

Inspiring the next generation: *design and technology in space*

Teacher Guide

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Image: UK Space Agency

Introduction

The space industry provides young people with an inspiring context for developing skills and for thinking about future roles and careers. This set of resources offers schools information and activities to inspire young people aged 11-16 and to understand the roles and impact of the space industry, increasing their awareness of and interest in the sector.

The resources are structured around **Satellite Launch Systems** and the **James Webb Space Telescope**, and have activities and information for pupils at Key Stage 3 and Key Stage 4, drawing on existing STEM knowledge, and applying it to real-life space contexts. As these resources will be explicitly linked to the curriculum they give teachers high quality, up-to-date materials that help them to deliver requirements, in an inspirational and engaging context.

Design and technology gives secondary pupils the opportunity to learn about a wide range of industry-relevant skills, including design, engineering, electronics, additive manufacturing, robotics, and computer control. Students develop higher-level thinking skills and technical capabilities that are valued by employers and critical to meeting future skills needs. It provides young people with the opportunity to apply the principles of science and mathematics in a practical and relevant way.



The UK Space Agency

The UK Space Agency is a government organisation, sponsored by the Department for Business, Energy & Industrial Strategy, responsible for strategic decisions on the UK civil space programme. It funds a number of space missions including space exploration, earth observation, the James Webb Space Telescope and satellite launch programmes, including commercial and satellite launch vehicles, helping to generate data and develop solutions to problems in areas such as Agriculture, Forestry, Urban growth, Disaster Monitoring, Defence and Security, Maritime and Natural Resource Management across the globe. As a commercial space age dawns it offers opportunities for growth for business and jobs in this sector also.



Tim Peake during his first spacewalk.

UK Space Agency
Polaris House
North Star Avenue
Swindon
Wiltshire
SN2 1SZ

<https://www.gov.uk/government/organisations/uk-space-agency>

Teaching resources

These resources will help teachers deliver technical knowledge, a core element of the Design and Technology GCSE, to their students from age 11 upwards, in particular:

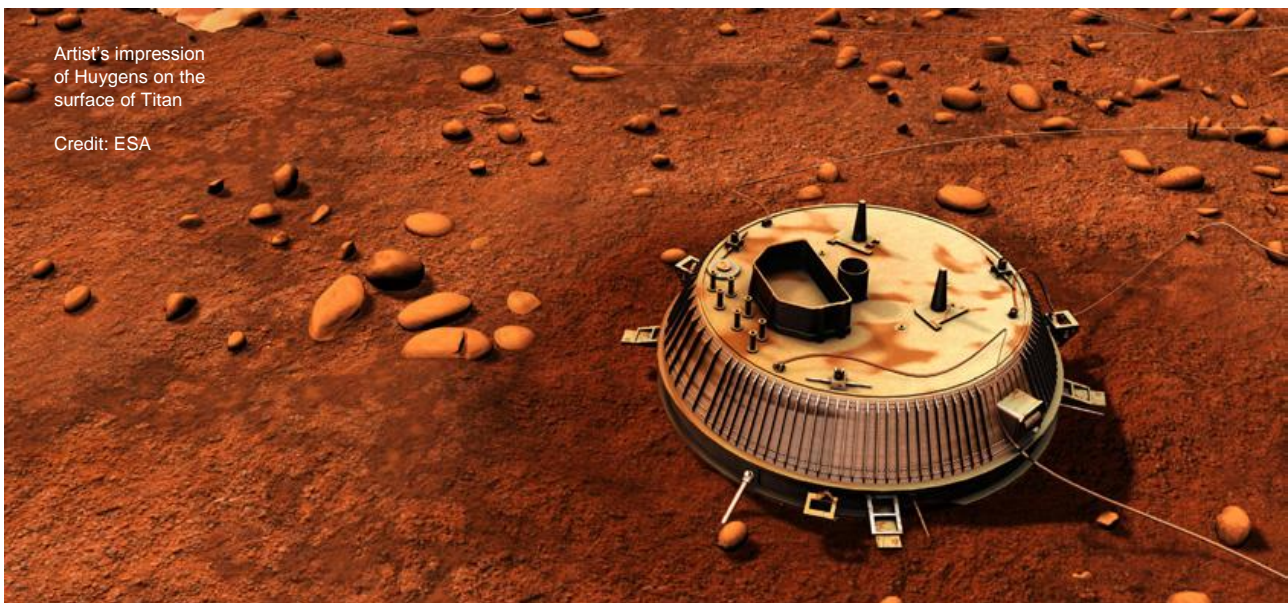
- How the critical evaluation of new and emerging technologies informs design decisions; considering contemporary and potential future scenarios from different perspectives, such as ethics and the environment.
- How electronic systems provide functionality to products and processes, including sensors and control devices to respond to a variety of inputs, and devices to produce a range of outputs.
- The use of programmable components to embed functionality into products in order to enhance and customise their operations.
- The functions of mechanical devices, to produce different sorts of movement, changing the magnitude and direction of forces.

