Citizens' Space

ESA's forum for a Citizens' Debate
2016 edition

Join us in this conversation on space!

Here is also our home

Science fiction
A day without satellites

Jobs, agriculture
Space in our daily lives

Handle with care!
A look at our planet and its challenges

The astronaut and the explorer
Jean-François Clervoy and Raphaël Domjan

THE EPIC ROSETTA STORY IN PICTURES TOLD TO MY CHILDREN

Join in the conversation: see our invitation on P.12

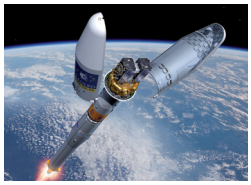
«We're expecting you!»

Dear participants in this Citizens Debate on Space in Europe,
When I was elected Director General of ESA by its 22 member states, I expressed the wish that we boost the ongoing dialogue with all our stakeholders and open up space to a broader public.
This Citizens' Debate will translate my declared intention into practice, by extending that dialogue to include people from all walks of life throughout Europe. This is no mere survey. This exercise has been designed to bring about genuine dialogue, during which we will listen to the questions and concerns raised, and maybe more than that: the expectations, wishes and also the dreams of those contributing to the conversation.

More than 2,000 of you will be gathering together on 10 September in ESA's 22 member states to take part.
This will be a huge first. We will listen with particular attention to what you have to say to us about space in your daily lives and space as a source of inspiration. Along with all those who have been involved in the preparations for this event, I myself am very much looking forward to following the discussions and seeing the results.
Finally, let me thank you for joining in this Citizens' Debate, and thereby playing your part in mapping out the way ahead for Europe's future endeavours in space.

Jan Woerner
ESA Director General

4. Joint interview
The explorer Raphaël Domjan and the astronaut Jean-François Clervoy



7. Spotlight
States, industries, citizens... 10 actors in space together

11. Human vs machine
Rivals or a winning combination?

15. Clean-up:
How to make space a cleaner sector

22. The big question
Why do we go into space? An expert replies

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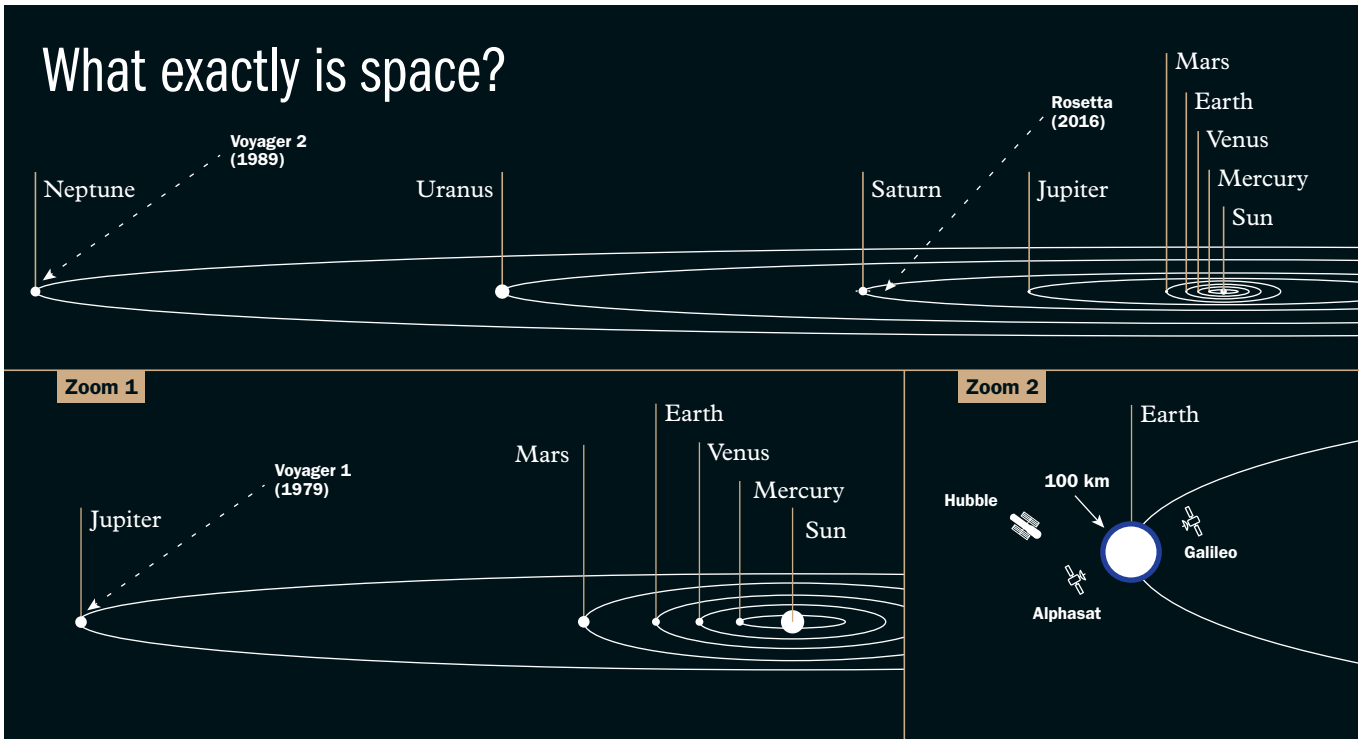
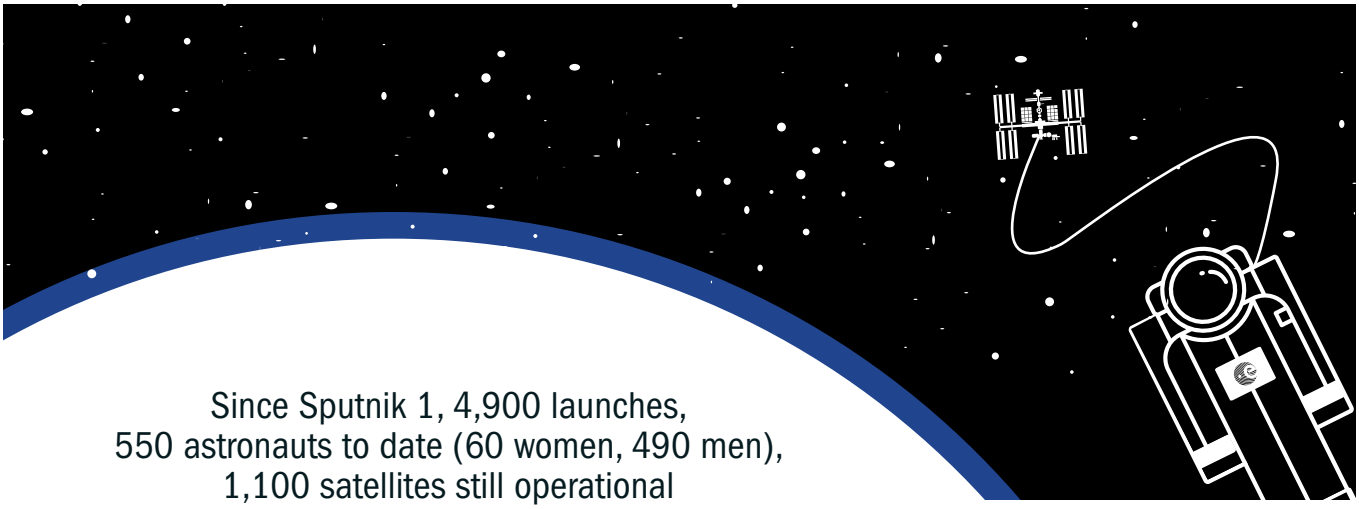


'Space'refers to everything situated beyond a terrestrial altitude of 100 km. It is an environment in which the planets, celestial bodies, dark matter and other cosmic matter are in motion. The human species has brought its personal touch to this immense scene: since Sputnik 1 in 1957, some 6,600 satellites have been launched. Around 3,600 are still in orbit, 1,100 of them operational. Satellites and probes are designed for many different purposes: to observe the universe beyond the solar system (Hubble), explore comets within the solar system (Rosetta), scan Earth (Meteosat), supply communication (Alphasat) or navigation (Galileo) services and help with gravitational research (LISA Pathfinder). The artificial i.e. human-built space objects in service that are farthest away from Earth are the twin Voyager probes: Voyager 1 studying the outer solar system is over 20 billion km away! Meanwhile, around our Blue Planet, permanent monitoring of space debris is taking place. We are tracking some 17,000 'objects' over 10cm in size, and it is estimated that there are about 700,000 items of debris of over 1cm encircling our planet. Since Yuri Gagarin in 1961, over 550 human beings have 'set foot' in space. Tragically, 18 of them died on mission.



Since Sputnik 1, 4,900 launches,
550 astronauts to date (60 women, 490 men),
1,100 satellites still operational

Denis Esnault - Sources : ESA, US Space Surveillance Network.

Jean-François Clervoy is a member of the ESA Astronaut Corps.

Raphaël Domjan, 'eco-explorer', heads the SolarStratos project.

«The adventure of going into space: still in its infancy»

Is space exploration an opportunity for humanity at large or a delusory and costly exercise? What room is there for private actors? How do we ensure that we don't turn space into a dustbin? Some tough questions for the astronaut Jean-François Clervoy and the explorer Raphaël Domjan to answer.

WHY SPEND SO MUCH MONEY ON SPACE MISSIONS? THERE ARE SO MANY NEEDS TO BE SATISFIED HERE ON EARTH.

Jean-François Clervoy : Contrary to received wisdom, these amounts of money are very much lower than those invested in sectors of more direct benefit to society. On average, the budget allocated to space in Europe is 12 euros per citizen per year. In France, the national education budget is approaching 1,000 euros per year per citizen. Moreover, space activities are recognised by independent studies as generating direct and indirect revenue significantly higher than the sums invested. These are investments rather than expenditure.

