“Man needs frontiers.”

Mueller, July 17, 1969

In December 1969, Mueller joined General Dynamics, a company whose financial difficulties were compounded by serious problems with several of its aircraft development contracts. As federal spending for defense and space R&D declined, revenue fell and in 1970 the company showed a loss. A hands-off manager, Roger Lewis hired Mueller to help solve some of the company’s technical problems, and on December 11 the new vice president for corporate development reported for work at General Dynamics headquarters in New York City. On several occasions during his short stay at the company he met with Teague, and in mid-April 1970 he shared his ideas about the administration’s plans for human spaceflight. Writing in support of space shuttle funding, he told Teague, “this single development is the key to all of our future space activity, both manned and unmanned ... Reusability is a prime factor. At least 100 round trips into space will replace one time use on a one way trip of all present launch equipment.” He called the space shuttle key to the nation’s defense, and to the control and utilization of space. And, he argued, “the space shuttle will save billions of dollars ... It will be a barrier to technological surprise. It will be an effective shield for our national security.”

After leaving NASA, Mueller continued to go to the Cape to witness Saturn launches. However, no longer an agency official, he sat in the VIP/Press stands across the river from the launch pad, which he referred to as “the boon docks.” Speaking at a space congress held in nearby Cocoa Beach before the launch of Apollo 13, he criticized plans to build the partially reusable space shuttle, saying, “the original space agency plans called for the development of a reusable spacecraft to greatly reduce the cost of getting men and supplies in and out of orbit ... It doesn’t make sense to build a train where you make the engine reusable but where

1 GD Press releases, 12/1/69, GEM-122-9; “Henry Crown, Industrialist Dies...,” NYT, 8/16/90; Mueller Interview, Slotkin, 6/9/10; Mueller to Teague, 4/15/70, GEM-111-5.
you throw away the freight cars each time you use it.” To use “a rocket that dropped into the sea after each launch would cause the whole effort to lose its significance.”

Perhaps he missed leaving the agency, although probably not when Apollo 13 ran into trouble on its way to the Moon. But he said the problems had nothing to do with the design or construction of the spacecraft, they occurred due to human error. And, “we had looked [at] all of those contingencies before Apollo 11 and my immediate reaction was well there are enough things they can do so they will get back.” As he explained it, “Some guy left a heater on when it was supposed to be off and ... [this subsequently] caused an explosion.” Nonetheless, in a letter to his mother dated April 28, he wrote, “As you can guess, I spent some very tense hours and a few very sleepless nights, but now that they are back we have learned why it all happened. I was down at the Cape for the launch ... It was a very strange feeling to be there strictly as a spectator for the first time!” Yet from the tone of his letter, it appears that he adjusted to life outside of NASA, or at least that is what he wanted his mother to believe. In the fall of 1970, Roger Lewis reorganized General Dynamics. He put six divisions under Mueller, promoted him to senior vice president, and announced that the reorganization would take effect in December. With expanded responsibilities, Mueller returned to his whirlwind ways. He visited plants, reorganized divisions, met with customers and members of his management team, and established a new reporting structure. To support his efforts, he brought Skaggs from NASA to New York as his director of management and operations. In all, he assembled a staff of ten to manage eighty percent of the company. However, just as he began his new job, Henry Crown, who owned a majority interest in General Dynamics and controlled the board of directors, shook up the top management. On October 22, David S. Lewis, the former president of McDonnell Douglas Corporation, replaced Roger Lewis (no relation) as CEO. Caught totally unaware, Mueller had a new boss. And as it turned out, this Lewis, a hands-on manager, did not want anyone between him and most of the company. As Mueller remembered, “that was pretty clearly going to be a real problem,” and it only “took Dave Lewis [a while] to decide he wanted to have me disappear.”

As it turned out, a board member of the System Development Corporation visited Mueller and asked if he would be interested in leading that firm at around the time Lewis told him “well you really ought to think about getting another job.” He knew that SDC had developed the software for the North American air defense system, and thought highly of their work, but did not know many details about the company. Unlike his job search prior to leaving NASA, this time he did not cast a wide net to evaluate his employment options; he liked the company and they liked him, though he did not know much about their business or financial condition. And after meeting with the SDC board in early February, they offered him the position of

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3 Mueller Interview, Slotkin, 6/9/10 and 2/22/11; George to Mums, 4/28/70, GEM-111-5; Mueller to Skaggs, 9/17-30/70, GEM-111-10; Skaggs to Slotkin, e-mail, 6/3/11.
chairman, president and CEO. It was a tempting opportunity, albeit a much smaller company than General Dynamics. However, after his recent experience he wanted to be his own boss. And as he recalled, it was a “challenge” and “quite an awakening.”

Then on January 27, 1971, the White House surprised Mueller by announcing that he would receive the National Medal of Science, becoming just the fifteenth engineer so honored. William D. McElroy, director of the National Science Foundation which administered the award, called it well deserved: “The National Medal of Science is the Nation’s premiere recognition for distinguished science achievements, and your work is richly deserving of this honor.” Mueller later learned that he received the award because two former Bell Labs colleagues, Edward E. David, Jr. and Harald T. Friis, the former previously Nixon’s second science advisor, appreciated his work at NASA. At the White House ceremony on May 21, the president presented the medal, reading a citation saying: “For his many individual contributions to the design of the Apollo system, including the planning and interpretation of a large array of advanced experiments necessary to insure the success of this venture into a new and little known environment.”

