



**British Astronomical Association**  
Supporting amateur astronomers since 1890

# Infinite Worlds

## High Flight

Oh! I have slipped the surly bonds of Earth  
And danced the skies on laughter-silvered wings;  
Sunward I've climbed, and joined the tumbling mirth  
Of sun-split clouds; — and done a hundred things  
You have not dreamed of — wheeled and soared and swung  
High in the sunlit silence. Hov'ring there,  
I've chased the shouting wind along, and flung  
My eager craft through footless halls of air . . .

Up, up the long, delirious burning blue  
I've topped the wind-swept heights with easy grace  
Where never lark, or ever eagle flew —  
And, while with silent, lifting mind I've trod  
The high untrespassed sanctity of space,  
Put out my hand, and touched the face of God.

John Gillespie Junior

The e-magazine of the  
Exoplanets Division  
Of the  
Asteroids and Remote Planets Section

Issue 4

2019 September

High Flight, written by John Gillespie Magee Junior (1922-1941) while still a teenager, is one of the world's best-known poems loved by aviators and astronauts. He was born in Shanghai, China, to an English mother and an American father. At the age of eighteen, he enlisted in the Royal Canadian Air Force, trained as a pilot, and was sent to England to fly a Supermarine Spitfire with 412 Fighter Squadron. After a high-altitude test flight, John wrote his parents a letter and enclosed a poem, this one, that the flight inspired.

Background image. Hubble Deep Field – Credit NASA/ESA.

### **Contents**

Section officers

Meetings

BBC program Sky at Night

Projects

Observations

Software

Discoveries – latest news

On-line courses

Web sites of interest

Astrobiology

Exoplanet space missions

Space

### **Section officers**

ARPS Section Director

Dr Richard Miles

Assistant Director (Astrometry)

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Assistant Director (Occultations)

Tim Haymes

Assistant Director (Exoplanets)

Roger Dymock

Exoplanet Technical Advisory Group (ETAG)

Peta Bosley, Simon Downs, George Faillace, Steve Futcher, Paul Leyland, David Pulley, Mark Salisbury, Americo Watkins

My thanks to those who have contributed to this issue.

### **BBC program – Sky at Night**

Sometime ago the BBC approached concerning an episode featuring exoplanets. We discussed various aspects including the ARIEL mission and involving the Hampshire Astronomical Group who have featured in previous episodes. Unfortunately, none of this was included in the program and amateur astronomy was written off in one sentence ‘Amateurs can’t image exoplanets’.

I wrote to the person I had been in contact with and my email and the response are shown below. A further response is awaited.

### **My email**

Just watched the Sky at Night Exoplanet program.

While it was quite interesting, I was very disappointed with the way amateur astronomers were cut out of this exciting venture in astronomy. While it is true that amateurs cannot image exoplanets directly, they can image exoplanet transits. This can be done with relatively

small telescopes and even DSLR cameras. The Exoplanet Transit Database at <http://var2.astro.cz/ETD/archive.php> lists numerous examples of such work.

Several astronomical organisations including the British Astronomical Association and the American Association of Variable Star Observers actively encourage amateurs to observe exoplanet transits.

I would urge you to put this matter right in a future program.

### **Response**

Thank you for your email! I'm sorry to hear that but I actually didn't work on this programme myself so I will forward your message on to the producer who did work on this. Personally, I would have liked to work with you on imaging transits.

### **Meetings**

[Asteroid and Remote Planets meeting](#) at Clanfield, Hampshire on 2019 September 29. Don't forget to book if you are come.

We also plan to hold a section meeting on the Saturday afternoon of the BAA Winchester Weekend – 2020 April 3 to 5. This event usually fills up quickly so do book early if you plan to come.

An exoplanet observing/imaging workshop is still under discussion. Possible ARIEL event.

### **Projects**

#### **Exoplanet imaging and discovery project**

<https://britastro.org/sites/default/files/Exoplanet%20imaging%20and%20discovery%20project.pdf> Mark Trapnell has kindly agreed to pilot test this. I am working on Version 2 which will include additional advice on how target observability and searching for exoplanets out of transit.

