Exploring the Solar System II – Spacecraft

How Do We Get There?

What Do We Do Then?

How Do We Get Images Back?

What Next?

70 Years of Spacecraft

Sputnik 1
Sputnik 2
Explorer 1
Vanguard 1
Luna 1
Pioneer 4
Luna 2
Luna 3
Pioneer 5
Venera 1
Vostok 1
Ranger 1
Ranger 2
Ranger 3
Ranger 4
Mariner 2
Ranger 5
Mars 1
Luna 4
Cosmos 21
Ranger 6
Zond 1
Ranger 7
Voskhod 1
Mariner 3
Mariner 4
Zond 2
Ranger 8
Voskhod 2
Ranger 9
Luna 5
Luna 6
Zond 3
Luna 7
Venera 2
Venera 3
Luna 8
Pioneer 6
Luna 9

Luna 10
Surveyor 1
Explorer 33
Lunar Orbiter 1
Pioneer 7
Luna 11
Surveyor 2
Luna 12
Lunar Orbiter 2
Luna 13
Lunar Orbiter 3
Surveyor 3
Lunar Orbiter 4
Venera 4
Mariner 5
Surveyor 4
Explorer 35
Lunar Orbiter 5
Surveyor 5
Surveyor 6
Apollo 4
Pioneer 8
Surveyor 7
Apollo 5
Zond 4
Luna 14
Zond 5
Apollo 7
Pioneer 9
Zond 6
Apollo 8
Venera 5
Venera 6
Mariner 6
Apollo 9
Mariner 7
Apollo 10
Luna 15
Apollo 11

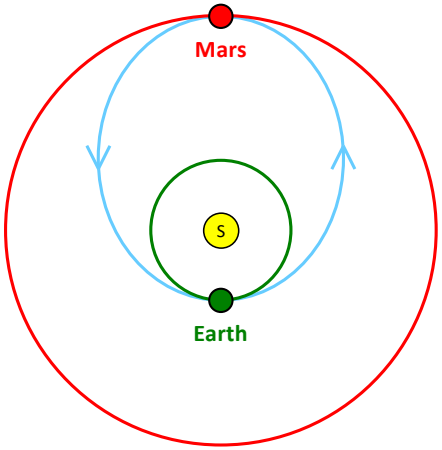
Zond 7
Apollo 12
Apollo 13
Venera 7
Luna 16
Zond 8
Luna 17
Apollo 14
Salyut 1
Mars 2
Mars 3
Mariner 9
Apollo 15
Luna 18
Luna 19
Luna 20
Pioneer 10
Venera 8
Apollo 16
Apollo 17
Luna 21
Pioneer 11
Explorer 49
Mars 4
Mars 5
Mars 6
Mars 7
Mariner 10
Luna 22
Luna 23
Helios-A
Venera 9
Venera 10
Viking 1
Viking 2
Helios-B
Luna 24
Voyager 2
Voyager 1

Pioneer Venus 1
Pioneer Venus 2
ISEE-3
Venera 11
Venera 12
Venera 13
Venera 14
Venera 15
Venera 16
Vega 1
Vega 2
Sakigake
Giotto
Suisei
Phobos 1
Phobos 2
Magellan
Galileo
Hiten
Ulysses
Yohkoh
Mars Observer
Clementine
WIND
SOHO
NEAR Shoemaker
Mars Global Surv
Mars 96
Mars Pathfinder
ACE
Cassini-Huygens
Lunar Prospector
Nozomi
Deep Space 1
Mars Climate Orb
Mars Polar Lander
Deep Space 2
Stardust
2001 Mars Odyssey

Genesis
CONTOUR
Hayabusa
Beagle 2
Spirit rover
Opportunity rover
SMART-1
Rosetta/Philae
MESSENGER
Deep Impact
Mars Reconnaiss
Venus Express
New Horizons
Hinode
STEREO
Phoenix
SELENE
Dawn
Chang'e 1
Chandrayaan-1
Lunar Reconnaiss
Solar Dynamics Obs
Akatsuki
PICARD
Chang'e 2
Juno
GRAIL
Fobos-Grunt
Yinghuo-1
Curiosity rover
Van Allen Probes
IRIS
LADEE
Hisaki
Mars Orbiter
MAVEN
Chang'e 3
Chang'e 5-T1
Hayabusa2

