

space:uk

principia

MISSION



Meet
the UK's
first ESA
astronaut



Life
on the
space
station



Science
at 27,000
kilometres
per hour



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Welcome



Welcome to this special edition of the UK Space Agency's *space:uk* magazine – packed with news, facts and features about UK astronaut Tim Peake's Principia mission to the International Space Station (ISS).

Tim was selected as a European Space Agency (ESA) astronaut in 2009 and was chosen in 2013 for a mission to the ISS. In this special issue, you can read about Tim, the mission, the science he will be conducting in orbit and how he can expect to find life in space – from looking down at spectacular views of the Earth, to the challenges of keeping the station running.

You can also discover more about the wide range of education projects that Tim is involved in (page 8). These are at the heart of the mission and Tim will be working on experiments with schools and colleges across the country. He will even be talking to students directly from space.

Space is an essential part of the UK economy, worth £11.8 billion, supporting more than 34,000 jobs and delivering a wide range of services and benefits to society. Those are important numbers but Tim's flight represents much more than that. It is exciting, aspirational and shows the UK at the forefront of the quest for new knowledge as we push the frontiers of science and move beyond the Earth.

The world has changed a great deal since Britain's first astronaut, scientist Helen Sharman, flew to Russian space station Mir in 1991. I am incredibly proud that we now have another British astronaut ready to inspire the next generation. I cannot wait to see those first images of Tim floating through the hatch into the ISS.

David Parker
Chief Executive, UK Space Agency





Principia: the mission

In December 2015, UK European Space Agency (ESA) astronaut Tim Peake is due to fly to the International Space Station (ISS).

Tim will be part of Expedition 46/47 to the ISS and his mission is known as Principia. The astronaut will remain on the station for more than five months, carrying out scientific experiments and a wide range of education projects.

Training

Timothy Peake was selected as an ESA astronaut in May 2009. The former military helicopter test pilot completed his basic astronaut training in November 2010.

Tim's training has included living underground in a cave system for a week to test teamwork, behaviour and performance in extreme environments. He has also spent 12 days living in NASA's Aquarius habitat, 20 metres underwater off the coast of Florida. This assignment focused on developing techniques and procedures for a mission to an asteroid.

In 2012, Tim completed training for spacewalks with both Russian and US spacesuits. Since being assigned his mission in 2013, he has been in intensive training on the Soyuz spacecraft, ISS and the experiments he will be carrying out in space.



Survival training in Russia Credit: GCTC

Principia

Tim's mission is known as Principia after British scientist Sir Isaac Newton's *Naturalis Principia Mathematica*, a three-part text describing the principal laws of motion and gravity.

The name was a popular choice from more than 4000 entries in a national competition. It is appropriate since Tim will spend his time on the ISS in conditions of weightlessness.



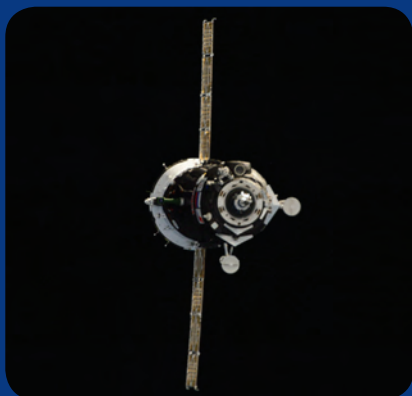
Tim with Sir Isaac and the original Principia at the Royal Society in London **Credit:** UK Space Agency, Alexander

Launch

Tim will launch in a Soyuz spacecraft from Baikonur Cosmodrome in Kazakhstan, the site of Russian launches since the dawn of the space age. Alongside Tim in the capsule will be Russian Soyuz commander Yuri Malenchenko and NASA astronaut Tim Kopra.

The Soyuz has proved to be one of the safest and most reliable spacecraft ever flown. Although the latest models contain sophisticated computers and communications systems, the basic design has remained unchanged for almost fifty years.

The flight to the ISS is due to take six hours. During this time the spacecraft needs to catch up with the ISS, which is travelling at more than 27,000 km/hour around the Earth. Although the Soyuz is designed to dock to the station automatically, the crew has to be ready to take over if anything goes wrong.



A Soyuz spacecraft approaching the ISS **Credit:** ESA, NASA



Astronaut's eye view of the Earth from the ISS Cupola **Credit:** ESA, NASA

On board the ISS

Within 24 hours of arriving at the ISS, Tim will start his work in the Columbus laboratory. His time on board will be carefully scheduled and overseen by ground controllers in Houston, Moscow and in the Columbus Control Centre in Germany (see page 20).

As well as working on experiments, Tim will have scheduled meal, rest and sleep breaks and will need to exercise for at least 90 minutes

a day. During his time off, he will be able to socialise, watch movies, talk to friends and family on the ground or simply float in the Cupola module looking down at the Earth.

The few times Tim can expect complete privacy are when he is resting in his cabin – which is around the size of a wardrobe – or when he is in the toilet.

For more about life on the station, see page 14.

Return to Earth

Tim is due to return to Earth in May 2016. The Soyuz is designed to land on solid ground and astronauts often describe the landing as feeling like a 'car crash' – particularly because their bones and muscles have weakened in space (see page 18).

Soyuz spacecraft land in the Kazakh Steppe and ground support staff race to intercept the spacecraft with helicopters. They then help lift the astronauts out of the capsule, which is scarred by its descent through the atmosphere.



The most recent ESA astronaut, Andreas Mogensen, is lifted from his Soyuz after returning to Earth **Credit:** ESA



Meet Tim Peake

The UK's first ESA astronaut sits down with *space:uk* editor, Richard Hollingham, at the European Astronaut Centre in Cologne, Germany to talk about training, the mission and music:

What are you doing at the moment?

I'm in the middle of medical testing. I've signed up for about 25 human physiology experiments, so they obviously need to know as much as they can about me before launch. Then they'll monitor me during flight and in the post-flight period as well.

Some of this is quite unpleasant isn't it?

I've had a couple of muscle biopsies – where doctors take a small pellet of my muscle, many MRI scans, x-rays, blood seems to be drawn on a daily basis, lots of urine samples having to be given, monitoring my temperature, my activity, blood pressure cuffs for 24 hours – that sort of stuff – so there's an awful lot going on.

You've had more than six years of training, do you ever have the opportunity to stop and think how far you've come?

The closer you get to launch, definitely the more excited you get about it. But also the busier you get. Those opportunities to reflect are few and far between but when I do get them on rare occasions, it really still blows me away with what I'm about to do.

Were there points during the training when you thought this is absolutely amazing and it's going to be even better in space?

There are several points during the training. I've always enjoyed the training

for spacewalks, wearing the full suit in Houston where we go underwater and train for about six hours at a time to do spacewalking. Also they have a Virtual Reality laboratory there – when you put the VR glasses on and you wear the gloves – it's so lifelike that you feel as if you're outside the space station looking down on planet Earth.

What's been the toughest part of the training?

One has been retaining lots of information over a long period of time. And part of that is knowing what you have to retain – what's important and what you've got ground support or documentation to help you with. And learning the Russian language.

