Then and Now: Fifty Years in Space

Michael D. Griffin
Administrator
National Aeronautics and Space Administration

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Good afternoon, and thank you for inviting me to give the luncheon keynote today. I hope to provide the material for a reasonable siesta, so that you will be alert for the afternoon events.

The AIAA has always been and will always be my primary professional society, so I believe I should start by paying respect to the wishes of our Executive Director and my longtime colleague, Bob Dickman. Bob has asked a number of us to recount the story of "when we knew"; i.e., when it was that we knew that the aerospace profession would become our future. I think that too many of you have heard my own story already, and I am a bit reluctant to bore you with it again, but maybe there is some value in getting it firmly into the record. Bob certainly thinks so, and so I'll recount it again.

Many of you have known me for a long time, and so you will not be surprised to hear that I was an unusual child, quite different from my parents and siblings, and from others of our acquaintance. There are pictures of me as a pre-kindergarten child trying to use my father's tools, and one of my very earliest recollections is of begging, each year, for my parents to get me an erector set for Christmas. This finally arrived, if I recall correctly, when I was in the second grade. I thought I had gone to heaven. If ever anyone was born to be an engineer, I was that person.

In 1954 or '55, when I was five or six years old, my mother gave me as a birthday or Christmas present the first book that I can specifically recall receiving. It was entitled *A Child's Book of Stars*. Today, we know that most of what is in that book is wrong, but across more than five decades, with the vivid clarity of some childhood memories that each of us has, I can recall how utterly fascinated I was with it. I read and re-read it until I had virtually memorized it. I marveled that

Halley's Comet would return in 1986, when I would be a whole thirty-seven years old – I couldn't imagine such a thing. I began seeking out other books and magazine articles having anything to do with space and spaceflight. Many people have noted how reading science fiction as a child got them interested in space and other technical careers. For me it was the reverse; I began reading science fiction because I was interested in space!

As a small child, I had no clear understanding of the difference between mathematics, science, and engineering, and I didn't care. I'm not sure that I really care all that much today. I did know that, whatever I did, it was going to have something to do with space. As time went by, I fell more broadly in love with the beauty of mathematics and its ability to describe the system of the world, with science and its quest to understand that world, and most of all with engineering and its fusion of mathematics, science, and human artistry, to create a world which had never been. But I remained in love with space, and later with flight in all its forms, and so that is where I chose to try to create that world.

That one book and that one decision shaped my life, sometimes in ways not so obvious. For example, I turned twenty-one in 1970, and I was fortunate – or maybe not – to be able to attain acceptable grades in college without expending much effort on schoolwork. So, you might not be surprised when I tell you that, shall we say, I experienced the '60s to their fullest. It was a turbulent time, and some of my cohort did not make it through; that era produced a lot of shattered lives. But for me, there was always a final governor on my behavior. No matter what, I would not indulge in anything that would prevent me from graduating and taking my place in the aerospace profession.

As a footnote to this story, I still have the book, thanks to the wisdom of mothers in preserving things that their careless children would discard. In as big a surprise as I have ever had, Eileen Collins and her crew presented it to me after having flown it, without my knowledge, on STS-114. Today it is mounted on my wall, together with photographs and a certificate of authenticity from the crew attesting to the event of its flight aboard *Discovery*. I suppose that is as close as I will get to spaceflight.

This reverie reminds me that our society loves to celebrate milestones – birthdays, anniversaries, or holidays that celebrate our heroes and heritage, that honor the great struggles our ancestors undertook and the sacrifices that they made in the service of our country, or that recall landmark historical and cultural achievements. This year, we in the space business are celebrating fifty years of

spaceflight dating from the launch of *Sputnik* on 4 October 1957. In the process, we honor its legacy, and look back thoughtfully on its influence on the course of human events. I go to Russia next month to join them in celebration of that achievement.

