BBC

FOCUS MAGAZINE *Collection*

VOL.03

UNKNOWN WORLDS

EARTH | OCEAN | SPACE

Journey to the centre of the Earth

The weird anatomy of a black hole

Exploring Earth's most mysterious oceans

David Attenborough on his worst-ever expedition

Hunting for exoplanets

The daring mission to colonise Mars

Deep-sea monsters lurking in the abyss

Inside the world's most deadly volcano

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WHERE ARE ALL THE **ACTIVE SPACECRAFT** IN OUR SOLAR SYSTEM?

Since Sputnik 1 was launched in 1957, humans have sent thousands of spacecraft into the cosmos. There are currently around 50 active* craft in our Solar System. Here's where they are and what research they are doing

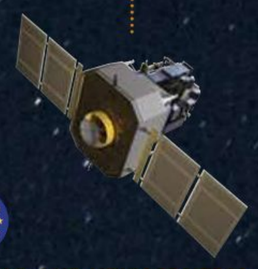
*not including miniaturised, amateur or commercial craft

INFOGRAPHIC: TIDY DESIGNS

SOLAR AND HELIOSPHERIC OBSERVATORY

The SOHO mission revolutionised our understanding of the Sun. It was the first time we'd had our closest star under near-constant surveillance. As well as providing valuable data on the Sun's magnetic activity, it also inadvertently discovered 3,000 comets as they buzzed past.

STEREO A/B (SOLAR TERRESTRIAL RELATIONS OBSERVATORY)
Building a 3D picture of storms erupting from the Sun. STEREO A is active, but contact was lost with STEREO B in 2014.



SOHO (SOLAR AND HELIOSPHERIC OBSERVATORY)
Studying the Sun's outer layers as well as the solar wind.

DISTURBANCE REDUCTION SYSTEM (DRS)
Part of a technology demonstration mission to track gravitational waves from space.

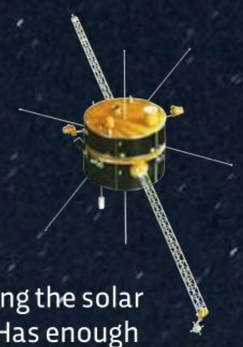
MERCURY

VENUS

SPITZER SPACE TELESCOPE
Taking infrared images of galaxies and nebulae. Most instruments have stopped working.

AKATSUKI
Studying Venus's atmosphere and cloud decks. Entered orbit in December 2015.

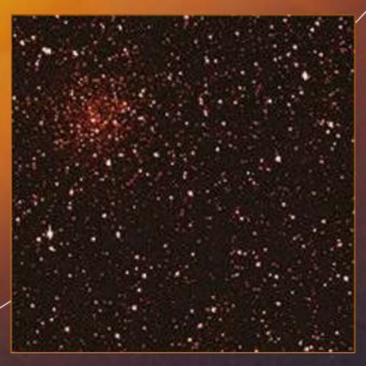
LAGRANGIAN POINT L1



WIND
Studying the solar wind. Has enough fuel to last another 53 years.

ACE (ADVANCED COMPOSITION EXPLORER)
Studying the Sun. Has enough fuel to last until 2024.

KEPLER
Detecting planets outside our Solar System, particularly those like the Earth.



KEPLER

Kepler is the king of exoplanet hunters. Since its launch in 2009, this observatory has uncovered over 2,300 alien worlds by looking for small drops in the brightness of stars as planets pass in front of them. From these 'transits', astronomers can work out the size of the planet and how far it orbits from its star – crucial to work out its temperature. Kepler's haul includes Earth-sized planets with temperatures friendly to liquid water and a world with two suns.

AKATSUKI

Many mysteries abound around Venus, and Akatsuki is the latest probe to take a closer look. It will search for lightning in the Venusian atmosphere, study the abundance and distribution of key gases and look at how the planet's heat is distributed in the lower atmosphere. And that heat is significant – Venus is the hottest planet, even though it isn't closest to the Sun. Letters from a public competition went along for the ride on engraved plates.