With an enhanced reputation, Mueller arrived in Santa Monica, California to lead SDC with a staff of 2,000 software developers. His task was to make the small not-for-profit company a commercial success. As he later explained, taking over and converting SDC to a profit making company became “a greater challenge than trying to get Houston and Marshall working together.” And his first task involved building a team, because, he said, “There are no more dedicated individuals than computer scientists.” However, a few days after arriving he asked himself “what have I gotten myself into?”

Mueller promptly began recruiting and hiring new managers with profit making and marketing experience to augment the company’s technical capabilities. As he said, “We knew we had a solid technical management ... Now all we needed were people who knew how to make profit.” He also brought in a number of key associates from NASA and the air force, and one of his first hires was Skaggs, who would earn a reputation at the company for action. He hired other talent to augment the old hands on board, and by March 1972 he had a number of executives with computing and aerospace backgrounds at SDC. He also recognized and promoted some existing SDC managers, mainly to fill technical and administrative management positions. The combination of SDC veterans and the new hires resulted in an eclectic group of people at the top of the company; and as Mueller recalled, SDC was “a fairly eclectic company.”

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4 Mueller Interview, Slotkin, 6/9/10.
6 Mueller Interview, Slotkin, 6/9/10.
7 Baum, *System Builders*, 165-167; Mueller Interview, Slotkin, 6/9/10; Mueller to Employees, James B. Skaggs Elected SDC President, 1/29/81, GEM-126-9.
Mueller continued his involvement with the civilian space program as a consultant to NASA, although SDC did not win significant business with the agency until after he retired. He served as a member of the Air Force Systems Command Advisory Committee for two years when Phillips became its commander in 1973, and joined the Air Force Studies Board, of which he remained a member until his retirement from SDC in 1983. These voluntary assignments required major time commitments, but it made good business sense because the air force was SDC’s main customer. He also became a member of the National Security Agency Scientific Advisory Board, advised the CIA, and joined the Defense Communications Agency Scientific Advisory Group. In addition, he contributed to a National Research Council study on Space Solar Power.8

Interested in helping to resolve the energy crisis in the 1970s, Mueller became a member of the congressional Office of Technology Assessment’s Energy Advisory Committee, reviewed the Carter administration’s energy plans, and advised Congress about the proposed National Energy Act, nuclear proliferation, application of solar energy, recovery of oil, and other energy issues. Working with the Office of Technology Assessment he evaluated plans for various projects in the late 1970s, and in the early 1980s participated in a congressional assessment of the space station as a member of the Civilian Space Station Advisory Panel.9

Throughout the 1970s, Mueller attended the annual International Astronautical Congress and chaired the 1976 congress in Anaheim, California. The event attracted astronauts and cosmonauts – including the crews of the recent Apollo-Soyuz Test Project – and space agency heads from around the world, along with almost one thousand space scientist and engineers from forty-three countries. The meeting turned out well, enhancing Mueller’s role with the IAF and its US member, the AIAA. As a result of this success he agreed to take on leadership roles at subsequent congresses. In 1978, AIAA’s members elected him president for 1979-1980. And he attacked this volunteer job like everything else he did, using the position to crisscross the nation, attending meetings, making speeches, and contributing to their monthly magazine *Aerospace America.* In July 1979 he wrote in an editorial, “It was ten years ago this month that man first stepped on the Moon. That exciting moment was the culmination of the most remarkable and sustained engineering program in history.” He congratulated those responsible, and proposed using the Apollo 11 anniversary “to stimulate a resurgence of interest in our space program.” Also around that time, he published another article in *Aerospace America* with the message that “America relinquished its commanding post-Apollo potential and now awaits the shock of


9 Mueller Interview, Slotkin, 6/9/10; Mueller Testimony, OTA, Washington, DC, 6/14/76, SDC Speeches.
another major Soviet achievement to create public backing for major space missions.”

On July 17, 1979, ten years and one day after the Apollo 11 launch, Mueller addressed an AIAA meeting, saying “the success of Apollo richly rewarded the American people.” He said that the reception given to the Apollo 11 crew upon their return to Earth was comparable to Charles Lindbergh’s triumphant return to the US in 1927. Yet in the ten years since that lunar landing, the nation “drew back from the promise of space,” and he found this discouraging. He believed the pullback to be temporary, though the country remained depressed in the aftermath of the Vietnam War, a stagnant economy, and record inflation. However, he said that a new space program could once “again provide a sense of purpose for all of us . . . Space is man’s manifest destiny. By accepting this destiny, we reaffirm our uniqueness as a species, and we open the door to unimagined potentialities.” He expanded on this theme in Huntsville, in a lecture honoring von Braun, who died in 1977. Quoting an article that his colleague wrote in 1949 forecasting the exploration of Mars, he said that if von Braun had thought of it, he would have said “Space exploration is our manifest destiny.” He spoke of Fredrick Jackson Turner’s frontier thesis, and added, “I am not constrained by professional niceties of the historian, I am perfectly willing to take that extra step and extend Turner’s thesis universally. Man needs frontiers . . . [If] a civilization draws back from a frontier because of fear of the unknown, it will inevitably decay.” He called space “the greatest frontier of all and it offers unlimited potential for mankind.” Following this speech, the Huntsville Times quoted Mueller saying, “Only when we gain the knowledge from the exploration itself can we gain a glimmer of the ultimate impact of that exploration. Thus, support of any true exploration must be an act of faith.”

