UK SPACE AGENCY

Impact Assessment: UK Space Agency Principia Campaign

Measuring the effectiveness of the Principia campaign and its impact on the nation.

Liftoff: the Soyuz TMA-19M rocket carrying Flight Engineer Tim Peake at the Baikonur Cosmodrome in Kazakhstan. Credit: NASA.

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Tim Peake at the Science Museum, London, on his post-flight tour.

FOREWORD

Every astronaut has things they want to achieve during their precious time in space. When I was assigned to a long duration mission to the International Space Station, I knew that I wanted to share the experience with as many people as possible and maximise this valuable opportunity.

Mission Principia was a unique chance to engage a young audience in science and human spaceflight. My career would not have been possible without a background in science and technology, so I wanted to help show young people how they too can increase their opportunities in life by taking an interest in STEM.

Fortunately, this matched the objectives of the UK Space Agency and I was delighted to support their wide-ranging programme of activities from horticulture and literacy to food and fitness – all of them based around STEM in some way. A staggering 33 million people engaged with the mission, with over 2 million students taking part in educational projects. This was only possible thanks to the efforts of the UK Space Agency, ESA and the dozens of partner organisations who embraced the potential of this mission.

Being able to interact with students directly from space and witness the impact was a highlight of the mission for me. Since returning from the International Space Station, I have been overwhelmed by the positive response to mission Principia and the way that it has changed people's attitudes towards science and space exploration. It is very gratifying to read this report and I am confident that the wider effects will be felt across all parts of the UK far into the future. Principia was far more than a mission to space, it was a journey of inspiration.

Tim Peake
European Space Agency Astronaut

Tim Peake meeting school children in Cardiff during his post-flight tour in September 2015.

EXECUTIVE SUMMARY

Tim Peake, the second British astronaut and the first to fly with the European Space Agency, spent six months in space as part of the Principia mission. Between 15 December 2015 and 18 June 2016, he lived and worked on the International Space Station carrying out scientific experiments. The UK Space Agency sought to capitalise on the interest in this mission, change how people thought about space and use the opportunity to engage and influence the next generation of scientists and engineers.

The UK Space Agency invested in this vision by running an extensive £3m programme of educational activities. The aim was to have: *A national celebration for everyone in the UK to engage with if they wish, inspiring greater interest and understanding of STEM in general and UK space matters in particular.*

The programme encompassed 34 separate education projects, mainly aimed at young people, and a series of communications activities that focused on key parts of the mission. The activities in the education programme covered a spectrum of ages and subjects, such as mass participation experiments in schools using seeds that had been in space. The communications activities crossed all platforms, with events across the UK, press conferences, and television and radio programmes.

This report summarises the campaign activities and describes the impact of the Agency's communications and education programmes on the public perception of space and particularly on young people. It explains how these impacts were assessed and shares lessons learned to inform future work inside and outside the UK Space Agency.

The key performance indicator in the UK Space Agency's 2014 to 2015 Corporate Plan was to: *'Exploit the education and inspiration value of the UK astronaut mission to the International Space Station in 2015 and reach 20 million people via press and media interventions'.*

As a result of the campaign, more than 33 million people engaged with the mission. Over the course of the Principia mission the UK public perception of space changed, with a 6 percentage point increase in the proportion of people recognising that space plays a vital role in the UK's economy. The changes in attitude were not just in terms of human spaceflight, but in areas such as satellites and space science as the mission was used to highlight the whole space sector and the importance of space to our everyday lives.

The education programme was the largest and most successful educational campaign to be organised in support of any European astronaut mission to date. By the end of 2016, at least 1.6 million young people had taken part in one or more of the 34 education projects across approximately 10,000 schools - equivalent to around 15% of all school children and one in three schools in the UK. These numbers have continued to grow since the calculations were made. Individual projects live on beyond the funding periods and the total number of young people who took part in education programme activities is now believed to be over 2 million.

Longitudinal analysis showed that, overall, attitudes of young children towards science subjects remained positive throughout the mission, in contrast to wider evidence that shows an expected downward trend as pupils progress through school. Among individual schools and pupils, there were statistically significant upward trends, with both schools and individuals reporting clear positive impacts on young people's attitudes.

This report concludes that the programme achieved its objectives and met all its performance indicators. During the course of the programme, awareness of the space sector among people across the country increased to 43%, with an increase of 6% agreeing that the space industry is important for the growth of the UK economy. It encouraged interest in science, technology, engineering and maths, collectively known as STEM subjects, as well as supporting other government objectives such as improving diet and fitness among young people. Finally, it provided a legacy of educational resources, using space as a context for teaching and learning, that continues to inspire children and teachers today.

Tim Peake at launch announcement press conference.

PURPOSE OF THE REPORT

The UK Space Agency compiled this report to:

Record the UK Space Agency's work and activities supporting Tim Peake's Principia mission on board the International Space Station (ISS) 2015 to 2016

Review the impact and legacy of the Agency's education, outreach and communications activities in relation to public investment in the mission

Identify lessons learned and make recommendations for any potential UK Space Agency campaigns in the future

This report does not aim to evaluate or review the complete investment of the UK in the ISS and related science programmes, though for information a brief synopsis of activities is included. An evaluation of the science programme will be undertaken as a separate exercise.

CAMPAIGN OVERVIEW

In May 2013, the European Space Agency (ESA) assigned British astronaut Tim Peake on a six-month mission to the International Space Station (ISS). Scheduled to fly in late 2015, Tim would become Britain's second astronaut and the first to be supported by the UK's participation in ESA's ISS programme.

The mission was expected to generate significant public interest and the UK Space Agency wanted to capitalise on this enthusiasm. The Agency wanted to use the platform to benefit the UK space sector through two complementary objectives: to encourage interest and uptake in STEM (science, technology, engineering and maths) subjects and careers in the space sector by giving students and individuals across the UK a chance to be a part of Tim's mission; and to increase knowledge and awareness of the space sector and the benefits it brings to the general public.

The ambition was to reach everyone, whatever their current level of interest, and was set out in a vision statement:

A national celebration for everyone in the UK to engage with if they wish, inspiring greater interest and understanding of STEM in general and UK space matters in particular.

The communications programme covered the mission's publicity, social media and major events, working with the UK and international media to relate the story of Tim's training, preparation for flight and his time in space.

The education programme delivered a broad selection of activities and projects connected to human spaceflight and the Principia mission that could be used by teachers, home-educators, extra-curricular groups, families or any other interested parties.

Both programmes were coordinated and delivered hand-in-hand with ESA's Communications and Education departments. Teams at ESA helped scope and manage Tim's time in Europe and provided an interface with the wider ISS community. The UK Space Agency created specific activities and mission milestones within the UK.

Unlike most other ESA astronaut flights, the UK was unable to support the Principia mission with a national programme of science experiments due to the limited time between the UK joining the ISS programme and the announcement of Tim Peake's flight. However, UK scientists were part of the science teams for a number of experiments and the UK sought to highlight these contributions through the communications programme

Tim Peake talks to students during an ARISS radio and video call at the Oasis Academy, Brightstowe, Bristol.

EDUCATION PROGRAMME

Introduction

The UK Space Agency's Education, Skills and Outreach Strategy[1] aims to use space as an inspiring context for teaching and learning in order to encourage young people to study STEM subjects and to follow STEM-related careers. This is intended to increase the pool of talent available to both the wider UK economy and to space sector employers who are struggling to recruit the skilled workers they need.

It has been obvious since the beginning of human spaceflight that, while space has a unique ability to engage many young people, the human interest provided by astronauts increases this enormously. The Apollo Moon landings are often cited as the greatest technological achievements of humankind, with the first human in space arguably regarded as an equal achievement. Both still capture the imagination in a way that the first spacecraft does not.

When the first British astronaut, Helen Sharman, flew to the Mir space station in 1991, it had not been possible for the Government to capitalise on the education opportunity since she flew as part of a commercial (non-government) mission and because Government policy at the time did not support human spaceflight. Instead the Agency's predecessor, the British National Space Centre, focused its modest education activities primarily on areas which aligned to its strategy, namely robotic spacecraft missions, carrying out astronomy, space science and Earth observation.

With Government support (through ESA) for Tim's mission, the Agency recognised a new opportunity for increasing levels of science engagement across the UK and a chance to expand its education and outreach offerings into the life sciences (medicine, physiology and biology), as well as areas of human interest such as health, diet and fitness.

Given the recognised need to increase the uptake of STEM subjects to support the needs of UK employers and the ambitious growth targets of the UK space sector, the Agency set about planning to capitalise on this unprecedented opportunity to use space to inspire interest in science and technology among young people.

In this section we describe the objectives of the education programme, how it was delivered and the impacts it created. We also draw out lessons for the future.

Objectives

The objectives of the education programme were to:

- Create a national programme across all parts of the UK including its more remote regions
- Support a broad range of curriculum subjects, not just traditional STEM subjects, but also subjects such as sports, health, art and literacy
- Appeal to all school-age children and to inspire interest in careers in science and technology generally
- Be inclusive and diverse e.g. by making sure outreach activities were aimed at the general public, especially those less likely to be engaged in science or space such as girls or those from disadvantaged areas
- Include both formal and informal education activities

The Principia education programme was aimed at a wide audience. The main targets were:

- Outreach to the general public, especially those not usually engaged in science or space
- Formal education, especially primary level
- Students considering careers in STEM or space

As a coherent programme, it was important to consider how each group led to the next. Having engaged young children at a science centre, for instance, the next step

[1] UK Space Agency Education and Skills and Outreach Strategy (April 2011): https://www.gov.uk/government/publications/uk-space-agency-education-skills-and-outreach-strategy, now succeeded by the updated version: https://www.gov.uk/government/publications/uk-space-agency-education-skills-and-outreach-strategy-2016

would be to ensure that there were opportunities to build their interest in STEM in schools. For those that decided to continue their studies into STEM A-levels or university degrees, it was important to signpost routes into careers in the UK space sector.

To achieve the greatest impact, the programme would have to link into as many different subject areas as possible. Previous projects provided excellent links to physics and maths, but had a limited audience. By broadening the remit to include such things as nutrition, gardening and literacy, it was possible to deliver science content to a much wider audience. This approach is especially effective for engaging members of the public generally uninterested in science and the very young, who see no boundaries between science and non-science topics. It also works well in primary schools where individual teachers have to teach the whole curriculum, and can combine topics from different subject areas under the inspirational theme of space.

It is clear from recent studies, most notably the ASPIRES research[2], that children under the age of 10 are an important audience, since they have not yet decided that STEM subjects are 'not for them'. In addition, few teachers in primary schools are science specialists and so are likely to need more support teaching subjects that appear technical, such as space. For these reasons it was planned from the outset that the programme would contain a strong emphasis on primary education.

The ASPIRES research also emphasised the importance of informal learning outside schools and the need to incorporate messages about future careers as part of educational activities. As a result, a second strand of the programme included a significant emphasis on informal education (for example, through family visits to science centres). Using this research, the aim was not just to engage young children, but also the adults who influence their career choices. By bringing them together in this way, these adults would be able to reinforce rather than

[2]https://www.kcl.ac.uk/sspp/departments/education/research/ASPIRES/ASPIRES-final-report-December-2013.pdf

undermine messages about how studying STEM subjects increases career opportunities.

At secondary level, with the constraints and demands of the curriculum and exams, it is harder for schools to find the time to bring in new areas of study, so the emphasis here was to create focused resources to help teachers deliver existing curriculum topics within an exciting context. Again there was an opportunity to help teachers by including STEM career messages alongside the science content.

There was less need to engage people at further and higher education since, by this stage, most students have already decided whether or not to pursue a STEM career. But it was still necessary to demonstrate the opportunities of a career in the space sector. Employers in the sector were encouraged to use the attention of the Principia mission in the media to promote their own areas of endeavour in order to highlight these opportunities. The Agency also embedded messages about career opportunities throughout its communications and Tim Peake himself agreed to be an ambassador for careers in the space sector.

Budget and targets

The education activity for the Principia mission spanned two reporting years: 2014 to 2015 and 2015 to 2016.

The education Key Performance Indicator (KPI) from the Agency's 2014 to 2015 Corporate Plan[3] was to:

'Deliver an effective education, skills and outreach programme for 2014 to 2015 including ESERO (European Space Education Resource Office); Space Academy; Space for All; Mission-X'. To measure this objective, the metric was set to: 'Engage over 80,000 people in space education, skills and outreach activities, by Quarter 4'

The KPI from the UK Space Agency's Corporate Plan in 2015 to 2016[4] was to:

'Exploit the education and inspiration value of the six month Principia mission to the International Space Station' by 'engaging 400,000 young people in education activities related to Tim Peake's mission by Quarter 4'.

The announcement of Tim's mission, in May 2013, was too late to secure dedicated funding for the 2013 to 2014 financial year (FY). The Agency was able to allocate a budget for its education programme of £400,000 for FY 2014 to 2015 and envisaged at least similar funding levels for 2015 to 2016. The Agency successfully bid to Treasury for a further £2m over two years, which would also include contributions towards communications spending of £150,000. This was announced in the Chancellor's 2014 Autumn Statement and brought the total budget to around £3m over 3 years for the education programme.

Table 1: Education Programme Budget

Financial Year	UK Space Agency Budget	Autumn Statement funding	Total
2014 to 2015	£ 400,000	-	£ 400,000
2015 to 2016	£ 370,000	£ 1,095,000	£ 1,465,000
2016 to 2017	£ 404,000	£ 780,000	£ 1,184,000
Total	£ 1,174,000	£ 1,875,000	£ 3,049,000

[3] https://www.gov.uk/government/publications/uk-space-agency-corporate-plan-2014-to-2015

[4] https://www.gov.uk/government/publications/uk-space-agency-corporate-plan-2015-to-2016

Delivering the programme

Once a plan and funding was in place, the Agency appointed a programme manager to oversee the work and sought partner organisations to deliver the projects and agree project objectives. The Agency had to ensure effective delivery and act as the main source of information on the technical aspects of the ISS. To avoid conflicts and confusion, the UK Space Agency acted as the single point of contact with ESA on all of these education projects – requiring a great deal of coordination and information management among the many partners – but ensuring a smooth process for agreeing demands on ESA for payloads (items that would fly to the International Space Station), crew time on the ISS, use of Tim's time before and during his mission, and other details.

Programme Content

Preparation work began in earnest in 2014. The immediate focus was on projects that would see items flown in space. The Great British Space Dinner, a competition for children to design a menu for Tim, had to be launched first because of the time needed to develop new foods and deliver them to the ISS before Tim's arrival. Heston Blumenthal would use the winning entries to create the dishes and Tim would eat them in space.

Partners were also identified for three major projects that would send hardware into space: Rocket Science (seed-growing experiment), Astro Pi (coding challenge) and Astro Academy Principia (physics demonstrations).

After the award of the autumn statement funding5 in 2014, work began on two major projects directly enabled through this funding: Destination Space (family shows, schools workshops and activities in science centres) and the *Tim Peake Primary Project* (hands-on support for primary teachers to deliver space activities). There were also planetarium shows planned for use across the UK and the *Space to Earth Challenge* (a fitness project building on the successful *Mission X* programme, a challenge aimed at primary schools that involved fitness activities, encouraging the participants to 'train like an astronaut'). Another nine grants were awarded through an open call in July 20156 and schools were invited to bid for funding to run their own small projects linked to the mission.

Destination Space being delivered at The Observatory Science Centre

In May 2016 a further call for projects was announced, with the aim of building on the successful mission and maximising impact and reach. Many existing partners applied to extend their projects, and two new projects were also funded: interactive displays at the Aberdeen Science Centre and the Novium Museum in Chichester.

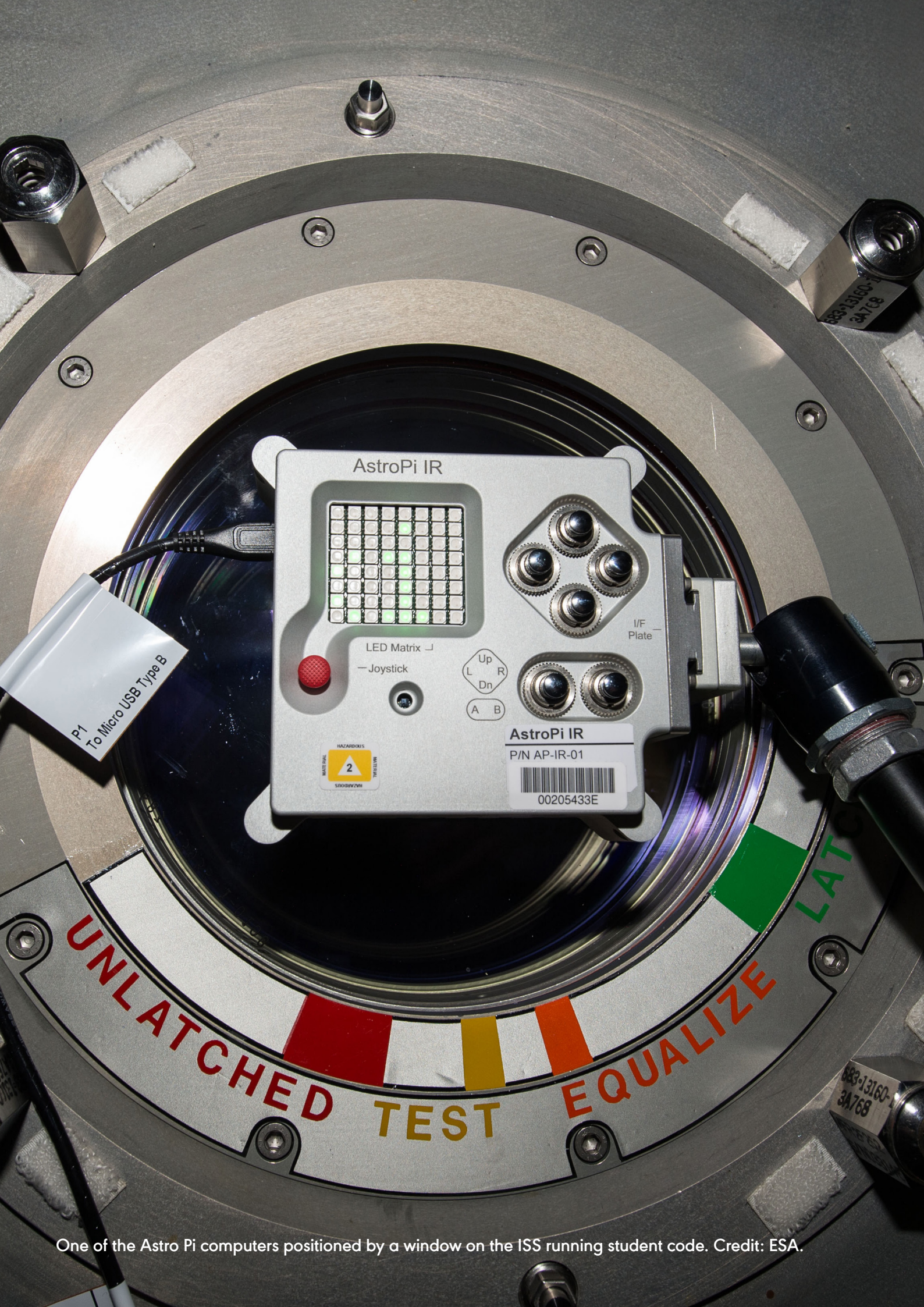
To provide a grand finale and celebration of the huge amount of work completed by UK children, the UK Space Agency organised two Principia Schools Conferences. These intense two-day events, conducted in November 2015 by the Universities of Portsmouth and York, attracted over 750 students from 5 to 19 years old. Each student presented the results of their work to their peers and experts as if participating in a professional science conference, helping to break down the idea that science is something that other people do.

All of the education projects were available via the UK Space Agency's Principia mission campaign site (now archived: www.principia.org.uk). ESERO-UK still hosts the Principia resources and many projects also have their own repositories.

A list of the Principia education projects is included in the Table 2 and further details of the outcome of each project are given in Table 3 on page 28. Final reports are available on request from the UK Space Agency.

[5] https://www.gov.uk/government/publications/spending-review-and-autumn-statement-2015-documents

[6] https://www.gov.uk/government/news/uk-space-agency-brings-astronauts-mission-to-children-across-uk



One of the Astro Pi computers positioned by a window on the ISS running student code. Credit: ESA.

Table 2: Principia Education Projects

Project	Organisation	Brief description of project	Age range	Subjects covered
Aberdeen Science Centre Exhibit	Aberdeen Science Centre	An interactive lab module, modelled on the Columbus research module of the International Space Station, where visitors can participate in a range of hands-on STEM activities and challenges.	All	STEM
Adventures in Space and Tim podcast	Helen Keen (with Centre for Life)	6 podcasts hosted by comedian and space enthusiast Helen Keen.	All	Science, technology, engineering
Amateur Radio on the ISS (ARISS) calls	Amateur Radio on the ISS (ARISS)	10 schools won a competition to speak to Tim Peake during his stay on the ISS using amateur radio equipment.	5 to 18	STEM, cross-curricular
Astro Academy Principia	National Space Academy	Online resources and CPD (Continuing Professional Development) sessions used demonstrations filmed on board the ISS to teach fundamental physics and chemistry.	11 to 18	Physics, chemistry, maths
Astro Pi	The Raspberry Pi Foundation and UKspace	A series of coding activities in schools, alongside three coding competitions for students to develop code to run on the two augmented Raspberry Pi computers (Astro Pis) on the ISS.	7 to 16	STEM, coding, music
Astro Science Challenge	Unlimited Theatre	An interactive space adventure using online films, stories and activities to get youngsters to take on missions where they learnt about space, weather, astronomy, computer coding and nutrition.	7 to 11	Cross-curricular, including numeracy, literacy and coding.
Astronaut Handbooks	Usborne	A guide to becoming an astronaut full of funny and fascinating insights. An abridged copy of the full version of the book was created for the Agency and is also available as a free download.	4 to 14	Literacy, STEM
Biorock	University of Edinburgh	Teacher lesson plans developed around the Biorock experiment (looking at the effects of microgravity on microbes). Tim filmed a supporting video while on the ISS.	11 to 18	Biology
Cosmic Classroom Inflight call	TES Global	A live one-hour lesson and Q&A by Tim, linked from space to the World Museum in Liverpool, live streamed on the internet into schools and supported by teaching resources.	4 to 11	Science

Project	Organisation	Brief description of project	Age range	Subjects covered
Destination Space	The UK Association for Science and Discovery Centres	A series of family shows, workshops and other events linked to the Principia mission.	5 to 14	STEM, physics, chemistry, biology, maths, engineering
Earth Observation Detective	National Centre for Earth Observation	A series of curriculum-linked classroom resources featuring Earth observation images and scientists, including a competition to choose a place on Earth for Tim Peake to photograph from space, interactive games and an app.	4 to 18	Science, geography, maths, computing
The Great British Space Dinner	British Nutrition Foundation with Heston Blumenthal	Youngsters designed a healthy balanced menu for Tim Peake to eat in space.	4 to 14	Science, maths, design & technology, PE, PSHE, nutrition/home economics
I'm an Astronaut, Get Me Out of Here	Gallomanor	Students chatted online with engineers, scientists, technicians, astronaut instructors, medics, flight controllers and other individuals who were involved in the Principia mission.	7 to 18	Physics, chemistry, biology, design & technology, engineering, maths
Into Film: Into Space	Into Film	A competition, supported by workshops and events, where young people created short films or animations, inspired by the Principia mission. STEM ambassadors delivered career talks, mainly in schools but also at public events.	5 to 19	Storytelling, digital literacy, film
Into Film Festival Talks	Into Film with space sector support	Screenings of 'Space Station 3D' and a 'Beautiful Planet' took place across the country as part of the Into Film Festival, accompanied by a talk from someone in the space industry	5 to 19	STEM, space outreach
Marvin and Milo cards	Institute of Physics	Postcards featuring experiments developed by the Institute of Physics to encourage young people to engage in physics.	4 to 11	Physics
Mission Starlight	Royal Society of Chemistry	A global experiment to investigate materials that block or reduce UV light.	7 to 16	Chemistry
Mission X 2015 to 16	Venture Thinking	Developed by NASA and ESA scientists and fitness professionals, to inspire students to learn about the science of nutrition and exercise and to increase their activity levels. The programme was open to schools around the world.	7 to 14	Physics, biology, technology, mathematic, PE, PSHE

Project	Organisation	Brief description of project	Age range	Subjects covered
Novium Tim Peake exhibition	Novium Museum	An exhibition about Tim Peake including his training and life on board the ISS, accompanied by a series of workshops, loan boxes and sleepovers for youngsters.	All	STEM
One Giant Read	Literature Works	A project with a space and STEM theme where participants shared their reading experience online to explore how science fiction inspired science fact. There were also book reviews and interviews with scientists.	11 to adult	Literacy, English
Planetarium shows	British Association of Planetaria	High resolution, photo-realistic images of the ISS screened across the UK in large, static and small, mobile planetarium domes.	All	Science
Principia Schools Conferences	UK Space Agency	Two conferences held in Portsmouth and York to showcase the work done by students across the UK who had participated in a Principia project.	4 to 18	Cross-curricular
Rocket Science	Royal Horticultural Society	An experiment where participants compared the growth of rocket seeds that have been to space with seeds that remained on Earth to investigate the effects of space on plant growth.	4 to 18	Science, maths, horticulture, citizen science
Royal Institution Lectures teaching resources	Royal Institution	A series of lessons for primary and secondary schools with teaching resources produced by The Royal Institution based on their popular 2015 Christmas Lecture, *How to Survive in Space*, delivered by Dr Kevin Fong.	7 to 16	STEM
School grants	ESERO-UK (European Space Education Resource Office for the UK)	ESERO-UK grant scheme allowed schools to bid for up to £6,000 to support their own Principia related activities.	4 to 18	Cross-curricular
Principia Space Diary	Curved House Kids and Lucy Hawking	The Principia Space Diary allows children to make their own book as they research Tim's mission. Schools can access the entire Space Diary online for free. There are also lesson plans, teaching materials, games and extension activities.	4 to 11	Primary science and literacy with secondary links to geography, PE, DT, SMSC (Spiritual, Moral, Social and Cultural Development) and maths

Project	Organisation	Brief description of project	Age range	Subjects covered
The Space to Earth Challenge	The Ideas Foundation	A challenge for students to use Tim's training regime to run, swim, cycle, climb, dance or exercise the 400 km distance from the Earth to the ISS orbit.	7 to 18	PE, science, maths
Speak to Peake	BBC Wiltshire	Before Tim's flight, BBC Wiltshire ran a competition for local schools. Students suggested questions to ask Tim. Selected pupils visited the UK Space Agency and put their question via Skype to Tim while he was training in Houston.	5 to 18	STEM
STARS project	Astrobiology Society of Britain	Scientists from 13 different institutions went to schools to give talks and workshops on Tim Peake's Principia mission, life aboard the International Space Station, astrobiology and the prospect of becoming an astronaut.	7 to 16	Biology, chemistry, science
Team Tim	Spacefund	Trained presenters delivered interactive science shows and featured 'live' satellite interviews with Tim.	4 to 11	Science, maths, coding
Three Minute Learning	University of Glasgow	An online resource for schools with short stories on space, science, engineering, arts and society, most of which were based on interviews with Principia personnel, including Tim.	11 to 16	Science, literacy
Tim Peake Primary Project	ESERO-UK	A range of organised space activities which included professional development for teachers and information on career opportunities in maths and science. A network of space ambassadors provided support.	4 to 11	Science, maths, English, geography, history, music, art, ICT, PSHE
TimPix	Institute for Research in Schools	Schools were offered the opportunity to carry out their own research using radiation data from Timepix detectors (based on technology from CERN) on board the International Space Station.	14 to 18	Physics, maths
Zero Robotics	European Space Agency	The *Zero Robotics* tournament turned the ISS into a gaming arena for football-sized satellites in a virtual field filled with obstacles. Students competed against each other, writing code to control satellites on the space station.	14 to 16	Coding, maths

Impacts of the programme

A programme as large and varied as this required careful evaluation to assess the reach and impact. This section explains the techniques used and the outcome of the review.

Review methodology

The Principia education programme consisted of 34 different projects that varied significantly in scope, size, and audience and delivery mechanism. It was a requirement that each project had an evaluation strategy in place. Each provided a final report to the UK Space Agency, detailing the reach and impact using metrics appropriate to the individual project.

Each project could then be judged on its own merits for impact and value for money but to review the education programme as a whole two studies were commissioned, one looking at the total immediate reach, the other looking to see if any longitudinal effects could be observed. These studies are described from page 30, along with some notes on the limitations of the data on which they are based on page 32.

A further section from page 32 describes the legacy of the programme.

Finally, to assess the overall impact, the UK Space Agency has combined all of these sources, together with data from the communications studies, and performed an overall assessment which is detailed from page 35.

Individual Project Outcomes

The UK Space Agency reviewed the outcome of all the education projects associated with the Principia education programme. Listed below in Table 3 are the audience engagement figures for individual projects, with the funding they received from the UK Space Agency as well as contributions from elsewhere. The table also lists the target audience against actual audience figures. Note that these audience figures are the number of pupils who took part in each activity and do not include wider audience reach through media or social media coverage, which are usually significantly larger figures.

Audience figures, however, cannot truly give an overall picture of the success and impact each of these projects, as the amount of time spent by each of the target audiences varies from short visits to intensive long duration projects. Details of the outcomes of each project are summarised below and in detail in each of the projects' final reports, which are available on request from each organisation or the UK Space Agency.

When considering the budgets of each programme, it is important to note that all project partners provided some amount of in-kind staff time towards the projects and many people also contributed unpaid work hours, so the contributions from the projects are higher than the funding values reflect.

Overall, the vast majority of the Principia education projects can be considered successful, and in some cases the projects greatly exceeded expectations and targets. A few did not reach as many people as planned, but still reported significant benefits to their audiences.

The stand-out highlights of the programme were the projects that delivered sustained engagement, high impact for large numbers of people and overall value for money. *Rocket Science*, *ARISS* and the *Principia Space Diary* were all very successful in these areas. All three

ARISS

"In February 2016 the Royal Masonic School for Girls arranged a live radio link with video to Tim Peake while on-board the ISS. We utilised this opportunity to arrange a number of events to inspire students about STEM subjects and their relevance to careers.

"As many of these girls are now approaching Year 12, we have seen a dramatic increase in the number of girls registering interest in A-level physics. When asked why they wanted to study physics, girls and parents alike quoted that the initial interest came following the ARISS event where they made the live radio contact with Tim Peake. They stated that it was 'nothing short of inspirational' and that their interest simply grew from this time.