#### **Planet Hunters TESS**

The recently launched Transiting Exoplanet Survey Satellite (TESS) is providing us with a huge amount of data that lets us look for planets outside of our own Solar System, including planets that could support life. The results may even bring us closer to answering the question that we all want to answer: Are we alone in the Universe?

There is a tutorial on this project at

[https://britastro.org/sites/default/files/Planet%20hunters%20TESS\\_0.pdf](https://britastro.org/sites/default/files/Planet%20hunters%20TESS_0.pdf)

#### **Pro-am – ARIEL**

We will learn more about [ARIEL](#) and potential amateur involvement at the [Asteroid and Remote Planets meeting](#) at Clanfield, Hampshire on 2019 September 29.

A list of observable planets will be available soon but see <https://arxiv.org/pdf/1905.04959.pdf> in the meantime.

A website of interest to amateur astronomers will be based on the existing [Exoworlds Spies](#) website.

## Observations

Paul Leyland suggests that would-be observers may be encouraged by reading of a (semi-)successful observation and be motivated to take up observations themselves. I totally agree with Paul – don't worry about whether your observations/results are not as good as they should be as there is always someone willing to guide you on to the right track. When making my first visual measurements of asteroid magnitudes in the dim and distant past I was very nervous about sending them in to the ARPS Director. No email in those days so it was all pen and paper on the pre-printed report forms.

## Observation of a Transit of the Exoplanet WASP-65b.

Paul C Leyland\*

**Abstract:** A transit of the hot-Jupiter WASP-65b was observed with the 0.4m Dilworth-Relay telescope at Tacande Observatory in La Palma. Despite a severe equipment malfunction, it was possible to measure a transit duration of  $168 \pm 6$  minutes and a transit depth of  $0.011 \pm 0.1$  magnitudes.

WASP-65b is a hot-Jupiter in a 2.31 day orbit around a  $V=11.9$  magnitude G6 main sequence star with J2000 coordinates 08h53m17.83s, +08°31'22.8". It was discovered in 2011 by Gomez *et al.*<sup>1</sup>

The transit of WASP-65b on 2019-03-08/09 (HJD 2458551.5) was observed with the 0.4m Dilworth-Relay telescope at Tacande Observatory (MPC code J22) in La Palma. This was the first complete observation of an exoplanetary transit undertaken by the author. Some 233 images were taken with an unfiltered SBIG-8 CCD camera cooled to -25C. Exposures were of 50 seconds each with a cadence of approximately one minute. UCAC4 494-051671 and UCAC4 493-053082 were used as comparison and check stars respectively. The raw measurements have been submitted to the BAA-VSS database.

The Exoplanet Transit Database facility<sup>2</sup> at <http://var2.astro.cz/ETD/> was used to analyze the observational data. The figures and table below are taken with permission from that site. In Figure 1 the upper light curve depicts the raw data; the lower shows the result after de-trending by removing constant and linear terms. In each case, the x-axis gives MJD = JD-2458551 and the computed light curve is given by the continuous line. At times between MJD = 0.52 and 0.54 the observatory dome failed to track the motion of the telescope, resulting in the spurious peaks in the light curves. The gap in the data at near MJD = 0.55 was when the dome controller was being reset. Residuals from the fitted light curve are shown in Figure 2.

The derived quantities are given in Table 1. Literature values, also taken from reference 2, are that the transit depth is 0.0138 magnitudes and the duration is 164.1 minutes. In light of the severe equipment malfunction, the agreement between these and the present measurements is regarded as satisfactory.

JD mid-transit:	$2458551.54409 \pm 0.00192$
HJD mid-transit:	$2458551.54874 \pm 0.00192$ <sup>[OBJ]</sup>
UT mid-transit:	2019-03-09 01:03:29
Duration:	$168.3 \pm 6.1$ <sup>[OBJ]</sup> minutes
Depth: mag	$0.0108 \pm 0.0011$

**Table 1**

\* Correspondence address: 19a Hauxton Road, Little Shelford, Cambridge, CB22 5HJ, United Kingdom. Email: [paul@brnikat.com](mailto:paul@brnikat.com).