II

Mueller rebuilt SDC with Skaggs’ help, and ten years after becoming a profit seeking company it had increasing revenues and profits. Meanwhile, the not for profit System Development Foundation that owned most of the company stock was eager sell its shares. Although the foundation had converted small amounts of equity into cash by several transactions over the years, it still owned two-thirds of the company. In 1979, Mueller recommended that SDC’s senior management seek a merger partner because attempts to go public had not been successful.

10 IAF, GEM-173 to 175; Draft Editorials, AIAA, 1979, Writings, GEM-241-14; Correspondence, Apollo 11, 7/16/74- 3/20/79, GEM-192-10.
12 Baum, System Builders, 259-285; Mueller to distribution, Draft Criteria, 1/16/80, GEM-154-2.
Fletcher, who had stepped down as NASA administrator in 1977, sat on the Burroughs Corporation board of directors, and in early 1980 he contacted Mueller to suggest that Burroughs buy SDC. Mueller turned this over to the foundation, and Burroughs began discussions to acquire all of SDC’s shares. A cash offer for $98 million was made on August 27, and the deal was closed on January 5, 1981. The foundation received $66 million in cash for their portion, nine times the value of SDC’s equity when Mueller had arrived in 1971. SDC had almost $200 million in revenues, more than four times the amount in 1971, and during ten years under his leadership the company had grown, diversified and become profitable. So at 63 years of age, he became chairman and CEO of SDC, operating as a Burroughs subsidiary, and Skaggs became its president and chief operating officer.\(^{13}\)

MIT’s Charles Stark Draper, 80 years of age in 1981, stepped down as president of the IAA and handpicked Mueller as his replacement, naming him acting president in December. At that time, the academy did little more than organize sessions at the annual International Astronautical Congresses, publish a scholarly journal, and honor members with diplomas. Mueller wanted to breathe new life into the organization; no mean task considering it had limited assets with greater liabilities. In 1982 Mueller officially succeeded Draper and, like his predecessor, remained president for many years, finally stepping down at the age of seventy-seven in 1995. After his election in 1982 Mueller reinvigorated the academy, making it more dynamic with an expanded and active membership. He selected new candidates to fill leadership roles, and grew the membership to include some of the foremost workers in the field of astronautics. Being president of the IAA gave him new speaking platforms, and over the next thirteen years he frequently spoke about the future of space exploration as he traveled the world. He expanded the academy’s reach by conducting meetings jointly with national academies of sciences, improved its finances, and began holding standalone specialized conferences. He enlivened the academy, decreased the average age of the academicians, and accomplished most of the objectives that he set himself. However, as his wife Darla once told your author, his involvement with the IAA is “only a footnote” in his extremely successful life.\(^{14}\)

In 1982 the original SDC had a revenue exceeding $263 million and a pre-tax profit of almost $23 million. Financial results continued on plan in 1983, but later in the year, shortly after his sixty-fifth birthday, Mueller retired from the company. At that point in his life he did not want to run another firm. When he married Darla J. Schwartzman (née Hix) in 1978, she had two pre-teen children, and the new Mueller family moved to Santa Barbara into a residence that overlooked the Pacific. After retirement Mueller devoted himself mainly to his new family, but he remained involved in outside activities and worked with the University of

\(^{13}\) Mueller Interviews: Slotkin, 2/22/10, 6/8-9/10; Mueller to SDC Board, 8/27/80, GEM-154-3; Baum, System Builders, 259-285.

California at Santa Barbara in human system research, a project which occupied him for several years.15

In 1986, in the wake of the Challenger accident and the report of the Rogers Commission, Fletcher returned as NASA administrator and awarded the National Academy of Public Administration a contract to study the effectiveness of agency’s management. NAPA tapped Phillips to lead a study group which included Mueller, Mathews, Skaggs, Lilly, and other NASA and industry Apollo alumni. At one of their first meetings, Mueller made several observations consistent with his approach to program management during the Apollo Program. Notes from September 23, 1986 quote him saying, “Any ability to trace decisions and updates between centers is now purely coincidental . . . NASA must clearly define interfaces and program information transfers and linkages.” He expressed concern that the agency had “lost sight of the concept of roles and missions,” allowing the center directors freedom to select the work they wanted to do. And, he argued, “NASA needs to develop institutional – and program – based strategic plans with a focus that goes beyond next year’s goals.” He continued working with the NAPA group, studying the agency’s organization and management until they issued their final report in early 1988, which said that NASA needed to improve its approach to policy development and recommended separating development of new programs from day-to-day operations. This project gave Mueller a close look at the agency once again, and he visited its major facilities, receiving briefings about the agency’s organization and management. Unlike other studies of its kind, this one had an impact when NASA relocated the International Space Station Program Office from Houston, the “lead-center,” to a centralized program office in Reston, Virginia. Another of Mueller’s ideas involved commercializing the space shuttle in order to “offload it from NASA and put it into commercial operation.” He discussed this at headquarters and in Houston, recalling “they supported the idea which was surprising to me.” However, in the end, nothing came of it.16

In July 1994, the nation celebrated the twenty-fifth anniversary of Apollo 11 and Mueller participated in some events commemorating the mission. Newspapers and magazines published articles looking back to the first lunar landing and forward to planetary exploration, including a mission to Mars. While many of these articles highlighted the accomplishments of the astronauts, and referred to von Braun and several of the others who contributed, very few mentioned Mueller. The nation had nearly forgotten the man who successfully managed human spaceflight during the race to the Moon. In a letter that Mueller wrote for publication at this time, he reminisced about the first lunar landing, and credited nine men with the accomplishment: Phillips, von Braun, Rees, Debus, Petrone, Gilruth, Low, Rudolph,

15 Mueller Interview, Slotkin, 2/24/10.
and Shea in that order (all of whom he had included on his list of thirteen in 1969). He wrote about the Apollo executives group and STAC, and concluded by saying, “These are only a few of the 250,000 men and women who worked directly on the Apollo Program. Every one of them is a hero in their own right.”

