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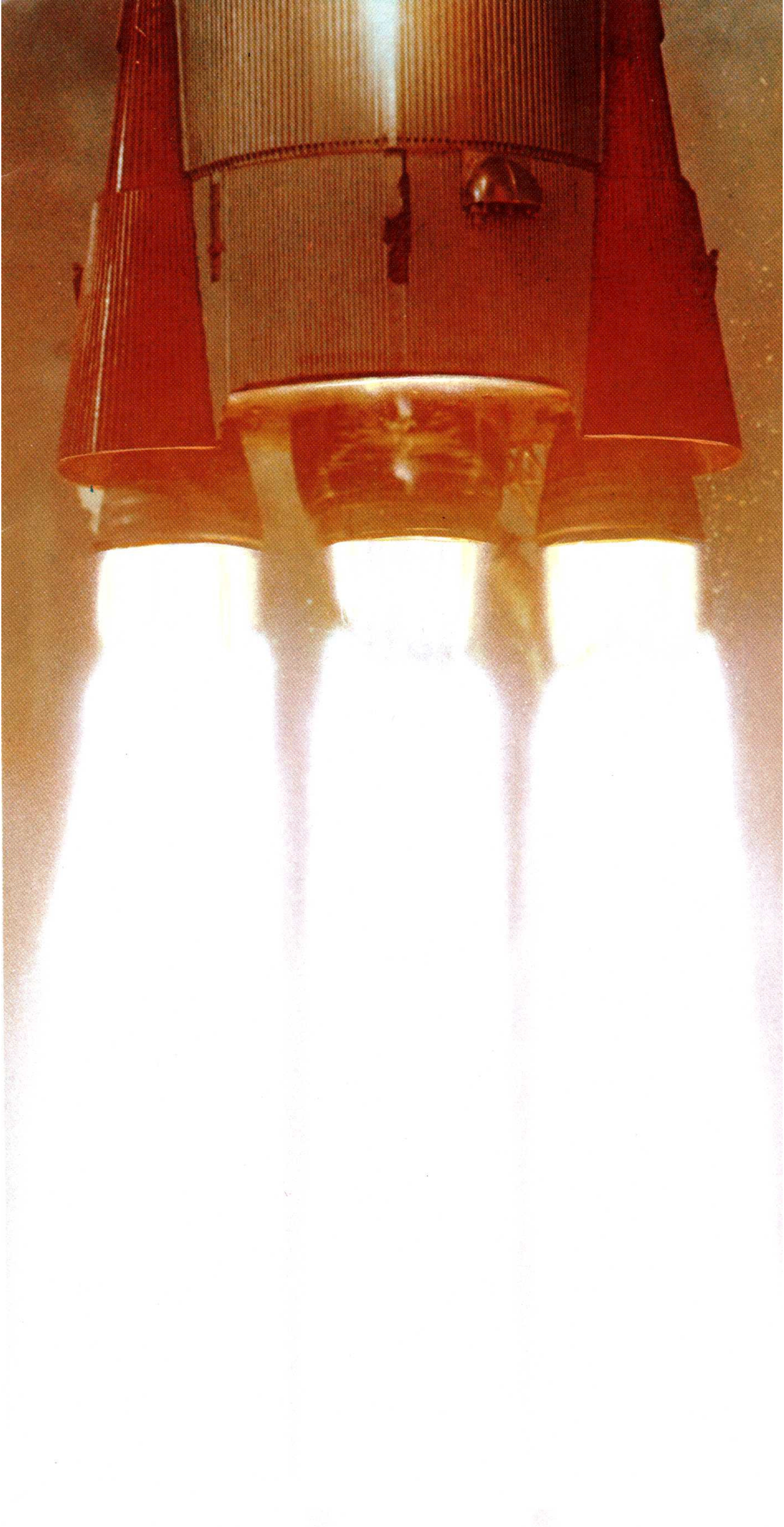


"Atlas has very little to draw on except engineering courage," So wrote *Aviation Week* in 1955. Since then, like a giant stylus skywriting across the heavens. Atlas has written space history for almost three decades. This is the story of the formative years.

