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SPACE > Wally Funk gets taste of space **p. 36** Space Data Integrator is operational **p. 37**

RISE OF THE PRIVATE ASTRONAUTS

Sirisha Bandla, Virgin Galactic vice president for research operations, aboard SpaceShipTwo on July 11.

VIRGIN GALACTIC

- UNITY-22 AND NEW SHEPARD-16 OPEN NEW CHAPTER IN HUMAN SPACEFLIGHT
- VIRGIN PLANS TWO MORE SHAKEDOWN FLIGHTS
- BLUE ORIGIN BOOKS PAYING PASSENGERS

Irene Klotz Las Cruces, New Mexico, and Van Horn, Texas

Richard Branson and Jeff Bezos are not the first private citizens to venture into space. That distinction falls to a Japanese journalist and a British chemist who visited Russia's Mir space station 30 years ago.

But Branson and Bezos, the high-profile founders of Virgin Galactic and Blue Origin, respectively, have the distinction of making spaceflights—albeit brief ones—aboard vehicles built and operated by their own companies. "We're going to build a road to space so that our kids and their kids can build a future," says Bezos, a multibillionaire who personally funds the Blue Origin space company from his Amazon riches.

After decades of fits and starts, private space travel is on firm footing, with two suborbital spacelines, orbital flights by SpaceX and seats for sale again on Russia's stalwart Soyuz. Boeing intends to open a second U.S. taxi service to the International Space Station (ISS) next year, following uncrewed and crewed flight tests of its CST-100 Starliner. SpaceX has sold a charter flight around the Moon, slated for 2023, aboard Starship, a two-stage reusable system currently in development.

"We've always wondered what's going to be the killer app in space. Well, I think we're looking at it—it's space tourism," Phil McAlister, director of commercial spaceflight at NASA, said during a July 13 panel session at the American Astronautical Society's John Glenn Memorial Symposium.

The first nongovernment astronauts were Japanese journalist Toyohiro Akiyama and British chemist Helen Sharman, who flew to Russia's Mir space station in 1990 and 1991, respectively. A decade later, U.S. entrepreneur Dennis Tito kicked off a string of private astronaut flights to the ISS. The missions, brokered by Space Adventures aboard Russian Soyuz spacecraft, stopped when NASA needed all the seats to ferry crew to the ISS after the space shuttles were retired in 2011.

With SpaceX—and soon Boeing—picking up NASA's business, Russia has reopened spaceflight sales on Soyuz. In October, Russian actress Yulia Peresild and filmmaker Klim Shipenko will ride to the ISS, accompanied by cosmonaut Anton Shkaplerov, to shoot scenes for an upcoming movie.

In December, Japanese entrepreneur Yusaku Maezawa and his television production assistant, Yozo Hirano, are slated to launch, along with cosmonaut Alexander Misurkin, on another private mission to the ISS. Maezawa also is the customer for the SpaceX Starship flight to the Moon.

For the first time, tourist flights to the ISS are available from the U.S. as well. Houston-based Axiom plans its inaugural mission in January, with flight services purchased from SpaceX.

Ahead of any of the upcoming private ISS sorties, SpaceX plans a 4-5-day free-flying orbital mission aboard a Crew Dragon slated to launch in September. The flight, known as Inspiration4, was purchased and will be commanded by U.S. entrepreneur and

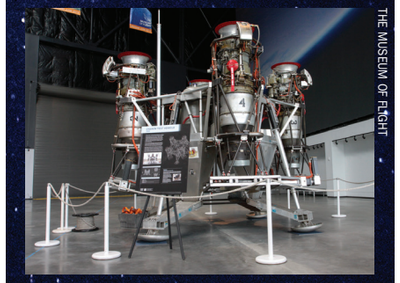
Steppingstones to Suborbital Spaceflight

After more than a decade in development, two U.S. companies demonstrated commercial human suborbital flight service in July by launching their billionaire founders as part of passenger crews. Here is a look at key milestones in the development of Virgin Galactic's SpaceShipTwo and Blue Origin's New Shepard.

