

11. Space exploration activities

Countries with space programmes are increasingly investing in down-to-earth space applications (e.g. telecommunications, earth observation) for strategic and economic reasons. Nevertheless, space exploration remains a key driver for investments in innovation and sciences, and it constitutes an intensive activity for major space agencies and industry. Significant achievements have attracted great public interest (e.g. landing on the Moon; Mars exploration by robots; probe landing on Titan).

Science and exploration. Space sciences and planetary missions have developed markedly over the years, with new actors joining in. This trend is reflected in the current and planned robotic exploration missions of the solar system, in which the United States, Europe, Japan, China and India are active players. As of the beginning of 2011, there are 3 satellites orbiting Mars (the United States, Europe), 2 active rovers on Mars' surface (the United States), 2 satellites orbiting Venus (the United States, China) and at least 7 probes flying throughout the solar system (Table 11.3). In 2009, Japan, India and China had all placed spacecraft into orbit around the Moon. In addition to those robotic missions targeted at extraterrestrial bodies, more than a dozen space science satellites are orbiting the earth. Two large international space telescopes (the United States, Europe) are active: the Hubble Space Telescope (launched in 1990, serviced in spring 2009) and SOHO, the Solar and Heliospheric Observatory (launched in 1995). Hubble's successor, the James Webb Space Telescope could be launched by NASA in 2014. Two other satellites are searching for earth-like planets outside the solar system: the international CoRoT observatory, led by the French Space Agency (launched in 2006) and NASA's Kepler observatory (launched in 2009). Swift is an ongoing NASA mission with international participation to study gamma-ray bursts (launched in 2004). Finally, moving away from earth orbit, ESA's Herschel and Planck space telescopes (launched in 2009) are positioned at the L2 Lagrange point – a gravitational stability point 1.5 million kilometres from earth to study infrared and microwave radiations. Dozens of ground-based telescopes are managed internationally (Figure 11.1).

Human spaceflight. More countries than ever are investing in indigenous human spaceflight capabilities (Table 11.2). The year 2011 marks the 13th anniversary of the International Space Station (ISS)'s on-orbit operations, with six astronauts continuously onboard since 2008, but also the planned end

of the space shuttle programme. Over the past couple of years, a new generation of professional astronauts was selected in the United States, the European Space Agency member states, Canada and China. After becoming in 2008 the third nation to independently complete a spacewalk, China plans to demonstrate autonomous rendezvous and docking manoeuvres in orbit in 2011, and launch a 30-tonne space station in the 2016-22 timeframe. India also announced plans to develop its own human space programme, with a possible first indigenous launch of an Indian astronaut in 2016.

Methodological notes

Space agencies publish key statistics about their current and upcoming space exploration missions. Several definitions for “astronaut” co-exist. The International Aeronautic Federation (IAF) calls anyone who has flown at an altitude of 100 kilometres an “astronaut”. The US Air Force set the limit at fifty miles altitude (80.45 km), while other organisations consider that a person must have reached orbital velocity and remain in orbit (above 200 km) to be considered an “astronaut”. The IAF definition has been used in Table 11.2.

Sources

European Space Agency (2010), *Space Exploration*, <http://exploration.esa.int>.

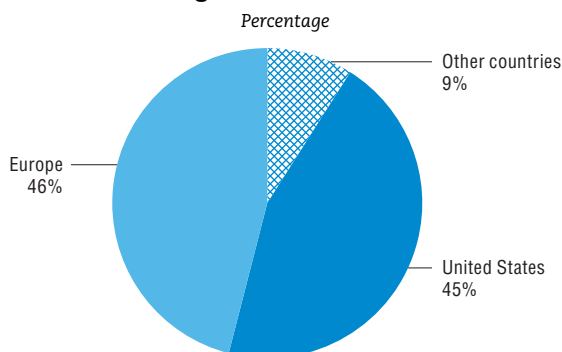
National Aeronautics and Space Administration (NASA) (2010), *Solar System Exploration*, <http://solarsystem.nasa.gov>.

National Research Council (2010), *New Worlds, New Horizons in Astronomy and Astrophysics*, Space Studies Board, Aeronautics and Space Engineering Board, Washington DC.

Note

11.2: China, the Russian Federation, the United States. 7 Russian, 1 US, 1 international.

11.1 Distribution of large optical infrared telescopes managed around the world
















11.2 Selected human spaceflight statistics

As of January 2011

Countries with autonomous capability to launch humans into space	3
Number of nationalities who have flown in space	40
Number of launches with humans onboard	+260
Persons who have flown into orbit	+510
Astronauts who walked on the Moon (1969-72)	12
Operational and inhabited space stations since the 1960s	9
Professional astronauts living in orbit (the International Space Station is continuously inhabited since 2003)	6
Number of paying orbital spaceflight participants ("space tourism")	7
Persons who have flown over the 100 km altitude threshold (including suborbital flights)	484

11.3 Planets and asteroids orbited and landed on since 1957

As of January 2011

Planet/celestial body	Number of missions	Number of planned missions	Orbiters	Landers/rovers	Selected missions
 Mercury	2	2 (orbiters planned, ESA, Japan)	..	..	Messenger (flyby in 2008) to enter orbit in 2011 (NASA). BepiColombo to launch in 2013 (ESA, Japan).
 Venus	+40	3 (NASA, ESA, the Russian Federation)	1 current orbiter (ESA Venus Express)	Last one: 1980 (the Russian Federation)	Venera 3 (the Russian Federation) was the first spacecraft to reach the surface of another planet in 1966.
 Earth	+10 000 satellites launched since 1957	Hundreds	Almost a thousand operational satellites	..	Satellites used for communications, navigation, meteorology, climate and space science.
 Earth's moon	+70	+10	2 current orbiters (NASA, China)	Latest one: 2010 (NASA)	Several orbiters and new rovers (China, India) are expected on the Moon by 2013-14.
 Mars	+40	7 (NASA, the Russian Federation, Finland, China, ESA)	3 current orbiters (NASA, ESA)	2 current rovers (NASA)	Mariner 9 (1971, NASA, 1st successful orbit), Mars 3 (1971, the Russian Federation, 1st landing).
 Phobos (Mars' moon)	..	1 (the Russian Federation, India)	..	..	Several flybys by probes on the way to Mars.
 Jupiter	+5	2 (NASA)	Last one: 2003 (NASA)	..	Several flybys, making Jupiter the most visited of the Solar System's outer planets. Juno orbiter (NASA) should launch in 2011 and reach Jupiter by 2016.
 Saturn	+5	..	1 current orbiter (NASA, ESA, Italy)	..	Several flybys by NASA probes since 1979 (Pioneer 11, Voyager 1 and 2).
 Titan (Saturn's moon)	1	..	Last one: 2005 (NASA, ESA, Italy)	2005 (NASA, ESA, Italy)	The Huygens probe landed on Titan, Saturn's largest moon, in 2005.
 Uranus	1	..	..	..	Flyby of the Voyager 2 probe (1986, NASA).
 Neptune	1	..	..	..	Flyby of the Voyager 2 probe (1989, NASA).
 Pluto (dwarf planet)	..	1 (NASA)	..	..	NASA's New Horizons space probe to fly by in 2015.
 Asteroids and Comets	+15	2 (NASA, Japan)	Last one: 2010 (NASA)	Last one: 2005 (returned samples in 2010)	Japan landed on and brought back surface samples from the asteroid Itokawa (2010). ESA's Philae (on the Rosetta spacecraft) should land on Comet Churyumov-Gerasimenko in 2014. NASA's Dawn space probe to enter into Ceres' orbit in 2015 (dwarf planet).



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