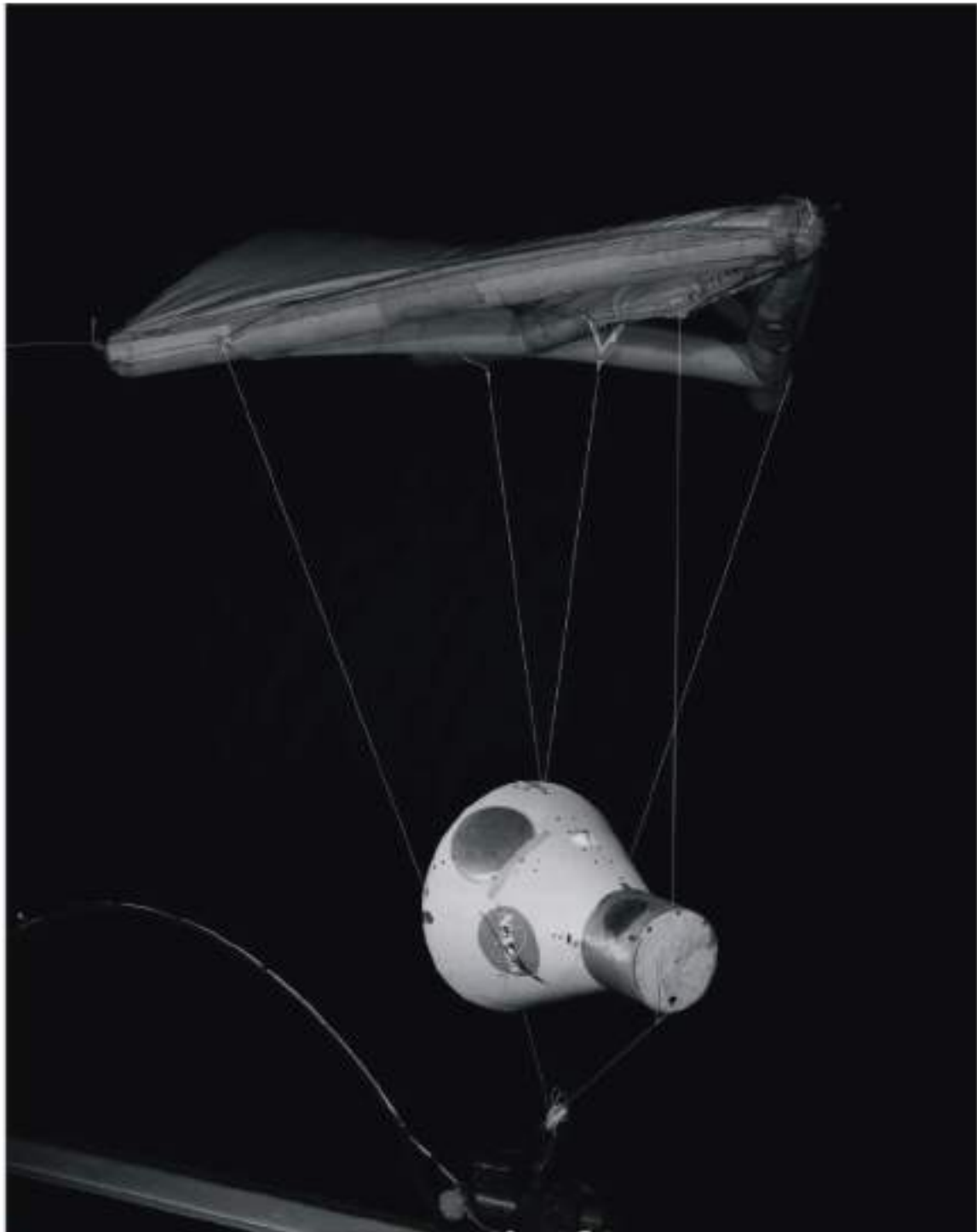


The Paraglider: How NASA Tried And Failed To Land Without Parachutes

The Rogallo wing was NASA's multi-million dollar 1960s attempt to stop ending its missions with splashdowns. It didn't work.

