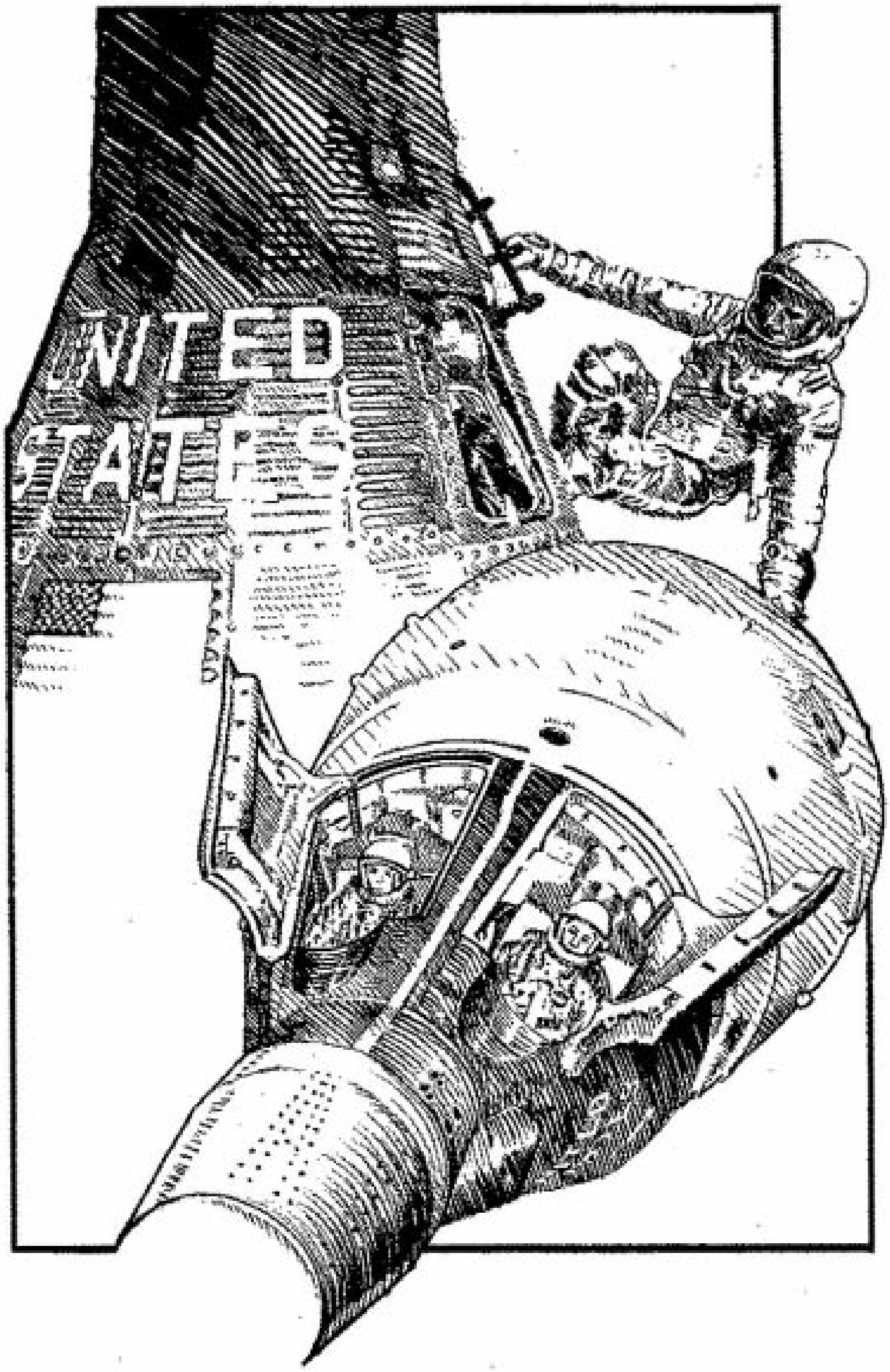
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CHAPTER 4: Human Dimensions

Few years have been so critical to the American space program as those between roughly March 1962, when old STG and new center employees began relocating to temporary quarters in Houston, and June 1964 when the new MSC formally opened for business. Few years have been so demanding of human energy, effort, and simple endurance. During these years, the Mercury, Apollo and Gemini programs ran concurrently while the MSC was being designed and built. Few years have been so productive. Not only did things get done, but a very important management system or style that became referred to later as the "Gilruth system" became implanted in the organization and culture of the developing space center.

During the spring of 1962, 751 STG/MSC employees moved to Houston from Langley, Virginia, and by July administrators had hired another 689 people who joined the staff in Houston. Personnel worked throughout a dozen buildings in disparate locations in Houston, while construction contracts were being let and buildings built on the site of the new center.[1] But the real business at hand had to do with putting Americans in space, not buildings on Earth.

Not only, said Bob Gilruth, is our mission "to develop here in Texas the free world's largest and most advanced research and development center devoted to manned spaceflight," but the real business at hand is "to manage the development of manned spacecraft and to conduct flight missions." In our work on these missions, he said:

> . . .during the past few months the Manned Spacecraft Center has doubled in size; accomplished a major relocation of facilities and personnel; pushed ahead in two new major programs; and accomplished Project Mercury's design goal of manned orbital flights twice with highly gratifying results.[2]

That was July 1962. By May of 1963, with six more successful manned Mercury flights completed, Mercury ended—and within the year, the first unmanned Gemini vehicle sped into orbit.

Mercury began unpromisingly on August 21, 1959, when the first Little Joe Mercury capsule prototype launch was canceled due to faulty wiring that sent the capsule, without the launch vehicle, on a premature trajectory a short distance out in the ocean from its launch point on Wallops Island. In 1960 there was talk of "slippage" in the space program. Rod Rose remembered that while awaiting delivery of the Mercury capsule, he urged Gilruth to "beat the Russians" by sending an astronaut aloft in a Little Joe module, but Gilruth declined saying that "we're running a research program, not a PR stunt team."[3] That attitude helped provide stability and direction during the high-pressure days of the early sixties.

In 1961 and 1962, amidst the suitcase environment of the move to Houston, Project Mercury enjoyed its greatest successes and the first Apollo systems began flight tests. On May 5, 1961, Alan B. Shepard, launched from Cape Canaveral and directed by the Mission Control Center at Canaveral as were all of the Mercury flights, completed America's first manned space mission. "When Ham (the chimpanzee which had flown

Mercury-Redstone (MR) 3, the United States' first manned spaceflight, was launched from Cape Canaveral May 5, 1961 (left). Astronaut Alan B. Shepard, Jr., piloted the "Freedom 7" to an altitude of 116.5 statute miles, attained a maximum speed of 5150 miles per hour, and landed 302 miles downrange from the launch site. The MR-4 (right), launched July 21, 1961, had an enlarged window hatch, improving the pilot's ability to see. The loss of the escape hatch at splashdown caused the craft to sink, but Astronaut Virgil Grissom was safely retrieved.

earlier test flights) refused to board the capsule, I had to make the flight," Shepard told a large audience at the Johnson Space Center years later (in 1989 during the 20th anniversary of the first lunar landing). Virgil Grissom followed Shepard into space in July. In September an unmanned Mercury capsule made a complete Earth orbit. While public attention focused on the Mercury program, a flawless launch of the first Apollo-type vehicle (a Saturn SA-1) was completed from Cape Canaveral on October 27, 1961. Enos made the first "chimpanzeed" orbital flight aboard a Mercury capsule in November, and finally, Mercury astronaut John Glenn completed the first American orbital mission (4 hours and 56 minutes) on February 20, 1962.[4]

Following Glenn's harrowing return within his capsule-turned-fireball through Earth's atmosphere, the entire flight being one of America's most closely followed news events of modern times, President John F. Kennedy expressed "great happiness and thanksgiving of all of us on the completion of Colonel Glenn's trip." But we have a long way to go in the "space race." ". . . this is the new ocean," Kennedy said, "and I believe the United States must sail on it and be in a position second to none."[5] Scott Carpenter made another significant step across the threshold of space soon thereafter.