Raphaël Domjan : The conquest of space is an undertaking that is of great benefit, for example in terms of our being able to expand our competences, our knowledge, our technologies, and then go on to develop 'cleaner' systems on Earth. Besides that, space exploration gives us the overview, the vantage point from which to see our civilisation in perspective. We live in a finite world: our ongoing conquest of space is helping to raise awareness of the ecological issues we face.

DOES THE CONQUEST OF SPACE STILL HAVE A FUTURE? HASN'T EVERYTHING ALREADY BEEN DISCOVERED?

Jean-François Clervoy : Astronautics is still in its infancy, being barely 60 years old. The potential is immense. At present, there are just 1,100 operational satellites in orbit around Earth. In about ten years' time, there will be several thousand, directly addressing the needs of humanity. Interplanetary probes are contributing to the exponential growth of our knowledge of our origins and of the evolution of our universe. This quest for knowledge is one of the noblest undertakings possible. And it is built on international cooperation. It contributes to fostering peaceful international relations and is a powerful driver for inspiring and motivating young people to engage with science.

Raphaël Domjan : Our exploration of the geography of Earth has taken centuries. Let us dream for one moment: if we want our civilisation to last, we will have no choice but to go elsewhere, especially as, sooner or later, our star, the Sun, will show signs of weakening...

That is not going to happen in the immediate future! But if we want to live beyond that, we will have to leave.

HAVING SULLIED EARTH, ARE WE NOT IN THE PROCESS OF DOING THE SAME TO OUTER SPACE?

Jean-François Clervoy : Becoming aware of the risks relating to space debris has prompted space-sector actors to stop creating further debris. The challenge today is to manage the debris accumulated up there since the start of the space age.

ARE HUMAN BEINGS GOING TO BEHAVE IN SPACE AS THEY HAVE DONE DOWN HERE ON EARTH, ENDANGERING OUR COMMON HERITAGE BY TRYING TO 'COMMERCIALISE' EVERYTHING IN SIGHT?

Jean-François Clervoy : In the not-too-distant future, it will be more profitable and ecological to exploit certain extra-terrestrial resources rather than those on Earth, whether it be for terrestrial or space applications.
We still need to define appropriate rules and develop the necessary technologies. Let us hope that space law, which only relatively recently came into being, can get good practices adopted akin to those already heeded for space activities today.

Raphaël Domjan : People would like the resources of our planet to belong to humanity at large. But we live in a capitalist system. Funding research projects or going into space requires huge amounts of money. One may regret this being so, but economic prospects can also be a driver for innovation.

NOWADAYS, IS IT NOT THE CASE THAT SPACE IS STILL 'RESERVED' FOR SPECIALISTS, WHEREAS IT WOULD BE IN THE INTERESTS OF ALL HUMANKIND FOR THERE TO BE OPEN ACCESS, WITH ALL COLLECTED DATA BEING OPEN- SOURCE?

Jean-François Clervoy : While the design and deployment of space systems remain a matter for specialists, their utilisation is very largely open-source already. Everyone has free access to satellite navigation (GPS), weather forecasts, TV channels via satellite dish, images of Earth viewed from space (Géoportail, Google Earth) and of course global-scale telecommunications. Almost all these services draw on space-based systems.

Raphaël Domjan : No one sees any problem with someone setting sail in their yacht to cross the Atlantic. One day, we may have access to space in the same way. For flying at altitudes above 100 km, you already don't need any authorisation. The limits here are technical and financial. Perhaps we will, however, need some basic rules for doing so.

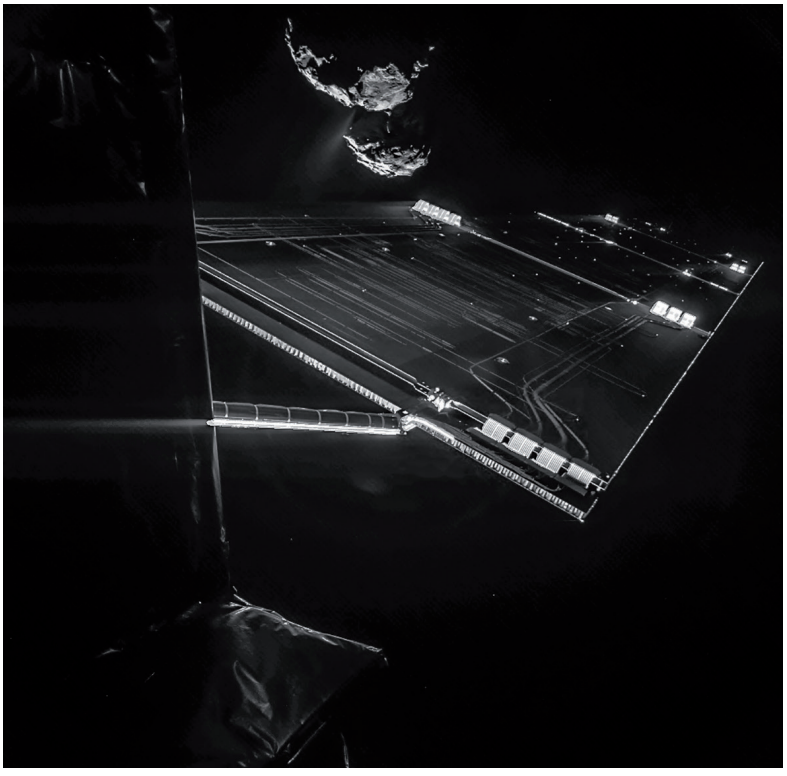
WE ARE WITNESSING AN EXPANSION OF PRIVATE-SECTOR FIRMS FOCUSING ON SPACE ACTIVITIES. DO WE STILL NEED (INTER) GOVERNMENTAL AGENCIES?

Jean-François Clervoy : Dedicated private-sector space firms have almost all been able to emerge thanks to the knowledge, technologies and space programmes originating from the space agencies. The risks linked to the powerful propulsion systems deployed and the extreme conditions of the space environment are, at the outset, taken →

Finding out more

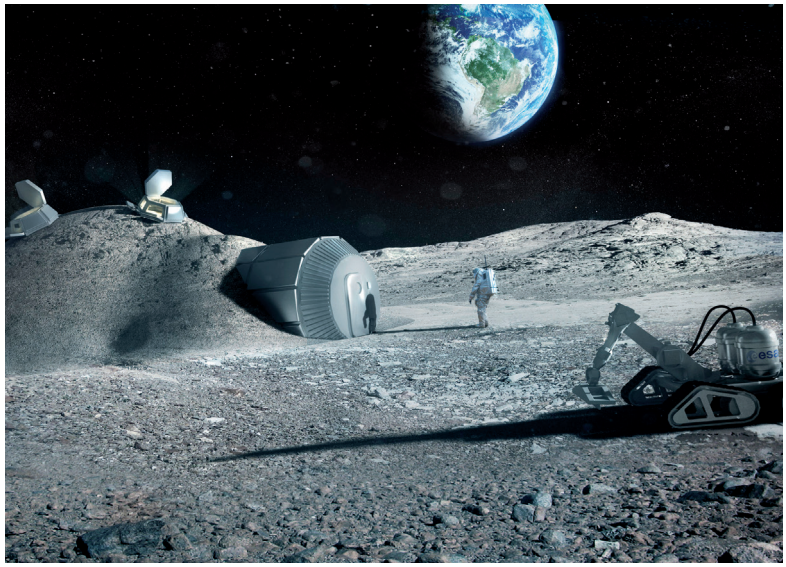
Cue the SolarStratos project: http://www.solarstratos.com

«Space exploration enables us to get an overview, to see our civilisation in perspective.» J.-F. Clervoy



Rosetta photographed by itself! A selfie 6.4 billion km from Earth.

ESA / Rosetta / Philae / CIVA



Lunar base project with construction by 3D printing.

Jean-François Clervoy (57), an engineer, is a member of the ESA Astronaut Corps, president of the company Novespace and an author. He has flown twice onboard Space Shuttle Atlantis and once onboard Discovery. He has clocked up a total of 675 hours in space.

Raphaël Domjan (44) is an 'eco-explorer', author and lecturer. He initiated and led the first round-the-world trip in a solar-powered boat (PlanetSolar). Heading an international team, he is currently preparing the SolarStratos project, which aims to approach outer space using a solar-powered plane. The first tests will go ahead in 2017.

→ by the space agencies. For any future new programmes, those agencies will maintain their role as pioneers and trailblazers. They will hand things over to the private sector when the risks have been overcome. Accordingly, Arianespace was able to emerge from the Ariane programme, set up by the French and other national space agencies in Europe. SpaceX has been able to develop thanks to the ISS programme, initiated by NASA.

Raphaël Domjan : The space agencies play an important role. There will be missions close to Earth, in geostationary or low-Earth orbit. In the near future, it will be private-sector firms that will be doing this. But beyond our planet and our solar system, the agencies will have a vital role to play regarding the conquest of space. For our own project, ESA's support for the initial feasibility studies and the space-based research on batteries was similarly crucial.

AS AN 'EARTH-BASED EXPLORER', DO YOU THINK THAT OUR ADVENTURES IN SPACE STILL MAKE SENSE? WHAT WOULD YOU EXPECT TO EMERGE FROM THEM?

Raphaël Domjan : Of course they do. First of all, I expect them to be the stuff of dreams, the pursuit of non-utilitarian goals. Our thirst for knowledge, our curiosity, the extending of our knowledge... All that has enabled us to become what we are, to understand also that we live in a finite world, to foster ecological awareness.

CONCERNING OUR ADVENTURES IN SPACE TO DATE, WHAT HAS GIVEN YOU THE GREATEST JOY. AND WHAT HAS BEEN THE BIGGEST DISAPPOINTMENT?

Raphaël Domjan : My greatest joy to date has been to spend an evening with Buzz Aldrin, Edgar Mitchell and Charlie Duke. When you shake the hand of a man who has walked on the Moon, that changes your perspective on things. These people are the Magellans, the Christopher Columbuses of space. As for my disappointments? Well, we used to be capable of going to the Moon, we had space shuttles. Now we have fallen behind with crewed flights. But there are grounds for hoping that the conquest of space, just like our environmental and climatic challenges, will encourage the peoples of the different countries to work together.

