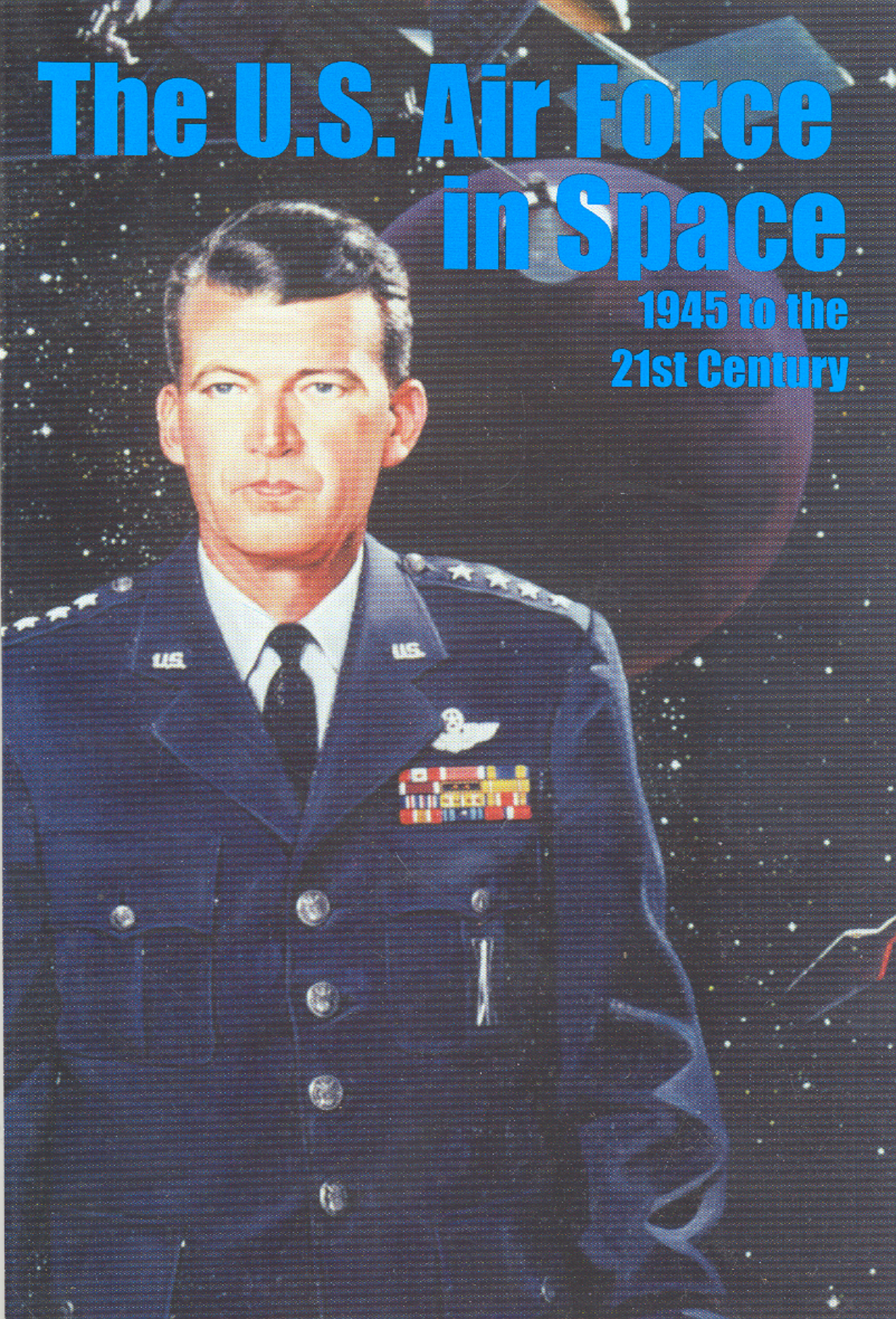
The U.S. Air Force in Space

1945 to the 21st Century



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Preface

On September 21 and 22, 1995, the Air Force Historical Foundation convened a historical symposium on the United States Air Force's experience in the development of space systems and their military applications. Held at the Andrews Air Force Base Officers' Club, Maryland, the symposium was the culmination of nearly a year-long planning effort headed by a committee chaired by Lt. Gen. Bradley Hosmer, USAF (Ret.). Other committee members included Donald R. Baucom, BMDO historian; George W. Bradley III, Air Force Space Command historian; Col. Louis H. Cummings, USAF (Ret.), the Foundation's executive director; R. Cargill Hall and Jacob Neufeld, senior historians at the Air Force History Support Office; and Maj. John Kreis, USAF (Ret.), a Foundation trustee. The symposium was co-sponsored by the Office of the Air Force Historian, in association with the Air Force Space Command and the Air University. Dozens of individuals affiliated with these organizations pitched in graciously and expertly whenever the committee solicited their assistance. We wish to acknowledge especially Lt. Gen. Patrick P. Caruana, vice commander of Air Force Space Command, who introduced one of the panels, and Major Kreis, who introduced another.

Gen. Bryce Poe II, USAF (Ret.), the Foundation president at the time, introduced the symposium. He was followed by the then Air Force Chief of Staff, Gen. Ronald R. Fogleman, who gave the keynote address. Secretary of the Air Force Dr. Sheila E. Widnall and the Vice Chief of Staff, Gen. Thomas S. Moorman, placed the subject in perspective and peeked into the future. Several other distinguished civilian and military officials related their experiences and perspectives, while scholars provided historical context. A perusal of the table of contents discloses a virtual "Who's Who" in Air Force space history.

The symposium was arranged in three chronological sessions beginning with the threshold of space in 1945 to 1961, the year that the Air Force became executive agent for space research and development. Gen. Bernard A. Schriever, USAF (Ret.), the service's leading missiles and space pioneer, provided invaluable recollections and observations. Panel two traced the evolution of space systems from R&D to operational status up to their employment in the Persian Gulf War. Former Air Force Secretary John L. McLucas and Gen. Donald J.

Kutyna riveted the audience's attention with their personal assessments. Finally, former Air Force Secretary Edward C. "Pete" Aldridge was among a select panel of senior leaders who looked at space "today and tomorrow."

The consensus among the two hundred men and women who attended was that this was a unique and extremely useful symposium and that its proceedings deserved to be published and disseminated widely.

R. Cargill Hall
Jacob Neufeld

Editors

Acknowledgments

The editors would like to thank three individuals for their assistance in preparing this volume for publication. From the Air Force History Support Office, Dr. George M. Watson proofread and commented on the manuscript and Dr. Priscilla D. Jones rewrote portions of text. Robert E. Bell, Chief, Air Force Graphics, designed the cover and the photo essay by Gen. Donald J. Kutyna.

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Introduction



Gen. Bryce Poe II, USAF (Ret.), President of the Air Force Historical Foundation, graduated from West Point in 1946. He earned an M.A. in history at the University of Nebraska and an M.S. in international affairs at George Washington University. General Poe flew more than ninety combat missions in Korea in RF–80 aircraft and later flew with the Royal Norwegian and Royal Danish Air Forces. Following graduation from the Armed Forces Staff College in 1960, he served in an Atlas missile squadron. In Vietnam, he flew 213 combat missions, mostly in RF–4Cs. Later, General Poe commanded the Air Force Logistics Command until his retirement in 1981. Since retiring, he has worked for the Congressional Office of Technology Assessment, National Air and Space Museum, and the Department of Energy.

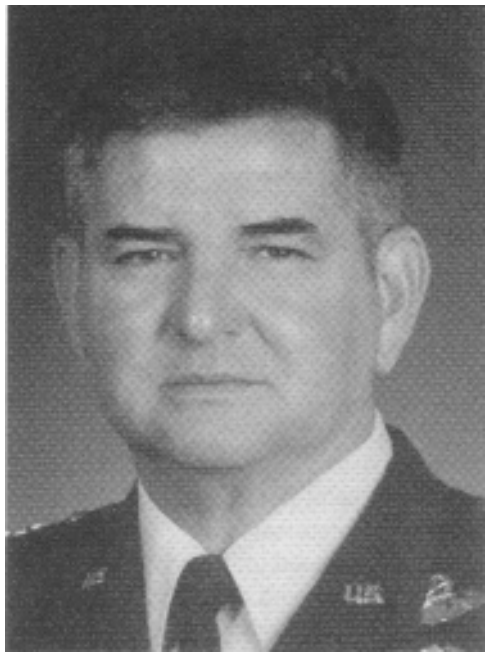
Opening Remarks

Gen. Bryce Poe II, USAF (Ret.)

At a symposium on air power in the early 1970s, the founder of the Air Force Historical Foundation and the first chief of staff of the new Air Force, Gen. Carl A. Spaatz, in retirement and ill health, found himself unable to attend. Instead he sent a message which so impressed me that I remember it still. General Spaatz wrote: "Tell everybody that we are getting out of flying too soon and into space too late." In the years since, these two elements, air and space power, which at first competed for resources but are now blended into a single, unique whole, indisputably comprise the best and most powerful military force in the world.

It is fitting, therefore, that another USAF Chief of Staff, who has a special interest in this subject, begin our symposium with some of his own thoughts on air and space power. Gen. Ronald R. Fogleman came to his present position with Air Force experience all across the board. He is an airman's airman. General Fogleman instructed student pilots, flew fighters in combat, made F–15 demonstration flights for international affairs, and later flew aerial tankers and airlift aircraft. Among his command jobs were several tough ones on the front line, such as going "eye-to-eye" with the North Koreans; he served as the air component commander in Korea at a very critical time. General Fogleman also had worldwide responsibility for dozens of actions as his Air Mobility Command people flew into and out of some of the most dangerous places on Earth. Currently, he is focusing particular attention on military space operations.

General Fogleman also is known as an historian — with an advanced degree in the discipline — having served as a history instructor at the Air Force Academy. We are honored to have him with us.



Gen. Ronald R. Fogleman was Chief of Staff of the United States Air Force (1994–1997). The general graduated from the U.S. Air Force Academy in 1963. In early assignments he instructed student pilots, performed combat duty as a fighter pilot and high-speed forward air controller in Vietnam and Thailand, was a history instructor at the Air Force Academy, and conducted flight operations in Europe — including duty as an F–15 aircraft demonstration pilot for numerous international airshows. Most recently he flew tanker and airlift aircraft. Over the past decade, he commanded an Air Force wing and air division, directed Air Force programs at the Pentagon, and served as commander of the Pacific Air Forces' Seventh Air Force, with added responsibility as deputy commander of U.S. Forces Korea, and commander of Korean and U.S. air components assigned under the Combined Forces Command. Prior to becoming chief of staff, he was commander in chief of the United States Transportation Command and commander of the Air Force's Air Mobility Command.

The Air Force and the Military Space Program

Gen. Ronald R. Fogleman, USAF

It is an honor to be here. I do pride myself on knowing the history of air power, not only the hardware involved, but also the personalities and the decision-making processes. When I reviewed your program, however, I was reminded how little I knew about the history of military space operations. The Air Force has a whole new generation of officers and enlisted airmen who are dedicated to this discipline of space. Along with the rest of the Air Force, they need to learn and know the history of military spacefaring.

As we attempt to fathom how this activity evolved, it is clear to me that in the 1950s and 1960s some Air Force members took it upon themselves to know and understand what the space and missile business meant, from both a technological and an operational standpoint. But they were relatively few in number, and in the early years, they remained somewhat apart from the mainstream Air Force. At least, that was the way the rest of the Air Force thought about them. A certain amount of integration took place, to be sure, because of the preeminent role that ICBMs and strategic deterrence played during the Cold War. Nonetheless, they were always in the background of day-to-day Air Force activities.

In my view, we got into the space business through the research and development community. For various reasons, however, the Air Force operators were never able to comprehend fully what the military space possibilities were, or how we could transition from research and development into the operational arena. I believe that over the last ten years or so we have made great progress in that transition. Therefore, the work that results from this symposium will be of great value to us.

Clearly, there have been some defining moments within the last few years that have helped in this process of moving space into the operational mainstream of the Air Force and its sister services. General McPeak called the Gulf War "the first space war," and he was right. The masterful prosecution of that war by Coalition forces on the land, at sea, and in the air in 1991, would not have been possible without military space systems.

Before that moment, in part because of classification, many service members did not know about or understand the importance of some of the space assets that we employed on the battlefield. Other service members did not know

about or understand them because they failed to recognize or take the time to learn just what they could do for the warfighter. Let me recount my own personal experience to describe just how poorly we in the operational Air Force understood military space systems.

At the time of Desert Shield and Desert Storm I was stationed overseas, in South Korea. My boss was a tremendous Army officer named Gen. [Robert W.] Bob RisCassi, CINCUNK. In Korea, we watched with interest as the Coalition build-up occurred and the war unfolded in the desert. General RisCassi was a friend of Gen. Norman Schwarzkopf and often talked with him, even while the war was in progress. We heard how effectively military space assets had served in securing the objectives that Schwarzkopf had on the battlefield.

After the war, General RisCassi turned to me and said, "Fogleman, I want you to get the Space Command people over here and I want them to tell us what it is they did for Schwarzkopf. I want them to tell us how long it will take for them to build that capability for us here in Korea, because it took them five months to build it for Schwarzkopf in the desert." I contacted US Space Command, specifically Gen. Don Kutyna, who was CINC Space at the time, and Gen. Tom Moorman, who was running Air Force Space Command, and I asked them to send a team to Korea. The team came over and conducted a survey. When the team members finished their survey, they briefed us and said: "You have in place in South Korea today everything that we built for Schwarzkopf in the desert."

We were embarrassed. What had happened over the years? Because South Korea always had been in the forefront of requiring national intelligence, it had received special attention from the intelligence community. Whenever a new program was developed and could be inserted somewhere, it went into places like the Combined Air Operations Center (CAOC) in South Korea. Unfortunately, our commanders in Korea were oblivious to this, and I count myself among that number. We knew almost nothing about the space assets that already were available to support our forces. For instance, one of the things that our forces sorely needed in the desert was access to good weather information. About five ground stations existed worldwide that downlinked weather data and images from the Defense Meteorological Satellite Program (DMSP). It happened that none them were located in Saudi Arabia or anywhere in Near East. We had to build a mobile station quickly and move it in there and use it.

Meanwhile, in South Korea at Osan Air Base, near the third hole on the golf course, there was a big antenna next to a white van surrounded by a security fence. We knew that whenever we hit a golf ball in there, we could not retrieve it. Although it looked like a satellite dish, we never took the time to learn exactly what it was. The installation turned out to be one of the five DMSP downlink stations that furnished weather data to our command, and we simply had no knowledge of that. Also, among the other data being fed through space into the CAOC in Korea, were overhead signals intelligence.

Early in the Gulf War one of my CAOC operators asked, "Do you wish to see the sights that are up in Iraq today?" I replied, "What do you mean, see the sights? Are you getting stuff sent to you by fax or what?" He said, "No. I can show you in real time which Iraqi radars are up and which ones are down." With some interest I went down to look, and sure enough, the real time capability existed, and I had never taken the time to learn about it.

That military space capability was available not so long ago, in 1991. As a result of Desert Storm, I believe that all of our operational commanders became much more cognizant of how space assets enhanced the employment of forces on Earth. To the credit of the national reconnaissance side of the house, it became much more open in sharing intelligence information and trying to pass it along quickly to the operational commander.

Why am I reviewing all of this? I want to emphasize that it is crucial to know about and understand what space capabilities exist today and how we can get to them. To that end, we need to know the history that brought us to today's capabilities. There are lessons for the warfighter here, and we should take advantage of them to help us move forward. We can expect to make some mistakes along the way. But we don't have to make the same mistake twice as we move ahead in the operational space arena.

In surveying how our Air Force has evolved, strategically, one of the biggest challenges before my generation of leadership is to determine when we can transition from one kind of platform to another. I see tremendous possibilities unfolding in the space arena. Virtually every problem that we face—compressed time lines for deployment, the tremendous demands on airlift to move our forces, and placing people in harm's way on such missions as AWACS, Joint STARS, or Rivet Joint — all of these problems have potential solutions that lie in space.

In my view, the next AWACS should not be an aerial 767 with a rotating dome and a crew operating 200 miles from the air battle. Instead, we ought to think about the next AWACS as a space-based radar system with communications connectivity that will allow its crew to operate in safety anywhere in the United States. That crew would see and track the air battle, and, communicating over space links in real time, furnish it to the people performing the area engagements.

Think of the airlift that we will no longer need. Think of the people who will no longer be put in harm's way as we go and do these kinds of things. There are great possibilities out there, but I do not believe that we can get to this space future without a thorough understanding of the past. That is the significance and value of this particular symposium, and I look forward to its publication. General Poe, I will read the proceedings with great interest.

Part I

The Formative Years 1945–1961



Gen. Bernard A. Schriever, USAF (Ret.), is the Air Force's leading missiles and space pioneer. Since his retirement in 1966 with thirty-three years of service, he has served in numerous advisory roles. Shortly after winning his wings, he flew in the Army Air Corps' air mail missions in the winter of 1934. He earned a Master's degree in aeronautical engineering from Stanford University. During World War II he maintained the Fifth Air Force's planes and flew combat missions as a B–17 pilot. After the war, he was entrusted with maintaining liaison between the air force and leading scientists. His foremost contribution was as Commander of the Air Force Western Development Division, where he directed the development of intercontinental ballistic missiles, which provide the backbone of our nation's defense. In 1959, he was named Commander of Air Research and Development Command and in 1961 of Air Force Systems Command. He directed Project Forecast, one of the most comprehensive long-range assessments of the military science and technology ever undertaken.

Military Space Activities
Recollections and Observations

Gen. Bernard A. Schriever, USAF (Ret.)

Military space activity began in late 1945, immediately after World War II. Although it is not widely known, Gen. Henry H. "Hap" Arnold, Commander of the Army Air Forces, played an especially important role in getting space on the Air Force's agenda at that time. I first came to know General Arnold some years before, as a young lieutenant just out of flying school. In 1933 I was assigned to March Field, California, then commanded by Lt. Col. Arnold. In those days, mind you, the commander of an airfield commanded everything. My mother was with me at March Field, and she became very close to Mrs. Arnold. As a result, I got to know Hap Arnold on a personal basis, which normally would not have happened to a second lieutenant. Arnold also served as the commander of the Western Division when the Army Air Corps flew the air mail in 1934. Under his command, I flew the night route between Salt Lake City and Cheyenne, Wyoming. I was only about eight months out of the flying school and we flew in open cockpit airplanes. We did not even have two-way communications, so that was quite an experience.

I

After World War II, I returned from three-and-a-half years in the Pacific Theater and was assigned to the Pentagon. Shortly after I arrived, General Arnold called me into his office and said, "Bennie, we have just completed a war which had a large number of major technological breakthroughs. All of the scientists who came out of academe and the laboratories around the country are going back to their schools. We need to maintain a close and cooperative working relationship with the scientific community. It is not enough just to have a close relationship with the aviation industry. From here on, we are also going to have to have it with the scientific community."

Arnold had talked to the Caltech scientist whom he greatly respected, Theodore von Kármán, even before the war ended, about the need for maintaining a close working relationship with the scientific community. He had asked von Kármán to put together a group of scientists and create an ongoing dialogue with the scientific community. The Air Force Scientific Advisory Board (SAB) resulted from that, and that group is still in operation to this day.





General of the Army Henry H. Arnold (left)
and Dr. Theodore von Kármán (right).

Arnold made several observations at that time, which I still remember well. First of all, he said, "The next war will not be fought like the last one. There will be major changes." He also said that we had won the First World War with brawn and the Second World War with logistics. (For a good bit of the time that I was in the Southwest Pacific I was in the logistics business and I can assure you that in that wide expanse of water and islands, logistics played an extremely important role.) Arnold said that the next major war would be won by brainpower. I think the Gulf War, though not a major war, nevertheless indicated that brains are taking over. (Incidentally, we lost only 148 people in that war, some by our own hands, and others in a lucky hit on a barracks that killed about thirty people. For the amount of activity in the Gulf War, it truly is amazing that we had such small number of casualties. Moreover, we did not have to level the enemy's cities to win the Gulf War. We took out his eyes, his ears, and his ability to communicate. The decisive factor and advantage that we had was in the quickness with which we concluded that war.)

Arnold felt strongly that we needed help from scientists to do certain things in advancing technology. He also believed that it was necessary to integrate technology with operational requirements and conduct a systems analysis, which would project technology forward by some ten, fifteen, or more years. Arnold had asked von Kármán to conduct such a study. "Do not just look forward for twenty years, although that should be your primary objective," Arnold directed, "but look forward for fifty years." Von Kármán's study, "Toward New Horizons," which we still talk about as one of the really outstanding forecast studies, served as a blueprint for building a new Air Force and really brought together the scientific community with the Air Force.

II

In December 1945, therefore, I was given a job called scientific liaison in a brand new office by that name in the Pentagon. I was at first uncertain exactly what to do about scientific liaison. Well, "liaison" meant the Air Force working with the scientific community in this case, and that is what I set out to do. In that job, which I held for about four years, I really established a working relationship with many of the leading scientists who had done such a great job during World War II.[1]

General Arnold also realized that the rocket, jet engine, nuclear weapons of mass destruction, and electronics developed during the war potentially placed the U.S. at risk to foreign attack over great distances for the first time in its history. The oceans had always served this country as a barrier to attack in a major war. With the technical breakthroughs in World War II, however, the potential of a long-range attack against the U.S. existed. At that time Arnold was thinking primarily about nuclear weapons and rocketry, and he became one of the first leaders at the top echelon of the military to recognize that we needed strategic intelligence before the outbreak of hostilities.

Arnold asked both von Kármán in his postwar study, and the RAND Corporation, for their assessments of strategic intelligence. (Arnold had established Project RAND, a consortium of various aircraft company representatives, at the beginning of 1946. It became the nonprofit RAND Corporation in 1948.) He made strategic reconnaissance a first priority and asked them whether an Earth satellite was feasible for accomplishing this mission.

In 1946, in an early part of that study, Louis Ridenour, one of our leading scientists who had done tremendous work in the electronics and radar areas, identified all of the military space missions that we have in place today. That is, strategic reconnaissance, surveillance, weather, communications, and navigation. In fact, RAND published an interesting history of these activities by Merton Davies and Bill Harris in 1988, and I recommend it highly. I have read it and can assure you, having been involved in most of these programs, that it is a very accurate historical account.[2]

There were lots of skeptics with respect to space in the postwar years, including a number of scientists. One of these was Dr. Vannevar Bush, a key American scientist during and after the war. Bush, who was working in the Pentagon, ridiculed Arnold's approach to space as infeasible and unimportant to national security in the future. Thus, space did not progress easily, even in the R&D days, and I will discuss a few more incidents with respect to the difficulties that we encountered.

These RAND space studies were conducted between 1946 and 1950, and continued for several years after that. In 1954, RAND recommended that we proceed with the development of a strategic reconnaissance satellite. The major technical breakthrough that occurred at that time was the thermonuclear war-



Dr. Vannevar Bush

head, which Edward Teller and John von Neumann reported in an SAB meeting at Patrick AFB in 1953. After the first thermonuclear heavy water device was exploded in the Pacific, Teller and von Neumann predicted that by 1960 we could have a dry thermonuclear weapon, weighing 1,500 pounds and yielding one megaton.

III

By the early 1950s I was running the Development Planning Office on the Air Staff, in the Pentagon. I had gone to the National War College and then went back to the Pentagon again with the job of Assistant for Development Planning. My job was to try to relate long-range technology to operational requirements and enhance the overall capability of the Air Force. The thermonuclear breakthrough created the ICBM program, and that program provided the resources and the know-how in the Air Force, in industry, and the scientific community to really get into space.

We moved forward by commissioning an SAB group to verify the predictions that had been made by von Neumann and Teller. The SAB panel did so in 1954. The recommendation to proceed on an ICBM program in 1954 was made by the Teapot study, prepared by a committee that John von Neumann headed. Many of the leading physicists who had been involved in the thermonuclear program served on this committee.

Gen. Nathan F. Twining, Air Force Chief of Staff at that time, had assigned top priority to the ICBM program. A few months later in 1955, the ICBM received the highest national priority among all military programs. President Dwight D. Eisenhower also was extremely concerned about a possible surprise nuclear attack against the U.S. by the Soviet Union. Without strategic reconnaissance, such an attack was of grave concern throughout the highest levels of the government.

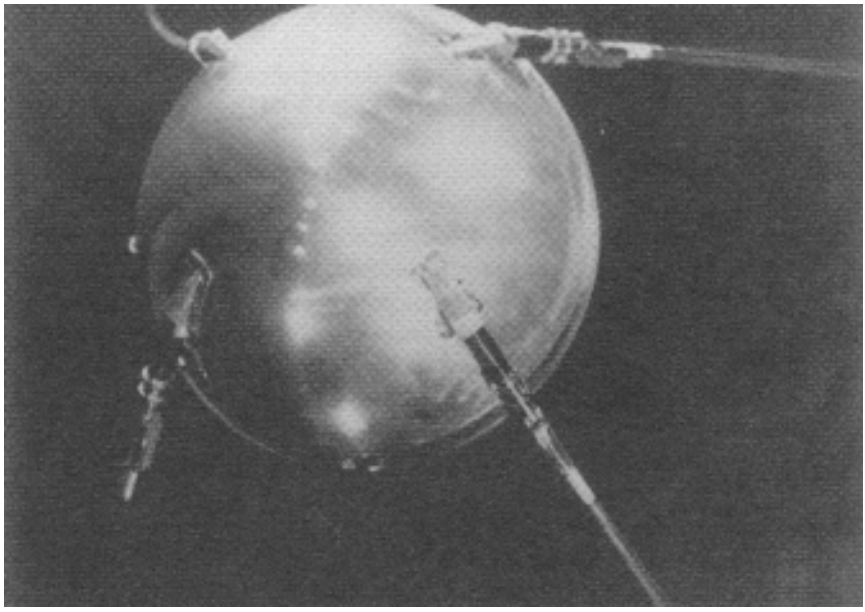
IV

In 1954 I was assigned responsibility for developing the ICBM program as commander of the Western Development Division (WDD), which the Air Force Research and Development Command had established on the West Coast. The ICBM program began with the Atlas, followed by the Titan and Minuteman missiles. President Eisenhower, meanwhile, had asked Dr. James Killian to head a special committee to see what could be done about acquiring intelligence that would prevent or at least forewarn of a surprise attack on the U.S. Unfortunately, in his recommendations to Eisenhower in February 1955, Killian did not place much hope on a space satellite. Consequently, development of the U–2 reconnaissance airplane and the balloon reconnaissance programs took priority over the Air Force Advanced Reconnaissance [Satellite] System (ARS, later the WS–117L) program.

The Western Development Division, on the other hand, which had been assigned responsibility for all Air Force space programs, recommended initiating full-scale development of the ARS. I remember that we had recommended undertaking a five-year program for $117 million. With that budget, we believed that we could have an initial operational capability by 1963. Instead of receiving full support, however, we obtained only $4 million for ARS, which permitted follow-up studies and some test work. So the skeptics had prevailed.

WDD's satellite office nonetheless pressed on. Reconnaissance satellites require polar orbits, and by 1956 it became obvious that in order to do polar launches we needed to establish a launch site in the U.S. The preferred site was Camp Cooke (now Vandenberg AFB) in California, then under control of the Army. I remember meeting with Charles Wilson, the Secretary of Defense, on this issue. We were seated around a long table on the third floor of the Pentagon. Wilson sat at one end, I was on the other end, and there were a number of people in between. After about an hour's briefing, Wilson finally said, "You can have Camp Cooke, but the Navy will retain Point Mugu at the south end of it, and there will be no live missile firings from Camp Cooke." Everyone knows how that worked out. Vandenberg became our major site for military space launches.

Let me give you an idea of the kind of climate we were living in at the time. In February 1957, in San Diego, I made a speech concerning military space and indicated that space would play an important role for national security in the future. The next day I received a wire from the Secretary of Defense's office: "Do not use the word 'space' in any of your speeches in the future." The launch of Sputnik I a few months later, in October of that year, changed everything. Suddenly, everyone got space-minded. I was flying back and forth from the West Coast to Washington, like a shuttlecock in a badminton game, making presentations to people in the Pentagon and to the Congress. "Why can't we go faster?" they demanded. "Why can't we do something?" They were thinking



Model of Sputnik I, first man-made satellite, launched October 4, 1957.

mainly about international prestige, because we had been out-maneuvered by the Soviets who launched the first satellite into orbit. We could easily have been the first ourselves; we had the capability to do it. In any case, space also became a very important element of the national security program.

In that regard, by the fall of 1960 we had recovered in mid-air the first satellite film capsule from a satellite that had a camera on board. It was called Discoverer XIV, although CORONA was the classified project name for the reconnaissance package on board the satellite. Therefore, we not only beat the date first proposed for an initial operational capability, but we collected a tremendous amount of strategic intelligence information on that flight. The CORONA Project quickly became the backbone of America's strategic reconnaissance capability and remained so for a number of years afterward.

V

Today we face what I consider to be a serious problem. Although we have developed a tremendous array of peacetime military space assets, how survivable are they? I do not believe that we have thought about space systems in the same manner that we have about systems on land, at sea, and in the air. The latter systems are survivable. In fact, survivability is one of the most important requirements that we impose on our military systems. Unfortunately, we have not applied that requirement as rigorously in the space arena.

The thinking today, particularly among the younger officers in the Air Force, however, is that space is going to be an integrated part of future military operations. I know quite a few of the younger officers in the Air Force, and they are on the right track. I have no doubt that they will get us there in the future, and that we will achieve a survivable, real wartime capability in space, just as we have the peacetime space capability today.



Gen. Bernard A. Schriever with models of missiles he helped develop.



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Civil-Military Relations in America's Early Space Program

R. Cargill Hall

The term "civil-military relations," as used here, refer to the relations between and among the organizations principally involved in America's formative space program between 1946 and 1961. Military and related defense services, by definition, were arms of the national government. Civil organizations on the other hand, represented both the private and public sectors. What were these organizations? If you could see it, the taproot of practical astronautics in this country might appear as a three-tined fork composed of military, scientific, and industrial interests. Among the military, they included elements of the U.S. Navy, specifically the Bureau of Aeronautics, the Office of Naval Research (ONR), and the Naval Research Laboratory (NRL); those of the U.S. Army Air Forces (later USAF), particularly the Bombardment Missiles Division at Wright Field, Project RAND, and the Western Development Division; and those of the U.S. Army, especially the ordnance components that would make up the Army Ballistic Missile Agency at Redstone Arsenal and its Jet Propulsion Laboratory at the California Institute of Technology (Caltech). The scientific groups included government advisory boards and other ad hoc panels such as the Air Force Scientific Advisory Board, the Technological Capabilities Panel; the V–2 Panel, later the Upper Atmosphere Rocket Research Panel; the upper air research panels of the Joint Research Development Board, later RDB, in the Defense Department; the Applied Physics Laboratory at Johns Hopkins University; the Carnegie Institution of Washington; the National Advisory Committee for Aeronautics; the National Academy of Sciences; and the National Science Foundation. As funding became available, industrial laboratories, such as Bell Labs, and America's airframe industry that included Convair, Martin, Bell, Douglas, and Lockheed, supported the research and development efforts of all the preceding organizations. Finally, key professional societies to which most of these organization's members belonged, appeared superimposed across our three-tined fork. They included the Institute of Aeronautical Science, the American Rocket Society, and the Institute of Electrical and Electronics Engineers (IEEE).

This brings us to the people. People staff organizations. People determine relations within and among organizations. People make history. Virtually all

those in America who engaged in studying and planning for space flight in the first decade after World War II, whatever organization they belonged to, knew each other personally or by reputation. It was a small world, this world of rocketry and astronautics, and its practitioners served together on the aforementioned panels and boards, and moved in their careers among government, industry, and the academy. A classic example was Louis N. Ridenour. A physicist who helped develop radar technology at MIT during World War II, Ridenour played a prominent role in the RAND satellite studies in the 1940s. Subsequently he served as a scientific consultant to the Air Force, became a founder of International Telemetering Company, and moved to Lockheed as one of its top managers. Before his untimely death, Ridenour won for Lockheed the Air Force satellite contract that would contribute greatly in the years afterward to that firm's commanding position in the aerospace market.

The names of other engineers and scientists from this era are as well or better known. Consider a few of them: Robert Salter, James Lipp, William Bollay, Eugene Root, Richard Porter, Simon Ramo, Milton Rosen, Wernher von Braun, William Pickering, Cmdr. George Hoover and Capt. Robert Truax, and Gens. Holgar Toftoy, John Medaris, Bernard Schriever, and Donald Putt. In the Pentagon, Donald Quarles, Assistant Secretary of Defense for Research and Development (later Secretary of the Air Force) cast the die for America's first space projects and set the national space policy to guide them. Other prominent scientists included Lee DuBridge, James Van Allen, William Baker, Homer Newell, Hugh Dryden, Joseph Kaplan, Detlev Bronk, Lloyd Berkner, and Alan Waterman. Among them can be found the "Charles River crowd," as General Schriever has termed a crucial group from the Boston area, that included Edwin Land, James Killian, Edward Purcell, James Baker, and George Kistiakowsky. Finally, with the launch of the first Soviet satellites in late 1957, three other powerful players appeared on the national space flight scene: the advanced technology manager of the Central Intelligence Agency, Richard Bissell, the first director of the Advanced Research Projects Agency, Roy Johnson, and the first NASA Administrator, Keith Glennan. They, along with all the rest of these men and their associates, to varying degrees, determined relations and shaped the way in which the formative American space program evolved.

Exactly what were the relations among the organizations that these men represented between 1946 and 1961? Relations among the military and civilian institutions turned on the astronautical actions and events at particular moments during that brief fifteen years. They divide rather neatly into three recognizable periods: satellite engineering analyses, definition of space missions, and design of satellite subsystems, 1946–1954; formulation of national space policy, approval of separate scientific and military satellite projects, and design and construction of ballistic rockets needed to launch Earth satellites, 1955–1957; and post-Sputnik organization of a national space program and assignment of space missions 1958–1961.



Louis N. Ridenour

I

During the first of these periods between 1946 and the end of 1954, relations differed markedly among the military and civil sectors. In the first postwar years, while satellite engineering analyses were prepared at Project RAND, the Air Force declined to collaborate with the Navy on a satellite project and instead competed for the exclusive assignment of space missions. Decisions in that realm followed in succession. After reviewing the studies accomplished, the Defense Department's Research and Development Board (RDB) in March 1948 determined that no single satellite application as yet identified could justify the costs of building the launch and space vehicles. But the RDB also consolidated all further government studies of Earth satellites at the reorganized RAND Corporation in Santa Monica, California. Two years later, in March 1950, Secretary of Defense Louis Johnson assigned to the Air Force responsibility for long-range strategic missiles, including ICBMs. That assignment gave to the service responsibility for eventual development of the large rockets needed to launch Earth satellites. A few weeks later, the RDB also vested jurisdiction for military satellites in the same service. With these responsibilities, Air Force leaders directed RAND to complete studies of a military Earth satellite.

The Air Force and Navy studies thus far conducted had ruled out the satellite as a weapons carrier, but claimed for it a number of important military support missions. An automated spacecraft could be used for meteorological observation and short range weather forecasting, relaying military communications, performing strategic reconnaissance, and improving navigation and guidance of terrestrial vehicles. But in a cold war world, one in which the Soviet Union possessed atomic bombs, all of those at work on the military satellite could agree that its most valuable, first-priority use involved one application:

as a reconnaissance platform from which to observe and record activity on Earth. When RAND completed studies of a military satellite and released its final report in March 1954, it described and recommended to the Air Force just such a vehicle. The Air Research and Development Command in November 1954 issued System Requirement No 5 that called for a competitive system design of this satellite among industrial firms.

If the RDB decision of 1948 took the U.S. Navy out of the military satellite business, at least temporarily, it had no effect on scientists and engineers in the Naval Research Laboratory who worked closely with their counterparts in academe on exploring the Earth's upper atmosphere using rockets. The U.S. Army had captured some 100 German V–2 rockets at the end of World War II. These rockets, along with German engineers including Wernher von Braun, were moved to this country. In 1946 Army Ordnance, assisted by the Germans, set about assembling and launching the V–2s in vertical flight profiles at White Sands Missile Range in New Mexico. American scientists were permitted to instrument the V–2 nose cones to assay the properties of the Earth's upper atmosphere and the fields and particles that interacted there. To identify and decide which instruments flew on these rockets, scientists from NRL, the Applied Physics Laboratory, Caltech, and other American universities, formed an ad hoc "V–2 Panel," later the Upper Atmosphere Rocket Research Panel. Aware of the limited supply of V–2s, these same scientists, working through the upper air panel of the Research and Development Board, secured authority for the Navy to contract with Martin for a follow-on sounding rocket called Viking. The first of them was launched at White Sands in 1949.

The American scientists involved in upper air research with rockets shared similar interests. Except for some tension over allocating rocket payload space and the decision for Viking instead of another rocket, they generally got along well together and with their military sponsors. Moreover, they encouraged the International Council of Scientific Unions (ICSU) to include rocket research of the upper atmosphere in its plans for an International Geophysical Year (IGY) to be held in 1957–1958. But rockets launched vertically fall back to Earth quickly. James Van Allen and other American scientists urged that a "long-playing rocket" place an instrumented payload in Earth orbit, where, depending on the orbital altitude achieved, experiments could be conducted for weeks or months. The ICSU, at its annual meeting in October 1954, endorsed that proposition: states should also launch scientific Earth satellites during the IGY.

By the end of 1954, the technology and justification for scientific and applied military satellites approached a critical mass. The Air Force had issued a system requirement for a reconnaissance satellite, established a project office for it in the Bombardment Missiles Division at Wright-Patterson AFB, and detailed Brig. Gen. Bernard Schriever to El Segundo, California, to oversee development and production of intercontinental ballistic rockets. If required, these rockets could be employed to launch Earth satellites. In August–September of

that same year, von Braun and his associates at the Army Ballistic Missile Agency in Huntsville, Alabama, teamed with the Office of Naval Research and produced a satellite proposal called Orbiter, to be launched atop an Army ballistic rocket. And members of the American Rocket Society, representing all of the military and civil organizations across the board, late in 1954 prepared a comprehensive survey of Earth satellite scientific and applied uses and, with the new year, submitted it the U.S. National Committee for the IGY in the National Academy of Sciences. Those who had participated in this work shared commonly an enthusiasm and high expectations for an American space flight project. Except for the initial competition over military space roles and missions between the Air Force and the Navy, relations among the space-minded members of all three groups between 1946 and 1954 remained essentially cordial and mutually supportive. In the absence of a space program, any success or advance by one group benefitted every group; all boats rose on the incoming tide. But these relations would change dramatically when, in 1955, President Eisenhower announced that the United States would launch a scientific Earth satellite.

II

Unbeknownst to all except a few Air Force members, in November 1954 Eisenhower determined to make peacetime strategic reconnaissance a national policy. To that end, he approved construction of the high-flying U–2 reconnaissance airplane in a super-secret enterprise known as Project AQUATONE. He assigned direction of this project to the Central Intelligence Agency, whose reluctant director, Allen Dulles, named Richard Bissell project director, teamed with select Air Force elements that furnished the infrastructure and eventually the U–2 pilots. This project grew out of a secret study ordered by Eisenhower in 1954 and performed for him at the direction of MIT president James Killian. Known as the Technological Capabilities Panel, the group's intelligence committee, led by Polaroid's Edwin Land, encouraged the U–2 project even though, in international law, the unauthorized overflight of another state's territory in peacetime was an illegal and warlike act. Recognizing this, the study group's final report issued in mid-February 1955 recommended launching a scientific Earth satellite. Such a satellite might establish the right of overflight in the regions "above" a nation's airspace, and with it a precedent for the free passage of any reconnaissance satellites to follow. Neither Killian nor Land at that time, however, viewed satellites as a likely prospect in the near term. Aircraft and balloons that employed existing technology remained their reconnaissance instruments of choice.

Donald Quarles, Eisenhower's Assistant Secretary of Defense for Research and Development, adopted another view. His office had subsumed the Defense Department's Research and Development Board along with its responsibilities



Project Orbiter Team, March 1955. **Seated, from left,** Cmdr. George W. Hoover, Frederick C. Durant III, James Kendrick, William A. Giardini, Wernher von Braun, Philippe W. Newton, Rudolf H. Schlidt, and Gerhard Heller. **Standing, from left,** Lt. Cmdr. William E. Dowdell, Alexander Satin, Cmdr. Robert C. Truax, Liston Tatum, Austin W. Stanton, Fred L. Whipple, George W. Petri, Lowell O. Anderson, and Milton W. Rosen.

for roles and missions, and could approve or deny virtually all defense research projects. Quarles numbered among a few Eisenhower confidants who knew about Project AQUATONE, he was acquainted with the proposed Army-ONR satellite project, and on reading Killian's secret report to the President in February 1955, judged its freedom of space thesis crucial for the future of American intelligence. He privately urged the U.S. National Committee for the IGY to request formally a scientific satellite project through the National Science Foundation, which it did. As intended, the director of the foundation, Alan Waterman, passed the request on to Quarles in March for review in the Defense Department. In April, Quarles obtained formal scientific satellite proposals from the Army-ONR team, which featured as its launcher the Redstone military ballistic rocket, and from the Naval Research Laboratory, which proposed the Viking sounding rocket with new upper stages to launch a satellite. At his request, an unenthusiastic Air Force later submitted a scientific satellite proposal using the Atlas ICBM as the booster. Quarles turned all of the satellite proposals over to his Advisory Group on Special Capabilities and asked that its members recommend a preferred project.

Astronautical action and events cascaded in the weeks that followed. They sharply altered the spirit of camaraderie that space-minded members of the mil-

itary, scientific, and industrial alliances previously had shared. In May 1955, Quarles submitted a proposal for launching an IGY satellite along with the suggested national policy to guide this activity to the National Security Council (NSC). By month's end, the NSC endorsed and the President approved Quarles's Earth satellite recommendations. The space policy emphasized the peaceful purposes of the endeavor, which was intended to establish the principle in international law of "freedom of space" and the right of unimpeded overflight that went with it. In late July, on returning from a four-power summit conference in Geneva, where Soviet leaders rejected his "Open Skies" proposal for reconnaissance aircraft flights, the President announced that the United States would launch a scientific Earth satellite as part of its contribution to the IGY. A few days later, in early August, the Defense Department announced that the Advisory Group on Special Capabilities had selected the NRL-Viking satellite proposal, known as Vanguard, over the Army Orbiter proposal. The National Science Foundation would direct this IGY satellite project, with logistic support provided by the Navy.

If the Navy and its team of scientists were now in the space business, the Army and its team were out of it, at least for the moment. The Air Force, meanwhile, was content to pursue its military satellite project. The service had issued a general operational requirement for a reconnaissance satellite in March 1955, and begun a design competition for it among three industrial firms in June. But none of the space interest groups had members on the National Security Council, and, with but a few exceptions, those members were unaware that a still-secret national space policy promoted the scientific satellite as a stalking horse for military satellites to follow.

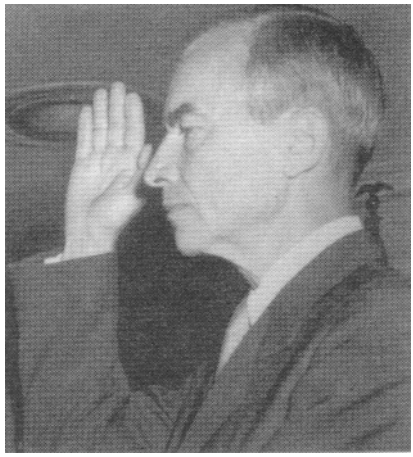
Selection of the Navy Vanguard proposal as America's IGY satellite project changed the relations profoundly among members of the astronautical fraternity in government service. Hereafter, an undercurrent of competition would replace collaboration at the surface of new and ongoing astronautical programs. It also marked a change for Donald Quarles. In August 1955 Eisenhower appointed him Secretary of the Air Force. But the pre-Sputnik space enterprise remained minuscule compared with expenditures on other civil and military government activities. While the Naval Research Laboratory assembled a team of contractors to design and build the rockets and spacecraft for Project Vanguard, the Air Force in June 1956 selected Lockheed to build its military satellite, for which two additional defense support missions had been identified: detection of rocket launchings from land or sea, and of nuclear detonations on Earth or in space. If the IGY satellite was to weigh tens of pounds and be launched by a modified sounding rocket, the Air Force satellite was to weigh thousands of pounds and be launched atop an Atlas ICBM. Known as Weapon System 117L (WS–117L), the reconnaissance spacecraft would be stabilized on three axes, photograph the Earth beneath, and its electronically-scanned film images radioed over a wide bandwidth to receiving stations in the United States.

As Air Force Secretary, Quarles could agree that the WS–117L reconnaissance satellite, compared with its IGY counterpart, represented an extraordinary technical challenge. But, in keeping with the national space policy he had fashioned, Quarles also seems to have determined that the civilian scientific satellite should precede its military counterpart into space. Whatever the reasons, in 1956 and 1957 he denied funding to the Air Force satellite project at Lockheed for anything more than subsystem design work. The Department of Defense, meanwhile, constrained all American military leaders from discussing publicly the military uses of outer space. That situation changed completely when the Soviet Union launched its IGY satellite on October 4, 1957. As one participant in the Air Force satellite project recalled: Suddenly, "Everyone became a space cadet and it wasn't necessary to plead our case any longer. Now the Washington crowd came to us and said: 'Where is your satellite? Why aren't you ready to launch?'" Before long, the President authorized the Army to begin a backup IGY satellite project called Explorer. Sputnik had triggered a national debate over the state of American technology and defense preparedness, one that further altered civil-military relations among American space protagonists. With the space age at hand, they asked themselves: which group or groups will control and direct a United States astronautical program now certain to be much larger than anyone had imagined?

III

President Eisenhower, working with his advisors and the Congress, answered these questions between late 1957 and 1961. The answers turned on issues of national security. A few weeks after the launch of Sputnik I, on October 28, 1957, the President's Board of Consultants on Foreign Intelligence Activities submitted its semiannual report to Eisenhower. Formed the year before to review and report on activities of the government's intelligence organizations, this eight-member board was chaired by James Killian and included Edwin Land. They advised Eisenhower that neither an advanced reconnaissance aircraft under study at the CIA, nor the Air Force readout reconnaissance satellite under contract to Lockheed, would achieve operational status before 1960. But the Air Force had added a film recovery reconnaissance satellite to the WS–117L program in the fall of 1957, and they recommended evaluating it as an interim solution. The President subsequently ordered a review of the readout and recovery reconnaissance satellite systems, which was organized and conducted in December at the direction of the new Undersecretary of Defense, Donald Quarles. Eisenhower, meanwhile, on November 15 named James Killian as his special assistant for science and technology and chairman of the Presidents Science Advisory Committee, or PSAC.

Following the reconnaissance satellite review in December, on February 7, 1958, Killian and Land met with Eisenhower. The President agreed to proceed

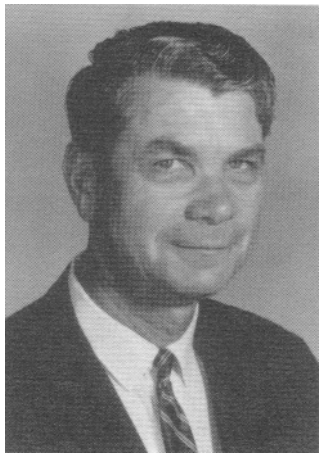


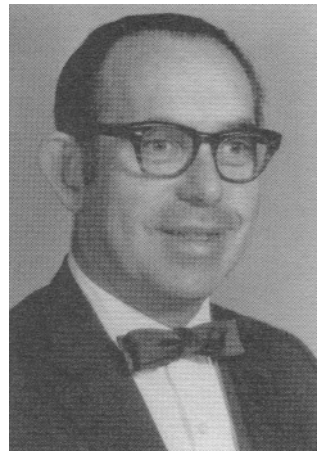


Donald A. Quarles, left, taking oath of office as Secretary of the Air Force, and James R. Killian, taking oath to be Eisenhower's Science Advisor.

with the film recovery satellite as a separate undercover project prosecuted in a manner like the U–2. The CIA's Richard Bissell would again serve as the project manager, assisted by elements of the Air Force. In this instance, however, another new entrant in the civil-military space area, the recently formed Advanced Research Projects Agency (ARPA) in the Defense Department, assumed responsibility for all military and civilian satellite projects. It also would have a temporary role in the film recovery satellite, eventually known as Project CORONA. In early 1958, Eisenhower was inclined to leave all civil and military space projects in the hands of ARPA and the Defense Department. Vice President Richard Nixon, James Killian, and other advisors, however, persuaded him that the nation needed a separate civilian space program unfettered by the security restrictions that attended military astronautics. The administration submitted that legislation to Congress in April and the President signed into law the bill that created the National Aeronautics and Space Administration (NASA) in July 1958. Although Air Force and Army leaders, especially, contested these choices, the organizational winners proved to be the newcomers on the space flight scene: the Central Intelligence Agency, which had not sought a space mission; the National Advisory Committee for Aeronautics, which had sought such a mission and now formed the nucleus of NASA responsible for all civil, scientific, and manned space flight systems; and the Advanced Research Project Agency in the Defense Department which still retained control over automated military space systems.