And how is your Russian?

It's at a stage where I'm quite happy with it. I'm never going to be very good at Russian, I'm not a natural linguist but I can certainly communicate in the Soyuz spacecraft and I can read all the documentation that I need to. So I'm happy with it.

You are due to launch to the ISS in mid-December, what are your main priorities when you're there?

First and foremost it's to be a good crewmember. People have invested so much in you and that means being able to work efficiently, accurately and conduct all the science activities. If you make a mistake that can have a really bad impact on the life expectancy of components on the space station or

:meet tim peake

a loss of science if we're operating a science experiment.

Then I have some personal aims for the mission as well. I'd like to share the mission as much as possible, I'd like to try and do as much educational outreach as possible.

The Principia education programme is quite ambitious...

We're really tried to target a diverse community in terms of who we're reaching out to – across all ages and across a spectrum of activities as well. That started from the very beginning with the mission name being a competition, the mission patch being chosen by Blue Peter viewers and since then we've had competitions with rocket seeds, the Astro Pi challenge, even my dinners have been designed by kids.

Astro Pi is a variation on the Raspberry Pi computer, did you have any knowledge of coding or interest in coding before you took on this project?

Very limited knowledge. But actually having said that, anyone who's as old as I am grew up in the days of the Sinclair ZX81 with the 16K RAM pack on the back



– that fell out – and loading up your games on a cassette tape that took 20 minutes, just to play Space Invaders. So I'm familiar with the concept of basic

computing. I think the Raspberry Pi is brilliant – going back to basics but also giving people the ability to create some really fun programs.



You will be on the space station at Christmas – are you looking forward to it?

I am looking forward to it. It's going to happen fairly soon after my launch and arrival on the space station. Of course I'm going to miss friends and family but it is going to be very soon after I've said goodbye to them. I'll still be in that phase where everything is unique being in space.

What about music on the station – how's your playlist coming along?

There's something very interesting I'm going to do. I've compiled a list of 75 tracks, which are my favourite songs. They've all got a bit of a British flavour to them or a space flavour and I'm going to run a competition called Space Rocks on twitter.



Spacewalking would be the ultimate thrill
Credit: ESA, NASA

About three times a week I'm going to tweet out the lyrics to one of my favourite songs and whoever tweets back the name of the artist and the song correctly will win a super-cool Space Rocks patch. Only 75 will be flown in space and I'll be giving them out when I get back.

You're already on the record as saying you're not going to follow Chris Hadfield and publically sing or play the guitar in space...

I'll be doing that in my own time [laughs]. There is a guitar on board and I will be playing it – I love to play – but I'm not sure I'm ready to release my skills to the world yet!

Is there one thing you're particularly looking forward to?

There are so many things. That first view of space, both from the Soyuz and the Cupola window is going to be truly incredible. Robotic operations – seeing another vehicle coming towards your spacecraft and being involved in that whole capturing and docking is going to be great.

If I have the opportunity to do a spacewalk then that will be the icing on the cake – that would be absolutely amazing experience. So a number of things throughout the mission that are going to be incredible.

Profile

Born in 1972, Tim attended Chichester High School for boys. During this time he was also a member of the combined cadet force before joining the Army as an Army Air Corps Officer. Tim has over 3000 flying hours and has flown more than 30 different types of helicopter and fixed wing aircraft.

Tim is married with two sons. Among his leisure activities he enjoys skiing, scuba diving, cross-country running, climbing, mountaineering and he completed the London Marathon in 2006. His interests include quantum physics and aviation.



Aiming high

Tim Peake's Principia mission will have a big impact on education across the UK. Sue Nelson explains how space will encourage students to reach for the stars:

It is only weeks before Tim Peake's launch to the International Space Station (ISS) and he is undergoing some vital last minute training. "I have learnt how to fix the toilet," Tim tells 70 pupils at Queen's Park primary school in London.

Not surprisingly, everyone laughs. But, as you can imagine, not having a working toilet on a space station would be no laughing matter. Even astronauts need plumbing skills.

The school children are sat in front of a screen during a live link up with Tim from the United States.

The first British European Space Agency (ESA) astronaut is at NASA but he has taken time off from his training to discuss his mission and answer questions from journalists and children alike. And everyone always wants to know how astronauts go to the loo in space.

"In terms of using the toilet it's very straightforward," says Tim. "It uses suction, a big fan to make sure everything goes in the right direction."

Almost too much information. But like many astronauts Tim loves engineering and science. Tim is a helicopter pilot, studied aeronautical engineering and wants the educational activities planned during his time on the Space Station to be "the benchmark of the mission".

Team Tim

The Principia mission is inspiring thousands of schools to take part in activities. These range from an interactive touring science show, called Team Tim, to undertaking the Space to Earth Challenge – covering the same 400 km distance between the Earth and the International Space Station (ISS) by cycling, running, swimming, dancing, climbing or exercising.

Queen's Park was one of those selected to take part in the Tim Peake Primary Project. Schools can still get involved in plenty of other activities, including one called Rocket Science.

Seeds of rocket, whose peppery leaves are often found in a green salad, will spend five months on the ISS and come back to Earth in March. In all, two million seeds – some from space, some not – will be sent to 10,000 schools.

“We’re going to try to see the differences between how a plant grows after its seed has been up on the space



Rocket Science was showcased at this summer's Chelsea Flower Show **Credit:** UK Space Agency, Alexander

station,” says 10-year old Susu El-Abbas. “There is no gravity up there but down here we have gravity so there’s a chance the flowers will grow more. I think there will be a difference.”

Susu enjoyed hearing about Tim’s mission. “My science teacher has really inspired me to learn more about space and how space looks and the way people discover it.”

[continues >](#)



Tim Peake's Principia mission patch was unveiled on Blue Peter **Credit:** UK Space Agency, Alexander

:aiming high

Stories

As well as science, numeracy and physical education, space will be incorporated into other areas of the curriculum, such as literacy.

“Children can write about space,” says Queen’s Park School head teacher Jonathan Smith. “They can think about stories that have been written about space and the history of space with Buzz Aldrin and Neil Armstrong. So there are opportunities right across the curriculum for children to become engrossed by space and inspired by it.”

Children’s author Lucy Hawking, daughter of the famous scientist Stephen Hawking, has also written the Principia Space Diary with Professor Peter McOwan from Queen Mary University of London. Funded by the UK Space Agency, it contains activities and challenges related to the mission.

The UK Space Agency has partnered with education charity Into Film to encourage young people to make short films around the theme of space exploration. A selection of the films



The Apollo Moon landings continue to inspire children today. This image was taken during the 1971 mission of Apollo 15

submitted to the Into Film: Into Space project (closing date 15 February 2016) will be screened on the ISS to entertain Tim and his crewmates.

The privilege of seeing Earth from space is reflected in the EO Detective activity. “The Space Station is an Earth observation laboratory,” says Tim. “It covers 90% of the populated areas of planet Earth.”

Pupils aged between 7-16 will do their own Earth observation by using photographs taken from space to investigate how our planet is changing.

