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Chapter 19

Mercury Primates[1]

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The first launch of a monkey aboard a rocket occurred on 11 June 1948. The rocket was the third V-2 flight of Operation Blossom, launched from White Sands Proving Ground (today, White Sands Missile Range) located in the Tularosa Basin of Southern New Mexico. Operation Blossom was an Air Force project which attempted to develop a parachute recovery technique for the V-2 nose section. The principal investigators for the biological experiment were Dr. James P. Henry and Captain David G. Simons, both from the Air Force's Aero Medical Laboratory at Wright Field (today, Wright Patterson Air Force Base).[3]

Henry and Simons used American born Rhesus monkeys (*Macaca mulatta*) for the flights. The personnel of the parachute branch at Wright Field, who developed the parachutes for Blossom, dubbed the passengers "Albert."

The opportunity to place a live passenger aboard Blossom #3 was presented just two months before the planned flight, so Henry and Simons had to work quickly.[4] They designed a capsule, which was convex on one side, to fit inside the V-2 warhead section, and square on its other three sides. In the words of the Air Force Technical Report: "By using all the space available in the capsule, it was possible, with difficulty, to place a 9 pound (4.1-kilogram) Rhesus monkey in it after installation of associated equipment."[5] Instrumentation for Albert I was crude, and it comprised electrocardiogram sensors and

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[1] Presented at the Twenty-Third History Symposium of the International Academy of Astronautics, Málaga, Spain, 1989.

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[3] Simons, David G., *Use of V-2 Rocket to Convey Primate to Upper Atmosphere*, Air Force Technical Report 5821, United States Air Force Materiel Command, Dayton, Ohio, May 1949, p. iii.

[4] Mallan, Lloyd, *Men, Rockets, and Space Rats*, Julian Messner, Inc., New York, 1955, pp. 86-87.

a mechanical lever device to measure respiration. Heart and breathing data were telemetered to the ground.

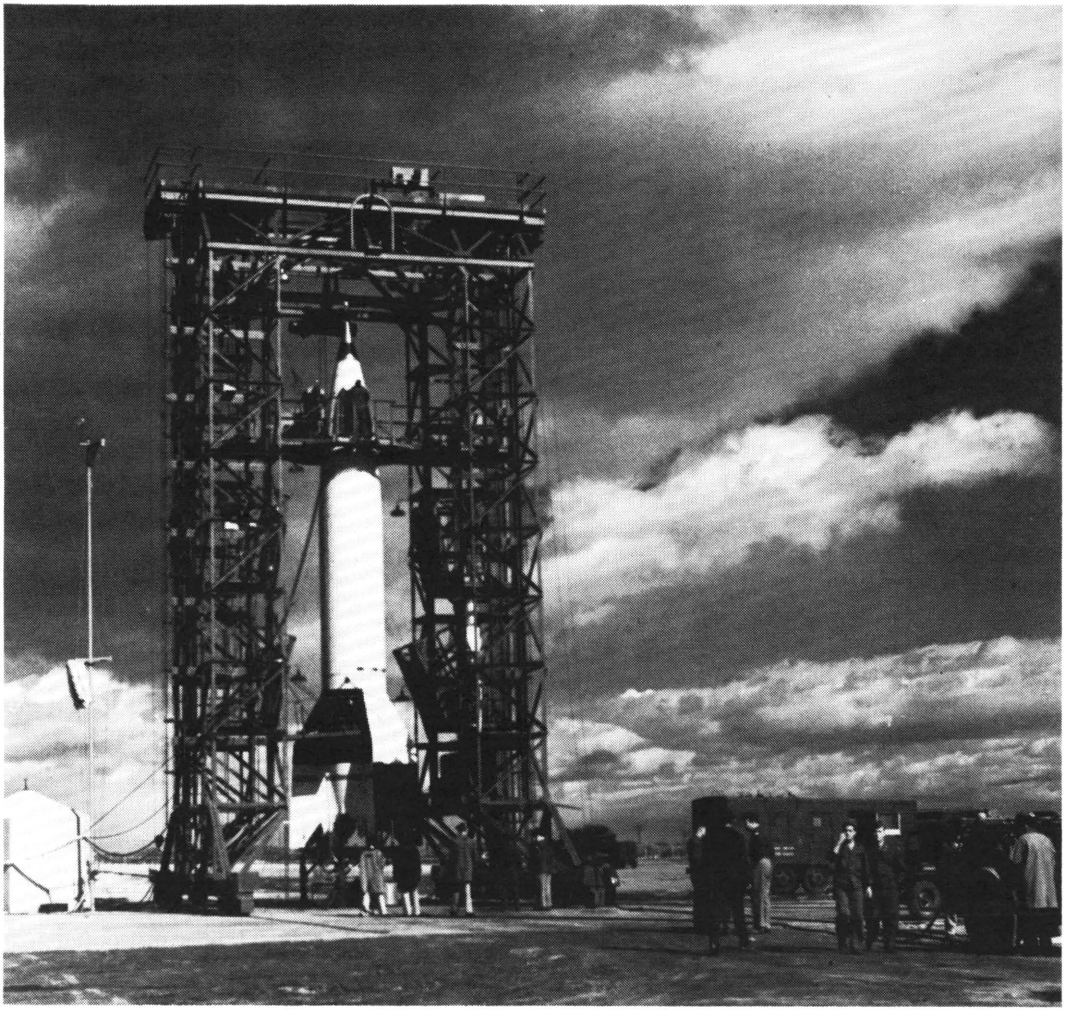

Figure 1 German V-2 rocket at the White Sands Proving Grounds.

The night before the launch, Simons injected Albert with 10 to 15 mg sodium phenobarbital, then sutured the electrocardiographic needles and respiration lever into place. As a further measure to protect the monkey, he also administered 2 cc Luminal as a muscle relaxant just before placing Albert in the capsule. The Luminal would help Albert endure a hard landing. Simons had to adjust the breathing sensor several times, as Albert switched from abdominal to thoracic respiration and back again, as the anesthesia deepened. Eventually, the respiration unit stopped working altogether.

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[5] Simons, David G., *op. cit.*, p. 4.

About 45 minutes before the planned launch time, Simons loaded the capsule in the V-2's payload section. An unknown wag at White Sands had written "Alas, poor Yorick, I knew him well" in chalk on one of the rocket's fins.[6] Just before launch, the apparatus failed to function, then apparently began working again. However, there was no indication of either heart action or respiration during the 59.5-kilometer high flight, so the investigators concluded that Albert I died prior to lift-off.[7] In any event, Albert I would have died on landing, for the parachute failed.

Henry and Simons repeated the experiment, on 14 June 1949, with Albert II. The capsule was completely redesigned and was a 91.4-centimeter long, 30.5-centimeter diameter cylinder. Again, the parachute failed and the monkey was killed. Telemetry indicated Albert II lived until impact.[8] Alberts III and IV, Cynomolgus monkeys aboard Blossoms 6 and 7 respectively, suffered similar fates.[9]

The next monkey flights were with the Aerobee research rockets. The United States Navy developed the Aerobee to carry instruments into the upper atmosphere as a complement to the Viking rocket. The first Aerobee flight was in the Fall of 1947. A short time later, the Air Force began their own program with Aerobee rockets, and they built a launch facility at Holloman Air Force Base, on the southeast edge of White Sands Proving Grounds near the city of Alamogordo, New Mexico. On 18 April 1951, the first aeromedical Aerobee took off from Holloman. The passenger was a Capuchin monkey. Unfortunately, the results from this flight were the same as the earlier V-2 experiments: physiological data on the primate's reactions to acceleration and weightlessness were successfully telemetered, but the parachute failed.

