertain and congested ground links or via private courier. Newspaper editors in the United States would be left in the same quandary as their television counterparts, especially in receiving news from remoter regions such as the Middle East, South Africa, and Southeast Asia.

Domestic television service of the major networks would be severely curtailed, not only to relatively remote locations such as Alaska and Hawaii, but even within the continental United States, About two-thirds of all cable television service would be shut down, for much of both the basic-service national programing as well as premium pay-television programing is transmitted to cable television systems across the Nation via

Table 3.—U.S. Government Civilian Satellite Systems

Program	Orbit	Purpose
GOES *(2)*	Geosynchronous	**Meteorological**
NOAA (3)	Geosynchronous	**Meteorological**
TDRSS (first launch early 1983)	Geosynchronous	**Communications relay from other satellites to ground**
HEAO (High Energy Astronomy Observatory)	LEO	**Scientific**
NIMBUS	Polar	**Meteorological**
TIROS	Polar	**Meteorological**
Landsat-3	Polar	**Earth observation**
Landsat-D (mid 1982)	Polar	
DE (2)	(1) Elliptical	**Electromagnetic field observation,** space science
(Dynamics Explorer)	(1) LEO	Scientific
SBS (3)	Geosynchronous	Communication data, voice, video
RCA (4)	Geosynchronous	Communication data, voice, video
Comstar (4)	Geosynchronous	Communication (COMSAT) data, voice, video
Westar (3)	Geosynchronous	Communication (Western Union) data, voice, video
AT&T (2)	Geosynchronous	Communication data, voice, video
Marisat (3)	Geosynchronous	Marine Communication (COMSAT) data & voice

SOURCE: Office of Technology Assessment.

The Seventies

Readings
1. Chap. 1, "Spaceflight and the Myth of Presidential Leadership."
2. Chap. 4 and 5, " Beyond Horizons."
3. Chap. 1 and 2, Wheelon.

Strategic Themes:

1. Retrenchment for NASA – NASA and the country out of sync.
2. A truck to nowhere – the seeds of the Challenger disaster
3. The growth of big science – Viking, Hubble and beyond
4. The seeds of use of space in war
5. The ABM treaty and the MIRV debacle
6. Détente verses competition with the Soviets
7. Growth in international and commercial space.

When President Nixon took office in 1969, NASA funding was already going down. The first Moon landing occurred in July 1969. The race was won! It was like the dog that caught the truck. What would it do now? To some extent NASA was caught in a time warp. NASA felt that after the first lunar landing it should get whatever funding it needed. In September 1969, a Space Task Group chaired by Vice President Agnew reported three possible long-range space programs for NASA. The first was a manned mission to Mars by mid-eighties, an orbiting lunar station and a fifty man Earth orbiting station served by a reusable shuttle. Funding for this option was $8 to $10 billion/yr. (Recall that at its peak NASA had received 5 billion/yr.). The second plan postponed Mars until 1986 and limited funding to $8 billion/yr. The third plan chose only the space station and shuttle, with annual spending between $4 billion-5.7 billion/yr. However relative to the long gone days of the early sixties, the mood of the country and of the President had changed. Nixon came from the Eisenhower mentality that saw the big manned effort as stunts. He was also much more interested in promoting cooperation rather than competition with the Soviets and the Chinese. Further he strongly believed in frugality in government spending. All these combined to make him cast a skeptical eye on the NASA requests. The country also had changed. In 1969, we had reached the Moon. The national mood was to turn to other issues especially in light of riots in cities, the war in Vietnam, etc. Flights to the Moon seemed boring. For NASA it was a boom or bust cycle. As a measure of this, the Congress reorganized the standing space committees out of existence and Nixon abolished the PSAC. Space became a secondary issue for the political establishment. Thus the last two Apollo flights were cancelled, the Apollo Application Program was reduced to one SKYLAB and in a blow to the Air Force the MOL was cancelled. President Nixon refused to support any of the options that NASA wanted. There was no congressional support for any big new initiative so NASA started to wither. It was only the 1972 election that saved something for NASA. The declining population in the aerospace industry in the big states of California, Texas and Florida forced the President to approve something for NASA. He chose half of half of option 3. The choice was for a Space Transportation System (STS), a space truck but the place it was to go to was cancelled. Thus a space truck to nowhere. It was even worse than that.

NASA had suggested a completely reusable design based around liquid rocket engines. The idea was to stop throwing away expensive hardware. Nixon would only give them half the money requested. Thus they did away with the completely reusable design and even worse with the liquid rocket engines. In a compromise to fit within a fixed $3.2 billion NASA budget, they chose a non-reusable main tank and worst of all, to make up the thrust they chose solid rocket motors. As an aside, Von Braun had said that no human should ever ride on solid rockets. They were just too dangerous. One in twenty-five blew up due to defects. They could not be stopped once lighted and thus had the potential for a major loss of life. However, to reduce development costs, NASA chose to go with solid rockets. In another first, they chose to go with Morton Thiokol, from the home state of the NASA administrator. Morton Thiokol was in Utah, which is where it manufactured the solid rocket segments. However a completed solid rocket would be too big to transport by road to a port to get it over to Cape Canaveral. Thus it had to be built in segments and integrated at Cape Canaveral. Thus the seeds were sown for the Challenger disaster of a decade or so away. As a continuation of the sixties mindset of higher, faster and farther, NASA chose to develop shuttle main engines which had the highest thrust to weight of any ever built. They would be wonders of technology. It was argued that each engine would be reusable for 100 flights and that the shuttle would fly 100 times a year. In the operational phase the cost for launch was supposed to be only $10 million a flight. Since its payload was 40000 lbs. To LEO it would give cost of $250/lb to LEO.

However even then some issues were seen. Since the STS could only go to LEO (~250km) it would have to carry an upper stage for it to be useful for any other obit. NASA thus sold itself to other organizations to get the support it needed. The Shuttle payload bay was sized for various military missions as well as the payload carrying capacity to LEO. It persuaded the Air Force to develop a solid propellant upper stage (IUS) to put 500 lbs. into LEO. It persuaded McDonnell Douglas to build two upper stages in return for a monopoly position. These were the PAM-D and PAM-A upper stages. It also started a cryogenic upper stage based on Centaur technology. NASA was in the desperate position (as it saw it) of having to do a big project to keep itself going and it was selling itself to get approval for the big project. The cost projections which finally sold the administration were based on a large number of flights a year which was based on a market which did not yet exist- (even today ~50 flights /yr worldwide). Thus there was a classic chicken and egg problem. In retrospect the fundamental problem was forcing a pioneering technical program to be justified in economic terms. In this sense there was a huge disconnect between NASA and the administration. Note that Apollo was never justified on economic terms.

The facts are that NASA has never managed more than eight STS flights a year, the SME needed to be replaced every flight and the cost estimates per launch range from $80 million to $500 million. There are three ways to estimate cost. The first is to take the total amount spent so far on STS and divide by the number of flights. This gives about $500 million/yr. The second is to take the annual amount in the NASA budget and divide by the annual flight rate. This gives about $250 million/yr. The last is to ask how much is saved when an STS flight is cancelled. This is about $80 million/yr. This last figure is telling since what are saved are only the consumables. Most of the cost is in the standing army necessary to operate and maintain the shuttle. This cost and the low reliability of the shuttle were not appreciated in the initial estimates. There was also some specious thinking at NASA about markets and either wishful thinking or an underappreciation of the difficulty of developing a new engine. The new engine contributed to the delays of the first STS launch until 1981 and have contributed greatly to the poor reliability of the STS. A truck it is not, it is much more like a finely tuned racecar.

President Nixon never saw space as a race or as a competition with the Soviets. In his mind, space and defense were much more clearly linked going back to the Eisenhower policy. Unhappily, the NASA administration under him, Tom Paine never seemed to appreciate where the President's position came from. Paine felt that Agnew was important in the administration and paid much attention to him rather than building a constituency in the OMB. This is a mistake that Webb would not have made. Paine kept trying to persuade the President of the value of doing things like a space station before the Soviets built there own. He never appreciated that the President actually wanted détente not competition with the Soviets. Paine left in 1970 and was replaced by Fletcher. Fletcher however seemed to have completely bought the NASA position of needing to do the next big thing and he made the critical decision on STS.

The Nixon emphasis and choices led to the first Apollo-Soyuz mission in 1975 as well as the Skylab (the first space station). Unhappily, the SME caused delays in STS meant that Skylab literally crashed to the ground in Australia while the STS was unable to get up and save it. The Apollo-Soyuz mission was pursued at Nixon's insistence (although after he left). It was almost an after thought in the space program and given the worsening relations with the Soviets that occurred by 1979 ultimately did not lead far. In any case, it's real objective was foreign policy not space policy.

Since Nixon thought of space as defense first, an especially important agenda item for him was the ABM program. The ABM treaty in 1972 had important implications for space policy. The ABM treaty restricted both sides to limited ABM systems, one deployed around the national capital and one at an ICBM site (Grand Forks). It formally recognized the role of satellite reconnaissance and agreed that verification could be carried out by national technical means consistent with international law. It thus made credible the policy of mutual assured destruction (MAD). It had another provision that later proved contentious for SDI and today. It restricted each party not to develop, test or deploy ABM systems or components that are sea-based, air-based, space-based or mobile land based. The space-based piece is the one that has proven difficult as technology has marched on.

The ABM treaty had the effect of making the whole system of reconnaissance, warning and communication satellites even more important. They were necessary to verify Soviet compliance and warn of any possible attack.

Something else that happened in the seventies that had a profound effect on future thinking on space policy was the development of MIRV technology for ICBM's. The US developed the technology for MIRV's first and in an example of where technology overtook policy, decided to MIRV its missiles and put multiple warheads on each missile. This was seen as destabilizing by the Soviets who rushed to develop their own MIRV capability. This capability on both sides led to a racketing up of the arms race and a destabilizing tension. Long detailed treaty negotiations then resulted which eventually succeeded in de MIRVing strategic missiles. Thus Pandora's box was barely closed. The implications for future space policy flow from the lessons learned from this. The doves on space weaponization quote this widely as an example of technology run amok. Where the opening of a technological door forced us down a path that in retrospect we wished we had not traveled down and from which we barely escaped. Thus it is feared the same thing will happen with space weapons.

The late sixties and early seventies also saw the seeds of what was to come in the first use of satellite systems in war. In the Vietnam War, there was extensive us of the directly downlinked weather data from DMSP and use of communication satellites. The DMSP data was to help target planners for figure out when to schedule raids on North Vietnam. The early DCCS satellites and COMSAT provided real time communications between Saigon and Washington. This enabled high-resolution imagery to be interpreted in Washington and sent back to Saigon. Whether this was a boon or a blessing is questionable because it later led to Washington based control of intelligence which was a handicap in the Gulf War. It also enabled command and control from DC of operations in Vietnam.

What also happened in the early seventies was the design of the GPS was laid down. It was conceived as a system to provide navigation data for long range bombers on the way to attack the Soviet Union. As a testament to the times, it had a large secondary payload of a nuclear detection monitor. Since it was only for long-range guidance it had a weak signal. It also had a civilian signal as an after thought. It was never intended for use in hostile regions, for precision use or for primarily civilian use.

The seventies were a period when several big science programs were started or came to fruition. Viking landed on Mars in 1976 and failed to find life. It cost almost $4 billion in today's money and represented another of the higher, faster, farther thinking. The Hubble Space Telescope and Galileo were started in this era. Each of these was a billion-dollar class program intended to do big science in a big way. While very successful the long time they took to come to fruition was instrumental in the calcification of NASA. No longer was it a big agency doing big things quickly; it became a small agency doing big things slowly. In a sense its heyday had passed and it was left mainly with past glories. NASA spending was down to 36% of its peak.

Under Presidents Ford and Carter, the space program continued at a steady but low pace. The urgency was gone and other issues e.g. energy now occupied the national agenda. This period has been called the NASA snooze. In the meantime, a space program was growing in Europe that would ultimately have significant consequences for American launch dominance.

As a matter of policy, the US was eager to share in scientific endeavors with the Europeans but refused to provide launch vehicle data unless the French agreed not to use any in military projects or do anything to undercut INTELSAT. To add insult to injury, the US sold the Thor-Delta technology to the Japanese when they had refused to do so for the French. Thus in 1972 a new European Space Agency was formed from the remains of the national programs. ESA developed an independent launch capability the Ariane that in 1979 succeeded in putting a European satellite in orbit from Korou. The French then formed a quasiprivate company to market the services of Ariane and the US launch share steadily eroded and after Challenger was lost for good.

In the meantime the Soviets turned their attention to space stations. They launched Salyut I in 1971 then a series of space stations staying for up to 6 months in space. They did experiments and learned how to live and survive in space. In contrast these were no US astronauts in space from 1975 to 1981. The Soviets also developed a Shuttle, used it once and then decided it was too expensive to operate and never used it again. The Soviets also developed satellite interceptors and had an operational ASAT system. The US never did develop an ASAT but did develop an F15 launched missile that destroyed one old satellite as a test in the 80's.

The commercial industry continued to grow under INTELSAT and the Open Skies policy in the US. The first domestic Comsat was launched in 1974 using C-band. By 1980, Ku band satellites were available. These ultimately enabled the now ubiquitous private networks (e.g. at Shell stations for card authorization). Once again the commercial market was growing.

Information Bank Abstracts
NEW YORK TIMES

December 8, 1973, Saturday

SECTION: Page 16, Column 6; (AP)

LENGTH: 43 words

JOURNAL-CODE: NYT

ABSTRACT:

Scientists at **NASA** rept on Dec 7 that 2 remaining gyroscopes aboard Skylab space station have begun to function erratically but that situation is no cause for alarm; say 3 astronauts could remain aboard space station for 2 wks in event 2d gyroscope fails

Information Bank Abstracts
WALL STREET JOURNAL

December 5, 1973, Wednesday

SECTION: Page 19, Column 4

LENGTH: 34 words

JOURNAL-CODE: WSJ

ABSTRACT:
Space Shuttle prime contractor Rockwell Internatl seeks subcontract bids from Bell Aerospace, TRW Systems and Aerojet Liquid Rocket; Pratt & Whitney gets **NASA** subcontract for work on Space Shuttle orbitor

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Information Bank Abstracts
NEW YORK TIMES

November 30, 1973, Friday

SECTION: Page 1, Column 7

LENGTH: 609 words

JOURNAL-CODE: NYT

ABSTRACT:
US Pioneer 10 spacecraft hurtles deep into magnetic field of Jupiter on Nov 29 and sends back data indicating that field's reach is greater than expected, strength 40 times that of earth's magnetic field and direction south instead of north; Ames Research Center scientists rept that Jupiter's mass is even greater than estimated, giving planet slightly stronger gravitational pull than had been anticipated; as result, Pioneer 10 is being drawn toward planet faster than planned and is now expected to arrive 2 mins early for closest approach--within 81,000 mi of Jupiter; spacecraft will send back 1st closeup images of Jupiter; Pioneer project deputy mgr Dr R C Nunamaker holds all spacecraft systems are operating normally; Dr S DeForest estimates that Jovian magnetic field stretches to diameter of more than 8-million mi; spacecraft magnetometer, which measures intensity as well as direction of magnetic lines, is transmitting data on field; Dr E J Smith of Jet Propulsion Lab repts that magnetism does not appear to be sufficiently strong to fend off solar wind the way it does; suggests that some sort of thermo plasma, gas consisting of low-energy particles, must be circulating just inside boundary to help magnetism deflect solar wind; scientists say thermo plasma could come from planet's upper atmosphere and from solar wind particles that are able to penetrate bow shock region; also rept that strength of Jupiter's magnetism about 4-million mi from planet seems to rise and fall in regular 10-hr phase; say phenomenon could be related to planet's rotation; Jupiter makes complete spin every 9 hrs and 55 mins; knowledge of strength and shape of Jupiter's magnetic field could give scientists crude model of planet's interior and probably suggest clues as to force that generates planetary magnetism; once scientists know strength of Jupiter's magnetic field they will be able to use ground-based radio telescopes to study dynamics of planet's radiation belts; Dr J H Wolfe comments; Smith explains that reversal of magnetic direction is connected with motions inside planet but declines to make any inferences as to Jupiter's internal structure on basis of preliminary magnetic data; Jupiter is only planet in solar system other than earth known to have intrinsic magnetic field and to have radiation belt particles trapped and accelerated by such a field; **NASA** planetary programs deputy dir Dr S I Rasool says study of planet's magnetism and radiation belts was one of prime mission goals; Dr J A Van Allen, who recommended guidelines for craft's instrumentation, comments; spacecraft was built by TRW Systems Inc under direction of Ames Research Center; contains 65 lbs of remote-sensing instruments, many of which have been operating on and off since spacecraft was launched in '72; spacecraft spins as if flies, giving instruments full-circle scan 5 times every min; uses radioactive decay of plutonium to generate elec power; is equipped with large 9-ft dish antenna to send and receive messages; each signal takes 45 mins to reach earth from Jupiter; imaging system, designed by Ariz Univ, is capable of producing 2-color images of Jupiter from electronic signals; Pioneer 10 has returned 150 pictures of planet; as craft approaches closer to Jupiter, 4 instruments will be focused on learning source, nature and intensity of planet's radiation belts; instruments are charged particle detector, designed by Chicago Univ, cosmic ray telescope, designed by Goddard Space Flight Center, Calif Univ's trapped radiation detector and Iowa Univ's Geiger tube telescope; schematic diagrams of Pioneer 10's scientific instruments and Jupiter

