→ GETTING READY FOR SPACE

Astronaut training
From the beginnings of the ‘space age’, Europe has been actively involved in spaceflight. Today it launches satellites for Earth observation, navigation, telecommunications and astronomy, sends probes to the far reaches of the Solar System, and cooperates in the human exploration of space.

Space is a key asset for Europe, providing essential information needed by decision-makers to respond to global challenges. Space provides indispensable technologies and services, and increases our understanding of our planet and the Universe. Since 1975, the European Space Agency (ESA) has been shaping the development of this space capability.

By pooling the resources of 22 Member States, ESA undertakes programmes and activities far beyond the scope of any single European country, developing the launchers, spacecraft and ground facilities needed to keep Europe at the forefront of global space activities.

The Member States are: 20 states of the EU (Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Romania, Spain, Sweden and the United Kingdom) plus Norway and Switzerland.

Seven other EU states have Cooperation Agreements with ESA: Bulgaria, Cyprus, Lithuania, Malta, Latvia, Slovenia and Slovakia. Croatia is negotiating a Cooperation Agreement. Canada takes part in some programmes under a Cooperation Agreement.
 ESA astronaut Paolo Nespoli during his first mission to the International Space Station
Humans have been venturing into space for decades now, exploring and testing their limits in a hazardous environment. However, not a single professional astronaut has left Earth without intensive training.

In the early days of human spaceflight, potential astronauts underwent extremely demanding and rigorous tests. Back then, the candidates had to be intelligent, comfortable with high-stress situations and, most importantly, physically fit.

While these requirements still apply, the programmes to prepare astronauts for space have evolved. Nowadays, a rigorous selection process and many long hours of training turn today’s potential astronauts into the spacefarers of tomorrow. Space agencies invest in the best people possible, and prepare them for working out of this world.

ESA requires a multitude of skills and capabilities from its astronauts. It takes years and many people to organise a space mission. Finding people with the ‘right stuff’ and training them for spaceflight is crucial.
What are astronauts made of?

There is no straightforward path to become an astronaut. There are no schools or university courses for it. What makes astronauts special is the ability to apply their knowledge and skills to specific tasks, to be ready to deal with failures, to react quickly and efficiently, and to be determined to succeed.

Candidates for ESA astronaut positions must have a complete package of qualifications and qualities. Further training will get them ready for their trips to space.

**EDUCATION**
High level of education in scientific or technical disciplines, coupled with an outstanding professional background. Operational skills, such as previous flying experience as a pilot, are a bonus.

**PHYSICAL CONDITION**
Good health and physical endurance are essential. Candidates are preferably aged between 27 to 37 years old by the time they apply for an astronaut position. They are mentally and physically healthy individuals, able to cope with physiological stress in a harsh and challenging environment.

**KEY SKILLS**
Good reasoning capability, the ability to work under stress, memory and concentration skills, aptitude for spatial orientation, psychomotor coordination and manual dexterity.

**COMMUNICATION**
ESA’s astronauts are ambassadors for the promotion of the benefits of spaceflight. Candidates should be good communicators, willing to share their experience with people on Earth, be active on social media, and take part in public relations activities, conferences and scientific lectures.

**PERSONALITY**
High motivation, flexibility, gregariousness, low level of aggression, and emotional stability.

**ADAPTATION**
It is a challenge to live and work in a confined space with other people for long periods. Astronauts-to-be must have the ability to adapt in stressful situations, work with cultural differences and maintain high working standards.
Applying for a star job

ESA has always been seeking new talent to reinforce its astronaut corps. Over 30,000 people from ESA Member States have applied to the three selection rounds organised over the years.

The latest call for astronauts was held in 2008. This was the first time the space agency undertook a European wide selection – the European Astronaut Centre managed a one-year selection process.

Over 8000 people answered the call. Using specific criteria and a computer-based tool, 20% of the candidates made it through the first cut.

From those, only around 900 were identified as the most promising applications for the next selection step: the psychological tests and interviews. This round assessed the cognitive and behavioural aptitudes of the candidates.