The first (partially) successful recovery finally occurred on the second aeromedical Aerobee, launched on 20 September 1951. After carrying a Rhesus monkey and 11 mice to 71.9-kilometers, the parachute deployed, and all the animals landed alive. However, there was some delay in recovering the capsule, and the New Mexico desert Sun was too intense; the monkey died of heat prostration about two hours later.

The third, and final, biological Aerobee flight at Holloman was made on 21 May 1952. This time, the capsule carried two Capuchin monkeys and two mice. The parachute worked properly after the capsule reached 57-9-kilometers, and it was recovered in time. All four passengers were in good shape. At last, the Air Force aeromedical team had proof that primates could survive journeys into the upper atmosphere.[10] Air Force Aeromedical Aerobee #3 was the last primate flight until 1959, when the Army and Navy each performed biomedical space missions with monkeys.

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[6] Mallan, Lloyd, *op. cit.*, p. 89.

[7] Simons, David G., *op. cit.*, p. 2.

[8] *Ibid.*

[9] Anderson, Michele, *et. al.*, *BIOSPEX: Biological Space Experiments*, NASA Technical Memorandum 58217, National Aeronautics and Space Administration, Washington, D.C., 1979, p. iv.

[10] Henry, James P., *et. al.*, "Animal Studies of the Subgravity State During Rocket Flight," *Journal of Aviation Medicine*, V. 23, No. 10, October, 1952, pp. 421-432.

On 13 December 1958, an Army Jupiter intermediate range ballistic missile lifted off from Cape Canaveral, Florida. Although the flight was primarily a ballistic missile test, Army program managers offered space within the nose cone, on a non-interference basis, for a biological payload. The available space was 12,200 cubic centimeters and the weight limited to 13.6-kilograms.[11] Researchers at the U.S. Naval School of Aviation Medicine in Pensacola, Florida selected the squirrel monkey (*Saimiri sciirea*) because of its small size and weight. However, this particular breed of monkey is highly excitable and shows wide variations in heart rate, respiration, and body temperature, depending on emotional state. Therefore, a training program became necessary to get the monkeys used to confinement in the capsule.

Investigators began screening monkeys by having them sit, restrained, in a flight couch for increasing periods of time. Monkeys which did not respond to the training, that is, those which continued to show signs of stress after repeated exposure, were removed from the program. Four days prior to the flight, Navy personnel from Pensacola took six monkeys to the Cape. Eleven hours prior to launch, two separate teams began preparing two monkeys simultaneously. Instrumentation for the primates included temperature, respiration rate, electrocardiogram, and chest sounds. By launch minus eight hours, the monkey to fly was selected and delivered, in its sealed capsule, to the launch pad. This monkey was named "Old Reliable." Telemetry indicated that Old Reliable endured the stresses of launch and weightlessness with no apparent ill effects. Unfortunately, at reentry, the nose cone was lost.[12] The experiment was repeated on 28 May 1959, with another Jupiter flight. This time, in addition to the Navy squirrel monkey capsule, the United States Army also participated by providing a capsule which carried a Rhesus monkey. The Army monkey was named "Able"; the Navy Monkey "Baker." Able was American born, Baker came from Iquitos, Peru.[13] The Army capsule was much larger than the Navy one, and weighed about 117 kilograms. The monkey was restrained in a couch designed to approximate the body angles proposed for the Mercury spacecraft.

The Jupiter lifted off at 2:35 a.m., EST. The capsule reached an altitude of 480 kilometers and landed 2,740 kilometers downrange. The U.S.S. *Kiowa* recovered the capsule, and both monkeys were released from their capsules and given thorough physical examinations. Both were in good health and had shown relatively minor distress during the flight.[14]

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[11] Graybiel, Ashton, *et. al.*, "An Account of Experiments in Which Two Monkeys Were Recovered Unharmed After Ballistic Space Flight," *Aerospace Medicine*, V. 30, No. 12, December 1959, p. 872.

[12] *Ibid.*, pp. 893-894.

[13] U.S. Naval School of Aviation Medicine, *Miss Baker* U.S. Naval School of Aviation Medicine, Pensacola, Florida, undated fact sheet obtained from Space and Rocket Center, Huntsville, Alabama.

[14] Graybiel, Ashton, *op. cit.*, pp. 923-931.

Able was flown to Walter Reed Army Institute of Research in Washington, D.C., where a total body radiation count was conducted. Next, Able traveled to the Army Medical Research Laboratory at Fort Knox, Kentucky, where the implanted ECG electrodes were to be removed. Unfortunately, Able had an adverse reaction to the anesthesia and died during surgery. A necropsy indicated her death was not in any way connected to the flight.

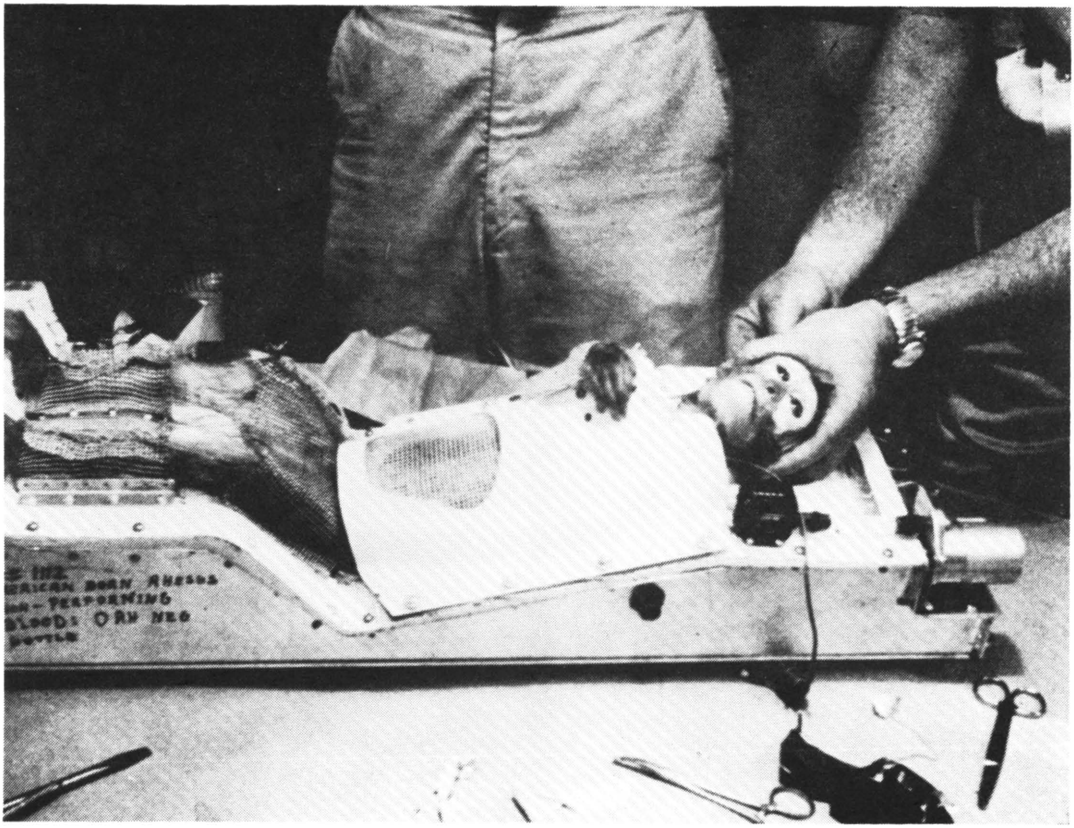

Figure 2 Army monkey Able being released from the life support couch after the 2,740 kilometer flight through space on a Jupiter rocket on 28 May 1959 (NASA photo M-113).