GRAPHIC: DIAGRAMS & DRAWINGS

Information Bank Abstracts
NEW YORK TIMES

November 25, 1973, Sunday

SECTION: Page 80, Column 4; (AP)

LENGTH: 79 words

JOURNAL-CODE: NYT

ABSTRACT:
Crew members aboard 3d Skylab mission take day off on Nov 24; **NASA** official says astronauts needed day off to get space station in shape for remainder of 84-day mission, and that they have spent several hrs each day searching for misplaced items, such as tools and checklists; crew will attempt to photograph Kohoutek comet and will alter slightly orbit of space station; day off will also allow mission planners to assess effects of failure of 1 of Skylab's 3 gyroscopes

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Information Bank Abstracts
NEW YORK TIMES

November 24, 1973, Saturday

SECTION: Page 62, Column 1; (AP)

LENGTH: 71 words

JOURNAL-CODE: NYT

ABSTRACT:
Failure of gyroscope aboard Skylab space station on Nov 23 raises fears that 84-day mission may be shortened; **NASA** official says laboratory can function effectively with only 2 of its 3 gyroscopes but that its maneuvers will be more difficult and will require increased use of control gas jets; crew members, Lt Col Pogue, Dr E G Gibson and Lt Col Carr, continue normal flight activities; Col Pogue photographs Kohoutek comet

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Information Bank Abstracts
NEW YORK TIMES

October 19, 1973, Friday

SECTION: Page 6, Column 1

LENGTH: 84 words

JOURNAL-CODE: NYT

ABSTRACT:

NASA discloses on Oct 18 plans for intensive scientific observations of Kohoutek Comet during its appearance in heavens in Dec; scientists hope to obtain 3-dimensional image of comet through use of earth-based cameras and equipment aboard Mariner 10 spacecraft, scheduled to be launched toward Venus and Mercury early in Dec; comet will also be observed from ground, from high-altitude aircraft, balloons, sounding rockets, unmanned satellites and other equipment aboard orbiting Skylab space station

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Information Bank Abstracts
NEW YORK TIMES

September 25, 1973, Tuesday

SECTION: Page 22, Column 4

LENGTH: 188 words

JOURNAL-CODE: NYT

ABSTRACT:

US Skylab 2 astronauts Capt Bean, Maj Lousma and Dr O K Garriott on Sept 24 make final preparations for splashdown; **NASA** drs say they expect astronauts to be very unsteady when they reach USS New Orleans, recovery ship, and try to flex muscles that have deteriorated somewhat from weightlessness; flight controllers express confidence that astronauts will have no trouble steering Apollo spacecraft, disabled by 2 leaks in maneuvering rockets, to accurate and safe return to earth; modified steering procedures were simulated successfully during ground tests last wk; P C Shaffer, who directed simulations and will be flight dir during return maneuvers, comments; Apollo mgr G S Lunney holds 2 leaks were found to be unrelated; 1st one was traced to stuck valve, probably caused by contamination in fuel line; 2d leak was caused by lose fittings in engine; Dr W R Hawkins, Johnson Space Center life sciences deputy dir, holds crew is in good condition; says astronauts have lost 7 to 8 lbs each; repts their physical condition seemed to stabilize after 39th day of mission; says he does not know why; map shows splashdown target

GRAPHIC: MAPS

Information Bank Abstracts
NEW YORK TIMES

August 18, 1973, Saturday

SECTION: Page 30, Column 3

LENGTH: 28 words

JOURNAL-CODE: NYT

ABSTRACT:
NASA on Aug 17 selects United Aircraft Corp to build experimental helicopter, Rotor Systems Research Aircraft; co's Sikorsky div estimates cost of project at $25-million

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Information Bank Abstracts
WALL STREET JOURNAL

August 2, 1973, Thursday

SECTION: Page 25, Column 4

LENGTH: 15 words

JOURNAL-CODE: WSJ

ABSTRACT:
Eur nations agree to participate in US space shuttle project, but insist on escape clause

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Information Bank Abstracts
NEW YORK TIMES

July 29, 1973, Sunday

SECTION: Page 1, Column 8

LENGTH: 182 words

JOURNAL-CODE: NYT

ABSTRACT:

Apollo spacecraft with Capt Alan L Bean, Maj Jack R Lousma and Dr Owen K Garriott aboard is launched from Cape Kennedy on July 28 on 2d Skylab mission, during which astronauts will spend 59 days aboard orbiting space laboratory; approximately 100,000 spectators watch launching, smallest crowd ever to observe venture of Amer astronauts into space; Capt Bean steers spacecraft to link-up with space station after 5 orbits of earth; crew enters space station and begins routine inspection; takes medication after reporting that they are suffering slightly from 'stomach awareness'; scientists at Houston Space Center rept thruster on 1 of 4 propulsion units on Apollo service module is leaking nitrogen tetroxide, but that problem will not interfere with rendezvous maneuvers or with spacecraft's ability to return astronauts safely to earth at end of mission; rept failure of another of space station's 9 gyroscopes; launching from Cape Kennedy described; illus; astronauts illus during breakfast at Cape Kennedy prior to launching and on way to launch pad; Dr Kurt Debus, **NASA** official, illus

GRAPHIC: PHOTOGRAPHS

Information Bank Abstracts
WALL STREET JOURNAL

July 5, 1973, Thursday

SECTION: Page 5, Column 2

LENGTH: 16 words

JOURNAL-CODE: WSJ

ABSTRACT:

United Aircraft and McDonnell Douglas Corp get US contracts for work on reducing jet-engine noise

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Information Bank Abstracts
NEW YORK TIMES

June 1, 1973, Friday

SECTION: Page 6, Column 4

LENGTH: 308 words

JOURNAL-CODE: NYT

ABSTRACT:

Skylab space station remains low on electricity on May 31, but crew proceeds with med experiments and operation of solar and stellar telescopes; flight controllers rept they are studying battery failure, 2d in mission, that has further reduced Skylab's electrical capacity; say electrical switch apparently became jammed in open position between solar-power panels and regulator that controls charging of battery; **NASA** repts 16 of vehicle's 18 batteries in Skylab's telescope unit are functioning normally, and that only effect of recent malfunction has been cancellation of planned multispectral photograph of earth and turning off of video tape recorders and a water heater; flight controllers instruct crew to recycle switches in electrical power system in attempt to recharge battery; Comdr Weitz repairs malfunctioning ultraviolet stellar telescope after partly disassembling gear drive on telescope's mirror system and discovering that piece of metal was jamming 1 of gears; redeploys telescope, which will photograph stars and Milky Way in ultraviolet spectrum, on a boom through airlock in wall of space station; Dr Kerwin aims array of telescopes at sun, continuing observations that have already provided scientists with photographs that could explain how particles in solar 'wind' escape sun's atmopshere; astronauts take turns in rotating chair in experiment to test their reactions to spinning in weightlessness; mission officials reaffirm tentative plans to resume earth-survey photography within day, but cameras and remote-sensing instruments will be used for limited periods; temperature inside Skylab is 82 degrees Fahrenheit, 10 degrees above desired level; problems besetting space station stem from loss of micrometeroid and thermal shield during launching from Cape Kennedy and because of failure of solar-power panel to deploy

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Information Bank Abstracts
NEW YORK TIMES

May 16, 1973, Wednesday

SECTION: Page 46, Column 2

LENGTH: 127 words

JOURNAL-CODE: NYT

ABSTRACT:
Ed, commenting on problems besetting Skylab space station, maintains 'a price is being paid for the effort to stage Skylab on a shoestring,' noting that **NASA,** as result of budget cuts, constructed space station 'out of existing bits and pieces of available equipment and eschewed much of the painstaking and expensive testing and retesting that contributed so largely to the brilliant record of accomplishment and safety scored by the Apollo program'; sees problems hinting at great difficulties and substantial expense involved in creation of 'even a small space station, let alone the large manned space laboratories many scientists are looking forward to'; urges coupling of programs by US and USSR into 'a truly internatl effort' which would benefit everyone

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Information Bank Abstracts
NEW YORK TIMES

April 14, 1973, Saturday

SECTION: Page 66, Column 1; (UPI)

LENGTH: 38 words

JOURNAL-CODE: NYT

ABSTRACT:
Rear Adm H S Ainsworth, comdr of USN's Pacific fleet, on Apr 13 blames human error for aerial collision between USN P-3 research craft and NASA Convair-990 near Moffet Naval Air Station, Sunnyvale, Calif, in which 16 were killed

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Information Bank Abstracts
NEW YORK TIMES

April 13, 1973, Friday

SECTION: Page 78, Column 6; (UPI)

LENGTH: 62 words

JOURNAL-CODE: NYT

ABSTRACT:
NASA twin-engine P-3 Orion turboprop and USN Convair-990 collide during landing approaches to Moffet Naval Air Station, Sunnyvale, Calif, on Apr 12 killing 16, including 11 **NASA** technicians and 4 USN personnel; wreckage of Convair illus on nearby golf course; map of Calif depicts site of crash; victims listed; B N Malibert, crew member aboard Convair, is sole survivor

GRAPHIC: COMBINATION (ANY 2 OR MORE)

Information Bank Abstracts
NEW YORK TIMES

March 3, 1972, Friday

SECTION: Page 1, Column 3

LENGTH: 95 words

JOURNAL-CODE: NYT

ABSTRACT:
US Pioneer 10 spacecraft launched toward Jupiter after 25-min delay because of unexplained tech problem; illus; upper 3d stage was added to Atlas-Centaur rocket to give spacecraft extra boost to enable it to escape earth's gravitational pull at record velocity of more than 31,000 mph; NASA officials say craft should reach Jupiter in 21 mos; craft's 11 scientific instruments expected to provide new data on Jupiter, asteroid belt between Mars and Jupiter and physical properties at boundary where solar system blends into rest of Milky Way; other key mission goals revd

GRAPHIC: PHOTOGRAPHS

Information Bank Abstracts
NEW YORK TIMES

February 25, 1972, Friday

SECTION: Page 7, Column 1

LENGTH: 91 words

JOURNAL-CODE: NYT

ABSTRACT:

US **NASA** technicians, Cape Kennedy Space Center, conduct final tests on 570-lb Pioneer 10 spacecraft and its Atlas-Centaur rocket, which has augmented power to drive craft away from earth at unprecedented escape velocity of 32,000 mph; if successful, Pioneer 10 will become 1st man-made object to fly beyond Mars, through asteroid belt and to Jupiter; will fly within 100,000 mi of Jupiter in Dec '73; will radio scientific data and take 1st close-up pictures of planet and then, with boost from Jupiter's gravity, will shoot out of solar system

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Information Bank Abstracts
NEW YORK TIMES

July 7, 1970, Tuesday

SECTION: Page 29, Column 7; (UPI)

LENGTH: 40 words

JOURNAL-CODE: NYT

ABSTRACT:
Sen, 32-28, defeats Sen Mondale amendment to cut **NASA's** fiscal '71 budget $110-million by halting design work on space shuttle; before vote, Sen Allott warned nation's manned space program would end after '74 if shuttle program is scrapped

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Information Bank Abstracts
NEW YORK TIMES

April 8, 1970, Wednesday

SECTION: Page 85, Column 6

LENGTH: 88 words

JOURNAL-CODE: NYT

ABSTRACT:
Sen subcom hearing on F-111; USN civilian expert K E Dental testifies that Gen Dynamics withheld evidence of 'major increases' in craft's expected weight for several mos of original Sen inquiry into program in '63; says it finally supplied data in Dec, 1 mo after inquiry was suspended; E C Polhamus, NASA expert, testifies agency warned in early '63 that high drag would seriously degrade craft performance but that Gen Dynamics insisted craft would exceed performance requirements and did little in way of airframe modification

Information Bank Abstracts
NEW YORK TIMES

March 24, 1970, Tuesday

SECTION: Page 9, Column 1

LENGTH: 79 words

JOURNAL-CODE: NYT

ABSTRACT:

Sen (McClellan) Permanent Subcom on Investigations to begin hearings on F-111; plans probe of hitherto secret rept that Govt engineers at **NASA** Langley Research Center made many recommendations in '63 and '64 for design changes to help craft meet range, acceleration and other requirements but that Gen Dynamics and USAF rejected virtually all of them; co and USAF officials close to project deny allegations, holding most of the ideas rejected would not have solved problems

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Information Bank Abstracts
NEW YORK TIMES

February 19, 1970, Thursday

SECTION: Page 12, Column 1

LENGTH: 81 words

JOURNAL-CODE: NYT

ABSTRACT:

NASA asks 6 aerospace cos to submit designs for space shuttle engines; cos listed; shuttle will have booster stage, containing cluster of engines to thrust it through atmosphere, and orbital stage with 2 or 3 engines that will power craft until it docks with space station; both stages will make controlled landings and be refurbished for use on up to 100 missions; **NASA** says preliminary flight testing will begin in '75; Marshall Space Flight Center is in charge of engine development

Information Bank Abstracts
NEW YORK TIMES

August 15, 1969, Friday

SECTION: Page 14, Column 4; (AP)

LENGTH: 33 words

JOURNAL-CODE: NYT

ABSTRACT:
7 astronauts in USAF's canceled Manned Orbiting Lab project named by **NASA** to Civil Astronaut Corps; names listed; 8th astronaut, Lt Col A H Crews, named to **NASA** flight crew operations directorate

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Information Bank Abstracts
NEW YORK TIMES

June 11, 1969, Wednesday

SECTION: Page 1, Column 1

LENGTH: 113 words

JOURNAL-CODE: NYT

ABSTRACT:
Deputy Defense Sec D Packard announces Defense Dept has canceled manned orbiting laboratory project because of 'urgency of cutting defense spending'; dept has spent $1.3-billion on project which sought to place 15-ton, 2-man spacecraft into earth orbit for reconnaissance and other mil missions; 6-yr history of project traced; HR, 328-52, approves bill authorizing $3.9-billion **NASA** budget for fiscal '70; earlier, rejected, by voice vote, Repr E I Koch amendment to cut manned space flight budget by $205-million because of pressing domestic needs; Hr approves Repr R L Roudebush amendment to **NASA** appropriations bill, specifying that astronauts place only US flag on moon

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SP-4212
On Mars: Exploration of the Red Planet. 1958-1978

6

Viking Orbiter and Its Mariner Inheritance

[155] During the closing days of 1968, the engineers at Langley, in consultation with specialists at JPL and NASA Headquarters, completed a Viking spacecraft design. Viking would have two major systems&emdash;an orbiter and a lander. While the lander would provide the means for safely delivering the scientific instruments to the surface, house, and provide the necessary power source and communications links for those experiments, the orbiter had a series of equally important functions in the Viking mission. The orbiter would transport the lander to Mars, provide a platform for the Viking imaging system so that proposed landing sites could be surveyed and certified, relay lander science information (pictures and other data in an electronic format) to Earth, and conduct scientific observations in its own right.

Despite early debates among NASA managers, it was only logical that the design and development of the Viking orbiter system he carried out at the Jet Propulsion Laboratory, where the engineering team already had an expertise in the design of planetary spacecraft. After building the Ranger lunar probes and the early Venus and Mars Mariner flyby spacecraft, the California engineers had gone on to build the Mariner Mars 69 flyby craft and were working on the Mariner Mars 71 orbiter when Viking was initiated. The Viking orbiter would borrow heavily from Mariner technology, with such specialized functions as the project demanded being added to the basic chassis.

Early plans for the Viking orbiter called for only a few modifications of the Mariner 71 craft. However, structural changes that permitted mating the lander to the orbiter and enlarging the solar panels led to significant alterations of the basic 1971 orbiter. During the long flight to Mars, the orbiter would have to provide power to the lander, especially during the periodic checkups on the lander's health and during occasional updates of the landers computerized memory. These additional energy requirements made it necessary to increase significantly the solar panels, from 7.7 square meters to 15.4.

[156] The decision to build a large soft-landing craft instead of a small hard-lander led to the requirement for a large orbiter. The orbiter would not only have to transport the lander. it could also have to carry an increased supply of propellant for longer engine firings during Mars orbit insertion, longer than those planned for the 1971 Mariner mission.[1] And an upgraded attitude control system with greater impulse, plus a larger supply of attitude control propellant, would be required to control the combined spacecraft. Table 26 categorizes the Viking orbiter subsystems as compared to Mariner 71, listing subsystems from Mariner requiring only minor changes, subsystems from Mariner requiring extensive modifications, and completely new subsystems designed for Viking.

