Destination Space
Phase 2 (Level 1): Final Report

A National Strategic Science Engagement Programme for families

In partnership with UK Science Centres

UK Association for Science and Discovery Centres

March 31st 2018

Contents

Executive Summary

The Programme Vision: To engage, inspire and involve families with school-age children, school groups and communities across the UK with the amazing stories, science, engineering achievements and innovative ideas of the UK's world-leading space science and engineering research, highlighting the relevance to people's daily lives and to society's future.

The Programme Mission: To create hands-on activities and resources to bring alive The James Webb Space Telescope, ExoMars and the satellite launch programme, and to work with UK Science Centres and a host of stakeholders to deliver activities. In addition, to develop the relationships required and to develop the content to deliver a wider inspirational national hands-on science and engineering programme celebrating UK space science, engineering and space exploration, that can be delivered in the future through the successful infrastructure of the UK's science and discovery centres and science museums.

ASDC are delighted to be working again with the UK Space Agency to create and deliver an exciting new National Space Education and Engagement Programme, Destination Space 2 (Level 1). This follows on from the success of ASDC's Destination Space Phase 1, where ASDC created resources, activities and equipment to engage children and adults with the latest space science and Tim Peake's mission to the International Space Station, and trained, equipped and supported 20 UK science centres to run these.

Overall, 733,017 people took part in Destination Space Phase 1, including 100,244 school children age 5-14 who participated in curriculum-linked space workshops and 75,741 people who met and spoke with a space scientist or engineer. The large-scale academic evaluation of over 12,000 school students showed that boys and girls enjoyed the activities equally and were equally inspired, and that proportionately more schoolchildren from disadvantaged backgrounds took part in the activities.

Destination Space 2 (Level 1), builds on all the expertise, training, knowledge and enthusiasm for space science and exploration currently in science centres across the UK, and with their schools and family visitors. Specifically, this programme creating great new resources and hands-on activities focusing on the science and engineering of the new James Webb Space Telescope, the ExoMars mission, satellite applications and the future potential for UK Spaceports.

The programme created all the content and resources along with a full training handbook and invited applications from UK Science Centres who had run Destination Space 1. The following five science centres were selected to deliver Destination Space 2 (Level 1)

- The Eden Project in Cornwall
- The National Space Centre in Leicester
- Jodrell Bank Discovery Centre in Cheshire near Manchester
- Dundee Science Centre
- Winchester Science Centre.

These centres were trained and equipped at the Training Academy in March 2018 to run this cutting-edge schools and families programme. These exciting new activities launch with families and schools from Easter 2018 and continue until February 2019. Together they will reach over 140,000 children and adults across the UK with the latest Space Science and Engineering.

In addition, as part of this Phase of Destination Space 2, ASDC has undertaken research with the Science Centres and Museums that delivered Destination Space Phase 1. We asked them how many people they have engaged since they reported their numbers to us on January 20th 2017 at the end of Destination Space Phase 1. At this point they had collectively reached 733,017 people.

The Science Centres and Museums have reported to us in detail, and we now know that since Phase 1 ended they have directly engaged an additional 181,629 children, young people and adults in Destination Space schools workshops, family shows and meet the expert events. Of these 52,104 were school students participating in curriculum-linked schools workshops and events, and 6,803 were teachers. **This brings the final total for ASDC's Destination Space to 914,646 for schools workshops, family shows and activities.**

Delightfully, in addition to this at least a further 1,135,786 people have been engaged in ASDC's Destination Space Phase 1 through all the newly created Space exhibits, exhibitions and programmes at the Science Centres, that have been created because of Destination Space Phase 1. These include programmes and exhibits and events that use the Destination Space equipment and content, and funding from the programme. This brings the **overall wider number of people engaged by** ASDC's **Destination Space Phase 1 to 2,050,432.** This is quite a tremendous legacy and the numbers will continue to rise year on year.

Each of ASDC's national programme is designed from the start to achieve legacy, and the success of this can be seen above. We are at such an exciting time in UK space history, with the new announcements of spaceports, the UK role in The James Webb Space Telescope and ExoMars and our leading role in satellite applications. It is our ambition that Destination Space 2 (Level 1) is the first part of a much wider programme that will bring this brilliant new space science and engineering to children, schools and families in many more regions of the UK in 2018 – 2020.

The programme has been designed to facilitate this, and to achieve excellent value for money should Destination Space (Level 2) be funded. We are poised and ready to deliver, and have the national infrastructure, proven ability and excellent trained staff across the UK to allow us to quickly and easily reach children and families more widely across the UK, creating an astounding legacy at this pivotal time.

1. An overview of Destination Space 2 (Level 1)

Introduction

As a nation and as a global society we have some grand challenges ahead, especially in relation to living better on our planet and ensuring there are sufficient resources for all inhabitants into the future. Now, more than ever we need our young people to be brave, entrepreneurial and innovative, to reach further and to be inspired by science and engineering as something they can be part of, that can solve challenges and make the world a better place. These themes of be curious, be brave and follow your dreams run throughout our programmes.

The Destination Space 2 (Level 1) programme continues the National and Strategic partnership between The UK Association for Science and Discovery Centres and the UK Space Agency, building on the success of Destination Space 1, to bring the latest space engineering and space science directly to families, schools and communities across the UK.

Destination Space 2 (Level 1) ran for six months and is the first part of what we hope will be a bigger national STEM programme (Level 2) reaching more families and schools with the latest space science and engineering. ASDC have created a host of resources all of which are now widely available for Science Centres, teachers, researchers and space scientists to use under Creative Commons to advance engagement in this area.

The UK Association for Science and Discovery Centres (ASDC) is the national charity that brings together the UK's major science engagement organisations to play a strategic role in the nation's engagement with science. Within our membership are over 60 of the nation's largest publically accessible science centres, discovery centres, science museums and scientific bodies. Every year in the UK, 20 million people of all ages and backgrounds choose to get involved with science at one of the UK's science and discovery centres or science museums. This equates to 385,000 people every week who come to our member centres to explore and discuss science in an involving and personal way. www.sciencecentres.org.uk

ASDC have created the content, activities, schools workshops and resources for Destination Space 2 (Level 1) and have selected, trained and are supporting five UK Science Centres to deliver the programme across the UK across 2018 and until February 2019. Through this national programme, together we will reach over 140,000 people with the James Webb Space Telescope and the ExoMars mission, as well as UK space ports and satellite applications.

This programme has been directed and project managed by The UK Association for Science and Discovery Centres who have considerable experience managing national strategic multi-partner science engagement programmes. The content has been created in partnership with researchers, engineers and academics as well as the teams from the National Space Centre, UK Space Agency partners, STFC, ESERO, Aberystwyth University, Satellite Applications Catapult and many others.

Destination Space Phase 2 (Level 1) began in September 2017 and completed on March 31 2018, with Science Centres continuing to deliver the activities until February 2019.

The Vision: To engage, inspire and involve families with school-age children, school groups and communities across the UK with the amazing stories, science, engineering achievements and innovative ideas of the UK's world-leading space science and engineering research, highlighting the relevance to people's daily lives and to society's future.

The Mission: To create hands-on activities and resources to bring alive The James Webb Space Telescope, ExoMars and the satellite launch programme, and to work with UK Science Centres and a host of stakeholders to deliver activities. In addition, to develop the relationships required and to develop the content to deliver a wider inspirational national hands-on science and engineering programme celebrating UK space science, engineering and space exploration, that can be delivered in the future through the successful infrastructure of the UK's science and discovery centres and science museums.

2. The Key Goals

The key goals for this six-month national programme, in order of importance, were as follows:

1. To inspire and intrigue children and their families and teachers with a pioneering sense of curiosity, questioning and adventure in relation to space, our planet and international human space endeavour.

2. To inspire science engagement professionals across the UK to help the children, families and teachers they engage to explore, test, experiment and discuss the brilliant creativity, innovation and entrepreneurship needed for space science and engineering programmes and exploration - with a specific focus on the James Webb Space Telescope, The ExoMars Mission, the satellite launch programme, spaceports and satellite applications.

3. To inspire both schoolgirls and schoolboys to consider careers in the space sector and in science and engineering more widely and to see the people involved in the latest space missions. All the evidence points to young girls especially feeling 'it's not for me' and we have aimed to counter this.

4. To build family science capital in the five centres we work with, and more widely and to encourage young people and families from all sectors of society to grow their interest in space science and to consider careers in this area.

5. To bring alive the areas of the UK's space science that have the greatest impact on all of us, show casing what happens if 'we switch space off'.

6. To train science engagement professionals embedded in ASDC member organisations across the UK to inspire families with the latest launches and recent developments in space science and engineering focussing especially on the James Webb Space Telescope, ExoMars, the satellite launch programme, spaceports and new technology providing a national educational legacy for this programme.

7. To increase the public engagement opportunities of UK space scientists and engineers (in a gender balanced way) and enable the public to meet them in informal settings.

3. The Key Audiences

The key audiences for this national programme are:

1. Science Centre and museum professionals in selected centres who will ensure The James Webb Space Telescope, ExoMars and other space content is included across their shows and activities, and develop relationships with space scientists and engineers so innovative content is delivered into the future.

2. Young people aged 5-14 to explore space, the James Webb Space Telescope, ExoMars, the latest satellite launches and applications and the engineering feats and spin offs from human space flight. There was a special focus on children aged 7 - 10, an age group that the ASPIRES academic report has showed is vital to engage for longer term interest and engagement.

3. Parents and families of these young people so they are equally inspired by what the UK and our European and International partners can achieve together and continued to inspire and encourage their children's science learning and career aspirations long into the future, seeking out other related activities.

4. Teachers visiting with school groups, to inspire them to engage their school students (aged 5-14) with the latest space science and to involve their students on an on-going basis, and to bring their classes back to science centres to discover more in astronaut programmes and science programmes.

5. UK Space Agency researchers and scientists to make it easy for them to share their excellent work with the public by offering great activities and methods to engage the public.

6. Other stakeholders such as other space networks and organisations so they can celebrate the range of world-leading space science and engineering expertise that the UK and ESA are involved with, and explore easy ways to engage the public.

7.

4. The Four Key Content Areas

The first phase of Destination Space ran for 3 years and reached 733,017 people. The focus was on human spaceflight timed to celebrate Tim Peake's mission, along with other areas of space engineering, science and the people involved.

This Phase of Destination Space is different. Rather than focusing on human spaceflight, it focuses on these four key areas of content:

1. **The James Webb Space Telescope:** There are a number of international teams involved in creating the instruments onboard The James Webb Space Telescope (The Webb Telescope). It is now scheduled to launch into space in Spring/Summer 2020, outside the timeframe of this six month programme, however Science Centres have been trained in all areas of its mission and are able to inspire schools and families with it as the mission develops.

2. **The ExoMars mission**: One of ESA's most ambitious scientific endeavours to search for evidence that life may have once existed on Mars. Again, the launch is scheduled for 2020 and ASDC have trained Science Centre staff on all areas of its mission and instruments so they can inspire schools and families as the mission develops

3. **UK spaceports:** This includes hands-on activities and demos as well as discussions around the satellite launch capability and the UK Space Industry Act 2018 (previously the Parliamentary Space Industry Bill) has unlocked the potential for spaceports and small satellite launch within the UK.

4. **Satellite Applications**: A host of hands-on demos that show case the smaller generation of satellites and reveal 'what happens if you switched space off?'

5. The Outputs of Destination Space Phase 2 (Level 1)

This project has delivered the following:

1. A suite of highly adaptable activities for use by Science Centres and museums across the UK that they can add to their family shows, events and schools workshops to promote The James Webb Space Telescope, The ExoMars mission and other areas of 'Key Content' given above.

2. A novel set of hands-on equipment and resources for each of the five selected Science Centres to use with families, schools and the wider public to explore the latest UK space science and research, focussing on the 'Key Content' areas.

3. Two brand new curriculum-linked 40-50 minute schools workshops for KS2 and KS3. The KS2 activity focusses on the ExoMars mission whereas the KS3 workshop focusses on The James Webb Space Telescope. (ASDC wish to note here that this was in addition to what was contracted, which was 'additional activities for KS2 and KS3').

4. Novel hands-on activities to use within a family show format focussing on the 'Key Content' areas to add to their existing Destination Space and other space-themed family shows.

5. A set of hands-on activities, demos and challenges all written up in the format of a magnificent new Training Handbook, focussing on The James Webb Space Telescope, ExoMars, spaceports and satellite applications.

6. A new suite of commissioned illustrations that can be used by all. Illustrations include the James Webb Space Telescope, ExoMars rover, a spaceport, satellites and both horizontal and vertical launchers.

7. A training academy for 10 Science Centre staff from the five selected Science Centres and museums across the UK to enable them to run the programme, and to help them adapt it towards each mission's launch window.

8. A meet-the-expert session format and guidance for the James Webb Space Telescope, ExoMars and space event days and activities for families, with introductions to guest space scientists and engineers on request.

9. A one-day Charrette[1], bringing together professionals from across the UK with the very best experience in hands-on activities to engage families with space science, with academics and researchers in this area.

10. Creation of a Science and Engagement Advisory group from the Charrette who were happy to advise ASDC on the latest space science and engineering for the programme.