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Images of round-bottomed capsules hanging beneath huge orange and white parachutes miles above the ocean are iconic of the Apollo era. But in many ways, splashdowns were a flawed landing method, so much so that NASA sunk \$165 million into a paraglider development program in the mid-1960s, with the goal of making splashdowns obsolete. Called the Rogallo wing, it was a runway landing system for the Gemini spacecraft that has become little more than a footnote in the history of America's Moonshot.

Splashdowns

Mercury, NASA's first manned spaceflight program, is what you might call a crash program. The largely automated capsule launched on a missile was the quick and dirty way to get a man into space before the Soviet Union, not a sophisticated spacecraft that could lend itself to more complicated long-term programs. Having the spacecraft splashdown was an equally simplistic solution. Rather than work out the details of piloting through the atmosphere from space, engineers opted to take

advantage of the Mercury spacecraft's blunt bottomed shape that, paired with a heat shield, would protect it from the searing heat of reentry before it splashed down in the wide expanse of the Atlantic and Pacific Oceans. The US Navy was the final piece of the puzzle, deploying ships to recover the astronaut newly returned to Earth.

But for all their engineering simplicity, splashdowns brought a massive logistical challenge. Though mission engineers worked out every detail of a flight, including the precise splashdown point, the potential was there for some unforeseen problem to change the precise landing location point by hundreds of miles. And so NASA had to deploy enough Navy ships to locate and recover the astronaut in his primary splashdown location as well as a number of secondary and contingency zones. Alan Shepard and Gus Grissom both flew suborbital missions in 1961 and had 10 and 8 ships Navy ships involved in their recovery, respectively. The number more than doubled when NASA started putting men into orbit. For John Glenn's 1962 mission, there were 23 ships in the Atlantic and one in the Pacific. Wally Schirra's flight in 1963 employed the largest Naval fleet with 21 ships stationed in the Atlantic and another 6 in the Pacific.

It was somewhat ironic that NASA's first spaceflight program used splashdowns. The Mercury astronauts were among the nation's physically fittest and most competent pilots who had distinguished themselves by their incredible ability to land troubled aircraft in averse situations. Now as astronauts, they were falling from the sky, risking drowning while the US Navy recovered them like wet rats. It was clear to NASA that taking advantage of the astronauts' piloting prowess would not only be safer for them, it would be cheaper by cutting down the cost of hiring a massive portion of the Navy. Not to mention, the fighter jocks wanted to fly their spacecraft, not ride inside them like passengers. With all this in mind, the Mercury Mark II-turned-Gemini program developed with runway landings as a main program goal.

The Rogallo Wing

Runway landings from space weren't entirely unheard of when program management started planning for Gemini. One of the early landing system proposals for the Mercury program had come from a research group at the Langley Research Laboratory. It called for a deployable wing that could turn the blunt-bodied capsule into a controllable gliding vehicle. The system was known as the Rogallo wing for its inventor, Francis Rogallo.