Charlie Bossart: "Tremendous strides pushing the state of the art were required, often with no guiding precedent."

In October 1945, Convair signed a contract with the Air Force to come up with ideas for missiles in four ranges, from 20 to 5,000 miles. The assignment went to engineers at Convair's Vultee Field Division, near Downey, California. They were already working on a short-range, rocket-powered missile for the Navy. Charlie Bossart, chief of structures at Vultee, headed the group. Bossart was born in Belgium, graduated from the University of Brussels in 1925, then came to this country and attended MIT, where he studied aeronautics.

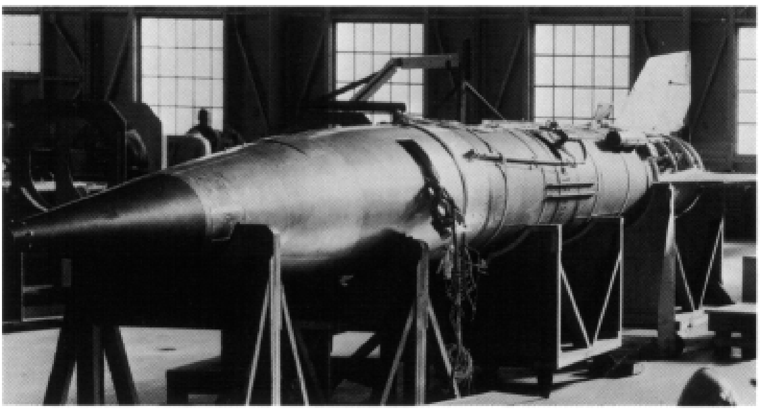
When Vultee closed, the engineers moved to San Diego. Almost from the start, they decided to concentrate on the toughest, but potentially most powerful, of the four missiles the study contract specified: a 5,000-mile ballistic missile.

Thus, an informal group of a few engineers set into motion what the Air Force was to call, "the greatest research and development undertaking in the history of the United States, exceeding in scope even the Manhattan Project."

Research rocket

Their initial assignment was to develop the Atlas forerunner called the MX-774 research rocket. The direct precedent was the German V-2 of the Second World War. V-2 engineers, in turn, were much indebted to American rocketeer Robert Goddard, whose experiments in the 1920s and 30s they had carefully studied. The V-2, like Goddard's rockets, was a one-stage, liquid-fueled affair, with vanes that moved in the exhaust as a crude steering device.

The German weapon had a range of only 200 miles, carried about a ton of explosives, reached an altitude of 50 miles and



speeds of 3,500 mph. The word accuracy barely applied. In a 200-mile flight, the V-2 would miss its target by 10 miles.

Bossart had to do much better than that. His first concern was weight. “You kid yourself right out of the picture if you don’t guess your weights correctly on a long-range missile,” Bossart pointed out. His engineers came up with several breakthroughs that drastically reduced weight. Bossart reasoned that since only the warhead (the actual weapon) need return to earth, why not separate the rocket right after the engines shut down in space, above the earth’s atmosphere? Then, the much lesser stress and heat of ascent would be all the missile had to withstand. The separable nose cone of the Atlas was the result.

Robert Goddard, writing of world’s first successful flight of liquid-fueled rocket: ”It rose 41 feet and went 184 feet, in 2.5 secs.”

The second major weight problem they tackled was the airframe. The V-2 was no precedent here because its airframe was built like a kitchen stove: a heavy, double-walled structure braced inside with steel ribs and stringers. There was a reason. The V-2 had to contend with the tremendous stresses of reentering the atmosphere, still attached to its warhead.