Jean-François Clervoy : My greatest joy is the perspective on its own destiny that the space age has given to humankind: we live on a confined and unique spaceship, and will probably do so for many generations to come. The best chance of our being able to live on is if we work together as a team on an international basis, to live in harmony with the biodiversity that surrounds us; this guarantees the best chance of our survival here on Earth, faced with an evolving environment. My greatest disappointment is this: that the difficulty of accessing space is such that too few human beings have been able to share the consciousness-changing experience of admiring their home planet from the unique vantage point of outer space.

WHAT ARE YOUR MAIN DOUBTS?

Jean-François Clervoy : The difficulty of explaining space as an educational exercise. It is intangible, invisible, inaudible... Its challenges are hard to get across in a comprehensible way to the general public. But the information technologies of the future (3D, 360°) associated with fascinating projects, 'tangible' ones like Solar Impulse, will serve to get us all thinking about possible scenarios for sustainable futures, thanks amongst other things to the services delivered by space-based systems.

Raphaël Domjan : I have no doubts. Everything is just a question of time. As long as we remain a civilisation, we will organise in order to go further, push back limits, make further discoveries. This is one of our defining traits, it's what being a human being is all about.

ESA / Foster + Partners

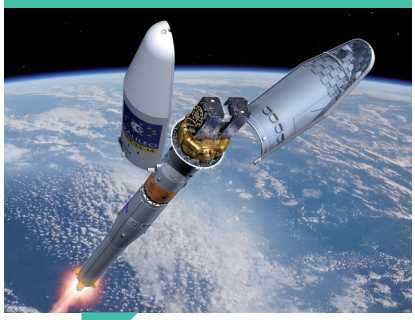
Who 'does' space ?

The conquest of space is a multi-player affair. Above our heads, a large number of actors are at work, including private-sector ones, of all nationalities. To get a clearer idea of this, we have classified them into ten categories.

1. The space agencies. Nearly 70 countries have a national space agency. The major ones are: NASA (USA) and the Canadian (CSA), Chinese (CNSA), French (CNES), German (DLR), Indian (ISRO), Italian (ASI), Japanese (Jaxa) and Russian (Roscosmos) agencies. The European Space Agency (ESA), set up in 1975 by 11 countries (Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom), is the only intergovernmental body: it currently has 22 member states.

2. The United Nations. The United Nations Organisation (UNO) has an Office for Outer Space Affairs (UNOOSA). This fosters international cooperation in the peaceful use of space and keeps a register of objects sent into space since 1957. The UNO also has a Space Debris Committee (within COPUOS) and a UN-SPIDER programme providing Space-based information Disaster Management and Emergency Response.

3. The European Union. The European Commission together with ESA coordinates a space policy which has four dimensions/focuses: Galileo, the global navigation satellite system; Copernicus, the civil Earth observation programme; space exploration; research and innovation within the space industry.



4. Defence. Armies, notably the Chinese, French, Russian and US armies, deploy reconnaissance satellites. The US army deploys the X-37B, a space shuttle test vehicle whose mission remains secret. China in 2007 tested an anti-satellite missile.

5. Intergovernmental organisations. Examples include: the European Southern Observatory (ESO), a major actor in astronomy in Europe, which has 16 members with Chile being the host country for its three observatories; the International Telecommunications Satellite Organization (ITSO), providing public telecom services; and the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat), which supplies satellite data and images for meteorology and climatology.

→

ESA photo / A. Le Floc'h - NASA - European Southern Observatory - ESA

6. Universities and research laboratories. These do basic research and develop the instruments and equipment flown on space missions. Many universities and schools throughout the world offer courses in space-sector fields.

7. Authorities. At national level, the Luxembourg government issued a call in early-2016 to the companies working on the commercial exploitation of asteroids and Near-Earth Objects*. At regional level, the NEREUS network aims to exploit the potential of space technologies to benefit citizens and member regions. Elsewhere, other regions are joining together to form competitiveness clusters, like the Aerospace Valley in France.
*See Glossary p.18

8. Industrial actors. From the construction of launchers and satellites to the commercial exploitation of asteroid minerals and satellite data, space is also an industrial and commercial arena. It is a sector in constant evolution, with strong growth prospects, which is attracting new private-sector actors.

9. Museums and theme parks. Their purpose is to popularise science and space missions. Their role is extremely important in terms of educating people about space and its applications, and inspiring future generations of scientists.

10. Associations. From local groupings of amateur astronomers to Universe Awareness (UNAWE), an international project which uses astronomy to bring science to children throughout the world, there are now countless associations involved with space-related issues.

Not forgetting... citizens. By taking an interest in the space sector, they can shape its future democratically.

Traveloscopy - Euro Space Center - UNAWE

Space: omnipresent in our daily lives

Our lives have been changed by the discoveries and applications stemming from space exploration.

❶ People transport
Satellite navigation has developed a great deal over recent years: it is a useful tool notably for car drivers, ramblers and tourists. It can also indicate the waiting time until the next bus, or improve safety by reporting to planes the visibility conditions of their destination airport.

❷ Logistics
On Earth, space-based systems help optimise delivery rounds; at sea, surveillance of shipping traffic.

❸ Agriculture
Navigation systems are increasingly to be found on farming machinery. They enable precision work to be done so as to harvest more, while limiting consumption (fuel, water, natural resources, chemicals).

❹ Services
Exploitation of satellites has improved the internet, television and weather forecasting services. It has also enabled the development of healthcare activities and distance learning.

❺ Jobs
According to estimates, the European space sector directly generates 38,000 jobs thanks to cooperation between industry, national agencies, the European Union and ESA. Supplementing that figure are the jobs arising from processing satellite data for terrestrial applications.

Denis Esnault

ESA

Technology with a bit of space

The space agencies and industry are focused day in and day out on carrying out their programmes. But they are also transferring their technologies to civil-sector firms.

What do an airbag, a solar panel and bodybuilding apparatus have in common? The answer: they have potentially all benefited from advances made thanks to space exploration.

Driving forward technology is one of the additional objectives pursued by space-sector actors. Let's take the case of ESA. While it has no formal remit to commercialise its services, it can nonetheless, once the research, development and qualification testing have been completed, hand over the responsibility for projects to external outfits. These may be intergovernmental or private-sector. They then take on the production and exploitation activities. This is the case with Eumetsat for meteorology, Arianespace for launch services and Eutelsat and Inmarsat for telecommunications.

Major enterprises like Airbus Defence & Space and Thales Alenia Space continue to create jobs for a highly skilled workforce. But many very small, small and medium-size businesses are also emerging in the sector. ESA is encouraging entrepreneurial initiative by investing in 12 «Business Incubator Centres», spread out across Europe.

144 firms 800 jobs

This initiative encourages the creation and incubation of start-ups, for which the business model is based on 'spinning off' technologies and systems from the space sector, destined for non-space markets.

Over the last 10 years, 144 firms have been incubated, the key to creating 800 jobs (2014). For instance, the start-up EATOPS supplies tools and systems for surveillance of oil and gas installations. Another start-up, GIAURA, aims to capture the CO_2 present in the atmosphere in the same way that that gas is recycled on spacecraft.

The programme draws on a European network of 'technology brokers' emanating from 14 member states. They notably include Umbilical Design in Sweden, Tech2Market in France and Tecnalia in Spain.

At the end of the line, the technologies are commercialised on a highly diverse range of markets: from carbon brakes in the automobile sector or equipment for disabled sports to high- performance clothing, or instruments measuring cardiac activity.

Civil or military?

NASA is the largest national space agency in the world and the US Defense Ministry is the largest satellite operator. The US space industry benefits from this, with over 90% of its annual sales being made to the government.

In stark contrast, European industry realises over 40% of its sales from contractual deals with commercial partners.

Joint European space programmes are carried out for «exclusively peaceful purposes». However, France, Italy, Germany and the UK consider space systems as forming part of their defence infrastructure.

So France's two Pléiades Earth-imaging satellites are designed for both civil and military (i.e. dual) use.

Human or robot:
Who will be first to launch?

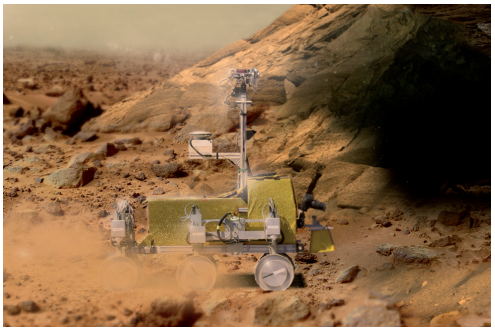
Will the space exploration of the future involve human beings or machines? The debate on this, which is as old as the literature of science fiction itself, has become a real issue that needs to be tackled as of now.

In less than 60 years, human beings have sent some 150 probes and robotic explorers far out into the solar system. The Voyager 1 probe, launched by NASA (1977), is the farthest space object from Earth in service, being 20 billion km away. Four exploration vehicles, called rovers, have successfully landed on Mars. Two are still operational: Opportunity and Curiosity. Meanwhile, some 550 men and women of 41 different nationalities have tasted the joys of human spaceflight. Despite the precautions taken, tragically, 18 were never to return: the conquest of space has cost the lives of the astronauts on Apollo 1, the Space Shuttle Challenger on lift-off in 1986 and Columbia on its return to Earth in 2003.

The human factor: vulnerability coupled with strength

Nevertheless, the human eye matters. The experience gained by US astronaut Harrison H.Schmitt proved invaluable on the Apollo 17 mission on the Moon, when it came to identifying and collecting 110 kg of geological samples. Flexible, effective, adaptable and full of initiative, we humans nonetheless bring to space one huge weakness, and that is our physical frailty. Yet space is an environment that is hostile to human life: extreme pressures and temperatures, radiation, absence of gravity, lack of oxygen, and so on. In order to live and work there, we need special spacecraft, life-support survival systems, and resupplies such as provisions, water, fuel and spare parts. This logistical imperative has a far higher cost than that incurred by dispatching a robotic exploration probe, although it does enable us to count on the human factor to put things right where necessary.