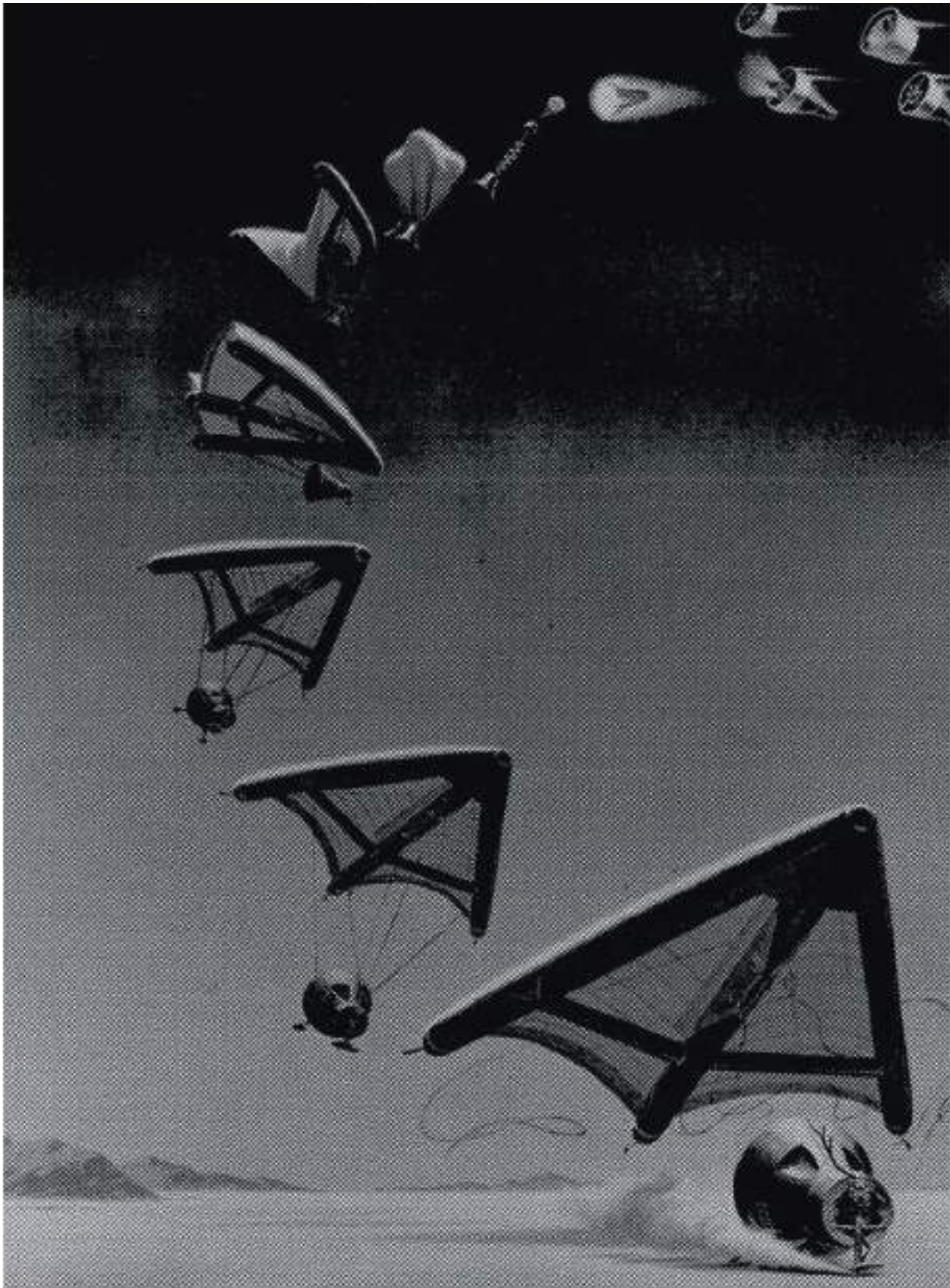
Rogallo was an amateur kite flyer who, after beginning working on flexible wings designs in 1948, had been given lab space to bring his ideas to fruition at Langley in 1958. Months after partnering with the aeronautics-turned-space agency, Rogallo had a viable system on his hands. The final design was a two-lobe, single-curvature, suspension-load wing that combined the slowing properties of a parachute with the rigid flexibility of an airplane wing. Deployed in the final phases of reentry, it could turn a capsule with limited control into a piloted vehicle.

Too complicated for the inaugural Mercury program, the Rogallo wing was brought back for consideration for the Gemini program, though it wasn't the only new landing system engineers looked at. One proposal called for a simple parachute controlled landing with retrorockets (much like the Soyuz uses today). Another used ejection, the crude but effective method of having the astronaut eject from the spacecraft moments before touchdown (which was the method the Soviets were using at the time with the Vostok spacecraft, though this wasn't well known in the West at the time). A third possible system was a parasail, a sort of cross between a parachute and a paraglider. There was also some discussion of turning the Gemini spacecraft into a lifting body, turning it into a vehicle with aerodynamic properties inherent in its design.

Gradually the list of possible landing systems was pared down to the parasail and the paraglider. Both were roughly equivalent

in terms of weight, landing area requirements, speeds, and rate of descent, but the paraglider had one big advantage: it was far more manoeuvrable. That cinched it, and the bonus lay in the potential public response. If NASA could do something the Soviets couldn't in an era where the American space program was being beaten at every turn, it would certainly raise national morale.