Involved with a number of startup companies throughout the 1970s, 1980s and 1990s, Mueller began his association with the Kistler Aerospace Corporation in February 1995, when Robert Citron and Walter Kistler visited him in Santa Barbara and asked him to join their board of directors. He told them that he had no interest in becoming a board member unless they made him CEO, something that surprised them. He did not want to get involved with Kistler’s new K-1 launch vehicle without being given control of its design. After learning that Kistler shared his dream of building a fully reusable launch vehicle, he saw the K-1 as an opportunity to develop “that first and most important link from the Earth’s surface to [low] Earth orbit,” he said. And while he had remained busy since retiring from SDC, he felt ready to return to full time work once again. After Kistler and Citron had thought his proposal over, they agreed to make him CEO.

So in April 1995, at the age of seventy-seven Mueller became CEO of Kistler Aerospace Corporation, initially signing on for three years, which stretched to eight. For a modest salary, he found himself the head of the startup company, and relocated to Kirkland, Washington. The design team that he found when he arrived consisted of “an interesting group of individuals,” but according to Mueller, none of them could design a reusable space vehicle. He realized they had problems because a major part of the development involved building new engines, although he said “when we began to test the engines they couldn’t control the thrust accurately enough to be able to fly it.” And after trying for some time, they could not stabilize the engines. Then things “got more interesting,” he said, and he spent a year trying to make the original design work before replacing the designers.

The new design team included people that Mueller felt “really understood this work.” One of the first people he brought in was Aaron Cohen, former director of the Johnson Space Center. In turn, Cohen brought Henry O. Pohl, an expert in engine design who had retired as chief engineer for the International Space Station. Cohen and Pohl helped to attract others, and Mueller hired Myers, the man who replaced him when he first left the agency and who had retired as deputy administrator of NASA in 1989. With this help, Mueller said, “we began to really try to understand what Bob Citron and Walt [Kistler] had put together and decided that it was unlikely to succeed. So we took off and tried to do something that would work.” Back in the space launch business, Mueller set out to do what he first planned at NASA, to build a completely reusable launcher because he

17 Apollo Program, Twenty-Fifth Anniversary, GEM-296-1; Names he left off the 1969 list: Bergin, Stoner, Richard and Kraft.
18 Gottfried to Mueller, 2/4/95, GEM-292-6; Mueller Interview, Slotkin, 6/10/10.
19 Correspondence, 1995, GEM-292-6; Mueller Interviews: Slotkin, 6/10/10 and 2/22-23/11.
believed the development of the communications satellite business finally justified
the need.\textsuperscript{20}

In 1996, Kistler Aerospace Corporation had discussions going with a number of
potential investors, strategic partners and contractors, and development and testing
of the K-1 was set for completion by 1999. The company won its first commercial
order for ten launches as part of Motorola’s Iridium venture from Space Systems/
Loral worth more than $100 million, which helped in their search for additional
funding. Mueller spent time on design work and attending design reviews, while
Kistler’s founders pursued funding. His strategy involved using major aerospace
companies as subcontractors in order to assure investors and customers of the
company’s viability. For example, in 1997 he hired Lockheed Martin to build the
K-1’s fuel tanks. And as they progressed towards initial launch date, Northrop
Grumman invested $30 million, with a promise of a similar amount in 2000 “if the
company proves it has the financial wherewithal to proceed with its first launch
test,” according to the \textit{Los Angeles Times}.\textsuperscript{21}

The design of the K-1 did not present major problems, but getting the funding to
build it did. “The real problems we have encountered,” Mueller said in 1999, “are
not the design, because we had a pretty competent crew of designers . . . probably the
best design team in the country.” The challenge involved building something
reusable that was also simple and inexpensive to operate. Because, “in the long run
it’s the cost of operations that determines the success or failure of any program,” he
explained. He anticipated using a ground crew of about sixty people, with a
turnaround time of nine days. And to do that, they had to look at each part of the
vehicle to insure that it was simple, foolproof, and reliable. A sophisticated K-1
health monitoring system would inform them what needed to be done after each
flight in order to get the vehicle ready for the next mission.\textsuperscript{22}

The company raised $400 million in capital and was well into development when
hit by the Asian financial crisis in 1997. Motorola’s Iridium venture went bankrupt
in 1999, and many of Kistler’s foreign investors backed away. Since most of the
money came from overseas, mainly from Asia and the Middle East, that spelled
trouble, and everything started to fall apart. Without funding to finish the K-1, the
company was impacted by marching army costs, which sapped the remaining funds.
Although they eventually raised a total of about $700 million, much of it was wasted
in supporting the staff while seeking additional funds, or was paid off as
subcontractor overheads. But for these delays, Mueller believed they could have
finished the K-1. They had planned to start flight testing in 1998 and conduct their
first commercial launch the following year, but that timetable proved unachievable

\textsuperscript{20} Mueller Interviews: Slotkin, 2/22/11 and JSC, 1/20/99.
\textsuperscript{21} Mueller Interview, Slotkin, 2/22/11; “Lockheed Gets Kistler Rocket Tank Contract,” 6/
3/19/99, \textit{LA Times}.
\textsuperscript{22} Mueller Interviews: JSC, 1/20/99 and Slotkin, 2/22/11.
without additional funds. As Mueller put it, Kistler Aerospace Corporation “always were on the brink of success,” and “we came close to succeeding.”