"The potential number of girls opting for A-level physics has more than doubled, and interest in taking astronomy GCSE has also increased with record numbers of girls registering their desire to study the course.

"Furthermore, our Head Girl last year went on to study physics at Durham and another former A-level student when on to study aeronautical engineering at Imperial College London. Both girls amended their original choices for university courses stating that the ARISS event had swayed their opinion towards these courses rather than their initial route."

Carol Black, The Royal Masonic School for Girls, Rickmansworth, one of the schools awarded an ARISS call

projects delivered engagement that was sustained, deep and well received by teachers as well as reaching large numbers for the cost expended.

The *Rocket Science* experiment had over 600,000 young people take part in a two-month long national experiment and overall teacher feedback was incredibly positive. This project delivered good curriculum-linked education that resulted in a real scientific experiment, using a modest budget and yet reaching four times the target audience. The appeal of interacting with something that had been into space, applying scientific processes and skills from start to finish in a large scale, real life, national experiment was of huge appeal to teachers and other educators. Some of this success came from working with a new partner who had complementary objectives but in a different subject area: each partner learnt from the other's existing audience to increase the reach of the project.

The *ARISS* in-flight calls were also a great success, significantly changing attitudes within the schools that took part. The scale of operation exceeded plans thanks to the huge enthusiasm and tenacity of the ARISS team, all of whom work on the project as volunteers. They lobbied for more link-ups, succeeding in getting ten for the UK instead of the usual three. Prior to the *Principia* mission, the UK had completed approximately twelve such contacts since the ISS ARISS programme became active in 2001, with the last direct contact with an astronaut on the ISS in 2009. Through the application process, schools had to demonstrate how they would maximize the education value of the link-up, and thus those schools that were awarded calls had ambitious plans and understood the value of what they were awarded. Feedback from schools show that the experience had a lasting legacy, and in some cases transforming the numbers of pupils taking STEM subjects at A-Level by orders of magnitude.

The *Principia Space Diary* has reached over 95,000 students so far, having been funded in two stages. Following the first year of the projects, it was clear from feedback and implementation that the curriculum-linked, cross-curricular project was being well-received by teachers, and so further funding was awarded to increase the reach and ensure a legacy version of the project would be available beyond the Principia mission. Feedback from teachers and home educators shows that students felt ownership of their diaries, taking them home and talking to their parents about the work, and educators plan to continue the project with future year groups.

ESERO's *Tim Peake Primary Project* also delivered sustained engagement over an entire academic year and was the key formal education component of the programme, with about one quarter of the total budget.

Principia Space Diary

"Initially I signed up for the project when I was an learning support assistant in a special school for boys with Autism. I wanted to use the diary in the class I was working in. By the time the program started I had accepted a promotion within the school which entailed providing targeted work to young people struggling with learning. The pupils all have Educational Health Care Plans and their learning has had numerous disruptions.

"The Principia Space Diary has been a valuable asset to my new post and the boys have loved it. The boys are mostly older than the targeted age groups but are educationally functioning at the learning levels that the diary covers. To begin with I started with only a few boys but the projects have been so popular that different groups have asked to be included. Some boys have even carried on with the work in their own time.

"Literacy is often slow to develop or absent in many children with autism and the diary has been ideal in developing the skills in an age appropriate way, keeping the boy's interest. I have noticed that the boys have had an increased concentration span and it has provided opportunities to experience and express meaningful communication. Many of the boys suffer impairments relating to social interaction and communication and the diary has provided a common link and a way of starting conversations at other times within the school day. "

Anne Logan

The project's final external evaluation, which used qualitative and quantitative data generated using surveys, telephone interviews, and face-to-face interviews with Space Ambassadors and teachers who had participated in the project, reported that the project "directly increased pupils' enjoyment and engagement in science, numeracy and literacy; increased pupil attainment in science; and increased teachers' confidence in teaching space-related topics and using space as a cross-curricular context for teaching". The project was among the more expensive ones, with a total spend equating to approximately £3.50 per pupil over the year. However, this is excellent value in view of the year-long engagement by primary schools and conclusions that the project had "a positive impact on pupils' enjoyment, engagement and attainment in science and, to some extent, in other areas of the curriculum" and "helped to improve teacher confidence in teaching space topics and raised the profile of science in schools". The impact is also not expected to be limited to one year, as we expect that the teachers will carry the skills and knowledge through to new classes in further years, and ESERO report that their space ambassadors are still working with schools even though the funding and project has formally ended.

The key project for *informal* education was the *Destination Space* project, also accounting for about one quarter of the overall spend on projects. This project successfully engaged family audiences, highlighting career opportunities and developing science capital across large numbers for a modest cost per engagement. Overall (as of February 2018) 914,646 children and adults participated in *Destination Space* taking part in the school workshops, family shows or at events to celebrate Tim Peake's launch and safe return from space. Teachers reported that the standard of the workshops was very high, and that about half of all young people taking part in the workshops reported that their activities had made them more interested in pursuing science options in the future. The project evaluation found that the programme reached people throughout the UK and that enjoyment of the programme was the same regardless of gender or background. The project reached a higher proportion of students from areas and schools high on the indices of multiple deprivation compared with the general population and slightly more girls than boys.

Cosmic Classroom completely changed the concept for a live link-up with schools. Historically these events have usually been focused on an individual school or a single room with little impact beyond those physically present at the event. In contrast this event delivered huge audience numbers of over 400,000 people through video streaming and at a modest cost, providing an hour of inspiring science engagement for just a few pence per child. The key to this was a collaboration with TES

Global, who had a large existing network of schools and an ambition for a major national broadcast. While there is anecdotal evidence of its impact in schools, further data was not captured, in part because of the very short interval between getting approval for the live link to the ISS and the date of the event itself.

These big national projects, providing the bedrock of the campaign, were augmented by successful local projects across the regions and helped to provide local connections. *Team Tim, STARS, Speak to Peake* and the *Aberdeen Science Centre Exhibit* all delivered to higher audience numbers than expected and reported good outcomes. *STARS* reported that students continued to talk about the things they had learnt for days afterwards. *Team Tim* reported that the ratings for both the question "Do you think Team Tim will have a lasting impact on the pupils?" and the statement "We have been inspired with science" scored an average of 4.9 out of 5.0 in both cases. The *Aberdeen Science Centre Exhibit* reported extremely positive increases in awareness of space, with 71% of visitors stating that they felt more confident about science in general.

The *Planetarium Clips* produced were provided to many local organisations through the British Association of Planetaria. 71 separate facilities downloaded the 12-minute suite of clips and these have been seen by over 220,000 people. 78% of these visitors were through mobile outreach domes, of the type used in schools, and overall viewing figures showed that 70% of the total audience was primary school children and 11% were secondary school children, with proportionally more pupils eligible for free school meals (FSM) and a higher proportion of pupils whose first language is not English (EAL) than that national average.

In addition to these local projects, individual schools were able to create their own activities supported by the *Schools Grants* scheme. This was administered by ESERO-UK, who were also running the *Tim Peake Primary Project*. £86,337 of grants were awarded to 71 schools across the UK for projects that supported and promoted Tim's mission. These were both within school and their local communities, and included activities such as space days, libraries and art projects. ESERO-UK reported issues with the reporting process, with the quality of reports from schools being highly variable, and this was improved with each round of funding. Where feedback was received it was positive, with schools reporting that the funds helped them to develop their STEM curriculum and engage students.

A number of projects were delivered online, and many had online resources that supported and extended the reach of the core project. *One Giant Read*, *Mission Starlight*, and *Adventures in Space and Tim* were all almost solely delivered through online mechanisms, and all reported that they met their delivery targets. The Royal Society of Chemistry, who ran *Mission Starlight,* reported that it was their most successful experiment to date, reaching more participants in the first four months

Cosmic Classroom

"Our school had been closely following Tim Peake's exploits on the ISS and so being selected to attend the Cosmic Classroom was an amazing opportunity that our school could not turn down. To get the chance to be part of history and talk to a real space hero through a live link was something our children will never forget. Coming from the Isle of Wight many of our children had never even been off the island so it was a great adventure travelling to the World Museum in Liverpool. The day was full of brilliant activities and opportunities for learning and the Principia staff had organised a packed programme ranging from robotics, to looking at satellite images to a Q and A session with an astronaut. The live feed itself was marvellous and many of the Science experiments that Tim did the children recreated when back in the classroom."

"The day has influenced our children since, especially with the work that we have done as a school on 'Gender Equality'. Many of our girls aspire to take careers in STEM and I believe much of this comes from the experience that they had at the World Museum. That day has sparked a love of science, space and spaceflight, even inspiring one of our children to start his own YouTube channel about space."

Graham Andre

than any previous experiment had in a year. This collaboration was not supported financially by the UK Space Agency. Instead it was supported only through in-kind funding, bringing a chemistry offering into the programme which had previously been lacking. Across all three projects, however, there is limited information available about the further understanding of the reach and impact they had owing to the nature of delivery. This limitation is acknowledged and ways to mitigate this should be explored further in the future, though it is not possible for the Agency to set formal reporting requirements on projects that it does not fund.

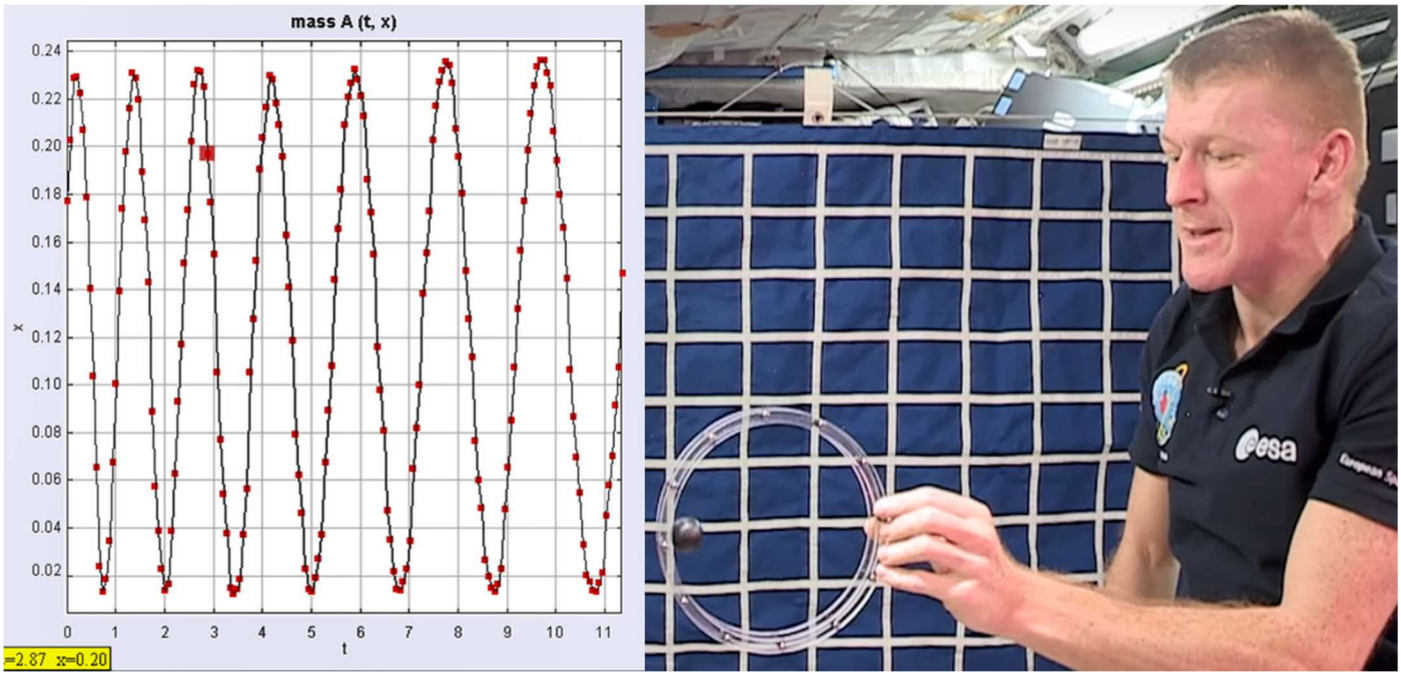
The *Astro Science Challenge* and *I'm an Astronaut, Get Me Out of Here!* both used online portals to provide more in-depth engagement and both reported that their activities helped to improve attitudes towards science The *Astro Science Challenge* was successful in encouraging children to consider science as a future career path, with 94% of their sample answering "Yes" or "Maybe" to the question "Would you like to be a scientist when you are older?" compared to 76% beforehand. The biggest shift in attitude was seen in the girls. *I'm an Astronaut Get Me Out of Here* found that participating in a session improved students' attitudes towards science, especially among those who were less interested in science jobs before taking part. In these instances, online registration made it easier to collect evaluation data compared to open access platforms.

The *Space to Earth Challenge* was the third largest project (in terms of funding) and built on the heritage of the successful Mission X activities that had been the main human spaceflight-related education programme in the UK prior to the Principia programme. It extended the fitness-led programme from primary to secondary school students through a programme of physical activity challenges in schools, led by visiting staff with excellent support from the Triathlon Trust and ambassadors such as World Paratriathlon Champion, Lauren Steadman. While the project achieved its targets, it was a relatively expensive project per child (around £6 per student) with limited possibilities for long-term engagement since it required professional sports equipment to be transported to schools across the country and high levels of trained staff to ensure the safety of students and staff. Although the challenge was always eye catching and popular at events, providing an intense experience for students, the link between fitness and orbiting spacecraft was hard to explain to teachers. Issues to consider in future include the need for specialist equipment and the clarity of the objectives.

NASA has led the International *Mission X: Train like an astronaut* project since 2010, with an annual challenge to schools for eight weeks each January. It uses astronaut training to encourage 8 to 12 year-olds to take part in fitness activities, to learn about diet and the underlying science. The UK has had the largest number of participants from the project's inception, with some 10,000 students taking part in 2015. This project was a natural fit for Tim's mission, capitalising on his enthusiasm for fitness training and his role as the international ambassador for the 2016 *Mission X* programme. As a result of this extra promotion, the numbers in the UK more than trebled to 35,000, despite relying on the same budget as in previous years. This has provided exceptional value for money with eight weeks of deep engagement for around £1.20 per student. In addition to the stated objectives, schools have taken ownership of this programme by running many space-related activities alongside it – from weekends of community activities to art and design, music and writing projects.

The UK Space Agency also promoted the ESA education project *Zero Robotics* as part of the Principia programme, though the UK Space Agency did not contribute to it financially. As such ESA provided no set targets or evaluation. Historically, take up had been poor in the UK and it was hoped that the spotlight provided by Principia might change that. Three UK teams participated in 2015 to 16, compared to a usual figure of either none or one. While not a resounding success, it still showed an increase in participation. ESA has since found that it is not fulfilling their objectives and no longer supports the project.

Biorock, RI Christmas Lecture resources, and *Astro Academy Principia* were all activities that provided education resources to teachers. All activities reported audiences over their targets with positive feedback, though further details are not available. In the case of *Astro Academy Principia*, the teaching resources could not be produced until after Tim had filmed a series of experiments in space and so the impact of this project is expected over future years and will be evaluated through



A screenshot from the Astro Academy Principia resources, showing circular motion

the ongoing work of the National Space Academy, who run the project.

EO Detective paired online teaching resources with a competition, both based on astronaut photographs and satellite images of the Earth. 1500 teachers helped around 44,000 students to investigate the environment using maths, science, geography and computing and around a thousand students entered the competition to win a photograph taken especially for them from the International Space Station.

Two projects, *The Astronaut Handbook* and *Marvin and Milo,* both known to be excellent quality due to the partnerships behind them, took the form of information that could be distributed to children. These were handed out to children and adults at various events and the *Astronaut Handbook* (in a special abridged version for the Agency) was particularly good value, costing less per unit than other typical goodies, such as stickers and pencils, but packed full of educational content. No specific evaluation on the effectiveness of these interventions was carried out, but informal feedback from staff shows they were well received and the *Astronaut Handbooks* were often seen to be a well prized handout, being a real book rather something perceived as lower value.

Five projects failed to reach their original target numbers, for a variety of reasons: *Planetarium Clips, Into Film: Into Space, Three Minute Learning, TimPix* and the *Novium Museum exhibition.* In addition, both the *Astro Pi* and *Great British Space Dinner* competitions, although formal target figures were not defined, did not reach expected numbers.

The *Planetarium Clips* had originally targeted more people but, due to on-orbit operational issues, the planned footage from the International Space Station was not recorded during the mission as hoped. This limited the audience although the clips are still in use and the number will continue to grow. Thinktank planetarium is showing the footage to approximately 66,000 people a year so the planned target will be reached eventually.

Into Film: Into Space reached 5,775 young people, short of its 10,000 overall target in both the workshops and the competition elements, with the largest shortfall being in the competition. Consequently, it became a rather expensive project in terms of cost per child (just over £8 each). From the evaluation received, it is clear that those who did take part drew great inspiration from the project and continued their filmmaking skills, but the impacts on knowledge of space appear to have been limited. The appeal of the project when selected for funding was that there was a crossover between creativity and digital, and the chance to bring space knowledge to a wider audience. Into Film are known education providers with an established network of over 12,000 schools that run film-based learning activities. The promotion of the

activity was good, and it was therefore surprising that take-up wasn't greater among film clubs, where the barriers to entry should have been relatively low.

Three Minute Learning (3ML) set targets of 10,000 students, and only succeeded in delivering to about a third of these. The team reported that they suffered from problems when scaling their software. 3ML was effectively a small pilot project and the Principia funding was a chance to grow the project. However, the software was found to be too slow as numbers rose, and the necessary code re-writes were beyond the scope of the small team. The team has learned from these issues, has put steps in place to resolve them, and the model will continue to grow. The Principia related content remains available, so the investment should see the stories reach the anticipated numbers in the future as the team evolves and expands using other funding sources.

TimPix struggled to meet its target figures of 7,200 with a modest engagement level of 2,100 students, though it reached more schools than planned (105 versus 80). The project was aimed at GSCE and A-Level students, and even with the limited reach, the costs of engagement per pupil (c. £8) are in line with expectation at this age range, and the engagement was sustained with teachers reporting increased confidence through the project.

The UK Space Agency's funding contributions for *Novium Museum Exhibit* targeted a reach of 13,425 people but in reality achieved about half that figure, with the majority of the shortfall in the reach of the loan boxes. The Space Saturday events were a success and met their targets, but a change from loaning the boxes - from 1 week periods to half terms - limited numbers, which Novium has also conceded were optimistic. However, the loan boxes continue to be used and become part of a focus of a longer term engagement. Feedback received was positive and the new space angle has allowed the museum to connect with many new schools in the area. The Agency's small contribution to the larger Novium project enabled the education part of the overall offering to take place and the money invested has allowed Novium to build a sustainable learning offer around space and Tim Peake, which is still popular.

Astro Pi was one of the first projects set up, in an initial collaboration with UKspace. The low numbers of children engaging in computer programming is a problem, and one that affects the space industry, so while it was acknowledged that there might be barriers, it was hoped that the appeal of space would overcome any reluctance. There were no formal targets set, but even with a degree of national news coverage, the initial take-up of around 500 people taking part in the

ASTRO PI

"The Astro Pi competition had a big impact on most of the team. The majority of the youngsters were at the time in year 5. When they left Cranmere a year later, they were asked for their Year Book to say what achievement during their time at Cranmere they were most proud of. I think all the Code Club team wrote some variation on "having my code run in space". Bear in mind that this group included some talented sports players, musicians and performers who had a number of successful achievements that they could have picked. Many of the team have gone on to enter other coding and Making competitions like Pioneers and Coolest Projects. The youngest member of the Astro Pi winning team was also part of a Cranmere Code Club team that entered the Raspberry Pi based robotics competition Pi Wars in 2017. Although competing against much older children, including some 6th form teams, Cranmere Code Club finished in a hugely impressive 3rd place.

"The results of the experiment and one of the pictures taken of Tim Peake by the Pi on the ISS are on display in the Computing suite as in inspiration for other children. Every pupil in year 6 last year entered Astro Pi Mission Zero and the same level of participation is planned for this year. Cranmere Code Club continues to be a popular after-school club and every term I have more children wanting to come along than I can accommodate. Computing and wider STEM activities have become a core part of education and the "Cranmere Experience" at the school and I believe that Astro Pi has a played a pivotal role in that."

Richard Hayler, Cranmere School, one of the participants in Astro Pi

competition was disappointing. In addition, under-resourcing from project partners in the consortium caused issues with project management, with the Agency having to take on this role for a time. Many lessons were learned through the early stages of the process, particularly that competitions with relatively high barriers to entry attract few entrants. Efforts were made by the Raspberry Pi Foundation to reduce these barriers though the creation of an Astro Pi emulator, an online tool that allows students to programme a virtual Astro Pi. These lessons were swiftly learned, and the audience figure of 17,000 people reflected the reach of the project at a number of events, such as the Big Bang Fair and the Bett conference over 2015 and 2016. Coupled with extensive website interest, there is evidence that people were engaging with the concept. The space hardware has been handed over to ESA, who are continuing to work with the Raspberry Pi Foundation to extend the project across Europe and with other ESA astronauts, growing it in size every year, with several thousand people seeing their code reach space each year.

Another early project, *The Great British Space Dinner,* also didn't have formal targets and, despite national coverage, didn't get the expected traction. The figure of 2,000 participants reflects the numbers of entries to the competition, but the majority of the costs were on videos to support the education resources, which were envisaged to support national coverage and interest and secure larger reach. This was a very early project, launched in May 2014, so awareness of Tim Peake and his mission was limited, contributing to the low uptake. Much of this activity was also linked to a documentary film for Channel 4. While there was considerable synergy, the mismatch in target audiences made it hard to focus this project on the intended audience of young people (Channel 4 mainly aims at an adult audience and so the school age competition was of little interest for them). Nevertheless the associated education resources continue to be used in schools and remain among the most popular downloads by teachers on the ESERO website.

Most of the projects supported through the Principia education programme were aimed at the widest possible range of students in order to encourage engagement with STEM. The Principia Schools Conference was devised to celebrate the achievement of those students who had taken these projects furthest. For those who had not considered a career in space, this was a chance to feel part of the sector, and for those who felt that science was something that other people do, this was a chance to feel for themselves what it is like to present results at a serious conference, just as 'real' scientists do. Some 800 students from every corner of the UK attended a conference at the University of Portsmouth or the University of York. Each presented their findings to an audience of their peers and professional scientists, divided into sessions for four different age groups from Key Stage 1 to Key Stage 5. Every student met Tim Peake personally and each conference included a second day with a wide range of hands-on activities for the local community. The evaluation and feedback was overwhelmingly positive. Most groups provided feedback and 68% reported that the impact on the child most affected would be life changing, with a further 26% reporting that the impact would be long term, changing views for years. Equally important, the evaluation found that the conference had a similar effect on the teachers, parents or carers. 90% reported life time or long term impact, with a further 4% commenting that, while they were already committed to STEM education, the event reinforced their views.

A student giving a performance at the Principia Schools Conference

Table 3: Funding and audience participation figures for Principia Education projects.

Audience figures reflect the number of people who took part in the activity and exclude wider reach through media or social media audiences.

Project	Total UKSA financial contributions (from 2014 to 2017)[7,8]	Financial contributions from elsewhere where known[9]	Original target audience[10]	Actual audience[11]
Aberdeen Science Centre exhibit	£30,000	£30,259	12,000	14,507
Adventures in Space and Tim podcast	£12,450	-	12,000	13,000
Amateur Radio on the ISS (ARISS) calls with Tim Peake	£25,109	£1,700	10,000	52,345
Astro Academy Principia	£15,357	£10,000	7,500	7,680
Astro Pi coding competition	£116,201	£40,000	Not defined	17,000
Astro Science Challenge	£45,500	£128,890	6,000	10,855
Astronaut handbooks	£5,200	-	10,000	16,957
Biorock	£0	-	Not defined	6,400
Cosmic Classroom In flight call	£27,208	-	100,000	400,000
Destination Space	£684,868	-	250,000	914,646
Earth Observation Detective	£33,387	£20,385	5,000	47,661
Great British Space Dinners	£64,542	-	Not defined	2,000
I'm an Astronaut, Get me out of here	£8,500	-	1,600	2,004
Into Film: Into Space	£48,154	£6,500	10,000	5,775
Into Film Festival Talks	£0	-	Not defined	6,280
Marvin and Milo	£4,000	-	2,000	2,000
Mission Starlight	£0	-	10,000	13,643
Mission X 2015/16	£50,000	-	25,000	35,287
Novium Tim Peake exhibition, workshops and sleepovers	£12,500	£56,500	13,425	6,532
One Giant Read	£22,150	£26,000	60,000	60,753
Planetarium shows	£45,981	£4,000	350,000	220,474
Principia Schools Conference	£46,783	-	2,000	13,743

7 This table does not include all items in the education budget..
8 The financial contributions show the final total amount of funding provided. In some cases this was extended beyond the original funding request through subsequent calls.
9 All financial figures exclude in kind contributions, which is many cases were significant values in terms of staff time, resources and other contributions.
10 The target audience figures are those from the initial, first proposals and do not include any further targets if funding increases were agreed.
11 Actual audience figures are the latest known by the UK Space Agency as of July 2018. In some cases, these are more up to date (greater) than those provided to the University of Durham for their analysis, which took data as known at March 2017.

Project	Total UKSA financial contributions (from 2014 to 2017)[7,8]	Financial contributions from elsewhere where known[9]	Original target audience[10]	Actual audience[11]
Rocket Science	£112,030	£30,000	150,000	600,000
Royal Institution Lectures Education Material	£15,000	-	3,000	14,400
School grants	£100,000	-	10,000	28,266
Principia Space Diary	£93,310	£13,000	15,000	95,000
The Space to Earth Challenge	£160,000	£106,000	15,000	26,350
Speak to Peake	£0	-	Not defined	500
STARS project	£8,000	-	1,600	4,000
Team Tim	£7,500	£1,500	10,000	31,014
Three Minute Learning (3ML)	£33,600	£30,000	10,000	3,493
Tim Peake Primary Project (TPPP)	£735,000	-	15,000	118,471
TimPix	£17,500	-	7,200	2,100
Zero Robotics	£0	-	Not defined	No data available

Total reach of the programme

Each individual education project was able to report their delivery numbers, outcomes and impacts but, in order to report on the overall reach, a summation figure was needed. It was clear from the outset that an accurate estimate of the total reach of the Principia programme could not be obtained from a simple addition of each project report because some schools and pupils engaged in multiple projects. The University of Durham was commissioned to review and analyse all the data from the separate projects and estimate the total reach of the programme[12], along with a number of other findings. The methodology used is detailed in Appendix 3.

These numbers were based on data provided up to March 2017. In many cases delivery or evaluation of projects was still ongoing. Subsequent data has since been received and incorporated into Table 3 on 28, which reflects final numbers in many cases.

These were the key findings from the analysis:

- *"Over 1.6 million children and young people from around 10,000 schools are estimated to have engaged in the education and outreach programmes linked to the Principia Mission from its start in 2014 and up to March 2017 - equivalent to around 15% of the total UK school population in any year and one in three UK schools*
- *"Many of the projects sent out resources or set up websites and are ongoing and so, when more recent figures for continuing projects are included, the overall total exceeds 2 million*
- *"The programme successfully reached schools and pupils of all ages in different phases of education (primary, secondary and post-secondary) and in different types of establishment (e.g. academies, community, voluntary and independent schools) in close proportion to the UK's overall school population*
- *"The Principia education programme was successful in reaching schools with higher than average numbers of children eligible for free school meals*
- *"Schools and participants in different parts of the UK (England, Scotland, Wales and Northern Ireland) were well-represented*
- *"Schools from large urban centres, towns and cities, rural villages and small hamlets were well-represented and broadly representative of the national distribution of schools"*

Longitudinal study of impact

To review the overall programme impact over a longer period of time, the UK Space Agency, in collaboration with the Economic and Social Research Council (ESRC), commissioned a study of the impact of human spaceflight on young people's attitudes to STEM subjects. The University of York followed a group of students over a three-year period. Its investigation began before the Principia mission started, continued beyond the mission and has now been extended further. There are many different influencing factors for each young person, over which we have no influence, but this study examined whether there were any changes in attitudes over the duration of the programme.

The study followed two cohorts of students aged 8 and 11 at the start of the project, over three years. It collected data at three points: pre-flight, immediate post flight and one year after Tim's flight. It adopted a mixed methods approach, gathering quantitative data through the use of an online attitude survey with students, and qualitative data through interviews with key informants, students and teachers. More details of the methodologies are in Appendix 2.

The University of York sought to investigate what impact the Principia mission might have on young people's attitudes to STEM subjects. The results of their study13 found that:

"The project data indicate students' attitudes to STEM subjects and space science are largely positive. They

[12] See, B.H. and Morris, R. and Gorard, S. and Griffiths, N. (2017) 'UK Space Agency Principia education programme report: the reach and spread of its projects', Project Report. Durham University, Durham. http://dro.dur.ac.uk/21760/

[13] Bennett, J., Airey, J., Dunlop, L., and Turkenburg, M. (2018), The impact of human spaceflight on young people's attitudes to STEM subjects. Final report to the UK Space Agency and ESRC, January 2018. York: Department of Education, University of York

recognised the importance of STEM subjects for society and people's everyday lives, and around a quarter of students considered themselves in a position to aim for a career in STEM."

The researchers noted that, unfortunately, it was not reporting from a zero baseline as the first set of data *"were collected at a time when Tim Peake's mission had already received considerable publicity. Thus... [the data points] are not comparing a situation of little or no knowledge [of the mission] with considerably increased knowledge."*

The study found that the generally very positive attitude did not change significantly over the study period, i.e. they remained generally very positive throughout the observation period, across both primary and secondary school children. Notably, the report goes on to state that:

"Evidence on research into attitudes to science points to young people becoming less positive about school science as they progress through secondary education (e.g. Bennett & Hogarth, 2009). The RISES project data indicate that this downward trend is not present."

In other words, in general young people taking part in these projects were more positive about science than would have been expected otherwise. The report is not specifically able to attribute this to the *Principia* project due to differences between participant groups and research instruments, but this suggests that the broadly status quo attitudes is a positive outcome of the study.

There is further evidence of success when looking more closely at individual pupils and schools. In both cases the report's findings do show statistically significant upward trends with both schools and individuals reporting clear positive impacts.