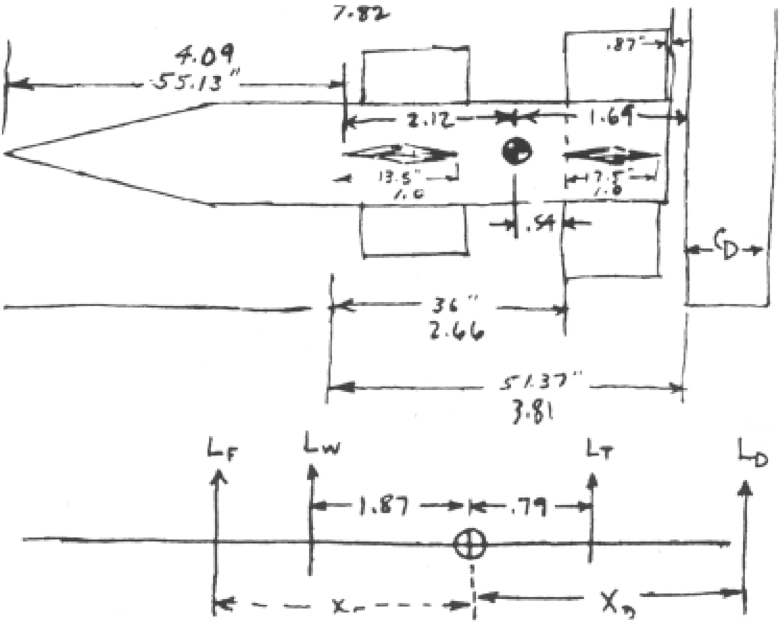
A fellow engineer said of him: "Jim Crooks has the biggest body and the biggest heart and the biggest brain around here."

The solution was to use a single, pressure-stabilized fuel tank that needed no internal bracing. (The theory was not new, but Bossart, who arrived at the idea independently, was the first person to put it into practice.)

The MX-774's hull was thus both the basic structure and the fuel tank. Internal pressure needed for the tank to keep its shape was exerted both by the liquid propellants and by the gas used to force-feed the propellants into the engines. When the rockets were stored or transported without fuel, the gas alone kept the tank stabilized. The engineers now had an airframe-to-propellant ratio three times better than that of the V-2.

Swiveling, or gimbaling, engines for flight control were another key innovation. The concept is as simple as turning a boat's outboard motor to control direction. (The Convair people didn't know that V-2 engineers had rejected the idea as unworkable.)

Next question: What about guidance, the electronics system that would tell the engines how to steer the rocket? Enter Jim Crooks, in 1946. Fresh out of Kansas State with a degree in electrical engineering, Jim jumped right into the technical nightmare of guidance. He and the engineers working with him soon decided that the answer was a combination of ground stations and on-board avionics. They set to work designing a complete ground tracking station, along with developing ultrasensitive autopilots, transponders, and other electronics packages that comprised the missile's on-board guidance system.



Using discarded parts, running crude tests with a hand-drawn cart playing missile, and finally conducting a few tests with aircraft, Crooks soon devised what was named the Azusa tracking system for ballistic missiles. The Azusa Mark II system became the permanent tracking system for all ballistic missiles launched at Cape Canaveral.

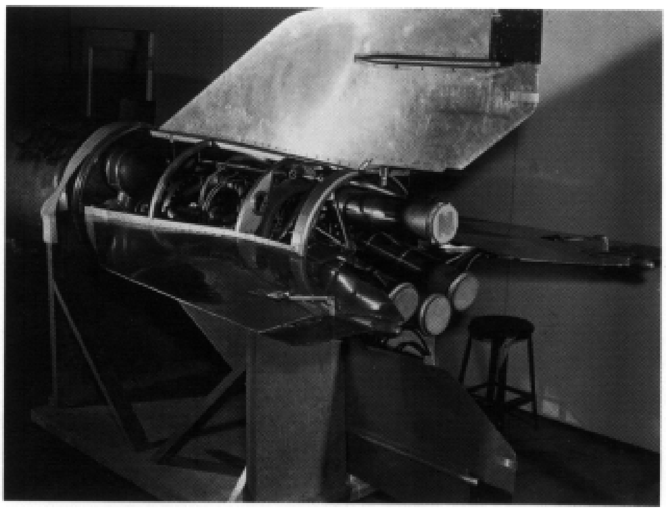
Lean days

The ideas kept flowing, but not the money. In July 1947, the MX-774 contract was abruptly cancelled in an Air Force economy move. At best, the engineers had been short on funds, but they had ordered three test missiles built and got hold of an old oil derrick as something they could use as a test stand for captive firings. The contract may have been cancelled, but they were making too much progress to stop now. They agreed to carry on as best they could. Crooks recalled, "Charlie Bossart was the spark. He kept us all going."