And so the Gemini paraglider was incorporated into the Gemini program with the understanding that it would persist into later program, notably Apollo, as well as any military programs that might arise from NASA technology. Splashdowns would remain as a backup landing method in case of emergency.



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How It Was Meant to Work

The theory of how a Gemini spacecraft would land by a Rogallo wing is fairly simple. The spacecraft would reenter the atmosphere from orbit using retrorockets just like the Mercury spacecraft did, beginning its fall through the atmosphere. The

ablative heat shield would protect the astronauts from the fiery reentry associated with atmospheric friction. Once the spacecraft reached thicker air, the paraglider would deploy from one side of the spacecraft, reorienting it from a blunt side down orientation to an "upright" one. From the astronauts' perspective, it would feel as though they were in an aircraft as they looked out their half-moon windows at the runway in front of them.

From there, landing would demand a whole new way of flying. The paraglider couldn't turn the spacecraft into a traditional aircraft; it didn't suddenly give the capsule ailerons or rudders for control. It also didn't totally turn the spacecraft into a glider since the wing generated some lift but not enough to work on its own.

The astronaut would control the mated spacecraft and paraglider by manipulating the cables connecting the wing to the spacecraft. By changing the wing's angle relative to the capsule it would change the mated vehicle's center of gravity, which in turn would change the angle and direction of the spacecraft's descent. Continual changes to the wing's angle would build momentum, effecting a larger change as the descent continued, giving more control to the piloting astronaut. When it came time to touch down, two rear skids and a forward skid would deploy and facilitate a smooth transition from air to land.



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Building a Training Vehicle

Around the time time NASA was adopting the paraglider into the Gemini program, test pilot Milt Thompson was working on the Dyna-Soar program at NASA's Flight Research Centre at Edward's Air Force Base. Dyna-Soar, a delta-wing glider designed to launch on a rocket then land on a runway after an orbital mission, was, to Thompson, the future of spaceflight. And when he heard about the Rogallo wing he saw it as a step to proving runway landings from space were viable. For Thompson, the paraglider was a perfect proof-of-concept vehicle, a hybrid between an airplane and a lifting body. He was fascinated.

He asked the Flight Research Centre's director Paul Bikle if he could start a small research program to investigate the flight characteristics of the paraglider, but the request was denied. The FRC was overloaded with the ongoing X-15 and Dyna-Soar programs and couldn't take on something else, Bikle said.

Undeterred, Thompson went behind his boss' back and took his new pet project to fellow curious pilot, Neil Armstrong. The pair reasoned that at some point astronauts would have to learn to fly the Gemini paraglider, so why not build them a training vehicle themselves? Bickle eventually found out that Thompson and Armstrong were building something they intended to fly and relented. He sanctioned a small paraglider research program, likely to spare his pilots' death by their own hand in a homemade machine. But even official, the paraglider research vehicle program remained small. There were no blueprints, just chalk lines on the floor to give builders a rough sense of what it should look like.

The vehicle was eventually called the Paresev and it came together quickly; the first was built in seven weeks for less than \$5,000 and it hardly looked like it could fly. The finished product, the Paresev 1, looked like a big tricycle made of steel tubing sitting under a fabric Rogallo mounted such that when the pilot turned an overhead control stick he controlled the wing. Pitching the paraglider wing forwards and backwards controlled lift and changing the angle of the sail gave directional control — like the mated Gemini-Rogallo, control came from manipulating the centre of gravity. It had no power source, no protection for the pilot from the elements, and a helmet offered the pilot the best defense against injury. And it was structurally sound enough; it didn't break when dropped from three and a half feet.



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Learning to Fly a Homemade Trainer

Thompson was the first to fly the Paresev. In January of 1962, he sat in the pilot's seat as it was towed behind a truck, testing the flight controls without rising into the air. Subsequent tests saw the tow truck drive fast enough for the paraglider to generate just enough lift to pull the Paresev about 20 feet off the ground. Thompson practiced control and landing on these low tow tests, and though he felt the Paresev handled as well as a wet noodle, he was nevertheless confident enough to take it up in the air just two months later.