The MSC's weekly journal, the *Roundup* described Carpenter's launch aboard "Aurora 7" on May 24:

> . . . a massive black silhouette poised on the skyline a mile and a half from the press site where hundreds of watchers held their breaths. Mercury-Atlas 7 hung for agonizing seconds, poised on a column of fire, then rose. She lifted into the low clouds, appeared again above them, flashed into the sunlight and out of sight, her heavy thunder rolling back over the Earth she had left behind.[6]

The flight marked "a major milestone in man's pioneering venture into space," but it almost ended in disaster when fuel and temperature problems aborted the flight earlier than planned, and Carpenter's landing was 250 miles off target. He, as the chimpanzee Ham had been years earlier, was finally located and retrieved.[7]

G. Merritt Preston managed launch operations for Mercury from Cape Canaveral, and the Mission Control Center at Canaveral directed flight operations. To be sure, Mercury flight operations were rather minimal because the capsule was not navigable. As Christopher Kraft explained later, Mercury flight control basically occurred before launch; because once you launched, the main function was to try to maintain contact and wait until it came down. Control center operations changed markedly with Gemini and Apollo. The

Astronaut John Glenn, Jr., enters the "Friendship" spacecraft during rehearsal exercises. Glenn made the first American orbital spaceflight in the Mercury-Atlas 6 craft on February 20, 1962.

Mercury Project Office as well as the home base for Mercury astronauts remained at Langley, Virginia, until November 1963, when the Mercury Project Office closed and Kenneth S. Kleinknecht and most of his staff moved to Houston.[8]

The center in Houston concentrated on the "new" projects mentioned by Gilruth—Apollo and Gemini—and much more so on the former than the latter. As Mercury neared completion, most Mercury project people moved directly to the Apollo program rather than into or through the Gemini program. This ultimately created some special problems for the manned space program.

In December 1961, Project Gemini (originally designated Mercury Mark II), a two-person manned spaceflight program, was initiated to provide experience in flight endurance, rendezvous, and extravehicular activity until Apollo became operational. Thus, for several years before being finally relocated at the Clear Lake site in late June 1964, the work of the space center included the operation of Project Mercury, design and contracting for projects Apollo and Gemini, the design and construction of the Manned Spacecraft Center, the recruitment and training of employees and astronauts, the testing of both Gemini and Apollo hardware and initial flights of both Gemini (Gemini I, April 8, 1964) and Apollo (SA-6, May 28, 1964) systems.[9]

". . . a massive black silhouette poised on the skyline . . . hung for agonizing seconds, poised on a column of fire, then rose. She lifted into the low clouds, appeared again above them, flashed into the sunlight and out of sight, her heavy thunder rolling back over the Earth she had left behind." Thus began Scott Carpenter's venture into space.

The technical challenges of achieving manned spaceflight sometimes seemed less imposing than the human dimensions. Although the space programs seemed to bring America to the leading edge of science and technology, the technology of space may actually have been more in place than the social engineering required to integrate such diverse fields as bioengineering, astrophysics, metallurgy, ceramics, and computer electronics. The management of these large scale endeavors went beyond such experiences as the construction of the intercontinental railroads in the late 19th century or building the Panama Canal in the early 20th century. Even the more recent Manhattan project of World War II and the Polaris missile program differed sharply in their costs, scale, and the extent to which they integrated diverse bodies of knowledge and technologies still in the research and developmental stage. There was little precedent for the most mundane business of determining costs, allocating contracts, and reviewing progress on such a large scale and in such a defined time period.

Moreover, NASA was enjoined to design, build, and operate machines never previously built, and to help create the knowledge and technology necessary to build and fly these machines. The new generation spaceflight vehicles had to be man-rated, that is, be certified as a safe environment for humans and be responsive to human operators. Despite the initial successes of Mercury, whether humans could long survive and function effectively in space had not been resolved. Unlike conventional aircraft, a space vehicle's maiden voyage was its first flight mission. There were no test flights into space. Spaceflight required innovations and inventions in technology, the accumulation of enormous human and material resources, and the development of new management structures and practices. Putting Americans in space was a most difficult assignment by every conceivable measure. The frontiers of space alluded to by President Kennedy were less beyond Earth and more at the site of MSC and its associated NASA installations, and in the workshops and laboratories of the developing American aerospace industries.

Spaceflight involved the Nation's best engineering and scientific talents and energies, and a considerable amount of the public's money. During its first 5 years of operation, total NASA annual expenditures jumped from about $300 million to $5.1 billion. By comparison, federal expenditures on defense (1959-1964) rose from approximately $45 to $55 billion. The administrative budget of the MSC went from $9.2 to $88.5 million between 1961 and 1965, and the direct Apollo budget soared to $2.7 billion.[10]

Despite frequent changes in formal assignments and on organizational charts, the management personnel working on the manned spaceflight programs remained remarkably stable. Most of those who began the program with the STG were there two or even three decades later. Most of those who came into the program at the Houston center remained there throughout their professional careers. Robert Rowe Gilruth was one of those who cast an indelible stamp on America's space program from its conception in 1957 until his retirement in 1973.

George Low, a NACA engineer from the Lewis Flight Propulsion Laboratory, went with Abe Silverstein and others from Lewis to NASA Headquarters in 1958, and became "Gilruth's representative in Washington" before he joined the center staff in Houston in 1964. Low referred to the MSC as:

> . . . Bob Gilruth's center. He built it in terms of what he felt was needed to run a manned spaceflight program. . . . it is clear to all who have been associated with him that he has been the leader of all that is manned spaceflight in this country. There is no question that without Bob Gilruth there would not have been a Mercury, a Gemini, or an Apollo program. Everything we've done, our approach, has grown out of the Bob Gilruth formula for running Project Mercury.[11]

Although the organization changed, Low said, and people came and went, the people who run the center and make the decisions have had primary management roles all the way through from the beginning, and they are people who shared Bob Gilruth's vision of what the center should be. Gilruth did not necessarily initiate ideas or projects; he rarely did so, but freely gave credit to those who did. His great strength was in sorting out the wheat from the chaff, and in inspiring others to accept his decisions.[12]

Thus, Low said, Gemini was Jim Chamberlin's idea, but it was Gilruth who "latched" onto the idea and pushed it into NASA circles, insisting that "we needed to learn how to fly in space in applications more sophisticated than Mercury before attempting to land on the Moon."[13] "Gemini 7/6," involving the orbit and rendezvous of two spacecraft, was another person's idea but adopted by Gilruth as a necessary step in spaceflight. "Bob," said Low, "is more of a leader than a manager. He has ideas; he inspires confidence and knows what's right and what's wrong; but he also expects the rest of us to originate ideas and carry them through to completion." It is Bob and his people who made things go, Low concluded, and added ominously, that "it's when someone comes along who hasn't been brought up under Bob and hasn't learned from him that we have problems."[14]

Low was both right and wrong about Gilruth. He was right that Gilruth inspired confidence and seemed to know instinctively what was right and wrong. He was wrong in attributing the entire space program so singly to Gilruth. Gilruth's success was due in good measure to the fact that he "truly represented" the people working with him. His management, according to Paul Purser, David Lang and others, could best be defined as "management by respect," and although they did not say so specifically, that respect derived largely from the technical expertise which Gilruth shared with his associates. To Gilruth, the STG and those who worked with him were "associates"—just that—not employees or underlings.[15] Thus, the MSC at its best represented a collegial association of engineers gathered together almost fortuitously to complete a task, to build a bigger, better, faster, and more complex machine than ever before had been built. To be sure, the collegiality did have a raw edge. MSC personnel also comprised a pool of talented, young and highly competitive engineers and astronauts who thought that collectively they were very good at what they were doing, and that individually each was better than the other.

Manned spaceflight required not only a regrouping of engineering and scientific knowledge, but a reorientation of the mind-set and culture of the engineering community. Although the engineering expertise of the NASA/MSC community was similar to that of the old NACA, there were distinct differences between the two which tended to be accentuated in the MSC culture. The NACA had been primarily a research, service-oriented organization. NASA, but especially the Houston spacecraft center, became a development-applications-operations organization. Thus, when decision time came at the Langley Research Center for an engineer to join the STG or not to join, or to go to Houston, Texas, or not to go, the underlying incentive had much to do with a personal preference for research or for development.

