



# Exploring the Solar System

Visiting other worlds

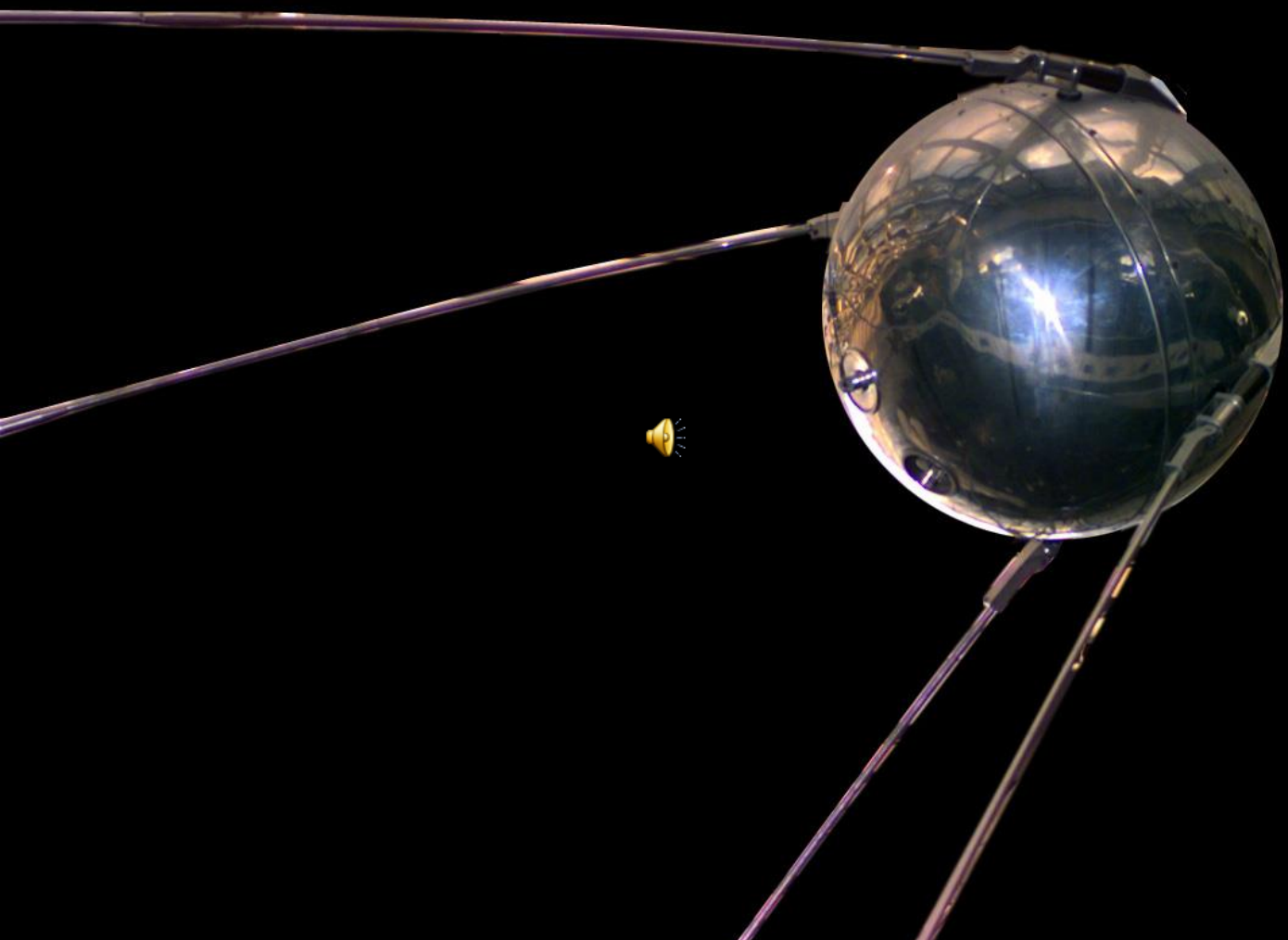
Jonathan Crass

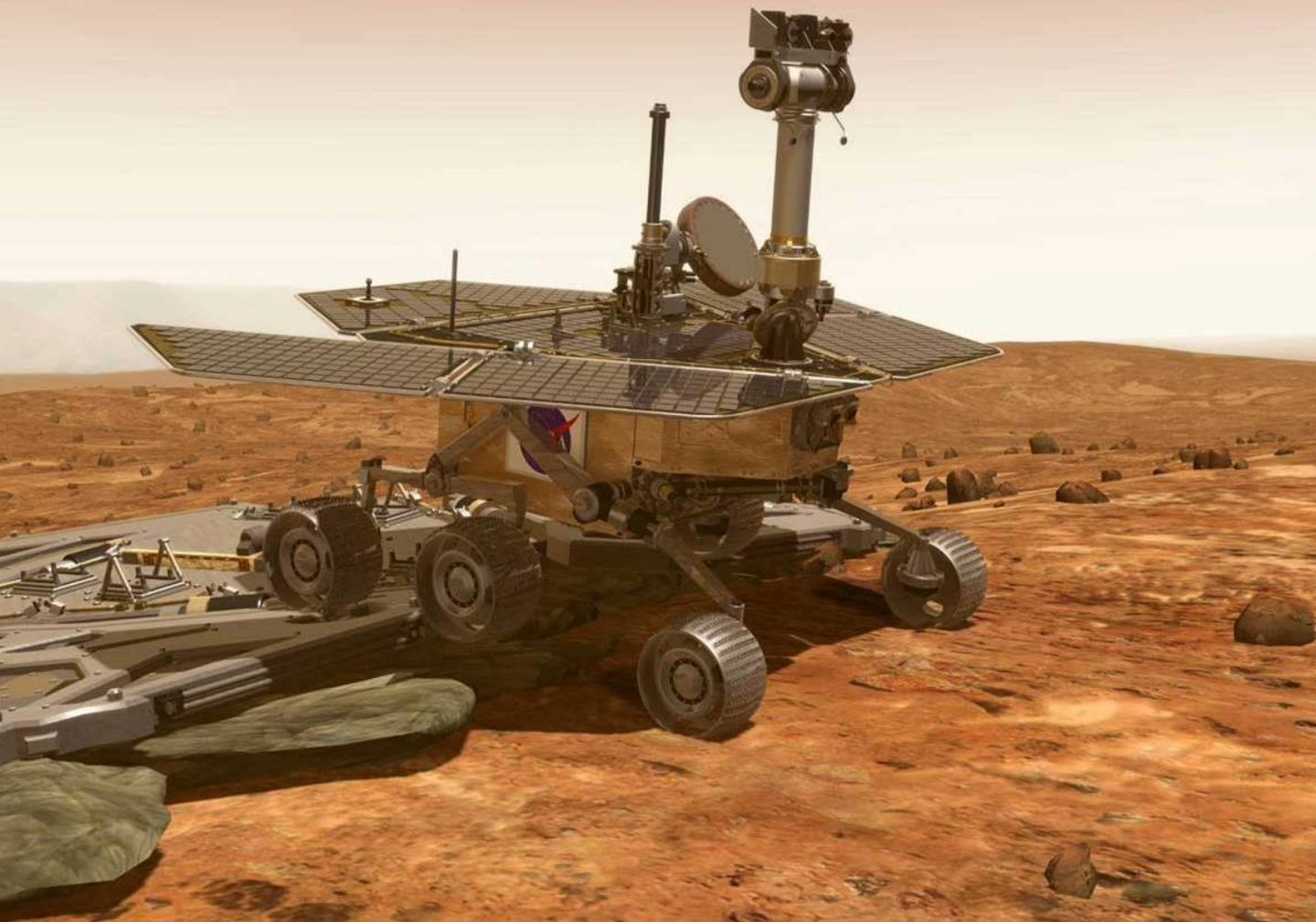


# Exploring the Solar System

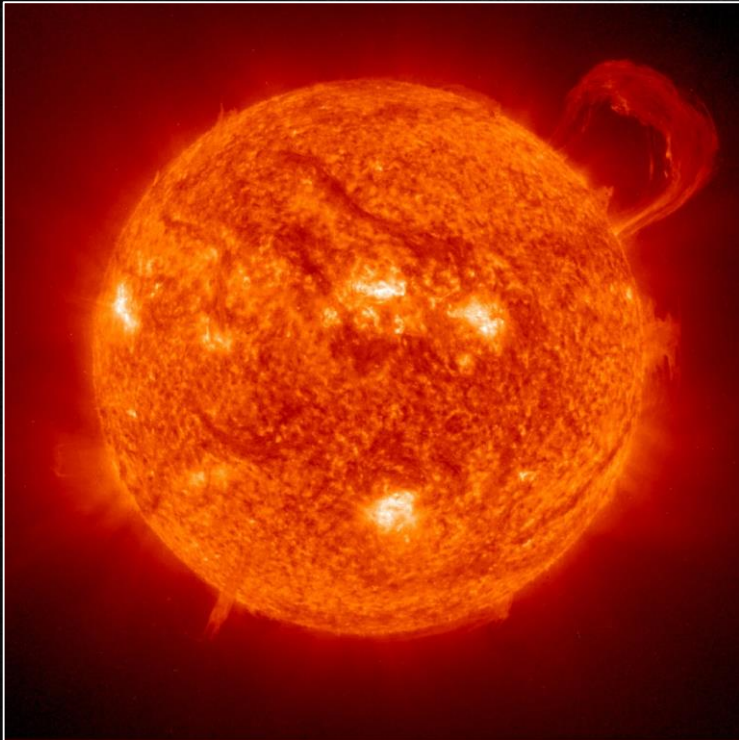
- Robotic Missions
  - The Sun
  - The Planets
  - The Outer Solar System
- The Curiosity Rover