Baker fared somewhat better. After the flight, she went back to the Naval Aerospace Medical Center in Pensacola. In July 1971, she and a companion, "Big George," moved to the Space and Rocket Center in Huntsville, Alabama, where she lived until her death in late 1984.[15]

[15] Space and Rocket Center, *Monkeynaut Baker is Memorialized,* Space and Rocket Center, Huntsville, Alabama, press release dated 4 December 1984.

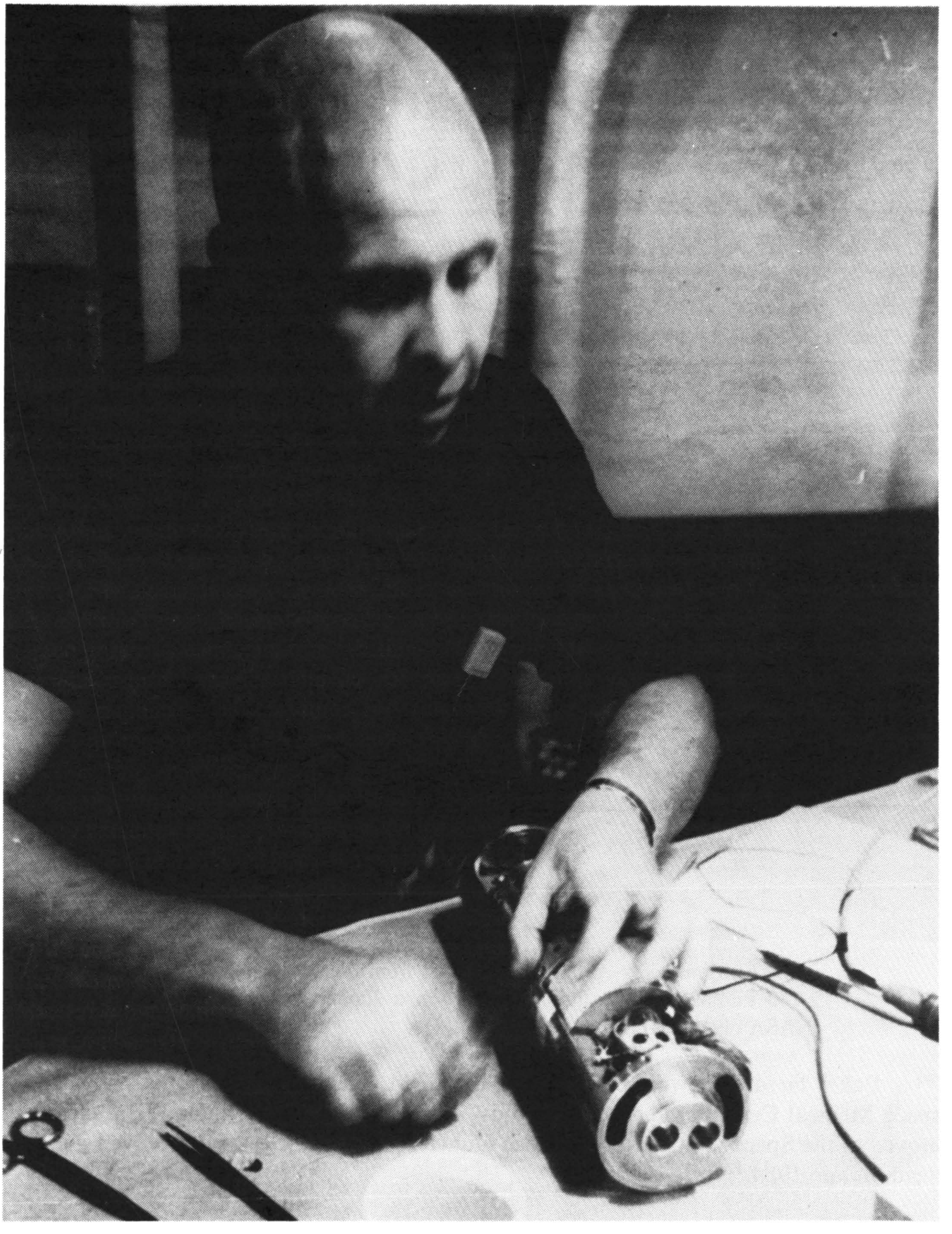

Figure 3 The Navy Rhesus monkey Baker, which flew with Able on the Jupiter rocket on 28 May 1959 (NASA photo M-92).

Project Mercury

Against such a background of research, the decision by NASA to test the planned Mercury spacecraft using primates was a logical one. On 13 and 14 April 1959, personnel from NASA and the Armed Forces met to draft the Project Mercury animal program.[16] They mapped out a program of nine flights, using Little Joe, Jupiter, Redstone, and Atlas launch vehicles.[17] On 2 June, Robert R. Gilruth, Director of Project Mercury, formally requested the services of the Aeromedical Field Laboratory at Holloman Air Force Base for the animal program.[18]