Unable to recover from its financial difficulties, the company filed for bankruptcy protection in July 2003. Mueller tried to shepherd them through reorganization, and kept the developers working. In 2004 he finally stepped down as CEO, although he remained chairman and chief vehicle architect. Despite all the money raised, in the end the company fell $100 million short and could not raise additional funds. Mueller remained with Kistler until he got sidelined with health issues that kept him out of action for several years. Nonetheless, he insisted, “the whole secret of a successful launch system is to reuse the parts.” In 2011, he still believes current approaches using expendable vehicles are too expensive, and it will take at least another generation of space vehicles before the commercial space transportation business will succeed.

III

The Introduction stated two objectives: first to describe Mueller’s contributions to human spaceflight, and second to provide a narrative of how he managed Gemini, Apollo and post-Apollo programs at the same time. He applied system engineering to program management to manage human spaceflight. He defined system engineering as a “discipline which involves all of engineering … applied to a particular system.” And he regarded system management as a “structure for visualizing all the factors involved as an integrated whole” – in other words, it was the application of system engineering to program management. He considered his greatest contribution to Apollo to be the program management system which he introduced, a modified version of the air force system program office methodology. With Phillips’s help, he imposed matrix management on the Apollo Program. The Apollo Program Office created dual reporting between the headquarters program management organization and project management offices at the centers. Each program and project office consisted of five functional organizations – the five box or GEM box organization – which included system engineering, program control, testing, reliability and quality assurance, and flight operations. The project offices remained in the centers, but the matrix separated the institutional responsibilities of the center directors from the program responsibility of the program directors, creating a decentralized system with centralized authority. At the top, Mueller reorganized the management council, and used it to manage the programs, with the program directors reporting to it. Separate from the program management system,

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24 “Kistler Aerospace Corporation’s K-1,” GlobalSecurity.org; Mueller Interview, Slotkin, 2/22/11; “Kistler Aerospace Files for Chapter 11 Bankruptcy Protection,” 7/23/03.
Mueller treated “external affairs,” by which he meant relationships outside of NASA, as part of the overall management system, and became adept at working with the politics of the space program.\(^\text{25}\)

The Gemini Program achieved all of its objectives, and by flying in space for fourteen days on Gemini VII “removed all doubts” about astronauts and equipment performing satisfactorily during the time needed to accomplish the lunar landing. During Gemini, NASA developed operational techniques for spacecraft rendezvous and docking critical to the success of Apollo. But only on the final mission, Gemini XII, did Aldrin prove that with proper training and equipment, astronauts were able to perform useful work while spacewalking. Mueller’s main contribution to Gemini consisted of applying management pressure to complete it on time and below the cost estimates that had been established before he arrived. A major change he introduced involved converting Gemini contracts to incentive fee based on cost and schedule, a technique he also applied to Apollo. In the final accounting, Gemini cost about $200 million less than the estimate for its completion when he joined the agency in September 1963, and despite being two quarters behind at that time it was finished on schedule. Because Gemini was further along when he arrived, he was unable to implement all of the facets of the program management system he applied to Apollo. Nonetheless, the parts of it that he put in place contributed to Gemini’s success. However, he never failed to give Mathews full credit for its success.\(^\text{26}\)

In September 1963, Mueller said, “Without much improved management … we will not achieve the lunar goal prior to 1972-1975 … at a cost of $35 billion or more.” But using the program management approach from the air force ballistic missile program, he set out to impose “the right set of working relationships between the centers and hold them there … long enough so that communications could grow.” In addition to the program management system, he used other management innovations. After receiving the Disher-Tischler study, he realized that he would have to change the traditional step-by-step approach to flight testing, and imposed all-up testing, a method first used in the Minuteman Program. Like most ideas, he did not invent all-up testing, but he applied it efficiently and used it to speed up Saturn development and cut years off of the schedule. Announced two months after arriving, all-up testing of the Saturn V began in 1968 with the flight of AS-501 (Apollo 4) after overcoming a one year delay caused by the disastrous AS-204 (Apollo 1) fire. Following the successful first Saturn V flight test, NASA faced the unsuccessful flight of AS-502 (Apollo 6). Officially a failure because it achieved only four of five major objectives, the second Saturn V was a successful flight test precisely because it revealed serious problems in the booster. After correcting these deficiencies, the agency flew AS-503 successfully and sent Apollo 8 to orbit the Moon.\(^\text{27}\)

\(^{25}\) Mueller Interview, Slotkin, 9/9/09; Mueller, Joint AIAA/CASI Meeting, Montreal, Canada, 7/8/68.

\(^{26}\) Mueller, Gemini Conference, Houston TX, 2/1/67.