While a first phase focused on skills such as psychomotor coordination, reasoning and English language, a second one looked into behavioural competence. The future astronauts had to show intercultural, interpersonal and performance aptitudes.

Only a small group went through rigorous medical screenings. The investment made in astronauts is high, so the risks of developing diseases in the future should be as low as possible. This is especially true in space, where medical treatment capabilities are limited.

The selection concluded with professional interviews for the finalists. Six new space travellers got the job – they are the European astronaut class of 2009.

The space selection process

- Initial selection according to basic criteria
- Two rounds of psychological tests and interviews
- Medical tests
- Interview with senior managers
- Final interview with ESA’s Director General
Astronaut training is key to the success of any mission. For all potential crew members, there are three phases leading to a spaceflight to the International Space Station:

- Basic training
- Pre-assignment training
- Assigned crew training

Training is tailored partially to the trainees’ background. Each astronaut completes the different phases and reaches proficiency at a different pace, depending on their previous experience, skills and tasks assigned to a mission. On the road to space, they would even assume some other duties, such as supporting engineers or taking extra lessons on medical emergency procedures.

↑ The sun rises behind the Soyuz launch pad shortly before the rocket is rolled out by train to its final stop on Earth at the Baikonur Cosmodrome, Kazakhstan
BASIC TRAINING
Every ESA astronaut starts the training cycle by completing an 18-month course at the European Astronaut Centre (EAC) in Cologne, Germany. Apart from introducing the ‘big picture’ of spaceflight, it gives a very solid background of all the disciplines astronauts will have to deal with during their career.

This phase begins with an overview of the spacefaring nations and their space agencies. Astronauts acquire basic knowledge on various technical and scientific disciplines relevant to human space activities – orbital mechanics, electrical and computer engineering, life and physical sciences under ‘weightless’ conditions. An important chapter in this phase gives them details on the European systems of the International Space Station, as well as ground systems such as launch sites and control centres. Learning Russian also comes with the package.

Basic training concludes by focusing on special skills such as robotic operations, aircraft piloting, human and behaviour performance development, and initiation in ‘extravehicular activities’, more commonly known as spacewalks. On completion of the basic training, candidates officially become astronauts.

PRE-ASSIGNMENT TRAINING
The astronauts start to study the elements of the International Space Station in more depth. They immerse themselves in ‘hands-on’ training using realistic mock-ups and simulators.

They learn how to operate the different modules, systems and subsystems of the Station and to fly and dock transport vehicles such as the Russian Soyuz. Training on spacewalks, Russian language and performance skills continue in this phase. They also get to know every corner of ESA’s Columbus laboratory in more detail, and how to use its scientific facilities. Astronauts are confronted with real medical operations in a hospital, where they learn how to assist their crewmates in case of health issues. These skills are reinforced later on during their specific training for a mission.

The better astronauts perform at this stage, the better their chances are to get challenging tasks on board the Space Station, such as spacewalks or robotic operations, among a multinational crew.

After every mission, active astronauts go back to pre-assignment training.

18 MONTHS  VARIABLE DEPENDING ON ASSIGNMENT

* Training length subjected to flight opportunities
ASSIGNED CREW TRAINING
As soon as an astronaut is assigned to a mission, the assigned crew training starts. The real countdown, with all the preparations for the tasks and experiments to be carried out in space, begins here.

Over about two and half years, the astronauts travel between the training sites of all five ISS partner organisations, learning about their systems and modules. This is a crucial phase to gain the knowledge and skills required for their specific spaceflight.

During this final stage, the crews that will meet in orbit train together. They learn to work efficiently as a team and according to their roles and responsibilities.

The crew tasks are individually tailored, always considering the particular astronaut’s experience and professional background. All astronauts are trained to deal with emergency situations. This includes failure analysis and repair activities.

After a series of final exams, the astronauts receive the green light from the ISS multilateral community to live and work in the orbital outpost. However, training does not end with the arrival at the Space Station. Even during their missions, astronauts follow refresher sessions relying on manuals, video explanations and teleconferences with their instructors on the ground. Simulators on board help them train for robotics and spacecraft rendezvous and docking.
Across the globe
Lessons on payloads and simulators around the world are challenging enough to follow, but even harder to organise. This decentralised training demands intensive coordination between the different space agencies involved.

