



EUROPEAN CULTURE COURSE

# The European Space Agency

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10 Chapters

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# Contents

|            |                                  |    |
|------------|----------------------------------|----|
| Chapter 1  | Why ESA? .....                   | 2  |
| Chapter 2  | Two Organisations .....          | 7  |
| Chapter 3  | How ESA Works .....              | 12 |
| Chapter 4  | Getting to Space .....           | 18 |
| Chapter 5  | Exploring the Solar System ..... | 23 |
| Chapter 6  | Telescopes and Earth .....       | 28 |
| Chapter 7  | People in Space .....            | 32 |
| Chapter 8  | Satellites at Work .....         | 37 |
| Chapter 9  | Partners and Rivals .....        | 42 |
| Chapter 10 | Why It Matters .....             | 47 |

# The European Space Agency

Course 1 · Chapter 1 · Why ESA? Scope & Sources

*Most people can name the American space agency and many can name the Russian one. Far fewer could say what the European Space Agency is, yet it has sent probes to comets, Mars and Saturn's largest moon, launches satellites from South America on its own rockets, and operates the satellites that tell your phone where it is and your weather forecast what is coming. This opening chapter explains why a space agency belongs in a course on European history and culture, sets out what the course covers, and shows how to read the sources. Space is a subject full of confident announcements, so the chapter marks what is firm and what is publicity.*

## Why a Space Agency?

Space is expensive, and no single European country after the Second World War could afford to compete with the United States and the Soviet Union on its own. The European answer was to pool money and expertise, and the agency that resulted is one of the clearest examples of European countries cooperating on something hard. It is also a record of their disagreements: who pays, who gets the contracts, who leads, and how closely to work with Washington or Moscow. That makes it a useful case study of Europe in practice, and not only a story about rockets.

### The question for the whole course

Is the European Space Agency a scientific organisation, an industrial programme or a political project? The honest answer is all three. The chapters take them in turn: the origins, the way the agency is run and paid for, the launchers, the science, the people, the satellites we use every day, and the partners and rivals.

## A One-Paragraph Version

The European Space Agency (ESA) is an intergovernmental organisation, headquartered in Paris, that was formed in the mid-1970s from two earlier European bodies, one for science and one for launchers (Chapter 2). Its member countries, around two dozen at the time of writing, contribute money according to their programmes and economies, and much of the work is carried out by

industry in those countries (Chapter 3). ESA is not an agency of the European Union, although the two work closely together. These are the basic facts, and each is developed in later chapters, with the dates checked as they appear.

## What the Course Covers

| Chapters | Theme                                                              |
|----------|--------------------------------------------------------------------|
| 2–3      | The origins, and how ESA is organised and paid for                 |
| 4        | Getting to space: the launchers and the spaceport in French Guiana |
| 5–6      | Exploring the Solar System, and telescopes and Earth observation   |
| 7–8      | People in space, and satellites in everyday life                   |
| 9–10     | Partners, rivals and politics, and what ESA says about Europe      |

### What the course leaves out

This is a history and explanation for general readers, not an engineering course. It does not describe how a rocket engine works, list every mission or rank the agency against others. Where recent missions and launches are mentioned, the course states a cut-off date, because the programme changes every year.

## Record, Publicity and Memory

Space programmes generate a great deal of confident language. Three kinds of claim need different handling.

### Record

Dates, launches, mission outcomes and treaty terms that appear in the agency's own documents and in reliable reference works. Most of this can be checked.

### Publicity

Headlines such as "historic first" or "mission accomplished". Agencies, governments and companies all want good stories, and a success can be described more warmly than the facts justify. A mission can also be a

success for the science and a disappointment for the schedule.

### Memory

What people recall of a launch, a landing or a failure. Good for atmosphere, unreliable for the exact year, the name of the probe or whether it was European or American.

### A note on accuracy

Dates, names and mission details in this course are given from general knowledge and checked as each chapter is written. Where a point is uncertain the text says so. Recent launches and the status of current missions change quickly, so check anything recent against ESA's own site before quoting it. The habit of separating record, folklore and memory is the same one used in the course The Eurovision Song Contest 1.

## Space in Everyday Life

Part of the case for studying ESA is that its work reaches ordinary life without being noticed. Weather forecasts depend on satellites. Satellite navigation guides drivers, ships and aircraft, and also provides timing signals that banks, mobile networks and the power grid rely on. Pictures of Earth from orbit are used to monitor farming, forests, floods and the climate. Few of these services are labelled as European, and fewer still are labelled as ESA, which is partly why the agency has a lower public profile than its American counterpart. Chapter 8 returns to this.

## Where to Read and Watch

- **ESA's own site.** It holds mission pages, news, images and recorded launches. It is the first place to check a date, a mission name or a status, and it is also an official source with a natural interest in good news, so read it with the publicity point in mind.
- **National agencies.** Agencies such as those of France, Germany, Italy and the United Kingdom publish their own accounts of joint projects.

- **Books and documentaries.** Look for histories of European space cooperation and of individual missions, which set the facts in context.
- **Launch and landing recordings.** Archive footage of major events shows how the agency presented itself in different decades.
- **Enthusiast sites.** Communities keep detailed lists and discuss missions closely. They are valuable but are secondary sources, so confirm important figures elsewhere.

## Exercises

### EXERCISE 1

In three sentences, explain why a space agency can count as European history. Use at least two points from this chapter.

→ Solution

### EXERCISE 2

Sort these into record, publicity or memory: (a) ESA is headquartered in Paris; (b) a press release calls a mission "a triumph for Europe"; (c) your recollection of watching a launch on television years ago.

→ Solution

### EXERCISE 3

Choose a fact about European space activity that you believe is true, write it down, then find a source for it. Note whether the source agreed or corrected you.

→ Solution

## Quick Reference

- **ESA:** an intergovernmental European space organisation, headquartered in Paris

- **Formed:** mid-1970s, from two earlier bodies (one for science, one for launchers)
- **Not the EU:** a separate organisation that works closely with it
- **Funded by:** its member countries, with much of the work done by industry in those countries
- **Handling sources:** separate record, publicity and memory
- **Best first check:** ESA's own site, read with publicity in mind

**Next chapter:** Origins: Two Organisations and a Convention, which looks at how European space cooperation began.

# The European Space Agency

Course 1 · Chapter 2 · Origins: Two Organisations and a Convention

*The European Space Agency did not start as one organisation. It grew out of two separate bodies created in the early 1960s, one that did well and one that failed, and it was shaped by a hard bargain among governments in 1973. This chapter follows that story: the postwar background, the science organisation, the launcher organisation, the reasons for its collapse and the compromise that produced ESA. The outline is widely agreed, but dates and membership lists vary between sources, so the chapter flags what should be checked.*

## The Background

In 1957 the Soviet Union launched the first artificial satellite, and by the end of the 1960s the United States had landed people on the Moon. Western Europe had strong scientists and an industrial base, but its countries were small compared with the two superpowers, and each spending its own money on space would have meant doing little. There was also a model to follow: CERN, the European nuclear research organisation founded in the 1950s, had shown that European governments could share the cost of an expensive scientific facility. Scientists argued that space science should be organised in the same way.

### The CERN example

The pattern of a shared laboratory funded by several countries came from CERN. It mattered because it proved to governments that pooling could work, and because it gave the space scientists a precedent to point to.

## Two Bodies, Two Jobs

In the early 1960s two European organisations were set up, with different jobs and different members.

|           | ESRO                                                                    | ELDO                                                                                              |
|-----------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Full name | European Space Research Organisation                                    | European Launcher Development Organisation                                                        |
| Job       | Space science: satellites and instruments                               | Building a European rocket                                                                        |
| Set up    | Early 1960s (generally 1964 when the convention took effect)            | Early 1960s (generally 1964)                                                                      |
| Members   | About ten European countries, including the UK, France and West Germany | A smaller group, including the UK, France and West Germany, with Australia providing a test range |
| Fate      | Merged into ESA                                                         | Wound up and merged into ESA                                                                      |

### Check the details

The founding years and the member lists are from general knowledge. The two conventions were agreed in the early 1960s and came into force a little later, so sources differ on which year to give. Confirm the dates and the lists of members in ESA's own history pages before quoting them.