[1] A charrette brings together experts with different backgrounds to come up with creative ideas to solve a problem or create a leap forward in a field. ASDC has used this successfully at the start of every national projects.

11. All the resources that Science Centres need to run activities with the James Webb Space Telescope, ExoMars mission and more, and all the marketing, branding and PowerPoints have been given to all Centres in electronic format.

12. Adaptations to the Phase 1 ASDC Destination Space Website www.destinationspace.uk and with the later addition over the spring of 2018 with newer content.

13. The creation of a new online and digital strategy, including social media, to offer opportunities to help all Science Centres reach their thousands of followers via Facebook, Twitter and other channels to assist across the delivery time frame.

14. Easy access for Science Centres to video footage and images for the James Webb Space Telescope and ExoMars to facilitate the latest imagery being used in multiple formats.

15. Specific guidance on using the UK and ESA space-related science as an opportunity to inspire girls with the physical sciences (including areas of maths and engineering) and to help all families explore STEM careers with their children.

16. A 'Press and Marketing Pack', with logos, illustrations, sample press releases and approved copy for web, as well as social media delivered in a flexible manner for centres to celebrate the latest space achievements and research.

17. A Destination Space 2 research and development working document, summarising all the ideas, hands on activities, experiments that had been uncovered through this 6 month research and development phase focussing on the James Webb Space Telescope and other key content areas. This is a working document that can be shared on request and not for publication.

18. A small research programme (by the ASDC team) to collect data on and assess:

    - how many children and adults have participated in Destination space since ASDC asked them to report on 20 January 2017, for our Final report in March 2017 at the end of the funded Destination Space 1 programme.

    - The variety of ways the programme has impacted Science Centres nationally.

6. The Development Partners

This programme was directed and project managed by The UK Association for Science and Discovery Centres who have considerable experience managing national strategic multi-partner science engagement programmes. The programme was developed in collaboration with a host of experts and partners including experts from:

- The UK Space Agency
- The National Space Centre, Leicester
- The Satellite Applications Catapult team at RAL
- The ExoMars team at Aberystwyth University
- The James Webb Space Telescope Team in Edinburgh
- STFC
- Expertise from a host of academics, researchers and engineers especially those present at the content development Charrette. All of these are thanked at the start of the Training Handbook.

7. The Five Selected Delivery Partners:

Selecting the Partner Science and Discovery Centres

ASDC sent out an invitation to participate document along with an application form to all 20 ASDC Destination Space Science Centres in December 2018. We sought five partners for Level 1.

ASDC held a bidders conference call earlier in January 2018 where all Science Centres interested in applying had the opportunity to dial in, hear about the programme from the ASDC CEO and project manager, have their questions answered and hear the responses given to others who would be bidding. This open framework has been used in all previous ASDC programmes and means there is absolute clarity about what centres need to deliver, schedules, audiences, grants, budgets and reporting before each centre applies. 13 Applications were received.

The following 13 organisations applied to take part:

1. Aberdeen Science Centre
2. Centre for Life
3. Dundee Science Centre
4. Eden Project
5. Glasgow Science Centre
6. Jodrell Bank Discovery Centre
7. Observatory Science Centre
8. National Space Centre
9. Techniquest Glyndwr
10. The Observatory Science Centre
11. Thinktank
12. W5
13. Winchester Science Centre

The Selection Panel

The applications were reviewed by the Selection Panel which met on January 30th 2018 and included staff from the following organisations:

- The UK Space Agency
- STFC
- ASDC

The following 5 science centres were selected to be trained and equipped as part of the project:

1. Dundee Science Centre
2. Eden Project
3. Jodrell Bank Discovery Centre
4. National Space Centre
5. Winchester Science Centre.

8. The Impact and Geographical Reach

Together, the ASDC membership attracts 20 million people each year. Some of our larger members attract several million people annually, and our smaller member centres attract 100,000 people every year. Within this six-month programme ASDC selected and trained five ASDC members to deliver the full programme, ensuring geographical reach whilst maximising the numbers of families that can take part. The map on the page previous shows the geographical location (in blue) of the five Destination Space Phase 2 (Level 1) partners. We would hope to extend this programme to the wider group of Destination Space Partners shown in white, if funding for a Level 2 is possible.

In our proposal, ASDC committed to reach ten thousand (10,000) people and this is what ASDC were contracted to deliver. Delightfully the five selected science centres were far more ambitions in their subsequent applications to ASDC and between the five selected centres said they could reach over 140,000 people in 2018 and early 2019. Over fourteen times the original proposal.

ASDC would like to note here that the centres who could reach larger numbers were selected for this programme (Level 1). If Destination Space Phase 2 (Level 2) is to be funded then this leaves the smaller reaching centres, where it is not expected that numbers will be as high.

Numbers Centres said they could reach in their bid	
The Eden Project in Cornwall,	100,000
The National Space Centre in Leicester	11,800
Jodrell Bank Discovery Centre in Cheshire	12,200
Dundee Science Centre	3,575
Winchester Science Centre.	18,730
Total	**146,305**

9. What each Science Centre was given:

ASDC understands that all ASDC members are different. They have different strengths and existing partnerships, different audiences and unique relationships. We know that every centre wants to play to their strengths and run slightly different activities and events and that each centre needs freedom over how they choose to run these with their visitors if they are to do their very best work. We always fully endorse this approach and indeed ASDC designed all elements of this project to maximise this flexibility. Our goal was that selected centres had the freedom to evolve and adapt the Destination Space content, to take advantage of their expertise and existing relationships and to adapt and update their offer as the missions progress.

The five selected science centres were given the following:

1. A set of adaptable hands-on equipment including a bespoke replica of the surface of Mars, a hands-on pocket satellite, a FLIR thermal imaging camera adaptable to fit an IPad or tablet device and eight class sets of infrared sources and other items.
2. Full and detailed training on how to use all the equipment, the hands-on experiments and all the related science and engineering for the missions and key content areas.
3. Places for two Science Centre staff to attend a two-day residential training academy. Their travel, food and accommodation were paid for by the project.
4. An excellent bespoke new Training Handbook for all staff involved.
5. A brand new schools workshop for 7-11 year olds, focusing on the ExoMars mission and in particular the capabilities of the ESA Mars rover (KS2).
6. A schools workshop for 11-14 year olds, focusing on space exploration via the new Webb Telescope and the properties of its sunshield and onboard instruments (KS3).
7. Adaptable and flexible activities and demos to add to the family show for children and their parents.
8. A £2,000 grant to assist with running the programme until February 2019.
9. All branding material, including newly commissioned illustrations of the Webb Telescope, ExoMars rover and a spaceport, and a banner and materials showing all of this.
10. A full marketing pack, including logos and sample press releases and text for the workshops for marketing leaflets.
11. Evaluation forms and instructions for the project evaluation programme.
12. Advice and on-the-phone support from ASDC and the project team throughout on any issue to maximise delivery, and to support staff working with new techniques and equipment.

The full set of project materials are available on request and will later be in the resources section of the Destination Space website (www.destinationspace.uk).

10. The ASDC Content Development Process

The content development process for Destination Space 2 (Level 1) began in September 2017 and with the partners at the kick-off meeting in October 2017. It continued for most of the next six months until the project completed on 31 March 2018. The process was led by the ASDC Project manager and involved the ASDC CEO, deputy CEO, and the rest of the ASDC team along with a host of external experts. Below is the ASDC content development process used for this programme. The timeframe was condensed and phases overlap as the whole programme from the initial content kick off meeting to delivery in centres has been just 6 months, rather than the usual 12 – 18 months.

The first phase of content development was the content research phase which brought together a wide range of ideas from the UK Space Agency scientists, public engagement professionals and engineers and scientists around the world. It began at the kick off meeting and culminated in the Charrette, where a summary table of all the ideas was collated. This is an internal document for the project team and the UK Space Agency to inform the next stage, (please note that this compilation of ideas is not in a publishable format). We also interviewed members of the UK Space Agency education and press teams, STFC colleagues, ESERO and others with unparalleled knowledge of the range of work being undertaken in the UK Space Sector.

The second phase of content development was the content definition phase which took the summary of ideas and began to prioritise what should be include in the kit and in the family show during this phase. We were looking for excellent and engaging experiments and hands-on activities that were either tried and tested and known to be successful, or those that we could create or develop. For example, perhaps activities had been created by a space researcher in an early format and we could develop (with their permission) the activity into something that would work for large numbers of the public in a Science Centre environment. This phase includes an element of discussions with suppliers to assess cost so we can maximise bulk purchases, negotiate discounts and assess lead times.

The third phase of content development was the content decision and purchasing phase. This is where we looked at the project to decide what to purchase and how many of each, and looked at what we could afford with negotiation, and purchased equipment with long lead times or development times. This stage overlaps with the phase before and after and is iterative. We find the best value for money approach has not been to sign off a full kit list then purchase it, as we want to ensure we purchase or develop the long lead time key items early and then maximise the use of funds and purchase additional equipment if savings can be negotiated in bulk purchases.

The fourth phase of content development was the handbook writing and the training academy development. Again, we would start this phase as soon as we confirm the first experiments and interactives to be included and can be written about. We would expect all four stages to be complete by the training academy. We needed to ensure ASDC has enough full sets of equipment so that everyone can use it at the training academies, and then we will send it out to centres after the academy and before they start delivering. Science Centre staff also need to train other staff in their Science Centres once they have been trained at the academy. To maximise marketing potential, we would ensure they had all the marketing resources at the training academy.

11. The Ideas Charrette

How ASDC Created this National Programme

ASDC has created a host of national strategic programmes and has refined a successful development process to ensure the highest quality resources, shows and workshops are created on time and within budget with often as many as 30 organisational partners.

To ensure the very best hands-on resources and activities were developed and included within the project, ASDC and the project team undertook a research and development phase finding what currently existed and what could be created in the timeframe for this six month programme, or for a larger programme if funds were secured. A key part of this process was the one-day Ideas Charrette.

The Ideas Charrette took place on Wednesday 17th January 10.30 am – 4.45 pm at The Cosener's House near RAL, Oxfordshire, OX14 3JD.

ASDC were delighted to have had such an exceptional group of participants, and the full list is given below. ASDC worked with colleagues from the UK Space Agency to identify these talented individuals who would join the team to brainstorm ideas, present their activities and discuss with us new approaches to make this programme as fun, unusual, innovative and engaging as possible.

As part of the content research, ASDC also explored what is already in development or delivery in relation to the James Webb Space Telescope, ExoMars and satellite launch capability by partners such as ESERO, the Science Centres, UK ATC at the Royal Observatory Edinburgh and local universities.

The project team then took all of the information from the charrette and combined this with their research and knowledge to create the research document. This formed the basis of the content development for all the Destination Space Phase 2 activities.

The Content Research Report

All the ideas, content and activities from the Charrette and wider research were collated by the Project team and put into a research report. This is a working document and ASDC is happy to make it available to the UKSA at any point. It is not in publishable format, rather a collation of all the ideas some of which were developed and used in this programme and others we hope to develop if a Level 2 is funded.

Charrette Participants and Photographs

Participants at the Charrette		
Organisation	**Name**	**Job Title**
ASDC	Dr Penny Fidler	CEO
ASDC	Shaaron Leverment	Deputy CEO
ASDC	Dr Jaclyn Bell	Space and Physics Project Manager
UK Space Agency	Jeremy Curtis	Head of Education and Skills
UK Space Agency	Susan Buckle	Astronaut Flight Education Programme Manager
ESERO	Tom Lyons	Teacher Fellow
STFC	Dr Olivia Johnson	Public Engagement Programmes Manager
STFC	Dr Martyn Wells	Optical Design Engineer
STFC	Madeleine Russell	Communications Officer
National Space Centre	Sophie Allan	Lead Physics Teacher
National Space Centre	Josh Barker	Education Presenter
Airbus	John Chinner	Engineer
Catena Space	Dr Adam Baker	Space Educator
Satellite Applications Catapult	Dr Chris Brunskill	Head of Small Satellites and Future Constellations
Satellite Applications Catapult	George Addison	Electrical Engineer
Cardiff University	Dr Chris North	Ogden Science Lecturer, STFC Public Engagement Fellow
Cardiff University	Dr Paul Roche	MSc Astrophysics Programme Coordinator
Institute for Research in Schools	Prof Becky Parker	Director
Oxford Space Systems	Dr Alex Brinkmeyer	Space Materials Engineer
Royal Astronomical Society	Dr Robert Massey	Deputy Executive Director
Royal Observatory Edinburgh	Alastair Bruce	Postgraduate Student
UK Rocketry Association / British Interplanetary Society	Charles Simpson	Chair and Honorary Fellow

12. The Science and Engagement Advisory Panel

Science and engagement advisory group

Organisation	Name
UK Space Agency	Jeremy Curtis
UK Space Agency	Susan Buckle
UK Association for Science and Discovery centres	Dr Penny Fidler
UK Association for Science and Discovery centres	Dr Jaclyn Bell
UK Association for Science and Discovery centres	Shaaron Leverment
ESERO-UK	Tom Lyons
STFC	Dr Olivia Johnson
STFC	Dr Martyn Wells
STFC	Madeleine Russell
National Space Centre	Sophie Allan
National Space Centre	Josh Barker
Airbus Defence and Space	John Chinner
Catena Space	Dr Adam Baker
Satellite Applications Catapult	Dr Chris Brunskill
Satellite Applications Catapult	George Addison
Cardiff University	Dr Chris North
Cardiff University	Dr Paul Roche
Goonhilly Earth Station	Matt Cosby
Institute for Research in Schools	Prof Becky Parker
Oxford Space Systems	Dr Alex Brinkmeyer
Royal Astronomical Society	Dr Robert Massey
Royal Observatory Edinburgh	Alastair Bruce
University College London	Prof Lewis Dartnell
UK Rocketry Association	Charles Simpson
Aberystwyth University	Dr Matt Gunn
Aberystwyth University	Dr Helen Miles

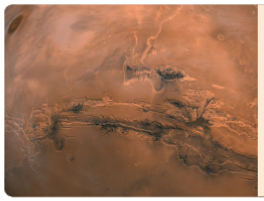
Many thanks to all those above who have advised the project, either by taking part in the project 'Charrette', or by advising throughout the project and helping to develop activities.