2000 Sept. 8 | Amazon founder Jeff Bezos establishes a new company, Blue Origin, with the goal of building the infrastructure for cheap, reliable access to space, much like the internet paved the way for companies such as Amazon. Blue Origin's first project is a reusable suborbital passenger vehicle called New Shepard, named after Alan Shepard, the first American in space.

AW&ST ARCHIVE

2004 Sept. 29 | Following an initial flight test on June 21, 2004, Virgin Galactic's SpaceShipOne completes the first of two suborbital flights with a single pilot aboard to clinch the $10 million Ansari X Prize. Richard Branson licensed the technology from Mojave Aerospace Ventures—a joint venture of Paul Allen, who funded SpaceShipOne, and Scaled Composites founder Burt Rutan—for a commercial vehicle known as SpaceShipTwo.



THE MUSEUM OF FLIGHT

2005 March 5 | Blue Origin launches its first flight-test vehicle, named Charon, to guide development of autonomous guidance and control technologies.

2009 Dec. 7 | Virgin Galactic unveils the first SpaceShipTwo vehicle, VSS Enterprise.

2012 Oct. 22 | Blue Origin tests New Shepard's launchpad escape system at its West Texas launch site. The pusher escape motor launches a full-scale crew capsule from a launch vehicle simulator. The capsule reaches an altitude of 2,307 ft. and then parachutes to a landing.

MARK GREENBERG/VIRGIN GALACTIC/GETTY IMAGES

2013 April 29 | SpaceShipTwo conducts its first powered flight.

NTSB

2014 Oct. 31 | A Scaled Composites flight test of SpaceShipTwo ends in tragedy after the ship's rotating tail boom is unlocked too early in the flight, causing the vehicle to break apart, killing co-pilot Michael Alsbury and seriously injuring pilot Peter Siebold, who escaped via parachute. The first SpaceShipTwo, VSS Enterprise, is destroyed.

BLUE ORIGIN

Sept. 17 | United Launch Alliance (ULA) and Blue Origin announce a partnership to develop the BE-4 engine that will power both ULA's Vulcan rocket and Blue Origin's New Glenn.

BLUE ORIGIN

2015 April 29 | Blue Origin conducts its first New Shepard flight test, sending the uncrewed vehicle to an altitude of 307,000 ft. at speeds that reach Mach 3. The capsule lands safely, but the propulsion module is lost due to a hydraulic system issue during descent.

pilot Jared Isaacman (*AW&ST* March 22-April 4, p. 14).

It was this kind of bustle that Peter Diamandis and others had in mind 25 years ago when they created the X Prize, which offered $10 million to the first team to build and fly a reusable privately funded human spacecraft. With financial backing from late Microsoft co-founder Paul Allen, Scaled Composites' SpaceShipOne won the competition in 2004. Captivated, Branson licensed the technology to develop a commercial version for his space company, Virgin Galactic, called SpaceShipTwo (SS2.)

Branson hoped to be on the first passenger flight as early as 2007, but upscaling the experimental, single-pilot SpaceShipOne proved more challenging than expected. The first SpaceShipTwo-class ship, VSS Enterprise, rolled out in December 2009; its first powered flight occurred in April 2013.

Enterprise flew two more times over the next nine months, reaching an altitude of 72,000 ft. Powered flight tests were suspended while engineers tested a new fuel grain for the ship's hybrid rocket motor, switching to a polyamide-based plastic in place of the hydroxyl-terminated polybutadiene, a form of rubber used for the first series of powered tests. Although that fuel had been used successfully in SpaceShipOne, developers encountered fuel-burn stability and power issues as they tried to scale the hybrid motor up to the size required by the larger SS2.

Powered flight tests resumed on Oct. 31, 2014, with Scaled pilots Peter Siebold and Michael Alsbury aboard Enterprise. But seconds after engine ignition, the vehicle broke apart due to the premature unlocking of its rotating tail section, called the feather, killing Alsbury and seriously injuring Siebold.

It took four more years for the next SpaceShipTwo vehicle, VSS Unity, to reach suborbital space and another three for Virgin Galactic to be ready to test the passenger cabin experience with a full crew aboard, which for SS2 will typically be four people. The next-generation SpaceShip III will be able to accommodate six passengers.