Table 26

Sources of Viking Orbiter Subsystems

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Mariner	Mariner Adaptations	New
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Radio	Structure	Computer/command
X-band transmitter	Attitude control	Data storage
Pyro control	Propulsion	Relay link
Omni antenna	Scan platlorm	High-gain antenna
	Temperature control	Science instruments
	Packaging	
	Data system	

A brief review of the Mariner 69 and Mariner 71 spacecraft will provide a better understanding of the technological relationships between the Mariner and Viking projects.

MARINER MARS 69

Born in the winter of 1965, Mariner Mars 69 was supposed to be only a modest improvement over *Mariner 4* . Early plans for a 1969 orbiter and hard-lander mission had been scrapped, and in its place a flyby craft had been substituted that would approach Mars at a distance of about 3200 kilometers, rather than the 13 800-kilometer pass made by *Mariner 4* in 1965. [2] The 1969 spacecraft would also carry more weight (384 kilograms) than earlier Mariners (*Mariner 2* -203 kg. *Mariner 4* -261 kg), because of the performance capability of its Atlas-Centaur launch vehicle. (Detailed information on the Mariner flights is given in Appendix C.) Building on Project Ranger and Project Mariner experience, JPL engineers borrowed a number of fundamental mission and systems features for use with Mariner Mars 69. The most important of these was three-axis stabilization (roll, pitch, and yaw), provided by gyroscopes and celestial sensors, switching amplifiers, and cold-gas jets. This attitude control system permitted orientation **[157]** of the solar panels and thermal shields, which provided temperature control, relative to the sun. The high-gain communications antenna could be aimed toward Earth to improve communications, and the scientific instruments could be directed toward the objects of their study. The attitude control system also permitted the craft to be maneuvered more precisely. [3] Other characteristics of the Mariner spacecraft included an extensive ground command capability and a large number of engineering and scientific telemetry measurements. The ground command capability was used primarily as a backup to the onboard central sequencer, a mini-computer that also reacted to commands from Earth.

Mariner Mars 69 followed the general design pattern of *Mariner 4* . The central body was octagonal with a magnesium framework (127-centimeter diagonal, 46-centimeter depth). with electronic assemblies and onboard propulsion system fitted into the equipment bays on all sides. Four hinged solar panels radiated from the body. On the side of the spacecraft opposite the solar panels was a platform for mounting the television camera, an infrared radiometer, an ultraviolet spectrometer, and an infrared spectrometer. The omnidirectional antenna and the fixed, high-gain, reflector antenna were attached on the side generally oriented toward the sun. Ground stations could communicate with the spacecraft continuously for tracking and the return of scientific data. Images would be stored by an onboard tape recorder for relay to Earth at a reduced play-back rate, since the cameras necessarily acquired imaging data at a rate much higher than the telemetry channel could accommodate.

As they worked on early Mariner and Ranger spacecraft, specialists at JPL had also evolved systems for tracking and controlling spacecraft from Earth, recognizing the requirement for a highly sensitive, steerable antenna (radio telescope) for communication with deep space probes. For continuous long-range coverage, a network of three stations, about equidistant in longitude, was normally sufficient. The first stations were at Goldstone, California; Johannesburg, South Africa; and Woomera, Australia. By the time Mariner 69 was ready to fly, there were eight 26-meter radio antennas and one 64-meter antenna in the Deep Space Network. Signals from the Space Flight Operations Facility at JPL were directed to the spacecraft by the appropriate ground station. [4]

As first established, Mariner Mars 69 had three objectives. The primary goal was to fly spacecraft by Mars to investigate that planet, establishing the basis for future experiments, especially those related to the search for extraterrestrial life. While exploiting existing technology, Mariner 69 engineers also hoped to develop new technology necessary for future missions. A tentatively approved objective to investigate certain aspects of the solar system was dropped from consideration by NASA Headquarters managers in April 1966. Mariner 69 would concentrate its efforts on Mars-related science. Experiment proposals were solicited and received by the Space Science Board, which acted as an advisory body to the NASA Office of Space Science **[158]** and Applications. As had been proposed several times before, an atmospheric entry probe was suggested, but it was also rejected as before, because it would have significantly increased both the time required to develop the craft and the budget for the project. Scientific payload selection was announced on 26 May 1966.

By mid-1966, the design of the mission and the spacecraft was well under way. Money was the problem faced by N. William Cunningham, program manager at headquarters, and Harris M. Schurmeier, project manager at JPL, and their Mariner 69 team. Successive budget cuts each fiscal year forced the team to defer delivery of certain parts and components, which repeatedly required the engineers to reschedule the assembly and testing of the spacecraft. The budget reductions also forced the deletion of some spare parts and tests and led to several mission design changes. Despite financial constraints, the Mariner project staff was able to expand the scope and effectiveness of the spacecraft. An increase in mission science, for example, affected the planetary encounter phase of the mission. JPL specialists developed an improved telemetry transmission system that would return information at a higher rate than previously possible, increasing the overall volume of scientific return substantially. Since scientists would be using their instruments more frequently, the central control computer and sequencer through which ground controllers talked to the science instruments and manipulated the instrument scan platform would experience greater demand.

As early as September 1966 at the second project quarterly review, it became apparent that the 1969 mission was going to be much more than just a repeat of the *Mariner 4* flight. The instrument scan platform alone had grown in weight from 9 kilograms to 59. Throughout 1967 and 1968, as work progressed on the spacecraft and Earth-based systems, Schurmeier reported to NASA Headquarters that experimenters would be able to take more pictures of the Martian surface with the Mariner 69 equipment than previously anticipated. The accumulated improvements in telecommunications-increased telemetry data rates, expanded communications network, and better computer processing-would lead to a rate of data transmission 2000 times better than anything they had received before. [5] For the scientists associated with the television experiment, this was exciting news. Instead of taking only 8 television pictures during the last day of the spacecraft's approach to Mars, Robert B. Leighton and his colleagues on the television experiment team could gather some 160 images, starting two or three days before encounter with the planet. These approach pictures of the entire planet would bridge the gap between photos taken from Earth and closer images gathered by Mariner 69 craft as they passed by Mars. [6]

Engineers and technicians at JPL assembled components supplied by about a dozen subcontractors into four spacecraft-a proof-test model (PTM), two flight craft (M69-3 and M69-4), and one assembled set of spares (M69-2). While the proof-test model would never fly, it was a very important **[159]** part of the 1969 project because it had to endure simulated conditions worse than any that were expected during the flight to Mars. The other three units were tested more gently on the vibration table to rehearse the launch and in the thermal-vacuum space-simulation chamber to practice the mission through deep space.

Following several visits to the test bench and much rebuilding and repairing, the craft were pronounced ready for their voyage. While the proof-test model remained behind in Pasadena to continue its service as a test article, the other three craft were sent to the Kennedy Space Center during December 1968 and January 1969. All went well with the preflight checks of Mariner F and Mariner G (preflight designations) until about 10 days before the scheduled launch. On 14 February while the Atlas-Centaur- Mariner F vehicle was standing on the pad undergoing unfueled simulation of launch, the Atlas began to collapse like a punctured tire. Most of the structural strength of the Atlas is provided by the pressure in its fuel tanks. While this balloon-like structure saves a great deal of weight, it means that the pressure must be maintained at a constant level. On this day, a faulty relay switch had opened the main valves, permitting the pressurizing gases to escape. As the Atlas began to sag on its launch tower, two alert ground crewmen sprinted to the scene and shut off manual valves inside the launch vehicle. Pumps restored tank pressure, and the big rocket resumed its original shape. The terrible scar in the thin stainless steel skin of the Atlas made it clear, however, that another launch vehicle would have to be used in its place.

The Centaur and Mariner components were unharmed, and on 18 February KSC personnel moved the Mariner F craft and the Centaur upper stage to the Atlas originally scheduled for Mariner G. Six days later, 24 February, *Mariner 6* began its journey to Mars. After being mated to a new Atlas shipped from San Diego by General Dynamics/Convair, the second Mariner 69 craft was launched on 27 March. [7] As *Mariner 6* and *7* were en route, another group of JPL specialists was at work preparing for the next mission to Mars.

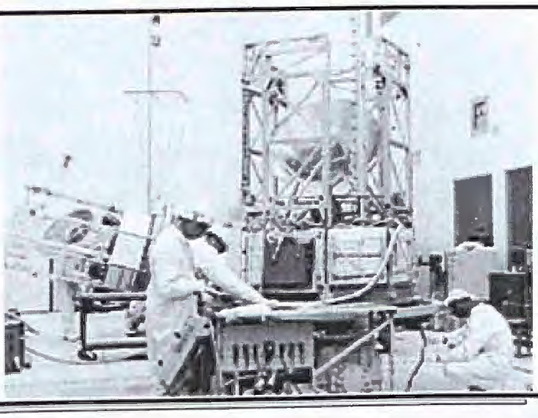
MARINER MARS 71

The battle over NASA's budget during the summer of 1968 had caused the agency's leadership to postpone beginning work on a Mariner Mars 71 project. NASA had begun the year by asking for $4.37 billion for fiscal 1969, or $218 million less than appropriated the preceding year. After the budget cycle was completed, President Lyndon B. Johnson signed an appropriation bill for $3.995 billion on 4 October 1968, the lowest since 1963. This figure, more than half a billion dollars less than the fiscal 1968 budget, sent NASA planners groaning back to their drawing boards. [8]

Despite the tight budget, $69 million was earmarked for the planetary program, to support Mariner Mars 69's flight and preliminary study of Mariner Mars 71 and Viking 73. Two and a half months after the project **[160]** approval document for the 1971 mission was signed, NASA Headquarters announced on 14 November 1968 that Jet Propulsion Laboratory had been authorized to begin work on the project. Dan Schneiderman was appointed project manager at JPL, and Earl W. Glahn was named program manager at NASA Headquarters. [9]

Mariner Mars 71 was described as part of a continuing program of planetary exploration. Unlike the previous Mariner flights, however, the 1971 mission was designed to orbit the planet with two spacecraft for a minimum of 90 days each. At a December 1968 meeting of the American Institute of Aeronautics and Astronautics, Oran W. Nicks, deputy associate administrator for space science and applications at NASA Headquarters, spoke of the value of orbiter flights and future orbiter-lander missions for the examination of Mars. He noted that *Mariner 4* , *6* , and *7* had given "snapshot views of the planet." The two 1971 orbiters would "provide powerful new tools for our survey of dynamic Mars." They were scheduled to "arrive at a time in the Mars cycle when the most striking seasonal changes are evident in the southern hemisphere." A combination of different orbits for the two 1971 craft would provide a complete survey of the entire planet. "The life-times expected from these orbiters will allow observations of the dynamic changes in clouds and surface features over a period of several months." [10] In addition to the improved observations the two orbiters would meet several other scientific objectives.

Mariner F and G spacecraft (below)-to be christened Mariner 6 and 7 on launch-are tested in preparation for their five-moth journeys to Mars to investigate the planet's atmosphere and surface. Solar arrays are not yet installed. At left, an Atlas-centaur launch vehicle thrusts Mariner 7 toward space from Cape Kennedy, Florida, on 27 March 1969, following the Mariner 6 launch in February.



[161] Scientists had four general objectives for the 1971 missions, including the search for "exo-biological activity, or the presence of an environment that could support exo-biological activity." They hoped to gather information that might help answer nagging questions about the origin and evolution of the solar system. A third goal was to collect "basic science data related to the general study of planetary physics, geology, planetology, and cosmology." The specialists were also interested in information that would assist in planning and designing a Viking lander mission on Mars, especially data that would affect landing site selection.

Five specific investigations also demanded the attention of the planetary scientists. The orbiter cameras would provide imagery that could update topographic maps of the planet's surface. The television team, led by Harold Masursky of the U.S. Geological Survey, anticipated photographs of a much higher quality (better resolution) than those taken by the 1964 and 1969 spacecraft. These images, and other orbiter sensors, would also allow the scientists to examine time-variable surface features. Some specialists thought the most obvious of these features-the "Wave of Darkening"-was seasonal. Were the variations the results of moisture, vegetation, or the movement of air-borne dust?[11] The long stay in orbit also would permit study of the composition and distribution of the Martian atmosphere, to gain clues about the planet's weather. A fourth area of study included temperature, composition, and thermal properties of the planet's surface; scientists would be looking for warm spots where life forms might have had a chance to survive. And the Mariner investigators wanted a closer look at the seasonal waxing and waning of the polar caps.[12] Besides studying these five areas, scientists would also be getting information on the internal activity, mass distribution, and shape of the planet.

To meet the objectives, the Mariner Mars 71 mission plan called for two spacecraft to perform separate but complementary missions. Mission A was designed primarily as a 90-day reconnaissance. The orbital path would give the spacecraft instruments a look at a large portion of the planet's surface. Orbiting the planet every 12 hours, the flight path would permit communication with the Goldstone tracking station during a lengthy portion of every alternate orbit. Mission B would study more closely the time-variable features of the Martian atmosphere and surface for at least 90 days, moving in a wide, looping orbit around the planet once every 32.8 hours.[13] Nicks believed that the Mariner 71 orbit missions and the 1973 Viking orbiter lander flights would be powerful study tools, permitting man to gain at least partial answers to several important questions: "Is there life elsewhere? Has life existed on nearby planets and disappeared for any reason? Can nearby planets be made suitable for life?"[14] But before they could begin to look for answers, the NASA-contractor team had to build the hardware.

Engineers at JPL had a basic philosophy about incorporating changes into each new generation of spacecraft: modifications would be included to

(l) adapt the previous design to unique requirements for the new mission,
(2) **[162]** overcome difficulties demonstrated in the previous mission, and
(3) incorporate new technology when a major improvement would provide a significant benefit in cost, weight, or reliability.[15]

The Mariner 71 spacecraft designers wanted to carry over as much of the design of the early Mariner spacecraft and ground equipment as possible. As they were quick to point out, the repeated use of experienced personnel, procedures, documentation, and facilities was a benefit to the project during tests, launch, and flight operations. The Mariner 71 spacecraft grew in size, weight, and complexity, however.

Table 27

Mariner 69 and 71 Spacecraft Comparisons

Spacecraft Feature	Mariner 69	Mariner 71
Shape	Octagonal magnesium frame	Octagonal magnesium frame
Size	127 cm diagonal; 45.7 cm depth	127 cm diagonal; 45.7 cm depth
Solar panels	112 cm x 90 cm (4); 4.0 sq m	112 cm x 90 cm (4); 7.7 sq m
Launch weight	412.8 kg	997.9kg

Besides growing much larger than its predecessors, Mariner 71 was also taking on a new major task, orbiting the planet Mars, not just passing by. As a consequence, the *propulsion subsystem* had to be completely redesigned to provide the necessary propulsion capability-a 1600-meter-per-second velocity change-to inject the spacecraft into Mars orbit. The 1971 design incorporated a 1335-newton (300-pound-thrust) engine, instead of the 225-newton (51-pound thrust) engine on Mariner 69. Nearly all the components needed for the 1971 propulsion subsystem (valves, regulators, and the like) had been used on previous spacecraft, but they had not been used in this particular combination. Although the propulsion subsystem was a new design, some inheritance from earlier Mariner systems was realized at the parts level by using flight-proven components.

Mariner 71's *data storage subsystem* was a completely new design, too. This all-digital, reel-to-reel tape-recording unit was, however, derived from earlier development activities at JPL. It incorporated selectable playback speeds of 16,8,4,2, and 1 kilobits[*] per second, with an eight-track capability **[163]** using two tracks at a time. High-packing density for this electronic information provided a total storage capability of 180 million bits on a 168-meter tape. Data could be recorded at 132 kilobits per second. In this subsystem, there was little or no design-hardware carry-over from previous programs.

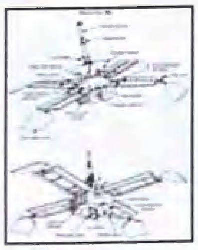
Design of the *central computer and sequencer* was altered to increase this onboard system's memory from 128 words to 512 words.[**] The modification provided the operational flexibility required for orbital operations, permitting repetitive sequences to be carried out. Other changes in the central computer and sequencer led to improved operations between the computer and the sequencer, better checks on stored information, and generally improved control over the spacecraft.

Of the four Mariner 71 onboard science instruments-television, infrared radiometer, ultraviolet spectrometer, and infrared interferometer spectrometer-only one was new to the Mariner series. The *infrared interferometer spectrometer* (IRIS) had been flown on the Nimbus weather satellites. It would provide information on the composition of the Martian atmosphere-measuring water vapor, temperatures at the surface, and the temperature profile of the atmosphere-and would examine the polar caps. Although the instrument was an adaptation of a previous design, many changes had to be made in it so that it worked on Mariner. To Mariner systems engineers, IRIS was a new instrument that they had to incorporate into their spacecraft design.

Television was another subsystem that was extensively modified. Installing two cameras on Mariner 71, the engineers could use circuitry, optics, and vidicon components from other systems. But there were difficulties. The Mariner 69 television equipment had developed background noise problems; a considerable amount of processing had had to be done to both analog and digital signals to convert them into usable video images. And the 1969 system had less dynamic range and was not as adaptable as the scientists needed for the orbiter mission. The Mariner 71 team developed an all-digital television system with eight selectable filters in the wide-angle camera, automatic and commandable shutter speeds, and picture sequencing. Another improvement reduced the effects on the optics of long exposure to the harsh space environment. Relying on existing technology minimized development costs and risks and provided the Mariner 71 scientific team a high-performance television system.