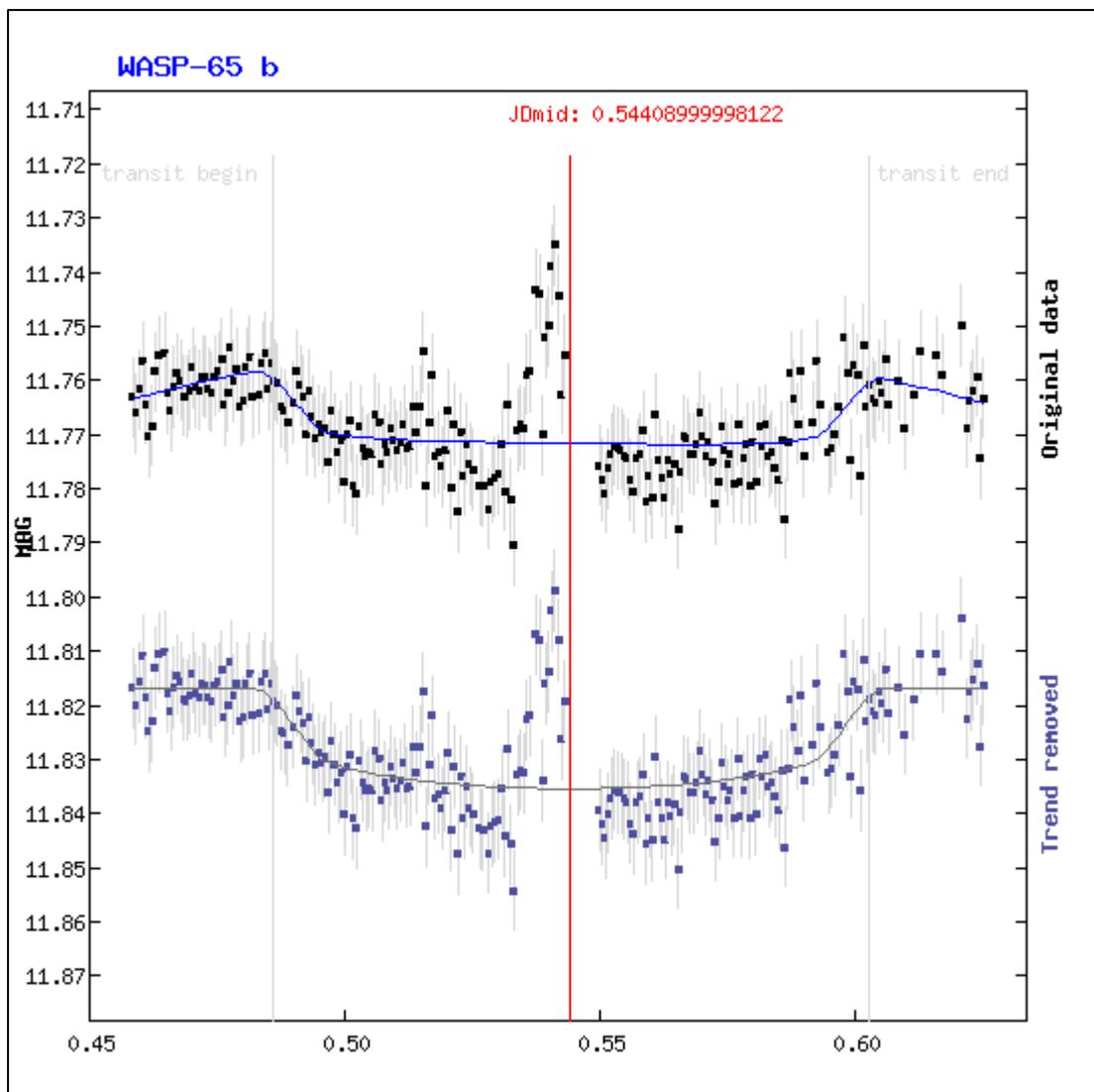


Figure 1

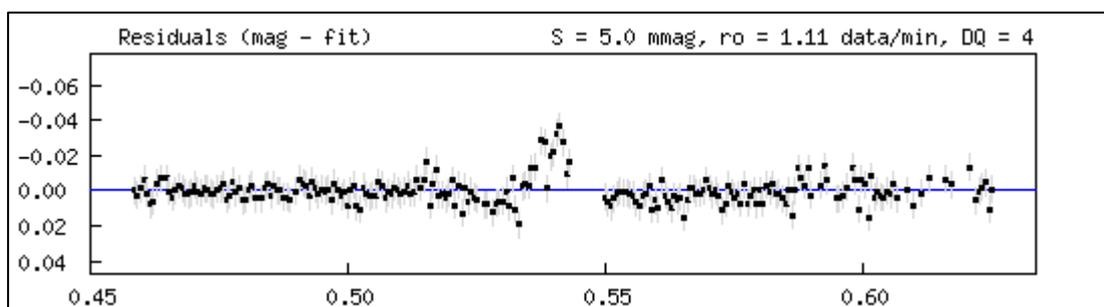


Figure 2

## References:

- 1 Y. Gómez Maqueo Chew, *et al.* (2013), "Discovery of WASP-65b and WASP-75b: Two Hot Jupiters Without Highly Inflated Radii", *Astron. & Astrophys.*, **559**, A36.
- 2 Poddany S., Brat L., Pejcha O., (2010), "Exoplanet Transit Database. Reduction and processing of the photometric data of exoplanet transits", *New Astronomy* **15**, 297-301 (arXiv:0909.2548v1).

## Software

### **EXOFASTv2**

Advised by Eric Watkins - EXOFASTv2: A public, generalized, publication-quality exoplanet modelling code - <https://arxiv.org/pdf/1907.09480.pdf>

We present the next generation public exoplanet fitting software, EXOFASTv2. It is capable of fitting an arbitrary number of planets, radial velocity data sets, astrometric data sets, and/or transits observed with any combination of wavelengths. We model the star simultaneously in the fit and provide several state-of-the-art ways to constrain its properties, including taking advantage of the now-ubiquitous all-sky catalog photometry and Gaia parallaxes.

EXOFASTv2 can model the star by itself, too. Multi-planet systems are modelled self-consistently with the same underlying stellar mass that defines their semi-major axes through Kepler's law and the planetary period. Transit timing, duration, and depth variations can be modelled with a simple command line option.

We explain our methodology and rationale as well as provide an improved version of the core transit model that is both 25% faster and more accurate. We highlight several potential pitfalls in exoplanet modelling, including the handling of eccentricity in transit-only