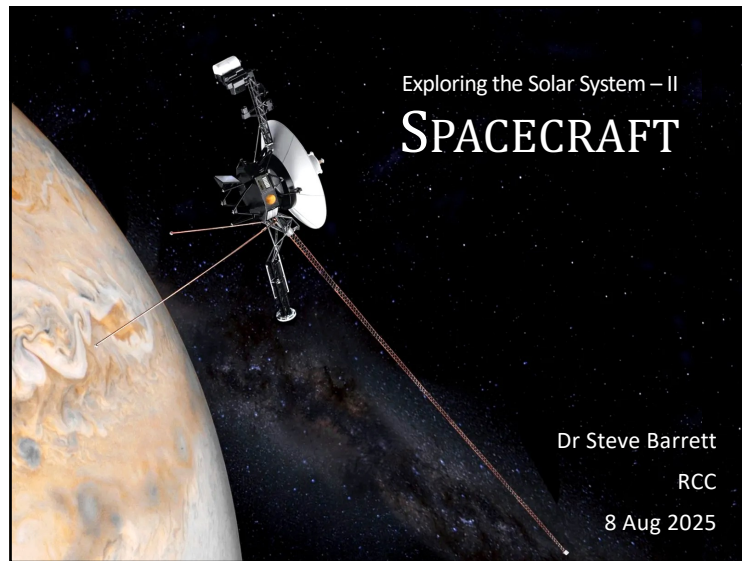


# Exploring the Solar System II – Spacecraft



## Exploring the Solar System II

## Spacecraft

How Do We Get There?

What Do We Do Then?

How Do We Get Images Back?

What Next?



2

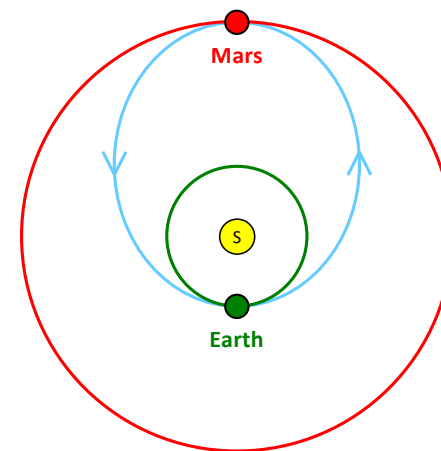
## 70 Years of Spacecraft

Sputnik 1	Luna 10	Zond 7	Pioneer Venus 1	Genesis	PROTON
Sputnik 2	Surveyor 1	Apollo 12	Pioneer Venus 2	CONTOUR	DISCOVER
Explorer 1	Explorer 33	Apollo 13	ISEE-3	Hayabusa	ExoMars
Vanguard 1	Lunar Orbiter 1	Venera 7	Venera 11	Beagle 2	OSIRIS-REx
Luna 1	Pioneer 7	Luna 16	Venera 12	Spirit rover	InSight
Pioneer 4	Luna 11	Zond 8	Venera 13	Opportunity rover	Quejiao
Luna 2	Surveyor 2	Luna 17	Venera 14	SMART-1	Parker Solar Probe
Luna 3	Luna 12	Apollo 14	Venera 15	Rosetta/Philae	BeqColombo
Pioneer 5	Lunar Orbiter 2	Venera 16	Vega 1	MESSENGER	Chang'e 4
Venera 1	Luna 13	Mars 2	Vega 2	Deep Impact	Beresheet
Vostok 1	Lunar Orbiter 3	Mars 3	Sakigake	Mars Reconnaissance	Chandrayaan-2
Ranger 1	Surveyor 3	Mariner 9	Giotto	Venus Express	Solar Orbiter
Ranger 2	Lunar Orbiter 4	Apollo 15	Suisei	New Horizons	Mars Hope
Ranger 3	Venera 4	Luna 18	Phobos 1	Hinode	Zhurong rover
Ranger 4	Mariner 5	Luna 19	Phobos 2	STEREO	Perseverance rover
Mariner 2	Surveyor 4	Luna 20	Magellan	Phoenix	Chang'e 5
Ranger 5	Explorer 35	Pioneer 10	Galileo	SELENE	Lucy
Mars 1	Lunar Orbiter 5	Venera 8	Venera 9	Dawn	CAPSTONE
Luna 4	Surveyor 5	Venera 10	Apollo 16	Chang'e 1	Dart
Cosmos 21	Surveyor 6	Apollo 17	Apollo 17	Chandrayaan-1	DAVINCI
Ranger 6	Apollo 4	Luna 21	Ulysses	Lunar Reconnaissance	Artemis 1
Zond 1	Pioneer 8	Pioneer 11	Yohkoh	Solar Dynamics Obs	HALO-1
Ranger 7	Surveyor 7	Explorer 49	Mars 4	AKARI	JUICE
Vostok 1	Apollo 1	Clementine	Mars 5	PICARD	Chandrayaan-3
Mariner 3	Zond 4	Mars 6	Mars 6	Chang'e 2	Luna 25
Mariner 4	Luna 14	Mars 7	NEAR Shoemaker	Aditya-L1	SLIM
Zond 2	Zond 5	Mariner 10	Mars Global Sur	GRAIL	Psyche
Ranger 8	Apollo 7	Luna 22	Mars 96	Fobos-Grunt	Peregrine One
Vostok 2	Surveyor 9	Zond 6	Mars Pathfinder	Curiosity rover	Nova-C
Ranger 9	Zond 6	ACE	ACE	Van Allen Probes	OSIRIS-REx
Luna 5	Apollo 8	Helios-A	Cassini-Huygens	LADEE	Chang'e 6
Luna 6	Venera 5	Venera 9	Lunar Prospector	Hiaki	Hera
Zond 3	Venera 6	Mariner 6	Nozomi	Mars Orbiter	Europa Clipper
Luna 7	Mariner 7	Viking 1	Deep Space 1	MAVEN	
Venera 2	Apollo 9	Viking 2	Mars Climate Orb	Chang'e 3	
Venera 3	Mariner 7	Helios-8	Mars Polar Lander	Chang'e 4	
Luna 8	Apollo 10	Luna 24	Deep Space 2	Chang'e 5-T1	
Pioneer 6	Luna 15	Voyager 2	Stardust	Hayabusa2	
Luna 9	Apollo 11	Voyager 1	2001 Mars Odyssey		