Initially, Virgin Galactic President Michael Moses said a practice crew would fly ahead of Branson to test flight choreography and systems. "After our last flight in May, the data came back really great . . . so we were able to say we can basically do those rehearsal items in ground training, and we're ready to fly Richard," Moses tells Aviation Week.

"We always had that as an option, but I don't like to make promises," he adds. "Richard loves to take what I say, write it down and then never let me forget I said it, so had I told him he would be flying next, that would [have been] some pressure there."

After 17 years, Branson got his ride on SpaceShipTwo on July 11, 2021, joining two pilots and three passengers for a shakedown flight, known as Unity-22, ahead of the start of commercial service. He returned flummoxed and tongue-tied. "Nothing could prepare you for the view of Earth from space," Branson said after the flight. "I'm just taking it all in. It's unreal."

Unity, the first of a planned fleet of passenger suborbital vehicles, returned from its fourth spaceflight in excellent shape, says Moses, though a thorough inspection and data analysis will be conducted prior to moving ahead with up to two more full-cabin flight tests ahead of the start of passenger service. One flight is a charter for the Italian Air Force, which will test researcher-tended payloads.

Branson, who turned 71 on July 18, was joined by mission specialists Beth Moses, Colin Bennett and Sirisha Bandla and pilots Dave Mackay and Michael Masucci on the July 11 flight.

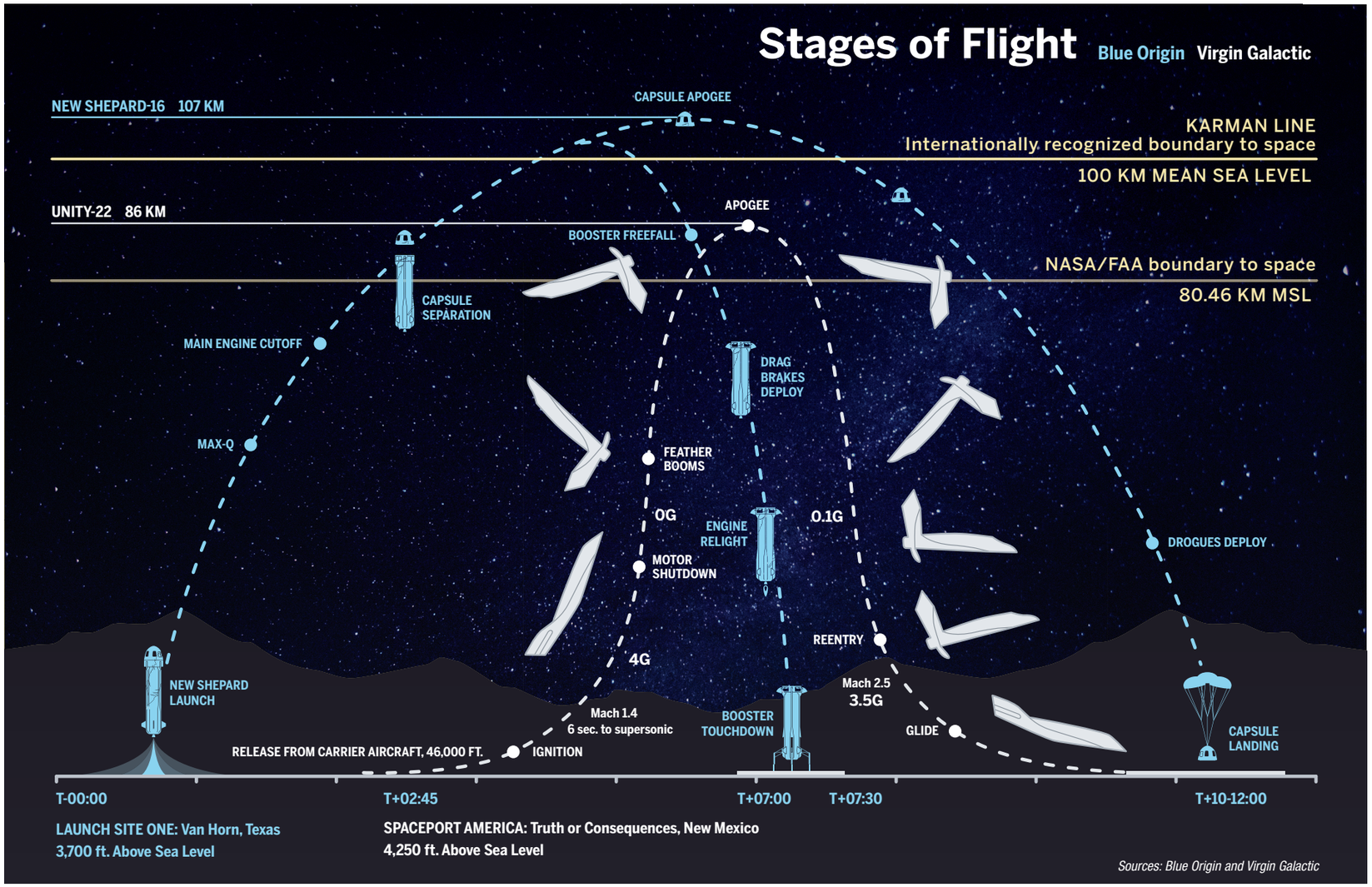
More than 350 guests, including SpaceX CEO Elon Musk, and 160 members of the media gathered at Spaceport America, near Las Cruces, New Mexico, to watch the flight, which began when Unity's White Knight Two carrier aircraft, piloted by Frederick "C.J." Sturckow and Kelly Latimer, taxied down the runway at 8:40 a.m. local time (10:40 a.m. EDT), then headed north over the New Mexico desert.