fits, that the standard exoplanet convention for  $\omega$  uses a left-handed coordinate system, contrary to most modern textbooks, how to avoid an important degeneracy when allowing negative companion masses, and a widely unappreciated, potential 10-minute ambiguity in the reported transit times.

EXOFASTv2 is available at this [https URL](https://www.cfa.harvard.edu/~avanderb/tutorial/tutorial.html) . The code is written in IDL, and includes an executable that can be run freely and legally without an IDL license or any knowledge of the language. Extensive documentation and tutorials are included in the distribution for a variety of example fits. Advanced amateurs and undergrads have successfully performed sophisticated global fits of complex planetary systems with EXOFASTv2. It is therefore a powerful tool for education and outreach as well as the broader professional community.

### **Kepler and K2 data analysis**

A Transit Light curve Tutorial for analysing Kepler and K2 data using the on-line program is available at <https://www.cfa.harvard.edu/~avanderb/tutorial/tutorial.html>

## Discoveries – latest news

### **L98-59b**

NASA's Transiting Exoplanet Survey Satellite (TESS) has found its smallest planet yet - smaller than Earth, larger than Mars. <https://exoplanets.nasa.gov/news/1587/tess-finds-its-smallest-planet-yet/>



The three planets discovered in the L98-59 system by TESS. Credit: NASA's Goddard Space Flight Center

See also the NASA Exoplanet Archive at

[https://exoplanetarchive.ipac.caltech.edu/docs/exonews\\_archive.html#29Aug](https://exoplanetarchive.ipac.caltech.edu/docs/exonews_archive.html#29Aug) for details of recently discovered exoplanets.