ASDC would like to thank wider members of the UK Space Agency, STFC and ESA.

ASDC would also like to thank the Destination Space Phase 1 Development partners: The Science Museum, The National Space Centre and Jodrell Bank Discovery Centres for so generously sharing their ideas, knowledge and activities at the very start.

13. The Training Handbook

The project set out to create and distribute pages to go inside the original Destination Space Phase 1 training manual. However, our ambitions propelled us to instead create an exceptional new fully detailed Training Handbook bespoke for Phase 2. This focusses on the James Webb Space Telescope, ExoMars mission, satellite applications and UK spaceports. A printed copy was given to all delegates at the Training academy, so they could train their staff to run the programme. The handbook detailed all the activities, and equipment and how it can all be used flexibly and adaptably. It included, experiments to try, activities, highlights of some scientists and engineers, school workshop scripts, activities, marketing information and an evaluation section.



The surface of Mars

A 3D relief model of the surface of Mars

Programme Use: Activity

Overview

This activity showcases the insteresting sites on Mars. A full 3D model of the complete surface of the Red Planet. Can you spot Olympus Mons, Hellas and the contenders for the ExoMars landing sites?

How it works

The Mars terrain model is a relief of the planet Mars. It is a cylindrical map projection meaning that the surface is unwrapped from a sphere and laid out onto a flat surface by stretching the top and bottom. That is why the craters near the top and bottom of the model are elliptical. The model is made to a lateral scale of 21.3 km per millimetre, so one millimetre on the model is about the size of central London. The vertical scale on the model has been exaggerated by a factor of 20 to make the height of things easier to see, otherwise the difference between the highest and lowest points would only be 1.3 millimetres.

The model is created using data from NASA's Mars Orbital Laser Altimeter (MOLA) which used a laser range finder to measure the height of the Martian surface from the Mars Global Surveyor satellite between 1997 and 2001. An image of the MOLA data set is shown on the following page. The dataset from MOLA was imported into Computer Aided Design (CAD) software and used to machine the surface model using a Computer Numerical Control (CNC) router from Polyurethane foam material.

Points of interest:

1 Olympus Mons

Olympus Mons is a shield volcano (built almost entirely of fluid lava flows) and is the biggest volcano in our solar system. The top of Olympus Mons is the highest point on Mars. At nearly 22 km high it is roughly two and a half times as high as Mount Everest. The base of the Olympus Mons is approximately 600 km across, about the width of France. Olympus Mons was formed approximately three billion years ago.

2 Valles Marineris

Valles Marineris is a system of canyons which stretch almost a fifth of the way around Mars near the equator. Valles Marineris is more than 4000 km long, 200 km wide and 7 km deep. This means it is more than ten times as long and wide as the Grand Canyon and around four times as deep.

Mars statistics

- Diameter of Mars: 6779 km
- Circumference of Mars: 21,344 km
- Highest point: Olympus Mons, 21,229 m above datum (equivalent to sea level).
- Lowest point: Hellas Crater, 8,200 m below datum.
- Mars Sol (day) length: 24 hours 40 minutes.
- Gravity: 38% of Earth's gravity

3 Gale Crater

Gale Crater is a relatively small crater, around 150 km diameter, near the equator of Mars. Gale Crater was the landing site of the NASA Mars Science Laboratory Curiosity rover. Curiosity has been exploring Gale Crater for more than four years now. It has covered more than 18 km in that time, driving from its landing site near the bottom of the crater up the side of Aeolis Mons (Mount Sharp) in the centre.

4 ExoMars landing sites

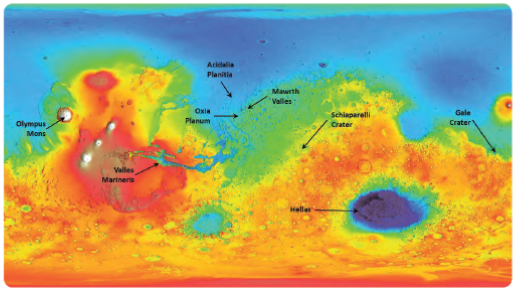
The final landing site for the ESA and Roscosmos ExoMars rover has not yet been decided. However, teams of scientists have narrowed the many options down to two contenders: Mawrth Vallis and Oxia Planum. Mawrth Vallis is one of the oldest valleys on Mars. It contains a number of clay minerals meaning it was wet in the past, and has lots of well-exposed sedimentary features. Oxia Planum contains a large area of exposed clay minerals which are nearly four billion years old.

5 Hellas

Hellas is an impact crater in the southern hemisphere of Mars. It is the largest visible impact crater known in the solar system and is more than 2,300 km in diameter and 7 km deep. The lowest point on the surface of Mars lies at the very bottom of Hellas.

6 The Martian

In the book and film of 'The Martian', astronaut Mark Watney is left stranded on Mars when the rest of the crew are forced to evacuate. Mark spends most of his remaining time on Mars in the 'Habitat' ('the Hab') in Acidalia Planitia, eating potatoes and trying to survive the harsh Martian environment. Mark drives 3,200 km in his electric-powered Mars Rover to Schiaparelli Crater where he is able to escape the planet on a waiting rocket.



Infrared (IR) camera

Visualising the infrared part of the electromagnetic spectrum

Overview

The IR camera can be used to discuss the James Webb Space Telescope and infrared satellite images of the Earth. This camera detects the IR radiation produced by molecular vibrations in materials. These vibrations are often referred to as temperature or heat.

How it works

Electromagnetic radiation is emitted across a spectrum of wavelengths. This ranges from gamma rays and x-rays which have short wavelengths, to microwave and radio waves with much longer wavelengths.

Humans have evolved to detect specific wavelengths on this spectrum. In particular, photopigments in the human eye are sensitive to certain wavelengths which fire nervous impulses to our brains giving us the sensation of colours. Wavelengths that are a little too long for us to detect with our eyes, are in the infrared. Our eyes cannot see these but we can detect them through our skin in the form of heat.

The IR camera contains electronic sensors that detect infrared radiation and convert it to a visible image we can see.

What sources of infrared can I use?

Technically anything that is warmer than absolute zero (-273 °C) will emit infrared radiation. The warmer the object is, the more IR radiation will be given off. The IR camera will apply a colour palette to make it easier to interpret the range of IR radiation being viewed.

Activities using the IR camera

1 Using infrared to see through dust clouds

The James Webb Space Telescope will detect in the infrared section of the electromagnetic spectrum and will see things we cannot see using visible light. This new telescope will be able to investigate unseen regions of space, and peer inside nebulae (clouds of dust and gas in space) inside which stars are formed. Telescopes like the Hubble Space Telescope have struggled to investigate these regions as the dust obscures the visible light, whereas infrared radiation can pass through.

To demonstrate this idea, use a plastic bin liner to represent a dust cloud. Ask a volunteer to join you at the front and to take on the role of being a star within a dusty nebula. Ask them to step inside the bin liner and to pull it up under their arms. The volunteer's lower body of course disappears, as the black bin liner obscures the passage of visible light. However, by pointing the IR camera at the volunteer, the audience can see on the screen that their legs are clearly visible through the bag. This is because, unlike visible light, the IR radiation can travel through the black bag to be detected by the camera.

2 Insulating the IR detectors

The Webb Telescope will be studying IR radiation from space. However, our closest star, the sun, gives off a huge amount of IR radiation which would effectively 'blind' the telescope. The Webb Telescope will therefore have a huge shield to protect the sensitive IR detectors from the heat of the sun. The heat shield will also separate and insulate the sensitive IR detectors from the heat generated by the onboard computers and navigation systems. This has been a huge engineering challenge to solve. Not least because the huge sunshield must perfectly unfurl from the rocket once in space.

The heat shield is made of layers of a material called Kapton. This material has special thermal properties which help it deflect and block the transmission of heat.

We can demonstrate the effects of the heat shield, using Mylar, a material with similar thermal properties to Kapton. Simply use the IR camera to look at a strong infrared source (a hot object) and place a piece of mylar, such as a mylar emergency metallic blanket or pane of glass coated in mylar, in front of the heat source and see the effect.

Interestingly, the glass acts as an infrared mirror, so you can also see the reflected thermal energy.

3 Active cooling

The Webb Telescope will keep cool using the heat shield and through radiation of heat into space. However, one of the instruments onboard needs to be much colder than the rest of the telescope.

This is the Mid-InfraRed Instrument, or MIRI, which will be able to see longer wavelengths of infrared radiation than the other instruments. For this it must be cooled to a temperature of 7 Kelvin (just seven degrees above absolute zero).

To achieve this, MIRI is fitted with a complex 'space fridge' that uses helium gas. The gas is pumped to the instrument, where it is allowed to expand. As it expands, it cools, absorbing heat from the instrument, which it then carries away.

This cooling can be demonstrated by spraying a can of deodorant or compressed air in front of the IR camera. The IR image clearly shows the darker, cold of the expanding gas.

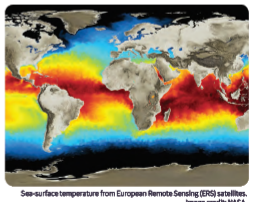
4 Sea surface temperature analogue

Using IR radiation we can investigate weather patterns on the Earth from space. A variety of weather and Earth observation satellites use infrared to tell us more about the movement of the atmosphere. IR can also be used to monitor the temperature of the surface of the oceans, which is vital as sea surface temperatures play a major role in weather patterns and climate here on Earth.

A full-sized test unit of the Webb Telescope Sunshield
Image credit: NASA Goddard Space Flight Center.

To demonstrate this, fill a tray with cold water and boil some water in a kettle. You will need to set the IR camera up to point at the tray of water and you may need to adapt the focus to make sure you can clearly identify the water currents. Carefully pour some of the boiling water into the tray. The difference in temperature will be visible on the camera and you will be able to see the water slowly start to swirl, mix and diffuse. You should also be able to see currents move within the water, driven by the convection effects of the warmer water rising within the cold water.

We can see in this image taken by a European Remote Sensing satellite what Earth's oceans look like in the IR spectrum. The yellow and red colours represent the hottest areas, while the darker colours show the colder regions.



Sea-surface temperature from European Remote Sensing (ERS) satellites.
Image credit: NASA.

14. The Training Academy for Science Centre Staff

The training process is fundamental to the success of this programme and considerable resource is put in to achieving excellence. Professional staff who are enthused and fully confident to impart the latest knowledge to their colleagues, teachers, schools children and family visitors back in their part of the UK are the key to success in all ASDC programmes.

The Destination Space Phase 2 two-day residential National Training Academy took place at the National Space Centre on March 20th and March 21st 2018.

Twenty people took part, including the ten science engagement professionals from the five selected Science Centres:

1. The Eden Project in Cornwall
2. The National Space Centre in Leicester
3. Jodrell Bank Discovery Centre in Cheshire
4. Dundee Science Centre
5. Winchester Science Centre.

They were trained in how to use all the equipment, resources and in the latest knowledge of multiple areas of space science and heard from a host of external speakers including engineers and scientists working on the missions. The project paid for science centre staff's travel, accommodation, food and training at the academies. The full programme is in Appendix 3.

