THE FRONT SEAT OF A CAR: INSIDE GEMINI

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Chapter 4 of Inside the Capsule

LIFE SUPPORT

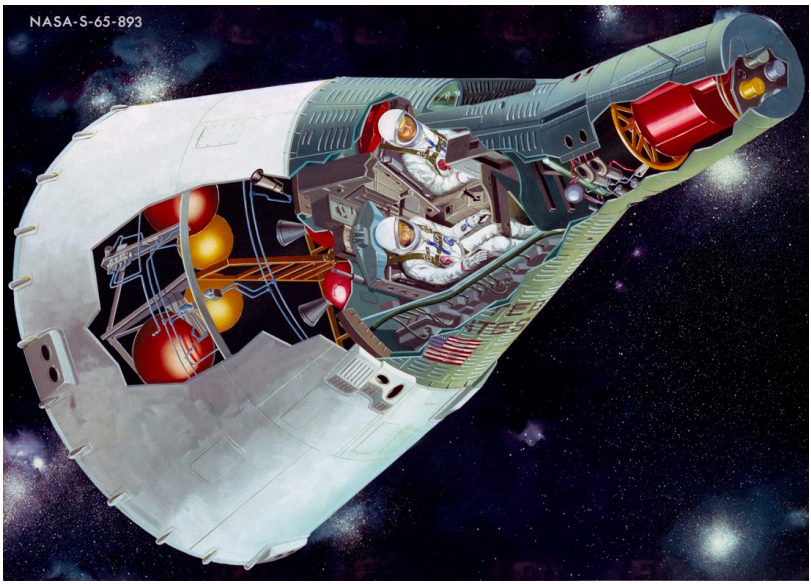
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CHAPTER 4

The Front Seat of a Car: Inside Gemini



The Gemini spacecraft.

Gemini is the spacecraft people forget, sandwiched between the first Americans in orbit and the men on the Moon, and it was the one that taught NASA how to live in space rather than visit it. Its whole reason for existing was time. Apollo would need crews to spend a week or more going to the Moon and back, and nobody yet knew whether two people could stand being shut together in a tiny cabin for that long, eating, sleeping, working and dealing with their own waste an arm's length from each other. Between March 1965 and November 1966, ten Gemini crews flew to find out, the longest for fourteen days. They also learned to change orbits, meet another ship, dock with it and work outside, and nearly every one of those firsts was paid for by somebody's discomfort.

The craft that brought them home was a blunt cone 10 feet 10 inches long and 7 feet 5 inches across at the base, weighing about 2,500 pounds, according to the Smithsonian's record of the Gemini VII capsule it holds. Two men sat in it side by side, shoulder to shoulder, each under his own hatch. Behind them, thrown away before reentry, was a section holding the fuel for the maneuvering thrusters, the fuel cells that made electricity and the braking rockets. The design was led by James Chamberlin, and his guiding idea, in his own words, was "to dissociate systems": put each piece of equipment in its own box, where it could be reached and replaced without pulling apart everything around it. It made Gemini far easier to build than Mercury. It did not make it any roomier.

The Seat and the Room

Each astronaut had his own seat, and each seat was an ejection seat, a rocket-fired chair like a fighter pilot's, the first in an American spacecraft and a cousin of the Vostok seat that had flung Gagarin out. They were also the main thing in the cabin. With two seats, two pressure suits and a panel between them, there was nowhere to stand up, nowhere to stretch out and nowhere to put anything that was not strapped, zipped or stuffed into a pouch. Food was stowed in the ceiling; when Neil Armstrong and David Scott wanted lunch on their flight in March 1966, NASA's official history records, they pulled it down from overhead. Two people sat closer together than a driver and passenger in a small car, and Gemini VII's crew lived like that for two weeks.

The hard part of the room was what it did to the body over time. Frank Borman and Jim Lovell were launched on 4 December 1965 to show that people could live weightless for fourteen days, a record that would stand until 1970. Lovell, the larger of the two, found the cabin harder to move in than Borman did. Some 45 hours into the flight he began taking off his pressure suit, and in that space the simple job took more than an hour. Eight of the flight's 20 experiments were medical, more than on any other Gemini flight, and NASA's summary of the program recorded

that the crews were aware, for a short while after landing, that their arms and legs had weight again and needed effort to move.



