Early Human Factors Studies for Spaceflight at the Aeromedical Field Laboratory at Holloman Air Force Base

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During the early 1950s, human spaceflight was clearly on the horizon. But the knowledge of how humans could survive and function during spaceflight was embryonic. Concerns fell into two categories: space biology and biodynamics. Specific issues in space biology were the effects of cosmic radiation, physical and psychological effects of microgravity, the capability to construct a space capsule that could ensure a safe environment for human survival and performance, and procedures for selecting astronauts. The biodynamics concern was whether the human body could tolerate the acceleration forces produced by rocket launch and the deceleration forces of atmospheric drag during re-entry.

The Aeromedical Field Laboratory at Holloman Air Force Base in Alamogordo, NM, became one of America's primary research organizations for examining those issues. Between 1953 and 1959, two men played pivotal roles in the investigations of these concerns. Both were Air Force flight surgeons. Colonel John Paul Stapp, M.D., Ph.D., headed the Aeromedical Field Laboratory, and Major David Simons, M.D., served under him as chief of the facility's Space Biology Branch. The creativity and dedication of both of them and those who served with them answered many basic concerns, and were instrumental in enabling NASA's manned space program to move forward.

As World War II was winding down, Wernher von Braun and other German engineers were brought to the United States with large amounts of V-2 missile components, launch equipment, and research documentation. They were instrumental in the rocket development at White Sands Proving Ground near Alamogordo. Beginning in 1946, Holloman researchers flew seeds, fungal spores, fruit flies, mice, and monkeys aboard V-2 and Aerobee rockets.[6] These suborbital flights achieved altitudes up to 80 miles, with cosmic radiation exposure lasting a few minutes. Investigations of microgravity were also performed. Animals sent on suborbital rocket flights experienced 2 to 3 minutes of zero g. They were filmed and monitored for vital signs during flight, and examined after landing to reveal any potential damage. From 1953 to 1958, rocket tests were reserved for military ballistic missile development, putting animal experiments on hold.[1,2,4,5]

Longer exposures were accomplished with helium balloons.[8] Various seeds, fruit flies, mice, hamsters, cats, dogs, and rhesus monkeys were flown as high as 18 miles for up to 28 hours. The only cosmic radiation effects that the researchers found was a statistically significant increase in white or gray hairs on black mice and guinea pigs, probably caused by the destruction of pigmentation cells.

Beginning in 1953, after earlier animal microgravity experiments in suborbital rockets, researchers at Holloman developed an alternative method for experiencing zero g. They began flying a series of parabolic trajectories which created a longer total microgravity exposure, though it was intermittent.[12] The flights, usually in an F-94C jet aircraft, carried humans, some of whom tested such abilities as eating, drinking, and urinating in microgravity.[13,14] Animals were also flown, with cats being useful test subjects because of their sensitive vestibular systems.[3]

While Simons was overseeing the space biology research, Stapp conducted biodynamics experiments using several devices that produced rapid acceleration and abrupt deceleration. The most versatile was the Daisy Track, which used a compressed air blast to propel a sled down a two-rail track that ended at a water-piston braking device. Deceleration forces exceeding 30 g's were of short duration, lasting a tenth of a second or less. Various sleds were developed so men or animals could be tested at virtually any combination of roll, pitch, and yaw. The most dramatic Daisy Track experience occurred in 1958, when Eli Beeding, seated upright and facing backward, unexpectedly experienced 82.6 g of deceleration measured momentarily at his chest sensor (40 g measured on the sled sensor). He suffered severe back pain, but recovered fully.

Stapp personally participated in all of his biodynamics experiments. In fact, he was the only one to ride the high-speed rocket-sled track at Holloman. On his third and final run on that track in 1954, nine rocket engines fired for 5 seconds, producing an acceleration force up to 9 g's. During the subsequent coasting period of 0.3 seconds, the acceleration force reached 10 g's and the speed reached 632 mph. The water brake brought the sled to a stop in 1.1 seconds, during which Stapp experienced a sustained deceleration of 25 g's, with a momentary peak of 46.2 g. He suffered some immediate consequences, primarily to his eyes, but he quickly recovered completely.[7,11]

With the issues of cosmic radiation, microgravity, and force tolerance adequately resolved, Stapp and Simons developed Project Manhigh to produce a capsule with the necessary life support and communication systems in which a pilot could perform scientific observations for at least 24 hours in a near-space environment.[9,10] The capsule was an 8 ft tall, 3 ft diameter, dome-topped cylinder. All three of the high-altitude balloon Manhigh flights in 1957 and 1958 encountered life-threatening emergencies, during which each pilot was able to perform appropriately despite the claustrophobic enclosure and hostile exterior environment. Simons himself piloted the second and most successful flight, at a float altitude of 101,500 ft. His flight lasted 32 hours, but because

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of the need to adjust to the oxygen-helium-nitrogen atmosphere in the capsule prior to launch, he was sealed in the capsule for 44 hours.

Test pilot Colonel Joe Kittinger and Simons were hand-picked for the first and second Manhigh flights, but a set of criteria was developed for selecting the third pilot from a group of volunteers. That to some degree became the starting point for developing Mercury astronaut selection criteria.

The Holloman research team succeeded in resolving concerns about man's ability to fly into space. Stapp summarized their findings about the human body: "He's awfully tough, a lot tougher than the machines he rides in."

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