Teachers can access every activity’s resources via the Principia and the European Space Education Resource Office (ESERO) websites.



Students will use images from space to observe how the Earth is changing **Credit:** ESA

Astro Pi

Students are also being encouraged to be creative with computers. “There’s an emphasis on computing and coding in the curriculum which is very important at primary and secondary schools now,” says ESERO UK’s Tom Lyons who, apart from being a teacher, is a former space engineer.

“A competition was run called Astro Pi, which is linked to two Raspberry Pi computers that are going to the Space Station, and Tim will be able to interact with them,” says Tom.

“In the primary school competition students designed what they wanted to run and the Raspberry Pi foundation have coded that up,” he says. “For the secondary competition a number of different schools came up with idea and, also, the code.”

The competition may be over but all schools can still get their hands on the kit and run the same experiments as Tim in their classrooms.

Co-funded by ESA and the UK Space Agency, ESERO UK is providing a network of more than 40 Space Ambassadors to help spread the word and bring space down to Earth. The aim is to increase school engagement with space, confidence with science and knowledge of what careers are available.

“What the UK Space Agency is trying to do with their education projects,” says Tom, “is to get into as many different areas of the curriculum as possible.”

The mission will leave a legacy as the educational resources can be used for years after Tim returns to Earth. During



his five months on the ISS, however, the astronaut will be fitting educational activities into his schedule whenever he can.

“Tim has said he’s hoping to set aside some of his free Saturday time for educational activities as well as his allocated time during the week,” says the UK Space Agency’s Libby Jackson. “He’s very keen that his mission engages as many people, particularly students, as possible.”

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Tim Peake with an Astro Pi and appropriate t-shirt **Credit:** ESA

Space festival

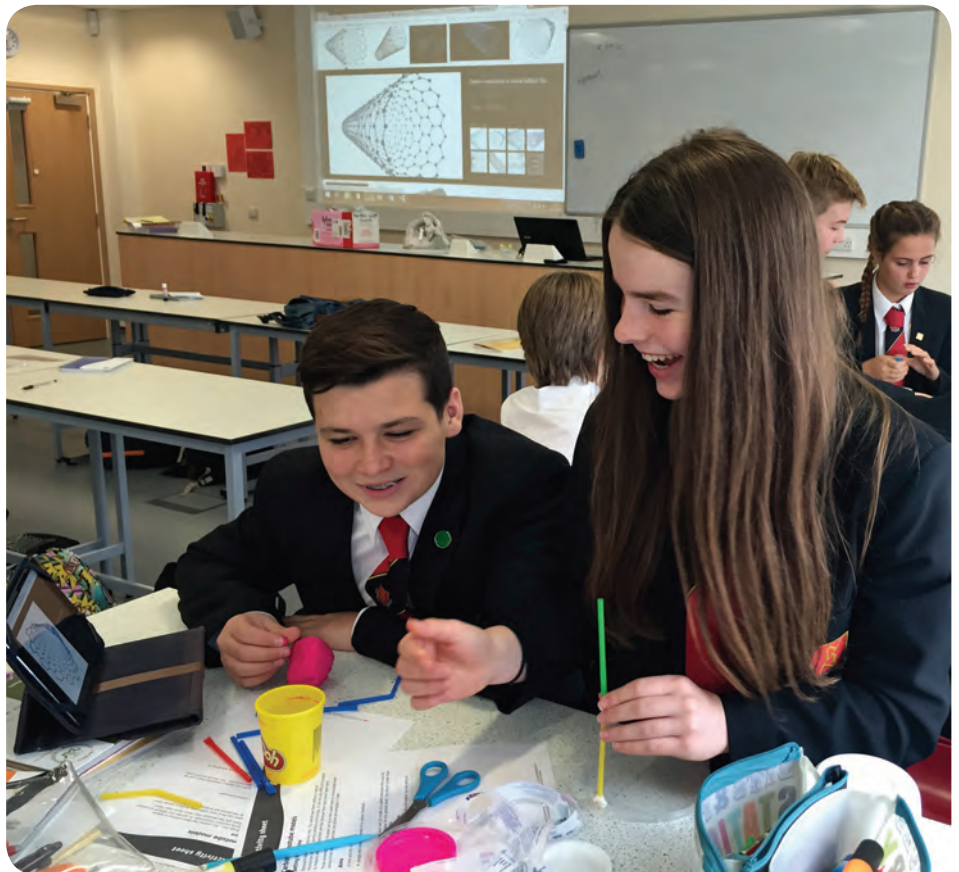
These activities will include filming videos, demonstrating science experiments and using an amateur radio on the International Space Station (ARISS) with schools. Ten secondary schools were shortlisted for the radio link up and, if chosen, they can't be late as the space station only has a ten minute window when it is across the UK.

A comprehensive school in St Albans is one of them. "We feel highly privileged to have been selected as one of the schools to link with Tim Peake," says Sandringham School Head, Alan Gray.

"This will be a cornerstone event in our promotion of the STEM agenda across Sandringham and its community and will generate massive interest in STEM subjects from students of all ages," he says. "Our plan is to hold a two-day Space Festival, culminating in the live link on day two. There will be numerous activities arranged that will promote STEM and provide challenge for all."

"Space really does have the ability to inspire everybody," says Libby. "I've not met anyone who doesn't look at photos from the Space Station and think 'wow'".

"We are putting together a programme that spans the curriculum and age ranges to ensure there is something for everyone," she says. "I'd like schools to take Tim's mission as a highlight for the whole year and to incorporate it into



their lessons – perhaps a music lesson here and a geography lesson there – to engage in this really exciting period of spaceflight."

Queen's Park Head, Jonathan, is definitely excited about what his students will experience. "I hope they will take away the inspiration behind it and that it opens up their eyes to a whole world of possibilities that, before this project, they might not have been aware of," he says.

"There are so many different jobs and careers and ways that their lives could go. But you need to know about them and I think this project will open their eyes and inspire them to work towards them and to succeed in life."

It has already made a difference to Susu. "I didn't know there was a home for people to go into space outside this planet," she says. "It's really taught me a lot about what people do, leaving their planet and their homeland. It shows me that they have to have trust and faith to go into space. You have to believe in yourself."



Space activities for schools

These are some just some of the activities you can get involved in:

I'm an Astronaut Get me Out of Here!

An online chat with the team behind Tim's mission

EO Detective

Earth Observation detectives use photographs from space

Rocket Science

How plants grow in space

Astro Pi

Students devise and code apps and experiments in space

Space to Earth challenge

Get active and train alongside Tim

ARISS

Link-ups via the amateur radio on the International Space Station

Mission X

Train like an astronaut

Destination space

Activities at local science centres

Into Film: Into Space

Produce your own space-themed film

The great British Space Dinner

Design your own menu for astronauts

To find out more detail about the space activities and to obtain educational resources visit principia.org.uk and www.esero.org.uk/timpeake

Space Station

has been continuously occupied since 2000.



International Sp

Destiny:

US science laboratory. This large section also contains the bulk of life support systems on the station.



Columbus:

The ESA laboratory is packed with experiments. This is where Tim Peake will spend a lot of his working time on the ISS.