58 MILLION KM FROM SUN

108 MILLION KM FROM SUN

ASTROSAT
India's first multi-wavelength observatory, it is mainly monitoring the sky for X-ray events.

HIGH ENERGY TRANSIENT EXPLORER 2
Carrying out the multi-wavelength studies of gamma-ray bursts (GRBs).

PROBA-2
Exploring the miniaturisation of space technology, this spacecraft mainly observes the Sun.

XMM-NEWTON
Observing objects in both X-rays and visible light.

INTEGRAL (INTERNATIONAL GAMMA RAY ASTROPHYSICS LABORATORY)
Tracking violent events across the Universe, including black holes.

HINODE
Exploring interactions between the Sun's magnetic field and the outer solar corona.

SPEKTR-R
Studying radio sources in the Milky Way and beyond.

CHANDRA X-RAY OBSERVATORY
Making X-ray observations of objects, including black holes and supernovae.

IRIS (INTERFACE REGION IMAGING SPECTROGRAPH)
Observing the Sun in ultraviolet light, exploring the corona, chromosphere and solar wind.

HISAKI
Making ultraviolet observations of the planets' atmospheres.

EARTH

FERMI GAMMA-RAY SPACE TELESCOPE
Performing an all-sky survey of gamma-ray sources, including AGNs and pulsars.

IBEX (INTERSTELLAR BOUNDARY EXPLORER)
Mapping the boundary between the Solar System and interstellar space.

DAMPE (DARK MATTER PARTICLE EXPLORER)
Looking for high-energy phenomena possibly associated with dark matter.

NEOWISE
Scanning for potentially threatening asteroids and comets.

CLUSTER II
Studying interactions between the Earth's magnetic field and the Sun, particularly during heightened solar activity.

SDO (SOLAR DYNAMICS OBSERVATORY)
Viewing the Sun in high definition.

HUBBLE SPACE TELESCOPE
Observing the Universe, mainly in visible light.

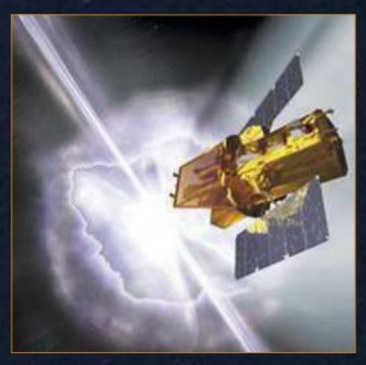
NUSTAR (NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY)
Conducting deep-sky searches for supermassive black holes.

AGILE
Observing gamma-ray sources, including gamma-ray bursts (GRBs) and active galactic nuclei (AGNs).

SWIFT GAMMA-RAY BURST MISSION
Detecting and analysing gamma-ray bursts (GRBs).

HUBBLE SPACE TELESCOPE

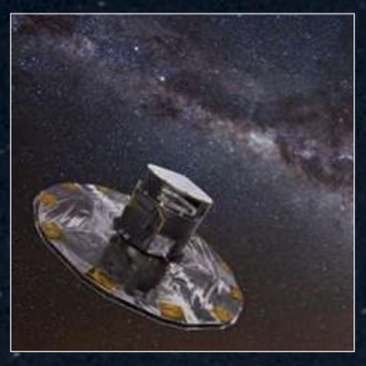
When the Hubble Space Telescope entered service in 1990, its images were found to be slightly blurry – traced back to a flaw in its primary mirror. A service mission in 1993 fixed the issue and, since then, the telescope has been beaming back spectacular images of the cosmos. The telescope's contribution to astronomy has been far-reaching, enabling scientists to pin down the age of the Universe, discover dark energy, and witness the birth of planets and stars.