The series of resources is aligned to the design and technology curriculum with clear links to maths, computer science and science learning.

Teachers may adapt the resources to suit their school's circumstances and prior learning.



The launch of Sentinel-5P from Plesetsk
Credit: ESA

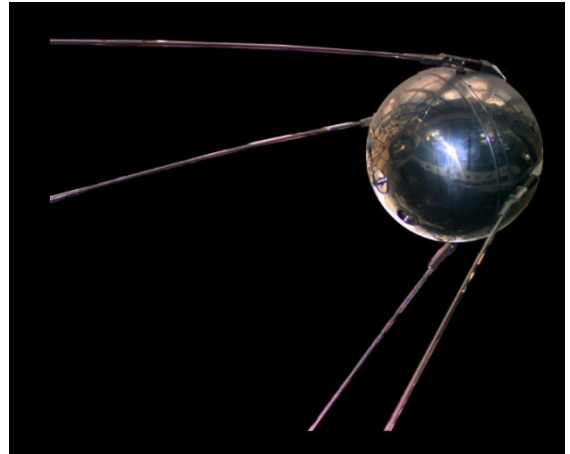


Artist's impression of Huygens on the surface of Titan

Credit: ESA

Satellite launch systems

These materials set out to improve pupils' understanding of space and show how our existing knowledge has developed. Pupils start by learning about satellite launch systems by building their own solid fuel rocket and using this experience to redesign and manufacture modified rockets. All of this takes place in the context of learning about the wide range of commercial space launch systems that are operating and in development.



Outcomes

After working through these materials pupils should be aware of:

- The range of satellite launch systems in use and under development.
- The different types of satellites that are launched into space.

understand:

- How satellite launch systems work and are operated.
- How satellite launch systems are designed and manufactured.
- The economics of space launch systems.

be able to:

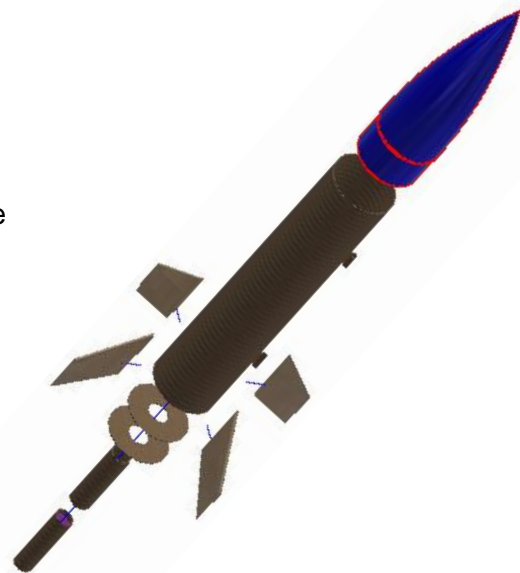
- Build their own solid rockets using low-cost materials and off-the-shelf rocket motors.
- Test their rockets and write reports making informed judgements about their performance.
- Use data and experience to re-design and manufacture more efficient rockets.

The resource contains teacher and pupil guidance and covers the following:

- Working in teams: Laws of motion
- Rocket flight profile
- Alternative launch systems
 - Balloon launch
 - Air launch
 - Runway launch
- Rocket build
- Rocket costings
- Rocket testing
- Measuring and recording rocket performance
- Rocket re-use
- Rocket refurbishment
- Costings for refurbished flights
- Rocket mass
- Computer simulations
- Mass analysis
- Motion simulation