Now, there are appropriate times and occasions for retrospection, and this is one of them. But to me it is always more important to look forward, and I like to use such historical milestones to measure our progress, and as a guide to setting challenging goals for the future. It is my hope that our greatest days lie always ahead of us. But with that said, another of my beliefs is that it is vitally important to learn from history, and the lessons available to Americans from our side of the *Sputnik* experience are no exception.

As anyone my age or thereabouts will recall personally, the Soviet Union's success with *Sputnik* was an almost unimaginable embarrassment for the United States. The reality of this event diverged impossibly from our image of ourselves and our place in the world. Notwithstanding the efforts and sacrifices of other nations, it was U.S. technical, industrial, and logistical superiority which had been decisive in the then-recent global war. Other nations, victors and vanquished, were prostrate for a generation after that war. Japan and Germany were flattened. China and most of Europe were little better off. Fifty-five million people around the world were lost; the Soviet Union alone lost twenty million. The United States lost a few hundred thousand, and our industrial infrastructure was untouched. Our nation stood like a colossus above the postwar world.

We had our own satellite development effort underway in support of the International Geophysical Year; putting an instrumented payload, the *Vanguard* satellite, into orbit was a publicly announced goal. The idea that we could be beaten to it by any other nation, not to mention by our declared adversary, was, for almost everyone, a paradigm-shifting event.

First and most directly, Americans felt vulnerable to Soviet missiles that, if they could place a payload in orbit, could also strike anywhere in the United States. In the generations since the founding of our nation, no other adversary had ever produced such a threat, and we had never imagined that anyone ever could. Nikita Khrushchev's November, 1956 admonition – "We will bury you." – reverberated in our collective consciousness.

But there was more. In being beaten so publicly by what we then regarded as a peasant nation, a nation whose totalitarian government embraced a set of

values abhorrent to nearly all Americans, we felt that we were falling behind in our much-vaunted technical know-how and industrial capability. The small metal orb beeping overhead, visible in the clear fall sky to anyone who looked – and nearly every did – reminded us of this. We felt that we were in second place in a new arena, that we lagged in exploring what President Kennedy later named, so perfectly, "this new Ocean". And we felt that it mattered.

Given the story I related earlier, you will not be surprised to know that, even at the age of eight, I followed these events avidly, scanning papers from *Weekly Reader* to *The Baltimore Sun* for news of space. I remember watching *Sputnik* from my home in Aberdeen, Maryland. I was hardly the only one doing so; as a nation, we looked up and contemplated the meaning of the Soviet accomplishment. The newspapers were full of both soul-searching analysis and opportunistic second-guessing. We questioned our military plans, our civilian research programs, and our educational systems, and made changes in all those areas and more. America's readiness – or more properly our lack of readiness – to explore and exploit the space frontier decided a presidential election.

So began the Space Race. *Sputnik* changed everything. When the first *Vanguard* launch failed in December, 1957, it spurred President Eisenhower to assign Army General John B. Medaris and his team, Wernher von Braun at Redstone Arsenal and William H. Pickering at JPL, to build the Jupiter-C rocket and Explorer-1 satellite, matching (four months after the fact) the Soviet feat. It spurred the creation of NASA in October, 1958, as well as the then-classified National Reconnaissance Office and its early CORONA satellites. It spurred Air Force General Bernard Schriever's team to develop the Atlas, Titan, and Minuteman ICBMs. It spurred Admiral Red Raborn and his team to develop the Polaris missile and the Fleet Ballistic Missile Submarine to carry it. It spurred more national spending on science, math, and engineering education to boost our nation's technical literacy, ultimately allowing us to win the Space Race and, eventually, the Cold War.

Millions of Americans, myself included, benefited from this investment of our nation's time, energy, and resources, and this investment helped me personally, and many others, even years later, to cut their teeth in the space business. We committed ourselves to the ideal that, as a nation, America must lead in space exploration. In President Kennedy's immortal words, prose but almost poetry, "For while we cannot guarantee that we shall one day be first, we can guarantee that any failure to make this effort will make us last." And, "We go into space because whatever mankind must undertake, free men must fully share."