## ESRO: A Quiet Success

ESRO built and launched scientific satellites and set up the technical centres that ESA still uses, including the research and technology centre at Noordwijk in the Netherlands and the operations centre at Darmstadt in Germany. It had no rocket of its own, so its satellites were launched by other countries' rockets, mainly American ones. It ran into disputes about money and about how much should be spent, but it produced working science missions and built a body of European expertise. In that sense it was the more successful of the two bodies.

## ELDO: A Rocket That Would Not Fly

ELDO was meant to give Europe its own launcher, a rocket named Europa. It was assembled in stages from parts supplied by different countries. The first stage came from Britain, a missile

design that had lost its military purpose, the second from France and the third from West Germany, with other countries supplying further parts. The idea of reusing a cancelled missile as a launcher was practical, but joining stages built in different countries was hard, and the launch tests failed repeatedly in the late 1960s and early 1970s. Each country managed its own part, and no one had the authority to hold the whole project together.

### Why it failed

The usual explanations are divided management, no single authority responsible for the whole rocket, rising costs, and countries that disagreed about whether the project was worth the money. The British decision to cut back its support is often cited, but it was one factor among several. The lesson drawn by European governments was that a launcher needed one lead country and one manager.

The British story has a side note. Britain developed and flew its own small satellite launcher, Black Arrow, and launched a satellite named Prospero into orbit in 1971 from the Woomera range in Australia. It remains the only British satellite launched by a British rocket (check the details). The programme was then cancelled, which shows how uncertain national support for space was at the time.

## The Bargain of 1973

By the early 1970s Europe had a working science organisation, a failed launcher project and a worry that it would depend on the United States for access to space. In 1973 European ministers met and reached a package agreement, often described as a compromise among the three largest space powers in Europe.

- **France** would lead the development of a new launcher, which became Ariane (Chapter 4), and would pay a large share of the cost.
- **West Germany** would lead the development of a space laboratory to fly in the American Space Shuttle, which became Spacelab (Chapter 7).
- **The United Kingdom** would lead a telecommunications satellite programme (this part was later changed, and the details should be checked).

The deal worked because each major country got something it wanted, and the key change from ELDO was that one country, France, took the lead on the launcher.

# ESA Is Born

The two earlier bodies were merged into a single agency. The ESA Convention was opened for signature in 1975, and the agency is generally dated from then, though the convention itself took until 1980 to enter into force (check both dates). ESA began with a group of ten or eleven founding states, including the UK, France, West Germany and Italy, and set its headquarters in Paris. Having science, launchers and applications under one roof, with a single management structure, was the answer to the problem that had sunk ELDO.

## Dates and founders

The founding year (1975), the date of entry into force (1980) and the number and names of the founding states differ slightly between sources, depending on whether Ireland and others are counted. Use ESA's own account and state which date you mean.

## Exercises

### EXERCISE 1

Name the two organisations that came before ESA, say what each was for, and say which one succeeded and which one failed.

→ [Solution](#)

### EXERCISE 2

Give two reasons why the Europa rocket failed, and say what lesson European governments drew from it.

→ [Solution](#)

### EXERCISE 3

Explain the 1973 compromise in your own words: who got what, and why it solved a problem that the earlier launcher project had not.

## Quick Reference

- **Model:** CERN, the shared European laboratory of the 1950s
- **ESRO:** space science; broadly successful; no launcher of its own
- **ELDO:** the Europa launcher; repeated failures; divided management
- **Black Arrow:** Britain's own launcher; Prospero satellite, 1971
- **1973:** package deal: France for the launcher, Germany for Spacelab, UK for telecoms
- **ESA:** convention opened 1975, in force 1980; headquarters in Paris
- **Check:** founding dates, member lists and the details of the 1973 deal

**Next chapter:** How ESA Works, which looks at members, money and the "fair return" rule.

# The European Space Agency

Course 1 · Chapter 3 · How ESA Works

*ESA is unusual because it belongs to governments but does most of its building through industry, is spread across several countries, and has to keep many members content at once. This chapter explains how it is organised: who the members are, how decisions are made, how it is paid for, the "fair return" rule that links money to contracts, where its main sites are, and how it differs from the European Union. As in the rest of the course, figures such as budgets and member counts change, so they are given in broad terms and flagged for checking.*

## Members and Status

ESA is an intergovernmental organisation. Its member states sign the convention, pay into the budget and sit on its governing council. At the time of writing there are around two dozen members, including the large industrial countries (France, Germany, Italy, the United Kingdom, Spain) and many smaller ones such as Austria, Belgium, the Netherlands, Sweden, Switzerland, Norway, Ireland, Poland, Hungary and Romania. Check the current list in ESA's own pages, because membership has grown over the years.

- **Full members.** They pay into the programmes and vote in the council.
- **Associate members and cooperating states.** A looser tie for countries that take part in some activities without full membership. Canada has long had a special cooperation agreement of this kind.

### Not all European countries, and not only EU countries

ESA membership is not the same as EU membership. The United Kingdom, Norway and Switzerland are members but are not in the EU, and some EU countries are not full ESA members. The section on the European Union below returns to this.

## How Decisions Are Made

The governing body is the ESA Council, in which each member state has a vote regardless of its size. The council sets the programmes and approves the budget. Every few years ministers responsible for space meet at a ministerial council to agree the next round of major spending,

which is when members decide how much to commit to each programme. The agency itself is run by a Director General. The details of the voting rules differ for different kinds of decision, so this course does not set them out.

## Mandatory and Optional Programmes

ESA's money is split into two parts, and the difference explains a great deal of how the agency behaves.

|                 | Mandatory programmes                                                  | Optional programmes                                                                        |
|-----------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| What they cover | The science programme, basic technology and the running of the agency | Launchers, Earth observation, human spaceflight, navigation, telecommunications and others |
| Who pays        | All members, according to the size of their economies                 | Members choose which to join and how much to give                                          |
| Why it matters  | Gives a stable base that no member can easily withdraw from           | Lets countries invest where their industries and priorities lie                            |

The optional system is flexible, and it lets a country with a strong interest in launchers, for example, take a larger role than one whose priority is Earth observation. It also means that the largest contributors have the largest say in the programmes they pay for. The total budget is several billion euros each year, but the exact figure changes, so check ESA's latest published figure before quoting it.

## Fair Return

The most distinctive rule is **geographical return**, often called "fair return" or by the French *juste retour*. Roughly speaking, the value of the contracts placed with companies in a country should match what that country contributes to the programme. If a country pays a given share, its industry receives about that share of the work.

|                 |                     |
|-----------------|---------------------|
| The case for it | The case against it |
|-----------------|---------------------|

Governments are more willing to commit money when they know it will support their own industry and jobs. It built a space industry in countries that would not otherwise have had one, and it keeps members from leaving.

The best company for a job may not be in the country that is owed the work. Splitting work across many countries can raise costs and slow projects, and it can be hard to hold together a rocket built in many places, which is not unlike the problem that sank the earlier launcher project (Chapter 2).

### The compromise

Return is balanced over a programme or over several years and not on each contract, and ESA has tried to introduce more competition. How far the system has really been loosened is a matter of argument.

### A familiar argument

The fair-return rule resembles other European arrangements in which money buys privileges, such as the automatic places given to the largest funders of the Eurovision contest, discussed in The Eurovision Song Contest 3. In both cases the funding countries accept a deal in which paying more brings a guaranteed benefit, and in both cases critics ask whether that is fair to everyone else.