The report concludes that that:

"... one can identify throughout the data individual areas of enthusiasm which could permit cautious optimism about the impact of the Principia mission on individuals, if not on the sample as a whole: some schools, some individuals, some girls, some boys, some survey items (or connected groups of survey items) show upward trends. As one of the key informants noted, only a small increase in numbers of young people entering careers in space science would represent a large increase of people in the area.

"Thus, the small and localised positive effects shown in the detailed analysis of the quantitative data provide the numbers to add weight to the qualitative data, which do reveal impact at the individual level. In relation to impact at school level, it is also clear from the data that members of a school's senior management team need to be engaged, if not directly involved, if interventions are to have an impact."

The full conclusions, based on the analysis of three surveys across the sample as a whole from the University of York's study, were:

"Attitudes to STEM subjects and to space have not changed significantly although the importance of STEM subjects for society was widely recognised, since attitudes to space were positive in Phase 1 and largely remained so in Phases 2 and 3 (note - Phase 1 data were collected when Tim Peake's mission had already received considerable publicity and therefore the Phase 1 and 2 data are not comparing a situation of little or no knowledge with considerably increased knowledge)

- *"There were substantial variations from school to school linked to the level of engagement of a school's senior management team - teachers and learning support staff enthusiastic about space, for instance, can communicate this enthusiasm to their students with appreciable effect - and this has implications for the provision of CPD to support interventions*
- *"Focus group comments revealed that engagement with Tim Peake's mission had a positive impact on a number of individual students with many young people pursuing careers in STEM subjects citing the positive influence of a particular teacher or event on their subject choice and career decisions - suggesting that longer term follow up of students participating in the project would be beneficial*
- *"Lack of confidence in abilities in STEM subjects, coupled with even greater lack of confidence about ability to work in the space sector, emerged as strong factors influencing decisions about subject and career choices"*

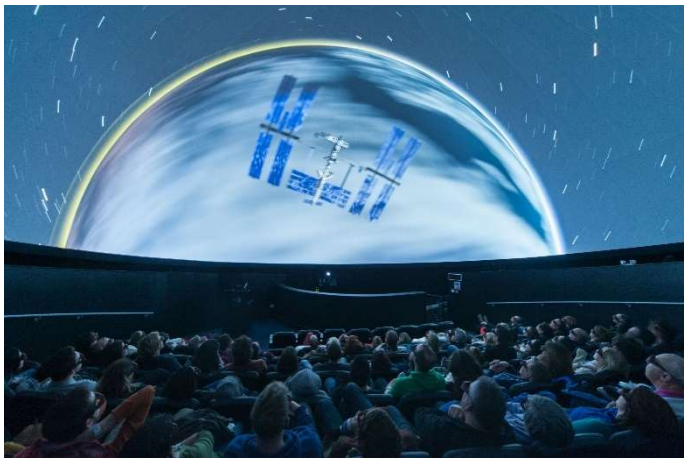
Data limitations

The lack of a control group is one of the biggest limitations of this analysis. This was particularly apparent for the longitudinal work carried out by the University of York. The national nature of the campaign meant that it was challenging to identify schools who had no awareness of the campaign and, even if they could be, the act of recruiting them for the campaign would make them aware and could also introduce observational bias.

Similarly, when considering overall effects and impacts, it is difficult to know for sure if the Principia campaign was the primary reason for any success or whether other influences contributed.

It was relatively straightforward to evaluate the impact of each small project but the scale and variety of the Principia projects made combined analysis difficult. While one project aimed to improve literacy among primary school children, another wanted to encourage engagement among young people in science or intended to help teachers learn how to use space as a context for teaching. The metrics for each project had to be different in order to judge these impacts. As a result, we must be careful not to trivialise the overall impact by only considering the simplest metrics that they all have in common, such as the number of pupils reached.

When looking across the projects, there was a wide variation in the quality of data provided back to the UK Space Agency, which has also hindered comparisons and conclusions. Some of this variation was expected, with the varying delivery methods limiting some of the data that was available. It was impossible, for example, to know the details of who received every copy of *The Astronauts Handbook* or the *Marvin and Milo* cards and what impact they had, while online resources have limited tracking ability. Some projects were able to break down the numbers reached very well and executed excellent evaluation strategies, while the data provided by others was patchy or estimates. Even though evaluation methodologies were required, and impact and numbers reached was a requirement of final reporting, some projects did not fulfil this requirement well.



The Planetaria clips being show at We are the Curious in Bristol

In particular, the University of Durham struggled with the varied nature of the data sets collected by the project partners, with different levels of detail. Data protection laws also prevented the projects from sharing data that could identify individuals. This meant they were sometimes unable to definitely determine if data from the same school referred to the same classes and pupils or not. Durham has recommended that the UK Space Agency request more standardised reporting from their projects in future. This recommendation is being reviewed and improvements will be implemented.

We are also aware, from anecdotal evidence, of schools who followed the mission in some way but did not register with the UK Space Agency or its partners. These impacts have not been captured at all by the data obtained or the analysis undertaken.

The Principia Legacy

Tim Peake returned to Earth 18 June 2016 yet the legacy of the Principia mission and accompanying education programme continues. All the Principia education resources are available for teachers, students and the interested public, either via the archived *Principia*[14] or ESERO-UK[15] websites. Principia's online presence remains available in other forms, such as the *Adventures in Space and Tim* podcast; *Three Minute Learning* stories; the *Cosmic Classroom* video; and the material supporting the Royal Institution lectures.

Apps to download are also available and relevant, such as those created for *Earth Observation Detective* and *The*

[14] www.principia.org.uk

[15] https://www.stem.org.uk/esero

LEGACY IN SCHOOLS

"Our school connection with space began in May 2015 when I challenged my year 9 class to design an object that could be 3D printed in space. We held a class competition and the best design was chosen to represent the school at the Big Bang Fair South East. The 3 students won the Mathematics prize for their project.

"When Tim launched in to space in December we watched live on IWB's around school. We received the Rocket seeds from the ISS and the Science department planted them to see if students could tell the difference. The PE dept used some of the Project X resources.

"On Tim's return the students who won the 3D printing competition were lucky enough to attend the Principia conference in Portsmouth and were delighted to meet Tim.

"Since then, Crochet Tim [the school's miniature Tim Peake mascot] has featured quite heavily in school trips – to Year 8 camp, Immersion days building and testing paper aeroplanes. He now has both twitter and instagram accounts Students are interested in seeing "Who has Crochet Tim met now?" and they get updates when he has met a new Science/Maths/Science/STEM celebrity!

"I organised for the school to take part in the Sally Ride EarthKam mission 60 and had some photos taken for us by the ISS which were then used in Geography lessons. I regularly share the ISS pass over times to get students looking up. The Christmas Liturgy last year featured photos taken by me of Jupiter and the Milky Way.We have also since sent Micro Tim into space with the SuGRE-1 rocket project in 2018. We also sent cress seeds to the edge of space with the @futuremartianUK ThalesUk Balloon project (2018) but we haven't planted the seeds yet this term.

"Whether this can be attribute to Principia, or just my Space Geek teaching, two of my yr 13 maths class have gone on to study Astrophysics and Astronautical Engineering this year. (1 male, 1 female). We are also in the process of starting a project with MSSL with our yr 12 Maths/Physics students classifying Mars "objects".

"I think we have done the Principia mission proud - we are still working on getting Space into more areas of the curriculum and hope to apply for the SpaceMark in the future.

Dawn Denyer, Assistant Headteacher St Wilfrid's School, Crawley, West Sussex

Astro Science Challenge. More formal teaching resources such as the *Principia Space Diaries, Great British Space Dinners, Biorock* and *Astro Academy: Principia* are accessible and applicable in a teaching environment for science, maths and literacy classes. All are available via the ESERO-UK website[16].

More informal learning opportunities still abound in the Science and Discovery Centres, with many continuing the popular *Destination Space* workshops and family shows and extending or creating exhibits, building on the resources and investment of the programme. The UK Association for Science and Discovery Centres report that at least a further 1,135,000 people have been engaged in the project through these legacy activities, and the numbers will continue to rise year on year. The museum exhibits at Novium and Aberdeen Science Centre are still in use today, continuing to deliver informal learning opportunities.

The education partners remain supportive of the UK Space Agency and other organisations by providing outreach activities at events and festivals throughout the year, such as the Farnborough International Airshow, the Royal Albert Hall's Festival of Space and the UK Space Conference.

Anecdotal evidence from these partners tells us that the majority of their projects continue to thrive and are as popular as when Tim was on the ISS. Many have

[16] https://www.stem.org.uk/esero/tim-peake

Children at a Space to Earth Challenege event at the University of Essex

provided quotes and stories of how their project has affected the young people involved in the short and long term.

For example, the Royal Masonic School (RMS), which hosted one of the ARISS contacts, identified a significant increase in the number of girls taking physics at A level following their involvement in Tim's mission through the school's radio contact with the International Space Station. The physics teacher noted:

"Since...taking part in our live radio link up with Tim Peake, the numbers of potential A-level physics students at RMS have vastly increased. We are hoping to have two AS groups in September, with record numbers of girls selecting the subject. [20 girls in 2 groups, previously expected numbers were 8 girls in one group]. The girls are now more aware of the range of possible careers which stem from taking physics/STEM subjects at A-level and beyond, and this will certainly have had an impact on their choices."

New variations of the original projects have also been developed, evolving and expanding their reach without further funding from the UK Space Agency. The National Space Academy is now working with the China National Space Agency to promote the Astro Academy: Principia resources in classrooms in China, as well as discussing the potential to fly the Astro Academy equipment with a Chinese astronaut. ARISS promotes and supports radio contacts with ESA astronauts along with the hosting school's STEM activities.

Astro Pi has built on its success and continues to work with ESA. The two Astro Pi computers that Tim took to the ISS remain onboard and are being used by other ESA astronauts to engage youngsters across Europe to get involved in coding challenges. In the 2017 to 18 challenge 6,800 young people (38% of which were female) across 24 different countries took part in the challenge, with nearly 2000 programmes written by young people being run on the Astro Pi computers on the ISS. Curved House Kids have built on the expertise and experience learned through the *Principia Space* Diary and will launch a new diary project with STFC in 2019 to support education outreach for the James Webb Space Telescope.

Other projects have continued to deliver the projects developed through the programme with other means of

support. For example, Unlimited Theatre took their *Astro Challenge* Space Shed on tour around UK festivals following the end of the mission, engaging family audiences with STEM experts in a variety of fields. SpaceFund's *Team Tim* show continues to run and the IRIS *TimPix* project is also continuing.

The UK Space Agency is funding and supporting further education opportunities through its programmes in exploration, Earth observation, and space launch. These build on the lessons learned and build on the success of Principia. For example, Spacefund was funded through the exploration programme to develop a new *Robokids* show based on the success of *Team Tim*, and Curved House Kids have created a new *Mars Diary* as a sequel to the Principia Space Diary. Other organisations such as the Institute for Research in Schools (*TimPix*), The UK Association for Science and Discovery Centres (*Destination Space*) and the Triathlon Trust (*Space to Earth Challenge*) were also funded and supported by the Agency following successful proposals to develop projects with a different space theme.

The UK Space Agency also supports ESERO-UK and the National Space Academy as part of their core funding to develop resources and deliver training, masterclasses, workshops etc. for primary and secondary school teachers.

Overall Programme Impact

At least 1.6 million children and one in three of all UK schools took part in the UK Space Agency's Principia education programme. The figure has certainly grown since the end of the reporting timeframe that the University of Durham used in their analysis and the UK Space Agency is confident that the total now stands at over 2 million children. Every region of the UK ran school activities, with a good balance of urban and rural schools and schools in deprived areas. All projects were equally accessible to boys and girls and, where gender was noted, this balance was distributed right across the UK.

The 34 projects reached across age ranges, from the earliest school years through to university students and the general public, though the large majority of the projects focused on primary school ages, identified from the outset as the key target audience. Six projects, which accounted for about 3.5% of the both the total audience and the spend on projects, focused only on secondary school aged children. Five projects focused solely on primary school level education, taking 33.6% of the spend and 28.3% of the audience. 12 activities covered the complete age range, and many aimed at the general public too, while the other 11 straddle the primary/secondary divide in some way.

The programme delivered excellent engagement in STEM while still covering the breadth of the curriculum. All the projects encompassed STEM, most often directly, but some indirectly through other subjects such as music, physical education, geography and literature. All education resources were developed with curriculum delivery in mind, recognising the fact that busy teachers do not have time to create their own or to cover subjects outside the curriculum.

The projects had varying degrees of engagement, catering for different learning environments and audiences. All activities engaged children for at least 30 minutes, and about 40% of engagements were deep, where activities which stretched over many weeks or months with repeated exposure to messages in activities such as *Rocket Science, Principia Space Diary* and *Mission X*. Both formal and informal education routes were catered for and collectively the two flagship projects in these areas, *Destination Space* and the *Tim Peake Primary Project,* accounted for approximately 40% of the total number of engagements.

There were activities for all levels of attainment: for example, the *Three Minute Learning* project was designed to help engage children who found it hard to engage with traditional teaching; while the *Principia Schools Conference* gave a platform for primary and secondary school pupils who had achieved the most to share what they had learnt with their peers and space experts. They could also experience for themselves what it was like to be a real scientist, breaking down the barriers that makes many feel this is something that other people do.

As evidenced by the University of York study and the final reports of all the projects, it is clear that in many cases these activities have had lasting impacts on individuals, classes, teachers, schools and families. Feedback included *"The Principia Mission and conference has not only brought so much education to my children but also*

inspired me to pursue STEM educating" from a parent who attended the Principia Schools Conference, and *"It was very interesting and I had a lot of my questions answered, it was cool to be talking to real live researchers and they gave me a lot of advice on how to get into a space related career"* from a student who took part in I'm an Astronaut Get me out of here!" These, and all the rest that run through the report, are commonplace in the feedback received.

There have been lasting impacts within schools. Notably the collective evidence, particularly from the University of York, suggests that the largest lasting impacts have been in schools where the senior management team embraced the whole Principia mission and the school collectively engaged. Direct evidence from secondary schools where this has been the case shows orders of magnitude levels of increase in pupils taking STEM subjects. At Sandringham School in St. Albans, for example, their uptake in all STEM subjects at A-level has tripled, with a significant increase in the number of girls studying science, particularly physics and chemistry. The Royal Masonic School for Girls in Rickmansworth has seen the numbers of A-Level physics students double.

At primary school level, the *Tim Peake Primary Project* evaluation provides evidence of the lasting impacts. A year after completing the project, 97% of teachers responding to the impact survey felt that pupils' engagement had increased as a result of the Principia projects and 75% felt that the project had increased pupils' confidence. The evaluation found that in general teachers did not feel able to assess the lasting impact on attainment of their students. Often this was because their students had moved onto secondary school or they were not teaching space or science at the time of the evaluation. Those that did comment reported very positive results. The performance in science of one cohort in Year 5, for example, was at 62% for age expectations, whereas at the end of Year 6, it was at 97%.

Evidence of longer term impact for individual projects is harder to find as none of the individual projects carried out follow up evaluation to see what the lasting impacts were. The University of York have been commissioned to extend their evaluation to follow some cohorts of children further through their school journeys to understand what these may be.

The wider impacts of the programme, supported and enabled by the communications campaign are also evident, though often harder to quantify through anecdotal evidence and other activities. The Agency learned, through social media and other avenues, of schools who were inspired by Tim's mission to learn more about space and science, but without engaging directly in the Agency's projects. Schools used activities and resources from the programme, designed and tested by experts and built on them to develop their own activities, which they will continue to use in future years.

One specific example of this wider impact is from the BBC writing competition, *500 words*, which found that Tim's mission had a direct impact on children's imaginations and awareness of space in their 2016 challenge. The Oxford University Press carry out an analysis of the 120,000 entries each year[17]. They found that the impact of Tim in 2016 on the children's stories was huge. Tim had never appeared in their analysis before but went straight to the top five most frequently named famous people, topping Shakespeare's Romeo and Macbeth, politicians David Cameron and Barack Obama, and even James Bond and Harry Potter.

Tim Peake was mentioned by both boys and girls equally and the stories came from all regions of the UK. Younger children, aged 8-10 in particular, wove Tim into their stories. The children also used significantly more space-related language than in previous years. They explored and invented entire universes, creating constellations of space words as they went along such as: rocket, portal, astronaut, spacewalk, space shuttle, intergalactic, asteroid, galaxy, holographic, space station, astronaut, countdown, International Space Station or ISS, millisecond.

The words spacewalk and space station showed the most significant increases, with children giving visual and

[17] BBC Radio 2 500 Words / Oxford Children's Dictionaries: Oxford Children's Corpus Summary Report 2016. Report prepared by: Oxford Children's Dictionaries, Oxford University Press, Great Clarendon Street, Oxford OX2 6DP

http://fdslive.oup.com/www.oup.com/oxed/children/500-words/FINAL_SUMMARY_500WORDS_OUP_CORPUS_REPORT_23MAY2016.pdf?region=uk

SUSTAINED ENGAGEMENT

"The contact made with Tim Peake on the ISS from Sandringham School in 2016 has had a significant and lasting effect on the attitudes and interest of young people in STEM related subjects. The school also learnt that putting effort into an annual whole-school event helps re-invigorate levels of interest and over time, provides a growing critical mass of young people who are inspired by things around them and the important of STEM to our lives.

"The contact was a challenge and was established part-way through the 10-minute communication window. As headteacher, I admired the resilience of the team (and Tim) in attempting to establish contact between Earth and the ISS, in particular the control Jessica (year 10) demonstrated in maintaining protocol under the pressure of silence, and then professionally managing the contacts between Tim and students in the limited time available once contact was established. This highlighted to everyone, including the young people, that things don't always work as you anticipate and that work-arounds are integral to science and technology. The questions posed to Tim and his clear and passionate responses captivated the students and motivated them. There was real excitement and joy which lasted for many weeks, and because it was broadcast both across the school devices and worldwide, will have had a similar impact on a much wider audience. We also tracked Tim's other contacts, and on two occasions set up a receiving station on the school field, with students controlling the antenna and receiver, and others sitting listening on the PA to Tim's response real-time to other students' questions. They learnt even more about how to track the ISS as it moved across the sky and the directivity of the antenna, together with the need to adjust for Doppler when tuning in to his signal. Great practical science and maths!

"Since the contact in 2016 we have seen a tripling of uptake in all STEM subjects at A-level, and more importantly a significant increase in girls into science – particularly physics and chemistry. We now run regular STEM clubs and activities each year with many focused on girls. Computer science has seen one of the largest increases in popularity with 3 A-level classes running next September. Girls are coding and visiting Google and who knows, there could be some future astronauts in the making!

"More importantly, we have learned that a collective event such as this provides the opportunity for everyone to talk about something they have in common. As a result, we now run a major whole-school event each year. In 2017 we launched a high altitude balloon which reached near space and fed back live telemetry data including video to all students via their devices. This was also screened in the main hall and during lunch everyone tracked the recovery vehicles racing across the Essex countryside to reach the balloon on its return to Earth. In 2018, during National Science Week every student will be planting a tree at a new local Forest – Heartwood. This finishes the project with over 650,000 trees planted, including these last 1400. A time capsule will be planted and the aim is to further stimulate the importance of us looking after our planet and protecting its future.

"All I can say is a huge thank you to Tim, the UKSA, and everyone else involved in helping to bring Space into our classrooms. This really does have a lasting impact and inspires young people to do things they may not have thought of doing otherwise."

Alan Grey, headteacher of Sandringham School, St Albans, which took part in the ARISS (Amateur Radio on the ISS) experiment:

detailed descriptions. Images of Tim's spacewalk had clearly provided inspiration, suggesting that children had been fascinated by images on TV screens, computers or smartphones.

There has been a considerable legacy from the programme already. It created resources that are still being used by teachers. *Earth and Space* is a topic on the English primary school national curriculum, usually taught annually or biennially to Years 5 and 6, and is included in the Environmental Studies topic in the Scottish curriculum. Evidence from the individual project evaluation reports shows that the resources created as

part of the programme will continue to be used in future years.

Those who received training continue to share and incorporate this knowledge in lessons. Many of the partner organisations involved in the Principia mission will continue to deliver space activities to their own audiences – for example the *Destination Space* programme in UK science and discovery centres has involved almost 200,000 more people directly with its shows, workshops and hands-on activities, engaging over a million more people with exhibits up to January 2018. This brings the total reach of *Destination Space* alone to over 2 million.

Lessons Learned

This programme broke new ground for the UK Space Agency in terms of scale, pace and numbers of partners. The learning curve was steep and so there are many lessons, both from what went well and from what could have been done better. These are recorded here to inform any future programme of this nature.

Choice of partners

Some of the projects with the biggest impact were in partnership with organisations outside the space sector. Their aims were complementary to ours rather than identical. Since we had not worked together previously, it was necessary to agree compatible objectives and define responsibilities, ensuring clarity of purpose. In contrast, with familiar partners it was easy to assume that these things were obvious, leading to greater opportunities for misunderstandings about objectives, responsibilities and costs. For example, we had worked closely with the National Space Academy and so made assumptions about what their project entailed rather than agreeing a sufficiently detailed specification from the start.

The new partners found the context of space to be novel and exciting for their audiences (and for themselves), allowing us to reach completely new audiences who had not been exposed to space previously. The Royal Horticultural Society brought a vast audience - 19,000 schools signed up to their Campaign for School Gardening - for whom space was an inspiring novelty. In contrast, partners within the space sector were less excited by space (since it was not novel) and their existing audiences were likely to be more familiar with the work of the space sector. This partly explains why the reach of the *Astro Pi* project, led initially by UKspace, was not larger.

In many cases the defining feature was the energy and enthusiasm of a few individuals who worked tirelessly to bring their projects to life once they had seen the power of space to gain the attention of young people. For this reason it would be worth considering a face-to-face element in the selection process.

Management

The UK's plans for education activities in support of Tim's mission far exceeded anything attempted previously by a European country in support of an astronaut. For this reason it was vital that we engaged ESA's education team from the start to ensure that they understood our planning and embraced our ambition. Our programme put heavy demands on their teams and so it was also important that we demonstrated from the start that we could deliver what we promised. The early activities succeeded in doing this.

We realised from early on that there needed to be a single interface between the UK and ESA, to avoid each project having to learn from scratch about the constraints of working with a space programme, especially those of the ISS and its astronauts. In addition, ESA would have to judge the merits of conflicting demands from many people representing many projects with a range of different objectives, priorities and levels of urgency. As the funding and oversight body, this role could only be carried out by the UK Space Agency. On rare occasions project partners made direct contact with ESA and in most cases this had a disruptive effect, causing confusion at ESA and disproportionate effort in the UK to repair misunderstandings. It seemed excessively controlling at times, but it proved to be the only way to avoid conflict and maximise the success of the whole programme.

Regular contact with the partners was vital to ensure that progress was being made. Given the tight schedule there was no time to waste taking a wrong turn, so regular reporting was crucial for good management of the programme.

We were lucky to be able to employ staff who had worked on the human spaceflight programme at ESA.

This gave a valuable head start in understanding how ESA operates in this area as well as the technical expertise to support our partners with practical ways to implement their ideas in orbit.

Despite this, there were too few staff to deliver this ambitious programme, especially in the build-up phase (due to the time taken for approvals to appoint) and towards the end (as many projects were still delivering after our funding had ceased). The chief effects were staff exhaustion and insufficient effort for monitoring and evaluation of the projects.

Within the Agency it was vital that the education and communications teams worked closely together. The only way that large numbers could be reached would be through the mass media, and the stories that prove most interesting to the media are often those that focus on young people and their efforts. This synergy should be at the heart of any large-scale education project.

Funding

The planning period of roughly 18 months was too tight – to ensure good management and well thought-out projects, two years should be allowed if possible (though this depends in part on the timing of future announcements of astronaut flights).

The funding from the Autumn Statement covered two years and hence allowed much greater impact than the normal in-year funding since this allowed planning, development of resources, training and delivery in succession rather than trying to do all these things within 12 months. This also allowed roll-out to begin at a time to suit the academic year or the ISS mission, rather than the funding year.

The agreements to fund partners gave a measure of control and ensured that we could monitor progress. Where there was no funding involved, it was almost impossible to exercise control. This made it hard to ensure that progress was being made or that projects would deliver. In these cases it might have helped to agree a memorandum of understanding (MoU) from early on to manage expectations. This made the *Cosmic Classroom* and the *Astro Pi* project more complicated to manage than would have been the case with an MoU in place.

Many of the projects could have continued to deliver for longer if funding had continued. For example, the ARISS programme of inflight calls using amateur radio continues at an international level, but there is no means to support UK schools or to promote the opportunity to them. The schools conference was a huge success and demand still exists, but without funding it is not possible to make this an annual event.

Scale and range of projects

The combination of targeted projects with defined aims (such as *Rocket Science*, *Destination Space* and *Astro Academy Principia*) alongside open calls for new ideas resulted in both a wide and deep engagement. This proved to be a successful strategy, building on reliable concepts as well as testing new ones.

The management required for the smaller projects was probably greater in proportion to their impact than for the larger projects. The limited effort available meant some smaller partners were not well supported. However, some of the most successful small projects were encouraged to grow and proved to be among the most cost-effective. Both the *Principia Space Diary* and the ARISS calls began as modest projects that grew to be some of the most effective in scale and impact, so this will always remain a matter of judgement. If effort is extremely limited then fewer, large projects should be considered, but if effort is available then a mixed portfolio of small and large projects allows new ideas to be tried and for diverse audiences to be engaged.

The large number of projects also ensured that a wide range of topics could be covered, tapping into the interests of many different types of audience. For example, primary school teachers could use a range of activities to help deliver many parts of the curriculum (witness the success of the *Tim Peake Primary Project*) and for older audiences there was something for anyone interested in being involved in the mission.

This also enabled us to take more risk: we would have considered the programme successful even if several projects had failed to deliver. In fact all were successful to a greater or lesser extent for a variety of reasons – from early intervention to sheer hard work - and the free promotion that came with such a high-profile mission.

The scale of operation of the bigger partners (e.g. RHS, ESERO, TES Global) combined with the large number of smaller partners meant that we were able to reach into every region of the UK. This was important in terms of the aims of the programme as well as the remit of the Agency as a national body.

Evaluation and reporting

With such a varied programme of activities, it is vital that all projects have clear initial targets, alongside standardised reporting for key metrics such as audience numbers, ages, gender balance and region. Clear impact evaluation methodologies should be included as part of funding agreements. Final reports should include comparisons of targets and actual results. This would make it easier to judge which projects are worthy of continuation.

With the benefit of hindsight, more careful scrutiny of targets would have been useful during the selection process – for example in terms of sizes of audience expected and depth of engagement. With more time to consider these things, it would have helped to investigate best practice in more detail. Considerable effort was spent in learning from other space agencies about their techniques, but it was surprising how little evaluation had been carried out elsewhere. Instead we might have gained more by talking to education practitioners outside the space sector in the UK.

The University of Durham recommended: *"In future, it would be better to build ideas for evaluation into the design and rollout of such projects. As a minimum, all projects should sign up to consistent data recording and reporting standards as a condition of their funding."* This recommendation has been noted and is being acted on.

The overall evaluation and reporting on the programme has been delayed as it was done inhouse. Some external evaluation in the future would lead to more timely reporting.

Recommendations from Reports

The report from the University of York study provided the following recommendations:

1. *"Young people have a limited sense of what is involved in careers in the space sector, and the STEM sector more widely, and assume such careers are beyond their reach. Targeted careers guidance, with information regarding the broad range of opportunities available, should therefore be a priority for further investment. (This might, for example, include the development of videos on a platform such as YouTube.)*

2. *"The crucial success of interventions depends on teachers. This would suggest the importance of investing in CPD programmes, equipping teachers with resources to enable them to engage the senior management team in their schools.*

3. *"The current school curriculum for STEM subjects contains very little about space science. As many young people view space science positively, with considerable impact at the individual level, it would seem there is a case for lobbying for more space-related content in the curriculum.*

4. *"For interventions and initiatives to be attractive to teachers, they need to make links with policy imperatives, including the curriculum and assessment. This is particularly the case at secondary level, where teachers report finding it difficult to adapt or go beyond what they perceive to be over squeezed and restrictive curricula, particularly in maths and science. "*

The report concludes that: *"While some of the above is by no means limited to the context of space, and largely confirmatory of similar findings in other contexts, the space cause could be well-served by continued or renewed efforts in these directions."*

Conclusion

The UK Space Agency's Principia education programme encompassed 34 projects that spanned the curriculum and school population, costing the agency about £3 million pounds across three financial years. It was the largest space education programme in the UK and the largest to support the activities of any European astronaut. At least 1.6 million children - now estimated to be over 2 million - took part from across the UK in one in three schools, with about 40% of engagements at a deep level and children taking part in sustained activities over a number of weeks or months.

THE PRINCIPIA EDUCATION PROGRAMME IN FIGURES

- ***Over 1.6 million young people*** engaged in one or more of the UKSA-funded activities by the end of March 2017. The figure continues to grow and is now estimated to stand at over 2 million
- Most of these engagements were of high quality and ***at least 30 minutes in length*** and 40% of them lasting weeks or months
- ***One in three UK schools*** took part in one or more Principia activity and from every part of the UK
- ***34 different projects*** were funded or supported by the UK Space Agency
- Projects covered both ***formal and informal education***
- ***Over 900,000 people have taken part in Destination Space*** workshops and other activities at science and discovery centres across the UK, with at least a further 1,130,000 visitors through exhibitions, interactive zones, and dedicated space themed galleries and activities as a result of the Destination Space national programme
- ***600,000 pupils from 8,600 schools took part in the Rocket Science*** seed-growing experiment. Of these, 65% schools submitted their results to the national database
- Space Ambassadors from the Space Education Office (ESERO-UK) helped ***1,257 primary schools deliver three or more of Principia education projects*** to 120,000 pupils
- ***400,000 students took part in the hour-long Cosmic Classroom*** with a live link to Tim on the International Space Station
- ***95,000 primary pupils used the Principia Space Diary*** to record their space activities over a school term
- ***220,000 people (70% primary school children) saw clips*** relating to Principia in planetaria across the UK

At a broad level, attitudes to STEM subjects were found to remain positive throughout the period of the Principia programme. At individual levels, there are clear lasting impacts of this programme are evident from the orders of magnitude changes in students taking up STEM subjects at secondary school level and the increased in attainment at primary school. It would be incorrect to extrapolate from individual results to suggest that this is true of all taking part, but it does highlight the possible effects that engagement in the programme can bring.