Tim Peake (above) at the controls of the Bridget rover (below).



These hard facts point to the need for cooperation. As ESA astronaut Thomas Pesquet emphasises: «Robotic probes are vital precursors to sending human beings to a planet. However, it is clear that for scientific exploration, the return on a crewed mission would be far more worthwhile thanks to the quick decision-making capabilities of human beings.» Without going as far as settling on Mars, the benefits of having astronauts onboard an orbiter, for example, would be significant. They could then, from their spacecraft, in real time, and without any communication delay, remote-pilot a rover moving about the Red Planet's surface.

ESA

Hello Houston! Hawaii here!

'Analog' missions aim to simulate, on Earth, the conditions of a real extra-terrestrial mission in space: i.e., cut oneself off from the outside world, choose a remote region, reproduce the interior of a spacecraft or a station on Mars.
In 2010-11, Mars500 simulated a return journey to Mars: 520 days, including 30 on the surface of the planet, with a multinational Russian-Chinese-European crew. NASA is for its part financing HI-SEAS, a space exploration analog mission sited on the slopes of a volcano in ... Hawaii.

In Antarctica too

ESA is a partner at the Concordia base in Antarctica, a joint French-Italian research station located on Earth's southernmost continent. Altitude: 3200 m. Average outside temperature: -50 °C. No sun during the 4-month winter. 'Ideal' conditions for studying the effects of isolation on the multicultural crew (psychological, health, sleep), as a precursor to carrying out long-duration space flights subsequently.

Finding out more

Read, on the Cornwell University website, a fascinating article by Ian A. Crawford, on 'dispelling the myth of robotic efficiency' in space exploration. According to this researcher, human beings will always outperform robots (download pdf): http://bit.ly/1UARWz0

Come and join our conversation on space!

On 10 September, you could be one of the 2,000 participants in the Citizens' Debate on Space Exploration. Everyone is invited, and if you feel like taking part, here is what you need to do.

This is a first. These exchanges will take place simultaneously in the 22 member states making up the European Space Agency (ESA). Each debate will bring together about 100 people for a full day. To take part, no specialist knowledge is needed - every citizen has a view they can share.

To facilitate and stimulate the discussions, participants will be divided up into small groups, so you won't have to speak in front of 100 people. Bear in mind that the aim isn't to persuade or reach agreement. The debate will produce «a citizens' view» reflecting the diversity of the views expressed. The day is being organised by ESA with the support of the Missions Publiques agency (Paris).

This magazine contains the information you need before the debate. Videos will also be shown on the day of the debate itself to get the discussions going. The questions to be put to the participants were compiled by an interdisciplinary committee of ESA experts. Giving the citizens of several countries the opportunity to speak is a new approach. It was initiated in 2009 by the DBT - Danish Board of Technology (World Wide Views). Missions Publiques initiated and coordinated jointly with the DBT the Citizens' Debate in the lead-up to the COP21 international climate change conference in Paris in December 2015. In all, 10,000 participants from 76 countries across five continents contributed to the citizens' view presented to the negotiators of 196 governments.

«If we exploit space the same way we've exploited the Earth, we'll end up destroying the whole universe.»
Helena (Spain)

«Space to me is the development and discovery of new horizons.»
Jan (Czech Republic)

«I see space as something that's a bit worrying, and that's why I'd like to find out a bit more about it.»
Julie (Norway)

«Exploit space? Why not, if it's legal. We live in a free world.»
Martin (Sweden)

«Space means endless possibilities.»
Lilána (Hungary)

«Space? I don't know anything about it.»
Chiara (Italy)

«Space: development, the future and helping each other.»
Sabine (Denmark)

«I'm worried space programmes could be developed for military purposes.»
Thor Oona (Switzerland)

Should we exploit resources in space? I'm OK with that.»
Andrezj (Poland)

Philip Schnurr - Gábor Huszti - Federico Tribbioli

22 countries for 23 debates

1. Greece - Athens (Corallia & si-Cluster) **www.corallia.org** & **www.si-Cluster.gr**
2. Romania - Bucharest (The Romanian Space Agency ROSA) **www.rosa.ro**
3. Estonia - Tõravere (Enterprise Estonia - EAS) **www.eas.ee**
4. Estonia - Tallinn (Enterprise Estonia – EAS) **www.eas.ee**
5. Finland - Helsinki (Kupla Productions Oy Ltd) - **www.kupla.com**
6. Norway - Oslo (Norwegian Space Centre) **www.romsenter.no**
7. Sweden - Gothenburg (Pernilla Warberg Consultant Limited Company) **www.pernillawarberg.se**
8. Denmark - Odense (Coworking Odense) **www.coworkingodense.dk**
9. Poland - Rzeszów (Technology Transfer Centre Cracow University of Technology) **www.transfer.edu.pl**
10. Hungary - Budapest (ORION Space Generation Foundation) **www.spacegeneration.hu**
11. Austria - Vienna (ICCR FOUNDATION) **www.iccr-foundation.org**
12. Czech Republic - Prague (Technology Centre CAS) - **www.tc.cz**
13. Italy - Rome (ISINNOVA – Institute of Studies for the Integration of Systems) **www.isinnova.org**
14. Switzerland - Lucerne (Swiss Space Center - SSC) - **www.space.ethz.ch**
15. Germany - Darmstadt (nexus Institute for Cooperation Management and Interdisciplinary Research) **www.nexusinstitut.de**
16. Luxembourg – Luxembourg (4motion) **www.4motion.lu**
17. France – Paris (Missions Publiques) **www.missionspubliques.com**
18. Belgium - Brussels (Missions Publiques) **www.missionspubliques.com**
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20. United Kingdom - Edinburgh (Keep Scotland Beautiful) **www.keepscotlandbeautiful.org**
21. Ireland - Cork (Camden Palace Hotel Community Arts Centre) **www.camdenpalacehotel.org**
22. Spain - Madrid (Knowledge Innovation Market - KIM) **www.kimglobal.com**
23. Portugal - Lisbon (Ciência Viva) **www.cienciaviva.pt**

«I'm worried some people could control space without really asking us what we think.»
Dimitri (Greece)

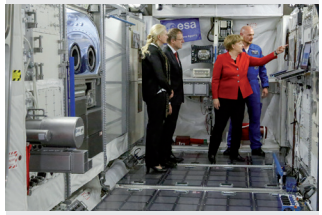
«It would be a good idea to send artists into space, they'd see things in a new way.»
Luis (Portugal)

«I hope space programmes are going to help us make our lives on Earth more environmentally friendly.»
Doris (Austria)

DR

Wide-ranging research

All kinds of research are conducted on board the International Space Station (ISS). In the area of medicine and biology: osteoporosis, vision, Alzheimer's; in social science, study of the astronauts' personal onboard journals; in physics, the study of fluids and gaseous combustion; in Earth sciences, measuring of wind speeds at the surface of the oceans; in the environmental field, photos of eruptions, unusual meteorological phenomena, natural disasters; not to mention cosmic rays, robotics and agronomy.



Columbus, European laboratory

The Columbus Laboratory (length 7m, diameter 4.5m) is a module controlled and monitored by ESA's Columbus Control Centre located at the German Space Operations Center (DLR) at Oberpfaffenhofen. In its first five years of operation, over 110 experiments were carried out on board at the request of more than 500 European scientists. The main purpose of Columbus is to make scientific discoveries and to develop applications that are useful on Earth.

Luca Parmitano (ESA) and Karen Nyberg (NASA) on board the ISS.

Space furthering knowledge

Orbiting 400 km above our heads, the International Space Station (ISS) is a permanent research laboratory.

The Station (length 109m, width 73m) is visible with the naked eye from Earth. There are always six astronauts on board. It is both a place where fifteen countries(1) cooperate and a permanent scientific research laboratory. Half its crew is replaced every three months using the Russian Soyuz spacecraft. ESA has been sending one or two astronauts on a mission every year since the European Columbus laboratory was docked to the ISS in early-2008.

Samantha Cristoforetti (ESA) busy running ..... at an altitude of 400 km.

Finding out more

To view the European Columbus laboratory, understand how it works and see the kinds of research conducted in it, visit ESA's website: http://bit.ly/29qgE6w

Shared findings

On board, the astronauts spend most of their time working on the scientific experiments for which they are responsible and for which they trained before their arrival. The Station has all kinds of equipment to enable them to do this. The research carried out relates either to long-duration crewed spaceflight (human physiology, life on board, maintenance and repair of the spacecraft) or to life on Earth. The findings obtained on board the ISS benefit all the world's population, through technology transfer programmes. With medical research, the astronauts are often both the operators and the subjects of the experiments, which begin before their flights and continue after their return to Earth (measuring of bone density, monitoring of cardiovascular system changes, etc.).

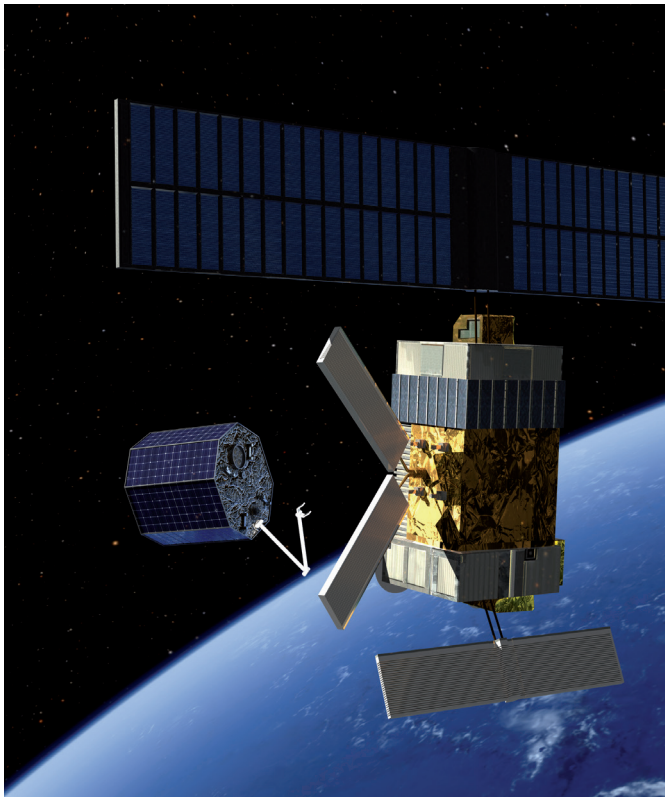
(1)The intergovernmental agreement on the International Space Station, which sets out the legal framework for the Station's utilisation, was signed in 1988 by the USA, Russia, Canada, Japan and ten ESA member states (Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden and Switzerland).