After reaching the designated drop zone, Unity was released at an altitude of 46,000 ft. The vehicle's rocket motor ignited, catapulting Unity to Mach 3 and a peak altitude of 282,480 ft., or 53.5 mi. At apogee, Branson and crewmates unstrapped from their seats to enjoy a few minutes of weightlessness and the view of Earth set against the backdrop of space. Unity glided to a landing at 9:39 a.m. local time.

"This is a landmark moment for our company and for our founder, who is right now showing that if you have the fortitude to follow your dream, you can make a huge and profound impact on the world," CEO Michael Colglazier said during a launch webcast, remotely hosted by TV personality Stephen Colbert.

The flight took place nine days ahead of when Bezos was due to fly on Blue Origin's first crewed mission, along with his brother Mark Bezos, aviation pioneer Wally Funk (see page 36) and the winner of a charity auction. The New Shepard-16 (NS-16) mission followed 15 uncrewed flight tests of the six-passenger, autonomous system, which launches from Blue Origin's private spaceport in Van Horn, Texas, just 220 mi. away from Virgin Galactic's New Mexico base.

Five days before the flight, Blue Origin announced that the unidentified auction winner had a schedule conflict and would be replaced by Oliver Daemen, an 18-year-old who participated in the auction with financial backing from his father, Joes Daemen, founder of Somerset Capital Partners in the Netherlands. Though Daemen



BLUE ORIGIN

Nov. 23 | Blue Origin launches its second New Shepard vehicle, this time successfully landing the booster. The rocket and capsule return to space two months later, demonstrating reusability. The vehicle will fly four more times, including a final flight in October, 2016 to test the capsule's inflight abort system.

RONROSANO/WIKIMEDIA

2016 Feb. 19 | The second SpaceShipTwo, VSS Unity, is unveiled. It was built by The Spaceship Co., originally a joint venture between Virgin Galactic and Scaled Composites.

BLUE ORIGIN

Sept. 12 | Blue Origin reveals details about its reusable orbital launch system named New Glenn, a nod to John Glenn, the first American in orbit. The 23-ft.-dia. rocket will be powered by seven reusable BE-4 engines.

2017 Dec. 12 | The third New Shepard vehicle begins a string of seven flight tests that ends in October 2020.

VIRGIN GALACTIC

2018 Dec. 13 | VSS Unity makes its first suborbital flight.

stopped bidding before the winning $28 million offer, he ended up buying a seat for an undisclosed sum on the next passenger flight. Potential customers were bidding "well into the 20s" of millions for a seat, says Blue Origin CEO Bob Smith.

"Congratulations on the flight," Bezos wrote on Instagram to Branson after Unity-22's landing. "Can't wait to join the club!"