The explosion of national interest in space after the launch of Sputnik I, demands that America "beat the Russians," and the assignment of space flight responsibilities had turned civil-military relations from open competition to





Merton E. Davies (left) and Amrom Katz of the RAND Corporation sold the concept of a film recovery reconnaissance satellite to the Air Force in 1957. It eventually became Project CORONA.

hostile rivalry. Perhaps the most noteworthy case during the next few years involved NASA's contracting for an upper stage rocket, called Vega, when the Air Force had a similar vehicle, called Agena, already under contract with Lockheed — but had declined to advise the new space agency of its existence for reasons of "national security." Scientists, meanwhile, hammered on NASA's door in attempts to secure for themselves and deny to compatriots instrument payload space on board any and all satellites. Airframe and electronics firms suddenly acquired more space business than they could handle, but eagerly sought even more; the needed employees and facilities could be found later. Obscure places like Cape Canaveral, Florida, turned overnight into boom towns reminiscent of the wild west. ARPA's first deputy director John Clark perhaps best described the prevailing atmosphere: "After we had been in business a few weeks," he recalled, "it seemed to me that everybody in the country had come in with a [space flight] proposal except Fanny Farmer Candy, and I expected them at any moment."

The post-Sputnik free-for-all in civil-military relations subsided between 1958 and 1961 as the Eisenhower Administration finished organizing the space program and assigning space missions. If NASA held responsibility for at least developing, if not operating, all American civil scientific and applications satellites and space probes, the military support missions already identified remained in the Defense Department. ARPA's control over these missions ended in September 1959, with assignments made to the Air Force, Army, and Navy. The Air Force resumed direction of its reconnaissance satellite, now called SAMOS, and gained responsibility for the Missile Defense Alarm System (MIDAS), and



Richard M. Bissell, Jr.,
CIA Director of Project CORONA.

for space-based detection of nuclear detonations, at that time termed Vela Hotel. The Army, despite its leaders' cries of anguish and vigorous protests, lost both the Jet Propulsion Laboratory and Army Ballistic Missiles Agency (ABMA) to the National Aeronautics and Space Administration. In return, perhaps, the Army did acquire temporary responsibility for developing military communications satellites, while the Navy gained responsibility for navigation satellites, both working with the Air Force for launch services and orbital command and control. Finally, and unknown to almost all of the military and civil participants, in the Central Intelligence Agency (CIA) continued to manage the secret CORONA project, working with a designated Air Force partner. With these assignments, only one space organization remained to be fashioned; in keeping with Eisenhower's preferences, it was formed secretly after the shoot-down of a U–2 airplane inside the Soviet Union on 1 May 1960.

In the national and international turmoil that followed the "U–2 incident" and the collapse of a summit conference, President Eisenhower ordered an evaluation of the solitary satellite reconnaissance effort still under military control, destined to be operated by the Strategic Air Command (SAC), the Air Force SAMOS project. The President's science advisor, George Kistiakowsky, who had succeeded James Killian, assisted by other President's Science Advisory Committee (PSAC) members including Edwin Land, conducted this assessment between June and August 1960. For all practical purposes, the military space program in 1960 was the SAMOS reconnaissance satellite project. Without it or a mission for military man in space, the Air Force could claim only a few space support missions of minor distinction and with dubious futures. Service leaders sensed trouble in this top-to-bottom government review, as well they might. SAC's Commander in Chief, Gen. Thomas Power, nevertheless undercut the Air Force position when, during a Kistiakowsky visit to SAC headquarters, he questioned the patriotism of the President's Ukrainian-born science advisor.

President Eisenhower considered Kistiakowsky's findings and recommendations at an NSC meeting in the White House on August 25, 1960. Review members judged reconnaissance satellites, like the U–2, to be vital national assets that should not be directed and controlled by any single military service. They proposed establishing a civilian office to direct SAMOS, one that reported to the Secretary of Defense. A special Air Force office on the West Coast would employ streamlined management and contracting methods to execute SAMOS, while reporting outside Air Force channels directly to a civilian manager located in the Office of the Secretary of the Air Force. Already approved by the Secretary of Defense and the Air Force's civilian leadership, Secretary Dudley Sharp and Undersecretary Joseph Charyk, the President endorsed the proposal. A few days later, Sharp issued the required directives. The new Defense Department office, headed by Joseph Charyk, would soon become responsible for all reconnaissance satellites and be formally named the National Reconnaissance Office (NRO) in 1961, early in the Administration of President John F. Kennedy. These actions completed the organization of the U.S. space program.

The new administration acknowledged the Eisenhower space mission assignments on March 6, 1961, when Secretary of Defense Robert McNamara issued DOD directive 5160.32. In what must have appeared as a major concession to one military service for those outside the Pentagon, it assigned to the Department of the Air Force responsibility for all "research, development, test, and engineering of Department of Defense space development programs or projects which are approved hereafter." Although it designated the Air Force as the lead military service in space, most of those on the Pentagon's third and fourth floors recognized the directive for the acknowledgment of existing space mission assignments that it was. Among them, Eugene Zukert, President Kennedy's recently appointed Secretary of the Air Force, considered the "hereafter" and snapped: "It was like getting a franchise to run a busline across the Sahara Desert." That perception, regrettably, shaped the attitudes toward military spacefaring of many Air Force leaders over the next twenty years.

For better or worse, the nation's civilian leaders who established the NRO also created an Air Force space contingent isolated from its service counterparts in the larger communities of civil and military space flight — and with it, another set of relations. Air Force company and field grade officers who stepped through the looking glass into this much smaller and restricted joint intelligence world might staff and run the NRO, but they reported to it and operated under its rules of assignment and promotion. The regular blue suit Air Force would come to view them as creatures of the NRO or of the CIA, whose "true service loyalties," as one officer recalled, "at least were suspect." Those among them who returned to the regular Air Force might not exactly be regarded as members of a "scheduled caste," but they would share more limited opportunities for promotion. Whatever their contributions to national security in that other world, very few would attain the rank of Air Force flag officers.

These last touches made to the nation's space organization and assignments in 1960–61 concluded a period of hostile, often bitter, relations among and between civil and military organizations involved in this enterprise. If responsibilities and relationships for some space missions remained to be ironed out, particularly those associated with navigation and meteorological satellites, beginning in 1961 civil-military relations became more cordial. Indeed, the Air Force and NASA soon struck arrangements to share experience and skills — and made good on them. The canting of liberals underscored the improved relations. By the mid 1960s so many Air Force officers held important management positions in NASA, those on the left declared, that the nation's civil space program was now being "militarized" from the inside out!



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The Air Force and Military Space Missions
The Critical Years, 1957–1961

David N. Spires

The period from late 1957 to the spring of 1961 represents the emerging years of the national space program and the Air Force's place within it. In the wake of the Sputnik crisis, the Eisenhower Administration implemented organizational and policy measures that provided the foundation of the nation's space program. Buffeted by pressure and counsel from an alarmed public and congressional and military spokesmen, President Eisenhower found himself fighting a rearguard action to hold to his view of civilian and military priorities for space activities within a reasoned budget. His dual military and civilian space program reflected his "space for peace" focus, one that fostered "open skies" for free passage of future military reconnaissance satellites. Given his sensitivity to overflying the Soviet Union for intelligence purposes, the civilian space program at first held center stage, while Administration officials consciously downplayed the military space role and service initiatives.

All three military services and their supporters chafed at the government's refusal to sanction a broadly based military space initiative in response to the Soviet advances in rocketry and space satellites. Air Force leaders found the situation particularly frustrating, arguing that their service should head a unified, DOD-oriented national space program that would embrace both military and civilian requirements. When national policy favored a civilian-led program dependent on military support, the Air Force then focused on becoming the "executive agent" for American military space activity.

The challenge proved formidable. Shortly after Sputnik, concerns over inter-service rivalry and duplication of effort prompted Administration officials to create ARPA (Advanced Research Projects Agency), a centralized agency for all DOD space research and development activities. In effect, the services lost their independent space programs to the new agency. Moreover, the creation of NASA in the fall of 1958 divided the space mission further and raised thorny issues of civil-military authority that persisted well beyond the Sputnik era. Despite repeated government statements to the contrary, for many the civilian NASA conducted "peaceful" space ventures, while ARPA and the military services, by implication, involved themselves in warlike or non-peaceful activities. Air Force leaders found the declaration "space for peaceful purposes" prevented

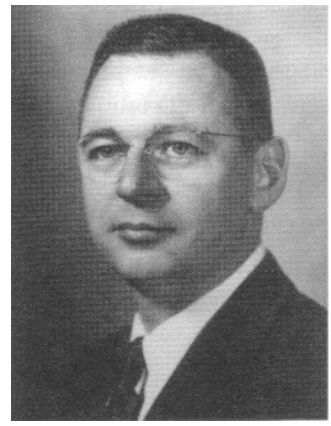
them from developing a space program necessary to overtake the Soviet lead and provide the nation the security it required. Air Force officials claimed defense support space missions such as communications, reconnaissance, and navigation, but they also sought a potential offensive mission through development of space-borne anti-satellite and anti-missile systems. President Eisenhower and other Administration leaders accepted the defense support missions as consistent with the peaceful uses of space, but ultimately rejected offensive space missions as inconsistent with national space policy.

Constrained by Administration policy, the Air Force also faced stiff competition from its service counterparts. Indeed, in early 1958, the Army and Navy could claim more experience than the Air Force in space, and their success in orbiting the nation's first satellites (Explorer and Vanguard) seemed destined to propel one of them to become the executive agent for the DOD space mission. Yet, by the spring of 1961, ARPA had been relegated to a research and development role, and the Army and Navy had been removed from any major role in space. The Air Force found itself designated the "executive agent" for military space defense support missions, with responsibility for the majority of military space development projects. While Air Force leaders considered the victory incomplete, it nonetheless established the Air Force as the nation's primary military service for space.

I

On the eve of the Sputnik satellite flights in late 1957, three developments already had propelled the nation to the threshold of space. The first involved President Eisenhower's resolve to forestall another "Pearl Harbor." As close advisor, James Killian, remarked, Eisenhower remained "haunted . . . throughout his presidency" by the threat of surprise nuclear attack on the United States.[3] To avoid this horror, prehostilities Intelligence data on Soviet military capabilities became absolutely essential, and the Administration found a near term answer in the U–2 high altitude reconnaissance plane. The long term solution would turn on the military reconnaissance satellite under development by the Air Force. Meanwhile, ballistic missiles, the best potential satellite boosters, also represented the best strategic weapons to prevent surprise nuclear attack. Establishing a policy of "space for peaceful purposes," the Administration followed what amounted to a dual space program that would focus on launching a civilian scientific satellite — known as Project Vanguard — to establish the principle of unimpeded overflight in space for the military satellites to follow.

The second development involved the "thermonuclear breakthrough" that solved much of the early ICBM dilemma. By early 1953, successful tests at Eniwetok led experts to predict the advent of thermonuclear warheads weighing only 1,500 pounds with a yield of one megaton. This meant that weight and accuracy criteria for the Air Force's Convair Atlas missile could be reduced



Trevor Gardner

significantly, making its development more feasible and, in the bargain, providing a satellite booster.[4]

The third development proved to be the advocacy of several determined government officials. Heading the group was Trevor Gardner, the "technologically evangelical" Assistant Secretary of the Air Force for Research and Development, who made it his mission in public life to convince the government that the nation must pursue a crash program to develop an operational Air Force ICBM or face nuclear disaster. In the fall of 1953 Gardner convened the celebrated Strategic Missiles Evaluation Committee of experts under the leadership of renowned Princeton mathematician and activist John von Neumann. The von Neumann report called for a drastic revision of the Atlas ICBM large booster program by assigning it the highest development priority and creating a new development-management agency in the Air Force to lead the crash program.

Gardner used the report to convince Air Force leaders in the spring of 1954 to create the Western Development Division at Inglewood, California, and appoint as its commander his dynamic young ally, Brig. Gen. Bernard Schriever. Shortly thereafter, Schriever arranged for the Air Force to contract the Ramo-Wooldridge Corporation as full-time technical consultants to his command to help develop a "light-weight" three-engine ICBM that featured a pressure-stabilized airframe housing the liquid fuel and oxidizer tanks. Schriever's command resorted to a number of managerial innovations, most notably the concept of "concurrency," or systems management, that would become common practice for the Air Force in the future. The Western Development Division awarded two contracts for major subsystem components. Thus, each Atlas component was "backed up" by an alternate that relied on a different design. Concurrency proved its worth when the Air Force successfully launched both the liquid-propellant Atlas and the solid-propellant Titan ICBMs by the end of the 1950s.[5]

Meanwhile, in 1956 Schriever's team became responsible for the Advanced Reconnaissance System, the WS–117L that had emerged from the Rand Corpo-

ration's Project Feed Back studies. That same year, the Air Force chose the design of Lockheed's Missile Systems Division, which envisioned a second stage booster-satellite capable of providing high pointing accuracy for its sensors in Earth orbit. Eventually this booster satellite would become the workhorse "Agena" that, together with its Atlas booster, would launch the heavier Air Force payloads of the 1960s.[6]

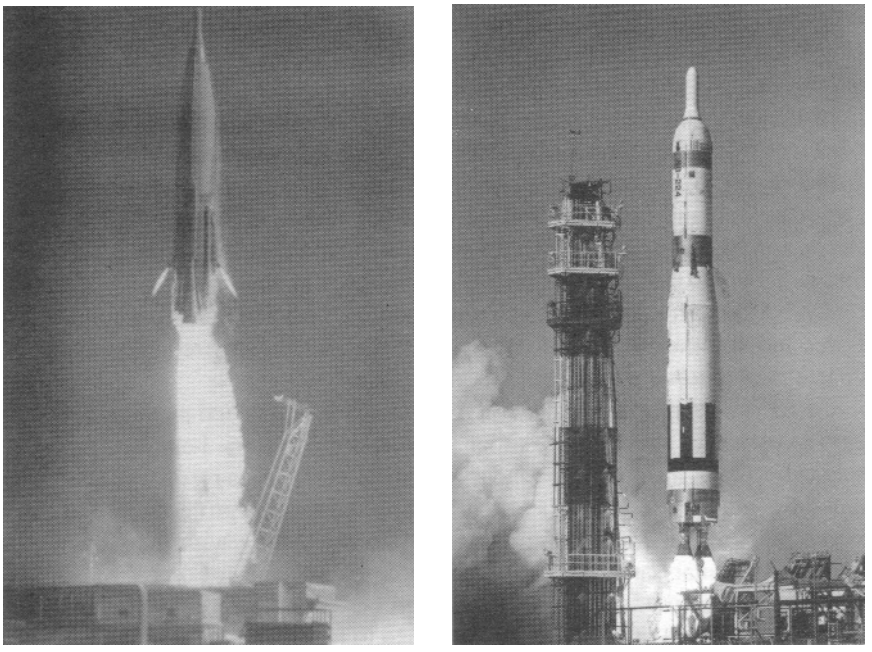
By late 1957 Air Force leaders began to meld these three developments — an emergent national policy of space for peaceful purposes, the thermonuclear breakthrough, and a high priority missile and satellite development program — into an agenda for an Air Force-led national space program.

II

In the immediate aftermath of the Sputnik launches, however, the Air Force remained positioned behind the Navy and Army, military services that prepared to launch their satellites under Project Vanguard and Project Orbiter, respectively. In the race for the space mission, Air Force chief of staff Gen. Thomas D. White and other spokesmen focused on defining space as a continuum of the atmosphere, a place for potential military-related operations, rather than a function or mission in itself, and the logical arena for Air Force activities. Early in 1958, Air Force leaders coined a new term, "aerospace," to describe their service's legitimate role in space, and promoted that claim at every opportunity.[7]

In late October 1957, a committee of distinguished scientists and senior Air Force officers chaired by Dr. Edward Teller recommended that the nation adopt a unified, closely integrated national space program under Air Force leadership. But in the unsettled post-Sputnik period it failed to move government officials to adopt a unified program under either military or civilian direction. In December, an Air Force announcement that a Directorate of Astronautics had been established on the Air Staff brought a storm of protest from Pentagon officials, and the Air Force quickly "disestablished" the offending office. Although administration officials readily declared the military reconnaissance satellite to be the government's single most important space project, they remained opposed to highlighting military initiatives for space that might encourage the Soviets to retaliate against reconnaissance satellites.[8]

Air Force hopes rose during the first week of 1958, when the Defense Department requested a list of proposed space projects from each of the three services. Air Force leaders viewed the request as an open door for approval of a USAF space program. Relying on the Teller report and a recent Scientific Advisory Board study that urged the Air Force to focus on its strong rocket development work, the "Air Force Astronautics Development Program" recommended five major space systems: Ballistic Test and Related Systems, a Lunar Base System, manned hypersonic (Mach 5 and above) Dyna-Soar manned orbital glider, and the WS-117L Advanced Reconnaissance System — along with



Launch of an Atlas from Vandenberg AFB, California (left), and a Titan from the Air Force Missile Test Center, Florida (right).

twenty-one major related projects. With the creation of the Advanced Research Projects Agency (ARPA) on February 7, 1958, however, frustrated Air Force officials realized that DOD's request to the services essentially represented an effort to gain information that would assist the new DOD agency in assigning development responsibilities among the Army, Navy, and Air Force.[9]

III

ARPA began operations amid a flurry of great expectations from its admirers and dire warnings from its detractors. As the central agency for military space, it sought to end the low military priorities heretofore accorded space technology in the absence of clearly defined military applications. It also hoped to avoid inter-service rivalry and wasteful duplication by centralizing decision-making power on space projects. Critics worried that ARPA would evolve into a "fourth service." ARPA never won the acceptance of Air Force space spokesmen, who saw no merit in relinquishing control over research and development to another DOD agency. The fate of the reconnaissance satellite program established the pattern. Initially the Air Force applauded ARPA's intention to accelerate the WS–117L program on "the highest national priority basis." By September 1958, however, ARPA had separated the program into component proj-

ects with revised designations. Operating on a project basis, the reconnaissance element, which received the name Sentry and later SAMOS, involved collecting photographic and electromagnetic reconnaissance data and transmitting the information by means of a "readout" system or actual aerial "recovery" of data packages by aircraft. The infrared sensing system project, named MIDAS, consisted of infra-red sensors designed to detect missile exhaust plumes and provide command centers a thirty-minute warning of an ICBM attack. Under the designation Discoverer, ARPA grouped "vehicle tests, biomedical flights, and recovery experiments." ARPA's direction signaled the end of "Concurrency." Although the new agency redistributed most programs back to the Air Force and the other services, it did so under contract, thereby retaining technical control and receiving credit for "its" programs.[10]

ARPA remained dependent on the services for qualified personnel, necessary experience, and resources that included laboratories, launch complexes, rocket boosters, test facilities, and tracking networks. As a result, ARPA designated the military services its executive agents for most projects, with the Air Force receiving a lion's share of eighty percent. Along with the former Advanced Reconnaissance System, these represented the Air Forces' most cherished space programs, including lunar probes, the 1.5 million-pound rocket booster, and a variety of measures designed to launch a military man in space. Although the Air Force remained unhappy with its subordination to ARPA on space matters, Air Force leaders quickly realized that cooperation with ARPA would prove the best means of gaining development responsibility for space projects and, later, operational responsibility as well.

IV

The National Space Act of July 29, 1958, formally established a dual space program comprising separate civilian scientific and military applications. However, despite the apparent logic in assuming that NASA would be responsible for civilian space activities and DOD would handle military interests, the demarcation line between civilian and military space concerns often proved artificial and unattainable. Moreover, NASA, like ARPA, represented another space agency that challenged the Air Force for space responsibilities and program funding. For the immediate future, the civilian space agency would depend heavily on Air Force assistance. Meanwhile, it absorbed Army and Navy space assets that helped drive the Air Force toward the military space mission.

The rise of NASA sounded the death knell of Army and Navy pretensions to a major military space role. When NASA commenced operations on October 1, 1958, it relied on the aeronautical research facilities and personnel of the National Advisory Committee for Aeronautics. But to achieve space capability quickly, NASA needed an infusion of programs, facilities, and funding from the

military services. With little objection from the Navy, NASA received Project Vanguard's personnel and facilities, including its Minitrack satellite tracking network, and more than 400 scientists from the Naval Research Laboratory. Potential Army losses, however, proved far more sweeping and contentious. They eventually included the California Institute of Technology's Jet Propulsion Laboratory (JPL), whose sympathetic director had visions of turning it into the "national space laboratory," and a portion of the Army Ballistic Missile Agency that included Wernher von Braun's team and its giant Saturn booster project. The major Air Force loss proved to be its manned space projects, which NASA combined under the designation Project Mercury.[11]

NASA's acquisition of Army and Navy space programs and personnel left the Air Force an indispensable ally of the fledgling agency. The Air Force agreed to construct infrastructure facilities at Patrick AFB, Florida, for NASA's space probes, and provide Thor boosters for the Pioneer lunar probes and Tiros cloud cover satellite. The service also supported development of the hydrogen and oxygen-fueled Centaur high energy upper stage, which it hoped to use in its own communications satellite program. Most important, the Air Force strongly supported Project Mercury, NASA's man in space project, by furnishing Atlas boosters and launching services, along with considerable technical, biomedical, and personnel assistance.[12]

By the end of 1958 the foundations designed to achieve American superiority in space had been laid. National policy prescribed space activities for peaceful purposes, while organizational arrangements promoted a dual effort with civilian, scientific aspects centered in NASA and military research and applications directed by ARPA. Yet much remained unresolved, not only between DOD and NASA, but within the military arena as well. Not only did the Air Force continue to face challenges over program development and operational responsibility from ARPA, but a new DOD office of Director for Defense Research and Engineering (DDR&E), appeared in late 1958 to add to the tension.[13]

V

In early 1959 the Air Force renewed its quest for the military space mission. An Air Staff review at that time described the necessary tactics. Rather than formally requesting operating responsibility for military space missions, the review asserted, the Air Force should demonstrate successful stewardship, rely on available hardware (especially boosters), and establish "squatters rights." Despite the presence of ARPA, the Air Force should initiate its own integrated space program while working to improve relationships with both ARPA and NASA. The Air Force "must assume the role of opportunist, aggressively taking advantage of each situation as it arises to assure that the Air Force is always predominate [sic] in any action that has a space connotation."[14]

Air Force spokesmen, led by General White and General Schriever, appeared before congressional committees to elaborate on the Air Force's "aerospace" policy and argue for independence from ARPA. Their testimony proved especially credible in light of the Air Force's growing involvement in space. Heading the list of major projects were the three elements of the former WS–117L Advanced Reconnaissance System. Development flights were scheduled in 1961 for both SAMOS and MIDAS, and even earlier for the broad based Discoverer Project. The latter represented a "cover" for the CIA-Air Force CORONA Project, and involved tests on satellite stabilization equipment, satellite internal environment, capsule recovery techniques, and ground support equipment that would lead ultimately to an intelligence revolution. Publicly, the purpose of these tests were charged to biomedical experiments for human space flight using mice and primates.

Despite serious difficulties with the satellite systems during this early developmental phase, the Air Force could claim that it managed the nation's most important satellite programs, and that it should be awarded operational responsibility for them in the near future. Under ARPA's direction, the Air Force also could cite its launch support for the Navy's Transit navigational satellite, the Army's Notus communications satellite program, and its own responsibility for the rapidly expanding satellite cataloguing project known as the Space Detection and Tracking System (SPADATS).[15]

VI

The Air Force's vigorous campaign for military space missions did not go unnoticed by Army and Navy leaders. In April 1959, Admiral Arleigh Burke, the Chief of Naval Operations, projected large-scale space operations in the near future, discussed the interests in space of all three services in them, and proposed creating a single unified military space command to take advantage of the "very indivisibility of space." Army Chief of Staff Gen. Maxwell D. Taylor agreed. But Air Force Chief of Staff Gen. Thomas White opposed the proposal because, he said, it violated the established policy of integrating weapons within unified commands. Space systems, he said, represented only better means of performing existing missions and therefore should be assigned to the appropriate existing unified or specified command.[16]

The Air Force strongly lobbied Defense Secretary Neil McElroy to oppose the Burke initiative. Characteristically, General Schriever provided the most convincing arguments for the counter campaign. He asserted that "since its inception" the Air Force had been operating in aerospace through the mission areas of strategic attack, defense against attack, and supporting systems that enhanced both the strategic retaliatory and active defense forces. The Air Force had important requirements for earth satellites, which represented aerospace vehicles of the foreseeable future. Schriever pointedly criticized the current



Neil McElroy

fragmented satellite program management and advocated a unified, systems development approach that would "achieve the most effective deterrent posture" by coordinating and integrating satellite systems within the broad Air Force strategic and air defense force. Moreover, Army and Navy requirements, the general asserted, would be best achieved by the Air Force acting as "prime operating agency of the military [national] satellite force." [17]

In the fall of 1959, Secretary McElroy sided with the Air Force position, removed ARPA from control of space system development, and assigned to the Air Force responsibility for "the development, production and launching of space boosters" as well as payload integration. Although operational responsibility would continue to be awarded to the military services on a case-by-case basis, the Air Force regained operational control of SAMOS, MIDAS, and the Dyna-Soar manned orbital glider — space systems with seemingly high growth potential. The end of the year also brought the official demise of ARPA as the central DOD agency for all space activities. The Air Force benefited most from ARPA's loss of 80 percent of its funding and from NASA's continued dependence on it for help. Project Mercury notwithstanding, with Dyna-Soar the Air Force's multi-faceted manned space program appeared secure. The Air Force seemed well on its way to gaining management responsibility for all service requirements as the Defense Department's executive agent for space.[18]

Even so, Air Force leaders continued to chafe under a national policy they considered produced too modest a space program and prevented offensive space weapon system development altogether. Air Force leaders remained well aware of the Administration's sensitivity to recognizing publicly the military space role, and of congressional worries that the Air Force would usurp NASA's civil space responsibilities. General White therefore declined to issue a comprehensive military space statement, noting that "publication of an official policy statement at a time when so many facets of the space program were still un-

decided would have unfavorable reverberations in Congress, the Office of the Secretary of Defense (OSD), and the other military services." [19]

The Air Force's pursuit of the space mission also suffered a major setback in late 1960, when it lost control of one of its most cherished space programs. The downing of the U–2 reconnaissance aircraft on May 1, 1960, destroyed plans for an East-West Summit Conference and limited American aerial reconnaissance flights to the Soviet periphery. That event, which brought the troubled SAMOS and MIDAS satellite programs more funding from the Administration and Congress, also triggered a reassessment of the reconnaissance satellite program at the highest government levels. The Administration's review resulted in a major reorganization in September 1960, one that placed the SAMOS reconnaissance program under a newly established Air Force office that reported to the Secretary of Defense. In short order, the entire SAMOS reconnaissance satellite program disappeared from public view and from blue-suit Air Force stewardship. Although the new office remained within the Office of the Secretary of the Air Force and employed serving Air Force officers, Air Force Headquarters found itself excluded from this highly sensitive project.[20]

Even while the Air Force found itself losing control of the reconnaissance satellite program, it took a major step to reinforce its technical capabilities. In June it created the non-profit Aerospace Corporation in Inglewood, California, to insure that the Air Force would have the technical competence to meet future space age challenges. By the end of the year, the new corporation had acquired more than 1,700 employees and responsibility for twelve major Air Force programs. Eventually the Aerospace Corporation would provide general systems engineering and technical direction for every missile and space program undertaken by the Air Force.[21]

VII

The arrival of the Kennedy administration in early 1961 appeared to secure Air Force space efforts. Shortly after his narrow victory, President John F. Kennedy appointed a committee chaired by MIT's Jerome B. Wiesner to review the country's space program. The Wiesner Committee included among its nine distinguished members Trevor Gardner, the dynamic force behind the Air Force Atlas ICBM program. While serving on the Wiesner Committee, Gardner also accepted an invitation from General Schriever to chair his own committee. Schriever hoped that Gardner would be able to produce a von Neumann-type of report that would lead to a "comprehensive, dynamic Air Force space development program" along the lines of the crash ICBM effort of a few years before.[22]

The Wiesner Report, meanwhile, issued on January 10, 1961, criticized the organization and management of NASA and what it termed a "fractionated military space program." It recommended the Air Force be made responsible for all military space development. Already providing ninety percent of the support

and resources for other military agencies, the Air Force, said the report's authors, represented the nation's "principal resource for the development and operation of future space systems, except those of a purely scientific nature assigned by law to NASA." Their recommendations also included more emphasis on booster development, manned space activities, and military applications in space.[23]

In fact, the President already had agreed to a new DOD directive that refocused military space efforts and named the Air Force the executive agent for the military space defense support missions. Shortly after taking office, Secretary of Defense Robert McNamara directed his staff to review the military space program in light of the Wiesner Report and reassignment of the space reconnaissance program. In a directive issued in March, the Defense Secretary decided to centralize the communication, navigation, and missile early warning military space systems within DOD by assigning "space development programs and projects to the Department of the Air Force, except under unusual circumstances." Air Force enthusiasm remained tempered by other parts of the directive that authorized each service to conduct preliminary research and that promised to assign control of operational space systems on a project-by-project basis. Nevertheless, by gaining responsibility for the development of military space systems, the Air Force had secured an advantageous position in its quest to control military space missions.[24]

The Defense Department's decision had been dependent on the Air Force getting its own house in order. On 17 March General White announced a major reorganization to better manage the missile and military space programs. The centerpiece of the Air Force reorganization of the spring of 1961 involved creation of the Air Force Systems Command, with responsibility for all development and acquisition of aerospace and missile systems. One of its four subordinate organizations would be a new Space Systems Division. No longer combined with missile responsibilities, space development received its own organization to better prepare the service for the expanded space role it expected to acquire. Gen. Bernard Schriever became the first AFSC commander upon promotion to four-star rank.[25]

Three days after the public announcement of the Air Force reorganization, on March 20, 1961, Trevor Gardner submitted his committee's report to General Schriever. This report concluded that the United States could not overtake the Soviet Union in space achievements for another three to five years without increasing significantly the Defense Department's space effort. It called for proscribing detailed space requirements and operational systems. Instead, he affirmed, the Air Force should lead the space community by developing new technology, with DOD and NASA focusing on fundamental "building blocks." Like the Wiesner Report, the Gardner study also called for military participation in a comprehensive, lunar landing program that would send astronauts to the moon and return them sometime between 1967 and 1970. The broad technolog-

ical capabilities resulting from such a major national effort, the report predicted, would provide important "fallout" for both military and civilian space purposes.[26]

The Gardner Report, and the flight on April 12, 1961, of Soviet cosmonaut Yuri Gagarin, who became the first man to orbit the Earth, prompted Pentagon and Air Force officials to revisit the national space program. This assessment, directed by the Air Force, also confirmed the conclusions reached by Trevor Gardner's committee and called for a large booster development program and a national lunar landing initiative. Although the Air Force recognized that NASA would head the expedition, it looked forward to a close, cooperative effort that would enable it to reenter the field of super booster research that had been a NASA preserve since October 1959.[27]

These recommendations ultimately became incorporated into the National Space Program announced by President Kennedy in May 1961. Shortly after receiving them, McNamara and newly appointed NASA Administrator James E. Webb proposed major initiatives and budget increases necessary to amend the Eisenhower space program and "establish . . . an 'Integrated National Space Program.'" Although the lunar landing objective topped their list of new space programs, they also called for developing global space communications and meteorological networks and large boosters for both civilian and military use. The Air Force expected to be in the forefront of these developments in the years ahead.[28]

VIII

Looking back on the critical years of the Eisenhower presidency, at the time of Sputnik, the Air Force appeared the least likely service to gain the military space mission. In the spring of 1961 it had acquired the development role for military space. Efforts to create a unified command for military space had been thwarted. Along the way the Air Force prepared for the space mission by establishing itself as the military service best able to support the "space for peace" policy it often found too constrictive. Its missile, booster, and satellite programs provided a dominant technological advantage in the race for space among the services, while creation of Air Force Systems Command and the Aerospace Corporation focused on the continued central role of space research and development.

To be sure, Air Force leaders would have preferred an expanded, Air Force-led space program that pointed toward space "supremacy," one that would deny space offensive operations to potential enemies. This the Eisenhower Administration categorically refused to permit. Prevented after Sputnik from leading a nation-wide space effort to overtake the Soviets, it found itself responding to ARPA's direction, then competing with NASA for funds and programs. Only with the demise of ARPA as an operational entity in late 1959 did the Air Force

regain its "own" space program. Even then the future course with NASA and DDR&E seemed unclear, while key programs continued to experience growing pains. Moreover, much of the Air Force space responsibility involved providing booster and infrastructure support to other agencies and offices, organizations which retained operational direction of communications, navigation, weather, and ultimately reconnaissance satellite programs. This did not always seem to reflect the aspirations of the service that had been assigned, in the words of General Schriever, the "prime responsibility for the military space mission."

Critics bemoaned the fragmented nature of military space organization and responsibilities that developed in the Eisenhower era. In the future General Schriever and other Air Force leaders would attempt to have the Air Force assume ARPA's potential role to become the sole military space agency equivalent to NASA on the civilian side. The Defense Department would disagree, choosing instead to pursue a policy of tri-service management of space development in the name of cost-effectiveness and service cooperation. Although the Air Force had achieved the dominant military space role through its authority to develop and launch military space systems and provide support to NASA, its more ambitious agenda would remain unrealized. Consequently, the Air Force's research and development organizations would exercise operational responsibility for the majority of space programs and systems for the Air Force and other agencies. This set the stage for intra- and inter-service tension over space roles and missions that would occur in future. Within the service, equally formidable roadblocks would have to be overcome before space could be institutionalized in the Air Force and be assigned to operating commands rather than the research and development community.

Above all, Air Force leaders remained convinced that space had to be approached in terms of its utility for traditional military operations. This would be an important legacy in the years to come, when space was recognized as an increasingly vital medium for supporting both strategic and tactical operations. By the spring of 1961, however, the Air Force had garnered the development role for military space missions. The challenge ahead would be to develop a military space program vital to the nation's defenses and provide for it a position in its own ranks equal to aviation.



Lt. Gen. John G. Albert, USAF (Ret.), graduated from West Point in 1949 and earned an M.S. in aeronautical engineering at the University of Michigan. Commissioned in the Air Force, he began a career in guided missiles and space. At the Air Force Ballistic Missile Division in Los Angeles, he served successively as a project officer on the Atlas ICBM, helped develop an operational communications satellite, and directed the Ranger and Mariner launch vehicle programs. In July 1963, he was assigned to Cape Kennedy, where he directed launches of the highly successful Gemini program. In August 1968, General Albert was assigned to Headquarters USAF, where he served in various policy posts until August 1970, when he became the Director of Space. In July 1972, he returned to Los Angeles as Deputy for Space Defense Systems; then became Commandant, Defense Systems Management College, at Ft. Belvoir; and Commander, Air Force Acquisition Logistics Division.

Balancing Technology and Reliability in the Early Space Program

Lt. Gen. John G. Albert, USAF (Ret.)

My subject concerns balancing reliability with advancements in technology during the early space program. No one here today has greater regard for advancements in technology than do I. What has happened over the last thirty to forty years in electronics approaches the unbelievable. In 1950 I studied wire-connected vacuum tubes at the University of Michigan, which, with the advent of the transistor, became obsolete very soon after. Then the silicon chip appeared, and now we talk about microelectronics, microprocessors, and the Pentium chip. Just as there were tremendous strides in electronics, similar strides were made during this same era in rocket and jet turbine engines, reentry techniques, orbital dynamics and control, and in other space-related fields.

General Schriever mentioned that we were able to move out rapidly in space because of advances made during the Air Force ballistic missile program. Talk about risk! Within a few years the USA had to perfect large rocket engines, accurate missile guidance systems, and capabilities for bringing warheads and later the spacecraft back into the Earth's atmosphere at speeds of Mach 25, which generated extremely high temperatures. What the Air Force accomplished in the ballistic missile program represents one of the great fundamental achievements of our age. It certainly made possible our space program.

There was another impetus: we were in a competition with the Russians in space. We wanted to be the first to get something to the moon and to pursue interplanetary exploration. NASA had just been established and its leaders hoped to start out with a bang by doing something important and inspiring for the nation. There was tremendous pressure on everyone to move ahead as quickly as possible.

I

Ranger and Mariner were two of the most significant early programs undertaken by NASA. Both were managed for the space agency by the Jet Propulsion Laboratory, a technical operating organization belonging to the California Institute of Technology. Although the national goal of a manned lunar landing and return had not as yet been enunciated by President John F. Kennedy, there

was great scientific interest in the moon. The Air Force had already tried unsuccessfully to impact the moon with Project Able in the late 1950s.

Ranger would be the first vehicle to land on the moon and send scientific data back to Earth: one of the many experiments on board was a seismometer which would detect moon quakes and thus determine the composition and maybe even the origin of the moon. A significant factor at that time was the avoidance of any contamination of the moon. Therefore, everything on the Ranger spacecraft was to be heat-sterilized; but raising every electronic component to a sufficiently high temperatures to sterilize it was not conducive to high spacecraft reliability. Mariner was the United States' initial program for interplanetary exploration. It was to be a Venus fly-by to determine solar winds and magnetic flux en route, to measure the chemical composition of the surrounding environment and to take temperature readings of the planet itself. Some of the common aspects of Ranger and Mariner were the Deep Space Network that sent commands to the spacecraft and received data from them, the three-axis stabilized spacecraft, a launch vehicle system capable of injecting the spacecraft into a transfer orbit that would result in lunar impact or Venus rendezvous, and a spacecraft with a mid-course correction capability. A major difference was that the moon could be reached in days, while the travel time to Venus was several months, and a flight was possible only every few years when an ideal relationship existed between the orbital positions of the Earth and Venus.

Ranger and Mariner were both intended to be launched by an advanced booster system called Vega, which, for various reasons, was subsequently cancelled. Until its cancellation, spacecraft design and engineering, the array of scientific experiments, power supplies, etc., were all built to be compatible with the Vega capability. The Air Force, meanwhile, had developed an Atlas-Agena launch booster for its classified programs (Discoverer, MIDAS, and SAMOS). the Agena served both as an upper stage rocket and as a stabilized spacecraft integral with the mission payload. The Atlas-Agena A had flown many times; however, the Agena B upper stage, with much greater thrust and impulse capability, was certainly not yet a proven vehicle. It was, however, for Ranger and Mariner the only available and possible game in town.

The Air Force agreed to supply NASA with Atlas-Agena B launch capability and hardware, and interject NASA requirements into the Air Force super secret environment at Lockheed's Missile and Space Company. In 1960 the Air Force assigned me as the service's Ranger/Mariner Program Manager with the responsibility of making the Atlas-Agena B perform the required launches for Ranger and Mariner. This assignment included system engineering and integration, funding, contracts with Convair for Atlas and with Lockheed for the Agena B, accelerated deliveries, and launch scheduling at Cape Canaveral.

Because of weight restrictions, the Ranger (and later the Mariner) project leaders at JPL had to set tremendous constraints on the spacecraft to reduce its

weight to the lowest possible level. By the same token, the Atlas-Agena B launch vehicle also had to be reduced in weight to be able to inject the greatest possible payload into a transfer orbit. This was a give and take tradeoff process for everyone involved for some time. An earlier speaker, Cargill Hall, has written a history of Project Ranger that addresses the difficulties that we encountered.

II

One of our weight reduction decisions, which was made for good reasons, was to jump from vacuum tubes to transistors in electronic systems. But we encountered serious problems in moving ahead so rapidly with the new electronic technology. The Atlas ICBM and the Atlas space launch vehicle both used the General Electric Mod III–A guidance system. The Mod III–A was a vacuum tube-equipped version of the guidance system that had flown many times with high reliability and accurate results. A transistorized version, the Mod III–G, was under development. Because the Mod III–G saved several hundred pounds of weight that could be transferred to the payload, it was decided to use it for Ranger and Mariner instead of the proven Mod III–A. Although a necessary decision, I still have nightmares thinking about the problems we had with the Mod III–G.

The General Electric Mod III guidance system directed the Atlas to fly a prescribed trajectory. It measured velocity via an X-band radar on the ground that interrogated a "pulse beacon" in the launch vehicle. There was also an L-band radar which worked with a "rate beacon" in the launch vehicle. The rate beacon produced a Doppler shift which acted as a vernier and improved accuracy. Initial test data from the transistorized Mod III–G was good and the guidance organization at the Ballistic Missiles Division (BMD), or Space Systems Division (SSD) by that time, was confident that the risk was not high.

At Cape Canaveral prior to launch of the first Ranger, however, the Mod III–G guidance system did not produce the proper signals. During every checkout test, spurious signals would be received. We would get erratic confirmation of SECO (sustainer engine cut-off). I also learned a term that I would prefer to forget: "multi-path." Whenever we became upset because of an improper signal problem, the engineers would say: "Don't worry, it's multi-path." What they meant was that an interaction existed between the guidance system and the gantry, or between the guidance system and cars going by on the road, or between the system and the antennas on the block house. But they were confident that the Mod III–G guidance system would work in flight.

It was a proverbial dart board. The engineers always had a good reason for the signals glitches, none of which were attributed to the transistorized airborne beacons. We changed out components numerous times. The problems persisted. I think that Col. Bob Duffy, chief of the SSD Guidance Division, became

disgusted with me because I was constantly on his back asking why we could not get through a test properly with the Mod III–G. Even he thought that multi-path was the problem and that the system would work properly in flight.

That was not the case. Two spacecraft were launched and failed to accomplish their mission because of Mod III–G system failures. In January 1962, the Ranger III mission nearly ended because the airborne pulse beacon failed. In July of that year, the Mariner I mission failed because of an airborne rate beacon failure. I remember well the outrage of Gen. Howell Estes, who is in the audience today, when I briefed him on the Mariner I failure.

The Ranger III mission that experienced the pulse beacon failure was a partial success. Although the spacecraft did not hit the moon as intended, the Atlas autopilot was accurate enough so that the spacecraft flew past it into deep space. Both deep space command and control capability was tested. Also, many of the scientific experiments successfully gathered data between the Earth and the moon.

In addition to the rate beacon failure on Mariner I, we uncovered a software problem with the guidance equations. In the guidance equations, there was supposed to be a flag designated as a hyphen which would disregard rate data in the event of an airborne beacon failure. Somehow, that hyphen had been left out of the equation, and when the rate beacon failed, search data were transmitted through the ground station and sent to the Atlas's command module. The Atlas launch vehicle tried desperately to follow these incorrect commands and was subsequently destroyed by Range Safety.

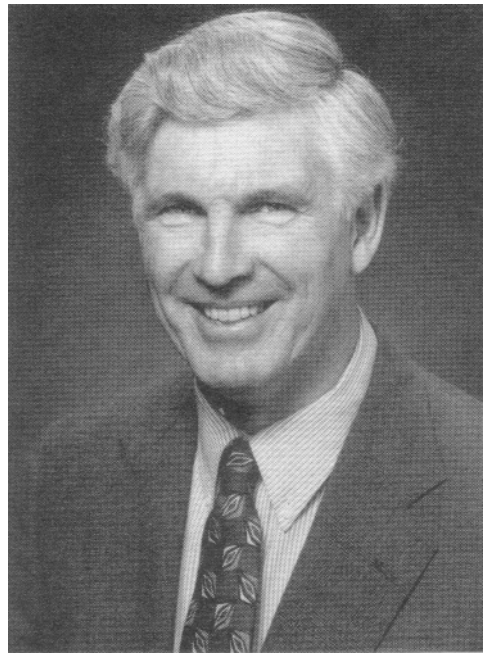
Later, the Mod III–G guidance system was grounded for a year or more, and the circuitry was completely redesigned to be compatible with transistors. Also during this time, qualification testing was completed. One could not simply substitute transistors for vacuum tubes. With the bugs worked out, the Mod III–G became a very effective guidance system and was used successfully in many space programs. In fact, I personally ran into it again in 1965–66 when I was launch director for the Gemini-Titan manned space flight project. The Mod III–G was the guidance system for Titan II and it worked flawlessly for all twelve launches. I do, however, remember one time during prelaunch checkout when we encountered spurious SECO and had to rerun the test several times. "Multi-path" came to mind, but again it was disproved. As I recall, one of the airborne beacons needed to be replaced.

III

The Ranger project manager at JPL was Jim Burke, and his counterpart on Mariner was Jack James. Both of these men were exceptionally competent and highly dedicated. Their tasks were to accomplish the mission, coordinate the scientific experiments, oversee spacecraft development, and provide for the deep space instrumentation ability to send commands and receive the signals

from the spacecraft. The Ranger lunar hard-lander spacecraft ultimately was successful, and later Rangers took television pictures of potential landing sites for Project Apollo. Mariner II, which was launched successfully ten days after the loss of Mariner I, provided tremendous data regarding the solar winds, the ion contours between the Earth and Venus, and the temperature and some of the atmospheric conditions on Venus.

Ultimately, it is people who make things happen. People develop the technology and determine the reliability of subsystems and systems. They make the decisions and provide the dedication, capability, and competence. The necessary decisions to switch to the untried new technologies, coupled with the abilities of the men who solved the problems, certainly led to the accomplishments in our nation's space programs in which we can all take pride.



Dr. Donald R. Baucom is the Ballistic Missile Defense Organization historian. He graduated from the U.S. Air Force Academy in 1962 and received the M.A. and Ph. D. degrees in history, both from the University of Oklahoma. He served twenty-eight years in the Air Force as a commissioned officer. Dr. Baucom served as assistant and associate professor of history at the Air Force Academy, taught history and strategic concepts at the Air War College, and was Director of Research, Airpower Research Institute. He is a past editor of the *Air University Review*, the professional journal of the Air Force. While with the Office of Air Force History, he published numerous articles on military history and various aspects of the military profession, and his book, *The Origins of SDI: 1944–1983* (University Press of Kansas) and earned him the 1994 Leopold Prize in history.

The Formative Years
Technology and America's Cold War Strategy

Donald R. Baucom

"There is an interplay between policy and technology," George Shultz wrote in his 1993 memoir *Turmoil and Triumph*. "Technology can make policy obsolete."[29] While Shultz's observation falls outside the period covered by our panel's papers, his comments go to the very heart of our conference theme, the interaction between technology, policy, and strategy. Moreover, this observation alerts us to the fact that these were "formative years" for more than one reason. Thus, in the process of summarizing this session's papers, I shall emphasize a few points which suggest that America developed an important element of her successful Cold War strategy between 1946 and 1961.

The actual inspiration for our conference theme was a statement by Gen. Bernard Schriever that appeared in the Winter–Spring 1960–61 edition of the *Air University Quarterly Review*:

> It may be said that warfare has acquired a new phase — technological war. In the past, research and development were only preparation for the final and decisive testing of new systems in battle. Today the kind and quality of systems which a nation develops can decide the battle in advance and make the final conflict a mere formality — or can bypass conflict altogether.[30]

This statement places Schriever squarely in a major stream of American strategic thought that stretches backward at least as far as World War II and forward to the end of the Cold War.

I

American military leaders emerged from World War II convinced that superior military technology was crucial, if not the key, to national security. Gens. George Patton, Brehon Somervell, Dwight Eisenhower and Hap Arnold all attested to the fact that military technology had been a major factor in the Second World War.[31]

Not surprisingly, the experience of America's top World War II military

leaders was translated into national policy when Eisenhower became president. In a January 1955 letter to his Secretary of Defense, Charles E. Wilson, Eisenhower wrote:

> Because scientific progress exerts a constantly increasing influence upon the character and conduct of war, and because America's most precious possession is the lives of her citizens, we should base our security upon military formations which make maximum us of science and technology in order to minimize numbers in men.[32]

Eisenhower's pronouncement would seem to represent a prevalent view. Between 1949 when the Soviets exploded their first atomic bomb and 1961 when Systems Command was established, references to the technological competition or war between the United States and the Soviet Union were common in the literature that discussed Air Force research and development. For example, in December 1957, the editors of *Air Force Magazine* wrote an article titled "Organizing for the Technological War." Here one reads the following:

> The world has now entered upon the scientific age, marked by a technological war between the US and the USSR, . . . The race for the conquest of space is today's major engagement in the technological war. And we must win it, for the nation which dominates space will be in a position to dominate the world.[33]

A quarter of a century later, similar sentiments were widespread among those who pushed President Ronald Reagan to launch the Strategic Defense Initiative (SDI). Since the collapse of the Soviet empire, a number of sources have attributed to SDI a significant role in its demise. These include former Prime Minister Margaret Thatcher, former Secretary of Defense Les Aspin, and Senator Sam Nunn. Additionally, a number of Russians, including Soviet dissonant Aleksandr Solzhenitsyn, as well as military and KGB leaders have attested to the role played by SDI in the demise of the Soviet Union.[34] These comments about SDI indicate that the concept of technological war continued to be a dominant theme in American strategic thought throughout the Cold War and supports the view of the editors of *Air Force Magazine* that space was the critical arena in our Cold War competition with the Soviets.

II

The idea that space was the critical battlefield in the Cold War lends a special significance to this year's conference on the Air Force and space operations. The papers of this first session have examined Air Force space activities in the formative years between 1946 and 1961 when the United States was lay-

ing the foundation for a highly successful national space program. My time is limited, so I shall give only a brief overview of each paper and then use selected points from the papers to elaborate on the theme that space technology played a major strategic role in our triumph over the Soviet Union.

General Schriever began our session by giving us a space-age pioneer's insights into some of the key events of the years covered in our session. He stressed General Arnold's seminal role in launching the Air Force into space and highlighted the milestones in the Air Force's march into space. He applauded the efforts of today's young officers to integrate space into our nation's operational military capabilities. His remarks provide an excellent framework for our entire conference.

The next three papers are complementary. Taken together, they re-enforce General Schriever's remarks and offer a coherent picture of Air Force efforts to carve out a role in space between 1946 and 1961. Cargill Hall presented a superb overview of how the American space community emerged and evolved between the end of World War II and 1961 when a DOD Directive designated the Air Force as the lead service for developing military space systems. This period witnessed a dramatic change in the relationships between the members of this community. At first, a spirit of harmony and cooperative camaraderie prevailed. Then, following the 1955 competition to see which agency would develop the first U.S. satellite, the climate in the community degenerated and was thereafter often marred by "open competition" and even "hostile rivalry."