\(^{27}\) “Organizational Meeting,” 9/4/63, O&M, GEM-84-11; Mueller Interview, 9/9/09.
Concurrency, another management innovation brought to NASA from the air force ballistic missile program, involved the parallel development of systems; and when Schriever led the air force ballistic missile program he developing multiple missiles and major subsystems in parallel in order to open options. Cost and schedule considerations prohibited developing concurrent boosters for the Apollo Program, but Mueller used concurrent development of major subsystems at NASA to guard against “show stoppers”. Another special consideration borrowed from the air force led him to establish the two industry executives groups to improve communications between the agency and its major contractors. He kept Congress informed through monthly briefings, and at the suggestion of his colleague from Bell Labs Charles H. Townes, he established the Manned Space Flight Science and Technology Advisory Committee to improve relations with the science community and serve as a sounding board for his ideas. Composed of some of the most prominent space scientists, medical doctors and engineers in the nation, Mueller credited STAC with major contributions, but he faced opposition from scientific community throughout the Apollo Program. These “special considerations,” as he called them, contributed to the success of Apollo by improving communications.

Mueller established an advanced programs organization to develop a post-Apollo program as part of the original reorganization of the Office of Manned Space Flight in November 1963. Initially calling the post-Apollo program the Apollo Extension Systems, NASA later renamed it the Apollo Applications Program and still later, as its focus tightened, the Skylab Program. Planning for the post-Apollo period took place from the day that he arrived, but not until Apollo-Saturn flight testing began in 1967 did he focus on what he called the space transportation system. As the agency experienced budget pressures, Mueller narrowed the focus of post-Apollo planning. However, after Webb’s departure he returned to planning and talking more broadly about the future of spaceflight. In a speech that he made in London in August 1968, he unveiled ideas about building a reusable space shuttle to travel between Earth and a space station in low orbit. Further planning led to a system that included multiple space stations which would be serviced by different types of space shuttles, including a nuclear powered interplanetary shuttle. Mueller’s promotion of the space shuttle, another idea he borrowed from others, earned him the sobriquet “father of the space shuttle.” However, he did not believe the space shuttle should stand alone – it was to be part of an elaborate space transportation system, like a “railroad” in space; and to be cost effective, it required to be fully reusable.

My second objective in writing this book was to interweave the story of Mueller’s work on Gemini, Apollo and the Apollo follow-on programs into a single narrative, just as he lived them on a day-to-day basis; a goal which I will leave to the readers to verify.

Over the years Mueller met many people who not only impacted his career, but remained friends and played important roles in his professional life. He said that he never planned his career, “it just happened.” He changed jobs, going from Bell Labs, to Ohio State University, to Space Technology Laboratories, to NASA. And after NASA he led the System Development Corporation until retirement. He kept himself busy and useful in retirement, devoting time to government and industry
boards and committees, and spent an enormous amount of effort rebuilding the International Academy of Astronautics, stepping down as president at age seventy-seven only to return to full time employment with Kistler Aerospace Corporation. He said none of these moves were planned, “it just was a set of circumstances that led to that being the logical thing to do at that time.” Reflecting in 2011, he said, “I never would have imagined I’d be in aerospace, although when I started as an undergraduate, I was thinking in terms of aeronautical engineering.” He did not get involved in the space business until he arrived at Ramo-Wooldridge/Space Technology Laboratories, but it came to dominate his life. He called his careers “very interesting,” all of them.28

In April 2011 the Smithsonian National Air and Space Museum in Washington recognized Mueller with the 2011 Lifetime Achievement Trophy for contributions to human spaceflight. At ninety-two years old, Mueller said, “Looking at it today, one of the fundamental drives for humanity is spreading from this small Earth into the rest of the solar system and the rest of the galaxy – and from there into the universe.” In accepting the award, he turned even more philosophical, and said, “I believe that men are going to live and work in space, and are going to explore and colonize the Moon as a stepping stone to establishing an outpost and then a colony on Mars . . .

28 Mueller Interview, JSC, 1/20/99.
As we build this new civilization and become citizens of the solar system I believe we will be building a better life for all men and, at the same time, building the capability required to men to go to the stars.”

29 Mueller Interview, Slotkin, 2/22/11; Mueller, Smithsonian Speech, 4/20/11.
Bibliography

PRIMARY SOURCES

Library of Congress, Manuscript Division, Washington, DC.¹

The Papers of George E. Mueller (Indicated as GEM in footnotes).
The Papers of Samuel C. Phillips (SCP).
The Papers of Thomas O. Paine (TOP).

Interviews²

Alphabetical by interviewee last name (Indicates reference in footnotes)


¹ To minimize space in footnotes, I have adopted the short hand as follows: Collection-box number-folder number. For example GEM, box 100, folder 2 is listed as GEM-100-2.
² Interviews are listed by name of interviewee, interviewer and date of interview as follow: XYZ Interview, Interviewer, date. For example Mueller interview conducted by Slotkin on February 22, 2011 would be listed as: Mueller Interview, Slotkin, February 22, 2011.


Freitag, Robert, Robert Sherrod, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12973, June 11, 1969, (Sherrod).


Holmes, Jay, Robert Sherrod, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12973, February 9 and 11, 1972 and June 28, 1972, (Sherrod).

Hull, Harrison, Robert Sherrod, NASA Headquarters Archives Historical Collection, Washington DC, Reference Number 13286, April 6, 1970, (Sherrod).


Kraft, Christopher C., Robert Sherrod, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12973, July 27, 1972, (Sherrod).


Lunney, Glynn, NASA Johnson Space Center Oral History Project (JSC), Houston, TX, February 8, 1999.


Mettler, Ruben, NASA Johnson Space Center Oral History Project (JSC), Houston, TX, April 7, 1999.


Mueller, George E., Paul P. Van Ripper, Cornell University, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 16203, December 7, 1966, (Van Ripper).


Ramo, Simon, NASA Johnson Space Center Oral History Project (JSC), Houston, TX, April 6, 1999.