## Sites

ESA does not work from one campus. Its work is spread across several countries, which again reflects the need to keep members involved.

- **Paris, France:** headquarters and policy.
- **Noordwijk, Netherlands:** the technical centre where spacecraft are tested and designed (ESTEC).
- **Darmstadt, Germany:** mission operations (ESOC), where missions are flown from the ground.
- **Cologne, Germany:** the astronaut centre.
- **Frascati, Italy:** Earth observation (ESRIN).

- **Madrid, Spain:** science data from space telescopes and probes (ESAC).
- **Harwell, United Kingdom:** a centre for applications and technology.
- **Kourou, French Guiana:** the launch site, covered in Chapter 4.

The list is a selection, and names and roles of some sites change, so check ESA's own page for the current set.

## ESA and the European Union

People often assume ESA is an EU body, but it is not. The two are separate organisations with different members, different rules and different histories.

|            | ESA                                                                        | European Union                                                                                   |
|------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Type       | Intergovernmental space organisation                                       | Political and economic union                                                                     |
| Members    | About two dozen, including some non-EU countries (UK, Norway, Switzerland) | EU countries only                                                                                |
| Founded    | Mid-1970s                                                                  | Much of its present form from the 1990s, with earlier roots                                      |
| Space role | Builds and operates space missions                                         | Owens and funds some programmes, such as navigation and Earth observation, and sets space policy |

The two work closely: for some EU programmes, ESA acts as the technical developer and the EU funds and owns the system. The details are covered in Chapter 8. This is also why the United Kingdom stayed in ESA after it left the EU, a subject returned to in Chapter 9. For the political background of the EU itself, see the course European Politics Fundamentals.

### Check before quoting

The member list, the budget figure, the roles of the sites and the exact relationship between ESA and the EU programmes are all subject to change. Use ESA's own pages and the EU's space pages, and give the date you checked.

# Exercises

## EXERCISE 1

Explain the difference between mandatory and optional programmes, and say why the optional system suits a group of countries with different priorities.

→ Solution

## EXERCISE 2

Describe the fair-return rule in your own words and give one argument for it and one against it.

→ Solution

## EXERCISE 3

Give three differences between ESA and the European Union, and name one ESA member that is not in the EU.

→ Solution

## Quick Reference

- **Type:** intergovernmental, about two dozen members, headquartered in Paris
- **Governing body:** the council, one vote per member
- **Mandatory programmes:** science and basics, paid by all
- **Optional programmes:** launchers, Earth observation and others, chosen by each member
- **Fair return:** contracts roughly match what each country contributes
- **Sites:** Paris, Noordwijk, Darmstadt, Cologne, Frascati, Madrid, Harwell, Kourou
- **Not the EU:** UK, Norway and Switzerland are members but outside the EU

- **Check:** the member list, the budget and the roles of the sites

**Next chapter:** Getting to Space: Ariane, Vega and Kourou, which follows the launchers.

# The European Space Agency

Course 1 · Chapter 4 · Getting to Space: Ariane, Vega and Kourou

*A space agency without a way of reaching space depends on someone else. Europe learned this early, and the rockets of the Ariane family, launched from a site in South America, are what turned a collection of satellite builders into a space power. This chapter looks at why Europe wanted its own launchers, how Ariane grew from the 1973 bargain (Chapter 2), why the launch site is in French Guiana, a famous failure in 1996 that is a favourite lesson for software engineers, and how the arrival of new competitors and a war changed the picture. The broad story is secure, but dates and flight records change, so the chapter flags what should be checked and stops at a stated cut-off.*

## Why Europe Wanted Its Own Rockets

The argument for independent access to space is partly about money and partly about control. If a country or group can only launch satellites on someone else's rocket, the owner of the rocket decides when, whether and on what terms. A story often told in this connection is that in the early 1970s the United States agreed to launch a joint European communications satellite only on condition that it was used for experimental purposes and not commercially, which showed European governments how dependent they were. The story is widely repeated, but the exact terms should be checked. Whatever the precise details, it is the standard explanation for why France pressed for a launcher and why the others agreed.

### Independence as a policy

The idea of "guaranteed access to space" has been the stated reason for European launchers ever since. It explains why Europe has kept building its own rockets even when it might have been cheaper to buy launches elsewhere.

## Ariane: From the 1973 Bargain to a Business

France led the development of Ariane, as agreed in 1973. The first rocket flew from the launch site at Kourou in French Guiana in December 1979 (check the date). A company, Arianespace, was set up in 1980 to sell launches to customers, and it is generally described as the first

commercial launch company. Over the next decades the Ariane family grew in power. The earlier versions, Ariane 1 to 4, carried commercial communications satellites for customers around the world and made Europe a leading provider of such launches for many years.

## Kourou

The launch site is in French Guiana, a French overseas territory on the northeast coast of South America. Its position is the reason it was chosen.

- **Near the equator.** The Earth spins fastest at the equator, and a rocket launched eastward gains some of that speed, which allows it to carry more or use less fuel, especially for satellites placed in a high orbit above the equator.
- **Open sea to the east.** Rockets fly out over the Atlantic Ocean, so spent stages fall into the sea and not on populated land.
- **French territory.** It is part of France, which gives the project a stable legal and political base inside Europe.

The centre was built by France in the 1960s, and ESA and France share its use. Later rockets, including the small Vega, also fly from there.

## Ariane 5 and the 1996 Failure

Ariane 5 was a much larger rocket, designed to replace Ariane 4. Its first flight, on 4 June 1996, ended in disaster: the rocket veered off course and destroyed itself less than a minute after lift-off. The satellites it carried, a set of four scientific spacecraft called Cluster, were lost (they were later rebuilt and flown). Nobody was hurt. An inquiry found the cause in the software.

### The software lesson

A component in the guidance system had been reused from the earlier Ariane 4. Ariane 5 was faster and flew a different path, so a number measured in its early flight no longer fitted the space set aside for it, and the software failed with an error when it tried to store it. The error was not handled in a safe way, and the backup unit, running the same code, failed in the same way. The rocket was told, in effect, to correct a course error that did not exist. For readers with an IT background, it is a textbook case of reusing code without re-

testing it under the new conditions. The cost of the loss is often given in hundreds of millions of dollars, but check the figure before quoting it.

The failure was costly and embarrassing, and the programme recovered. Ariane 5 went on to a long run of successful launches and was for many years one of the most reliable commercial rockets in the world. It launched major scientific missions, including the James Webb Space Telescope in December 2021 (Chapter 6), and was retired in 2023 (check the date).

## **Vega: A Smaller Rocket**

Alongside the large Ariane, Europe built a smaller rocket, Vega, which first flew in 2012 and is intended for light satellites, especially for Earth observation. An improved version, Vega-C, followed in 2022. Vega-C suffered a failure in its second flight at the end of 2022, and returned to flight later (check the details). Small rockets are a crowded market, and Vega competes with many new commercial launchers.

## **Russian Rockets at Kourou**

For about a decade ESA and Arianespace also launched Russian Soyuz rockets from Kourou, filling the middle of the range between Vega and Ariane. After Russia's invasion of Ukraine in February 2022, Russia withdrew its support for the Soyuz launches at Kourou, and the arrangement ended. The effect was larger than a single loss, because Europe lost a rocket just as the Ariane 5 was approaching retirement and the new Ariane 6 was still delayed.

## **Ariane 6 and a Gap**

Ariane 6 was designed as a cheaper successor to Ariane 5, flexible enough to fly with two or four boosters. It was delayed several times, and it first flew in July 2024 (check). While Ariane 5 was gone and Ariane 6 was not ready, Europe had no operational heavy launcher of its own for a period, and some European missions and satellites had to fly on American rockets. The Euclid space telescope and some navigation satellites are examples reported as launched on SpaceX Falcon 9 in this period (check each). To many observers this gap was a serious blow to the policy of independent access.