The cost of the programme provided good value for money. With a total programme spend of £3 million and approximately 2.8 million engagements (some people experiencing more than one), the average cost of each engagement to the programme was just over £1, which compares favourably with other education projects funded by the UK Space Agency. This cost does not reflect the significant contributions from the project partners in in-kind contributions, staff time and volunteer hours and, of course, the drive of teachers, parents are carers to deliver the projects to young people, increasing the value for money to the UK Treasury.

The scale of the programme was achieved partly through significant funding, which was then used to lever additional effort and funding from organisations with complementary interests and existing audiences and networks. In general, this was more successful than collaborations with organisations in the space sector as it allowed us to reach new audiences and to introduce an exciting new context for their own messages.

Analysis from the Royal Academy of Engineering found that those with STEM first degrees earn a wage premium of about 4.5% over the course of their working lives, compared with those with other degrees, particularly if

Tim Peake meets students at the Principia Conference

they work in a STEM occupation.[18] This wage premium also exists for STEM qualifications at lower levels, especially for technology and engineering qualifications.

A rough calculation based on research estimates from the Department of Business, Innovation and Skills of the lifetime value of a degree[19] suggests that the total private and social benefit from having a STEM degree may be worth an additional £20,000 in private and social benefits over the course of a lifetime (compared to non-STEM graduates). This suggests that if only an additional 150 students take STEM subjects at degree level as a result of the Tim Peake outreach programme (0.0075% of the estimated two million students reached), then the £3m investment would be paid back. Feedback from the Principia Schools conferences alone suggests that this has been achieved many times over.

The programme clearly met and exceeded all of its objectives. The figure for the total number of children reached, known to be at least 1.6 million children and estimate to have topped 2 million, exceed the target reach of 480,000 defined as a Key Performance in the UK Space Agency's corporate plan by at least a factor of three.

The programme set out to offer a broad spread of activities, include all parts of the UK, to appeal to all school-age children (with a stronger focus on primary school-age) and to inspire interest in careers in science and technology generally. The 34 projects reached across the age ranges, from the earliest school years through to university students and the general public, though the large majority of the projects focused on primary school ages. Analysis from Durham University found that the reach of the programme reflected the proportion of schools in different geographical regions, and in reasonable proportion to the different phases of schools.

[18]https://www.raeng.org.uk/publications/reports/the_labour_market_value_of_stem

[19] https://www.gov.uk/government/publications/university-degrees-impact-on-lifecycle-of-earnings

The programme was particularly successful in attracting a diverse audience with above average numbers of schools with high levels of disadvantaged pupils in terms of proportion of pupils eligible for free school meals (FSM) and proportion of pupils whose first language is not English (English as an additional language or EAL) taking part.

The programme was a huge success for a number of reasons. Significantly, the opportunity and the subject matter were seemingly of universal appeal, which was uniquely possibly with a British astronaut supported by Government. The engagement of the media was key to the success of the education efforts and the educations and communications efforts worked side by side, each supporting and enhancing the other. The commitment and drive from the UK Space Agency team and all their partners underlies all of the project successes and it would have been impossible without this.

As is to be expected in a programme of this size, there were some issues, significantly around reporting and evaluation. These lessons will be carried forward into future programmes.

The appeal of a single large programme, focused around a clear mission, enabled many different organisations, groups and individuals to come together to support the wide range of education objectives. By providing activities and contexts to help teachers deliver their own objectives – such as activities to engage the whole school, enrichment activities to help pupils become more engaged with subjects, topics to help children with enquiry-based learning, cross-curricular activities to reinforce learning, and ideas about a range of career paths and role models. Educators learned about space to deliver activities, space experts got involved in education and outreach, while children and members of the public gained an insight into a range of STEM topics in the context of space.

Naturally the programme benefitted from a high-profile role model in the form of Tim Peake. He proved to be an ideal ambassador for the UK's space programme with an infectious enthusiasm while supporting our education objectives. His natural rapport with young people of all ages was invaluable in engaging new audiences. Tim's dedication in carrying out a range of tasks was outstanding - from public appearances before and after his mission, to enthusiastic use of social media to highlight opportunities, including recording of many messages and demonstrations in space, often during his recreation periods.

There is much that has been learned through this programme, particularly from unexpected successes to areas that did not deliver as much as was expected or hoped for. The model of the programme can, and should, be used in future for any programme likely to significantly capture the public's attention to deliver similar successes. By building on the successes and lessons learnt from Principia, and from other successful campaigns such as ESA's activities around the Rosetta mission, future missions such as the European ExoMars rover flight, and any future second flight of Tim Peake, can deliver even more outcomes.

The Education team at the UK Space Agency does not want to lose the momentum built up over the last few years surrounding Tim's mission. At the time of writing it is unknown when he will fly again, but the European Space Agency has indicated that they intend to assign all of Tim's astronaut class a second flight in due course. It is therefore important to start building on those lessons learned in preparation for the another mission, whenever that may be. In the meantime, the Education team is investing in other areas within the Agency who will benefit from an education and outreach programme similar to Principia's and will be primed to take on the challenge again for Tim's next mission.

Post flight tour interview. Credit: ESA.

COMMUNICATIONS CAMPAIGN

Programme Overview

The Principia Communications campaign was structured around a series of mission 'anchor points' to act as a catalyst for media activity or public engagement.

Public interest was always expected to be high. Resources, however, were limited so the joint team chose to focus their efforts on a number of key anchor points for Tim's mission. Media and communications activities at these anchor points supported and highlighted the work being done by education colleagues on a programme by programme basis. This gave partner organisations a platform to show off their work to the world and encourage more schools and students to take part.

The Communications campaign also recognised the importance of the Education programme, supporting its activities throughout the mission with close working between both teams. The Times Educational Supplement event, *Cosmic Classroom*, in February 2016 was one example where this collaboration proved particularly effective, as the Communications team worked with Liverpool's World Museum venue in the run up to the event. By using its media partners for marketing, we helped deliver it successfully to the 400 students who attended in person, as well as the 400,000 students who watched the event online.

Table 4: Key communication 'anchor points' for the Principia mission

Date	Mission Event	UK Event
6/11/15	Pre-launch	Final pre-flight Press Conference attended by national and international media.
14/12/15		Horizon *Tim Peake Special: How to Become an Astronaut* (BBC Two).
15/12/15	Launch	UK launch events in four nations, including the *Stargazing Live Special* (BBC Two), broadcast live from London's Science Museum.
28/12/15		Royal Institution Christmas Lectures *How to Survive in Space* (BBC Four) to celebrate Tim Peake's mission.
12 to 14/1/16		*Stargazing Live* (BBC Two) - three editions devoted to the Principia mission.
15/1/16	Spacewalk	Additional *Stargazing Live Special* edition broadcast (BBC Two) covering Tim Peake's spacewalk.
20/3/16		*Heston's Dinner in Space* (Channel 4). Chef Heston Blumenthal created meals for Tim Peake to eat in space.
24/4/16		London Marathon - as runners on the ground complete 26 miles around the city's streets, Tim Peake covered the same distance in space.
18/6/16	Landing	National news coverage
10/16	Post-flight tour	Multiple events around the country

Planned Objectives and Key Messaging

The Government Communications Service's Professional Assurance process signed off the UK Space Agency's communications objectives for the campaign in 2015. They covered all aspects of the campaign, including the run up to the flight, launch, the six-month tour and a post flight tour in the UK.

These objectives were:

1. **More informed citizens**

- Inspire advocates for space, engineering and science. Of those surveyed for a Department of Business Innovation and Skills study, 13% mentioned space when asked what they associated with science. It was the third most common response.
- Run two surveys to capture public perceptions of the UK space sector and Tim's mission before and after his flight. We expected to see a significant improvement in attitude and awareness in the second survey.
- Generate increased engagement with Government's activities in space, and assess this through social media engagement, newsletter subscriptions and website traffic by December 2016.

2. **Successful take-up of a service**

- Increase participation in the education activities around Tim's flight – engaging over 2 million people in the mission including running education activities in 10,000 schools. If even 0.005% (100 extra people) go on to study science then the programme will produce a positive return.

3. **Investment and growth**

- Increase the perception of the UK being at the cutting edge of space science, engineering and innovation at home and internationally. Tim's mission was part of boosting the UK space sector's international profile, particularly within ESA.

These objectives were reflected in the UK Space Agency's 2014 to 15 corporate plan, with the following key performance indicator:

Exploit the education and inspiration value of UK astronaut mission to the International Space Station in 2015. Reach 20 million people via press and media interventions by Quarter 4

These campaign objectives were developed into the following key messages that underpinned all activities:

The UK is backing the first British ESA astronaut to the International Space Station. Tim was selected because he is the best of Britain and years of dedication and training have made him the next of the great British explorers.

Tim is an inspirational role model for young people across the UK. Space is an important means of engaging children with STEM subjects and Tim's mission encourages children to aspire to new heights.

The UK is great in space. The UK space industry contributes £11.8 billion to the UK economy and is continuing to grow. It currently employs more than 37,000 people in the UK and hopes to create 100,000 new jobs by 2030. The sector offers careers for engineers, researchers, software designers and many more.

Everyone can get involved. This is a historic moment, bringing the country together to celebrate Tim's mission.

The following target audiences were agreed with ESA as part of the joint campaign:

- General public in ESA Member States and in particular the UK
- Decision makers, such as political and institutional authorities in all ESA Member States and the UK in particular
- Primary and Secondary school pupils and teachers
- University students
- Science community
- Industry partners, in particular within the UK

Budget

Table 5: Communication campaign budget

Category	Item	Budget
Design	Branding	£25,000
	Website	£26,000
	Education Videos	£70,000
Events	Exhibition Support	£72,000
	Grants for launch events (total costs for England, Scotland, Wales and NI)	£120,000
	Welcome home event	£40,000
Press	Media relations costs (including travel, disbursements and logistics; media handling delivered in-house)	£34,000
	Support for inflight calls	£27,000
	Satellite feed for launch	£25,000
Evaluation	Research	£40,000
	Total communications expenditure	**£479,000**

Output and Impact

Principia Website

The UK Space Agency recognised the need for a unique UK-focused Principia mission website. The design and build of the site would support the UK Space Agency by amplifying our key messages and building an understanding of Tim's mission objectives. The focus was on raising awareness of the mission's cultural, educational and scientific impact.

Despite a number of competing outlets, including three separate ESA web entry points, principia.org proved to be a valuable touchpoint for teachers, students and the general public audiences in the UK. Over the course of the mission, the campaign website hosted an estimated 150,000 users viewing 46,000 pages over 197,000 sessions on the site.

Launch events

The UK Space Agency issued grants to national partner organisations to run launch events in the national capitals to help build a groundswell of support for the mission.

Organising groups in Belfast, Cardiff and Edinburgh created local partnerships with Agency support. The Agency took a lead role in organising the flagship London event on Exhibition Road, home to the capital's two world renowned scientific museums, and host site for the BBC's *Stargazing Live* broadcast.

11,000 visitors, including 2,500 school children, watched the launch broadcast live at London's Science Museum.

Professor Brian Cox and Dara Ó Briain presented two special *Stargazing Live* programmes covering the launch, docking and first moments of Tim's arrival on the International Space Station.

The launch was covered on national news, with media coverage including: BBC Breakfast, broadcast news across national radio stations, the World Service and regional TV and radio stations. BBC News, ITV News, Channel 4 News and Sky News covered the Principia launch celebrations in their main bulletins, along with CBBC Newsround, BBC Radio 5 Live, and BBC Radio 1 Newsbeat. There was also coverage in national newspapers, including The Guardian, Daily Mail, Daily Telegraph, The Times, The Sun, The Independent, the Evening Standard (plus a comment piece), Metro, BBC News online and Yahoo News.

The UK Space Agency worked closely with the Edinburgh International Science Festival to ensure the Principia Mission was high on the news agenda in Scotland. Broadcast journalists from STV TV, Sky News, BBC Scotland TV and Radio and the Scottish Press Association attended resulting in a reported 300 individual articles.

Press and Media

In the lead-up to launch (October to December 2015), ESA's media monitoring service recognised the Principia mission as the most influential mission of that term, with the mission representing 40% of ESA's total impact over the period, reaching 257.3 million contacts – 95% of them via the British media.

The UK Space Agency supported a trip for British press to the launch itself in Kazakhstan in December 2015, in addition to the BBC's dedicated team of 40 who travelled to the launch to support the *Stargazing Live Specials*.

The UK Space Agency commissioned the media monitoring service Meltwater to provide a media coverage summary which reported on the following communications anchor points. In total Meltwater estimates 8,400 separate editorial mentions of Tim Peake and the mission throughout the campaign.

Table 6: Print and online media mentions per day at various mission highlight points

Date	Mission Highlight
6 November 2015	509 articles during Tim Peake's preparation for the Principia Mission, talking about inspiring children about science and engineering with the experiments and exercises he'll be undertaking on the ISS.
15 December 2015	912 articles as Tim Peake launched into space and became the first Briton to serve on the ISS.
15 January 2016	258 articles when Tim Peake embarked on his first spacewalk - the first Briton to walk in space.
20 March 2016	152 articles around the broadcast of Channel 4's "Great British Space Dinners" programme with celebrity chef Heston Blumenthal.
24 April 2016	144 articles as Tim Peake ran the London Marathon in space on a treadmill.
19 June 2016	708 articles when Tim Peake returned to Earth.

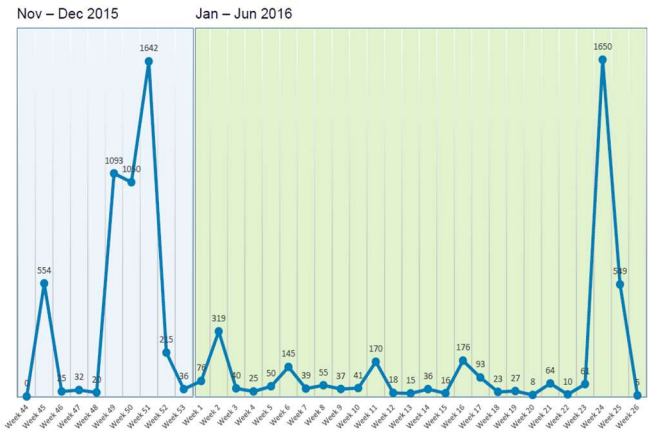


Figure 1: Print and online media mentions per week across the mission

Broadcast

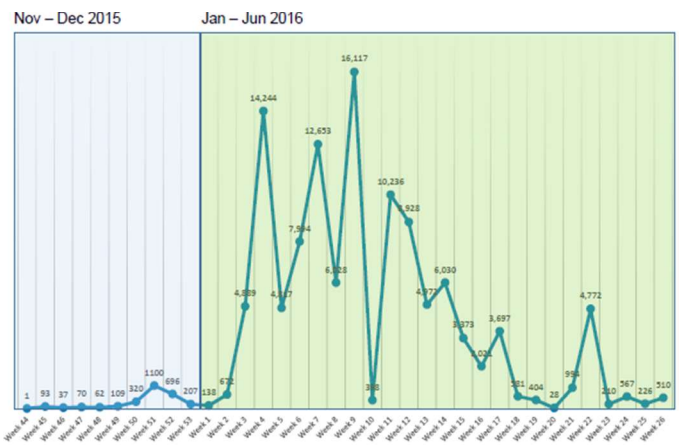
The UK Space Agency recognised the value of key strategic broadcast partnerships in building the public narrative for the Principia mission. These included a BBC Horizon documentary on Tim Peake's mission training and preparation, two BBC *Stargazing Live* special broadcasts dedicated to Tim's launch on 15 December 2015 (reaching 5.8 million - 700,000 more than normal), support for the regular three episode *Stargazing Live* broadcasts in January 2016 dedicated to Tim's mission and a Channel Four programme, *Great British Space Dinner,* with Heston Blumenthal.

The media partnerships were one of the most successful elements of the Principia campaign, with the YouGov *Public Public Attitudes to Space Survey* reporting that 63% of respondents considered broadcast to be their main source of news on the mission.

Table 7: Social media highlights through the mission

Date	Twitter Highlight
14 December 2015	Day before launch: 123,000 impressions
15 December 2015	Science Museum launch event: 108,000 impressions
20 January 2016	Our request for questions for Tim for him to answer from space: 41,000 impressions
22 January 2016	Call to take part in the Principia mission: 61,000 impressions
3 February 2016	*Cosmic Classroom* on the 2nd Feb: 60,000 impressions
11 February 2016	World first ham video from space: 21,000 impressions
2 March 2016	Rocket Science seeds returning to Earth: 69,000 impressions
29 April 2016	Tim controlling METERON from space: 72,000 impressions
17 May 2016	Federation Aeronautique Internationale call with Tim: 88,000 impressions
14 June 2016	#WelcomeHomeTim tweet with link to Facebook competition: 52,000 impressions

Figure 2: Social media exposure over the course of the campaign



Social Media

The UK Space Agency focused on Twitter and Facebook during the mission as the primary social media channels. These were as part of the wider digital campaign, which included the Principia website. This enabled us to engage with a large, diverse audience and build online support for the mission with the creation of hashtags like #GoodLuckTim and #BritInSpace.

We worked with ESA, who supported Tim Peake in the use of his social media account from the ISS. Insight from previous missions, and the success of NASA astronaut Chris Hadfield, showed that channels operated by astronauts themselves are likely to be the most effective communications channels because of their authenticity.

As expected Tim's named Twitter account was the most popular during the mission. The audience was interested in seeing his personal experiences of life in space. The timeline below, compiled by Meltwater, shows social media exposure over the course of the campaign. The peaks can be matched to particularly engaging tweets from Tim. Four of the most popular tweets are included in **Error! Reference source not found.**, demonstrating the power of imagery.

Events

In addition to events around the launch, a number of existing high-profile scientific and industrial events were considered when planning the Principia campaign. These included the Cheltenham Science Festival, where Tim Peake spoke from the ISS to attendees via satellite link (8 June 2016), and the Farnborough International Airshow (16 July 2016), where, following his return from space, Tim appeared alongside Business Secretary Greg Clark. Each of these events presented an opportunity to reach a slightly different audience for the key messages around the Principia campaign.

We commissioned event organisers to collect footfall figures, as well as secondary and tertiary metrics to measure public engagement with the key messages. We provided organisers of all major events, whether for the launch or the post-flight tour, with a framework for evaluation as one of the conditions of the grant funding. We received reports from each of the funded launch event locations, using the following metrics:

- Number of visits to event web pages
- Footfall
- Informal feedback, gathered via volunteers to be reported back in wash up meetings
- Formal feedback survey results gathered at and following the event about visitor experience and attitudes towards space and STEM
- Increase in numbers of people registering for Tim Peake and UK Space Agency newsletters and social media feeds
- Social media reaction

Figure 3:Four of Tim Peake's most popular tweets during the mission

Overall Impact

Survey

The Agency commissioned YouGov to conduct two surveys on Public Attitudes to Space in the UK, including comparisons with other space agencies, the role of the UK Space Agency, and what role space plays in our daily lives.

The studies were based on a nationally representative survey of the UK adult population with a boost of students at secondary schools aged 11 to 15 at each stage.

The first survey took place from 9 to 14 December 2015, to measure the public's perceptions before the mission. The second survey took place after the mission, from 22 to 28 November 2016. The first acted as a baseline from which the second stage of research could track changes in attitudes and awareness of the Principia Mission, the UK space industry and space related topics more generally.

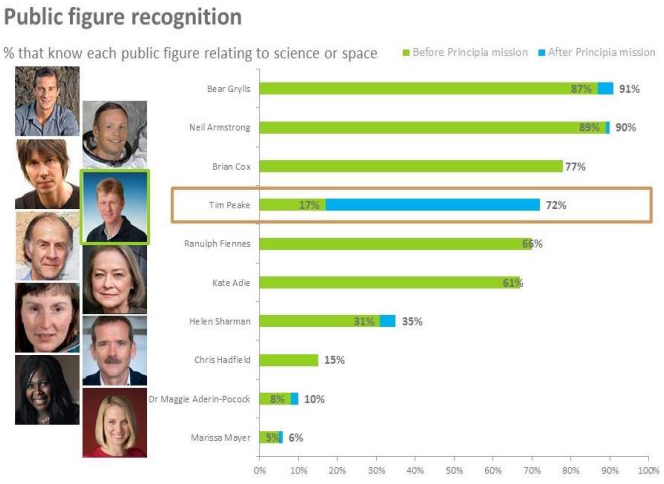
The report first identified the level of awareness the public had of Tim Peake and the Principia mission, then more widely around the UK's involvement in space related activities. The public's perceptions of and engagement with the UK space industry was then explored in more detail. This was further examined through space related topics generally and by identifying interest. Finally, the report would assess the public level of knowledge about careers in the space industry, with a focus on the perceptions and interests of the secondary school students surveyed.

Findings

The results from YouGov's *The Perception of Space* study demonstrated the success in raising the profile of both Tim Peake and the Principia Mission following the coordinated campaign of broadcast, press and digital media activity. We also saw marked increases in public perceptions of the UK space industry and space related activities more generally.

When shown a list of ten names and faces of people in the public eye, around three in four people (72%) said they had heard of Tim Peake (six out of ten, or 61% among secondary schoolers). This represented a large increase from before the mission when fewer than one in two (17%) had heard of Tim Peake. The chart below shows the increase in knowledge of the Principia mission itself, from 57% before to 77% after.

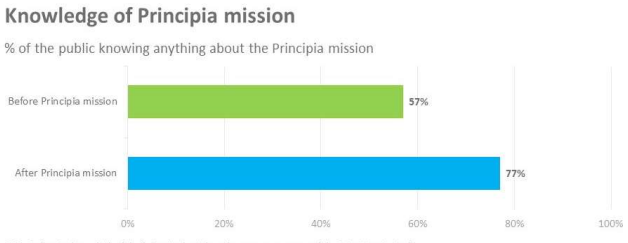
Figure 4: Change in public figure recognition over the course of the mission



Q3: Here are a group of people who are in the public eye. Which, if any, of the following people have you heard of.
Base: Before Principia mission (2,480); After Principia mission (2,399)

There was also an impressive impact on broader perceptions away from the specifics of Tim Peake and his Principia mission. The study showed a five percentage point increase in the number of adults who were aware that the UK government invests in space related activities. After the mission and associated communications activity, almost three in every four people (74%) knew this fact.

Figure 5: Change in public knowledge of the Principia mission



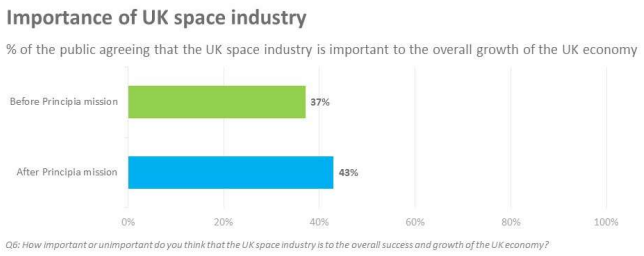
Q12: Before today, which of the following best describes your awareness of the Principia mission?

There was also a six percentage point increase in the numbers of people agreeing the space industry is important to the overall growth of the UK economy, as shown below.

When asked specifically about UK space related activities, three in four people could name at least one activity. The use of satellites was a popular response (66% of adults mentioning satellites in relation to

communication, 61% for navigation). Monitoring the Earth for weather (64%) and environmental changes (58%) were other common responses among adults. Secondary school students answered similarly to the population as a whole.

Figure 6: Change in public perceptions of the UK space industry's inmportance over the mission



Generally, fewer people felt informed about a career in the space industry when compared with other comparable industries, although there was a three percentage point increase after the mission, from 22% to 25%, in people who felt they knew a lot or a little about working in the space sector. Promisingly, for the future success of the sector, this rose to 30% among secondary school children (up from 26% before the mission). This put their knowledge of a career in the space industry above their knowledge of the automotive and aviation industries (27% and 26% respectively).

Conclusion

The UK public's perception of space changed over the course of the *Principia* mission. This was not only in terms of Tim's mission and human spaceflight, but in areas such as satellites and space science. It was a great vehicle for highlighting the whole space sector and the importance of space to our everyday lives.

The audience and circulation figures for the media coverage obtained on launch day alone topped 33 million, with a further 1.5 million views of social media content. Meltwater estimated there were 8,400 separate editorial mentions of Tim Peake and the mission throughout the campaign.

The YouGov's *The Perception of Space* survey found that the attitudes of an estimated 4 million people (6% of the UK population) positively changed, from before to after the mission, who now recognise that space is valuable to the overall growth of the UK economy.

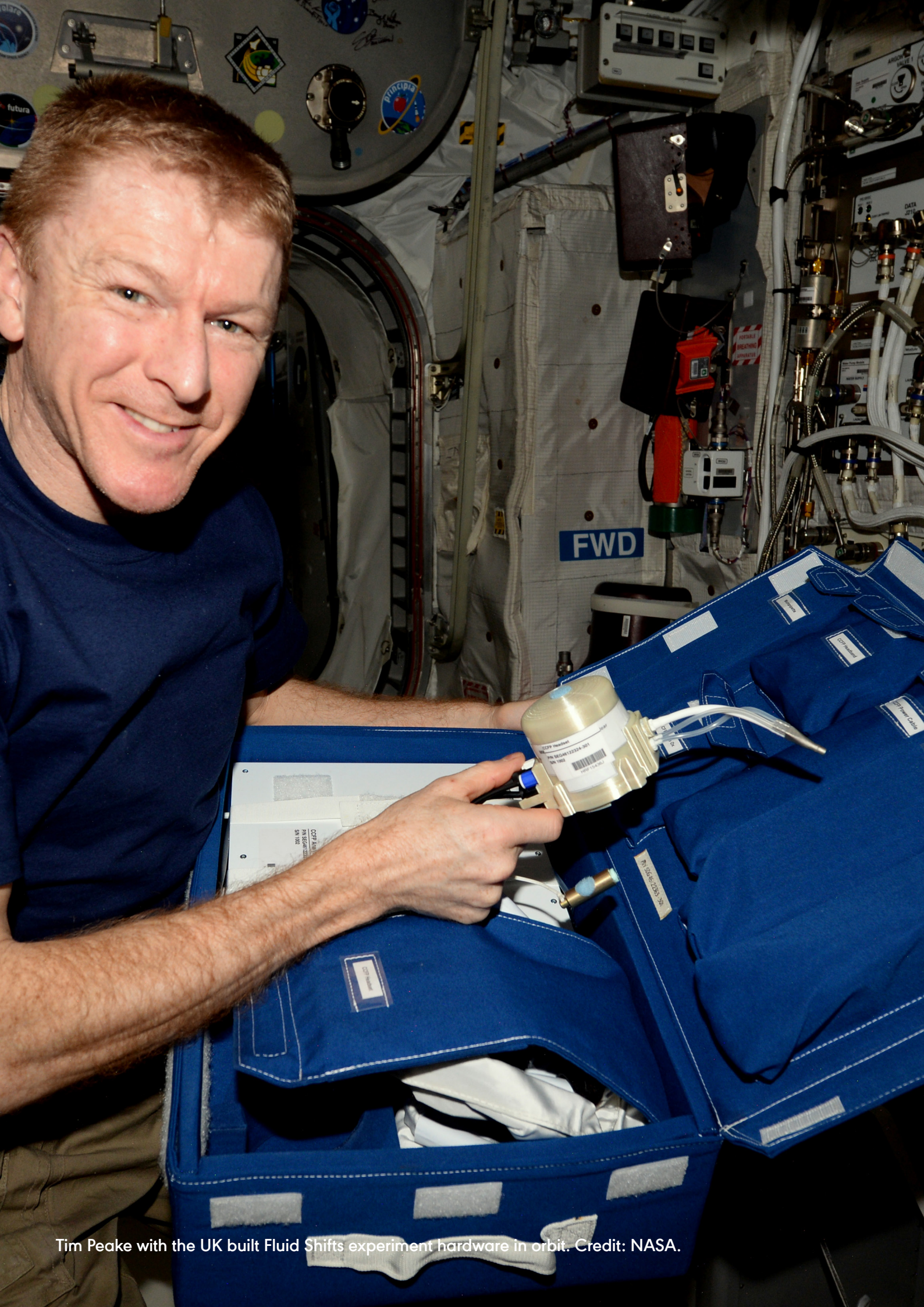
The communications plan was ambitious and delivered impressive results despite facing challenges in the planning and run up to launch. Coordination between the UK Space Agency and ESA was critical to its success and, while there are lessons to be learned and a recognition that objectives will not always align perfectly, strong relationships were forged. These will serve a potential second mission for Tim well.

The success of Tim's social media profile was expected but still highlighted the importance of considering which channels work best to deliver messages to specific audiences. There is a balance to be struck between the authenticity of an astronaut's personal profile and the more corporate, campaign messages that is our task to deliver. Openness and discussion around these challenges are the best way to meet them.

The launch events delivered impressive audience engagement figures which were elevated significantly by the media partnerships built by the UK Space Agency when planning this campaign. The media partnership model worked well in general but with the emergence of more diverse media platforms, future campaigns may benefit from a wider range of partnerships to ensure our messages our reach the right people at the right time.

Running this campaign placed significant resource pressure on the UK Space Agency communications team, which meant that other Agency projects needed to be de-prioritised. Recognising the resource implications of such campaigns earlier on in the process would benefit both the campaign and wider projects.

A great deal of experience was gained throughout the campaign and it is important that this is shared so that the lessons learned can be used in future campaigns, both for the UK Space Agency and across the Government Communications Service. This will add further value to the investment made to make the Principia campaign happen.



Tim Peake with the UK built Fluid Shifts experiment hardware in orbit. Credit: NASA.

SCIENCE PROGRAMME

Overview

There was no national science programme for the Principia mission. Given the time between the UK joining the ISS programme (November 2012), the announcement of the flight (May 2013), the planned launch date (November 2015) and the required timescales for implementing a national programme, it was impossible to design new experiments for Tim's flight. Instead, the UK Space Agency highlighted the collaborative research projects which included UK scientists.

This contrasts with other ESA Member States, who have been able to use the occasion of their national astronauts to conduct nationally-funded experiments. However, UK scientists were part of science teams for a number of experiments and the UK sought to highlight these contributions.

The main experiments involving UK researchers were:

Thermolab and NEQUISOL. These two experiments used the Electromagnetic Levitator (EML), a furnace that is used for studying the behaviour and properties of metals in a microgravity environment.

SUPVIS-M. This remote robotics experiment was part of the ESA's METERON project preparing for human-robotic missions to Mars, the Moon, or other celestial bodies.

BOSS and BIOMEX. Both these astrobiology experiments, on the ISS EXPOSE-R2 external facility, studied the behaviour of biomolecules in space.