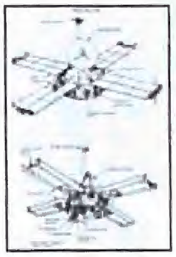
Major changes were made in the *attitude control subsystem* to adapt it to the requirements of orbital flight. To accommodate a new autopilot and computer logic changes, the Mariner 71 engineers designed new attitude control electronics and redesigned the inertial reference unit (a device that. . . .

[164]



Mariner Mars 1964.

[165]



Mariner Mars 1969.

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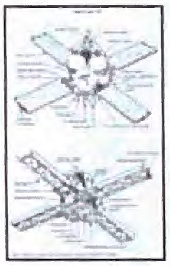

Mariner Mars 1971.

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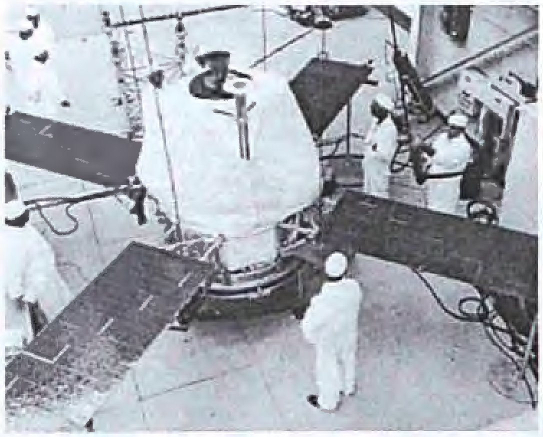
[167]....gives continuous indication of position by integration of accelerations from a starting point). They included an acceleration sensor (accelerometer) that would control the firing duration of the propulsion-subsystem rocket engine. To maintain spacecraft attitude stability, gyroscopes were modified from Mariner 69 hardware. Sensors, both solar and star, which help determine the spacecraft's location in space, were considerably altered for the orbital flight. Mariner 71's attitude-control gas-jet system was similar to the 1969 subsystem with only minor modifications.

The *data automation subsystem* was designed to contain a new logic function to accommodate the requirements of the scientific instruments and orbital flight. Integrated circuitry and packaging techniques were directly borrowed from Mariner Venus 67 and the 1969 Mars craft. The structural subsystem, or the basic chassis of the spacecraft, was a successful adaptation of the 1969 octagonal frame. Electrical energy requirements were provided by an adapted *power subsystem* , which used new nickel-cadmium batteries and enlarged solar panels like those used in 1969. The radio subsystem, which borrowed technology from the Apollo program was altered to eliminate earlier problems. Other systems requiring only minor changes included command, telemetry, antennas, scan platform control, infrared radiometer, and ultraviolet spectrometer. The Mariner 71 final project report notes, "The design changes which were incorporated underwent considerable review and debate prior to approval so that the maximum inheritance could be realized," keeping the total number of changes the engineers had to make in the Mariner hardware to a minimum.[16]

FIRST PHASE OF VIKING ORBITER PLANNING

Working within this milieu that stressed building on proved technological concepts, the engineers at Langley and JPL also made maximum use of earlier subsystems for the Viking orbiter. First considerations for a design of a Titan-Mars 1973 orbiter mission had begun even before the 1971 Mariner or 1973 Viking flights had been approved. A Titan-Mars orbiter....



Assembly of Mariner 9 at Jet Propulsion Laboratory. The spacecraft's solar panels are spread.

[168]....design team led by Casper F. Mohl was established at JPL in August 1968. with Dalton D. Webb, Jr., as the group's Langley representative.

Casey Mohl was an advanced mission planner at the California lab. He had worked on *Explorer 1* and on several lander capsule studies for Ranger. During the Voyager effort, he had participated in the capsule systems advanced development activities, part of JPL's hard-lander studies. When the laboratory began to work with Langley's Advanced Spacecraft Project Office on the 1973 mission, JPL Director Pickering assigned Mohl and a group of his colleagues to the "pre-project effort," and the men began to study the diameters, and weights of possible 1973 orbiters. 17 As they worked, they discovered that every time the Langley people "did something to the lander, it ricocheted back to the orbiter, especially into the [propellant] tank sizing."

Orbiter size was limited by the diameter of the Centaur launch shroud, which was 3.65 meters. Weights considered during the fall of 1968 ranged from 454 to 680 kilograms for the orbiter and 590 to 907 kilograms for the lander. At this early stage in the planning, many suggestions for the mission design were made, including one by JPL engineer Robert A. Neilson that the 1973 flight be made using a 1971 orbiter without scientific instruments or scan platform. Later, of course, such an idea would be unthinkable, but during the mission definition period one of the alternatives called for using the orbiter simply as a bus to deliver the lander to Mars. 18 The two JPL orbiter proposals presented to the Langley Research Center Advanced Space Projects Office on 9 and 30 October did not include any scientific instruments for the orbiting vehicle, as the JPL planners wanted to consider initially only the minimum number of modifications in the 1971 orbiter, just then beginning to take shape on the drawing board. 19

By mid-November 1968, the JPL advanced planners had gone about as far as they could with the design of an orbiter for 1973 without approval of the project by Congress and the president. But at a 5 December meeting, a very pleased Casper Mohl told the "out-of-orbit" design team that the Titan-Mars 73 project had received the approval of the Bureau of the Budget; they could proceed with the development of an orbiter design while Langley worked on the lander. Although the orbiter science payload would not be defined until the Mariner 69 results were known, John Naugle said that, for planning purposes, the candidate experiment hardware in descending order of priority would include: Mariner 71-style television camera, high-resolution infrared radiometer, infrared interferometer spectrometer, near-infrared mapper, x-ray spectrometer, three-channel ultraviolet photometer, and polarimeter. Projected weights for the orbiter at launch were 1880 to 2130 kilograms, and the lander would weigh between 680 and 920 kilograms, with approximately 70 kilograms allocated for orbital science instruments. 20

[169] Between mid-November 1968 and mid-February 1969, JPL worked on a "baseline orbiter conceptual design" for the Viking mission, while the project office at Langley concentrated on staffing key management positions. In Pasadena 13-14 February, JPL hosted a review of its conceptual design for the orbiter. The Viking spacecraft (orbiter and lander) was to be launched by a Titan IIID-Improved Centaur, which could lift a combined weight of 3330 kilograms (2513 kilograms for the orbiter and 817 kilograms for the lander). The orbiter and lander would have a minimum life of 90 days after touchdown on Mars. The lander would have communications links directly with Earth stations and through the orbiter, which would serve as a relay satellite.

A key element of the February presentation was the technology that would be borrowed from Mariner 71. For electricity, the Viking orbiter power subsystem was essentially the same as for Mariner 71, providing lander power during transit and early orbital cruise periods. For 50 days of solar occultation during the 1973 mission, the spacecraft would be without the benefit of the sun's energy for one-half to three and one-half hours in each orbit. The increased distance of Mars from the sun during the Viking mission and the revised science instruments also led to some new requirements for the power system. New solar panels were designed, along with a new battery and battery charger. Minor changes were made in the power distribution circuitry, but the core of the entire system was borrowed from Mariner design. [21]

Industry representatives would later write to James S. Martin, Viking project manager at Langley, complaining about JPL's conservative orbiter design. L. I. Mirowitz, director of planetary systems at McDonnell Douglas Astronautics Company in St. Louis, believed that "spacecraft performance could be judiciously improved by considering some newer components; for example, the [central computer and sequencer] has a 512 word sequencer weighing [12.5 kilograms], the current state of the art permits use of a lander computer and sequencer that has a 6000 word capacity and weighs [11.3 kilograms]." [22] A. J. Kullas at the Denver Division of Martin Marietta Corporation also believed that weights could be reduced and performance improved by being less conservative than JPL had been in its engineering. In one instance, Kullas suggested that newer kinds of electrical cabling would permit a weight reduction from about 49 kilograms to 39, a saving of 20 percent. [23] While there was no doubt that the JPL baseline orbiter design could be improved, the conservative engineering was not unreasonable in an era of stringent budgets and equally tight schedules. Building on previously proved hardware concepts helped to ensure space- craft reliability within the budget and on time. The specialists at JPL evaluated alterations to the basic design, and the orbiter did change over time, but conservative engineering prevailed. [24]

[170] *Organizing Orbiter Management*

Early in April 1969, a formal Viking Orbiter Office was set up at JPL to replace the ad hoc arrangements that had existed since the official initiation of the 1973 landing project. Pickering announced the establishment of the management office on the 17th and named Henry W. Norris Viking orbiter manager. Casey Mohl's team went out of business at about the same time, and some of the members of that group joined Norris. A native Californian and graduate of UCLA, Norris had worked in aviation and space activities at General Precision Inc. before joining JPL at the age of 41 in 1963. During the Mariner Mars 69 mission, Norris served as spacecraft systems manager. Kermit S. Watkins, deputy to Norris, came to the Viking project from the JPL Office of Flight Projects, having also been assistant program manager for the Surveyor lunar landers. [25]

Other key personnel members appointed to the orbiter team by Director Pickering included Allen E. Wolfe, spacecraft systems manager, and Conway W. Snyder, Viking orbiter scientist. Wolfe had been spacecraft systems manager for Project Ranger and for the *Mariner 5* Venus mission in 1967. A nuclear physicist by education, Snyder had worked at the California Institute of Technology on Navy rocket research projects during World War II. He joined the JPL physics staff in 1956 and was principal investigator on three space experiments that studied the solar wind, becoming *Mariner 5* project scientist. [26] While Norris, Watkins, Wolfe, and Snyder were essential. highly visible members of the orbiter staff at JPL, they represented only the top of a large pyramid. When the orbiter management held its first weekly staff meeting on 1 April 1969, Norris told the participants that their sessions were not designed to resolve problems, but to discuss them "in sufficient depth to understand and identify items for separate action. " [27]

One of the immediate concerns of the project managers was the growing cost of the orbiter as projected in periodic estimates. Early in February, Charles W. Cole, manager of the Advanced Planetary Missions Technology Office at JPL, informed Martin that the hardware for the total orbiter system (two flight craft, spares, and test models) would cost nearly $147 million, while the total amount needed by the California laboratory to get the orbiters ready for flight, with test equipment and facilities, would be $161 million. Cole attributed the high figures to recent increases in hardware requirements, accelerated delivery schedules, and more extensive test procedures. The Viking orbiter would require several major pieces of new hardware (table 28), and the designers at JPL had based their cost projections for this equipment on the master schedule given them by the Viking Project Office. But the people in California did not believe that the schedule was realistic. For example, the JPL engineers were convinced that such an early delivery date for the engineering test model of the orbiter would require a major acceleration of orbiter system and subsystem design plans, which in turn would demand an earlier selection and design of scientific....

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[171] Table 28

Major Test and Flight Hardware to be Developed by JPL for the Viking Orbiter

.		Scheduled Delivery Dates		
Equipment	Purpose or Function of Equipment	As of 10 Feb. 1969	As of 13 Mar. 1969	As of 7 Aug. 1969
.				
Orbiter structural test model (STM)	Also called development test Model (DTM). For qualification testing of basic orbiter structure, including vibration, static modal, and separation of orbiter from lander tests	mid-Feb.1971	15 Sept.1971	15 Aug.1971
.				
Thermal Control test model (TCM)	Tear For thermal qualifications of orbiter systems. During tests, TCM to be mated with lander capsule thermal effects simulator to test effects on orbiter of lander heating. Both STM and TCM to be returned to JPL by 1 Aug. 1971 for laboratory testing.	1 Mar. 1971	1 Dec. 1970	1 July 1971
.				
Engineering test model (ETM)	To validate physical and functional interfaces between orbiter and lander capsule and between spacecraft and people, procedures, and facilities associated with combined systems tests. To be assembled from early production components for orbiter; flight-qualified parts not necessary. Could be updated after tests for use in Deep Space Network compatibility testing and launch center testing.	1 Aug. 1971	1 Dec. 1971	1 Feb. 1972
.				
Proof-test model (PYM)	To demonstrate orbiter design adequacy by performance of qualification tests, including vibration, shock, and thermal/vacuum. Also to be used for propulsion-system-interaction tests.	1 Feb. 1972	15 July 1972	1 Aug. 1972
.				
Flight orbiters	Three flight-ready orbiters to be fabricated by JPL, two to be launched, and third to be held as backup before launch and as systems test vehicle during mission.	1 Aug. 1972 1 Sept. 1972 1 Oct. 1972	15 Oct. 1972 15 Nov. 1972 15 Dec. 1972	1 Jan. 1973 1 Feb.1973 1 Mar. 1973

SOURCE: "Viking Project and Design Requirements Specification", n.d., encl. to S.R. Schofield, "Minutes of the 17th Viking Orbiter Design Team Meeting Held 20 March 1969," memo, 24 Mar. 1969; Charles W. Cole to James S. Martin, "JPL Resource Requirements for Viking Project," 10 Feb. 1969; Langley Research Center, "Viking Project Orbiter System (VOS) Master Working Schedule," 13 Mar. 1969; and LaRC, "Viking Project Orbiter System (VOS) Master Working Schedule," 7 Apr. 1969.

[172]....instruments and related equipment than JPL had planned. These schedule changes would have to be translated into direct dollar increases. But even extra dollars could do only so much toward relieving the problems imposed by the increased tempo. Cole wrote to Martin, "In JPL's opinion, the significant schedule risks not further reducible by bringing additional money and manpower to bear." What they would need was close coordination among the Viking Project Office at Langley, the lander contractor, and the JPL orbiter team to minimize the risks if they were to build a program that was "suitably balanced and mutually acceptable." **28**

During the spring months of 1969, the orbiter schedules were revised by the project office to give Pasadena teams some more time and the budget a little breathing room. Rising expenditures, however, continued to be a major concern of Viking personnel on both coasts, although evaluating the budget promised to become a more comprehensible, concrete process once the agency selected an industrial contractor to design and build the lander. Only then would they be able to determine a firm figure for he cost of the entire project. **29** In late February 1969, NASA had issued a request for proposals for the lander and, on 29 May, selected Martin Marietta Corporation from the three bidders for the contract. With this choice made (discussed in chapter 7), the Viking project entered a new phase.

Early in June when Jim Martin and his colleagues met with representatives from the new lander contractor and JPL, nine working groups were established. Of these, one of the most important, from the perspective of the budget and scheduling, was the spacecraft interface and integration working group. Formed as the common ground for discussion between the Viking Project Office at Langley and the spacecraft builders at JPL and Martin Marietta, this working group allowed the three organizations to exchange information and ideas on spacecraft construction and hardware interface. Donald H. Kindt at JPL was named the Viking orbiter/lander capsule integration engineer. The interface-integration working group met for the first time on 10 and II June and. after their sessions, representatives from all three organizations took "action items" home to consider before they met again. **30**

Another aspect of the increased tempo was the further proliferation of committees and working groups. By the end of June 1969, the amount of paperwork reaching Henry Norris's desk at JPL was growing dramatically. All managers in NASA programs, whether government or contractor employees, had to become accustomed to reading thousands of letters, memoranda, telexes, meeting minutes, reports, and other documents in the course of a project. Besides the meetings of the orbiter design team, 28 other conferences had been held by the end of June. The Viking orbiter project staff had held 12 meetings by 2 July, and the Viking orbiter mission design team started a new series of work sessions 30 June. By the time the orbiter was ready to fly the personnel of the orbiter design team (and its successor, the orbiter system design team), who oversaw the spacecraft's design and **[173]** fabrication would meet formally more than 250 times. The mission planners who worked out the flight details for the orbiter-navigation and tracking-met 143 times before the Viking launches.

Although Kermit Watkins noted as early as August 1969 that "we are beginning to become inundated with documentation," all the meetings and paper allowed Norris and his orbiter team to keep abreast of the myriad of details that went into planning and building the spacecraft. At the Viking Project Office in Hampton, Virginia, Jim Martin used similar tools to keep tabs on the progress or lack of progress of the lander. Viking was not brought to fruition by paperwork alone, but the mountain of documents the teams left behind provides some clues to the enormous number of man-hours that went into getting the project off the ground. **31**

During the remainder of 1969, the Viking orbiter personnel worked on a number of key tasks in defining the design of the spacecraft and the nature of its scientific payload. Norris participated in the first meetings of the Viking Project Management Council; Norris, Watkins, and their colleagues worked out the second and third versions of the "Viking mission definition" document; orbiter staff members received a briefing on the preliminary science results of Mariner Mars 69; and the staff took part in the first quarterly review of the whole project. These activities were typical of activities during the next five years.