3

## From Earth To Mars



Not to scale



4

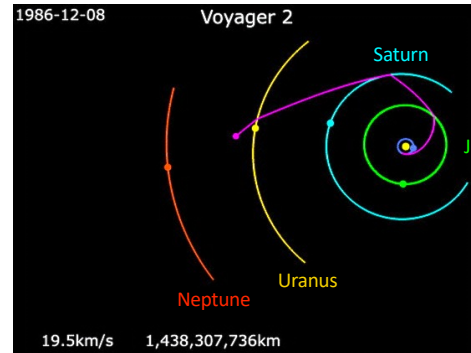
# Exploring the Solar System II – Spacecraft

## Gravity Assists

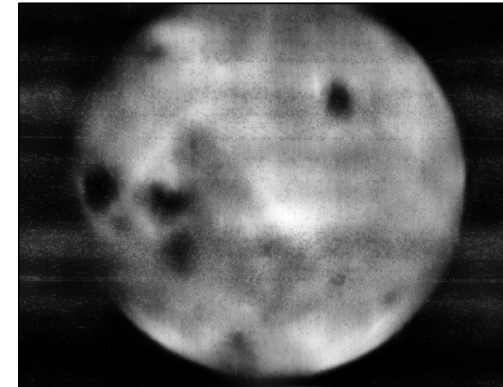
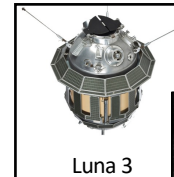
What about getting to other planets in the solar system?

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



Far side of the Moon – Oct 1959

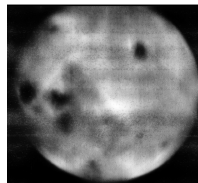
## Imaging Technology

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.

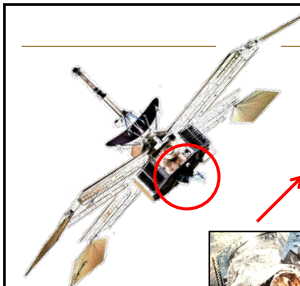
The signal from the photomultiplier was then **transmitted** to the Earth to allow an image to be constructed (like a fax machine).