Toward the end of his paper, Hall mentioned the cooperative strategy the Air Force followed in becoming lead service for military space developments. This minor theme in Hall's remarks was the central point of the paper presented by David Spires, who sees the Air Force as already out to dominate the military space arena in 1957, the point at which his paper begins. Spires, like Hall, noted that the Air Force had achieved this goal by 1961, in spite of the emphasis in U.S. policy on non-military uses of space. This thrust in America's space policy forced the Air Force into a low-profile strategy that stressed cooperation, first with ARPA and then with NASA, in order to win the responsibilities it sought.

This cooperative strategy was brought to life for us in General Albert's paper, which draws on his personal experience as the Air Force director of launch vehicles for NASA's Ranger and Mariner program. General Albert described what was entailed in introducing a new technology into the Atlas rocket. Focusing principally upon the transistorizing of the Atlas guidance system, he argued that when technological innovations are introduced into operational systems, the people who manage the process and complete the work are critical. They must see that the introduction of any new technology is carefully controlled so that promised improvements are not undercut by reductions in system reliability that can result from bugs and glitches in new hardware.

From this, it seems clear to me that discipline and meticulous attention to details were hallmarks of the procedures pioneered by people like General

Albert in these early days of the space age. Indeed, these procedures constitute one of the main ingredients of the successful American space program that helped end the Cold War.

Another major characteristic of our space program is its bifurcation into civilian and military components. Both Hall and Spires comment on this division, with Spires noting that this division was generally unrealistic. On this point, Spires seems to echo the views of historian Walter McDougall who has written that the early years of the Cold War were marked by

> the growing realization that the separation of military and civilian activities was increasingly artificial in an age of scientific warfare and total Cold war. Even scientific programs, under a civilian agency, were tools of competition in so far as an image of technical dynamism was as important as actual weapons. The space program was a paramilitary operation in the Cold War, no matter who ran it. All aspects of national activity were becoming increasingly politicized, if not militarized.[35]

Further doubts about the validity of a boundary between civilian and military space programs were raised by Spires and Hall. Both men explained that America's IGY satellite, Vanguard, was a "stalking horse" for the U.S. reconnaissance satellites that were expected to follow. Eisenhower, Killian, and Quarles hoped that the scientific satellites launched during the IGY would establish the principle of freedom of space, conveying the right of unimpeded overflight for all subsequent satellites. Also undermining any separation between civilian and military programs was the widespread service of Air Force officers with NASA, as described by Cargill Hall.

That the Soviets faced the same problem is apparent from the recently published memoirs of Roald Sagdeev, a Russian emigre scientist who now heads the East-West Center for Space Science at the University of Maryland. Here, Sagdeev stated that Soviet launch facilities were operated by the military from the earliest days of the Soviet space program.[36]

To assert that the U.S. and Soviet Union faced the same problem is not to say that we sought similar solutions. America's efforts to achieve the civil-military division seem to have been sincere, driven by those in the Eisenhower administration and in American society who sought to pursue scientific research in space unencumbered by the security restrictions that attend military operations in this realm. On the other hand, Soviet statements about peaceful and scientific uses of space were so duplicitous that they prompted extreme cynicism even within the Soviet space community itself. Again, I turn to Sagdeev for evidence on this point. After describing an event in the Soviet space program that he found particularly revolting, Sagdeev wrote: "Science was only a hostage to high-level politics, of the games played by the government and party leaders in the corridors of power."[37]

In spite of the difficulties posed by two separate space programs, one directed to civilian space science and applications, the other to military space developments and applications, the divided effort paid handsome dividends for the United States. At one point in his paper, Cargill Hall noted that in 1958 President Eisenhower wanted to give responsibility for all satellite development, civilian and military, to ARPA. He was persuaded to propose a separate civilian space agency by James Killian, his science advisor, and others who argued that the U.S. needed a space science and applications program open to the world, without any security restrictions. This led to the legislation that established NASA, and indeed the programs of NASA constituted a part of our space effort that was truly open and visible to the world.

In the transparent realm of its civilian space program, the U.S. demonstrated a national prowess and genius for space technology. This demonstration, underscored by Projects Apollo and Viking, convinced the Soviets of America's technological superiority and demoralized them. Thus, space technology, civil and military, played a key role in our Cold War victory and proved that space was a critical arena in the Cold War, just as the editors of *Air Force Magazine* had proclaimed in 1957.

To support my point about the demoralization of the Soviets by America's space program, I refer once more to Sagdeev. According to him, in 1973, the Soviets were preparing four spacecraft for missions to Mars when they discovered that microchips in all of the craft had become contaminated during the launch preparation process. In spite of this known problem, the Soviets launched all four vehicles toward Mars with predictable results: two missed Mars altogether, one was destroyed in trying to land on Mars, and the fourth was largely debilitated. Sagdeev called this episode "the single biggest disaster in the Soviet space program." [38]

This spectacular Soviet failure contrasted sharply with the smashing success of America's Viking program, which placed two landers on Mars in 1976. Sagdeev said that Soviet scientists were very impressed by the "overwhelming" success of the Viking and "envied" their American counterparts. America's highly successful space program, Sagdeev said, "created in us a kind of inferiority complex." [39] Was it not reasonable for the Soviets to believe that a technology base that could produce a Viking could also produce highly reliable ICBMs and effective space-based missile interceptors like Brilliant Pebbles?

III

I believe it was an important strategic insight for America's leaders to perceive that the Cold War was, at its heart, a technological war between the superpowers. And if the Cold War was principally a technological war, for thirty-five years space technology was at the cutting edge of "combat."

I expect our conference will help illuminate an important facet of America's

Cold War strategy and contribute to a better understanding of the West's victory in its prolonged conflict with Communism. Viewed from the macro-level, it seems to me that this strategy was a thorough-going success. In forty-five years of the Cold War, fewer than 150,000 Americans died in combat. Yet, we defeated a powerful enemy that had inflicted 3.5 million battle deaths on the Germans between June 1941 and May 1945. Furthermore, our victory was even cheap for our Soviet opponents who had lost around twenty-five million people in the Great Patriotic War.

Finally, I would like to end where I began. When the Cold War started in the wake of World War II, one could scarcely have imagined that the decisive theater in this conflict would be space. Nevertheless, by 1961 at the end of "the formative years," space technology had opened up an entirely new domain for military activities. This technological revolution was as significant as that produced by the application of the airplane to warfare and confirms the statement by Secretary of State George Shultz with which I began my remarks. Technology, indeed, "can make policy obsolete."

Part II

Mission Development and Exploitation Since 1961



Maj. Gen. David D. Bradburn, USAF (Ret.), graduated from West Point and holds advanced degrees from Purdue and George Washington University. He was a pilot in Korea, with fifty missions, before switching to R&D in the early 1950s. In 1957, he was assigned to the first USAF satellite project, WS–117L. He subsequently held positions of increasing responsibility in USAF space programs, including Director of Space Systems in Washington and Director of the Office of Special Projects in Los Angeles. Since retiring in 1976, he has served as the JCS representative and member of the American delegation to the U.S.-Soviet ABM Talks and TRW's Director of Engineering. A conceptual planner and a pioneer in the military applications of space vehicles, he is also a member of the Daedalians.

Evolution of Military Space Systems

Maj. Gen. David D. Bradburn, USAF (Ret.)

It is a pleasure to join old friends and perhaps shed some light on the times that we lived through and events in which we participated. The scientific basis for the Air Force's leadership in space began with the Project RAND satellite report of 1946, prepared for Maj. Gen. Curtis E. LeMay, then Army Air Forces Deputy Chief of Air Staff for Research and Development (DC/AS for R&D). Another RAND satellite report, called Feed Back, was published in 1954. It described a reconnaissance satellite in considerable detail and affirmed that it could be built and that it would prove to be an exceptionally useful collector of intelligence.

I

For me, the space business began in the spring of 1957 when I reported, as a young captain, to the WS–117L Project Office in Gen. Bernard A. Schriever's Western Development Division (WDD) in Los Angeles, California. WS–117L was the Air Force's Advanced Reconnaissance System, a comprehensive satellite project based on RAND's studies and on other work undertaken by the Air Force. In those days you could say the effort involved reconnaissance, but you could not say it was a satellite. Later, the rule tended to be that you could say it was a satellite, but you could not say that it involved reconnaissance.

WS–117L plans called for equipping the Strategic Air Command (SAC) with reconnaissance satellites in the early 1960s, launched from Vandenberg Air Force Base, California. WS–117L plans also included a continuing program of R&D satellite launches. By 1957 Lockheed had been selected as the prime contractor, but the project moved ahead slowly for a lack of money. Then, in October, the Soviet Sputnik went into orbit and suddenly there was money all around. From the WS–117L work came the Lockheed Agena satellite vehicle — comprised of Subsystems A, B, C, and D. Various payloads were identified as other alphabetic subsystems. The Agena used the Bell rocket engine, first designed for the detachable pod for the B–58 bomber, and it became a mainstay of the U.S. space program. The Agena, launched more than 300 times over the next twenty years, served either as an upper stage booster or, in addition, as the orbiting satellite vehicle.

II

The first launch which I directed was Thor/Agena 2355, launched from Vandenberg AFB on December 21, 1964. Walt Carrier and Pat Mulcaire were the main Lockheed people on the scene. Our communications link across the country to the operations team in Washington, D.C. used state-of-the-art technology, TWX — teletype to you younger folks. At 0745 hours the range safety officer said, "A passenger train will enter the Base danger area at 0755 and won't clear until your window is closed at 0830. Do you want to go early?" I thought about our calculations of thermal constraints during ascent and decided not to launch before the time planned, at 0800. I told the launch team to hold at T minus 30 seconds and wait. At 0750 I sent the message, "Holding for train." At the opening of the window at 0800, the range safety officer said, "The train has stopped outside the Danger Zone. The Range is clear." I replied, "pick up the count," and thirty seconds later the people back East got another message: "Liftoff." We had stayed with our good, conservative plan and had not suffered from "go-itis," but, in Washington, the entire story was told by those two messages: "Holding for train" and "Liftoff."

We did not shoot over the train, but everybody in the Pentagon thought we had. Years later I heard that a lot of yelling went on in the center there, and somebody exclaimed, "Dave shot it right over that train! I knew he would, the little . . . expletive." Well, we flew up to the Air Force Satellite Control Facility (SCF) in Sunnyvale later in the day and heard good news. The message said: "PAC Room reports Code 3," which meant the payload was working right, as reported from the tracking station at New Boston, or "Boss." Four days later it was over, a perfect mission from start to finish.

III

The chain of command for acquisition of the launch vehicles, the conduct of launches, and operation of the SCF tracking network, ran through the Air Force Systems Command (AFSC). Operational commands took over once a satellite was in orbit, as, for example, in the case of the Defense Support Program (DSP) early warning satellites and the Defense Meteorological Satellite Program (DMSP) vehicles. This proved a good arrangement for that period. Special credit goes to General Schriever who invented AFSC and made the entire operation work much better than an earlier arrangement, which had split the acquisition responsibility for air and space systems between Air Matériel Command and the Air Research and Development Command, AFSC, established in 1961, was a great tool for the space business and has a proud history.

WS-117L also had a tracking, command, and communications network called Subsystem H, designed for operation with low-orbiting satellites. Subsystem H evolved into the Sunnyvale Satellite Control Facility and the array of

tracking stations around the Earth that we now know as the SCF. This facility just celebrated its thirty-fifth anniversary in Sunnyvale, and had some old-timers there including myself and Gen. Bill King. Under WS–117L there were many classified payloads, some of which were cancelled, while others continued under tighter security classification. One of the most successful over the long run, was Subsystem G, the missile early warning infrared (IR) payload. Known as the Missile Defense Alarm System (MIDAS) during development, by 1970, after several generations, it became the highly important and successful geosynchronous infrared early warning satellite termed the Defense Support Program.

IV

As an Air Force project manager in the 1960s and 1970s, I served in an organization that developed satellite technology and deliberately put it into operation as soon as it could be made to work. This was the pattern on the CORONA Project, which was recently declassified. Management decisions were based on immediate feedback from satellites operating in orbit and the findings were applied to the spacecraft in the factory. This tight loop allowed us to go through a generation of design every year or so, making design changes either in response to technical problems or because of what we learned from the mission itself. Management of the arrangement depended upon a very short and direct chain of command, and upon a highly motivated and competent contractor team; Lockheed and the Lockheed associates and subcontractors are the best example with which I am acquainted. In this particular arrangement, the Air Force project team always remained small and never consisted of more than five-to-ten people. Everyone worked hard. Project officers took personal pleasure in their efforts on space missions, because the results were quickly observable.

Contract incentives keyed to performance of the satellites in orbit helped motivate the contractor team. Under these incentives, if the flight was successful, a high fee of about 15 percent of the negotiated cost of the contract would be paid. If the flight proved less than successful, the fee would be reduced accordingly. These were cost-type incentive contracts, with incremental funding from year to year. This proved a good method of motivation and of approach. It allowed the project officer to operate like the leader of a task force, responsible for setting goals, supervising development, providing leadership, and motivating the whole contractor and government team.

V

All Air Force satellite projects at all levels of security classification, starting in 1960 and up through 1990, were under central management in a way,

because all channels led to the Secretary of the Air Force. These projects made an effective set. For example, DMSP weather satellites flew in orbits that were timed to provide weather data during the daylight hours so that classified satellites could have the latest predictions to use in their mission programming. This greatly improved the "batting average" of the film-limited collection systems. Also, the space-based infrared DSP missile early warning system added a crucial alert element — that is, a separate phenomenology from the Earth-based early warning radars — to our missile forces, which helped to discourage surprise attack.

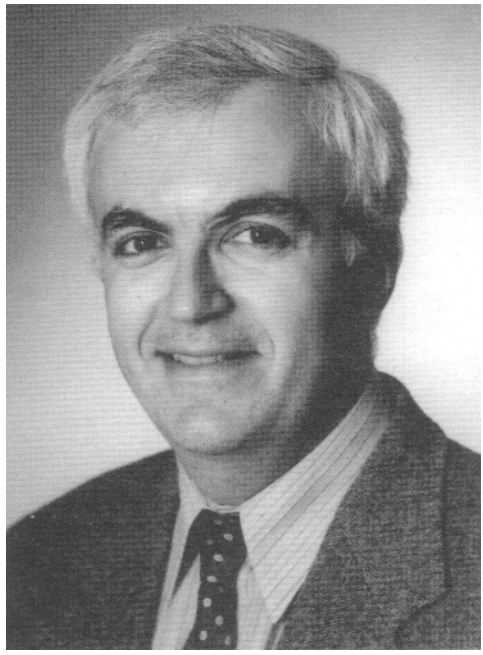
I believe that the requirements process worked very well, with the Secretary of the Air Force at the center of it. There are architectural issues coming up now which were handled in the 1960s and 1970s, and even later, by an engineering-trained Secretary of the Air Force, as John McLucas will agree. Apparently I was promoted to general officer and eventually Director, Office of Special Projects (SP), because everybody thought I had shot over that train back in 1964.

During my tour as Director, from 1973 to 1975, relations with SCF were always good. The SCF commanders and the control teams at the ground station sites and at Sunnyvale were supportive of the SP mission and really competent. The SP Director was allowed to choose the SCF Commander, which was a general officer's billet. Many good men served in this job including Bill King, later an SP Director, Lew Norman, John Schmitt, and John Browning. The Director of SP also served as the Deputy Commander of Space Division for Space Operations and had a "chop" on the SCF budget. These tools really made it easy for the SP Director to get things done.

The biggest space operation with the SCF during my tour occurred when we sought to fly one of our birds outside of its design limits to help NASA with the Skylab manned mission. Rich Gray, Bill Sampson, and Lee Roberts were there. After the risks were made known — and they were considerable — our contractor teams all lined up and said they would waive their right to protest under the incentive provisions. John McLucas, the Secretary of the Air Force, secured the approvals needed and allowed us to go ahead. Then the whole exercise went off beautifully. With the help of Myron Krueger of NASA and many others, we helped the Skylab crew overcome a serious technical problem and produce a most successful mission. This illustrates how the SP Director, the contractors, and his SCF team could improvise when the occasion called for it. The unmanned world sent a salute to the manned world. Again, you could take pleasure in the efforts that produced these kinds of results.

The decision to keep our space projects on the R&D track and thus to make fast changes from generation to generation was a significant one. I think it gave us a lead over the Soviet Union. It is even possible that their space program, with many launches but with little technical progress, resulted from a decision on their side to standardize equipment, which left them behind technically. Had we standardized sooner, would we have been left behind?

Today, it is a good idea to have the Air Force Space Command in the requirements loop. You must remember, however, that we had many generations of satellites per project officer's career in those early days. In the new era, in which space systems are more standardized, we most likely will see many generations of project officers per satellite system!



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Manned versus Unmanned Space Systems

Adam L. Gruen

Gertrude Stein once wrote: "If you have anything important to say, for God's sake, say it at the beginning." Therefore, let me begin with my conclusion: In judging manned versus unmanned space systems, you first have to understand what it is you want to do. Second, you have to decide if that "it" is worth doing. Only then can you sit down and say, "How do I get where I want to go?" In sum, a military or a civil planner should not ask what kind of systems can be constructed in space. Rather, he should ask what can the space systems achieve on Earth.

I

When we talk about any system, by definition, a human will be "in the loop." Therefore, in defining of any space system, one must establish where the humans are physically located. Once located, what they are supposed to do and how will they interact with the machines? Let me provide a few examples.

If there are humans on Earth communicating with machinery in space, then what you have is called generically an *unmanned space system*. If the artifact, that is, the physical object in space, is pretty much passive, we call it an *orbital satellite*. If it can change orbits on command and do lots of other "nifty" things, we can call it an *unmanned spacecraft*.

If the artifact has the potential to support humans in space, however, we call it a *manned space system*. The term "support" is loosely defined — I am not necessarily talking about an environment that is Earth-like with 14.7 pounds per square inch (psi) and a 20 to 80 percent oxygen to nitrogen atmosphere, radiation shielding, a coffee pot, and a working porcelain toilet. Generally, if any aspect of the artifact is designed to accommodate humans within an enclosed, pressurized volume, it graduates into what can be called a *manned space platform* or a *manned spacecraft*. The distinction depends on whether it stays in orbit or not. For example, the Space Shuttle is a manned spacecraft because it comes back to Earth.

Finally, if the artifact is designed for local human operator control, in which the direct, real-time physical presence of the human is integral to the operation of the machine over a prolonged period, then we call it a *manned space station*.

If a space station has humans inside of it at all times, we can call that a *permanently manned space station.*

II

Back in the early 1920s, when the concepts of spacecraft and space stations were first fleshed out by a group of visionaries and rocket enthusiasts, the idea that a spacecraft could function robotically, without human presence was not seriously considered. That was, after all, an era in which the wireless telegraph and the radiotelephone or two-way radio were brand new technologies; the gyrocompass and automated feedback control were experimental; the entire electronics industry was still in its infancy; and the word "robot" was invented for the first time. Even aircraft were being designed for active pilot control.

But future trends were already evident. Unmanned flying bombs had already been invented, and more and more aircraft designers were trying to figure out ways to make airplanes inherently stable, so that a pilot could do something other than spend all of his or her time in the cockpit attending to the flying.

Spacecraft theorists also addressed this issue. Since the point of a spacecraft or space station was to have a human up there observing the Earth or the stars, or engaging in physics and chemistry experiments, or communicating with ground stations, one needed to design a spacecraft that was highly automated, so that the human would not spend all his or her time flying it.[40]

By the beginning of the Space Age in 1957, automation technology had improved to the point that the aerospace industry could begin to do cost-benefit analysis on the physical presence of humans in a craft. On the threshold of manned space flight, at a 1960 symposium sponsored by the RAND Corporation and NASA, two engineers from the Martin Company in Baltimore, M. A. Grodsky and R. D. Sorkin, wrote a brilliant paper on that very point. After weighing the pros and cons, they settled on the notion that you wanted humans on board a space station because a human being was the ultimate system component — lightweight, reprogramable, and already designed and tested.[41]

Before I explain, let that argument sink in for a moment. In 1920, we wanted automation to help humans to "do their thing." By 1960, we needed humans to help machinery do its thing. Grodsky and Sorkin argued that the human being was essential to keep down the weight of the craft. If a human could make repairs, then you would not need to carry spares, or design the craft with redundant components. Of course, the weight saved had to be balanced against life support components and the mass of consumables such as food, air, and water that a human would need. Still, these engineers ran the numbers and concluded that having a full-time repairman on-site was a net plus.

More important, they argued, it was very expensive to design a machine to do more than one task. You needed to radio-communicate with the machine to reprogram it, so there was a technical limit on when and how fast you could

secure reprogramming. In contrast, having a human brain up there meant you could switch tasks in real-time. That brain could figure out the reprogramming and just do it.

Best of all, the human brain could adapt to unexpected and unforeseen circumstances virtually in real-time, with or without help from the ground. Therefore, it was not necessary to design a craft to cover every contingency or mission, or to spend years down on Earth programming for specific circumstances.

III

All of this highly technical argument was based on measurable criteria of mass-to-volume ratios, design and construction costs, and limiting factors such as microprocessor speed and baud rates. Arguments based on technical factors can quickly erode like sand castles on the beach. As technology improves, capability increases and limiting factors of one moment cease to limit in another moment. Perhaps you figure out how to reprogram the machine faster, or perhaps you invent a new lightweight component so that redundancy is not such a big problem.

The advance of technology is important to understanding a big difference between civilian and military paradigms on what to do with humans in space. For the most part, civilian space systems have been defined in terms of what they are, while military space systems have been defined in terms of what they do.

To put that another way, NASA was created in the aftermath of Sputnik as a research and development agency and with a charter that included manned space flight. As the "space race" intensified, NASA officials focused on creating technology that could place humans into space. Once it got the humans into space, they hoped to do useful things with them. The U.S. Air Force wanted to do militarily useful things in space. The question was whether humans in space were necessary to do them. For a while, these two roads were the same and the two institutions traveled down them together. In the end, however, the two roads would diverge.

IV

The earliest U.S. Air Force feasibility studies of a military space station program go back to 1960. At that time the Air Force conceived a two-phase program, consisting of a Military Test Space Station, to be launched prior to 1965, and an "advanced" type to be launched prior to 1970.[42] Why break it up into two distinct projects? In 1960, no one had any real clue about the space environment and how it would affect humans. Microgravity — what was then called Zero-Gee for more than thirty seconds — was a mystery. Radiation was a mystery. Whether humans could stand the G-forces of re-entry was a mystery.

The objective of a Test Space Station, which was later renamed the Manned Orbiting Laboratory (MOL), was self explanatory: to find out more about how humans worked in space. That still left the nagging question of missions and doctrine for an operational manned station weapons space system. Quite simply, what were humans supposed to do stationed in Earth orbit, assuming that they could survive?

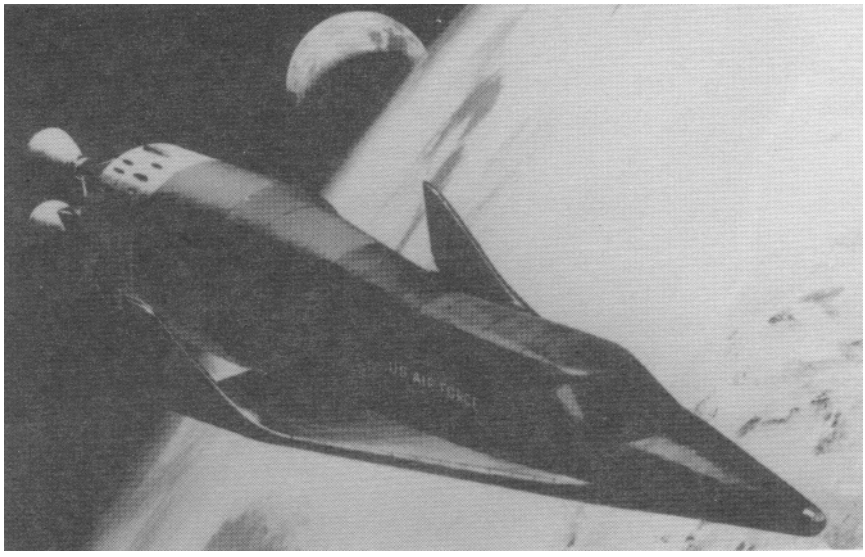
The general idea was to extend traditional Air Force missions into space: surveillance and reconnaissance; interception; bombardment; and command, control, and communications (C^3). Of these general categories, interception and bombardment were better suited to an object that could easily change orbits, namely a space plane. Originally, interception referred to satellite interception. Once you start thinking along these lines, however, a whole range of tactical space missions opens up; for example, inspection of enemy assets in space, destruction of those assets, repair or defense of your own assets, and combat space patrol to intercept enemy interceptors. It gets pretty complicated and presumably would follow the evolution of aerial warfare in the twentieth century.[43]

To do any, or possibly all, of these missions in 1957, the Air Force began a project for a single-seat space plane called ROBO (for rocket-bomber), later labeled the Dynamic Soaring spacecraft, or simply Dyna-Soar, and finally to be identified as the X–20. It would be the first and last time any Air Force project ever was deliberately called "Dyna-Soar."

The great undoing of the space plane concept was that the Department of Defense had no real desire to open up a whole new battlefield. The Dyna-Soar project was strangled precisely because the Kennedy administration did not want to extend the arms race into outer space, especially because that might threaten the reconnaissance satellites upon which the nation now depended. The key was the principle of unrestricted overflight in space, or "freedom of space." U.S. political leaders were not particularly concerned with Russian spy satellites, they just wanted to avoid giving the Soviet Union an excuse for intercepting U.S. spy satellites.

In short, the X–20 was judged as potentially a destabilizing weapon system. If we had one, the Soviets would want one, and that could hurt us a lot more than it would hurt them. So that knocked orbital bombardment and interception out of the picture as strategic missions, but it still left surveillance and reconnaissance and C^3 — cameras and radio equipment in space, to be blunt. Whether humans, with their brains and their eyeballs, were needed, nobody knew. But the Air Force wanted to find out.

In the period from 1960 to 1964 two agencies sought the same thing. NASA and the Air Force wanted to construct a MOL for the purpose of testing the space environment. In 1961 NASA Administrator James Webb and Secretary of Defense Robert S. McNamara agreed that neither would try to develop one without agreement from the other. They reaffirmed their agreement in 1963.[44]



Artist's depiction of the Dyna-Soar in orbit.

Meanwhile, specialists in both organizations rushed to come out with lists of experiments that they wanted to do, which largely determined what a space station would look like and how it would be designed. Not surprisingly, the lists came out looking much the same. Aerospace contractors were naturally delighted to have two potential customers instead of one; indeed, one claimed that the studies it presented to both NASA and the Air Force were really identical, they just had differently colored covers.[45]

V

When the Dyna-Soar project was cancelled in late 1963, it left NASA's plate of manned space flight piled high with the Mercury, Gemini, and Saturn/Apollo programs. Secretary of Defense McNamara already had decided to replace Dyna-Soar with the MOL, and, in an agreement with NASA that limited MOL missions to one month in orbit, he assigned its development to the Air Force. Instead of a space plane, the Air Force was given the go-ahead to modify a two-seat Gemini spacecraft for its own use with MOL, called Gemini B. NASA managers, meanwhile, began to work on ideas for a second generation operational space station.[46]

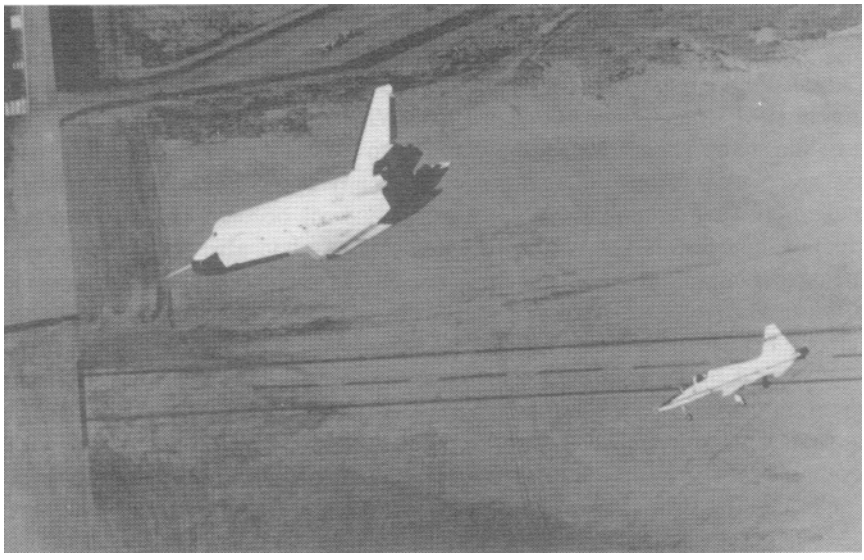
This outcome was exactly the opposite of what one might have rationally predicted. The institution with a vested interest in practical, useful space operations was given the task of developing a technology, while the agency whose mission was to develop technology started thinking about operational space stations.



Artist's depiction of a Gemini B/MOL launch on a Titan IIIC.

At any rate, from 1965 through 1969, the Air Force trained astronauts for the Gemini B and built an MOL prototype that actually got as far as the launch pad, but no further. The Department of Defense cancelled the Gemini B/MOL project in 1969. The total cost to the taxpayers in today's dollars was probably about $5 billion.[47]

Why was it cancelled? The stated reasons were essentially cost and obsolescence. That is ironic in light of the fact that Congress underfunded the project to begin with. The schedule had to be stretched, and as a result, obso-



The shuttle Enterprise on its approach to Edwards AFB, California.

lescence began to seep into the picture. Every year that the Gemini B/MOL project was delayed, NASA's technical experience improved. Also, by 1969, the lunar landing was a success, and there were excess Saturns lying around that could be converted into a bigger, better MOL called Skylab.

The question remains: Was MOL doomed from its inception? Probably. Looking back on it now with the 20/20 historical hindsight, the entire project was an insurance policy. The U.S. had two agencies working on the problem of man-in-space on twin tracks in case one derailed. The cancellation of the MOL project actually changed nothing from the strategic point of view. The missions of reconnaissance and surveillance and C^3 remained. It was just that the Air Force had no choice but to pursue them with robotic equipment until such time as NASA proved that humans could live, prosper, and accomplish useful assignments in Earth orbit.

In the 1970s, therefore, the Air Force struggled not so much with NASA as with others interested in those same strategic missions, such as, the other armed services, the Central Intelligence Agency (CIA), and the National Reconnaissance Office (NRO). Compared with those heavy-hitters, NASA actually could be considered a friend. More than once the Air Force dug deeply into its budget to help NASA finish the Space Shuttle program.

VI

After the first successful Space Shuttle flight in 1981, NASA immediately brought up the subject of an operational space station. NASA Administrator

Nathan M. Beggs sought out the Department of Defense as a partner for the proposed multi-billion dollar project. To Beggs surprise, Secretary of Defense Caspar Weinberger passed. Why was the DOD cold on an operational space station in 1981 when it wanted one in 1960? What had changed? There are many possible answers. First, technology had improved to the point that the old Grodsky and Sorkin calculations no longer made any sense. Materials, computers, and microwave communications systems had all become lighter, stronger, smaller, and faster. The ability to write software had also improved, which meant that one could actually design some fairly smart machines to do real-time observations. Robotic spacecraft, moreover, were operating reliably on orbit for ten and fifteen years before failing.

Second, the space shuttle system existed, so the Air Force did have a means to test humans in space for up to ten days. In that period of time, you could test most of what you needed to know about the effective use of human brains and eyeballs. Furthermore, with the Space Shuttle, you could retrieve and repair some satellites from low Earth orbit. The Strategic Defense Initiative (SDI) had not been announced yet, but it was clear to Air Force planners that an orbiter could be used to test new techniques and materials in support of the SDI.

Naturally, Secretary Weinberger was very concerned that the Space Shuttle fleet would be available and robust. He believed that the budget for man-in-space was zero-sum. If one spent more for a space station, he argued, you would spend less on Space Shuttles. Therefore, Weinberger may have opposed the space station because he thought it would hurt, not help, military man-in-space efforts. However, perhaps the simplest explanation is that the Department of Defense could not identify a manned mission that made any sense. Here I quote from a 1983 report to the White House:

> Studies to date have identified no unique cost effective contributions that man-in-the-loop can make to the execution of military missions such as surveillance, navigation and communications. Further considering the cost of developing and procuring one or more space stations and the difficulty in making a space station survivable, questions are raised concerning the reliance that could be placed on the availability of a space station in conflict.[48]

If today there is an Air Force colonel somewhere deep in the bowels of the Pentagon with the job of defining military missions for physical human presence on board a spacecraft, then I do not envy him the assignment. We are fast reaching the point where on Earth we barely even need humans flying weapon systems in the combat zone at all. Cruise missiles and remotely controlled drones increasingly are the systems of choice. To be sure, this puts a premium on the importance of C^3, because much of this technology can only be effectively controlled by satellites and the Global Positioning System (GPS).

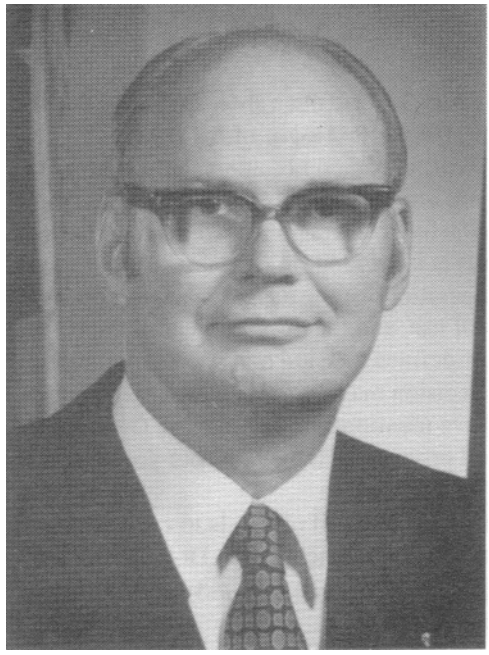
Perhaps there will be a role for humans in space in the twenty-first century. It may not be a very glamorous role, but there might be some logic to it. For example, launching a new space-based asset might take too much time. It might be faster and easier to send a trained mechanic up to repair the damaged one. Who knows? Maybe if we had thousands of satellites in low Earth orbit and enough of them are malfunctioning at any given time, we would want to station someone up there at all times. But with system reliability steadily increasing, we will have to ask the cost-benefit analysts about that one.

VII

The historian Alex Roland once shared with me the definition of a fanatic. It is someone who, having lost sight of his objective, redoubles his efforts. I trust my point is clear: if you do not understand exactly what mission you are to perform, then you are in big trouble. However, that may be a little too simplistic an explanation for how weapons systems are introduced to the battlefield. Historians generally acknowledge that the introduction of new kinds of weapons systems into the operations of the armed services depend on a combination of mission, doctrine of use, and the development of the technology itself.

Without a well-defined mission or doctrine, political and economic factors tend to dominate decision making for new weapon systems. Two excellent examples, which I have mentioned today, are the Dyna-Soar and the MOL. I did not address the SDI program of the 1980s, but you can probably add that to the list, too.

The ultimate lesson from all of this is to concentrate on what you want to achieve and when you need to achieve it. Do not worry about where man will appear in the loop. That will emerge quickly enough if you understand what it is you want to do.



Hon. Dr. John L. McLucas is active on boards of directors of private and pro bono organizations and is a consultant to several similar groups. A frequent speaker on aerospace topics, he is the author of *Space Commerce* (Harvard University Press) and served as Secretary and Undersecretary of the Air Force (1969–1975), where he was also Director, National Reconnaissance Office. He earned a B.S. in physics from Davidson College, an M.S. in physics and mathematics from Tulane University, and the Ph.D. in physics and electrical engineering from Pennsylvania State University. He was a radar officer in the U.S. Naval Reserve and Pennsylvania ANG. He was a member of the Council of the National Academy of Engineering and a member of the Academy Committee on Science and Engineering Public Policy. From 1975–77 he was the FAA Administrator. Earlier, he was Deputy Director of Defense Research & Engineering (1962–64) and served as Assistant Secretary General of NATO for Science from 1964 to 1966.

The U.S. Space Program Since 1961
A Personal Assessment

John L. McLucas

As far as we know, military commanders have always wanted to occupy the high ground. A commander wants to see the area of battle, analyze the situation, assess the forces, and plan the next move. In other words, he wants to see the "big picture." When balloons and then airplanes became available about a century ago, they were quickly adapted for reconnaissance, directing artillery fire, and otherwise helping to see the big picture. When we learned how to go into space, it quickly became the new high ground.

I

Before the Space Age, nobody spent much time worrying about national space policy. But we knew instinctively (and from science fiction) what we would do if we could go into space. Some of the most enduring reasons for using space have been to:

advance foreign policy
enhance national security
expand scientific knowledge
inspire our youth
broaden our vision of life
advance education
maintain a technological/competitive advantage
improve terrestrial services (communications, navigation, weather)
explore the utility of people in space versus robotic activity
promote private sector activity in space
promote commerce (raise exports and improve balance of payments)
exercise world leadership
explore the solar system and the universe

Including all of the reasons which have been made in one policy statement or another would produce a very long list; however, the reasons become more and more repetitive as we add more refinements.

To these generic considerations, national leaders have added specific missions. In 1961, President John F. Kennedy added the Apollo visits to the moon. In 1984, President Ronald Reagan approved the start of Space Station Freedom. The goal of the space station was to provide a permanent human presence in space and promote space exploration. This mission was obviously not totally new but it did make things more explicit.

Why does the military operate in space? Among the major national security activities in space are:

communications, both passive and active
reconnaissance/surveillance
weather observation
navigation
early warning
geodesy/mapping

The list of military missions can grow only slowly because the obvious missions are essentially mature by now, but the picture on the civil side is different as various entrepreneurs come up with new service offerings. Some of them are based on their own assets in space and some are civil uses of military systems like the Global Positioning System (GPS).

To rationalize these space applications, the need for a national space policy was anticipated in 1955 when the Eisenhower Administration was getting ready to approve the Vanguard satellite for the International Geophysical Year (IGY). Opinion was divided whether we required anyone's permission to fly the IGY satellite over other countries. Ike's policy paper of May 1955 preserves the discussion: "Considerable prestige and psychological benefits will accrue to the nation which is first successful in launching a satellite.... A small scientific satellite will provide a test of the principle of 'Freedom of Space.'" The paper went on to state that a small satellite would be no threat to anyone that it overflew, and that even a large satellite could not be used to drop a weapon since anything "dropped" would continue in orbit alongside the satellite.

II

By the end of World War II various technological developments had come into their own. Many strategic thinkers predicted that certain weapons developed near the end of the war would be key to future warfare. It was obvious that the German V–2 ballistic missile, the myriad electronic guidance and control techniques, and the atomic bomb could be the basis for whole new classes of weapons unlike anything in the past. Our mastery of rocketry, inertial platforms, and a thousand electronic devices provided the major weapons in the years following the war up to the present.

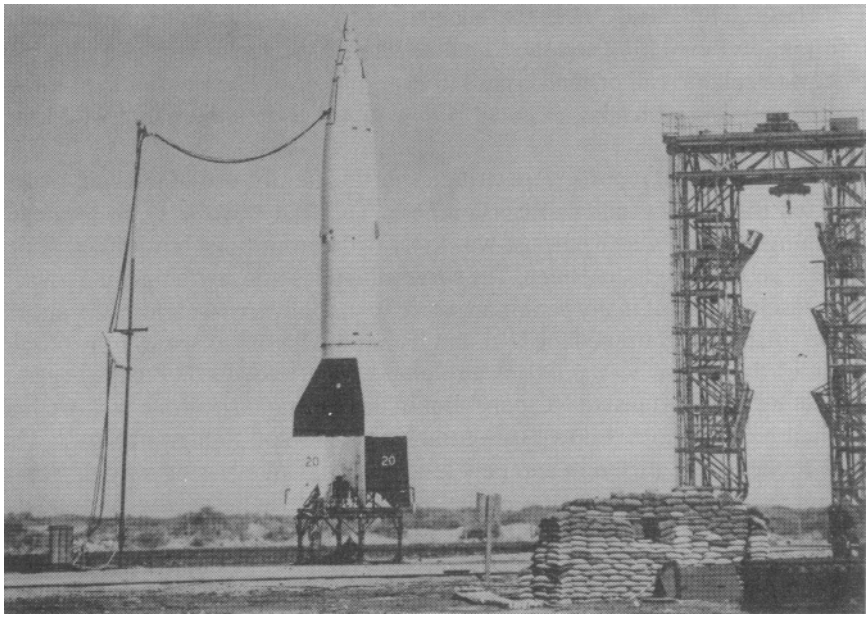
These technical advances also enabled the Space Age, which brought us the Information Revolution and the so-called Global Village, where everyone can place a telephone call or send e-mail to everyone else. The saturation of information and data which has resulted is now giving us heartburn and will do so for a long time.

Two important reports were written shortly after the end of the war, which affected the subject under discussion here. The first was the U. S. Strategic Bombing Survey, whose purpose was to try to determine just how effective the various air campaigns had been. The survey did not settle anything, but it raised the consciousness of many people about weapons delivered over long distances. In the fifties, we examined the V–1 and V–2 robot bombs to see what we could make of them. The V–1 pilotless airplane, with a weapon on board, began a ratcheting-up of offensive weapons. But in the closing days of the war, we had learned how to shoot it down using tracking radar and fighter airplanes. The V–2 rocket was a different and new kind of threat. We had no way to stop it except to attack the launch sites on the continent, defeat the enemy, and end the war. The V–2 would make a huge difference in the offense/defense balance.

The other report I want to cite was a study done at Douglas Aircraft under Army Air Forces sponsorship on what rocketry and science could do if the military were willing to put up satellites. The report was quite prescient and also bullish on the possibilities for doing various militarily useful things in space. A technical team, many of whose members were already well known, and others who would later become well known, performed the study. Their report was written in the Engineering Division of Douglas Aircraft company on an Army Air Forces project. The report, called *Preliminary Design of an Experimental World-Circling Spaceship*, was dated May 2, 1946. Here was an early look into how the military could capitalize on space capabilities organized by a yet-to-be-formed Air Force working through a yet-to-be-formed RAND Corporation, which grew out of the Douglas effort. (I should also mention Vannevar Bush's report, "Science: the Endless Frontier" and Theodore von Kármán's report, "Toward New Horizons," both of which are regarded as seminal works and have probably had even greater influence than the two which I mentioned.)

I must also cite the creation of the United Nations (UN) in this context because the UN soon became involved in space policy through its Committee on the Peaceful Uses of Outer Space. In 1967 the U.S. and dozens of other countries signed the space treaty which acknowledged the principle "freedom of space," prohibited weapons of mass destruction in space, and codified several other important international legal principles that apply to space.

President Dwight D. Eisenhower came into office in 1953 as the American-Russian relationship became increasingly confrontational. The Soviet Union had set up puppet governments in the various Eastern European countries and began isolating them entirely from Western influence. Ike worried about that and about Soviet military developments. The Russians were known to be



Testing a captured V–2 rocket at Holloman AFB, New Mexico.

working hard on missile development and on nuclear weapons. He authorized military "snooper" airplanes to find out all they could and commissioned the development of the U–2 to overfly the Soviet Union. In an unannounced gesture, in 1955 at Geneva, he invited the Russians to engage in an Open Skies aerial reconnaissance program over our territory, while we examined their geography for military systems buildup. Communist Party Chairman Nikita Khrushchev rejected this idea with disdain.

There followed a race to perfect various missiles of battlefield range and some of theater range. While utilizing the reconnaissance capabilities we had, including the U–2, it was obvious that the need for better reconnaissance greatly exceeded our ability to acquire it. Knowing that the U–2 would have a short life as a reconnaissance platform, Ike accepted advice to start a reconnaissance satellite called CORONA, which was based on one element of an Air Force satellite program then underway, called WS–117L.

III

The Air Force had been formed as an independent service in 1947, at which time all three services began building missiles for various scales of hostilities. The Army worked on missile development, especially battlefield weapons and the Navy and the Air Force developed air-to-air and air-to-ground missiles. Eventually, all three services worked on IRBMs, while the Air Force worked on

ICBMs as well. As these weapons' development proceeded, it became more and more obvious that the rockets built for carrying weapons over long ranges could be modified to launch satellites. President Eisenhower oversaw the adjudication of the roles of the services which led to the Army getting out of long range missiles but keeping the anti-ballistic missile (ABM) role, based on its previous IRBM activity. The Army's team of scientists, including Wernher von Braun, was transferred to NASA and became the heart of NASA's space capability.

On the scientific side, various people were looking into how rockets could be used to advance the cause of science. They saw the IGY as a good way to further that cause by operating space satellites. Of course, one of the military departments would have to launch the IGY satellites. This led to much discussion about which service was best qualified. Although the IGY worked out all right, the three military services competed over which one was best prepared to launch satellites. Meanwhile, the Soviets launched Sputnik on October 4, 1957. The Space Age began when it did because technology permitted space flight, and because of the geo-political situation. Much of what happened in those days revolved around a contest of wills between the U.S. and the Soviet Union.

Opening up space was a difficult endeavor in any case, but the political situation which we faced was even more of a challenge. Not only did we want to accomplish various objectives, but we wanted to appear to be a leader — especially after the Russians got into space ahead of us — albeit by only four months. The Russians had the same problem of wanting to appear strong and capable although, having gone into space first, they had some "free rides" with the public while this country sought to catch up.

This situation caused each side to engage in what became the space race. Whatever was done by either side in the space race was done not just for its own scientific or engineering merits, but equally or even more importantly it was done for international prestige — how it would look to the outside world. It became a matter of prestige, pride, and public posturing. The political contest of wills formed the backdrop for all that subsequently happened. All this led to the need for some definitive space policy. President Eisenhower became very personally involved in the first American space policy development.

As I mentioned, the IGY in 1957–1958 provided a strong impetus to the space program. It was an extension of a concept of scientific exploration of geophysical phenomena which had been formalized twice before in an International Polar Year, one held in the late nineteenth century and one during the Great Depression of the thirties. The first was sparked by increasing interest in exploring the Arctic regions and the second by the desire to understand radio propagation when Marconi demonstrated that radio waves could span the oceans. While such a "year" was held every generation or so, in 1957 at the time of IGY, it was obvious that this particular year would permit something totally new — we could do the IGY with sensors of one kind or another positioned in space. As the IGY approached, the space component of the project became one of the main events

rather than just an enabler of it. Dealing with the issue of whether we needed to ask anyone's permission to launch the IGY satellites further demonstrated the need for a comprehensive space policy.

In my view, one of the most significant aspects of initial U.S. space policy is that it justified and established a dual space program. First, there would be an open civil space science and applications program intended to benefit the American people and "all mankind." This led to the need for enabling legislation, which in 1958 caused the creation of NASA to carry out the program. Second, there would be a classified military space applications program designed to take advantage of what space might do to improve our military posture.

In the Soviet Union, on the other hand, only a single program existed and it was run by the military. Note that the U.S. and Soviets started in the same place, with both programs driven by military interests. I credit Mr. Eisenhower with having set forth what has continued to be our policy of the parallel development of civil and military space programs, each drawing heavily from the accomplishments of the other. Some may view that division of effort as "artificial" or counterproductive, but both space programs were meant to draw on the same technology base to the maximum extent possible. And we should not overlook the fact that the military has provided most of the astronauts and that several generals have played key roles in NASA development efforts, notably Gens. Samuel Phillips, James Abrahamson, and Thomas Stafford.

At a USAF space conference, some might argue that we do not need to cover the civil side, but in my view that would totally distort any talk about or understanding of space affairs. Furthermore, I point out that the Russians maintained a unitary approach for decades, an approach in which the military ran the whole show. Everybody knows that it cost them the option of becoming competitive with the West in civil and commercial space systems. As a consequence, they gave up the opportunity of earning hard currency which they certainly could have used to their advantage. It has been only in the last few years that the Russians have had a civil space program, whereas we have had a thriving civil and commercial space program for thirty years and an impressive science program for almost forty years. Our very first satellites discovered the Van Allen Radiation Belt. We ought to remember that President Eisenhower and his advisors did us an incredible favor by their policy actions of forty years ago.