Viking Project Management Council

Jim Martin formed the Viking Project Management Council*** in March 1969. Since Viking was the first planetary project in which several NASA centers and contractors would be participating in the design, development, and operation of major spacecraft elements, the project manager believed that a management council would "facilitate common understanding of the overall project objectives and provide a forum where technical and management problems can be freely discussed." At the first meeting, 18-19 August at the Martin Marietta factory outside Denver, each of the systems managers gave a brief status report on his organization's work to the 50 persons attending.

Henry Norris outlined the orbiter design, covering such topics as the relationship between the orbiter and lander during the cruise phase of the trip to Mars, the orbiter's weight budget, and communications equipment for the Viking spacecraft. Noting that orbiter and lander weights were a recurring concern, he told Martin and the other participants at the council meeting that a system of weight bookkeeping must be established between Langley and JPL. By this time, the entire spacecraft was projected to weigh [**174**] 3316 kilograms, with the weight of the orbiter at 605 kilograms without propellants. Jim Martin agreed; someone from the Viking Project Office would be assigned to the problem. Norris also reported that procurement had begun for the orbiter components and work was already under way on tasks that would require a long lead-time. The spokesman from JPL noted in summary that additional orbiter personnel at the laboratory would be selected shortly, including some persons that were finished with their Mariner 69 activities. [32]

Once all the systems managers gave their reports, l3 working group chairmen presented information about their work. Norris later told his colleagues at the Jet Propulsion Laboratory that the sessions "proved to be very beneficial in helping to identify and clear the air on a number of interface concerns." In particular, the two days of discussion helped to clarify the roles and responsibilities of individuals and organizations. [33] Equally significant, it gave the managers from scattered geographic locations an opportunity to meet with one another. Face to face, they could take the measure of their colleagues as they worked on problems of mutual interest. This and subsequent meetings of the management council would force the men to work with other human beings, not faceless signatures on memos. The council was just one part of Jim Martin's strategy for forging a team from a group of disparate individuals and organizations.

VIKING MISSION DEFINITION NO. 2

The Viking project definition document was another element in Jim Martin's attempt to create a viable Mars exploration activity. Revised several times, the document gave project participants a general description of the Viking missions. By August 1969, the document had been updated five times, the latest edition being called "Viking Project Mission Definition No. 2." This 21-page paper was prepared by a group working under A. Thomas Young, the science integration manager, at Langley. Three men had to approve it before it was released 11 August 1969-Gerald Soffen, project scientist; Israel Taback, engineering manager and deputy project manager; and Jim Martin. "Viking Project Definition No. 2" contained a more nearly complete description of the entry and lander science experiments that would be included in the lander capsule and the lander. These experiments had been defined through the work of the Science Steering Group, chaired by Jerry Soffen. [34]

In August 1969, there were eight science instrument teams: orbiter imaging, biology, molecular analysis, meteorology, entry science, radio science, seismology, and ultraviolet photometry. Each of the lander experiments was further described in the "Viking Lander Science Instrument Teams Report," which served as an important reference on the state of instrument design, the scientific rationale for the experiments, and for studies that might lead to ways of increasing the scientific capability of the instruments. The instrument team report and "Viking Project Definition [**175**] No. 2" provided the basis for spacecraft design negotiations with Martin Marietta and the starting point for "early Project activity including the initiation of mission, spacecraft and operations design." [35], Although the mission definition was geared toward getting lander hardware design and fabrication started, it also had significant impact on the orbiter design team.

Henry Norris told his people at a 27 August staff meeting that the mission definition had been distributed to all the JPL division representatives. Since this was a controlling document for the project, Norris's team would have to reconcile its "resources," or budget, with its baseline definition of the orbiter. Some differences existed, for example, between the communications requirements as stated in the definition document and as pursued by the JPL engineers. "The main requirement causing a significant impact is that of the orbiter having the capability to communicate with either lander." Norris asked division representatives "to flag any other areas of disagreement," [36]

As Norris and his staff worked on the orbiter design, the mission definition continued to evolve. A number 3 edition would be ready in January 1970 after the final selection of science investigators by NASA Headquarters in December.

The number 4 version would be prepared in the early spring of 1971, reflecting any changes that came from the Viking project critical design review. Finally, some time after June 1972, "Viking Project Mission Definition No. 5" would be issued to reflect lessons learned from the Mariner 71 mission. From October 1969 onward, the mission definition documents would be used in conjunction with "project specification" documents to monitor the effort. [37] Meanwhile, the science results from *Mariner 6* and *7* had to be incorporated into the Viking plans.

MARINER 69 SCIENCE RESULTS

Scientific investigators from the Mariner 69 team presented a series of briefings and press conferences on their findings from the Mars flyby missions. The first major briefing and press conference were held on 11 September 1969, the day the preproposal briefings for prospective Viking science investigators were scheduled in Washington. While less tentative than the results presented at a 7 August press meeting, John Naugle indicated that the September briefings were really only progress reports. The final meeting of the scientists was scheduled for spring 1970, and more detailed accounts of individual experiments would be published in various journals.

Robert Leighton described the results of the television experiment at the September science briefing. "Before the space age, Mars was thought to be like the Earth, polar caps, seasons,. . . .rotates in 24 hours, etc." This view of the Red Planet "was largely the legacy of Percival Lowell who popularized the idea of reclamation projects to get the water supposedly from the polar caps down to the equator where the farmers were." Although scientists **[176]** had rejected the Lowell ideas of an inhabited Mars long before *Mariner 4* , they were not prepared for the stark, lunarlike images acquired during that mission. Pictures from *Mariner 6* and *7* , according to Leighton, showed that Mars was "like Mars," with its own characteristic features, "some of them unknown and unrecognized elsewhere in the solar system." [38]

Leighton noted during the press conference that areas to be photographed by the Mariner 69 missions had been chosen to "cover as many different kinds of classically recognized features on Mars as possible, dark and light areas, oases." *Mariner 6* 's track traversed the equatorial zones and crossed a great many light areas, such as the circular great desert of Hellas, "and dark areas, like the region called Hellespontus. *Mariner 7* took a sweep of pictures along a meridian (north to south) that included the south polar cap. The 60-fold increase in the data transmission rate produced for the 1969 spacecraft yielded many more pictures than the scientists had originally hoped.

Table 29

Pictures from Mariner Mars 69

.	Original Projection		Pictures Returned		.
Mission	Far Encounter	Near Encounter	Far Encounter	Near Encounter	Total Useful Pictures
.					
Mariner 6	8	25	50	26	428
Mariner 7	8	25	93	33	749
Total	16	50	143	59	1177

Because of the large number of craters, the television team described Mars as more moonlike than Earthlike. In the *Mariner 6* near-encounter frame 21, which covered a territory of 625 000 square-kilometers, there were 156 craters ranging in diameter from 3 to 240 kilometers, There were many hundreds more that were 500 meters across or smaller. The classical area Nix Olympica (18°N, 133°) was identified as a very large, "white-rimmed" crater some 500 kilometers in diameter, with a bright spot in the center. Cratered terrain, the parts of the Martian surface on which craters are the dominant topographic form, were widespread in the southern hemisphere. Although knowledge of cratered terrain in the northern hemisphere was limited, since fewer photographs were available, some cratered areas appeared as far north as

20°. Two kinds of craters were seen in the pictures, large and flat-bottomed and small and bowl-shaped. Flat-bottomed craters were most evident in *Mariner 6* frames 19 and 21, and their diameters ranged from a few kilometers to a few hundred. Shallow, they had a diameter-to-depth ratio of 100:1. The smaller, bowl-shaped craters, best seen in *Mariner* **[177]** *6* frames 20 and 22, resembled lunar primary impact craters, and some of them had interior slopes steeper than 20 degrees. The flat-bottomed craters were of interest to the Mariner 69 investigators because they were unlike most craters discovered on the moon.

The chaotic terrain seas a puzzle. *Mariner 6* frames 6, 8, and 14 illustrated "two types of terrain-a relatively smooth cratered surface that gives way abruptly to irregularly shaped, apparently lower areas of chaotically jumbled ridges." A belt of the latter terrain lay within a band 1000 kilometers wide and 2000 long at about 20¡ south, between the dark areas Aurorae Sinus and Margaritifer Sinus. Perplexing the scientists because it was nearly craterless, this region of short ridges and depressions was unlike anything on the moon.

Hellas, centered at about 40° south, was the best example of the so-called featureless terrain. At the resolution limit of the 1969 cameras (the cameras could not see objects smaller than 300 meters in diameter), this desert area appeared devoid of craters. Leighton and his colleagues noted: "No area of comparable size and smoothness is known on the moon. It may be that all bright circular 'deserts' of Mars have smooth floors; however, in the present state of our knowledge it is not possible to define any significant geographic relationship for featureless terrain."

Especially bothersome was the fact that pictures taken during the *Mariner 7* traverse showed that the dark area Hellespontus, west of Hellas, was heavily cratered. "The 130- to 350-kilometer-wide transitional zone is also well cratered and appears to slope gently downward to Hellas, interrupted by short, en echelon scarps and ridges." Once the flat floor of Hellas was reached, the craters disappeared. "Craters are observed within the transitional zone but abruptly become obscured within the first 200 kilometers toward the center of Hellas." The possibility of an obscuring haze was rejected because in *Mariner 7* frame 26 "the ridges of the Hellas-Hellespontus boundary are clearly visible, proving that the surface is seen; yet there are virtually no craters within that frame. Thus the absence of well-defined craters appears to be a real effect." [39]

In seeking to explain the relationship of these various kinds of terrain to the light and dark markings noted in telescopic observations, Leighton and his colleagues had a number of thoughts. First, the contrast of light and dark markings on Mars varied with wavelength, as had been known for a long time from telescopic photography. In the violet range of light, "bright" and "dark" areas were essentially indistinguishable since they have approximately the same reflectivity. With increasing wavelength, contrast was enhanced as redder areas became relatively brighter. The distinction between bright and dark areas on the surface was usually more obvious in far-encounter views than in near-encounter views. The clearest structural relationship between a dark and a bright area was that of Hellespontus and Hellas. Chaotic terrain appeared lower in elevation and at the same time more reflective than the adjacent cratered areas. Whether chaotic....

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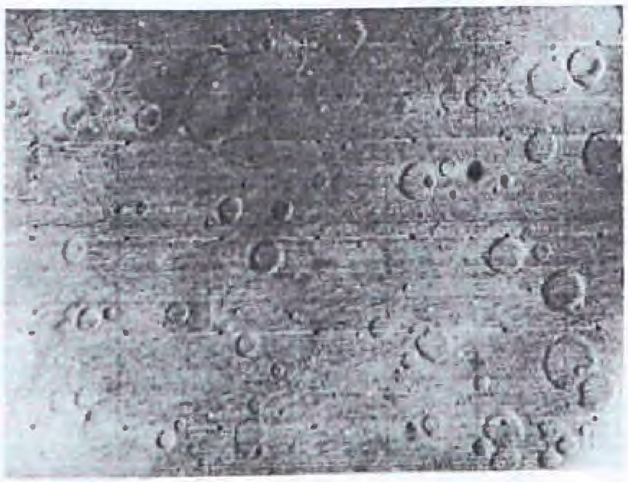
[178]



Mariner 6 took near-encounter photos of Mars on 31 July 1969. Frame 19 (above), 3613 kilometers from the surface, shows flat-bottomed craters a few kilometers to a few hundred wide. High-resolution frames 20 (left) and 22 (below) show smaller, bowl-shaped craters, resembling primary impact craters found on the moon.

[179]....terrain was extensive enough to include previously identified bright areas remained to be determined, Still, some of the areas traditionally thought of as oases were being identified with large, dark-floored craters such as Juventae Fons or with groups of craters such as Oxia Palus. In addition, at least two classical "canals" (Cantabras and Gehon) coincided with the quasi-linear alignment of several dark-floored craters, Other canals, showing up as irregular dark patches, would probably on closer inspection be associated with a variety of physiographic features. Leighton and his colleagues reported another correlation with earlier observations, Some drawings and "maps" of Mars portrayed a circular bright area within the dark region south of Syrtis Major and east of Sabaeus Sinus, In the Mariner 69 pictures, the investigators found a large crater in approximately the same place, The experimenters hoped to devote many hours to a comparison of these new Mariner pictures with earlier maps and photographs in an attempt to identify topographical features.

Clues to Evolution of Mars

What did the *Mariner 6* and *7* pictures tell scientists about the evolution of the planet's surface? The absence of Earthlike tectonic forms indicated that in recent geologic time the crust of Mars had not been subjected to the kinds of internal pressures that have modified and continue to modify the surface of Earth. Since the larger craters probably had survived from a very early time in the planet's history, the scientists inferred that Mars' interior is, and probably has always been less active than Earth's. The TV experimenters noted that one theory argues that Earth's "dense, aqueous atmosphere may have been formed early, in a singular event associated" with the creation of the planet and its core. Tectonic features, therefore, might be related in origin to the formation of a dense atmosphere, and "their absence on Mars independently suggests that Mars never had an Earthlike atmosphere."

Building their case further for the unearthly nature of Mars, the television specialists commented on the age of the cratered terrains, comparing Martian surface features with similar features on the moon. Both bodies showed heavily cratered and lightly cratered areas, evidently reflecting regional differences in meteoroid bombardment, or response to it, over the life-span of the surfaces. The thin atmosphere on Mars (contrasting with no atmosphere on the moon) possibly had produced recognizable secondary effects in crater form and size distribution. Also, the scientific community generally accepted that the number of craters on the moon could not have been produced in its 4.5 billion years at the estimated present rate of impacts. An early era of high bombardment must have been followed by a long period at a greatly reduced rate. A rate per unit area as much as 25 times that on the moon was estimated for Mars. Since even the most heavily cratered areas seemed to have aged relatively uniformly, "this again suggests an early episodic history rather than a continuous history for cratered Martian terrain, and increases the likelihood that cratered terrain is primordial."

[**180**] The existence of primitive undisturbed terrain on Mars would have a number of important ramifications, especially for scientist looking for extraterrestrial life:

> If areas of primordial terrain do exist on Mars, an all important conclusion follows: these areas have never been subject to erosion by water. This in turn reduces the likelihood that a dense, Earth-like atmosphere and large, open bodies of water were ever present on the planet, because these would almost surely base produced high rates of planet-wide erosion. On the Earth, no topographic form survives as long as 108 [100 million] years unless it is renewed by uplift or other tectonic activity. [40]

Extrapolating further from this line of reasoning, the scientists found that the Martian environment apparently had not changed much during the life of the planet; thus, there was little possibility of a dense atmosphere or water that could have aided the evolution of primitive life forms.

Norman Horowitz, a biologist at Cal Tech and long-time participant in NASA exobiology studies, thought nothing in the new data encouraged the belief that Mars harbored life, "But the results also don't exlude this possibility." This was essentially what the exobiologists had expected, since Martian life was almost certainly microbial if it existed and would not be easily detected from flyby missions. "We have certainly seen no signs of the noble race of beings that built the canals or launched the satellites of Mars, I'm pretty sure they don't exist." *Mariner 6* and *7* data did strengthen the earlier conclusion that water was extremely scarce on Mars and that was a seriously limiting factor for the search for life. While no clouds, frosts, or fogs had been seen in the new pictures, minute amounts of water vapor had been detected in the atmosphere. "Mars is a cold desert by terrestrial standards. If there is life on Mars, it must be a form of life that can utilize water in the form of water vapor or ice." Horowitz added that it was possible that extensions of our own terrestrial life, evolutionary adaptations," could live under such conditions. The exobiologist repeated what he had said many times: "The search for life on Mars is not sustained by optimism about the outcome. Anyone who is carrying on this work because he is sure he is going to find life, I think, is making a mistake. The search is sustained by the tremendous importance that a positive result would have, scientifically and philosophically, and until then we are obliged to continue the search." One of the major reasons they were exploring the Red Planet for life was to test their current notions about the origin of life. "We don't want to fall into the logical trap of using these notions to disprove in advance the possibility of life on Mars. We want to get there and make a direct test." [41]

Effects on Mariner 71 and Viking

Leighton, during the 11 September 1969 press conference, said that each Mariner spacecraft had "in its turn revealed a new and unexpected, no doubt significant kind of terrainNow I leave it to you to figure out how many new surprises there are still waiting for us on Mars." While Mars [**181**] spacecraft evolved from one mission to the next, Leighton believed that he and his colleagues should not "fight the last war" with the Viking spacecraft. Instead, they must realize that they were still only its the initial stages of exploring Mars. "Flexibility in design [and] adaptability in execution" were incredibly important. [42]

The distinctive new terrain revealed in the Mariner 69 pictures emphasized the importance of "an exploratory, adaptive strategy in 1971 as opposed to a routine mapping of geographic features." Very early in the first 90-day Mariner 71 mission, all of the planet should be examined with the A-camera, and selected targets should be studied with the higher-resolution B-camera, to correlate the extent and character of cratered, chaotic, and featureless terrains, and any new kinds of terrain, with classical light and dark areas, regional height data, and so on. Leighton and colleagues thought that a second objective should be the search for and examination of areas that indicated the possible presence of local water. The complex structure found in the south polar cap called for close investigation, particularly to separate the more permanent features from those varying daily or seasonally. A look at the north polar cap also promised to be "exceedingly interesting."