ESA–Grothues / ESA / NASA

Debris: operation spring clean

Space actors acknowledge that their activities are inherently polluting. In 2012, Europe set up the Clean Space initiative, focusing on three areas to help achieve a cleaner space sector.

There's a hair-raising scene in the film «Gravity», where two satellites collide in orbit, producing a cloud of debris. The debris hits a Space Shuttle and the International Space Station, leaving the two astronauts who were repairing the Hubble space telescope stranded in space. Yet this is not entirely fictitious, as there is at present no international regulation obliging a country to remove or destroy the space debris it produces. There are estimated to be over 29,000 objects measuring more than 10cm orbiting the Earth. These include fully operational satellites, but also the old upper stages of launchers, launch adapters, and all kinds of other debris.



ESA / Mixed-Reality Communication GmbH

Artist view of a robotic arm capturing a large space debris.

Finding out more

Space Debris Mitigation Guidelines (UN, pdf): http://bit.ly/1UAcE60
Clean Space programme (ESA, pdf): http://bit.ly/1P5LsY2

As each piece can endanger a space mission, the debris needs to be mapped and technologies developed to remedy the situation.

Capturing a satellite

Several national agencies have set up their own initiatives. Europe's is called «Clean Space». The first of its three measures, Cleansat, aims to reduce the production of debris as from launch. Since the launcher's main stage and fairing fall back to Earth, inhabited regions are avoided and, where possible, launchers head out over the sea. Once launched, satellites are positioned in low-Earth orbit or in geostationary orbit (see Glossary). At end of life, geostationary satellites should be moved to a graveyard orbit to make way for 'newcomers'. As a logical follow-on to the Cleansat programme, e.deorbit aims to control the increase in the number of space debris in orbit by 'removing' the largest of them before they collide with others. If successful, the e.deorbit mission will attempt to 'capture' a decommissioned ESA satellite in 2023. This would be a world first. Finally, the Clean Space initiative involves space actors working on the ecoDesign programme, upstream of a mission. This encourages the use of materials and processes that are more environmentally and natural-resource friendly.

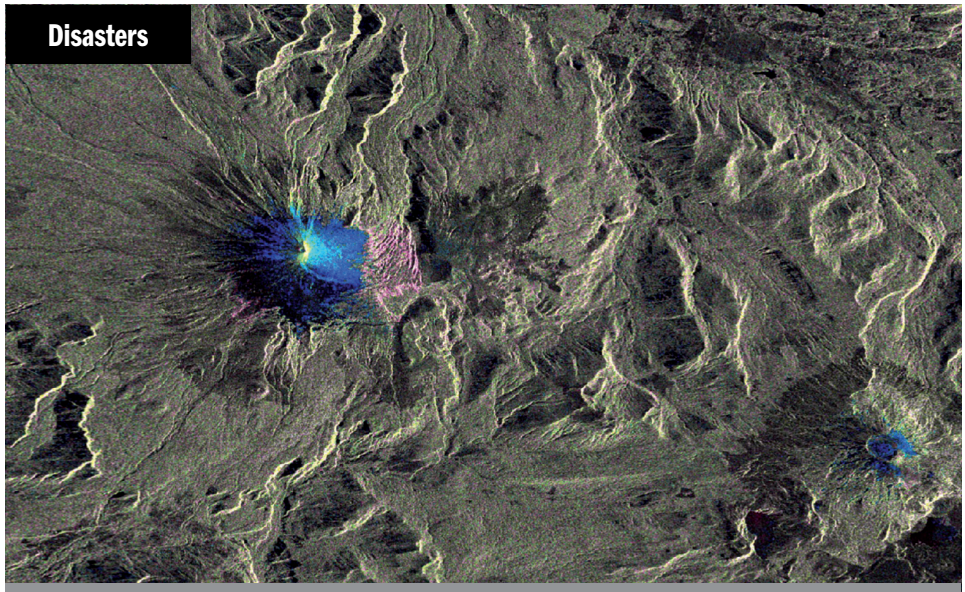
What is this debris?

There are hundreds of pieces of debris that are potentially dangerous for the International Space Station (ISS). Those whose trajectory comes within the 'safety area' are tracked particularly closely. As they approach, a debris avoidance manoeuvre might be made. If that is not possible, crews take refuge in the Soyuz spacecraft.

Glossary

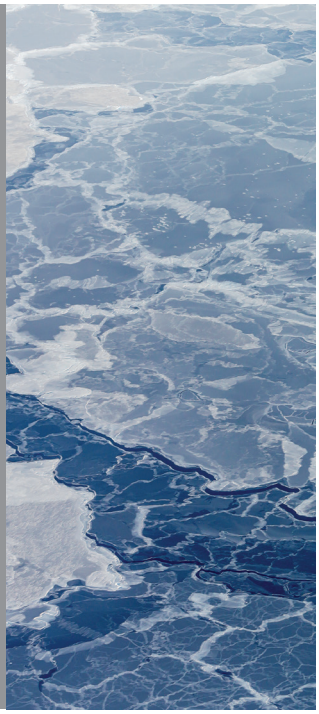
The «**fairing**» is the aerodynamic tip of a launcher, which is jettisoned in two parts at an altitude of about 110 km. «**Decommissioned**» describes a satellite that is taken out of service. The «**low-Earth orbit**» is the part of the Earth's orbit that lies below an altitude of 2000 km. The «**geostationary orbit**», about 36,000 km above the equator, is coveted (for telecommunications and meteorological satellites).

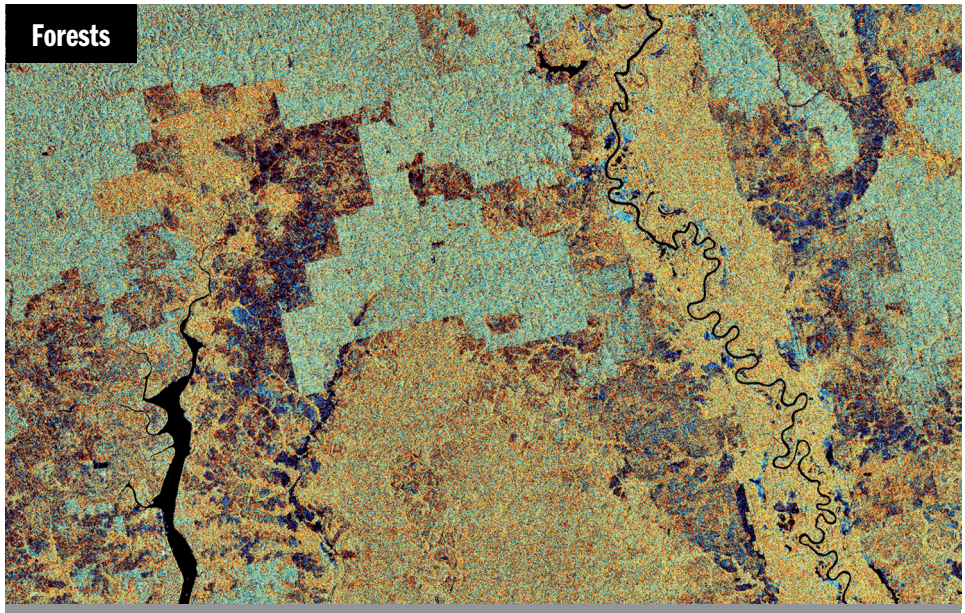
Space serving humankind



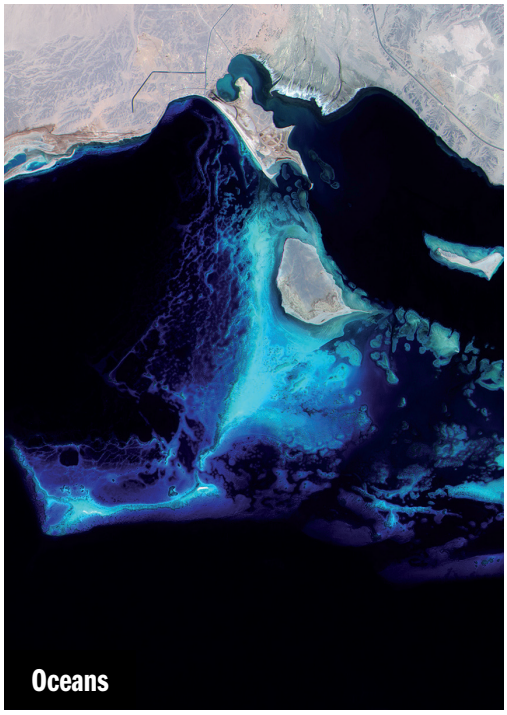
Locate the populations affected, choose the most efficient means of transport to bring aid to them - that is the objective of the International Charter on Space and Major Disasters, set up in 2000. The fifteen space agencies that have signed the Charter undertake to provide their space data free of charge to countries affected by major natural or man-made disasters.

Measure and limit greenhouse gas emissions, predict major changes in climate, adapt to those changes... Climate change is one of the greatest challenges facing humankind. Of the fifty climate variables recognised internationally, twenty-six can be observed only from space.