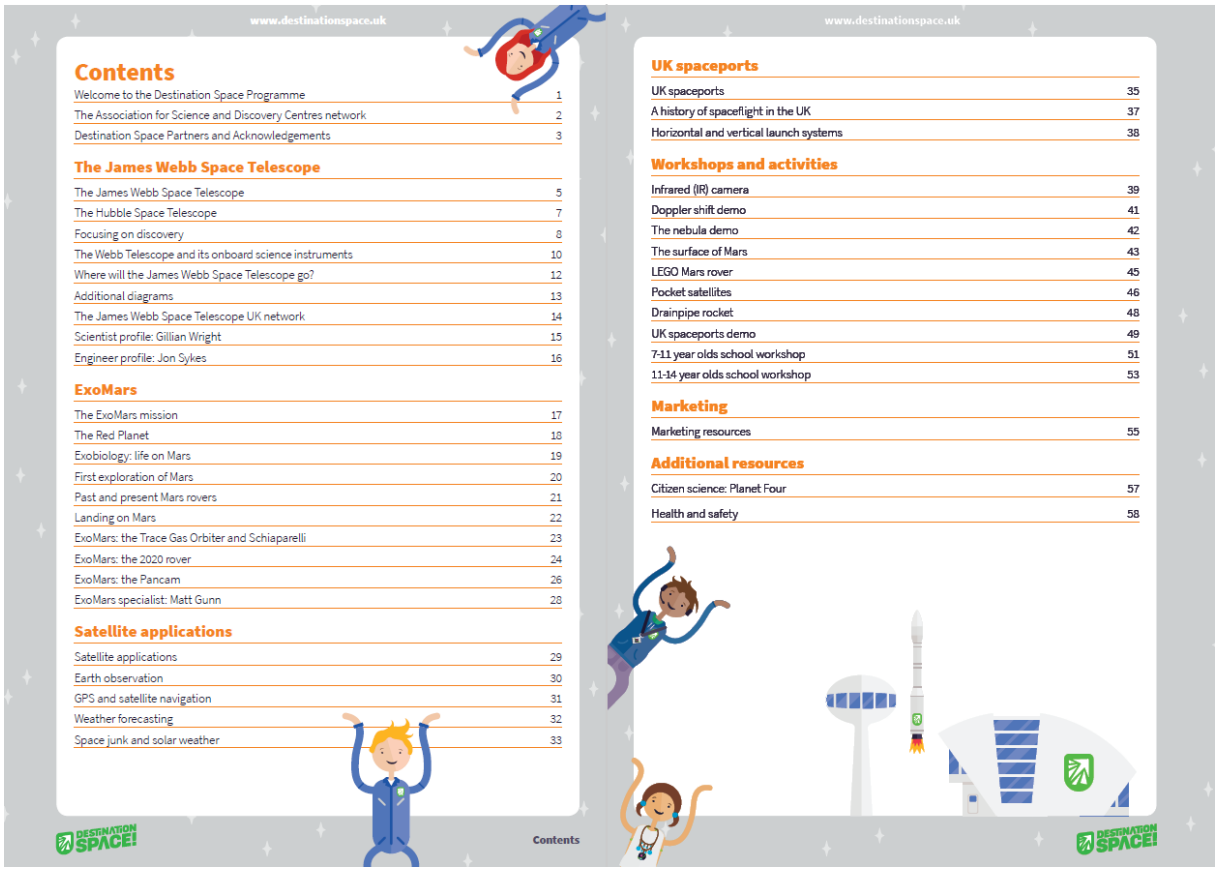
Topics covered included:

- An introduction to the research and the work of the UK Space Agency
- How to run all the experiments and hands-on science activities
- How to use all the equipment and maintain it
- How to run the new KS2 and KS3 schools workshops
- How to run the family activities
- Evaluation and reporting
- A full review of the project branding and logo usage
- Resources, images, videos and more
- Ideas to engage children from disadvantaged areas and gender equity
- Social media strategy, and resources online

Photos of the Training Academy

15. The Equipment and Activities

ASDC created an attention-grabbing set of activities and equipment for this programme, which has been purchased by ASDC for the selected five Science Centres to a value of £2,000 each (inclusive of VAT). Staff at each centre were trained in its use at a training academy and full details of all the equipment and activities can be found in the programme handbook and on the Destination Space website. Below is the contents page of the handbook to give an overview of what is included.



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Contents

Contents

The equipment and activities focussed on these 4 key content areas

1. James Webb Space Telescope
2. The ExoMars Mission
3. Satellite Applications
4. UK Spaceports and satellite launch programmes

The James Webb Space Telescope

The James Webb Space Telescope is now expected to launch into space in May 2020. NASA announced recently (March 27 2018) that issues with the spacecraft integration have led to this further significant delay. This launch is after the timeframe of this six-month programme and the subsequent one year delivery of the Science Centres. Therefore, a range of content has been developed around the James Webb Space Telescope, including content in the handbook, activities and demos and the five selected Science Centres have been trained to deliver these activities both within this project and up to the launch and beyond.

The James Webb Space Telescope is a collaboration between the European Space Agency, NASA, and the Canadian Space Agency. The telescope will offer unprecedented resolution and sensitivity from the long-wavelength visible light through the mid-infrared range and it aims to look further out into space than ever before for humans to better understand the formation of galaxies, stars and planets, and to image exoplanets.

The idea for The James Webb Space Telescope has been in plan for 20 years and involves a host of UK and European expertise in its development and creation, much of which is celebrated in this programme. We also highlighted that for humans on our planet to look further out into space than ever before, we have had to collaborate internationally. To achieve something as remarkable as this on a planetary scale, humans have had to work together across borders to deliver the astounding engineering and scientific ingenuity and funding to make this happen.

The launch of the telescope will be a giant step in the human quest to understand our place in the universe. With the largest telescope mirror ever placed in space, this programme brings these ideas alive, celebrating the people who have made it happen, the engineering challenges it had to solve and the scientific questions it will answer. For example the activities and training covers these areas:

- The James Webb Space Telescope features a sunshield the size of a tennis court to keep its mirror and four science instruments below −230 °C (40 K).
- If the sun warmed the instruments it would effectively blind the telescope so the sunshield has 5 layers of protection that is equivalent to SPF 1,000,000.
- The telescope will be so powerful that it would be able to see something the size of your fingernail from 24 miles.
- It will sit a million miles from earth, so can't have someone popping in to top up coolants, clean the mirrors and regularly maintain it.
- It is the largest space telescope ever made.
- The fabulous feat of engineering origami to get such a large object in to the small nose cone of a rocket to launch it into space.
- The engineering to make it unfold perfectly on the first attempt in space. If it doesn't, all the funding and decades of work will be lost so testing, re-testing and perfecting this mechanism is vital.

Project information and hands-on demos on the Webb Telescope

The Handbook has sections on the following;

- Introduction to the James Webb Space Telescope
- The Hubble Space Telescope
- Focusing on discovery
- The Webb Telescope and its onboard science instruments
- Where will the James Webb Space Telescope go?
- The Electromagnetic spectrum
- Annotated diagram of The James Webb Space Telescope
- A map of The James Webb Space Telescope network in the UK
- Scientist profile of Gillian Wright
- Engineer profile of Jon Sykes
- Hands-on Experiments with the Infrared (IR) camera
- Hands-on Doppler shift demo and redshift
- The nebula demonstration seeing the invisible

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How will the Webb telescope help us understand the assembly of galaxies?

One key objective of the Webb Telescope is to observe some of the most distant galaxies which we see today as they were billions of years ago, when they were very young. Visible light which has travelled such a long distance through our expanding Universe reaches us at infrared wavelengths. The Webb Telescope's ability to image in infrared and do spectroscopy over the 0.6 to 27 micrometre infrared band make it perfectly suited to understand galaxy growth, how metals are formed inside galaxies and how the shape of galaxies evolve.

The birth of stars and protoplanetary systems

While stars are a well-known topic of astronomy, only in recent times have we begun to understand them in more detail. One hundred years ago we did not know that stars are powered by the nuclear fusion of hydrogen nuclei inside their core. Nor did we know that stars are continually being formed in our galaxy.

There's much we still don't know. How, specifically, do dusty gas clouds collapse to form stars? How do stars liberate the heavier chemical elements they produce back into space for recycling into new generations of stars and planets? Why do most stars form in groups and why do many solar systems have massive planets orbiting very close to their parent star?

How can the Webb answer these questions?

The Webb Telescope will begin to unravel the birth and early evolution of stars by imaging protoplanetary discs. Protoplanetary discs are clouds of gas and dust that are in the process of forming new solar systems. Our solar system would have had a protoplanetary disk five billion years ago.

By observing in near and mid-infrared, the Webb will observe details inside these protoplanetary discs, potentially revealing how turbulence and vortices in the disc can lead to planet formation. Using spectroscopy and the instruments onboard, the Webb Telescope can analyse the makeup of the dust and gas that is building protostars.

Artist impression of Solar System formation. Image credit: NASA.

The origins of life

Understanding the formation of the Earth and how our solar system evolved to support life is a key objective for all of astronomy and is central to the Webb Telescope science programme. In order to understand life on Earth and our present solar system we must understand the processes that drive planetary formation, the evolution of planetary systems as a whole and the physical and chemical properties that point to the potential for life on other worlds.

By imaging in near and mid-infrared, the Webb Telescope will be able to probe into the heart of solar systems at various stages of their development and use spectroscopy onboard to analyse the chemical composition of exoplanet atmospheres. Observing differences between winter and summer, looking for the chemical signatures of methane or water or finding a planet with a similar atmosphere to Earth are all future possibilities for the Webb Telescope.

Other scientific capabilities

The Webb Telescope will enable significant progress on the studies of populations of stars within and outside our Milky Way galaxy and the study of nearby galaxies and active galactic nuclei (dense, bright regions at the centres of galaxies believed to be the result of accretion onto supermassive black holes).

Although the Webb Telescope has four key science goals, its capabilities as a space observatory extend far beyond this. Some of the Hubble Space Telescope's greatest scientific discoveries were of things no one had planned for.

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The Webb Telescope and onboard science instruments

The telescope is the size of a tennis court, yet it has to fit into the top of a rocket for launch. Brilliant and beautiful mechanisms have been devised to pack the telescope and allow it to unfurl when it is on its journey out to its final destination, 1.5 million km from Earth.

Launch and deployment

The James Webb Space Telescope is scheduled to launch in 2019 on an Ariane V rocket. Due to the dimensions of the Ariane V rocket and the size of the telescope, it needs to be collapsed down for launch. Each intricate part of the telescope is designed and engineered to unfold to its fully operational size completely unassisted, whilst out in space. This unfurling will take two weeks to complete.

What parts make up the Webb Telescope?

The Webb can be divided up into 4 main parts:

1. **The Optical Telescope Element**
2. **The Sunshield**
3. **The Spacecraft Bus**
4. **The Integrated Science Instrument Module.**

1 The Optical Telescope Element (OTE)

The primary mirror consists of 18 hexagonal beryllium segments each 1.32 metres in diameter. The mirrors are coated in gold to best reflect the longer wavelengths of infrared light. Each mirror segment can be independently adjusted to

Image credit: NASA / Francis Reddy (Syneren Technologies).

Image credit: NASA / Chris Gunn.

optimise focus and performance of the telescope. The mirrors will be controlled by the NIRCam instrument (using image-based wavefront sensing).

Did you know?

The primary mirror on the Webb Telescope weighs approximately 705 kg and each mirror is aligned to an accuracy of 1/10,000th of the thickness of a human hair.

The primary mirror has a large 25 m^2 area to reflect light coming from distant stars and galaxies. This light is reflected onto a secondary mirror which in turn reflects the light back through the primary mirror into the Integrated Science Instrument Module, where it is directed onto one of the module's four instruments.

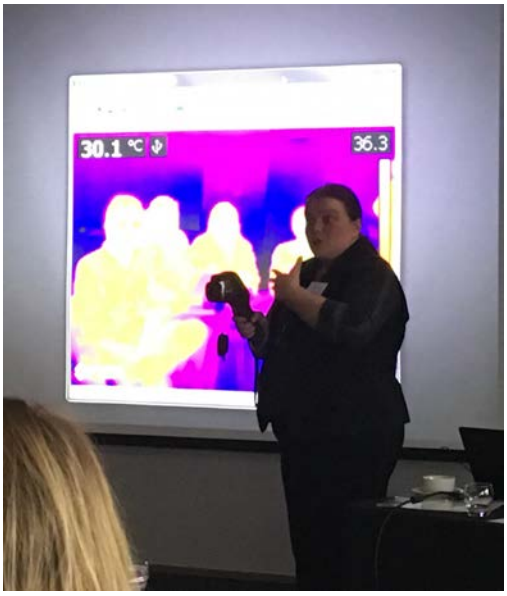
2 The Sunshield

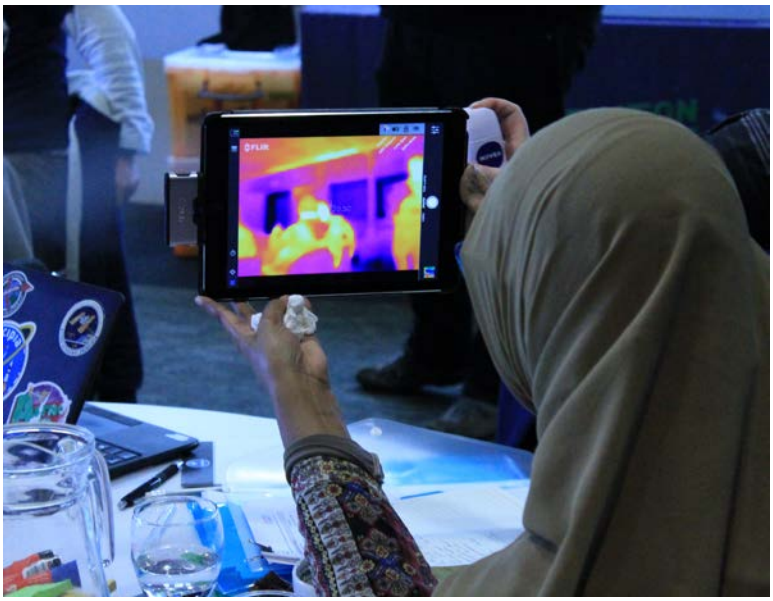
Due to the sensitivity of instruments onboard the James Webb Space Telescope, the spacecraft must be shielded from the thermal effects of the Sun. The Webb Telescope sunshield protects the Optical Telescope Element (OTE) and Integrated Science Instrument Module (ISIM) modules from direct sunlight as well as light from the Earth and stray moonlight.