Unity:

Joins the US and Russian sections. This was the first US section of the station.

Zarya:

This first module of the ISS was launched in 1998. It initially provided power and life support and is now mainly used to store supplies and fuel.

Robotic supply ship:

The ISS is supplied by several robotic spacecraft including Progress, Cygnus, Dragon and, in the past, the Space Shuttle and ESA's ATV.



Space Station (ISS)

Kibo:

The Japanese laboratory is attached to a large open platform where experiments can be exposed to the harsh space environment.

Solar arrays:

These 35 metre long arrays supply power to the station. Batteries store the electricity when the ISS is in shadow.

Cupola:

This European module provides astronauts with a unique view of the Earth.



Zvezda:

The living module for the Russian section of the ISS where crew gather for meals. It also houses life support, power systems and a toilet.



International

Orbiting 400 km above the Earth, the ISS h

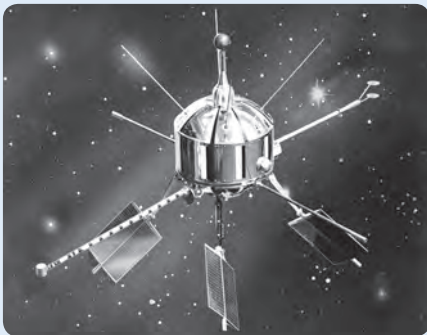


The history of British astronauts goes back more than fifty years:

Engineers at the British Interplanetary Society come up with a plan to convert captured German V2 rockets into manned spacecraft. Although the design is feasible, the Government turns it down on grounds of cost.



As the Soviet Union and US begin the race to the Moon, Britain becomes the world's third space nation, with the launch of scientific satellite Ariel 1. The UK establishes expertise in space science and satellite manufacturing but steps back from human space flight.



Tim Peake is selected as an ESA astronaut. He is chosen – from thousands of applicants – alongside candidates from Denmark, France, Germany and Italy.



The UK races ahead in aviation and missile development. The British-built Comet becomes the world's first passenger jet. Meanwhile engineers at Farnborough develop pressure suits for high altitude flight – technology that will eventually be used in NASA space suits.

The Government announces the first British astronauts. They train to launch the UK Skynet satellites from the Space Shuttle. When Challenger explodes shortly after lift-off in 1986, the remaining Shuttle fleet is grounded. Skynet is launched on conventional rockets and the British astronauts never fly.



Helen Sharman becomes the first British astronaut. She is selected from more than five thousand candidates in a public competition. During her seven-day mission to Soviet space station Mir, she carries out science experiments and speaks by radio to school children back on Earth.



During the next two decades several British-born astronauts fly to orbit. These include Michael Foale who is on board Mir when it is hit by a supply ship.







Life in space

What can Tim Peake expect aboard the International Space Station? *Space:uk* talks to ESA astronaut Paolo Nespoli about life in space – from taking a shower to clouds that look like pizza:

You have flown twice to the ISS, how different was being on the Space Station compared to all your training?

There is nothing that can prepare you for microgravity. On Earth you can experience it for a few seconds during training but that's it. You will only discover what is going to happen to your body and how things behave once you go into space.

What do you miss most about the space station?

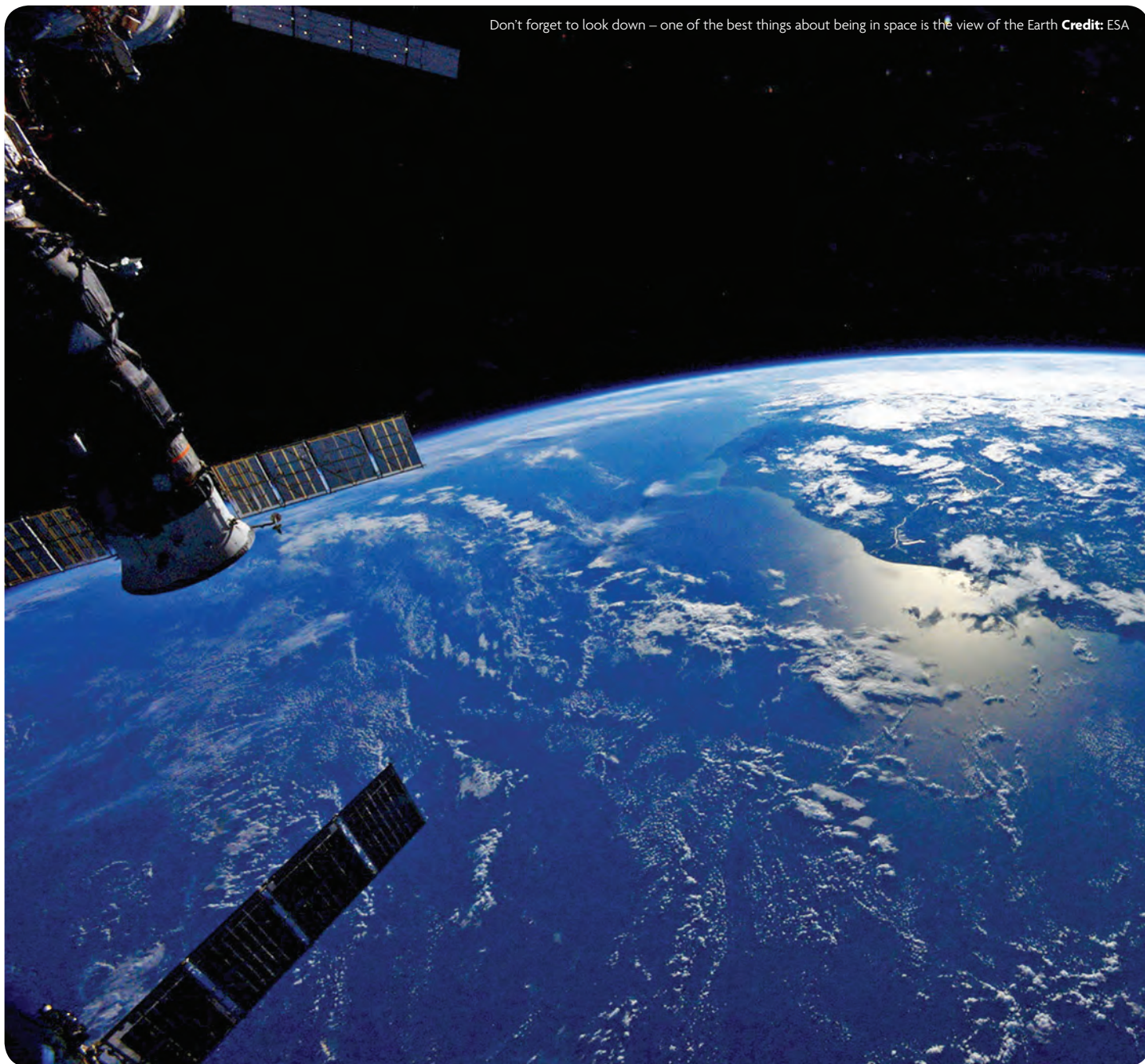
The Space Station has two things that you cannot find anywhere else on Earth: first of all, the environment where gravity is simply not felt and secondly, the ability of looking at Earth in a different way. It's totally different to what you see from space 400 kilometres away. These two things make this place really unique.