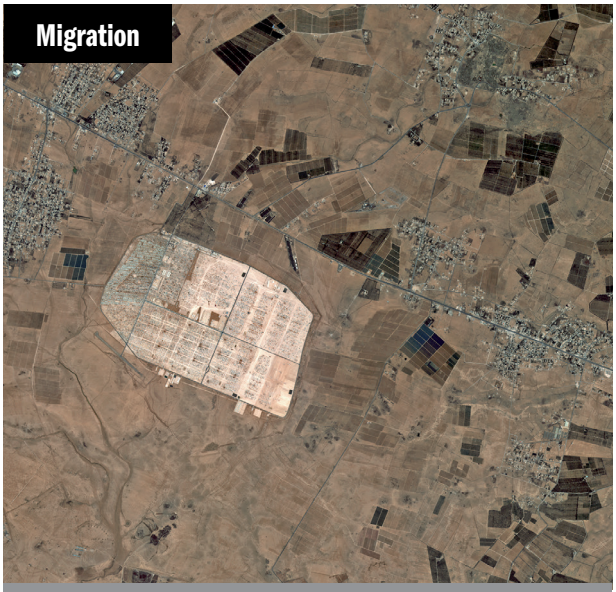
Deforestation, being difficult to detect at ground level, is monitored by satellite, particularly in the framework of the international REDD+ initiative. This aims to reduce greenhouse gas emissions linked to deforestation and to forest degradation. The efforts made by the countries concerned to prevent deforestation can be evaluated using satellites.



Telemedecine, improving telecommunications on the ground, helping with disease eradication... Resources making use of space are especially effective when it comes to healthcare, particularly in developing countries. The ability to identify isolated inhabited areas using satellite images also enables preventive vaccination programmes to be carried out or the risks of insect-borne epidemics to be anticipated.

Governments need to take difficult decisions concerning matters of major importance. They can be helped in this by the exploitation of space data. The applications and services arising out of space activities can serve to improve living conditions in many ways, especially in developing countries, thus contributing to meeting the United Nations' sustainable development objectives.

From space, the Sentinel satellites under Europe's Copernicus programme continuously scrutinise the planet's oceans, measuring temperature, salinity, currents, sea ice, water level, surface winds and even water chemistry and biology (plankton concentrations), as well as chlorophyll content. Some marine animals are also monitored by satellite, using for example Argos transmitters.



Europe's Earth observation programme, Copernicus, can supply data and images to the various organisations working in the area of migration. These can be used to evaluate how far refugee camps extend and how they are evolving or for example to help monitor borders and maritime trafficking.

What's the weather like up there?

The various layers of the Earth's atmosphere are subject to the influence of the Sun, solar winds and cosmic radiation. This is known as space weather, and it can seriously disrupt navigation services, telecommunications, TV broadcasting and meteorological services.

Glossary

A **near-Earth object** can be an asteroid or a comet in the solar system whose orbit around the Sun brings it close to the Earth. The AIDA mission aims to assess the impact of an asteroid and decide whether to deflect it.

Illustration of a Near-Earth Object (NEO).

Brief encounter with an asteroid

The risk of a collision between an asteroid and the Earth is taken very seriously by space specialists. Sitting about waiting for a hypothetical encounter is not on the cards.

"The dinosaurs became extinct because they didn't have a space program.» So joked Arthur C. Clarke, the science-fiction writer famous for his novel «2001: A Space Odyssey». Will our space programmes be able to save us, poor earthlings, from a chance and perhaps fatal encounter with a meteorite?

Finding out more

The NEOShield-2 programme: www.neoshield.net
NEO statistics: http://neo.ipl.nasa.gov/stats/

Space agencies have tackled the issue head-on. By early-2016, 14,412 near-Earth objects had been identified, almost all of which were asteroids, plus about a hundred comets. Of that total, 1,696 objects were described as «potentially hazardous» because their trajectory will bring them to within 7.5 million kilometres of Earth, and their diameter is thought to exceed 150 metres. One last figure: of the asteroids considered to be potentially hazardous, 157 are larger than 1 kilometre in diameter.

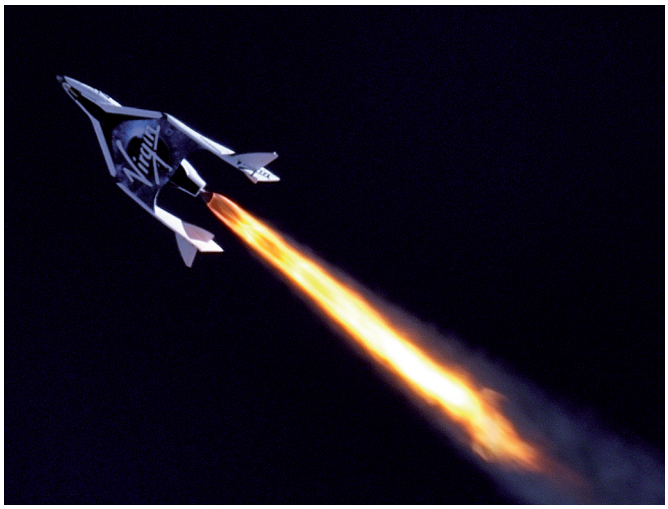
How about deflecting asteroids?

Firms and space agencies the world over are currently working on this aspect of protecting the Earth. Funded by the European Union, the NEOShield-2 consortium brings together eleven European firms and research institutes. It is developing technologies and doing research on near-Earth objects.
ESA is also working on three projects: firstly, on a system able to scan the sky every night to detect uncatalogued NEOs, and raise the alarm; secondly, on mitigation measures applicable to small objects; and lastly, on how to deflect the largest objects. Sending a spacecraft to deflect an asteroid is one of the scenarios being examined. To that end, a joint ESA-NASA mission, dubbed AIDA, is being studied.

ESA / P Carril

A $250,000 dollar ride

Historically, space exploration has been the preserve of national agencies. With the latter's blessing, commercial firms are opening up a whole new chapter. The objective: to send the likes of you and me into orbit, or just about.



Test flight of Virgin Galactic's SpaceShipTwo.

Dennis Tito (left) was the first space tourist. In 2001 he travelled to the International Space Station aboard a Soyuz, accompanied by Russian cosmonauts Talgat Musabayev (centre) and Yuri Baturin (right).

"Only 555 people have been to space. Virgin Galactic is opening space to the rest of us.» Quite a promise, but what is it worth? The company set up by the ebullient entrepreneur Richard Branson is offering 2 to 3 hours in space - at an altitude of at least 100 kilometres - on board a spacecraft designed for 6 passengers and two pilots, for the modest sum of $250,000... But Virgin Galactic is not alone. For instance, the spaceplane project by Airbus Defence and Space could be offering its first commercial space flights around 2024, at the earliest.

Dennis Tito, the pioneer

Tourist flights on a large scale are still some way off, given the considerable technical challenges that remain to be overcome. At the same time, the idea of space tourism is no longer far-fetched. In April 2001, Dennis Tito was the first «ordinary earthling» to go into space; he travelled on board a Soyuz and stayed on the International Space Station (ISS).
Space tourism projects, accompanied by a great deal of media coverage, highlight a new and much broader phenomenon, which is the opening up of space exploration to private-sector firms. Until recently, it was the preserve of States, via their national agencies and/or the European Space Agency. Now, however, especially in the USA, entrepreneurs are investing millions of dollars to develop technologies enabling the space dream to become reality or starting up projects on a small scale, such as the CubeSats or the balloons launched to the frontiers of space.

"Space 4.0"

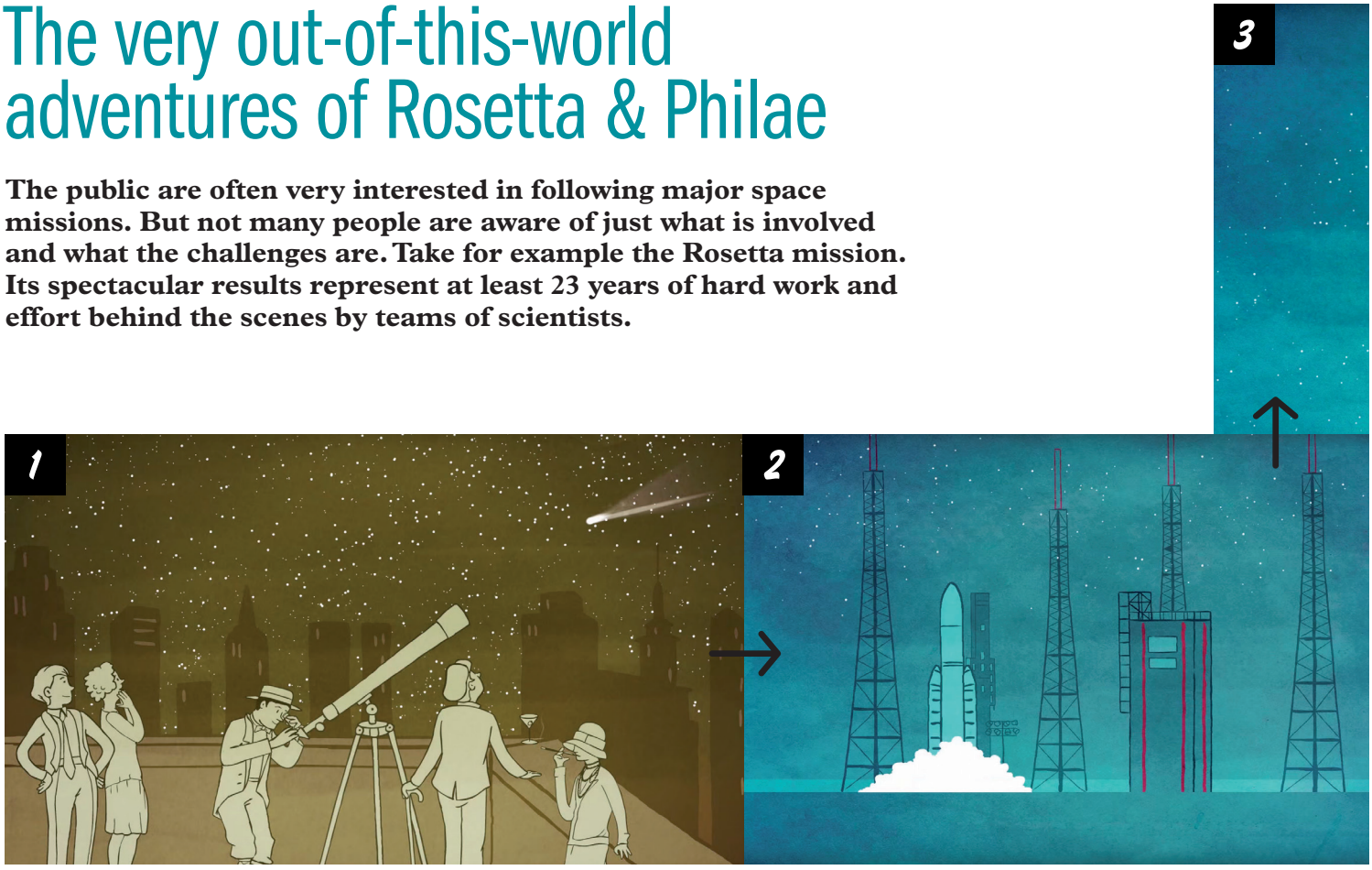
NASA had always developed its spacecraft in-house, but in 2010 took a change of direction, soliciting proposals for the development and supply of a spacecraft to transport astronauts to the ISS. NASA selected and is now supporting three proposals (Boeing, SpaceX and Sierra Nevada). In Europe, Jan Woerner, the ESA Director General, believes we have now entered the «space 4.0» era. What this means is that space is now an integral part of our everyday lives and can be seen as a source of inspiration. In that context, new challenges are becoming apparent. They relate to interactions with society, the commercialisation of space, industry's changing role and an increase in cooperation. A new chapter in history is about to be written.