### **Teegarden's star**

An international research team led by the University of Göttingen has discovered two new Earth-like planets near one of our closest neighbouring stars. Teegarden's star is only about 12.5 light-years away from Earth and is one of the smallest known stars. It is only about 2,700 °C warm and about ten times lighter than the Sun. Paper at <https://arxiv.org/pdf/1906.07196.pdf> CARMENES, mentioned in the paper is the Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-Infrared and optical Echelle Spectrographs - <https://carmenes.caha.es/index.html> A list of their discoveries can be found at <https://carmenes.caha.es/ext/science/index.html#anchor:planets>

### **K2-18b**



Artist's impression of K2-18b  
Credit ESA/Hubble, M. Kornmesser

The host star is an M2.5 red dwarf and its associated exoplanet was discovered by Kepler in 2015.

Using data from the NASA/ESA Hubble Space Telescope, water vapour has been detected in the atmosphere of a super-Earth within the habitable zone by University College London (UCL) researchers in a world first. K2-18b, which is eight times the mass of Earth, is now the only planet orbiting a star outside the Solar System, or exoplanet, known to have both water and temperatures that could support life - <https://sci.esa.int/web/hubble/-/hubble-finds-water-vapour-on-habitable-zone-exoplanet-for-the-first-time-heic1916>- The relevant paper is published in Nature Astronomy - <https://www.nature.com/articles/s41550-019-0878-9> The UCL Centre for Space Exochemistry Data is here - <https://www.ucl.ac.uk/space-exochemistry-data/>

### **On-line courses**

**Imagining Other Earths** <https://www.coursera.org/learn/life-on-other-planets>

Are we alone? This course introduces core concepts in astronomy, biology, and planetary science that enable the student to speculate scientifically about this profound question and invent their own solar systems. All the features of this course are available for free. It does not offer a certificate upon completion.

**Emergence of Life** <https://www.coursera.org/learn/emergence-of-life>

How did life emerge on Earth? How have life and Earth co-evolved through geological time? Is life elsewhere in the universe? Take a look through the 4-billion-year history of life on Earth through the lens of the modern Tree of Life! This course will evaluate the entire history of life on Earth within the context of our cutting-edge understanding of the Tree of Life. The influence of Earth system processes (meteor impacts, volcanoes, ice sheets) on shaping and structuring the Tree of Life This synthesis emphasizes the universality of the emergence of life as a prelude for the search for extra-terrestrial life.

**Our Earth: Its Climate, History and Processes** <https://www.coursera.org/learn/our-earth>

Develop a greater appreciation for how the air, water, land, and life formed and have interacted over the last 4.5 billion years.

### **Web sites of interest**

**UCL Centre for ~Space Exochemistry Data** - <https://www.ucl.ac.uk/space-exochemistry-data/> The Centre for Space Exochemistry Data (CSED) is an interdisciplinary hub that will take exoplanet science and astrochemical research to a new level by facilitating connections between observational data from space missions, deep learning techniques and quantum physics modelling of complex molecules.

**Interstellar Research Centre** - <https://www.interstellarresearchcentre.com/>

An organisation with wide ranging objectives. From their website; Our physicists, mathematicians, astronomers and engineers are interested in a broad range of problems that we typically refer to as the big questions of life, the Universe and everything. What unites us is using the tools of scientific enquiry to create our hypothesis upon which our theories are based. However, we are also not afraid to perturb accepted notions of thought so as to push into new paradigms of knowledge.

“The only way of discovering the limits of the possible is to venture a little way past them into the impossible.” Arthur C Clarke.

## Astrobiology

### **Life on Mars?**

Do the methane ‘spikes’ detected by NASA’s Mars rover Curiosity indicate the presence of life? Methanogens are a group of well-studied single-celled microorganisms on Earth that can thrive in oxygen-deprived environments (in fact, oxygen can be toxic to many of these microbes). They live in wet places (like marshes) and populate the digestive tracts of animals generating methane as they metabolize carbon dioxide and molecular hydrogen for energy. There are also nonbiological, geochemical production mechanisms, however. For example, should water react with the minerals in rock, serpentinization may occur, from which methane is a by-product - <https://www.nasa.gov/feature/jpl/curiosity-detects-unusually-high-methane-levels>