The next round of tests had Thompson in the Paresev towed to 5,000 feet behind a small airplane at which point he'd release the line and guide it down for a landing. Taking care to stay above the tow plane's wake on the ascent to avoid being buffeted around, Thompson made two successful Paresev landings that first day but found the exercise grueling. What had been noodley sluggishness on ground tow tests seemed worse in the air, so much so that he'd had to wrap his legs around the control stick to take the strain off his arms on the second test.

From there the program had a mix of failures and successes. One ground tow test flown by Bruce Peterson (the real Six Million Dollar Man) ended in a crash hard enough to destroy the Paresev's nose. A new vehicle had to be built, the Paresev 1A, and the upside was that it gave engineers a chance to change the control system from a centre stick to cables. But there were still problems. During one air tow test the needle fell off the airspeed indicator forcing Thompson to stay tethered to the plane to land lest he lose all sense of how fast he was going. Another test had Thompson deploy a smoke bomb in flight. Designed to make the small vehicle more visible in photographs, it left the pilot struggling to see where he was landing.

Problems aside, the Paresev was becoming reliable, and by September of 1962 other pilots started familiarizing themselves with trainer. Among them were Gus Grissom, the Mercury astronaut heavily involved in building the Gemini spacecraft, and Neil Armstrong, who joined NASA's astronaut corps that same month.

The Paresev, for the moment, stood as proof that NASA's Gemini paraglider program might be the agency's ticket away from splashdown landings. But things weren't going as smoothly with NASA's test program.



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From Concept to Reality... Sort Of

In 1961, around the same time Thompson got the idea to build the Paresev, the contract to build the Gemini spacecraft was awarded to McDonnell aircraft, the same company that built the Mercury spacecraft, and a separate contract for the paraglider was awarded to North American Aviation, the company behind the X-15.

Tests of the Rogallo wing began in January 1962. Scale Gemini models with fixed paraglider wings were dropped from helicopters to test wing configurations and deployment methods. Models were also tested in wind tunnels to gather data on paraglider performance and lift. These initial tests yielded a mix of successes and failures, though the latter outweighed the former. The paraglider demonstrated a nasty tendency to disintegrate during particularly violent wind tunnel tests, calling into question its structural stability in flight during adverse landing conditions. But engineers let that major failure slide, arguing that NASA would sooner change the landing point of a mission than force astronauts to land in inclement weather.

The Rogallo program pressed on. According to the Gemini program schedule as it was in mid-1962, the first unmanned mission would land by parachute in September of 1963 with the second debuting the paraglider the following month. The manned missions would follow suit, the first landing by parachute and subsequent flights landing by paraglider.

But this schedule seemed overly optimistic as continued testing brought more failures. Wings failed to deploy or failed after deploying, both situations destroying test vehicles and the mounting problems delayed the paraglider's inclusion in Gemini. In May of 1963, paraglider landings were pushed to the tenth flight meaning the novel system would have an extremely limited application. Setbacks also affected North American's contract. It was revised around the same time to stipulate that the contractor give NASA a working system but made no mention of the paraglider's inclusion in an actual Gemini mission.



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Gemini Takes Flight Without a Paraglider

On April 8, 1964, the unmanned Gemini 1 launched and landed by parachute, proving that this tried and true method was a viable one for NASA's second spaceflight program. And the agency was starting to feel a time crunch. Not only were manned Gemini missions close on the horizon, but the end of decade lunar landing goal was fast approaching. The paraglider

was looking less and less likely to be part of America's path to the Moon. The final nail in its coffin, as far as Gemini was concerned, came on February 20, 1964, when NASA Associated Administrator George Mueller announced to the Gemini Program Office that all 12 Gemini flights – two unmanned and 10 manned missions – would all end with splashdowns. As though holding onto some last hope, the program quarterly report ending in February 1964 still said the last three missions would land by paraglider.

In May of 1964, NASA and North American agreed to continue the paraglider research program but for data-gathering purposes only. Two months later, Gemini Program Manager Charles Matthews removed the paraglider as a program requirement entirely. The paraglider gets only a cursory mention in December of 1964 before it disappears from the official program history entirely.