The cultural delineation between one group of engineers and the other, and indeed between the old NACA and the new NASA, is reflected in part in the careers of Langley engineers such as W. Hewitt Phillips and Robert G. Chilton. Phillips participated in early studies of Earth versus Moon orbital missions and space rendezvous feasibility, but he chose to remain at Langley and concentrate on research. Chris Kraft, who worked under Phillips at Langley for many years before coming to Houston, described him as his mentor and one of the most knowledgeable and ingenious aerospace engineers. Phillips taught him most of what he knew about engineering, Kraft said. After more than four decades observing the growth and programs of NACA and NASA and the Johnson Space Center from the perspective of his laboratories at Langley, Phillips objected to what he called “research by decree.” Ideas, he said, cannot be superimposed from the top. And buildings or centers, he said, must be filled with people who can generate ideas.[16]

Robert G. Chilton, who worked with Phillips at Langley in 1959 and 1960, easily chose the STG and Houston. Chilton, as head of the Flight Dynamics Branch under Maxime Fagets’ Flight Systems Office became a key ingredient in the “development” aspects of the manned spaceflight ventures.[17] Whereas Hewitt Phillips’ work might end with the conceptual and theoretical framework for a space rendezvous, the developmental engineer wanted to make it happen. But the demarcation between the research engineer and the operations or developmental engineer was not nearly so marked as the delineation between the scientist and the engineer.

The basic reaction of the scientific community to Sputnik was to avoid the heroics and concentrate on upgrading the status of science along a broad front in American society. Sputnik and space offered an opportunity for American scientists, but of a different cast than that for the engineer. Most advocated federal support for expanded educational programs, more scientific input in (and control of) weapons development and better working conditions for scientists in federal agencies and projects. Months after Sputnik, the American Association for the Advancement of Science presented a major discussion and document on “science and public policy,” but made no mention of a manned space mission. Many scientists and their organizations actively sought to dissuade others from participating in a crash program in space. Only later did the scientific community join in support of an independent civilian space agency—as something preferable to the spectre of a military space agency.[18] But the dichotomy or tension between space as a subject of research and space as the arena for manned flight continued throughout the manned spaceflight programs.

A similar cultural “stress” pervaded the engineering community, where the research engineer who provided the theoretical design for a space capsule stood at some distance from the operations engineer who wanted to fly it. Development became the bridge between the research and the applications or operations engineer. Development, which might be equated to the refinement stage of invention (in which the invention becomes functional and marketable), provided a framework for the spin-off or creation of new ideas and for identifying new applications for old ideas. Development also provided a key element in the unique management style that characterized not just the director, Robert Gilruth, but the entire MSC engineering community. As Max Faget observed, in the early days of the manned flight programs, “there was not a lot of substance to spacecraft technology.” Much of what was learned came through experimentation. “We had our own hobby shops,” Faget said.[19] In these shops, MSC engineers helped create the new technology of space, which in fact, often was the application of old technology in new ways.

Managing engineers at the space center coupled the older NACA “do-it-yourself” in-house tradition with the newer NASA system of contracted work as an effective management and quality control tool that was really an intrinsic part of the so-called "Gilruth system." Thus, engineering divisions and laboratories at the center became miniature developmental and manufacturing centers where prototypes of flight systems, such as Mercury (Little Joe) capsules, heat exchange devices, or computer hardware and programs were devised or perfected. MSC engineers knew what the contractor was producing and how to manage and direct that production because they participated in the design and had hands-on experience in the fabrication and testing of the product.

Chris Kraft, in fact, explained the Gilruth management system as a "make it work, and if it doesn't work find something that will" attitude. Because of their hands-on experience, NASA engineers could more effectively manage the work of the NASA contractors. It also meant that center engineers became cooperators and collaborators with the contractors, rather than simply purchasers of hardware produced by a manufacturer from a given set of specifications. Managing engineers wanted their contractors to succeed and assisted them in that effort. In the design, manufacture, or operation of components, NASA engineers were usually as knowledgeable and experienced, or more so, than their counterparts in industry. This "nuts and bolts understanding" more than anything else defined the relationship between the engineers and staffers within MSC, and between the center managers and their contractors who produced the final product. Organizational flow charts and diagrams meant little compared to the fact that a group of engineers sat down and tried to do a job they understood a little better than those outside their community.[20] As time passed, the MSC management/contractor relationships became institutionalized in such roles as the subsystem manager, contract representatives, program management offices, and contract change boards.

Under the collegial style of management, the pattern of authority relationships became very suffused. Relationships between programs, divisions, and individuals tended to "float." Communications occurred on both horizontal and vertical levels on a selective, as-needed basis. Program or division heads under such a system operated with considerable authority and responsibility and could assume somewhat more or less of either as they required. They were answerable, not so much to a superior, but to their peers. The collegial system of management worked in part because routine administration was divorced from project management.[21]

Gilruth and his managing engineers concentrated on engineering and left the more routine fiscal and personnel management to carefully selected associates. One of Gilruth's great strengths was his ability to find the right people to do the job and then give those persons full authority and responsibility. Bob Piland described Gilruth as less an administrator and more a "genius in handling people."[22] As time passed and programs developed, management style and structures began to change, but the basic system or concept remained much the same.

Until the move to Houston, Gilruth directed Project Mercury. Charles J. Donlan served as Assistant Director for Mercury until September 1959 when he became Associate Director for Project Mercury (Development) and Walter C. Williams was appointed Associate Director for Project Mercury (Operations). Donlan, who completed work in aeronautical engineering at Massachusetts Institute of Technology in 1938, worked in the Langley Spin Tunnel and the Stability Tunnel before heading the High-Speed 7- by 10-foot Tunnel, and later worked closely with Gilruth before becoming his technical assistant. Williams, who had supervised tests for NACA of the Bell XS-1 in which Charles E. "Chuck" Yeager flew the first manned supersonic flight, appropriately remained the "operating" director of Project Mercury during the move to Houston until he was replaced in a general reorganization that brought Kenneth S. Kleinknecht to head the Mercury Project Office in October 1962.[23]

At that time three project offices (Mercury, Gemini, and Apollo), three functional or line offices (Engineering and Development, Operations, Information and Control Systems), and a variety of support offices reported to the Director. Offices, designations, and work assignments tended to be very fluid and amorphous during the earlier years, and organizational charts at best only reflect a moment in time and imply a rigidity that did not exist.

Gilruth delegated matters having to do with personnel hiring and pay (not recruitment), business affairs, contracting and purchasing to an extremely able team organized by Wesley L. Hjornevik. Gilruth gave him a "wide area of responsibility . . . perhaps wider than most administrative people in other centers in NASA," Hjornevik recalled. When he joined the STG at Langley in March 1961, Hjornevik said, of the 700 people assigned to the STG only 30 or 40 were in support positions while the remainder were all technical people. Administrative support came from the Langley Research Center staff. Thus Hjornevik had to build an administrative support staff from scratch.[24]

Hjornevik recruited Dave Lang from the Air Force to handle contracts and procurement. Lang had been the contracting officer for the B-70 bomber program before joining the MSC group. In having responsibility for negotiating, awarding and administering all contracts for procurement by the center, including the contracts for the research, development and manufacture of manned spacecraft and related equipment, Lang (assisted by the source evaluation boards chaired by an engineer) spent literally billions of dollars during his long tenure, and he did so in a way that would complement rather than lead or impose upon the program and technical work.[25]

What we were trying to do, Hjornevik explained many years later, was to help these people succeed, both the program offices and the contractors. Hjornevik and Lang assigned contract and procurement office representatives to project offices and, when appropriate, to the contractors. These representatives considered themselves staff people for the work to which they were assigned. Thus, when a project office or a contractor needed to purchase a certain piece of equipment or develop a contract or subcontract, the "business" aspects of getting it done would be dispatched as quickly and efficiently as possible. It eliminated much of the hostility, lethargy, and bureaucracy characteristic of large-scale enterprises. It was not, Hjornevik admitted, always successful.[26]

Hjornevik picked Rex Ray from the Atomic Energy Commission to be Chief of Finance because of his work there with private contractors and in auditing contracts. Stuart Clark, a deputy director of personnel with the Army Ballistic Missile Agency in Huntsville, had greatly impressed Hjornevik as a man with "a lot of ideas, who was very personable, and who had experience recruiting the kind of people that we would need in the R&D business." As with contracting and procurement, the personnel officer assigned representatives to program offices and major divisions at MSC so that they could respond immediately to the needs of those offices. This approach eliminated much of the

Dr. Max A. Faget (December 1964), Assistant Director for Engineering Development, Manned Spacecraft Center. Dr. Faget strongly influenced the design and development of every American spacecraft from Mercury through Shuttle.

traditional stress between the administrative and operating divisions.[27]

Hjornevik brought with him from NASA Headquarters Charles (Chuck) Bingman and Phil Whitbeck, who later became Deputy Director for Administration. For the construction of buildings and facilities, Hjornevik recruited a team from widely diverse backgrounds including Leo T. Zbanek, I. Edward Campagna, and James M. Bayne. Zbanek had experience in managing the logistics of heavy construction in the Taconite iron ore system in Minnesota; Campagna had just completed the management of a major research construction project for the Department of Agriculture at Ames, Iowa; and Jim Bayne, an architect, came from an architectural firm in Detroit, Michigan, and "was extremely capable in original design and control" of major projects.[28] The emphasis on cooperation and contractor support complemented the collegial style of management at MSC. A spirit of cooperation and commitment also contributed significantly to the completion of the missions of the MSC.

