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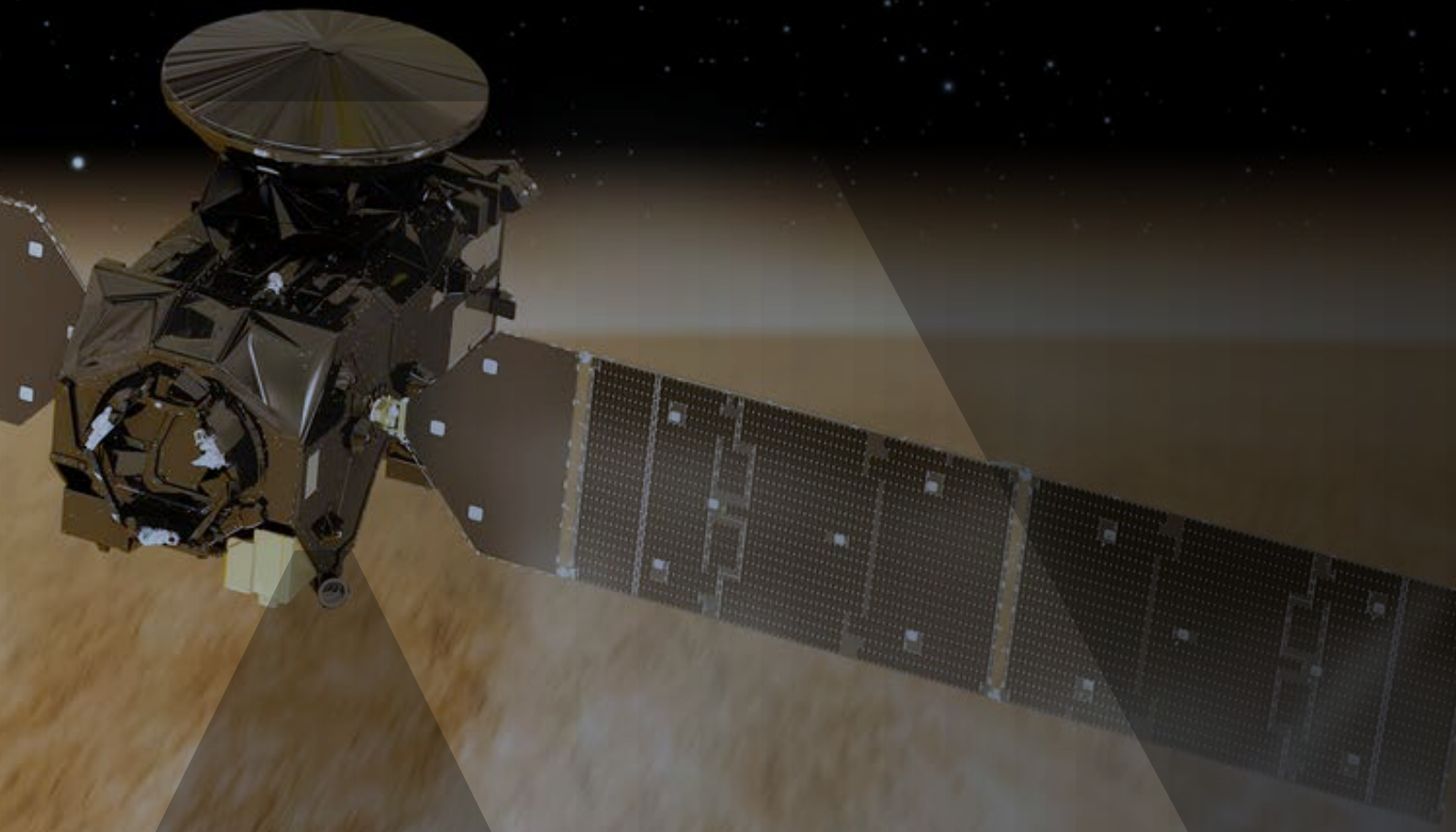
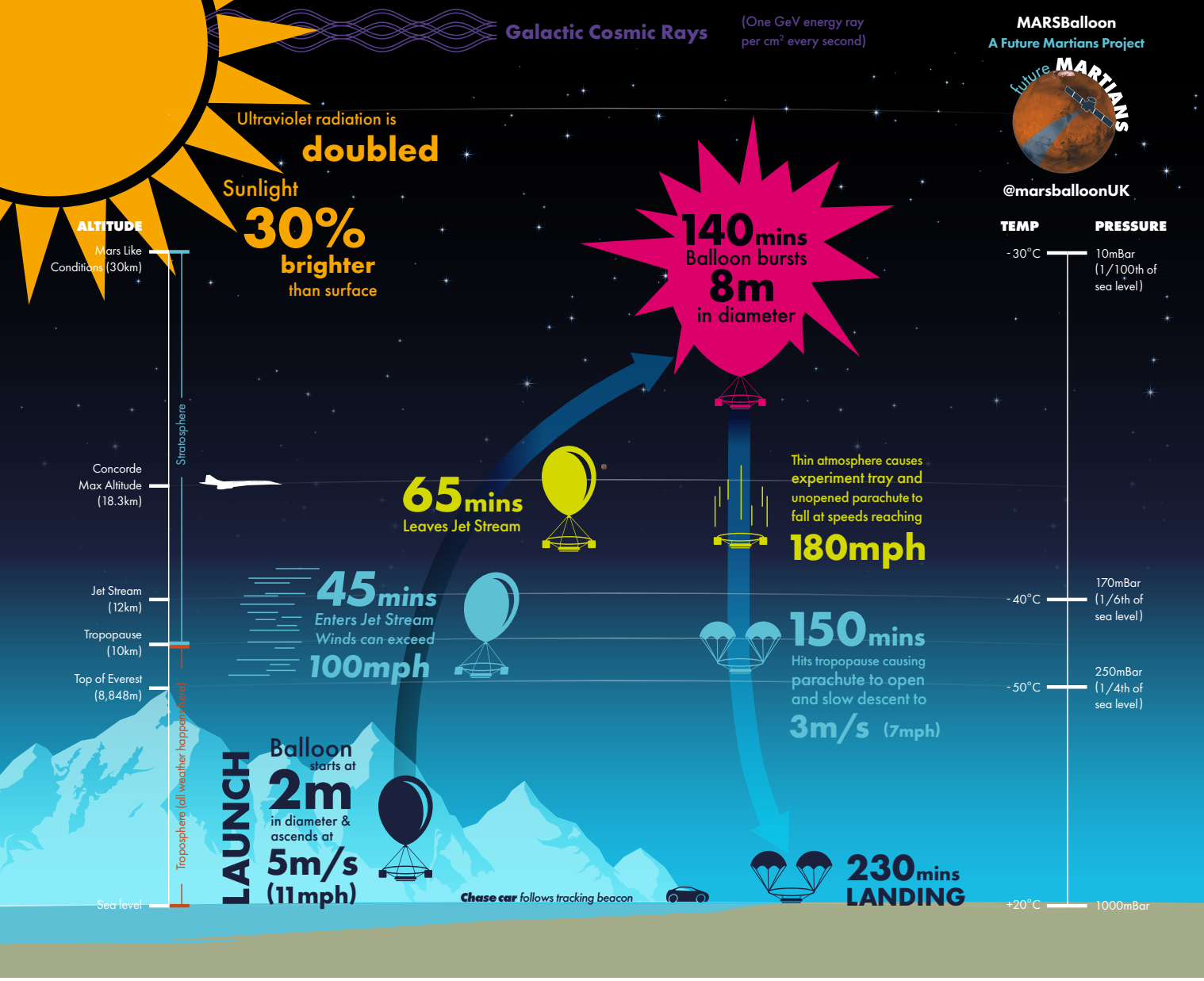