That is point number one, and it goes back to the very beginning of the Space Age. My second point is equally venerable and draws on President Franklin D. Roosevelt's announcement of an unlimited National Emergency on May 27, 1941. In it, he tied the security of the United States to "freedom of the seas." President Eisenhower and each of his successors have stressed the position that we do not need anyone's permission to fly in space; freedom of space is the counterpart of freedom of the seas, just as space law is the counterpart of maritime law. For generations, the ships of seafaring nations have plied

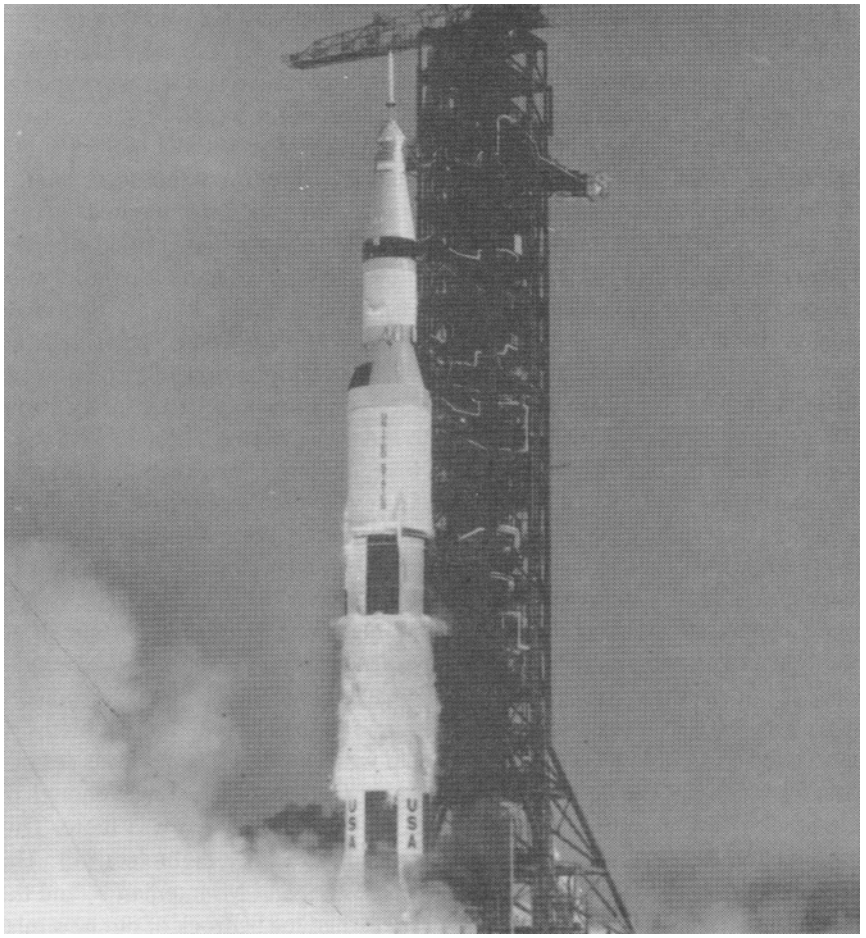
the high seas for commercial and military purposes and the tradition of open access to the world's oceans is so well established that it is considered a strong act of war to interfere with free passage. Since the world is not always totally friendly, we need to maintain the ability to assert our right to operate freely in space. I believe that we can and should do that quietly, without making a big deal out of an anti-satellite (ASAT) program. I will return to that topic later.

When the Russians got into space before us, they suddenly loomed ten feet tall and received credit for having created a missile gap — never mind whether it really existed. The perception of a missile gap caused us to push parallel missile development programs in the Air Force and Navy. Gen. "Bennie" Schriever created the Western Development Division (WDD) in Los Angeles and the work at Wright Field transferred to WDD. People, money, and priority were made available to him. Admiral "Red" Raborn got the same charter for the Navy and set up a "Special Projects Office" to develop Polaris. These efforts went quite well and accomplished the goal of bringing into operation both a reliable land-based and a seagoing missile force. In key areas, where considerable technological uncertainty existed, we pursued parallel paths concurrently until we knew enough to choose a single approach. Over time, we put the missiles in place and gradually improved their reliability and accuracy.

The controversy over the bomber and missile gaps raised the issue of an intelligence gap. Obtaining better reconnaissance and better intelligence became vital. President Eisenhower established what became the National Reconnaissance Office (NRO) to meet this need. Although the NRO had its problems, it succeeded extremely well. The missile gap was found to be much less serious than first thought, but we were uncomfortable until we had searched enough of the Soviet land mass to assure ourselves that we knew what was there. This brought the Russians down in stature from ten to only eight feet tall. The combination of the USAF ICBMs — Atlas, Titan, and Minuteman — and the Fleet Ballistic Missile (FBM) program established the bedrock of our new missile capability and deterrence posture.

IV

As interest in space built up, the Eisenhower era transitioned to the Kennedy era. When Kennedy came into office, many key people on the Eisenhower team were willing to let the Space Age proceed at its own pace. The Democrats, with a more activist role in mind for government, wanted to "get the country moving again." The Kennedy team was partly motivated by political factors and willing to play up perceived shortcomings of the previous administration. But it also saw the Soviet threat as requiring a more aggressive stance on space. For various reasons, the Kennedy team focused on showing that the Russians, though ahead in the space race, did not exceed us in overall technical capability. President Kennedy asked Robert McNamara, Lyndon Johnson, and



Lift off of Apollo 11, which carried the first man to the moon.

James Webb what the U.S. could do that the Russians clearly could not. This led to a speedup of NASA activity and specifically to Kennedy's announcement in May 1961 of the Project Apollo initiative. Support for the NASA Syncom communications satellite was lacking in the Eisenhower years, so the Kennedy team also pushed and got support for that — as well as for a satellite called Relay. Although long-range rockets and communications satellites were not ideas originating with them, the Administration did create something new. It was a commercial communications satellite system based on international treaty, with Comsat Corporation as the U.S. representative, and to which all other countries were invited to join. The INTELSAT consortium thus was formed to operate the communications satellite system, which is still going strong today with 136 member countries.

The Kennedy team was sure that the Project Apollo manned lunar landing was something the Russians could not do. Hence, pursuing it to a successful completion would reestablish U.S. technical superiority. Indeed, Apollo did just what it was supposed to do, and the world applauded. When we landed on the moon in 1969, no one wondered any longer who was ahead in the space race. However, our success in beating the Russians has left us wondering ever since, especially since the Cold War wound down, just how important man-in-space really was then or is today.

Two good reasons have been offered in support of "man-in-space" activities. First, many people believe that without human space flight, the overall interest and support for space programs would greatly diminish. Second, many others also believe that man's desire to explore the universe requires putting people into space.

Meanwhile, NRO's CORONA program gave us the strategic intelligence necessary for high-level policy decisions on how best to proceed vis-a-vis the Soviet threat. We could size and pursue our ICBM and FBM programs with confidence that we were not being hopelessly outdone by the Russians. Because of the NRO's special classified treatment, however, fewer people had access to its products than might have been desirable. So there were both good and bad effects of creating something called the NRO.

Creation of the NRO at the end of Eisenhower's second term established yet a third *de facto* space activity to which various layers of the military had only limited access. It developed a technique of streamlined procurement and program management which was worthwhile in its own right. However, it also divided the military space program, taking a huge bite out of total space activity and shrinking the amount of space work still under normal military development procedures and control. I believe that this arrangement, while accomplishing its main purpose of expediting space intelligence gathering, also "turned off" many senior Air Force leaders from devoting serious thought, time, energy, and effort to what space really could offer the regular Air Force.

The NRO has always been controversial. About two years ago I wrote a paper, "Lessons Learned through Thirty Years of NRO Management." Before writing it, I canvassed several senior Air Force officials to get their views on the advantages and disadvantages of having created the NRO when we did. By and large, they supported the need for the NRO, because something like it would have had to have been invented, but they cited several serious disadvantages that came with its advantages.

Advantages of the NRO

Ability to act and move swiftly

Stable budgets and generally well-managed programs within budgets (smaller cost overruns)

Ability to offset USAF tendency to short-change military space programs in favor of military aviation

Staffing continuity, with good corporate memory

Limited visibility to nay-sayers, thus achieving efficiency

Generally high quality people

Loyalty of staff: many people stayed with the program at the cost of promotions because they possessed authority to act and took pride in the results achieved

Staff included multi-service representation, providing benefits to other services

Some progress on TENCAP (tactical exploitation of national capabilities)

Disadvantages of the NRO

Split military space program when unified program would have been better (conceptually)

Allowed CIA to dominate collection activities including building hardware

Frequently over-classified work, resulting in too limited a distribution of results

Strategic emphasis hamstrung USAF learning about how to apply space assets to tactical needs

Bred jealousy and negative space attitudes in some key USAF people

Some viewed NRO funding as extravagant, with too-easy access to funds

Although there were many good and significant results from creating the NRO, especially in its success at delivering strategic intelligence to its customers, it obviously was not all positive. The pros and cons of NRO management and procurement practices versus standard Air Force practices have not, in my view, ever been properly debated and resolved.

I understand John Deutch had plans to conduct such a review before he changed jobs to head the CIA. It remains to be seen whether he or anyone else will take an initiative to change the NRO. (Recently, the subject has come up in discussions about reorganizing space responsibilities and decisions to create a space architecture, but I know of no pending review.)

Various Air Force projects nonetheless took advantage of our increasing knowledge of space and our increasing ability to operate there. Through essentially normal procedures, the Air Force built the Defense Satellite Communications System (DSCS) family of communications satellites which, although initially fraught with reliability problems, seem now to have operated normally for

about two decades. Also, the missile early warning surveillance system, known as MIDAS, which eventually became the Defense Support Program (DSP), has had a long and successful history. Today, the GPS constellation of navigation satellites is finally operational after twenty years in gestation. Whether we can cite development of the GPS as an example of good management by the Air Force is questionable.

I left government in 1977 and went to COMSAT. I remember several Air Force officers came to see me in the years afterward and they asked how we were able to do so well in commercial satellite communications while they were still bogged down in unacceptable reliability problems and unacceptable cost/schedule overruns. I pointed out that Comsat built things it knew would work because they absolutely had to work for us to earn any money. On the other hand, the Air Force pushed the state of the art to a much greater extent, and this exacted a high price in cost and reliability. The Air Force was determined to do things on a grander scale and to achieve some very desirable technical objectives. The Air Force paid a price for sometimes pushing too far and too fast. I stressed that Comsat's greater success was not surprising under the circumstances and that we were not any smarter, but that innovation is always expensive. Certain Air Force officers were doing a lot of breast beating while paying that high price during the time in question. Incidentally, several of the satellites that Comsat put up in the mid-1970s are still earning money for the corporation, even though they have suffered several partial failures. Some of these remarkably reliable communication satellites will soon celebrate their twentieth anniversary operating in space.

V

Should the military rely only on its own assets in space or should it look more broadly at what is available? In recent discussions with the Secretary and Chief of Staff of the Air Force, we got into the question of military use of civil space assets. The military needs to monitor continuously whether it is taking adequate advantage of the opportunity to acquire services from the civil side. This is another reason why a military audience should be interested in staying abreast of civil activity in space.

The civil space program is divided between what NASA does and what other departments and agencies do. NASA leads in science and R&D, including life support in space for extended periods. NASA also has responsibility for deep space exploration at lunar distances and beyond. Other agencies, including the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), and the Federal Aviation Administration (FAA), have special roles in space.

The normal role of the U.S. Government in civil space science and applications has basically stabilized. NASA is deeply involved in space science, with

its so-called large observatories that orbit the Earth and spacecraft that fly to Venus, Jupiter, and the Sun, as well as to asteroids and other bodies in the solar system. In applications, NASA is still active on the communications research front with the Advanced Communications Technology Satellite (ACTS). NOAA continues in the weather observation business and is responsible for Landsat, although Landsat is operated by a private company.

NASA has the primary role in manned flight. While there is no rule that precludes the military from placing people in space, there is a long-standing reluctance on the part of many to increase the cost of military space operations by using people in space, where robots can do the work as well or even better. But, I may be expressing too personal a view on this matter. Certainly many military people think we have been mistaken not to have had more involvement with military people in space. An attempt at a compromise on this issue can be seen in the continuing use of Air Force and Navy pilots in the astronaut program.

There have been two major programs in which USAF tried to develop a vehicle for manned space flight. The first was Dyna-Soar, the second was the Manned Orbiting Laboratory (MOL). Dyna-Soar was developed in the late 1950s. Boeing was given a contract to develop a kind of one-man glider which would be launched into space on a Titan ICBM booster and would follow a semi-ballistic trajectory before gliding back to Earth. The concept included the possibility of carrying a weapon, but its actual mission was never clear. In the late 1950s the Eisenhower administration took the position of denying approval of weapons in Earth orbit; this further compromised Dyna-Soar's role. Dyna-Soar became a vehicle for testing military subsystems in space. But as the program's cost grew and its mission became more vague, it lost support.

Early in the Kennedy administration, Secretary McNamara redirected the Dyna-Soar Program to that of a hypersonic reentry research vehicle and designated it the X–20. This pointed up even more the program's high cost for a non-operational mission. In 1963 it was cancelled and replaced by the MOL, a cylindrical laboratory that attached to a Gemini two-man spacecraft, capable of a 30-day stay in space. It was billed as a way of testing the potential role of military man in space. MOL had various payloads, but was essentially a manned reconnaissance vehicle with cameras. It gradually evolved to include operating in an almost robotic mode to get the best performance out of the equipment where man was not expected to be able to react fast enough to achieve full system capability.

This program was in full swing when I returned to the Pentagon in 1969. The R&D package had been under development for three or four years at that time and its cost was supposed to have peaked already. But the budget was still growing larger and for the last two or three years, the estimated cost to complete the R&D remained constant. In 1969, the USAF R&D budget was $2.5 billion and MOL accounted for one-quarter of that total. Most of us in the "decision

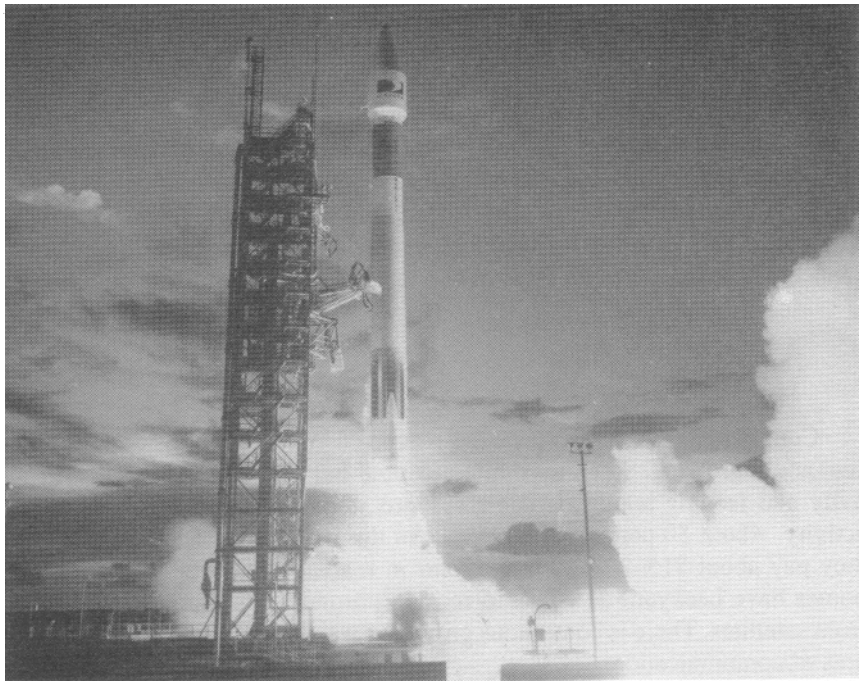
loop" decided that MOL's questionable mission and increasing cost were not a good match. It was getting too big to be worth the drain on the service budget. We decided to cancel MOL, and on June 10, 1969, the axe fell. A disappointed Robert Seamans, a NASA alumnus who at the time was Secretary of the Air Force, felt committed to support MOL. He was very upset with the cancellation and asked Defense Secretary Melvin Laird's permission to go to the President and seek a reversal of that decision. Mr. Laird agreed and Seamans spent an hour and a half with the President Nixon trying to reverse the cancellation; Seamans failed to sway the President.

VI

Commercial activity in space has reached a level of billions of dollars per year and is growing. Satellite communications has become the largest such activity and feeding television cable systems is the largest component of this activity. About 50 percent of all homes in the U.S. have television cable and they pay about $15–20 billion per year in rent. About three or four million homes have backyard antennas to receive normal TV programs fed directly from satellites. There is continuous growth as we think of new variations in the area of communications.

Commercial satellite communications dates from 1965. By 1970, people were talking about expanding the field from international to domestic use. In 1975, COMSAT was readying six satellites, three for domestic use and three for maritime service, with both services going operational in 1976. While COMSAT had a virtual monopoly on international space communications, no such charter was ever granted for domestic service; so in addition to COMSAT's entry into domestic activities, several other companies also began operations, notably RCA and Western Union. Over time, the field has grown to include dozens of companies with new ones springing up continually. Cable TV has been the biggest user of such satellites. At various times, there has been a glut of capacity and at other times a marked shortage, but that is the way commercial business is often conducted. Commercial satellite communications has now experienced three decades of solid rapid growth with no end in sight.

In 1979 while I was at COMSAT, we decided to activate direct broadcast and the first satellites we planned were to have six channels of programming. That was what the technology of the time permitted. We soon concluded that such a system would not be economical with so few channels. As far as direct broadcast was concerned in the U.S., things went on hold for a very long time. In Europe, domestic satellite service also had been delayed and when it did develop, it developed as a hybrid cable TV feed system and a "poor man's" direct broadcast system. Several systems with a few channels got underway, gradually expanding with time. Meanwhile in the U.S., the eight-foot diameter



Launch of an Atlas IIA carrying a commercial broadcasting satellite.

backyard antennas came into use and several million units were sold. These units tapped signals meant for cable TV feed and bridged the gap, while the technology for true direct broadcast continued to advance.

Last year several American companies started putting up systems offering 150 channels into dishes of only a few feet in diameter; it was a whole new ball game. Receivers are now being installed at a rate of 100,000 a month, and prices are falling so that receivers cost from $500 to $1,000. Some experts believe that direct broadcast service (DBS) will capture 25 percent of the existing cable market of some fifty million homes; others say there will be a plethora of homes sporting both cable and DBS.

Several companies plan to launch low-earth-orbit (LEO) satellites for mobile and cellular services, both voice and data. Such services will involve both big and little satellites in LEOs. There seems no end to these communications ideas and variations on a theme. U.S. space policy in the field of domestic space communications seems to be to "Let a hundred flowers bloom," and the policy is producing a good, colorful crop.

All of this commercial activity bears on what the military should do about the ever-growing expansion of communications needs. Years ago, COMSAT approached the Pentagon with an offer of communications capacity for ties to our forces overseas. The concept fit very well with the military need for diver-

sity to reduce dependence on any single system. The Defense Communications Agency (DCA) adopted a policy of splitting their traffic between commercial suppliers and its own facilities, such as the DSCS satellites. The DCA split the military use of commercial capacity between satellites and undersea cables. I believe this arrangement ensured the best of continuous communications in the face of potential failure of any one system. The arrangement produced a new environment for COMSAT. Our NATO allies and many other countries now use the facilities of INTELSAT, the international consortium, of which COMSAT is the U.S. member. The situation is similar for INMARSAT, the maritime consortium, in which some of its capacity is used by the U.S. Navy.

Pressure has been building in the U.S., and to a lesser extent in other countries, to modify further the role of these consortia which began life as virtual monopolies. Just as there was pressure to break up AT&T, some people think we ought to break up INTELSAT. In the last ten years, there have been gradual shifts in the competitive world affecting INTELSAT; several undersea cables have been approved to compete with INTELSAT and at least two commercial satellite systems have joined the competition. In the years ahead, INTELSAT and INMARSAT will face increasing pressure to act less like monopolies, and the U. S. Government must find ways to preserve the advantages of those two consortia, while giving freer rein to the competition. INTELSAT will have a continuing role in terms of providing connectivity to remote places for years to come and the government must assure INTELSAT an opportunity to operate as long as it is needed without permitting it to retard service expansion. While this can be done over time, it will be a challenge.

In remote sensing, the commercial market has been hamstrung by security restrictions imposed to prevent anyone from building or operating systems which might compromise national security. NASA had been instructed not to offer resolution better than thirty meters on the Landsat satellite system. Of course any private U.S. system, if it existed, would have been similarly restricted. At that resolution, potential private suppliers felt that the market was too small for commercial systems to succeed. NASA's Landsat (later turned over to NOAA) was the "only game in town." We have had to rely on Landsat (more recently operated by the private contractor, EOSAT) to supply civil needs as well as any military needs not covered by DOD's own satellite systems. This situation changed slightly when the French system, SPOT, began operating at ten-meter resolution.

With the demise of the Soviet Union, however, new rules were adopted on what resolution should be permitted to the civil government and to the private sector. A one-meter resolution was approved. The Department of Commerce has authority to license operators of such systems and has dealt with several new applicants recently. As a result, we now have three companies who say they will put up high resolution systems because they think they see an expanding market. They foresee a market measured in billions of dollars over the next five

years. I believe they are right. The Department of Commerce has approved all three applications for licenses and it remains to be seen if the systems actually will go into operation. It is doubtful that all three companies will follow through to put up satellites, but one or two should become operational, offering resolutions of three meters and at least one company for one-meter resolution.

The principle of commercialization was embodied in the Remote Sensing Act of 1984, with the government serving as anchor tenant (and more) on Landsat VI/VII. The Landsat program was stymied by gradual failures of Landsats IV and V. Then there was the precipitous loss of Landsat VI and we have seen several years of precarious funding for Landsat VII. This does not bode well for Landsat's future. Recent new proposals of three or four companies to field one-meter resolution systems in the late 1990s of narrow swath may help fill the vacuum, but are not one-for-one replacements for Landsat. Nonetheless, their potential existence is encouraging.

VII

The United States Air Force has not been as aggressive as it should have been in pushing certain developments in space. For example, in 1980 as a member of the Scientific Advisory Board, I chaired a summer study on the Air Force in Space. General Schriever was among those who served on my panel. When I gave the close-out briefing to several Air Force officials, the general was very enthusiastic about what we had done. Schriever sought to arrange with the Chief of Staff to schedule my briefing at the next Corona Conference of USAF four stars generals. When I later asked him how he made out, "Bennie" said he had been advised that the service's military leaders were too busy to include an extra item on their agenda. He was quite chagrined that he could not persuade the Chief to give him the time or attention to include that short briefing on the agenda.

To my view, Air Force interest in space was fairly late in coming. Owing to a coincidence or otherwise, serious Air Force interest in space appeared only after the appointment of a Chief of Staff with a space background. Gen. Lew Allen had held every job in the NRO except my own when he became Chief in 1977, and a few years after that, in 1982, the Air Force Space Command was created. This interest peaked with the remarkable performance of military space systems in the Gulf War. One did not have to be a "rocket scientist" to see that our DSCS communications, DMSP weather monitors, DSP missile early warning, and GPS navigation satellites made all the difference in the world in how that war was fought.

About two years ago, several Air Force leaders, and especially the Chief of Staff, Gen. Merrill A. "Tony" McPeak, spoke out on the need for the Air Force to realize what had happened and to take space more seriously in a practical sense. McPeak also worked to include space doctrine in the Air Force psyche.

I believe his views were more than welcome since they showed a Chief who was giving much overdue attention to the promise of space for general utility by the working Air Force. The present Vice Chief of Staff, Gen. Thomas Moorman, is a well known space proponent. There are signs that Gen. Ronald R. Fogleman also shares this same interest and viewpoint.

VIII

An important aspect of space policy is connected with the GPS constellation of navigation satellites. Although developed primarily for military use, its other civil uses were taken into account from the very beginning and some provision was made for them. Still, it was impossible to foresee just how significant a technological driver GPS would be for a host of commercial applications. High level debates have begun to rage about whether we can afford to allow the military to restrict the nonmilitary uses of the system. To do so, following Soviet practice, can cause us to forego enormous opportunities for dozens or hundreds of payoffs in as many fields.

To consider these opportunities, Congress recently commissioned a pair of studies which are just now completed. They were performed by the National Academy of Sciences working with the National Academy of Engineering, and the National Academy of Public Administration. Both groups examined the future of GPS. Both recommended that GPS remain under control of the military, but both also recommended that the government also broaden management of the GPS system to include personnel from outside the Pentagon, and, second, that the military stop degrading signal quality in an attempt to make it less useful to potential enemies. The writers of the report believe we can accomplish the desired objective of denial to enemies by other means and that continuing to degrade the GPS signal is costing us dearly in complicating its use for other extremely valuable commercial purposes.

I agree with the substance of these reports, but again, reasonable people can come down on either side of the debate. In any case, the DOD and especially the Air Force can be proud of having created a system which is so valuable commercially that it seems the whole world wants to adopt it for its own. Three years ago, Gen. Jim Abrahamson chaired a study for the Radio Technical Commission for Aeronautics (RTCA) that examined the applications of GPS to civil air navigation and air traffic control. That study got the FAA's attention. Two years ago, I chaired a study on what specific actions the FAA should take to implement GPS use. Our report recommended a number of steps which could accelerate the availability of GPS to the aviation sector. We said the FAA was moving much too slowly.

Since 1974, having been the Air Force Secretary at the time of the GPS go ahead, I have become almost a GPS "junkie." As the FAA Administrator in the 1970s, I could not get the FAA interested in GPS. In the more recent study, I

was happy to see that the FAA was at least ready to talk about it. FAA has in fact speeded up its actions to adopt GPS as a primary if not *the* primary aerial navigation system. As a result of the FAA study which we completed last year, I bought a license plate for my car which I have here as Exhibit A. It says GPS NOW. My second car now has a GPS plate, too. It reads GPS MET, which celebrates a second GPS application.

A group in which I am involved recently completed an experiment in space in which we used GPS signals to study the atmosphere. Most people know that GPS-derived position fixes have to be corrected for atmospheric distortion of the signal. It turns out that by using special extra-stable GPS receivers, we can measure the distortion so accurately that it tells us certain characteristics of the atmosphere which meteorologists want to know. In addition to telling you where you are, GPS also can tell you what the weather is. We enthusiasts claim it can collect billions of dollars worth of data per year at a ridiculously low cost. Since the system operates worldwide, it can be especially valuable in all those out-of-the-way places where we do not have good weather data but which are important for building a worldwide weather data base.

The people at the Jet Propulsion Laboratory (JPL) and Stanford University who developed the technique of studying radio signal distortion to learn something about the atmospheres of other planets, tried unsuccessfully to sell NASA officials on the idea of using GPS to collect meteorological data on Earth. They failed completely; NASA said it would never work. Three years ago, several of us working privately rounded up some $3 million of support from NSF, NOAA, and FAA, and we persuaded NASA to allow us at our cost to fly an experiment on a satellite ordered for another purpose. We added a package to the NASA satellite weighing eight pounds and drawing seventeen watts of power. During April and May 1995, we collected enough data to validate the concept and are looking at what steps to take next to field an operating system. This is just one more example of how powerful it is to have a signal like GPS which is so stable that it opens up whole new fields of science. I offer another prospective space policy statement: exploit GPS signals for all they are worth!

IX

During the Cold War, one often heard that the U.S. was much more dependent on satellite survival than were our potential enemies. Thus, the argument ran, we could not rely on mutual deterrence to protect our satellites. As the Cold War ended in 1991, the effectiveness of satellites in helping win the Gulf War led others to conclude that U.S. satellites are likely to be attacked in any future war. While opinions differ on the extent to which this is so, defense planners must take the possibility into account.

To reduce the likelihood of a successful attack, there are certain obvious steps that can be taken, most of which have already been implemented. These

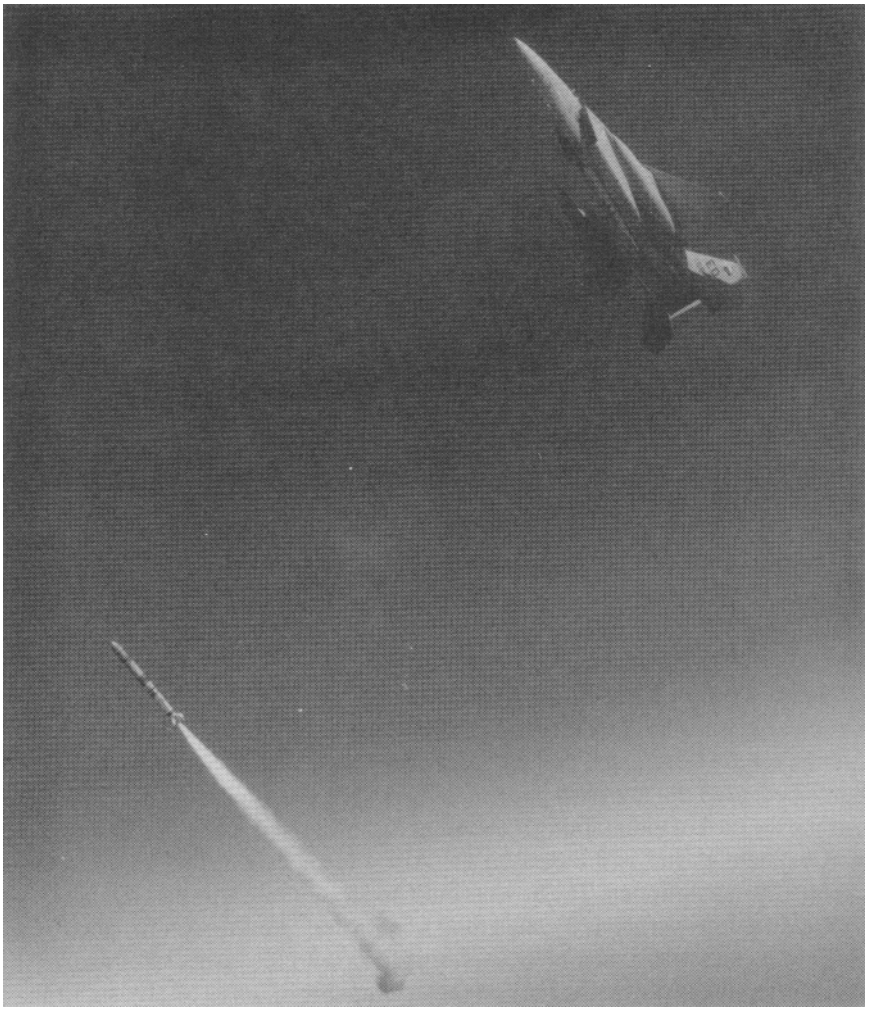
include making it difficult for anyone to take over control of these assets, putting up numbers of identical or similar satellites, or storing backup vehicles in orbit. We can even harden them, or, as a last resort build an ASAT system such as the one planned to operate from a fighter aircraft. (In the late 1970s we tested an ASAT consisting of a rocket carried and launched from under an F–15. The rocket mounted a payload built by LTV for the Army — the so-called miniature homing vehicle (MHV). That program proceeded to the point of demonstrating that such an ASAT system could indeed intercept and destroy a spacecraft. However, its existence led to a heated Congressional debate about whether the country actually needed an operational ASAT. In the end, the program was stopped after the demonstration phase.)

The much-heralded new technology that is assisting NASA in its smaller, faster, cheaper mode, will permit the proliferation of certain satellites at greatly reduced costs. Such systems can certainly augment their military equivalents, which are frequently much more expensive. Because of the problem of inadvertent interference, we should design space systems to avoid this problem as much as we can.

In the early years of the Space Age, the U.S. debated whether it needed to develop the ability to shoot down space assets of potential enemies. Following the U.S. high-altitude nuclear tests in the early 1960s, Thor missiles on Johnston Island in the Pacific, used to launch the bombs for those tests, became the basis for a direct-ascent Earth-based ASAT called Project 437. Because it employed a nuclear warhead to kill satellites, many people questioned whether it would ever be used. I terminated that project during my tenure as Secretary of the Air Force because I did not see a good match between the likelihood of its eventual use and the cost of maintaining it. Another Earth-based ASAT system, activated at Kwajalein Island and based on the Army Nike-Zeus ABM site, also was eventually discontinued. The Soviets built and tested an Earth-based ASAT that avoided nuclear warheads by launching a co-orbital satellite which maneuvered close to its target and then blew itself up along with the target satellite.

During those times, the only adversary capable of doing us any significant harm in space was the Soviet Union. There are now a half dozen countries that can threaten American spacecraft. But with the sky full of military and commercial satellites clustered in particular orbits, the idea of detonating ASATs that are bound to generate thousands of fragmentary projectiles, is uneconomic to the point of being counterproductive. The exploding fragments could easily and unintentionally knock out other multi-million dollar satellites. Moreover, DSP early warning satellites would pinpoint the launch location of any ASAT, and I imagine U.S. terrestrial retaliation would be swift and certain. Considerations such as these should give any nation pause before starting "warfare in space."

For some systems, building a few extra satellites is the best survivability technique. In addition to the protective measures mentioned above, we can have redundant spacecraft; making them less expensive and then proliferating them



Test of an ASAT missile carried aloft on an F–15.

is undoubtedly the best approach. In 1979, I chaired a Defense Science Board study on what was called enduring command and control. We concluded that putting a transponder for communications on every satellite to be launched was a good survival technique.

GPS satellites are an example of a proliferated system. They are in relatively invulnerable orbits about 12,000 miles high. Since there are twenty-four GPS satellites, the loss of one or two, while inconvenient, would not rob us of service. GPS gains additional survivability by being used by people in a hundred countries. An attacker, in addition to sure military retaliation, would face worldwide outrage.

There are many defensive measures we can take. For the reasons enumerated, however, I believe there is no urgent need to adopt offensive measures against the possibility of hostile damage to our satellites. Essentially, all countries that have a space capability are either friendly toward the U.S. or at least not disposed to attack us.

A few countries do represent a serious potential threat to the U.S. But the few despotic states that have a strong animus toward this country have serious problems simply maintaining their conventional military forces, let alone taking on the sophisticated task of creating and fielding a reliable ASAT system. Why would they undertake an exceptionally expensive ASAT activity just to destroy a few U.S. satellites? Furthermore, with the extensive intelligence resources that the U.S. devotes to keep track of their military actions, it is highly unlikely that they could develop and test such a system without revealing its existence. If these states have any desire to be accepted into the community of nations, such hostile actions would delay that acceptance indefinitely.

I am optimistic that new technology will reduce the cost of spacecraft and lead to a proliferation of relatively low-cost military reconnaissance/surveillance systems, each tailored to a given application. As long as the principal focus of overhead systems was the Soviet Union, strategic factors determined our intelligence collection and our priority targets; typically we targeted nuclear facilities and the like. This led to fielding very small numbers of very expensive satellites, which in turn led to difficulty in assigning adequate priority to tactical targets important to military commanders in the field. Gradually, more and more attention has been devoted by the military services — especially the U.S. Army and Navy — to building a system of Earth stations to receive tactical targeting data directly from space.

This development should lead to a reevaluation of the massive strategic systems of the 1970s and 1980s and mark a trend toward lower cost space systems, systems which will be more flexible collectors of various information. The best deterrent to enemy action against any class of American satellites is to have a dozen or so of them up there; knocking out one would not change our total capability enough to justify escalating the war by attacking space assets.

In the near future, the U.S. will have the advantage of at least one civil satellite imaging system in Earth orbit with a one-to-three meter resolution. Although not ideal for military use, such systems could go a long way toward filling any gap caused by the loss of primary assets. The U.S. Government certainly will continue to rely on its own overhead systems, but it will also receive data from any civil systems which are built under U.S. auspices. Again, proliferation helps deterrence.

In addition to any civil systems that will appear on the scene, friendly countries are now building and launching space reconnaissance satellites. The U.S. doubtless will make arrangements to share data if need be. The existence of more and more overhead systems also should give pause to any country contem-

plating an attack on space vehicles. Would the destruction of one or two of them accomplish its purpose if many other similar satellites remained? This line of reasoning leads me to urge the Air Force to work harder on cost reduction of spacecraft so that we can count more on redundancy as a deterrent to enemy attack.

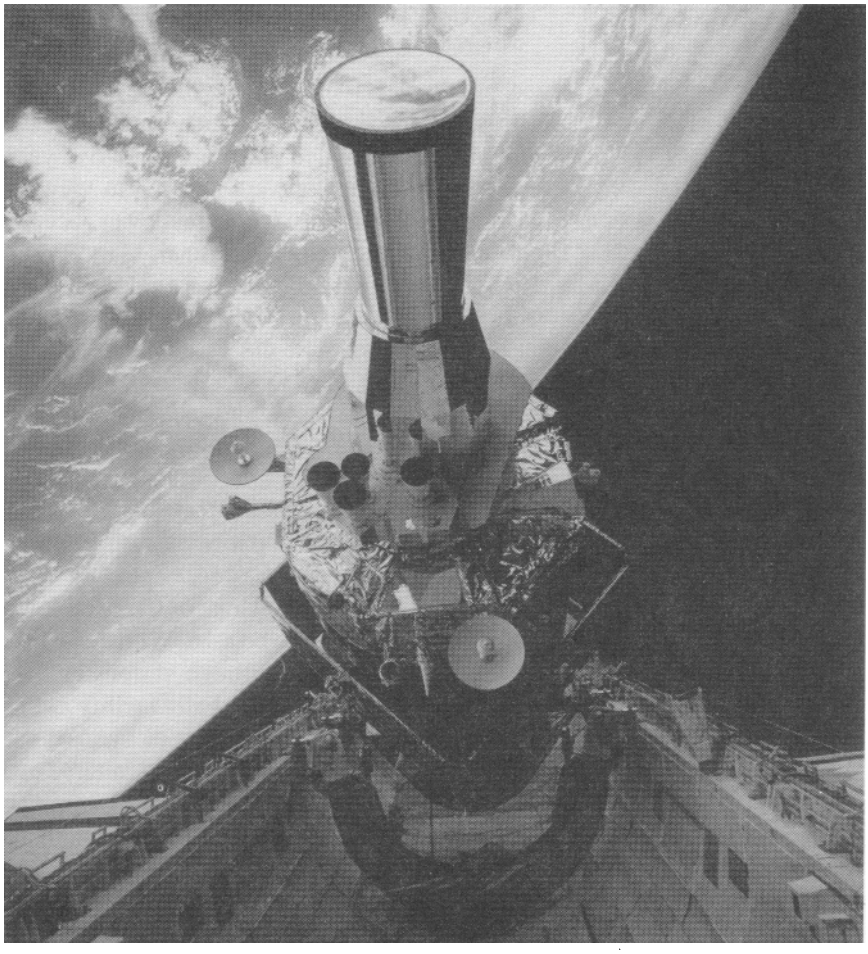
Beside multiple space systems, the U.S. possesses sophisticated reconnaissance airplanes in the tactical forces. These aircraft also will help fill the gap if any space assets were rendered ineffective for whatever reason. The typical military engagement involves forces in relatively restricted areas. The intelligence needs of such forces more often than not can be satisfied mainly by airborne sensors. The Air Force would do well to continue development of a new generation of tactical reconnaissance aircraft — both piloted and unpiloted. Their existence would further reduce the likelihood of an attack on American reconnaissance satellites.

Finally, this country should state publicly for any potential enemies that any attack against U.S. assets in space will provoke certain retaliation against the offender on Earth. To support that policy, the U.S. must maintain an extremely capable early warning space surveillance system (DSP is quite good at this task; its successor, SBIRS, will be even better) to identify the aggressor if an attack takes place.

With billions invested in space assets, discretion demands that the U.S. exert every effort to discourage space weapons. I am of two minds about seeking treaties banning space weapons at a time when there is no apparent threat. Even without agreement to keep all weapons out of space, I do not believe that any current threat to our satellites justifies deploying an ASAT. Admittedly, we should continue to do R&D to assure that we are on top of the latest technology. Although a ban exists on placing weapons of mass destruction in space, pushing for a ban on all weapons in space might gain us credit on the world scene. Certainly, assuming the posture of a space vigilante and ostentatiously building ASATs — whether based on Earth or in space — is totally out of character and out of keeping with the times. With the Cold War behind us, people around the world expect to enjoy the benefits of the peaceful exploitation of space technology. How would they welcome a new round in the space race which would dim the prospects of using space for better education, economic growth, and an improved quality of life?

As long as no serious threat of space warfare exists, I believe that we should maintain a watchful eye and take the obvious steps already outlined: reduce spacecraft vulnerability, keep ASAT R&D up to date, and proliferate smaller reconnaissance and surveillance systems — both spacecraft and aircraft. These efforts, together, comprise the most sensible and prudent approach to the "potential" threat of space warfare.

As for the related field of ballistic missile defense, we have moved from Ballistic Missile Defense (BMD) to the Strategic Defense Initiative (SDI) and



DSP satellite deployed from the shuttle during the STS-44 mission.

back to BMD. The current BMD Office can do its job with Earth-based weapons designed for theater or point defense. To be sure, rational points can be made on both sides of the debate over whether we need to place weapons in space for ASAT purposes or for missile defense. I happen to believe in our original space policy of "freedom of space," and in maintaining space as a sanctuary from weapons in peacetime for as long as we can. If we do our R&D properly, we neither need to place weapons in space nor give up any important advantage in the process.

The National Space Act of 1958, modified many times since, still calls for U.S. leadership in space. The United States can gain much in exercising that leadership by expanding the peaceful uses of space rather than engaging now in programs to develop weapons for space warfare.

X

A recent change in space policy declassified most of the CORONA program. CORONA was the first real space reconnaissance system back in 1960. In February 1995, the administration decided that after thirty-five years it would not violate any state secrets if the public were allowed to view the CORONA camera system and it images. When President Eisenhower accepted responsibility for the U–2 flights after the shootdown of Francis Gary Powers over Soviet territory in May 1960, he announced that there would be no more aerial overflights of Soviet territory by the U–2 or any other American airplane. The reason he could make that concession when he did was that he knew we were almost in position to do the job with CORONA. Four months later, CORONA 14 successfully returned film from space and continued to bring home pictures of missile site construction and many other targeted areas over the next twelve years. We retired CORONA in 1972, after collecting hundreds of thousands of feet of film from thousands of targets.

I am optimistic that this valuable resource will find many uses in civil life. An item of policy which the U.S. has followed from the very beginning is that remote sensing data such as that collected by civil versions of CORONA will be available on a nondiscriminatory basis to anyone who asks. With the declassification of CORONA, its results can be accessed through various archival means including the Department of the Interior's Sioux Falls facility, which since 1972 has stored and made available a veritable treasure of Landsat data similar to the CORONA product. Hundreds of receiving stations scattered over the surface of the Earth have made their collections available to thousands of users in the fields of land-use planning, agriculture, and environmental monitoring, to name a few applications.

Though the U.S. Government was rather slow in declassifying CORONA products, it did not do too badly on declassifying weather satellite data. As Air Force Under Secretary in 1973, I was able to get DOD concurrence to release DMSP weather images and related data. I am reminded of an interesting anecdote from those days. Shortly after telling our people that these data would be released, I showed some visiting newspaper reporters sample DMSP data from the Middle East, at the time of the Yom Kippur War. Although the resolution on Earth of DMSP photos was of the order of three or four miles and hence did not show military targets, they showed clearly which oil fields had been attacked, because the flares from the refineries which normally lit up the area were not there. I remember Jerry Friedheim, the Assistant Secretary of Defense for Public Affairs, saying, "John, why don't you hold off on giving out any of those pictures until things calm down over there?" In the interests of good relations with the Pentagon Third Floor, I complied.

Another recent change in space policy involved a reorganization of the Pentagon hierarchy dealing with space. In response to concerns expressed by

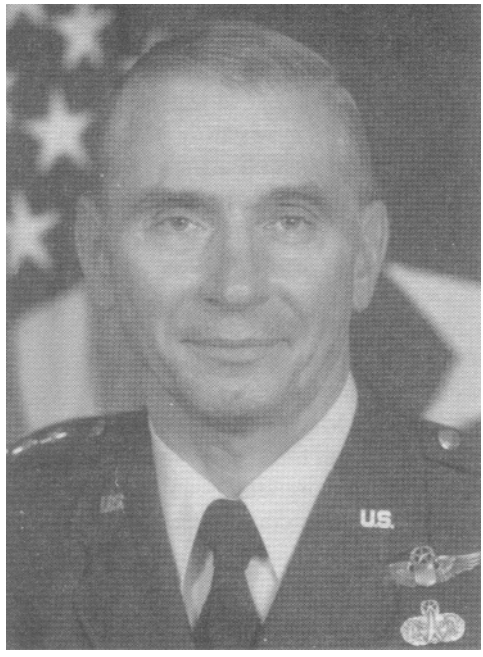
the House Armed Services Committee, DOD officials reviewed their organization for space programs. During that review, various Air Force officials made proposals on how best to organize for space. Some Air Force proposals sought for the service a much larger role in space management and they were considered too extreme, virtually giving the Air Force control of military space. The DOD has adopted a plan which appears to give the Air Force a leading role, but keeps for the Third Floor the policy and oversight role. As I understand it, the intent was to ensure that all DOD space activities were coordinated by a space architect; the architect would ensure compatibility and smooth operations among the different systems and space communities.

This need has been well known for decades, because the military forces of different services have not always been able to communicate with each other in joint exercises. In the spring of 1995, an organization was agreed to, which placed the Defense Acquisition Executive in the lead space policy role, with the Air Force Acquisition Executive reporting to him. Underneath him, the space architect, Maj. Gen. Robert Dickman, reports through Air Force channels but receives oversight and tasking from another new appointment, the Deputy Under Secretary of Defense (Space), namely Robert Davis.

A Joint Space Management Board with a small staff is to coordinate space activities between the CIA and the Pentagon. As with so many organizational arrangements, this can be made to work if the principals approach the issues to be addressed with good will. Many details remain to be worked out — such as the tie-in between the NRO and the Air Force. However, I am optimistic that, with good will on all sides, this organizational arrangement will work harmoniously and improve the design, operation, and uses of military space flight for the nation.

Acknowledgment

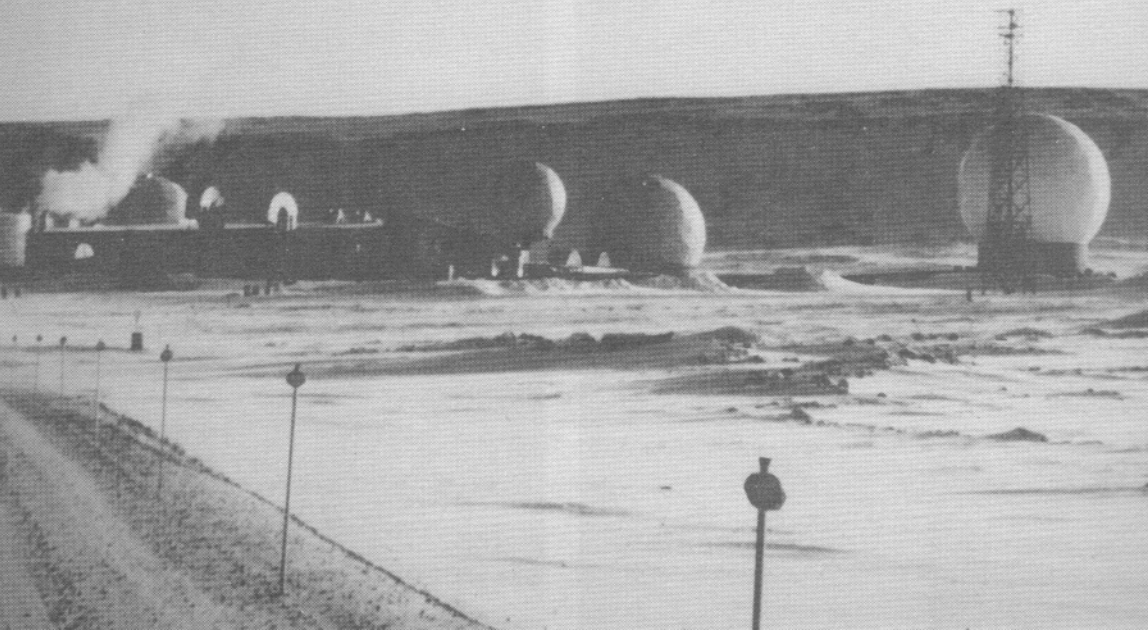
I wish to thank those on the Air Staff and the Secretariat, from the Chief of Staff and Secretary on down, who aided me in rounding up information for this paper. I am especially indebted to Col. Bob Cox and Maj. Vic Villhard. I also received assistance from members of the DOD staff, for which I am grateful.



Gen. Donald J. Kutyna, USAF (Ret.), is Vice President, Advanced Space Systems, at Loral Corp. Before retiring in July 1992, he commanded NORAD, the U.S. Space Command, and Air Force Space Command. A graduate of West Point, he also earned an M.S. degree in aeronautics and astronautics from MIT. After his first USAF assignment as a B–47 combat crew commander, he became a student and then staff director at the Aerospace Research Pilot School at Edwards AFB. During the Vietnam War, General Kutyna served with the 44th Tactical Fighter Squadron, completing 120 missions aboard the F–105. In 1982, he became deputy commander for space launch and control systems, where he managed the DOD Space Shuttle Program. In 1984, he was named director of Space Systems and Command, Control, and Communications at Headquarters USAF. In January 1986, he served as a member of the presidential commission that investigated the space shuttle Challenger accident.

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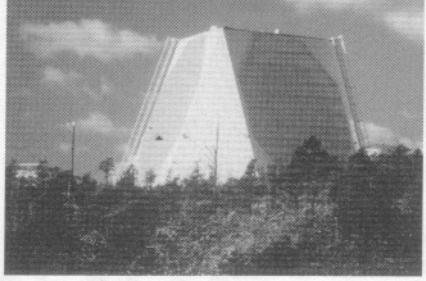
Space Systems in the Persian Gulf War



A photo essay, excerpted from the seminar presentation by

Gen. Donald J. Kutyna, USAF (Ret.)

The Persian Gulf War was the first conflict where space played a major role in support of our land, sea, and air forces. And it marked the first time that combatants, at all levels, felt the presence and effect of our space systems on their missions. Indeed, our space forces were available before the war, during the war, and after the war because they were already on orbit and the space force structure is used just as much in peacetime as during times of crisis. Worldwide navigation and weather information in peacetime require the same satellites on orbit as during wartime. And, intelligence garnered from space is probably more important before a crisis starts to avoid our being surprised. Essentially, the forces available in space before a war starts will be the same as those after it starts. That is fortunate because we could not have supplemented our space forces, even if we had wanted to during the war.