They set up a test site on Point Loma in San Diego and hunkered down to carry on with what MX-774 funds remained, plus some money from Convair.

Following test firings in San Diego, the three MX-774s were launched in 1948, at White Sands in New Mexico. Premature engine burnout marred all three tests, but not before they had verified the three concepts that became basic to Atlas success: separable nose cone, gimbaling engines, and pressurized tank. Also encouraging was the fact that in reaching supersonic speeds, the missiles had successfully passed through the most critical vibration, control, pressure, and aerodynamic stages.

With the outbreak of the Korean war in early 1951, defense appropriations increased. Things loosened up and Convair got an Air Force contract to study the respective merits of ballistic and glide rockets. Having maintained momentum on their own, the MX-774 group was ready.



General Schriever: "Our prestige as world leaders might well dictate that we undertake lunar expeditions and even interplanetary flight."

As in the earlier study, Bossart's team chose the ballistic concept. The Air Force agreed and Convair began studies and component development for an ICBM based on the proven features of the MX-774. They had their work cut out for them. The Air Force now requested a rocket capable of delivering a 3,500-pound warhead 6,325 statute miles (5,500 nautical miles) that would land with an accuracy of two to three miles from its target.

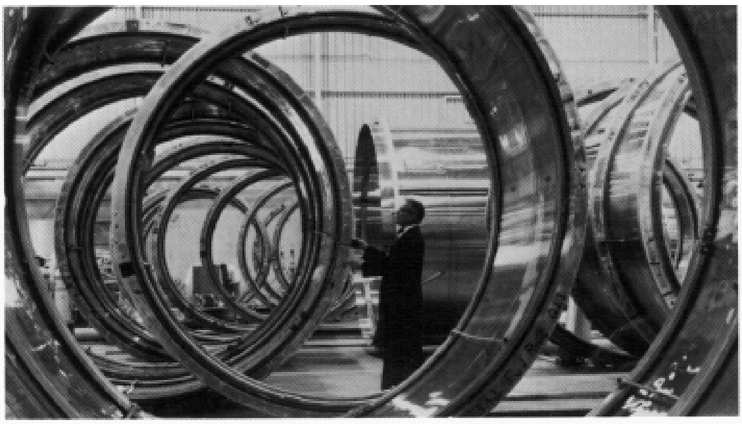
The engineers had done their work well in developing the MX-774 as a springboard. But now, like athletes in the Olympics, they were challenged to go faster, higher, and farther. That's the only way their rocket would meet the requirements.

New answers needed

The question of holding down weight while greatly increasing size needed new answers. They had used aluminum for the MX-774 tank, but that would have to be riveted and they rejected that material. The answer was a special cold-rolled stainless steel that could be welded. Convair engineers developed a new welding technique specifically for the Atlas. It was one of many contributions to manufacturing technology the Atlas program was to make.

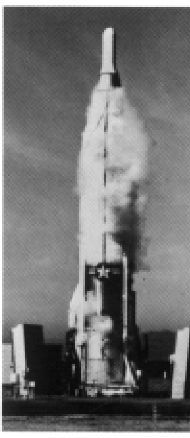
Tank weight with stainless steel would be acceptable, because every one of the sections was thinner than a dime. The tank they developed for Atlas (and still the basic tank today) was pared down to a diameter of 10 feet and a length of 75 feet (depending on the nose cone).

The question of fuel led engineers to consider everything from alcohol through exotic concoctions until they settled on a combination of a kerosene derivative called RP-1 and liquid oxygen.



For propulsion, the engineers developed a unique one-and-one-half-stage system they had first advocated in 1949. Here's how it works. The Atlas has a total of five engines. At launch, all five are ignited, combining their power for maximum thrust at liftoff.

The three main engines consist of two boosters and a sustainer in between. After about two minutes of flight, the booster engines stop firing and drop away. The sustainer engine continues to burn until the rocket reaches top speed. Then, its job finished, that engine shuts down. Two small vernier, or trim, rockets are mounted externally on the tank base. They are directed by on-board guidance to fire, if necessary, to make final, precise course adjustments for the nose cone before it streaks ahead on its own, after separating from the main body.