Finding out more

Is a space tourist an astronaut? Should he or she take out full insurance cover? Is it possible to buy a plot of land on the Moon? Get the (entirely serious) replies from an expert by clicking on: http://bit.ly/28SE9UQ

The very out-of-this-world adventures of Rosetta & Philae

The public are often very interested in following major space missions. But not many people are aware of just what is involved and what the challenges are. Take for example the Rosetta mission. Its spectacular results represent at least 23 years of hard work and effort behind the scenes by teams of scientists.



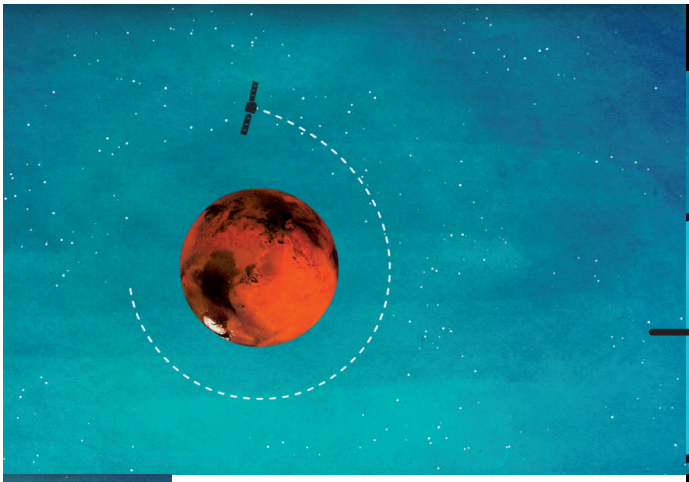
1 Rosetta took at least eleven years to prepare. The mission was 'selected' in 1993. Its initial objective was to reach comet 46P/Wirtanen, but after Rosetta's launch was postponed by one year, 67P/Churyumov-Gerasimenko was the comet chosen instead.

2 Early on 2 March 2004, Rosetta rose up atop an Ariane 5 from Europe's spaceport at Kourou in French Guiana. Rosetta weighed 2.9 tonnes, including 1.7 tonnes of fuel, and was equipped with solar arrays spanning 32 metres. On board Rosetta were the Philae lander and 11 measuring instruments.

7 Rosetta continued to observe the comet until September 2016, when it was scheduled to land on it. This last phase marked the end of Rosetta's life, after more than twelve years of faithful service.

8 The results of the observations of the core of comet 67P raise great hopes: resolving the mystery of the origins of our solar system and better understanding the mechanisms governing the formation of planetary systems around other stars. The composition of comets is the same as that of the solar system in its initial stages, more than 4,600 million years ago, when it was still in its infancy.

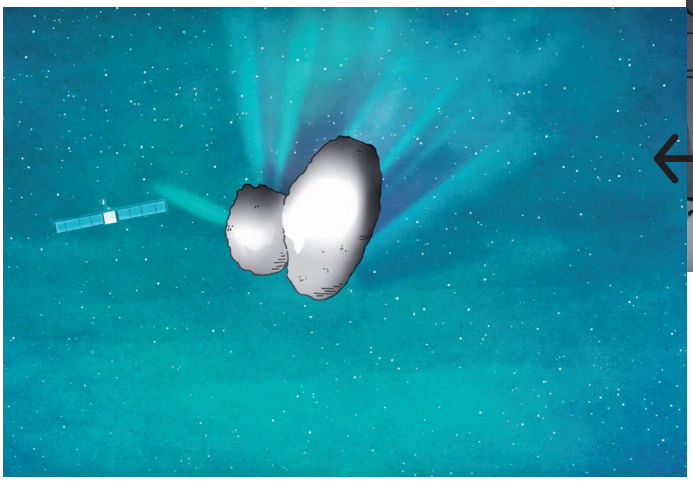
ESA / Design & Data

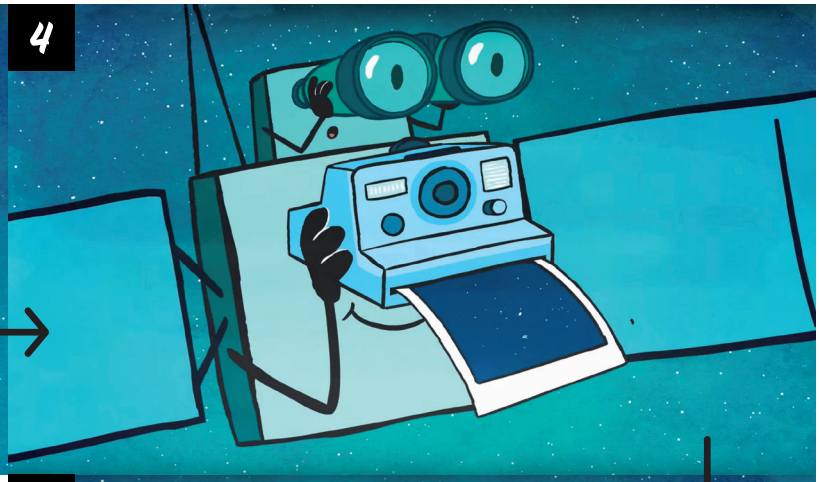


3 Before coming close to 67P, Rosetta carried out three flybys of Earth and one of Mars, and approached asteroids Steins and Lutetia. It flew close to the Sun five times, journeying 6.4 billion kilometres in all.

4 A total of 50 subcontractors and 2,000 people from 14 countries worked on the mission. The total cost of the operation was 1.4 billion euros, of which 200 million euros went on the Philae module alone. The mission was led by ESA, thanks to the contributions of its member states and of NASA.

5 Rosetta spent two months exhaustively mapping the surface of the comet, as well as making important gravity, mass and shape measurements. It also studied its dust-laden gaseous atmosphere, called the coma, and analysed the plasma environment and its interactions with the Sun's outer atmosphere, the solar wind.





6 The Philae lander is named after an island in the Nile on which the obelisk whose insciptions helped to decipher the Rosetta Stone was found. Rosetta arrived at 67P on 6 August 2014, and after an initial study and selection of a landing location, Philae was released, landing on the comet's surface on 12 November 2014.

Finding out more

Watch again and again the very out-of-this-world adventures of Rosetta & Philae: http://bit.ly/1tADJw8

Who does space belong to?

A number of entrepreneurs, some of whom are famous and many very rich, have become involved in space ventures over the last few years, having been motivated to do so for a variety of reasons. The SpaceX launcher (Elon Musk), Virgin Galactic's human spaceflight (Richard Branson) and Blue Origin's New Shepard (Jeff Bezos) are among the hundreds of projects referred to as 'New Space'. Moreover, Luxembourg wants to attract firms specialised in the exploitation of resources on asteroids.

The Overview effect

We travelled into space, and discovered... the Earth and became aware of its beauty, its fragility. This is the Overview effect.
"One text which refers to space travel before the 17th century is that of Lucien de Samosate (in about 120 AD), relates Jacques Arnould. His hero takes a vulture wing and goes to the Moon. And the first thing he does is look at the Earth. Gagarin's first words were "I see Earth! It is so beautiful!" It will be our reference for a long time to come."

"Space authorities must adopt an ethical stance"

Why do we go into space? What do we go there to do? Are there ethical limits to space exploration? We put these questions to a specialist, Jacques Arnould.

BEFORE GOING INTO SPACE, HUMANKIND WAS BOTH ATTRACTED TO SPACE AND AFRAID OF IT. WHY WAS THAT?

All cultures are both drawn to the sky and frightened of it. It appears in the first artistic representations, in mythology, in cosmogonies [theories or myths of the origins of the universe] ... According to the European tradition, until the 17th century, above us was an unreachable cosmos, which approached perfection and was quasi-divine. But then Kepler showed us that the cosmos and the Earth were one, and that one day we would be able to explore it.

SHOULDN'T WE STOP POLLUTING SPACE?

Our vision of the sky is of a perfect and sacred place. When we launch satellites, we do so not to sully space but because of a thirst for knowledge. Sending Hubble to take images of the Universe is an extraordinary journey. Satellites turned towards Earth help us to live together better. Sacred does not mean we should touch nothing, but rather that we should not do anything just any old how.