PROCYON
DSCOVR
ExoMars
OSIRIS-REx
InSight
Queqiao
Parker Solar Probe
BepiColombo
Chang'e 4
Beresheet
Chandrayaan-2
Solar Orbiter
Mars Hope
Zhurong rover
Perseverance rover
Chang'e 5
Lucy
DART
CAPSTONE
Danuri
Artemis 1
Hakuto-R 1
JUICE
Chandrayaan-3
Luna 25
Aditya-L1
SLIM
Psyche
Peregrine One
Nova-C Odysseus
DRO A/B
Queqiao-2
Chang'e 6
Hera
Europa Clipper

From Earth To Mars



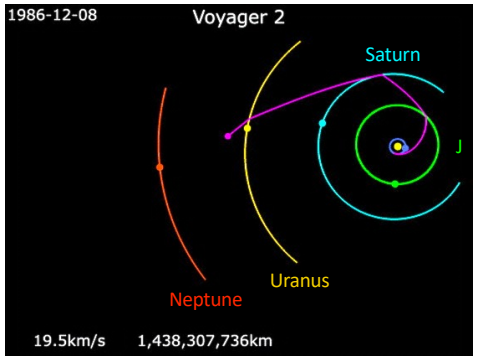
Not to scale

Gravity Assists

What about getting to other planets in the solar system?

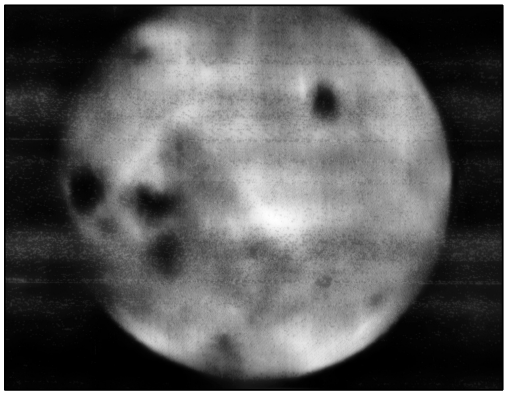
In the 1960s it was realised that flying a spacecraft close to a planet can 'slingshot' it onwards at higher velocities.

Hence exploring the outer solar system can be carried out faster and cheaper.



Imaging Technology

Luna 3



Far side of the Moon – Oct 1959

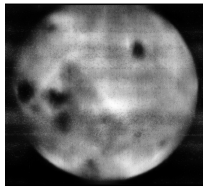
Imaging Technology

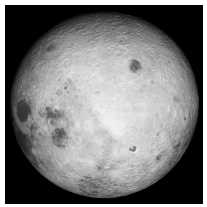
After exposure, the **film** was developed, fixed and dried.

The developed film was then **scanned** by a CRT (cathode ray tube) spot projected through the film onto a photomultiplier.

The signal from the photomultiplier was then **transmitted** to the Earth to allow an image to be constructed (like a fax machine).

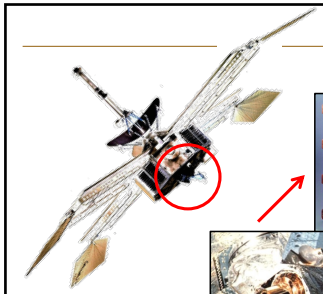
For comparison, an image taken 50 years later from the NASA Lunar Reconnaissance Orbiter (LRO).