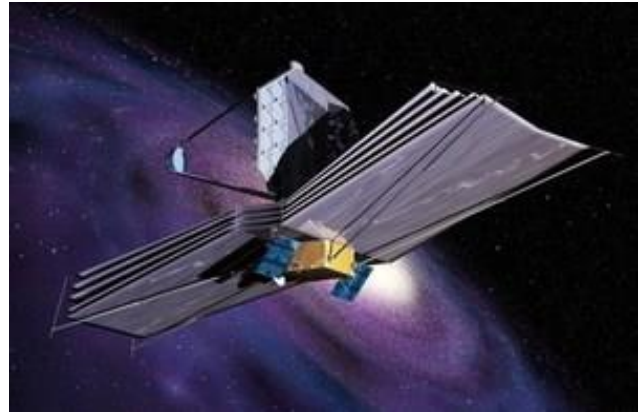
Extended projects – age 14+

- Solid fuel rocket motors
- Motor burnout
- Height and altitude
- Rocket structures and materials
- Aerodynamics
- Payloads
- Datalogging, micro controllers and guidance systems



James Webb Space Telescope

Here pupils start by learning about the history of astronomy from the earliest optical telescopes to modern day space telescopes and use this knowledge to create their own telescope whilst learning about their design and operation. This all takes place in the context of the James Webb Space Telescope due for launch in 2019 and the likely uses for the data it gathers.



Outcomes

After working through these materials pupils should

be aware of:

- The development of telescopes and how they are used to improve our understanding of the Universe.
- How astronomical telescopes work and the uses the information they collect is used for.

understand:

- How telescopes work and how they are used.
- The design of telescopes including the James Webb Space Telescope.
- How the observations made using telescopes are used.

be able to:

- Build their own telescope using low-cost materials.
- Test telescopes and write reports making informed judgements about their performance.
- Use their telescope to make observations on earth and in the night sky.

The resource covers the following aspects:

- Parts of a telescope
- Sourcing lenses
- Finding the focal length of a lens
- Tube length
- Reducing tube diameter
- Testing
- UK involvement
- Careers
- Near Infra Red Camera (NIRCam)
- Near Infra Red Spectrograph (NIRSpec)
- Mid-Infrared Instrument (MIRI)
- Near InfraRed Imager & Slitless Spectrograph (NIRISS)

Extended projects – age 14+

- Chromatic aberration
- Newtonian telescope
- Eyepieces and focusing systems
- Stands/tripods
- Pan/tilt movement
- Equatorial mount
- Motorised axes for smooth movement
- Camera/phone adapters
- Telescope bodies

Further D&T skill development might include making a mount for lenses or a stand for the telescope, and customising the tube with vinyl graphics.

D&T across the curriculum

These activities provide ample opportunity for including cross curricular work, particularly in maths, science, computing and English. Check with colleagues in other departments to ensure that the correct levels are being addressed.

The maths component of the GCSE is now 15% and pupils should be encouraged to get into the habit on incorporating number, measurement, ratio and proportion, algebra, geometry and statistics, including showing working out, in their design planning.

Materials, light, electrical systems, forces and of course physics are all relevant areas of science that are used in these activities.

CAD, CAM and software for e-portfolios are aspects of computing that apply.

Opportunities for developing speaking and listening through discussions, negotiations and presentations are plentiful as well as written work.

Applying the National Curriculum at Key Stage 3

The National Curriculum for Key Stage 3 states:

Through a variety of creative and practical activities, pupils should be taught the knowledge, understanding and skills needed to engage in an iterative process of designing and making. They should work in a range of domestic and local contexts, such as the home, health, leisure and culture, and industrial contexts, such as engineering, manufacturing, construction, food, energy, agriculture (including horticulture) and fashion.

When designing and making, pupils should be taught to:

Design

- *use research and exploration, such as the study of different cultures, to identify and understand user needs*
- *identify and solve their own design problems and understand how to reformulate problems given to them*
- *develop specifications to inform the design of innovative, functional, appealing products that respond to needs in a variety of situations*
- *use a variety of approaches, such as biomimicry and user-centred design, to generate creative ideas and avoid stereotypical responses*
- *develop and communicate design ideas using annotated sketches, detailed plans, 3-D and mathematical modelling, oral and digital presentations and computer-based tools*

Make

- *select from and use specialist tools, techniques, processes, equipment and machinery precisely, including computer-aided manufacture*
- *select from and use a wider, more complex range of materials, components and ingredients, taking into account their properties*

Evaluate

- *analyse the work of past and present professionals and others to develop and broaden their understanding*
- *investigate new and emerging technologies*
- *test, evaluate and refine their ideas and products against a specification, taking into account the views of intended users and other interested groups*
- *understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists*