# Robotic Exploration





# The Sun



## Size

695,508km

109.2 × size of Earth

## Mass

$1.989 \times 10^{30}$ kg

333,060 × mass of Earth

## Length of 1 Day

25.38 × Earth days

## Surface Temperature

5,500°C

# Hinode

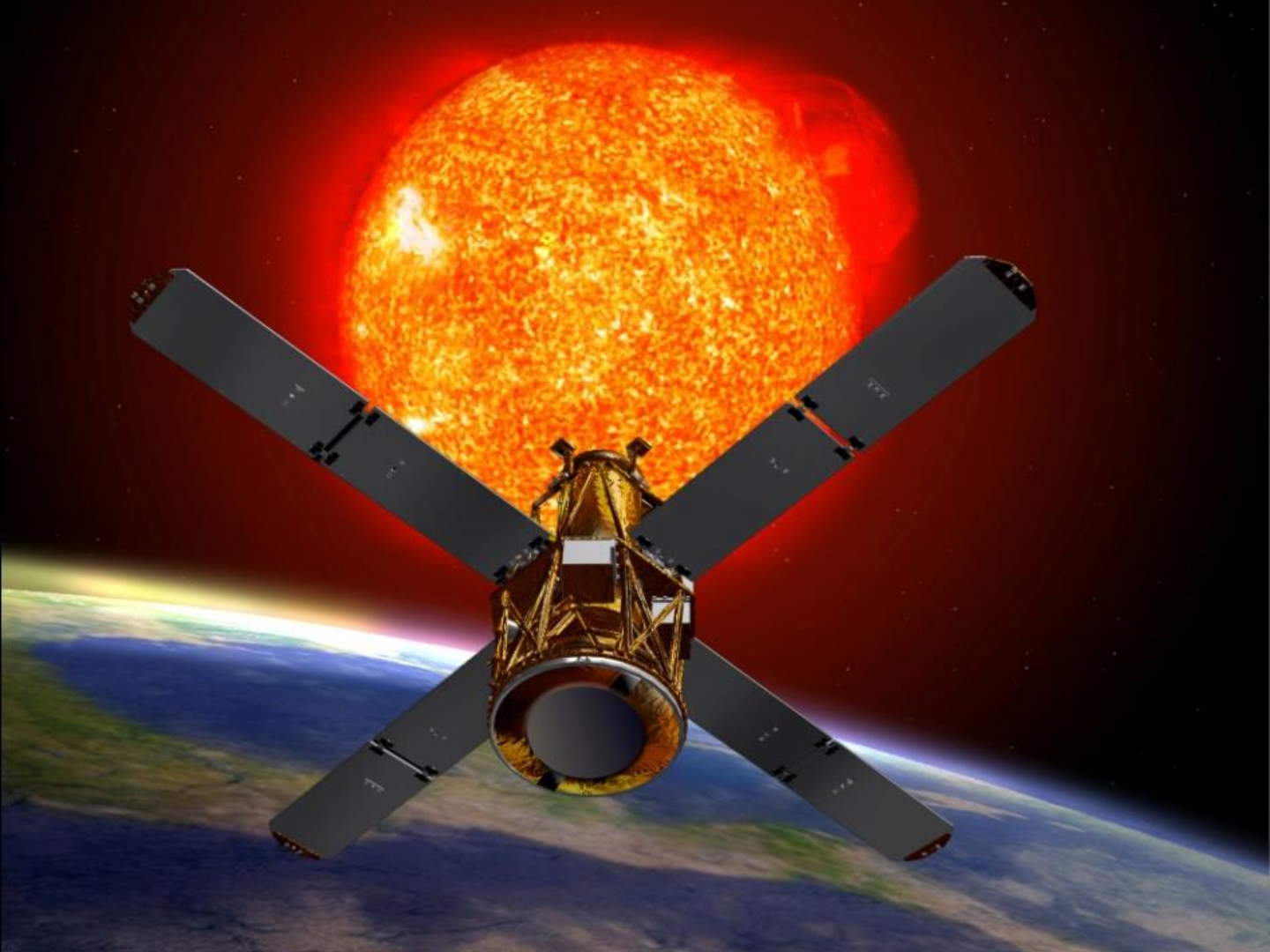
- Launched: 22<sup>nd</sup> September 2006
- Looking at magnetic fields of the Sun in optical, extreme UV and X-Rays
- First images on 28<sup>th</sup> October 2006





# RHESSI

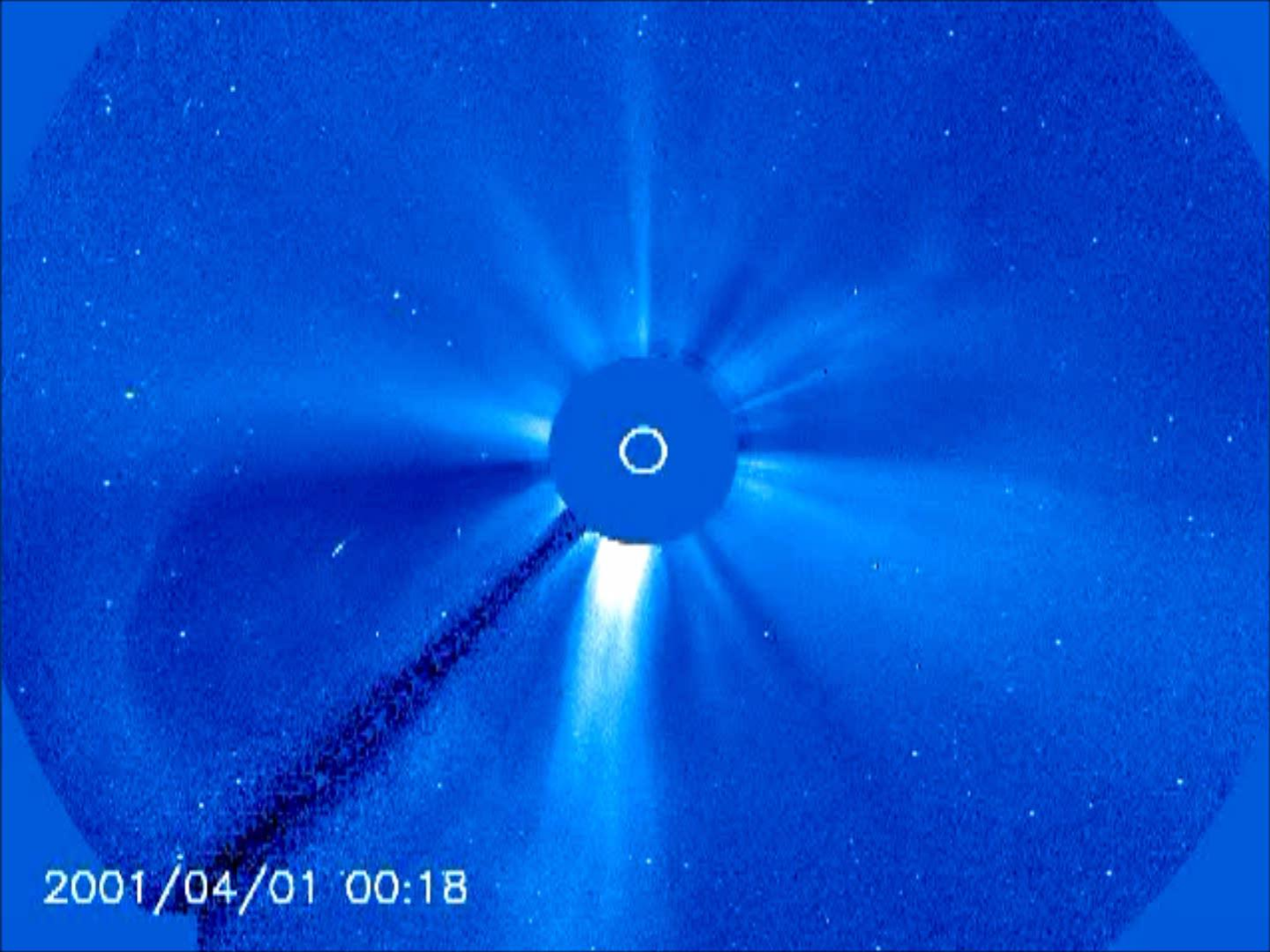
- Launched: 5<sup>th</sup> February 2002 from Kennedy Space Center
- Observe the Sun in X-Rays and Gamma Rays



# SOHO

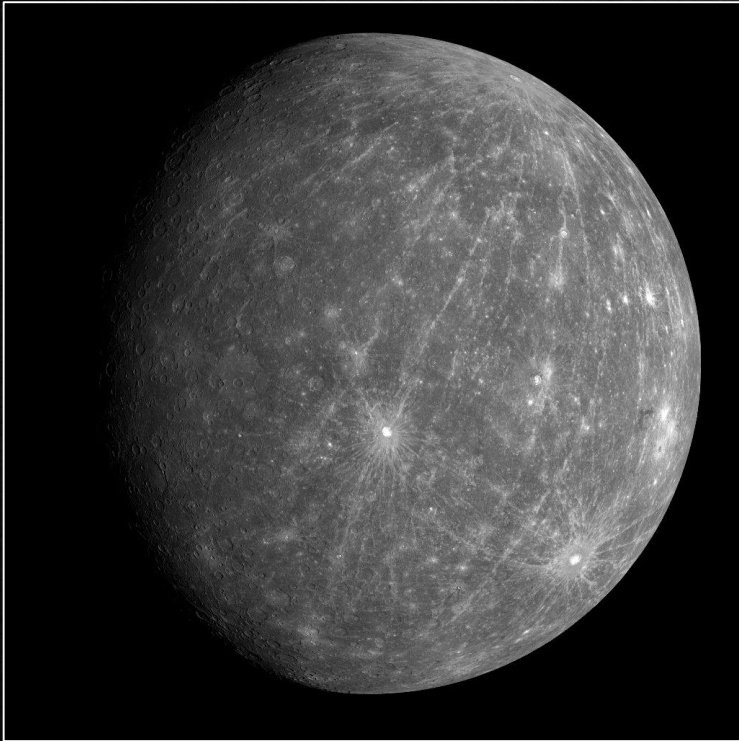
- Launched: 2<sup>nd</sup> December 1995 from Cape Canaveral Air Station
- Began operating on 24<sup>th</sup> June 1998



A blue-tinted image of a compact disc (CD) or digital versatile disc (DVD). The disc is centered in the frame, showing its characteristic circular shape and a central hole. A radial groove is visible, extending from the center towards the edge. The background is a dark, textured blue. In the bottom-left corner, there is a white timestamp.