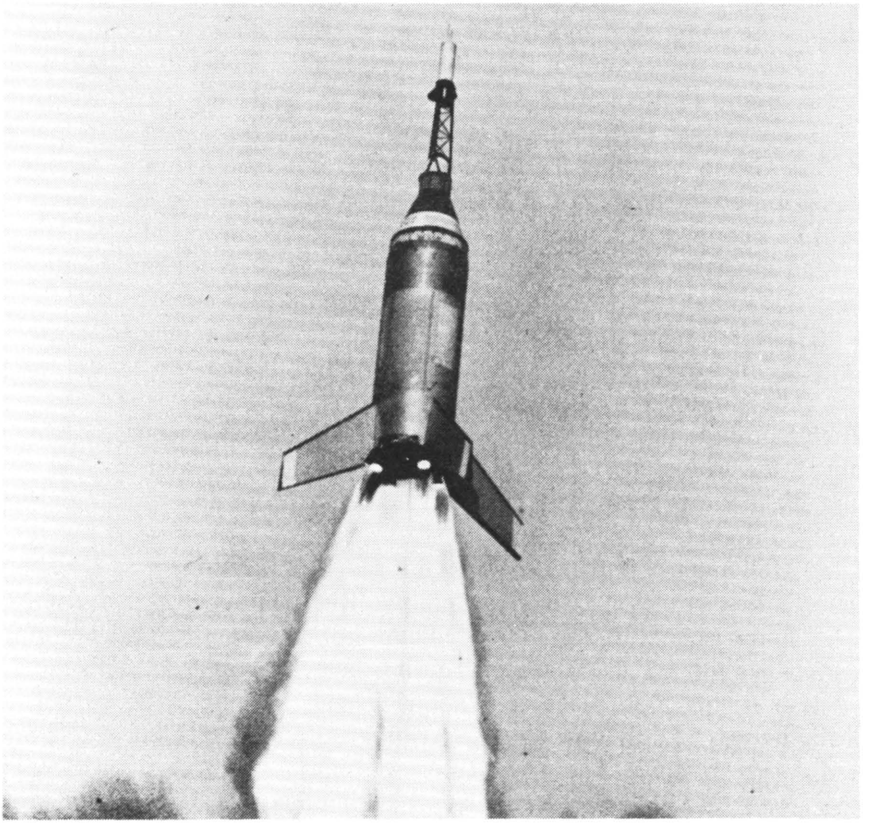

Figure 4 The Little Joe booster, used as a test and development vehicle for the U.S.A. Mercury program (NASA photo M-70).

[16] Henry, James P., and Mosely, John D., *Results of the Project Mercury Ballistic and Orbital Chimpanzee Flights*, NASA SP-39, National Aeronautics and Space Administration, Washington, D.C., 1963, p. 3.

[17] Grimwood, James, M., *Project Mercury: A Chronology*, NASA SP-4001, National Aeronautics and Space Administration, Washington, D.C., 1963, p. 50.

[18] Bushnell, David, *The Aeromedical Field Laboratory: Mission, Organization, and Track-Test Programs*, 1958-1960, Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1961, p. 10.

Brigadier General Don Flickinger, Assistant for Bioastronautics at Headquarters Air Research and Development Command, noted that the Aeromedical Field Laboratory had the only colony of large primates in the Defense Department, and they had a broad background of research. He also noted, though, that the Aero Medical Laboratory at Wright Field had responsibility for animal training and studying animal behavior in "unusual" environments. Rather than move the primate colony to Ohio, Flickinger directed that the personnel, mission, equipment, and funds necessary to support Mercury be transferred to the 6571st Aeromedical Field Laboratory at Holloman.[19]

Original plans to prove the Mercury spacecraft included two flights with the Jupiter as booster. During such a flight, the capsule would encounter an entry loading of 20 g's, which was the worst case anticipated during an Atlas abort. Program plans made in early 1959 called for the second of these Mercury Jupiter flights to contain a primate to qualify the environmental control system.[20] However, on 1 July 1959, Abe Silverstein, Director of Space Flight Development at NASA Headquarters, sent a formal memo to the Space Task Group canceling the Mercury Jupiter program. Mercury Jupiter was canceled because program planners felt all the data which could be obtained from these flights could be obtained by aborting one of the already planned ballistic Atlas tests. In addition, using an Atlas for this test had the advantage of providing additional operational experience to the crews who would later launch manned spacecraft.[21]

But the concept of testing the spacecraft with primates remained, and during the same time frame that the Mercury Jupiter was being terminated, the animal test program took shape. The program was intended to verify a successful space flight prior to manned flight; provide data on physical and mental demands encountered by a human pilot; evaluate the life support system under flight conditions; and test the procedures and training for medical personnel. The 6571st was tasked with providing chimpanzees for four planned flights.[22]

But the Holloman chimpanzees were not the first passengers to fly aboard Mercury. Mercury's first primate passengers were two Rhesus monkeys, Sam and Miss Sam. The U.S. Air Force School of Aviation Medicine in San Antonio, Texas proposed placing these monkeys aboard the spacecraft during launch abort tests with the Little Joe rocket.[23] These flights took place at Wallops Island, Virginia. The purpose of these biological flights was to provide data on physiological response to the acceleration loads encountered during an abort. These two flights did not use a production Mercury spacecraft. Rather, they used boilerplate vehicles which duplicated the Mercury configuration. On 26 May 1959, personnel from the Space Task Group (which supervised Mercury)

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[19] *Ibid.*, pp. 10-11.

[20] NASA Space Task Group, *Project Mercury Status Report No. 2 for Period Ending April 30, 1959*, Space Task Group, Langley Field, Virginia, 1959, p. 25.

[21] Grimwood, James M., *op. cit.*, p. 65.

[22] NASA Space Task Group, *Project Mercury Status Report No. 3 for Period Ending July 31, 1959*, Space Task Group, Langley Field, Virginia, 1959, pp. 19-21.

[23] Grimwood, James M., *op. cit.*, p. 48.

and the School of Aviation Medicine met to discuss plans for the so-called biopak experiments.[24] It is interesting to note that, by that time, Lt. Col. David G. Simons, who helped launch the first monkeys aboard V-2's in 1948, had transferred to the School of Aviation Medicine and headed its Bioastronautics Branch.

The first of these monkeys, an American born male, was named "Sam," an acronym for the School of Aviation Medicine. Sam blasted off aboard Little Joe 2 (LJ-2) on 4 December 1959. He was housed in a sealed container 45.7-centimeters in diameter and 91.4-centimeters long. The cylindrical capsule weighed 56.3-kilograms. In addition to the monkey, the LJ-2 biopak contained track plates of barley, nerve cells from a rat, tissue cultures, and similar specimens. Flight objectives for LJ-2 were to determine the motions of the spacecraft/launch escape tower during a high-altitude abort; observe the Mercury's entry dynamics without a control system; and evaluate the recovery system. Fifty-nine seconds after launch, the abort sequence began, with the craft at an altitude of 29,290 meters and a speed of Mach 5.5. The spacecraft reached an apogee of 85.32-kilometers, landed successfully in the Atlantic, and was recovered about two hours later. Sam was in good shape from his journey.[25]

The next flight, Little Joe 1-B (LJ-1B), carried an American born female Rhesus named "Miss Sam." LJ-1B was a repeat of the LJ-1A flight, which was itself a repeat of the LJ-1 mission. On 21 August 1959, 31 minutes before scheduled launch, the escape tower motor of LJ-1 fired, sending ground crews scurrying for cover. Fortunately, no one was hurt. This flight was to have been a test of the escape system under the most severe combination of dynamic pressure, Mach number, altitude, and flight-path angle. The spacecraft contained a pressure sensing system, which should have triggered an abort about 30 seconds after launch. On the re-launch, LJ-1A, on 4 October 1959, the sensor fired the escape motor igniter, but motor pressure was slow building up, and the flight performance was less than desired. So another reflight, LJ-1B, was planned.[26]

LJ-1B lifted off on 21 January 1960, with Miss Sam on board. One of the test objectives of this flight was to study the physiological effects of rapid onset of reverse acceleration during an abort at maximum dynamic pressure. During this flight, all went as desired, and the spacecraft reached an altitude of 15 kilometers, a speed of 3,251 kilometers per hour, and it landed 18.8 kilometers downrange. Thirty minutes after launch, Miss Sam was back at Wallops Station, none the worse from her flight.[27]

While the School of Aviation Medicine biopak flights were underway with the Little Joe, the 6571st personnel were busy. Just a few weeks after the program began in the spring of 1959, flight protocols, to include launch preparation and recovery procedures, were already being defined. Initial plans called for a total of ten chimpanzees to be trained and tested, so a supply of backup animals would be available. Chimpanzee

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[24] *Ibid.*

[25] *Ibid.*, p. 85.