Each of the partners is in charge of training astronauts on the elements that they contribute to the International Space Station. For example, training at the European Astronaut Centre focuses on the Columbus systems and ESA scientific payloads.

Training figures
- More than 200 people take care of each astronaut’s training programme across the globe
- The average time spent for training and preparation time on each site: Russia 48%, USA 40%, Europe 6%, Japan 4% and Canada 2%
- An astronaut spends up to 150 hours under water, practising for spacewalks
- Around 100 hours are needed to fully qualify an astronaut to operate, monitor and maintain Europe’s Columbus module and its experiment facilities
- ESA astronauts spend additional 120 hours in mission preparation, including scientific data collection, debriefings and public appearances
- About 30 astronauts a year are trained at the European Astronaut Centre
Living in space requires versatility and multitasking. Astronauts must be operators, scientists, plumbers, fire fighters, cleaners and even doctors and ‘guinea pigs’.

Piloting a spaceship, manipulating a robot or spacewalking are some of the critical tasks an astronaut should master before leaving Earth. Astronauts must work as a team and learn how to best communicate with their crew mates.

There are many more duties they have to learn, for example, repairing the air conditioning system on the Space Station or taking blood samples.
Mastering the spacecraft

The Soyuz has been used for human spaceflight missions longer than any other spacecraft – since 1967 – and it is presently the only means for a crew of up to three to reach and leave the International Space Station. New spacecraft are being developed to transport people to the Station and beyond.

Training on the Soyuz spacecraft is extremely challenging. While most of its systems work in automatic mode, astronauts need to be able to operate it manually in all possible scenarios. They spend hundreds of hours studying every system of the spacecraft at the Gagarin Cosmonaut Training Centre near Moscow.

The crew re-enact over and over the three key stages of a Soyuz flight: launch and insertion into orbit, rendezvous and docking, and undocking and return to Earth. Simulators help them practise flight manoeuvres and learning the best response to off-nominal situations, from a communications glitch to a full-blown emergency.

Russian is the official language on the Soyuz. It is also spoken aboard the International Space Station, where the official language is English, so astronauts need to be fairly fluent, and get a good understanding of technical space terms.

↑ View of a Soyuz spacecraft as it approaches for docking with the International Space Station
Living out of this world
The International Space Station is one of the greatest engineering works ever created by mankind. This ‘weightless’ laboratory offers the possibility to perform experiments efficiently in microgravity, like no other low-gravity platform.

There are more than 100 experiments running on board at any time. Astronauts study the Station’s scientific facilities and learn how to operate each payload assigned to their mission.

The orbiting complex has been permanently inhabited since 2000. It has more liveable space than a conventional six-bedroom house, and is equipped with two toilets, sleeping quarters and fitness facilities.

However, like a house, it needs constant maintenance. Astronauts are trained to solve technical problems, and become proficient in the use and repair of all equipment. The troubleshooting challenge is constant. They train in full-size mockups to find their way around the International Space Station’s two sections (the Russian and the US orbital segments), getting to know them inside-out.
Working in Columbus

The Columbus laboratory is Europe's largest contribution to the International Space Station. Since 2008, the facilities of this multifunctional module have been producing scientific data across a range of disciplines.

To learn how to monitor all the systems and keep the laboratory running, astronauts from around the world receive hands-on training in a Columbus mockup at the European Astronaut Centre.

A simulator and standalone training models of the four experiment racks (Biolab, Fluid Science Laboratory, European Physiology Modules and European Drawer Rack) help astronauts prepare to carry out science in unique conditions.
Spacewalkers
Spacewalks are among the most demanding tasks of an astronaut’s career. Working outside the International Space Station is the ultimate challenge.

Astronauts prepare for spacewalks in huge water tanks, operating equipment and tools in ‘neutral buoyancy’, meaning they neither float nor sink. Although it is not exactly the same as being weightless in space, it is the closest you can get on Earth.