SWIFT

Swift is designed to study gamma-ray bursts (GRBs) – intense, short-lived flashes of the most energetic form of light in the Universe. A real stalwart, it was launched in 2004 with an intended shelf life of two years, but is still operating today. So far it has seen over a thousand GRBs. When a cosmic explosion triggers the telescope, a text message is sent to the on-call astronomer so that they can coordinate any follow-up observations.

150 MILLION KM FROM SUN



GAIA

Gaia is an astrometry telescope with the task of measuring the positions and distances of stars in our Milky Way galaxy with unprecedented precision. Twenty million stars will be analysed to a precision of one per cent. It was launched in 2013 and in April 2018 astronomers will release the hotly anticipated second batch of data to the wider astronomical community. Gaia is also studying exoplanets and distant quasars, as well as asteroids in our own Solar System.

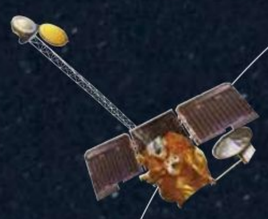
GAIA
Accurately cataloguing the positions of a billion stars.

MRO (MARS RECONNAISSANCE ORBITER)
Monitoring Martian climate and mapping future landing sites.

OPPORTUNITY
Searching Mars for signs of past water and amenable conditions for life.

MARS EXPRESS
Performing comprehensive analysis of the Martian environment.

ARTEMIS P1/P2
Studying the interaction of the solar wind with the Moon.



2001 MARS ODYSSEY
Detecting evidence of past or present water on Mars.

MAVEN (MARS ATMOSPHERE AND VOLATILE EVOLUTION MISSION)
To discover how Mars lost its atmosphere and liquid water.

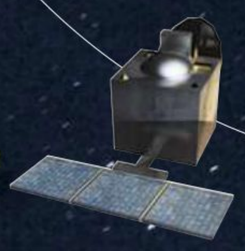
MARS

EXOMARS TRACE GAS ORBITER
Investigating the source of Martian methane.

LRO (LUNAR RECONNAISSANCE ORBITER)
Making detailed lunar maps for future manned and robotic exploration.

MOON

CURIOSITY
Assessing suitability of Martian environment for microbial life.



MARS ORBITER MISSION
Demonstrating technology for future Indian Martian mission.

HAYABUSA 2
Will survey an asteroid and return a sample to Earth. Due to arrive at asteroid 162173 Ryugu in July 2018.

CERES

VESTA

DAWN
Now orbiting the dwarf planet Ceres having already visited Vesta.

HAYABUSA 2

Its predecessor was the first time we'd returned a sample of an asteroid to Earth. However, that mission was plagued with problems, so hopefully this time things will run more smoothly and return more material for scientists to study.

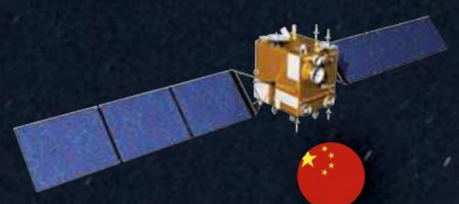
LAGRANGIAN POINT L2

DAWN

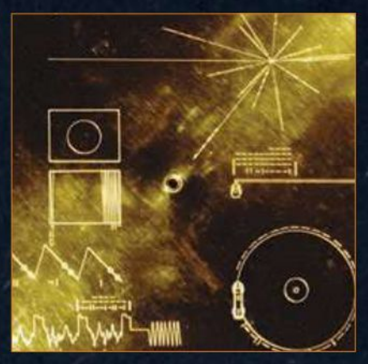
Dawn has gone down in history as the first probe to enter into orbit around two completely separate bodies in the same mission. Its innovative ion propulsion technology was key to getting in and out of the gravitational field of these two protoplanets. The white spots it has detected on Ceres suggest the possibility that there may be areas of water ice. Such missions are crucial precursors to any future attempts to mine asteroids for their wealth of resources.