The sunshield produces a stable cryogenic environment, preventing thermal expansion of the telescope's optical elements. It is also crucial for the operation of the observatory as the mirror and instruments used to observe infrared light must be kept extremely cold to avoid thermal emission from the telescope itself completely drowning out the cosmic signal it is trying to detect.

The nebula demonstration seeing the invisible

Experiments with the Infrared and a thermal imaging camera



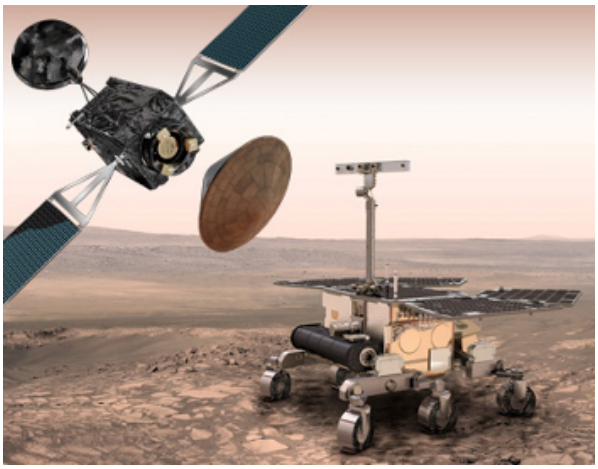


The ExoMars Mission and Mars Rover

ExoMars is one of ESA's most ambitious scientific endeavours to search for evidence that life may have once existed on Mars.

Less than three years from now, the ExoMars rover will blast off and head for the planet Mars. If all goes according to plan, the European-built rover and a Russian surface platform will be delivered safely onto the planet's orange, dusty plains.

The landing site will be chosen because of the high potential for finding well-preserved organic material, and the ExoMars rover's primary task will be to search for evidence that life may have once existed on the Red Planet. The rover will be equipped with a drill that is designed to collect material from inside rocky outcrops and at depths of up to two metres beneath the surface.



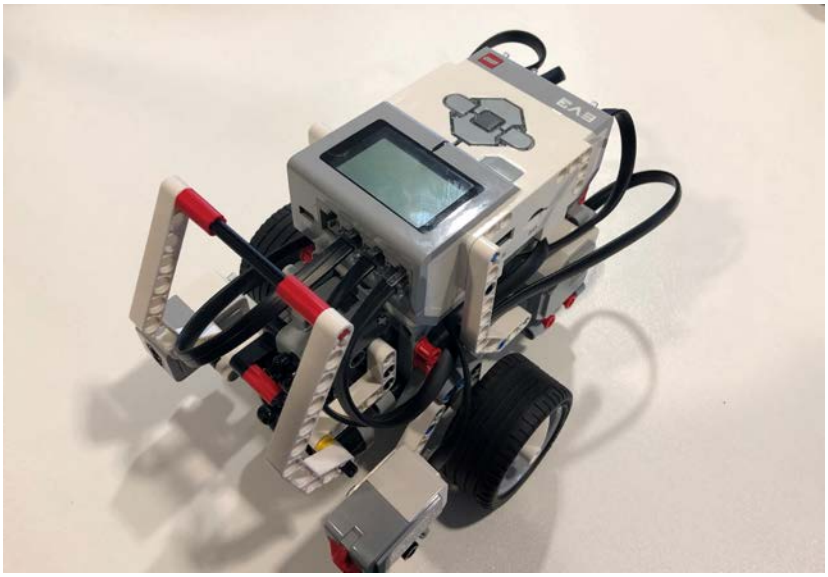
The ASDC programme, brings together a host of information and research in this area, and created hands on activities and experiments for schools and families so science centres could bring the content alive.

Content and hands-on demos on ExoMars

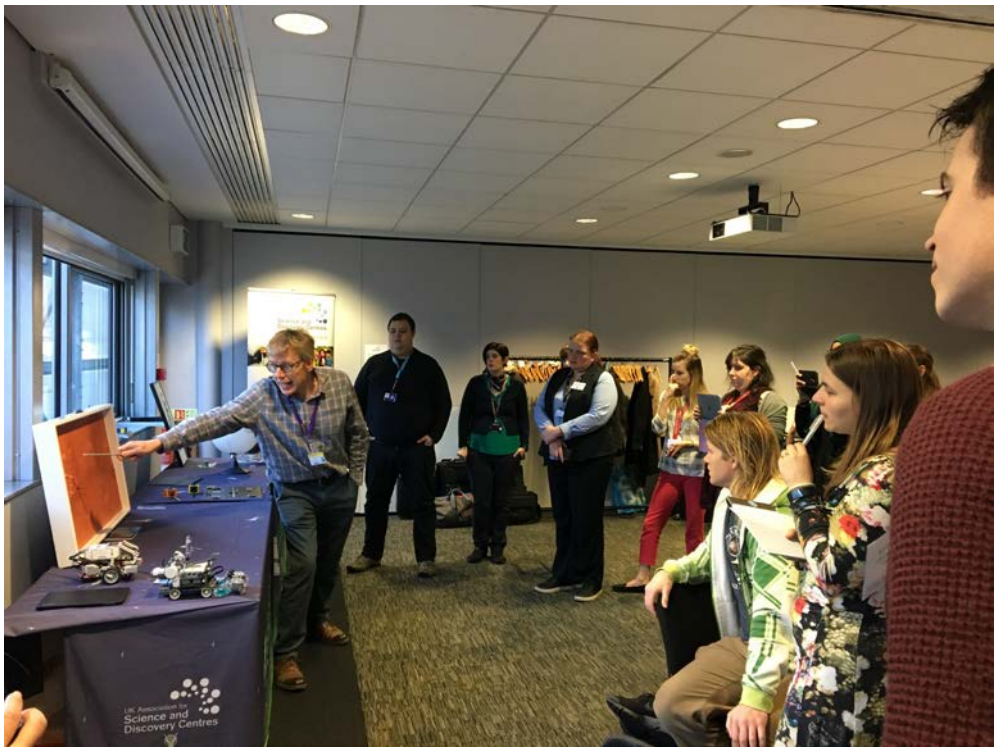
- The areas of The ExoMars mission
- The Red Planet
- Exobiology: life on Mars
- First exploration of Mars
- Past and present Mars rovers
- Landing on Mars
- ExoMars: the Trace Gas Orbiter and Schiaparelli
- ExoMars: the 2020 rover
- ExoMars: the Pancam
- ExoMars specialist: Matt Gunn
- The surface of Mars hands-on demo
- The Mars globe
- The LEGO Mars rover

The LEGO ExoMars Rover

The ExoMars mission will be Europe's next step in exploring one of our closest cosmic neighbours. Our LEGO rovers are designed to give to give people a hands-on rover experience. Like the ExoMars rover our rovers can be programmed and contain a suite of sensors.



The Surface of Mars and globe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Satellite Applications

ASDC developed content and trained the Science Centres to deliver activities around the applications of satellites and ‘what happens if you switch space off,’ as well as Earth observation.

The following areas were covered in the handbook:

- Satellite applications
- Earth observation
- GPS and satellite navigation
- Weather forecasting
- Space junk and solar weather
- Hands on Demo using a Pocket satellite

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Global positioning systems (GPS) and satellite navigation

The Global Positioning System (GPS) is a network of over 30 satellites orbiting the Earth at an altitude of 20,000 km. It can give a three dimensional position to within a metre of accuracy.

How did GPS come about?

GPS originated in America in the early 1970's when the US Department of Defense (DoD) wanted to ensure a satellite navigation system that was stable and robust for military use. Using ideas from US Navy scientists, the DoD launched its first navigation system satellite in 1978. A satellite system comprising of 24 satellites became fully operational in 1995. Civilian use of GPS was granted in the 1980's before it was fully completed.

How does GPS work?

Today, wherever you are on the planet, there are at least four GPS satellites 'visible' at any one time. Each satellite transmits information about its position and time at regular intervals. These signals travel at the speed of light and are picked up by your GPS receiver. Your device then calculates how far away each satellite is based on how long it took for each of the signals to arrive.

Once you know how far away at least three satellites are, your device can pinpoint your location using a process called 'trilateration'. The more satellites a receiver is connected to the more accurate a location it can determine.

How do satellites know what time it is?

GPS satellites have atomic clocks on board to keep accurate time. Atomic clocks are designed to measure the precise length of a second. According to the International System of Units (SI), one second is defined to be the time it takes a caesium-133 atom to oscillate exactly 9 billion, 192 million, 631 thousand and 770 times (9,192,631,770). In an atomic clock, these oscillations of atoms act like a pendulum on a grandfather clock. They are far more precise than conventional clocks.

Satellite navigation systems like GPS, GLONASS, and Galileo rely on precise time measurements to calculate positions accurately.

How high up are these satellites?

Navigational satellites are generally placed in medium Earth orbit (MEO) between 2,000 km and 35,000 km above Earth. There are four major constellations of navigational satellites. These are the US's Global Positioning System (GPS), Russia's Global Navigation Satellite System (GLONASS), the European Union's Galileo developed by ESA, and China's BeiDou Navigation Satellite System (formally called COMPASS).

How did we cope before GPS existed?

Before humans built satellites, navigation was done by looking at fixed stars in the night sky. Maritime navigators used nautical charts to determine their position in the sea. A tool called a sextant was the most essential instrument for celestial navigation. You can still use tools like this to determine your position anywhere on the Earth's surface to within a hundred metres or so, so long as you have an accurate clock.

Today, space-assisted GPS has taken over and become indispensable for any sort of aerial, land or maritime navigation.

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Weather forecasting

Weather forecasts are made by collecting data on our atmosphere's current behaviour (particularly the temperature, humidity and wind). Meteorologists can then interpret this complex data to determine how the atmosphere will evolve in the future.

Weather satellites

Weather satellites are primarily used to monitor the weather and climate of the Earth. This type of satellite can be polar orbiting, cover the entire Earth asynchronously (at different times), or be geostationary (hovering over the same spot on the equator).

How does a weather satellite work?

Weather satellites carry instruments called radiometers that scan the Earth to form images. These instruments usually have some sort of small telescope or antenna, a scanning mechanism and one or more detectors that detect either visible, infrared or microwave radiation, for the purpose of monitoring weather systems around the world.

The European Space Agency's Meteosat satellite provides coverage of Europe and Africa.

Polar satellites

The first weather satellite in existence was called TIROS-1. It was sent up by the United States and was polar orbiting. This is when a satellite passes over the North and South Poles during its orbit. Polar orbiting satellites sit much closer to the Earth, around 800 km above us. This means they

The first weather satellite TIROS-1. Image credit: NASA (KOSPSO).

can take sharp photographs (much sharper than geostationary satellites), however being so close to the surface of Earth means they only see a small section of Earth at one time.

Geostationary satellites

Six years after the first polar-orbiting satellite was launched, geostationary satellites were put into orbit. A satellite in geostationary orbit will be positioned at a very high altitude, around 35,880 km above the surface of the Earth. That's nearly 88 times higher than the ISS. A satellite positioned at this height requires elaborate telescopes and precise scanning mechanisims in order to image the Earth at high resolution. This type of satellite can view the same region of the Earth throughout the course of a day. This is useful for monitoring real-time weather emergencies.

Is this how they predict the weather on TV?

The Met Office is one of the organisations that gives the UK its weather updates. It uses satellite data to build weather modelling systems. These are computer-based models that map and predict what the weather will do next.

Sometimes weather forecasters on TV get it wrong. This is because sometimes the weather changes rapidly, especially in the UK. For example, rain during the summer months is difficult to predict. It develops quickly and over a small area of land, with forecasters getting it wrong almost 40% of the time.

Minimum temperature is also difficult to forecast, particularly in winter. This is because it depends on whether nights are clear or cloudy. This can be tricky to forecast, as it depends on there being enough sunlight during the day to 'dissolve' the upper surface of clouds (called cloud decks).