### Cut-off and checks

This chapter stops at the early flights of Ariane 6 and does not describe the most recent launches or the plans for reusable rockets, which change quickly. Check ESA's and Arianespace's pages for the current state of Ariane 6 and Vega-C before quoting anything about them.

## A New Competitor

The commercial launch market changed in the 2010s when American companies, above all SpaceX, began reusing the first stages of their rockets and cutting prices. European rockets had been built to be thrown away after use, and the cost difference became a political issue. This is one of the strongest challenges to the fair-return and shared-industry model from Chapter 3, and Chapter 9 returns to it.

## Exercises

### EXERCISE 1

Give two reasons why Europe wanted its own launcher, and two reasons why Kourou is a good place to launch from.

→ [Solution](#)

### EXERCISE 2

Explain in a few sentences what went wrong on the first flight of Ariane 5 in 1996, and say what general lesson for software the failure is used to illustrate.

→ [Solution](#)

### EXERCISE 3

Describe how the Soyuz departure, the retirement of Ariane 5 and the delay to Ariane 6 combined to leave Europe without its own heavy launcher for a time, and say why that

matters to the idea of independent access.

→ Solution

### Quick Reference

- **Why:** independent access to space, helped by a story about US conditions on a European satellite (check)
- **Ariane 1:** first flight December 1979 from Kourou; Arianespace set up 1980
- **Kourou:** near the equator, open sea to the east, French territory
- **Ariane 5:** failed on its first flight in June 1996 (software reused from Ariane 4); later very reliable; retired 2023
- **Vega:** small launcher from 2012; Vega-C from 2022
- **Soyuz at Kourou:** ended after the invasion of Ukraine in 2022
- **Ariane 6:** first flight 2024 after delays
- **Check:** all dates, the current state of Ariane 6 and Vega-C, and the cost of the 1996 loss

**Next chapter:** Exploring the Solar System, which follows ESA's probes to comets, Mars and Titan, and the Beagle 2 story.

# The European Space Agency

Course 1 · Chapter 5 · Exploring the Solar System

*ESA's science missions are what most people mean when they think of the agency at its best: a probe flying through the tail of a comet, a lander touching down on a moon of Saturn, a spacecraft circling Mars for more than twenty years. This chapter follows the best-known missions in order and includes the story of Beagle 2, a small British lander that rode with ESA to Mars and did not do what was hoped. Mission details are given from general knowledge and flagged where they should be checked, and the chapter stops at a stated cut-off, since some missions are still under way.*

## Giotto and Halley's Comet (1986)

Giotto was ESA's first deep-space mission. Launched on an Ariane rocket in 1985 (Chapter 4), it flew close to Halley's Comet in March 1986 and returned the first close pictures of a comet's nucleus, the solid core inside the cloud of gas and dust. It passed within a few hundred kilometres of the nucleus at very high speed. Dust damaged the spacecraft and its camera, but it survived, and it was later sent to a second comet. It matters because it showed that Europe could carry out a difficult deep-space mission at a time when the larger agencies were also sending probes to Halley, and the choice to approach so close was a bold one.

## Huygens on Titan (2005)

The Cassini–Huygens mission was a joint project of NASA, ESA and the Italian space agency. NASA's Cassini orbited Saturn. ESA supplied the Huygens probe, which separated from Cassini and descended through the thick atmosphere of Titan, Saturn's largest moon, in January 2005. It is generally described as the first landing on a body in the outer Solar System. It sent data back for a short time, and revealed a landscape with channels and what appear to be dry riverbeds. Because the probe was carried and relayed by Cassini, the mission is a good example of how ESA and NASA divide the work (see Partners later in the course).

## Mars Express (2003 onward)

Mars Express was ESA's first mission to another planet. The orbiter was launched in June 2003 and entered orbit around Mars in December of that year, and is generally reported to have kept working for more than two decades (check the current status). Its cameras produced detailed pictures of the surface, and its instruments looked for water ice and studied the atmosphere. It was built quickly and at a modest cost, using designs developed for another mission, which is part of why it was seen as a success.

## Beagle 2: A British Lander on a European Ride

Mars Express also carried a small lander, **Beagle 2**, named after the ship that carried Charles Darwin. It was a British project, led by Colin Pillinger of the Open University (a point of interest for anyone who has studied there). Its aim was to land a compact laboratory on the surface and search for signs of life, in particular chemical clues that might have a biological origin. It was not an ESA lander in the way Huygens was: ESA provided the ride to Mars, and the lander itself was developed in Britain, with funding that came from several sources.

| Stage           | What happened                                                            |
|-----------------|--------------------------------------------------------------------------|
| Launch          | Carried to Mars on Mars Express in June 2003                             |
| Separation      | Released from the orbiter in December 2003 to land on its own            |
| Landing attempt | Due to touch down on Christmas Day 2003; no signal was received          |
| Aftermath       | Declared lost in early 2004; an inquiry looked at funding and management |
| Rediscovery     | Spotted in images from an American orbiter in 2015, on the surface       |

The ending is the most interesting part. For more than a decade Beagle 2 was assumed to have crashed. Then, in 2015, high-resolution images from NASA's Mars Reconnaissance Orbiter showed that it had in fact landed safely. It appeared that it had opened only partly, and the unopened panels probably blocked its antenna, so it could not call home. Pillinger had died in 2014, before the discovery. The fate of the lander was therefore a case of an almost-success: it reached the surface and failed to function, probably through a problem in the final stage, and not through the landing.

### What Beagle 2 teaches

It was a small, low-cost, ambitious project squeezed by limited funding and a fixed launch date, and later reviews pointed to gaps in testing and management. It also shows how a national project can ride on a shared programme: ESA provided the opportunity, but responsibility for the lander itself was British. Whether it should have been funded more generously or never attempted is a matter of opinion.

### A cheese-shaped aside

A British Mars lander that nearly worked, built on a modest budget by enthusiastic amateurs and professionals, invites comparison with Wallace and Gromit, whose home-built rocket reached the Moon (in *A Grand Day Out*, where the Moon turned out to be made of cheese). The comparison is affectionate and unfair in both directions. The cartoon rocket landed safely and found a good supply of cheese, and Beagle 2 landed but could not tell anyone.

### Check the details

The dates, the cause of the silence and the funding arrangements for Beagle 2 are given from general knowledge and should be checked against the inquiry reports and the reports of the 2015 discovery. In particular, the extent of the partial opening and the reasons for the failure are explanations, not certainties.

## Rosetta and Philae (2014)

Rosetta was one of ESA's best-known missions. Launched in 2004, it travelled for ten years and in 2014 became the first spacecraft to go into orbit around a comet, 67P/Churyumov–Gerasimenko. It released a small lander, Philae, which in November 2014 touched down on the comet's surface, the first soft landing on a comet. The landing did not go to plan: the lander bounced and came to rest in a shadowed spot, with too little sunlight for its solar panels, and contact was brief. It was located in photographs only in 2016. Rosetta itself ended the mission by landing on the comet in 2016. Even with the problems, the mission was widely described as a major success for the science.

## Further Out

- **BepiColombo.** A joint mission with Japan to Mercury, launched in 2018 and due to enter orbit around the planet in the late 2020s (check the dates).
- **JUICE.** A mission to study Jupiter's large icy moons, launched in 2023 and due to arrive in the early 2030s (check).
- **Solar Orbiter.** A mission to study the Sun from close range, run jointly with NASA.
- **ExoMars.** A Mars programme whose first part, an orbiter, reached Mars in 2016, while the rover has been delayed repeatedly; Chapter 9 returns to its connection with Russia.

## What the Missions Have in Common

Most ESA science missions are built through the mandatory science programme (Chapter 3), which gives them a more stable budget than the optional programmes. Many rely on partnerships with NASA, and many have ridden on Europe's own launchers. They are also usually selected through a competitive process among scientists, and then built by industry in the contributing countries. The result is that Europe has been strongest where it picks missions carefully and works with others, and has tended to be less visible than the larger agencies.