[26] *Ibid.*, pp. 81-82.

[27] *Ibid.*, p. 89.

training began at the Aeromedical Field Laboratory in July 1959.[28] As with earlier programs, the training began with conditioning the primates to restraint in the spacecraft.

Figure 5 Miss Sam, the female Rhesus monkey, flown on Little Joe 1-B on 21 January 1960.

In the spacecraft, the chimps sat in pressurized containers, which fit into the area for the astronaut couch. The container had a clear plastic dome, so the animal could be

[28] NASA Space Task Group, *Project Mercury Status Report No 3 for Period Ending January 31, 1959, op. cit.*, p. 20.

observed. An oxygen inlet fitting on the lower right side of the capsule connected to the pressure suit environmental control system. The fitting was identical to those on the astronaut's helmets, so the environmental control system could be tested and used without modification. The chimp wore a nylon mesh restraint suit, which had flaps with eyelets along the shoulders, back, and legs. Matching flaps were attached to the seat back, so the chimps were laced into the capsule. The suits restrained the chimps' torsos and legs, while allowing them to move their arms, so they could operate a performance test panel during flight. The performance panel was built into the lid, or front half, of the primate container. McDonnell Aircraft, the spacecraft prime contractor, designed and fabricated the primate containers.

Figure 6 Miss Sam, on her life support couch, being loaded into her capsule (NASA photo 60-MLJ-2).

During the flight, the chimpanzees operated a psychomotor performance panel. This panel comprised a display of lights and handles, which the primates had to operate in response to the lights. In addition to training to endure prolonged restraint and isolation in the capsule, the chimpanzees had to be restrained to operate the psychomotor panel.

By the end of 1959, Aeromedical Field Laboratory personnel had trained six chimpanzees, and another 26 were expected to arrive from Africa the following March.[29] The

[29] NASA Space Task Group, *Project Mercury Status Report No. 5 for Period Ending January 31, 1960*, Space Task Group, Langley Field, Virginia, 1960, p. 25.

animals, all relatively young chimpanzees weighing about 50 pounds, were trained with one of two different psychomotor panels. The panel for the Redstone flights was relatively simple. It presented one of three possible lights and contained three handles, which had to be depressed in response to the lights. A force of 8.9 newtons was needed to operate each lever, so they could not be activated by launch. The lights were, from left to right, blue, white, and red. The red light was a so-called "continuous avoidance" signal. The chimp had to depress the right lever every 15 seconds to avoid an electric shock. A blue light required a response within 5 seconds. The blue light, a "discrete avoidance" signal, came on every two minutes in flight. During training, however, it was used at random intervals, so the chimpanzees did not learn a particular pattern. The sub-orbital panel did not give a food reward for correct answers. Rather, it was a relatively simple shock-avoidance task device only.[30]

The orbital panel, by comparison, was a much more elaborate device. It presented colors and symbols, which the primate had to respond to. As with the ballistic panel, incorrect answers resulted in a mild electric shock. Correct answers during certain phases of the flight were rewarded with drink or banana-flavored pellets.[31]

Chimpanzee training included runs on the human centrifuge at the Wright Air Development Center to expose them to acceleration, noise, and vibration. The centrifuge was a good tool for simulating the *duration* of acceleration during the boost phase of a mission, but it could not produce rapid changes in g-loading. For rapid onset of acceleration and simulation of launch, the best tool was the High Speed Test Track at Holloman. For re-entry deceleration and oscillation, the Wright Field centrifuge was the best device. Researchers used another Holloman facility, the Daisy Test Track, to simulate the impact of splashdown.[32] The Daisy facility was a 220-foot long test track used for deceleration studies. Since it was air-powered, it was named for the Daisy Air Rifle. The g-loading at deceleration could be tailored by varying the configuration of the water brake.

The first high speed test track run took place on 6 August 1960. The rocket sled carried three primate capsules. With such an arrangement, three chimpanzees could be exposed to the same acceleration profile. This was desirable for conducting comparison studies on the effects of acceleration, and the profiles could never be precisely duplicated between different track runs. On the first run, only one capsule was occupied; the other two were replaced with ballast. Four 1.8 KS 7800 Sparrow motors, fired in sequence, powered the sled. It reached a velocity of 127 meters per second, less than desired. Because the velocity was below predictions, the deceleration from the water brakes was also low. Another problem encountered during this test was that the water brakes sprayed a plume of water which blocked the camera view of the chimp. However, researchers placed the chimp on the Daisy track immediately after the rocket sled run and received a good 20-g simulation of a water impact.[33]

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[30] Henry, James P., and Mosely, John D., *op. cit.*, pp. 15-16.

[31] *Ibid.*, pp. 16-19.

[32] Bushnell, David, *op. cit.*, pp. 47-48.

The next sled run, on 25 August, was made without any passengers. After the below predicted performance of the first run, researchers wanted to test a new propulsion system configuration. For this run, a fifth booster was added to the fourth stage. Final velocity was higher—175 meters per second, but there were still problems with the water brakes. A new configuration for the sled was needed. The next run, with the new sled and no passenger, occurred on 29 September. The velocity was still below expectations, but there was no problem with water spray.

On 26 October, another chimpanzee rode the sled. Again, the performance was less than predicted, but a deceleration of 8 g's was obtained, which was high enough to satisfy test conductors. As with the first chimpanzee test, a Daisy track run followed the rocket sled. This test also included a psychomotor panel in the capsule. Results were encouraging; the subject showed no performance decrement during either the high speed track or Daisy track runs. After this test, further high speed track runs were suspended until the time came to test chimpanzees for orbital flight.[34] As things worked out, such runs never occurred.

During the fall of 1960, a further supply of untrained animals was obtained from Africa, and the supply of trained animals was adequate for both the Redstone and Atlas missions. The second Mercury Redstone flight had been identified as the first chimpanzee flight. Preparations for the Mercury Redstone 2 (MR-2) flight reached a new level of activity with the delivery of Mercury spacecraft #5 to the Marshall Space Flight Center in Huntsville, Alabama, on 30 September 1960. At Marshall, engineers conducted booster compatibility tests, then shipped the spacecraft to Cape Canaveral on 11 October.[35] The booster didn't arrive at the Cape until 20 December.[36]

To support the primate activities at the launch site, the Air Force procured and installed seven trailers adjacent to Hanger S. Hanger S was the astronaut quarters at Cape Canaveral. Four of the trailers were arranged to provide two separate animal caging and training areas, each with four cages. Each area contained a Mercury training spacecraft, psychomotor testing cubicles, and flight preparation areas. The reason for maintaining two separate, identical caging-training areas was to preclude any possibility of the spread of disease among all the primates. Another trailer was equipped as the medical area, with an x-ray machine and surgical table. The sixth trailer was the transfer van for carrying the chimpanzees to the launch pad. The last trailer was used for housing personnel who were on duty at night, and also as the office.[37]

MR-2 animal operations began at Cape Canaveral on 2 January 1961. On that date, 6 chimpanzees (4 females and 2 males) arrived along with 20 medical support personnel. They arrived three weeks before the flight to give the chimpanzees time to settle in to their new environment, permit the support team to train at the launch site, and allow

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[33] *Ibid.*, p. 49.