MARSBalloon
Teacher's Pack 2024



Welcome!

This pack has been designed to provide all the information you need for your school class or club to take part in the MARSBalloon STEM project. The objectives of the project and the benefits to your students are:

1. **To provide first-hand experience of designing experiments to go into space and visit other planets**
2. **To encourage students to consider future careers in the UK space industry**
3. **Opportunities to win prizes in multiple categories (see rules for more details)**

This pack can be freely distributed to other school teachers, but in order to take part they will need to register on the project website.

This pack includes:

- Everything you need to know about organising your students to take part in the MARSBalloon UK STEM outreach project
- Information on careers for your students in the UK space industry
- Ideas for experiments

Project Summary

The MARSBalloon project is run by STEM Ambassadors from Thales Alenia Space in the UK and is supported by Thales in the UK.

The aim is to test anything that humans or robots could be doing on Mars in the future.

This year we plan to launch over 150 experiment capsules on a high altitude balloon 30km up into the Earth's atmosphere, a place where the conditions of air pressure, temperature and radiation are similar to those on the surface of Mars.

Mars is the subject of numerous robotic exploration missions. Several missions launched in 2020, and future launches include the ExoMars Rosalind Franklin rover, industrially led by Thales Alenia Space. Potential human habitats in the future mean that there are still a great many aspects to be tested before launch. This project will allow students to test how various items would respond to the Martian environment, many of which have never been tried before, to potentially make new scientific and engineering discoveries.

History of the Project

The first MARSBalloon pilot project, sponsored by the UK Space Agency, took place in 2013. It flew 140 experiments made by students from Bristol and Bath.

Since then, we have launched over 1000 experiments from more than 300 schools in the UK. In 2023, we launched 209 experiments from 84 schools, our biggest launch yet.

Future Martians is the name of the Thales Alenia Space UK outreach program. Our goal is to bring space science and engineering to the younger generations and inspire them to become future scientists, engineers, and perhaps, future Martians in the first Martian habitats.

MARSBalloon is our flagship activity for primary and secondary school students.

UK Space Industry

What is it?

The UK space industry is a large collection of research institutions and engineering companies, distributed around the UK, that work with many European countries to build spacecraft that monitor our climate, provide global communications and explore the solar system.

What jobs are there?

There are a wide variety of technical jobs required to run a space mission; from the engineers who design, build, test and launch the satellite, to the operators who guide the satellite to its destination and the scientists who retrieve and analyse the results.

This primarily requires students with degrees in either physics or an engineering discipline, however it is certainly not limited to this. The annual starting salary for a full time satellite engineer or space scientist starts from about £27,000. If your students are interested in joining the space industry, check spacecareers.uk for more information.

There is also a new higher apprenticeship in space engineering designed to help students become technicians which could lead to a full BEng degree.

The UK will need at least 30,000 more scientists and engineers by 2030 to keep up with government ambitions to increase the size of the space industry from £9bn/year to £40bn/year. The main aim of this project is to help cover this shortfall by encouraging students to consider space careers, one of the most rewarding in the solar system!

Can my students become astronauts?

UK citizens can now become professional astronauts for the European Space Agency.
Most professional astronauts started out by becoming pilots, or acquiring degrees in science, engineering or medicine. The future of space exploration is continuously evolving, and is always open to specialists that are passionate in their fields.

In order to be selected you need to be healthy, well-motivated, an excellent team player and ready to learn a lot of new skills.

Professional astronauts are currently being trained for long duration stays on the International Space Station, landings on the Moon, asteroids and even Mars.

The latest ESA class of astronauts was announced in 2022. There are three British Astronauts in that class: Rosemary Coogan (Career Astronaut), Meganne Christian (Astronaut Reserve), and John McFall (Parastronaut Feasibility Study Member).

How to take part

Teachers – you should follow all these steps to ensure your students' experiments fly:

1. **Register your interest on our website by the 8 March 2024.**
   It is first-come-first-served so get your registration done ASAP at thalesgroup.com/futuremartians
   After you've registered, wait for email confirmation that you have a place on the balloon which will be sent after the 1st April.
2. The confirmation email will include ID codes for each of your experiments. These will be used by us to return your experiments to you. The email will also include an experiment submission form which you must fill out and send in with your experiments. This lets us know what you are doing and how to get the experiments back to you. If you think you should have received a confirmation email but haven't then email us at mars.balloon@gmail.com.
3. Decide with your class/club on an experiment that fits in with the rules given on the next page of this pack.
4. Buy a standard Kinder™ egg (eating: optional!) and save the toy capsule as it is the preferred option for MARSBalloon experiments. However, if they are not available (e.g. due to a recall), a standard film canister is an acceptable substitution that will fit our launch platform. If you can't get hold of either of these then your experiments can be sent in any cylindrical hard plastic sealable container which has a width/diameter of 2 to 3.2cm and less then 8cm high. The width rule ensures we can fit them in the launch tray and they will not fall out during the flight.
5. Design, build and test your experiment and put it inside.
   Keeping one or more identical control experiments in a safe place in your classroom is recommended, for comparison post-flight.
6. Write your ID onto two locations on the outside of the capsule in permanent marker pen. Feel free to decorate the rest of the capsule in any way you like as long as the two IDs remain clearly visible.
7. Post the experiment, along with a completed experiment submission form which will be sent to you via email when your place on the balloon is confirmed. We must receive the experiment(s) and form by the 30 April 2024 to ensure your place on the flight.