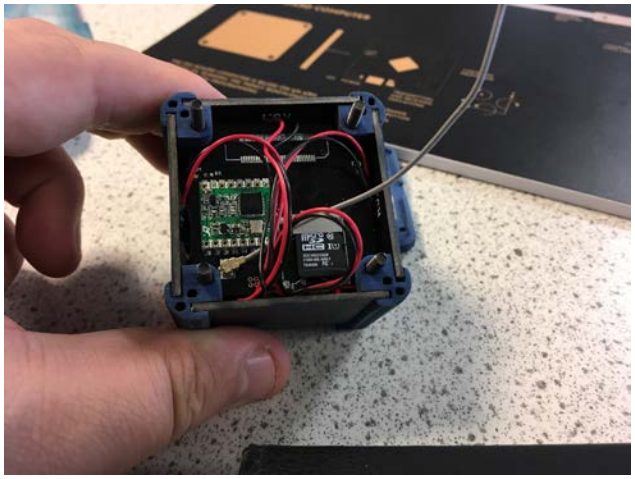
Examples of content included:

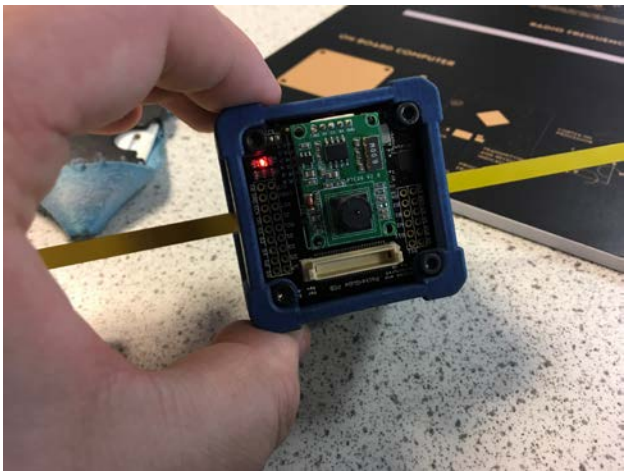
1. How satellites are used for navigation and tracking from planes and marine traffic to driverless cars and GPS car systems.
2. How Earth observation and satellite navigation is used in disaster relief and logistics.
3. How satellites are used for the ordinary everyday world, invisibly helping, for example, controlling traffic lights, across the finance sector and in cashpoints.
4. Their uses in entertainment for TV and radio.

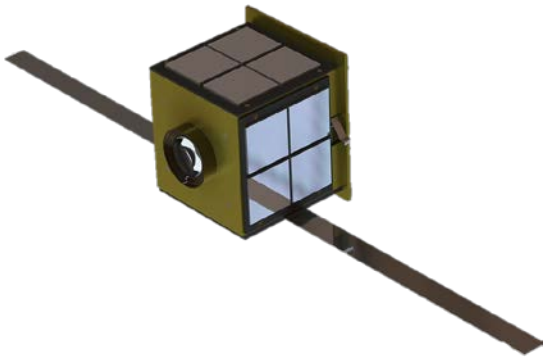
Hands on Demo using a Pocket satellite

Satellites are getting ever smaller. The PocketQube satellite is a type of mini-satellite used in space that is 5 cm cubed. It has enabled the design and production of workable satellites at low cost. CubeSats are slightly bigger at 10 cm cubed and both use off the shelf components for their electronics.

ASDC were delighted to work in partnership with the Satellite Applications Catapult to offer a new hands-on demo for UK Science Centres to engage their schools and public with. The new design was created for this programme and in partnership with the team at the National Space Centre. This activity allows science centres to assemble, adapt and operate their own mini-satellite, and to show how the satellite can take a photo of their audience and see the data downloading as a stream of code.





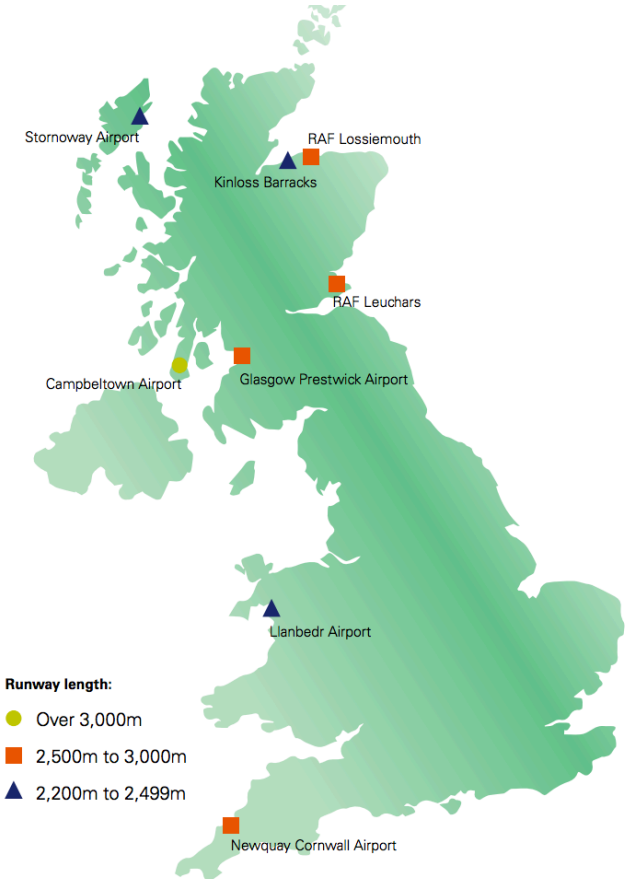


UK Spaceports

In the timeframe of this programme, there have been considerable developments around the potential for spaceports in the UK, and therefore ASDC (enthusiastically) added extra components about spaceports including hands-on demos. In our proposal we had said 'ASDC will touch on this area for content research, but it will not be part of the delivery of the programme in this phase'. The main additional cost to include much more than anticipated on both spaceports and satellite applications was in ASDC staff time and this is reported separately. We should note here that ASDC is happy to keep the programme cost as planned and budgeted.

ASDC spoke with the UK Space Agency satellite launch programme team for this area of content development and included information on the new Space Industry Act. The following areas were covered:

- UK spaceports
- A history of spaceflight in the UK
- Horizontal and vertical launch systems
- Hands on Demo on where UK Spaceports might be located
- Hands on Demo on spaceports worldwide (the drywipe globe)
- A new improved rocket demo (using a drainpipe as a guide)



The Hands-on spaceports demo

16. Gender equity, underserved families and discussing STEM Careers

ASDC published a report commissioned by BIS (now BEIS) about how Science and Discovery Centres attract wide audiences across the UK. The project manager and CEO have celebrated opportunities across the breadth of the programme (www.sciencecentres.org.uk/reports/underserved) to ensure Science Centres are considering inclusion in everything they do. ASDC is also the UK leading partner for the EU programme Hypatia, to increase gender equity in STEM. All the findings from Hypatia were included in the training academy to ensure all the learning from across the EU in Hypatia is within this programme.

17. The Equipment List

The Science Centres received the following pieces of equipment:

Box 1
100 x mini test tubes and lids
2 x Mylar sheets
1 x laminated Mars map
8 x pointers for the Mars surface
16 x spaceport magnets
2 x packs of blue tack
20 x 3ml syringes
10 x packs of litmus / pH paper
8 x IR thermometers
1 x FLIR IR camera
20 x green pegs
White card
Coloured paper
Black card
7 x IR lamps
1 x Lego rover charger
4 x 100 pack of glow sticks
2 x black drywipe markers
1 x pack of 10 multi-coloured drywipe pens
1 x pack of stickies for the underside of the Mars surface

Box 2
25 x beakers
1 x infrared lamp
2 x tubs of regular sand
1 x tub of red sand
1 x tube of black sand
1 x tub of bicarbonate of soda
30 x plastic collecting tubes
20 x pipettes
1 x citric acid
4 x Destination Space logo stickers
4 x bottles with sports caps
1 x pilates band

Additional (unboxed / stand-alone)
1 x UK / World map on magnetic board
1 x Lego mindstorms kit
1 x drywipe globe
1 x Mars globe
1 x Mars surface

1 x drainpipe section
1 x Destination Space banner
2 x Training Handbooks
1 x remote controller for the Lego Mars rover
1 x UBO satellite
2 x magnetic boards and magnetic image
1 x memory stick with documents and software installed

Additional Kit for the UK Space Agency

Six sets of equipment were produced. One each for the five science centres and one kit for the UK Space Agency for their own outreach and that of their colleagues. At the end of the project, and with approval from the UK Space Agency, ASDC also purchased some items to facilitate outreach events that ASDC went to on behalf of the programme, such as at the Albert Hall Festival of Space event in 2018.

18. The Schools and Families Activities

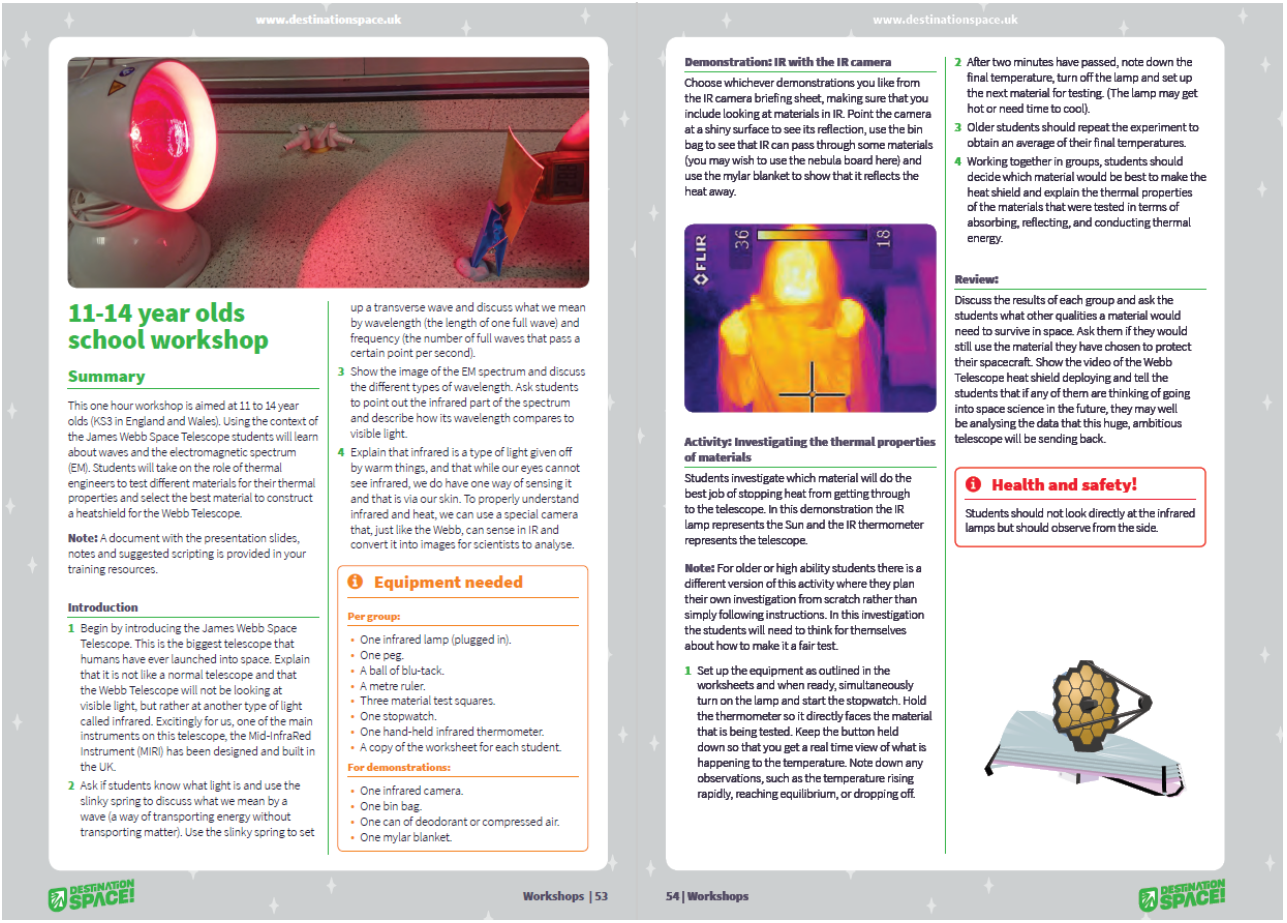
The project development team collaboratively developed schools resources and family show activities using the information gained at the charrette. All the activities were flexible and modular and could be used to add to the family show or as part of schools workshops.

Schools Workshop Age 7-11 (KS2)

This exceptional curriculum-linked schools workshop focuses on the new European ExoMars mission and how it will put a rover onto the surface of Mars to search for evidence of life. Developed in partnership with space scientists and engineers working on the Mars mission, this one-hour hands-on workshop enables students to take on the role of the mars rover and drill for samples to test the soil they find.

Schools Workshop Age 11-14 (KS3)

This exceptional curriculum-linked schools workshop was developed in partnership with space scientists and engineers. It enables students to get hands on with equipment to better understand the electromagnetic spectrum, infrared, redshift and explore materials using the infrared camera. They can also find out the very latest in exploration of our universe through the amazing science and creative engineering involved in building the new James Webb Space Telescope and launching it deep into space to see the early universe in ways we have never seen before.



www.destinationspace.uk

11-14 year olds school workshop

Summary

This one hour workshop is aimed at 11 to 14 year olds (KS3 in England and Wales). Using the context of the James Webb Space Telescope students will learn about waves and the electromagnetic spectrum (EM). Students will take on the role of thermal engineers to test different materials for their thermal properties and select the best material to construct a heatshield for the Webb Telescope.

Note: A document with the presentation slides, notes and suggested scripting is provided in your training resources.

Introduction

1 Begin by introducing the James Webb Space Telescope. This is the biggest telescope that humans have ever launched into space. Explain that it is not like a normal telescope and that the Webb Telescope will not be looking at visible light, but rather at another type of light called infrared. Excitingly for us, one of the main instruments on this telescope, the Mid-InfraRed Instrument (MIRI) has been designed and built in the UK.