[34] *Ibid.*, pp. 49-52.

[35] Grimwood, James M., *op. cit.*, p. 114.

[36] *Ibid.*, p. 120.

[37] Henry, James P., and Mosely, John D., *op. cit.*, pp. 7-8.

the subjects, which came from an altitude of 4,300 feet, to physiologically adjust to the Cape's sea level atmospheric pressure.[38]

Besides providing important physiological and psychomotor data on the effects of space flight on higher primates, the MR-2 mission also gave launch and recovery teams their first operational experience with a live payload aboard the Mercury spacecraft. Spacecraft #5 contained several new pieces of equipment and systems, which were being flight tested for the first time. These included the environmental control system, the attitude stabilization system, live retro-rockets, voice communications system, and the "closed loop" abort sensing system, and landing bag.[39]

Launch was set for 31 January 1961. At 8:00 a.m. (T minus 26 hours, 54 minutes), medical personnel thoroughly examined all six chimpanzees. Then each was tested on the psychomotor panel. When these tests were concluded, the flight animal and a back-up were chosen. One of the males performed better than the others, was also very good-natured, and was selected to make the flight. He was subject #65, who became known as "Ham." Like the rhesus monkeys who flew aboard the Little Joe tests, Ham's name was an acronym, for the Holloman Aero Medical Laboratory. One of the female chimps was selected as his back-up.

Ham weighed 16.7 kilograms, was born in the Cameroons, West Africa, and was estimated to be 44 months old at the time of flight. In the fifteen months previous, he received 219 hours of psychomotor training and had been subjected to simulated Redstone launch profiles in the Wright Field centrifuge.

Nine and a half hours before the scheduled lift-off, at 1:00 a.m., Ham received another physical examination. At this time, technicians attached the physiological sensors and dressed him in disposable diapers and plastic waterproof pants. Following a test of the sensors, he was dressed in the nylon mesh restraint suit and laced and zipped into the capsule. The back-up chimp was similarly prepared at the same time. Secured in the couch, Ham was taken into the transfer van, where he received a snack. The lid was fitted over the capsule and secured. At 5:04 a.m., 5 hours, 50 minutes before scheduled launch, the transfer van began the trip to the launch pad.[40]

Air Force Master Sergeant Edward Dittmer accompanied Ham up the gantry, and he installed the primate capsule in the spacecraft. Dittmer, a Certified Aeromedical Technician from the Aeromedical Field Laboratory, was responsible for many of the chimpanzee training and handling activities. On 31 January 1961, Master Sergeant Dittmer dressed Ham and prepared him for flight. Throughout the animal program, he spent a considerable amount of time with the chimpanzee, and nearly 30 years later he still spoke fondly of Ham.[41]

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[38] Swenson, Loyd S., Jr., Grimwood, James M., and Alexander, Charles C., *This New Ocean: A History of Project Mercury*, NASA SP-4201, National Aeronautics and Space Administration, Washington, D.C., 1966, p. 312.

[39] *Ibid.*, p. 311.

[40] Henry, James P., and Mosely, John D., *op. cit.*, pp. 9-10.

[41] Oral History interview, Edward C. Dittmer by George M. House, the Space Center, Alamogordo, New Mexico, 29 April 1987.

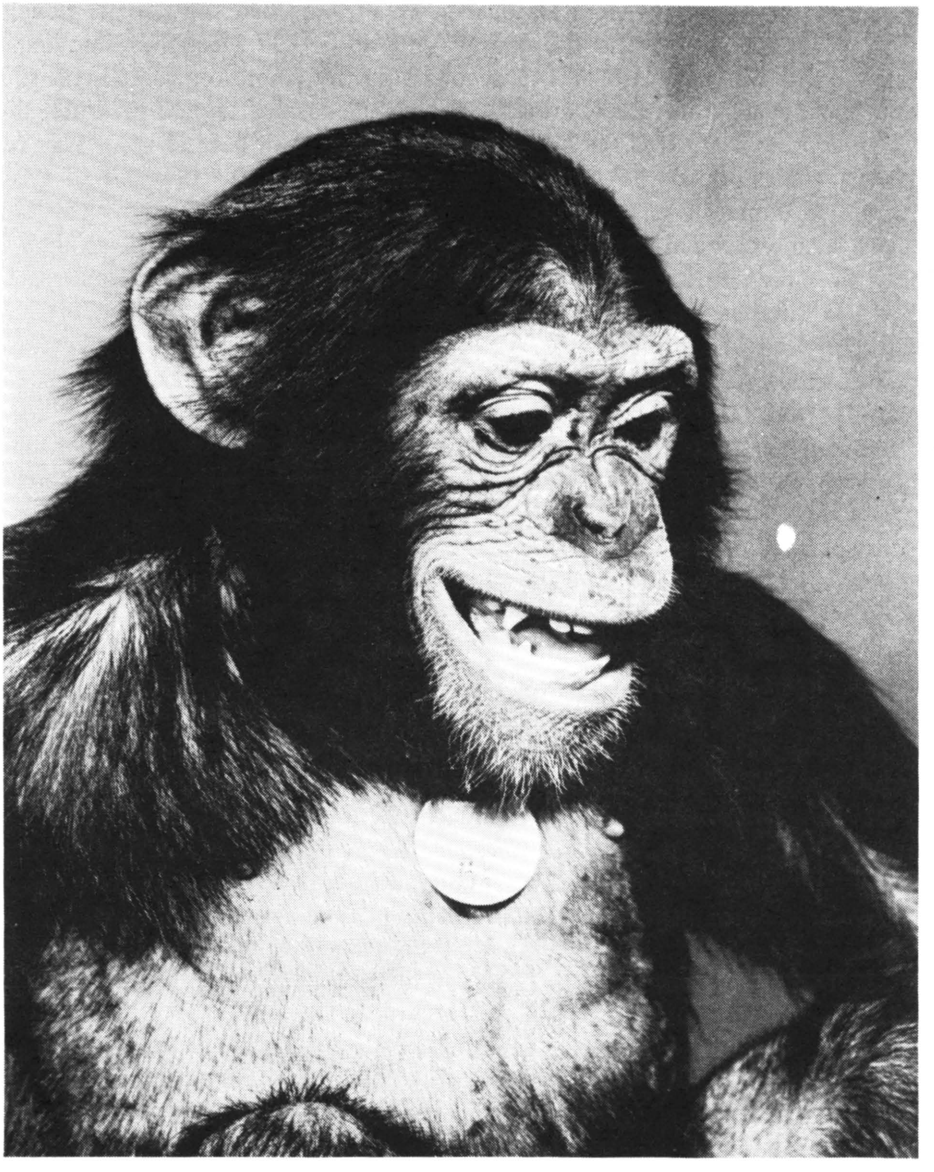

Figure 7 Ham, the first U.S.A. chimpanzee to fly in space, reached an altitude of 253 kilometers on the Mercury Redstone 2 rocket on 31 January 1961.