There's also a lot of personal and professional satisfaction. You feel part of something important. You are working constantly and, of course, you are missing family members and friends, going out, having a pizza and a beer and relaxing. But at the same time you have so much more.

[continues >](#)

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Don't forget to look down – one of the best things about being in space is the view of the Earth **Credit: ESA**



I told myself not to fall into the trap of sitting there and missing things and to just look at other things that are available and focus on those, because it's on you to discover them. When I did that I put myself back into the shoes of a ten year old that is trying everything. So there was almost no time in space when I missed things because I was discovering new things.

But at one point, I was taking pictures of clouds and I looked at those pictures later and thought 'ooh, this looks like a pizza'. Then I looked at a few more pictures and thought this one looks like a pizza margarita, this one like a quattro stagioni...

By the third pizza I thought something is wrong here. This may be a message. I'm probably missing freshly prepared food and being with some friends!

There are no windows in the European Columbus laboratory, was it difficult to work without natural daylight?

Space is really a weird environment when you are on the space station because essentially you are falling down to Earth, continuously travelling at a speed of 27,000 kilometres per hour and you are spinning around the Earth one full turn every one and a half hours, which gives you a sunset or sunrise every 40-50 minutes. So you

get 16 sunsets, 16 sunrises per day in this constant cycle of day night, day night.

You learn to sync your body clock with a watch, with artificial time – the space station is synced up with GMT so it's really good for people in the UK. But you don't always feel the need to look outside because it's sometimes very distracting and disconcerting.

It can feel funny when your watch tells you it's midnight, time to go to bed, and you look outside and it's bright and you feel the full heat of the Sun like at midday. But you get used to it after a while.

Tim Peake did a live link up from NASA in Houston with a school in London recently. He said he was being trained to fix the toilet! How important is that skill up in space?

In space you spend most of your time fixing things because the Station needs to be maintained. It's not as if you can

call Houston up and say 'can you send a plumber up because the toilet is broken?' Somebody needs to do it. Not one person by the way. Everybody gets trained how to fix a toilet but you don't want to be the one that breaks it.

It's not as simple as a regular toilet on the ground. A toilet in space needs to

capture whatever should not fly away. You need to be able to condition it so it doesn't degrade and we recycle some of the waste products.

Several years ago both toilets on the Space Station broke and they were in trouble [laughs]. You need to be able to fix it as soon as possible!

[continues >](#)



ESA's Andre Kuipers replacing an ISS urine tank, proving that being an astronaut is not always a glamorous profession. Credit: ESA, NASA

The space station must smell pretty bad!

No, that's a common mistake. The environment control of the life support system constantly mixes the air. It is continuously checked, cleaned, replenished with oxygen and spewed out again. It's amazing. Have you ever smelt the air after a thunderstorm? That clean ozone feel? This is the way it smelt to me. If there was a bad smell it would last for a few seconds then it was gone. The air was clean again.

What advice would you give British astronaut Tim Peake before his first mission?

He's really nice to be around and also very technically minded. You give him anything and he tackles it so there's no advice I can give him from a professional point of view.

So I'd probably tell him what people told me on my first flight which was simply to slow down and to take time to enjoy your stay up there. Look down from the window and don't feel you need to be 100% every moment of the day.

Going into space for six months is like a marathon – you should not start running like a 100 metre race. That's what you do at the beginning because you try to do everything.

I think in week three in space I slept four hours each night because I thought everything was important. But then you start feeling tired, making mistakes and having problems so you soon realise you need to take time off, need to sleep, look out of the window and think of something else.

You are going back into space for a third mission in 2017. Did you ever think that would happen?

Though I was selected in 1998 as an astronaut, it took almost ten years before I flew for the first time. Then it took another five years before I flew again. When I came back for the second time, I thought that was probably it.

Space is bad for you

Fancy a trip into space? In the 2009 Star Trek movie, doctor Leonard McCoy describes space as "disease and danger, wrapped in darkness and silence." He has a point; living in space is definitely bad for your health. Here are some of the symptoms:

Nausea:

The inner ear is very sensitive to the loss of gravity. This affects balance, coordination and even how you track moving objects – potentially dangerous if you are piloting a spacecraft. Many astronauts feel sick for their first few days in space. Globules of vomit floating around a space capsule can be particularly unpleasant.

Fat face:

Our metabolism tends to push fluids towards our heads. Without the effects of gravity, astronauts end up with swollen faces and blocked noses.

Effects on eyesight:

A recent study found that two out of three astronauts suffered loss of eyesight after living in space. The causes are not fully understood but doctors identified swelling of the optic nerve, changes to the shape of the eye and an increase in pressure on the brain.

Muscle and bone loss:

Without gravity, astronaut muscles quickly waste away. Even heart muscle loses condition. Lack of gravity also has the effect of causing bone to weaken as large amounts of calcium leach into the bloodstream. To combat these effects, astronauts exercise at least 90 minutes a day.

Disease:

Several studies suggest that spaceflight has a detrimental effect on the immune system. NASA research using fruit flies found that in space white blood cells were less effective at fighting infection. Even more worrying are the effects of cosmic or solar radiation. The ISS is relatively protected within the Earth's magnetic bubble – the magnetosphere – but out in deep space, on the way to the Moon or Mars for example, the dangers of lethal doses of radiation become of increasing concern.