## Exercises

### EXERCISE 1

Match each mission with what it achieved: Giotto, Huygens, Mars Express, Rosetta. Say which of them involved a partnership with NASA.

→ Solution

### EXERCISE 2

Explain why Beagle 2 was not an ESA lander in the way Huygens was, and summarise what happened to it between 2003 and 2015.

→ Solution

### EXERCISE 3

Pick one mission from the chapter. Say what it was meant to do, what actually happened, and whether you would call it a success, giving one reason.

→ Solution

### Quick Reference

- **Giotto:** Halley's Comet, 1986; first close pictures of a comet nucleus
- **Huygens:** landed on Titan, 2005; joint with NASA's Cassini
- **Mars Express:** Mars orbiter from late 2003; ESA's first Mars mission
- **Beagle 2:** British lander (Open University, Colin Pillinger); lost in 2003; found on the surface in 2015
- **Rosetta and Philae:** orbited and landed on a comet, 2014
- **Further out:** BepiColombo (Mercury), JUICE (Jupiter's moons), Solar Orbiter, ExoMars
- **Check:** dates, Beagle 2 details and the status of missions still under way

**Next chapter:** Telescopes and Looking Back at Earth, which turns from the planets to the stars and to our own planet.

# The European Space Agency

Course 1 · Chapter 6 · Telescopes and Looking Back at Earth

*Not every space mission goes to another world. Many of ESA's most valuable missions stay close to home, looking outward at the stars or back at Earth. This chapter covers both: the space telescopes, from its part in the Hubble Space Telescope to the James Webb Space Telescope and the star-mapping missions Hipparcos and Gaia, and the Earth-observation satellites that watch the weather, ice, oceans and land. It is a less glamorous side of the agency than comets and landers, but it is where much of the science and much of the everyday value lies. Mission details are given from general knowledge and flagged where they should be checked.*

## Why Put a Telescope in Space?

The Earth's atmosphere blurs and blocks light, and some kinds of light, such as X-rays and much of the infrared, hardly reach the ground at all. A telescope in orbit sees more sharply and in more wavelengths. The price is that it must be launched, cannot easily be repaired and has to work on its own. ESA's science programme (Chapter 3) funds a series of space observatories chosen by competition among scientists.

## Hubble and the James Webb Space Telescope

Two of the most famous telescopes were joint projects with NASA, and ESA's share in them is an example of the partnership running through the course.

- **Hubble Space Telescope.** Launched in 1990 by NASA. ESA took part from the start, supplying equipment including its solar panels and an instrument, and receives a share of the observing time (the share is often quoted as around a sixth, but check).
- **James Webb Space Telescope.** A joint project of NASA, ESA and the Canadian Space Agency. It was launched in December 2021 on a European Ariane 5 rocket from Kourou (Chapter 4), which was ESA's contribution to the mission, along with instruments. It observes mainly in the infrared and works far from Earth.

### A European launch for an American telescope

The launch of the James Webb telescope on an Ariane 5 is a point of pride, since Europe provided the rocket for NASA's flagship telescope. It also shows the value of having a reliable launcher of one's own, which is the point of Chapter 4.

## Mapping the Stars: Hipparcos and Gaia

One of Europe's real strengths has been *astrometry*, the precise measurement of the positions and movements of stars.

- **Hipparcos.** Launched in 1989, it measured the positions of over a hundred thousand stars very accurately. Its catalogue was published in the 1990s.
- **Gaia.** Launched in 2013, it set out to map positions and motions for around two billion stars in the Milky Way, which makes it a three-dimensional map of part of our galaxy. It is generally reported to have ended its observations in 2025 (check), but the data is still being processed and released.

The practical consequence is that astronomers all over the world use the Gaia catalogue as a reference, and it has been one of the most cited data sets in astronomy.

## Other Space Observatories

| Mission           | What it looked at                                                            |
|-------------------|------------------------------------------------------------------------------|
| XMM-Newton (1999) | X-rays from hot gas, black holes and galaxy clusters                         |
| Herschel (2009)   | Far-infrared light from cold dust and star formation                         |
| Planck (2009)     | The faint afterglow of the early universe (the cosmic microwave background)  |
| Euclid (2023)     | The shape and distribution of galaxies, to study dark matter and dark energy |

### Check the dates

Launch years and mission lengths are from general knowledge. Several of these missions have ended, and Euclid is recent, so check ESA's mission pages for their current status.

## Looking Back at Earth

ESA has a long record in Earth observation. Its early ERS satellites, launched in the 1990s, used radar to measure the sea, ice and land through cloud and in the dark. The large Envisat satellite, launched in 2002, carried a suite of instruments to study the atmosphere, oceans, ice and land, and it operated for about ten years before contact was lost in 2012 (check). Later missions focused on specific questions, for example CryoSat on the thickness of polar ice, and Aeolus on measuring winds.

## Copernicus

The largest present effort is **Copernicus**, a European programme for observing the Earth. It is an EU programme, and ESA builds and develops the satellites, the Sentinel family, while other organisations run the services that use the data. Different Sentinels carry radar, optical cameras and instruments to monitor the atmosphere and oceans. The data is made freely available, and it is used for:

- tracking floods, fires and other emergencies;
- monitoring farming, forests and land use;
- watching sea ice, sea level and ocean conditions;
- measuring air quality and the climate.

This is a good example of the division of roles described in Chapter 3: the EU funds and owns the programme and ESA provides the technical expertise. Chapter 8 returns to it, and Chapter 9 looks at how the United Kingdom's access changed after it left the EU.

### The value of free data

Making Earth-observation data freely available has helped researchers, companies and governments around the world, including in places that could not afford their own satellites. It is among the clearest ways in which European space spending reaches ordinary uses, even though few users think of it as European.

## Exercises

### EXERCISE 1

Explain two advantages of a telescope in space compared with one on the ground, and one disadvantage.

→ Solution

### EXERCISE 2

Describe ESA's part in the Hubble and James Webb telescopes, and say why the Ariane 5 launch of the James Webb telescope mattered.

→ Solution

### EXERCISE 3

Explain what Copernicus is, who funds it and who builds the satellites, and give three uses of its data.

→ Solution

### Quick Reference

- **Why space telescopes:** sharper images and light the atmosphere blocks
- **Hubble:** launched 1990; ESA a partner from the start
- **James Webb:** NASA, ESA and Canada; launched on Ariane 5 in December 2021
- **Hipparcos and Gaia:** star-position mapping; Gaia launched 2013
- **Other observatories:** XMM-Newton, Herschel, Planck, Euclid
- **Earth observation:** ERS, Envisat, CryoSat, Aeolus
- **Copernicus:** EU programme; ESA builds the Sentinel satellites; free data
- **Check:** launch dates, mission end dates and current status

**Next chapter:** People in Space, which turns to the European astronauts.

# The European Space Agency

Course 1 · Chapter 7 · People in Space

*The European Space Agency has astronauts, a training centre and a laboratory in orbit, yet it has never built a spacecraft of its own to carry them. That is the central fact of Europe's human spaceflight: strong in contribution, dependent on partners for transport. This chapter looks at how Europeans first flew, the Spacelab laboratory that came out of the 1973 bargain (Chapter 2), the Columbus laboratory on the International Space Station, some astronauts worth knowing, including a British one and the first Hungarian in space, and the question of why Europe never built its own crew vehicle. Details are given from general knowledge and flagged where they should be checked.*

## Flying as Guests

The first Europeans in space flew as guests of the two superpowers. In the late 1970s and early 1980s the Soviet Union invited citizens of friendly countries to fly on its missions, under a programme known as Intercosmos. A Czechoslovak flew first in 1978, and a Hungarian followed in 1980: **Bertalan Farkas**, who flew to the Salyut 6 space station on Soyuz 36 in May 1980 and became the first Hungarian in space (check the date). France had its own agreement with the Soviet Union, and a French astronaut flew in 1982. For Western European countries outside such deals, the American Space Shuttle was the route.