"If the effects of the Mariner 6 and 7 results on Mariner '71 are substantial, they at least do not require a change of instrumentation, only one of mission strategy. This may not be true of the effects on Viking '73." The Mariner 69 television specialists believed the discovery of so many new, unexpected properties of the Martian surface and atmosphere added a new dimension to selecting the most suitable landing site for Viking. Viking might be even more dependent on the success of Mariner 71 than had been supposed. From the improvement in the image resolution obtained by the 1969 B-cameras, scheduled also for use on Mariner 71, the team thought that an improved system might profitably be included in the Viking orbiter, designed to examine the fine-scale characteristics of terrains even more closely before choosing a landing site. [43]

At its 11 September meeting, the Viking Science Steering Group agreed that a joint meeting of Mariner 69, Mariner 71, and Viking 73 scientists would be useful. Jerry Soffen suggested that such a session would permit a more thorough examination of the *Mariner 6* and *7* information. At the same time, the science strategies for later flights to Mars could be more widely discussed, Plans called for the joint meeting to be held in early 1970 after the final selection of Viking investigators. Generally, Viking interest in the polar regions as a target for primary investigation diminished after hearing the early Mariner 69 reports." [44]

The Viking orbiter science briefing on 12 September concentrated largely on the orbiter imaging system and its role in providing pictures that would help find landing sites. Orbiter science objectives included:

- obtaining information for landing site selection for Viking,
- **[182]** obtaining repeated coverage of landing sites during the lifetime of landers on the surface,
- obtaining information for selecting landing sites for future missions,
- making scientific investigations using the orbiter radio System, and
- obtaining information for studying the dynamic characteristics of the planet and its atmosphere.

Of the 57 kilograms allotted for orbiter science instruments, more than half (32 kilograms) was set aside for the imaging system. For many months, the specialists would discuss alternative approaches to the design of the camera system, as technical and fiscal issues affected the final design of this important piece of Viking hardware. [45]

QUARTERLY REVIEW

As another step toward regularizing the management of the Viking "project, Jim Martin arranged for the first of a series of project-wide quarterly reviews at the end of the first week of October 1969. Each systems manager was given 90 minutes to summarize progress in his area of responsibility. Henry Norris noted that this process was less detailed than the reports he had given in similar reviews at JPL in the past; instead his presentation was" delivered in tutorial style." [46] What is the orbiter? What is its function? How does it work? What is the progress to date? Are there any problems? If so, do they affect other systems and what steps are being taken to solve the difficulties? Over two days, many, many topics were covered.

The JPL presentations on the orbiter were typical of those given during the quarterly review. Norris opened with a brief overview of the schedule for the orbiter and his projected activities for the next three months. Richard K. Case of the orbiter design team reported on the configuration of the orbiter as it had evolved to date, summarizing telecommunications plans for the orbiter, lander, and Earth stations and briefing the group on steps being taken to integrate scientific experiments. Peter T. Lyman told his colleagues about the orbiter guidance and control propulsion subsystem, a complex subject to master. Lyman, a new member of the orbiter team, was the perfect man to tackle it. After 10 years at the University of California at Berkeley, he had worked on Mariner 64 and helped plan hardware for the ill-fated Voyager. During Mariner 69, Lyman had been the project engineer from the Engineering Mechanics Division, overseeing much of the construction of the two successful Mariner craft. G. P, Kautz, in his turn, reviewed the manpower and funding JPL would need to develop the orbiter, closing with a list of the problems it faced. [47]

[**183**] The quarterly review was followed up by two additional meetings in October. Langley Director Edgar Cortright held a session for the other center directors and key Viking project personnel, and Jim Martin convened a Viking Project Management Council meeting. The consensus was that the project was off and moving at a reasonable pace. Fewer problems seemed to have surfaced than might have been expected at this stage. Harris Schurmeier, the Mariner 69 project manager, noted that Viking was more complex than earlier projects because so many more partners were in the game. With all the different groups involved and with the limited dollars available, he thought the participants needed to establish clearer channels for handling problems.

Jerry Soffen also commented on the need for better communications. Although the quarterly review had been held to secure the participation of the many constituencies in the decision-making and reporting process, many of the scientists had left the meeting before the second day's discussions. Soffen's observation triggered a 45-minute session on how best to integrate the scientists into the project. Nearly everyone agreed that the investigators had to understand the fiscal and technical aspects of Viking so that they could appreciate the relationships of their own activities to the whole enterprise. The scientists would have to learn that their experiments were only a part of a very large undertaking. [48] As the specialists returned to....

Table 30

Viking Project Orbiter System: Critical Schedule Activities, 1969

Activity	Required Date
.	
Project spec approved	1 Dec. 1969
Orbiter investigators identified	15 Dec. 1969
Concepts approved and first drafts covering orbiter-lander interfaces	1 Nov. 1969 to 2 Jan. 1970
Orbiter system design concepts and general configuration established to allow subsystem function and design requirements to be prepared	15 Jan. 1970
.	
Critical problems:	
1. Many activities must start with preliminary data, requirements	
2. Schedules must be achieved	
3. Little or no recovery time	

SOURCE: Martin Marietta Corp., Denver Div., "Viking Project Quarterly Review Held October 7 & 8, 1969 at Langley Research Center; Presentation Material," PM-3700005, Oct. 1969. Since events were to alter the Viking's project's calendar, the systems management offices would be forced to revise their plans many times. This is one early schedule.

[184] Table 31

Viking Project Orbiter System: Baseline Conceptual Design Changes, Expected Weights, 1969

Item Changed	Baseline Weight (kg)	Expected Weight (kg)	Cause
.			
Orbiter (less propulsion)	627	606	1. Design to "flight loads" analysis
			2. Use of lightweight solar cells
			3. Reevaluation of expected subsystem weights

Propulsion (inerts and residuals)	385	302	1. Substitution of helium for nitrogen as pressurant
			2. Reduction of required Delta V = 1575 mps to Delta V = 1420 mps
			3. Increase in nozzIe expansion ratio frmn 40:1 to 60:1
Usable propcellant	1420	1263	4. Use of selected injectors for I_{sp} = 289 sec.
Lander capsule adapter	22	21	1. Design to "flight loads" analysis
Lander capsule	816	995	.
Spacecraft adapter (includes destruct package and transition adapter)	149	130	1. Design to "flight loads" analysis
.			
Viking spacecraft launch weight	3419	3317	.

SOURCE: Martin Marietta Corp., Denver Div., "Viking Project Quarterly Review Held October 7 & 9, 1969 at Langley Research Center: Presentation Material." PM-3700005, Oct. 1969.

. . . .their various tasks after the saturating experience of the review at Langley, storms began to gather on the project's horizon.

During the remainder of 1969, one of the questions that nagged NASA managers who were looking for ways to pare the budget was, Is the orbiter essential to the Viking mission? This was an especially difficult question because eliminating the orbiters would obviously save a great amount of money, $100-165 million. For project personnel at headquarters and Langley who thought that the direct- versus out-of-orbit delivery issue had been settled nearly a year before, the revival of this question was disturbing.

On 13 September 1969, NASA's Lunar and Planetary Missions Board, an advisory group, agreed that the orbiters should be preserved, as they would give greater mission flexibility and a higher chance of mission success. When released from orbit, the landers could be expected to touch down in an elliptical area (called a footprint) 180 by 530 kilometers; with a direct entry that footprint would be increased to 500 by 900 kilometers. An **[185]** orbiter-based mission would use the orbiter cameras to survey potential landing sites, which although not guaranteeing success would permit the Viking team to assess and eliminate obviously hazardous landing regions. But most significant, an orbit relay link would allow two-thirds more information to be sent to Earth than the lander alone could manage. With these considerations, the Lunar and Planetary Missions Board drafted the following resolution:

> A balanced program in develop a deeper understanding of man's neighborhood of the universe should remain a goal of NASA's lunar and planetary program. After examining Mariner 6 and 7 results, the [Lunar and Planetary Missions Board] emphasizes that landing of scientific instruments on Mars in 1973 remains a task of major importance.
>
> The cost of the Viking program now represents a substantial part of the funds at present available to the planetary program. Nevertheless, the[Lunar and Planetary Missions Board] considers the Viking program should go forward as planned.
>
> A Mercury-Venus flyby, the continued exploration of Venus, the introduction of a small planetary orbiter program, and the initiation of a major program to explore the outer planets are all essential to an orderly exploration of the solar system. NASA should develop those programs as required for this exploration. [49]

Although there would be several delays and unexpected twists and turns along the way, this resolution described the basic Strategy NASA's planetary programmers would follow during the 1970s. Before it could be implemented, however, Walt Jakobowski and his team in the Viking Program Office at NASA Headquarters had to fight many battles just to preserve the basic Mars orbiter-lander mission. All of their work would be affected by a worsening budget crisis in Washington.

MONEY PROBLEMS AT NASA

The summer of 1969 was a time for triumph and despair. *Apollo 11* landed on the moon in July, but at almost the same time NASA's budget was cut severely. Despite being an enthusiastic supporter of the Viking project and wanting to pursue an aggressive program of unmanned planetary exploration, Thomas O. Paine, appointed administrator in March, began to preach fiscal restraint to the Viking managers as early as June 1969. He told John Naugle, his associate administrator for space science and applications, that Viking and the other advanced planetary projects would have to be managed wisely because NASA was living in an era of great pressures to reduce the budget. The space agency's expenditures were being subjected to considerable public scrutiny and debate. [50]

Paine's worries were well founded. When the House Committee on Appropriations reported 19 June on the NASA budget request, the projected fiscal 1970 funds were nearly $300 million less than the previous year. **[186]** Five days later, the Senate Committee on Aeronautical and Space Sciences recommended a further reduction of $250 million. Late in July, Paine talked with President Richard M. Nixon about the space program as they flew to the Pacific splashdown site of *Apollo 11* . The president said that he personally was very enthusiastic about American space activities, but his administration could not direct large amounts of resources to the space program until the war in Vietnam had been ended. Nixon was reflecting the budget-cutting mood of Congress and the lack of public support for new space initiatives. Reactions to the report of the president's Space Task Group also affirmed the need for a fiscally responsible space program. [51]

To develop goals for the post-Apollo period, President Nixon had appointed a special Space Task Group[****] in February 1969. Although acknowledging that a new rationale for the American space program had to be sought - competition with the Soviet Union was no longer a realistic justification for NASA's activities-the task group rejected the idea that a manned mission to Mars in the 1980s should be the next great challenge accepted by the United States. The negative responses made on Capitol Hill and in the press to the manned Mars goal reinforced the group's decision. A July 1969 Gallup Poll, for instance, found 39 percent of 1517 persons polled nationally favored attempts to land a man on Mars; 53 percent opposed. Of the 21- to 29-year-olds, 54 percent favored the project and 41 percent opposed, but 60 percent of those over 50 opposed. [52]

As delivered to President Nixon on 15 September, the Space Task Group's report, *The Post-Apollo space Program: Directions for the Future* , had backed away from an early manned landing on the Red Planet. The focus for the next decades in space was on the development of hardware and systems that would ultimately support a manned mission to Mars at the close of the 20th century. After a presidential briefing on the report, Nixon's press secretary said that the president agreed with the group's rejection of an overly ambitious program aimed at an early landing on another planet but also with its refusal to propose a program that would terminate all manned space activities in the post-Apollo years.[53] Six months were to pass before President Nixon personally reacted to the task group's findings, and by that time Congress, through the appropriation process, had shaped the immediate future for NASA's programs by restricting the agency's budget even further.

As the budget for fiscal 1970 went through successive parings and the public enthusiasm for space projects continued to dwindle, Naugle and his associates at NASA Headquarters grew more and more concerned about the continuing increases in costs for Viking. On 26 August 1969, Naugle wrote Ed Cortright and other top Viking managers to review his "personal **[187]** philosophy" on the subject. Naugle told the Langley director that "current indications of an increase over earlier estimates are of concern; particularly in light of the need to minimize Federal expenditures." He was especially worried about "cost overruns which in times of tight budgets, will inevitably result in disruption to the Viking Project or to other projects." While the associate administrator recognized the importance of the Mars mission and while he did not care to "establish arbitrary or unrealistic cost ceilings" that could also jeopardize the success of the effort, he did want everyone in the Mars project to ensure "that Viking [was] tight, efficient, well-engineered, and well-managed." Every effort had to he made to use existing technology "to minimize development risks and associated costs." Naugle recommended a very careful study of the proposed test program to determine if any paring could be done in that area. "While we cannot omit necessary development and tests, neither can we tolerate frills." [54]

But the costs for Viking continued to grow. When first presented to Congress in March 1969, the Viking price tag had read $364.1 million, an unsound estimate. At the time, the design of the spacecraft had not been clearly defined. By August, the expected cost had risen to approximately $606 million, with an additional $50 million for the launch vehicles. In testimony before the Subcommittee on Space Science and Applications of the House Committee on Science and Astronautics in October, Naugle admitted that the total cost of Viking would run about $750 million. Representative Charles A. Mosher of Ohio asked Naugle what he meant when he said that the $750 million "included an allowance for a minimum number of changes." The NASA spokesman responded that past experience with planetary programs indicated that the agency could expect a 15 to 20 percent increase in the cost of a given project. "So, in the case of Viking, we are including in this $750 million estimate about $100 million for mandatory changes or for trouble that we may get into in the project." NASA was using $650 million as its target, but Naugle told the congressmen that "we are only so wise and only so able to foresee into the future."

Representative Thomas N. Downing of Virginia expressed his concern about these projections since they had already grown more than 30 percent to little more than a year. Naugle noted that the figures presented in 1968 were based on a still poorly defined spacecraft. "What we have founds that we underestimated the weight of both the orbiter and the lander." The additional weight could be translated into more man-hours of labor, which to turn could be translated into more dollars. On top of that, the cost of those man-hours had also increased. All the congressmen were disturbed. Joseph E. Karth, the subcommittee chairman, pointed out that his group had to sell these cost escalations on the House floor and it would not be easy. Naugle's statements that everything was being done to keep costs in line were not all that reassuring to Karth, who believed that NASA had "so far failed miserably in that regard." After trying to convince the subcommittee that the agency had "made a substantial effort to accurately determine **[188]** funding requirements before beginning hardware development," Naugle and his staff renewed their attempts to control the project managers. Since Congress would not suffer another project with a huge cost overrun, Don Hearth and others working for Naugle sought to establish controls over Viking that would prevent sudden and unexpected expenditures by the engineers in the field. [55]

For all their concern and activity, the men at NASA Headquarters could not prevent the budget crisis. When President Nixon signed the fiscal 1970 appropriations bill on 26 November, the total amount - $3.697 billion- was $299 million less than appropriated the previous year. At the same time, the Bureau of the Budget was already beginning to chip away at the dollars the space agency was seeking for 1971. Robert P. Mayo, director of the Bureau of the Budget, found himself in an awkward position; he had promised President Nixon a balanced budget, but finding places where he could reduce expenditures was very difficult. Throughout the fall of 1969, a stiff debate ran between the space agency and the budget people, and some of the meetings Paine, Mayo, and their staffs held were not pleasant.

In light of the Space Task Group's report, Paine reasoned that he could not recommend a budget of less than $4.25 billion for NASA. He told Mayo in a letter: "This is a difficult time. Please do not think me unfeeling toward the many claimants for your scarce budgetary resources." But Paine thought that inefficient agencies were being rewarded with increased budgets while NASA was being penalized. "The people of NASA have produced outstanding resultshile reducing costs and personnel more than any other area of government. . . . .Space offers the President now a highly productive program and his greatest leadership opportunity." Unfortunately, the dollars did not go to the successful. [56]

For Viking, the budget cut was devastating. Before Congress had a chance to consider the budget, Nixon's administration cut $20 million from the amount requested for the Mars lander project for 1971. The picture was unpleasant. With the decline in resources, aggravated by inflation, Administrator Paine had to reduce expenditures. [57]

Table 32

NASA Appropriations, FY 1968-1971 (in billions $)

Budget Item	FY 1968	FY 1969	FY 1970	FY 1971
Total NASA budget	4.5889	3.9952	3.6967	3.3126
Lunar & Planetary Programs:	.1250	.0923	.1388	.1449
Mariner Mars 71	-	-	.0454	.0296
Viking 73	-	-	.0400	.0350
Mariner Venus Mercury 73	-	-	.0030	.0211

[**189**] Paine was convinced that the only alternative to the delay of Viking was its cancellation. At noon on 31 December 1969, Paine told John Naugle that further analysis of the federal budget for 1971 by the Bureau of the Budget had disclosed a $4-billion problem; NASA had been asked to reduce its request by $225 million. The administrator and his associates considered three ways to cut dollars-delay Viking from 1973 to 1975; cut the Viking orbiter completely and reduce further the Office of Manned Space Flight budget; or eliminate manned flights after the final Skylab flight in 1973. The second and third options would not provide the necessary reduction, and the Bureau of the Budget, with President Nixon's agreement, thought that deferral of Viking was the best step. Naugle spent the rest of that day working out the details of Viking's slip, taking time out to note for the record: "1 left at 4:30pm to welcome the New Year and the new decade in a bleak mood-feeling that two years of careful planning for Viking had been wiped out in four hours by a combination of a budgetary error and the article in the [Washington] Post on Monday, 29 December, by Cohn stating that scientists at the [American Association for the Advancement of Science] Meeting had advocated a reduction in the NASA science program." NASA's space projects were under criticism as part of a general outcry against federal spending that did not contribute to the solution of social problems like pollution and feeding the poor. While scientist Carl Sagan pointed to the Defense Department as the real source of budget misallocations, other "authorities" questioned NASA's current proposals to send manned missions to Mars. Caught in the midst of the antimilitary, antitechnology furor was Viking. During the last hours of 1969, NASA nearly lost another opportunity to land on Mars at all. [58]

After two weeks of scrambling to reorganize the space agency's programs, Tom Paine made a public statement of the changes the 1971 budget would require. Mindful of recent criticisms, he commented:

> We recognize the many important needs and urgent problems we face hereon earth. America's space achievements in the 1960's have rightly raised hopes that this country and all mankind can do more to overcome pressing problems of society. The space program should inspire bolder solutions and suggest new approaches.NASA will press forward in 1971 at a reduced level, but in the right direction with the basic ingredients we need for major achievements in the 1970's and beyond.