150 MILLION KM FROM SUN

228 MILLION KM FROM SUN



CHANG'E 2
Exploring the Moon and asteroids. Currently 100 million kilometres from Earth.



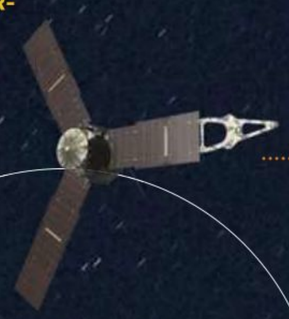
VOYAGER 1

In August 2012, it was confirmed that Voyager 1 had reached intertellar space. But it still has a long way to go before it reaches the Oort Cloud – technically still part of the Solar System. Instead, it has left the magnetic influence of the Sun, as the solar wind is lost in the winds of other nearby stars.

VOYAGER 2
Explored Jupiter, Saturn, Uranus and Neptune. Now close to interstellar space, 17.5 billion kilometres from Earth.

VOYAGER 1
Explored Jupiter and Saturn and is now in interstellar space some 21 billion kilometres from Earth.

JUNO (JUPITER NEAR-POLAR ORBITER)
Arrived at Jupiter in July 2016. Now exploring the gas giant's composition, magnetism and gravity.



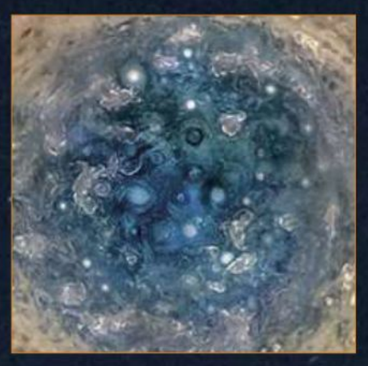
JUPITER

SATURN

URANUS

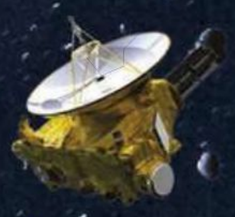
NEPTUNE

PLUTO



JUNO

Since arriving at Jupiter in the summer of 2016, Juno has sent back stunning high-definition images of the Solar System's largest planet. Its scientific objectives include exploring Jupiter's composition, investigating the existence of a solid core, and deciphering why the planet's Great Red Spot is shrinking. Three aluminium Lego figures were carried along for the ride – one of the Roman God Jupiter, his wife Juno and Galileo, the first astronomer to observe the planet through a telescope.



NEW HORIZONS
Explored Pluto and is now heading for the Kuiper Belt object 2014 MU69.

OSIRIS-REX
Will arrive at the asteroid 101955 Bennu in 2023 and return a sample to Earth.

CURIOSITY

As planetary missions go, few are as daring as Curiosity. Previous Martian rovers had been lowered onto the Martian surface inside inflatable balls, which slowly deflated to leave the machine to roll out onto Mars. But Curiosity was gently lowered onto the surface via an intricate 'sky crane'. Curiosity has now experienced two full cycles of the Martian seasons. At time of writing, it was exploring Vera Rubin Ridge on the northwestern flank of lower Mount Sharp.

NEW HORIZONS

When the mission set off in early 2006, the world it was heading to was still a planet. Later that year, however, Pluto was downgraded to dwarf planet status. New Horizons finally ended its nine-year journey to the Kuiper Belt in 2015. For the first time, we had crisp, close-up images of Pluto. Scientists were left baffled by its smooth, crater-free surface, suggesting it must have some kind of geological activity that constantly re-sculpts its surface.