### **3D-printed skin and bone for humans to Mars**

3D printing human tissue could help keep astronauts healthy all the way to Mars. An ESA project has produced its first bio printed skin and bone samples - [http://www.esa.int/Our\\_Activities/Space\\_Engineering\\_Technology/Up-side-down\\_3D-printed\\_skin\\_and\\_bone\\_for\\_humans\\_to\\_Mars](http://www.esa.int/Our_Activities/Space_Engineering_Technology/Up-side-down_3D-printed_skin_and_bone_for_humans_to_Mars)

## Exoplanet missions

### **Characterising Exoplanet Satellite (CHEOPS)**

ESA’s satellite to investigate the structure of exoplanets between the sizes of Earth and Neptune using ultrahigh precision transit photometry will launch between 2019 October 15 and November 14 - <https://sci.esa.int/web/cheops/-/61469-how-cheops-will-investigate-planet-hosting-stars>

## Space

Journeying, even to the exoplanet, is going to considerably exceed the ‘One giant leap for mankind’. One can but be hopeful as there is renewed interest in exploring the Solar system and beyond be it robotically or by humans. There is much more going on than included here so let’s look at these stepping stones to the stars.

### **Low-Earth orbit**



Sierra Nevada’s Dream Chaser spaceplane has been selected by NASA to provide cargo delivery, return and disposal services for the International Space Station - <https://www.sncorp.com/what-we-do/dream-chaser-space-vehicle/>

## **ESA Space Rider**

Initially proposed in 2016, ESA's Space Rider re-entry vehicle provides a return to Earth and landing capability that complements the existing launch options of the Ariane and Vega families. Having recently completed system and subsystem preliminary design reviews, Space Rider is advancing quickly towards the Critical design review at the end of 2019. Launched on Vega-C, Space Rider will serve as an uncrewed high-tech space laboratory operating for periods longer than two months in low orbit. It will then re-enter the Earth's atmosphere and land, returning its valuable payload to eager engineers and scientists at the landing site. After minimal refurbishment it will be ready for its next mission with new payloads and a new mission.

[http://www.esa.int/Our\\_Activities/Space\\_Transportation/Space\\_Rider\\_Europe\\_s\\_reusable\\_space\\_transport\\_system](http://www.esa.int/Our_Activities/Space_Transportation/Space_Rider_Europe_s_reusable_space_transport_system)

## **Lunar exploration**

NASA is committed to landing American astronauts, including the first woman and the next man, on the Moon by 2024. Through the agency's [Artemis](#) lunar exploration program. As the first major step to return astronauts to the Moon under Space Policy Directive-1, NASA is working with nine American companies on delivery services to the lunar surface through Commercial Lunar Payload Services (CLPS) contracts. These companies will bid on delivering science and technology payloads for NASA, including payload integration and operations, launching from Earth and landing on the surface of the Moon -

<https://www.nasa.gov/content/commercial-lunar-payload-services>

## **In-Situ Resource Utilisation (ISRU)**

Living off the land as it is more commonly known on Earth. [Planetary Resources](#) is embarking on the world's first commercial deep space exploration program. The purpose is to identify and unlock the critical water resources necessary for human expansion in space. Sourcing water is the first step to creating a civilization in space. Water is used for life support functions and can also be refined into rocket propellant. The initial mission will identify the asteroids that contain the best source of water, and will simultaneously provide the vital information needed to build a commercial mine which will harvest water for use in space.