Hatch closure was completed by 7:10 a.m., and the gantry was removed 55 minutes later. Launch was scheduled for 10:51 a.m., but it had to be delayed because of an overheated AC/DC power inverter in the spacecraft. Mission managers wanted to launch by noon to allow recovery teams plenty of time before nightfall, just in case anything went wrong.

Lift-off occurred with less than six minutes to spare, at 11:54:51 a.m. The Redstone's engine performance ran higher than expected, causing the trajectory to be slightly higher than desired. More serious, however, was that the booster depleted its liquid oxygen supply early, and the engine shut down 137.5 seconds into the flight. Engine shutdown was expected at 143 seconds, so the engine pressure sensors in the automatic abort system were still armed. Sensing the loss of engine pressure, the new closed-loop abort system fired the launch escape motor a half second later. This resulted in a velocity for the spacecraft of 2,270 meters per second, as opposed to a planned velocity of 1,970 meters per second, which increased the range of the capsule. The retrorockets also jettisoned automatically when the escape motor fired, so they would not fire to slow the spacecraft before re-entry, adding to the overshoot. Ham reached an apogee of 253 kilometers, 66 kilometers higher than planned, and landed 679 kilometers downrange, instead of the planned 467 kilometers. G-loading during reentry was similarly greater than predicted: 14.7 g's, nearly 3 g's higher than expected. Ham endured 6.6 minutes of weightlessness during his 16.5-minute flight.[42] Despite the extra g-loads, Ham's performance during the flight was good. He operated the right lever 50 times and only received two shocks for slow response. On the discrete avoidance task lever, his score was perfect.[43]

Ham splashed down about 100 kilometers from the nearest recovery ship. On landing, the heat shield bounced up into the capsule's titanium pressure vessel and punctured it in two places. To compound the problem, a cabin pressure relief valve jammed open during launch, and admitted more water into the Mercury. The landing bag, which doubled as shock absorber on splashdown and sea anchor to stabilize the spacecraft as it floated in the water, tore, and the heat shield was lost. Recovery teams found the capsule on its side and taking in water. When the helicopter crew picked up the spacecraft about 2 1/2 hours after splashdown, they estimated it contained about 360 kilograms of sea water. Yet, Ham was safe and dry inside his primate container. The spacecraft was taken to the nearest ship, the *LSD Donner*. An immediate post-flight examination showed him to be somewhat fatigued, slightly dehydrated, but in overall good shape after his epic flight.[44] Following the examination, personnel tried to coax Ham back into the spacecraft for photographs. He wouldn't go. When he arrived back at Cape Canaveral and the chimpanzee compound, he ran directly over to his handler, Master Sergeant Dittmer.[45]

Following the flight, Ham was eventually retired to the Smithsonian Institution's National Zoological Park in Washington, D.C., where he lived until 1981, when he was transferred to the North Carolina Zoological Park in Asheboro, North Carolina. At the North Carolina Zoo, he was integrated with a colony of other chimpanzees, and he remained there until his death, on 17 January 1983, from heart and liver disease. His remains were returned to Alamogordo, New Mexico, just outside Holloman Air Force Base, and buried at the International Space Hall of Fame.

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[42] Swenson, Loyd S., Jr., *et. al.*, *op. cit.*, pp. 315-316.

[43] Henry, James P., and Mosely, John D., *op. cit.*, pp. 21-24.

[44] Swenson, Loyd S., Jr., *et. al.*, *op. cit.*, p. 316.

[45] Dittmer Oral History Interview, *op. cit.*

Following the Redstone problems during the MR-2 flight, authorities at the Marshall Space Flight Center added another mission, the MR-BD (for Booster Development), to the schedule. This flight occurred on 24 March 1961. Since this mission was solely to test and man-rate the booster, it carried a boiler-plate spacecraft. Besides the MR-BD, three more Mercury test flights followed MR-2 in the first five months of 1961. Two of these were Little Joe tests, and one was an unsuccessful Atlas flight. None of these carried biological payloads. The next time Mercury flew with a passenger, it carried America's first astronaut, Alan B. Shepard, Jr. Shepard's flight occurred on 5 May 1961 and lasted 15 minutes. The Redstone performed as planned, and he reached a peak altitude of 115 miles, landing 302 miles downrange. The successes of Ham and the MR-BD were certainly factors in the decision to proceed with the manned flight.[46]

Another factor was the successful Soviet manned space flight, *Vostok-1*. In a flight lasting 108 minutes, Soviet Air Force Major Yuri Gagarin orbited the Earth one time on 12 April. Gagarin reportedly suffered no ill effects from his flight, so there seemed to be no question about man's ability to withstand the rigors of space travel. However, a test of the Mercury spacecraft life support system under orbital conditions was still needed, so preparations continued for the chimpanzee orbital flight.

As previously described, the orbital psychomotor panel contained the continuous avoidance—discreet avoidance (CA-DA) tests like the ballistic one, plus an oddity problem where the chimpanzee had to differentiate between shapes, a delayed response test, and a problem where the chimp had to pull the lever exactly 50 times. Problems were presented in cycles, with six-minute rest periods between. Correct answers on the delayed response test was rewarded with a drink of water. For exactly 50 lever pulls, the chimpanzee received a banana-flavored pellet. There was no penalty (an electric shock) for an incorrect response on either of these two tests.

Several new items of physiological monitoring equipment were introduced for this flight. The most complex was a system to continuously measure arterial and venous blood pressures. Continuous, direct blood pressure measurements required invasive techniques. To measure arterial pressure, a length of PE 50 polyethylene tubing, with a diameter of about 1 millimeter, was inserted in the anterior tibial artery on the chimp's right leg. Similarly, the saphenous vein was used for venous pressure. The major difference between the two was that the venous pressure tube was inserted far enough to reach the inferior vena cava, just below the diaphragm. The catheter lines were connected to two syringes filled with a dilute heparin solution. Pressures were measured with electronic transducers. Outputs from the transducers went to a galvanometer oscillograph, which recorded the measurements on 16 millimeter film.[47]

The orbital primate test was slated for the Mercury-Atlas 5 (MA-5) mission. Counting the Big Joe flight, this would be the sixth launch of a Mercury by an Atlas booster and only the third attempt at an orbital mission. And the first orbital attempt, with MA-2, failed. MA-5 used spacecraft #9 and launch vehicle 93-D. Spacecraft #9 arrived at the Cape just after Ham's flight on 24 February 1961. The booster arrived on 9 October.[48]

[46] Swenson, Loyd S., Jr., *et. al.*, *op. cit.*, pp. 318 and 330.

[47] Henry, James P., and Mosely, John D., *op. cit.*, pp. 59-65.

Primate operations at Cape Canaveral began on 29 October 1961 with the arrival of 3 chimpanzees and 12 personnel. They joined 2 chimps and 8 personnel already there from previous tests. As for the earlier Redstone mission, medical personnel conducted practice countdowns, and the primates performed practice sessions on psychomotor panels to maintain proficiency.