ESA astronaut Samantha Cristoforetti on the ISS treadmill **Credit:** ESA, NASA

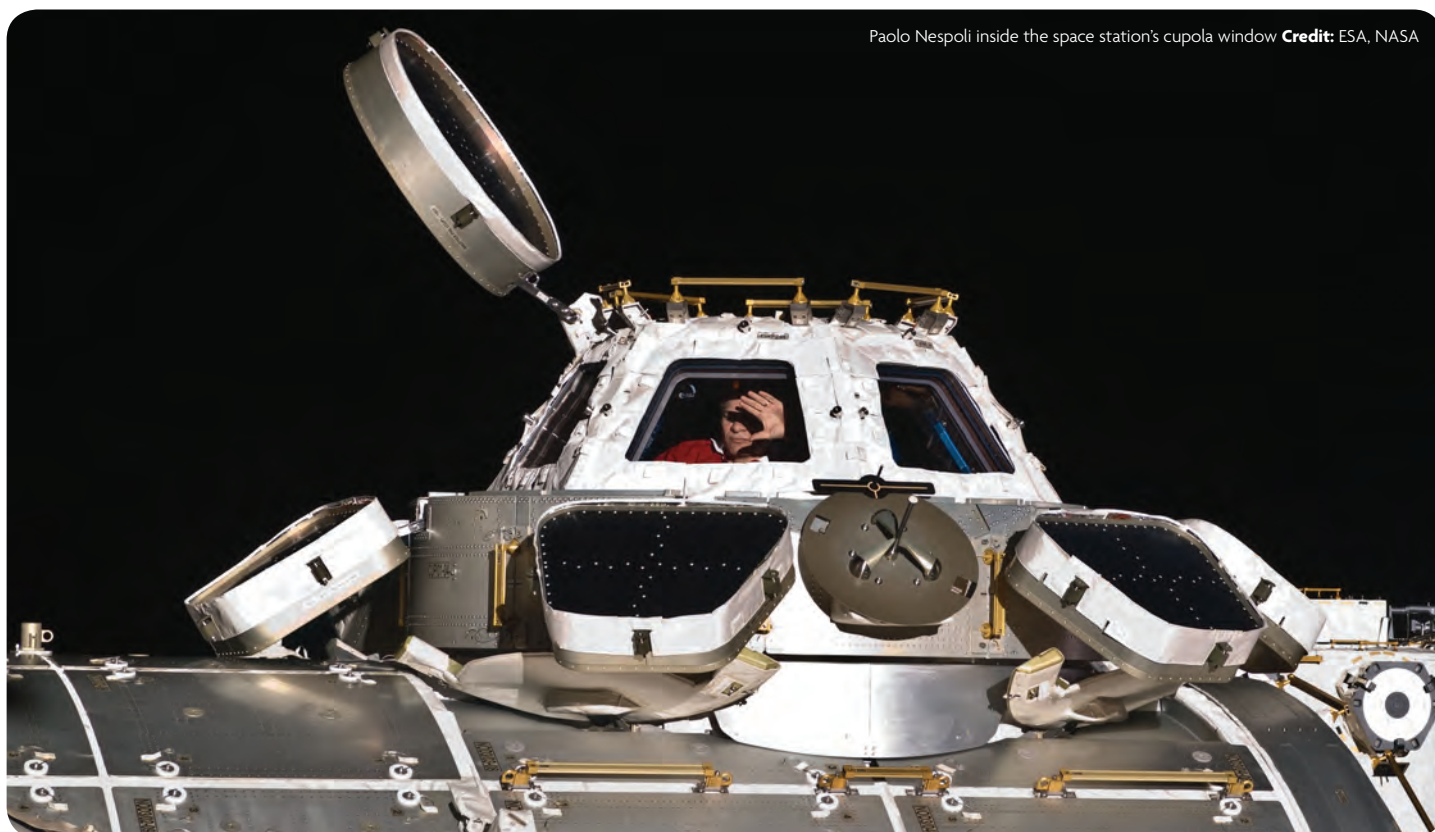
Flying once is incredible. Flying twice is double incredible but at the same time I've put many personal resources into it. Six months in space is a long time but on the other hand you prepare for years and years. It's good that agencies still consider this training a useful resource.

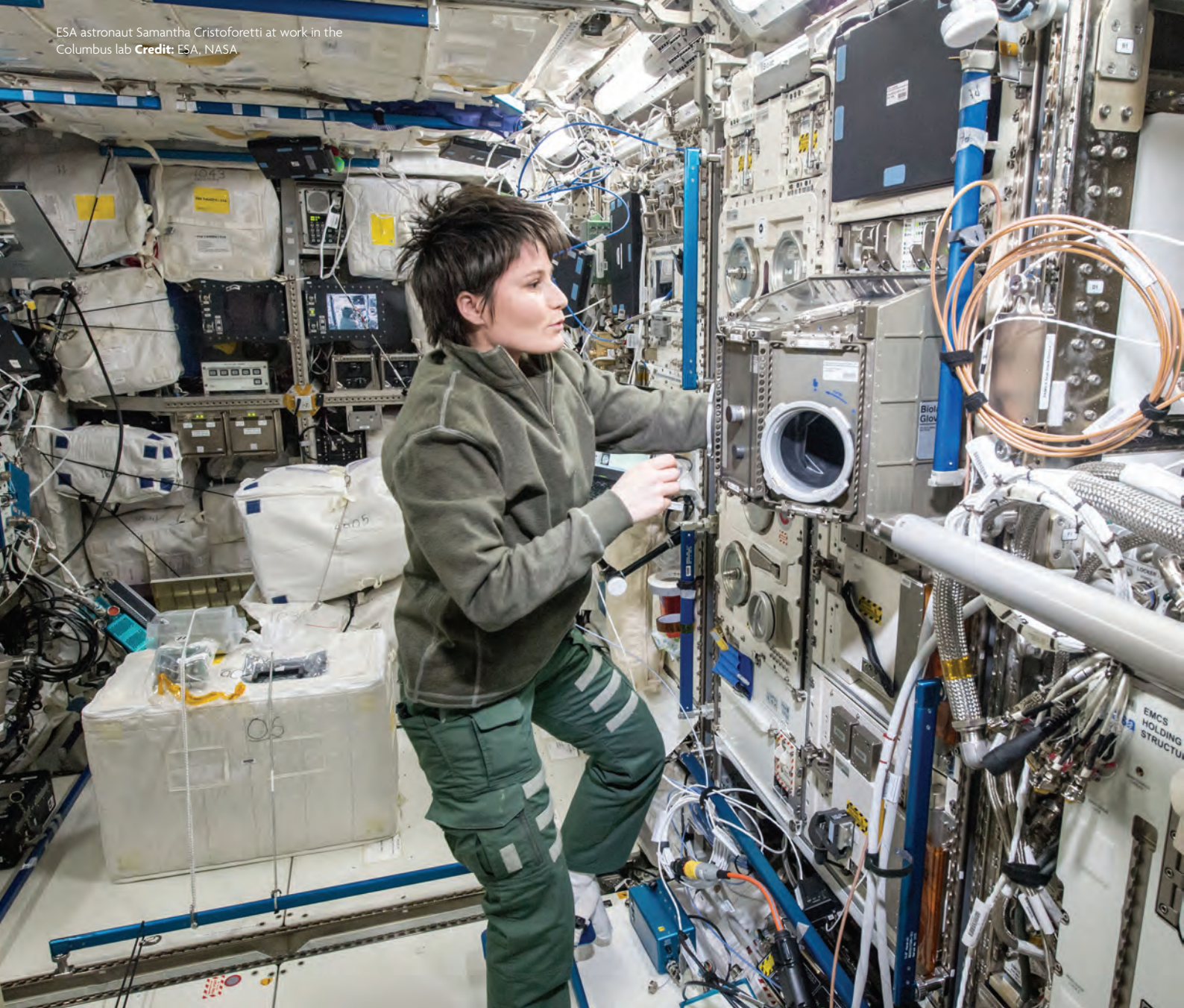
I'm not exactly young but at the same time I have a lot of experience on the Space Shuttle, and a lot of experience on the Russian side and on the space station, so when the Italian space agency told me they were looking for somebody with this kind of profile, I thought for a second and then said: 'Of course I'm available!'

NASA astronaut Kjell Lindgren corrals a supply of fresh fruit, recently delivered to the ISS by an automated Japanese spacecraft
Credit: NASA



Paolo Nespola inside the space station's cupola window **Credit:** ESA, NASA





Science in space

The International Space Station is an orbiting science laboratory equipped with a unique range of experiments, as Sarah Cruddas reports:

One of the most important reasons for exploring space is the scientific knowledge we gain. Tim Peake's mission to the International Space Station (ISS) will be no exception. During his stay 400 km above the Earth, Tim will work on more than 30 experiments in his role as the UK's first ESA astronaut.