Those missions, including Mercury, Gemini, and Apollo, were contemporaneous and interdependent programs and were all under way prior to the relocation of MSC to Houston on March 12, 1962. Preceding that move, on January 15, Gilruth organized the center. He created independent project offices for Mercury, Gemini, and Apollo, and the Office of Research and Development (redesignated within the year as the Office of Engineering and Development), under the authority of MSC Assistant Director Max Faget. Faget's office had responsibility for creating and implementing programs for research and development in the areas of space research, space physics, life systems, and tests and evaluations to support and advance manned spacecraft development. Four divisions under him included a Spacecraft Research Division headed by Charles W. Mathews, the Life Systems Division under Stanley C. White, and a Systems Evaluation and Development Division directed by Aleck C. Bond. Each division then established various "branches" which were in turn subdivided into such "sections" as might be required. These could be and were reformatted as often as required, thus the idea again was not to establish a static organizational structure, but to organize to complete the jobs required. Certain elements necessarily retained some permanency. For example, the Structures Branch operating under Mathews' Spacecraft Research Division managed a Heat Transfer Section, a Loads Section, and a Structural Analysis Section, which provided basic engineering analysis and design for any of the program units or contractor projects.[29]

When Kenneth Kleinknecht became Manager of Project Mercury (October 1962), Walt Williams assumed broader functions as Associate Director of the center. The Mercury Project Office had full responsibility for technical direction of the McDonnell Aircraft Corporation and other industrial contractors assigned Mercury projects, and for coordinating Mercury activities and flights with other centers and agencies.[30]

Notably, those who had "done Mercury" that is, participated in the conceptualization and design of the project, such as Max Faget, Paul Purser, Robert Gilruth, Chris Kraft, and Aleck Bond "flowed" into new programs and problems which even now began to supercede Mercury in terms of engineering and management effort. But for the most part, with the notable exception of Chris Kraft, the STG-development types could be found in the "line" or functional offices, such as Faget's Research and Development Office, rather than in the operations or projects offices. It had to do in part with personal preferences or predilections of the engineering character, but it also had to do with keeping a core of managing engineers in the mainstream of all MSC/JSC programs so they might provide the necessary coordination and interfacing with project offices.

"As the organization grew, everybody recruited [was] from outside," Joseph P. Loftus, Jr., Assistant Director for the Johnson Space Center explained. The more senior recruits tended to go to the program offices, the younger recruits to flight operations or the engineering and development type offices where they could be trained in the "disciplines and modes of operations that they were endeavoring to establish," or the "Gilruth system." In addition, as people came off Project Mercury, they often found themselves assigned to technical studies in the development office where their knowledge and experiences could begin to be applied to the new projects.[31] By 1962, Gemini, but especially Apollo, demanded more and more of the center's energies, while the operations elements under Mercury carried that program to its conclusion and developed the expertise to be used when flight operations commenced with Gemini and Apollo.

James A. Chamberlin, formerly Chief of the Engineering Division, became manager of the new Gemini Project Office. Chamberlin had been a key instigator of the Gemini project urging the need to develop operational and flight competencies in preparation for Apollo. Faget suggested the craft contain two astronauts, rather than one, to provide a wider range of flight options. As true with the Mercury office, the Gemini Project Office had authority for technical direction of the industrial contractors, such as McDonnell Aircraft, and had full authority to deal directly with the contractors and with related government agencies.[32] The Gemini program, in part because of its more compressed time frame, sandwiched between Mercury and Apollo, and because of the AVRO contractor-oriented experiences of Chamberlin as well as the Mercury background of the Gemini principal contractor, McDonnell Aircraft, functioned somewhat more autonomously than either Mercury or the following Apollo project.

Mercury engineers moved with Max Faget from Mercury to Apollo-related work, leaving Gemini more in the hands of Chamberlin and the contractors. This transition, or lack of it, was more the product of necessity than of intent. Having three concurrent projects on-line strained the limited personnel of the program. Since Gemini was built upon the previous experiences of Mercury and its contractors, most personnel began to concentrate on the Apollo program, while leaving Gemini to the management of the

Gemini Project Office. But the apparent apartness of the Gemini program resulted in the failure to fully transfer the learning experiences of the Gemini program to Apollo, and later created stress within MSC.

Concurrent with the Mercury and Gemini appointments, Gilruth named Charles W. Frick to manage the Apollo Spacecraft Project Office, with Bob Piland as Deputy Manager. Piland probably had more hands-on experience with the Apollo project than any other space center engineer. Piland was given the job in November 1959 to head an STG study (including H. Kurt Strass, John D. Hodge and Caldwell Johnson) of circumlunar manned spacecraft design and flight, presumably in response to an ongoing study by the Goett Committee on the feasibility of a lunar landing, and by the "New Projects Panel" under Strass which recommended work on a three-person second generation (lunar?) spacecraft.[33]

Many Langley and STG personnel, including Gilruth at this early stage, tended to favor Earth orbital missions, such as a manned space laboratory with a possible lunar landing 10 or 15 years beyond. Others, including Max Faget, supported the idea of a large Earth-launched "Nova" rocket ship that could orbit the Moon and return. Other ideas that quickly began to compete included a lunar orbit from an Earth orbit "sling-shot" launched on a Saturn rocket, a lunar landing using a rendezvous vehicle with a mother ship in lunar orbit (which could have been launched variously by a Saturn or Nova class rocket), and a lunar landing from a rendezvous vehicle in Earth orbit. As interest grew and options became more clear, Gilruth appointed Piland "Chief of Advanced Projects" in September 1960 under Max Faget in what was then the Flight Systems Division. But Gilruth did not acknowledge the existence of an "Apollo" type program and personally preferred Earth orbital missions. He did, however, approve the formulation of "guidelines" for "advanced manned space vehicles" which were addressed to all NASA centers for research and recommendations. These guidelines, or Ground Rules for Manned Lunar Reconnaissance as they were originally styled, gave rather sharp definition to what would become the Apollo program as early as March 1960. Subsequently, in early 1961, a Headquarters committee chaired by George Low concluded that lunar landings could be made either by direct-ascent or by Earth-orbital-rendezvous modes. And of course, Yuri Gagarin's flight and President Kennedy's May 25, 1961, call for a lunar landing redirected energies to consider how a landing should be achieved, rather than whether it should be attempted at all. At that point, in May 1961, Gilruth and Faget created the Apollo Project Office under Piland's direction.[34]

The Project Office approved three concurrent study contracts of $250,000 each to General Electric, General Dynamics, and Martin Marietta. Contacts were also made with Massachusetts Institute of Technology (MIT) engineers for recommendations on possible lunar flight projects. Feedback began to come in from other NASA centers as well. At the conclusion of the contractor and in-house studies, a 3-day meeting attended by more than 1000 persons, including industry and government representatives, was held in Washington where, Piland said, a "huge data dumping" occurred. Out of this convocation came the specifications and work statements for a command and service module suitable for lunar or Earth orbit. A request for contractor proposals (RFP) was released in September 1961, and an evaluation team including Piland, Walter Williams, Max Faget, Wesley Hjornevik, Dave Lang and others met at the Chamberlin Hotel in Old Point Comfort, Virginia, to review the proposals. In a very close decision, the award for design and construction of a lunar command and service module went to Rockwell International over Martin Marietta. Meanwhile, NASA awarded a separate contract to MIT for the development of a guidance and navigation system. The Rockwell contract was let on December 15, 1961, following which the "old" organization, including Piland's Apollo Project Office which functioned under Faget's Flight Systems Division, was disbanded; and effective on January 15, 1962, the new organization with the autonomous Mercury, Gemini and Apollo Project Offices "reconvened" in Houston, Texas.[35]

At that time, the primary management activities for the center, including research and development activities, also moved "on site," but 2 more years would pass before the center became fully operational and the last large contingent of personnel moved to the site. Paul Purser, Special Assistant to Director Gilruth, and Wesley Hjornevik, Assistant Director for Administration, moved with Gilruth to the new center. Walter C. Williams, the Associate Director, became the Mercury project officer at Langley, with Flight Operations and Flight Crew Operations under his direction. Kleinknecht's Mercury Project Office in Houston maintained liaison with Williams' operations activities and had responsibility for Mercury planning and coordination with contractors and other centers. When Williams moved to Houston in the fall to assume his duties as Associate Director for Operations, the three flight operations divisions included a Preflight Division headed by G. Merritt Preston, a Flight Operations Division headed by Christopher C. Kraft, Jr., and a Flight Crew Division under W.J. North.[36] By the end of 1962, the management personnel of the space center were organized as indicated on figure 2.