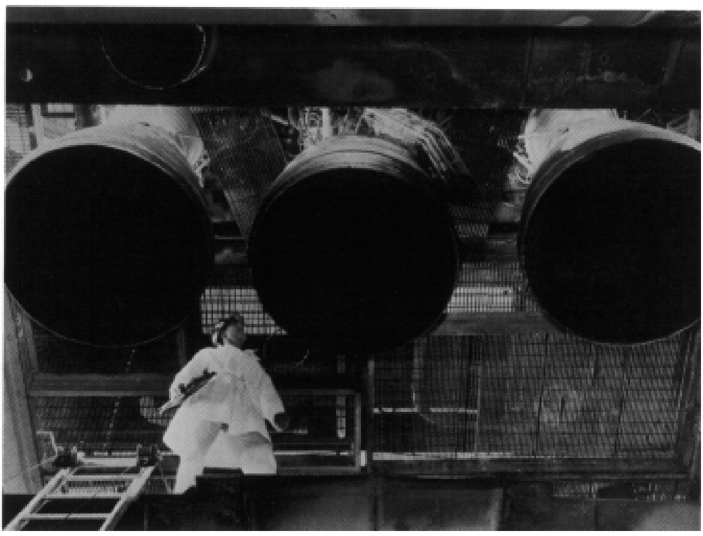
This staging system also licked the biggest propulsion problem of the early 1950s: ignition reliability, which was then less than 50 percent. With Atlas, all engines were seen to ignite properly before liftoff, and mission success did not also require second-stage engine firing in space.

Guidance for the earlier Atlases was radio-inertial, making use of Jim Crooks' Azusa ground tracking system in tandem with on-board (or inertial) avionics. Guidance later became all inertial.

Top priority

In early 1954, when it looked like a pretty sure thing to the Air Force that nuclear warheads could be made small and light enough to ride atop an intercontinental missile, the Atlas program was given top national priority. All hands now began a crash effort to build both the missile and a network of 11 Strategic Air Command ICBM Atlas bases from Maine to California.

General Bernard Schriever was made overall director as commander of the Air Force Ballistic Missile Division. Born in Germany, Schriever came to this country at



Jim Dempsey: "In many areas, it is not technology that is holding us back; it is our ability to manage the task."

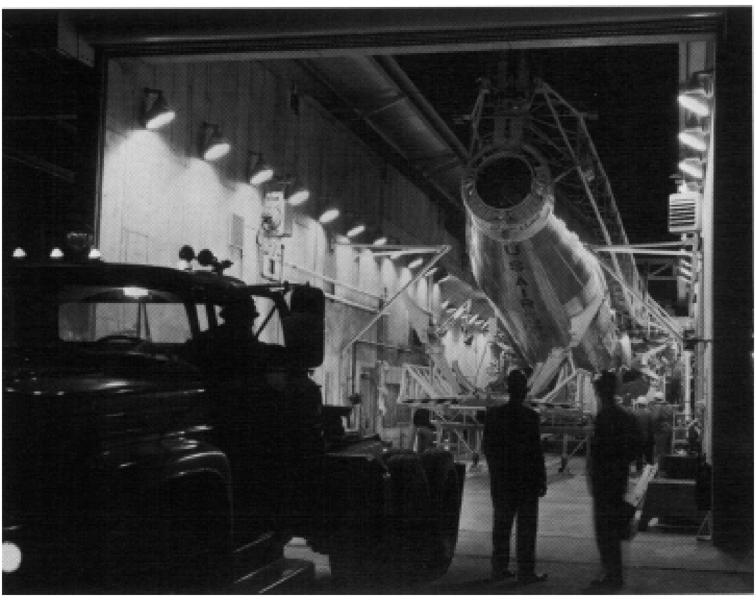
the age of seven. He received an engineering degree from Texas A&M and a master's in aeronautical engineering from Stanford. He joined the Air Corps in 1933. Assigned to the Pentagon after WWII, he soon began to attract attention for his persuasive interest in the potential of missiles as weapons in the Air Force arsenal.