SHOULD WE COLONISE SPACE?

People have been asking that question since the start of the space age. Some are very much against. Others say that space exploration is the search for life. Really, the question is not whether we are entitled to colonise space, but whether we should allow ourselves to be entitled to do so.

WHAT ABOUT THE EXPLOITATION OF SPACE MINERALS?

The projects by the USA and Luxembourg are an opportunity to review space law, which historically has given States a lot of leeway. Nowadays private-sector firms are offering efficient and cheaper services, the thinking being that space is profitable, which is part of a liberal rationale. What are we going to do about the spirit of the space pioneers, who wanted space to be a common asset for humankind? The debate is only just beginning.

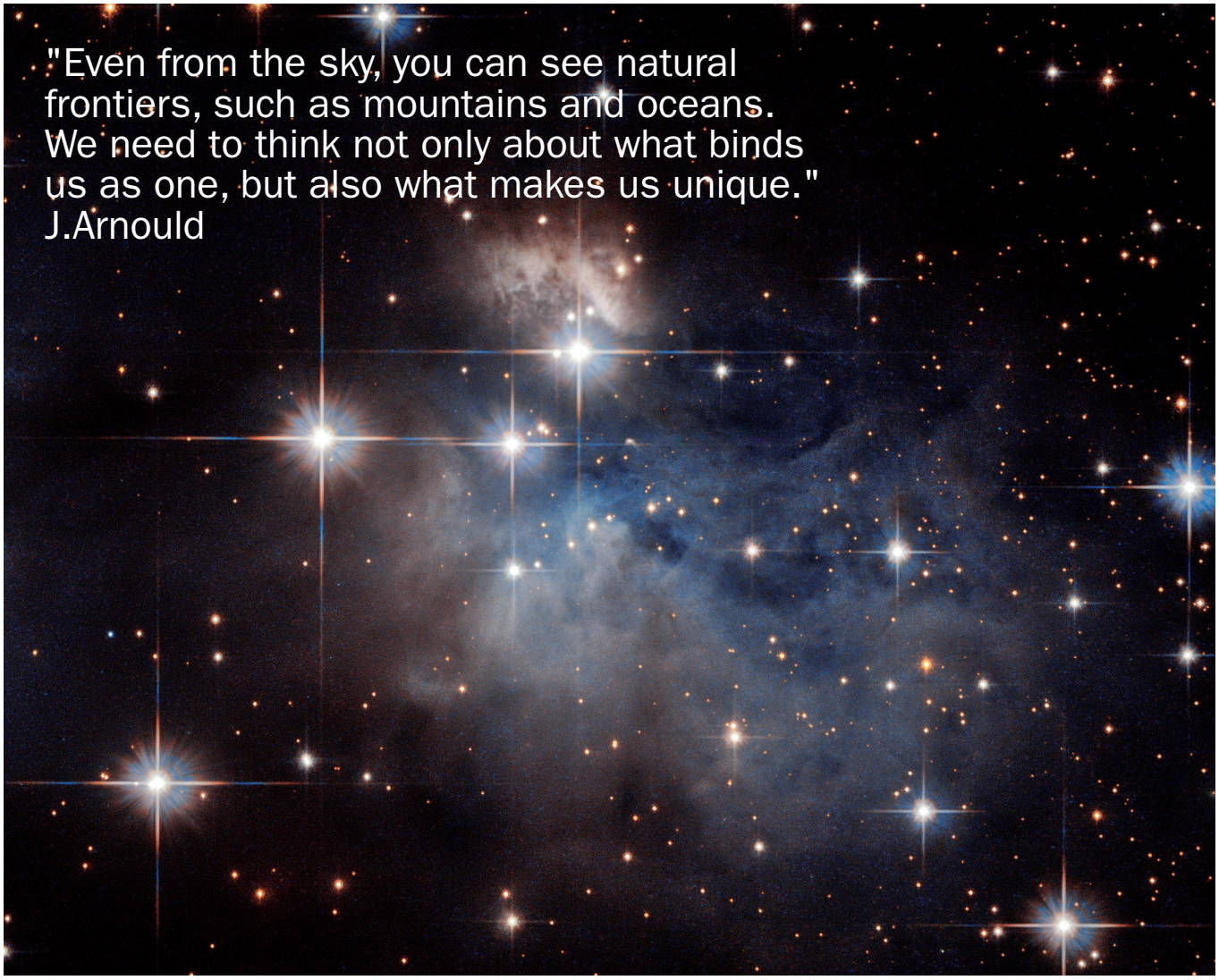
WOULD YOU SAY THAT SPACE LAW OFFERS A KIND OF CITIZENSHIP OF THE WORLD?

In a way, yes. We can see this concept of a common heritage of humankind applied to the ocean depths and to Antarctica. But even from the sky, you can see natural frontiers, such as mountains and oceans. We need to think not only about what binds us as one, but also what makes us unique.

SHOULD HUMAN BEINGS GO INTO SPACE?

I haven't found a good exploration philosophy. The question of whether we should explore space will always be present. Ethics makes it possible to shed light on the situation and enrich it, in order to facilitate decision-making. The answer will depend on the era and on the resources available. Currently, Europe thinks humans should go into space, in a cooperative framework, as doing so calls for very considerable resources.

Official SpaceX Photos - DR



ESA

CITIZENS BENEFIT FROM THE MANY DATA PROVIDED BY SATELLITES, BUT WHO CONTROLS THAT? IS THERE NOT A BIG BROTHER RISK?

Yes, there is. The technical expertise should be there as part of a more general discussion, involving all of society's actors. In my opinion, it is not so much privacy that is at stake. More important is the responsibility that that knowledge of the data confers on those holding them.

I MUST EMPHASISE THAT HISTORY HAS NEVER UNTIL NOW 'OFFERED' THE POSSIBILITY OF ASSOCIATING TOTALITARIAN REGIMES WITH SUCH INTRUSIVE, SOPHISTICATED TECHNOLOGIES...

The risk of a Big Brother very much bigger than Orwell's is indeed there. This is a fundamental issue. And it is not just States. Google at present knows a great deal about me. This is just the start. Ethics does not answer these questions, but does enable us to ask them and share them.

IS IT NOT VITAL TO INCORPORATE SUCH QUESTIONS IN TECHNICAL DECISION-MAKING PROCESSES?

If we don't know where we're going, we'll go astray. The first question we should ask ourselves is: why are we doing this and for what purpose? My conclusion is that the ethical input must be there explicitly in decision-making space bodies.

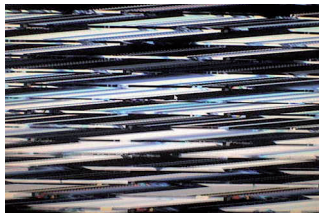
Jacques Arnould is an ethics expert at CNES, France's space agency, and author of the book "Demain l'espace".

Finding out more

You can read more about the issues mentioned in this article in the book "Demain l'espace" by Jacques Arnould (published by Cherche-Midi in French). For more info: https://spacegate.cnes.fr/fr/demain-l-espace
About the overview effect : www.blueturn.earth

My (hellish) day without satellites

A complete, massive breakdown of all satellites leads to unprecedented planetwide chaos. Description of an incredible day. (This is fictitious.)



4:53 AM **Brussels time** The ESA team on duty is perplexed: several screens have suddenly gone totally black. It would seem that images produced by numerous Earth observation satellites are no longer being transmitted. A crisis unit is set up.

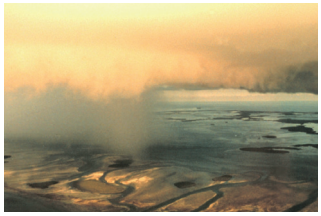
5:45 AM Contact is made with the team's counterparts at NASA, who have observed the same thing. All satellite transmissions seem to have 'blown'.

8:00 AM Radios relay the incredible news that all 857 satellites around the Earth have definitely broken down.

9:42 AM Major cities in Asia, Russia and then Europe experience huge traffic jams. Around the main European logistical centres, in Rotterdam (Netherlands), Hamburg (Germany), Barcelona (Spain) and Rungis (France), fleets of heavy-goods vehicles are immobilised. Without satellite signals, GPS systems are down, but car and lorry drivers have lost the knack of reading good old paper maps.

1:50 PM Weather forecast services in the USA are panic-stricken.

TV news bulletins announce that 857 satellites have broken down.

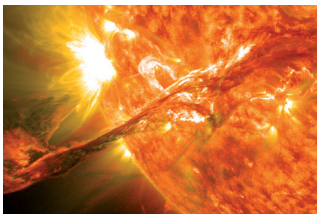


This is the middle of the hurricane season, but the forecast for a few days' hence is vague to say the least. The information conveyed by sounding-balloons and airlines in the absence of satellites doesn't give much to go on. The White House calls an emergency meeting to consider the preventive evacuation of several large cities in Florida.

3:50 PM The list of companies forced to lay off their workers - at least for a few days - gets longer and longer. Without GPS-connected tools, excavation work and construction sites for bridges, tunnels, buildings, etc. grind to a halt. It's going to be necessary to fall back on 20th century measuring instruments. Retired employees are asked to help out.

5:00 PM The Olympic Games are under way, but no live broadcasts are possible. The price of tickets shoots up. Going to the stadium has become the only way of following the Games.

6:45 PM Financial services are unable to synchronise and shut down, ATMs no longer work, oil pipelines cease transporting black gold, farmers can no longer guide their tractors accurately. It seems that a large part of the economic sphere is paralysed.



7:27 PM The world's space agencies issue a joint press release. The cause of the breakdown has been found. All satellites are affected. The cause of the incident was a colossal unanticipated solar eruption. It will be a week before the situation returns to normal.

Finding out more

Watch a fake TV news announcement about a satellite breakdown
http://bit.ly/28W3iNy

DR - CNES - PEO, ACWA - Citizen59 / Flickr - NASA Goddard Space Flight Center