## Spacelab and the First ESA Astronauts

Spacelab, the laboratory built by Europe under the 1973 agreement and led by Germany, flew in the cargo bay of the Space Shuttle. Its first flight was in late 1983. On board was the German physicist **Ulf Merbold**, usually described as the first ESA astronaut to fly in space and the first non-American to fly on the Shuttle (check). ESA had selected its first astronauts in 1978, and the group included Claude Nicollier of Switzerland, who later flew several Shuttle missions and worked on repairs to the Hubble Space Telescope (Chapter 6). Spacelab flew a series of missions in the 1980s and 1990s and gave European scientists a laboratory in orbit.

### Why Spacelab mattered

It was the first large European contribution to human spaceflight, and the arrangement of 1973 meant it was a European laboratory in an American vehicle. That pattern, of Europe providing a module while a partner provides transport, has repeated ever since.

## The European Astronaut Centre

ESA's astronauts are based at the European Astronaut Centre in Cologne, Germany, which selects and trains them (Chapter 3). They come from member countries, and ESA tries to share flights across those countries in line with their contributions, an echo of the fair-return rule. A new class was chosen in 2022, and it included, for the first time, a project to select an astronaut with a physical disability, a "parastronaut". The British Paralympian and surgeon John McFall was selected for that role (check the details).

## Columbus and the International Space Station

Europe's main contribution to the International Space Station (ISS) is the **Columbus** laboratory, launched in 2008 on an American Space Shuttle and attached to the station (check the date). ESA also built other parts, including a viewing dome, the Cupola, and several connecting modules. For a few years Europe also flew its own cargo spacecraft, the Automated Transfer Vehicle, which delivered supplies and fuel to the station between 2008 and 2014 and could boost its orbit (check).

| Person                         | Why remembered                                                   |
|--------------------------------|------------------------------------------------------------------|
| Ulf Merbold (Germany)          | Flew on the first Spacelab mission in 1983                       |
| Claude Nicollier (Switzerland) | Several Shuttle flights, including Hubble repairs                |
| Samantha Cristoforetti (Italy) | Long stays on the ISS, and later commanded the station           |
| Alexander Gerst (Germany)      | Two long stays on the ISS, and commanded the station in 2018     |
| Thomas Pesquet (France)        | Two long stays on the ISS and a wide public following            |
| Tim Peake (United Kingdom)     | Long stay on the ISS, 2015–2016, with Britain's first ESA flight |

### Check each name

The table is a selection from general knowledge and is not a ranking. Dates, roles and commands should be confirmed on ESA's astronaut pages before quoting them.

## A British Example: Tim Peake

Britain's route into space has been unusual. **Helen Sharman** became the first Briton in space in 1991, flying to the Soviet Mir station on a privately funded mission, and not through ESA. Britain, which for many years chose not to take part in ESA's human spaceflight programme, later changed course. **Tim Peake** flew to the ISS in December 2015 on a Russian Soyuz as an ESA astronaut and stayed for about six months. His mission, called Principia, included a spacewalk and a run of the London Marathon on a treadmill aboard the station, and it was followed closely in Britain (check the details). It is generally seen as the point at which British public interest in ESA rose.

## Hungary in Space

Hungary's story is a good example of how national flights and ESA relate. After Farkas flew in 1980, the Hungarian-born software designer Charles Simonyi, who worked in the United States, flew to the ISS as a private participant in 2007 and again in 2009 (check). In 2025 a second Hungarian, Tibor Kapu, flew to the station on a commercial mission as part of a Hungarian national project (check the details). Hungary joined ESA as a full member in 2015 (Chapter 9). The details of the 2025 flight, including who organised it and how it relates to ESA, should be confirmed before quoting.

## The Missing Spacecraft

For all this, Europe has not had its own way to carry people to orbit. In the 1980s it planned a small spaceplane, *Hermes*, which was cancelled in the early 1990s because of the cost. ESA astronauts have therefore flown on the American Space Shuttle, on Russian Soyuz rockets and, more recently, on American commercial capsules. ESA is also building the service module for NASA's Orion capsule, which is intended to carry crews to the Moon under the Artemis

programme, in return for flight opportunities for European astronauts (check the current status). So Europe remains a contributor to human spaceflight, and not an independent operator.

### **A pattern across the course**

Europe is strong in science, instruments and modules, and weaker in the vehicles that carry people. This is the same pattern as with the Beagle 2 lander (Chapter 5): European projects often depend on a partner for the final step, whether a launch, a landing or a seat.

## **Exercises**

### **EXERCISE 1**

Explain how the first Europeans reached space, and name the Hungarian who flew in 1980 and the route he took.

→ [Solution](#)

### **EXERCISE 2**

Describe Spacelab and Columbus: what each was, how it reached space, and what they show about Europe's role in human spaceflight.

→ [Solution](#)

### **EXERCISE 3**

Explain why Europe has never had its own crew spacecraft, and say what ESA does instead.

→ [Solution](#)

## **Quick Reference**

- **Early flights:** guests of the Soviet Union and the United States; Hungary's Bertalan Farkas flew in 1980
- **Spacelab:** European laboratory in the Shuttle bay; first flight 1983 with Ulf Merbold
- **Astronaut centre:** Cologne, Germany
- **Columbus:** Europe's ISS laboratory, launched 2008; the ATV cargo ships 2008 to 2014
- **British examples:** Helen Sharman (1991, not ESA); Tim Peake (2015 to 2016, ESA)
- **Missing piece:** no European crew vehicle; Hermes cancelled in the early 1990s
- **Check:** all dates, the 2025 Hungarian flight and the Artemis arrangements

**Next chapter:** Satellites in Everyday Life, which turns to navigation, weather and communications.

# The European Space Agency

Course 1 · Chapter 8 · Satellites in Everyday Life

*Most people meet space through their phone, the weather forecast and the television, not through a rocket launch. This chapter looks at the satellites that quietly do the work: the navigation system Galileo, the weather satellites that feed forecasts, and the communications satellites. It also explains who owns and runs them, since several different organisations are involved, and the division of work between ESA and the European Union becomes clear here. Dates and numbers are given from general knowledge and flagged where they should be checked.*

## Galileo: Europe's Own Satellite Navigation

Satellite navigation lets a receiver work out its position from signals sent by satellites. The best-known system is the American GPS, which was built and is run by the United States military. Europe's own system is **Galileo**, named after the Italian astronomer. The reasons for building it were similar to the reasons for building Ariane (Chapter 4): reliance on another country's system means relying on its decisions. Galileo is run under civilian control and not military control, and its signal is designed to be available whatever the political situation.

- **Development.** The first test satellites flew in the mid-2000s. The first operational satellites were launched in 2011, and initial services were declared in 2016 (check these dates).
- **Size.** A constellation of around thirty satellites in medium Earth orbit, of which most are in service.
- **Services.** A free open service for everyone, a high-accuracy option, and an encrypted service for government users called the Public Regulated Service.
- **In your pocket.** Many modern phones use Galileo signals alongside GPS, so a reader may be using it without knowing.

### Who owns Galileo?

Galileo is an EU programme, owned and funded by the European Union and managed by an EU agency. ESA designs and develops the system and procures the satellites. This is the pattern described in Chapter 3, and it means that Galileo is a European system and not

strictly an ESA one. It also explains why the United Kingdom's position changed after it left the EU (Chapter 9).

## Timing, Not Only Position

Navigation satellites carry very accurate atomic clocks, and their signals are used as a source of precise time. Much of modern life depends on this: mobile phone networks, financial trading, electricity grids and data centres all use satellite time signals to keep their clocks aligned. Most users are unaware of it. For readers in IT, it is a reminder that a network clock can ultimately trace back to a satellite, and that a fault in such a system can have wide effects. Galileo suffered a prolonged outage of several days in 2019 (check the details), which was widely reported and showed the point.