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

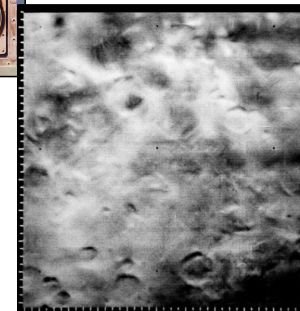


LRO 2009

## Imaging Technology



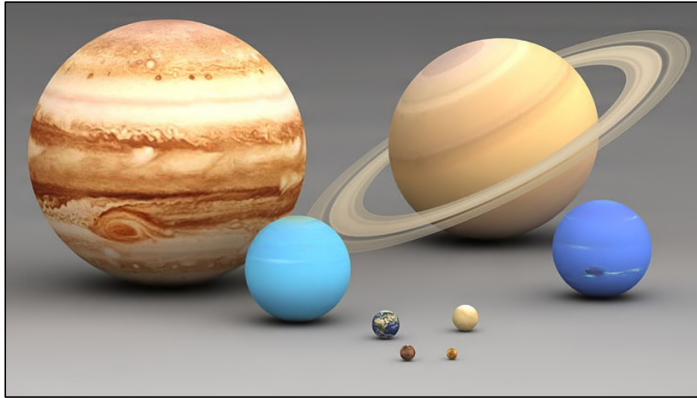
World's first **digital** camera



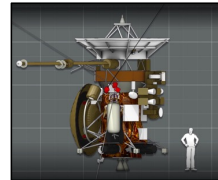
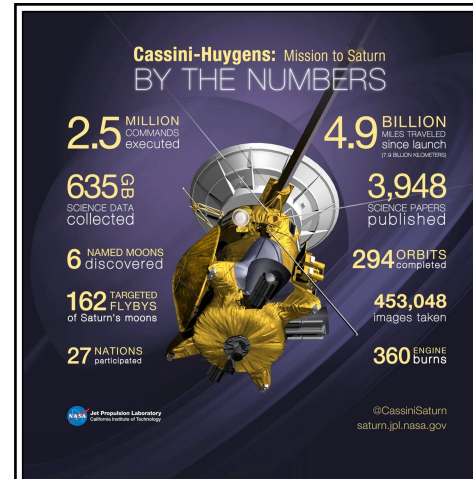
Mars – July 1965

# Exploring the Solar System II – Spacecraft

## Planets of the Solar System

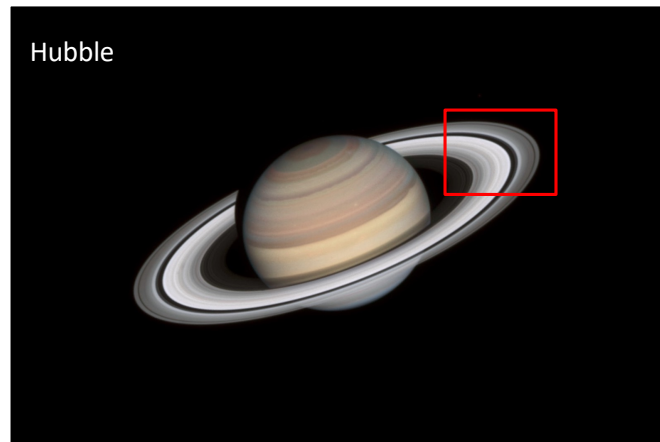


## Cassini

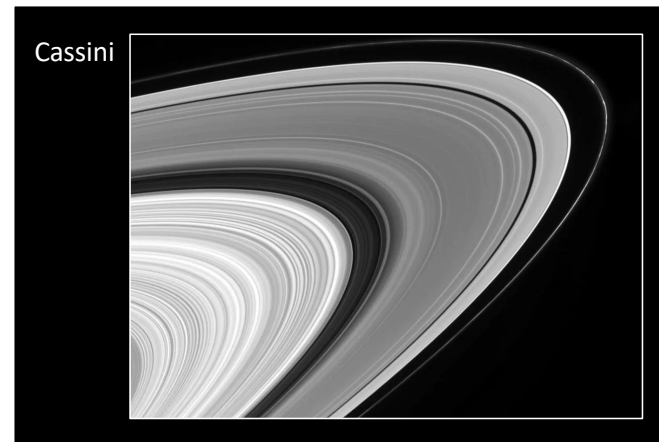


Cassini explored Saturn and its rings and moons from 2004 until it was crashed into Saturn in 2017.