The year 1962 had been an incredibly busy but productive one for the spaceflight program. It all took an enormous amount of energy and hard work by the space center personnel. Newcomers (and most were) had to be assimilated and learn their jobs. Dennis Fielder remembers that "everything was in motion" when he arrived on the scene. He described it as a "Brownian motion," the rapid oscillation of small particles suspended in fluids. "What you were supposed to do was not easy to find out," he said. "You had to reach out and capture people."[37]

Meetings were interminable. The MSC Senior Staff met every Wednesday at 9 a.m. and every branch, division, section, and project had meetings—and then representatives of each met with the others. There were so many meetings that Bob Piland in the Apollo Project Office issued a memorandum urging a reduction in the number of meetings and in the conflicting and excessive requirements for participation in those meetings. Practically the entire staff worked long days, 6 and 7 days a week, and took no vacations. Hjornevik issued a memorandum insisting that for reasons of health and morale, every staff member receive (and take) their vacation for a minimum of 2, and preferably for 3, consecutive weeks.[38] Perhaps understandably, family and marital difficulties of NASA/MSC families rose.

Virginia McKenzie remembered "those nerve-racking times" when her husband Joe, with the Apollo Project Office, was spending most of his time traveling—so much so that their children believed that the airport was where their father worked. "Invariably," she said, "whenever Joe was out of town, something would break at home." After taking care

Manned Spacecraft Center, 1962

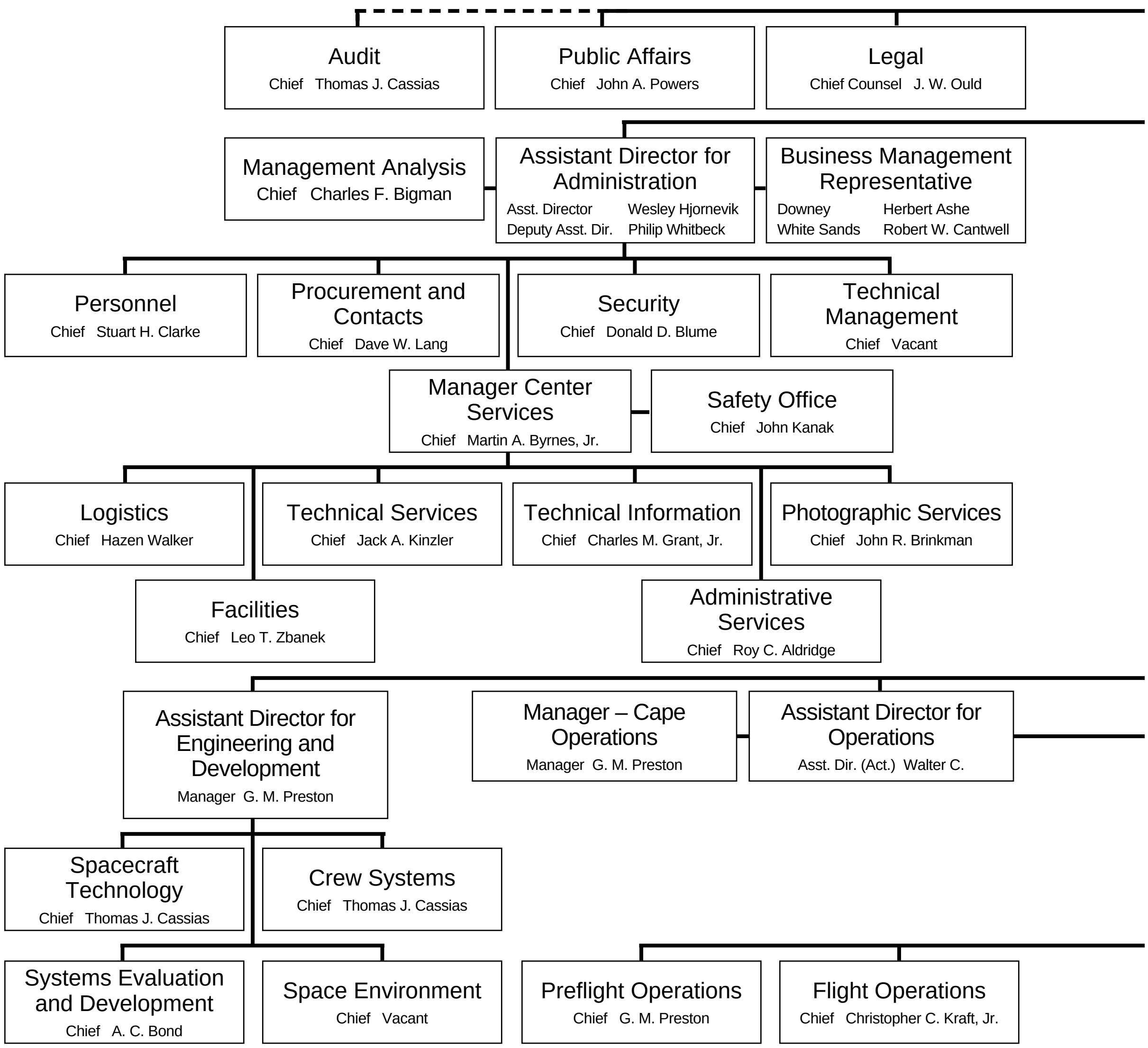
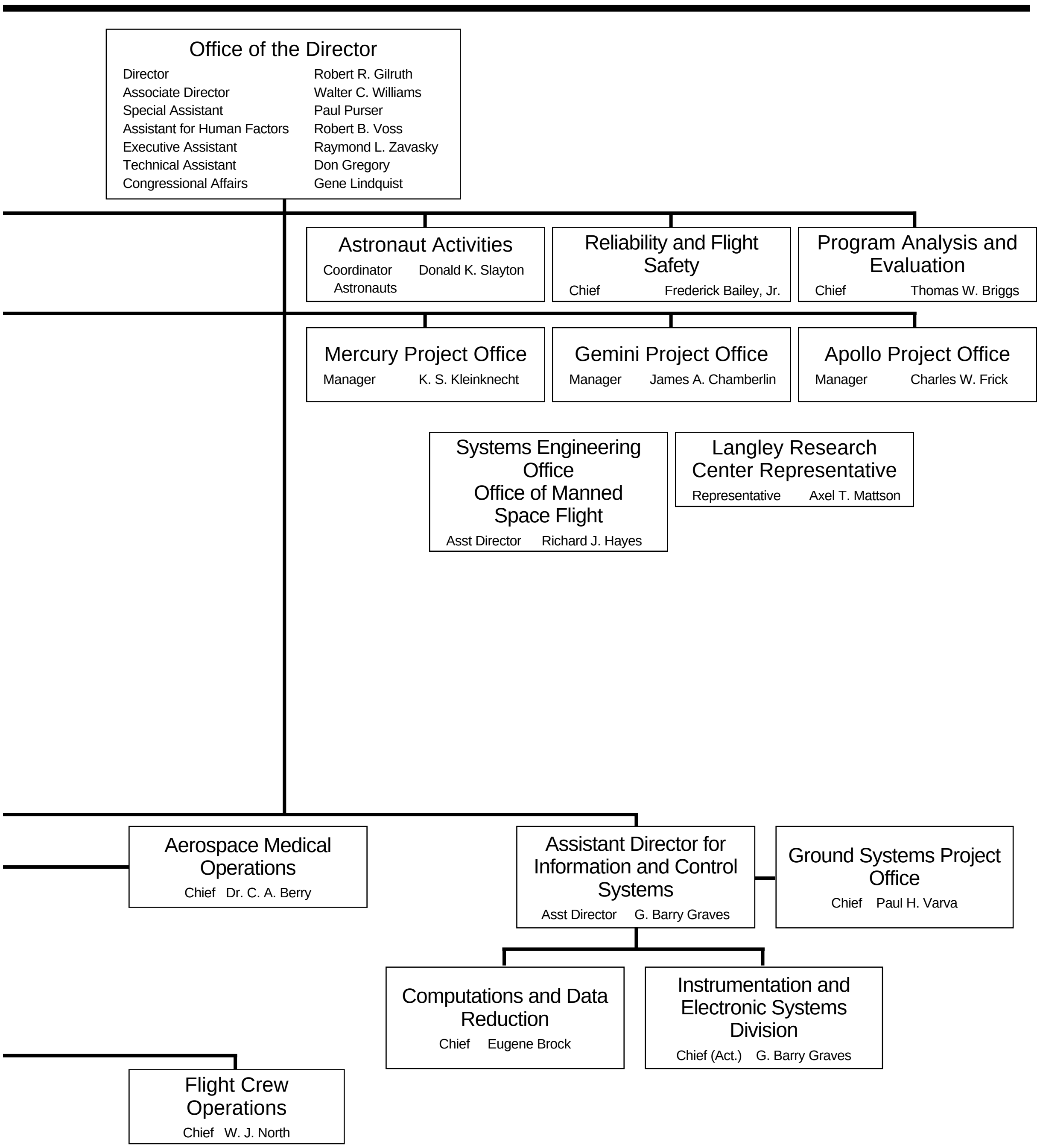