Technical knowledge

- *understand and use the properties of materials and the performance of structural elements to achieve functioning solutions*
- *understand how more advanced mechanical systems used in their products enable changes in movement and force*
- *understand how more advanced electrical and electronic systems can be powered and used in their products [for example, circuits with heat, light, sound and movement as inputs and outputs]*
- *apply computing and use electronics to embed intelligence in products that respond to inputs [for example, sensors], and control outputs [for example, actuators], using programmable components [for example, microcontrollers].*

Links to maths and science

With the GCSE now having 15% of its marks for maths, preparatory work at Key Stage 3 using realistic scenarios is a valuable way of getting students used to its inclusion. Estimating material quantities and developing plans for buildings have maths included in any case and this is often an easier way for some pupils to absorb the concepts of number, place value, fractions, geometry and ratios.

Science links include understanding the principles of forces and properties of matter and materials. (NC)

GCSE in Design and Technology at Key Stage 4

The single title Design and Technology GCSE specifications require students to:

- Identify their own contexts
- Carry out their own research
- Identify opportunities for new products and systems

Specifications from the Awarding Organisations are available at the following links:

- [OCR D&T GCSE specification](#)
- [AQA D&T GCSE specification](#)
- [Eduqas D&T GCSE specification](#)
- [Edexcel D&T GCSE specification](#)

The Contextual Challenge (non-examined assessment component) of the GCSE now accounts for 50% of the overall marks.

Careers advice

There are many and growing opportunities for careers in the sector. This advice is aimed at young people at school, including advice on GCSE and A Level choices, apprenticeships, and work experience. There is plenty of information and advice available at each of the following links.

- https://spacecareers.uk/?p=careers_resources
- <http://www.ukspace.org/what-we-do/careers/>
- <https://www.gov.uk/government/organisations/uk-space-agency/about/recruitment>
- <https://www.careersinaerospace.com/start-here/12-15/>
- <https://nationalcareersservice.direct.gov.uk/job-profiles/aerospace-engineer>

Job profiles and opportunities – a range of job opportunities within the space industry:

- https://spacecareers.uk/?p=job_profiles
- <https://successatschool.org/advisedetails/262/Jobs-in-space-that-are-out-of-this-world>
- <https://www.allaboutcareers.com/index.php?/careers/career-path/aerospace-avionics-engineering>
- <http://www.futuremorph.org/my-future-finder/space/working-in-space/>, including links to the National Careers Service
- <https://www.space-careers.com/jobcenter.html>

Interviews – a range of interviews with real space professionals across the sector:

<https://spacecareers.uk/?p=interviews>

Day in the Life of... Space Videos:

<http://www.futuremorph.org/my-future-finder/space/day-in-the-life-of/>

National Space Academy – Space Engineering Qualification:

<https://nationalspaceacademy.org/programmes-for-students/space-engineering>

Further information

UK Space Agency:

<https://www.gov.uk/government/organisations/uk-space-agency>

European Space Agency (ESA):

<http://www.esa.int/ESA>

SpaceUK – the space sector magazine with the latest space sector news and packed with educational material:

<https://www.gov.uk/government/collections/spaceuk-the-space-sector-magazine>

UK Space missions and programmes:

<https://www.gov.uk/government/collections/uk-space-missions-case-studies-and-programmes>

Women in Space

- Women in NASA:
<http://www.futuremorph.org/my-future-finder/space/women-space/women-nasa/>
- Women in Space on line database:
<https://jobs.telegraph.co.uk/women-in-space/>

Resource links

Links to resources are included in each of the challenge outlines. The following will be of help for general Design and Technology guidance and information on building services.

Estes Model Rocketry kits are available from www.LogicRC.com or from www.modelrockets.co.uk

A classroom set of rocket parts might include:

- Viking bulk back of 12 - £59.99 - <https://www.logicrc.com/?s=c:0,c:D,c:D050&ItemId=D-ES1755>
- Launch controller & launch pad - £24.99 - <https://www.logicrc.com/?s=c:0,s:launch%20pad,c:D,c:D120&ItemId=D-ES2222>
- Rocket motors A8-3 pack of 24 - £55 - <https://www.logicrc.com/?s=c:0,s:a8-3,c:D,c:D111&ItemId=D-ES1781>

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