## Saturn

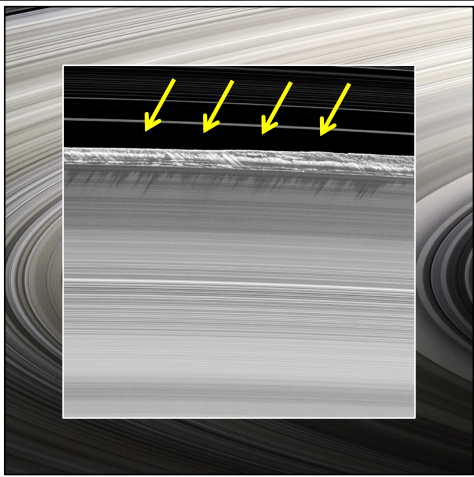


## Saturn's Rings



# Exploring the Solar System II – Spacecraft

## 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

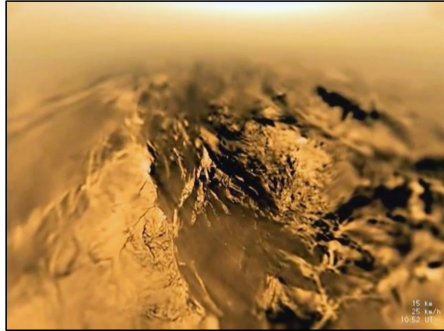


Huygens hitched a ride on Cassini and was released in 2005 to land on the moon Titan.

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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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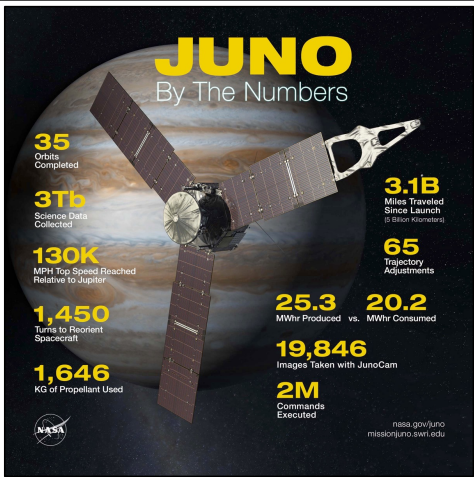
16



# Exploring the Solar System II – Spacecraft

## Juno

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



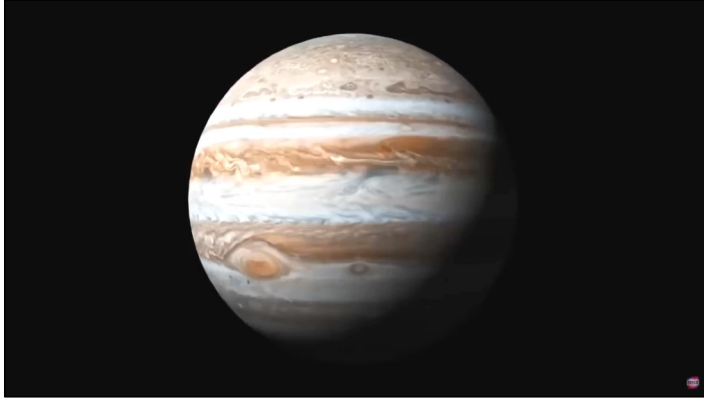
**35** Orbits Completed  
**3Tb** Science Data Collected  
**130K** MPH Top Speed Reached Relative to Jupiter  
**1,450** Turns to Reorient Spacecraft  
**1,646** KG of Propellant Used  
**3.1B** Miles Traveled Since Launch (5 Billion Kilometers)  
**65** Trajectory Adjustments  
**25.3** MWhr Produced vs. **20.2** MWhr Consumed  
**19,846** Images Taken with JunoCam  
**2M** Commands Executed

[nasa.gov/juno](http://nasa.gov/juno)  
[mission@uno.swin.edu](mailto:mission@uno.swin.edu)

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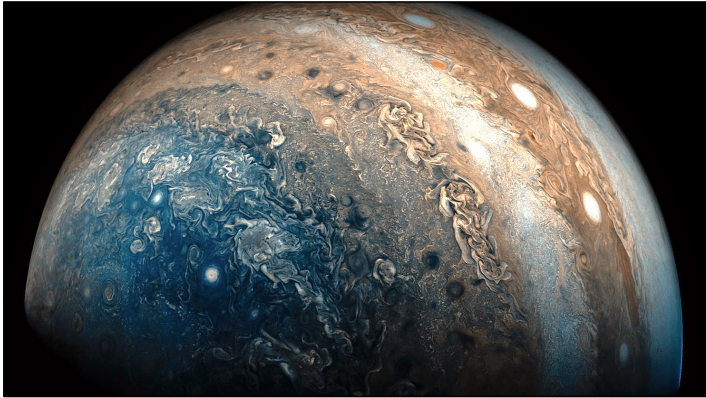
## Unwrapping Jupiter



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## South Pole of Jupiter




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## 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.