On July 20, a date selected to commemorate the 52nd anniversary of the Apollo 11 Moon landing, Bezos did just that, boarding his company's New Shepard spacecraft for a 10-min. 10-sec. thrill ride into suborbital space. NS-16 marked the first time a crewed spacecraft made a debut flight without test pilots, test engineers or professional astronauts aboard.

While Blue Origin has experienced astronauts on staff, the company opted to demonstrate space tourism on its human spaceflight debut, a show of confidence in the fully autonomous New Shepard system. "We know the vehicle is safe," Bezos said in an interview with CNN ahead of the flight. "If the vehicle is not safe for me, then it's not safe for anyone."

Blue Origin intends to parlay its experience operating New Shepard commercially into New Glenn orbital spaceflight services and beyond. "We want to get really good at operational space travel, [so that it is] more like a commercial airliner and less what you think of as traditional space travel," Bezos said.

The company also is supplying engines for United Launch Alliance's (ULA) new Vulcan rocket.

At 8:11 a.m. local time, the 60-ft.-tall New Shepard, consisting of a single-stage propulsion module and a 530-ft.^{3} crew capsule, lifted off from Blue Origin's West Texas launch site. Powered by a single liquid-oxygen-and-liquid-hydrogen-burning BE-3 motor, New Shepard shot straight up into the clear morning sky, marking this vehicle's third flight.

About 2.5 min. later, at an altitude of approximately 32 mi., the BE-3 shut down, paving the way for the booster to separate 20 sec. later and begin its descent back to the launch site. The booster deployed an air brake, then briefly relit its engine to slow its speed before releasing landing legs and touching down 2 mi. from the launchpad at 8:18 a.m. local time.

Meanwhile, the capsule continued climbing to an altitude of 351,210 ft., providing Bezos and his crewmates with a few minutes of weightlessness and a spectacular view of Earth through the capsule's six large windows, each 3.5 ft. tall X 2.3 ft. wide.

After about 3 min., the passengers returned to their seats and strapped on their five-point safety harnesses to prepare for the return trip to Earth. With the seats reclined, the crew experienced up to five times the force of gravity before a trio of drogue chutes, followed by three main parachutes, unfurled to slow the capsule's descent.

Just before touchdown, a retrothrust system released a cloud of air beneath the spacecraft, slowing it to about 1 mph. The capsule settled onto the desert floor at 8:21 a.m., and four more people were added to the list of humans who have flown at least 50 mi. above Earth.

"My expectations were high, and they were dramatically exceeded," Bezos said after the flight. "Zero G may have been one of the biggest surprises because it felt so normal, almost like humans evolved to be in that environment."

The oldest person to reach space is now 82-year-old Funk, a professional pilot with more than 19,000 hr. of flying time. In the early 1960s, she and 12 other women successfully passed the same grueling medical tests that NASA's all-male Mercury 7 astronauts underwent. The agency, however, did not begin accepting women into the astronaut corps until 1978. At the other end of the spectrum is Daemen, who graduated high school last year and plans to start college this fall.

Following a microgravity payload flight, Blue Origin intends to finish the year by flying a total of 10 paying passengers—four on NS-18 in late September-October and six on NS-19 in the November-December timeframe. Blue Origin has not settled on a price for New Shepard rides, opting for now to let customers make offers. Sales are approaching $100 million, Bezos says.

The auction, which closed June 12, drew more than 7,500 people from more than 150 countries, says Smith. "Clearly, there's really high interest, so the question really gets down to: 'What's the price point? How far down will we actually be able to get to?'" he asks.

Tickets to fly on SpaceShipTwo and the upcoming SpaceShip III vehicles sell for $250,000 and are likely to increase before they decline.

The high-profile rides of Branson and especially Bezos stoked long-simmering concerns about space becoming a playground for the wealthy. U.S. Rep. Earl Blumenauer (D-Ore.) called for a tax on space rides undertaken purely for pleasure.