   We will fly your experiments during May – June, but our launch windows are weather dependent. We'll keep you updated on our Twitter feed so you can follow the launch live.
8. After the flight wait for the experiments to be returned by post.
   Upon return fill out the results form (which will be provided post-launch) so that we can tell others what happened.
9. Tell your students that they are now space scientists!

All experiments and forms should be posted to:
MARSBalloon Team
Thales Alenia Space in the UK
Building 660
Bristol Business Park
Coldharbour Lane
Bristol BS16 1EJ

Make sure you have registered on the website:
thalesgroup.com/futuremartians

Make sure you send the experiments with the submission form– entries without this may not be accepted!

Follow the Mars Balloon project online:
thalesgroup.com/futuremartians @marsballoonUK mars.balloon

The Rules

Tick off the following to make sure you comply with the rules

- ☐ All experiments must come from a school class or registered club.
- ☐ Ideally, the experiments should be related to humans or robots operating on the Martian surface, but experiments related to outer space and Earth's upper atmosphere will be happily accepted.
- ☐ You must write your ID code in permanent marker on two locations on the outside of the capsule so that we can identify it later.
- ☐ Maximum 20g per capsule which includes the ~4g mass of the capsule.
- ☐ Your class will be guaranteed at least one slot on the flight but feel free to send us more and we will try our best to fit them all on-board. On average, we usually have space to fly 2-3 experiments per class.
- ☐ Send a maximum of 10 experiments and clearly prioritise them in your experiment submission form in case we can't fly them all.
- ☐ The capsules cannot contain live animals or insects (for ethical and practical reasons).
- ☐ Please note that experiments will be travelling through the post and may have to wait for acceptable flight weather conditions so do not send experiments that degrade quickly, e.g. live cultures, perishable food and some plants (plant seeds are fine).
- ☐ The capsules cannot contain any poisonous or hazardous materials that pose a risk to us or anyone else on the ground.
- ☐ Capsules can be completely open (the lid can be removed if needed) or sealed but they must not protrude excessively and block other experiments. Note that air will leak in or out through the seam and hinge unless adequately covered. If the lid is removed, the experiment will need to be secured within the capsule base in some other way. The ride down can be a bit bumpy!
- ☐ The capsules will be mounted vertically with the lid at the top unless otherwise requested.
- ☐ The seams and hinge of the capsule will leak fluid if not properly sealed. Liquids need to be double bagged inside the capsule, the capsule itself is not leak-proof.
- ☐ The experiments will be filmed by an HD camera throughout the whole mission, but changing light conditions and distance mean that you should not rely on it for your results.
- ☐ The capsules can be decorated any way you like.
  Note that only the top half will be visible on the camera during the flight. Ensure that they still fit snuggly in the tray,the decorations shouldn't protrude too much in the bottom half.

The team have the right to refuse to fly any experiment which does not comply with these rules and/or may pose a danger to persons or other experiments. Refused experiments may not be returned.

The Awards

Six experiments will be selected and given special awards, three experiments from primary schools and three from secondary schools. The award categories are:

Best Decorated (Primary only)
Show your creative style by decorating your experiment capsule any way you like! Make it stand out in our video, the winner and runners up will be placed in the forefront of our camera's view.

Innovation Awards (Primary & Secondary, one each)
Think outside the capsule, these awards will go to the experiments that use MARSBalloon in the most inventive and extraordinary way.

Engineer's Choice Awards (Primary & Secondary, one each)
Wow our team of engineers with the design and detail of your experiment, they will decide these awards based on the scientific value and rigor of each entry.

VIP's Choice (Secondary only)
Our VIP (to be announced) will select this based on their own high standards and experience in the space industry.

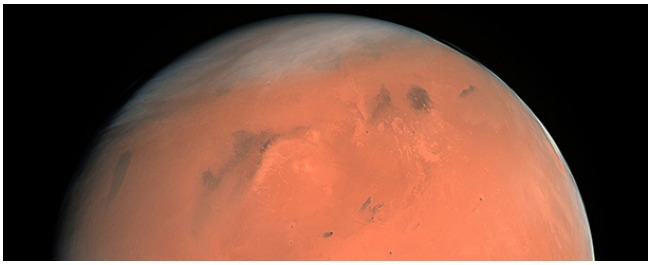
For details on some previous winners, please check our website: thalesgroup.com/futuremartians

Please note: Thales Alenia Space in the UK and the MARSBalloon team reserve the right to alter the selection criteria for these awards at any time.