## Improving GPS: EGNOS

Before Galileo, Europe built a system called EGNOS, which corrects GPS signals over Europe and is used above all in aviation, to make landings and approaches safer. It is a good example of a European contribution to a system that Europe does not own.

## Weather Satellites

Weather forecasts depend on satellites that watch clouds, temperatures and winds from orbit. The European satellites are the **Meteosat** series, which hover over a fixed point above the equator, and the MetOp satellites, which circle the Earth from pole to pole. They are operated not by ESA but by a separate organisation, **EUMETSAT**, a European body for weather satellites with its headquarters in Darmstadt, Germany. ESA develops the satellites and EUMETSAT runs them, which is another instance of the division of roles. A new generation of Meteosat satellites began to launch at the end of 2022 (check).

### Three organisations, one forecast

A forecast on British television may draw on data from satellites that ESA built, EUMETSAT operates and a national weather service, such as the Met Office, processes. None of the

three is the EU, though the EU uses the data too. The chain of organisations is the reason space is so rarely described as one thing.

## Communications

Communications satellites carry television, telephone traffic and data. ESA supports European industry in this field through programmes that help companies develop new satellites and technology, but most communications satellites are built and run by companies. The European operator Eutelsat began as an intergovernmental organisation and was later turned into a company, and in recent years it has merged with the OneWeb network (check). The EU has also planned a secure communications constellation of its own, partly in response to the growth of American constellations and to concerns about reliance on them. Plans like this change quickly, so check the current position.

## How the Work Is Divided

| Service                        | Who owns or funds it   | Who builds or develops it  | Who runs it                  |
|--------------------------------|------------------------|----------------------------|------------------------------|
| Galileo (navigation)           | EU                     | ESA and industry           | EU agency                    |
| Copernicus (Earth observation) | EU                     | ESA and industry           | EU and partner organisations |
| Meteosat (weather)             | EUMETSAT member states | ESA and industry           | EUMETSAT                     |
| Telecommunications             | Companies              | Industry, with ESA support | Operators                    |

### Check before quoting

The table simplifies a complicated set of agreements, and the names of agencies and the split of responsibilities change from time to time. Treat it as a guide to the pattern, and check the current arrangements with the EU space programme pages, ESA and EUMETSAT.

# Exercises

## EXERCISE 1

Explain why Europe built Galileo when GPS already existed, and say who owns Galileo and what ESA's role is.

→ Solution

## EXERCISE 2

Describe two everyday things that depend on satellite navigation, and explain why precise time is as important as position.

→ Solution

## EXERCISE 3

Using the weather forecast as an example, name the three kinds of organisation involved and explain why space is rarely "one thing".

→ Solution

## Quick Reference

- **Galileo:** Europe's civilian navigation system; EU-owned, ESA-developed
- **Timing:** atomic clocks in the satellites; used by networks, finance and power grids
- **EGNOS:** corrections to GPS over Europe, used in aviation
- **Weather:** Meteosat and MetOp, operated by EUMETSAT
- **Telecommunications:** mainly companies, with ESA support
- **Pattern:** the EU or another body owns and runs; ESA builds
- **Check:** dates, the satellite count and the current arrangements

**Next chapter:** Partners, Rivals and Politics, which looks at NASA, Russia, China, Brexit and commercial competition.

# The European Space Agency

Course 1 · Chapter 9 · Partners, Rivals and Politics

*ESA never works alone. It depends on partners, competes with rivals and answers to member governments whose politics change. This chapter looks at its relationships with NASA, Russia and China, the effect of the war in Ukraine on joint projects, what Brexit did and did not change for the United Kingdom, how countries such as Hungary joined, and how the arrival of fast, commercial space companies challenges the old model of a government agency. This is the part of the course closest to current events, so it is the most likely to be out of date, and the text says what to check. Recent events end with the course cut-off of 2026.*

## NASA: The Closest Partner

ESA's most important partner is the United States. The two have worked together on a long list of projects: Cassini–Huygens, the Hubble Space Telescope, the James Webb Space Telescope, the International Space Station and the Orion capsule, whose service module ESA supplies (Chapters 5 to 7). The relationship is generally close but not equal. NASA's budget is several times larger, and Europe has often provided a part of a mission, such as an instrument, a launch or a module, while the United States leads. Some joint plans have been scaled back when American budgets or priorities changed, and the future of some projects, including a joint plan to return samples from Mars, has been uncertain (check the current status).

## Russia and the War in Ukraine

Cooperation with Russia was long and practical: Russian rockets launched ESA astronauts, Soyuz launched from Kourou (Chapter 4), and Russia was a partner in the International Space Station and in the ExoMars programme. Russia's invasion of Ukraine in February 2022 changed this quickly.

- **Soyuz at Kourou.** Russia withdrew and the launches ended (Chapter 4).
- **ExoMars.** The plan to launch a European rover on a Russian rocket in 2022 was suspended, and ESA later ended the cooperation. A new plan to launch the rover with American help has been discussed for the late 2020s (check).
- **The ISS.** Cooperation on the station has continued in some form, as it depends on both sides, but the political context has changed.

### A lesson in dependence

The loss of Soyuz and the delay to ExoMars show how much ESA's plans depended on one partner. Many people in European space now argue for more independence in launch and in key technology, which is the same argument that justified Ariane in the 1970s (Chapter 4).

## China

Cooperation between ESA and China has been limited and cautious. There have been some joint science projects, and Europe has provided support for Chinese missions in places, but American law and wider political tensions make close partnership difficult. A joint scientific mission between ESA and China has been planned (check the details), and European astronauts have been reported to be learning Chinese in case of future cooperation with China's space station. The picture is changing, so treat any statement about it as dated.

## Brexit and the UK's Place in ESA

Brexit raised an obvious question: does leaving the European Union mean leaving the European Space Agency? The answer is no. ESA is a separate intergovernmental organisation (Chapter 3), and its members include countries outside the EU, such as Norway and Switzerland. The United Kingdom stayed a full member, kept its seat on the council and continued to take part in ESA programmes, and its contribution was later raised.

What Brexit did change was the UK's position in the programmes owned by the EU rather than by ESA (Chapter 8).

| Area              | Effect of Brexit (as generally reported)                                                                                           |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------|
| ESA membership    | Unchanged; the UK remained a member                                                                                                |
| Galileo and EGNOS | The UK lost its role in the programme, including access to the encrypted government service; British companies lost some contracts |

| Area                 | Effect of Brexit (as generally reported)                                                                                                                                             |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Copernicus           | The UK's participation was uncertain for a time; later reports say it was restored through a wider agreement on EU research programmes (check)                                       |
| Industry and funding | Some firms lost work, while the UK government invested in its own projects, including a stake in the OneWeb satellite network, and studied a national alternative to Galileo (check) |

### Check carefully

The treatment of the UK in Galileo and Copernicus involved long negotiations and later changes, and details vary between reports. The safest summary is that the UK stayed in ESA while losing or renegotiating its role in the EU's space programmes. Confirm each point with a current government or ESA source.

## Joining ESA: The Case of Hungary

New members have joined over the years, including countries from the former Eastern bloc. Hungary signed up to the ESA Convention in the 2010s and became a full member state in 2015, after an earlier period of cooperation (check the dates). The route to membership usually starts with a cooperation agreement, then an associate status, then full membership, with the aim of getting contracts for national industry in return for contributions (the fair-return idea from Chapter 3). For a smaller country, membership is mainly a way to gain access to space projects that it could not afford alone.