FIGURE 2. Organization as of 1962


Office of the Director
Director Robert R. Gilruth
Associate Director Walter C. Williams
Special Assistant Paul Purser
Assistant for Human Factors Robert B. Voss
Executive Assistant Raymond L. Zavasky
Technical Assistant Don Gregory
Congressional Affairs Gene Lindquist
Astronaut Activities
Coordinator Donald K. Slayton
Astronauts
Reliability and Flight Safety
Chief Frederick Bailey, Jr.
Program Analysis and Evaluation
Chief Thomas W. Briggs
Mercury Project Office
Manager K. S. Kleinknecht
Gemini Project Office
Manager James A. Chamberlin
Apollo Project Office
Manager Charles W. Frick
Systems Engineering Office Office of Manned Space Flight
Asst Director Richard J. Hayes
Langley Research Center Representative
Representative Axel T. Mattson
Aerospace Medical Operations
Chief Dr. C. A. Berry
Assistant Director for Information and Control Systems
Asst Director G. Barry Graves
Ground Systems Project Office
Chief Paul H. Varva
Computations and Data Reduction
Chief Eugene Brock
Instrumentation and Electronic Systems Division
Chief (Act.) G. Barry Graves
Flight Crew Operations
Chief W. J. North

of Kent Slayton while astronaut Donald "Deke" Slayton's wife looked for a home in Houston, Grace Winn felt constrained to tell Slayton later that "he had better stay home more so Kent would know who his daddy is."[39] As it turned out, the manned spacecraft work consumed the entire family and not just the employed spouse.

Following the very successful and celebrated flights by John Glenn and Scott Carpenter (who had been called in to replace Deke Slayton in whom doctors detected an irregular heartbeat), NASA readied the Mercury Atlas-8 flight for astronaut Walter M. Schirra. Schirra was scheduled for six orbits, instead of the three flown by Glenn and Carpenter, and a water-based landing somewhere in the Pacific. The mission sought to check oxygen and fuel consumption, telemetry, and heat control characteristics for extended periods in space.[40]

Schirra flew a virtually trouble-free flight on October 3. The craft reached a speed of 17,500 mph with an estimated perigee of 100 miles and an apogee of 176 miles:

> The return of Schirra and his spacecraft to Earth with almost pinpoint accuracy was an extraordinary tribute to the engineering skills attained by Project

Source: *Roundup* (May 29, 1963)

FIGURE 3. A Chronicle of the Last Mercury Flight

TABLE 2. Project Mercury Flight Data Summary

Flight	Launch Date	Maximum Altitude			Maximum Range		Maximum Velocity			Flight Duration:
		Feet	Statute Miles	Nautical Miles	Statute Miles	Nautical Miles	Ft/sec Earth-fixed	Ft/sec Space-fixed	Mph Space-fixed	Lift-off to Impact hr:min:sec
Big Joe 1	9-9-59	501,600	95.00	82.55	1,496.00	1,300.00	20,442	21,790	14,856.8	13:00
LJ-6	10-4-59	196,000	37.12	32.26	79.40	69.00	3,600	4,510	3,075.0	5:10
LJ-1A	11-4-59	47,520	9.00	7.82	11.50	10.00	2,040	2,965	2,021.6	8:11
LJ-2	12-4-59	280,000	53.03	46.08	194.40	169.00	5,720	6,550	4,465.9	11:06
LJ-1B	1-21-60	49,104	9.30	8.08	11.70	10.20	2,040	2,965	2,021.6	8:35
Beach abort	5-9-60	2,465	0.47	0.41	0.60	0.50	475	1,431	976.2	1:16
MA-1	7-29-60	42,768	8.10	7.04	5.59	4.85	1,560	2,495	1,701.1	3:18
LJ-5	11-8-60	53,328	10.10	8.78	13.60	11.80	1,690	2,618	1,785.0	2:22
MR-1A	12-19-60	690,000	130.68	113.56	234.80	204.00	6,350	7,200	4,909.1	15:45
MR-2	1-31-61	828,960	157.00	136.43	418.00	363.00	7,540	8,590	5,856.8	16:39
MA-2	2-21-61	602,140	114.04	99.10	1,431.60	1,244.00	18,100	19,400	13,227.3	17:56
LJ-5A	3-18-61	40,800	7.73	6.72	19.80	17.20	1,680	2,615	1,783.0	23:48
MR-BD	3-24-61	599,280	113.50	98.63	307.40	267.10	6,560	7,514	5,123.2	8:23
MA-3	4-25-61	23,760	4.50	3.91	0.29	0.25	1,135	1,726	1,176.8	7:18
LJ-5B	4-28-61	14,600	2.77	2.40	9.00	7.80	1,675	2,611	1,780.2	5:25
MR-3*	5-5-61	615,120	116.50	101.24	302.80	263.10	6,550	7,530	5,134.1	15:22
MR-4*	7-21-61	624,400	118.26	102.76	302.10	262.50	6,618	7,580	5,168.2	15:37
MA-4	9-13-61	750,300	142.10	123.49	26,047.00	22,630.00	24,389	25,705	17,526.0	1:49:20
MA-5	11-29-61	778,272	147.40	128.09	50,892.00	44,104.00	24,393	25,710	17,529.6	3:20:59
MA-6*	2-20-62	856,279	162.17	140.92	75,679.00	65,763.00	24,415	25,732	17,544.1	4:55:23
MA-7*	5-24-62	880,792	166.82	144.96	76,021.00	66,061.00	24,422	25,738	17,548.6	4:56:05
MA-8*	10-3-62	928,429	175.84	152.80	143,983.00	125,118.00	24,435	25,751	17,557.5	9:13:11
MA-9*	5-15-63	876,174	165.90	144.20	546,167.00	474,607.00	24,419	25,735	17,546.6	34:19:49

Listed range is earth track
Big Joe - MA Development Flight
MR-BD = Booster Development Flight

LJ = Little Joe
MR = Mercury-Redstone
MA = Mercury-Atlas

*Manned Flight

Source: *Roundup* (June 26, 1963)

Mercury-Atlas 9, a Mercury spacecraft boosted into orbit by an Air Force Atlas rocket, carried Gordon Cooper on a 34-hour orbital mission beginning May 15, 1963. It was the last Mercury flight.

