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Giving Mercury Wings

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Introduction

As 1959 opened, the newly created NASA appeared to be well on its way with Project Mercury. In January 1959 the Space Task Group (STG) had chosen McDonnell as the capsule's contractor and had already made key decisions on its design (see **America's First Spaceship** in the April 15, 1999 issue of *SpaceViews*). While a modified Atlas ICBM would eventually launch Mercury into orbit, it was recognized early on that smaller rockets would also be required for various test flights. As soon as NASA was formed and Project Mercury organized in October of 1958, STG officials had begun negotiations to procure the rockets they needed.

One of the smaller ones was the Redstone. This short range tactical missile was developed by a team at the ABMA (Army Ballistic Missile Agency) under the direction of Wernher von Braun. Since its inception in August 1953, the Redstone had been developed into a highly reliable rocket. A modified version of the Redstone was used by the ABMA as the basis of a launch vehicle that sent America's first satellite into orbit (see **Project Orbiter: Prelude to America's First Satellite** in the January 1998 issue of *SpaceViews*).

Among the many proposals to send men into space that circulated during 1958 was von Braun's Project Adam. It proposed to send a man on a suborbital flight using a Redstone rocket. While Project Adam was rejected, the idea of using the Redstone to test Mercury in a short suborbital flight was attractive. A modified Redstone would be capable of reaching a speed of 2.0 kilometers per second (1.2 miles per second) and a peak altitude of about 185 kilometers (115 miles) - roughly orbital altitude. A total of 5 minutes of weightlessness would be experienced during the 15 minute flight.

On January 16, 1959 STG placed an order for eight man-rated, Chrysler-built Redstones. Two of the rockets would be used for unmanned test flights to qualify Mercury-Redstone combination, develop checkout procedures, and gain experience. The remaining six Redstones would be used for manned suborbital test flights allowing all six of the anticipated Mercury astronauts to each make a short foray into space (in the end seven astronauts were actually chosen but the Redstone order remained unchanged). The first Mercury-Redstone launch was planned for December of 1959 with the first manned attempt taking place the next month - only one short year away.

Along with the Redstone rockets, STG also ordered a pair of Jupiter IRBMs from ABMA. The larger Jupiter missile would be capable of hurling the Mercury capsule to a peak speed of 4.9 kilometers per second (3.0 miles per second). While still short of the 7.8 kilometers per second (4.9 miles per second) required to attain orbit, it would provide a realistic reentry test for Mercury's innovative ablative heatshield. A single test of the Mercury-Jupiter would take place sometime in the last quarter of 1959 before the first Mercury-Redstone flight. The second Jupiter would serve as a backup in case of a problem.

New Rockets

While the Redstone and Jupiter missiles allowed important tests to be performed prior to manned orbital missions, these launch vehicles were ill suited and too expensive for certain types of tests. One of the more obscure of the originally proposed tests of the Mercury capsule required no launch vehicle at all. Instead a large balloon would carry a production version of the capsule to an altitude of 25 kilometers (16 miles) where it would be exposed to a near-space environment for extended periods. This would allow engineers to measure radiation levels and determine how the spacecraft operates under cold conditions.

But other tests would require the use of specially designed rockets such as the Little Joe. This very simple yet adaptable launch vehicle was originally proposed by STG's Max Faget for use in testing Mercury's important launch escape system. The fin stabilized Little Joe had no guidance system and used clusters of solid rocket motors to propel a capsule and its attached launch escape tower to speeds and altitudes that simulated critical flight conditions that would be experienced during an actual ascent. The escape system would then be activated and put through its paces.

Little Joe was designed to use various combinations of solid rocket motors to achieve different flight profiles. Inside Little Joe were mountings for four large rocket motors. Based on the Sergeant rocket, they came in two varieties known as Castor and Pollux. Four smaller motors based on the Recruit rocket supplemented the larger foursome. These eight motors could be ignited in various combinations at preprogrammed times to achieve a desired flight profile. In theory Little Joe could propel a Mercury capsule to a speed of 2.9 kilometers per second (1.8 miles per second) and reach heights in excess of 160 kilometers (100 miles). Even though it could supply as much energy as a Redstone, Little Joe was not suitable for manned flights due to the lack of a guidance system and the inability to shut off solid motors once lit. Little Joe's major advantage over the Redstone was price: Each Little Joe cost one-fifth as much as a Redstone.

Although it was capable of hurling a Mercury capsule into space, the Little Joe was used exclusively for tests of the important launch escape system at altitudes of 9 to 30 kilometers (30,000 to 100,000 feet). Given this rocket's low cost and flexibility, Little Joe was ideal for the task. In a typical test flight, two large and all four small solid rocket motors would ignite at liftoff. The remaining two large motors would ignite at predetermined times to achieve the goals of a particular test flight. Typical apogees for these flights were in the 15 to 85 kilometer (50,000 to 280,000 foot) range. On December 29, 1958 North American Aviation's Missile Division got the contract from STG to build seven Little Joes. At the beginning of 1959, the first Little Joe flight was set for July 1959.

The Atlas, which would send Mercury into orbit, was a modified version of the operational Atlas D ICBM. The launch of a stripped down "hotrod" version of the Atlas B into orbit as part of Project Score had already demonstrated that the Atlas could orbit a payload (see **The Talking Atlas** in the December 1998 issue of *SpaceViews*). Incorporating all the upgrades of the D-model plus new features required to man-rate the rocket, the Atlas-D would be capable of placing a 1,350 kilogram (3,000 pound) capsule into a 210 kilometer (130 mile) orbit.