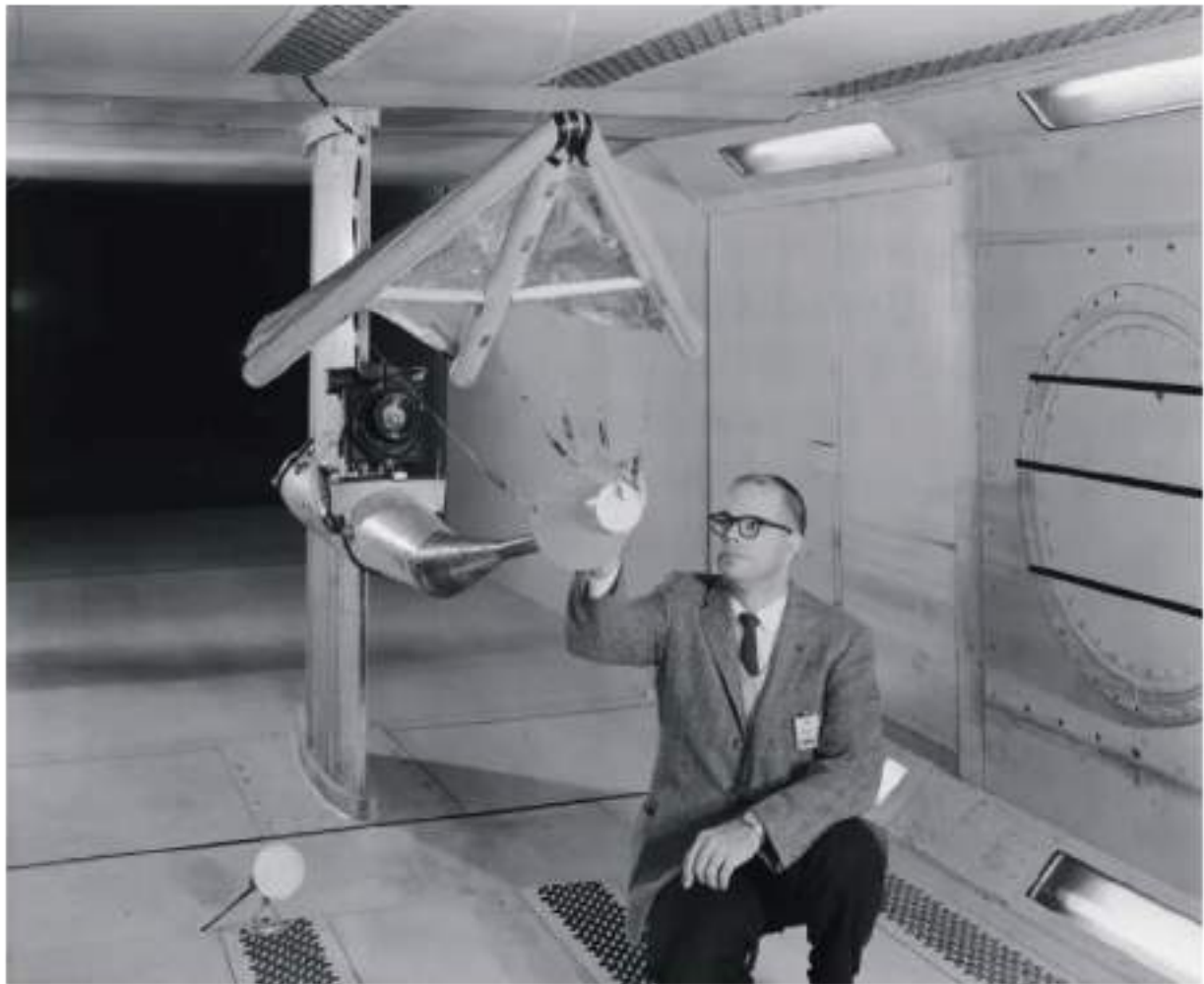
Manned Paraglider Flights

There were vain attempts to retain the paraglider after it was removed from the Gemini program. North American's modified contract stipulated it prove the system's pilotability, and this led to the Test Tow Vehicle or TTV, which began manned flights in 1964.