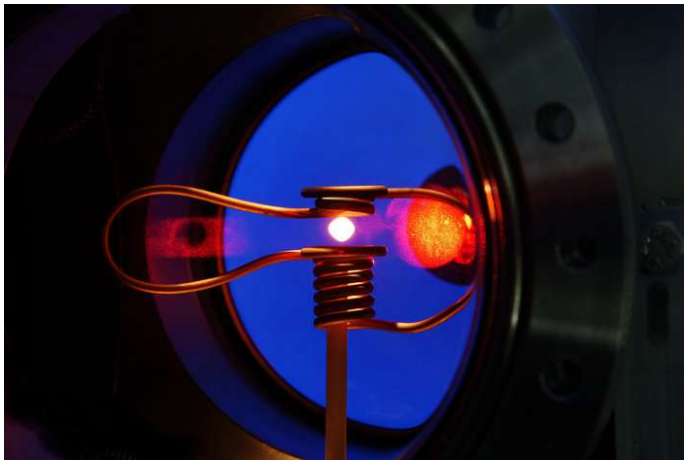
Fluid Shifts. This experiment is studying how an astronaut's physiology changes during long duration flight and is using UK hardware to measure the relative intracranial pressure.

These experiments are detailed further in Appendix 4.

34 ESA scientific experiments and technology demonstrations were carried out by Tim:

- 12 human research
- 4 biology
- 8 materials science
- 2 solar research
- 2 radiation dosimetry
- 6 technology demonstrations

The mission was highly productive. ESA used 116 hours of Tim's time for their scientific experiments, compared to the 68 hours 'due' to ESA under the terms of their operating agreements with NASA. This was possible due to experiments being defined as 'reserve' activities, those which could only be done if all of the main planned activities were completed and planning and time allowed.



The Electromagnetic Levitator furnace that Thermolab and NEQUISOL used

Review

The UK Space Agency's science objectives for Principia were:

- to use the communications activity supporting the Principia mission as a vehicle to raise public awareness of UK research that uses the facilities offered by human spaceflight
- to shine a spotlight on the success of UK science and technology, particularly in the world of ISS, highlight these areas, foster growth, and encourage continued scientific excellence.

Throughout the Principia mission, science messaging was included in all communications and education activities. Wherever possible, the UK Space Agency sought to educate the general public about the scientific work that is undertaken on the ISS and in other space environments.

Science, both linked to that on board the ISS and the science and technology that keeps it in orbit, underpinned the educational and outreach activities. Projects such as *Rocket Science, TimPix* and *STARS* included direct references to research that was being carried out on the ISS.

A set of resources around *BioRock*, a UK led experiment, was developed as part of the education programme. Unfortunately delays in the flight of this experiment (now planned for early 2019) limited the promotion opportunities but this resource remains available and will be used when the experiment does fly.

Throughout the campaign it was clear that the human interest story captivated the media and the general public but, despite efforts, it was difficult to engage the media and general public in details of the science success stories. A dedicated press conference, focussing on the UK science endeavours, received a significant number of questions related to everyday life on-board the ISS and Tim's mission in general.

Despite the best efforts of all involved, at the end of the mission, the YouGov *Public Attitudes to Space* survey found that one in two adults (51%) thought Tim Peake spent most of his time in space doing scientific activities.

This concern was echoed in the RISES report, which noted the same findings and attracted comment from among the study's informants, for example one science teacher said:

"... the BBC had a spread on him and in the short blurb saying what he'd been up to they said, 'Tim did a spacewalk, ran the London Marathon and was chased around the ISS by a gorilla'. And they didn't talk about any of the science he's done, they just focused on those bits. "

The report further notes:

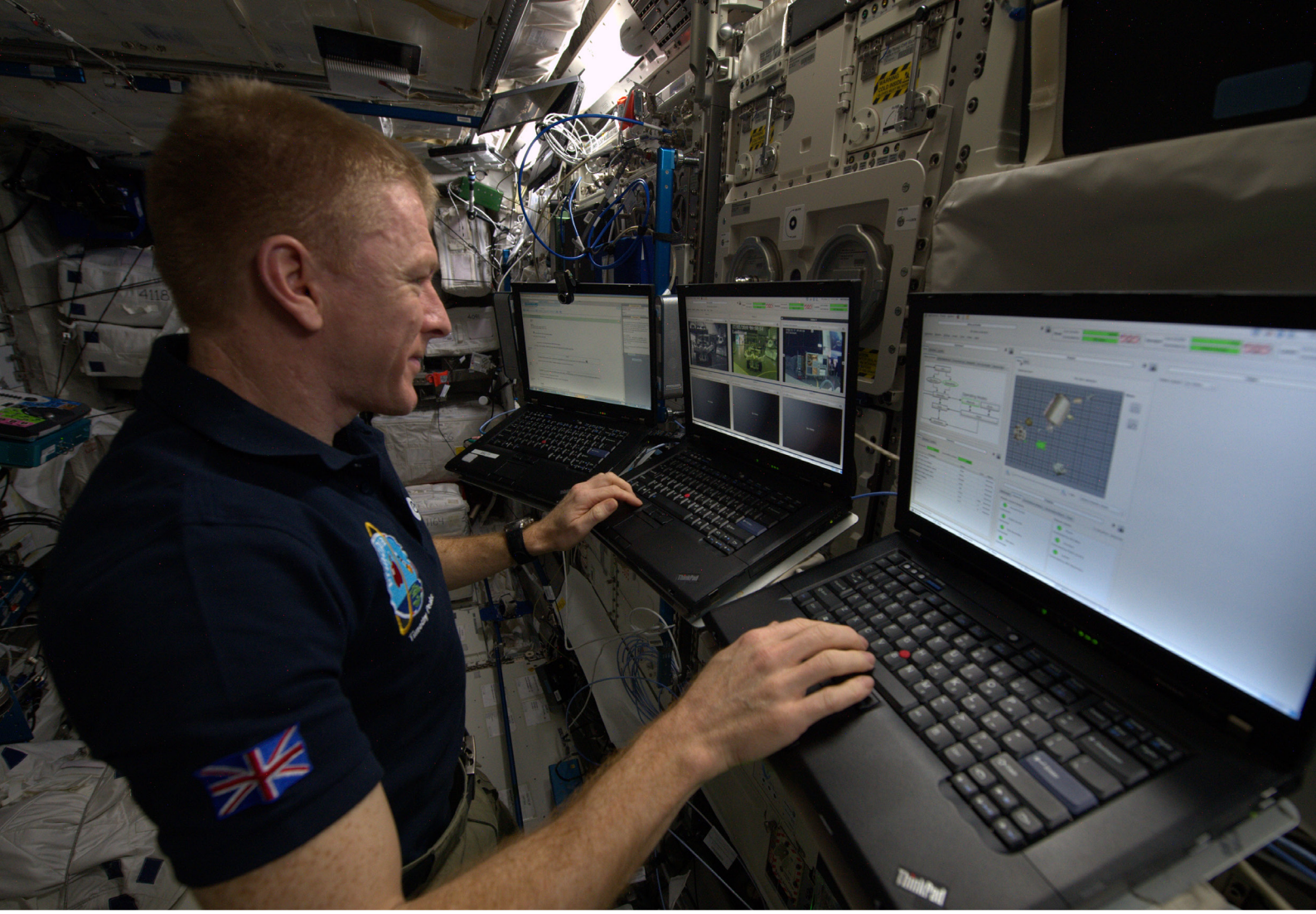
"This lack of science focus perhaps explains the lack of understanding of the scientific purpose of Principia, and the association of human spaceflight with NASA rather than ESA or the UKSA, which were ideas prevalent amongst children and adults, even at Phase 3 of data collection."

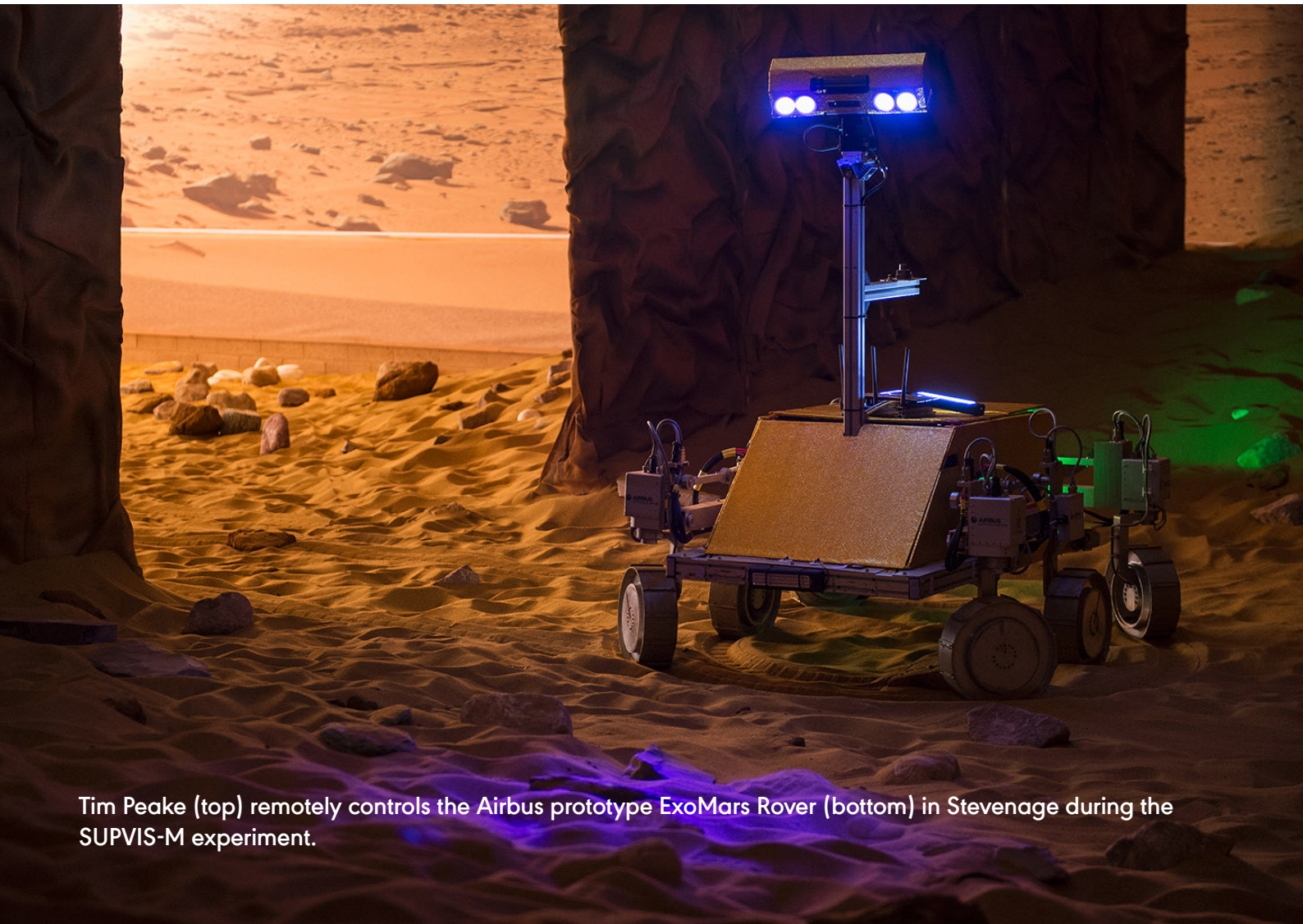
A national science programme, funding UK academics and industry, would have enabled a critical mass of UK led science experiment to take place on the ISS during the Principia mission. This would have provided more concrete stories and hooks for the media, and opportunities for the education programme to deliver activities directly related to these programmes, thus extending the education and communications benefits further.

Lessons learned

For any future flight of a British astronaut, a national programme of science experiments would provide a focus for the communications, education and outreach campaigns. This would enable the science messaging to be told more strongly than in the Principia campaign, where it was often overshadowed by the interest in day to day life on the ISS. Preparation for such a programme would need to start in advance of the confirmation of flight date, which is typically two to three years before flight. Development of hardware can take several years and must be on board the ISS ahead of the arrival of the astronaut.

Such a programme would also allow the education, outreach and communications campaigns to provide a focus on how the experiments are built; highlighting the engineering that leads to the science.





Tim Peake (top) remotely controls the Airbus prototype ExoMars Rover (bottom) in Stevenage during the SUPVIS-M experiment.

UK pictured from the ISS. Credit: Tim Peake/ESA/NASA.

OVERALL CONCLUSIONS

Overview Conclusions

The UK Space Agency's Principia campaign broke new ground. There had never been such a sustained and wide-reaching engagement with space in the UK. The campaign reached at least 33 million people through communications activities and at least 2 million children across one in three UK schools taking part in education activities. A lasting positive impact was observed in both cases and the programme clearly achieved its objectives and met performance indicators, exceeding targets by some margin.

The campaign, with a relatively modest investment of approximately £3m across the education and communications activities across three years, was value for money and a worthwhile investment.

Principia changed the UK public's perception of space, not just in terms of Tim's mission and human spaceflight, but in areas such as satellites and space science. It was a great vehicle for highlighting the whole space sector and the importance of space to our everyday lives.

The campaign raised the awareness of the space sector among people across the country to 43%, with an increase of 6% (approx. 4 million) agreeing that the space industry is important to the growth of the UK economy. It encouraged and maintained interest in STEM subjects as well as supporting other government objectives such as improving diet and fitness among young people. Finally, it provided a legacy of educational resources, using space as a context for teaching and learning, that continues to inspire children and teachers today.

Communications and education/outreach are two sides of the same coin and the two campaigns complemented each other. The education activities harnessed the powerful PR campaign and Tim's growing celebrity to drive the scale of the education campaign. Meanwhile the communications campaign utilised the education campaign for narrative, which appealed to the mass media. These grew together and both then took opportunities to highlight messages around careers and the wider space sector.

Unfortunately, the overall objective to focus on the scientific messaging was weakened by the lack of a dedicated science programme. For future missions these should be considered a triumvirate that must work together with coordinated campaigns and messaging.

Legacy

The legacy of the Principia mission continues to be felt across both education and media some two years after Tim Peake's return to Earth.

In this time since Tim has returned, space has remained part of the national conversation and the wider impact on the general public is notable. While impossible to accurately quantify or assign all credit to the Principia mission, it is clear that space has remained higher up in the UK public's consciousness, with many major high street brands using space in their ranges and advertising. Tim Peake remains a celebrity, with activities noted in the press from appearance in the Royal Box at Wimbledon to being touted as a potential contestant for Strictly Come Dancing.

Across the arena of education, there is clear evidence of lasting impact, from the improved and increased library of education resources that are continuing to be used in classrooms and by home educators, to the afterschool science clubs and other groups that were set up during the programme and continue to flourish now. The orders of magnitude changes in take up of A-Level subjects seen in some schools, and the increase in engagement and confidence in primary school pupils, show that Principia had a lasting positive impact.

The true legacy of Principia will not be known for many years, but we are confident that in years to come the space sector and, more widely, careers related to science, will be filled by people who can trace their inspiration back to the six months that Tim Peake spent on the International Space Station.

The consequences of no investment

Tim Peake's mission was enabled by the UK investments in ESA's ISS programme and would still have taken place without the Agency's education and communications programmes. But the European Space Agency would have had sole responsibility and any related activities would have been Europe-wide and therefore of limited scope. Previous ESA education programmes linked to astronaut missions typically see engagement figures in the thousands or tens of thousands across Europe. The figures from UK efforts dwarf these.

There is no doubt that there would have been interest in the UK in any offerings from ESA, but the impacts would not have been so significant. The range and breadth of offerings for teachers were key in encouraging sustained engagement throughout the year and the most notable results have been seen in schools that embraced the mission across the academic year. Without an education programme, there would have been nothing near the level of engagement in STEM subjects observed. That opportunity would have been missed forever.

Although there would have still been wide media interest in Tim and the *Principia* mission without the UK Space Agency communications efforts, the messaging would not have been targeted to the needs of the UK space sector. It would have been impossible to not engage as the national agency but, by investing funds and efforts, the messages placed out there promoted the entire UK space sector.

Recommendations

The UK should instigate a rolling programme of space education activities at a similar scale to build on this successful example, this time using the whole of the UK space programme to inspire interest and engagement with science and technology. Although such a programme cannot rely so heavily on the impact of such an effective ambassador as Tim to focus attention, it can instead draw on an increasing range of high-profile space activities. These can be linked to additional areas of the curriculum and illustrate new opportunities for rewarding careers in growing sectors.

During the previous two years several million young people have been inspired by space activities. Rather than allow that interest to weaken or die, it is now crucial to use a sustained programme of space activities to maintain and build the skilled workforce that UK employers need. Such a programme would have an even bigger impact if it were linked to another astronaut mission.

The Principia mission demonstrated the power of human spaceflight to engaged and inspire audiences with science and technology. If Tim were to be assigned another flight, a varied and broad range of educational activities could build on the legacy of Principia and capitalise on the exciting research he would be able to carry out in space. The UK should support such a flight with UK involvement in microgravity research and demonstration of in-orbit techniques as part of the preparation for future exploration of the solar system.

Future programmes should build on the lessons learned during this programme – for example, aligning activities with a range of key curriculum areas, working with new partners outside the space sector, embracing the human elements of space and harnessing existing networks and audiences to increase the reach.

Tim Peake spacewalk selfie. Credit: ESA/NASA.

APPENDIX 1: EDUCATION PROJECT DETAILS

Aberdeen Science Centre Exhibit		Aberdeen Science Centre	
Subjects covered:	STEM	**Age range:**	All
UK Space Agency contribution:	£30,000	**Financial contributions from elsewhere (where known):**	£30,259
Target Audience:	12,000	**Actual Audience:**	14,507

Summary: Aberdeen Science Centre (ASC) has seen the expansion and enhancement of the space zone through the creation and installation of an interactive lab module exhibit, based on the Columbus research module of the International Space Station (ISS). This facility has provided all visitors to ASC with the opportunity to participate in a range of hands-on science, technology, engineering and mathematics (STEM) practical activities and challenges in a themed and immersive environment.

Alongside self-led learning activities, workshops have been developed which are facilitated by ASC staff. These include a Day & Night show, a robot arm workshop and snap circuit workshop, which are all suitable for family audiences. The module is also being used at weekends and for Little Explorer Days as the backdrop for storytelling sessions and activities for under 5s. ASC have also revamped the Space Birthday party, incorporating the lab module into the delivery of Space on the Spot.

Evaluation Strategy: Delivery numbers, teacher and pupil feedback, visitor evaluation

Impact: Aberdeen Science Centre had an engagement target of 12,000 visitors for the first three months of the lab module (January 2017 – March 2017). As of March 2017, ASC has engaged with 14,507 visitors on the exhibition floor since the install of the Columbus module.

Overall, visitor feedback relating to the lab module has been positive.

Analysis of just some of the feedback from families who participated in the lab module survey, after engagement with the exhibit:

- Everyone stated that they liked space more than before (47% a lot more, 53% a bit more)
- 71% stated that they felt more confident about science in general
- 78% wanted to find out more about the space sector after their visit to the centre
- 72% think that experiments on the ISS are relevant to their lives on Earth
- 76% rated the Space on the Spot as good (22%) or very good (54%)

The gender balance for completed surveys was nearly 50:50 (55.7 female, 44.3% male). From post codes visitors, as expected, were mainly from Aberdeen City and Aberdeenshire, however there were also responses from Dundee, Inverness, Glasgow, Edinburgh and Northampton.

Aberdeen Science Centre Exhibit	Aberdeen Science Centre

Feedback:

Teacher Feedback

"Great day out, the pupils loved the ISS module and being able to dress up for the day"

"Brilliant, staff were excellent during the circuits workshop bringing what could be a difficult topic to life"

"The floor space has really improved throughout the last year; the space area was a hit with all the children"

"It's great to see the legacy of Tim Peake within the Science Centre"

School Feedback

"The most exciting thing I learned was that astronauts got to go out on a robot arm just to fix things, and I got to use one" – Pupil, P4

"I liked learning about the ISS and how the robot arm worked" – Pupil, P5

"My favourite thing was learning all about the planets in the ISS, I got to be Mercury!" – Pupil, P4

"My favourite bit was dressing up as a spaceman, I learned electricity was fun" – Pupil, P4

"I liked finding out about space" – Nursery child

Weekend Feedback

"Great day out, we came due to the rain as we have not visited before. We weren't expecting to have such a wonderful time; the Space on the Spot was the highlight"

"Good day had by all, the new space exhibition has help improve the floor activities – we will be back"

"The space module is a brilliant space, it would be good to have staff on-hand to explain the activities to some of the younger children and get them interested in space at an early age"

"Kids loved the storytelling session, staff in the space area were brilliant"

"space module was good, but could be expanded on – information panels on the outside, more graphics, and fact bubbles inside"

Adventures in Space and Tim Podcast		Helen Keen (with Centre for Life)	
Subjects covered:	Science, technology, engineering	**Age range:**	All
UK Space Agency contribution:	£30,000	**Financial contributions from elsewhere (where known):**	£0
Target Audience:	12,000	**Actual Audience:**	13,000

Summary: Comedian and space enthusiast Helen Keen created 6 podcasts inspired by Tim Peake's mission and all the wonders of the cosmos. Episodes are hosted on Soundcloud, iTunes and across other podcasting platforms/feeds as at March 2017. Multiple interviews were recorded over several months in person and via Skype. The aim was to show the diverse ways space and space missions can impact and inspire. E.g. in episode 3 there are interviews with the US-based Oscar-nominated screenwriter of Hidden Figures, Allison Schroeder, who had an early interest in STEM and interned at NASA, as well as scientist Dr Rory Hadden from the University of Edinburgh with one of his postgraduate students, who is currently working with NASA and ESA on a study of fire in space.

Evaluation Strategy:	Listening figures, teacher feedback, social media response

Impact: The podcasts will have further reach than just the platforms where they are currently available for download. For example, Episode 3 featuring the interview about Hidden Figures, is being shared by the Ada Lovelace day project and blog with their network. Episodes 4 and 5 will be shared by the Science and Technology Facilities Council's networks and episodes 3, 4 and 5 will be being shared and promoted by Edinburgh University locally and with their networks.

Listening figures will continue to increase over time, because podcast growth tends to be spread out over a long period. The listening figures for podcasts are completely different from those for a radio show, for instance, that's only broadcast once and where listeners cluster around that single broadcast. Even if radio programmes are available online, it is usually for a week or month. In contrast, older podcasts tend to remain online after new ones are made available. Any time a new listener comes along, they have the opportunity to go back and listen to all the previous podcasts too.

Feedback:

"Absolutely fascinating!"

"Never seen or heard my two boys (6 & 9) sit so still and listen so well"

"Wow...Copenhagen Suborbitals, this is so exciting, no I never knew about their initiative, but I will follow their progress now, admiration to these people"

"Loved it! Shall be watching the amateur space travellers with keen interest. After all it wasn't a government or big business that have us powered heavier than air flight, just two dudes from a bike shop"

Amateur Radio on the ISS (ARISS) calls		Amateur Radio on the ISS (ARISS)	
Subjects covered:	STEM, cross-curricular	**Age range:**	5 to 18
UK Space Agency contribution:	£25,109	**Financial contributions from elsewhere (where known):**	£1,700
Target Audience:	10,000	**Actual Audience:**	52,345

Summary: Schools and educational establishments were invited to submit applications to host a two-day space STEM event, targeting students and young people, with the aim of increasing awareness in the STEM subjects. The highlight of this was a scheduled radio contact with Tim Peake during his time aboard the ISS.

The final choice of schools to host each of these contacts depended on the operational constraints (such as ISS orbits and crew availability), on school availability and on other relevant factors such as school facilities, skills and impact. In the end, through the perseverance and ambitions of the ARISS team, ten schools hosted a live link with Tim Peake from the period January 2016 – May 2016. As well as HAM Radio, HamTV links were put in place in 7 of the 10 schools where operations allowed and Principia's use of HamTV, as part of the live contact, was the first globally recognised operational deployment of HamTV.

ARISS functions through volunteer radio amateurs who use their expertise and dedication to inspire youngsters into STEM and space subjects. The UK Operations team comprised of eight licensed radio amateurs, a mixture of retired and working individuals, who mobilised for each school with as little as seven days' notice due to the nature of ISS timeline approval within the payload teams at NASA Johnson Space Center, Houston.

Evaluation Strategy: Contact Evaluation forms submitted within one week of the contact

Impact: All the schools gained significant media attention, particularly with the local press and some, like the examples below, received significant national and international coverage.

Sandringham was the first school to have an ARISS contact, and therefore gained a lot of media attention. They carried out significant analysis of the viewing figures from local and national TV and radio stations as well as social media. Sandringham's Social Media #Sandspace achieved 898,795 impressions, 817 posts, 240 users, 408,253 reach, 63% female. The ARISS Operations UK team reported that more than 1,300 concurrent connections to their live web stream were observed during the contact with Sandringham.

Royal Masonic School was the second school to host a contact, but the first to experience a live video feed of Tim Peake via HamTV. One Facebook post by the BBC Three Counties Radio team (who covered the contact live during their DriveTime program) is believed to have one of the biggest views that any ARISS Principia social media posting has received. The contact took place on 11 February 2016 and by the 18 February 2016 had received over 40,000 separate views.

Each of the 10 schools selected had multiple other local schools join for the contact, so the impact was further reaching than just the host school. For example, City of Norwich School had 32 separate schools throughout the East Anglia geographical region tune into the live contact

Amateur Radio on the ISS (ARISS) calls	Amateur Radio on the ISS (ARISS)

Feedback:

"ARISS, Amateur Radio on the International Space Station, provided me with a unique opportunity to talk to students all over the world about space, science and the importance of education.

"During my time on orbit on the International Space Station, I had the privilege of talking to 23 schools worldwide and specifically, ten schools in the UK. These ten UK schools were part of the "GB1SS Listening and Standing By..." programme developed by ARISS UK in consultation with the UK Space Agency and included many of the Principia outreach providers.

"The range, depth and often complexity, of the questions that I was asked by more than one hundred UK students during these brief ten minute ARISS contacts, showed me just how important my mission had been to you, how intensely you followed my mission and the science that I was carrying out. On a personal level, it was hugely enjoyable and gave me an important connection with planet Earth

Congratulations to every school involved – it is forever, your ten minutes of Principia history."

Tim Peake

Facebook reaction to RMS call on BBC Three Counties Radio:
https://www.facebook.com/BBC3CR/videos/1299409430076432/

St Richards, BBC South East: https://www.facebook.com/BBCSouthEastToday/videos/10154116229478648#

Astro Academy Principia		National Space Academy	
Subjects covered:	Physics, chemistry, maths	**Age range:**	11 to 18
UK Space Agency contribution:	£15,357	**Financial contributions from elsewhere (where known)**	£10,000
Target Audience:	7,500	**Actual Audience:**	7,680

Summary: Tim conducted and filmed a series of simple demonstrations on the International Space Station (ISS) using a set of kits and procedures designed and built by the National Space Academy to illustrate fundamental aspects of physics and chemistry curricula, comparing results in micro-gravity with those in classrooms on Earth for the *Astro Academy Principia* project. The demonstrations cover secondary science topics including: circular motion; collision physics; and kinetic theory of gases and simple harmonic motion. The programme also included dynamic analysis of more than 40 of the demonstrations conducted by Tim allowing students and teachers to conduct individualised sophisticated dynamic analyses using "Tracker" software.

Tim's demonstrations were put together with Earth-based filming to create a series of five films. These are accompanied by written teacher guides using the classroom expertise of the National Space Academy, whose UK wide team is comprised of award winning and Ofsted rated "outstanding" subject specialist teachers with years of experience and excellent records of exam results. The video clips of Tim and video captures of dynamic analyses have also been released as standalone clips which teachers can use independently in their lessons.

Evaluation Strategy: Teacher feedback, website tracking

Impact: Since its launch in October 2016, *Astro Academy Principia* (AAP) resources and activities have been at the core of National Space Academy (NSA) delivery for students and teacher training in the UK and overseas. Metrics to date since the programme launch include:

- Over 5,000 secondary school and over 500 primary school students in the UK used AAP activities in NSA masterclasses
- 900 UK teachers participated in NSA training featuring AAP
- Over 750 international students used Astro Academy Principia activities in AAP masterclasses delivered in Norway, China and the United Arab Emirates (UAE)
- Over 140 international teachers have been trained in the use of AAP in programmes conducted by the NSA for ESA, the UAE Space Agency and in China programmes
- In addition, the NSA has led intensive training in the use of the AAP activities for over 100 Ogden Trust Science Officers, Teacher Fellows and Institute of Physics "Stimulating Physics" teaching coaches who lead on national physics teacher training and support

The British Council used AAP (through translation of films and teaching guides into Russian) in the UK-Russia Year of Science and Education 2017

Astro Academy Principia	National Space Academy

Feedback: Teacher comments (through training and use with students) include:

- *"The use of Tracker is suggested in the Core Practicals for A2 Physics - having the videos of Tim's experiments in space to analyse are a great addition to our teaching resources"*
- *"AAP is enlightening – great resources. Great to have real dynamic experiment results from the ISS straight into curriculum physics teaching"*
- *"Tracker analysis is outstanding for my students"*
- *"Teacher guides very rich - videocaptures are immediately insertable into existing lessons"*
- *"Fantastic – brings physics to life and excellent for triple science GCSE revision"*
- *"Excellent for A level momentum and circular motion demonstrations and Year 13 extension thermodynamics for Oxbridge entrance preparation"*
- *"AAP is truly inspiring - lovely film clips, rich content in teacher guides"*

"The Astro Academy Principia activities and resources have revolutionised my teaching of fundamental concepts from GCSE to A level and Cambridge Pre-U teaching"

Astro Pi		The Raspberry Pi Foundation and UK Space	
Subjects covered:	STEM, coding, music	**Age range:**	7 to 16
UK Space Agency contribution:	£116,201	**Financial contributions from elsewhere (where known):**	£40,000
Target Audience:	Not defined	**Actual Audience:**	17,000

Summary: In early 2015 school students were asked to design science experiments to be run by two augmented Raspberry Pi computers (called Astro Pis) on board the ISS. Participants were provided with identical computer hardware kits on ground which they used to code software to carry out their experiments. The software was submitted on the competition website and the winning teams had their experiments run on board the ISS during Peake's mission with collected data downloaded to ground for analysis by the students.

The Astro Pi music competition in early 2016 required school students to either; code software to turn the Astro Pi computer into an "iPod like" MP3 player; or to code music (in synthesiser software called Sonic Pi) for Peake to listen to via the MP3 player software. The MP3 player software and music from the winning teams was then uploaded as a crew care package for Peake.