General Schriever summed up the Atlas effort: "The ballistic missile requires for its own operational capability its own vast support structure — launching pads, gantry cranes, blockhouses, tracking equipment, testing, maintenance, and supply facilities, along with its own production base, the industrial plants of America."

Many major concerns were now involved besides Convair, among them the Rocketdyne Division of Rockwell International, General Electric, Burroughs, and Aerospace Corp. The Ramo-Wooldridge Company reported to Schriever as technical director and systems manager.

Schriever and his staff of Air Force personnel were responsible for production of both missiles and warheads and for building the Strategic Air Command bases.

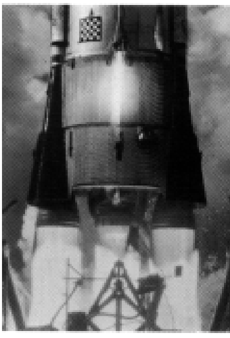
"The Air Force put an umbrella over us," a Convair executive recalled. "We had plenty of dog fights underneath the umbrella, but without the Air Force, we wouldn't have gone anyplace. Those guys were thrust into managing as complex a program as ever existed. That meant heart attacks and ulcers and divorces. They had them all."



Nor were the Convair people immune while playing a major role in the huge job of activating Atlas bases. They planned base layouts, supervised construction, developed countdown procedures, and trained fledgling Air Force missilemen, while continuing work on the missile itself.

Enter new leadership

The vastly enlarged Atlas effort at Convair needed a new manager. The company's choice was Jim Dempsey, a West Point graduate with a master's in aeronautical engineering. He was only 33 when he came to Convair, in 1953. Dempsey was a good choice. He could handle both administrative and technical problems.



Shortly thereafter, a man of boundless imagination joined the Atlas team: V-2 alumnus Krafft Ehricke. From the first, he began to generate ideas for using Atlas as a space vehicle. (Later, Ehricke was to play a key role in developing Convair's Centaur upper stage, the first space vehicle successfully fueled by liquid hydrogen.)

As the basic Atlas design task began to wind down and production planning increased, Mort Rosenbaum took over as chief engineer. He had joined Convair in 1936, after graduating from MIT.

By the end of December 1954, Convair had redesigned Atlas to its present basic configuration. In January 1955, production began. In less than five years from that date, Atlas became operational as an ICBM, in September 1959, at Vandenberg Air Force Base in California.

Krafft Ehricke: "The Atlas is like a big truck. You can use it to carry men, equipment, most anything you want, into space."

First flights

As the missiles began coming off the assembly line at Convair's new Kearny Mesa plant in San Diego, built specifically for the Atlas program, engineers continued to play a vital role in test and development. Their flight test plan for the complicated missile was to move from the simple to the complex, building up to a complete missile that could carry out the full ICBM mission. In this way, missile components and systems could be progressively tested, with shortcomings more easily identified and corrected as testing proceeded.

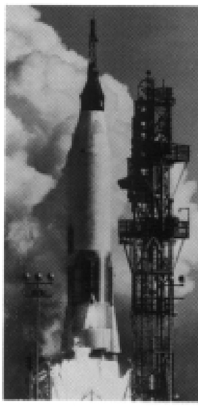
Thus, the A series was the simplest possible missile that could leave the ground. This missile did not have the sustainer engine and only rudimentary guidance. It was intended for a flight of only 600 miles.

Mort Rosenbaum: "If you don't perform, you better get out of the business."

Flight testing, at Cape Canaveral, began in June 1957. That very first flight had to be terminated after 51 seconds, but that was time enough to collect valuable data and to prove the basic principles of Atlas. The public got a different story. Sample headlines from the day after: "Mile-High Blast Ends First Big Test of AF Weapon." "Rocket, Believed an Atlas, Explodes."

Yet, several years later, in a period of less than nine months, Atlas made 21 successful flights in a row.

The first successful flight of an A series — and therefore of any Atlas — was in December 1957, from Cape Canaveral. The flight was a shot in the arm for America's sagging confidence in the nation's space program. Just a few weeks before, the Soviets had launched Sputnik I. That had been followed in the U.S. by the spectacular failure of a Vanguard rocket. Coincidentally, that first Atlas flight was made on the 54th anniversary of the Wright Brothers' first successful flight.