## National Agencies and ESA

Alongside ESA, major countries keep their own space agencies. France has CNES, Germany has DLR, Italy has ASI and the United Kingdom has the UK Space Agency (check the current structure, which has been reorganised). These agencies run national programmes, represent their governments in ESA and often pay for a large share of ESA's work. The relationship is a mixture of partnership and rivalry, and some of the arguments in ESA, over leadership and money, are really arguments between national agencies.

# The Commercial Challenge

In the 2010s and 2020s private companies, led by SpaceX, changed the economics of space. Reusable rockets cut launch costs, and large satellite constellations changed communications (Chapter 4 and Chapter 8). This put pressure on the ESA model, in which governments contribute money in return for contracts, and projects take many years. ESA has responded by encouraging European launch start-ups, buying services from companies and arguing for more European independence. Whether a government-led agency can adapt as fast as the market is among the main open questions in the field, and recent decisions at ESA's ministerial meetings should be checked for the latest answer.

## Exercises

### EXERCISE 1

Describe how the war in Ukraine affected ESA's plans, naming two specific effects, and say what lesson many people draw.

[→ Solution](#)

### EXERCISE 2

Explain why Brexit did not take the United Kingdom out of ESA, and say what it did change.

[→ Solution](#)

### EXERCISE 3

In about 150 words, argue whether a government-led agency like ESA can compete with fast commercial companies, giving one point on each side.

[→ Solution](#)

## Quick Reference

- **NASA:** closest partner; Cassini–Huygens, Hubble, Webb, ISS, Orion
- **Russia:** Soyuz at Kourou and ExoMars lost after the 2022 invasion
- **China:** limited, cautious cooperation
- **Brexit:** the UK stayed in ESA but lost or renegotiated its role in Galileo and Copernicus
- **Hungary:** full member state from 2015 (check)
- **National agencies:** CNES, DLR, ASI, UK Space Agency
- **Commercial space:** reusable rockets and constellations challenge the old model
- **Check:** every item above; this chapter dates fastest

**Next chapter:** Capstone: What ESA Says About Europe, which draws the course together.

# The European Space Agency

Course 1 · Chapter 10 · Capstone: What ESA Says About Europe

*This last chapter steps back from the missions. It asks what ESA has been, what it shows about European cooperation, where it has succeeded and where it has fallen short, and how to talk about it carefully. It draws on the earlier chapters and ends with suggestions for further reading and viewing. As throughout the course, it separates what can be checked from publicity and memory, and the exercises ask you to do the same. Recent events end with the 2026 cut-off.*

## What ESA Has Been

ESA grew out of two bodies, one that succeeded and one that failed, and a bargain among the largest European countries (Chapter 2). It is run by member governments, paid for through mandatory and optional programmes and held together by the fair-return rule (Chapter 3). It gave Europe its own rockets from French Guiana, with a famous failure in 1996 and a gap in the 2020s (Chapter 4), and it built science missions that reached comets, Mars and Titan, including a British lander that arrived and could not call home (Chapter 5). It looked outward with telescopes and back at Earth with satellites (Chapter 6), put Europeans into space without ever building a crew vehicle (Chapter 7), and supports services in everyday life that are mostly owned by others (Chapter 8). It depends on partners and faces rivals and political shocks (Chapter 9).

## What It Tells Us

### About cooperation

European countries can pool money and expertise on something hard, and it has lasted for fifty years. It works best when there is a single lead and clear division of work, and worst when responsibility is shared out stage by stage, as in the failed launcher project.

### About national interest

The fair-return rule and the national agencies show that each country wants something back. Cooperation here is a bargain, not a surrender of interests.

### About ambition

### About dependence

Europe has been strongest in science, instruments and satellites for practical use, and weaker where an expensive, risky vehicle is needed. It has often provided the module and left the transport to a partner.

The wars and rivalries of recent years showed how much depended on single partners. The old argument for independent access to space has returned with force.

### The course's question, answered carefully

Chapter 1 asked whether ESA is a scientific organisation, an industrial programme or a political project. A careful answer is that it is all three at once, and the balance changes with the mission and the decade. It is a scientific success, an industrial compromise and a political achievement that depends on continued agreement among governments. As my own judgement, and not a finding, ESA looks to be at its best when it is working in partnership with a clear mission, and at its weakest when it has to move faster than a group of governments can agree.

## Where It Succeeded and Fell Short

| Succeeded                                                     | Fell short                                    |
|---------------------------------------------------------------|-----------------------------------------------|
| Science missions such as Giotto, Huygens, Rosetta and Gaia    | Having no crewed vehicle of its own           |
| A reliable launcher business for decades                      | A gap in launch capacity in the 2020s         |
| A shared industry across many countries                       | Cost and delay from splitting work by country |
| Satellites used daily for weather, navigation and the climate | Low public awareness of the agency's role     |

## Record, Publicity and Memory

The same three categories from Chapter 1 apply to the whole course.

| Kind      | Examples from the course                                                                                                                                                              |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Record    | The mid-1970s founding; Ariane's first flight in 1979; the June 1996 Ariane 5 failure; Huygens on Titan in 2005; Beagle 2's loss in 2003; the end of Soyuz launches at Kourou in 2022 |
| Publicity | "Historic first" and "triumph for Europe" language; claims that every mission was a success; round numbers for budgets and economic benefits                                          |
| Memory    | Which probe was which, whether a landing was European or American, the year of a famous launch                                                                                        |

### What still needs checking

Many facts in this course came from general knowledge and a small number of supplied points, and the text has said so as it went: founding dates and member lists, budget figures, mission and launch dates, the status of Ariane 6, Vega-C and ExoMars, the Beagle 2 details, the 2025 Hungarian flight, and the changing position of the UK in the EU's space programmes. Before using any of them elsewhere, check each against ESA's own site and a reliable second source.

## What to Read and Watch Next

- **ESA's own site.** Mission pages, images and recorded launches, read with the publicity point in mind.
- **National agencies and EUMETSAT.** Their accounts of joint projects often fill in what ESA's pages leave out.
- **Related courses.** The course European Politics Fundamentals covers the wider political setting, and The Eurovision Song Contest, on this site, is another example of European countries sharing a network and arguing about fairness (see The Eurovision Song Contest 3 for the Big Five and The Eurovision Song Contest 6 for hosting costs). A planned course on the European Union will cover the political side of Galileo and Copernicus.
- **Archive footage.** Watch the Giotto and Rosetta coverage, and compare how the agency presented itself in the 1980s and the 2010s.
- **Your own memory.** If you watched a launch or a landing, write down what you recall and test each point against a source.

## A Closing Thought

A space agency seems like a story about machines, but this one is as much about governments, money and trust. The rockets and probes are the surface. Underneath are bargains about who pays, who builds and who leads, and the question of whether many countries can act as one. That is a reasonable thing for a course to take seriously, and the missions are a good reason to enjoy it.

## Exercises

### EXERCISE 1

Write a one-paragraph history of ESA, naming at least one fact from each of Chapters 2, 4, 5 and 9.

→ [Solution](#)

### EXERCISE 2

Pick one claim from the course and classify it as record, publicity or memory. Explain what you would check to confirm it.

→ [Solution](#)

### EXERCISE 3

In about 150 words, argue whether ESA is mainly a scientific organisation, an industrial programme or a political project, giving one point on each side.

→ [Solution](#)

## Quick Reference

- **Origin:** ESRO and ELDO merged; the 1973 bargain; ESA from the mid-1970s

- **How it works:** member governments, mandatory and optional programmes, fair return
- **Launchers:** Ariane from 1979; Kourou; the 1996 failure; the 2020s gap
- **Science:** Giotto, Huygens, Mars Express, Rosetta, Gaia, Webb
- **People:** European astronauts without a European crew vehicle
- **Everyday:** Galileo, Copernicus, weather satellites
- **Politics:** NASA, Russia, Brexit, Hungary's membership, commercial space
- **Habits:** separate record, publicity and memory; check before quoting

**Course complete.** Return to The European Space Agency 1 for the scope and sources.