Previous winners

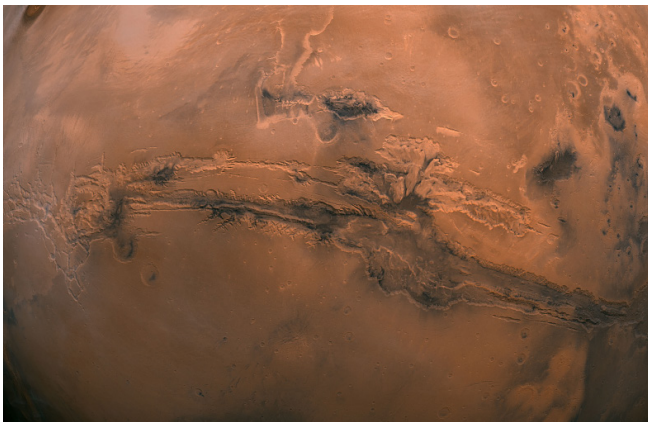
The Martian Surface

Mars is known as the "Red Planet" because of its distinctive colour, which can even be discerned when looking at Mars in the night sky. It is the next planet out from the sun from Earth, and is a little more than half the size of the Earth. It is home to Olympus Mons, the largest volcano in the solar system, although all volcanic activity on Mars has long since ceased. It also hosts a vast canyon system called Valles Marineris that is eight times wider than the Grand Canyon on Earth.



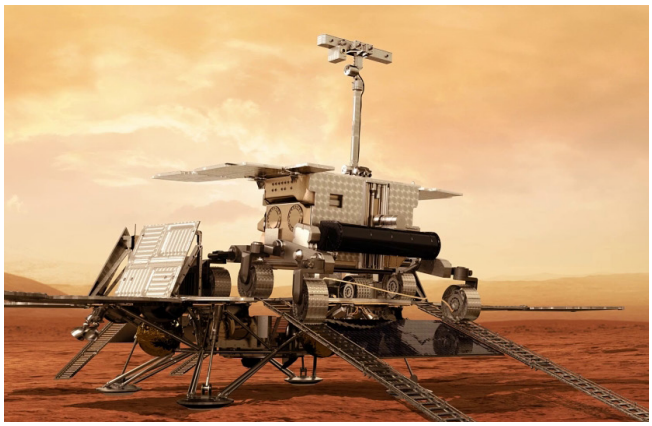
The surface appears dry and dusty, but there is growing evidence that the surface of Mars once flowed with liquid water, and indeed may still do so in isolated places today. This raises the possibility that Mars may be home to life, though if it does exist it is likely to be microbial in nature, and not little green men! It also raises hopes that Mars may one day be able to support a human colony, although there are many technological and biological challenges to be overcome before that becomes possible.

Missions to Mars



So far humanity has launched 50 missions to the red planet (of which less than half arrived intact!) and yet we are only just beginning to understand the variety of past and present environments that have existed or exist now. There are currently two NASA Rovers on the surface of Mars, Curiosity and Perseverance, returning daily images and data about conditions.

2020 saw three missions heading for the red planet (NASA's MARS 2020 rover and helicopter, China's HX-1 Rover and UAE's Hope Orbiter). The ESA ExoMars Rover mission, originally scheduled for launch in 2020, is currently suspended, and undergoing a review of its launch options. The ExoMars Rover, named Rosalind Franklin, was developed with Thales Alenia Space as the industry lead, and is designed to search for life on Mars. In the longer term, missions to collect and return a sample of Mars are in the planning stages, and the ultimate aim is to send humans to explore.



Challenges of Exploration

There are three main differences between the conditions at the surface of Mars and those on the Earth that will challenge future astronauts and their equipment:

- **Much lower air pressure:** the pressure from the atmosphere is about 1/100th of that experienced on Earth, this causes some materials (particularly plastics) to 'outgas' where trapped gases and moisture expand, weakening their structure.

- **Much lower temperature:** this can have effects on the equipment that the astronauts might use, as well as challenging them to keep warm themselves.

- **Increased radiation:** this includes Galactic cosmic rays (very high energy particles which come from dying stars), Solar Proton Radiation (medium energy particles from the solar wind) and ultraviolet radiation (which causes sunburn and some materials to glow). All of these can damage electronic memory, organic cells and leave marks on photographic film.