Evaluation Strategy: Entries to the competition, website tracking

Impact: The impact of the Astro Pi project goes beyond the competitions that ran during Tim's time aboard the ISS. The Raspberry Pi Foundation created different educational resources, online material and developed a free emulator for the flight hardware that can all be used for years to come.

The Raspberry Pi Foundation developed 15 online educational resources to support teachers and participants of the Astro Pi competition, by the end of 2015 these has received a total of 346,103 pageviews. Between January and April 2016 these has received a further 283,025 pageviews.

The 2015 Astro Pi competition received entries from 285 schools and 692 individual students were directly involved in producing these entries. The subsequent music competition in early 2016 received entries from 40 schools represented by 70 individual students. These entries represent a significant time commitment by each participant.

The Raspberry Pi Foundation also developed an online emulator for the flight hardware to scale future participation beyond what is possible by providing physical hardware kits. This emulator can be used on any Internet-connected computer.

Raspberry Pi developed six new Code Club projects for the 150,000+ children in the 10,000+ Code Clubs around the world to use with the online emulator. The projects will enable Code Clubs in the UK and internationally to use the emulator to create projects using the Astro Pi hardware and set that learning in the context of human spaceflight and the ISS. Since the Astro Pi resources were updated to include the online emulator in March 2017, they have received a total of 85,488 unique pageviews up to May 2017. The six Code Club projects have had a combined total of 5,252 unique pageviews up to May 2017. They expect their usage numbers to increase over time as more and more Code Clubs become aware of the projects via continued promotion of these from their Foundation's communications to volunteers and clubs.

Astro Pi	The Raspberry Pi Foundation and UK Space

After Tim Peake's mission to the ISS, the Raspberry Pi Foundation continued to work with ESA on further coding competitions. They ran the European Astro Pi competition for young people aged 16 and under, as part of the Proxima ISS mission (Thomas Pesquet's six month mission to ISS). Between October 2016 and February 2017, 3,794 students from 15 countries participated in the European Astro Pi competition. These students were able to use the online emulator in their work for the competition. The four blog posts Raspberry Pi wrote to promote the Sense HAT and the accompanying projects were viewed a total of 96,995 times. The Raspberry Pi Foundation are continuing to work with ESA to make Astro Pi an annual European wide coding competition running every school year.

Feedback:

"I am so happy I got to be part of this competition and I'm amazed that I am one of the winners! My entry was inspired by space and sci fi and I am currently working on another song on SonicPi."-Isaac Ingram

"[Following her Astro Pi competition win] Hannah and I ran an Astro-pi code stall at the Royal Holloway College on the open day 2016, and it was very rewarding to see Hannah engaging with the younger visitors to the open day trying out code examples from worksheets to explore the Sense-hat features. It was a success as we busy for 6 hours from opening until close with young visitors. In the last year of primary school they setup an astro-pi club. Running the code club for a year, helping others really showed that she could hold her own when dealing with computer technology. Now in year 9 of senior school she has taken the option to do computer science at GCSE, and is enjoying the practical aspects such as lego-robotics and some coding in swift and python." John Belshaw, father of Hannah, an Astro Pi competition winner.

Astro Science Challenge		Unlimited Theatre	
Subjects covered:	Cross-curricular, including numeracy, literacy and coding	**Age range:**	7 to 11
UK Space Agency contribution:	£45,500	**Financial contributions from elsewhere (where known)**	£128,890
Target Audience:	6,000	**Actual Audience:**	10,855

Summary: The *Astro Science Challenge* is an interactive space adventure free to all UK schools, home educators and families. Children aged 7-11 work to become space agents as they take part in missions created in partnership with leading science organisations. Run by Unlimited Space Agency, the *Astro Science Challenge* uses Tim's Principia mission to inspire children to engage in science, maths and English through online film, story and classroom activities, with free lesson plans provided for teachers.

The *Astro Science Challenge* is a series of 18 Activity Plans for use as the basis of lessons for students. Unlimited Space Agency has also created a story world, accessed through an app or on desktops, which references the real science and enhances and deepens children's engagement through their interaction with fictional characters. Students can use the *Astro Science Challenge* app to follow the story, create their own Cadet account and choose their avatar, to write and upload all their work and to claim badges when they've finished a Mission. Team Leaders can monitor their Cadets' progress and award badges for completed Missions though the Team Leader Admin section on this website.

Evaluation Strategy: Online metrics

Impact: One of the purposes of the last phase of the *Astro Science Challenge* was to 'future proof' the materials so that they would have longevity. While some updating from time to time will be needed to reflect scientific advances, the investment in the app design and development, the updated materials on the web version and administration interface will return, over a longer timescale, a greater reach than the original, time specific project.

Further promotion is planned throughout the spring and summer of 2017. This will include promotion and information about the App within UNSA's new Space Shed installation and performance which will tour to ten outdoor arts festivals during the summer of 2017, including Blue Dot, Latitude and Wild Rumpus festivals reaching mass audiences with How I Hacked My Way Into Space: the story behind the *Astro Science Challenge*.

Future impact: the story behind *The Astro Science Challenge* 'How I Hacked My Way Into Space' has been playing to large audiences at festivals across the UK. The show was expected to reach around 10,000 by 2017. They anticipate that sign-up using the app will continue to grow steadily and will spike again during future space missions.

Astro Science Challenge	Unlimited Theatre

Feedback:

Quotes from *The Astro Science Challenge* Final evaluation report:

"I liked learning about Tim Peake and his mission on the ISS, it was like we were actually helping him prepare!"

"I enjoyed the Astro Science Challenge because it's not just normal lessons its a bit of everything."

"I learnt science can be fascinating and really fun."

"I learnt never to give up and be tenacious."

"I read about the international space station because I want to know as much as I possibly can. I didn't even know the ISS was even there."

"I could become an astronaut when I am older and study more about space."

The Astronaut Handbook		Usborne	
Subjects covered:	Literacy, STEM	**Age range:**	4 to 14
UK Space Agency contribution:	£5,200	**Financial contributions from elsewhere (where known):**	-
Target Audience:	10,000	**Actual Audience:**	16,957

Summary: The Astronaut handbook was written by Louie Stowell and is a guide to becoming an astronaut, full of funny and fascinating insights, plus a personal message from Tim Peake.

The handbook allows you to discover how you become an astronaut, the training you must undertake, how to travel into space and what to do when you're up there. It included a foreword from ESA astronaut Tim Peake, the first British astronaut to embark on a mission to the International Space Station, and was published in association with the UK Space Agency.

An abridged version of the full book was produced for the UK Space Agency by Usborne, shared both as a free physical copy and available free to view online.

Evaluation Strategy: None

Impact: As this was a book to be bought by the public, it is difficult to find out the impact it has had on those readers except for anecdotal evidence and book reviews.

Feedback:

Comments relating to the full book:

"A superb book all about how to become an astronaut... There's a lot of humour in it, and it's full of those little details that just make a book special" - judges comments, Royal Society Young People's Book Prize 2016

"A great non-fiction book, full of information for all space lovers. The children found it fun to read as well as educational due to the illustrations and funny comments. It would certainly inspire children" - Practical Preschool and Primary Teacher Awards

Biorock		University of Edinburgh	
Subjects covered:	Biology	**Age range:**	11 to 18
UK Space Agency contribution:	£0	**Financial contributions from elsewhere (where known):**	-
Target Audience:	Not defined	**Actual Audience:**	6,400

Summary: BioRock is an International Space Station experiment that will study the effects of microgravity on the growth of microbes on rocks. Its motivation is to understand how microbes behave in space, how space conditions affect their ability to grow (form 'biofilms') on solid surfaces and whether they could be used in mining and other useful industrial and life support processes in space.

Teacher lesson plans were developed around the experiment and Tim filmed a supporting video whilst on the ISS. The Astrobiology Summer Academy, which is run every year by the UK Centre for Astrobiology (UKCA) offered a way to link teacher training and lesson plan development directly into BioRock.

Evaluation Strategy: Not known.

Impact: The BioRock resources have been incorporated into the resource 'Astrobiology in the Classroom'. Our lesson plans are also available on TES resources. Since upload, they have been downloaded 2,900 times and viewed 6,493 times.

The BioRock lesson plans in the Astrobiology Academy run each year. Since the lesson plans were developed, sixty-four teachers have used the lesson plans at the academy and they have been used to teach over a hundred students per teacher, constituting an outreach of about 6,400 students.

The video made by Tim Peake has been incorporated into a video about the BioRock project, describing more generally the role of microbes in space and their beneficial and detrimental roles in different processes in space. This has been uploaded onto YouTube and can be viewed here: https://www.youtube.com/watch?v=5_52HPrvudg and is now incorporated into the lesson plans. It has also been linked to your lesson plans collection.

The Biorock experiment is due to launch in early 2019 and the resources will be promoted as part of the launch.

Feedback: Not available at time of writing

Cosmic Classroom Inflight Call		TES Global	
Subjects covered:	Science	**Age range:**	4 to 11
UK Space Agency contribution:	£27,208	**Financial contributions from elsewhere (where known):**	-
Target Audience:	100,000	**Actual Audience:**	400,000

Summary: A one-hour live lesson from Tim Peake was conducted while he was aboard the ISS on 2 February 2016. It was live streamed and watched live by nearly half a million school children around the world. The World Museum in Liverpool hosted the *Cosmic Classroom* live event presented by space medicine scientist and TV personality, Dr Kevin Fong. Twelve classes (around 300 children) from schools around the country were part of the audience at the museum, selected based on their questions - submitted by hundreds of schools across the UK - to ask Tim during the event.

Tim Peake answered the questions posed by schools via the video messages they sent, or directly by some of the lucky pupils in the audience. He also conducted a few short experiments to show the effects of microgravity on different materials. The full lesson from space is available on YouTube and can be viewed here: https://www.youtube.com/watch?v=mRuBvf-Qrno

TES Global also produced resources for teachers including colourful fact cards on space, the ISS and our solar system, and solar system cut-outs.

Evaluation Strategy: Online audience numbers, social media

Impact:

TES analysed the data and estimated that more than 400,000 children watched and took part in live demonstrations in their classrooms, across 58 countries worldwide.

- 11,800 teachers pre-registered for the event day via the TES website
- More than 7,000 videos, of children's questions for Tim, were submitted to TES
- 300 children from 12 schools across the UK were in the live studio audience

Across social media:

- Hashtag #CosmicClassroom trended at number 1 for six hours in the UK on Twitter, comparable to One Direction releasing an album or US presidential race in the US
- 4,200 instances of hashtag (number of tweets)
- 7 million reach (number of people who saw the hashtag in their streams) (9 million in total)
- 35 million impressions (number of times the hashtag appeared in streams)
- Visibility of 4 'instances' per person (tweets of hashtag per person reached)
- 63% of tweets from women

Cosmic Classroom Inflight Call	TES Global

Feedback:

"The children will take away so much more from this day than I could possibly teach them in a term..." Vicki Capstick, Year 3 and 4 teacher at Shap CE Primary, near Penrith, Cumbria, who travelled to Liverpool for the event.

Destination Space		The UK Association for Science and Discovery Centres	
Subjects covered:	STEM, physics, chemistry, biology, maths, engineering	**Age range:**	5 to 14
UK Space Agency contribution:	£684,868	**Financial contributions from elsewhere (where known):**	-
Target Audience:	250,000	**Actual Audience:**	914,646

Summary: Destination Space is a national STEM programme to engage, inspire and involve families with school-age children, school groups and communities across the UK with the amazing stories, science and achievements of human spaceflight, as part of the celebration of Tim Peake's Principia mission.

The UK Association for Science and Discovery Centres (ASDC) and partners created, developed and delivered an excellent set of science engagement equipment along with a suite of activities including an interactive hands-on family show, three curriculum-linked STEM workshops for schools, a series of 'meet the expert' activities and special event and branding materials. ASDC then selected, equipped and trained 20 UK science centres to deliver the full Destination Space programme to inspire people across the nation with Tim Peake's mission. ASDC also supported the UK Space Agency at a number of events such as Farnborough International Air show, the Royal Albert Hall's Big Space Day and Blue Dot Festival held at Jodrell Bank.

Overall 914,646 children and adults have participated in Destination Space as of July 2018, taking part in the school workshops, family shows or at events to celebrate Tim Peake's launch into space and safe return. Of these, 100,244 were school students who had been brought by teachers to science centres to take part in specific curriculum-linked schools' workshops. Overall, 75,741 people met and spoke with a space scientist or engineer through the special meet the expert events, helping to showcase the types of careers that are possible with science.

Evaluation Strategy:	Independent evaluation, consisted of standardised evaluation forms and short interviews, designed for each key stage. A questionnaire was designed for the teachers and visiting families

Destination Space	The UK Association for Science and Discovery Centres

Impact: Overall students from 1,671 different schools participated in the Destination Space Programme at the 20 centres. Analysis of the school postcode on the indices of multiple deprivation revealed that overall more children came from schools from the fifth most deprived quintile (23.1%) than from the first most affluent quintile (17.6%). This means across this ASDC programme and throughout the UK, the science centres are as standard reaching a higher proportion of the students from areas and schools high on the indices of multiple deprivation, than are in the population.

For each of the 12,120 students evaluated, their results were also analysed against their school postcode to see if those children from more deprived regions showed any difference in their enjoyment or interest of the workshops or in their subsequent interest in studying science. There was no significant difference on any of the areas analysed: children from schools in the most deprived areas on the indices of multiple deprivation are just as likely to be enthused and inspired by these hands-on science and space workshops as children from more affluent areas.

Another excellent result of the academic evaluation related to gender. Much of the content was physics and engineering based, and across almost every question and across all ages, girls and boys showed the same level of enjoyment of the workshops and activities, interest in science, and desire to study science as a result of the workshop. This is a remarkable finding for a national physics and engineering STEM programme. However, it is not unexpected, as ASDC had designed the whole programme to be gender neutral, had ensured science centres were mindful of the gender balance and have created and delivered other national physics and engineering programmes that also successfully and equally appealed to both genders.

The following are just some of the Key Findings.

Impact on children with families:

- 92% said that they would be more likely to be interested in studying science in the future
- 95% of the children participating in a family group reported that they liked space 'a lot' or 'a bit' more than they did before the show

Teachers' views on impact:

- 98% of teachers rated the activities as very good or good
- 99% of teachers considered that the knowledge of the centre staff was very good or good, and valued the enthusiasm, the knowledge and the approachability of the staff.
- 97% of teachers considered that the access to the science content was very good or good

Impact on the school students:

- 90% of students aged 5-7 evaluated enjoyed the workshop with girls enjoying the show slightly more than boys (91.8% females and 87.6% males).
- 55.6% of students aged 5-7 said that they would find a job in space interesting when they grew up, and 28% were not sure. Boys were significantly more likely to be interested in a job in space than girls (59.7% of boys and 51% of girls).

Destination Space	The UK Association for Science and Discovery Centres

Feedback:

573 Teachers were also evaluated, with the results as follows:

- 97% would recommend the workshop to other teachers
- 98% rated workshop as very good or good
- 98% rated the equipment as very good or good
- 84% will use activities and ideas in class
- 99% rated the knowledge of the staff running the workshop as very good or good

Of the 12,120 school students evaluated:

- 90% of 5-7 year old students enjoyed the workshop (n=3,272)
- 55.6% of students aged 5-7 said that they would find a job in space interesting when they grew up
- 92% of 7-11 year old students said they had enjoyed the science workshop
- More than half of 7-11 year old students said that the workshops made them more interested in having a job in science
- 93% of 11-14 year old students thought that the activities would help them with school science
- 59% of these students said that they had never used this type of equipment in school before, and only 6.5% of students reported that they used similar equipment often
- 47.5% of 11-14 year old students felt that the activities made them feel more interested in studying science in the future while 49% said that they were just as interested after the workshop as they were before

Of the 1,692 children visiting with their families who completed an evaluation:

- 92% said that they were more interested in studying science in the future
- 79% declared that they were more interested in science than before the show
- 95% reported that they liked space more than they did before the show

"*I liked the robot arm because it was challenging and I like challenges*" (Pupil, age 9, female)

"*I am more interested in having a job in science, because there are a lot of interesting things that I now want to know*" (KS2 Student, Bede Community College)

"*They were fascinated by the experiments they did – a lot of the children have really developed an interest in science that they did not have before. A fantastic school trip – thank you!*" (Year 4 teacher)

"*It has introduced them to the world of work involving science*" (Year 4 teacher)

"*Very good knowledge, pitched at a good level, captured the interest of all and good balance between talking and interaction with the class. They'll be asking more questions and enthusiastic about science*" (Teacher, St Monans PS, Fife; First Level schools workshop.)

"*I did not really like science but I do now*" (9 year old girl after the Destination Space workshop)

"*I think the children were fully engaged and the experience has definitely increased their curiosity for science!*" (Year 5 teacher)

Earth Observation Detective		National Centre for Earth Observation (NCEO)	
Subjects covered:	Science, geography, maths, computing	**Age range:**	4 to 18
UK Space Agency contribution:	£33,387	**Financial contributions from elsewhere (where known):**	£20,385
Target Audience:	5,000	**Actual Audience:**	47,661

Summary: The Earth Observation (EO) Detective teaching materials use fascinating astronaut photographs and satellite images of the Earth. Students discover how Earth observation scientists investigate our changing world while studying concepts and ideas from maths, science, geography and computing. The initial phase of the project also received funding from the Natural Environment Research Council (NERC).

During the Principia mission, NCEO ran a competition to give children around the UK the opportunity to win a photograph taken especially for them from the International Space Station. There were around a thousand entries with interesting ideas on how to use space-based photographs.

Following the success of the first phase, NCEO received further funding from UK Space Agency to design additional materials. These include online resources with a careers focus, colouring books for use in the classroom and at home, and family games and an iPad app showcasing photographs taken by Tim Peake during the Principia mission and imagery from ESA's Sentinel 2 satellites.

The teaching materials are available from ESERO-UK's dedicated page for resources related to Tim Peake's mission. Other resources and updates are available on the EO Detective blog, which is regularly referenced by a Twitter feed, originally set up to support the competition.

Evaluation Strategy: Website data, physical resources distributed, event attendance data

Earth Observation Detective	National Centre for Earth Observation (NCEO)

Impact: Based on the number of file downloads from STEM Learning, and making a reasonable assumption about class sizes, NCEO estimate classroom activities have been used by approximately 1,500 teachers with around 44,000 children. Comments from experienced space ambassadors suggest that the curriculum resources for younger children have been a very helpful introduction and that children have enjoyed using them. Additional activities developed for workshops and displays have had significant engagement at a range of events, reaching at least 3,000 people in addition to school users. Classroom materials have been used at ESERO's teachers' summer school in 2016, Leicester University's summer Space School and form part of the Polar Explorer programme being run by STEM Learning.

The competition garnered nearly 1,000 entries and much interest from adults and the prize-giving event in conjunction with the National Space Centre included a quiz that introduced a wider audience to applications of Earth observation.

NCEO had the opportunity to interview Tim Peake in March and asked a range of questions that support the teaching materials. The complete interview is hosted online by NCEO (with pointers from the blog) and by STEM Learning (with supporting files for teachers). The interview was premiered at the games workshop where people of a range of ages helped to develop the resources for families. 300 card packs have been distributed and resources for all the games using them are available online.

NCEO intends to develop the blog further and keep the Twitter account active, and data from STEM learning shows the resources produced in the first phase were still being downloaded in the academic year 2016 to 17. This indicates that the impact of the project is likely to continue to grow.

Feedback: *"With thanks for a great inspiration for our learning about longitude and latitude, space, mapping, literacy and numeracy all rolled into one!"* (St Louise Primary East Kilbride)

"I used "From the ground and from the sky" today with year 3. They were very interested in the photos from space and did well with the matching activity. I'm planning to use the other lessons with years 4, 5 and 6 over the next few days." (St Mary & St Andrew's Catholic Primary School,Preston)

"Toby really enjoyed it as it covered lots of fun sciencey-spacey things and makes you think as well." (Parent, Swindon)

"Thank you very much for coming to Meadowdale Primary School yesterday to help us in our topic of Space. The pupils really enjoyed comparing the photographs and learning about what it takes to do your job. The resources you brought were great [...] In particular, the large satellite photographs proved a real hit [...]I'm already thinking that next year we would love to have you back to enthuse the pupils about space and what you do at the university." (Meadowdale Primary School, Market Harborough)

"We had a good day with the EO Detective stuff on Friday –all KS2 came through at some point in the day and, after doing a scaled-down version of the Astronaut or satellite activity with me, they went on to the competition entry [...] As ever it was fascinating to see the range of kids' knowledge from those who could recognise New York (without reading!) 'cos they'd been there, to a not-insignificant number who didn't recognise Britain! The Lego astronaut generated much discussion too!" (Sacred Heart Academy, Loughborough)

Great British Space Dinner		British Nutrition Foundation with Heston Blumenthal	
Subjects covered:	Science, maths, design & technology, PE, PSHE, nutrition/home economics	**Age range:**	4 to 14
UK Space Agency contribution:	£64,542	**Financial contributions from elsewhere (where known):**	-
Target Audience:	Not defined	**Actual Audience:**	2,000
Summary: The Great British Space Dinner, developed by the British Nutrition Foundation and supported by Heston Blumenthal, challenges students to design a menu suitable for astronauts to eat in space. The activities get students thinking about and understanding the nutrition and underlying science of healthy eating as well learning about the impact that space flight has on the human body. The Great British Space dinner is supported by fun, informative and downloadable education resources with videos from Heston Blumenthal			
Evaluation Strategy:	Competition entries, download metrics of resources and videos.		
Impact: The competition reaches about 2000 people, fewer than hoped at the start of the campaign. However, the resources have subsequently been promoted through the ESERO website, and in the period from September 2015 throuhg to August 2018 they were among the most popular resources on the website. ESERO's estimate that the resources have now reached 124,380 children ,the third biggest reach of all resources.			
Feedback: Not available at time of writing.			

I'm an Astronaut, Get Me Out of Here		Gallomanor	
Subjects covered:	Science, design & technology, engineering, maths	**Age range:**	7 to 18
UK Space Agency contribution:	£8,500	**Financial contributions from elsewhere (where known):**	-
Target Audience:	1,600	**Actual Audience:**	2,004

Summary: On the I'm an Astronaut website students got to ask members of the Astro Support Team anything they wanted in four different rounds leading up to, and during, the Principia mission. The students challenged the Team over fast-paced text-based live chats and then voted for their favourite Team member to win a prize of £500 to communicate their work with the public.

The Astro Support Team was made up of engineers, scientists, astronaut instructors, medics, flight controllers: anyone who has a role to play in Tim's mission and the International Space Station, and who showcases the wide range of possible space-related careers. The Astro Support Team also nominated schools to take part in a live chat with Tim Peake once he had returned to Earth.

Evaluation Strategy: Survey to students, teachers and Astro Support team, + google analytics

Impact: The impact of the project was shown from students, teachers and the Astro Support Team. The event improved students' attitudes towards science, especially among those students who were less interested in science jobs before taking part (+0.8 score increase on average in response to survey questions). There were more than 23,000 unique visitors and over 200,000 page views of the I'm an Astronaut site over the course of the project.

100% of the teachers who responded to a survey were satisfied with their experience of the event, with the majority (93%) saying they were "very satisfied". Written feedback from teachers indicated they had found the event enjoyable and worthwhile for their students and themselves and supports the view that students with potentially low interest in science found the event engaging. A strong majority of teachers agreed with a range of positive outcomes from taking part. In particular, 96% felt more aware of their students' attitudes to towards STEM, and 98% saw their children were more confident asking questions about science, technology and maths in their lessons.

Members of the Astro Support Team said they wanted to do more public engagement after taking part, and 100% agreed they had gained a better understanding of how students see their work. They were satisfied with the experience and felt that the online engagement was an effective way to engage with students. 85% said they wanted to do more public engagement after taking part, and 77% felt they were more confident communicating their work.

Feedback: *"It was very interesting and I had a lot of my questions answered, it was cool to be talking to real live researchers and they gave me a lot of advice on how to get into a space related career"* – Student

"I really enjoyed the experience and the variety of people during the touchdown stage allowed the children to find out about a wide range of areas" – Teacher

"We wanted to have our lower ability sets (who also have some behaviour problems) taking part and it has been fantastic for their engagement and they enjoyed it hugely" – Teacher

Into Film: Into Space		Into Film	
Subjects covered:	Storytelling, digital literacy, film	**Age range:**	5 to 19
UK Space Agency contribution:	£48,154	**Financial contributions from elsewhere (where known):**	£6,500
Target Audience:	10,000	**Actual Audience:**	5,775

Summary: Partnering with Into Film, a film and education not for profit organisation, Into Film: Into Space (IFIS), was a UK-wide project for 5-19 year-olds that delivered a varied programme to celebrate Tim Peake's historic Principia mission to the International Space Station, combining young people's enthusiasm about science, technology and film.

The project included filmmaking workshops, visual effect careers talks, science behind the screen events, and playlists of youth made short films for inspiration and a filmmaking competition where eight winners had their films selected to be watched in space by Tim Peake on board the International Space Station (ISS). This was the first time that young people's short films had ever been screened in space.

Evaluation Strategy: Google analytics, social media, feedback

Impact: The project resulted in eight youth-made short films to be seen in space for the very first time. IFIS reached 1,169 young people from across the UK directly through the filmmaking competition process, and was brought to the attention of approximately 4,600 students through events and talks. The reach of the project was: over 72,000 Into Film newsletters were circulated, 48 pieces of regional and national press coverage were achieved, with a total reach of approximately 750,000, web activity provided an additional 13,857 page views and 11, 794 unique page views. These were in addition to the 5,594 referrals achieved from social media, including Facebook and Twitter.

Feedback:

"We entered this competition as it sounded like an interesting challenge, an opportunity to try something new, never expecting that weeks later our film would be orbiting the Earth! The result of all our hours spent storyboarding, planning, researching, some vicious battles with uncooperative tech and one painful 5am start to drop our GoPro into the swimming pool have all been worth it! We are very proud to be able to walk around telling our actors that their faces- and our work- have been viewed in space. This competition has been great fun, and will stay with us for a long time" - Alexandra and Charlotte, Winning Filmmakers, Stowe School

"I am so excited for the film to go to space, what an amazing achievement that I will keep with me for life. It will be a wonderful thought that Tim Peake watched our film and I want to thank Into Film so much for this opportunity. I really enjoyed making the film, I love the project" - Rowan, Sawston Video College

"I am so pleased that I got involved in this competition, I can't believe my film is going into space, I will never forget this moment. I am proud of myself and the rest of the group, thank you Into Film for this amazing chance" - Zac, Sawston Video College

".....it was just terrific to be part of something very exciting and congrats to the filmmakers who's work made it into space, a wonderful achievement!" - Shortlisted Filmmaker, Cut Ltd

Into Film Festival Talks		Into Film with space sector support	
Subjects covered:	STEM, space outreach	**Age range:**	5 to 19
UK Space Agency contribution:	£0	**Financial contributions from elsewhere (where known):**	-
Target Audience:	Not defined	**Actual Audience:**	6,280
Summary: As part of the Into Film Festival, a free nationwide set of screenings for school children, people from across the space industry gave talks at screenings of A Beautiful Planet and Space Station 3D, which were shot on-board the ISS. These talks highlighted the work of the space industry, their careers, and the activites available as part of the *Principia* education programme			
Evaluation Strategy:	Audience figures from Into Film		
Impact: Staff from			
Feedback: Not available at time of writing			

Marvin and Milo cards		Institute of Physics	
Subjects covered:	Physics	**Age range:**	4 to 11
UK Space Agency contribution:	£4,000	**Financial contributions from elsewhere (where known):**	-
Target Audience:	2,000	**Actual Audience:**	2,000
Summary: These are comics developed by the Institute of Physics to encourage young people to engage in physics in exciting ways.			
Evaluation Strategy:	None		
Impact: As these comics were given away to the public, there was no follow up on how they were used and what impact they had.			
Feedback: No direct feedback available.			

Mission Starlight		Royal Society of Chemistry	
Subjects covered:	Chemistry	**Age range:**	7 to 16
UK Space Agency contribution:	£0	**Financial contributions from elsewhere (where known):**	-
Target Audience:	10,000	**Actual Audience:**	13,643
Summary: Mission: Starlight, a global experiment on ultraviolet light (UV) protection, designed to teach students about what UV light is, how it can be blocked, and why this is important for astronauts and everyone on Earth, It was the sixth 'Global experiment' (an international collaborative practical and outreach demonstration for primary and secondary science students) from the Royal Society of Chemistry, and their most successful by far. The project consists of four standalone experiments, designed to challenge all ages and abilities with all resources being easily sourced and affordable.			
Evaluation Strategy:	Teacher feedback, website tracking		
Impact: Mission: Starlight wouldn't have come about without the opportunity to link their global experiment programme to Tim Peake's historic mission. Since launch it has been a key draw for their 4 million annual Learn Chemistry users and featured in the SciStarter citizen science newsletter to over 50,000 participants, plus on partner content sites like TES.com and the ESERO resource site, hosted by STEM Learning. The programme achieved official CREST Award accreditation, which has made it a great draw for teachers. Mission: Starlight is a favourite activity of their two dozen UK and Irish Education Coordinators and their network of hundreds of volunteer Royal Society of Chemistry members and STEM Ambassadors. It is a visible example of the investment the Royal Society of Chemistry makes in education. Their members and coordinators love it for its simplicity and impact, and they have loved it more for being able to link the science to Tim Peake's mission. Mission: Starlight has been demonstrated to tens of thousands, at a space-themed Teachmeet at Burlington House in London, at the National Ploughing Championships in Ireland, in the middle of King's Cross and Paddington Stations, at the Blue Dot festival at Jodrell Bank, at Big Bang events across the country, at the Gravity Fields Festival in Grantham, and at the Space Centre in Leicester (with Helen Sharman), and more.			
Feedback: Not available at the time of writing			

Mission X 2015/16		Venture Thinking	
Subjects covered:	Physics, biology, technology, mathematic, PE, PSHE	**Age range:**	7 to 14
UK Space Agency contribution:	£50,000	**Financial contributions from elsewhere (where known)**	-
Target Audience:	25,000	**Actual Audience:**	35,287

Summary: Mission X is a programme developed by NASA and the European Space Agency's scientists and fitness professionals to inspire students to learn about the science of nutrition and exercise as well as to increase their activity levels. The programme is open to schools around the world. The programme was managed by Venture Thinking on behalf of the UK Space Agency.