There are lots of things to take into consideration to carry out a successful spacewalk. It is not only about the tasks you have to perform, but also about the way you handle yourself in space. This requires strong psychomotor, cognitive and behavioural skills.

To start with, it is vital for the spacewalker to be aware at all times of where a crew mate and the equipment are. Together with a high level of situational awareness, astronauts must have a good understanding of the spacewalk as a whole. Working outside the Station, they get the big picture relying on frequent communications with ground control. Spacewalkers must show decision-making, problem-solving and communication skills.

↑ ESA astronaut Luca Parmitano during his first spacewalk
Coordination with the crewmates and mission control is vital while working at peak performance for hours on end. The average duration of an extra vehicular activity is about six hours. Being tired or overworked can easily lead to fatal mistakes in the high-risk environment of space.

The bulky spacesuit does not make things easier. With limited visibility and mobility inside it, astronauts learn to work ‘slowly fast’ for the sake of safety and efficiency. Working with life-size mockups of the Station under water, they practise moving between modules and exchanging equipment. The crew must be able to manoeuvre in the suit and guide themselves around the Station using handrails and tethers.

**European fast track**

ESA has developed a unique EVA training to help European astronauts bridging the gap between their scuba diving certification and NASA's spacesuit qualification. The programme immerses them into the Neutral Buoyancy Facility, in Cologne, equipped with replicas of the spacesuit and tools.

These underwater lessons boost their skills before getting into real spacesuits at the American and Russian facilities. Known as ‘EVA Pre-familiarisation, Proficiency Rebuilt and Recurrent Training’, this programme gives them a head start on the core training on EVA and ISS operations.
Learning how to handle a robot in space

Robotic arms on the Station are used to grab and berth cargo vessels. These automated machines help relocate modules and external payloads, and are instrumental to reshape the International Space Station. The space robots also assist astronauts during spacewalks.

Imagine using two joysticks to work a long mechanical arm that can only be seen via cameras and occasionally through a window – and all in weightlessness. Learning how to pilot the robotic arm requires ‘mental gymnastics’ to understand the motions of the arm.

An astronaut needs to be capable of foreseeing the end result of their commands, regardless of the arm’s configuration. The operator on board uses three different cameras at the same time to understand the spatial environment.

This task requires specially trained teachers and courses to perfect the skills needed. It takes weeks of intense hands-on practise to qualify as an operator of the International Space Station’s robotic arms.

ESA’s astronauts receive thorough grounding in general robotics during their basic training at the European Astronaut Centre. They learn how to smoothly guide the arm while clearly reporting about its choreography to the ground controllers.

↑ The SpaceX Dragon commercial cargo craft in the grasp of the Space Station Remote Manipulator System
Behave like an astronaut

Space can be a very stressful place to live and work. Astronauts face many challenges: isolation, confinement, extreme environment, enforced interpersonal contact and limited external communication to name but a few. And one thing is certain for all space missions: things can always change.

What are the behaviours of an ‘ideal’ astronaut? Crews must have a great ability to adapt to various situations, understand cultural differences and keep high working standards. Learning to work as a team in isolation, with no outside help and only limited rescue capabilities, is part of becoming an effective astronaut.

ESA has developed a Human Behaviour and Performance course that prepares astronauts to deal with cultural differences, communication and teamwork for long-term stays on the Space Station and beyond. Using space exploration analogues, international crews experience challenges similar to those encountered during long-duration spaceflight.
**Exploration analogue training**

**CAVES**
ESA’s CAVES training takes an international crew of astronauts a few hundred metres underground to work under real exploration conditions. For six days, the ‘cavenauts’ live, explore, conduct ‘cavewalks’ and cooperate in a pitch-black cave in Sardinia, Italy, isolated from the outside world. They get a taste of the potential dangers – a very valuable experience for their team skills and operational behaviour. In addition to exploring, mapping and surveying the underground caverns, astronauts perform technology tests and conduct a scientific programme that includes geology, meteorology and the search for life, as they would on a mission to another planet.