Spaceflight is a strategic capability for our nation. We are fully fifty years into it now, measured from the launch of *Sputnik*. But equally, we are *only* fifty years into it. If you joined the space program after college graduation in 1958 or '59, like my friends and mentors Glynn Lunney and Arnie Alrich, it all fits within a single long, full, tumultuous career. So we need to maintain a sense of perspective. Fifty years into the development of aviation, we didn't have even the first of the passenger-carrying jets that brought most of us to this conference. And fifty years into the development of open ocean seafaring, Carnival Cruise Lines was not one of the foreseeable outcomes. We have only just begun to sail the new ocean of space. We have a very long way yet to go. So let's spend a bit of time today to look back at where we have been, where we are, and where we are going.

Fifty years ago, we in the United States were not yet aware that we were about to be surprised by *Sputnik*. We did not know that, little more than a year later, a new agency would be formed from elements of Navy, Army, and NACA laboratories. We did not know that seven test pilots would, in the spring of 1959, be named as the nation's first astronauts, and would begin preparing for brief, single-seat trips into space. First and foremost, the goal was to beat the Russians to that prize. We all know how that turned out.

But times have changed. People change. Fifty years ago I looked up in the sky to watch *Sputnik* pass, can remember still the annoyance I felt, even at the age of eight, that we were not up there also. Today, two Russians and American astronaut Clayton Anderson are living and working in orbit aboard the International Space Station, the greatest engineering project in the brief history of the Space Age. Next month, NASA's Expedition 16 Commander Peggy Whitson, Russian Flight Engineer Yuri Malenchenko, and spaceflight participant Sheikh Muszaphar Shukor, a Malaysian physician, will lift off from Baikonur to join them on the ISS. Later in October, Space Shuttle *Discovery* and the STS-120 crew will launch from Kennedy Space Center, carrying the Node 2 *Harmony* module, built in Italy, which will be used to connect the European and Japanese laboratory modules. With the Space Station, NASA and our international partners have maintained a permanent human foothold in space since October 2000. We are learning to live and work in space 24/7, 365 days a year. We are engaged in a partnership with our former rival, and even pay for some of their crew and cargo service to the International Space Station. Naturally, I would rather be providing funding to U.S. commercial crew and cargo transportation providers, especially after we retire the Space Shuttle in 2010, but that is the position in which we find ourselves.

The Space Station is an engineering test bed and scientific laboratory to study and mitigate the hazards of long-duration spaceflight, just as sailors hundreds of years ago learned how to stave off the debilitating effects of scurvy and other hazards during long sea voyages. In the process, we will also develop new technologies which will improve life here on Earth. For example, the exacting techniques used for preserving food for our space missions have found their way into the Food and Drug Administration's safety standards. On our last Shuttle mission, we flew a muscle atrophy experiment for the pharmaceutical company Amgen. Recently, a convention of the American Medical Association endorsed NASA's efforts in human spaceflight and the technologies and techniques we have developed for doctors. And last week, I signed a Memorandum of Understanding between NASA and the National Institutes of Health to conduct joint medical research onboard the ISS.

Now, while I yield to no one in my belief that the advancement of the arts and sciences of human spaceflight is crucial to this nation, it is not the only measure of our progress over the last fifty years. Even our earliest robotic satellites produced truly lasting scientific results. Just over fifty years ago, *Explorer 1* allowed James van Allen to infer the existence of the radiation belts circling Earth that now bear his name. And *Vanguard 1*, launched a few months later, showed that the Earth was not actually round, but in fact was a bit pear-shaped. NASA's work in space physics and Earth science continues today, albeit on a much grander scale, and we have added many new disciplines to our scientific repertoire in the meantime.