2001/04/01 00:18

# Mercury



Distance from the Sun

57,909,227km

0.387 × distance to Earth

Size

0.3829 × size of Earth

Mass

0.055 × mass of Earth

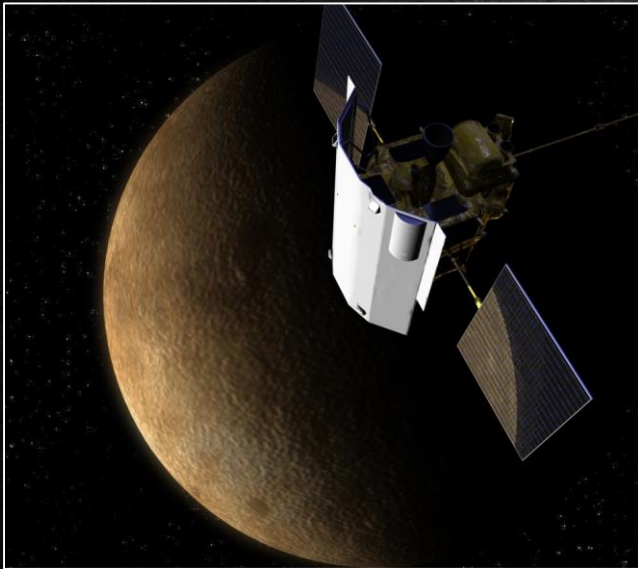
Length of 1 Day

58.81 × Earth days

Length of 1 Year

0.241 × Earth years

# Messenger



# Venus



## Distance from the Sun

108,209,475km

0.723 × distance to Earth

## Size

0.9499 × size of Earth

## Mass

0.815 × mass of Earth

## Length of 1 Day

243.68 × Earth days

## Length of 1 Year

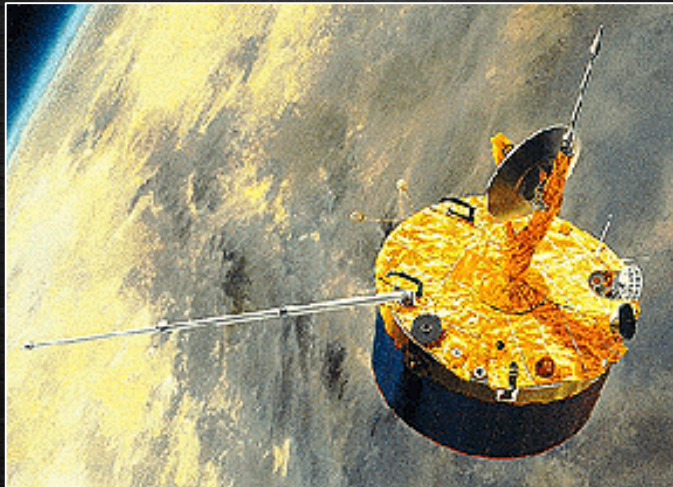
0.615 × Earth years





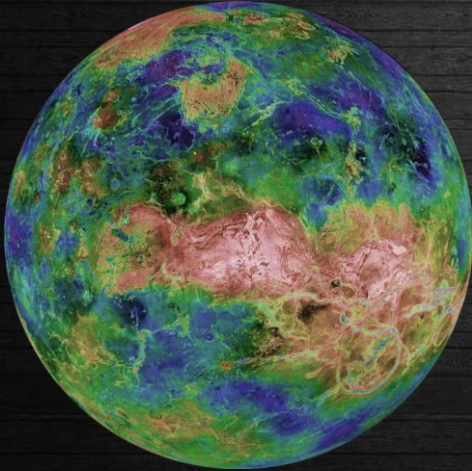
# The Pioneer Project

- Launched: 20<sup>th</sup> May 1978 from Kennedy Space Center
- Mission ended: 8<sup>th</sup> October 1992



# Magellan

- Launched: 4<sup>th</sup> May 1989
- Entered orbit: 10<sup>th</sup> August 1990
- Used Radar to look through clouds on Venus



# Earth



## Distance from the Sun

149,598,262km

1 Astronomical Unit

## Size

6,371km in radius

## Mass

$5.9722 \times 10^{24}$  kg

## Length of 1 Day

23.934 hours

## Length of 1 Year

365.26 days

# The Moon



Distance from Earth

384,400km

$0.00257 \times$  distance to Sun

Size

1,737.5km in radius

Mass

$7.3477 \times 10^{22}$  kg

Length of 1 Day

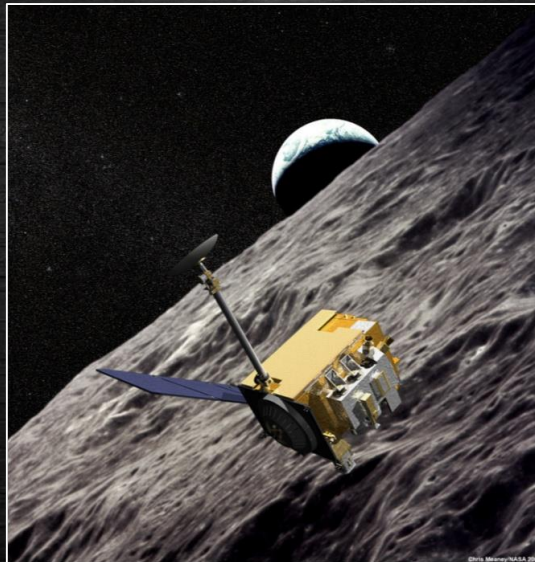
27.322 days

Length of 1 Year

27.322 days

# Lunar Reconnaissance Orbiter

- Launched: 18<sup>th</sup> June 2009
- Precursor to future manned missions to the moon



# Mars



## Distance from the Sun

227,943,824km

1.524 × distance to Earth

## Size

0.5320 × size of Earth

## Mass

0.107 × mass of Earth

## Length of 1 Day

1.026 × Earth days

## Length of 1 Year

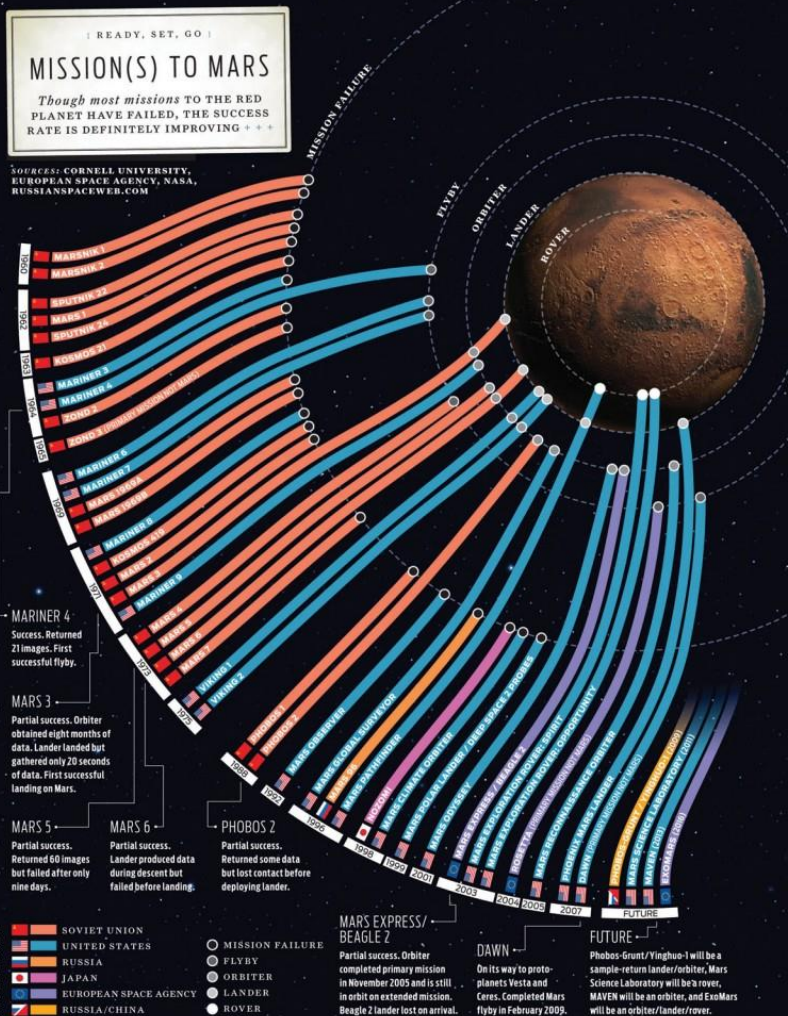
1.8808 × Earth years

| READY, SET, GO |

# MISSION(S) TO MARS

Though most missions to the red planet have failed, the success rate is definitely improving + + +

SOURCES: CORNELL UNIVERSITY, EUROPEAN SPACE AGENCY, NASA, RUSSIANSPACEWEB.COM



**MARINER 4**  
Success. Returned 21 images. First successful flyby.

**MARS 3**  
Partial success. Orbiter obtained eight months of data. Lander landed but gathered only 20 seconds of data. First successful landing on Mars.

**MARS 5**  
Partial success. Returned 60 images but failed after only nine days.

**MARS 6**  
Partial success. Lander produced data during descent but failed before landing.

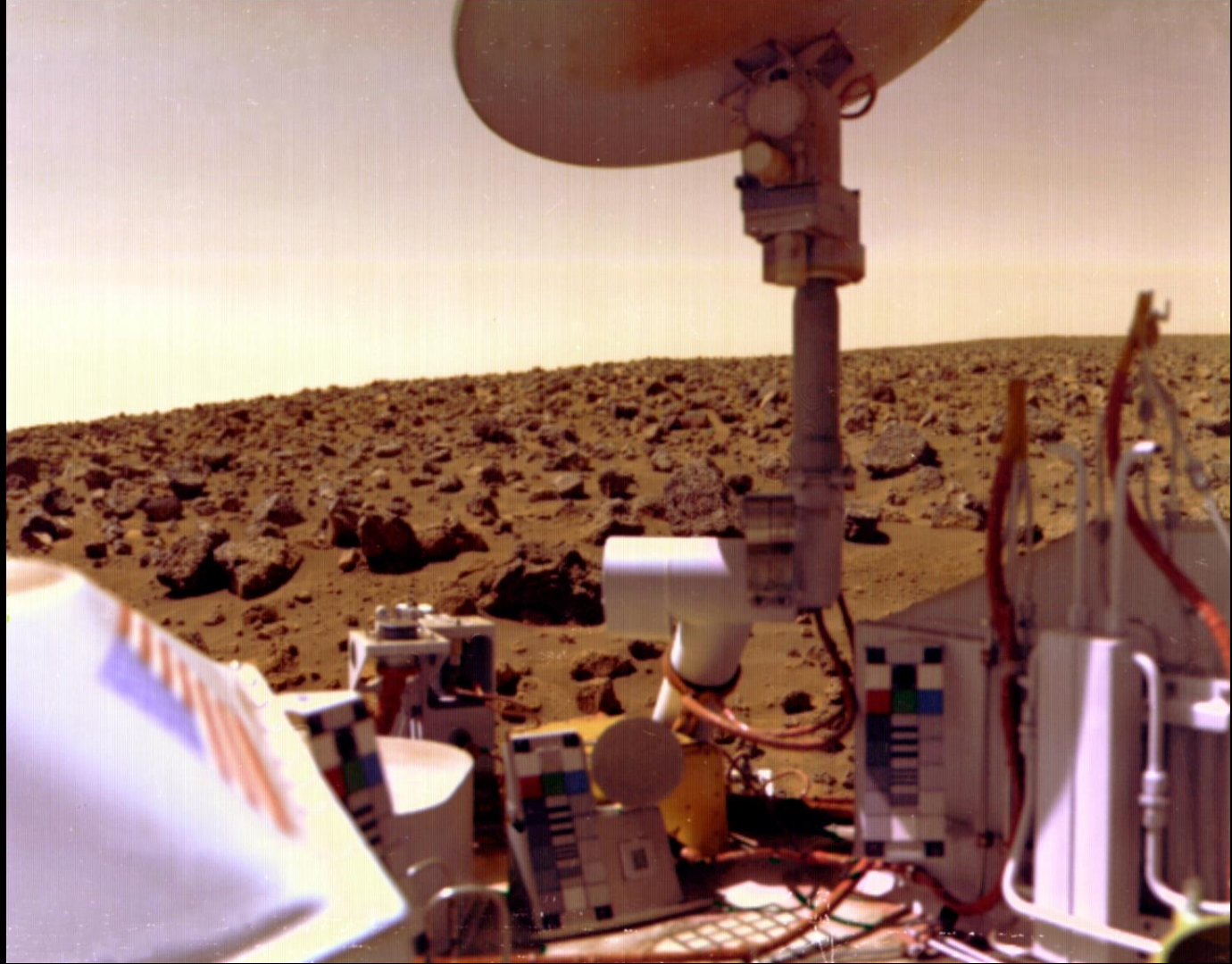
**PHOBOS 2**  
Partial success. Returned some data but lost contact before deploying lander.