> Mercury personnel. The spacecraft was spotted from the deck of the carrier as it dived toward Earth at a speed of about 270 miles per hour, leaving behind a vapor trail like a high-flying jet aircraft. At about 21,000 feet the drogue parachute could be seen fluttering behind Sigma 7, and the main chute billowed visibly at 10,000 feet to abruptly slow the plunge.[41]

The flight provided all of the checks and assurances believed necessary for a full 1-day orbital mission.

That mission, the last of the Mercury flights, left the pad at Cape Canaveral in Florida on May 15, 1963. The launch suffered odd delays. After a delay for the weather, reported the *Roundup,* all systems were finally "go": the "Atlas launch vehicle was go; the miniature but no less complicated spacecraft was go; the weather was go; Cooper was go." But the simple diesel engine which must move the gantry away from the firing line would not go. It wouldn't even start. Another try was delayed for a radar problem in Bermuda. Cooper left the capsule and went fishing, but returned the next morning for a perfect lift-off which brought him into 22 orbits during a day and a half in space. On the return, his electrical system failed, and Cooper piloted his craft back to within 4 miles of his target ship. Cooper went on to be the guest of honor at numerous parades and dinners. A parade in Honolulu turned out 250,000 spectators with equal numbers in Washington, D.C. and Houston; Cocoa Beach, Florida, with a population fewer than that number mustered 80,000, and 4.5 million people lined New York City parade routes. And with that grand finale, Mercury went out of business. On June 12, 1963, Administrator James E. Webb announced that there would be no more Mercury shots, and that NASA would concentrate on Gemini and Apollo—as indeed the MSC was already doing.[42]

Despite the successes with Mercury, Apollo was encountering problems—largely organizational "people" type problems, both on the center level and at Headquarters. The Apollo Spacecraft Program Office under Charles W. Frick, who had duty with the NACA Ames Research Center before moving to Convair as the designer and chief engineer for the Convair 880 and 990, attempted to make the Apollo program a "center within the Center." He absorbed more and more of the responsibilities of the supporting functional branches. Cooperation between center directorates and the Apollo Project Office waned. Competition and rivalry developed. Part of the problem derived from Frick's preference for the "industrial" boss style of management rather than the collegial "cooperative" style traditional with the center and virtually required by the contractual programs. Technically, NASA/MSC could not "boss" its contractors, but it could cooperate with, assist, and "manage" them. Finesse and tact were required. Frick finally informed NASA Headquarters that he was being forced to resign, and wanted to know what Headquarters was going to do about it. George Low replied that the matter was a center affair and Frick left. It may have been, in part, that Frick's heart had never been fully in his new job. He never gave up his home in La Jolla, California, and lived "out of a suitcase" in Houston.[43]

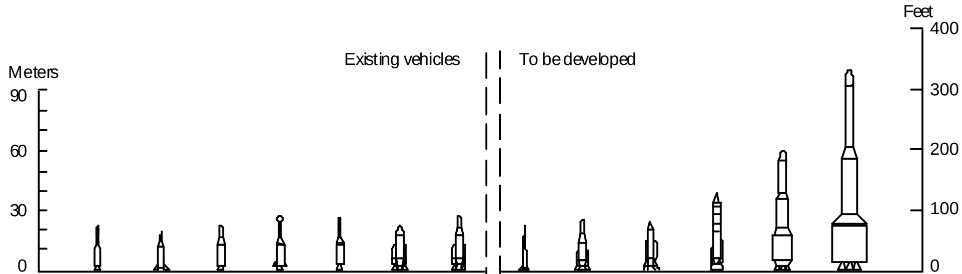
Bob Piland assumed the duties of acting Apollo Project Manager, but within months, asked that a permanent manager be appointed to replace him. Gilruth asked that Joseph F. Shea be sent from NASA Headquarters to manage the project, with Piland to resume the deputy role. Shea, according to Piland, had fought the battle at "higher levels" for a Moon-orbit-rendezvous flight—and prevailed. Shea accepted the MSC Apollo position, but only with the understanding that Walter C. Williams would assume duties in Washington as Mission Director—not that Shea wanted Williams in that particular position, but that he preferred *not* to work directly under the authority of Williams at MSC. Williams did go to Washington, and Shea came to Houston, and the exchange eased, but did not resolve, the difficulty of meshing the program offices with the functional divisions of the center. Contractors, for example, might get a favorable evaluation in a project office, only to have it vetoed by the functional engineering and development office. This problem was later resolved when George Low came to the Apollo Project Office and gave the functional offices (and hence the center rather than the project office) authority over contract progress.[44]

Similarly, on the Headquarters level, the growing assumption or "usurpation" of the presumed center autonomy by the missions or project offices led to many difficulties and a general reorganization of NASA management. In September 1961, in response to the developing Apollo lunar program, Administrator Webb abolished the existing program offices and created four new ones including Advanced Research and Technology, Space Sciences, Applications, and Manned Space Flight—the latter to have authority over all spaceflight activity. D. Brainerd Holmes, whom Webb appointed Director, came to NASA from the Radio Corporation of America (RCA) Defense System Division. An electrical engineer, Holmes was project engineer on the Alaskan-Arctic early warning system. Webb and Holmes planned to give Headquarters greater authority over spaceflight programs in the future than it had exercised over Mercury.[45]

Mercury, for all practical purposes, through the cooperation of Silverstein and Low, operated as a NASA center cooperative effort with the STG/MSC assuming the leadership role. The "federalist" style of center association, under which each center enjoyed considerable autonomy but cooperated (usually) in the completion of tasks, conflicted with the centralist or industrial management system which Holmes began to impose, and with the rather fierce spirit of independence which each center and especially the new MSC seemed to be developing.

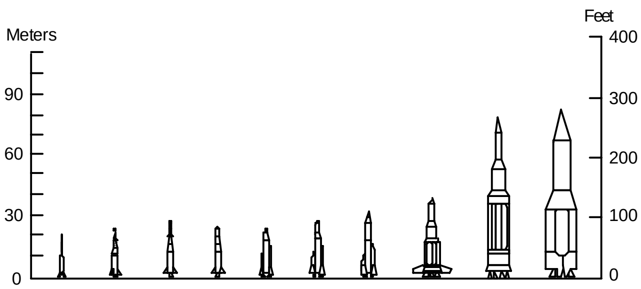
Holmes had appointed Joe Shea from Space Technology Laboratories as his deputy (before Shea transferred to the Space Center) to concentrate on systems engineering. George Low worked under Holmes on programs. The systems organization, Low said, "tried to run the show technically from Washington; while on the program side we tried to function as we had in Mercury and Gemini, i.e., letting the centers do the work" and Headquarters stepping in to help when needed. Holmes helped in resolving the Apollo lunar versus Earth-orbit-rendezvous issue, and most of the basic Apollo decisions were made during his tenure. He also created a Management Council which brought center directors and associate directors and NASA administrators together in a policymaking body; but by appearing to assume full program authority at the Washington level, he created tremendous conflicts with the MSC managers and with the Administrator and Deputy Administrator at Headquarters. Finally, Holmes was removed from his position, the old Manned Space Flight (program) Office was abolished in September 1963, and George E. Mueller became Associate Administrator for Manned Space Flight, with George Low as Deputy Associate Administrator.[46] Changes in the higher administrative echelons had little impact on progress in the Gemini and Apollo programs, which were already largely in the hands of the contractors.