**NEEMO**
Much like space, the undersea world is a hostile, alien place for humans to live. The NASA Extreme Environment Mission Operations, or NEEMO, sends astronauts to live for a few days in Aquarius, the world’s only undersea research station. Sitting 20 m below the sea surface in the Florida Keys, the base and its surroundings provide a convincing analogue for space exploration: confined living space, total reliance on life support systems and no option for a quick return. The crewmembers experience some of the challenges of a mission to a distant asteroid, planet or moon. During NEEMO missions, the ‘aquanauts’ are able to simulate living on a spacecraft and test spacewalking techniques for future space missions.
Space doctors

Hundreds of kilometres away from the nearest hospital, astronauts need to be able to handle medical emergencies in space. There is no doctor on board, but two crewmembers act as paramedics. They are trained to provide basic medical support on long-duration missions, from stitching wounds to filling teeth.

Where no ambulance can reach, the crew relies on a medical checklist on board, which helps them to diagnose sick or injured crewmates, and several kits containing common drugs and emergencies. A medical team on Earth also supports astronauts if health problems occur.

European astronauts practise through highly realistic simulations and some real-life emergency cases to get an impression of what they might encounter in space. Medical procedures can differ in weightlessness – floating needles are a hazard, for example. ESA training builds their confidence and experience in dealing with medical problems.

↑ ESA astronaut Andreas Mogensen during a practical lesson in medical procedures and techniques
Survival training
Astronauts go through survival courses in extreme environments, preparing themselves to face all kinds of situations in prolonged isolation and under psychological stress. There is always the possibility of an emergency landing in a faraway place. Crews have to learn to survive in harsh climates while waiting for rescue, only relying on very basic items and the emergency pack in their Soyuz capsule.

Emergency training
In space, training for the unexpected becomes even more crucial. It is no wonder a large part of the training is geared towards emergency procedures and safety measures. Astronauts train countless times to handle potentially life-threatening situations in orbit. They have to be mentally prepared to deal with spacecraft depressurisation, fire or a toxic atmosphere.
Only excellent trainers make the best astronauts. An international network of instructors has the out-of-this-world challenge of preparing men and women for work on the International Space Station. Space agencies want to be sure that the astronauts will make the best possible use of the precious time they will spend in space.

Instructors face a complex process with high rewards – making them capable to efficiently work in space gives them great satisfaction. While teaching must meet the highest quality standards, they also have to maintain the tension and interest of their ambitious space apprentices. And all of that without having been into space themselves.

Training is coordinated between the major international partners of the ISS, each being responsible for instructing astronauts in the operation of their modules, tools and vehicles. A core team of 30 European instructors is certified according to multilaterally agreed standards. They accumulate expertise to turn astronauts into the best possible operators in weightlessness.

There is a regular flow of astronauts coming to train at the European Astronaut Centre (EAC). In addition, flight controllers and instructors from partner organisations are trained to be up-to-date with the protocols and learn from each other. Some 70 people from all over the world receive tuition to tend the ESA elements of the Space Station in the centre each year. ESA staff is also trained at partner facilities in several countries.

Astronaut training database
European instructors rely on a complex database to schedule training activities. It is also useful to store training records. With an engineering approach, this unique IT tool helps them to keep track of various aspects of astronaut training. From reports to the astronauts’ calendar, it contains all the training material developed by ESA since 1994.

A career for life
ESA has an Astronaut Department in charge of managing space travellers’ activities. This includes career management, as well as maintenance of proficiency and physical fitness. Even when not assigned to a mission, astronauts can take up their duty supporting the mission from ground, for example, taking charge of the communications with the crews in orbit. They can also provide support to the development of ESA technology programmes, in so-called ‘collateral’ duties.
ESA astronaut Thomas Pesquet (top) receives guidance from his astronaut colleague Frank De Winne
Ground support
The person in charge of communicating with the crew for any Columbus-related issue is called the ‘Eurocom’. Eurocoms answer any call from space and relay feedback from the ground control team.