**MARS EXPRESS/BEAGLE 2**  
Partial success. Orbiter completed primary mission in November 2005 and is still in orbit on extended mission. Beagle 2 lander lost on arrival.

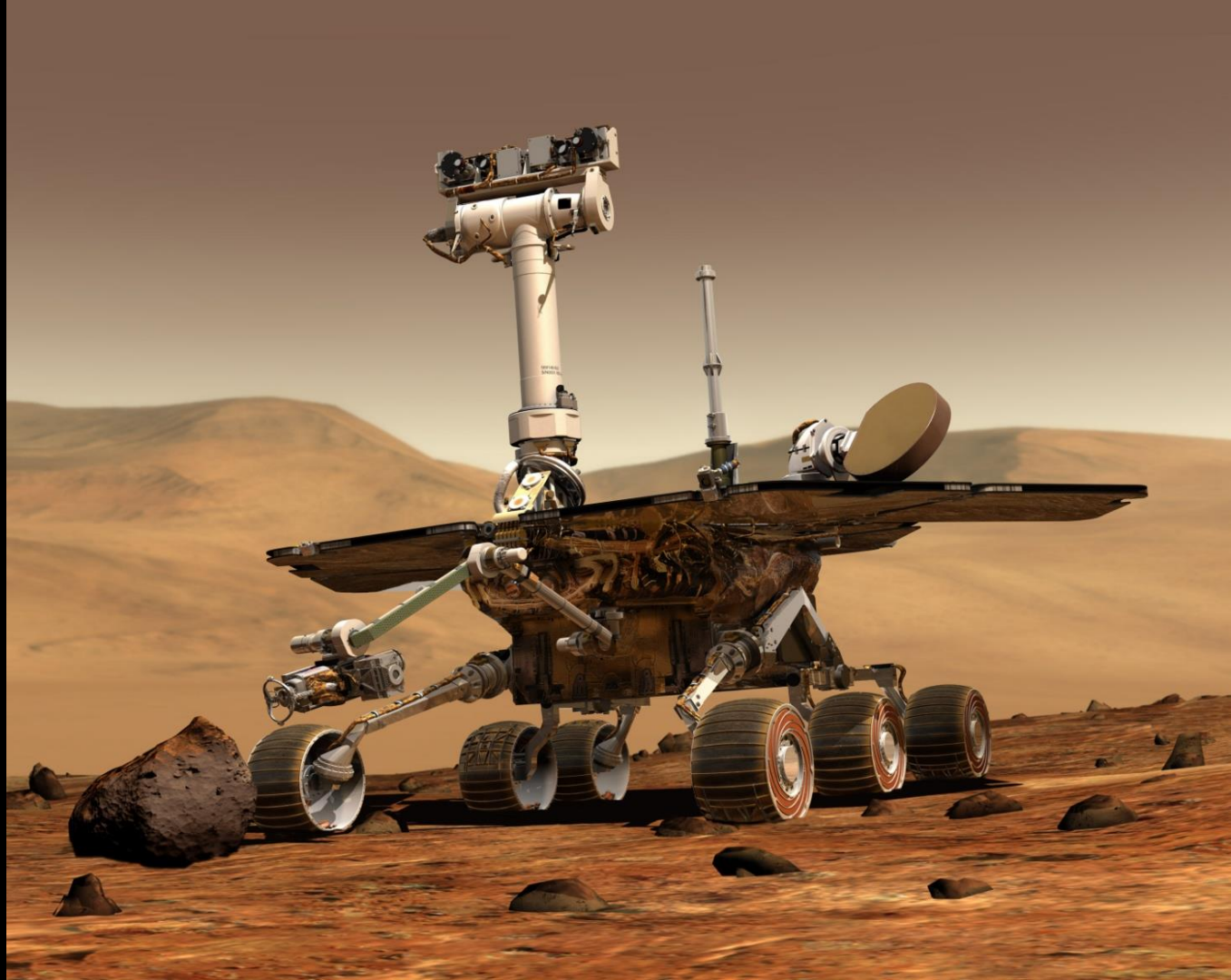
**DAWN**  
On its way to proto-planets Vesta and Ceres. Completed Mars flyby in February 2009.

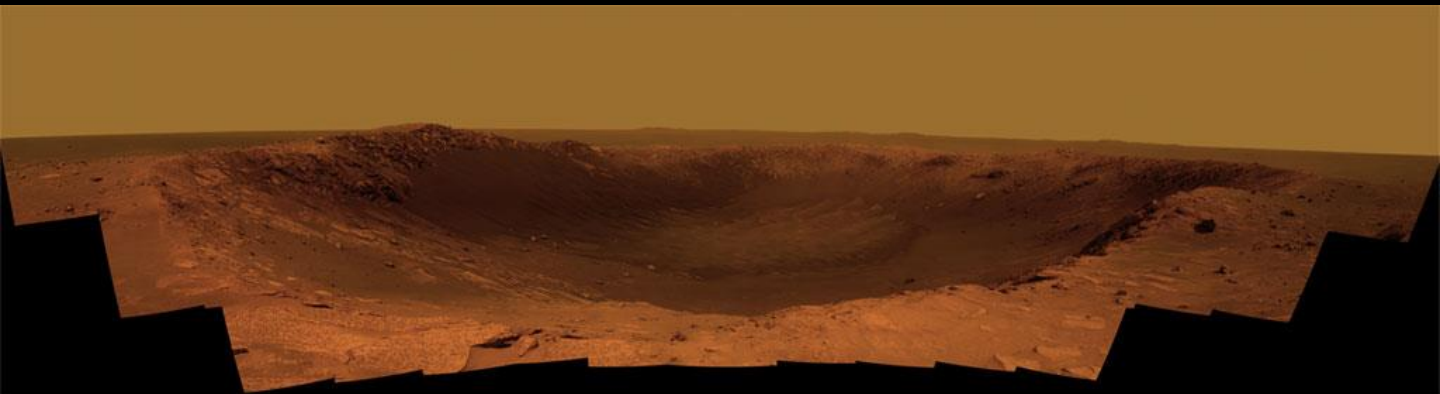
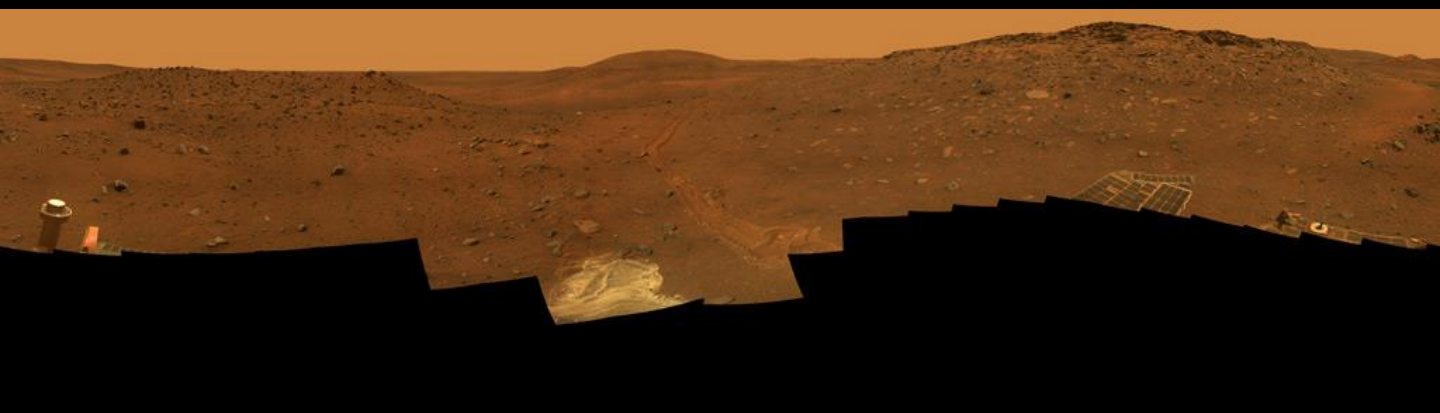
**FUTURE**  
Phobos-Grunt/Vinghuo-1 will be a sample-return lander/orbiter, Mars Science Laboratory will be a rover, MAVEN will be an orbiter, and ExoMars will be an orbiter/lander/rover.