1959



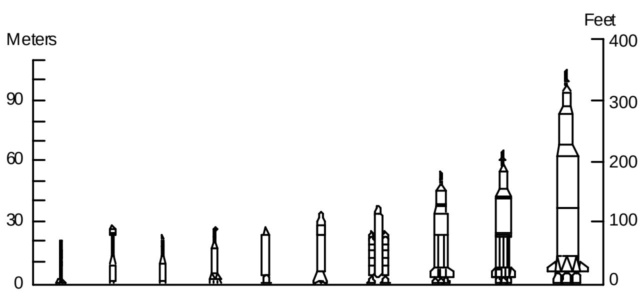
kg of payload	Vanguard	Jupiter C	Juno II	Thor-Able	Thor-Hustler	Atlas	Atlas-Able	Scout	Atlas-Hustler	Vega	Atlas-Centaur	Juno V	Nova
to 185-km orbit	9-23	11	45	90	180	70	1000	70	1450	2600	3300	8600-15,000	70,000
to escape			9	35	45		145		330	600	1200	2000-3600	24,000

1962



kg of payload	Scout	Thor-Able Star	Thor-Agena B	Delta	Atlas	Atlas-Agena B	Centaur	Saturn	Advanced Saturn	Nova
to 185-km orbit	70	400	230	730	1200	2300	3900	9100	90,700	158,800
to escape			30			340	1000		38,600	68,000

1963



kg of payload	Scout	Thor-Delta	Thor-Agena	Atlas-Agena D	Titan II	Atlas-Centaur	Titan IIIC	Saturn I	Saturn B	Saturn V
to 185-km orbit	150	420	712	2900	3500	4300	11,400	10,500	16,000	114,800
to escape		47		430		1050	2300			43,000

Characteristics

The launch vehicles used by NASA during the agency's first 10 years are illustrated above. Two proposed vehicles, Vega and Nova, are also shown. Two boosters borrowed from the military, Atlas and Thor, were used with several different upper stages. Atlas was paired with Able to create a vehicle for orbital missions. Able, Agena, and Delta were added to Thor to increase that missile's range and versatility. Juno and Vanguard vehicles contributed to NASA's early space science program. Redstone missiles were man-rated to boost the first Mercury astronauts onto ballistic trajectories, and Gemini astronauts rode modified Titan IIs into orbit. Two distinct vehicles, Little Joe I and Little Joe II, were used to test and qualify launch techniques and hardware for the Mercury and Apollo programs. The Saturn family of launch vehicles was developed specifically to support the Apollo lunar exploration venture. And Scout, which changed over time as its engines were upgraded and its reliability improved, was NASA's first contribution to the launch vehicle stable.

Source: Linda Neuman Ezell, *NASA Historical Data Book*, II, *Programs and Projects, 1958 - 1968*, 3, 24.

FIGURE 4. Launch Vehicles

North American Aviation received the prime contract for the three-man Apollo spacecraft vehicle in 1962. Its design required rendezvous capability, accommodations for a 14-day mission for the three-man crew, and the option of accommodating larger crews for shorter missions. An expendable service module and lunar landing module would be components of the Apollo craft. Grumman Aircraft, the prime contractor for the Lunar Excursion Module (LEM), proposed a preliminary design for such a vehicle as early as May 1961 while doing one of the "feasibility" studies for Piland's "Advanced Projects Office." Grumman, in turn, by July 1963 selected six major subcontractors, including RCA, which received the $40 million contract for LEM electronic subsystems and engineering support.[47] The Apollo spacecraft would be the product of a large assortment of industrial contractors and subcontractors working under the relatively close guidance and supervision of an equally diverse NASA management contingent representing numerous branches, divisions, and project offices.

The proposed launch vehicle for the Apollo spacecraft, now designated as a Saturn I, was the responsibility of Marshall Space Flight Center. The Saturn emerged from a considerable history of experimental and design work dating back to initial studies in 1957 by Von Braun's team at the Redstone Arsenal of a rocket booster that could launch heavy loads into orbit (9,000 to 18,000 kilograms or 20,000 to 40,000 pounds). Work by the Army Ballistic Missile Agency, development contracts with Rocketdyne for the Thor-Jupiter engine, and a 1959 contract with Rocketdyne for the Saturn preceded NASA's assumption of responsibility. Douglas Aircraft received the contract for the Saturn second stage, the new Marshall Space Flight Center (Von Braun's group) received program responsibility, and contracts with Pratt & Whitney, Convair, Chrysler and other contractors led to the first Saturn test launch (first stage) in October 1961. The next year, in late April, the second of 10 Saturn (C-1) test and development flights, preparatory to a planned 1964 orbital mission, made a fully successful lift-off. It was powered by eight H-1 engines which developed 1.3 million pounds of thrust and climbed to an altitude of 135 miles in 115 seconds.[48]

The decision to develop a more powerful Saturn booster, even while development of the C-1 continued, led to work on the Saturn 1B by Chrysler and Douglas and work on uprating the H-1 engine by Rocketdyne. Still not satisfied, on November 10, 1961, NASA accepted proposals from five contractors for the development and production of yet more advanced Saturn boosters than the 1B, using Rocketdyne F-1 and J-2 engines. Contracts for three of these Saturn V booster stages were let to North American, and Boeing and Douglas received first stage and third stage contracts, respectively.[49] By 1963, NASA, and especially the MSC and the Marshall Space Flight Center, focused its energy and attention on Apollo. Even while the Mercury project was peaking, Gemini was coming "on line" and the new MSC was under construction.

Finally, in November 1963, Gilruth abolished the Mercury Project Office and completed the reassignment of Mercury personnel to Gemini and Apollo projects. He appointed Christopher C. Kraft Director of Flight Operations and Deke Slayton Assistant Director for Flight Crew Operations and head of the Astronaut Office. Near the end of that month, President John F. Kennedy and Vice President Lyndon B. Johnson arrived in Houston, and the center encouraged employees to see the motorcade. The next day, November 22, Kennedy arrived at that fatal day in Dallas.[50] The Nation was shocked and deeply grieved by the untimely death of the President—one who was so instrumental in the expansion of the Nation's manned space program. Administrator Webb publicly and the NASA community privately vowed to meet his challenge of May 1961.

Personnel and contractors redoubled their efforts on the Apollo and Gemini projects. Gemini, having been announced in 1962, was "reconfigured" in January 1964, when MSC managers working with North American found it necessary to abort the paraglider landing system in favor of a Mercury-type parachute water landing. But progress was being made on many fronts. Several groups of astronauts were in training, successful unmanned suborbital tests of the Gemini-Titan I were made, Titan IIs were test-fired, a new mission control office was being established in Houston rather than on the Cape as under the Mercury project, new astronaut pressure suits and greatly enhanced ground-based computer control systems for Gemini and Apollo were being developed, and perhaps most importantly, the support and the confidence of the Nation, and certainly of the new President, Lyndon B. Johnson, remained with the NASA missions despite domestic problems relating to race, education, segregation, and the growing involvement of American combat forces in southeast Asia.

And, almost 4 years after its selection, the manned spacecraft people in Houston, Texas, really had their new home. Between February 20 and April 6, 1964, some 2100 MSC personnel moved into their new Clear Lake quarters, and the final move from all leased facilities in Houston to new on-site quarters began on June 24, 1964. No Americans flew in space in 1964. It had been a year, as the *Roundup* summarized it, "of filling the pipeline with hardware," and it could have added, "of filling the MSC with buildings."[51]

George Mueller, the Associate Administrator for Manned Space Flight, summarized the very brief history of the Manned Spacecraft Center for the MSC Senior Staff in October. "We can congratulate ourselves," he said, "on a particularly impressive set of accomplishments while this rapid growth was taking place." He noted that the Marshall Space Flight Center had completed the development of the Saturn I, the Kennedy Space Flight Center (Cape Canaveral) now had tuned its launch operations, and here at the Manned Spacecraft Center, he said, "you have special reasons for pride."[52]

"You began in 1961 with a budget of $200 million; in 1964 the center operated with a budget of about $1.475 billion—50 percent greater than the entire NASA budget for 1961. The center had 4277 employees by the end of 1964, a fivefold increase. You constructed a brand new plant from the ground up," he said. "All of this was accomplished while you were flying six manned Mercury missions, conducting the Gemini program at top speed, and building up to a full head of steam on Apollo." And he added, "The creation of this center—the people, the physical plant, and the associated industry team—in the pressurized environment to which you all have been subjected over the last few years is a remarkable achievement, probably without parallel. The country owes a great deal to Bob Gilruth and all of you for the tremendous job you have done."[53]

Then Mueller went on to review the recent history of human entry into space beginning with Sputnik, the flight of Yuri Gagarin, and the great leap forward in the American manned spaceflight programs through the Mercury, Gemini and Apollo projects.

He talked about the things NASA had promised to do, the things it had failed to do, and the things that must be done, for paradoxically, he explained, "now we are in a sense paying the price for our success." There was a sense of rising expectations on the one hand, but a growing aura of complacency on the other. He also talked at great length about the changing mood in Congress and the high dollar costs of manned spaceflight.[54] Within the 7 years of the flight of Sputnik in October 1957, Americans had arrived confidently and competently on the threshold of space, but the technology, the ground rules and, perhaps necessarily, the management systems were in a constant state of change. Space was no easy business.