Replicating Mars

The challenge of designing any mission to the Red Planet is to test your equipment in a similar environment to that it will operate in when it reaches Mars. The question is, where on Earth can we find similar conditions to those on Mars? MARSBalloon offers a solution to this problem.

Below is a comparison between the conditions on the surface of Mars and the target of the MARSBalloon project; 30km altitude above the Earth. At this altitude the three challenges discussed above are replicated:

MARTIAN SURFACE

Pressure:
0.006Bar

Average Temperature:
-55˚C

Gravity:
3.75m/s^2

Magnetic Field Strength:
≈0.4μT

Galactic Cosmic Rays
>0.01/cm^2/s

Solar Proton Radiation
≈1/cm^2/s for energies up to 1MeV

Ultraviolet Intensity:
≈0.06W/cm^2

Total Solar Intensity:
≈0.6W/cm^2

Atmospheric Composition:
95% CO_2, 3% N_2, 1.6% Ar

EARTH AT 30km ALTITUDE

Pressure:
0.005-0.01Bar

Average Temperature:
-50˚C

Gravity:
9.80m/s2

Magnetic Field Strength:
≈50μT

Galactic Cosmic Rays:
>0.01/cm^2/s

Solar Proton Radiation:
>1/cm^2/s for energies up to 1MeV

Ultraviolet Intensity:
≈0.07W/cm^2

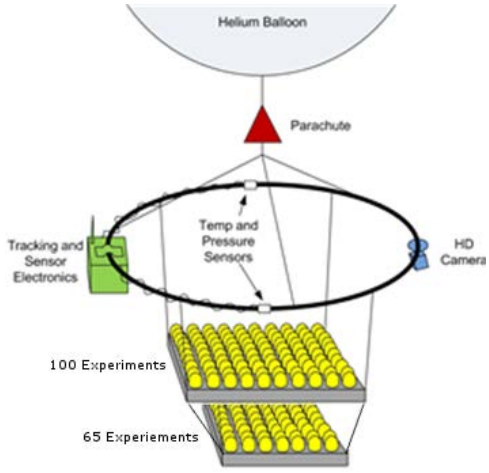
Total Solar Intensity:
≈1.3W/cm^2

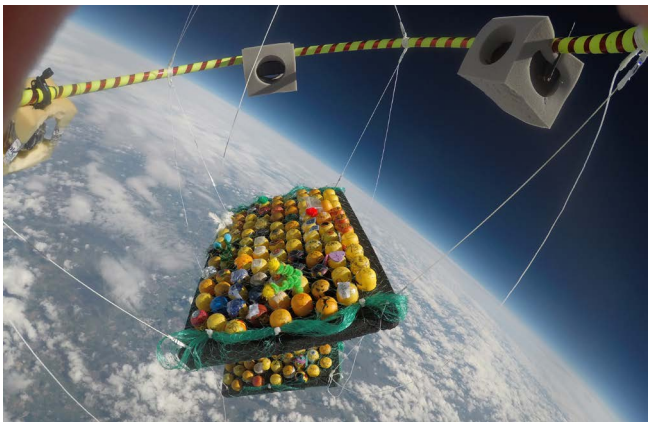
Atmospheric Composition:
78% N_2, 21% O_2, 1ppm O_3

These numbers are estimates and are subject to large daily variations (except gravity, that doesn't usually change). As you can see some things are very similar (pressure, temperature, radiation) and some things are very different (gravity, magnetic field, solar intensity and atmospheric composition). You will need to keep this in mind when designing your experiments.

The Mission

Each MARSBalloon launch will carry over 150 capsules into the Mars surface-like conditions of 30km altitude. This is accomplished by the use of a large helium balloon, over 3m in diameter during launch, which expands to over 8m in diameter before it bursts at 30km.





Points to Note

- The capsules will be placed upright into evenly spaced holes in two foam trays that are ~20mm deep. The base of the tray will be solid and a fine mesh will be placed over the top of the capsules to prevent any falling out during the balloon burst or landing.
- At least two cameras will film at 30fps throughout the mission.
- The ambient air pressure and temperature will be logged on the carrier platform throughout the mission.
- If you have any special handling requirements (e.g. activate just before launch) then please indicate this on your experiment submission form.
- The anticipated time to recovery of the experiments is three to six hours after launch.
- Whilst we will take every possible precaution to ensure all of the experiments are recovered safely, due to the risky nature of the project, Thales Alenia Space in the UK and Thales in the UK cannot be held liable for the loss or damage to student experiments.
- The pressure and temperature data recorded on the platform will be made available as soon as it is processed.
- A summary of the camera footage will be published on the MARSBalloon website soon after the flight.
- The complete footage will be made available on request.