Engineers and technicians are trained to monitor, control and command the Columbus lab oratory from the ground and support the astronauts in space. Teams frequently run a series of simulations that rehearse all aspects of the space mission. At EAC, a control room is specifically dedicated to run such simulations. Flight controllers learn to support both routine situations and emergency scenarios.

Medical care
A long stay in space has many physical consequences, including the loss of muscle and bone mass and strength, as well as reduced cardiovascular capacity. ESA’s Crew Medical Support Office helps each astronaut to minimise the adverse effects of spaceflight back on Earth.

Fitness and medical experts develop physical fitness programmes for pre-flight preparation, in-flight countermeasures and post-flight rehabilitation. ESA tailors these programmes to each individual, taking into account personal preferences as well as exercises validated by sports sciences. Preparation and rehabilitation activities include physiotherapy and advanced technology equipment.
HOME TO EUROPE’S ASTRONAUTS

↑ The European Astronaut Centre in Cologne, Germany
European Astronaut Centre
The European Astronaut Centre is the headquarters for all ESA’s space travellers. It is the centre for astronaut selection, training and medical support.

Europe’s ambitious manned space programme set the need for preparing astronauts to succeed in orbit already in the late 1970s, when the first Europeans were chosen to train for the Spacelab-1 mission.

Since its foundation in 1990 in Cologne, Germany, EAC rapidly became the home base for European astronauts. Here, they receive constant assistance before, during and after their flights. A single European Astronaut Corps integrates them as one strong team.

Decades of intensive support to human spaceflight have created unique technical, operational and scientific expertise found nowhere else in Europe. Today, the centre has over 100 staff drawn from ten different countries, including ten active astronauts.

Training hub
What happens at the astronaut headquarters? There is a lot to do before, during and after a European astronaut goes to space.

• Training
• Planning
• Supporting ongoing missions
• Keeping proficiency up
• Maintaining health and fitness
• Promoting human spaceflight and exploration
Full size mock-up of the Columbus science lab at the European Astronaut Centre. Simulators and other hands-on equipment enable astronauts to learn about the European parts of the International Space Station.
Training environment
EAC has a variety of training tools and facilities available to support crew training. Astronauts can practice normal operations, recover from malfunctions and train to replace failed onboard equipment.

Training facilities include physical fitness rooms, classrooms, communication and data-handling facilities and computer-based training systems.

Columbus simulator
Hands-on training for commanding and monitoring all systems of ESA’s Columbus laboratory takes place in this training module.

Payloads
Standalone training models for each scientific rack of the Columbus laboratory (BioLab, Fluid Science Lab, European Physiology Modules and European Drawer Rack) allow parallel training. For smaller experiments, dedicated models are used to support the familiarisation.

Neutral Buoyancy Facility
Spacewalks are practised in a huge water tank. The demanding diving exercises in the 10-m deep pool include the use of tools and equipment, work around mockups and follow communication protocols.

- A team of 30 instructors develops European training courses for missions to the International Space Station. This is not restricted to European astronauts.
- A six-person crew needs over 580 hours of training to efficiently operate, monitor and maintain the European modules, visiting vehicles and experiment facilities on the Space Station
A stunning view of the planet at night from an altitude of 400 km. The lights of Moscow, Russia are visible with one of the Space Station's solar panel arrays on the left. Aurora and the glare of sunlight lie along the Earth's horizon.
Seen from space, planet Earth has no borders. In creating the International Space Station, humankind has learned to work together in a unique model for multicultural and international cooperation.

Training programmes developed for astronauts from different nationalities are a prime example of what can be achieved by working together. ESA has been pooling resources in close cooperation with the US, Russian, Japanese and Canadian space agencies to build a complete training plan certified and recognised by all partners.

To date, over 100 astronauts from USA, Russia, Canada and Japan have undergone training at EAC alongside ESA’s space travellers. European teams have benefited from an all-round exchange of experience, accumulating human, operational and scientific expertise in manned spaceflight activities.

Shoulder to shoulder, European astronauts get ready for missions to go farther into space than ever before.