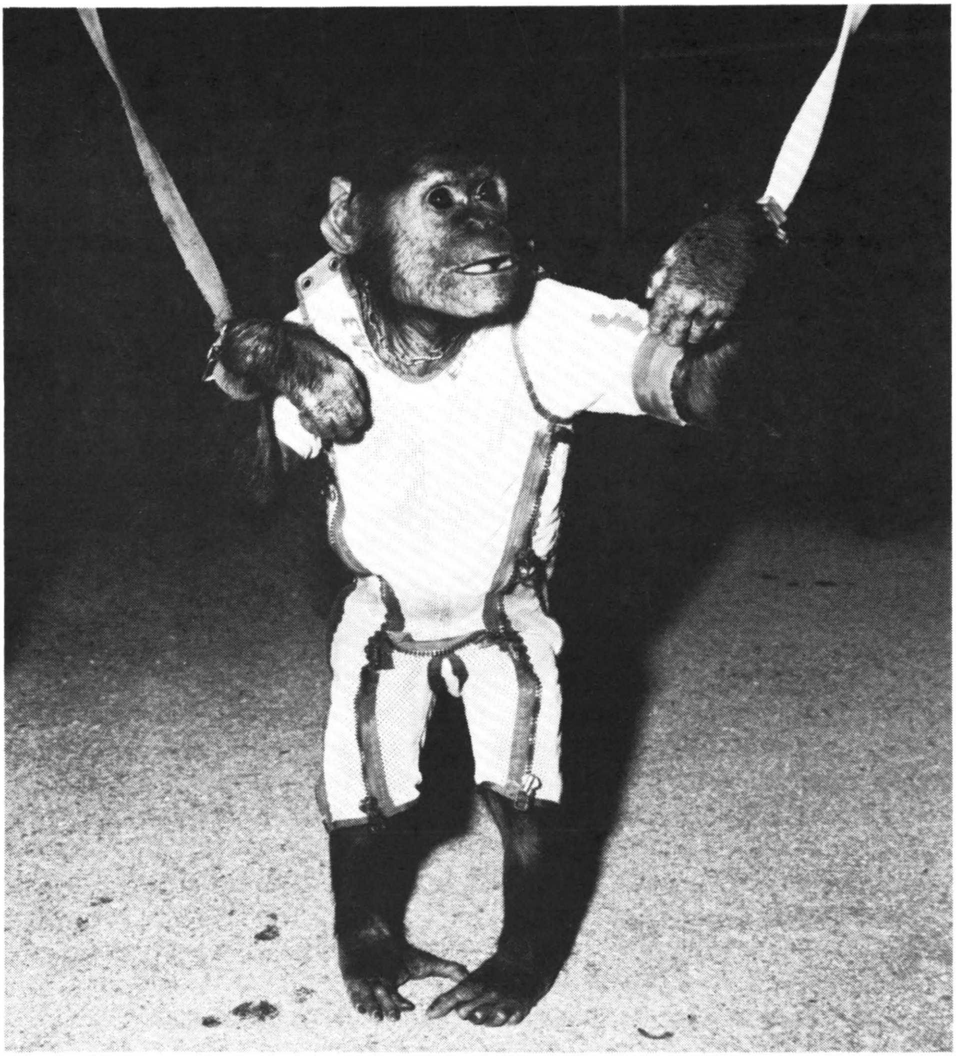

Figure 8 Enos, the 19 kg male chimpanzee, who made two orbits of the Earth on 29 November 1961 (NASA photo 61-MA5-10A).

MA-5 was postponed twice, once because of problems with the booster and spacecraft, the second time because of a hydrogen peroxide leak in the spacecraft, and it was finally scheduled for 27 November 1961. Two days before the flight, the three primary

[48] Grimwood, James M., *op. cit.*, pp. 124 and 150.

chimpanzees, which included Ham, received thorough physical examinations and 270 minutes of training on the task panel. After this, the flight subject was selected.

Chimpanzee #81, a 19-kilogram male estimated to be 63 months old, was chosen. His name was "Enos," which was taken from the Hebrew word for man. Enos had previously been exposed to centrifuge runs at the University of Southern California, and he had received about 1,263 hours of training since the Air Force purchased him on 3 April 1960.[49] Enos had a different temperament than Ham. Ham was affectionate and liked to be held; Enos did not. Most of the time, Enos was kept on a tether. Probably because of his temperament, many people regarded Enos as a mean chimp. According to Mr. Dittmer, this was not the case. Enos simply did not like to be handled and was "feisty."[50]

Lift-off came at 10:07 a.m. on 29 November 1961. During the booster phase of the Atlas ascent, Enos was subjected to 6.8 g's. The acceleration dropped when the booster engines were jettisoned, then it peaked at 7.6 g's. Following booster separation, the MA-5 spacecraft entered an orbit with a perigee of 160.1 kilometers, an apogee of 237.2 kilometers and a period of 88 minutes, 26 seconds. The mission was to go for three orbits. Everything went well throughout the first orbit, with the only anomaly noted being that the on-board clock was 18 seconds fast. But, as the spacecraft passed over Muchea, Australia, telemetry indicated excessive capsule motion and thruster firings, although the proper attitude was maintained. At the next pass over the Canton Island tracking station in the South Pacific, controllers knew something was wrong. A malfunctioning thruster was allowing the spacecraft to drift away from the proper 34° attitude. When the automatic attitude sensing system detected the drift, it corrected it, burning more fuel than desired. The environmental control system also began to overheat during the second orbit.

Enos may not have known about these problems, but he was acutely aware of another malfunction. On the second session of the multiple symbols problem, the center lever malfunctioned, so he was shocked even if he pulled the correct lever. Fortunately for Enos, flight controllers decided to end the flight after the second orbit because of the thruster problem. Enos landed in the Atlantic Ocean, about 320 kilometers south of Bermuda, 3 hours and 21 minutes after launch.[51]

Post flight evaluation led mission managers to conclude that an astronaut on board could have compensated for both the attitude and temperature problems, and they were generally delighted that the spacecraft had performed so well in automatic mode. A thorough examination of Enos showed him to be in good shape from his flight. The stage was set for the first Mercury manned orbital flight.

Enos was returned to Holloman Air Force Base on 7 December. In the Fall of 1962, he developed shigella dysentery, which resists treatment by antibiotics. After

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[49] Henry, James P., and Mosely, John D., *op. cit.*, pp. 39 and 53.

[50] Dittmer Oral History Interview, *op. cit.*

[51] Henry, James P., and Mosely, John D., *op. cit.*, pp. 35-38.

nearly two months' treatment, he died on 4 November 1961. The necropsy showed his death was in no way related to his space flight.[52]

Figure 9 The Mercury Atlas 5 rocket, carrying the chimpanzee Enos on a scheduled 3 orbit mission lifts off from Cape Canaveral (NASA photo S-62-8310).

[52] *Medical File, Chimpanzee #81, Enos*, New Mexico State University, Primate Research Institute, Holloman Air Force Base, New Mexico.

Conclusion

The primate tests of the Mercury spacecraft were significant in several respects. First, they provided proof that the environmental control system worked under actual space conditions. The psychomotor tests proved that higher primates could function in space, and that the noise and acceleration of launch, the weightlessness of orbital flight, and the stresses of reentry would not incapacitate a human pilot. And they provided the launch, mission control, tracking station, and recovery personnel with valuable operational experience in dealing with living passengers in Mercury flights before the first manned missions.