Illustration by Science Photo Library

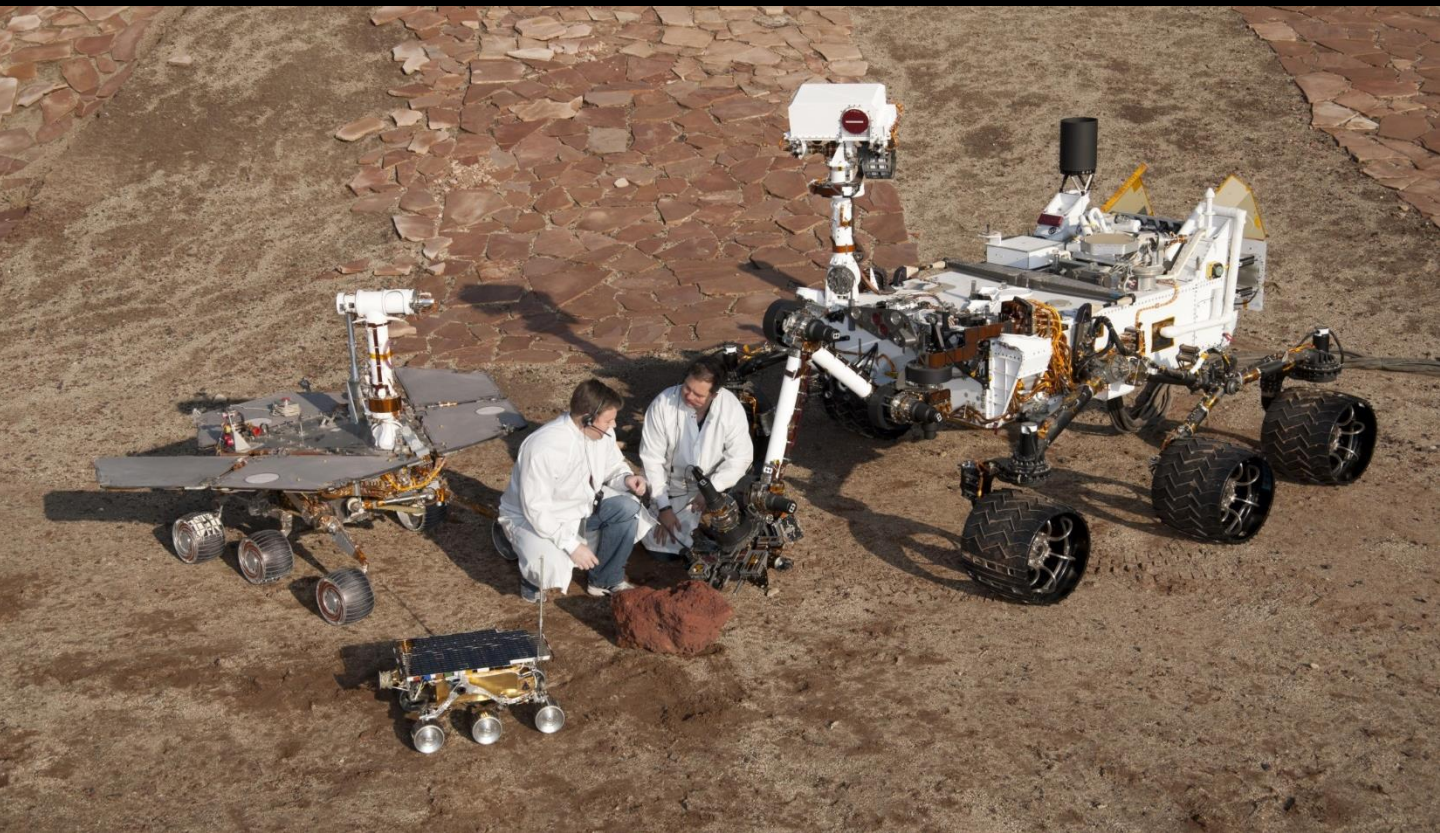


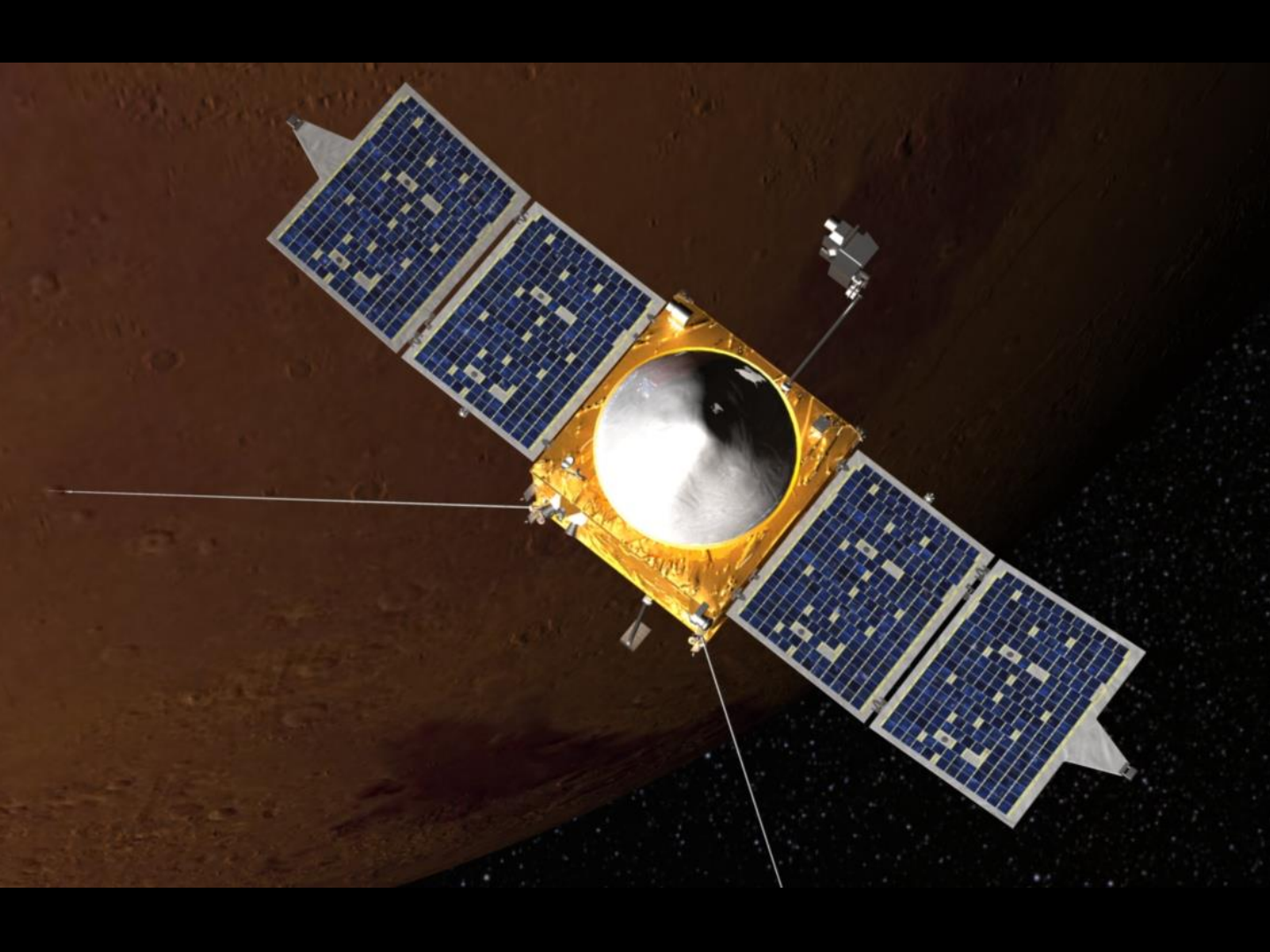




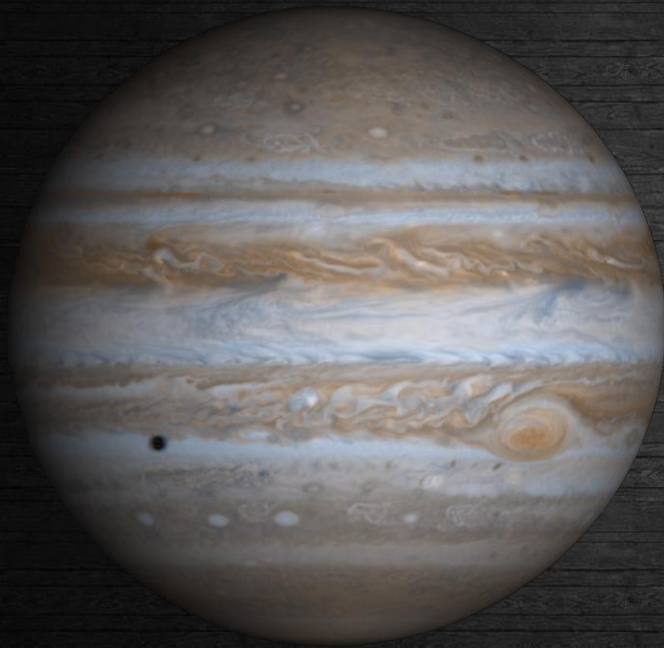








# Jupiter



Distance from the Sun

778,340,821 km

5.203 × distance to Earth

Size

10.9733 × size of Earth

Mass

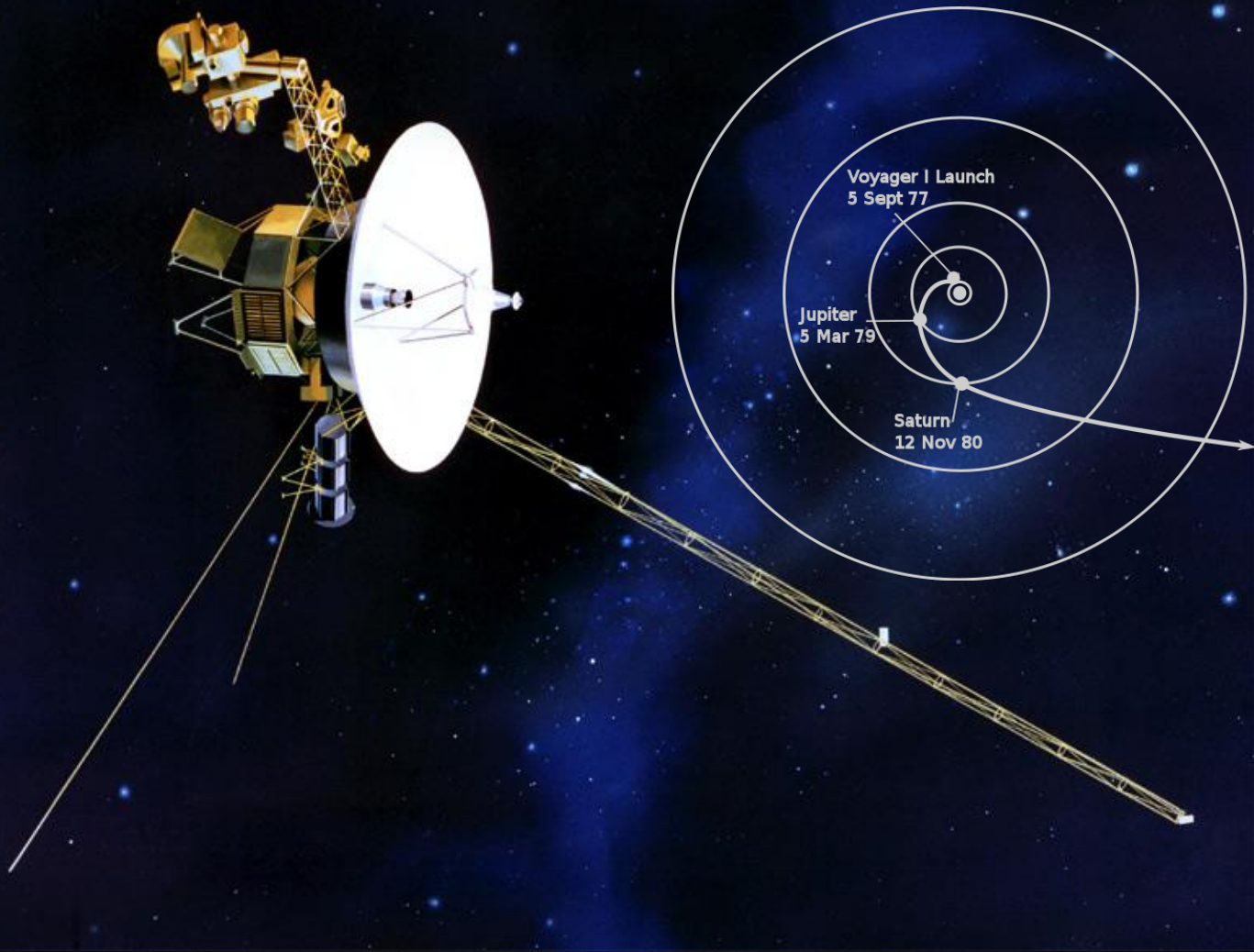
317.828 × mass of Earth

Length of 1 Day

0.41354 × Earth days