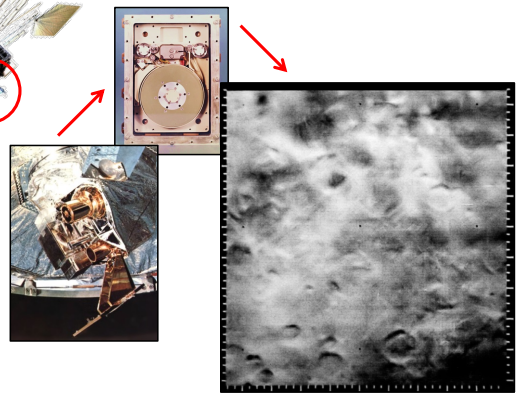
LRO 2009

Imaging Technology



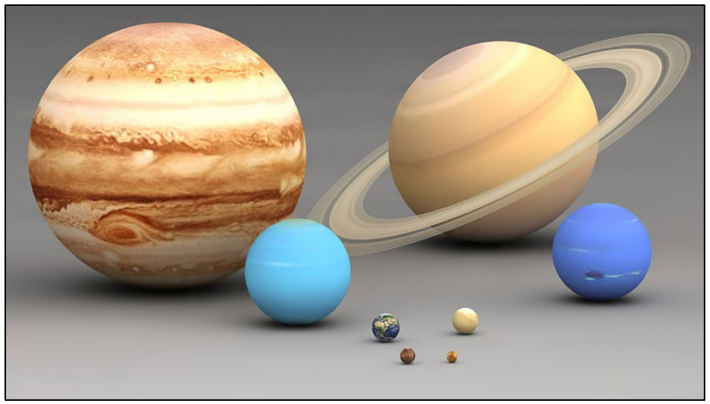
Mariner 4

World's first **digital** camera



Mars – July 1965

Planets of the Solar System



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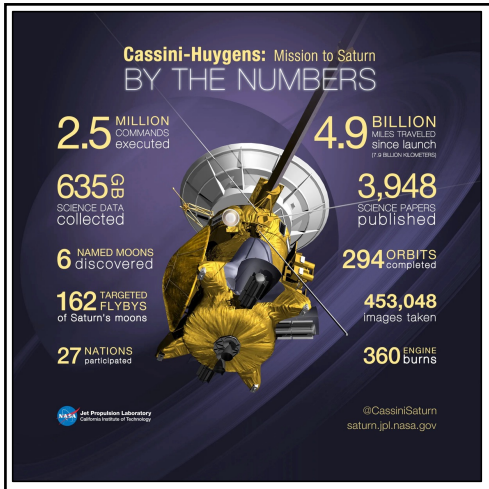
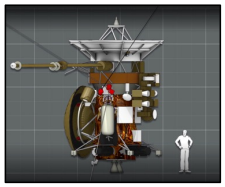
Cassini



Cassini explored Saturn and its rings and moons from 2004 until it was crashed into Saturn in 2017.



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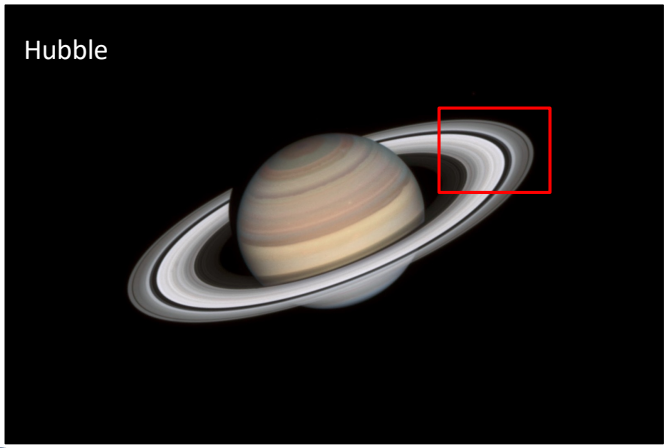
Saturn



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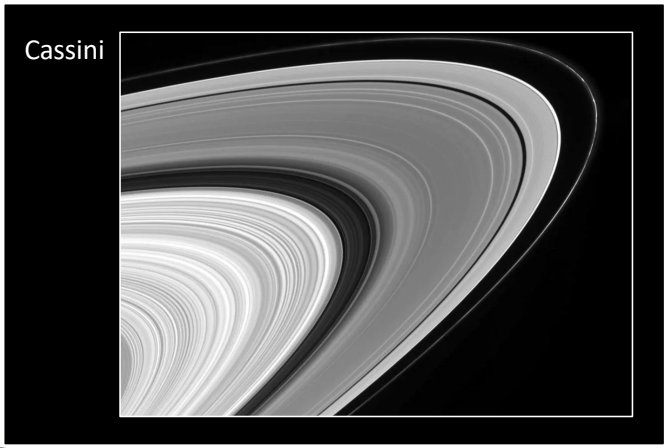
Saturn's Rings



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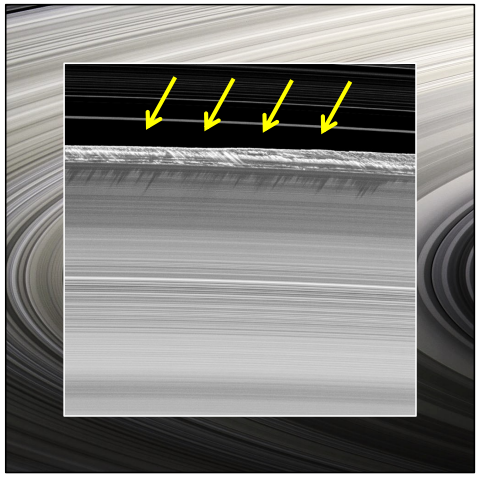
Saturn's Rings



The ring system is very flat: more than 250,000 km in diameter, but only a few metres thick.

When the Sun was in the plane of the rings, some ring particles cast long shadows.

