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News & Highlights

Space Tourism Begins to Take Off

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A record number of non-astronauts flew into space in 2021, including a 90-year-old actor, a physician's assistant, a football player turned TV host, a Dutch teenager, and four billionaires. The companies that sent most of these civilians aloft—Virgin Galactic, Blue Origin, and SpaceX—hope the flights will inaugurate a boom in space tourism. Blue Origin, started by Amazon founder Jeff Bezos, claims it has sold nearly 100 million USD of tickets for upcoming trips [1], while 700 people have paid up to 450 000 USD apiece for places on future flights by Virgin Galactic, launched by British billionaire Richard Branson [2].

Space tourism has come a long way in just the last two years [3]. The recent and upcoming flights are significant because the more craft head into space, "the better we get at it," said Mason Peck, a professor of astronautical engineering at Cornell University in Ithaca, NY, USA. These initial flights will "smooth the way for everybody," he said, and potentially help resolve some lingering issues. For instance, they could enable governments to establish consistent regulations for the industry.

The first space visitor to pay his own way was California businessperson Dennis Tito, who in 2001 dropped 20 million USD to fly aboard a Russian Soyuz rocket to the International Space Station (ISS) [4]. A handful of other space tourists bought rides to the ISS on Russian rockets over the next few years [5]. The craft continue to deliver occasional visitors to the ISS, including a Russian movie crew that spent 12 days filming there in October 2021 [6]. However, "the ISS is not set up for tourists, and it was never meant to be," said Laura Forczyk, founder of Astralytical, a space consulting firm based in Atlanta, GA, USA.

Virgin Galactic, Blue Origin, and SpaceX took different approaches to reach space and offer different experiences to their customers. Virgin Galactic's current design, SpaceShipTwo, is an 18 m long space plane powered by a liquid- and solid-fueled rocket motor that can generate 27 000 N of thrust [7]. Along with two pilots, it can accommodate up to six passengers. An aircraft lifts SpaceShipTwo to around 15 km before releasing it. The rocket engine then kicks in for around a minute, sending the craft to an altitude of more than 80 km. Travelers can unstrap from their seats and test the feeling of weightlessness, after which they buckle in again and the plane glides back to the surface [7,8]. The craft first carried a passenger, a Virgin Galactic employee, in 2019, and Branson and three other company officials rode on its fourth spaceflight on July 11, 2021 (Fig. 1) [9]. During the 59 min trip they were weightless for four min and reached an altitude of 86 km [10]. Unlike on trips with Branson's other commercial flight ventures, the passengers had to wait until landing to pop the champagne.

Nine days later, on July 20, 2021, Bezos and three fellow passengers roared into space in the crew capsule atop Blue Origin's New Shepard rocket, a single-stage booster whose liquid oxygen-fueled engine generates 489 000 N of thrust [11,12]. The craft has no pilots and relies on automatic controls [13]. During the roughly 10 min flight, the capsule and rocket separated, and the passengers experienced a period of weightlessness [14]. While the reusable rocket landed separately, the capsule with its passengers parachuted back to the surface (Fig. 2) [14]. Bezos' flight was the first from Blue Origin to ferry passengers rather than cargo, and in October

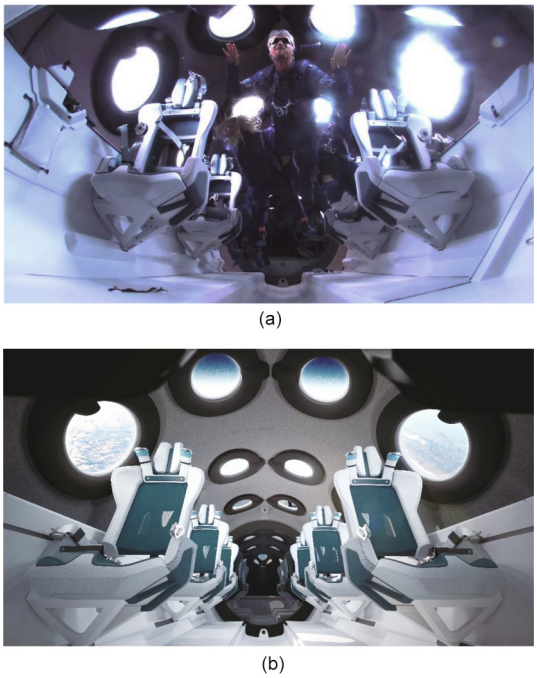

Fig. 1. (a) Richard Branson and three fellow passengers enjoy the feeling of weightlessness during a Virgin Galactic flight in July 2021. (b) The interior of Virgin Galactic's SpaceShipTwo features reclining seats made of aluminum and carbon fiber, soft surfaces in the cabin to prevent injury during weightlessness, and mood lighting. Credit: Virgin Galactic (public domain).