The experiments will include biology, materials science, technology, medicine and even studies on the brain. Some

experiments will be unique to Tim, where he is the test subject. Others will have started long before he has arrived at the space station and some will continue long after he has left.

The research Tim will be working on will be carried out in the cylindrical Columbus laboratory – the first permanent European research facility in space.

Columbus is jam-packed with research equipment and outside platforms to support experiments in space science, Earth observation and technology.

This is an environment that cannot be recreated on Earth. It enables astronauts to take full advantage of microgravity, as well as the extreme radiation, vacuum and isolation of the space environment.

Unique lab

“The Columbus module on the ISS is a unique lab, with applications in many fields,” says Andrew Kuh, Human Spaceflight and Microgravity Programme Manager for the UK Space Agency.

“Medical experiments conducted here improve health for astronauts but also the health of people on Earth,” says Andrew. “Technology demonstrations have applications in industry and help us produce new products.”

Even the fundamental research is essential. “When research is driven by curiosity you never know where it will lead,” adds Andrew.

But Tim will not be conducting his experiments alone. At the Columbus Control Centre (known as Col-CC) near Munich, a large number of staff on the ground will oversee his work.

In a room, which Columbus Flight Director Simon Challis describes as looking “just like the set of Apollo 13”;



Columbus seen during a spacewalk in 2008
Credit: ESA, NASA

24-hour support will be provided to Tim. With a minimum of three staff working at any one time, they sit in an impressive control centre facing a big screen at the front and communicate using headsets.

The role of the ground crew here is to help Tim and the others conducting experiments. “We have a mantra,” explains Simon, “crew, vehicle, mission.”



A view of the Columbus Control Centre near Munich. In the foreground is ESA's TV commentator, Richard Hollingham, covering the launch of astronaut Andreas Mogensen Credit: ESA

continues >

Cool-headed

The role of the ground support staff is vital. “The experiments simply can’t be done without the ground crew,” says Libby Jackson, who used to work at Col-CC but now manages the UK Space Agency Education and Outreach Programme.

“What many people don’t realise is the experiments are run by the ground crew,” says Libby. “The team on the ground is responsible for making life in space for the astronauts as easy as possible, planning crew days in detail minute-by-minute seven days ahead.”

Tim will carry out these science experiments to a carefully planned schedule, working to a tightly controlled mission timeline. On some days his job will be like working in any other lab, except he will be able to float between experiments.

“Lucky he is a cool-headed guy,” says Andrew. “For some scientists he is carrying out their life’s work”.

During the day the team at Col-CC support Tim in case he has any questions, or if there are any problems. And of course the ground crew oversee



ESA astronaut Alexander Gerst with the Biolab experiment **Credit:** ESA, NASA

safety – essential if there is a fire or the space station springs a leak. But even when Tim and his fellow astronauts are asleep, experiments will still be going on.

“Experiments on the ISS are divided into two categories,” says Simon. “Ones where the crew are the subject and then

everything else.” For experiments where Tim is the subject, scientists on the ground will guide him. For example, the Energy experiments will see him having to eat a special diet and take regular samples of his own urine.



Tim training in Houston on the airway monitoring experiment. Astronauts have to carry out many experiments on themselves **Credit:** NASA

Mars rover

One of the most exciting experiments will see Tim use a console on the ISS to control a rover on Earth. The rover lives in the Mars Yard in Stevenage and Tim will guide it around, testing the robotics and communications.

The next generation of space explorers could use the knowledge gained from this experiment to guide a rover around the surface of Mars from an orbit above the Red Planet. This job is much easier closer to the surface than controlling rovers from Earth, where there is a time delay for commands.

Other science being carried out from the ISS involves experiments using the EXPOSE facility, which is mounted to the outside of the station. Microorganisms will be exposed to the space environment to investigate how they survive. “This will help us to unpick

where life could possibly exist in the universe,” say Andrew. “This could help us understand how life came to be here on Earth.”

Tim will also be carrying out plenty of educational experiments (see page 8), which he has described as “the benchmark” for all the activities he is engaging in.

Even after Tim’s mission has come to an end there will still be further British science experiments flying on the space station. “It’s great to see more British scientists getting involved as we progress with manned spaceflight,” says Libby.

Although Tim will be the only Brit on the space station, there will be plenty of others supporting him on the ground. “The focus is on Tim,” says Simon, “but

at ESA there are many British people working here, helping to make it possible.”

“When I was a kid growing up, I thought it was difficult to get into human spaceflight. Everything seemed to be in the USA,” Simon says. “The reality is that now Europe has a strong role with the ISS.”

Tim’s mission is just the tip of the iceberg. “The future,” says Simon, “is very bright for people in the UK who want to work in human spaceflight.”

“Medical experiments conducted here improve health for astronauts but also the health of people on Earth”

Andrew Kuh, UK Space Agency



Tim will be controlling a Mars rover – in Stevenage – from the ISS
Credit: Airbus Defence and Space

The (strange) rituals of spaceflight

After six years training Tim Peake knows how to fly a Soyuz spacecraft, walk in space, conduct experiments and even fix the ISS toilet. However, before he blasts off to the space station, he will have to take part in rituals that go back to the dawn of the space age.

Ceremony

Every astronaut that flies in a Russian spacecraft takes part in a number of ceremonies. These include paying respects to the first man in space – Yuri Gagarin – at the Kremlin Wall in Moscow, raising flags and planting trees. A priest even blesses the crew and spacecraft.

A long avenue of trees at Baikonur represents every astronaut that ever launched from the cosmodrome and provides a living monument to their endeavour. By the time of his launch, Tim will have planted his own tree.



A Soyuz crew – including ESA astronaut Andreas Mogensen (right) – leaves the crew bus for the launchpad **Credit:** ESA, NASA



ESA astronaut Samantha Cristoforetti signs the door of her room at the cosmonaut hotel in Baikonur **Credit:** ESA

Signing

In Russia most things have to be officially stamped and signed-for. Before he flies, Tim will have signed-off the spacecraft he is launching in – certifying it is fit for flight – the door of the room he sleeps in during his last night on Earth and a wall in the cosmonaut museum at Baikonur.

Coins

Russian rockets are rolled out to the launch pad horizontally, pulled slowly along a railway track. It is considered good luck for coins to be placed on the line to be crushed by the wheels of the engine.

On the other hand, it is thought to be bad luck for the crew to watch the roll-out of the rocket, so they stay away. In fact it is remarkable how much superstition is involved in launching hi-tech space rockets.

Cuddly toy

Just as some people have toys or fluffy dice hanging from the mirror in their car, so spacecraft have cuddly toys hanging from the instrument panels. As well as serving as mascots, the toys float in microgravity to show the crew that they have successfully reached orbit.

Urine

On his way to the launchpad in 1961, Yuri Gagarin needed to go to the toilet. Apparently (because no-one knows for sure) he got out of the bus and urinated against the back wheel. Ever since, in the spirit of tradition, cosmonauts and astronauts have been expected to do the same.