Gemini VII, home to Borman and Lovell for fourteen days, photographed from Gemini VI during their rendezvous in orbit. The whole of the crew's living space was inside the small cone at the front.

NASA, photographed from Gemini VI, 15 December 1965. Public domain.

The Air and the Pressure

Gemini breathed pure oxygen, like Mercury. On the pad the cabin was filled with oxygen at slightly above sea-level pressure, and in orbit it held about 5 pounds per square inch, the equivalent, NASA's doctors noted, of the air pressure at 27,000 feet. The suits ran lower still, at 3.7. To head off the bends, the crews breathed pure oxygen for two hours before each flight to wash the nitrogen out of their blood, and the doctors found no sign of the bends on any Gemini mission. The oxygen had smaller costs. In the first two or three days of most flights the crews

had stuffy noses, which the doctors put down to the pure oxygen, and on one flight a crewman's eyes were badly irritated by lithium hydroxide, the carbon dioxide absorber, getting loose in the suit circuit.

The suits were the real argument. Engineers at McDonnell found that the cabin's environmental system actually worked better with the suits off, but NASA and McDonnell did not like the crew being so exposed. The best way to put out a fire in space was still to let the air out of the cabin, as it had been for Mercury, and that was impossible with two men in shirtsleeves; and the men needed their suits if they had to use the ejection seats. The compromise for Borman and Lovell was a lighter suit, the G5C, made by the David Clark Company, with a soft cloth hood that zipped on in place of a hard fiberglass helmet. It weighed 16 pounds against the 23 and a half of the standard suit and could be taken off and laid beside the seats. NASA's managers still insisted that one man stay suited at all times, and that both be suited for launch, rendezvous and reentry, and the argument over who wore what ran for nearly six days of the flight.



Gemini VI and Gemini VII during their meeting in orbit, December 1965.

Food and Water

Gemini's food was a menu, for the first time, and by the program's end a typical day aboard came to about 2,400 calories over three meals. NASA's 1967 summary lists one day's worth for the 14-day flight: grapefruit drink, chicken and gravy, beef sandwiches, applesauce and peanut cubes for the first meal; beef pot roast, bacon and egg bites, chocolate pudding and strawberry cereal cubes for the second; potato soup, shrimp cocktail, date fruitcake and orange drink for the third. Half or more of the food was what the engineers called rehydratable, dried meals packed in bags that let the crew add water and then squeeze the food out without it floating away. The rest was bite-sized, eaten in one mouthful and softened by saliva. About half of both kinds was freeze-dried, and some of the rest was dried and pressed. A day's food for one man took up 130 to 162 cubic inches, a little over two to two and a half liters.

The food was rarely as good on orbit as it was on the menu. Armstrong's chicken and gravy had been soaking in its bag for half an hour and was still dry in spots, and his brownies were stuck together and crumbly and scattered scraps around the cabin. Every crew lost weight, between none and 13 and a half pounds a man, and the doctors concluded that more calories and more water had to go down in flight. The most famous Gemini meal was not on any menu. On the first crewed flight in March 1965, John Young pulled out a corned beef sandwich that Schirra had bought at Wolfie's in Cocoa Beach and handed it to Grissom, who took a few bites and put it away because he did not want crumbs floating in the cabin. Congress was upset, NASA wrote new rules on what astronauts could carry, and the official food, the history notes, had only been aboard to test its taste and packaging anyway.

ONE DAY OF GEMINI MEALS

Meal A	**905 calories**	grapefruit drink, chicken and gravy, beef sandwiches, applesauce, peanut cubes
Meal B	**829 calories**	orange-grapefruit drink, beef pot roast, bacon and egg bites, chocolate pudding, strawberry cereal cubes
Meal C	**684 calories**	potato soup, shrimp cocktail, date fruitcake, orange drink
Total	**2,418 calories**	
Rehydratable share of menu	**about 50 to 60 percent**	
Food volume per man per day	**130 to 162 cubic inches**	

NASA, Gemini Summary Conference, NASA SP-138, 1967, table 16-VII

What two men in a cabin the size of a car's front seat were meant to eat on days 2, 6, 10 and 14.