The 'bumps' are ~ km in height.

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Saturn

Cassini took this image as it flew into Saturn's shadow – a view not possible from telescopes on Earth.

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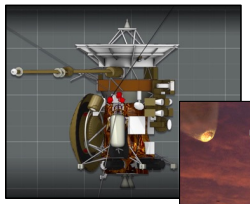
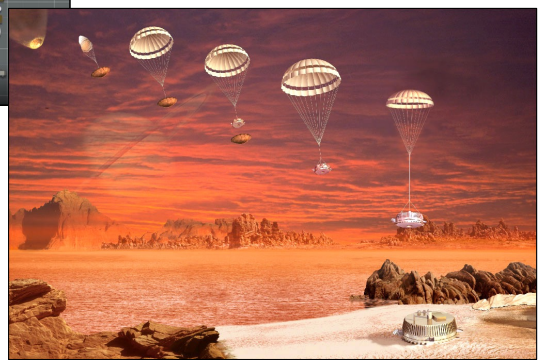
Cassini–Huygens



Huygens hitched a ride on Cassini and was released in 2005 to land on the moon Titan.



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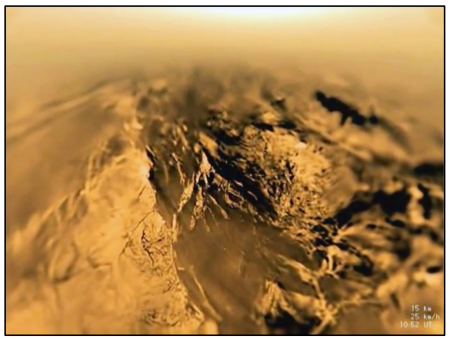
Cassini–Huygens



As the Huygens lander plunged through Titan's hazy atmosphere, it took images of a landscape of mountains and lakes.

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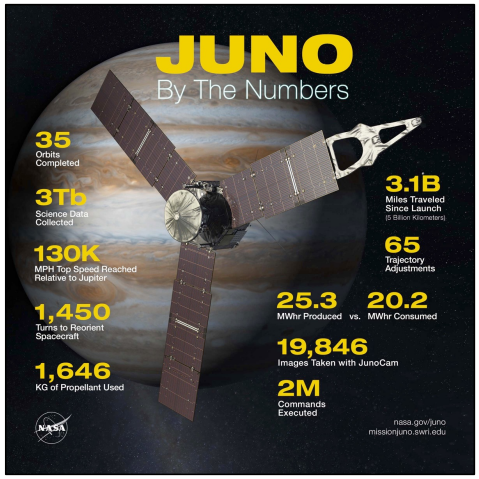
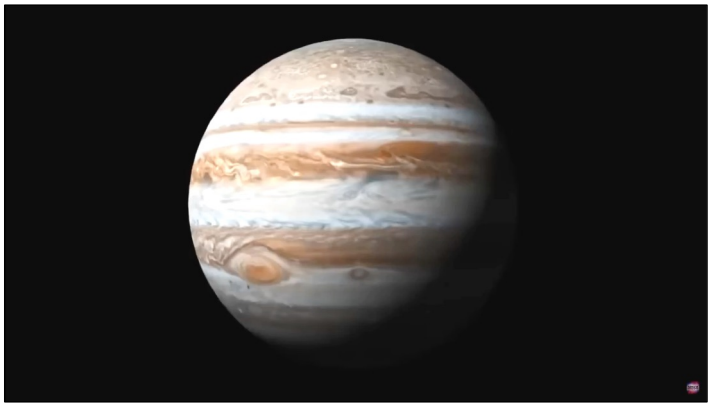
Juno



Juno arrived at Jupiter in 2016 after a five-year journey.

Unwrapping Jupiter



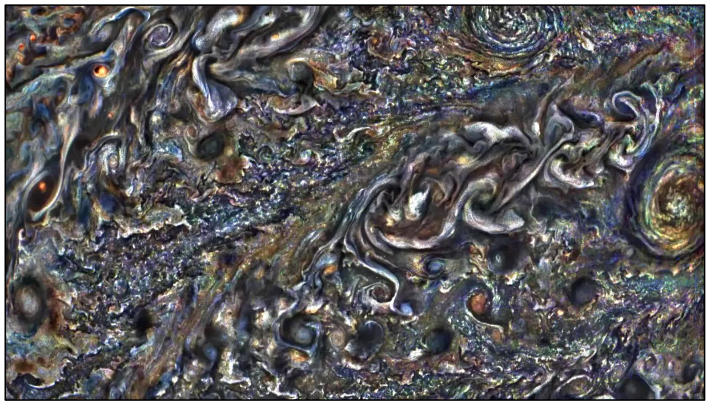
South Pole of Jupiter

Storms On Jupiter

Juno images of Jupiter's storm systems can look like watercolour paintings left out in the rain.

