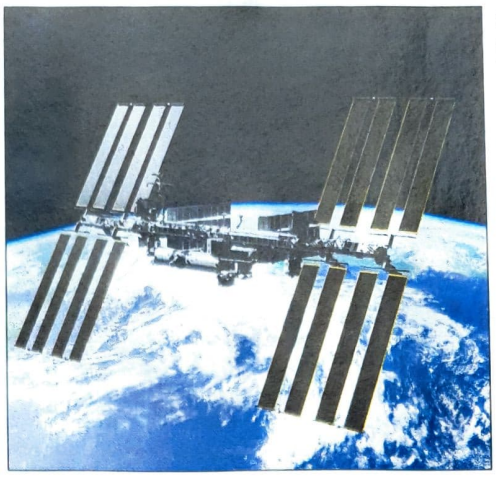
# Humanity's outpost in space

*Last month, a SpaceX module became the first private spacecraft to dock at the International Space Station. But what is the ISS for?*

**How did the ISS come to exist?**

Space stations have been dreamed of since the late 19th century, and actively planned since the beginning of the space age. However, Nasa put its plans on hold while it prioritised the "sprint to the Moon", while the Russians launched the first rudimentary space station, Salyut 1, in 1971. The Salyut's three-man crew spent 23 days in orbit, returning early due to an electrical fire; all of them died on re-entry to the Earth's atmosphere when a pressure valve malfunctioned. Nasa then launched its first space station, Skylab, in 1973. The ISS is the world's ninth space station, and by far the largest and longest-lived. The project was officially launched in 1984, when the then-US president Ronald Reagan declared: "I am directing Nasa to develop a permanently manned space station and do it within a decade."



*Two bathrooms, a gym and an acre of solar panels*

**How was it put into space?**

Bit by bit. It had always been designed as an international project, and Europe, Canada and Japan all eventually signed up; but progress was long delayed by technical and funding problems. However, the collapse of the Soviet Union in 1991 left the Russian space industry on its knees, and Nasa saw an opportunity to tap its expertise and bring down costs. Nasa and Russia's Roscosmos then merged their space station programmes, and on a freezing morning in November 1998, the Russian-built Zarya spacecraft was launched from Kazakhstan. The Zarya's service module served as the foundation block for the ISS, onto which a total of 15 modules were added: nine from the US, three from Russia, two from Europe and one from Japan, delivered on a total of 42 assembly flights, 37 on US space shuttles, five on Russian rockets. In November 2000, the first three astronauts arrived: two Russians and one American. It has been inhabited ever since.

**What does it look like today?**

All the different sections – pressurised habitation modules, laboratory modules, docking ports, airlocks, robotic arms – are bolted onto a backbone, the "Integrated Truss Structure". Together, they make up the largest spacecraft ever built: its total length is 357 feet (about the same as a football pitch). Its wingspan is 240 feet, and it weighs 420 tonnes. It orbits Earth at an altitude of 240 miles, travelling at 17,120mph, and completes one circuit of the globe every 90 minutes. This means that the six crew members usually on board at any one time pass through 16 sunrises and sunsets a day. It is one of the most complex objects ever produced by mankind, and – according to Guinness World Records – the most expensive single object ever built, with a final projected cost of over $100bn.

**What is the station for?**

The initial deal between Nasa and Roscosmos said that it would be a laboratory for testing space technologies and the effect of being in space on the human body, as well as an observatory and "a staging base for possible future missions", such as journeys to the Moon or Mars. Research is undertaken into astronomy, astrobiology and meteorology. The biggest single experiment is the Alpha Magnetic Spectrometer, a particle-physics detector designed to detect antimatter in cosmic rays. But some astronauts say that its real *raison d'être* is more romantic. "It is our first great human outpost in space," says the Canadian astronaut Chris Hadfield – an extraordinary feat of international cooperation, and an "amazing platform for human self-discovery".

**How is it made habitable?**

The living and working space in the station is larger than a six-bedroom house, and has six sleeping quarters, two bathrooms, a gym, and a 360-degree view bay window (*see box*). Power is readily available in space: the ISS is powered by eight solar arrays, providing more than an acre of solar panels in total. Everything else necessary for life – food, water and oxygen – comes via cargo spacecraft from Earth. However, "closed loop" systems have been developed to preserve supplies. And as much as 80% of water used by the astronauts is recycled; waste water, sweat, condensation and urine are collected ("yesterday's coffee is tomorrow's coffee", as astronaut Douglas H. Wheelock put it). Exhaled $CO_2$ is recycled too, to reclaim the oxygen: it is trapped and processed with hydrogen (made from waste water by electrolysis) to form water and methane; the methane is then vented into space. Some edible plants are also grown on board.

**Is the private sector involved?**

Increasingly. The private sector is picking up the slack from Nasa, which has been unable to fly its own astronauts to the ISS since the retirement of its space shuttle programme in 2011, and had relied on expensive rides from Roscosmos instead. In May, the billionaire entrepreneur Elon Musk's SpaceX become the first private spacecraft to carry crew to the ISS: its Crew Dragon capsule successfully took US astronauts Doug Hurley and Bob Behnken on board on 31 May. Between 2001 and 2009, seven space tourists – or "private space explorers" went to the ISS, at a price of $20-25m per trip. Nasa has announced that it will allow increased access to the ISS for marketing, business and tourism.

**What is the ISS's future?**

It's not entirely clear. It costs Nasa some $3-$4bn a year, and there have been serious questions over its future funding in recent years. Nasa, along with the European Space Agency and Roscosmos, is now working on a new Lunar Orbital Platform-Gateway station which will orbit the Moon, and serve as a staging for Moon landings and possibly Nasa's transport to Mars. China also hopes to have its own station up and running by 2022. Even if the lifespan of the ISS's hardware is extended, it will have to come down eventually – most likely in a controlled crash somewhere in the South Pacific.

## Life on board the ISS

Most of the 240 astronauts of 19 nationalities who have visited the ISS have stayed for missions lasting about six months. But others stay longer: the record is held by the American Scott Kelly and the Russian Mikhail Kornienko, who each spent 340 consecutive days on the ISS from 2015-16. Living in a "micro-gravity" (very low gravity) environment has its challenges. Food comes vacuum-packed, while salt is added in liquid form to stop its sprinkles flying away. Ingredients are taped to tables, and belongings are attached to walls using Velcro. Showers are replaced with dry soap and shampoo; toilets rely on vacuums to dispose of waste. Crew members must exercise for 2.5 hours a day to prevent muscle loss (they use a treadmill connected to a wall and attach bungee cords to themselves, running "straight down towards Earth", says Reid Wiseman, a Nasa astronaut). Shifts last 12 hours – astronauts are given one day a week off as respite from the grind of maintenance jobs and scientific experiments (as well as the dangerous jobs, such as the 200 or so spacewalks performed). Even sleep is strange: the lack of gravity means their bodies form a zombie-like pose, with the arms forwards. "It's kind of scary," says US astronaut Nicole Stott.