Forty-plus years ago, as a teenager I waited anxiously to see the first close-up photographs of the Moon, by *Ranger 7*, and a bit later went through the same nail-biting exercise as *Mariner 4* executed the first Mars fly-by. And I will simply never forget, as a young JPL engineer in the late '70s, taking meals in the cafeteria while watching fresh new views of the moons of Jupiter from *Voyager 1* and, later, *Voyager 2*, come up on the television screens. Today's planetary scientists can look forward to such new views of Mars every day, right from the surface, as *Spirit* and *Opportunity* continue to break new trails. And our presence extends out to Saturn, where *Cassini* similarly rewards us with new views of Saturn and its moons, every day. By 2011 we'll add Mercury – a very tough place to reach – to the list with the MESSENGER spacecraft, and in 2015 we'll finally reach Pluto with *New Horizons*.

As a young flight controller at Goddard in the early '70s, I had my virtual hands on the controls for the early Radio Astronomy Explorers. Today, engineers and astrophysicists like NASA's John Mather are designing, building, and controlling spacecraft that deal with issues that having metaphysical and religious overtones – the birth, life, and death of stars, galaxies, and our very universe.

Edwin Hubble discovered in the 1920s that the universe was expanding; in the late 1990s, astronomers using the *Hubble Space Telescope* discovered that the expansion of the universe was actually speeding up. Astrophysicists today explain such phenomena in terms of "dark matter" and "dark energy". This just *means they can't see it and don't understand it. Recent observations by* Hubble, combined with the European Very Large Telescope in Chile, Japan's Subaru telescope in Hawaii, the VLA radio telescope in New Mexico, and the joint NASA-ESA *XMM-Newton* satellite, have revealed a loose network of filaments where normal matter in the form of galaxies accumulates along the densest concentrations of dark matter. That is the only way, so far, in which we know it's there. This unseen dark matter comprises approximately 20% of the mass-energy density of the observed universe, while dark energy makes up maybe 75% of the universe. Everything we see, everything we know anything at all about, makes up the remaining 5%.

These are the deepest mysteries that there are, and it is heady stuff for someone like me, a simple aerospace engineer from a small town.

But the National Academy recognizes the significance of these issues, and has set the Joint Dark Energy Mission, or JDEM, as its highest priority for NASA's Beyond Einstein program. We support that priority, and I look forward to working with Sam Bodman and Ray Orbach at the Department of Energy to turn this mission into reality. As with most space science missions NASA conducts, it is my hope that we will also have a great partnership on JDEM with CNES, the French Space Agency. I discussed this with Yannick D'Escatha a few days ago, during his recent visit to Washington, and I look forward to working together with him on other projects and programs as well.

International cooperation is the *sine qua non* for so many of NASA's science missions – astronomy and astrophysics, planetary science, heliophysics, and Earth sciences – just as it is in our human spaceflight endeavors. It is through such work that we find our common humanity, discovering that what connects us is far more important than what divides us.

I believe that the art, science, and business of engineering for space exploration to be the hardest thing we do as a people. It is also the grandest expression of human imagination of which I can conceive. Members of the AIAA know this to be true. Just ask SpaceX, whom I will be visiting later for a progress update. Or ask the Northrop Grumman folks in Redondo Beach, who are building the *James Webb Space Telescope*. Or those up the road at JPL in Pasadena, where they are building the Mars Science Lab, or those at KSC preparing to launch the *Dawn* mission to the asteroid belt next week. My hope is that when we contemplate the majesty of our universe resulting from complex instruments operating at a Lagrange point, or landing on the surface of Mars, we appreciate the effort that went into making such technological miracles happen. They truly are "miracles" by the standards we used only 50 years ago.

But it is not only the miracles that matter. Less than a year from now, NASA will launch the final servicing mission to *Hubble* on Space Shuttle *Atlantis*. My hope is that members of the astronomy and astrophysics community will not only thank the astronauts who risk their lives in making this mission happen, but also that we all pause to recall the Hurricane Katrina rideout crew who risked their lives to save the Michoud Assembly Facility near New Orleans, where the Space Shuttle External Tanks are manufactured. They were just as instrumental in making the *Hubble* servicing mission happen.