Experiment Ideas

Space medicine?
- How would Mars-analogue conditions affect common medicines?

Is there an easy way to detect cosmic rays? Can you count them?
- Cosmic rays leave marks on undeveloped photographic film.

Can you feel the wind?
- The low pressure means that wind is much weaker on Mars, but could you feel it?

Will MP3 players work?
- The low pressure means that sound doesn't carry as far.
- Radiation can corrupt electronic memory.

Would you get a sunburn?
- There is less atmosphere to protect you from ultraviolet light.
- Is there an easy way for astronauts to detect it?

What happens to the rubber in tyres?
- Cold temperatures and pressure have big effect on some materials.
- What happens to the Young's Modulus (elasticity)?

What happens to chemical reactions?
- Would everyday devices based on chemical reactions still work?

What happens to yeast cultures?
- Would they survive the low pressure, temperature and radiation?
- Could you make bread on mars?

How can we protect against radiation?
- Some metals are good at stopping radiation. Which has the lowest mass?

Does the calorific value of food change?
- Some oil based foods, e.g. peanuts, could lose energy to evaporation. Can you measure the loss?

What happens to lubricants/sealants/adhesives?
- Gas bubbles escaping from viscous materials can dramatically change their properties.

How do you get rid of heat?
- Low air pressure makes convective (air) cooling much harder.

Does cold effect watches?
- Digital clocks can speed up or slow down in response to changes in temperature.

Can you recharge a battery with a solar panel?
- There are no fossil fuels on Mars, so renewable energy is very important.

Can you grow crystals?
- Do they grow larger or smaller?
- Are they a different colour?

Do glowsticks last as long?
- Future Mars explorers will need to be able to search caves.
- Is the light producing time affected by temperature?

What effect does radiation and the Mars environment have on seeds?
- You could send seeds on the balloon and grow them when you get them back alongside some seeds that have stayed in the classroom.
- What happens to photosynthesis? Are there any seeds that could grow on Mars?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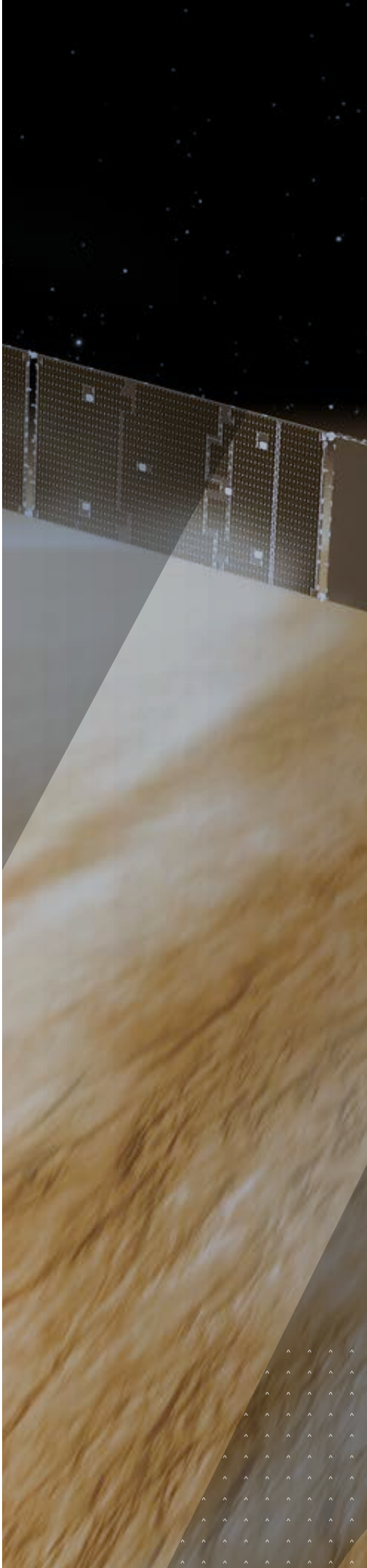

THALES

350 Longwater Avenue, Green Park,
Reading RG2 6GF
UK
+44 118 943 4500

> thalesgroup.com/uk <

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