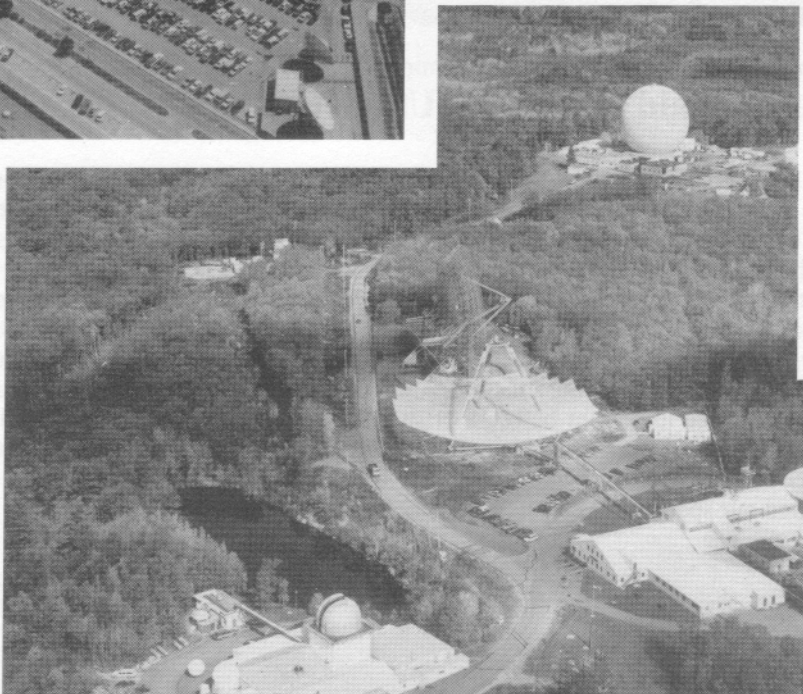














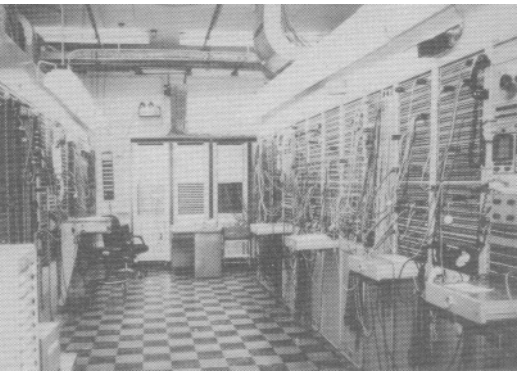
Space, to most people, suggests satellites on orbit. However, a large infrastructure of bases, command and control networks, and space sensors support those satellites. There were some sixty bases around the world, including Vandenberg, Patrick, and Thule, as well as many installations manned by only four or five people on remote mountain tops who maintained space equipment.

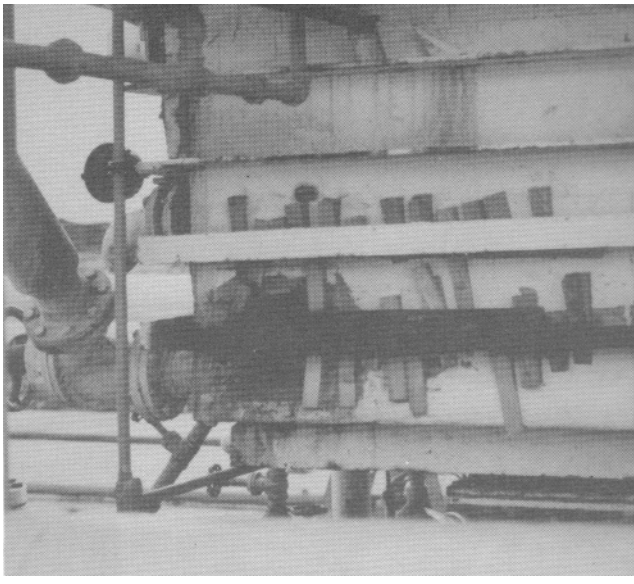
Our major organizational entities in space are the United States Space Command and its Army, Navy, and Air Force Space Command components. While the Air Force held the lion's share of the funds and people invested in space, the contributions of the Army and Navy were also vitally important.

A cursory look at our range facilities today suggests that they are in good shape. Upon closer inspection, however, a different picture emerges. The genesis of the problem stems from the early 1970s, when the United States decided to develop the Space Shuttle as a reusable launcher. Then, in February 1978, Congress halted production of any additional expendable launch vehicles. The expendable launchers went out of production in 1986. Coincidentally, that same year the Challenger accident occurred and the Shuttle was grounded. As a result, there were no launchers to substitute for the Shuttle. We tried, but could not gain approval, to fund more Titan launch vehicles and launch pad upgrades, resulting in an extended shutdown of military space launches after the accident.

Today, the launch pads are held together by "wooden wedges and duct tape." Major pieces of equipment are rusting and impede progress in the quest to modernize our operational space assets. The electronic equipment is not much better and "Radio Shack" boxes are launching billion-dollar satellites on our ranges. The same is true with range control centers. We are not using state-of-the art equipment, we are using 1960s technology.

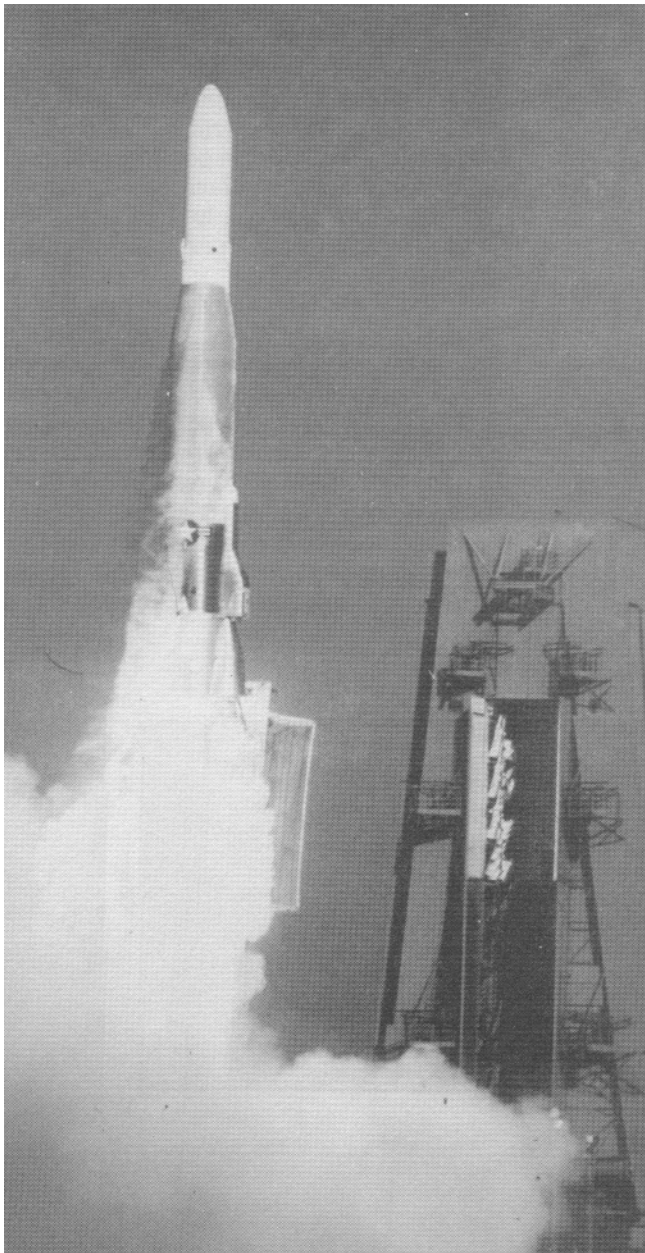
As an example, to convert from a Titan to an Atlas launch set up requires going through a control room, pulling out cables, and reconfiguring them. We are acquiring new programs, such as the Evolved Expendable Launch Vehicle, which promise to fix many of these ills, and the space budget has risen significantly to modernize the ranges so that we can be more responsive in the future.

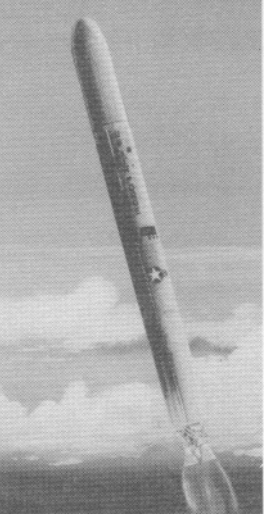
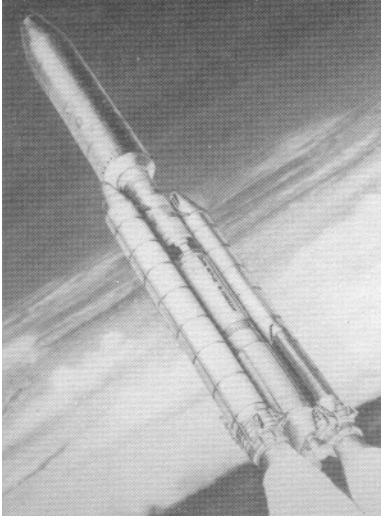


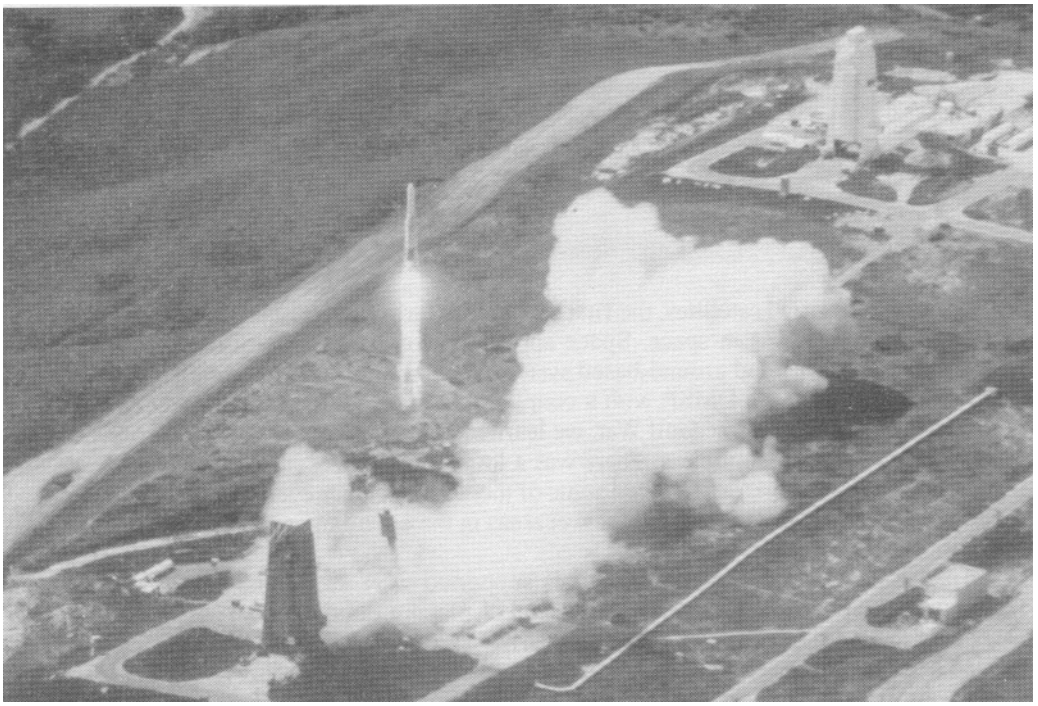


There was a major impediment concerning our launch vehicles. The Space Shuttle no longer served DoD space operations, but we had many good expendable launch vehicles. Still, while the Titan IV carries heavy payloads to orbit, the process to get that booster off the ground takes anywhere from 200 to 270 days. The Gulf War was much shorter than that. It proved impractical to even consider getting off the ground in time to augment our satellite forces. The same was true of the Atlas, where processing time took from 60 to 90 days. The Thor/Deltas and Titan II vehicles had similar problems: it takes 70 to 80 days to process a Delta and almost 140 days for a Titan II.



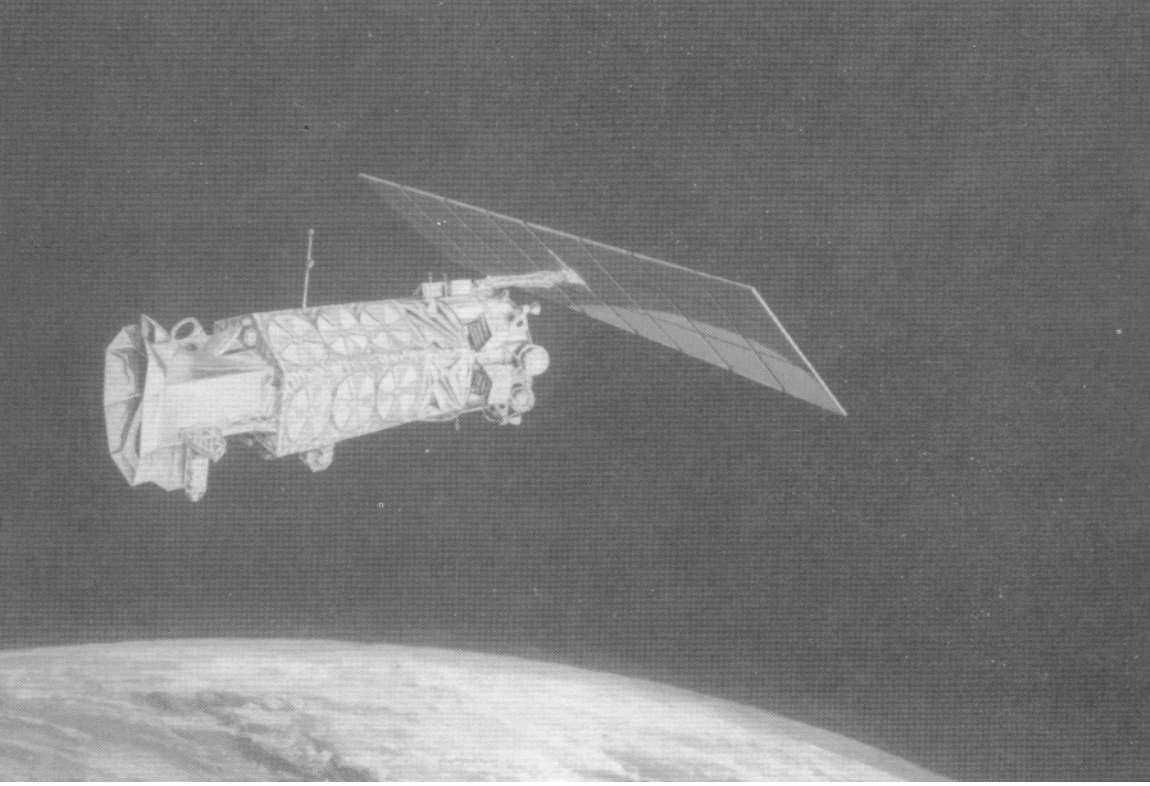




Even satellites on orbit experience time consuming problems. Once, we had a Defense Meteorological Support Program (DMSP) satellite go out, while the second one—of the two in the constellation—malfunctioned. The first satellite "died" in September and (despite our best efforts) we could not launch a replacement until April of the following year.

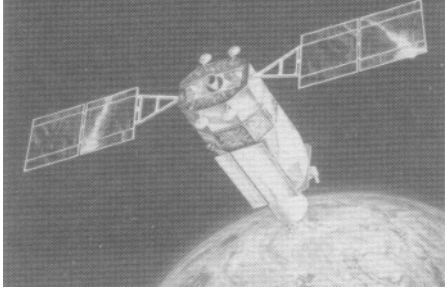
We were fortunate that our satellite force structure sufficed for the Gulf War. There were several "birds" on orbit, including warning, communications, weather, multi-spectral imagery, and navigation satellites. Also, the intelligence community had a full complement of operational satellites on station. Excluding the Global Positioning System (GPS) constellation of twenty-four satellites, the NRO has more, and also different types of satellites on orbit than does the Air Force.

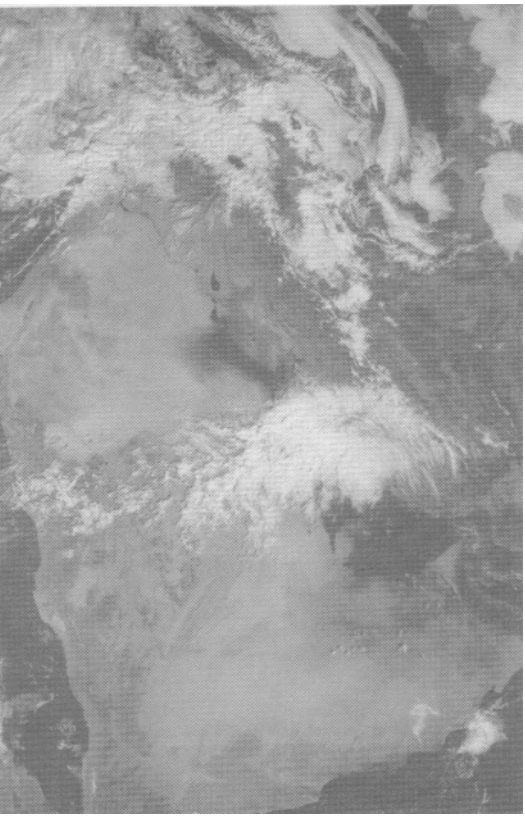


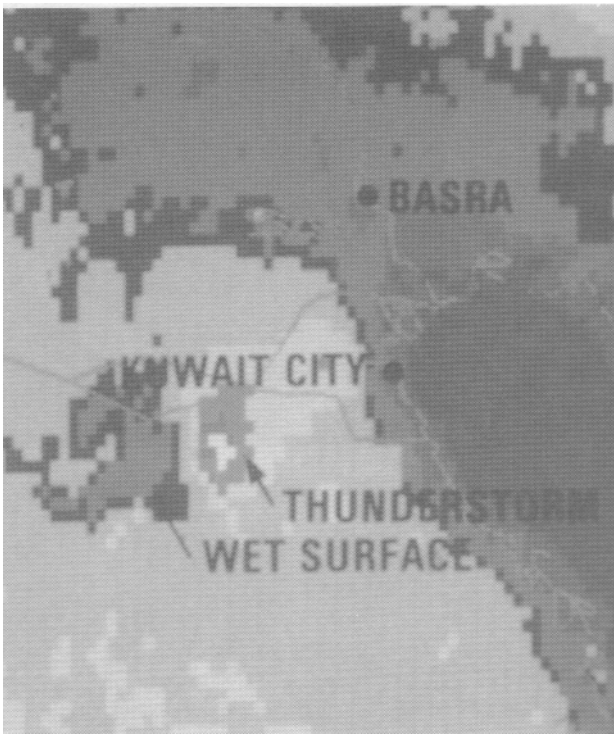
Of our unclassified satellites, the first category is force enhancement, one of our primary missions in space. Space applications enhance our military forces' capabilities beyond ground-based systems. Among the most important are weather satellites, the DMSP, with a couple of them on orbit continuously. During the first day of the Gulf War, we learned that the so-called *featureless* desert was hardly featureless. There was a lot of cloud cover in Iraq, and in fact, during the war we experienced some of the worst weather ever over the region. However, DMSP pinpointed the wet areas in the environment and provided much needed data.

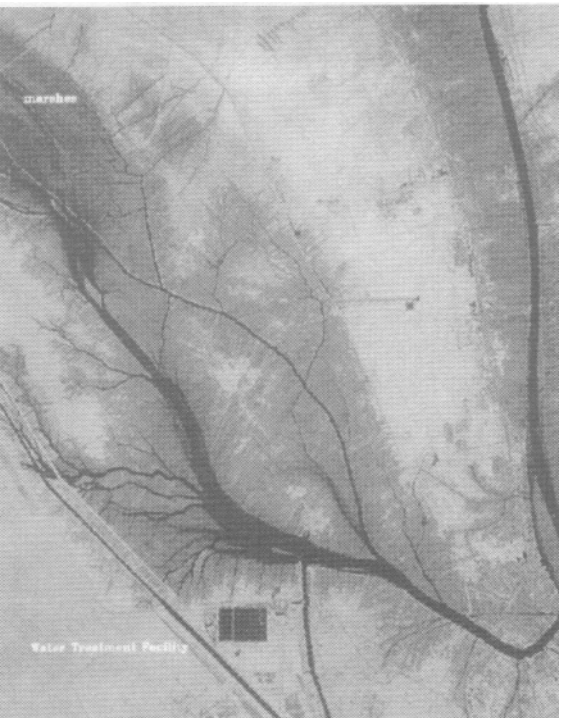
Among the missions weather satellites supported were strike planning, redirection, weapons loading, air refueling, and displaying flood plains. These were vital to Gen. H. Norman Schwarzkopf. His "Hail Mary" maneuver succeeded because the general knew the weather and was able to move his tanks effectively. The one drawback was the need to have a Mark 4 weather van in theater to get weather information. Only thirty-seven Mark 4 vans were distributed worldwide among the Army, Navy, Air Force, and Marines. We did not have one in Saudi Arabia when the crisis occurred because of the van's low priority on the "Tip Fiddle" (TPFDL, an acronym for Time-Phased Force Deployment List) and did not get one in-country until the Marines brought in a van a month before the war began.

In desperation, Army Space Command bought some commercial computers and displays and used the TIROS, a civilian satellite, to get their weather. Later in the war we acquired more vans. Gen. Robert Yates, commander of the Air Force Materiel Command, tried a "fix" by installing a portable set-up. In the future we will have better and smaller equipment, capable of accompanying the troops anywhere they go.

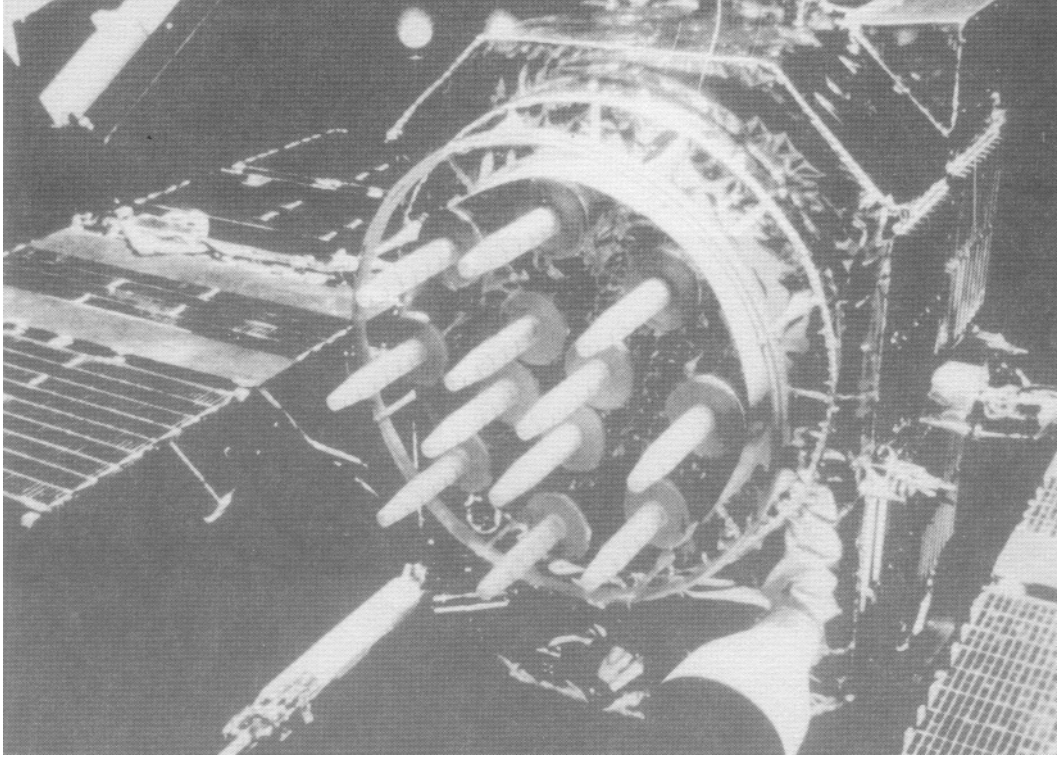




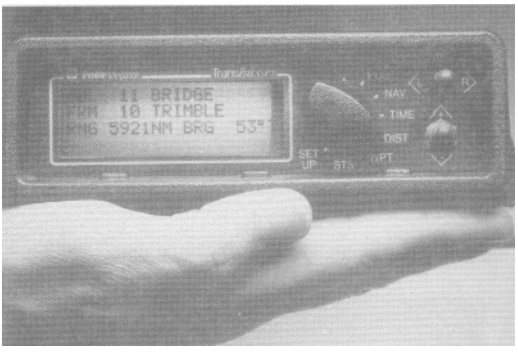

BASRA
KUWAIT CITY
THUNDERSTORM
WET SURFACE


marshes
Water Treatment Facility







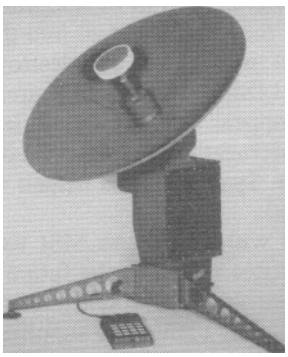

Transceiver
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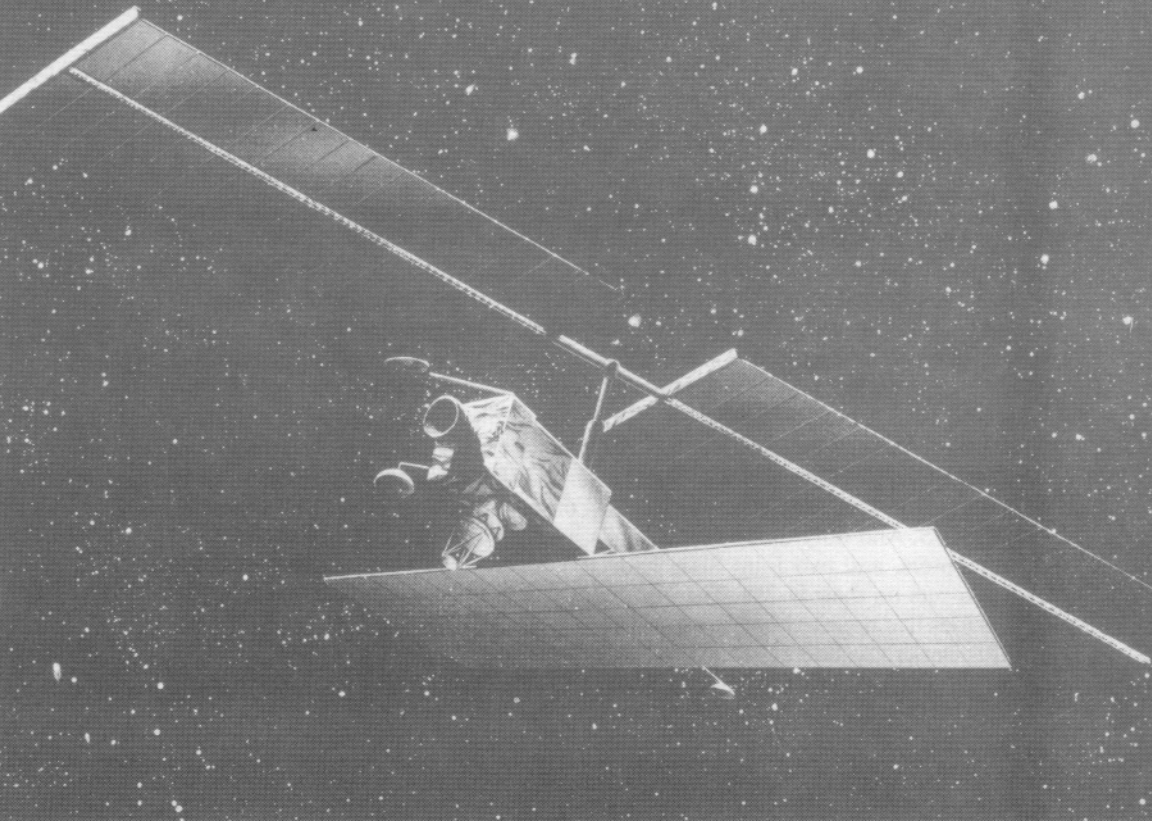
Another force enhancement is the GPS spacecraft, a wonderful system of twenty-four satellites on orbit. The GPS is controlled by Air Force crews from the Consolidated Space Operations Center and serves Army, Navy, Air Force, and Marines, as well as a large civilian market. It has great accuracy. Although a full constellation of GPS satellites was not yet on orbit in time for the Gulf War, what we had available performed very well. Seven years earlier, we conducted tests using GPS and an F–4 to determine bombing accuracy from 10,000 feet, obtaining a Circular Error Probable (CEP) of between twenty and thirty meters. When the war started, the CEP was improved to about ten meters. However, only seventy-two Air Force fighters—F–16Cs and Ds—carried GPS. And only thirty-seven B-52s, twenty-one Rivet Joints, a couple of helicopters, and two Joint Stars had GPS receivers. The Army had installed seven sets on their U-21s. The Navy had ten installed on mixed aircraft. The Marines had none. Although we were really slow in getting this system up, the GPS worked wonders.

The Army was especially resourceful. Before the war, Colonel Roland Ellis, who headed Army Space Command, demonstrated GPS receivers to fellow Army officers in the field; he showed them what GPS could do and how to employ them. Although the Army did not recognize the value immediately, Ellis showed them how GPS could sight artillery with incredible accuracy and how to avoid getting lost in the desert and mountains. Thus, the Army was prepared to use GPS. The Army had 200 sets and the Air Force provided another 100. The Army used duct tape to put them on helicopters, tanks, and all manner of vehicles. They ordered 7,500 sets once the war started and, by the end of conflict, had almost 3,500 sets in the field. Soldiers also used a commercial receiver called Magellan; many were sent from relatives back home, so that the GIs would not get lost in the desert. (Capt. Scott O'Grady, our airman who was later shot down in Bosnia, had a commercial GPS receiver; he did not have a military unit.) GPS was used for everything imaginable. On the first night, Apache helicopters carried GPS receivers to position and launch their Hellfire missiles. Our tanks would not cross a mine field unless they had GPS receivers and coordinates for that field. GPS helped deliver Meals Ready to Eat to the troops out in the dunes.







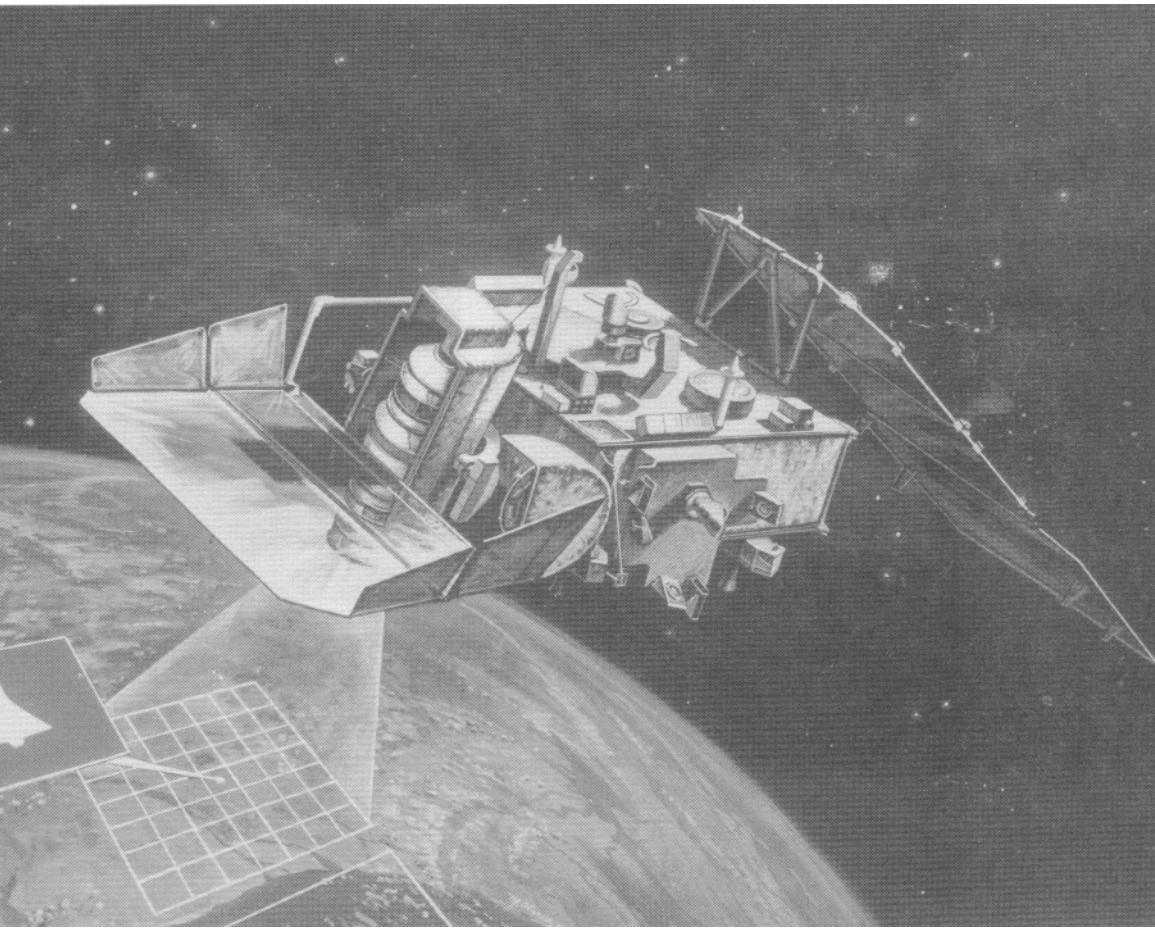


Another force enhancement capability, Multi-Spectral Imagery (MSI), involves taking pictures of the ground at different frequencies, providing images that the human eye cannot see. MSI is broad area surveillance, and we do not have systems other than short range, limited duration unmanned aerial vehicles that provide broad area data. One particular MSI image pointed out that Kuwait airport was off by a mile and a half from where it was shown on navigational charts. To counter such inaccuracies and produce better maps, the Army Space Command started using MSI photos of different areas where its troops were working. MSI brought out and showed in broad scale Saddam Hussein's tank traps, trenches, and other defenses, enabling U.S. forces to maneuver around them. In another MSI image, in a different frequency, one could pick out swamps that might not otherwise be seen. On the "Highway of Death," where the Iraqis tried to escape near war's end, we determined from an MSI image that they could not go into the fields; they had to stay on the highway. We cut off the highway and destroyed the forces.

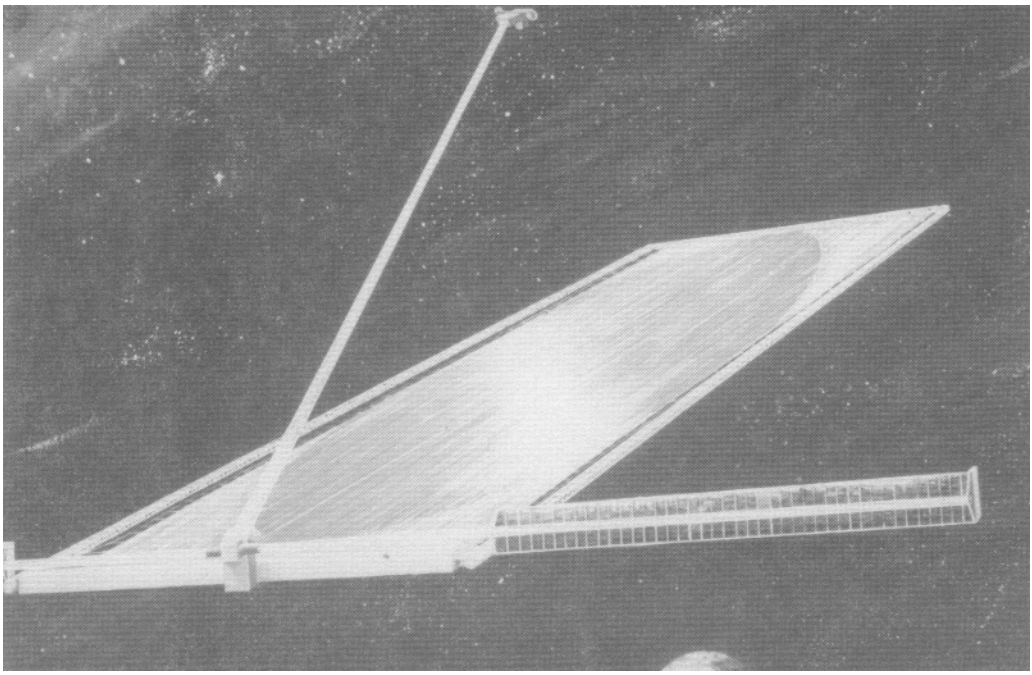
In yet another MSI image, the dark areas shown are sabkhats. To a tank commander, these appear as white sandy flats over which he assumes he can drive. However, underneath the sabkhats is deep water, in which a tank would sink up to its turret. Space systems helped us to see through the sand where these dangers lurked.

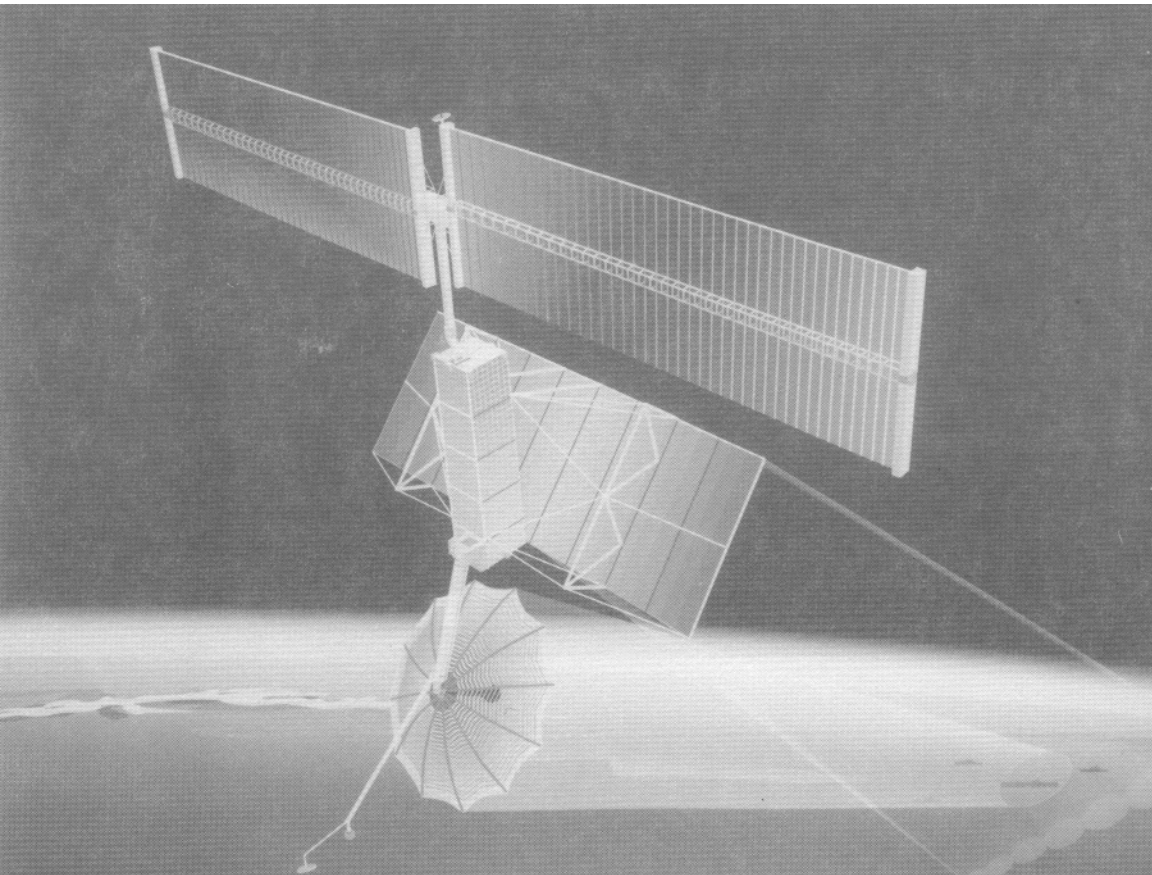
One limitation with respect to MSI was that LANDSAT came around only once every fourteen days. In the future we will obtain information from commercial satellites coming around more often. It was recently predicted that there would be more than thirty suppliers of MSI before the year 2000—some with radar resolutions down to one meter.

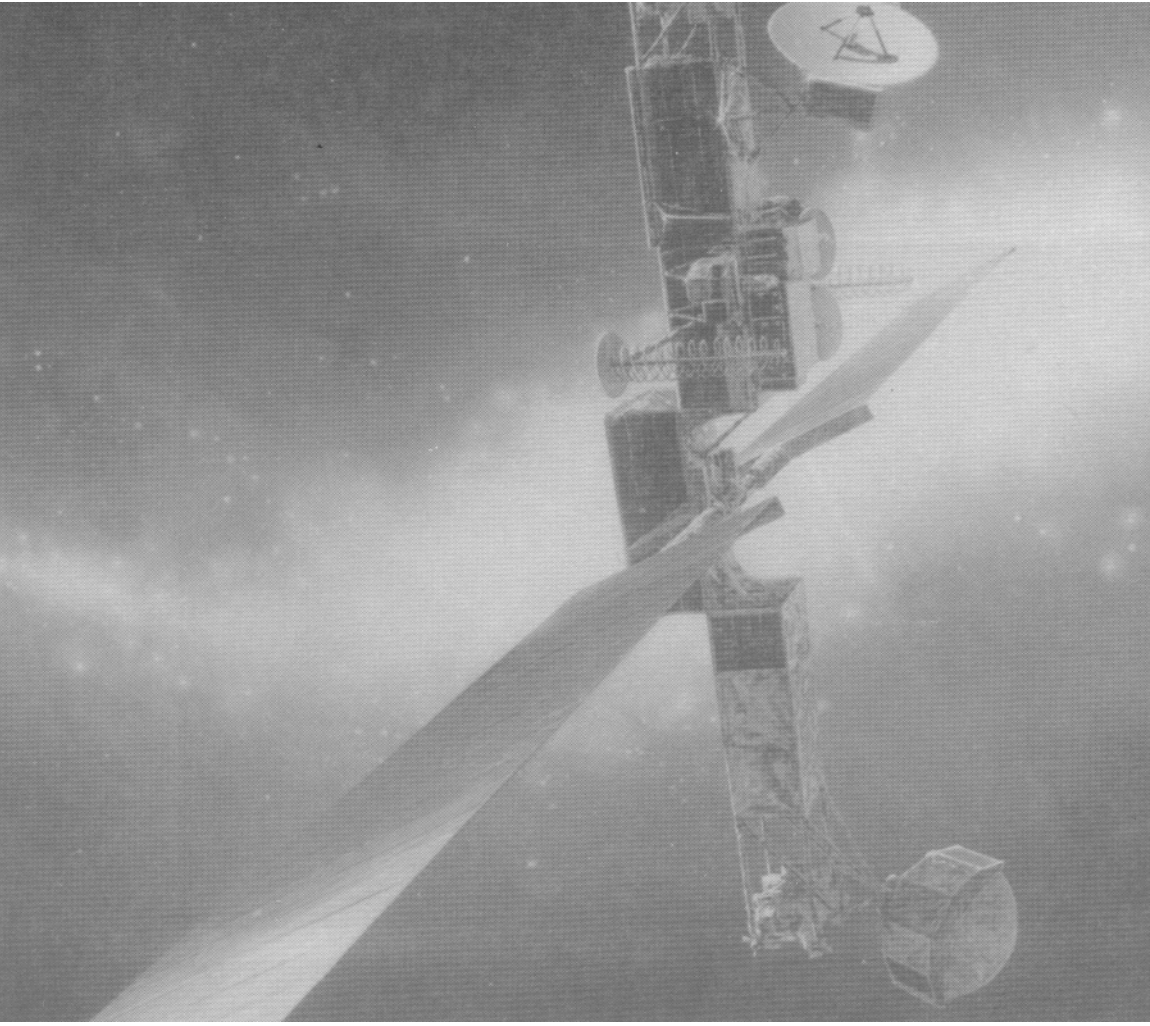

Kuwait City

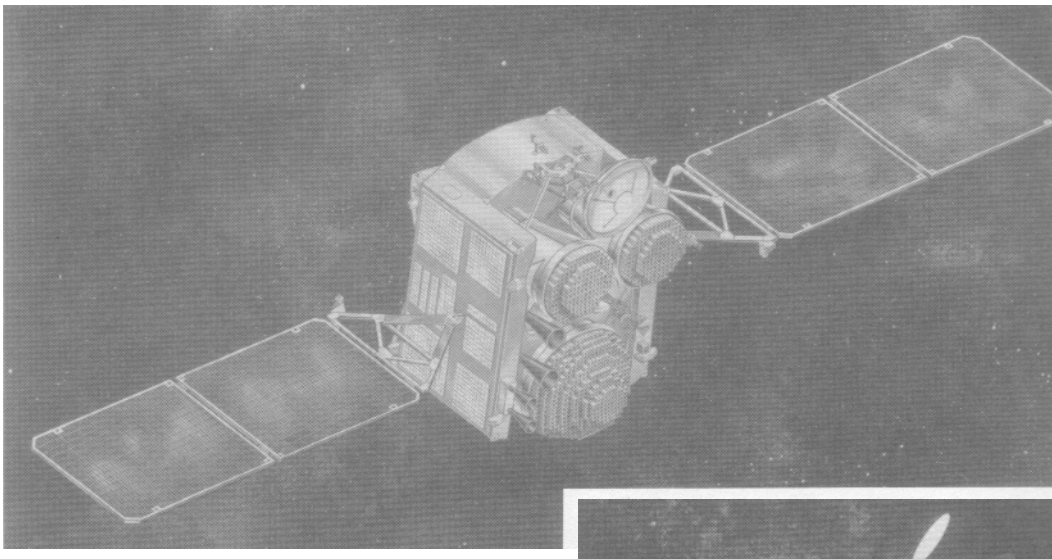


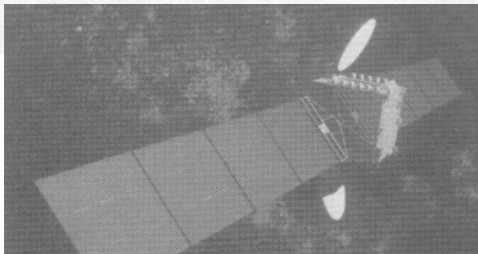
The "black world," represented by the National Reconnaissance Office (NRO), played a very important part in this war. Although the NRO was unjustly criticized for having faulty or inadequate intelligence, General Schwarzkopf enjoyed their highest priority. The difficulty was that we could not get it to him. We had a relocatable intelligence data receiver van, but we could not get it in-country for the same reasons the DMSP vans could not enter. A van did finally arrive in December; the war was to start January 17th. The van had a six megabytes per second transmission rate capability, but controllers only used one and one-half megabytes because the Defense Satellite Communication System (DSCS) was overloaded. There were so many pictures that providing intelligence was like going through a narrow 1.6 megabyte funnel. Then, when the data arrived, we could not distribute it properly because we lacked in-country distribution networks. In the future, everyone will have MSI imagery, although we might not want all to have it.

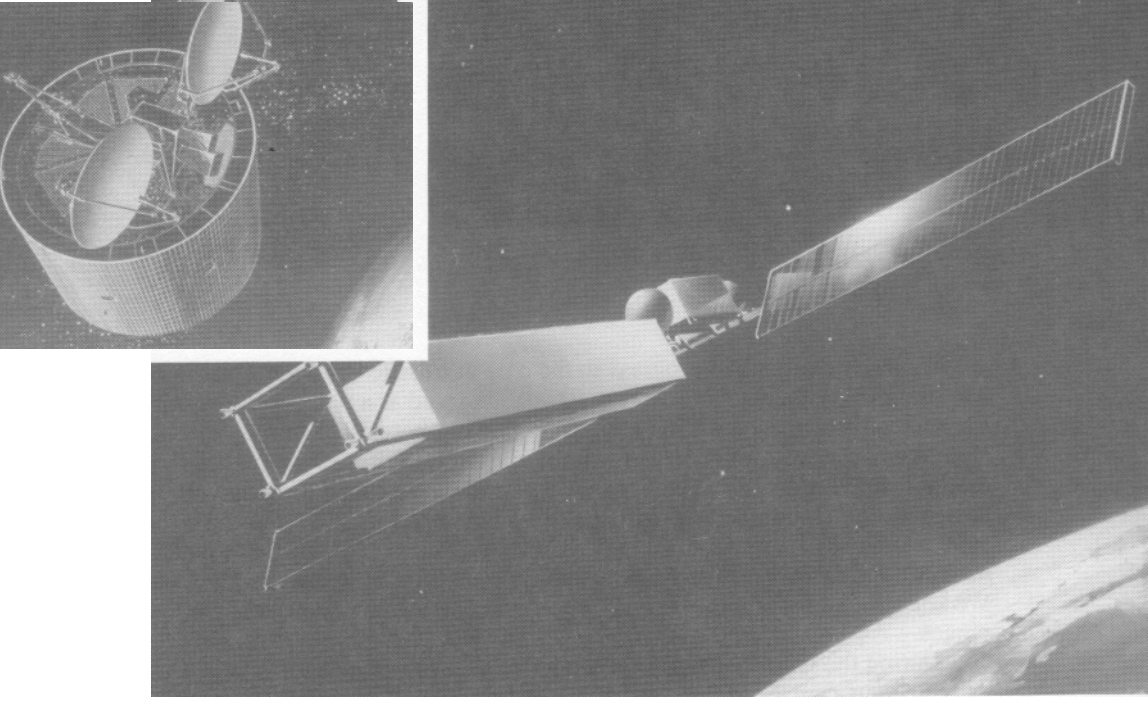










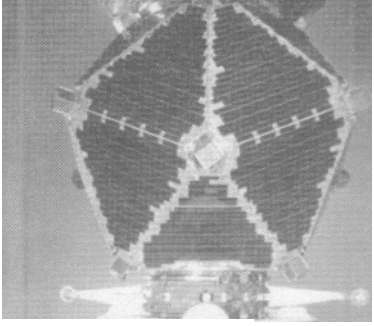


During the Gulf War, 90 percent of communications into the theater was via satellites. Many believe that, in the future, communications will be carried by fiber optics. We knew where the Iraqi nodes were, targeted all of Saddam's fiber, and took out his communications links. Among our different communication systems were DSCS with spot beams, which were very highly jam resistant; and the Navy FLEETSAT, which had a broad area of surveillance coverage, but was not jam resistant. While Saddam did not jam our satellites, our own transmissions did. Unfortunately, we did not have MILSTAR—a totally secure, jam free system; its terminal can be carried in a suitcase and set up in two and one-half minutes.