Mission X takes place every year from January through to March. Schools who register for the challenge will receive invitations to a range of additional space outreach activities. The website hosts blogs about school activities and teams of students log the different activities they have achieved as part of an international community effort to get the mascot Astro Charlie to the Moon. Over 1,000 teacher handbooks were printed and distributed to the education community. *Mission X* activities have featured at a number of science festivals organised by *BBC Stargazing Live*, Camp Bestival, universities and by regional science festivals. A handbook for teachers was published and circulated to over 2,000 teachers.

Evaluation Strategy: Analytics on participants

Impact: Mission X is one of the longest running astronaut inspired education outreach programmes, having been set up as an international effort in 2011. Tim Peake was the Mission X Ambassador on the International Space Station for the 2015 challenge and posted videos and tweets encouraging young people to exercise. Two special Mission X activities inspired by Tim Peake were created to coincide with the mission – the Peake Lift-off Burpee and the 24.7 Challenge linked to Tim's marathon run in April. Many of the schools that were involved have embedded Mission X into the curriculum and have taken part in the programme year on year.

High profile events hosted by the Glasgow Science Centre and Royal Aeronautical Society, The Farnborough International Air Show, World Space Week, Salford City Stadium, Cambridge University, Qinetiq, University of South Wales and the All Parliamentary Space Committee were used to help launch and celebrate achievements. A number of schools and teachers involved were first adopters for other Principia activities. The Mission X programme was supported by a number of external partners and volunteers from organisations such as UKSEDS, the British Interplanetary Society, and from universities such as Kings College London, Queen Mary University of London, Manchester Metropolitan University and Teesside University as well as companies such as Qinetiq.

There were also registrations from other organisations like the Scouts group, home educators and individuals and the materials have been used by other organisations such as Science Made Simple. There was a spike in activity in 2017. The likeliest reason for this is Tim's mission into space and his return in June 2016. This had generated a lot interest in the programme because of the media attention at that time. The Mission X Programme was awarded The Royal Aeronautical Society Team Award for its achievements in outreach.

Mission X 2015/16	Venture Thinking
Feedback: Feedback from all providers has generally been very positive – one scout leader said the about the materials. *'Brilliant for all ages. Helped with programme planning for scouts'* Teachers*: 'Mission X generated a real buzz of excitement, and the group carried on meeting long after Mission X finished. It has enthused a whole group of year 7 students to learn more about STEM subjects.'* *' Excellent for team building and self-confidence. Brought out skills and qualities in pupils they (and we) didn't know they had!'* *' Really good impact on the whole school and it promoted a brilliant sense of togetherness amongst pupils from Year 1 to Year 6.'* *' It is an amazing project and I would recommend it to all schools around the world.'*	

Novium Tim Peake Exhibition		Novium Musuem	
Subjects covered:	STEM	**Age range:**	All
UK Space Agency contribution:	£12,500	**Financial contributions from elsewhere (where known):**	£56,500
Target Audience:	13,425	**Actual Audience:**	6,532

Summary: Inspired by Chichester born astronaut, Tim Peake, the Novium Museum's exhibition tells the story of his extraordinary journey, from life as a schoolboy growing up in Chichester, to being the first British ESA astronaut to travel to the International Space Station. The exhibition allows visitors to experience Tim's mission first hand by beginning their journey by stepping into the museum's 'rocket lift' where they can learn all about the Soyuz rocket before blasting off into the museum's 'outer space' level. They can discover what it's like to live in space, from eating, sleeping to exercising in the ISS.

The UK Association for Science and Discovery Centre's Programme, Destination Space, is also backing the exhibition, which explores careers in space in order to inspire young people to follow in Tim's footsteps. The UK Space Agency helped fund a competition to win 10 space themed sleepovers in the museum for schools across 5 counties, as well as funding 'Space Saturdays' – free, drop in family demonstrations running every Saturday between January – March 2017, as well as new space themed loan boxes, which are free for schools to borrow.

Evaluation Strategy: Visitor numbers, social media, feedback, delivery numbers of sleepovers and loanboxes

Impact: As well as a huge increase in visitor numbers to the museum, Novium have received an increase in school booked learning sessions as well as group sleepovers for schools and community groups. Their first Tim Peake themed family sleepover, which took place in April 2017, sold out completely within a month – the first time they have ever had a public sleepover sell out that far ahead of time. Donations in the first month after the exhibition launched saw a percentage increase of 316% in comparison to the same period from the previous year.

Posts relating directly to the Tim Peake exhibition achieved a reach of 1.2 million on their social media channels from September – December 2016, and the announcement and launch of the exhibition received both local and national media coverage.

The Tim Peake Exhibition won the best Temporary exhibition award at the national museums and heritage awards in 2017.

Feedback: Not available at time of writing

One Giant Read		Literature Works	
Subjects covered:	Literacy, English	**Age range:**	11 to adult
UK Space Agency contribution:	£22,150	**Financial contributions from elsewhere (where known):**	£26,000
Target Audience:	60,000	**Actual Audience:**	60,753
Summary: One Giant Read is a fully accessible shared reading experience presented online in the style of a blog site which offers easy to access reading materials and content themed to the Principia Mission. It presented complex science factby introducing concepts through the medium of more popularly understood science fiction. Audiences interacted with the site by listening to recordings of text and poetry based around a monthly theme and then listened to science podcasts made by specialist scientists and researchers providing the contemporary science approach. The themes and responses linked to the Principia Mission and drove audiences to Space Agency and other official sites of the Mission for more information.			
Evaluation Strategy:	Analytics of page views and social media reports		
Impact: The partner organisations who supported this project through newsletters, social media and website work represented a potential audience of 13 million (National Library networks, National Trust, RNIB, Plymouth University, UKSA, Literature Works and Poetry Archive). Since project launch until 2016 there have been 42,935 page engagements through the One Giant Read site, 4,800 engagements through the Literature Works Facebook site and 16,438 views to the Poetry Archive site - total individual visits - this is by over 13,500 people through the One Giant Read site and partner sites, but not including Literature Works social media/Facebook (see qualifying comments below). Total Views 64,173. The site has been visited by 91 countries world-wide, over 80% by UK but also including Russia, USA, Germany, Kyrgyzstan, Brazil, Canada, Australia, France and Ireland			
Feedback: Not available at the time of writing			

Planetarium Shows		British Association of Planetaria	
Subjects covered:	Science, space	**Age range:**	All
UK Space Agency contribution:	£45,981	**Financial contributions from elsewhere (where known):**	£4,000
Target Audience:	Not defined	**Actual Audience:**	220,474

Summary: British Association of Planetaria (BAP) created stunning, highest resolution, photo-realistic graphics that are being shown in large, static and small, mobile planetarium domes across the country. Inside these planetarium domes the audience could watch a show to explore the different modules of the ISS and find out how this space laboratory relates to the wider exploration of the solar system.

Evaluation Strategy: Surveys directly emailed to participating planetarium professionals gathered Quantitative data (audience metrics) and qualitative data (methodology, value, experiences).

Impact: In six months, between December 2015 and June 2016, the clips were viewed by 128,251 people at 829 events. 70.7% of the total number of visitors (over 90,000 individuals) were through mobile outreach domes who travel out to schools and communities and visit audiences that are traditionally underrepresented.

In addition to the continued use of the current Tim Peake clips within planetarium domes in the UK, the UK Principia planetarium project was discussed at the International Planetarium Society Conference in Warsaw, Poland and during the Ecsite Space Group Preconference at in Graz, Austria. An article about this collaboration was also published in the international publication 'The Planetarian' in advance of these sessions. In attendance at these sessions were fulldome filming experts, European, American and Japanese colleagues keen to view innovative and new footage, informal and formal educators keen to promote the ISS and human space flight within their own locations, research scientists and a NASA astronaut. The international audience projected by European planetarium professionals downloading these resources was projected to reach 280,000 by June 2017.

Following the, a final legacy launch clip was produced which has furthered this audience. From June 2016 to April 2017, a further 92,223 visitors to UK planetaria have enjoyed this suite of immersive resources, bringing the total audience to over 220,000 children and adults. 70% of this audience are Early Years and Primary aged school children, 11% of this audience are secondary school children, from both mainstream and Special Education Schools. These planetarium shows have taken place at over 1600 separate events across the nation.

The British Association of Planetaria are confident that the resources will be used into the long term with UK and international audience viewings currently exceeding 500,000. In addition, a growing number of individuals are downloading the 360 version of the resources for use with VR headsets such as google cardboard, for an immersive ISS experience within their own homes.

Feedback: *"The Tim Peake /ISS animations are amongst the best fulldome visuals I have ever seen."* (FullDome Planetarium Show supplier)

"I think we totally nailed it in terms of maximum wow-factor and learning impact from the whole suite of Principia clips - genuinely awesome clips that blow kids' minds day in, day out. The final, launch sequence has been incredibly effective. So, on behalf of all the thousands of adults and children who've been thrilled by the Principia suite in my domes, I bow down with deep gratitude and appreciation!" British Association of Planetaria member:

Principia Schools Conferences		UK Space Agency	
Subjects covered:	Cross-curricular	**Age range:**	4 to 18
UK Space Agency contribution:	£46,783	**Financial contributions from elsewhere (where known):**	-
Target Audience:	2,000	**Actual Audience:**	13,743

Summary: The Principia Schools Conferences took place on 2 and 5 November 2016, hosted by the University of Portsmouth and the University of York.

Youngsters from across the UK applied to attend the conferences by submitting the work they had done related to Tim Peake's Principia mission. This work was celebrated by the medium of presentations, posters, 3D models, songs and dances, all in some way connected to the Principia mission. Experts from the space industry as well as teaching and education professionals chairing and watching sessions were astounded at the high quality of presentations. Tim Peake made it a priority to come to both Schools Conference venues, and despite there being over 400 children present on each day, he visited each group and met every child.

The UKSA Education Partners also joined for the Activity Outreach day ac`companying the Schools Conference days. There were a variety of activities and workshops to take part in; including rocket launches, Earth Observation, filming and directing, Triathlon Trust sports activities, TimPix and Space Diaries activities. Over 400 children attended with their school groups at the University of Portsmouth on Tuesday 1 November, and over 2,500 members of the public attended the University of York on Sunday 6 November.

Evaluation Strategy: Analysis of participants to conference, teacher feedback forms

Impact:

An online survey was conducted after the events, 112 groups provided answers, from the 180 groups who attended.

- *Was attending the conference day an educationally worthwhile experience?:* 88% strongly agreed; 9% agreed
- *Do you think the UK Space Agency should organise a similar conference day again?:* 88% said yes, with only 3% 'not sure'
- *Overall, was the outreach activity day worth coming to?* 69% strongly agreed; 26% agreed
- *What do you expect was the level of impact the event(s) had on the *child* that was most affected?* 64% said: Life changing, their views will have been permanently altered, 26% said: Long term, their views will have changed for years. Just 3% said: Short term, their views will have changed for a few weeks or months; or No impact. The other 7% wrote personal comments e.g. *"[My student] has always wanted to pursue a career in the space sector. The event reinforced and empowered her to do so."*
- *What do you expect was the level of impact the event(s) had on the *adult* that was most affected?* 48% said: Life changing, their views will have been permanently altered. 42%: Long term, their views will have changed for years. Only 6%: Short term or no impact The other 4% wrote personal comments e.g. *'Our Headteacher is still sharing the sense of awe and wonder with prospective parents visiting our school.'*

Anecdotal evidence collected since has shown the longer term impact of the projects and conferences, and the engagement of these students continues.

Principia Schools Conferences	UK Space Agency

Feedback:

"It made me more committed to try and take pupils to events/conferences where they can share with other children. It has also made me think more about how I can promote science careers within primary schools."

"This was a project and experience that grew and grew and the proudest achievements I've taken part in and lead in school. From a tiny 'seed' of an idea to be involved with the rocket science project and watch a UK astronaut blast off into space, destination ISS, this has opened up so many opportunities to work with companies, projects and events in school linked to space and STEM. It has given lots of professional opportunities for other members of staff in school too thanks to the Enthuse Award. I am now trying to find other experiments that as a school we can be involved in which the answer is unknown as I believe that this engages some of the students much more."

"Fantastic impact - the children were exceedingly motivated - we were inspected by Ofsted two days after the conference and the conference will be mentioned in the report as the children were buzzing so much. As a result of the talks we saw we are now creating our own plastic bottle greenhouse and eco garden. A truly brilliant experience."

"The impact is understanding the role of the UK space sector which motivates teachers and children to be interested and want to find out more about the sector. Also, being able to put learning into a context of real-life events ensures children raise their aspirations to set and achieve personal goals."

"The three children in our group have all been immensely inspired by the Schools Conference, more so than what they gain at school. It helped them realise that there are so many different ways they could be involved without in the space industry without being an astronaut. Also, visiting a university for the first time made them aware of what universities are and they are now keen to go to university too! As an adult (the children's parent and educator) in our group, the conference has made me want to create and educate more widely STEM initiatives linked to the space industry. Being at the conference and seeing so many youngsters inspired makes me want to share my experience, knowledge and skills in a similar way. After 30 years working in engineering, I feel I can contribute in a similar way to those at the conference, I want to be standing on the stage at the conference hall inspiring! I intend to develop a STEM programme, run a STEM club and create links with local schools."

"The Principia Mission and conference has not only brought so much education to my children but also inspired me to pursue STEM education. My children didn't want to leave York and, when we did actually leave, it was a little emotional because we all appreciated that we were leaving behind a once in a lifetime event. When a seven year old says he wants to be an astronaut and actually believes it is actually possible, you can see that the seeds have been sown. You touched us, you succeeded in your mission. Thank you."

Rocket Science		Royal Horticultural Society	
Subjects covered:	4 to 18	**Age range:**	Science, maths, horticulture, citizen science
UK Space Agency contribution:	£112,030	**Financial contributions from elsewhere (where known):**	£30,000
Target Audience:	150,000	**Actual Audience:**	600,000

Summary: The aim of this national experiment was to investigate whether space travel affected the germination and growth of rocket lettuce seeds and whether this could help us understand more about how astronauts might be able to grow their own food on long space missions or even another planet in the future. Over 8,600 schools and groups across the UK signed up to receive a packet of seeds that had been flown aboard the ISS while Tim was there, and were given a mission to grow the seeds once they returned alongside an identical packet of seeds that had remained on Earth.

The young space biologists conducted their experiments just as professional scientists would, learning about blind trials, randomisation and sampling. The children nurtured their seedlings from April through to June 2016 in a blind science experiment, taking specified measurements and carefully recording their data ready to be inputted later into a national results database. In addition, participants set their own hypotheses on the scientific question: How does space travel and exposure to the conditions of the space environment affect rocket (*Eruca sativa*) seed germination and plant growth?

Evaluation Strategy:	Teachers and group leaders were asked to sign up to Rocket Science by completing an online form, which included mandatory completion of a statement in response to the question: *"What impact on your pupils and benefits do you hope to achieve by taking part in this experiment?".* Students were also asked to take measurements of their seedlings throughout the experiment to discover whether space travel affected the germination and growth.
Impact:	

Rocket Science	Royal Horticultural Society

Impact: 600,000 young people took part in the experiment, engaging in horticulture and science, as well critical thinking, observation and analysis. Throughout the experiment over 1,000 photos were shared via social media by participants. 65% of schools and groups submitted their data to the national results database, proving how dedicated the children were to see the experiment through to the very end and that the experiment was accessible enough that so many schools ran it to its completion. Collectively they found that the space seeds did not grow as well as the seeds that had remained on Earth, most likely due to their exposure to radiation, however they did grow.

By the end of Rocket Science, press coverage across print, broadcast and online had reached 184 million people with an AVE of £2.05 million.

Ahead of the experiment, the Royal Horticultural Society received thousands of statements from teachers detailing why they wanted to take part in the experiment which they commissioned the University of Surrey's School of Environmental Psychology to analyse. Applicants were asked, 'What impact on your pupils and benefits do you hope to achieve by taking part in this experiment?' On the basis of their response to this over-arching question, twelve specific questions were formulated.

Following the experiment, they published a report 'Rocket Science: Our Voyage of Discovery' which presents the scientific results and the outcomes and benefits. The photographs and quotes from pupils within this report speak for themselves. Rocket Science mattered to everyone who took part and impacted on them in a huge number of ways. Pupils were inspired to continue or start studying science, felt like part of something big, and were excited to take part in a project that had not been done before.

Feedback:

"Through the UK Space Agency, we learnt about scientific methods including randomisation. We like to think that Cottenham Village College has helped the growth of human knowledge about space travel and plant biology" – Pupil, aged 13, Cottenham Village College, Cambridge

"I learnt how it feels to make an actual contribution to science and how team work is very important in that" - Pupil, Devonport High School for Boys, Plymouth

"Thank you Tim Peake for your videos which have inspired me to study science" - Pupil, Eldon Primary School, London

"I have learnt how important randomisation is for a fair scientific test" - Pupil, aged 10, Gilnahirk Primary School, Belfast

"We learnt that seeds grow differently in different environments. We felt very excited about this project. Gardening is more interesting that we thought" - Pupil, aged 9, Park Grove Primary School, York

"I really, really want to be a scientist" - Pupil, aged 6, Christ Church Primary, Battersea

"I learnt from Rocket Science about space science and gardening. It made me feel accomplished and I felt really focused when we were planting the rocket" Pupil, aged 9, Chudleigh Knighton C of E Primary School, Devon

Royal Institution Lectures Education Material		Royal Institution	
Subjects covered:	STEM	**Age range:**	7 to 16
UK Space Agency contribution:	£15,000	**Financial contributions from elsewhere (where known):**	-
Target Audience:	3,000	**Actual Audience:**	14,400

Summary: The Royal Institution (RI) produced free inspiring teaching resources suitable for primary and secondary school children, based on their popular 2015 Christmas Lecture, How to survive in space and supplemented the lectures with some live online chats, working with Gallomanor and *I'm a Scientist, Get Me Out of Here!* project.

The resources and 'live chats' followed the Lectures, focusing on space travel and on Tim Peake's mission to the ISS. They ranged across multiple STEM subjects, although with a particular focus on biological and medical science. Resources were produced separately for primary and secondary classes. The RI selected elements of the Lectures' content that are relevant to the current curriculum and create clips with accompanying materials. These included guidance notes on the use of the clip, PowerPoint slides for use in class, links to other relevant resources, and where appropriate activity worksheets for students together with instructions for teachers.

Evaluation Strategy: Usage of video clips, teacher feedback

Impact: As of September 2016, usage of the video clips (a reliable indicator of actual use of the resources) has been 325. With an estimated class size of 30, the resources have reached approximately 9800 students so far. The online discussion forum, run by Gallomanor Communication, 'I'm an astronaut, get me out of here' was the most successful CHRISTMAS LECTURES-themed zone they have ever run. They had 767 registered users asking 895 questions. The majority of registered users were school groups rather than members of the public.

Feedback: Not available at time of writing

Schools Grants		ESERO-UK	
Subjects covered:	Cross-curricular	**Age range:**	4 to 18
UK Space Agency contribution:	£100,000	**Financial contributions from elsewhere (where known):**	-
Target Audience:	10,000	**Actual Audience:**	28,266

Summary: ESERO-UK grant schemes for schools, funded by the UK Space Agency, allowed schools to bid for a grant of up to £6,000. All UK schools could apply for a grant. There were three rounds of grants given in total.

The grants were awarded based on criteria such as: the extent of alignment of the project to Tim Peake's Principia mission; the impact of the project; the educational elements of the project; the size and diversity of the audience that will be reached; how the project provides a vehicle for extending the legacy of Tim's mission in schools and their wider communities.

Evaluation Strategy: Feedback forms from schools

Impact: In total, £86,337 of grants have been paid to 71 schools across the UK. A diverse range of schemes were funded including:

- Space Week activities
- Space based/related classroom activities
- Stargazing events for the pupils, parents and the local community

The grant scheme has been successful in embedding space activities and resources into schools. Many teachers reported that the activities, developed as part of the scheme, would be used in subsequent years. All teachers reported an increased enjoyment in space based topics due to the activities enabled by the grants.

In addition to having a positive effect on pupils, teachers reported increased confidence in delivering space-related activities and themes. Teachers also reported a greater appreciation of using space as a context for teaching subjects across the curriculum: from traditional STEM subjects to art and creative writing.

Many schools have used the receipt of the grant as an opportunity to engage with other schools, businesses and professional bodies in their area. A large number of the schools have encouraged the local communities to attend their events or have subsequently publicised the schools' activities in local media. In these schools, this has increased the engagement with the scheme beyond the confines of the school and into the local community.

Feedback:

"The secondary students were inspired when they realised where their STEM studies could take them. One has signed up for a week long Space Residential at King's College in July."

"Elevated levels of interest in science across all schools, feedback from the launch event was excellent. New links have already been formed with students in the high schools and we hope this will also facilitate scientific transition projects."

Principia Space Diary		Curved House Kids and Lucy Hawking	
Subjects covered:	Primary science and literacy with secondary links to geography, PE, DT, SMSC and maths	**Age range:**	4 to 11
UK Space Agency contribution:	£93,310	**Financial contributions from elsewhere (where known):**	£13,000
Target Audience:	15,000	**Actual Audience:**	95,000

Summary: The Principia Space Diary allows children to make their own book as they research Tim's mission. It was first created for children to follow Tim's mission whilst he was still on board the ISS, but has since been adapted to be a timeless curriculum-linked primary science programme that can be used at any point in the school calendar.

Students explore the different roles involved in supporting Tim on his journey, from that of a space doctor in looking after Tim's health, to scientists who navigate space debris as Tim journeys to and from the ISS. The Space Diary combines literacy and visual literacy learning with STEM subject learning to create fun, engaging activities for students aged 6 to 8. The book itself can be personalised by students, giving them ownership and empowering them to create a lasting memory of Tim's mission. Written and developed by author Lucy Hawking and publisher Kristen Harrison, and with guidance and contributions from Professor Peter McOwan and experts at the UKSA and ESA, the book is brought to life with fantastic illustrations by Ben Hawkes.

Videos, filmed at the Cosmonauts exhibition with the support of the Science Museum, are available to watch and include space experts like Dallas Campbell, Sheila Kanani, Richard Garriott, Lucy Hawking, Professor Stephen Hawking and Helen Sharman.

Teachers are fully supported with detailed teaching notes, videos, lesson plans, curriculum guides and ideas for differentiation for Key Stage 1 and Key Stage 2. Teaching notes were developed in collaboration with Heather MacRae who provided initial drafts and links to other Principia projects. A team of primary teachers from every region in the UK provided region-specific curriculum links and expertise in specific primary subject areas. Coding activities have been created with Raspberry Pi and Code Club UK and the Zappar app allows students to access content via mobile phones and tablets.

Curved House Kids continue to run the Space Diary programme with schools signing up and participating throughout the school year.

Evaluation Strategy: Participant evaluation, metrics, website statistics, feedback from students and teachers

Principia Space Diary	Curved House Kids and Lucy Hawking

Impact: The first edition of the Space Diary (published 2015 to 16) aimed to reach 15,000 students in 500 schools. It ended up with registrations of over 60,000 students in 1732 schools. The second edition (published 2017) had 1,612 new registrations, made up of 519 schools, 1,037 home educators and 56 organisations/clubs. Over 35,000 new students registered in 2017 which, combined with the first programme, brings the total number of students reached to 95,000.

Cumulative highlights include:

- 95,000 students registered in 3,344 schools and home education settings
- 38,500 printed books distributed to schools for free including 8,500 which went out via the ESERO Space Ambassadors network
- Over 90,000 downloads of teaching materials from the Principia Space Diary website
- 95% of teachers surveyed after the first Space Diary programme said they would run it again

The big surprise in 2017 was the significant increase in home educators, from 141 in 2015 to 16 to 1037 in 2016/17. Website statistics were very encouraging not only in terms of the number of visits to the Space Diary website, but also the number of downloads, indicating sustained engagement.

What really stood out in the feedback comments is how both teachers and home educators utilised all of the available materials – books, links, teaching notes, videos, other Principia programmes and resources and more. The testimonials reflect the accessibility of this programme and reinforce the value in investing in content at a deep level and the importance of multi-modal learning to give every child a way to connect with complex scientific concepts.

Feedback: *"...The girls thoroughly loved doing the space diary (although the eldest did have hers scribbled across several times by her younger sister!!). The eldest has now decided she wants to be a flight engineer on the International Space Station when she's a 'proper grown up'."*

"I liked the use of stickers as it helped to motivate me and was a good reward system and I could see that I was getting somewhere. I would highly recommend completing the space diary to children of my age as it's really fun and also practical and something you can do with friends."

"The new vocabulary the pupils have learnt has been brilliant - they can now all talk about Soyuz, gravity, the ISS etc and this combined with learning about different astronauts has led to some fantastic writing, both factual reports on different astronauts and creative writing about how it would feel in space. This has been a real benefit of this programme, each chapter has led to infinite possibilities in all curricular areas..."

The Space to Earth Challenge		The Ideas Foundation	
Subjects covered:	PE, science, maths	**Age range:**	7 to 18
UK Space Agency contribution:	£160,000	**Financial contributions from elsewhere (where known):**	£106,000
Target Audience:	15,000	**Actual Audience:**	26,350

Summary: The Space to Earth Challenge used Tim's training programme to inspire interest in fitness, science, maths and technology. The project was managed by The Ideas Foundation working closely with the Triathlon Trust, The European Astronaut Centre and university partners (Cambridge University, Durham, Kings College London, Teesside University) who created bespoke science lessons themed around the physical challenges of preparing for a return to space. Schools that registered were provided with newsletters and were given access to Tim's exercise data. The website hosted all the resources so that schools and youth groups could create their own challenge day and individuals could take part independently. Schools and individuals were encouraged to share their progress using twitter.

It challenged students to run, swim, cycle, climb, dance or exercise the 400 km distance from the Earth to the ISS orbit. The activities were scheduled and adapted to run in parallel with the mission itself but also designed to align with and complement Mission X activities. The Space to Earth Challenge website hosted an online badge system, and education materials focused on physics, mathematics, materials and biomedical engineering with a sport and space theme. A challenge pack was also available so that schools and other organisations could organise their own community challenge. The challenge model was designed with input from young people, educators and sports people to have a wide appeal to individuals, schools or community organisations. The activity was fully inclusive and children (some of whom had never peddled a bike before) were able to join in through the use of static bikes and a hand operated bike, to enable all children to join in irrespective of their physical ability level.

The challenge provided a fun and high energy focus for exercise and science. Ambassadors such as World, European and Olympic Paratriathlon medal winner, Lauren Steadman, inspired the children to achieve their best. TV presenter Dallas Campbell helped host launch events and created film assets.

Evaluation Strategy: Metrics, google analytics, feedback from students and teachers

The Space to Earth Challenge	The Ideas Foundation

Impact: The Space to Earth challenge focused on reaching students and teachers who may not have had a strong interest in science. The focus of accessing students through PE lessons and PE faculties however did generate interest in space and brought new audiences to become engaged with Tim Peake and the Principia mission. It also helped students not necessarily motivated in fitness to be more aware of the need for fitness and encouraged more sporty students to think about science. The involvement of the Ideas Foundation and Triathlon Trust and commitment and professionalism of the whole team to creating an amazing offer for the children was vital to the success of the programme. The team featured high profile female scientists and physicists at events, who were positive role models for the students.

We hosted as many in-school events as possible with the Triathlon Trust team organising high energy, professional challenge events which motivated students and teachers. Events were held across the country from Scotland, to Wales, Norwich and Chichester at over 343 schools and ensuring that over 26,300 students (especially students from less advantaged communities and including students with special needs) took part in high impact sport activities. The Space to Earth challenge activities have featured at the Principia conferences and the UK Space Conference with whole families enjoying taking part in the challenge. The total number of km clocked up on bikes, running and swimming was 61,885.

The model is continuing to be popular with the Triathlon Trust running legacy events in Spring 2017 supported by Accenture and the Lottery Fund. Students and schools shared their experiences on YouTube, twitter and Instagram. The model can easily be replicated for future missions.

Media impressions included 2600 tweets creating 772,614 impressions and 16,311 engagements. The website resources received 28, 473 page view and 21,020 unique page views with peaks in December 2015 and June 2016. The Astro Tim app, produced by Octagon Studio and released to coincide with Tim's landing, was downloaded 11,600 times.

The impact for many of the over 24,000 participants was realising that they needed to improve their fitness levels and that high impact exercise can be fun and energising.

Feedback: *"The children have been absolutely buzzing. From arriving at school and seeing the flags and bikes, to going home with bright red cheeks. It has been fantastic! The whole event was so well organised. Thank you so much for sharing this amazing project with Heyhouses!"*

"I've been Head of PE at this school for over 20 years and we've had all the sports in....rugby, netball, tennis...you name it they've all been here. This is the most engaging activity I've ever seen. These kids are not the easiest to work with, but look at them.....they are all engaged and trying their hardest. You've got it spot on" - Secondary School Head of PE

"I was dreading this activity. We were told we had to do it and I hate sport. But we worked as a team to achieve our targets, and when I was running and feeling so tired but pushing myself to go on – I forgot about all the stress that I am feeling. When I finished, I felt a real nice buzz and relaxed and didn't fancy eating my crisps but just wanted a cool glass of water. I'm going to try and do more sports because I hadn't realised it can make you feel good" - Student, Bristol Secondary School

Speak to Peake		BBC Wiltshire	
Subjects covered:	Space, STEM	**Age range:**	5 to 18
UK Space Agency contribution:	£0	**Financial contributions from elsewhere (where known):**	-
Target Audience:	Note defined	**Actual Audience:**	500
Summary: Before Tim's flight, BBC Wiltshire ran a competition for local schools. Children were asked to suggest questions to ask Tim, and the best answers were selected to come to the UK Space Agency and ask Tim their question via Skype, who was training in Houston. BBC Wiltshire supported the competition in schools with further lessons and coverage on the radio.			
Evaluation Strategy:	Audience listening figures, feedback from participants		
Impact: In addition to the 500 or so entries that were received, there will have been many more who listend to the broadcasts (BBC Wiltshire's weekly listening figures in June 2017 were c. 97,000 according to RAJAR figures). The projected established a working relationship with BBC Wiltshire that continues to this this day.			
Feedback: Not available at time of writing			

STARS Project		Astrobiology Society of Britain	
Subjects covered:	Biology, chemistry, science	**Age range:**	7 to 16
UK Space Agency contribution:	£8,000	**Financial contributions from elsewhere (where known):**	-
Target Audience:	1,600	**Actual Audience:**	4,000

Summary: The STARS Project was a science community-schools educational project directed at KS2 & 4 pupils delivered by the Astrobiology Society of Britain (ASB). STARS comprised three coordinated components; (i) a pre-STARS teacher's resource pack, (ii) a STARS presentation and a (iii) STARS post-session project pack.