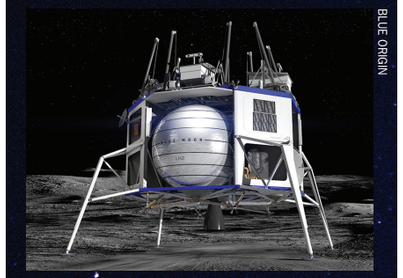
His colleague, U.S. Rep. Doug Lamborn (R-Colo.), was more sanguine. "Congratulations on your successful spaceflight," he wrote to Blue Origin on Twitter. "The future is bright for American space innovation. Now please get back to work on the engines for ULA's Vulcan rocket." ✪

JOHN KRAUS/INSPIRATION4

The Inspiration4 crew (from left) Chris Sembroski, Hayley Arceneaux, commander and financier Jared Isaacman and Sian Proctor took a parabolic training flight for the next private spaceflight—a 4-5 day orbital mission aboard a SpaceX Crew Dragon.

YUSAKU MAEZAWA VIA TWITTER

In addition to chartering a SpaceX Starship mission for a flight around the Moon, Japanese entrepreneur Yusaku Maezawa, left, is in training for a tourist flight to the International Space Station, along with his television production assistant, Yozo Hirano, that is slated to launch on Dec. 8. The flight aboard a Russian Soyuz capsule was arranged by Space Adventures.



BLUE ORIGIN

2019 May 9 | Blue Origin unveils a lunar lander concept vehicle called Blue Moon and a third engine development program, the BE-7.

VIRGIN GALACTIC

Feb. 22 | Unity conducts a suborbital flight test with its first passenger, chief trainer Beth Moses, aboard.

2021 Jan. 13 | Blue Origin debuts its fourth New Shepard vehicle for future crewed flights.

VIRGIN GALACTIC

March 30 | Virgin unveils the next-generation SpaceShip III.

VIRGIN GALACTIC

May 22 | VSS Unity reaches space for the first time, from New Mexico's Spaceport America, its base for commercial operations. The spaceport was built in 2006-12 at taxpayers' expense.

June 12 | Blue Origin concludes an online auction to sell its first ride on New Shepard, with proceeds to benefit the company's educational

BLUE ORIGIN

After 60 years, pilot Wally Funk got her taste of space.

nonprofit, Club for the Future. The winning bid: $28 million.

July 11 | Richard Branson joins three Virgin Galactic employees in the passenger cabin of VSS Unity for a shakedown flight ahead of the start of commercial services.

July 20 | Jeff Bezos flies aboard New Shepard with his brother Mark Bezos; pioneering aviator Wally Funk, who trained for spaceflight in the 1960s; and Blue Origin's first paying passenger, Oliver Daemen, who replaced the auction winner after a schedule conflict prevented him from making the flight.

Astronaut Wings for Wally

Irene Klotz Van Horn, Texas

THE SAME DAY BLUE ORIGIN MADE ITS FIRST HUMAN spaceflight, sending four passengers into suborbital space, the Federal Aviation Administration issued new FAA Commercial Space Astronaut Wings eligibility requirements.

Among the passengers aboard Blue Origin's New Shepard was pioneering aviator Mary Wallace "Wally" Funk, who cast her eye on spaceflight more than 60 years ago.

At 22, Funk was among a group of female pilots who participated in rigorous medical evaluations as part of a study to determine if women could physically and mentally fly in space. The test protocols matched what NASA was using to assess its first group of astronauts, the all-male Mercury 7. The women came to be known as the Mercury 13.

Until July 20, none of them had ever flown in space. "I can't find words to describe how happy I was when I found out that Wally was finally going to be getting a spaceflight," Eileen Collins, the first woman to become a NASA space shuttle pilot and commander tells Aviation Week. "This is an incredible dream come true for her."

Blue Origin made no exceptions for Funk's age. Like all New Shepard passengers, Funk, 82, had to meet all functional requirements to fly, including the stamina to climb seven flights of stairs in 90 sec. (Passengers have to climb up the launch tower to reach New Shepard's hatch.)

Under the FAA's new guidelines, Funk does not meet the requirements for Astronaut Wings. In addition to flying beyond 50 mi., candidates need to be trained as crew and demonstrate activities during flight that are essential to public safety or contribute to human spaceflight safety, reads FAA Order 8800.2.

But the FAA also established an honorary award, noting: "There could be individuals whose contribution to commercial human spaceflight merits special recognition."

As a poster child of the new space age, Funk has that one in the bag.