General Schwarzkopf needed total connectivity with his troops. Even though the Saudis had some in-country communications, most of Schwarzkopf's communications in-country was via satellites. The general's philosophy was to set up a mobile communications station, then move his forces forward with another mobile station. As soon as the latter was set up, the first was deactivated, and leapfrogged to the next position. Thus, Schwarzkopf had continuous communications connectivity throughout the conflict, and never lost it.

As for terminals, we had big twenty-footers for FLEETSAT, and small ones for unique applications. Our special forces went behind the lines looking for SCUDs using small, commercial INMARSAT terminals.

Since launch constraints were a problem, the answer was to use whatever was already on orbit. One can use commercial satellites to report routine data and military satellites for more critical functions. Cellular systems include Global Star, Iridium, and a couple of other commercial ones. These are free of DoD development funding and do not profit from the military, but from the civil market. Still, they are on orbit and we ought to factor them into our plans, because wherever our troops are in the world, day or night, twenty-four hours a day, they are going to see at least two of these satellites.

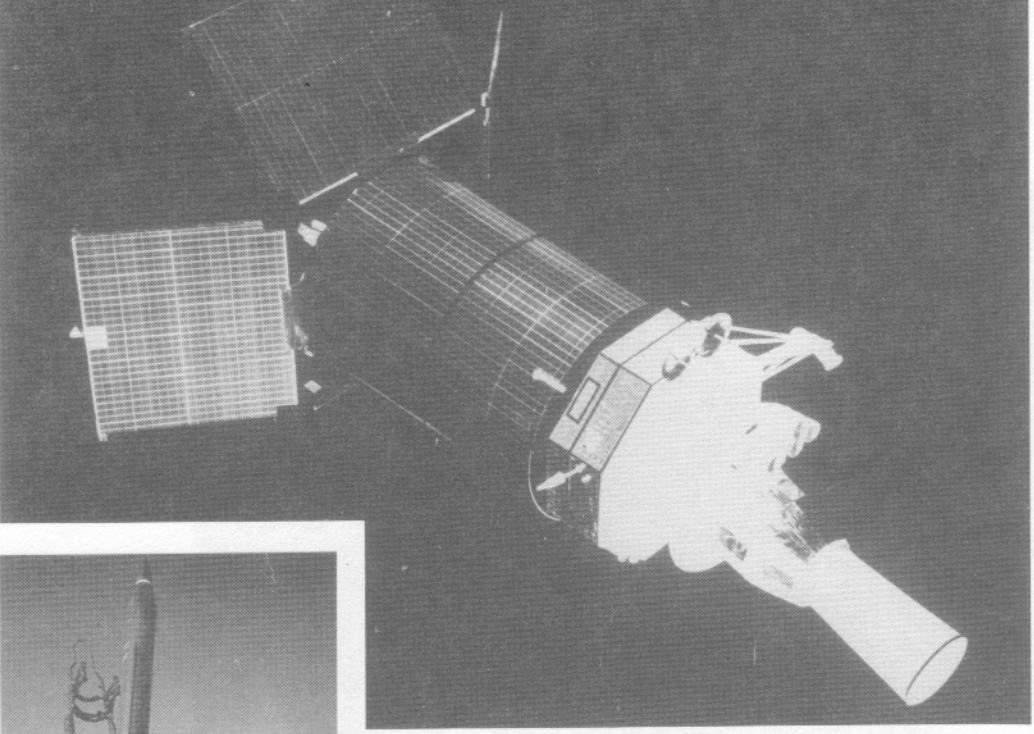


We made really good progress in the area of missile warning. The system was designed primarily for Soviet ICBMs and served as a wonderful trip wire. We had ballistic missile warning radars around our borders protecting the U.S. However, since we wanted to pick up missiles at launch, we had placed three or more DSPs on orbit. These gave us worldwide coverage. Although not designed for small tactical ballistic missiles, like SCUDs, our crews at NORAD and U.S. Space Command had tracked some 600 of these smaller missiles during the wars in Afghanistan, Iraq, and Iran, before the Gulf War. We knew their characteristics, what they looked like when launched, and their ranges.

During the Gulf War's air campaign, we declared that SCUDs were tactically insignificant, however, they were extremely significant politically. Every night we viewed scenes of SCUDs coming in, and after they hit, innocent men, women, and children being carried out. This got the American public's attention. It was very important we do something about SCUDs. We moved DSP, and took off dual coverage from other areas, and positioned DSP satellites to look down at Saddam. We had very good coverage. We were worried, however, about the vulnerability of our ground stations to terrorist attack. We had a half dozen pairs of mobile ground station vans in New Mexico and moved them to clandestine safe places. They could back up our fixed ground station, should a terrorist take one out.

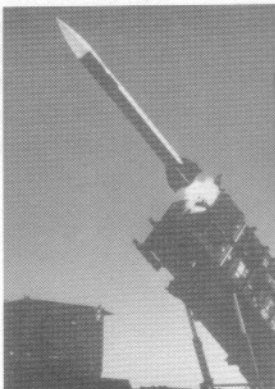
Missile warning has always had wonderful communications; but unfortunately, the communications centered on the strategic mission. NORAD and Space Command communications were designed to inform the National Command Authority of a Russian attack and to execute our aircraft, missiles, and submarines retaliatory force. We used those communications when the Gulf War was about to start. Saddam did us a great favor when he test fired three SCUDs on December 2nd. They were fired from east to west, toward Israel, but we knew they were going to fall short because of their range. Saddam wanted to see what he could do. We picked up all three, but when the first SCUD was fired, the console operator could not believe his eyes and did not report it. When we looked at the tapes afterwards, we saw it. We picked up the next two SCUDs and gave warning, which took about eight and one-half minutes to broadcast. A SCUD flies for seven and one-half. In effect, we told those in the target area that the blast they heard a minute ago was a SCUD. We worked on that.

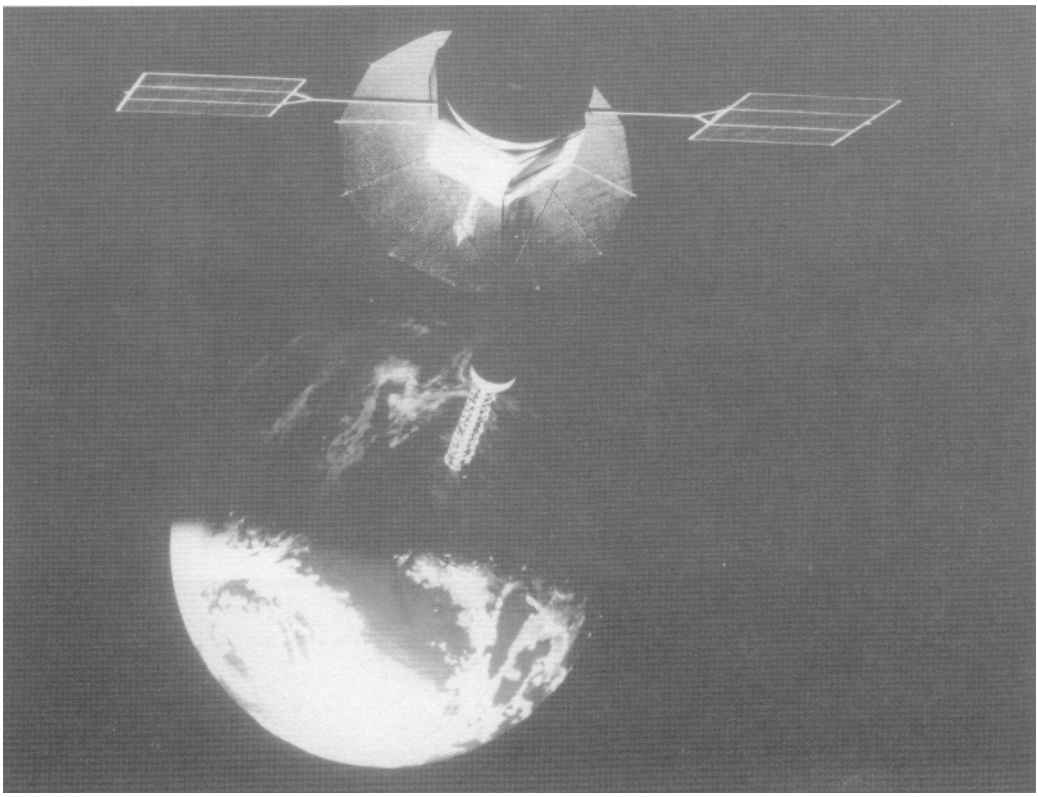
Another problem was locating Iraq's mobile SCUD missiles. We found what we believed may be a mobile launch site and tried to calculate how far and where a mobile SCUD would move over time after launch. Our fighters could search in these areas. Although we did not strike a mobile or transportable launcher during the war, we refined the procedures and will do better next time.







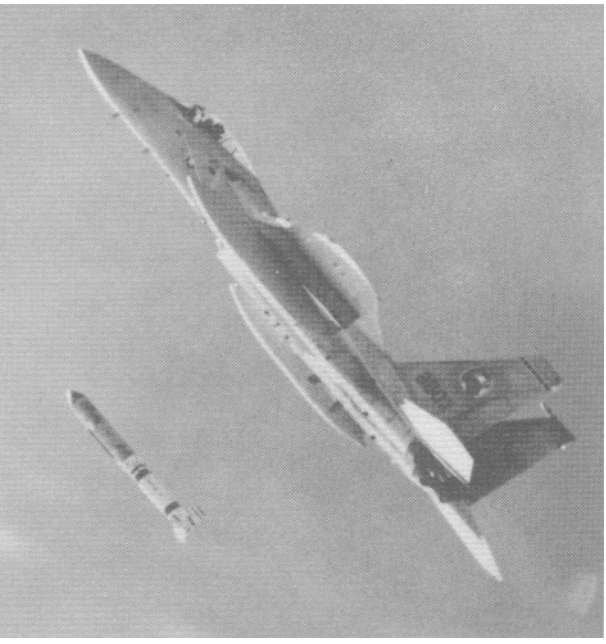


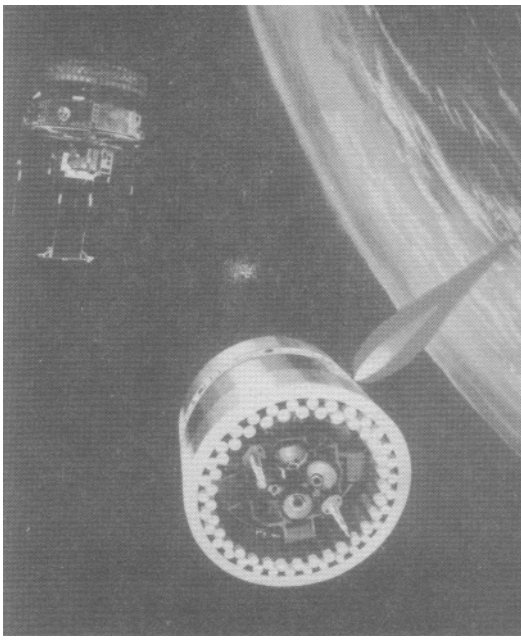


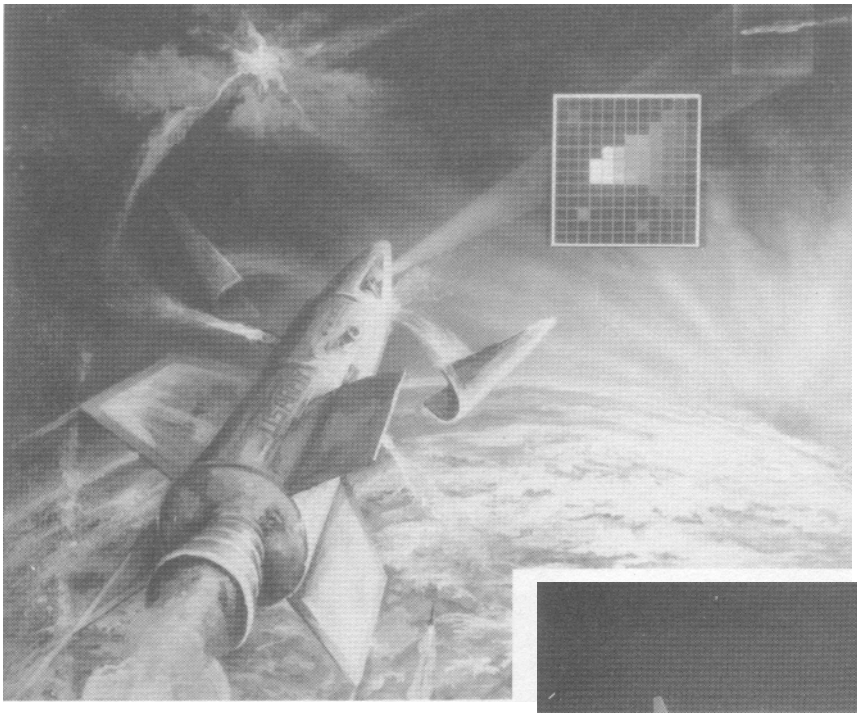
We received access to Strategic Air Command's worldwide communications network, which kept track of all their forces. Now, we could get SCUD warning from DSP. That allowed us to get warning of SCUD launches to the troops in Saudi almost at the speed of light. It worked perfectly. The troops on the other end had time and opportunity to put on chemical gear, and provided time for the Patriot missiles to arm up.

We executed well in SCUD warning because we had a "lock" on what was going on in space. We knew what the birds up there could do, their condition, their idiosyncrasies, and the best intelligence. Furthermore, we had seasoned professionals on the consoles, and that really counts. In the Tonkin Gulf incident, a misinterpretation of radar signals caused our ships to start shooting at each other, prompting the congressional resolution that led us into the Vietnam war. Before the Gulf War started, there were 400,000 Iraqis on one side of the border and about 300,000 American troops and allies on the other. We could not afford a Gulf of Tonkin type of false warning. I remember telling my people, "I can explain your missing the first missile. I cannot explain giving a false missile alert which causes retaliation, and then Bingo, 700,000 people are at war," because of it. We need professionals on the consoles.

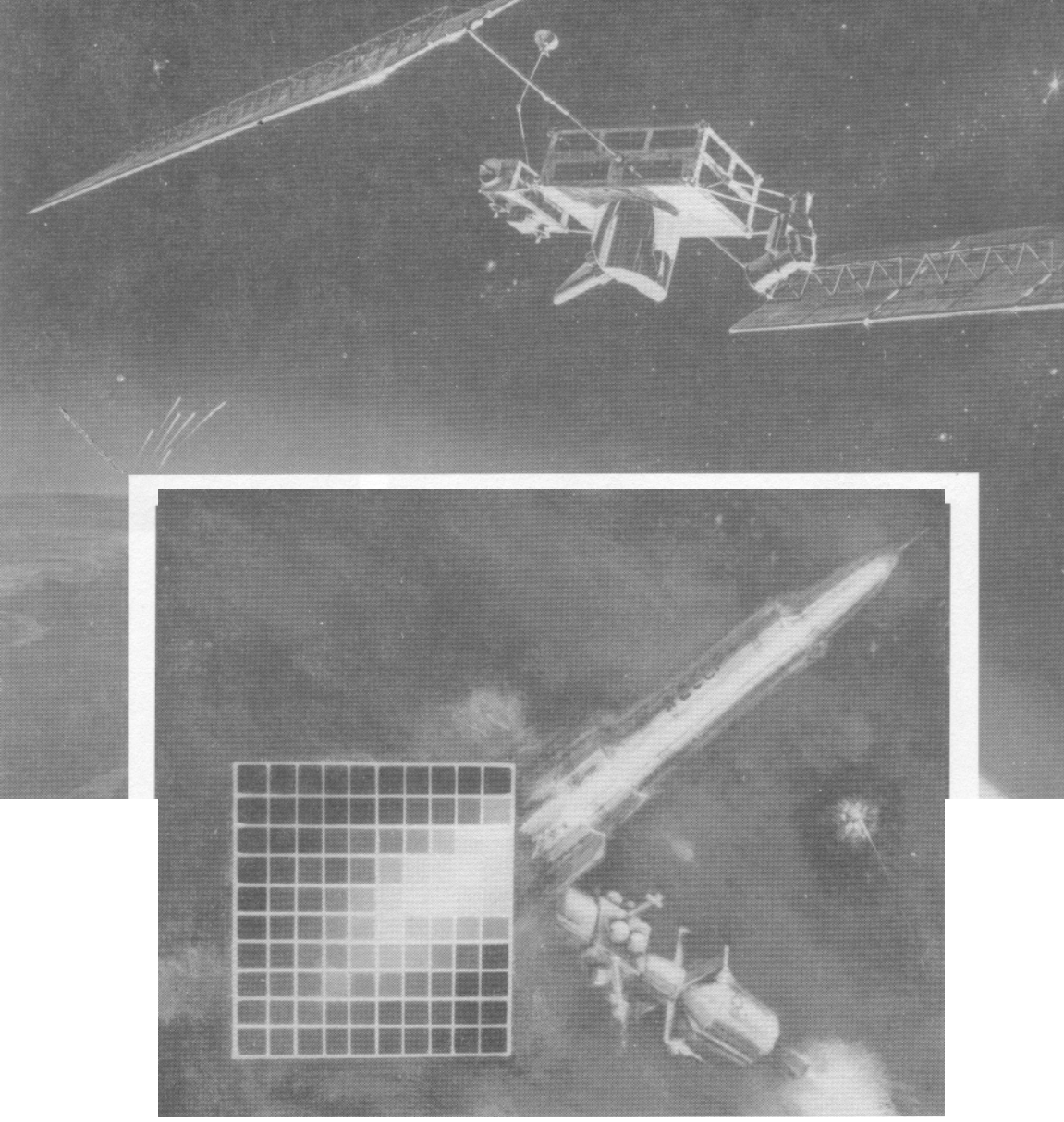






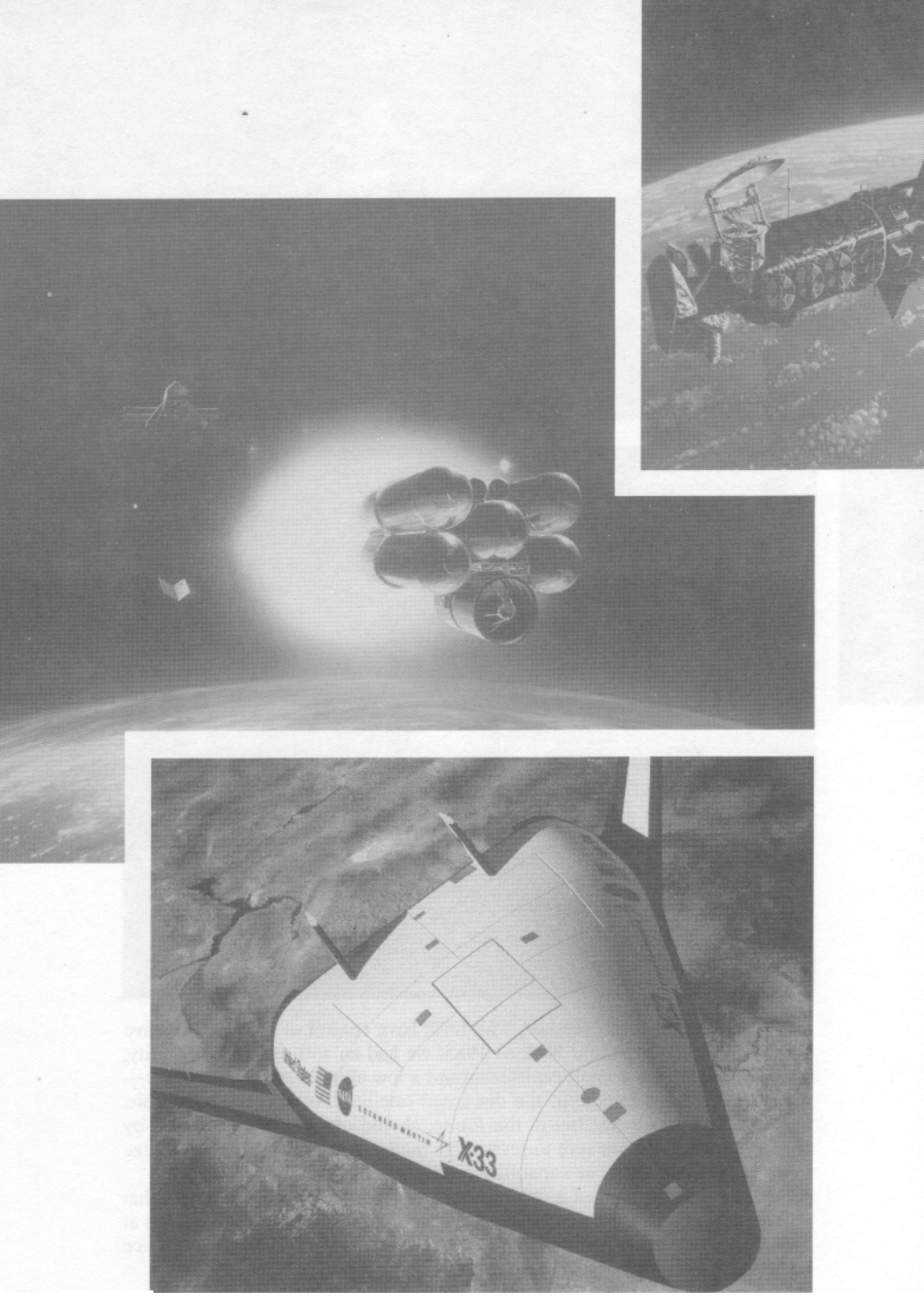


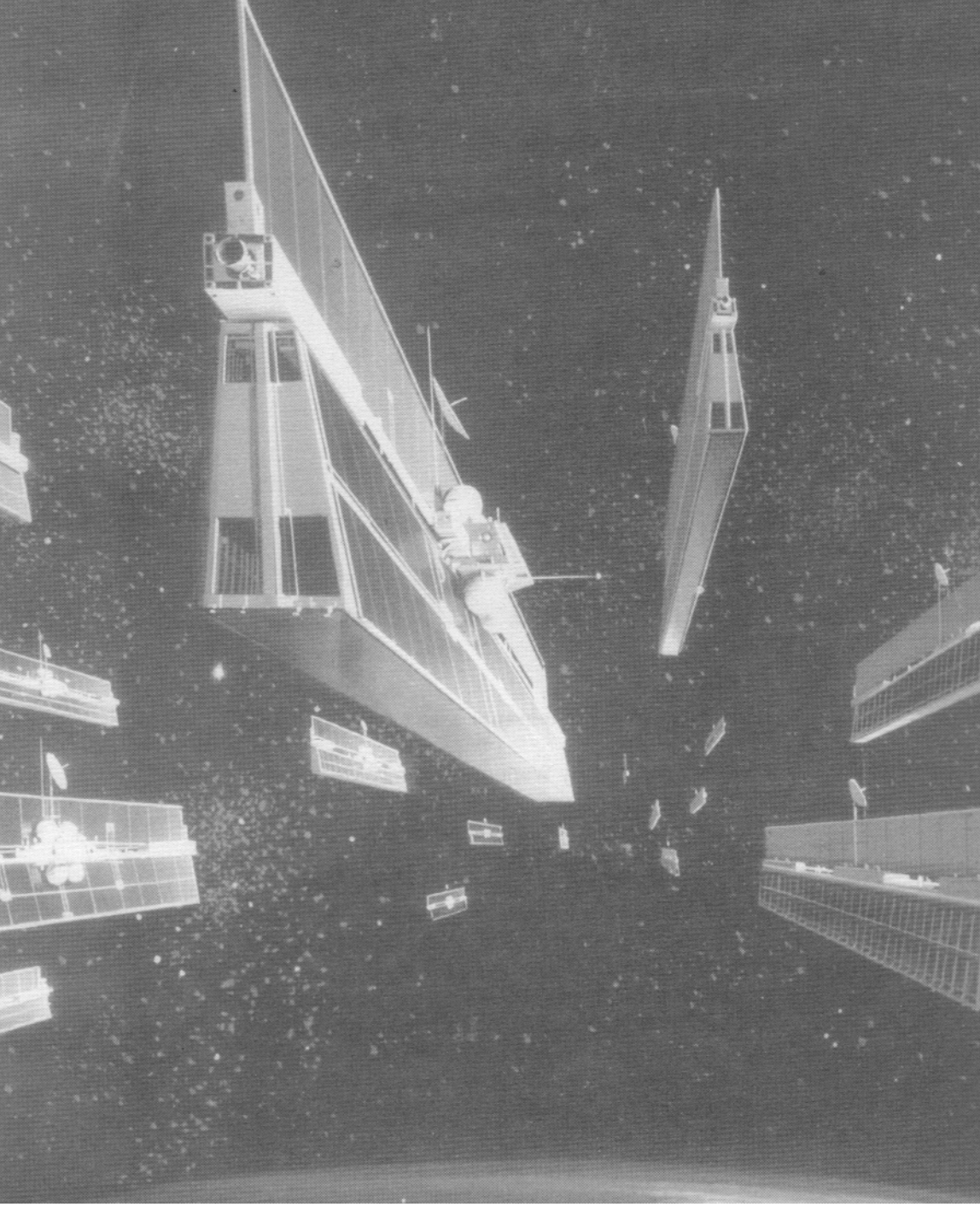




Gen. Bernard Schriever said, "We must have control of space as we have control of the seas." As far back as 1985, we had an anti-satellite capability, when an F–15 fired a small canister toward a low altitude satellite in space—the canister hit the middle of the discarded satellite. Political considerations preclude their use today, but in the future, should our forces be targeted by enemy satellites, we are sure to revisit this matter. Are we going to neutralize those satellites or not? The capability certainly is there, if we need it.

In the future, we need a credible missile defense. We have missiles that will destroy missiles. We need space-based sensors that can pick up SCUDs at launch. My favorite is Brilliant Pebbles. I would like to get to them from space because we would be over the enemy's territory.


United States
LOCKHEED MARTIN
X-33



Space must be ingrained into our planning and practice. We should have space courses in every school at every level. We must practice to use space systems. Unless we practice it in every exercise, it will not be used in war. I believe that our CINCs are starting to appreciate that.



Identification of photographs used on pages 103–126.

Page 103 Ballistic Missile Early Warning System (BMEWS) site, Thule, Greenland.

Page 104 (top center) Pave Paws radar installation.
(top left) BMEWS site 1, Thule, Greenland.
(top right) Consolidated Space Operations Center, Schriever AFB, (formerly Falcon AFB) Colorado.
(left center) the "Blue Cube," Onizuka AFS, California.
(right center) Space Surveillance Center.
(lower right) Rusting chiller at downrange tracking station.
(lower center) Millstone, New Hampshire

Page 105 (left) Interior view of remote tracking station.
(right) Deteriorating chiller at downrange station.

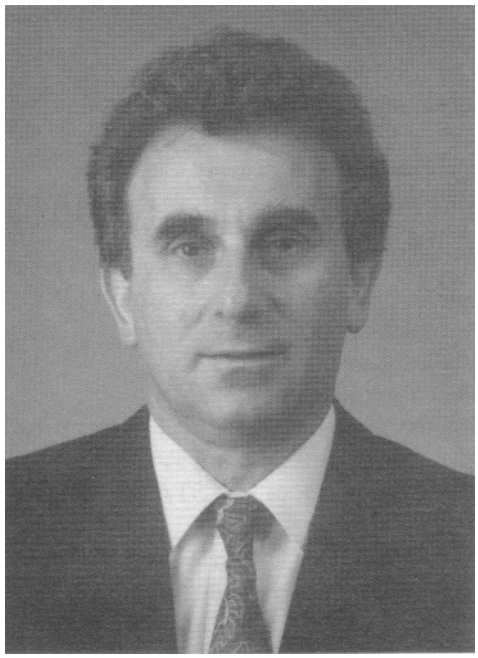
Page 106 (left) Launch of Space Shuttle Challenger.
(right) Launch of Atlas.

Page 107 (top left) Artist's concept of Titan II in flight.
(top center) Artist's concept of Titan IV in flight.
(top right) Artist's concept of Delta II in flight.
(center) Launch of Atlas Agena at Vandenberg AFB, California.

Page 108 Artist's concept of DMSP satellite.

Page 109 (top center) Artist's concept of early warning satellite.
(top left) DMSP photo of Iraqi theater on first day of Desert Storm.

Page 109 (lower left) MSI satellite photo depicting surface moisture.
(lower right) Mark 4 weather van.
Page 110 (top) GPS satellite, Block I.
(left) Mobile ground station.
(right center) Transpak GPS, small lightweight ground receiver.
(lower right) INMARSAT portable satellite communication receiver.
Page 111 (left) Magellan commercial GPS receiver.
(center) EHF suitcase terminal.
(right) EHF suitcase terminal packed in carrying case.
Page 112 Artist's concept of classified satellite.
Page 113 (top left) Interior view of Space Defense Operations Center.
(top center) Commercial communications satellite.
(right) Tank, guided by GPS, crosses minefield during Desert Storm.
(left center) MSI photo of Kuwait City.
(bottom) "Highway of Death," from Kuwait City to Basrah.
Page 114 Artist's concept of Teal Ruby satellite.
Page 115 (top) Artist's concept of L-band space-based radar.
(bottom) Artist's concept of space-based wide-area augmentation system (radar/IR).
Page 116 (top) Artist's concept of MILSTAR.
(center) Artist's concept of DSCS III.
(bottom) Artist's concept of Military Direct Broadcast satellite.
Page 117 (left) Artist's concept of DSCS II satellite.
(center) Artist's concept of MILSTAR satellite.
Page 118 Vela satellite.
Page 119 (top) Artist's concept of DSP satellite.
(left center) Scud missile readied for launch.
(center) Scud missile kill in Desert Storm.
(bottom right) Patriot missile launch.
Page 120 Artist's concept of Fleet Satellite Communication System satellite.
Page 121 (top) ERINT developmental kill.
(bottom) Space Surveillance Center.
Page 122 (top left) F-15 launches ASAT missile during test.
(top right) Artist's concept of ASAT kill vehicle.
(center) Artist's concept of THAAD kill vehicle seeker.
(lower right) Artist's concept of airborne laser.
Page 123 (top) Artist's concept of space-based surveillance system satellite.
(bottom) Artist's concept of LEAP kill vehicle sensor.
Page 124 (top right) Artist's concept of DMSP satellite.
(center) Artist's concept of Brilliant Pebble satellite.
(bottom) Artist's concept of X-33 space plane.
Page 125 Artist's concept of space-based radar distributed system.
Page 126 Titan launch facilities at Cape Canaveral, Florida.



Jacob Neufeld is a senior historian with the Air Force History Support Office. He was the Director of the Center for Air Force History from 1992 to 1994. Currently, he is editor in chief of *Air Power History*, the quarterly journal of the Air Force Historical Foundation. Neufeld earned the B.A. and M.A. degrees in history at New York University and did doctoral work at the University of Massachusetts, Amherst, and at the University of Maryland. He was an adjunct professor in U.S. history at the latter institution, as well as other colleges. Neufeld has authored and edited numerous works in military history and the history of technology, including *Development of Ballistic Missiles in the United States Air Force, 1945–1960*; *Reflections in Research and Development in the United States Air Force*; and *Makers of the United States Air Force*. He has also published histories on World War II and on the Vietnam War.

Mission Development and Exploitation An Overview

Jacob Neufeld

The Cold War was a technological war in which the United States and the Soviet Union used their respective national means and intelligence resources to monitor and stay abreast of the technical and military progress of their opponents. Space operations were on the cutting edge of this conflict, principally because they were so highly visible and symbolic.

I

Maj. Gen. David D. Bradburn, USAF (Ret.), reviewed the history of the evolution of military space systems, from RAND's preliminary 1946 report to Project Feed Back, which stressed the potential usefulness of reconnaissance satellites. His participation began in 1957 when he joined General Schriever's Western Development Division on the WS–117L Advanced Reconnaissance [Satellite] System. The Soviets' launch of Sputnik that year liberated funding for the American space effort. During the 1960s and 1970s Air Force Systems Command (AFSC) was assigned the task of developing space systems and facilities, keyed to day-to-day results and with immediate feedback of design information. In essence, the experimental satellites that were launched served also as operational systems, despite the fact that their capabilities continued to improve. General Bradburn noted that this acquisition process succeeded in that it allowed the Air Force "to go through a generation of design every year or so," and that the requirements process worked well, with the Secretary of the Air Force at the center. For the future, General Bradburn counselled that Air Force Space Command take a more active role in the requirements process.

II

Adam Gruen's thesis is that in the absence of clear missions, doctrine, or technology, political and economic forces dictate decision making. Moreover, the merits of any proposed space system must be measured against competing systems that might achieve the same objectives at less cost and risk. Created essentially as a research and development agency, the National Aeronautics and

Space Administration (NASA) became intent on placing humans into space to maintain public support. "What would humans do in space?" Gruen asks. Mulling over this question, he found that the interests of NASA and the Air Force eventually diverged. Thus, the Air Force sought to accomplish militarily useful things in space. The Air Force's traditional missions — surveillance and reconnaissance, interception, bombardment, and command, control, and communications — were suited to a space plane, such as the Dyna-Soar. However, Dyna-Soar was cancelled in 1963 because its development threatened to heat up the arms race. Similarly, political and economic considerations doomed the Manned Orbiting Laboratory (MOL).

III

John L. McLucas, a former Secretary of the Air Force and Director of the National Reconnaissance Office (NRO), reviewed the imperatives of the space program that furthered our foreign policy and security objectives. He credits President Dwight D. Eisenhower for much of the success of the American space program, noting that the President predicated our space policy on the "freedom of space," with the aim to achieve Open Skies that would benefit the U.S. and ultimately "all mankind." The major difference in policy between the two world powers was that, while the USSR assigned all space operations to its military, Eisenhower divided U.S. space operations between the military and civil sectors. Further, American military space missions were divided between "white" world programs, operated by the military services, and "black" world programs run under extreme secrecy by other specialized governmental agencies, including the NRO. The results, he believes, indicate that the American arrangement worked better because it was more competitive. In retrospect, McLucas observed, there was no "missile gap" that favored the Soviets, and the American missile and space programs won the space technology race.

Although the acquisition of space systems under the streamlined "black" world management certainly benefitted the American military, it had one serious drawback. Namely, that with the loss of responsibility for certain space missions, the Air Force also lost its enthusiasm for integrating space into its war fighting operations. Thereafter, through the 1980s, the Air Force was just not aggressive enough in pursuing space technology. Also, although the service entered the space arena to protect its roles and missions interests, it only gradually accepted the usefulness and indispensability of space systems.

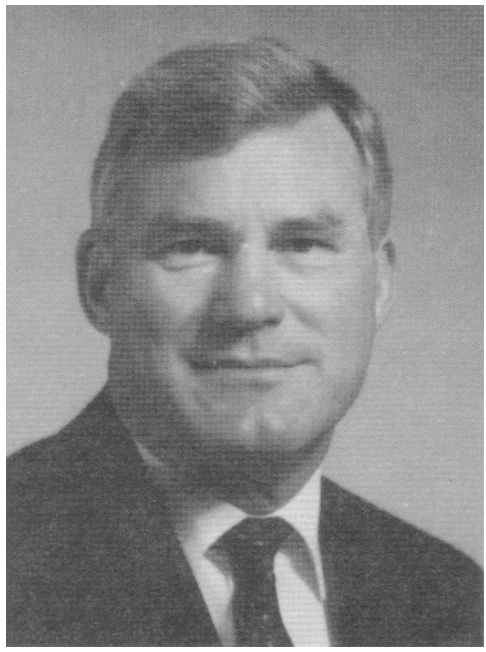
IV

Was the Persian Gulf War the "first space war?" According to Gen. Donald J. Kutyna, USAF (Ret.), the answer is that the Gulf War marked the first time that war fighters felt the effects of space on their operations. (Technically, he

defined a "space war" as the conduct of offensive and defensive operations in space.) Kutyna noted that American space forces were available in the Gulf before, during, and after the conflict — they were in orbit all along. Among the Air Force's space assets at that time — representing some 85 percent of DOD's space investment — were communications, weather, multi-spectral imagery, intelligence, navigation, and missile warning satellites. In addition to the satellites, the general noted that we must consider the launch vehicles used to deliver the satellites into space and the control facilities needed to operate the satellites. How well did these space systems fare? He reviewed the application of these systems during the Persian Gulf War in terms of their effectiveness, uniqueness, value in mission/support planning, and impact on the battle. He concluded that, despite their shortcomings, and there were many — including serious problems related to expendable launch vehicles, neglected support facilities, and equipment shortages — our space systems fared very well indeed. Perhaps more important, the utility of space systems has been established to the point where they have now become indispensable to waging war, much as airplanes proved indispensable in the Second World War.

Part III

Military Space Today and Tomorrow



Brig. Gen. Earl S. Van Inwegen III, USAF (Ret.), is Director for the Air Force/ Civil Business Unit in TRW's Data Technologies Division. He joined TRW in 1988, after twenty-eight years in the Air Force. A 1960 graduate of the Air Force Academy, he earned an M.B.A. degree in R&D Management from San Diego State College. He has over 5,000 flying hours as a command pilot and navigator, including a Vietnam tour. He later entered the space and technology arena, with positions in the Space and Missile Systems Organization, Headquarters USAF, and Air Force Space Command. During his USAF career, he worked in the Military Space Systems Division, and in 1992, he was Program Development Manager for the Spacecraft Technology Division and was responsible for SDI space programs. In addition, he has served as the International Military Space Systems Program Development representative as well as coordinator for all Space and Defense SDI programs. He was also the JCS representative to the Defense and Space negotiations in Geneva in 1985.

The Air Force Develops An Operational Organization for Space

Brig. Gen. Earl S. Van Inwegen III, USAF (Ret.)

In the early 1970s, space systems supported military operations in Vietnam, providing weather and communications especially. I remember Gen. Jerome O'Malley recounting about his return from a particularly harrowing mission up north in an RF–4. When he arrived back at the operations center at Ton Son Nhut Air Base in South Vietnam, he saw displayed on the table all these great overhead pictures of North Vietnam. Not surprisingly, he asked, "where did you get these? I just returned from a mission up there getting my butt shot off trying to obtain the same pictures in my RF–4." One of those present responded, "an SR–71 flew over and took them. The crew was not in any harm's way." Now you can say the same thing about satellites today. But in any case, to hear him tell it, that particular episode woke him up, and later O'Malley became one of our great unsung space advocates. There were also a lot of new capabilities emerging at that time: GPS navigation satellite system, the advanced DSCS communication satellites, the DSP missile early warning satellites, the Space Shuttle, and the space budget was increasing.

I

In 1974 the Commander in Chief of Aerospace Defense Command (CINC ADCOM) sent a letter to the Air Force Chief of Staff suggesting that there might be an opportunity for an enhanced space organization in Colorado Springs in ADCOM, which at that time was an Air Force specified command. I think that might have been the first formal step toward a space command, although I heard yesterday that some other steps were taken of which I was unaware. That was Admiral Burke's attempt to get a unified command in the late 1950s and early 1960s. The 1974 letter from CINC ADCOM to the Chief, however, may well be the first documented Air Force step.

Later in 1974, the Chief sent a letter to all Air Force major commands (MAJCOMs) asking their commanders three questions: Should there be a space organization? If so, whose organization should it be? Should it be an existing command? Should it be your command, or should it be another MAJCOM? The results proved inconclusive. In 1975 Brig. Gen. David Bradburn chaired the

New Horizons II study, which was primarily technically oriented. It did have some operational implications, however, because it described various space systems that could support the war fighter and it addressed some operational issues.

In early 1977 a space policy study looked at all of the space missions, classified as well as the unclassified white world space missions, and all of the functions associated with those missions from R&D right down to who utilized the data produced by the space systems. The study produced a huge matrix of systems across the top and functions down the side, and there was a color code for each organization involved in each of those functions for each of those systems. It became known affectionately as the Navaho Chart because of the many colors associated with the different functions and systems. To my knowledge, this was the first visual representation of how complex things were in space development and operations because you could identify the many organizations involved in the different functions of the many space systems that existed at the time. In February 1977 that study prompted a CINCSAC letter to the Chief which said, in effect, "something really needs to be done about this."

Gen. David Jones, the Air Force Chief of Staff at that time, had visited Colorado Springs and toured Cheyenne Mountain. He expressed concern about the number of people sitting around waiting for something to happen. In April 1977, he chartered a very close hold, small, special study group. I think there were only five people involved, headed by Brig. Gen. James Creedon on the Air Staff. The group was to look at how the service might eliminate NORAD and ADCOM. Because of the political implications of NORAD, with Canadian involvement, eliminating that organization was not a tenable option. The group concluded that the service should keep NORAD, but look at the ADCOM functions and organization very closely.

II

This conclusion prompted a second, somewhat wider but still closely held study that focused on ADCOM, which at that time held the air-defense, space surveillance, and missile warning missions. This study committee was headed by Lt. Gen. William Creech, who was the Assistant Vice Chief of Staff. Brig. Gen. Robert Herres was the deputy up at Electronic Systems Command (ESC), and he was quite involved in this study committee. Col. Pete Todd, now a retired major general, was the action officer of that committee.

About ten people were involved in this study: two from ADCOM, (I represented space surveillance and Tom Sawyer was the Air Defense representative), and other members represented SAC, TAC, Headquarters USAF, and Air Force Systems Command. We had an office right next to the Chief's office in the Pentagon. My boss did not know what I was doing. Every week I would have to come to the Pentagon for two days and work on this study.

We put together papers which were sent to ESC for General Herres to review. We worked at it and went through iterations for several months. General Jones would walk in and review things, especially our matrix. The matrix consisted of functions to be performed versus resources, and Jones picked the one that had the maximum number of functions that he judged had to be retained, but could be accomplished with the least resources. It was our job to mash the choices together into an organizational effort. We looked at air defense, space surveillance, command and control, the political issues regarding Canada and the United States, and potential dollar savings.

The final recommendation, published in what we called "the Green Book," was to disestablish ADCOM. The air defense assets would go to TAC, and the space surveillance and missile warning assets would go to the Strategic Air Command. A small Air Force air defense element would be retained to deal with unique situations in which there might be unilateral U.S. air defense activities in which Canada would not participate, such as air defense operations involving Cuba. There had to be an Air Force element to provide operational control (OPCON) over air defense in those situations. However, the space surveillance assets went over to SAC, and the missile warning OPCON was retained in Cheyenne Mountain in the Air Defense Center.

Needless to say, ADCOM took issue with this study, particularly Maj. Gen. Bill Burrows, the XP, Maj. Gen. Bruce Brown, the DO, and Gen. "Chappie" James, the CINC. General James, who was actually in the hospital at that time with a bad heart, had prepared and signed an extraordinary letter to the Chief; it was eight pages long. Let me read to you the first sentence of that letter: "I have strong objections to the approach, logic, appropriateness, rationale, adequacy, and accuracy of the study proposing reorganization of U.S. strategic defense forces." That was the first sentence.

After eight pages, the final sentence affirmed: "The study proposal, if approved, will not provide the commander, his subordinates, the United States Air Force, nor the nation, the responsive and responsible strategic aerospace defense required to support national objectives in agreed international commitments. I urge you not to submit it as a U.S. Air Force proposal." But hidden in the eight pages was another sentence that read: "The ADCOM proposal sustains an existing and qualified foundation for current and future operational management of expanding United States Air Force space operations." Shortly afterward General James suffered a heart attack and was removed as CINC. He was replaced by Gen. James Hill in December 1977.

ADCOM presented a briefing to Gen. Richard H. Ellis, who was CINC SAC, and members of his staff, a few weeks later in 1978. General Hill and a whole cadre of general officers were present in the war room in the Chidlaw Building in Colorado Springs. The presentation was called "Potential Pitfalls in the Reorganization of Space Surveillance and Warning Assets," and it outlined the concerns that the command had in transferring the space surveillance

and missile warning assets to SAC. The major issue involved combining the nation's offensive retaliatory strike force and the nation's early warning defense arm-like detailing the fox to guard the hen house.

We were in trouble at the beginning of the briefing when General Hill said to General Ellis: "Would you care to sit at the head of the table?" He accepted, and we knew that was the death knell. But the briefing was given. At the end of it, General Ellis polled the general officers in the room and asked them if they had any valid concerns in transferring these assets from ADCOM to SAC. Everybody said no except General Burrows, who was seated at General Hill's left. He was the last one to be polled, and he gave a rather poignant argument on why the transfer was ill-advised and should not happen. But his was the only voice in opposition and he was voted down at the time. Subsequently, the Chief directed that the Green Book recommendations be implemented. A small group remained at ADCOM that urged creation of a space organization based on the nucleus of assets and people in ADCOM.

This die-hard group prepared a briefing affectionately called the "Dead Horse" briefing, a term coined by General Brown. He observed that "you don't have to look into a dead horse's eyes to tell if he has died." We finally got that briefing up to General Hill, and it worked as a wake-up call. He finally realized that there was a valid need for an operational space organization. He became one of the champions of the proposal after that briefing. The staff officers, including Jerry May, persuaded him that a space organization was the way to go.

III

Studies continued. A Space Operations Steering Committee (SOSC) was formed under the XO at the Air Staff, XOXFD, that was the focal point. Shortly afterward, a study called the "Utility of Military Crews in Space," was completed in 1978. This was followed later in 1978 by a "Space Mission Operations and Planning Study," (SMOPS), in which Thomas Moorman and Robert Dickman were involved. Initiated on the Air Staff, it created an advocacy group, a cadre of zealots if you will, at the lieutenant colonel, major, captain, and colonel level who focused on making something happen in terms of an operational organization for space. SMOPS recommended designating the Air Force as DOD executive agent for space, and it offered five alternatives for conducting space activities, including an Air Force command for space.

In 1979, Air Force Manual 1–1, "Functions and Basic Doctrine of the Air Force," identified space operations for the first time as one of the nine basic Air Force operational missions, which led to Dick Henry's comment that, "space is not a mission, it's a place." Nonetheless, it was included. And about that time, the Defense Space Operations Committee was formed under Charles Cook, who was on the Air Force Secretariat staff. It was a Defense Space Operations Committee to pool the space elements of the other services.

A space division now was formed on the Air Staff in XOO, XOORS, which was a spinoff from the Reconnaissance Division down in the vault, down in the "F ring" of the Pentagon, in the basement. Space activities were no longer simply a component of the acquisition community. Incidentally, not many people know there is an F ring in the basement. It is under the GSA parking lot. When the GSA would wash the cars above, the water would run down the walls in the basement. But the focus in XOORS was on TENCAP, the Tactical Applications of National Space Systems, which had a congressional mandate. That mandate provided ten special compartmented intelligence (SCI) slots to the Air Force to work on integrating national capabilities into operational activities.

IV

Headquarters USAF, meanwhile, directed that the Green Book recommendations be implemented. The Air Defense resources of ADCOM transferred to TAC in October 1979. Then, on November 9, a watershed event occurred. An "untagged" test tape injected into operations at Cheyenne Mountain triggered a false alarm of a missile attack. It prompted a false alert that caused something of a national furor. I was at the Air Staff at that time, and Saturday morning I was called into Gen. Lew Allen's office to explain what happened. Though the details were as yet unavailable, at least we got people to understand some of the early warning functions and how the troops operated at NORAD.

In December 1979 the space and missile warning assets transferred from ADCOM to SAC, and Gen. James Hartinger replaced General Hill as commander at NORAD. About the same time, Hans Mark replaced John Stetson as Secretary of the Air Force, and in March 1980 ADCOM was formally disestablished as a specified command. The Green Book recommendations had been implemented, and that appeared to be the end of it.

On June 3, 1980, however, another missile attack false alert occurred in Cheyenne Mountain, this time caused by some bad chips in one of the computers. But this false alarm triggered numerous investigations and studies, some of which focused on the fact that ADCOM had been pulled apart. They generally found that insufficient emphasis had been placed on what was one of the most critical missions of the U.S. military space program, missile early warning and deterrence.

The Air Force Scientific Advisory Board next conducted a "Summer Study on Space" in 1980. It basically found that the service had been successful over the last fifteen years in conducting space operations, but concluded that "currently, the Air Force is inadequately organized for operational exploitation of space and has placed insufficient emphasis on inclusion of space systems in an integrated force study."

Air Force Systems Command, which had charge of space operations, then established a Deputy Commander for Space Operations, which at that time was

Maj. Gen. Jack Kulpa, who was director of SP and also the Deputy Commander at SAMSO. General Kulpa subsequently headed a space launch and control definition study that eventually resulted in the Consolidated Space Operations Center (CSOC).