The Toilet

There was no toilet. Urine went into a roll-on rubber cuff and bag descended from the device first flown on Mercury. Solid waste went into a bag, and the bag was the most hated piece of equipment of the decade. A 2007 NASA review of every waste system ever flown describes it: a bag of nylon and polyethylene with an adhesive ring at the top that stuck to the astronaut's buttocks, and a finger cot, a rubber finger sleeve, built into the side. There was no airflow to draw anything away, so the astronaut used the finger cot to push the waste down into the bag, cleaned up with wet wipes and tissues and put those in too, added a germicide to stop bacteria working and kneaded it through the contents

by hand, then rolled the bag up, sealed it and put it in a second, vented bag for storage.

The review is blunt about the result. The system was marginally functional, the crews described it as very distasteful, the bag was hard to position, and it was hard to use without soiling yourself, your clothes and the cabin. It did nothing for the smell, which in a cabin that size was prominent, and it took up to 45 minutes each time, so that for much of the day the odor was there. Crews hated it so much that some kept up the preflight measures and took medication to avoid needing it at all. Before every flight the crews ate a low-residue diet, and from Gemini V onward they also took a laxative and usually a suppository within two days of launch; on the shorter flights that was usually enough to avoid the bag altogether, and a drug that slowed the gut was carried for anyone who needed it. On a fourteen-day flight there was no avoiding it.

Sleep

Gemini crews slept in their seats, sitting up, with the windows covered to make a night, and they slept at the same hours as they would have at Cape Kennedy. NASA's doctors found they never slept well on the first night in space, and across the program they slept less than they would have on the ground, though not so little that it hurt their work. Every crewman reported the same odd posture: arms floating up and folding at chest height with the fingers laced together, and legs lifting slightly. Sleep was often a matter of turns. On Gemini VII, Lovell's first twenty-four hours out of his suit passed and he chose to sleep suitless a second night, and Borman agreed even though he was the one still sweating. Near the end of the flight, when Houston confirmed that a failing fuel cell would hold out to the last day, Borman slept better than on any other night in space.

Heat and Cold

The suits were warm and the cabin was close. On Gemini VII's first night Borman found his suit warmer than he had expected and had to turn the cooling knob to its coldest setting. By the time Lovell got his

suit off, two days in, both men had stuffy noses and burning eyes and Borman was complaining that he was too warm; the cabin improved once Lovell was out of his. Then the arrangement turned against Borman. Even with his suit fully unzipped and his gloves off he sweated while Lovell stayed dry, and Lovell, who tried a set of light flying coveralls, took them off after fifteen minutes because they were too hot. About 100 hours in, Borman asked Mission Control, through the capsule communicator Gene Cernan, to let him take his suit off too, and he was careful to have it put to the chief astronaut Deke Slayton first, so it would not reach flight director Christopher Kraft as an emergency.



The Gemini VII crew, Jim Lovell and Frank Borman.

Outside, heat was the danger. A Gemini astronaut working outside the cabin was cooled by the oxygen flowing through his suit, and a man working hard could make more heat than the flow could carry away. On Cernan's own spacewalk in June 1966, he felt neither hot nor cold for most of it, but at one point his back grew hot; later analysis found that some of the suit's insulation had come apart and let the sunlight through. At the end, wrestling with a mirror on the outside of the

spacecraft, his suit's cooling was overtaxed and he became extremely hot for the first time.

The Way Out

Gemini kept ejection seats instead of a Mercury-style rescue tower, and the reason was the rocket. The Titan II that launched it burned fuels that ignite on contact and react much less violently than the fuels of the Atlas, so Chamberlin believed that if it failed it would burn rather than explode outright, giving a seat time to throw a man clear. He also disliked escape towers, which had caused trouble on Mercury. Making a seat that would work was the hard part. Before liftoff the cabin sat about 45 meters up on top of the loaded rocket, and the seat had to fire from there in a path stable enough to clear an exploding booster and high enough for the parachutes to open. No seat in the world could do it. McDonnell's suppliers, Weber Aircraft for the seat and Rocket Power Inc. for the rocket catapult under it, tested it from a 45-meter tower at the Naval Ordnance Test Station at China Lake in California, built earlier for Sidewinder missile tests. The first test there was on 2 July 1962. Even working, the seats covered only the start of the climb. Mercury's tower had stayed on until about two and a half minutes into the flight, while Faget reckoned the Gemini seats would be usable for only about the first 40 seconds, until the rocket neared the speed of sound; above that, the crew would stay in the spacecraft and ride it down after it separated from the rocket.