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(a)

(b)

Fig. 2. (a) After a successful liftoff in April 2021, Blue Origin's re-usable New Shepard booster returned to the launch pad. (b) The crew capsule from the rocket parachuted to the surface after separating from the booster. Credit: Blue Origin (public domain).

2021 his company launched a second crew that included 90-year-old actor William Shatner of *Star Trek* fame [15]. A third successful flight with six passengers, four of whom paid undisclosed amounts for the privilege, took off in December 2021 [16].

By climbing to just over 100 km, Bezos and his crewmates crossed the Kármán line, the imaginary boundary that some experts argue marks the beginning of space [17]. Blue Origin tried to needle one of its rivals by pointing out that SpaceShipTwo does not fly that high and contending that its passengers do not reach space [17]. However, where space begins remains a matter of debate, noted Forczyk. National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA), which regulates aircraft safety in the United States, put the boundary at 50 miles (about 80 km) above the surface, an altitude Branson and the other SpaceShipTwo passengers surpassed [17].

The two companies have also jousted over their amenities. Virgin Galactic boasts that SpaceShipTwo "has more windows than any other spacecraft in history," while Blue Origin touts the size of the windows in its crew capsule [8,13].

So far, SpaceX is the only company to deliver tourists into orbit. The company has made itself indispensable to NASA, shuttling crews to and from the ISS with its Falcon 9 rocket and Crew Dragon capsule [18]. In 2021 it also won the 2.9 billion USD NASA contract to build the lunar lander for the planned Artemis mission to the Moon's surface, now scheduled for 2025 or later [19,20]. Unlike his fellow billionaires, SpaceX founder Elon Musk has not launched himself into space. Instead, in September 2021 one of his Falcon 9 rockets lifted off with a crew of four private citizens (Fig. 3), one of whom paid the undisclosed cost of the flight, estimated to be around 200 million USD [21,22]. The passengers circled the Earth for three days and ascended to a Bezos-shaming altitude of 585 km before their Crew Dragon capsule splashed down in the ocean off Florida [21].

Fig. 3. SpaceX's Inspiration4 mission, the company's first to carry only tourists, prepares to lift off from the Kennedy Space Center in Florida in September 2021. The crew members spend three days orbiting the Earth, reaching an altitude of 585 km. Credit: SpaceX (public domain).

All three companies plan to ramp up their offerings. Virgin Galactic has paused flights to restore and upgrade its craft but says it will run three trips per month by 2023 [23,24]. SpaceX has signed a contract to send four tourist groups to the ISS in 2022 and 2023 [25].

There have been some glitches on space tourist flights. The SpaceShipTwo mission carrying Branson deviated from its course during descent, spurring the FAA to ban further launches for more than two months [26]. And the toilet leaked on SpaceX's September 2021 private flight—toilets are one of the trickiest technologies for spacecraft engineers [27,28]. Neither SpaceShipTwo nor Blue Origin provides toilets, and Bezos once advised that passengers should "go to the bathroom in advance" [29].

No major engineering obstacles will prevent the three companies from expanding space tourism. Their designs rely on lessons from 60 years of spaceflight experience by the United States and other countries, said Peck. "From a technological perspective, we have learned what we need to know about sending people into low-Earth orbit."

Other factors will affect how many civilians soar into space, however. One is government regulation. In the United States, the FAA has taken a hands-off approach to spacecraft safety, only ensuring that the flights do not harm people on the ground [30]. Companies have also enjoyed wide latitude in other areas, such as how much and what type of training passengers receive. Although the spaceflight industry applauded this early "learning period," said Forczyk, now that flights are becoming more common "everyone is waiting for the FAA to get involved" and provide clear rules.

Another factor that could influence the amount of space tourism, Peck said, is the proliferation of debris in the Earth's orbit. The ISS sometimes must change course to dodge space junk [31], and a collision could be disastrous for a shipload of tourists, Peck said. "We may need to clean up space to ensure that it is safe for commercial spaceflight."

Whether space tourism really takes off will also depend on one other factor: "They have to make a profit," said Forczyk. Whether the companies can attract enough wealthy clients willing to hand over hundreds of thousands or millions of dollars for a quick ride into space remains to be seen. Still, they are already looking to take passengers beyond the Earth's orbit. In 2023, SpaceX's new Starship spacecraft [32] is scheduled to fly Japanese billionaire Yusaku Maezawa and eight crew members on a circuit around the Moon [33] (in a warm-up to this coming adventure, Maezawa flew to the ISS in a Russian Soyuz capsule, arriving on December 8, 2021 [34]). Peck predicts that customers will demand even more thrilling experiences: "The remoteness of a flyby would not be as valuable to most people as putting your feet on the Moon."

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