2 Ask if students know what light is and use the slinky spring to discuss what we mean by a wave (a way of transporting energy without transporting matter). Use the slinky spring to set up a transverse wave and discuss what we mean by wavelength (the length of one full wave) and frequency (the number of full waves that pass a certain point per second).

3 Show the image of the EM spectrum and discuss the different types of wavelength. Ask students to point out the infrared part of the spectrum and describe how its wavelength compares to visible light.

4 Explain that infrared is a type of light given off by warm things, and that while our eyes cannot see infrared, we do have one way of sensing it and that is via our skin. To properly understand infrared and heat, we can use a special camera that, just like the Webb, can sense in IR and convert it into images for scientists to analyse.

Equipment needed

Per group:

- One infrared lamp (plugged in).
- One peg.
- A ball of blu-tack.
- A metre ruler.
- Three material test squares.
- One stopwatch.
- One hand-held infrared thermometer.
- A copy of the worksheet for each student.

For demonstrations:

- One infrared camera.
- One bin bag.
- One can of deodorant or compressed air.
- One mylar blanket.

www.destinationspace.uk

Demonstration: IR with the IR camera

Choose whichever demonstrations you like from the IR camera briefing sheet, making sure that you include looking at materials in IR. Point the camera at a shiny surface to see its reflection, use the bin bag to see that IR can pass through some materials (you may wish to use the nebula board here) and use the mylar blanket to show that it reflects the heat away.

Activity: Investigating the thermal properties of materials

Students investigate which material will do the best job of stopping heat from getting through to the telescope. In this demonstration the IR lamp represents the Sun and the IR thermometer represents the telescope.

Note: For older or high ability students there is a different version of this activity where they plan their own investigation from scratch rather than simply following instructions. In this investigation the students will need to think for themselves about how to make it a fair test.

1 Set up the equipment as outlined in the worksheets and when ready, simultaneously turn on the lamp and start the stopwatch. Hold the thermometer so it directly faces the material that is being tested. Keep the button held down so that you get a real time view of what is happening to the temperature. Note down any observations, such as the temperature rising rapidly, reaching equilibrium, or dropping off.

2 After two minutes have passed, note down the final temperature, turn off the lamp and set up the next material for testing. (The lamp may get hot or need time to cool).

3 Older students should repeat the experiment to obtain an average of their final temperatures.

4 Working together in groups, students should decide which material would be best to make the heat shield and explain the thermal properties of the materials that were tested in terms of absorbing, reflecting, and conducting thermal energy.

Review:

Discuss the results of each group and ask the students what other qualities a material would need to survive in space. Ask them if they would still use the material they have chosen to protect their spacecraft. Show the video of the Webb Telescope heat shield deploying and tell the students that if any of them are thinking of going into space science in the future, they may well be analysing the data that this huge, ambitious telescope will be sending back.

Health and safety!

Students should not look directly at the infrared lamps but should observe from the side.

The Destination Space Family Show: Additional Content

The Destination Space Phase 1 family show is a 30 minute show aimed at families with children aged 7-11. Many centres are still running this across their weekends and holidays. The new content provided through this programme was perfectly suited to add activities to these shows and guidance was given at the Training Academy to facilitate this. Science Centres can use content from any of the four key content areas to enhance, adapt or lengthen their current shows.

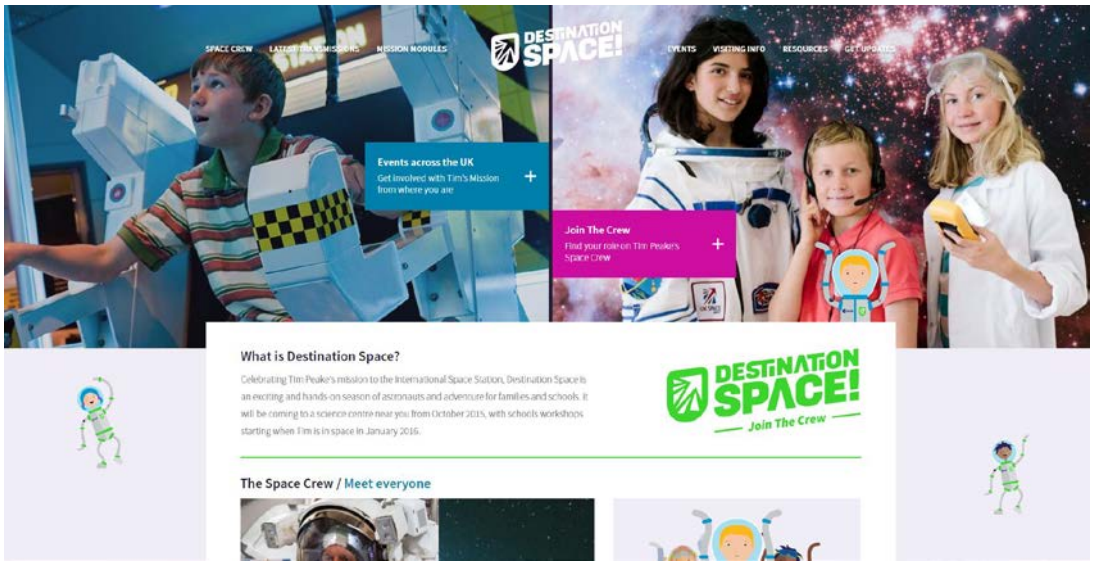
Meet the expert session

Guidance was provided on holding meet the expert sessions for the project and practical tips for working with academics and industry were provided at the training academy. Centres were encouraged to utilise existing links with universities and industries to ensure local collaborative working.

All resources for the shows and workshops will be available online at **www.destinationspace.uk**

19. The Website and Social Media

The Destination Space Website www.DestinationSpace.uk was developed for Phase 1 and has been enhanced and adapted for Phase 2. This process is on-going as new content becomes available.



Destination Space resources including a digital copy of the handbook, images, videos and media for Phase 1 and will shortly combine this with Phase 2 content. The website serves two functions:

1. As a place where all the project resources are located, for Destination Space Phase 1 and Phase 2. This allows all science centre staff to have access, not just those we trained. It also allows access from all other science centres and museums across the world who want to use the resources. In particular our partners across the UK and Europe can use the materials, ideas and resources in a manner that is easy for both ASDC and the organisation wanting to use the content, including ESA, STFC and their staff should they wish.

   The website includes equipment lists, training handbook, consumables information, show formats and scripts including PowerPoints, all the logo and marketing guidance and brand assets and guidelines, as well as a host of links to other areas of research. It is central to what we do that our resources are open and usable by everyone, to provide maximum impact in everything we do.

2. The website also acts as an easy place where the public can go after an event at a science centre, to find out more and be linked to more content and research. In general they are linked through this landing page to other sites under the UK Space Agency control and potentially from the science centres who are part of the project.

20. An overall Identity and Marketing pack

For continuity and to achieve recognition on a national scale we used an adapted version of the Destination Space Branding from Phase 1. For Phase 2 we used it without the 'Join the crew' strapline.

ASDC created a marketing package to assist learning teams and marketing professionals to market the activities easily and time effectively to students, teachers and families. This consisted of:

- Logos and all the brand assets.
- Development of new illustrations specific to ExoMars and the James Webb Space Telescope, satellite applications and UK spaceports.
- Sample press releases, including standard descriptors of all the partners.
- Sample copy describing the shows and activities for use in flyers and online.
- Guidance on identity and logo usage and how to credit all partners.
- Images and their credits for science centres to use in flyers and on websites.
- Space characters centres can use to enliven their artwork.

21. Evaluation

As agreed, the evaluation will be very light touch in this phase. It has involved ASDC creating a set of short standard evaluation questionnaires to be completed by some schools and a small number of families visiting the five centres. The Science Centres will type up the forms into our online form and ASDC will collate the results of these questionnaires and report on them.

The evaluation looks for

- Increased curiosity and enthusiasm for learning more about the space science and engineering sciences
- A desire to know more
- Attitudes to space science and engineering science
- Awareness and knowledge of The James Webb Space Telescope and ExoMars after an event.

The forms ask gender and age, and school postcode so more detailed analysis can be done later if needed.

The CEO of ASDC, Dr Penny Fidler, has authored several high-level reports on evaluation mechanisms used in assessing the impact of Science and Discovery Centres and the Informal Learning Sector (for example those commissioned by BIS) and has spoken internationally on the subject. ASDC will create an online mechanism to enable the centres to transcribe and upload details of their evaluation.

We anticipate that the ASDC project manager to analyse the data, however we would be happy to discuss the evaluation budget should an external evaluator or a fuller academic evaluation be desired.

The evaluation part of this programme will be created centrally and undertaken in person by staff at each of the five Science Centres. The details of the evaluation plan are given below.

Evaluation Commitments of each Science Centre

- To supply to ASDC the metrics of how many people took part and what they did (who, what, where, when, how) on the reporting deadlines given above.
- To complete at least 100 evaluation forms with school children and 40 with families and to type up and submit these evaluations online in the manner given by ASDC.
- Evaluation results are needed online from each centre at the interim reporting date and the final reporting date.
- An interim report on their activities will be required on 21st September 2018.
- A Final report of activities required on 28th February 2019, including publishable photos.

Metrics (who, what, where, when, how)

The five Science Centres will provide ASDC with the following information as part of their interim report and their final project report:

- Numbers of participants to each event.
- Type of event e.g. family show, sleepover, schools workshop and age range.
- Target audiences involved families, Key Stage or approximate children's age.
- Areas of content covered, what were the activities.
- Were scientists involved and the nature of their involvement.
- To supply at least 5 good photos of the events that can be used by the project for publicity, including on the web.
- Social media and online coverage. Press and PR coverage in all media
- Male / female split of schools workshops.
- Postcode data of schools, to analyse regional dispersion.

Reporting Deadlines

- The five Science Centres will provide ASDC with their interim reports on Friday 21st September 2018.
- They will send their Final reports to ASDC at the end of the project by 28th February 2019.
- ASDC will report on March 31 2019 to the UK Space Agency.

22. Programme Schedule

The programme began in October 2017 and started with the project planning, research and development and kick off meeting. ASDC then reviewed of all the stakeholders and held specific meetings with STFC and ESERO to explore options.

Between October 2017 and December, the project manager also collated and developed the content to create the research document and find out what other partners and stakeholders are doing and what activities they have that we might use or develop.

At the start of 2018, ASDC created an invitation to participate and received applications from science centres. In January 2018 we selected five science centres and later contracted them.

The training academy was held in March 2018, and centres could begin delivery shortly afterwards and into 2018.

Science Centre Delivery Schedule

Delivery of family shows and schools activities in science centres is from March 31st 2018 until February 28th 2019. Their final reports are due to ASDC by Thursday 28th February 2019.

Science Centres specified in their proposal which of the half terms, holidays (summer and / or Easter) and weekends they would be running the show and activities.

Key dates for 2018 - 2019	
2018	
Tuesday 20th and Wednesday 21st March 2018	Training Academy for two members of staff from each Science Centre
Thursday 29th March 2018	Grant claim for £2000 from Centres to ASDC
Friday 30th March 2018	Good Friday, Easter holiday begins
Saturday 31st March 2018	Delivery period begins by Science Centres
Friday 21st September 2018	Interim report submitted to the ASDC project manager
2019	
Thursday 28th February 2019	Completion of the programme. Final report due

23. Leveraging the ASDC national network

The UK Association for Science and Discovery Centres (ASDC) is a national organisation that brings together the UK's major science engagement organisations to play a strategic role in the nation's engagement with science. Within our network are over 60 of the nation's largest publicly accessible science centres, discovery centres, science museums and scientific bodies. Together, our vision is for a society where people of all backgrounds and in all parts of the UK are inspired and fully involved with the sciences.

Every year in the UK, 20 million people of all ages and backgrounds choose to engage with science at one of the UK's science and discovery centres or science museums. This equates to 385,000 people every week who come to our member centres to explore and discuss science in an involving and personal way. Over half (ten million) are girls and women. Over half, are school-age children.

This programme leverages this national infrastructure, expertise and investment. Science and Discovery Centres and science museums are already embedded in the heart of their communities in England, Ireland, Scotland and Wales. They all have long-term relationships with communities, schools and families as well as local institutions such as universities, industry, local government and the media.

ASDC selected five Science Centres to partner with to deliver this programme and will make the resources and content available widely, and on social media. This will offer families and the wider public across the UK new and exciting opportunities to discover, discuss, question and explore the latest UK Space programmes and to find out about the women and men who are making these important innovations in space engineering and advances in human knowledge.

This programme currently is only in five Science Centres. It could have so much more impact if it were in 15 - 20 locations.

24. Legacy and the Ambition to run a full National Programme

This legacy of Destination Space Phase 2 (Level 1) is enormous.

Rather than reaching 10,000 people as proposed, we will now be reaching over 140,000 people. However the delivery is focussed in just five parts of the UK, and our ambition is run an enhanced version of this programme in at least 15 parts of the UK, covering England, Wales, Scotland and Northern Ireland.

We are poised at such an exciting time in space history. Decisions on Spaceports are just about to be announced, and local people will want to discuss and talk through what this means for their communities. The international collaboration for ExoMars is a huge success with the UK at the centre of the ExoMars rover development and a launch date just 2 years away. The James Webb Space Telescope has a number of UK teams working in international partnerships to create or test various instruments before its launch into space in two years, and the UK is an acknowledged world-leader in building satellites and all the myriad of applications.