A real brotherhood

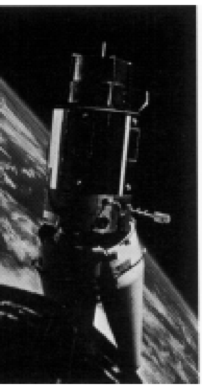
The tempo of the flight-test program increased and so did the stresses on everyone involved. Looking back several years later, an Atlas engineer commented, "We were inventing ways to test things that had never been built before. Then, sooner or later, we had to fire a rocket with the whole world watching. But let me tell you, we were all fused in a real brotherhood. Something happens when men are scared together."

As a weapon, Atlas had become the nation's strategic Sunday punch with performance beyond expectations, including flights of more than 9,000 miles and placing the missile's nose cone within 800 yards of its target.

As a space booster, Atlas was rapidly achieving prominence. That role was demonstrated worldwide in December 1958, when an entire Atlas was sent into orbit and beamed back to earth a recorded Christmas message from President Eisenhower. A few years earlier, Ehricke had mentioned to Jim Dempsey that an Atlas could easily be put into orbit and when Washington asked what

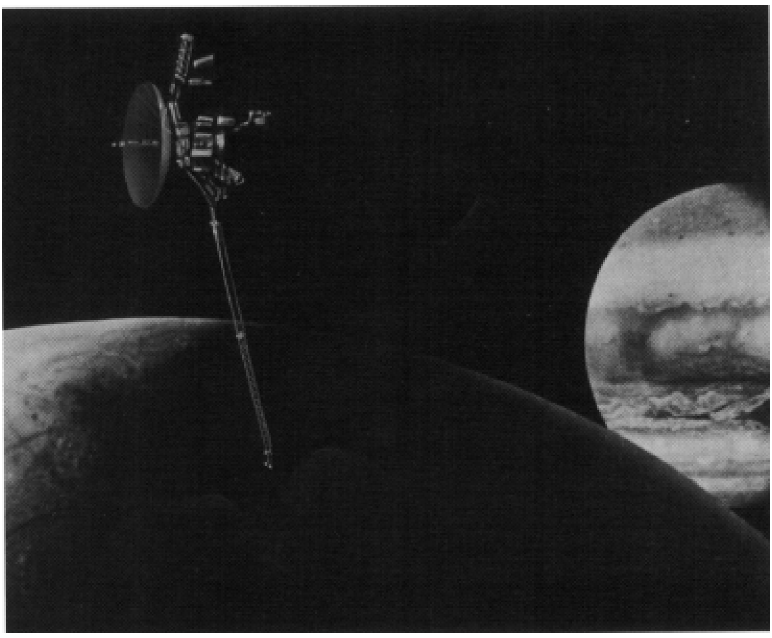
Convair could do quickly to bolster national prestige with a space spectacular, Dempsey remembered and suggested putting that four-ton object into orbit.

On-board avionics also received and relayed messages from ground stations in this country. Atlas thus became the nation's first booster for communications satellites. Even bigger headlines about Atlas in its space role were to come in February 1962, when the vehicle boosted Mercury astronaut John Glenn into orbit.



Atlas contributions continue

National defense considerations led to the development of Atlas. Yet it was part of a weapon system for only six years, from 1959 to 1965, when the rocket was phased out as an ICBM. Its role in space is now in its third decade. In early years, Atlas launched the first interplanetary flyby, the first lunar impact by an American spacecraft, the first televised pictures of the moon, and the first closeup pictures of Mars. Its many other contributions to space exploration can only be touched upon here. Alone, or in combination with Centaur and other upper stages, Atlas has launched communications satellites that provide worldwide television, telephone, and radio service, weather satellites, planetary missions, scientific space probes that have been useful in many areas, navigation satellites — all these and more. Atlas is an example of the highest achievements in aerospace engineering. As an ASME National Landmark, it commemorates the efforts of the engineers and craftsmen who made it a reality.



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