Evaluation Strategy: Impact assessments from schools

Impact: The STARS project ran for a total of five months from February to June 2016. During this time, 25 scientists from 13 different institutions delivered a total of 72 visits to KS2 and KS4 level age children, both within school settings and home education groups. For most of these visits, ASB speakers voluntarily gave multiple talks to different classes and age groups. The overall feedback for the STARS project has been extremely positive despite only receiving 15 evaluation forms, due to the heavy teaching loads and busy schedules of the teachers. ASB received data that stated that over 1,020 children were spoken to within just the 15 schools that returned the forms and from observations of the speakers themselves. Considering the number of schools that were visited, and that two or more talks were given at each one, ASB estimate that over 4,000 children were engaged during this project.

Questions relating to the content of the STARS talks and the speakers themselves were all very positive. In the comments section of the form several teachers and leaders mentioned that the students continued to talk about the things they had learnt for days afterwards and that many parents had passed on that they were also sharing these facts at home. ASB's impact also extended beyond the schools themselves into public engagement education. ASB were contacted by several PhD students wanting to be involved but nervous as they had never given a talk to school children before. ASB received many emails from these students conveying how much they enjoyed and valued this experience afterwards.

Feedback:

"Thanks very much to Louisa for running the sessions for us. Both sets of students really enjoyed the talk and enjoyed the chance to ask questions. A longer session would be great as they were fascinated by the idea of life on Mars. The KS2 children went on to a creative writing class in our English department and the pictures of tardigrades etc obviously stuck with them as they wrote their postcards from Mars!"

"The children thoroughly enjoyed the session and being able to ask questions that they knew their teachers could not answer! The presenters were very good and were happy to be led by the children's questions. Thank you for the opportunity!"

"Everyone absolutely loved the talks. The children have been talking about it ever since, and so have the staff! We would be delighted to hear further talks or be involved in future projects; the children thought it was awesome."

Team Tim		Spacefund	
Subjects covered:	Science, maths, coding	**Age range:**	4 to 11
UK Space Agency contribution:	£7,500	**Financial contributions from elsewhere (where known):**	£1,500
Target Audience:	10,000	**Actual Audience:**	31,014

Summary: Team Tim aimed to engage primary school children and their teachers with STEM with an exciting and inspirational and entertaining hour long interactive show. Team Tim features a pre-recorded "live" interview with Tim Peake which along with a beguiling mix of live performance, animation and lots of audience interaction is designed to inform and educate as well as fire children's imaginations. Pupils help Tim to keep fit, do quick calculations, conduct science experiments, launch satellites, grow plants and perform a thrilling spacewalk to fix the ISS.

Evaluation Strategy: Teacher evaluation forms

Impact: Team Tim has been a great success with very positive teacher feedback. Spacefund reached a total of 31,014 primary school pupils and teachers with the Team Tim show.

Spacefund achieved a perfect 5 out of 5 general satisfaction from all the schools they visited in the second round of events from October 2016 to March 2017. All teachers felt that the show would have a lasting impact on the children, also scoring 5 out of 5.

Teachers also felt that their children had been inspired with science, gained a better understanding of astronauts' role on the International Space Station and the UK's involvement in Space.

Principia funding in the second round of events enabled Spacefund to specifically target a large number of deprived primary school aged children in a flexible way and staff were especially thankful for receiving Team Tim for free.

Feedback:

"The Staff and children alike enjoyed the show tremendously. Thank you very much" - St Patricks Catholic Primary School.

"It will have a lasting impact on both children and adults" - John Donne Primary School

"Great explanations and links to children's own lives to support understanding" - Dilkes Academy

"A brilliant show! Inspirational! Many, many thanks!" - Sandown Primary School

"So engaging and well-presented that it caught the imagination of our youngest (reception) to the oldest (Y6)" - St Jospehs Primary School

Three Minute Learning		University of Glasgow	
Subjects covered:	Science, literacy	**Age range:**	11 to 16
UK Space Agency contribution:	£33,600	**Financial contributions from elsewhere (where known):**	£30,000
Target Audience:	10,000	**Actual Audience:**	3,493

Summary: Three Minute Learning (3ML) is an online resource for schools with short stories on space, science, engineering, arts and society, most of which were based on interviews with Principia personnel, including Tim Peake.

Evaluation Strategy: Independent evaluation, undertaken a series of interviews with teachers.

Impact: An independent evaluation was conducted to investigate the success of the programme and to provide reliable data on the benefits gained by pupils. This was undertaken through a series of interviews with teachers.

Overall, the response was extremely positive. The report concluded that the 3ML resource is clearly a successful resource for teaching literacy across the curriculum. Pupils find the activities enjoyable and rewarding; teachers value the quality of the stories, the effectiveness of the format and the activities.

The design of the resource allows for considerable flexibility in its application. During 3ML, Principia teachers used it for whole-class activities, for individual set work, home study, support and extension activities. It has been used across subjects, as part of guided reading, as a whole-school initiative, and as part of Astronomy electives. The resource is valued by secondary teachers of English as well as science and school librarians, and has been successfully used in the primary. It is supporting science teaching, topical science, interdisciplinary learning and literacy skills.

Feedback:

"Since using 3ML, my children have become much better at working out what a word means, when they don't know it. We recently did some reading tests – taking groups of kids out and asking them questions -- and my class were much stronger at it. "

"3ML is a good way to bring science into reading. It appeals to the reluctant reader especially the boys. They almost don't realise they're reading. Seeing other children's responses is a really good way to start a discussion and get them to think about their own. They like that other children are going to see their answers. That's motivating. I particularly like that it's science based. "

"Sometimes literacy tasks go on too long and they switch off. 3ml is quick and easy to use. It's very simple to explain to them. The stories are so short they almost don't realise it's a literacy task. There isn't anything like it available for science teachers."

"We think it is a neat package and covers topical science and literate scientists well. We also think it is good training for extracting information when the pupils come to do their assignments. Some boys with behavioural problems have really taken to it."

Tim Peake Primary Project		ESERO-UK	
Subjects covered:	Science, maths, English, geography, history, music, art, ICT, PSHE	**Age range:**	4 to 11
UK Space Agency contribution:	£735,000	**Financial contributions from elsewhere (where known):**	-
Target Audience:	15,000	**Actual Audience:**	118,471

Summary: The ESERO-UK Tim Peake Primary Project used space to increase the engagement of primary school children with science, numeracy and literacy, with a dedicated network of space ambassadors. ESERO-UK worked with primary schools in order to increase enjoyment, engagement and confidence in learning science using the context of space. They also aimed to increase teacher confidence in teaching space topics

The ESERO-UK network of space ambassadors helped schools take part in a range of space activities that were created to support Tim's mission to the ISS. These activities also include professional development for teachers. The Space Ambassadors are a group of experienced educators with a passion for space and include both space experts and those from teaching background.

Evaluation Strategy: Teacher feedback and follow up survey 1 year later

Impact: The overall picture shows that 1,257 schools and under 119,000 young people were involved in the ESERO's Tim Peake Primary project (TPPP).

The TPPP was very successful overall. 99% of teachers agreed that the overall quality of the project was very good or good. There were very positive educational outcomes for pupils, with 99% of teachers stating the project directly increased pupils' enjoyment and engagement in science, as well as in numeracy (87%) and literacy (89%). Moreover, 97% of teachers reported an increase in pupil attainment in science.

Pupils' knowledge of STEM careers increased. 84% of teachers agreed that the TPPP increased pupils' knowledge of career opportunities available to them if they studied a STEM subject. There were very positive impacts on teachers: 99% of teachers stated an increase in confidence when teaching space topics, and an increase in cross-curricular teaching opportunities using the context of space in literacy and numeracy. Furthermore, over 94% of teachers rated the CPD provided by Space Ambassadors as good or very good.

The impact on schools was also very positive; 97% of teachers stated the project helped to increase the profile/priority of science at their school, and helped to meet school development priorities in science or other STEM subjects. The project provided long-term sustainable impacts for teachers and schools. Teachers and SAs found the resources to be of a high quality and extremely useful, with teachers now embedding these in their schemes of work to use in future academic years.

The use of both educational experts and space experts created a group of highly qualified ambassadors that helped to improve teachers' expertise and competence of using space as a context for teaching.

Tim Peake Primary Project	ESERO-UK

Feedback:

"And what we did do is discover quite a handful of children who really loved space and have since then brought in pieces of work that they've chosen to do at home or pieces of research...so I think it's just really... phenomenal, I wish I could do it all the time." (Teacher)

"I think we certainly improved the interest and the uptake, particularly girls, that was my focus really to get the girls interested in STEM. I think we did do that so I think the legacy element of it certainly helps in that respect." (School Science Coordinator)

"Children enjoyed using space as a way of developing their working scientifically, such as finding out how craters developed, using fair test." (Survey Response)

"I've had teachers say to me that particular child there would have never ever behave like they have while we were running the Tim Peake workshops. You know we've had children who were really quiet come out of themselves and got involved. We've had the ones are not particularly good at science and maths are anything like that and again have come forward have been really engaged and totally enamoured with it all, so I think the impact has been huge." (Space Ambassador)

"For pupils the impact that stands out is the engagement and enjoyment of pupils with SEN or barriers to learning." (Survey Response)

"And when eight and nine-year-olds are talking about 'streamlined' and 'air resistance' and 'thrust', it's great, it's great to hear that language.... They can explain things much more confidently using scientific words, so has so many knock-on effects on the whole curriculum you know. "(School Science Coordinator)

TimPix		Institute for Research in Schools	
Subjects covered:	PE, maths	**Age range:**	14 to 18
UK Space Agency contribution:	£17,500	**Financial contributions from elsewhere (where known):**	-
Target Audience:	7,200	**Actual Audience:**	2,100

Summary: The TimPix project offers schools the unique opportunity to carry out their own research using radiation data from Timepix detectors (based on technology from CERN) on board the International Space Station. These detectors monitor the type of radiation astronauts and cosmonauts come experience while in orbit. The radiation comes from the Sun and other sources outside our Solar System.

TimPix and CERN@School are part of the new Institute for Research in Schools – a national charity supporting sixth form students in performing original academic research.

Evaluation Strategy: Website statistics, feedback from schools

Impact: Overall there were 8,743 users with 34,791 page views from the website launch in March 2016 to the end of February 2017. TimPix is the most active set of pages on the website after the home and about us section.

On the 22nd March 2017, a short item was featured on the BBC news website about a discovery made within the TimPix data by a student from Tapton School in Sheffield. This was then picked up by a wide range of sites, including 84 news websites and social media postings. It was number 5 on most read list on BBC OnLine (with the top four all relating to the Westminster attack). After the BBC coverage of the student from Tapton School working on the TimPix Data (see below), the subsequent 24 hours saw 322 visits (the average number of page views was double the norm) and TimPix was understandably the largest at 100 page views followed by TimPix 101.

TimPix also gave some of those students that took part a chance to present their work in prestigious events. For example, one group of pupils from Ayr Academy travelled to CERN in September 2016 to present their work on the TimPix project to the Medipix collaboration. The Medipix collaboration are responsible for the development of the detector technology used on the International Space Station. The presentation from the students was very well received. For some of the students, this was their first trip outside of Scotland.

Over 250 schools are now registered with IRIS and this number is growing weekly. The resources established via the Principia grant will continue to be used and the TimPix project will be promoted and offered to new and existing partner schools.

Feedback: Not available at time of writing.

Zero Robotics		European Space Agency	
Subjects covered:	Coding, maths	**Age range:**	14 to 16
UK Space Agency contribution:	£0	**Financial contributions from elsewhere (where known)**	-
Target Audience:	Not defined	**Actual Audience:**	No data available
Summary: The Zero Robotics tournament turns the ISS into a gaming arena for football-sized satellites in a virtual field filled with obstacles. Students compete against each other, writing code to control the satellites on the space station.			
Evaluation Strategy:	None provided		
Impact: The ESA competition was promoted as part of the Principia campaign in the UK. Usual take up was very limited, with previous years competitions attracting no teams, or just a single team. In the 2015/16 year three UK teams took part in the competition.			
Feedback: Not available at time of writing			

APPENDIX 2: YORK STUDY

Methodology

The project adopted a mixed methods approach, gathering quantitative data through an online attitude survey with students, and qualitative data through interviews with key informants, students and teachers. Additional quantitative data from the National Pupil Database (NPD) allowed for the characterisation of schools participating in the project.

The target groups of students were those aged 7 to 11 (Key Stage 2) and 11 to 14 (Key Stage 3). The three-year duration allowed data to be gathered at three points: Phase 1 (baseline) data prior to Tim Peake's mission to the International Space Station in November 2015, Phase 2 data (immediate follow-up) in the period following the mission) and Phase 3 data (longer-term follow-up) data approximately one year later. The project collected data from two cohorts of students, aged 8 and aged 11 at the start of the project.

The study recruited 23 primary schools and 18 secondary schools. Two primary schools and three secondary schools withdrew from the study between the two phases of data collection due to school staff turnover and illness. Across Phases 1 and 2, data was gathered from 614 students in 21 primary schools and 897 students in 15 secondary schools.

APPENDIX 3: DURHAM STUDY

Methodology

The UK Space Agency provided Durham University with data from each project relating to the number of participants. Each project maintained its own records of activities and participation, with no uniform agreed approach to recording or presenting participation. In practice, the data recorded and provided by the different projects differed widely in terms of details, owing in many places to the different methods of delivery for different projects. Several projects did not provide data on the number of participants – just the school or other establishment where the project took place or where participants were recruited. None of the projects provided data on individual participants. These inconsistencies and missing details made the analysis more difficult, and the results less secure. This means that the 'reach' of the programme can only be our best independent estimate.

Of the 32 projects with data, 24 provided lists of schools or other settings and organisations along with numbers of participants. Although these data were sometimes invalid or incomplete (see below), they are the most valuable. Some of these provided further details such as the age or year group of participants, for example *Rocket Science*. Another two projects provided lists of schools or other settings but not the numbers of participants. The remaining projects gave less detail than this – sometimes for the very good reason that the project was of a different type, such as a website gauged in terms of the number of hits, or an educational resource measured in terms of the number of schools it was sent to, without knowing whether the resource was used or not.

Finding a total

The headline figure for programme reach is the total number of participants across all 32 projects for which we have any data. Without individual registrations, it is not possible to eliminate entirely the duplication of participants across different projects (where an interested individual has participated in more than one). As a substitute, we have done three things:

First, the University of Durham totalled separately the figures that were not measured in terms of participants – such as website downloads or resources sent to schools.

For the other figures, where the same school (or organisation) appeared within a project more than once, this was because different year groups participated or the project ran for successive years with the same age group. We collapsed these entries to create a total for that project in that school.

Where the same school (or organisation) appeared across different projects, and it was clear that different year groups participated, nothing was done. If it was clear that same year groups participated in different projects, or it was not clear whether it was the same year groups, we had to estimate the overlap between projects (to avoid over-estimating the overall reach of the programme). Where we did not know the identities of the schools, we estimated the level of overlap with other schools by using the known level of overlap for the schools whose identities we did have. Estimating this overlap required knowledge of the size of each participating school or organisation.

Identifying the schools

For almost all the projects no school unique reference numbers (URN) were collected. Instead we were given lists of schools and organisations names, along with postcodes for 24 of the projects. Some schools had no names and some had no postcodes. The postcodes were needed to identify the schools since their names were not always unique. There are hundreds of St Mary's, for example. For the most part, we used Edubase (a publicly available database of schools and their characteristics), and matched institutions via names and postcodes where these were available. Edubase only contains information about schools in England, some offshore islands (e.g. Jersey and Guernsey), and a few schools in Wales. Some of the England postcodes did not identify an institution or match with an Edubase record. For the other UK countries of Northern Ireland, Scotland and Wales, participant institutions are simply totalled by region. Institutions outside the UK are simply totalled. The list of institutions is therefore not complete. There were

also participants registered as being educated at home, or by parents, and no school information is available for these.

One of the advantages of linking to Edubase to determine the size of each school or college is that it also leads to information on the type of school (independent, academy, technological college, community school), phase of schooling (primary, secondary, sixth form), its location (region, urban or rural), and levels of potential disadvantage (assessed by proportion of pupils with free school meal eligibility, and English as an additional language). We analysed participation for all of these characteristics including size. This enabled us to go beyond reach, and consider also the kinds of participants in the overall programme as far as possible from these limited data. We did this by comparing the participating schools with the equivalent figures for all schools in England.

Pre-primary, nursery and primary schools are counted as primary phase. Middle and all-age schools are classified as primary or secondary based on the ages of the pupils. All education institutions with only students above Year 11 (e.g. further and higher education and sixth form colleges) are classified as post-secondary. Academy schools include all autonomous schools (Academy Sponsor Led, Academy Converter, Foundation and Free schools). Voluntary schools include both Voluntary Aided and Voluntary Controlled. We have classified special schools, pupil referral units, hospital schools and alternative education units as 'Other' provision. Where the institution is unknown or the postcode is missing or clearly wrong, we total participation in a 'not known' category.

Nationally there are a total of 26,912 schools in the database. Of these, 70% are primary and 13% are secondary schools. The 'others', including special schools, independent schools and some Welsh establishments, make up 16%. For a number of reasons, we compared only schools in England for participation in the different projects. First of all, because the majority of school participants were from England. Secondly, Edubase does not include most UK schools outside England, and the national database for the other devolved administrations had very different classification of school types and even school phase (as in Scotland).

However, for projects where the majority of participants came from outside England, as in the *Three Minute Learning* project where 87% of participants originated from Scotland, we did an analysis of the distribution pattern of the participants there. It is not possible to do similar things for all projects as others did not include postcodes for Scotland.

For the *Cosmic Classroom* in-flight call with Tim Peake, we only have information on the latitudes and longitudes of the participants. In this case, we used Google maps to work out the location of these places and present the data on a distribution map. This was a time-consuming and laborious task as there were over 12,000 cases, each one individually searched. Google locations are not always precise and some coordinates pointed to the middle of the Mediterranean Sea, for example.

Many projects provided figures that look like more like estimates than actual participation. For example, estimates were based on class sizes and the number of classes. Several events involved unspecified schools and pupils, such as visitors to the National Science Centre and the outreach day. There is no way of estimating overlap for these, and so the final figures are likely to be an over-estimate of reach, in this regard.

For projects like *Destination Space,* where a large number of participants are from the public, we analysed participation by schools and the public separately. Since not all registrations came from schools (there were individuals, charity organisations and youth groups), we analysed where each registration came from to ascertain the geographical spread of interest.

Estimating the overlap between projects

To estimate the likelihood that an individual listed in one school participated in more than one project, where the school was part of two or more projects, we used a very simple form of the capture, mark, recapture technique from ecology (Gorard 2003). To use this technique, we had to first determine if the pupils from the same school participating in the different projects are the same pupils. Where it is clear that pupils are from different year groups, these pupils will be counted as separate individuals. However, where it is not clear that different year groups were involved, the probability of any one individual participating in that school is computed as the

number of participants in each project divided by the number of eligible pupils. The chance of any one individual being part of two projects is then defined as the product of the probabilities of participation for each school. Where we did not know a key piece of information, we had to assume no overlap. Where it appeared that the whole school took part in one activity, no addition was made for other activities. Otherwise, the total for each school was computed as the largest number in one project plus 20% of the remaining participants. Fractions (of participants) were ignored.

Difficulties with identifying schools

Some schools were listed by their commonly known names, which were not the same as those registered in the national database. In some projects as many as 25% of postcodes were incorrect. Many had typographical errors, e.g. PO2 written as P0Z, FY4 written as FYA, YO31 was listed as TO31 and so on. Sometimes one letter was missing. Some schools were listed as [the name of a school] and other schools. It was impossible to know the identity of the other schools. It was also not always clear whether the schools were only venues for an event or schools where the participants came from.

In the *Rocket Science* data, over 142 schools could not be located by their given postcode. This represented 5,231 young people. There were a number with postcodes labelled as 'tbc' (to be confirmed). About 25% of postcodes in the Conferences project were incorrect. In these cases we used the names and locations of the schools to determine the school but this was not always possible when the name of the school was incomplete or too vague.

In the *Into Film* competition, only some of the school names were given; the rest just consisted of the names of towns and their postcodes. In a handful of cases the postcodes were those of schools, but in most of the cases the postcodes were not related to schools. There was no way of telling whether the postcodes were wrong or whether the entries did not come from schools. We used postcode finders to check if they were schools or not.

Overall, there were 33,090 cases with no school name (usually just a post code), 16,826 cases were home-educated, 397 were individual participants not affiliated with schools or any organisations or groups (just listed as individuals), and a further 662 schools were listed as having no participants or zero participants.

APPENDIX 4: EXPERIMENTS WITH UK INVOLVEMENT

Thermolab and NEQUISOL

The electromagnetic levitator (EML) is a furnace used for studying metals on the International Space Station's European Space Agency Columbus laboratory. The EML heats metals up to 2,100°C and rapidly cools them. This is essentially what blacksmiths have been doing for centuries, creating steel tools by heating, hammering and quenching in water. This process sets the steels structure and causes it to be hard and stay sharp.

Using the EML, this age-old process was given a space age update: creating molten metals without gravity, or a container to hold them. The liquid metal is levitated, fixed in position, either in a vacuum or a gas, and its changes during heating and cooling are measured by high speed cameras and other sensors.

The physics underlying the process of heating, melting and solidification of metals and metallic alloys is highly complex and affected by many factors. By removing gravity and the container holding the metal from the equation, you can observe the fundamental properties of different metals, alloys, rates of cooling and so on much more accurately. This data can then be used to design new materials with specific useful properties: strong, lightweight, conductive, pliable or rigid.

Two experiments have used the EML with significant UK involvement: NEQUISOL (Non-equilibrium Solidification of Industrial Alloys) and Thermolab.

Thermolab

Traditionally, trial and error was used to test new alloys. Increasingly, largely thanks to improvements in processing power, computers can model and predict the properties of new alloys. However, before they can do so, they need to have reliable data on the properties of the constituent materials.

Thermolab is delivering these parameters, investigating the temperatures and physical properties of industrial alloys. This will help scientists improve models of industrial processes for the aerospace, automotive and consumer electronics industries – ultimately leading to materials produced more quickly, cheaply and with less waste – good both for the environment and for companies' bottom line.

Professor Koulis Pericleous at the University of Greenwich is a member of the international Thermolab team. His team studied the stability of the EML, making sure that the forces induced by the coils were balanced, to give measurements to the required degree of accuracy.

NEQUISOL

Non-equilibrium Solidification of Industrial Alloys (NEQUISOL) is looking at the rapid solidification of industrially important alloys. Cooling these alloys quickly, to below their freezing point, causes dendrites to form as they solidify. Dendrites are 'tree-shaped' crystal structures that resemble ice on a car windscreen. The NEQUISOL project was analysing this process in comparison with ground-based studies. To date, mostly nickel-aluminium alloys have been used, but aluminium-silicon alloys and silicon-germanium materials will now be studied too. These materials may give a variety of advantages in industrial applications – ultimately leading to more efficient processing and lower energy requirements in many different settings.

Professor Andy Mullis, Director of the Institute for Materials Research at the University of Leeds, will lead ground-based studies against which the space experiments will be compared. A 6.5 metre 'drop-tube' at Leeds simulates the microgravity experienced in space, dropping objects and studying them in free-fall – after all, everything in orbit around the Earth is essentially just in an extended free fall.

Professor Mullis' team will also be conducting simulations of the expected solidification morphologies, using a technique called phase-field modelling. The Leeds group leads the world in using such simulations with unprecedented spatial resolution.

Why these materials

Nickel-aluminides (Ni-Al) are potential materials for high temperature structural materials, particularly for applications such as gas turbines, where lightweight, high temperature operation can deliver much greater energy efficiency. Ni-Al catalysts are used extensively in

industrial hydrogenation reactions (everything from pharmaceuticals to margarine) but are attracting a lot of attention in applications such as H-fuel cells, where the Ni-catalysts can replace platinum at vastly lower cost.

Aluminium-silicide (Al-Si) is one of the main classes of light weight structural alloys, with Al-alloys being used extensively in aerospace applications. This material has been around for a long time and is relatively well understood – however, Al- and Al-Mg alloys with very small (0.1-0.2%) additions of scandium can dramatically improve modulus and stiffness. NEQUISOL will study a 0.2% scandium alloy to help elucidate the strengthening mechanism of this 'magic ingredient'.

METERON and SUPVIS-M

METERON (Multi-Purpose End-to-End Robotic Operation Network) is a European project to prepare for human-robotic missions to the Moon, Mars and other celestial bodies. The project is organised around a series of experiments, testing technologies and adapting traditional ways of working. METERON is implementing an infrastructure to test communications, operations and robotic control strategies. Operational considerations such as which tasks are robotic and which human, and what data is needed to support the monitoring and control of assets, will feed directly into plans for how to explore, and the design of communication systems.

SUPVIS-M (Supervisory Control of Mars Yard Rover) was one in a series of METERON experiments. Building on previous tests, the European Space Agency, UK Space Agency and Airbus Defence and Space UK worked together to investigate distributed supervisory control of robotic assets in a simulated planetary environment. Airbus built a Mars Yard, in Stevenage, Hertfordshire, to develop the locomotion and navigation systems for ESA's ExoMars rover vehicle and provides a realistic Mars-like environment to test systems. The experiment provided valuable data to assess the benefits of human involvement in a rover's path planning.

A representative mission scenario was set up, where a rover was commanded to go from a brightly lit environment into a challenging dark location (to emulate a cave or a shaded crater) and identify a number of science targets. The Mars Yard was split into two areas, one lit and one in darkness.

From one end of the yard, Airbus's MARS rover, named 'Bridget', was commanded from ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, to the edge of the shaded area. Then at the edge of the 'cave', control of the platform was passed to Tim, on board the ISS, who commanded Bridget to drive across the yard, avoiding obstacles and identifying potential science targets, which were marked with a distinctive UV fluorescent marker. Once the targets had been identified and mapped, Tim drove rover out of the shaded area and handed control back to ESOC to drive the rover back to its starting point.

To make the scenario and operation more realistic, the time in the shaded area was limited to emulate the rover energy depleting. In addition, Tim was not provided with an explicit path or routing instructions: he decided and executed the operation of the rover based on the visual cues fed back to him and his own perception of the terrain and the environment.

This project built upon previous tests related to the setup of the teleoperation architecture and demonstrated the control of the same rover from three separate and distant locations (the UK, Germany and the ISS). It provided another level of complexity by demonstrating how a rover can traverse difficult terrain thanks to human control with limited visual feedback and provide valuable data to shape a wide range of future exploration missions.

EXPOSE-R2

EXPOSE is miniature photochemistry laboratory dedicated to astrobiology. Developed by ESA, it is mounted outside the ISS to allow exposure of chemical and biological samples to outer space. Scientists trying to unravel the origins of life often study organisms in extreme conditions: the Arctic and Antarctic; the Atacama desert; acidic rivers such as Rio Tinto in Andalucía; deep-sea thermal vents, and so on. The aim is to learn more about the limits to life and how organisms adapt to different environmental conditions. This has implications for how life may have arisen and evolved on the early Earth, and on other places in the Solar System, such as Mars or Jupiter's moons.

The unique orbital laboratory of the International Space Station (ISS) allows us access to another extreme

environment – space – with a combination of conditions not present on Earth, and gives scientists the opportunity to study how organisms react in a highly controlled way. Exposure to the space environment has a number of aspects and implications for our understanding of how and where life can survive: the different radiation conditions; the extreme vacuum; the extreme changes in temperature.

EXPOSE involves a combination of in situ measurements and laboratory analysis of samples returned from space. EXPOSE R-2 is the third in a series, following successful missions launched in 2008 and 2009 – one mounted onto the exterior of the European Columbus module ('EXPOSE-E'), one mounted on the Russian Zevzda module ('EXPOSE-R').

EXPOSE-R2, also mounted outside the Russian module, spent 18 months attached to the outside of the ISS, from August 2014 until February 2016. It had two main experiments: BIOMEX and BOSS, both with significant involvement from Professor Charles Cockell, University of Edinburgh.

BIOMEX studied whether life or its component biomolecules can survive on the surface of Mars. Different compartments each containing different organisms, such as bacteria, algae, fungi. Some of these were protected by an artificial Mars soil, to a variety of depths, and some will even have a 'Martian' atmosphere, rich in carbon dioxide, whilst others will be left entirely exposed to space. This will help understand the habitability of the Martian surface and inform future exploration of the Red Planet.

BOSS (Biofilm Organisms Surfing Space) studied biofilm and non-biofilm forming organisms, comparing how they respond to UV radiation. It is thought that biofilm forming organisms may be better able to withstand UV radiation; this experiment tested this idea, and tried to answer why that may be the case. This will improve understanding of where and how microbes can thrive, with implications for better understanding biofilms, and microbial resistance, on Earth.

Fluid Shifts

One of the risks of spaceflight is that, in weightlessness, fluid in the body shifts, mostly in a head-ward direction. This can increase brain pressure, which may in turn push on the back of the eye, affecting astronauts' vision. Many astronauts have complained of temporary, and in some cases, permanent, problems with their eyesight. How and why this happens is not well understood. A NASA experiment called Fluid Shifts is looking at the underlying physiology, monitoring the changes in astronauts' bodies and testing ways to counteract them.

One of the most important signs to measure is the change in brain pressure but monitoring this is a challenging task in space. A British company, Marchbanks Measurements Systems (MMS) Ltd, has pioneered a unique solution: a simple, non-invasive device which is placed in the ear.

Research at University Hospital Southampton NHS Foundation Trust shows that there is an open fluid link between the brain and ear. Brain pressure changes are transferred to the inner ear and are measured in term of tympanic membrane displacement (TMD) by the MMS Cerebral and Cochlear Fluid Pressure (CCFP) Analyser. Both baseline pressure shifts and pressure waves can be measured. The baseline pressure is a surrogate for lumbar puncture (sometimes called a 'spinal tap'), and it is thought that the brain pressure waves provide a 'signature' to underlying disorders. This will be a crucial part of the Fluid Shifts investigation.

Marchbanks Measurement Systems from Southampton is headed by Dr Robert Marchbanks. He and his team have developed a method which uses slight changes in the inner ear to assess brain pressure. This is not only useful for monitoring astronaut health, but could have widespread application on the ground. For example, in emergency situations, being able to quickly and accurately measure a patient's brain pressure leads to speedier treatment – crucial in determining their medical outcomes.