V

Enough studies had been done, and now it was time for action. We had parallel space activities going on at the Air Staff, at ADCOM, at SAC, and at Air Force Systems Command. The focus shifted to establishing in the Air Force an operational organization for space. In 1981, the service decided to put the CSOC in Colorado Springs. Lt. Gen. Jerome O'Malley became XO on the Air Staff, and actively supported the concept of a space command. Another unsung heros in these events, whose name is rarely brought up, was Maj. Gen. Jack Chain. He became the XOO down in the basement of the Pentagon.

At General O'Malley's first staff meeting as XO, he asked the staff to come up with the key things that XO had to do to move the Air Force forward. The first one, of course, was to ensure that we were equipped and trained for a strong strategic deterrent posture. But the second one was that the Air Force was improperly organized for space operations.

General Chain brought that issue back as the XOO and called his space operations mafia together. Chain told them, "I want you to put together a briefing on a proposed space organization and the rationale for why it should be in the Air Force and why it should be a separate command." He continued, "I'm going to call it 'the Fester Briefing' because I'm going to put it on General O'Malley's desk and it's going to sit there and fester until he does something about it."

Meanwhile, Gen. Bennie Davis, who had no hand in the previous events, replaced General Ellis as CINCSAC. Gens. James Hartinger, CINCNORAD, and Thomas Marsh, Commander of AFSC, got together to discuss raising the issue of a space command at a Corona conference. The Air Force Directorate of Space (AF/XOS) was established in September 1981 to provide a focus for space affairs at headquarters. Craig Covalt, an *Aviation Week* reporter, came down and said, "I'd like to get a little background information. I've been primarily dealing in the civil space matters, but what is this Directorate of Space?"

We talked to him for a while, and he said, "This will just appear as a few sentences in the front of *Aviation Week*." Well, it turned out to be a full-page article, and he sent us a copy with a note that said, "I hope I didn't do anything untoward. Your comments were for nonattribution."

But there was a comment in the article that "The Directorate of Space was formed to dispel Air Force attitudes that tended to view space as R&D and not operations." That comment caught the eye of Gen. Lew Allen, who was the Chief of Staff, and he reportedly said, "If that's what the space cadets in the basement think, they'll never get out of the basement of this building!" General

O'Malley was not amused either. That same month, in September 1981, SAC XP recommended to the CINCSAC that the space assets be returned to ADCOM. Then in October, the first annual Naval Space Symposium was held in Monterey, California, and that was a real wake-up call for the Air Force when its leaders saw what the Navy was thinking of doing in space.

Brig. Gen. Tom Brant on the NORAD staff took a trip to SAC and happened to discuss these events with General Davis. In reference to returning the former space assets to ADCOM, Davis said, "What we have to do is figure out how to walk the cat back." Shortly thereafter, a SAC message advised ADCOM that a SAC committee was reviewing organizational relationships between SAC and ADCOM. It suggested that ADCOM conduct a similar review and then have a joint conference to bring the results of both those studies together.

About this time, Air Force Under Secretary Edward C. Aldridge gave a speech at the American Astronautical Society, in which, for the first time, he stated publicly, "I believe the right answer may be to form a space command to operate our satellites and launch services," a very prophetic comment. Ken Kramer, the U.S. Representative from the Colorado Springs area, introduced a bill to change the name of the Air Force to the Aerospace Force. Air Force Secretary Verne Orr, though unenthused about changing the service's name, recognized that it might be advisable to create a space command.

VI

In January 1982, SAC and ADCOM representatives got together in Project Cat Walk to discuss ways of "walking the cat back." Also in January 1982, The GAO issued a report that criticized the DOD for poor management of space systems. The report recommended a single manager for military exploitation of space, identified the CSOC as potential nucleus for a future space force or future Space Command, and recommended withholding funding until DOD came up with an overall plan for the military exploitation of space.

An Air Force Planners Conference was held the following month, in February 1982, at which Brig. Gen. Neil Beer, the XP at ADCOM, gave a briefing on the rationale for a Space Command. That same month, at the Corona South meeting, General Marsh the AFSC commander, presented a proposal for a reorganization of space activities. In essence, he said, "There is not enough interface between designers and users. We should 'dual hat' the commander of Space Division as the commander of the Space Command."

Consequently, Air Force Chief of Staff General Allen directed Generals Hartinger and Marsh to get together and study the issue and make recommendations by April 1982. They formed two working groups, one at ADCOM and the other at Air Force Systems Command. Then the Secretary of the Air Force sent a letter to the Vice Chief asking for a review of organizational options for space, with a recommendation submitted to him before the summer of 1982.

Finally, we got the Fester briefing to General O'Malley at XO. Lt. Col. Vito Pagano was the spear catcher in this exercise. The rationale that we presented at that time was that we needed to get the R&D flavor out of space and get the operational flavor in, and General O'Malley came unglued. He used one four-letter word four times in one sentence which I had never heard anybody use before. Anyway, he listened. General Chain was not there. He came in late, so we caught the flak for the O'Malley briefing. There were a lot of points of contention between operations, non-engineer operators, and R&D. I remember Brig. Gen. Ralph Jacobson, AF/RDS, came down and got a briefing on TENCAP. "You'll put non-engineers in those space operations positions over my dead body," he declared. Bill Savage remarked, "Well, we've got two for one in this case."

There were a lot of concerns about that issue. Leaders of NASA, SAMSO, the NRO, and AF/RDS all expressed concern about placing non-engineers into operational positions. Above and beyond that, the name change was an issue. The complexity of space systems was an issue. The transfer of assets was an issue. Operational control was an issue. Resource management was an issue. The interface with the national space communities was an issue. The NORAD interface was an issue. The unified versus specified command was an issue. Advocacy was an issue. And wartime operations for space was an issue.

VII

General O'Malley visited Colorado Springs on April 15, 1982, and he saw a chart that showed a Space Command organization that General Hartinger had. The Air Force Secretary, you recall, had asked for a reply on this matter before summertime. A subsequent meeting took place among Hartinger and Marsh and the conspirators on the Air Staff. At the end of this briefing, Hartinger pulled out the chart that earlier he had shown to O'Malley. That chart showed an operational Space Command. O'Malley had said, "Yes, that's it. That's what we need." It happened to be Hartinger's birthday.

The Space Operations Steering Committee — which had been formed on the Air Staff — was then assigned to refine the organization and develop the transition. It took all the previous plans, briefings, and studies and merged them into an action plan that contained basically three options: an ADC option, an AFSC option, and Gen. Russell Dougherty's option, which provided for a Space Command headquartered in Washington, D.C. The evaluation criteria employed were military effectiveness, improved efficiency, and feasibility of implementation.

At this time Gen. Charles Gabriel became the Chief of Staff, with O'Malley as the Vice Chief, and Chain as the XO. In the transition plan, one of the key issues was creation of a specified versus a unified command. The paperwork was written very carefully to mention a joint command without mentioning

either term in the hope that the new space command would evolve into a specified command. Vito Pagano took the transition announcement of the formation of Space Command up to O'Malley's office and waited for him to approve it. About twenty minutes later O'Malley came out arm-in-arm with VAdm. Gordon R. Nagler. On the bottom of the announcement about the formation of Air Force Space Command, O'Malley had penciled in, "It is the Air Force belief that the Air Force Space Command will develop quickly into a unified command with the Navy, Army and Marine Corps."

We took it up to General Chain, and he was livid. I found out the other day that Gen. Tom Moorman, who was a colonel at ADCOM when the public announcement was read, exclaimed aloud, "What idiot made that change in the public announcement?" Gen. Bruce Brown, NORAD J3, motioned him aside and said: "It was General O'Malley." Needless to say, there was a lot of emotion all around. But on June 21, 1982, the service announced that the Air Force Space Command would be activated on September 1, 1982. That outcome, in my view, was a victory for the operational forces in the Air Force.



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The Air Force Civil-Industrial Partnership

Edward C. "Pete" Aldridge

My topic is the partnership between the Air Force, the civilian industrial sector, and the civil space missions. It is a timely, interesting, and challenging topic, especially in the post-Cold War times that we are facing today. I will start with some fundamental observations about this relationship.

First, essentially all of our space systems are being supplied by the commercial aerospace industry, some of them supplied under contract to the government, some under contract to another commercial organization, and some built and operated directly for economic profit. There are a few exceptions to this generalization. These exceptions mostly involve prototypes or experimental payloads, special launch vehicles, or elements of ground stations that are designed and built in government facilities.

I

A constant national security imperative will call for the development, acquisition, launch, and operation of militarily unique space systems. These systems will be augmented with capabilities obtained through commercial procurement or through commercial services to meet some military requirement. This combination will ensure that the Air Force and the Department of Defense always will have a strong and lasting relationship with the aerospace industry in the United States.

The imperative for civil space activity, on the other hand, is obtained through the vision and efforts of our national leaders. Therefore, the nation's support for the civil space program is likely to be variable, depending upon the political, domestic and economic imperatives of the day. This would imply that the relationship between the aerospace industry and the military, as they support the civil space program in the future, is likely to be uncertain and based upon the case-by-case needs of the specific civil space program.

In the 1960s and the 1970s, as you have heard, these space community relationships were dominated by the military threat from the Soviet Union. The U.S. military space program was aimed at providing vital reconnaissance, missile early warning, and communications. It was driven by the build-up of the nuclear and military capability of the former Soviet Union. Indeed, a few weeks

ago, on August 18, 1995, we celebrated the thirty-fifth anniversary of the first photo taken from space and returned to Earth from a CORONA spacecraft.

The civil space program in these two decades was driven by considerations of international prestige, a desire to reassert American technological leadership, and the expressed intention to beat the Soviet Union in a "race" to the moon. The commercial space program was just emerging, based largely upon the technology developed by the military services in launch vehicles and communication satellites.

During this period, the U.S. military and civil space programs evolved side-by-side, but they were mostly "stovepiped," with little sharing of technology between the two communities or even within and among the military services. The National Reconnaissance Office (NRO) represented one stovepipe, while the military space projects represented other stovepipes. However, I contend that even within the U.S. Army, Navy, Air Force, and later on even in the Strategic Defense Initiative (SDI), the space activities of each were insulated from one-another and from other parts of their own services.

The aerospace industry supported both the military and civil space communities, but a great wall existed between the two space programs because of security requirements and for other reasons. Reliability problems prompted the government to enforce military specifications and standards on the space contractors. You will recall that we had many losses of satellites before we obtained the first complete CORONA success from launch through orbit to recovery of a film capsule on Earth. Can you imagine a space program today sustaining many successive failures and still continuing with the support of the President, the Department of Defense, or Congress?

II

The 1980s saw fundamental changes. Military space capabilities expanded, adding operational weather and navigation satellite systems with significantly improved military capabilities. The SDI mission was added in 1983. The concept of a protracted nuclear war introduced extreme demands on space satellite design and reliability requirements, and it markedly increased cost. Meanwhile, a national "Shuttle-only" launch policy forced the military space program to depend upon the manned civil space launch vehicle, and to optimize military payloads to meet the Space Shuttle size and weight-lifting capability.

This combining of civil and military launch operations was really a "shotgun" marriage. I attempted to learn why the Air Force agreed to this wedding, and the only rationale I could find was that Air Force leaders unquestioningly accepted the policy because they were betting on the lower launch costs promised for the Shuttle. This approach would free more funds for purchasing satellites, and any launch uncertainties could be offset with more redundancy on-orbit. Commercial satellites, however, either had to use the Space Shuttle or

foreign-built launch vehicles, and many of the commercial payloads began to transfer to the French Arianne expendable launch vehicle (ELV). Commercial space technology trailed significantly behind the military space technology.

During this period, military space operations came into its own with the creation of the military space commands. The military space budget expanded and new missions and capabilities appeared — all driven by the Soviet threat and a worldwide proliferation of high technology weapons. I recall a busy time in the mid-1980s, with numerous programs and many dealings among the military services and industrial contractors, as we developed new capabilities and made block changes to our satellite designs. Of course, the one major event, the loss of the Space Shuttle *Challenger* in January 1986 reopened ELV production lines and recreated a commercial space launch potential for the U.S. industry.

But foreign launch vehicles had already captured a significant market share, and this was the "dark age" for our launch capability. In addition to the *Challenger* accident, we had lost two Titan–34 ELVs in a row, as well and an Atlas and a Delta; even an Arianne had a launch failure. As you will recall, the Space Shuttle fleet was grounded for about three years while we converted shuttle-optimized DOD payloads to ELVs, and the commercial satellite people increasingly moved to Arianne. Some of you may not know it, but the cost of that transition from the Space Shuttle back to an ELV capability for the Department of Defense amounted to about $16 billion.

III

The environment of the 1990s is different. The Soviet threat no longer exists and has been replaced by a worldwide potential for conflict with lesser nations, some of which control weapons of mass destruction. Continued demands are placed on the military's space capabilities, with a new emphasis on what is called "information warfare" — driven by the demonstrated benefit of the information dominance on the battlefield in Desert Storm. In 1991 we fought, as some people have said, "the first space war," but I am reminded that it was the first "space applications war" against Iraq.

Commercial technology today, with few exceptions, equals military technology. Certainly, the downsizing of the defense industry is affecting the industrial base for space. Mergers and acquisitions dominate the attention of our industrial leaders. We nonetheless have stability in the space budget. In fact, the space budget is one of the few activities in the Department of Defense that is not declining. But we nonetheless see a significant decline in the public and Congressional support of our civil space budget. There are urgent calls inside of Congress and elsewhere to cut the costs and complexity of all our space systems — military and civilian.

Meanwhile, commercial and international space activities are on the rise. In fact, I would say they are "exploding." The information technologies open

tremendous opportunities for new global communication missions for the space industry. If successful, these systems will place extreme demands on our launch industry to put them in orbit. I will say the space launch industry in the recent past has not kept pace with the satellite industry expansion, and this has given rise to shortfalls in launch capacity in the near term. I spoke with an executive of Hughes Space Systems the other day, and he has a satellite ready to go but cannot find a launch vehicle that he feels he could fly within the next two years.

We are beginning to see the development of new launch vehicle concepts, but they are probably several years from maturing. Meanwhile, we will continue to limp along with less efficient and more costly space launch systems than we are capable of building. I am encouraged by the award of the new evolved expendable launch vehicle (EELV) contracts that offer us a chance to improve reliability and responsiveness, and to lower costs for space launch in the next several years.

IV

We are beginning to remove the stovepipes in space activity with the declassification of the NRO, the move of all weather satellites to NOAA, and with NASA given responsibility for reusable launch vehicles. Of course, the International Space Station is a classic case of cooperation, and we have a new DOD Space Architect who is seated at the space community table. We expect and hope that he will remove the stovepipes that remain.

Each space nation is increasingly dependent on others for success in space. This development is something new. The French Arianne, the Chinese Long March, and other vehicles launch U.S.-built satellites. Arianne 5, the Japanese H–2, and the Russian Proton likely will support the International Space Station, in addition to the Space Shuttle. The American Delta and Atlas are launching satellites for foreign countries. So we are all dependent on each other for success to get to space. Moreover, attainment of higher reliability in performance coupled with a need to reduce space systems costs would suggest less government oversight of contractors, relaxation of military specifications and standards, and the expanded use of commercial practices and procurement.

But one size does not fit all. We need to ensure that we do not throw out the lessons of the past for some perceived near-term and short-lived benefit. Selected and tailored application of the principles of acquisition reform make sense. Nonetheless, we need to be very selective in the use of new acquisition reforms for high cost, high capability systems procured in limited numbers. Our approach to managing acquisition of the Global Positioning System (GPS) would be significantly different than that for MILSTAR. We could afford a failure of a GPS satellite. We could not afford a failure of a MILSTAR satellite.

V

What does the future hold? We will see the dominance of commercial space technology emerge, where the DOD will be a minor player and not influential in the electronics and information technology marketplace. Stovepipes in military and civil programs will be removed. Sharing of technology, dual-use systems, and the integration of military and civil systems to meet military needs will become commonplace. The military will look to commercial organizations to supply commodity-like space capabilities and services, such as communications, for the majority of its missions. Only a few unique missions remain that will continue to be supplied under contract directly for and to the military.

We may see the beginnings of a move toward acquiring a more efficient space transportation system based on reusable technology. But we still must find an economic enabler that will permit its development for larger payloads. One could argue today that this technology might be available at the lower end of the payload capacity spectrum, but it is very difficult to talk credibly about a cost-effective Titan–IV-like capacity employing a reusable space launch vehicle.

Efforts to launch and operate the U.S. Space Station will continue. The scientific exploration of the solar system will be accomplished by robotic systems based upon international cooperation. If we ever undertake some type of manned space exploration in the future, it will be different from what has gone before. It will likely be an international venture in which we share technology, subsystems, and funding. The U.S. will be dependent on key components of other nations for the project's success, and we will not control, but rather share in, direction of the project.

There remains the question of whether we will see the emergence of a "space force." The enabling conditions that might make such an idea a reality are information warfare and support of precision strike missions. They most likely will become the driving functions for future military space systems. We must operate in the future where we can dominate the battlefield with information available to us and deny this type of information to our adversary. Given the immense leverage that space systems afford the warfighter on Earth, we may be entering a period when serious consideration of a space force to conduct such missions, as a dominant part of the Air Force, may be appropriate and timely.



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Near Term Issues for the Air Force in Space

Maj. Gen. Robert S. Dickman, USAF

There are not many space meetings where I appear as the kid on the agenda. I will tell you that at this meeting I am not just a kid, but the baby. Gen. Bernard Schriever's retirement in 1966 coincided with my commissioning in the Air Force, and, not to make you feel old, sir, but between the two of us we span a long Air Force past. Gen. Jack Albert was the Director of Space, RDS, on the Air Staff when I signed on in his shop for my first tour in the Pentagon in 1972. Dr. John McLucas was the Air Force Secretary at that time. Maj. Gen. David Bradburn was the mystery person who the more senior officers in our RDS office just whispered about. You see, we were a "white world office" and not supposed to know that General Bradburn existed, much less know that he had fired a rocket over that train at Vandenberg AFB!

The historians who preceded me have provided a scholarly view of the past. My former bosses, Mr. Aldridge, Generals Kutyna, Moorman, Kelley, and Van Inwegen, have offered first person singular descriptions of what has happened since 1961. I found General Van Inwegen's talk fascinating. I am pleased that somebody has remembered and noted all of those dates, and was interested to learn just how near death some of us in the space business really were.

The subject of near-term issues is clearly the only one that I could address at a gathering like this. Of course, there is always a risk asking anyone in the Pentagon to talk about near-term issues. The risk, for those of us who are in the building, is our focus, which is so immediate that it may have little relevance a month or a year later.

I think that in this case the problem is just the opposite. The issues that we are working on today are issues that go back ten, fifteen, or twenty years. The dilemma, of course, is that if an issue exists, it means that you must have to fix something. The presumption is that if you have to fix something, then something already is broken. Please do not take this survey of issues as a statement that everything that the Air Force is trying to do is to fix problems.

I

In the last two decades alone, there have been three major studies on the role of the Air Force in space. The first one General Van Inwegen mentioned. Conducted in 1978, it was called the "Space Mission Organization and Planning

Study." Secretary of the Air Force Dr. Hans Mark chartered this study and it was conducted by USAF/XO, led by Lt. Gen. Andy Anderson. The second one took place ten years later, in 1988. It was chartered by Secretary of the Air Force Pete Aldridge, and was conducted by Maj. Gen. Pete Todd at Air War College. The third study was performed by Lt. Gen. Tom Moorman in 1992 at Space Command, before he came east.

These studies encompass three distinct eras of our space history: the first appeared a few years before Air Force Space Command was formed, the second was conducted a few years after the formation of a unified U.S. Space Command, and the last one was performed after "the awakening" that came with Desert Storm. Each one was a hallmark event in the evolution of our own role in the business.

I would like to begin by paraphrasing two conclusions from those reports. First, converging influences affect the Air Force, including increasing military dependence on space, exploding technologies, growing friction over service roles, and budgetary competition. Second, leadership is committed to institutionalizing space, but capabilities are not well understood, multiservice-user systems are expensive bills to pay, technology push still drives programs, and we can't get the product to the warfighters because of classification.

I would challenge anyone in the audience to identify which of those three studies those quotes were taken from, but the interesting measure is that we would say exactly the same thing today. This is not to suggest that we haven't made enormous progress in space — organizationally, technically, and in terms of utility of the war fighter. Rather, I think it is a reflection that those earlier studies were correct: space has become far more important to the nation and to our military capabilities. That trend line of activity and engagement by the other services is accelerating up, not slowing down, and in a fashion that is almost budget independent. Thus, reaching closure on tough issues like organization, like the institutional involvement of the Air Force, is just simply hard to do and it is not going to get any easier.

Beyond things like the budget, which is always an issue, I suggest that there are really three over-arching space issues challenging the Air Force leadership today. I will begin with the one that was at the core of much of yesterday's discussions, although not identified explicitly. It has occupied an enormous amount of the senior leadership's time and energy over the past year.

II

General Moorman's 1992 Blue Ribbon Study concluded that the competition among multiple space acquisition agencies had resulted in inefficiencies and less effective forces. It recommended that the Air Force become the single manager for DOD space acquisition. Last summer, the Air Force proposed to OSD and the other services that we be designated as the executive agent for all

space acquisition, but not all space operations, with Naval Space Command and Army Space Command continuing to function as they do today. It was a well-thought-out proposal, I think, and made enough sense that it was largely reiterated by the White Commission on Roles and Missions. That is, the commission also agreed that there should be a single agency for space acquisition, and that the Air Force should serve in that capacity.

No one, not even someone as skilled inside the Beltway as General Moorman, anticipated the "animosity" expressed in the responses of the services and of the Joint Staff. That reaction, I think, has meant that virtually any proposal on military space advanced over the last six or eight months, has proceeded on the basis that any solution is better than one proposed by the Air Force. Indeed, those debates became a forcing function within the Department of Defense and on the Hill, and we are in the midst of some major organizational changes within the DOD, which Dr. McLucas described for you briefly yesterday.

I would not suggest that these changes, including the stand up of a Deputy Under Secretary of Defense for Space, the designation of a DOD Space Architect, and the establishment of a Joint Space Management Board are a mistake. Quite the opposite. I think once the dust settles we will have a much stronger national security space program. Would I have preferred that the Air Force receive the lead role for space in the DOD? Certainly, wearing my blue suit, I would prefer it. To be honest, however, and except in our technical performance, we had not established the track record to make that case.

Whether in terms of interaction with the customer or in our own acquisition success in the white world itself, the Air Force has not gotten very good marks. There are a number of acquisition reforms underway, some rather straightforward, some that change our relationships with contractors in very fundamental ways. The goal clearly is to be more responsive and more efficient. But, as Mr. Aldridge would tell you in much blunter terms than I would, we are going to have to work very hard to prove that we are still just as effective — and that will certainly prove a challenge.

Within the Air Force our issue today is not how to become king of the hill, but to determine how to work within the joint structure to preserve our core competencies and deliver superb products that are focused on the needs of the joint warfighter. If we do that, we will not have to worry about what our role in space should be, because customers will come to us. If we cannot do that, then we probably did not deserve the position we coveted in the first place.

III

The second issue is closely related to the first one on organization, and has to do with the Air Force relationship to our space customers. The conclusion of every assessment that I have ever read concerning how well the four military services use space capabilities and integrate space into their visions, long-term

planning, and warfighting doctrines, places the Air Force in last place — or equal with the Marines and tied for last place.

The Air Force vision talks about building the world's finest military space force. In that regard, we have been incredibly successful — whether it has been missile early warning, communications, navigation, weather, or any of the classified programs that the Air Force has been involved in. Altogether, we have fielded and operate some extremely capable space programs. Space is at the leading edge of the Air Force's acquisition reform. Our new systems are mentioned virtually any time that the Secretary and the Chief of Staff go out and hit the stump — just as you heard the Secretary, the Chief, and the Vice Chief speak yesterday. Just a few years ago — and a lot of folks here will remember this very clearly — if you could get any Air Force four-star outside of Colorado Springs to mention space in a speech, it was cause for drinks at the bar.

The U.S. Army space policy, on the other hand, asserts: "The Army is the DOD leader in establishing space architecture and requirements to support air-land warfare and theater operations." You cannot attend a briefing on how the Army is going to fight in the twenty-first century, anywhere up or down its chain of command, and not hear about space. The Army is buying over 95,000 GPS receivers, portable weather receivers, a variety of SATCOM terminals, and direct downlink receivers for sensors. This is a prolific and very well educated customer.

The U.S. Navy has had SATCOM installed on all of its ships for fifteen or twenty years, including every fighting and support unit afloat, equivalent in the Air Force to equipping every organization with SATCOM down to the squadron level. These installations include UHF, SHF, or EHF or two out of three and sometimes three out of three, depending on the Navy unit's mission. The Navy is pioneering the military use of direct broadcast and GPS on their ships, and cruise missiles are not an afterthought. Incidentally, the demonstration of direct broadcast will take place this coming summer or fall, and involves the transmission from an Air Force site to an acquisition site of joint force air component commander representatives, and there is not a single Air Force recipient of that space test.

Many of you heard the story, perhaps apocryphal but probably not, about the Admiral who declared that he did not need any space stuff because he had Classic Wizard! Whether or not the Navy really is the biggest tactical user of space isn't debated. Navy leaders have said it so often that they believe it, and so does the rest of the military community.

Then there is the USAF. In her talk, the Air Force Secretary mentioned Scott O'Grady, the F–16 driver who was shot down and then rescued in Bosnia. She said that O'Grady had a GPS receiver with him. But, if you listened carefully, the Secretary said that it did not come through Air Force supply channels. O'Grady's squadron had bought it commercially and passed it around among the pilots. Although he had the receiver, no one had taught him to use

it! He only knew how to read latitude and longitude, and did not know that there were way points for major landmarks.

The Space Warfare Center at Colorado has done some great demonstrations over the past few years that show how to put space information directly into the cockpit. But so far it has been mostly demonstrations with little follow-up. If you go into the field and talk about space capabilities with line pilots or their flying squadron commanders, they do not know what it can do for them and most don't care, because they do not see a link between space their mission. We do not have Air Combat Command actively engaged in much of this debate. That is precisely where it has to happen if space support of the warfighter is going to be institutionalized within the Air Force.

As I said earlier, we have made some strides. GPS is a part of every guided munitions program now. We are becoming much more proactive about protecting our space systems, such as GPS, while denying an enemy's ability to exploit either our space systems or their own. But, these initiatives remain narrowly focused and bespeak more a commitment from the senior Air Force leadership than they do a broad understanding at the individual level.

So the second issue involves getting beyond a terrestrial perspective, of thinking of space as satellites, launch vehicles, and various widgets — the GPS receivers, survival radios, or intelligence terminals. We must start thinking about applying space capabilities in warfare — in the air, on land, at sea, *and* in space.

Earlier this week at the Air Force Association, the Chief of Staff reminded us that when you peel back the layers, when you get past all the fluff, the fundamental purpose for the Air Force is to fight and win our nation's wars. If we are to be as good a space customer as we are a supplier of space systems, our warfighters need to conceptualize how we are going to fight and then demand of the space community the capabilities needed to quickly win those fights.

IV

The third issue, not unrelated to the first two but certainly as enduring, has to do with our people — how we train, what we train for, refining assignment and promotion policies, and determining career paths. I am referring here specifically to the space arena.

We cannot expect the fighter pilots that I mentioned to include space in their planning and tactics and doctrine unless they know something about the systems and the environment. Every space study ever conducted has called for better education and training across the Air Force at all classification levels, from accession training through the war colleges and beyond. The challenge, of course, is to fit it within an incredibly full curricula that is already under pressure to add more courses as we become more jointly oriented. The reality: we still do not have much about space in our educational process.

The space operations career field more than doubled a couple years ago when missileers were combined with space operations. Lots of good people came into the business, very good people with some very good records. The commander of the launch wing today at Vandenberg is a career missileer. The commander of the missile warning and surveillance wing in Colorado Springs is a career missileer.

I have no concern over missileers commanding space wings. I am concerned that we have not been managing the pipeline to produce space people who could compete successfully for those jobs. Two of the last three directors of operations at Air Force Space Command came to the job with less than three years experience in either space or missiles. And the wing commander at the Cape today is a career bomber pilot. The Air Force, fortunately, is blessed with exceptional people, people who can move into new areas because they are smart and capable as leaders. They will succeed. But I wonder how often a naval aviator has been put in command of an attack submarine?

The Air Force billet for the program executive officer for space, the one- or two-star general who oversees all major space acquisitions in the white world, has been vacant for half a year. The Command of the Phillips Laboratory, the centerpiece for space technology, remained vacant for several months. There has not been a general officer promotion in the National Reconnaissance Office since the late 1980s. Although I have not read everyone's biography, I think that at the Pentagon, with the exception of General Thomas Moorman, there is not a single general officer outside the acquisition field who has even had one tour in the space program. Within Air Combat Command and Air Mobility Command, I doubt there is a wing commander today who has had a career broadening tour in the space field — and I'd be surprised to find a squadron commander with such experience.

It boils down to how we manage the careers of those who work in space and those who will be leaders of combat forces. How do we make space operations a core competency of the Air Force and move it out of a specialized niche where a small number of folks work in that business?

I would observe in conclusion that we have made substantial progress, and, in comparison with where we were five, ten, or fifteen years ago, we are moving forward. An increasing number of warfighters are being assigned to Air Force Space Command. The commander of Air University is a person with space operations experience, as is the Vice Chief of Staff of the Air Force. The Chief of Staff and the Air Force Secretary are "space smart." They understand the programs. They understand the systems, and they accept what is now accepted almost as universal truth among the other services: "In the future, space power will be as critical to combat as air power is today."

That projection appeared in Pete Todd's space study eight years ago. That study and the ones conducted before and after it all concluded that the Air Force had to address three major issues: determine our role in space with respect to the

rest of the community, integrate space operations into our own warfighting, and institutionalize space throughout the Air Force.

As any historian might observe on assessing developments since our service entered the Space Age, "things have not changed all that much."



Lt. Gen. Jay W. Kelley is Commander, Air University, Maxwell AFB, and Director of Education, Air Education and Training Command. A 1964 graduate of the U.S. Air Force Academy, he served in a number of command positions, was assigned to the organization of the JCS, was Vice Commander of the Air Force Space Command, and Director of Public Affairs, Office of the Secretary of the Air Force. He holds an M.S. degree in political science, has completed Air Command and Staff College, and was a Research Associate at the International Institute for Strategic Studies, London. He graduated from the National War College, Fort Lesley J. McNair, and attended the Senior Executives Program in National and International Security, John F. Kennedy School of Government, Harvard University, and the Program on Foreign Politics and National Interest, MIT. During his career General Kelley has served in a number of capacities in Air Force missile and space programs and activities.

Long Term Prospects for the Air Force in Space

Lt. Gen. Jay W. Kelley, USAF

When you leave this symposium, most of you will travel home by airline from National, Dulles, or Baltimore-Washington International Airports. But suppose that at the end of the jet-way is a bus, not a plane. And it takes you to the end of the runway, where you see a fuselage, wings, engines, and parts all there. While you wait, they assemble the airplane; then you board, the pilot runs some checks, lights up the engines, and away you go! That is also the way this country goes to space today. As Don Cromer said, we tend to use the launch pad more as an extension of the factory than a runway. Oh yes, there are only a couple of pieces of concrete on each coast to launch a given rocket. There is something wrong with this picture — we can do better!

I

Recently we conducted a study at Air University called SPACECAST 2020. Looking at that work from a technological point of view, we found things of value in the future, such as the rocket fuels that Chuck Yaeger used many years ago — JP–5 and hydrogen peroxide. From a philosophical point of view we looked at the future and noted clearly that information of all sorts, as Secretary Aldridge has just pointed out, is key to battle management. Vehicles pre-positioned in outer space provide us an advantage for acquiring and transmitting it. But information has got to reach somebody in order to be useful, and to that end it flows through an architecture, today we call C^4I. The first word in that abbreviation is "Command." We have a "command-oriented" architecture for passing orders down the chain of command from the commander-in-chief. It is not designed to work so well from the bottom up. So we should not be surprised when you consider Desert Storm, that you find a person in the field saying, "I couldn't get the intelligence information I wanted." And you have another person in Washington saying: "I sent you 1,000 pictures. The one you wanted had to be in there somewhere."

We need a new architecture so that the person in the field can get information he needs when he needs it and in the form that he needs it. We need a "demand-oriented" architecture for passing this information from space to complement the command-oriented architecture that we have now.

Air Force in Space

Everybody is familiar with America's airways. Many of you are going to go fly them this afternoon. But who is working on the nation's spaceways? If space is going to be as useful and popular as we all believe it will be, who is working on controlling spaceways? And by this observation, I do not mean radio frequency parking places in geosynchronous orbit.

SPACECAST 2020 focused more on being in space than getting there. We assumed that by 2020 somebody would have solved the problem of getting into space economically and that we would have a good solution to the space lift issue. Then we thought again and decided to come up with a few alternatives and ideas of our own, in the process, looking at our present space launch capability.

Do you know the United States Air Force does not assemble and launch any space lift vehicle? Contractors do it, and do it very well. We watch, but we do not do this work. It is rather like baseball, I guess, and we are the team owner. We always have a nice seat at the game, but we do not play the game. We do not play third base, and we do not bat. Nor do we assemble, maintain, or launch space lift vehicles. During our study, therefore, we set up teams to look at space lift. One looked at the nearer alternative forms of space lift systems, and another looked at some of the more radical means that do not depend upon a tail of fire. The radical team found much the same as I think other studies have, including anti-matter as a possible source of power. To be sure, the study did not find a great deal of immediate utility to it or that harnessing anti-matter was very likely in the near term. The alternative space lift team did find something of potential value. A young fellow, Mitch Clapp at Phillips Lab, produced a concept for a Trans-Atmospheric Vehicle (TAV) rocket plane. Now, there are a lot of paper airplanes and paper concepts, but there is more to this idea of a TAV.

II

With that backdrop, how do we move on in the far future? How do we move on from here? Let us look at how we plan. Today I would say we have a rather linear process in planning; it is evolutionary, if you will. Major commands in the Air Force come up with requirements. There is always a follow-on bomber, a follow-on fighter, a follow-on space lifter, and we have another major command that actually does the development of the vehicle that is wanted. Up at Headquarters Air Force we do analytical planning. We crunch the numbers and identify which of the alternatives and options might be better than another. At the Office of the Secretary of Defense on the third floor, other officials, together with Congress, do the corporate planning by identifying the vehicles to be funded. It is a rather linear process that occasionally takes advantage of an opportunity as it arises.

I do not suggest that we are devoid of opportunity or excitement in this process. We have done some things pretty well, including the U–2, SR–71, some magnificent space systems, the B–2, and the F–117. But I would suggest

that creativity and innovation need to be more a part of the normal planning that we do in this Air Force, instead of by exception. Creative, maverick planning, that will lead to and assure an Air Force in space in the far future, needs to be embraced. By itself, of course, all evolutionary planning is not inherently bad nor is all maverick or revolutionary planning entirely good. But maverick planning *can* identify new points to aim for, and evolutionary planning can help you get there and take advantage of the vantage of space.

Both planning approaches are or can be empty without a vision. Without vision, one might argue that the route makes no difference, for each will produce an outcome that is undistinguished. Leadership must recognize the aimpoints, furnish the vision, and change the outcome. Think about this, if you will. What if the road beyond 2020, 2030, or 2040 is more peaceful than violent? What if our country's adversaries fragment into international gangs and cartels instead of an Evil Empire, and we find that technology proliferation, in turn, stimulates greater economic and technical competition across the planet. And, because of this, the use of the vantage of space increases significantly, because someone flattened the speed bump called space lift so that it becomes affordable, reliable, and routine versus the example of today's available space lift.

So where is the Air Force in this future scenario? Where is the Air Force in the future of space? Let me answer by talking a minute about something that I do not believe will change. Human nature will not change. Somebody is always going to want the other guy's stuff. We all heard Secretary Aldridge talk about information becoming increasingly important. In fact, it is becoming critically important for a competitive advantage. Alvin Toffler was at Air University the other day talking to our students, and I would like to pass on two or three of his observations. Computer sales, desktop PCs, and related hardware and software exceeded the sales of television sets. The headline August 9, 1995, in *USA Today*: "Windows 95 Won't be Delayed." In the stock market, Microsoft's value exceeded the value of General Motors. We are approaching a time when knowledge and the ability to obtain it is more valuable to us than most tangible things.

That is important. Information translates into power and wealth. As we move along this road, someone will want to achieve leverage and power by denying information to someone else. Space will increasingly become the place to gain or deny that information and thus wealth and power along with it. So the importance of space in daily life will increase and become more vital. Therefore, the importance of who builds and maintains the capability for defense in that environment is heightened, not diminished.

III

One might argue that whoever builds our future space capability will face the same sort of business considerations that prevail today — opportunity, need,

competency. It is certainly possible and probably likely, I think, that the role of defense in a daily sense on Earth will evolve or devolve, depending on your point of view, toward an international constabulary. But even so, it seems to me, that even then it will always be necessary to protect against the high-end threat; i.e., that threat which can bring us to our knees, that threat which can directly impact our vital national interest. Once we have become as dependent, as I believe this country and others will become, upon the vantage of space, then I believe that denial of that vantage will strike at our vital national interest and therefore promote an unequivocal military mission in space. Thus, the need for space defense missions is clearly there.

Do we sustain, or do we throttle back on a lead in space that we already have? The Air Force has clearly demonstrated competency in space. Jacques Klein suggests that as we look back in military history we find certain things of particular interest to certain nations. Rome was known for its roads and its legions, and maneuvering the great phalanx at a time when commerce moved by land. Britain was known for its ships and its Royal Navy when world commerce depended on the sea. At a time when airways and spaceways are and will remain vital to our national interest and others, America will be known for its air and space power, both of which are at the heart of the Air Force competencies.

But Saturn flies no more, and we did not build Energia or Arianne. So who is going to be in the driver's seat when the space lift speed bump gets flattened and the breakthrough occurs? Will America and the Air Force rather be known for MTV or for a TAV, for staying on the evolutionary line of development or for going to a maverick planning system that aims higher? For doing or for watching?

It has been argued that "space is a place, not a mission." I believe space, however, is more than just a place. Space permits you to see over not just the next hill, but over all hills. In space you do not inhabit just one time zone but all time zones. Space is more about time than means. The Air Force and its industry teammates have always had the vision and have always been the innovators. Yes, and we have had some mavericks, too, at times.

I believe we do have a place in space in the long term, and that place is continuing to lead through performance and innovation, as we have always done. I believe we are not writing the last chapter of the Air Force in space. We are writing the next chapter, and everyone here should be a part of it.

The Air Force in Space Today and Tomorrow
An Overview

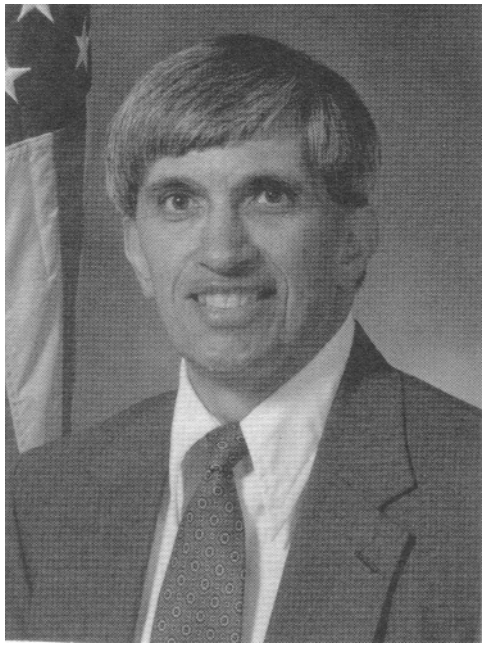
George W. Bradley III

Some fifty years ago Theodore von Kármán issued a preliminary report, "Where We Stand," that explored the fundamental realities of future aerospace power. The report was a result of a request from Gen. Hap Arnold who asked von Kármán to gather the best experts, take a look at the latest scientific developments, and determine where the U.S. Air Force should be twenty years hence. The interesting fact about what von Kármán and his group came up with is not what they got wrong but how right they were. In addition to projecting jet propulsion and supersonic flight, von Kármán predicted the advent of long-range guided missiles with highly destructive payloads. Based on the von Kármán group studies and other research, in November 1945 Arnold wrote a report to then Secretary of War Robert Patterson in which he described the future importance of missiles and satellites. In his report, Arnold cautioned against a shortsighted focus on current forces, saying, "any Air Force which does not keep its doctrines ahead of its equipment and its vision far into the future not only deludes the nation into a false sense of security but deludes itself."

I

Our speakers are part of a continuing tribute to Arnold's determination to always keep looking forward. Only by looking to the future can we truly maintain national security. Arnold, however, based his analyses not only on prospective technology but on lessons from the past, on looking at trends over time and trying to make good judgments about what should and would happen in the future. All of our speakers have used history to illustrate their points, and thus, even though our panel focused on the Air Force in space today and tomorrow, the subject is certainly a legitimate component of a historical symposium.

Their thoughts represent an insightful view on policy, strategy, and technology. In review, we can divide our speakers into two groups. General Van Inwegen set the stage by exploring the historical context of an important organizational component of today's Air Force, Air Force Space Command. Three other speakers looked to the future of that command, the Air Force, and



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the nation as a whole. General Van Inwegen's presentation is a skillful insider's look at the evolution of decision-making and a measured account of the key decision-makers who brought about the formation of Air Force Space Command. He offered an excellent account of the various studies, meetings, events, and policy debates that led to the formation of an operational command for space. From an institutional and organizational standpoint, his presentation was an objective chronological study of significant milestones. It is often said that only the intellectually challenged will criticize a paper for what it does not say, as opposed to what it does say. I must confess that is exactly what I am going to do, although my comments primarily involve the focus rather than the substance.

First, while General Van Inwegen carefully outlined many of the reasons the nation needed an operational command for space, he might have given more weight to the importance of arms control treaties of the 1970s. They were fundamentally dependent on space reconnaissance and surveillance systems and the associated warning infrastructure. Those treaties provided an impetus for the development of an operational command. On the other hand, he gave credible weight to the importance of the Air Force's commitment to the Space Transportation System, or Space Shuttle, as an impetus towards an operational organization, and that was a very important factor.

Another area that might have received greater emphasis was the reaction of the U.S. Army and Navy leaders to Air Force plans for formation of its new Space Command. General Van Inwegen was, perhaps, too much the statesman and avoided commenting on the other services to prevent inflaming old perceptions. For example, was there really an agreement with the Army and especially the Navy that a Joint Space Command was the price of their acquiescence to an Air Force Space Command? He hints at it, but he does not exactly say so. This is an important nuance in the formation of the command, and its tale is perhaps something that still needs to be documented. Despite these minor reservations, General Van Inwegen's analysis remains a highly informed review of the establishment of the first operational command for space in the entire American military. Especially noteworthy were Van Inwegen's estimates of the importance of the great men who led to the establishment of this command, men like Gen. Jerry O'Malley, Secretary Hans Mark, and Secretary Pete Aldridge, all of whom were instrumental in Gen. James Hartinger's initiatives.

Our other three speakers provided an important look at future possibilities. Secretary Aldridge presented an insightful overview of the inherent interconnections within the Air Force space program and its civil and commercial counterparts. He offered a judicious overview of the evolution of the U.S. space systems, military as well as civil and commercial. Aldridge noted the growing interdependency of all sectors of space ventures, arguing that stovepiping, for example, prevented the teaming of black and white, read civil and military, programs; such segregation would no longer prove acceptable or affordable.

II

Issues of cost, technical complexity, and other marketplace factors are driving connectivities in all facets of the space world. While acknowledging the continuing need for military unique systems, Mr. Aldridge quite rightly argues that commercial not military drivers will dominate the space arena in the future. Echoing many other space intellectuals, the former Secretary observed that future space missions will be dominated by unmanned robotic satellites rather than by manned spacecraft, and certainly the only drivers for a manned mission will lead towards international rather than uniquely American teams. He concluded with an interesting question. Does the command, the birth of which was aptly described by Van Inwegen, represent the forerunner of a true space force? It took three decades to go from a Signal Corps aerial component to an Air Force, and it may take that long again to go to a Space Force. Whether we get there or not may not be so much a question, but simply a matter of time.

While Secretary Aldridge considered future relationships among the Air Force and the civil and commercial space sectors, Gen. Robert Dickman was asked to go farther and take a fundamental look at the near term future of the Air Force and of Air Force space activities. He did this, but clearly focusing on the predictions of recent studies, that is, the SMOPS study, the Todd study, and the Moorman 1992 Blue Ribbon Panel. He pointed out that these three studies and numerous other studies shared a lot in common and, ironically, so much in common that to an extent they are redundant in their findings and conclusions. Using these studies as a fulcrum, General Dickman suggested that the near term future of the Air Force in space is fraught with obstacles and opportunities. He cited three. The first involved organization, and was tied to the Air Force drive to become the DOD agent for space acquisition. What struck me as interesting were the objections that other services raised to this initiative, which were similar to those that Van Inwegen pointed out as objections to the establishment of the Air Force Space Command itself more than a decade ago.

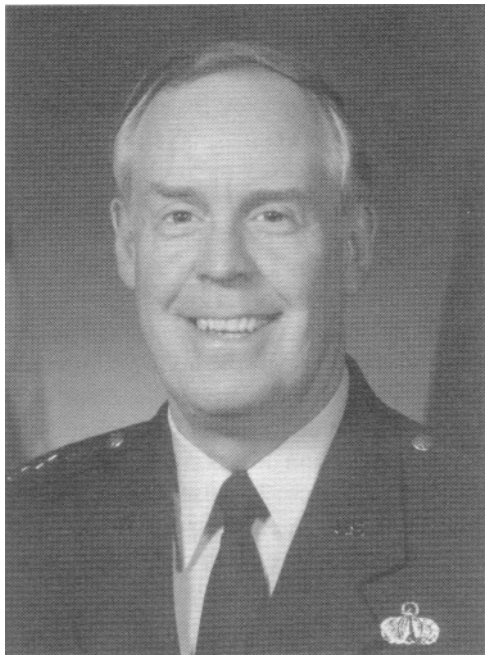
III

That underscores a fundamental theme that I think has surfaced throughout this symposium, space support of military operations and who should control it has provoked some fifty years of contention among the three services. That concern has remained a constant. General Dickman's second point is ironic and sad because it is so true. The reason the other services perhaps do not trust the Air Force to run the entire space show is because our service has not always distinguished itself in space matters, and the Army and Navy can claim that they are using space applications better than the Air Force. The third challenge to the Air Force as suggested by General Dickman, involves the need to properly educate and develop career paths for space operators that are on a par with and

recognized as equally important to other career paths in the Air Force. Dickman argues that despite the strides made by the Air Force Space Command, space training and understanding of space issues are still not institutionalized in the Air Force to the extent that they need to be. Until General Schriever and Dr. von Kármán become as well known to our young airmen and officers as were Arnold and Foulois, we still have a long way to go.

General Kelley's long-range vision of the Air Force is complementary, looking at the future of space in a broader perspective. Using SPACECAST 2020 as a starting point, General Kelley made several telling predictions about the future of space. As Commander of Air University, he played an instrumental role in the spring of 1993 when General McPeak initiated a study that evaluated future space capabilities and technologies. In many respects, it can be compared with von Kármán's "Towards New Horizons" studies, and it takes a very comprehensive and technology based assessment of what the future will look like. SPACECAST 2020 resulted in a number of white papers assessing emerging technologies in developing space applications that would impact the nation in the next century or next millennium. General Kelley made a number of observations using those studies as a backdrop. He also gave a very interesting evaluation of nontraditional space applications. He speculated that once the cost of access to space is solved, it will open the door for an explosion of uses. The question is what nation will be in the driver's seat for that new launch technology? He pointed out that much like the impact that computers have had in the information age, the application of less costly launch technology will make an explosion in the uses of space. He also addressed the hard question of funding and defending our investment in space. Because we have become so dependent on space and will become more dependent in the future, any threat to space operations will be a threat to our way of life. Defending what we have placed in space may become one of the most important missions of the Air Force in the future.

Combined, the panelists have given a novel assessment of space today and tomorrow. Their comments are a fitting end to our exploration of the history of the Air Force in space, and represent an essential starting point for future scholarship.



Gen. Thomas S. Moorman, Jr., was Vice Chief of Staff, United States Air Force (1994–1997). Commissioned through AFROTC as a distinguished military graduate, he served in various intelligence and reconnaissance related positions in the U.S. and worldwide. While stationed at Peterson AFB, Colorado, in 1982, he became deeply involved in the planning and organizing the Air Force Space Command. During his Pentagon tour in 1987, he also provided program management direction for Air Force satellites, space launch vehicles, anti-satellite weapons and ground-based and airborne strategic radars, communications, and command centers. Additionally, he represented the Air Force in the SDI program. As commander and vice commander of Air Force Space Command, General Moorman was responsible for operating military space systems, ground-based radars and missile warning satellites worldwide, as well as maintaining the ICBM force.

The Air Force in Space, its Past and Future

Gen. Thomas S. Moorman, Jr., USAF

The Air Force Historical Foundation has played a key role in the rich heritage of our service, documenting its record of accomplishments and its evolution to become today's dominant provider of air and space power in the world. Examining the agenda for this conference, I see it has again assembled a distinguished group of speakers, many of whom are my former bosses — like General Schriever, Dr. McLucas, General Bradburn, Mr. Aldridge, and General Kutyna — some of the real movers and shakers in our space history. The Foundation also has brought together some exceptional historians including Cargill Hall and Jack Neufeld. So I feel rather like Elizabeth Taylor's next husband on his wedding night — he knows what is expected of him, but the real challenge is to make it interesting. Given the quality of presenters at this symposium, I thought long and hard about what I might be able to add. How might I provide a perspective on the past and tie it together with the present and the future?