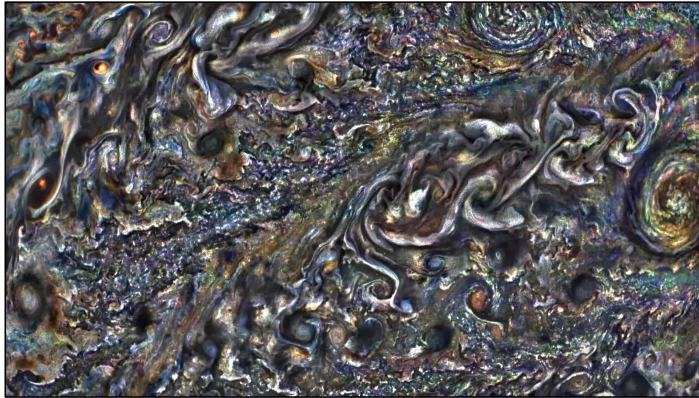


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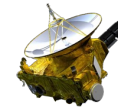
# Exploring the Solar System II – Spacecraft

## Storms On Jupiter



## Solar System

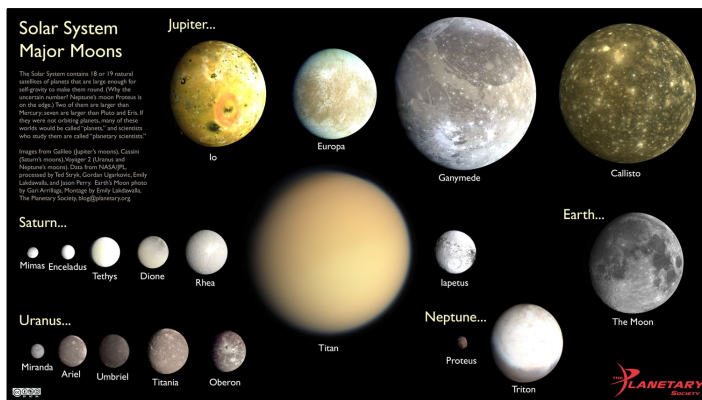
The Solar System is not just the Sun and 8 planets



New Horizons is exploring beyond Pluto

There are also over 300 moons!

## 300+ Moons



## Future Missions



Juice



Europa Clipper

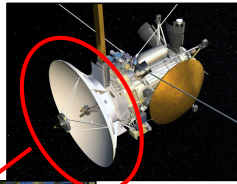


# Exploring the Solar System II – Spacecraft

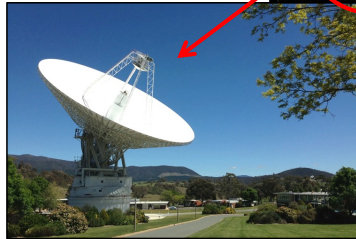
## Future Communications

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

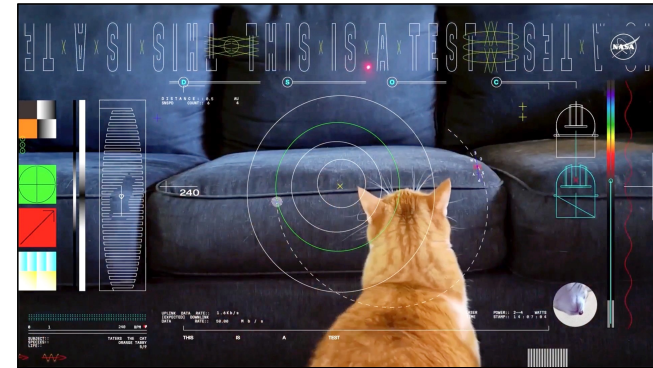
... and an even bigger radio dish on Earth.



Lasers would provide faster transmission and need less power.



## 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

## Want To Know More?

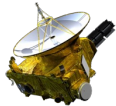
[ESA.int/Science\\_Exploration/  
Space\\_Science/BepiColombo](https://esa.int/Science_Exploration/Space_Science/BepiColombo)



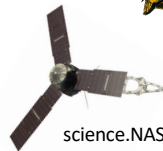
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mission/cassini](https://science.nasa.gov/mission/cassini)



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Dr Steve Barrett

RCC

8 Aug 2025