Length of 1 Year

11.8626 × Earth years



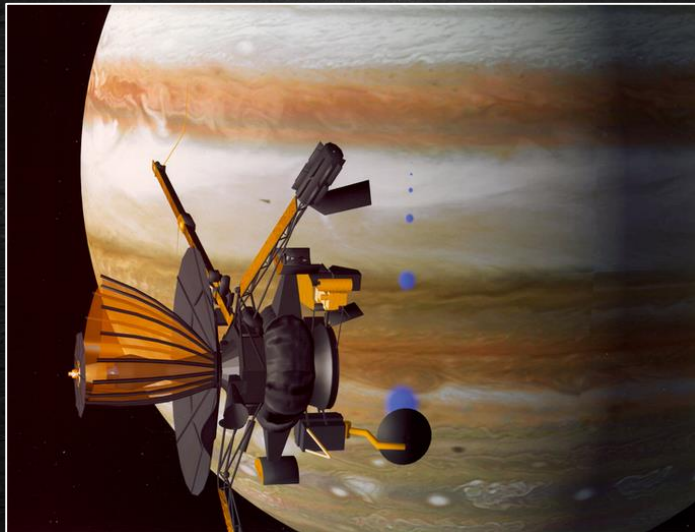
Voyager I Launch  
5 Sept 77

Jupiter  
5 Mar 79

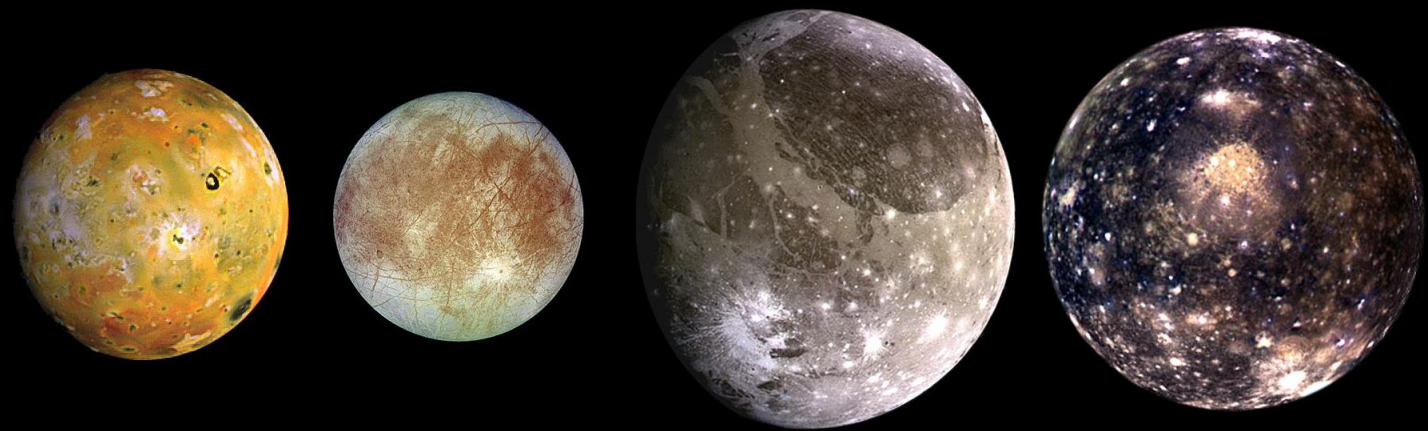
Saturn  
12 Nov 80

# Galileo

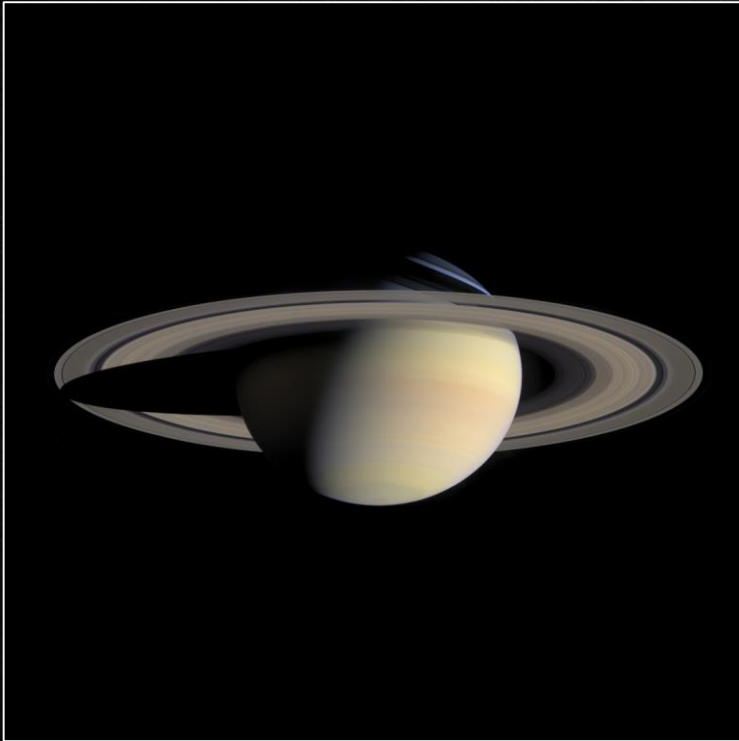
- Launched: 18<sup>th</sup> October 1989
- Entered Orbit: 7<sup>th</sup> December 1995
- Mission Ended: 21<sup>st</sup> September 2003