In trying to capture the history of the military space program, I considered various approaches. There are a variety of theories about what shapes history — great leaders, economic and social conditions, and conflicts. I am going to talk about several critical events that I think defined the evolution of military space. Bear in mind that the choice of events is my own, but I believe the events chosen shaped the course of astronautics in profound and fundamental ways.

I

Although most are aware that astronautics had its real start in World War II with the advent of the V–2, followed by the early RAND reports on the feasibility of satellites and methodical rocket ship developments in the 1950s, the first defining moment for space occurred in 1957. The Soviet Sputnik was the ultimate "bell ringer" for the U.S. and, on October 4, 1957, the "Space Race" was on. Dr. James Killian, President Eisenhower's science advisor, referred to the event as a "crisis of confidence that swept through the country like a windblown forest fire." President Eisenhower eventually called it a "favor," because the first Earth satellite set the international precedent of freedom of passage in outer space, with the accompanying right of overflight of all nations at orbital

altitudes. Sputnik also galvanized Air Force efforts and gave Gen. "Bennie" Schriever the attention and priority he required to develop our military space and missile systems.

President Eisenhower and his advisors had been influenced by the International Geophysical Year (IGY) of 1957–58, which, among other scientific efforts, challenged nations to place an artificial satellite in Earth orbit. They purposely sought to test the concept of "freedom of space" in international law and to emphasize the "peaceful purposes" of space to establish an acceptable climate for reconnaissance satellites that were then under study. Moreover, Eisenhower wanted to make a distinction between military and civil space. Consequently, in early 1958 he introduced legislation that resulted in the National Aeronautics and Space Administration, or NASA, establishing thereby two space sectors. He would add a third sector — intelligence — that embraced reconnaissance satellites, near the end of his second term in office in late 1960. There followed in 1961 the formal creation of the National Reconnaissance Office (NRO). In this process Eisenhower broke out space science from under the military and assigned it to NASA, and he generally allowed the first two space efforts to follow independent paths.

II

These events took place at the height of the Cold War, when U.S. leaders had almost no reliable information on the status, composition, and disposition of Soviet armed forces. To obtain this intelligence and learn exactly how many long range bombers and missiles threatened this country, President Eisenhower authorized the reconnaissance of "denied territory" using balloons and the secretly developed U–2 high altitude airplane. But overflight of another nation's airspace without its permission remained, under international law, an illegal and provocative act. That fact was underscored in another critical event on May 1, 1960, when the Soviet Union shot down a U–2 aircraft that was attempting to survey the number and location of ICBMs deep inside its territory. If that shoot-down precipitated an international furor, it proved to be a shot in the arm for U.S. satellite reconnaissance systems then under active development. Shortly thereafter, Air Force and CIA satellite reconnaissance efforts were consolidated in a U–2 form of management organization — the National Reconnaissance Office (NRO). Satellite reconnaissance, which eventually was accepted by the international community, initially and understandably was highly sensitive and remained highly classified for a variety of technical and foreign policy reasons.

After 1960, reconnaissance satellites quickly became indispensable to the nation's security, and Eisenhower's successors sought to protect these space assets at all costs. The Soviets, meanwhile, developed a primitive but highly visible, co-orbital "killer satellite" interceptor that could be used to attack and destroy space satellites in low Earth orbit. From 1968 to 1982 the Soviets

achieved a 50-percent success rate with these anti-satellites (ASATs). This created a sense of paranoia about our vulnerability in space. Moreover, unlike the ever changing American ASAT programs, the Soviets ran a sustained ASAT program. Over the years, the American efforts included SAINT, the Thor nuclear-tipped missile or 437L Program, and the F–15 Miniature Homing Vehicle.

This shifting situation provided impetus for another critical event: President Gerald Ford's 1976 ASAT national security decision memorandum (NSDM) and his survivability study (NSDM 333). These documents established policies for the employment of ASATs "commensurate with planned use in crisis and conflict." Incidentally, the requirement for an ASAT capability has been a cornerstone of U.S. space policy in every administration since President Ford, and President Clinton reaffirmed this policy in his first term. The need for ASATs and the issue of "weaponizing space" has been an active political debate since the mid-1970s. Congress went so far during the Reagan administration as to prohibit ASAT tests against objects in space. That prohibition stalled the development of American air borne and space-based ASAT systems. Nonetheless, Congress recently authorized $30 million for Army development of an Earth-based kinetic ASAT.

III

In 1972, the big debate involved what civil space programs should be continued or reduced in the post-Apollo, post-Vietnam budgets, in light of inflation and competing social programs. In the civil space arena, NASA advanced three new-start options: manned flight to Mars, a manned Space Station, and/or development of a manned Space Shuttle launch vehicle, known as the Space Transportation System (STS). President Nixon and his Space Task Group chose the least expensive STS option, a decision that marked another critical event. Cost-effective arguments for the Shuttle at that time were based on a dubious estimate of sixty launches per year with rapid two-week turn-around on the pad. As a result, this decision stunted development of new expendable launch vehicles (ELVs) and had a huge dollar impact on NASA and on the Air Force, especially in its facilities and O&M budget. For example, the Vandenberg AFB Space Launch Complex (SLC) No. 6, constructed to handle Shuttle flights into polar orbit, cost the Air Force about $6 billion, but, in the aftermath of the Space Shuttle *Challenger* accident in 1986, the pad was never used.

Flawed Space Shuttle launch rate and turn-around assumptions in the 1970s drove low-cost flight estimates ($10 million per flight in fiscal 1971 dollars), which proved to be wildly incorrect (the true total cost of each Shuttle flight is not known, but it is at least $250 million in fiscal 1995 dollars). Moreover, in the late 1970s, the Air Force committed to the Shuttle as a "sole dependency,"

meaning that, to help make the Shuttle cost effective, all military satellites eventually would be launched on a fleet of four Space Shuttle vehicles. Existing military satellites required major configuration and design changes to meet the shorter/wider STS cargo bay and to accommodate the horizontal and vertical loads. The *Challenger* accident halted all satellite launches temporarily for thirty-one months and forced equally expensive satellite redesign efforts in a move back to ELVs.

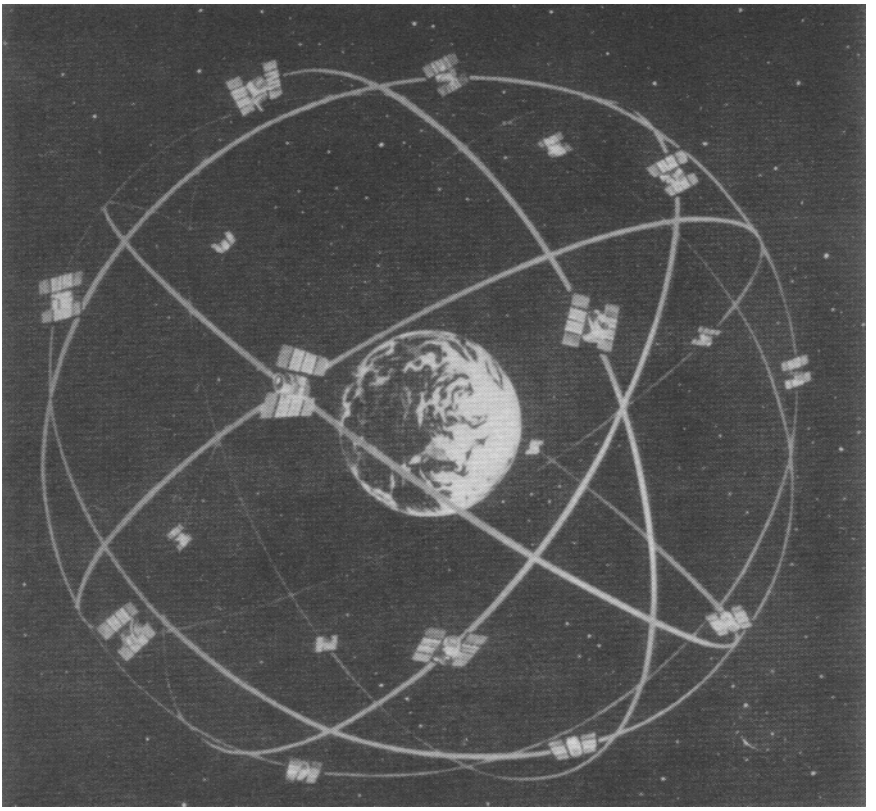
The first launch of a NAVSTAR Global Positioning System (GPS) navigation satellite in 1978 proved to be another critical event. These navigation satellites, in their completed constellation, would provide to a receiver a position accuracy of fifteen meters in latitude, longitude, and altitude. This military space system has had enormous ramifications for warfare, transportation, surveying/mapping, and even science of the atmosphere on and above the Earth's surface. This space system had multiple weapon system applications, including the aiming of precision guided munitions (PGMs), ballistic and cruise missiles, and artillery fire. It can guide ships, tanks, and people precisely to a destination across featureless oceans or deserts. It has revolutionized aviation command, control, and communications (C^3). Indeed, its commercial applications have dwarfed the military uses, a development that could ultimately threaten exclusive military control of the GPS. Altogether, the effect of GPS was so profound and such a warfighting enabler that it ensured that the military would hereafter be highly dependent on space systems.

Another critical event occurred in 1978, the same year that the first GPS satellite was launched. In October of that year, President Jimmy Carter issued PD–37, the first comprehensive inter-sector space policy. This document provided for deterring and defending, gaining assured access, and negating and enhancing military space operations. It provided enduring national security space guidelines, which have essentially been endorsed by subsequent administrations. This PD codified military space objectives for ASAT, launch, security, and related military activities in space.

IV

Established in 1982, Air Force Space Command represented another seminal event: the first major organizational change in military space affairs since the creation of the NRO in 1961. It came as a result of many needs and trends, including increasing Air Force budget for space. The Soviet military space threat and the growing U.S. dependency on automated, pre-positioned space systems such as weather, navigation, communication, and missile early warning satellites.

A series of studies on military space, conducted in the 1970s, preceded creation of Air Force Space Command. Initially, there was some resistance to a space command from the NRO and Air Force Systems Command (AFSC).



Artist's depiction of GPS constellation.

Some of the leading personalities involved in the stand-up of space command were Air Force Secretary Pete Aldridge, and Generals Jerry O'Malley and Jim Hartinger. Creation of Air Force Space Command ushered in decade of reorganization. In the years that followed, the Navy Space Command, the U.S. Space Command, and the Army Space Command were created. We also began a serious transition from an R&D-oriented space activity to space operations. The latter provided a "mindset change" and started the normalization of space within and among all of the services.

Almost ten years later in 1990–91, Desert Shield/Desert Storm, or the Gulf War–which is sometimes referred to as the first space war–took place. Fortunately, Desert Shield gave us six months to get ready. For several reasons, this conflict provided ideal circumstances to showcase space; they were ideal for surveillance, reconnaissance, and warning operations. For example, the geography, terrain, and weather of the Near East. Another factor, the working infrastructure for using space systems on-orbit and on the ground had been largely established. We had a unified/component space command structure in

place. The missile threat was covered by the Defense Support Program (DSP) early warning satellites. Our advantages included having smart weapons to conquer the weather. The campaign required precision intelligence. Also, we were fortunate to have a "dumb enemy," who tested his Scuds in December, thereby providing an operational readiness inspection (ORI) for our space warning satellites and the associated command and control.

The Gulf War was a watershed event for military space and, if it didn't represent our "first space war," *per se*, it certainly opened peoples eyes to military space capabilities. We went from a marketing approach of "let me tell you what space offers" to an applications approach of "let me tell you what space *did* for you." A light bulb went on in the mainstream military. There was a monumental shift to applications and increased emphasis on warfighter support, perhaps best represented in the Air Force by the Space Warfare Center.

Before Desert Storm, the Air Force mission statement read: "To defend the United States through the control and exploitation of the air." Although space activity had been underway in the Air Force for 30 years, the mission statement had not changed because basically space systems and the capabilities they offered were a mystery for the mainstream Air Force. After Desert Storm, Air Force Chief of Staff Gen. Merrill McPeak, in a speech at a Maxwell AFB in June 1992, changed the mission statement by adding the words "air and space." In making that change, General McPeak encountered little dissent, and with it Air Force space operations were formally legitimized and placed conceptually on an equal footing with air operations.

While these events were taking place, the Air Force remained committed to supporting the commercial and civil space sectors. Real property use agreements were reached, grants were made to commercial space providers, and the National Polar Orbiting Environmental Satellite System (NPOESS) was established with the Department of Commerce to provide meteorological forecasting. The Air Force expended $10 million in grants in both 1993 and 1994. We executed leases for the commercial use of and support at specified launch pads and payload processing facilities. As a result, in 1995 there have been more commercial launches than military ones at our Florida and California spaceports. Finally, the service has collaborated with the Commerce Department to combine the low altitude military and civil meteorological satellite programs, DMSP and Tiros.

V

Although mindful of Yogi Berra's advice, "never make predictions, particularly about the future," I will disregard it and offer some thoughts about how military space may evolve. We cannot know the future with any certainty, to be sure. But in the near-future, I believe we can expect to see more interdependence, technological change, increased commercial dependence, and new mili-

tary missions. The pace toward interdependence among space sectors will increase dramatically while the barriers among and between them will virtually disappear. This will occur because of cost considerations and user demand. The resultant changes will be manifested in launch operations, satellite command and control, and space communications, weather, and navigation systems.

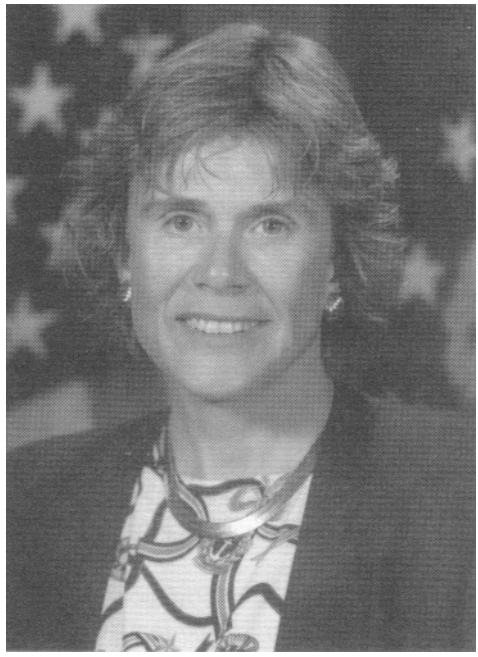
We have probably peaked with respect to the sizes of satellites, and hence the pendulum will likely swing toward much smaller, miniaturized satellites. The litmus test of this change will turn on the success or failure of Iridium-like communications satellites and Brilliant Eyes-class surveillance satellites. If today's projections are even 50 percent right, we will see an extraordinary proliferation of communications and remote sensing satellites over the next five years.

I expect to see two trends in industrial relations. The Defense Department and the Air Force will increasingly look to the commercial sector for space services. On the satellite side, the bellwether is the Global Broadcast wideband communications system. I see less and less military-provided space support functions as well. For example, the evolved expendable launch vehicle (EELV) proposals are likely to have contractor provided launch teams instead of Air Force launch teams.

Space weapons have always been the most controversial subject. My personal view is that the pace of development of space weapons will be driven by the threat. Given that today we see an ever increasing proliferation of ballistic missiles, weapons, and space systems, I think it is a question of when, not if, space weapons will be authorized and developed. There is no question that space systems are the most effective and efficient way to perform ballistic missile defense.

Overall, I think we will see the importance of space to the Air Force continue to grow and become more important, especially in defining the military role of the Air Force. Also, we may see existing aerial missions transitioning to space, such as airborne surveillance, AWACS, and JSTARS.

In closing, let me reiterate and underscore the important role played by the Air Force Historical Foundation. I salute its President, Gen. Bryce Poe. By organizing and conducting this extraordinary symposium, the Foundation has shed needed light on the beginnings of the military space program and recognized the many folks who were pioneers. I really applaud those efforts as I have been concerned for many years about documenting our space history. Your efforts also will serve as a precedent for future symposia so we can preserve this storehouse of Air Force space knowledge. With the movement to declassify significant elements of the military space program, it is time to shine the spotlight especially on the Air Force's contribution. The Air Force, without question, provides the world's most sophisticated and capable space force, and with your support it will continue to provide the unique competitive advantage our terrestrial forces need to remain the best in the world.



Hon. Dr. Sheila E. Widnall was Secretary of the Air Force from 1993 through 1997. Previously, she served on the USAF Academy Board of Visitors, and on advisory committees to the Military Airlift Command and Wright-Patterson AFB, Ohio. Dr. Widnall was a faculty member of the Massachusetts Institute of Technology for twenty-eight years and became an associate provost at the university in January 1992. A professor of aeronautics and astronautics, she is internationally known for her work in fluid dynamics, specifically in the areas of aircraft turbulence and the spiraling airflows, called vortices, created by helicopters. She has served on many boards, panels and committees in government, academia and industry, and has authored some seventy publications.

Space Power and the United States Air Force

The Honorable Sheila E. Widnall
Secretary of the Air Force

Let me say at the start that I think the Air Force Historical Foundation is performing a critically important function in sponsoring this symposium. The reason is that very few people really know the history of astronautics, beside what they have learned from watching "The Right Stuff" and "Apollo 13." When we think of air power, on the other hand, the majority of us immediately conjure up images of the Wright brothers at Kitty Hawk, the Spirit of St Louis, World War I dog fights, and P–51 Mustangs escorting B–17s over Europe in World War II.

But what do we know of the history of space power? Most of us can put the NASA manned space programs in the right order, and we all know that Forest Gump was the commander of Apollo 13. But very few Americans know the rich history of the CORONA reconnaissance satellite program. How many know it took 12 failures before the first CORONA satellite made it to orbit and worked correctly? How many know we could take 30-foot resolution pictures of Russian missile fields in 1960?

Likewise, not many Americans know of the trail-blazing paths that led to our nation's current space system capabilities in ballistic missile early warning, satellite communications, global navigation, weather forecasting, and imaging from space! Which brings me back to why today's conference is so important: most of us remember the military space program as a *black* program. Too secret to discuss in the open. We would not even call it space. We would refer to space support as "national security capabilities" or "other sources."

But times are changing. Space is coming out of the closet. I am sure many of you were surprised at the recent CORONA ceremony at the National Air and Space Museum and seeing declassified satellite imagery and reconnaissance satellite hardware! I was lucky enough to attend this ceremony, and I know those of you who worked on CORONA felt great satisfaction you could finally talk about this pioneering work!

The move to transition space out of this "black program" mentality is at least part of the motivation behind the current space management discussions. The integration of Air Force and 'national security' space systems will not only more closely align the highly classified systems to the needs of the warfighter,

but will serve to pull more of those systems out of the black world and into the white world. So the timing of this symposium is excellent. We are at a pivotal point in the history of space. Just look at the indicators. A push is on to make space operations routine, normalized. An explosive growth of commercial space ventures is taking place, and fighter pilots are actually asking for space support.

In fact, it is because I believe we're at this pivotal point in history, coupled with my desire to help space "out of the closet," which led me last year to set three goals for the Air Force in space:

Make space support to the war fighter routine.
Improve military cooperation with civilian space efforts.
Make space launch routine and affordable.

I am pleased to report that we are making tremendous progress on each of these goals, and many of you in this room contributed. Let me talk briefly about each of them.

I

Those who remember military space as a collection of black programs will also remember space supporting the strategic nuclear forces. However, we have witnessed a dramatic transition, with our emphasis placed on supporting the tactical commander conducting conventional military campaigns. Just look at Desert Storm, the first space war, using space-based ballistic missile early warning, secure space communications, GPS navigation, and other intelligence collection functions. And currently in Bosnia, our military space assets are providing support to UN peacekeepers every day. In fact, since Desert Storm whetted the appetite of the joint forces, we can hardly keep up with the requests!

The Tomahawk missiles that found their Bosnian targets last week were guided by GPS. And our new Joint Direct Attack Munition, to be tested soon, will use GPS to greatly improve our gravity bomb accuracy. Scott O'Grady had a commercially purchased GPS receiver with him, and so he was able to tell the search and rescue teams his position exactly.

Space superiority has emerged as a critical element of today's military operations. Support from space is becoming the quintessential force multiplier. And this year we are focusing our scarce resources on some key space modernization programs, one of the few mission areas where you will find 'new" program starts. We recently awarded a Space Missile Tracking System contract in May and awarded the Space Based Infrared system contracts in August. Both of these key elements of the Air Force's Space Based Infrared architecture will greatly enhance our joint missile warning capabilities.

We now have a fully operational constellation of GPS satellites on orbit, and we plan to order 33 more this winter. We continue to improve global com-

munications with satellites such as MILSTAR, and plan to launch the second MILSTAR this winter.

II

Our second goal, to improve our cooperative efforts with the commercial civil space communities, is motivated by two conditions. First, the pace of commercial space and information systems technology can only be characterized as explosive! And second, as budgets of all organizations get tighter, it is imperative that we leverage each other's efforts. We need a broad national industrial base for space and we will only achieve it by working together. I am proud to report the Air Force is way out in front in helping to form this national industrial base.

Just look at the last twelve months! We have approved leases and awarded dual-use launch grants for commercial space ventures at Vandenberg and Cape Canaveral. For the next three years, we plan to support more commercial satellite launches on Air Force launch pads than military satellite launches. We formed a joint NOAA-Air Force program office to build weather satellites. And we're well on our way to helping the FAA baseline GPS use for commercial aviation. We also recently empowered seven joint DOD-NASA teams to increase cooperation in areas like satellite control, base services, and space launch. So you can see our cooperation with the civilian space sector has increased dramatically in just the last year. I expect to see even more as we move to this common American industrial base.

III

Working on our third goal of routine and affordable space launch, the Air Force took a big step toward this national industrial base. Last month we awarded four contracts starting the Evolved Expendable Launch Vehicle (EELV) program. The goal of this program is to provide the nation with a family of low-cost launch vehicles early next century. This will lower the cost of both military and commercial access to space and represents a major step for the nation in ensuring the long-term competitiveness of our commercial launch industry.

Some might argue that we should let the commercial space world worry about the new booster and just buy launch services. We don't agree, because we are filling a military requirement. The French and Japanese governments, moreover, pour development money into Arianne and the H–2 boosters resulting in lower unit cost on the international market. If the Air Force efforts on EELV succeed in leveling the playing field a little bit, then I say good!

I have visited the overseas launch sites at Kourou and Tenagshima. I have seen first hand the international competition aggressively pursuing the launch

business. I believe the Air Force EELV program will simultaneously lower the cost of getting Air Force payloads to space and provide America's competitiveness a shot in the arm.

IV

In closing, I applaud what you are doing with this symposium, helping to remove the cloak of secrecy surrounding the military space world. I would like to leave you with three final thoughts:

Number One: Space is a growth area. Although "modernization" funding is down 50–60 percent since 1989, the Air Force space budget has remained constant, and thus the percentage of our budget spent in space has actually grown.

Number Two: Space Superiority is an Air Force Core Competency. The Air Force has deep historical roots in the space business. We have been the lead service since the 1950s, and have built and maintain a tremendous infrastructure to launch and operate our space forces. At 30,000 strong, we have tremendous expertise in the men and women in the Air Force who work our space acquisition and operations. These Air Force personnel account for over 90 percent of the total DOD space work force. And since space is a core competency, the Air Force invests five billion dollars per year on space programs, over 80 percent of all the dollars DOD spends on space.

Number Three: Space is a competitive advantage for America. With our forces on orbit, space gives us an unfair advantage militarily, which is exactly what we want. Commercially, our military accomplishments have translated into several lucrative business ventures, helping to form a national industrial base. So we must use our space expertise as a competitive advantage to meet not only American defense objectives, but American economic objectives as well.

Thanks in large part to Air Force space systems, the United States has the capability to act globally. Sustaining this capability requires an investment in and commitment to space. In the world of the 21st century, our success as a nation will rest on our capability to exploit air and space. Our challenge as the stewards of this country's military air and space capabilities — the Air Force and our partners in industry alike — is to sustain the competitive advantage we have built over the past decades.

Space has always been an exciting place. From the early years of rocket development through programs like CORONA on the cutting edge of technology, to the promise of tomorrow's space systems, the Air Force has led this nation's efforts. You can be proud of this heritage. I know I am!

Notes

1. Von Kármán's efforts and Arnold's interests led to the formation of the USAF Scientific Advisory Board and to Gen Schriever's early association with it, alluded to here. For details, see Thomas A. Sturm, *The USAF Scientific Advisory Board: Its First Twenty Years, 1944–1964* (Washington: Office of Air Force History, 1986).

2. Merton E. Davies and William R. Harris, *RAND's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology* (Santa Monica, Calif: The RAND Corporation R–3692–RC, September 1988).

3. James R. Killian, Jr., *Sputnik, Scientists, and Eisenhower. A Memoir of the First Special Assistant to the President for Science and Technology* (Cambridge, Mass: The MIT Press, 1977), p 68; R. Cargill Hall, "Origins of U.S. Space Policy: Eisenhower, Open Skies, and Freedom of Space," in John M. Logsdon, et. al., eds., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, Vol. I, *Organizing for Exploration* (Washington: NASA SP–4407, 1995), pp 218–20.

4. Robert A. Divine, *The Sputnik Challenge* (New York: Oxford University Press, 1993), p 22. See also the discussion in Edmund Beard, *Developing the ICBM. A Study in Bureaucratic Politics* (New York: Columbia University Press, 1976), pp 129–51.

5. For the most comprehensive studies of the missile program and Gardner's role, see Beard, *Developing the ICBM*, pp 143–94, and Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force, 1945–1960* (Washington: Office of Air Force History, 1990), pp 95–151; John T. Greenwood, "The Air Force Ballistic Missile and Space Program (1954–1974)," *Aerospace Historian*, Vol. 21, Winter 1974, pp 190–97. Also see Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985), pp 106–7. For a concise assessment of Schriever's career, see Jacob Neufeld, "Bernard A. Schriever: Challenging the Unknown," in *Makers of the Modern Air Force*, John L. Frisbee, ed. (Washington: Office of Air Force History, 1987), pp 281–306.

6. Robert L. Perry "Origins of the USAF Space Program, 1945–1956," V, History of DCAS 1961. AFSC Historical Publications Series 62–24–10 (Los Angeles, Calif: Air Force Systems Division, Space Systems Division, 1961), pp 40–45; McDougall, *The Heavens and the Earth*, pp 107–11; Davies and Harris, *RAND's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology*, pp 53–55, 63; Bruno W. Augenstein, *Evolution of the U.S. Military Space Program, 1945–1960: Some Key Events in Study, Planning, and Program Management* (Rand Corporation, September 1982), pp 6–8.

7. Memo, Col V. A. Adduci, Assistant Director, Legislative Liaison (SAFLL) to Assistant Deputy Chief of Staff, Plans and Programs, "Policy Coordination Section Activities," November 7, 1957; Gen Thomas D. White, "At the Dawn of the Space Age," *The Air Power Historian*, Vol. V, No. 1 (January 1958): 15–19; Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907–1960*. Vol I (Maxwell AFB, Ala: Air University Press, 1989), pp 553–54 [hereafter cited as Futrell, *Ideas, 1907–1960*]. The following year "aerospace" officially entered the Air Force lexicon with its appearance in the revised Air Force Manual 1–2, United States Air Force Basic Doctrine.

8. Robert Kipp, "Space Detection and Tracking. A Chronology," (Peterson AFB, Colo.: Air Force Space Command Office of History), March 1990; Augenstein, *Evolution of the U.S. Military Space Program*, p 11; Lee Bowen, "The Threshold of Space: The Air Force in the National Space Program, 1945–1959." (Washington: USAF

Historical Division Liaison Office, September 1960), pp 20–22; and Hall, "The Origins of U.S. Space Policy," pp 228–29.

9. Bowen, "The Threshold of Space," pp 22–24; USAF Scientific Advisory Board, *Report of the Scientific Advisory Board Ad Hoc Committee on Space Technology*, December 6, 1957. Committee members included David T. Griggs, Clark B. Milligan, Mark M. Mills, W. H. Radford, H. Guyford Stever, Edward Teller, and C. S. White; Futrell, *Ideas, 1907–1960*, p 590; Divine, *Sputnik Challenge*, p 98.

10. For a discussion of the Air Force-ARPA relationship, see Bowen, "The Threshold of Space," pp 24–34; Futrell, *Ideas, 1907–1960*, pp 590–94; U.S. House of Representatives, Committee on Government Operations, "Government Operations in Space (Analysis of Civil-Military Roles and Relationships)," House Report No. 445, 89th Congress, 1st Session, June 4, 1965, pp 31–35, [hereafter cited as House Report, "Government Operations in Space"]; R. Cargill Hall, "The Eisenhower Administration and the Cold War: Framing American Astronautics to Serve National Security," *Prologue*, Vol. 27, No. 1, 1995, pp 62–69; Maj John B. Hungerford., Jr, *Organization for Military Space: A Historical Perspective*, Report No. 82–1235 (Maxwell AFB, Ala: Air Command and Staff College, 1982), pp 25–28; History (S), Headquarters, Air Research and Development Command, Vol I, 1 July–31 December 1959, Chapter 1, information used is unclassified.

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12. J. D. Hunley, ed., *The Birth of NASA: The Diary of T. Keith Glennan* (Washington: NASA SP–4105, 1993), pp 9–15.

13. On broader aspects of the Eisenhower-engineered Defense Reorganization Act of 1958 which created the DDR&E, see Futrell, *Ideas, 1907–1960*, pp 573–86; see also, House Report, "Government Operations in Space," pp 53–55.

14. Memo, HQ USAF, DCS Plans to DCS Development, "Air Force Objectives in Space," February 5, 1959.

15. *Ibid*; and Memo, AFDAT, "Background Information on Current Air Force Position in Space," n.d. [ca. March 1959]. For descriptions of systems and programs, see Department of Defense, Annual Report of the Secretary of Defense and the Reports of the Secretary of the Army, Secretary of the Navy, Secretary of the Air Force, July 1, 1958 to June 30, 1959 (Washington: Government Printing Office, 1960), pp 20–25, 334–35; James Baar and William E. Howard, *Spacecraft and Missiles of the World*, 1962 (New York: Harcourt, Brace & World, Inc., 1962), Chapters 3 and 4; Horace Jacobs and Eunice Engelke Whitney, *Missile and Space Projects Guide 1962* (New York: Plenum Press, 1962); Bowen, "The Threshold of Space," pp 43–48; Max Rosenberg, *The Air Force in Space, 1959–1960*, SHO–S–62/112 (Washington: USAF Historical Division Liaison Office, June 1962), pp 31–49; SAMOS had long been considered an acronym for Satellite and Missile Observation System. It seems that WS–117L Project Director Col Fritz Oder adopted the name only to signify the island home of Midas. For an unclassified account of this reconnaissance program, see Jeffrey T. Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper Business, 1990), pp 44–64.

16. Rosenberg, *The Air Force in Space, 1959–1960*, pp 18–21.

17. Ltr, Lt Gen B. A. Schriever, Commander, ARDC, to Lt Gen R. C. Wilson, Deputy Chief of Staff, Development, May 18, 1959, w/atch, draft letter to Secretary of Defense Neil H. McElroy.

18. Rosenberg, *The Air Force in Space, 1959–1960*, pp 18–21, 27–31; Futrell, *Ideas, 1907–1960*, pp 593, 601; House Report, "Government Operations in Space," pp 53–55. Adm. Burke returned to the idea of a unified space command in the spring of 1960, but again failed to convince the Defense Secretary that a joint military space agency was needed.

19. Rosenberg, *The Air Force in Space, 1959–1960*, p 13.

20. Carl Berger, *The Air Force in Space, Fiscal Year 1961*, SHO–S–66/142 (Washington: USAF Historical Division Liaison Office, April 1966), pp 34–43; R. Cargill Hall, "The Air Force in Space," unpublished classified draft chapter, May 1984, info used is unclassified; Richelson, *America's Secret Eyes in Space*, Chapter 2; Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945–1984*. (Ithica, N.Y.: Cornell University Press, 1985), pp 44–46. Despite the passage of time, Berger remains the most convincing source for early SAMOS developments.

21. The Aerospace Corporation, *The Aerospace Corporation: Its Work, 1960–1980* (Los Angeles: Times Mirror Press, 1980), pp 15–25.

22. Ltr, Lt Gen B.A. Schriever, ARDC/CC, to Trevor Gardner, Chairman and President, Hycon Manufacturing Co, "[committee on space development program]," October 11, 1960.

23. Berger, *The Air Force in Space, FY 61*, pp 3–5; Stares, *Militarization of Space*, pp 60–62; Memo, Department of the Air Force, Memorandum for Chief of Staff, USAF, "Report to the President-Elect of the Ad Hoc Committee on Space, January 1961.

24. Berger, *The Air Force in Space, FY 61*, pp 5–6; DOD Directive 5160.32, "Development of Space Systems," March 6, 1961.

25. The personal relationship between Gen Schriever and Deputy Defense Secretary Roswell Gilpatric played a significant part in the McNamara directive and the creation of AFSC. See Berger, *The Air Force in Space, FY 61*, pp 6–10; History (S), Headquarters, Air Research and Development Command, Vol I, 1 January–31 March 1961, History of Air Force Systems 1 April–30 June 1961, I–22 to I–52, (information used is unclassified); U.S. Air Force Oral History Interview, Gen Bernard A. Schriever, (USAF Ret) with Maj Lyn R. Officer and Dr. James C. Hasdorff, Air Force Historical Research Agency, Air University, Montgomery, Alabama, No. K239. 0512–676, 20 June 1973, pp 23–25; Rick W. Sturdevant, "United States Air Force Organization for Space: The Operational Quest, 1943–1993," Unpublished Special Study (Peterson AFB, Colo.: Air Force Space Command Office of History, December 1993), pp 20–22.

26. Berger, *The Air Force in Space, FY 61*, pp 10–14; Memo, Trevor Gardner, et. al., to Secretary of the Air Force Eugene M. Zuckert, April 23, 1961.

27. Berger, *The Air Force in Space, FY 61*, pp 15–25.

28. *Ibid.*

29. George P. Shultz, *Turmoil and Triumph: My Years as Secretary of State* (New York: Charles Scribner's Sons, 1993; A Robert Stewart Book), p 250.

30. Bernard A. Schriever, "The Operational Urgency of R&D," *Air University Quarterly Review*, Winter–Spring 1960–61, p 230.

31. During World War II, Lt Gen George S. Patton, Jr., had seen the devastating effects of artillery shells exploded over German troops by proximity fuzes and wrote to an ordnance officer: "The new shell with the funny fuze is devastating.... [W]hen all armies get this shell we will have to devise some new method of warfare. I am glad that you all thought of it first." (George S. Patton to Levin Campbell, December 29, 1944, quoted in James Phinney Baxter, III, *Scientists Against Time* [Cambridge, Mass: MIT Press, 1968], p 236.) In December 1944 Lt Gen Brehon Somervell, commanding general, U.S. Army Service Forces, told the National Association of Manufacturers that "our tactics, our strategy, our victories have been shaped" by an approach to war that stresses the use of materiel to reduce American casualties. The Soviets, he noted, did not have this option and had lost 4.2 million men between June 1941 and June 1943. American loses of such a magnitude would "be nearly fatal to us." For Somervell, the strategic significance of superior technology was "just a simple case of arithmetic. More materiel equals fewer casualties, a shorter war." (Brehon Somervell, Address before the National Association of Manufacturers, New York, December 6, 1944, pp 1-3. A copy of this

address may be found in Box 21 of the Papers of H. H. Arnold, Library of Congress Manuscript Division.) After the war, Gen Dwight Eisenhower stated that if the Germans had been able to develop and use their V-weapons six months earlier, the invasion of Europe "would have proved exceedingly difficult, perhaps impossible." He went on to say that if the Germans "had made the Portsmouth- Southampton area one of [their] principal targets, Overlord might have been written off." (Dwight D. Eisenhower, *Crusade in Europe* [Garden City, N.Y.: Doubleday & Company, 1948], p 260.) An example of Arnold's views are found in this quotation: "the first essential of the airpower necessary for our national security is preeminence in research. The imagination and inventive genius of our people — in industry, in the universities, in the armed services, and throughout the nation — must have free play, incentive and every encouragement. American air superiority in this war has resulted in large measure from the mobilization and constant application of our scientific resources." (Henry H. Arnold, "The AAF Looks Ahead," *Air Force: The Official Service Journal of the U.S. Army Air Forces*, March 1945, p 14.) That the roots of America's Cold War view of technology, policy, and strategy extend back beyond World War II is suggested in these remarks made by inventor John Ericsson to President Lincoln in the midst of the Civil War: "The time has come, Mr. President, when our cause will have to be sustained, not by numbers, but by superior weapons. By a proper application of mechanical devices alone will you be able with absolute certainty to destroy the enemies of the Union. Such is the inferiority of the Southern States in a mechanical point of view, that it is susceptible of demonstration that, if you apply our mechanical resources to the fullest extent, you can destroy the enemy without enlisting another man. [Ericsson is quoted in Robert V. Bruce, *Lincoln and the Tools of War.* Urbana: University of Illinois Press, 1989, p 68.]

32. Dwight D. Eisenhower, "Letter to the Secretary of Defense on National Security Requirements," January 5, 1955, p 3, in *Public Papers of the Presidents of the United States, Dwight D. Eisenhower, 1955, Containing the Public Messages, Speeches, and Statements of the President, January 1 to December 31, 1955* (Washington: Government Printing Office, 1959).

33. "Organizing for Technological War," *Air Force*, December 1957, pp 41–45, 48.

34. For statements by world leaders on the role of SDI in ending the Cold War, see Les Aspin, Regular Defense Department Briefing, May 13, 1993, transcript in OSD Supplement, May 14, 1993, p A5; Sam Nunn, "New Directions in Missile Defense Policy," July 27, 1993, part of Building a Greater Missile Defense Consensus: An IFPA Congressional Seminar Series on Missile Defense; Sam Nunn, Summary of Remarks and Questions and Answers, Institute for Foreign Policy Analysis Breakfast Seminar Series, July 27, 1993 (summary provided by Thomas Johnson, BMDO Chief of Congressional Liaison); Margaret Thatcher, *The Downing Street Years* (New York: Harper Collins Publishers, 1993), pp 247, 450, 463; Margaret Thatcher, quoted in Sue McMillin, "SDI Acted as Deterrent, Thatcher Says," *Colorado Springs Gazette*, [August 4, 1990], pp A1, A3 (a video clip of Thatcher's remarks is included on SDI/BMDO Video Tape No. 5, Version 3.1, "Technical Progress in SDIO," edited September 2, 1992); George P. Shultz, *Turmoil and Triumph: My Years as Secretary of State* (New York: Charles Scribner's Sons, 1993), pp 508, 577; Rowan Scarborough, "Ex-Leaders Revisit Cold War's Deathbed," *Washington Times*, October 10, 1995, pp A1, A20; Rowan Scarborough, "Cold War Confab Not One for the Gipper," *Washington Times*, October 10, 1995, p A20. For statements by former Soviet officials, see Aleksandr Yakovlev, quoted in Don Oberdorfer, *The Turn: From the Cold War to a New Era — The United States and the Soviet Union, 1983–1990* (New York: Poseidon Press, 1991), p 186; "SDI, Chernobyl Helped End Cold War, Conference Told," *Washington Post*, February 27, 1993, p A17 (another edition of the February 27 *Post* carried this article

on p A24); "Cold War End Hurried by SDI and Chernobyl," *Washington Times*, February 27, 1993, p A3; Makhmut Gareev, quoted in *BMD Monitor*, May 20, 1994, p 174; Vyacheslav Dashichev quoted in Peter W. Rodman, *More Precious than Peace: The Cold War and the Struggle for the Third World* (New York: Charles Scribner's Sons, 1994), pp 310–11; Sergei Kondrashev quoted in George Weigel, "Cold Warriors Are Vindicated by the Archives," *Los Angeles Times* [Washington edition], January 12, 1995, p 11 [reprinted in *Current News*, January 13, 1995, p 12]; quotations from a number of former Soviet officials may be found on pp 23–24 of a transcript of "Collapse at the Center," the fourth episode of "Messengers from Moscow," a 1995 series that PBS aired on January 13, 20, and 27, and February 3 (transcript distributed by Pacem Distribution International of Beverly Hills, California). For Solzhenitsyn's views, see David Remnick, "Profile: The Exile Returns," *New Yorker*, February 14, 1994, p 77.

35. Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Publishers, 1985), p 174.

36. Roald Z. Sagdeev, *The Making of a Soviet Scientist: My Adventures in Nuclear Fusion and Space, From Stalin to Star Wars* (New York: John Wiley & Sons, 1994), p 166. Sagdeev stated: "All of the country's launching sites and space polygons had been placed, from the very early days of the Soviet space program, under the supervision of the military."

37. Sagdeev, *Making of a Soviet Scientist*, pp 156–58. Sagdeev gave a fascinating account of how the Soviets pushed the launch of *Sputnik* III in the spring 1958 in order to influence an Italian election. The Italian Communists had been importuning Khrushchev to do something spectacular in space to "bring our Communist party a few more million votes." (p 158)

38. Sagdeev, *Making of a Soviet Scientist*, pp 176–77.

39. *Ibid.*, pp 236, 238.

40. The earliest description of the use of automatic systems on board a space station can be found in Hermann Oberth, *Die Rakete zu den Planetenraumen*, (Munich and Berlin: Verlag von R. Oldenbourg, 1923), pp 78–97. A translation of this work is available as *Rockets in Planetary Space*, (Washington: NASA Technical Translation F–9227, 1965). A later edition was titled *Wege zur Raumschiffahrt*, (Munich-Berlin: R. Oldenbourg, 1929). A translation is available as *Ways to Spaceflight*, (Washington: NASA Technical Translation F–622, 1972).

41. M. A. Grodsky and R. D. Sorkin, "Man's Contribution to an Operational Space Station Concept," p 114–19, in *Proceedings of the Manned Space Stations Symposium*, (MS/RAND/NASA, Los Angeles, April 20–22, 1960).

42. Emanuel Schnitzer, "Report of visit to Wright Patterson AFB to attend Midterm Briefing on Military Test Space Station on February 7, 8, and 9, 1961," February 23, 1961. NASA History Office.

43. Roy F. Houchin II, "The Diplomatic Demise of Dyna Soar: The Impact of International and Domestic Political Affairs on the Dyna-Soar X–20 Project, 1957–1963," *Aerospace Historian*, v. 35, no. 4 (Winter/December, 1988), pp 274–80.

44. James E. Webb and Robert S. McNamara, "Recommendations for Our National Space Program: Changes, Policies, Goals," May 8, 1961, pp 9, 12. "Apollo 1961 Decision Documentation." File, President John F. Kennedy section, NASA History Office. A more detailed overview of that and subsequent agreements was presented in Harold Brown, Director of Defense Research and Engineering, to George P. Miller, Chairman, House Committee on Science and Astronautics, "NASA-DOD Relationships," March 6, 1964, in response to a letter from Miller to Secretary McNamara of February 17, 1964, p 8. of U.S. House of Representatives, Report of the Subcommittee on NASA Oversight of the Committee on Science and Astronautics, *The NASA-DOD Relationship*, 88th Congress, 2nd session (Washington: GPO, 1964). L. W. Vogel, memorandum to Mr. Webb, Appendix C, "NASA's Contribution to National Security," December 13, 1965.

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45. Interview with David Greenshields, April 12, 1988, Reston, Virginia.

46. Claude Witze, "Is There a Price on Dyna-Soar?" *Air Force Magazine*, v. 47, (January 1964), p 12. William Leavitt, "MOL: Evolution of a Decision," *Air Force Magazine*, v. 48 (October 1965), p 37. William Leavitt, "President Johnson and Space," *Air Force Magazine*, v. 47 (January 1964), p 50. "Air Force Given Space Laboratory Mission," *Aviation Week and Space Technology*, v. 80, (December 16, 1963), pp 29–30; "Agreement Reached on MOL Status, NASA to Continue Station Studies," *Aviation Week and Space Technology*, v. 80, January 6, 1964, p 98. William Leavitt, "Memo on MOL," *Air Force Magazine*, v. 47 (February 1964), pp.74–76, Robert C. Seamans, Jr., and Harold Brown, memorandum for the Secretary of Defense and the NASA Administrator, "Joint NASA-DOD Review of National Space Program," January 31, 1964. "NASA-DOD coordination" file, NASA History Office. For a brief description of USAF future hopes beyond MOL, see Brig. Gen Joseph S. Bleymaier, USAF, "Mapping Out the MOL," *Space Digest*, v. 7 (June 1964), pp 43–47.

47. The Department of Defense had already spent $1.3 billion (1969 dollars) on MOL when it was cancelled in June 1969. Air Force Systems Command, "Statement Made Today by the Deputy Secretary of Defense, David Packard," June 10, 1969.

48. U. S. Department of Defense, "Department of Defense Requirements Review for SIG (Space), Manned Space Station Study," [June 1983], p 1. For a complete contextual explanation, see chapter nine of Adam L. Gruen, "The Port Unknown: A History of Space Station Freedom," unpublished ms. available in the NASA History Office.

Abbreviations and Acronyms

ABM	Anti-Ballistic Missile
ABMA	Army Ballistic Missiles Agency
ACTS	Advanced Communications Technology Satellite
ADCOM	Aerospace Defense Command
AFB	Air Force Base
AFSC	Air Force Systems Command
ARDC	Air Research and Development Command
ARPA	Advanced Research Projects Agency
ARS	Advanced Reconnaissance [Satellite] System (later became WS–117L)
ASAT	Anti-Satellite
AT&T	American Telephone and Telegraph
AWACS	Airborne Warning and Control System
BMD	Ballistic Missile Defense or Ballistic Missile Division
BMDO	Ballistic Missile Defense Office
BWI	Baltimore Washington International Airport
C^3	Command, Control, and Communications
Caltech	California Institute of Technology
CAOC	Combined Air Operations Center
CENTCOM	U.S. Central Command
CEP	Circular Error Probable
CIA	Central Intelligence Agency
CINC	Commander in Chief
CINCUNK	Commander in Chief, United Nations Forces in Korea
COMSAT	Communications Satellite Corporation
CSOC	Consolidated Space Operations Center
DBS	Direct Broadcast Service
DCA	Defense Communications Agency
DC/AS	Deputy Chief of Air Staff for Research and Development for R&D
DDR&E	Director for Defense Research and Engineering
DEFCON	Defense Condition
DMSP	Defense Meteorological Satellite program
DO	Director of Operations
DOD	Department of Defense
DSCS	Defense Satellite Communications System
DSP	Defense Support Program

Abbreviations

Dyna-Soar	Dynamic Soaring
EELV	Evolved Expendable Launch Vehicle
ELV	Expendable Launch Vehicle
ESC	Electronic Systems Command
FAA	Federal Aviation Administration
FBM	Fleet Ballistic Missile
GAO	General Accounting Office
GPS	Global Positioning System
GSA	General Services Administration
ICBM	Intercontinental Ballistic Missile
ICSU	International Council of Scientific Unions
IEEE	Institute of Electrical and Electronics Engineers
IGY	International Geophysical Year
INMARSAT	International Mobile (formerly Maritime) Satellite
INTELSAT	International Satellite
IR	Infrared
IRBM	Intermediate Range Ballistic Missile
JCS	Joint Chiefs of Staff
JPL	Jet Propulsion Laboratory
JSTARS	Joint Surveillance Target Attack Radar System
LEO	Low Earth Orbit
LTV	Ling-Temco-Vought Corporation
MAJCOM	Major Command
MHV	Miniature Homing Vehicle
MIDAS	Missile Detection Alarm System
MIT	Massachusetts Institute of Technology
MOL	Manned Orbiting Laboratory
MREs	Meals Ready to Eat
MSI	Multi-Spectral Imagery
MTV	Music Television
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCA	National Command Authority
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NPOESS	National Polar Orbiting Environmental Satellite System
NRO	National Reconnaissance Office
NSC	National Security Council
NSDM	National Security Decision Memorandum
NSF	National Science Foundation
O&M	Operations and Maintenance
OPCON	Operational Control
OSD	Office of the Secretary of Defense

PGMs	Precision Guided Munitions
PC	Personal Computer
PSAC	President's Science Advisory Committee
ROBO	Rocket Bomber
RTCA	Radio Technical Commission for Aeronautics
SAB	Scientific Advisory Board
SAC	Strategic Air Command
SAMOS	Satellite and Missile Observation System
SAMSO	Space and Missile Systems Organization
SCF	Satellite Control Facility
SCI	Special Compartmented Intelligence
SCUD	Iraqi Ballistic Missile
SDI	Strategic Defense Initiative
SECDEF	Secretary of Defense
SECO	Sustainer Engine Cutoff
SIOP	Single Integrated Operational Plan
SLC	Space Launch Complex
SLGR	Small Lightweight Ground Receiver
SMOPS	Space Mission Operations and Planning Study
SOSC	Space Operations Steering Committee
SP	Special Projects
SSD	Space Systems Division
STS	Space Transportation System
TAC	Tactical Air Command
TAV	Transatmospheric Vehicle
TPFDL	Time-Phased Force and Deployment List
TV	Television
TWX	Teletype
UN	United Nations
USAF	United States Air Force
USSR	Union of Soviet Socialist Republics
WDD	Western Development Division
WS–117L	Weapon System 117L (see ARS)
XO	Director of Operations
XP	Director of Plans

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