In a few years, this Michoud workforce will turn its attention to building the *Ares 1* and *Ares 5* rockets. While ESA's *Ariane 5*, which will launch the *Webb Space Telescope*, can loft approximately 21,000 kg to low-Earth orbit, the *Ares V* will be able to launch more than six times that amount. The *Ares* launch vehicles are being built primarily for human spaceflight, but my hope is that the engineers designing robotic spacecraft to be launched over the coming decades will take advantage of this new capability. Our nation has not seen such a capability since the *Saturn 5* last flew in 1973, so it behooves us – not simply NASA, but all of us in the space business – to begin now to think of innovative ways to use these launch systems for greater scientific, and other, benefits over the next fifty years.

We will soon be ready to discuss how we in NASA are organizing the workforce at our ten field centers to lead and support development for our next major Exploration programs, including the beyond *Orion* and *Ares 1* – the *Ares 5*, the Lunar Surface Access Module, and other lunar surface systems. This is the Exploration work to be done over the next 10-15 years, and I hope to entice international and commercial partners to be part of turning these ideas into reality. We have a lot of work ahead of us.

While most of these projects and programs will not begin in earnest until after the Shuttle is retired, we need to plan now for the work ahead. I want the young people in NASA and at our contractors who are working today on the Space Shuttle, Space Station, and Exploration programs to know that they will have more to do beyond the five-year government budget horizon, and I want even younger people in colleges and universities to know what the future holds for them if they join us in this journey. I also want to make it perfectly clear to our current workforce that, if funding for NASA remains as we anticipate, I do not foresee any need for Reductions in Force, RIFs, at NASA. I realize that this has been the subject of considerable unpleasant speculation over the past several years, primarily due to the lack of stability in our programs as we struggled to pay for Space Shuttle return-to-flight costs, and numerous other reductions and re-directions in NASA's budget. My hope is that those days of instability are behind us.

NASA's most important resource – even beyond the budget the Congress provides – is its people, the scientists, engineers, and technicians who make our nation's space program possible, whether they work directly for NASA or not. And our biggest threat today, our biggest management challenge, concerns those people. Space Shuttle retirement and transition to a new system is an upheaval that occurs not even as often as once in a generation. We are trying to manage this challenge as best we can with the resources we have been given. We are all concerned that we not repeat the mistakes of the 1970s in the transition from the Apollo to Shuttle programs. What was planned as a two-year gap in human spaceflight turned into six. Because we did not sustain the commitment which had been made in the '60s, because real-dollar funding in the post-Apollo years was so severely reduced, there was an exodus of talent from the program, squandering national capability and weakening the industrial base. We must not allow that to happen again. We must commit ourselves, as a nation, to the space enterprise. We must commit to leadership, not followership, in space exploration. It matters.

I've touched on some of the rational and acceptable reasons for which we explore space, but I hope you will allow me a moment to share with you a recent lesson that reflects the real reasons why I think most of you in this room decided to go into the space business. Last July, Space Shuttle *Atlantis* was being ferried across the United States after landing at Edwards AFB. Due to weather conditions, the B-747 ferry crew needed to make an unscheduled stop in Amarillo, Texas. Within a few hours, the word had spread on radio and television that the Space Shuttle had landed in Amarillo. What began with a few passers-by near the airport

turned quickly into an impromptu pilgrimage by several hundred and then several thousand people, parents and children, to see our nation's Space Shuttle on display.

Especially poignant in this story is the fact that this airport was named after Rick Husband, Commander of Space Shuttle *Columbia* on February 1st, 2003. Those of us in the space business will never, must never, forget the lessons of that day, just as we remember those we learned on January 27th, 1967, and January 28th, 1986.

I want to conclude on that note of remembrance. We must remember how we felt in October 1957, we must remember how we felt in February 2003, and we must understand how such events change our lives and the course of human affairs – especially as we consider what we choose to do in the future. And for those in the space policy arena who wonder, sometimes, what the meaning and value of the space program is to the American people – remember the story of that stopover in Amarillo.

We are only fifty years into the development of space, with milestones of both joy and tragedy behind us. Preparing for, and having, a part in it has filled my life. I have been very lucky.

Thank you.