Incidentally the first American in space, Alan Shepard, had a similar problem. Unfortunately, he was already inside his capsule so had to urinate in his spacesuit. During later missions astronauts were issued with nappies.



Astronaut Reid Wiseman and the toy Giraffe he took into orbit **Credit:** Wiseman

Get involved

There are plenty of ways you can get involved in Tim's mission:

Launch party

Why not organise a party to follow Tim's launch to the ISS or join one of the many being organised around the country? To find an event near you or to download a launch event pack, visit the Principia website.

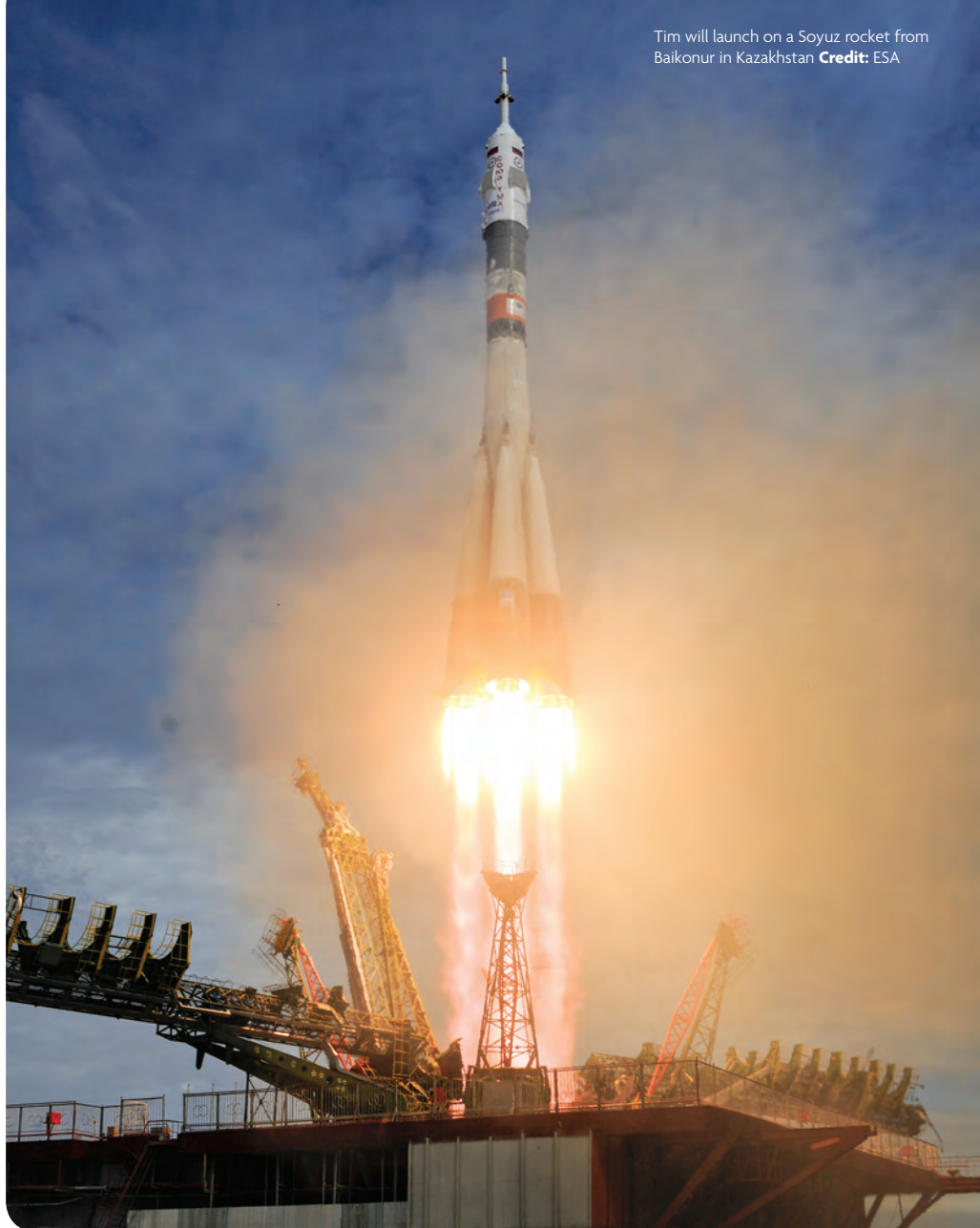
The launch, docking and hatch opening will be streamed live on the ESA website. The ESA coverage starts an hour before launch and includes expert astronaut commentary and insider video following all the launch preparations.

During his five-month mission Tim will be shooting videos and taking part in video link-ups with Earth. These will also be posted or streamed on the ESA website.

Follow Tim's launch here: www.esa.int



Inside the Lego Soyuz at London's Science Museum
Credit: UK Space Agency



Tim will launch on a Soyuz rocket from Baikonur in Kazakhstan **Credit:** ESA

Events

There are plenty of events being organised in the build up to, and throughout, Tim's mission – from film shows to lectures and interactive talks. The Science Museum in London even has a full-sized Lego Soyuz capsule on display. Find the details on the Principia website, where you can add any events you are organising.

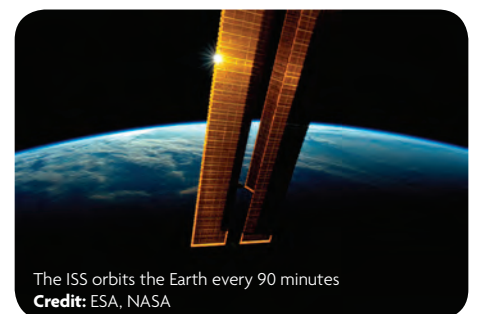
School and student activities

Tim's mission is packed with experiments, activities and events for students and schools (see page 8). There is still plenty of time to get involved in many of these projects. You could even make a short film to be shown in space. Find the details on the Principia website.

Spot the ISS

Around the size of a football field and orbiting 400 km above the Earth, on a clear night the ISS is easy to spot from the ground. The Principia website shows the current position of the ISS.

The ISS crosses almost every position on the Earth once every six weeks, so there are regular opportunities to see this incredible structure. You can even wave to the astronauts...they could be waving back!



The ISS orbits the Earth every 90 minutes
Credit: ESA, NASA



UK SPACE
AGENCY

Tim Peake's five-month Principia mission to the International Space Station (ISS) is supported by the UK Space Agency. The agency is at the heart of UK efforts to explore and benefit from space – one of the fastest growing and innovative sectors of the economy.

The UK is a world leader in many areas of space research, business and innovation. British scientists and engineers build and operate communication, navigation and Earth observation satellites. The UK is involved in missions to study our planet, explore other worlds and investigate the wider cosmos.

Tim Peake will be the first British European Space Agency (ESA) astronaut to visit the ISS. On board the station he will carry out valuable scientific research and an extensive range of education activities – helping to inspire a new generation of scientists, engineers, mathematicians and space explorers.

principia
MISSION