Even though the Atlas D was critical to Project Mercury, it was also vital to national defense in its intended role as an ICBM. As a result, NASA projects including Mercury had to compete with the USAF for Atlas-Ds coming off of the assembly line. NASA's STG placed the first order for an Atlas from the Air Force Missile Division on November 24, 1958. A single, more readily available Atlas C was initially ordered to perform a suborbital reentry heating test using an ablative heatshield-equipped boilerplate model of the Mercury capsule. With the availability of the Atlas D the following month, NASA modified its request ordering a total of nine D-models and deleting the interim C-model. Later more were added bringing the total order to 14 Atlas-D missiles.

In order to save weight, Mercury made use of a new ablative heatshield which was originally scheduled for testing during ballistic flights on the Atlas and Jupiter. (NASA)

At the beginning of 1959 the Mercury-Atlas reentry test was scheduled for July of 1959. The first unmanned orbital test was scheduled for January 1960 and a manned orbital attempt that April. While such an aggressive development schedule would have guaranteed that America would reach space before the Soviet Union, in reality it proved to be far too ambitious.

Falling Behind

As 1959 progressed, STG officials were beginning to experience a degree of sticker shock with Mercury as finances began to spiral out of control. By the spring

McDonnell's original $18.3 million estimate for a dozen capsules that NASA had ordered quickly skyrocketed to $41 million including spares and support equipment. Similarly Mercury's launch vehicles also began climbing in price. The in January of 1959 USAF raised the unit price of an Atlas by 32% to $3.3 million. Similarly ABMA also increased the price of the Redstone and Jupiter. With a Jupiter now costing as much as an Atlas, the Mercury-Jupiter flights were finally scrapped on July 1, 1959. In a further move to control costs, the balloon flight was also canceled with a cheaper test to take place inside a modified wind tunnel.

With the full scope of the difficulty in developing the Mercury capsule and supporting hardware beginning to dawn on STG and NASA officials, the ambitious flight schedule also began to slip drastically. Even by March of 1959 NASA had slipped the first manned Mercury-Redstone flight originally planned for January 1960 to no earlier than the end of April. The first manned Mercury-Atlas flight was now pushed back to September of 1960. But within a month these dates had slipped again with the first manned Mercury-Atlas flight now not expected to take place before May of 1961 - a delay of 14 months just in the opening four months of 1959.

But as STG and other NASA managers wrestled with project costs and schedules, the development program was proceeding steadily. The first Little Joe flight was finally ready for launch on August 21, 1959. The objective of LJ-1 (Little Joe 1) was to test the launch escape system during an abort at maximum dynamic pressure (or max-q"). Although the first Mercury capsule would not be available for months, an appropriately equipped boilerplate model was used instead for this test. Unfortunately LJ-1 failed 31 minutes before it was scheduled to be launched. A faulty circuit inadvertently ignited the escape rocket while LJ-1 was still on the pad. The launch escape system did perform this unintended on-pad abort flawlessly flying to a height of 600 meters (2,000 feet). While the capsule's drogue chute opened as expected, insufficient electrical power prevented the deployment of the main parachute. The capsule was destroyed on impact.

With this inauspicious start, engineers prepared for the first Mercury-Atlas ballistic test flight called "Big Joe". The purpose of this flight was to test the new ablative heatshield that had been selected for use on orbital Mercury flights. The Atlas 10-D missile would carry its payload to an altitude of 160 kilometers (100 miles) and accelerate to 7.5 kilometers per second (4.7 miles per second) - just short of orbital velocity but enough to meet the test objectives. Again a boilerplate capsule was used for this test. In addition to the heatshield, the capsule carried instruments to monitor its performance and the aerodynamic heating characteristics of the Mercury design. Big Joe would also be the first full scale flight operation of the Mercury program.

The launch of the "Big Joe" ballistic test on September 9, 1959. (NASA)

On the morning of September 9, 1959 (40 years ago this month) Big Joe lifted off. As the Atlas 10-D rocket arced over the Atlantic and gathered speed, the pair of booster engines failed to jettison as intended. Carrying the additional weight, Big Joe only reached a speed of 6.64 kilometers per second (4.13 miles per second). The velocity shortfall caused the capsule to come down 800 kilometers (500 miles) short of its intended landing zone. To make matters worse, the capsule separated from its launch vehicle two minutes late. The tiny capsule's attitude control propellant was quickly exhausted as it tried in vain to rotate the capsule 180 degrees for reentry.

Despite the string of failures which threatened the mission, the robustness of the Mercury design was ultimately proven. Even without attitude control, the capsule righted itself during reentry owing to the capsule's shape and careful placement of its center of gravity. While the slower reentry speed of this flight subjected the heatshield to less total heating, the peak heating rate was much higher than originally planned due to the steeper descent. Despite the punishing conditions, the boilerplate capsule made a safe landing and was recovered six hours and 41 minutes after the start of its 13 minute mission. Close inspection of the capsule afterwards showed that only 30% of the heatshield had ablated away and that the capsule was perfectly protected despite the punishing flight - Big Joe was a success after all!

Little Joe 1B launch on January 21, 1960 carrying the rhesus monkey Miss Sam. (NASA)

Over the coming months additional Little Joe test flights were made. On October 4, 1959 LJ-6 was launched and successfully qualified the launch vehicle structure and command system. A month later LJ-1A was launched to repeat the aborted LJ-1 mission. This time the mission failed when the escape motor ignited too late missing max-q conditions. One month later LJ-2 successfully tested a high altitude abort during an 11 minute mission that also carried a Rhesus monkey named Sam. The objectives of LJ-1 were finally met on January 21, 1960 with the launch of LJ-1B. This flight also carried a simian passenger named Miss Sam. Despite the many problems encountered and the slipping schedule, by the end of 1959 Project Mercury was well on its way.

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