The seats were never used, and the one time they might have been shows what they meant to the men sitting in them. On 12 December 1965, Walter Schirra and Thomas Stafford's rocket ignited and shut down 1.2 seconds later, when an electrical plug dropped out of its base too soon and started the cockpit clock. By the rules they should have ejected: if the clock was right, the rocket had lifted off, and a fall of even a few centimeters would have dropped 150 tons of propellant back onto the pad. Schirra, who as commander would have pulled the D-ring that fired both seats, felt no motion and did not pull it, and the rocket stood. Stafford said later that an off-the-pad ejection meant more than 20 g and probably months with an injured back. Schirra put it more

simply. "It's ... death or the ejection seat," he said. There was a further danger nobody had tested. Stafford later recalled that on the pad the cabin held pure oxygen at 15 or 16 psi, a little above sea-level pressure, and the seats had been tested with the cabin filled with nitrogen, never with oxygen, so nobody knew what firing the hatches and seats in that atmosphere would do.

TWO WAYS OFF A FAILING ROCKET

	MERCURY	GEMINI
System	Rocket tower on the nose pulls the capsule away	Each astronaut fired out on his own rocket seat
Why	The Atlas's fuels could explode violently	The Titan II's fuels were judged to burn rather than blow up
Usable	Until the tower was dropped, about two and a half minutes in	Only the first 40 seconds or so, by Faget's estimate
Who fires it	Automatic, or the abort handle by the pilot's left hand	The commander's D-ring fires both seats

Gemini traded the tower for two seats, and the decision to use them sat with the commander's hand on the D-ring.

The Flight Where It Nearly Went Wrong

On 16 March 1966, Armstrong and Scott made the first docking between two spacecraft, joining their Gemini to an unmanned Agena target rocket. Not long after, out of radio range on the night side of the Earth, Scott glanced at the panel and saw that the attitude ball, the instrument that showed which way the ship was pointing, read a 30-degree roll. "Neil, we're in a bank," he said. They assumed the Agena was to blame and shut down its controls, and the motion stopped for four minutes and then started again, faster. With their own thruster fuel down to 30 percent, they undocked, Armstrong gave the thrusters a long hard burst to back away, and the spacecraft immediately rolled faster still. When they came into range of a tracking ship, Scott reported, "We have

serious problems here ... we're tumbling end over end up here." The ship was turning about once a second. They could no longer read the dials over their heads, they were dizzy and their vision was blurring, and they were close to their physical limits.

"All that we've got left is the reentry control system," Armstrong said, meaning the separate ring of thrusters reserved for steering the capsule home. "Press on," Scott answered. They shut down the maneuvering thrusters and switched in the reentry thrusters, and when the hand controllers finally answered, Armstrong stopped the spin. Bringing the main thrusters back on one at a time, they found that thruster number 8 had stuck open and kept firing. The mission rules said that once the reentry thrusters had been used, the flight had to end as soon as possible, because those thrusters were the only means of lining up the capsule for the braking burn. With the rest of the flight cancelled, flight director John Hodge chose an emergency landing area, and they came down in the Pacific on the seventh orbit.

Cernan's flight in June 1966 nearly went wrong outside the ship. He climbed out on 5 June to try a rocket backpack called the Astronaut Maneuvering Unit, stowed at the rear of the spacecraft, on a walk planned to last 167 minutes. Everything took longer than in training. There were too few handholds, the Velcro patches meant to hold his gloves and boots in place were too weak, every movement of an arm or leg set his whole body moving, and he had to fight his stiff suit the whole way. Ten minutes after sunset his faceplate began to fog. When he rested it cleared a little, and when he worked it fogged again, until he was nearly blind. Strapped into the backpack, he and Stafford decided he could not safely fly a machine he could not see out of, or take it off one-handed in open space, and Mission Control agreed. He groped his way back to the hatch, overheated wrestling with the mirror, and fogged over completely. With their helmets almost touching, Stafford still could not see Cernan's face through the glass. The walk lasted 128 minutes. Later tests in an altitude chamber found that a spot of anti-fog solution kept the faceplate clear, and later Gemini crews carried it.



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