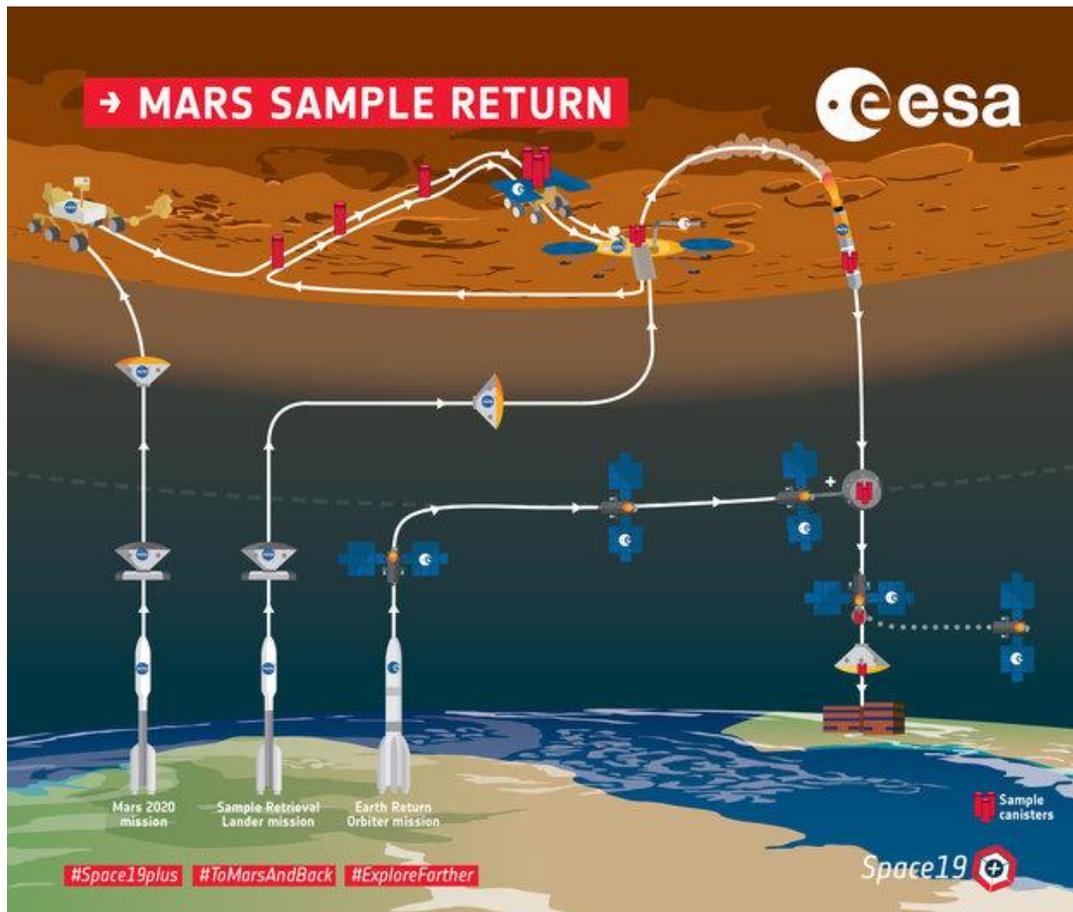
## **Mars**

### **Europe to Mars and back**

Europe has been in orbit around Mars for more than 15 years and is almost a year away from launching its first rover mission, but ambitions are already running high to go one step further: returning a sample from the Red Planet.

Mars Sample Return is a joint ESA/NASA mission to gather Martian material and return it to Earth -

[http://www.esa.int/Our\\_Activities/Human\\_and\\_Robotic\\_Exploration/Exploration/Mars\\_sample\\_return](http://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/Exploration/Mars_sample_return)



Mars Sample Return Overview

### And beyond

Lightsails have been proposed as one way of travelling interstellar distances -

<http://www.planetary.org/explore/projects/lightsail-solar-sailing/>

### Risks to human space flight

There is little known about the effects of space radiation on the human body. Astronauts cannot see or feel it, yet the high doses they are exposed to outside Earth's cocoon pose health hazards for trips to the Moon and Mars. To help investigate and find out more, European scientists can now accelerate atoms at close to the speed of light to learn how to protect astronauts -

[http://www.esa.int/Our\\_Activities/Human\\_and\\_Robotic\\_Exploration/Research/Radiation\\_sensitive](http://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/Research/Radiation_sensitive)

An astronaut on a mission to Mars could receive radiation doses up to 700 times higher than on our planet – a major showstopper for the safe exploration of our Solar System. A team of European experts is working with ESA to protect the health of future crews on their way to the Moon and beyond -

[http://www.esa.int/Our\\_Activities/Human\\_and\\_Robotic\\_Exploration/The\\_radiation\\_showstopper\\_for\\_Mars\\_exploration](http://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/The_radiation_showstopper_for_Mars_exploration)

Roger Dymock

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2019 September 13