In Destination Space 2, ASDC have created an exceptional programme that tackles and celebrates all these areas and uses hands-on activities and demos to provide an opportunity to talk and discuss these advances, as well as to inspire young people who we hope will one day be our innovators and entrepreneurs in the UK space sector.

It seems a missed opportunity to have this programme only available in Dundee, Winchester, Cornwall, Manchester and Leicester (excellent as they are) when we have the means, the infrastructure, the appetite and skilled professionals ready to deliver this content right across the UK.

Throughout our development of this Phase, we have maximised what we can deliver, whilst keeping a thorough account and list of all the extra ideas, activities and resources. This would increase the value for money of this programme if funds were secured for Level 2 and allow us to quickly and easily reach children and families more widely across the UK.

Appendices

Appendix 1: Building on the success of Destination Space Phase 1

Destination Space was a national STEM programme which engaged, inspired and involved 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 a national celebration of Tim Peake's Principia mission.

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 and celebrate Tim Peake's mission.

The families programme of Destination Space launched in the October half term 2015, followed by the schools programme in January 2016. ASDC reported on the delivery that continued in the science centres until January 20th 2017, and many centres are still continuing to engage their audiences with the programme. The programme completed in March 2017 and the final project report was submitted to the UK Space Agency and is available here.

Overall **733,017** children and adults participated in Destination Space, taking part in the school workshops, family shows or at events to celebrate Tim Peak's launch into space and his return. Of these, **100,244** were school students who were brought by teachers to science centres to take part in specific curriculum-linked schools' workshops. Overall, **75,741** children and adults 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.

In addition, Destination Space special events engaged audiences at a wide variety of events across the UK including Farnborough Airshow, Blue Dot Festival and the Principia Schools conferences in York and Portsmouth.

ASDC and partners also created a vibrant, public-facing website (www.destinationspace.uk) to showcase Destination Space events across the country, give open access to all the programme resources and enable people to continue exploring the science and adventure of Tim Peake's Mission online and through social media.

Independent academic evaluation of the Destination Space programme was conducted by Professor Justin Dillion of the University of Bristol.

12,120 students were evaluated following their participation in a workshop to explore if there had been any changes in, for example, their interest in science or their desire to study science. The evaluation also collected postcode data of the school for every child evaluated.

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 is delightful as it 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. We are delighted to report that 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.

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 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. 49% of students said that they were just as interested after the workshop as they were before.

Of the 1692 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.

Destination Space Phase 1 Science Centres

The 20 UK Science Centres and Museums that took part in Destination Space Phase 1 are listed below and on the Map. **ASDC would select from this group for the next phase.**

1. Aberdeen Science Centre
2. At-Bristol Science Centre
3. Cambridge Science Centre
4. Centre for Life
5. Dundee Science Centre
6. Dynamic Earth
7. Eden Project
8. Eureka! The National Children's Museum
9. Glasgow Science Centre

10. Jodrell Bank Discovery Centre
11. The National Space Centre
12. Royal Observatory Greenwich
13. Science Museum
14. Techniquest
15. Techniquest Glyndwr
16. The Observatory Science Centre
17. Thinktank, Birmingham Science Museums
18. W5 Interactive Discovery Centre
19. Winchester Science Centre and Planetarium
20. World Museum, Liverpool Museums

An example of legacy from Destination Space 1

As an example of legacy, which we have not yet reported, The Eden Project was so inspired through Destination Space 1, that they ran an entire summer programme in 2017 focussed around space reaching over 100,000 people. It was such a huge success that they plan to do this again in 2018 across the summer programme. Eden's programme will now have the Destination Space Phase 2 content within it, including the Spaceports enabling discussion around whether Cornwall will have a Spaceport at Newquay airport. They will also be looking at how to survive on Mars and the plants to grow and systems to put in place to support life on this inhospitable planet. They are also looking at how satellites are used to observe our own planet earth in a variety of ways. The legacy from just this one example is clear, and the demographic of Eden visitors across the summer (especially the rainy days) is largely those without a special interest in science.

Map of the 20 UK Science Centres and Museums that delivered Destination Space 1

Appendix 2: Example of Evaluation Forms

Destination Space (Phase 2)

Workshop Questionnaire for Students aged 11-14

We would like to find out what you thought of today's Workshop.
Please complete this form and return it to a member of staff. Thank You.

---

1. How old are you? Please circle.

11 12 13 14 15

2. What is your gender?

Female Male ……

3. Did you enjoy the workshop? Please circle.

YES	NOT SURE	NO

4. What did you like most about the Workshop?

4. What were the two things (bits of knowledge, or experiences) **that you think you'll most remember from this workshop?**

1. 2.

5. Would you recommend this Workshop to other people your age?
Please circle your answer.

YES	NOT SURE	NO

5b. Why?

6. Have you used this type of equipment before at your school?
Please circle one answer:

Yes, often	Yes, occasionally	No, never

7. In what ways, if any, is this workshop different from the science practicals you do in school?

8. How much do you think today's activities will help you with school science? Please circle.

A lot	Quite a lot	A little	Not at all

8b. Please tell us why

9. How did the Destination Space workshop (and today's activities) make you feel about studying science or engineering in the future? (Please circle).

MORE INTERESTED	THE SAME	LESS INTERESTED

8. How did this workshop make you feel about maybe one day having a job that involves science or engineering?

MORE INTERESTED	THE SAME	LESS INTERESTED

Can you tell us why?

11. Do you have any other comments or suggestions that you'd like to share with us?

Name of your school ……..

Appendix 3: The Training Academy Programme

The Training Academy

Tuesday 20th and Wednesday 21st March 2018
Endeavour and Atlantis shuttle suites
The National Space Centre, Exploration Drive, Leicester LE4 5NS

Day 1: Tuesday 20th March

12:30 – 1:30pm	**Arrival, registration and lunch**	
1:30 – 3:00	Welcome Introductions to the Project Team and the UK Space Agency	Dr Penny Fidler, CEO of ASDC
	Introductions by all the participants	All Delegates
	Introducing ASDC An overview of Destination Space 2 Covering the project vision, mission, a broad overview of the equipment and resources, grants and your delivery timeframes.	Dr Penny Fidler, CEO of ASDC
	Introducing the Space topics in Destination Space 2: The James Webb Space Telescope The ExoMars Rover Satellite Applications Satellite Launch Systems in the UK	Dr Jaclyn Bell, Space and Physics Project Manager, ASDC
	The Training Handbook and additional resources	Dr Jaclyn Bell
	An overview from UK Space Agency: Strategy, spaceports and future exploration	Jeremy Curtis, UK Space Agency
	Health and Safety across the project and your responsibilities	Dr Penny Fidler
3:00 – 3:20	**Coffee break**	

3:20 – 4:00	Where are we now, and where are we going? The Future of Satellite applications, human spaceflight, ExoMars, and will we return to the moon?	Prof. Anu Ojha OBE Director of The National Space Academy, and member of the ESA Human Spaceflight and Exploration Science Advisory Committee
	The James Webb Space Telescope	
4:00 - 5:30	**The Hands-on experiments** • An overview of the telescope • What is the infrared? • Why does The Webb Telescope use Infrared? • The new Infrared camera • Seeing nebulae • The Redshift band and discussion • The Doppler shift visualised	Sophie Allan, National Space Academy
	Where did it all begin: The story of star formation!	Shaaron Leverment, Deputy CEO, ASDC
	The James Webb Space Telescope The international collaboration, the UK role, the heat shield and MIRI	Dr Olivia Johnson, STFC Campaign Lead for JWST Public Engagement. UK Astronomy Technology Centre, Royal Observatory Edinburgh
5:30pm	**Close**	
5:45 / 6pm	Taxis back to the hotel	
7:45 for 8:00pm	**Dinner at The Mumbai Inn** **Meet in the foyer at 7:45 to walk there for dinner at 8:00pm (few minutes walk)**	

Day 2: Wednesday 21st March 2018

9:00am	**Taxis leave hotel**	
9:15 – 9:30	**Coffee and arrivals at The National Space Centre** Please go to the same room as the day before.	
9:30	Welcome back and overview of both days	Dr Jaclyn Bell
9:35am	**Mars exploration and the ExoMars mission**	
	Introducing The ExoMars Mission	Dr Jaclyn Bell and Sophie Allan
	Hands on Demo with the Mars Surface, and the Mars globe	Dr Jaclyn Bell
	Features on The Surface of Mars and what's special about the Mars Rover and PanCam	Martin Nelmes, Associate Lecturer Aberystwyth University
	The Mini Mars Rovers Demo, Including how to assemble and program the Lego EV3 Rover	Josh Barker, National Space Centre
	Is there life on Mars? The Mars coring experiment	Sophie Allan
	Any Mars questions?	Sophie Allan
11:00 - 11:20	**Coffee break**	
11:20	**Satellite Applications:** **What happens if you switch space off?**	
11:20	The Hands-on Box of Satellite Applications	Jeremy Curtis UK Space Agency
11:30	**The PocketQube satellite and the Hands-on Demo** • What are cube sats and pocket sats? • How to run the demo • How to set up the equipment • Round table discussions to answer questions	Josh Barker, The National Space Centre George Addison, Nano Satellite electronic engineer, Satellite Applications Catapult
1:00 – 1:45	**Lunch and group photo (1:35pm under the Soyuz)**	
2:00 - 3:30	**Training on the School Workshops and Activities** • KS3 workshop (focussing on The Webb Telescope) • KS2 workshop (focussing on ExoMars) • Additions for your Show • Any Questions on the hands-on activities	Sophie Allan National Space Academy Lead Physics teacher and Josh Barker, The National Space Centre
3:30 -3:45	**Coffee and cake break (15 minutes)**	
3.45 – 4:15	The marketing resources and website	Dr Penny Fidler
	Reaching wider audiences and gender equity	Dr Penny Fidler and Shaaron Leverment, ASDC
	Your evaluation commitments, contractual commitments, Health and Safety and any questions.	Dr Penny Fidler

	Opportunities with citizen science	Dr Jaclyn Bell
4:15	**Spaceports in the UK**	
4:15 - 4:45	**UK Spaceports** • Will the UK have Spaceports? • Where might they be? • Hands-on demos: Where are good locations worldwide? Where are potential UK Spaceports • and finally …The Mini whoosh bottle Rocket demo	Dr Jaclyn Bell Josh Barker
4:45	Final questions and your next steps	Dr Penny Fidler
4.50pm	**Close** **(and filling in your evaluation forms)**	
5.00pm	**First Taxis to the train station, or stay and talk to the team**	

The ASDC Project Team

This programme was directed and project managed by The UK Association for Science and Discovery Centres. ASDC has considerable track record in running a host of national multi-partner programmes.

Dr Penny Fidler

Dr Penny Fidler is the CEO of The UK Association for Science and Discovery Centres, and the creator and Director of both Destination Space, which engaged over 733,000 people, and Explore Your Universe which attracted over 347,000 people. She has directed this programme.

Penny holds a PhD in neuroscience from Cambridge University and has twenty years' experience working in the field of science engagement, including six years setting up then working in a landmark millennium science centre. She is the founding CEO of ASDC and prior to this post ran her own Exhibitions and Neuroscience Consultancy setting up innovative projects in the UK and internationally.

As CEO of ASDC Penny has founded and directed many national strategic science engagement projects on subjects ranging from astrophysics to molecular biology. Each has an emphasis on bringing the latest excellent science and scientists to the fore so adults and children across the UK can share what science is really about. She has also consulted and worked worldwide and has spoken in the UK Parliament on the importance of informal science learning and advised colleagues at Number 10 about encouraging more girls into science.

Dr Jaclyn Bell (PhD, MSc, BSc)

This programme has been project managed and content managed by Dr Jaclyn Bell for ASDC. Jaclyn has a PhD in Theoretical Particle Physics and both an undergraduate and postgraduate degree in Mathematical Sciences. In addition to an outstanding academic record in which Jaclyn was in receipt of several prestigious scholarships and awards, she also has 11 years expertise in working with children, young people and under-served communities in various capacities.

Alongside her university education Jaclyn delivered science-based education programmes throughout Merseyside on a voluntary basis, with experience of managing, coordinating and evaluating youth and educational based initiatives for key organisations. She also founded and ran a STEM-based initiative, funded by the Department of Business, Innovation and Skills in 2015. Most recently Jaclyn has taken part in the BBC Science production 'A*stronauts: Do You Have What It Takes?*'. For this she was selected from over 3,000 applicants to take part and to undertake tests similar to those used in the astronaut selection process.

Shaaron Leverment and the team

Shaaron has 20 years' experience working in science engagement and education and is the Deputy Director of ASDC. She is the former president of the British Association of Planetaria, a Fellow of the Royal Astronomical Society and a national network representative at the International Planetarium Society. She holds a first class honours degree in Psychology, Anatomy and Zoology, qualifications in astrobiology and research methods, and a recent Masters in Applied Neuropsychology. Shaaron is also the founder of the Space-focussed, hands-on science outreach business 'Explorer Dome' that engages 50,000 school children every year.