While NASA diminished its total activities, the agency would "not dissipate the strong teams that sent men to explore the moon and automated spacecraft to observe the planets." Paine listed the following actions as being consistent with the requirements of the 1971 budget:

> 1. We will suspend for an indefinite period production of the Saturn V launch vehicle after the completion of Saturn V 515.
> 2. We will stretch out the Apollo lunar missions to six-month launch intervals, and defer lunar expeditions during the [Apollo Applications [**190**] Program] space station flights in 1972 [actually flown in 1973, as Skylab flights.]
> 3. We will postpone the launch of the Viking/Mars unmanned lander from 1973 to the next Mars opportunity in 1975.

With the closing of the Electronics Research Center in Cambridge, Massachusetts, these actions would reduce the number of persons (including contractors) working on NASA projects from 190 000 at the end of fiscal 1970 to about 140 000 at the end of fiscal year 1971. [59]

Although Viking survived, there was considerable confusion at first over what the modified project would be. Henry Norris and his orbiter teammates officially learned about the change in plans on 12 January 1970. [60] At the Viking Orbiter Staff meeting in Pasadena the next day, Norris explained that they had been asked to examine two alternatives for 1975 Viking missions- the basic 1973 orbiter-lander mission rescheduled for 1975, or a direct-entry lander mission. This renewed debate over what was called "Options A and B" brought a sense of *deja vu* among the working people. [61]

Besides an additional direct dollar cost of about $102.2 million, JPL learned from the program office at headquarters, other problems were associated with deferring Viking to 1975. Steps would have to be taken to bolster morale among the scientists and engineers. The several false starts on Viking's predecessors and the cancellation of Voyager had already discouraged many. As with all complex projects, a strong and highly motivated team was essential for success, and a limited sum of money would have to be made available during fiscal 1970 and 1971 to hold the existing team together and permit some meaningful work on the aspects of the mission that would pose the greatest technical challenges. The balance of the Viking project would be budgeted at 1970 levels, but slipped two years. An additional five percent would be added to compensate for possible inflation.

William J. Schatz of the JPL Propulsion Division pointed out two other problems caused by the delay. A mission in 1975 would require a longer flight time; Mars's position relative to Earth would require a different trajectory. Previously, the mission analysis and design people had used Voyager 1973 work to plan for the 1973 Viking flight. A 1975 launch would require the specialists to start trajectory and flight path analyses from scratch. New calculations would demand more manpower and computer time, both of which cost money. Hardware alterations would also be required. Changes in the materials used for the propulsion systems might be necessary to ensure their reliability, and the use of helium as a pressurant would have to be reevaluated. But beyond these technical considerations was the economic impact of the stretchout. "Of prime importance," said Schatz, was the retention "of a qualified team of engineers at the rocket engine contractor during the stretchout period." The engine manufacturer, Rocketdyne, a division of North American Rockwell, was already laying off **[191]** personnel, "jeopardizing their ability to support our development program." Other vendors were either closing their doors or dropping assembly lines for certain components because of the general poor condition of the economy. JPL was planning to procure many items it needed for Viking as soon as possible and place them in bonded storage until it was ready to assemble the spacecraft. [62]

During late January and early February, NASA Headquarters, Langley, and JPL personnel continued to evaluate the future course of Viking. After receiving a 28 January briefing by various Viking staff members, John Naugle decided on 10 February that the agency would pursue its original plan to fly an orbiter-lander combination. Positive words of support for the Viking team were put on record by George M. Low, NASA deputy administrator, and Naugle. Both men knew that the real work had just begun, but they appreciated the teamwork displayed during the latest crisis. Low told his colleagues, "Viking holds the highest priority of any project or program in NASA's Planetary Program. Viking holds a high priority among all of NASA's programs." [63]

The Space Science Board of the National Academy of Sciences also underscored the value of continuing with Viking, but the board's endorsement carried some reservations. Philip Handler, president of the Academy, had suggested to NASA Administrator Paine in mid-November 1969 that a Space Science Board review panel be established to evaluate the balance among the scientific disciplines supported by space agency funds. The last such review had been held in July 1966 at a time when National Academy and NASA personnel had assumed that the budget for space activities would continue to increase. Paine accepted Handler's offer, but advised him and his colleagues to weigh carefully the impact of any recommendations to shift money from one project to another. Any recommendations to cancel programs that had already gone through an elaborate approval process within NASA would, in the existing budgetary climate, "almost certainly lead to the curtailment of the on-going [programs] with little chance that additional funds [would] become available for [any] program which the Board feels should be increased." [64]

The Space Science Board team that evaluated NASA's space science activities was known as the Viking Review Panel, reflecting the amount of money being spent on the Mars project and the concern generated by the postponement of the Mars landing. The panel report issued on 24 March 1970 combined praise and concern. NASA was complimented for its work to defining a project that accurately reflected the payload recommendations of the Space Science Board's 1968 study, *Planetary Exploration, 1968-1975* . Cost projections, however, caused some division among the members of the panel. Some believed that the potential return from the Mars mission was so great that $750 million was justified. Others expressed concern that "within the extremely restricted budgetary climate, NASA must set much more limited goals for itself in order to achieve a balanced scientific effort." This **[192]** latter group feared that Viking's high cost would cause the space agency to lose other "less costly by equally valuable missions."

Some participants in the review were worried about the complexity of the Viking science payload, the most sophisticated payload planned to date, with many new experiments. A two-year delay of the Viking launch might indeed be beneficial. "The additional two years can be devoted to an extensive test of the abilities of the payload, increasing confidence in [it]."

Since it appeared that future budgets for space activities would be low, the Viking Review Panel recommended that "considerably more modest planetary missions" be initiated in the years to come. Single, complicated, expensive projects like Viking were too risky-politically and technologically. Realistically appraising the Viking Review Panel's pronouncement, John Naugle told Paine, "It is, I think, in view of the talk by the scientific community these days, an accurate and as good a statement about Viking as we could expect." [65]

WORKING TOWARD JULY 1975

Money problems would always haunt the Viking project. The scarcity of dollars especially affected the development of the lander and its science payload and repeatedly tried people's patience and equanimity. Early in 1973, Joseph R. Goudy, the Langley Viking Project Office resident engineer at JPL, commented on budget cuts that led to the dismissal of about 200 employees at the California laboratory on rather short notice:

> These cutbacks have created a different atmosphere and environment, resulting in a change in attitude. Six months ago, when the [Viking Project Office] came in with a new requirement or direction that required additional or premature effort, it was generally accepted with the attitude. "We don't think it's necessary but it's their money; if they want it, we'll do it." Now, with the Orbiter having to take rather severe cuts, this is no longer considered "their" money and the attitude has become much more critical. if not down-right hostile. [66]

Henry Norris, looking for ways to keep his orbiter personnel from reacting too negatively to the repeated budget cuts, tried to convince them-and for the most part he succeeded-that the budget was just one of the many realities that a good engineer or manager had to live with and work around as he tried to do his job.

The tasks assigned to the orbiter teams were laid before them in a five-year schedule, which ended with a pair of mid-summer 1975 launches. The master plan was presented for the first time at the Viking Project Management Council meeting in February 1970, and it reflected the changes brought by the stretchout.

The pace of the work at JPL assumed a rhythm familiar to the people who had worked on other NASA projects. The determining factors, "drivers"....

[193] Table 33

Viking Orbiter Schedules

Event	Proposed before	Proposed after	Actual
	1 Jan. 1970	1 Jan. 1970	Dates
Preliminary design review	May 1970	Jan. 1972	19-20 0ct. 1971
Critical design review	June 1971	Jan. 1973	9-IO July 1973
Start proof-test spacecraft test	Aug. 1972	March 1974	Jan. 1974
Qualification test completed	Nov. 1972	July 1974	Jan. 1975
Shipment of first flight hardware to KSC	Feb. 1973	Dec. 1974	Feb. 1975
Launch	July 1973	July 1975	20 Aug. 1975
			9 Sept. 1975

SOURCE: Information on the 1970 master plan was awaken from Henry Norris, "Viking Orbiter Project Staff Meeting-Minutes of January 13 and 14, 1970," memo, 19 Jan. 1970.

....in NASA parlance, for the designers and engineers were master schedules that determined when major hardware components had to be completed so the launch dates could be met. But the realities of designing and building the spacecraft did not always conform to calendar milestones, and the variance led to frequent revisions of the schedules. At every step along the way, the work was formally documented in a large number of Viking project documents. By cross-checking and coordinating these documents, the project manager at Langley could be assured that the orbiter, lander, science payloads, launch vehicles, ground support equipment, flight control facilities, and the tracking system would all function as required when the hardware was brought together and assembled for the launch and flight to Mars. This system of mass documentation, formal reviews, telecons, and informal conversations worked because the people associated with the effort believed in delegated management. Jim Martin's centralized responsibility and authority for Viking was a key factor to the project's success, but equally important was the esprit de corps among the Viking teams at the working level. [67]

The troops at JPL functioned within divisions responsible for specific engineering activities or disciplines. Norris and his orbiter staff allocated funds, prepared plans and schedules, assigned tasks, and received progress reports, but the divisions carried out the actual design and development of the spacecraft and experiment hardware, as well as prepared and operated such facilities as the Deep Space Network and the Space Flight Operations **[194]** Facility. Each division chief and his subordinates not only supervised their personnel but also selected the engineers who represented their divisions on the orbiter team.***** 68

The structure of management at JPL did not fit Jim Martin's management scheme. The people at Langley had always worked through a more centralized organization, in which everyone was directly responsible to the project director, and the Viking Project Office was uneasy with the JPL system. Martin knew that the organizational structure of the lab would not likely be changed just for this mission, so he went to Pasadena in the early spring of 1970 to observe firsthand how JPL worked. Specifically, he wanted to know: How had JPL dealt with hardware problems in the past? How did it plan to manage the Viking orbiter in the future? How would it control the flight phase of a mission? 69

Henry Norris believed that the time Martin spent with division managers and Viking representatives at JPL led him to understand more clearly the lab's approach to project management. Martin was still "not entirely comfortable" with the organization, Norris reported, but at least the project director had been exposed to it and the men who filled the ranks. Likewise, the people at JPL began to appreciate the sources of Martin's concerns and continued to work with the project office to improve and strengthen JPL management control over the teams in Pasadena. 70

Although they had adopted different approaches, the personnel at Langley and JPL were working toward the same goal. Once the baseline orbiter configuration had been established in February 1969, the next major orbiter goal was the preliminary design review (PDR). This formal review, held on 19-20 October 1971, came at the end of the conceptual phase for the design of the orbiter systems; the specialists were now ready to work on the detailed design of the hardware. Once the basic soundness of all aspects of the orbiter was approved, the teams would head for the next important milestone, the critical design review (CDR). Getting to the PDR had been a major accomplishment. made difficult by the repeated problems with the budget; but the teams at JPL had completed their design work and coordinated their efforts, attending weekly meetings and frequently using the telephone along the way. In fact. more than 60 meetings were held that directly impinged upon the design of the orbiter.

The preliminary design review gave all interested parties a look at the orbiter as JPL planned to build it. Once the conceptual design was complete, work on the design of breadboards, or first working test models, of the basic orbiter subsystems would begin. These designs would be evaluated at subsystem PDRs an once approved, work on e breadboards would **[195]** proceed, with their suitability for conversion into flight hardware being confirmed during a series of subsystem critical design reviews. A general A general CDR for the entire Viking orbiter system would certify the readiness of the orbiter staff to go to the next step-building the flight-ready orbiters.

By October 1971, the orbiter had assumed the basic configuration it would have when launched in 1975. The spacecraft had grown considerably larger than its Mariner Mars 71 predecessor. Most noticeable visually were the larger solar panels and the larger high-gain antenna. But all the internal subsystems were taking on a Viking identity of their own as well. The Mariner inheritance was still there, but instead of directly transferring subsystems from one craft to another, the engineers were borrowing from Mariner experience and know-how. Still, it was this transfer of technological knowledge from Mariner Mars 71 and Mariner Venus 73 that permitted the Viking orbiter personnel to get the craft ready to fly on time with a minimum of problems and money crises.

Jack Van Ness, deputy Viking project manager, recorded in his "Viking Weekly Highlights Report" that the orbiter system preliminary design review was well organized and informative. Only 22 action items remained for solution. "This relatively small number is somewhat indicative of the clarity and thoroughness of the presentations." At the conclusion of the review, the Viking Advisory Review Panel and the Orbiter System Manager's Advisory Panel provided a favorable overall evaluation of the orbiter status. None of the evaluations turned up any critical problems that would give Martin's Viking Project Office cause for concern. 71

With the PDR behind them, Norris's people began to prepare the detailed designs of the 21 orbiter subsystems. Soliciting requests for proposals from industrial contractors, selecting companies to build the subsystems, and negotiating contracts occupied the months from October 1971 to July 1972. One contract was not let until July 1973. Meanwhile, the various divisions at JPL bad begun to work on the subsystems that would be built at the laboratory. Preliminary design reviews for these subsystems began in January 1972 and lasted until late November.

Close on the heels of the PDRs came the subsystem critical design reviews, which spanned January to July 1973. When the subsystem CDRs were completed, a general CDR at JPL 9-10 July 1973 evaluated the entire orbiter system as it had evolved to date. The CDR panel, the Viking Advisory Panel, and the Orbiter System Manager's Advisory Panel all expressed their confidence in JPL's performance and the quality of the teams' work. [72] The technical problems being encountered by the orbiter were the routine kind that appeared during the course of most spacecraft projects-recurring difficulties with poor-quality integrated circuits and an unhappy experience when an early production propulsion tank ruptured because of a metallurgical failure.

During the summer of 1973, only two subsystems caused genuine concern. The infrared thermal mapping (IRTM) subsystem was behind **[196]** schedule, but by mid-July the Santa Barbara Research Center had the trouble under control, and the subsystem CDR was held that month. The data-storage-subsystem tape recorder's failure to operate at a satisfactory speed put it on the Viking Project Office's "Top Ten Problems" list. In October the "54L" integrated circuits were also added to the list. Overall, however, the orbiter was shaping up as a well-behaved spacecraft, and everyone was pleased. Concern over the orbiter's financial problems was constant, but the project management was confident that Henry Norris's teams were on schedule and doing well. By drawing on Mariner heritage, they had the Viking orbiter under control. [73]

In mid-1973, the orbiter hardware entered the test phase. The first test, called the modal test, was conducted with the orbiter development test model, to determine if the mathematical model used for the engineering load analysis was correct. The modal test ran from late May until the end of July. A week later, General Electric delivered the first computer command subsystem. In late August, the propulsion-system engineering test model was test-fired at the NASA Edwards Test Station in California, while at JPL the flight-data-subsystem breadboard was checked out with other pieces of hardware that were to be linked to it, such as the visual imaging subsystem, the IRTM, and the atmospheric water detector. During the first and second week of September, other tests were run to determine the effect of shock on various orbiter instruments. Joseph Goudy reported to Martin on the 14th that the results from the pyrotechnic shock tests were much better than they had anticipated: "None of the subsystems that were on board for the tests appeared to have suffered any adverse effects" The sensitive instruments would not be harmed when the spacecraft was explosively separated from the Centaur launch vehicle stage and the lander was explosively separated from the orbiter. [74] In mid-December 1973, JPL completed the vibration stack test of the orbiter and lander development test models. Since this was the first time that orbiter and lander hardware had been mated and tested together, everyone in Pasadena was particularly satisfied when no important questions were raised by the examinations. [75]

With the new year upon them, the orbiter team focused its attention on final assembly of the proof-test orbiter and tests of this first flight-style hardware. These qualification tests would determine the spaceflight worthiness of the orbiter system designs as they had been rendered into hardware. The assembly process took three months as each of the subsystems was checked out and assembled onto the orbiter bus. During April and May, the engineers at JPL conducted the system readiness test, verifying the functioning of all orbiter components. The successful examination of the orbiter hardware prompted Goody to report to the Viking management at Langley that they were on schedule and that the assembly of the proof-test orbiter had served as a "pathfinder" for the fabrication of the flight orbiters. [76] In the process of building this first craft, officially designated Viking orbiter 1 (VO-l), the spacecraft assembly personnel members at JPL learned some....