Seamans, Robert, NASA Johnson Space Center Oral History Project (JSC), Houston, TX, November 20, 1998.

Seamans, Robert, Paul P. Van Ripper, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 16203, December 6, 1966, (Van Ripper).


Shea, Joseph F., NASA Johnson Space Center Oral History Project (JSC), Houston, TX, August 26, 1998.


Note: All NASA JSC oral histories in his book are available online at the following address, http://www.jsc.nasa.gov/history/oral_histories/participants.htm, accessed June 20, 2009.

OTHER PRIMARY SOURCES: NASA HEADQUARTERS ARCHIVES HISTORICAL COLLECTION, WASHINGTON, DC

White House Documents (By date):

Dulles to Hagerty, October 8, 1957, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12401.
“Discussion at the 339th Meeting of the National Security Council, Thursday, October 10, 1957, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12400.
Eisenhower to Killian, November 22, 1957, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12306.
Eisenhower to Johnson, January 21, 1958, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12401.
Eisenhower to Swenson, August 5, 1965, NASA Headquarters Archives Historical Collection, Washington, DC, Reference Number 12377.
NASA Documents:

Mueller Speeches: (unless otherwise indicated Mueller speeches are in NASA Archives, Mueller speech collection, listed by date of speech)
Technology Club of Syracuse, Syracuse, NY, February 1, 1964.
Commencement Address, Missouri School of Mines and Metallurgy, Rolla, MO, May 31, 1964.
Apollo – The Challenge to Telemetering, Annual Banquet of the National Telemetering Conference, Los Angeles, CA, June 3, 1964.
Bibliography

Commencement Exercises, New Mexico State University, University Park, NM, June 6, 1964.
“Address before the Professional Group on Antennas and Propagation of the IEEE,”
Presentation before the Senior Management of the Manned Spacecraft Center,
Houston, TX, October 5, 1964.
“Man’s Role in Man-Machine System in Space,” American Institute of Aeronautics
and Astronautics Luncheon Third Manned Space Flight Meeting, Houston, TX,
Address before the National Association of Real Estate Boards, Los Angeles, CA,
November 12, 1964.
Joint Meeting of the Columbus Sections of ASME, IES and AIAA, Columbus, OH,
Technology Club of Syracuse, Syracuse, NY, February 1, 1965.
Committee of 100 of the Greater Titusville Chamber of Commerce, Cocoa Beach,
FL, March 12, 1965.
Colloquium, Department of Electrical Engineering, University of California,
Second Space Congress, Cocoa Beach, FL, April 6, 1965.
News Conference, Manned Spacecraft Center Mission Control Announcement,
Houston, TX, April 19, 1965.
School of Electrical Engineering, Purdue University, Lafayette, IN, April 22, 1965.
Lunar Exploration Symposium, Marshall Space Flight Center, Huntsville, AL, April
26, 1965.
Space Medicine Branch, Aerospace Medical Association, New York, NY, April 28,
1965.
“Apollo Extension Systems, Opportunities for Advanced Space Applications,”
SAE Aerospace Fluid Power Systems & Equipment Conference, Los Angeles, CA,
May 19, 1965.
Fifth National Conference on the Peaceful Uses of Space, and St. Louis Bicentennial
Space Symposium, St. Louis, Missouri, May 26, 1965.
Eighth National Symposium, Society of Aerospace Material and Process Engineers,
First Annual Rudolph Bannow Memorial Address, Bridgeport, CT, June 28, 1965.
Annual Convention, American Trial Lawyers Association, Miami Beach, FL, July
27, 1965.
“Some Applications of Apollo,” XVI International Astronautical Congress, Athens,
Greece, September 14, 1965.
Hartford Rotary Club, Hartford, CT, October 4, 1965.
Annual Joint Conference on School Management, Columbus, Ohio, November 10,
1965.
American Power Conference, Chicago, IL, April 26, 1967.
Thirteenth Annual Meeting, American Astronautical Society, Dallas, TX, May 3, 1967.
Physics Colloquium, Harvey Mudd College, Claremont, CA, December 12, 1967.
Economic Club of Detroit, MI, February 12, 1968.
Chamber of Commerce, Denver, CO, March 8, 1968.
Dedication of Grissom and Chaffee Halls, Purdue University, Lafayette, IN, May 2, 1968.
Joint AIAA/CASI Meeting, Montreal, Canada, July 8, 1968.
20th Century Club, Hartford, CT, November 11, 1968.
Statement before the Committee on Science and Astronautics of the House of Representatives, Washington, DC, March 4, 1969.
National Space Club, Washington, DC, August 6, 1969.
Speech at KSC (Transcript), John F. Kennedy Space Center, FL, September 30, 1969.
Presentation to NASA Senior Staff, Office of Manned Space Flight, Washington, DC, December 4, 1969.
Remarks to Senior Staff, Marshall Space Flight Center, Huntsville, AL, December 8, 1969.
Address before the American Society of Civil Engineers, Houston, TX, April 16, 1970, General Dynamics, Speeches, GEM-112-1.
Commencement Address, Benjamin Franklin University, Washington, DC, June 26, 1970, General Dynamics Speeches, GEM-112-8.
National Telemetering Conference, Los Angeles, CA, General Dynamics Speeches, GEM-112-14.
XXIst International Astronautical Congress, Constance, West Germany, Eugene Sanger Medal Award, October 8, 1970, General Dynamics Speeches, GEM-113-1.