The TTV flights were a series of full-scale piloted drop tests that had a North American test pilot towed to altitude by a helicopter and then dropped, forcing him to land as though returning from orbit. The first pilot to try his hand in the TTV was Charles Heizel, a pilot who had already cut his teeth with the system by training in the Paresev. The first captive test in July with the TTV still tethered to the helicopter was a success. The first free test in August was not. As soon as Hetzel severed the towline, the Gemini went into a violent spin. Hetzel was forced to eject, breaking a rib in the process.

After five months of additional unmanned testing, Don McCusker found himself in the TTV in December as the program resumed manned flights. On an early flight, he successfully guided the TTV for five minutes before hitting the dry lakebed at Edwards AFB hard, so hard that the landing could have been considered a controlled crash. North American responded by beefing up the vehicle's shock absorbers.

In all, North American test pilots, including McCusker and future Apollo 13 command module pilot Jack Swigert, made 12 successful landings during 1965, but it was far too late to reincorporate the Rogallo wing into the Gemini program.



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The Paraglider's Last Hurrah, and Demise

Seeking some outlet for all the time and money it had sunk into the paraglider program, NASA looked at other possible applications. Langley engineer Mac C. Adams recommended

the paraglider be incorporated into Apollo follow-up programs, the Apollo Applications Program and the Apollo Extension Series—two programs proposed in 1965 to use Apollo hardware in developing an Earth-orbiting laboratory and a manned lunar outpost. Adams' idea was that without the time crunch of a lunar landing, this program would have enough time to work out the kinks of the paraglider.

This prompted NASA to reopen paraglider contracts, but it was short-lived. NASA was fast losing its Apollo-era funding and any future applications of this lunar technology to other goals was called into question. As post-Apollo programs were constrained and finally cut towards the end of the 1960s, the paraglider was again dropped from any future NASA programs.

The paraglider's last hope came from the Air Force, which was developing its own Gemini-based program in the latter half of the 1960s with the Manned Orbiting Laboratory. MOL, a larger version of Gemini with an added module behind the heat shield to increase a crew's living and working space, replaced the Dyna-Soar program in 1963. And with NASA having done the preliminary work on the paraglider, the USAF was considering adopting it into this military space program. But it didn't last. In 1966, two years after NASA removed the paraglider from the Gemini program, it was removed from MOL as well. The Air Force felt no need to duplicate the challenges and failures NASA had endured fighting to make the system work. MOL on the whole was cancelled in 1969 after just one unmanned test flight.

In theory, the paraglider was a great way for NASA to move away from splashdowns — it was lightweight, pilotable, and could be fitted into a spacecraft without significant redesigns. But even a decade of research couldn't iron out all the kinks. Gemini took huge steps forward in space for NASA, facilitating the first spacewalks, first rendezvous and docking in space, and testing the fuel cells that would power an Apollo spacecraft for the full two weeks needed to get to the Moon and back. But the

paraglider remained just out of reach. Every Apollo-era mission ended with a splashdown, including the last vestiges with Skylab and the Apollo-Soyuz Test Project. It wasn't until it radically changed spacecraft with the space shuttle that NASA finally managed to get away from splashdown landings, though it is making a return to ocean landings with the Apollo-inspired Orion spacecraft.

*Sources: This article was largely pulled together from old articles on Vintage Space with the goal of having a summary to go along with some videos I've posted and am planning to post on my You Tube channel. The original Vintage Space articles are: [Rogallo after Gemini](#); [Losing Rogallo From Gemini](#); [Inventing Landings](#); [The Paresev](#); [Bringing Down a New Bird](#). — check those out if you want way more details! Other sources: Hacker and Grimwood. *On the Shoulders of Titans: A History of Project Gemini*; Milton Thompson with Curtis Peebles. *Flying without Wings*; Virgil I. "Gus" Grissom. *Gemini: A Personal Account of Man's Venture into Space*.*



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My academic background is in the History of Science, but I've been interested in spaceflight since grade school when I found a cartoon of two astronauts on the Moon. I've parlayed my seven-year-old self's curiosity about the Apollo program into a career as a spaceflight historian and freelance writer.