[197] Table 34

Growth in Capacity of Data Storage Subsystems

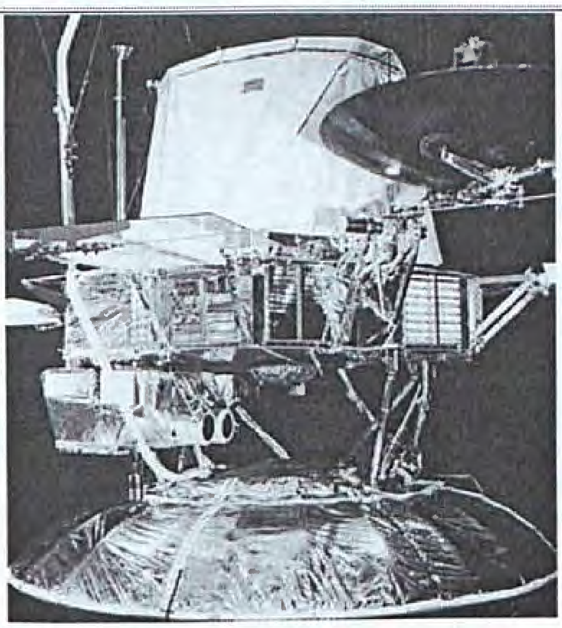
.	Mariner 64	Mariner 69	Mariner 71	Viking 75
.				
Number of tape recorders	1	1	1	2
Number of tracks	-	4	8	8 x 2
Recording rate	-	16 200 bits per sec	132 000 bits per sec	301 172 bits per sec, tracks 1 through 7; 4 and 16 kilobits per sec, track 8
Playback rate	81/3 bits per sec	270 bits per sec	1, 2, 4, 8, or 16 kilobits	1, 2, 4, 8, or 16 kilobits
Storage capacity	5.4 million bits	23 million bits	180 million bits	640 million bits x 2

Length of tape	100 meters	111 meters	168 meters	384 meters x 2
Weight	-	19 kg	11 kg	7.7 kg x 2
Contractor	-	Lockheed Electronics Co. Inc., Plainfield, N.J.	Lockheed Electronics	Lockheed Electronics

NOTE: The data subsystems (reel-to-reel tape recorders) used on the Mariner and Viking spacecraft permitted recording scientific data and sobsequently playing it back through the communications subsystem for transmission to Earth. As the number of experiments increased and the amount of data to be stored and played back grew, successive data storage systems became more complex. Each new tape recorder had greater capacity, posing new technological challenges. In Viking, each data subsystem rape recorder weighed 3.3 kg less than the Mariner 71 data subsystem recorder, while having 3.6 times the information storage capacity.That accomplishment took time and caused some real headaches for the Viking managers, but the completed recorders worked very successfully during the missions.

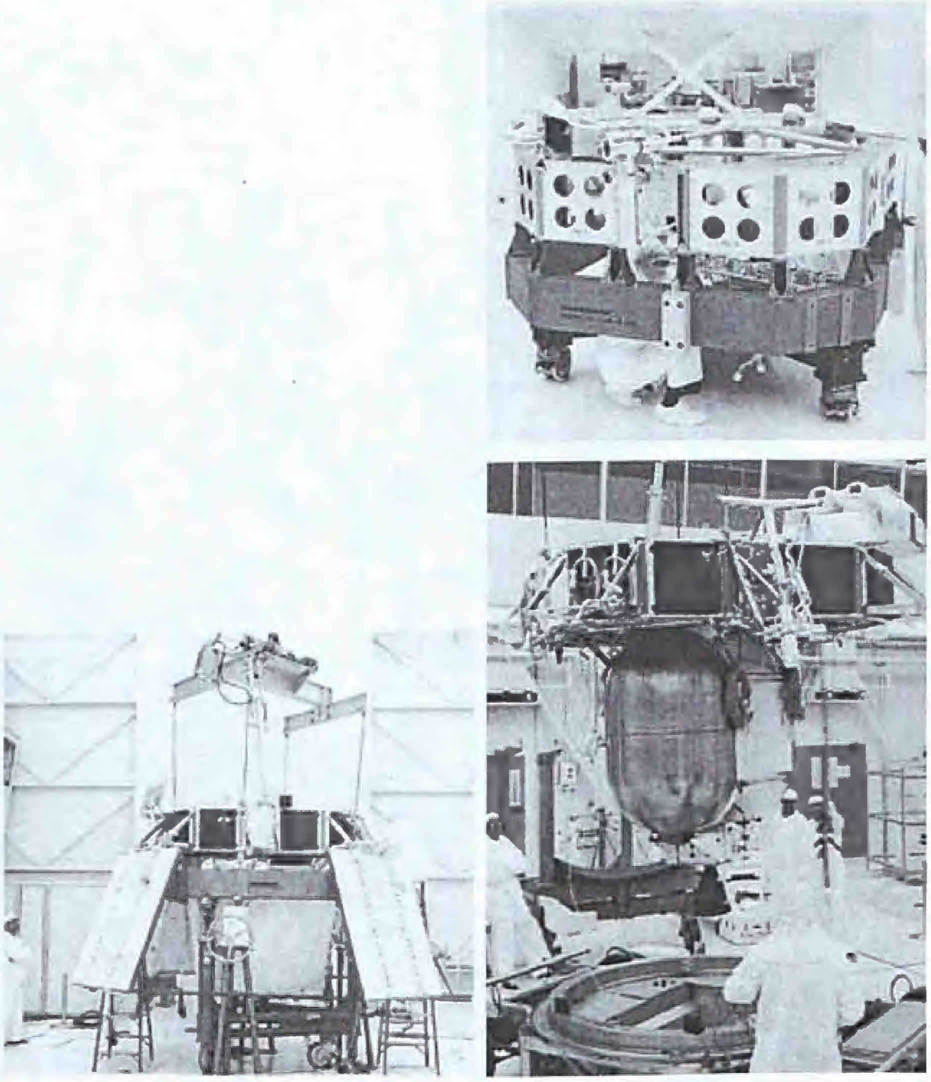
[**198**]....important lessons that would help them build Viking orbiter 2 and 3, the orbiters that would fly to Mars. One problem they encountered was the lack of sufficient work stands, particularly during the installation of the thermal insulating blanket. More stands were ordered, to avoid any bottleneck during the assembly of the flight articles. The proof-test orbiter was moved on 8 May from the Spacecraft Assembly Facility to the Environmental Laboratory, where it would go through the rigors of vibration, electromagnetic interference, pyrotechnic, thermal vacuum, and compatibility tests during the summer of 1974. At the same time, engineers would begin assembling and testing VO-2 and VO-3. [77]

On schedule with satisfactory results, the VO-1 tests were completed in late August. As the JPL team turned its attention to readying VO-3 for early examination, however, unexpected budget problems brought a change in plans. [78] On 27 September, the orbiter staff was forced to order all testing of the third orbiter to cease. The second test team was disbanded; no money was available for testing. VO-3 was put into storage, and the proof-test orbiter (VO-1) was redesignated a flight unit. VO-1 and VO-2 would be the....



The thermal-control model of the Viking orbiter mated to the lander thermal-effects simulator was used in August 1973 to verify the effects solar radiation would have on the spacecraft. The science platform with imaging system and other instruments is attached under the orbiter.

[199]



Building the Viking Orbiter at Jet Propulsion Laboratory in 1974. Men working inside the chassis, right, fabricate the orbiter bus structure. Below right, they attach the propulsion module to the propellant tanks. Below, solar panels are in place on the nearly completed orbiter.

[**200**]....spacecraft sent to Mars. To ensure the acceptability of the proof-test hardware for flight, a series of meetings were held during the next several weeks. [79] But an orbiter design qualification review scheduled for early October 1974 lost much of its significance, since the change in plans had thrown off JPL's timing. As one participant observed, it was hard for a review panel "to determine if the Orbiter met all of its requirements in spite of all the testing that has been done." [80]

After several more months of work, orbiter VO-1 was verified for flight on 9 January 1975, and the VO-2 tests were completed on the 31st. The orbiters were shipped to the Kennedy Space Center in February, where a series of preflight checks would be made through the spring and summer. [81] The Viking orbiter, remarkably close to early weight predictions (see table 35), was a very carefully tested piece of equipment. For the teams at JPL, the design, development, fabrication, and assembly had, for the most part, gone according to plan, schedule, and budget.

Table 35

Viking Orbiter Specifications, 1969-1975

Orbiter Element	Baseline Orbiter	PDR Orbiter	Flight Orbiter
	Feb. 1969	Oct. 1971	Feb. 1975
.			
Bus dimensions:			
- Long sides	-	-	139.7 cm
- Short sides	-	-	50.8 cm
- Height	45.7 cm	45.7 cm	45.7 cm
.			
Distance from launch vehicle attachment points to lander attachment points	-	3.29 m	3.29 m
.			
Distance across extended solar panels, tip to tip	7.80m	9.75 m	9.75 m
.			
Weight with fuel	2298.6 kg	2304.3 kg	2324.7 kg
.			
Weight of fuel	1862 kg	1404.8 kg	1422.9 kg
.			
Weight of science instruments	57.6 kg	65.4 kg	65.2 kg
- Visual imaging system	21.8 kg	42.05 kg	40.05 kg
- Infrared thermal mapper	13.6 kg	7.48 kg	9.30 kg
- Mars atmospheric water detector	-	15.90 kg	15.90 kg

SOURCE: JPL "Viking Project Orbiter System, Visual Presentation, February 13, 14, 1969"[Feb.1969]; JPL "Viking 73 Project Orbiter System PDR, October 19-20,1971, Presentation Material ' [Oct.1971]; and Martin Marietta Aerospace, Public Relations Dept., The Viking Mission to Mars (Denver, 1975). pp.III-25,III-27,III-32,III-33.

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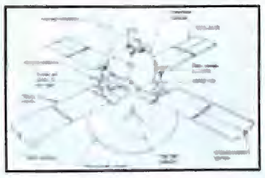
[201]



Configuration of the mated Viking orbiter and capsule in cruise mode.

Carl D. Newby, supervisor of the Spacecraft Development/Mechanical Support Group, oversaw the assembly of the orbiters. It was the biggest spacecraft Newby and his team had built, and because it was so big it was an easy craft on which to work-they had room to move around during the assembly process. Newby pointed out that it requires a special personality to work on space hardware and a special dedication. Fabricators come to view the spacecraft as part of their lives, to care about it. Working in a closed environment, they have to learn to live with one another, as well. Spacecraft builders must be adaptable, very careful, and thoughtful. One false move, one thoughtless motion can destroy an assembly or component worth thousands of dollars or months of time. Damage to a spacecraft usually also requires requalification of the injured components or perhaps requalification of the entire craft. Workers on the Viking orbiters-many had worked on Ranger most had worked on the Mariners-were very fond of their spacecraft.As Newby repeatedly reminded the specialists at JPL, the orbiter was a "good spacecraft to work on, it was on time and on budget." [82] Building the Viking landers, however, was a completely different story.

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[*] *Bit* , is the abbreviation for binary digit and stands for the smallest unit of computer-coded information carried by a single digit of binary notation. This form of notation is a system of expressing figures for use in computers that use only to two digits, one and zero. A kilobit equals 1000 bits.

[**] A *word* in a computer memory is a binary number containing a specific number of bits and is used as the unit of meaning.

[***] Membership in the council included J.S. Martin-chairman, W.J. Boyer, H.E. Van Ness, I Taback, F.W. Bowen-secretary, and E.A. Brummer, Langley; R.H. Gray, Kennedy Space Center; W. Jakobowski, NASA Headquarters, E.R. Jonash, Lewis Research Center; A. J. Kullas, Martin Marietta; and H.W. Norris and N.A. Renzetti, JPL.

[****] The membership included Vice President Spiro T. Agnew, chairman; Secretary of the Air Force Robert C. Seamans; Administrator Thomas O. Paine; Science Adviser to the President Lee A. Dubridge; and, as advisers, Under Secretary of State for Political Affairs U. Alexis Johnson, Atomic Energy Commission Chairman Glenn T. Seaborg, and Bureau of the Budget Director Robert P. Mayo.

[*****] Divisions and their representatives assisting the Viking orbiter staff at JPL, spring 1970: Quality Assurance and Reliability, G.E. Nichols; Project Engineering, V.R. Galleher; Data Systems, G.F. Squibb; Space Science, M.T. Goldfine; Telecommunications, J.R. Kolden; Guidance and Control, A.E. Cherniack; Engineering Mechanics, W.J. Carley; Astrionics, J.D. Acord; Environmental Sciences Simulation, N.R. Morgan; Propulsion, W.J. Schatz; Mission Analysis, P.K. Eckman; and Technical Information and Documentation, S.B. Hench.

INDEX PAGE

What President Nixon Didn't Know

By Julian Scheer

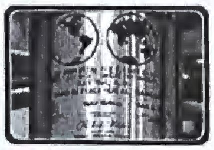
Special to space.com
posted: 01:39 pm ET
16 July 1999

Neil Armstrong's first words upon stepping onto the moon will never be forgotten. Nor will the words engraved on the plaque fastened to the lunar lander that remains on the surface of the moon. Julian Scheer, who helped guide NASA through those historic years, tells us how those words traveled from Washington to the Moon.

--Lou Dobbs

When I think of the first manned lunar landing, my mind's eye has the image of the lunar lander, moon dust piled against its legs, sitting on the moon's surface. And I see the plaque fastened to it, which reads, "We Came in Peace for All Mankind."

Images



The Plaque that hangs on Apollo 11's ladder would have read differently if Nixon had had his way.

It almost did not read that way.

I was sitting in my office one day early in 1969 when NASA Administrator Tom Paine rushed room. "Peter Flanigan called from the White House," he said. "Do you have a plan ready for th

We had done a great deal of work in planning what would occur when the Apollo 11 astronaut lunar surface and some thought of what President Nixon's involvement might be, but the final segment had not been committed to paper.

"We have to be at the White House at 2 p.m.," Paine said.

A secretary rushed to a local stationery store in downtown Washington and purchased three fal bindings and dividers. She had "President Nixon, Apollo 11 Participation" embossed on the co knocked out an index and we began assembling the data needed to fill in the sections: a missio a time-line of events the White House might use, a sample script of a telephone conversation f Office to the crew on the lunar surface, a photo of the plaque we would leave on the lunar surf

Time was short. Typewriters were busy. We quickly filled in the pages but we ran out of time.

NASA's government limousine was a black Checker cab, a boxy un-limo looking vehicle. Pair in, carrying sheets of paper and the newly purchased binders.

As the auto sped down the streets from NASA Headquarters in the Southeast of Washington tc House, Paine and I pushed the taxi's jump seats against the front seat, and collated our noteboc floor of the vehicle as we got closer and closer to the White House.

Not wanting to appear unprepared, we walked into Flanigan's office and almost casually tosse notebooks on his desks. Clearly, we made an impression; NASA had been prepared for this da while. Flanigan, a former New York investment banker, was a hard-nosed guy on Nixon's staf known for his high energy level and efficiency.

We did not see the President that day but Flanigan called a few days later. The President had n notes, he said, and he would send the margin notes to us. There was one thing the President wa -- the plaque to be left on the lunar surface, which read "We Came in Peace for All Mankind." strange. I was certain the White House had already seen one version of the plaque.

The President wanted "Under God" inserted after the word "Peace".

"Peter," I said, "there is no universal god. We do not want to offend any religion..."

"Julian," he said, "the President was insistent."

I did not want to admit that the plaque had already been made and affixed to the lunar landing had been through a whole series of pre-flight tests at Houston.

We had begun in April to consider what to do on the lunar surface and what might be left behi wording on the plaque had had a lot of attention. Willis Shapely, who headed our study comm conferred with the Librarian of Congress, the Archivist of the United States, the Smithsonian I National Space Council, congressional committee staffs, and others. (The decision to plant an flag, incidentally, came after much discussion because we did not want to create the impressio U.S. claimed the moon. We feared the charge that the United States was attempting to establis sovereignty.)

I protested again.

"Julian, that's what it is going to be."

"Peter..."

"Dammit, Julian, the President wants that change. The president is big on God."

"What?"

"Julian, Billy Graham is here nearly every Sunday. The President wants 'God' on the plaque!"

There was nothing left to do but say "yes."

It occurred to me that in the rush of events, no one would remember. That worked out. The pla
been resting on the Sea of Tranquility for 30 years is the original, without the benefit of Presid
editing.

Julian Scheer was Assistant Administrator of NASA for Public Affairs from 1962-1971, includ
five lunar landings. This article was written expressly for space.com.

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