# Saturn



## Distance from the Sun

1,426,666,422km

9.537 × distance to Earth

## Size

9.1402 × size of Earth

## Mass

95.161 × mass of Earth

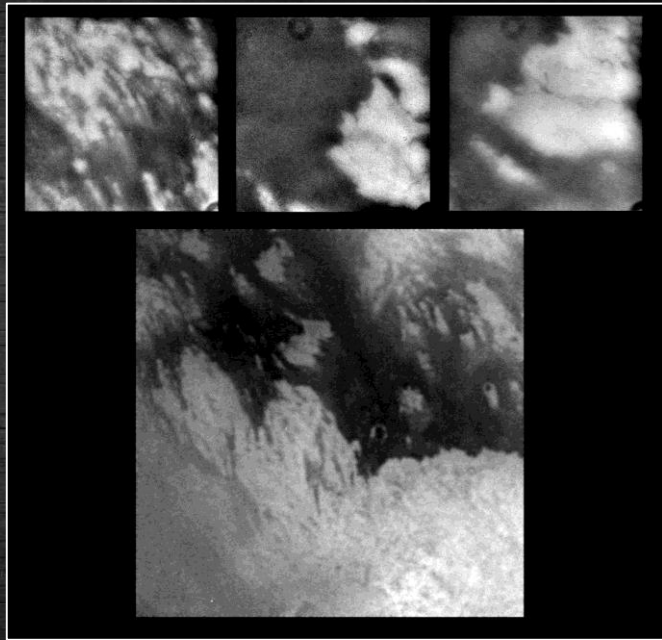
## Length of 1 Day

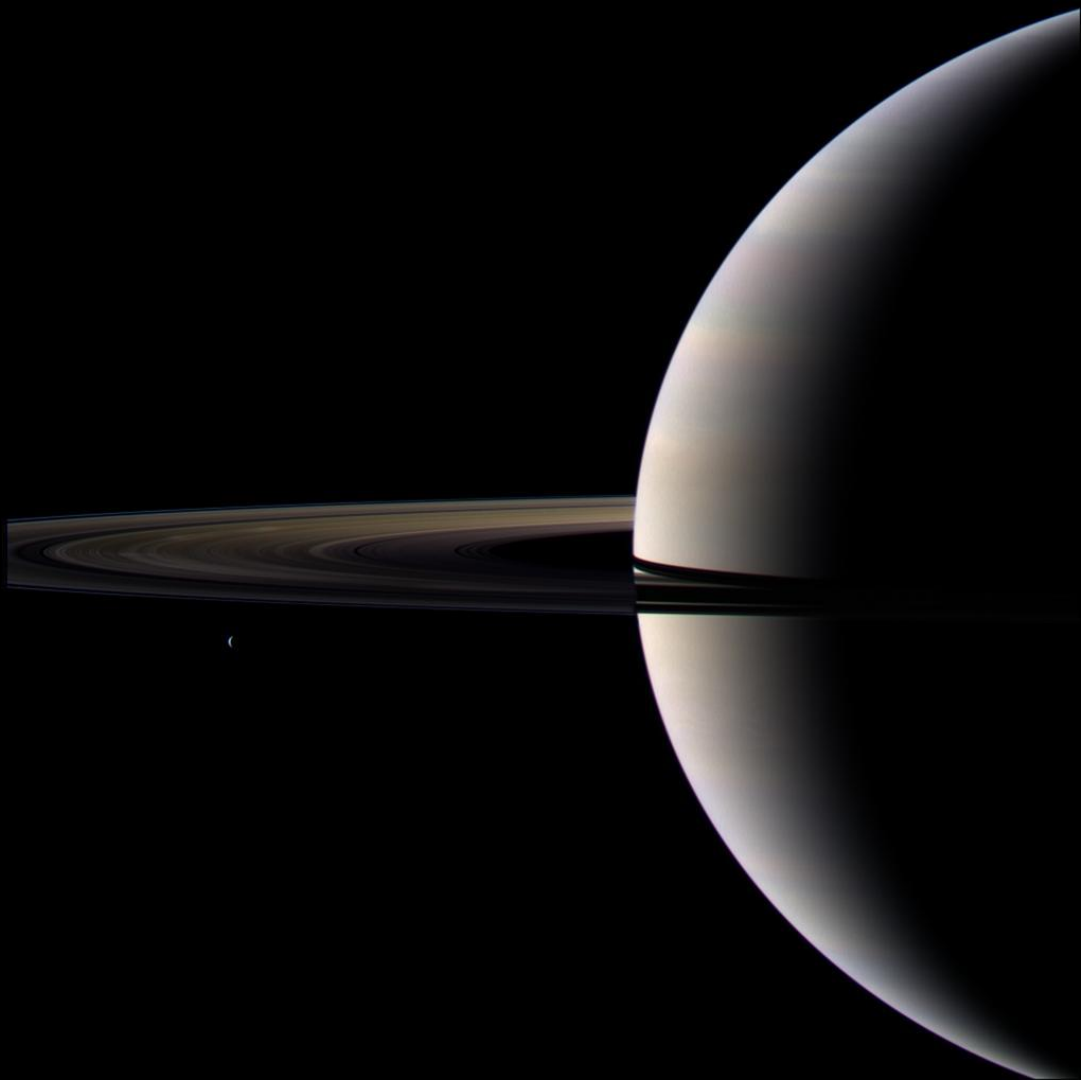
0.444 × Earth days

## Length of 1 Year

29.4475 × Earth years

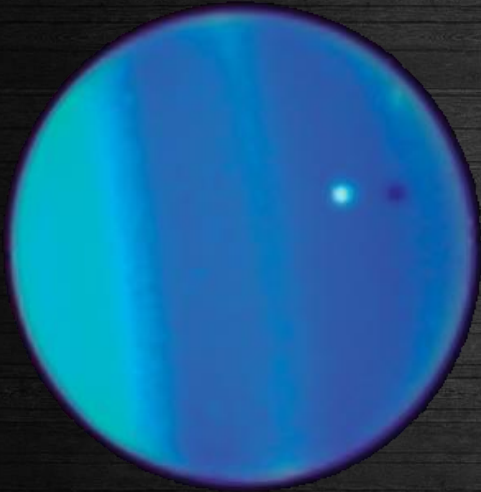
# Cassini-Huygens







# Uranus



Distance from the Sun

2,870,658,186km

19.189 × distance to Earth

Size

3.9809 × size of Earth

Mass

14.536 × mass of Earth

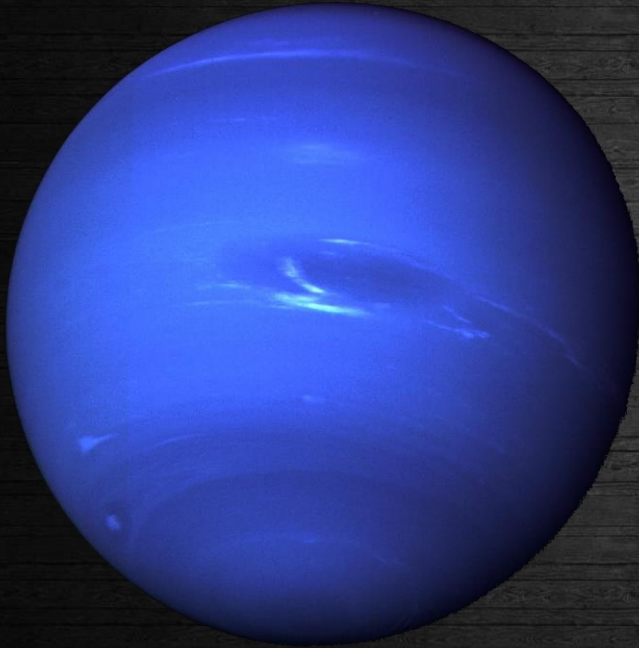
Length of 1 Day

0.718 × Earth days

Length of 1 Year

84.017 × Earth years

# Neptune



Distance from the Sun

4,498,396,441 km

30.070 × distance to Earth

Size

3.8647 × size of Earth

Mass

17.148 × mass of Earth

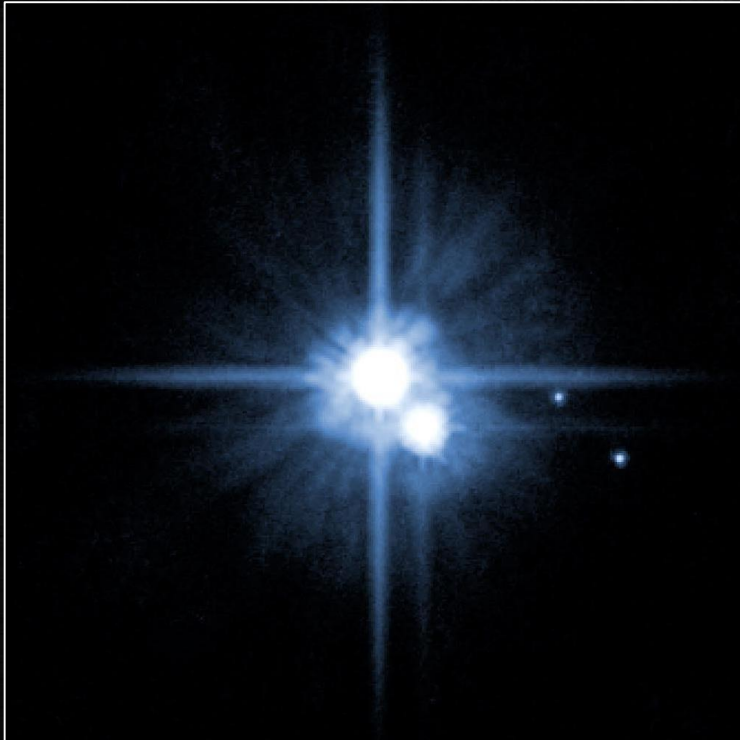
Length of 1 Day

0.671 × Earth days

Length of 1 Year

164.791 × Earth years

# Pluto



Distance from the Sun

5,906,440,628km

39.482 × distance to Earth

Size

0.1807 × size of Earth