779 MILLION KM FROM SUN

1.43 BILLION KM FROM SUN

2.87 BILLION KM FROM SUN

4.50 BILLION KM FROM SUN

5.91 BILLION KM FROM SUN

The James Webb Space Telescope (JWST) is due to launch later this year

FUTURE MISSIONS

The big missions due for launch over the next few years that will explore our Solar System and beyond

WORDS: **JHENI OSMAN**

TESS

TARGET **Exoplanets**
LAUNCH DATE **March 2018**

NASA's new telescope **TESS** (**Transiting Exoplanet Survey Satellite**) will hunt for planets outside of our Solar System. We currently know of 3,584 exoplanets, with a new one discovered virtually every week. Unlike its predecessor the Kepler space telescope which studied some 150,000 distant stars, TESS will scan the whole sky, and is expected to find some 20,000 candidates in its first two years.

PARKER SOLAR PROBE

TARGET **The Sun**
LAUNCH DATE **Summer 2018**

NASA's **Parker Solar Probe** will venture closer to the Sun than any spacecraft has ever gone before – 'diving' in and out of its atmosphere, known as the corona. Its main goal is to analyse the solar wind – a continuous stream of electrified gas (plasma) launched from the Sun's atmosphere into space. Knowing more about the solar wind should help to protect the technology that we rely on day to day – such as sat-navs, telecommunications and power stations.

NASA/ATLAS

BEPICOLOMBO

TARGET **Mercury**
LAUNCH DATE **October 2018**

ESA's **BepiColombo** will study the innermost planet in our Solar System. Studying Mercury from Earth or an Earth-orbiting telescope is difficult, because it always appears close to the Sun in the sky. And it's tough to get there, basically because the planet's orbital speed is much higher than Earth's – it orbits the Sun at 48km/s on average. The space-craft's main orbiter will be wrapped in thick thermal blankets to cope with 10 times more solar energy than in Earth orbit and intense infrared radiation – Mercury's surface is a toasty 430°C. The mission hopes to find out more about the solar wind, and investigate the planet's large iron-nickel core, its sodium-rich 'exosphere', the origin of its polar ice deposits and its mysterious magnetic field.

JWST

TARGET **From exoplanets to deep space**
LAUNCH DATE **October 2018**

The largest and most advanced orbital observatory ever built, NASA's **James Webb Space Telescope** (**JWST**) will look at the Universe in infrared, allowing us to see a side of the cosmos that has been largely hidden. It will peer through the veils of dust around stars and catch light that has been travelling since the start of the cosmos, investigating all sorts, from the smallest to the largest things in our Universe.

CHEOPS

TARGET **Exoplanets**
LAUNCH DATE **Late 2018**

ESA's **CHaracterising ExOPlanets Satellite** (**CHEOPS**) will improve our current understanding of how exoplanets form. By measuring a planet's size and mass, scientists hope to work out its composition, such as whether it is gaseous or rocky.

SOLAR ORBITER

TARGET **The Sun and inner heliosphere**
LAUNCH DATE **February 2019**

ESA's **Solar Orbiter** will study the Sun and the inner heliosphere – the uncharted innermost regions of our Solar System. The spacecraft will orbit the Sun at a distance of 60 solar radii, braving its fierce heat to provide unique data and images of our star.

LUCY

TARGET **Jupiter's 'trojans'**
LAUNCH DATE **2021**

NASA's **Lucy** spacecraft will tour Jupiter's 6,000-plus 'trojans' – asteroids which share the planet's orbit. The hope is that the mission will reveal clues as to how planets and other bodies in our Solar System formed.

PSYCHE

TARGET **16 Psyche**
LAUNCH DATE **2022**

NASA's **Psyche** spacecraft will journey to the unique metal asteroid 16 Psyche, which orbits the Sun between Mars and Jupiter. It's thought to be the exposed nickel-iron core of an early planet, so the mission hopes to investigate the origin of planetary cores.

PLATO

TARGET **Exoplanets**
LAUNCH DATE **2026**

ESA's **PLAnetary Transits and Oscillations** of stars (**PLATO**) craft will hunt for extrasolar planetary systems, and explore the properties of terrestrial planets in the 'habitable zone' – the region around a star where the conditions could be 'just right' for life.