The dark spot is a deep vortex of swirling clouds, imaged when Juno passed only 15,000 km above the cloud tops.

Storms On Jupiter



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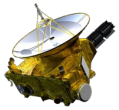
Solar System

The Solar System is not just the Sun and 8 planets



New Horizons is exploring beyond Pluto

There are also over 300 moons!

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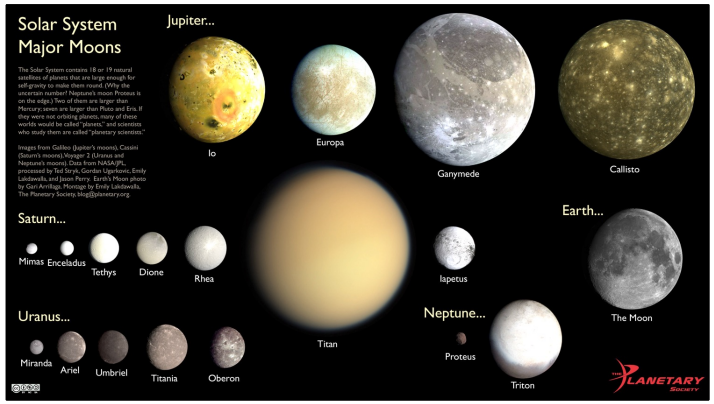
300+ Moons



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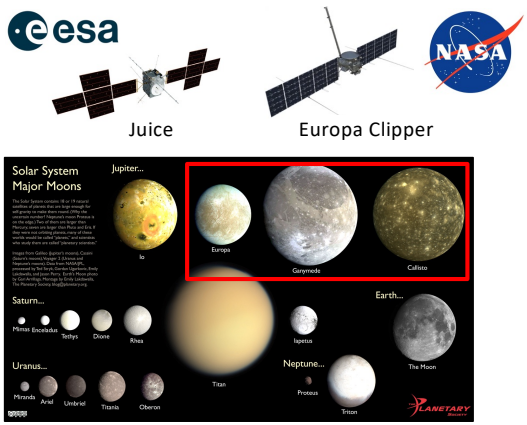
Future Missions



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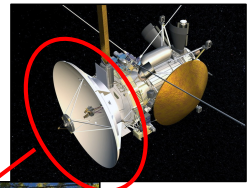
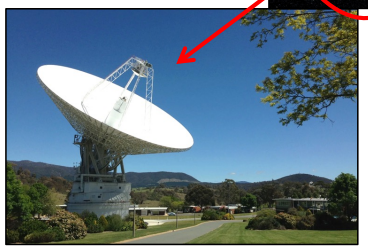
Future Communications

Data is sent back to Earth by radio using a big dish on the spacecraft ...

... and an even bigger radio dish on Earth.





Lasers would provide faster transmission and need less power.

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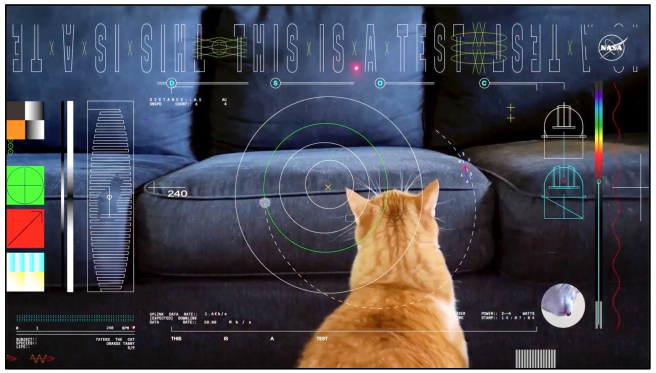
Future Communications



Laser data rates: 260 Mb/s at a distance of 50 million km
8 Mb/s at a distance of 400 million km

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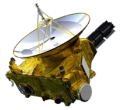
Want To Know More?

ESA.int/Science_Exploration/Space_Science/BepiColombo

science.NASA.gov/mission/cassini



science.NASA.gov/mission/new-horizons

science.NASA.gov/mission/juno

ESA.int/Science_Exploration/Space_Science/Juice

science.NASA.gov/mission/europa-clipper

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