Pioneers Banquet, Cocoa Beach, FL, April 24, 1970, General Dynamics Speeches, GEM-113-5.


Eighth Aerospace Systems Meeting, California Institute of Technology, April 1971, SDC Speeches, 1971-1974, Mueller’s Personal Collection. (Also note that many of Mueller’s speeches delivered while at SDC are in the SDC section of his papers at the Library of Congress, see boxes 131 to 135).


Canadian Aeronautics and Space Institute, Ottawa, Canada, May 1, 1979, SDC Speeches, 1979-1980, Mueller’s Personal Collection.


Addresses to the AIAA Sections in Los Angeles, St. Louis, Baltimore, Orlando/Cape Canaveral, November 26-29, 1979, SDC Speeches, 1979-1980, Mueller’s Personal Collection.
“Bob Seamans at the Helm!” Seamans Memorial at MIT, Boston, June 10, 2009.

NEWSPAPER AND MAGAZINE ARTICLES

(By date)
New York Times Collection (1923-Current file); ProQuest Historical Newspapers
Midwest College Enrollment, 1940: “Report regarding Enrollment in Some of the leading Mid-Western Colleges and Universities,” Document 746, Stated Meeting of the Board of Trustees of the Trustees of Purdue University, January 16-17, 1940, Purdue University Libraries, Archives and Special Collections, e-Archives. Mueller Fellowship: Purdue University, Board of Trustees Minutes, June 8, 1940, Purdue University Libraries, Archives and Special Collections, e-Archives.

Untitled, Space Daily, June 14, 1963, 766.


SECONDARY SOURCES: INTERNET BOOKS
(By author)
Hacker, Barton C. and Grimwood, James M. On the Shoulders of Titans,
SECONDARY SOURCES: INTERNET ARTICLES
(By Subject)


Saturn V lift weight: www.nasa.gov/audience/foreducators/rocketry/home/what-was-the-saturn-v-58, Access date, April 18, 2011.

PUBLISHED BOOKS
(By Author)


Johnson, Stephen B. *The Secret of Apollo, Systems Management in American and


**PUBLICATIONS BY GEORGE E. MUELLER (1963-1969)**


“Apollo – gateway to challenge,” Electrical and Electronic Technician Engineer,”
Institution of Electrical and Electronics Technician Engineers (UK), November 1969, GEM-110.

“NASA is not collapsing,” The Sunday Telegraph (UK), November 16, 1969, GEM-110.


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<th>Full Form</th>
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<tr>
<td>AAP</td>
<td>Apollo Applications Program</td>
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<tr>
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<td>American Astronautical Society</td>
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<td>AASA</td>
<td>American Association of School Administrators</td>
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<td>Apollo Executive Group</td>
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<tr>
<td>AES</td>
<td>Apollo Extension System</td>
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<td>AFTE</td>
<td>American Federation of Technicians and Engineers</td>
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<td>Air Force Base</td>
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<td>Astronaut Maneuvering Unit</td>
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<td>Associated Press</td>
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<td>Apollo Program Office</td>
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<td>Achievement Awards for College Scientist (foundation)</td>
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<td>Apollo-Saturn Space Vehicle</td>
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<td>American Telephone and Telegraph Company</td>
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<td>ATDA</td>
<td>Augmented Target Docking Adapter</td>
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<tr>
<td>ATM</td>
<td>Apollo Telescope Mount</td>
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<tr>
<td>BIS</td>
<td>British Interplanetary Society</td>
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<tr>
<td>BMD</td>
<td>Ballistic Missile Division (USAF)</td>
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<tr>
<td>Caltech</td>
<td>California Institute of Technology</td>
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<td>CASI</td>
<td>Canadian Aeronautical and Space Institute</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
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<td>CIA</td>
<td>Central Intelligence Agency</td>
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<td>Configuration Management</td>
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<td>Department of Defense</td>
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<td>Earth Orbit Rendezvous</td>
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Abbreviations

NAREB National Association of Real Estate Boards
NRC National Research Council
NSA National Security Agency
NSIA National Security Industry Association
NSSDC National Space Science Data Center
NSC National Space Club
NSF National Science Foundation
NYT New York Times
O₂ Chemical symbol for oxygen
OART Office of Advanced Research and Technology
OMSF Office of Manned Space Flight
OSSA Office of Space Science and Applications
OTA Office of Technology Assessment
PERT Program Evaluation Review Technique
Ph.D. Doctor of Philosophy
PUOS Peaceful Uses of Outer Space
PSAC President’s Science Advisory Committee
PSI Pounds per Square Inch
QC Quality Control
RCA Radio Corporation of America
R&D Research & Development
R&QA Reliability & Quality Assurance function
R-W Ramo-Wooldridge Corporation
RN Reference Number (NASA historical archives)
SA Saturn-Apollo (refers to Saturn booster)
SCP Samuel C. Phillips
SE System Engineering
SETA System Engineering and Technical Assistance
SETD System Engineering and Technical Direction
S&ID Space and Information Systems Division (NAR “space division”)
SDC System Development Corporation
SPO System Program Office
SSB Space Science Board, also called “the science board”
STAC Science and Technology Advisory Committee for Manned Space Flight
STG Space Task Group (a name used several times for different groups)
STL Space Technology Laboratories, Incorporated
TIE Technical Integration and Evaluation
TRW Thompson Ramo Wooldridge, Incorporated
UCLA University of California at Los Angeles
UN United Nations
USAF United States Air Force
USIA United States Information Agency
UPI United Press International
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