Mass

0.002 × mass of Earth

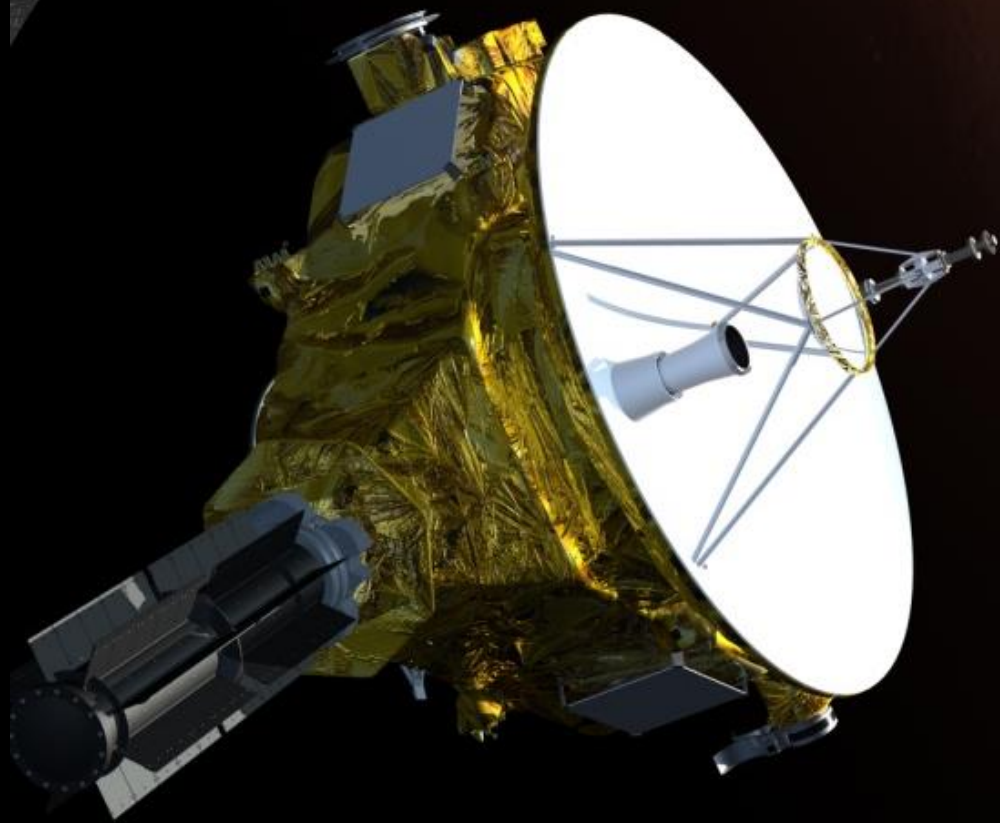
Length of 1 Day

6.387 × Earth days

Length of 1 Year

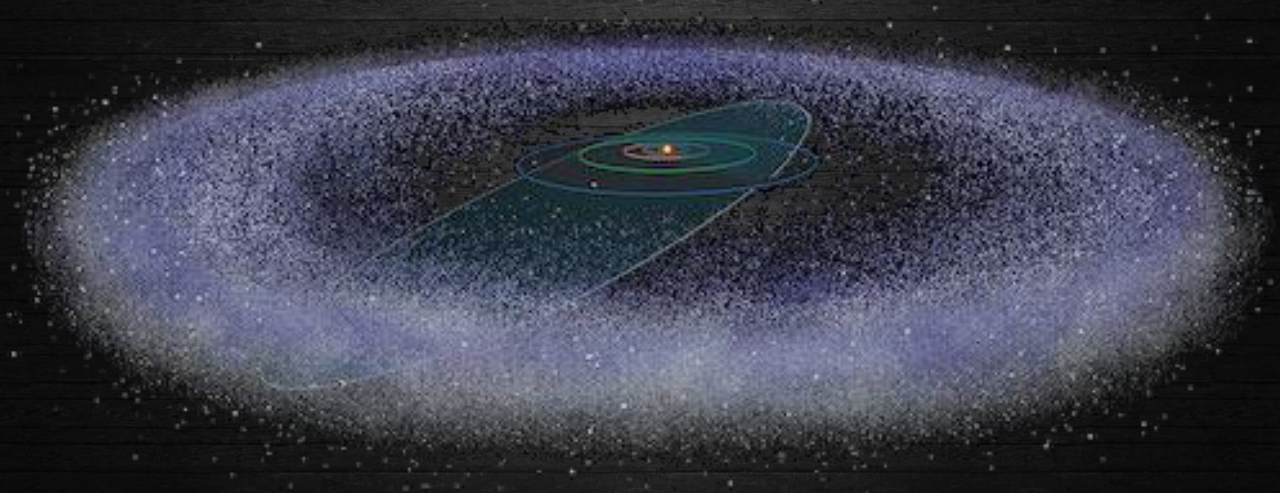
247.921 × Earth years





# And beyond...

- Kuiper Belt

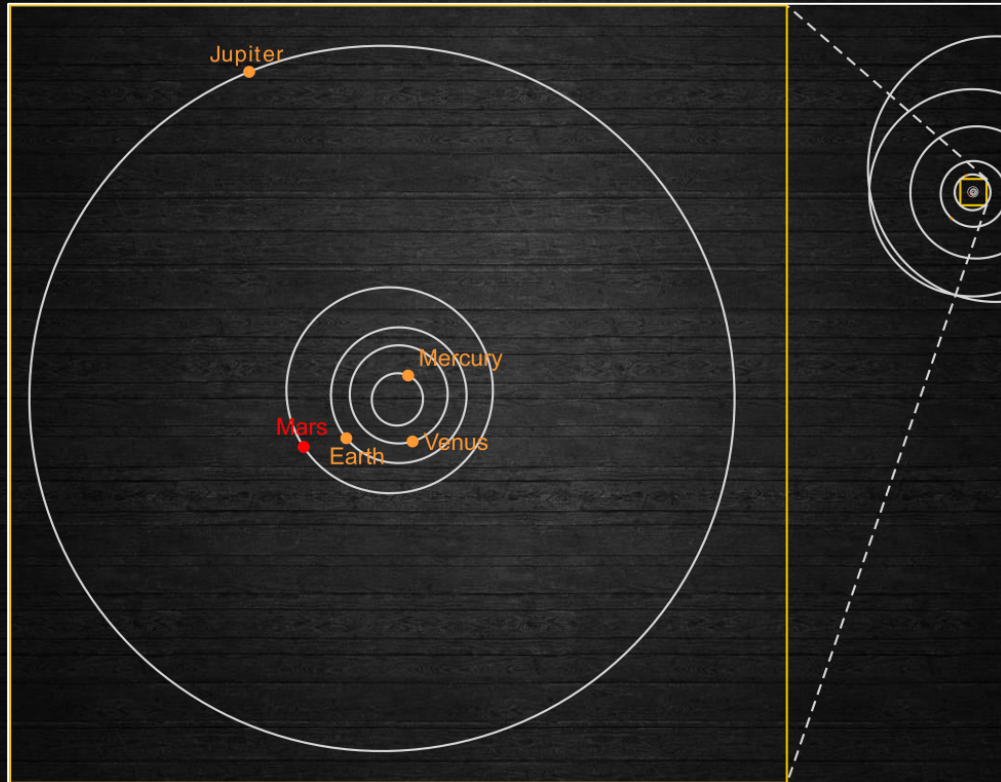


# The Curiosity Rover





# Getting to Mars

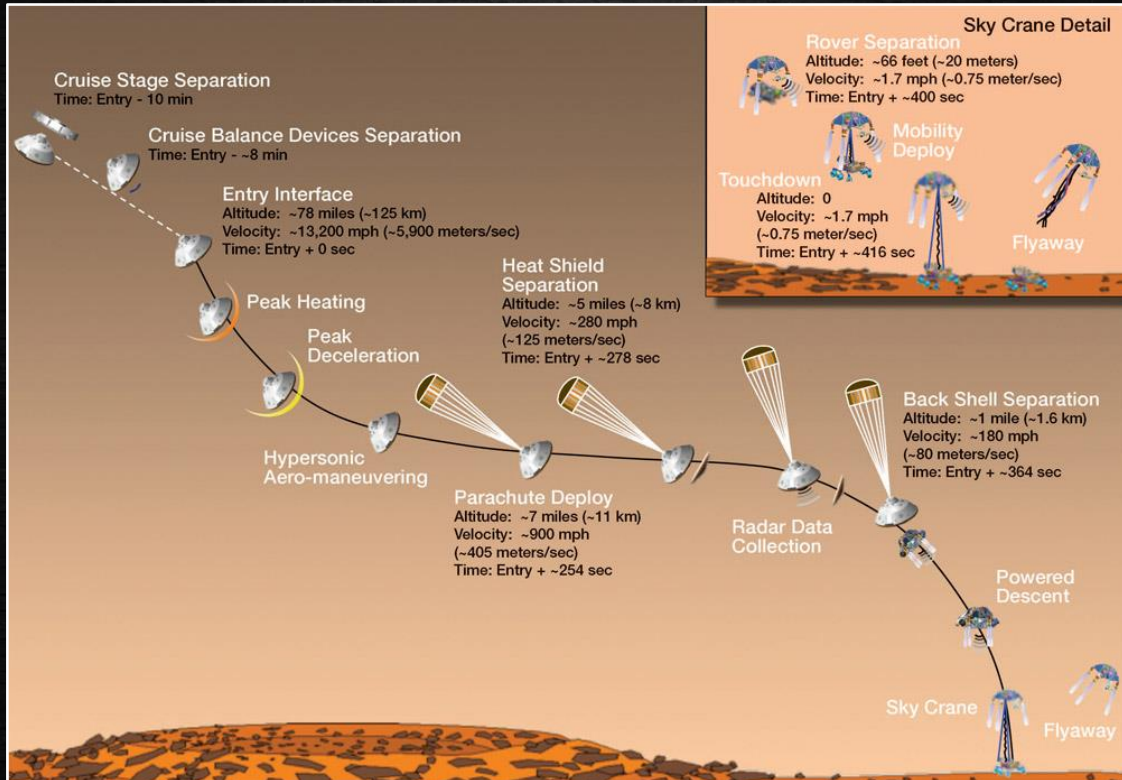


# Landing

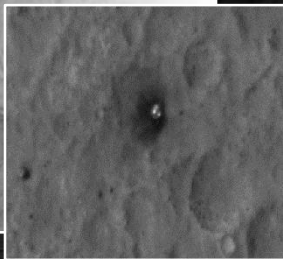
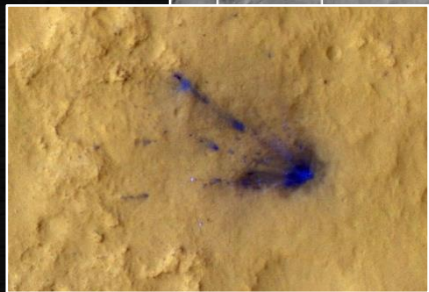
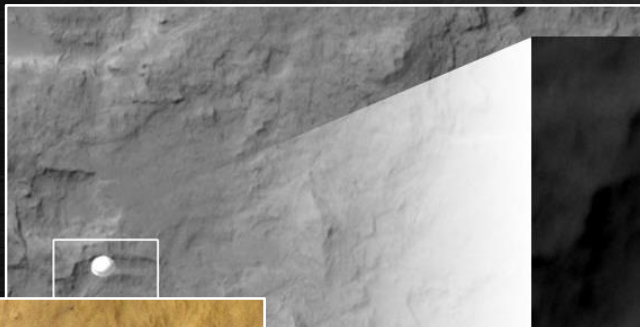


- Friction
- Parachute
- Thrusters
- Air bags

# Landing Curiosity







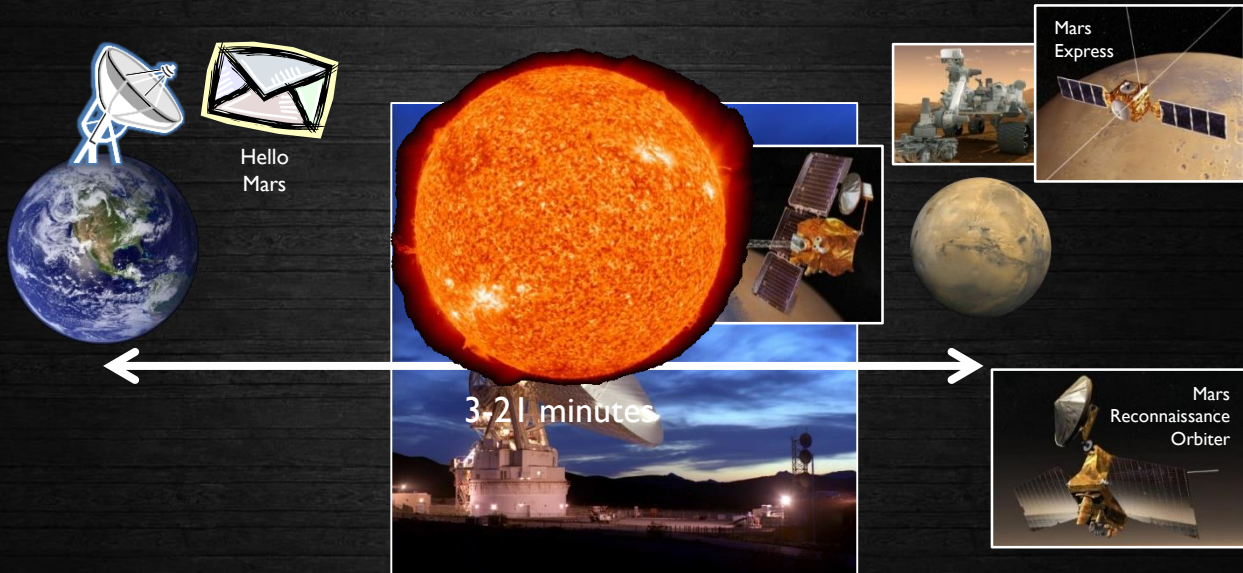
YOUR EXCUSE FOR  
ANYTHING TODAY:

"SORRY—

I WAS UP ALL NIGHT  
TRYING TO DOWNLOAD  
PHOTOS TAKEN BY A ROBOT  
LOWERED ONTO MARS  
BY A SKYCRANE."



# Communicating with the Surface





“The overall scientific goal of the mission is to explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present.”

# The Rover



# Instruments

## Systems

- Control
- Power
- Communication

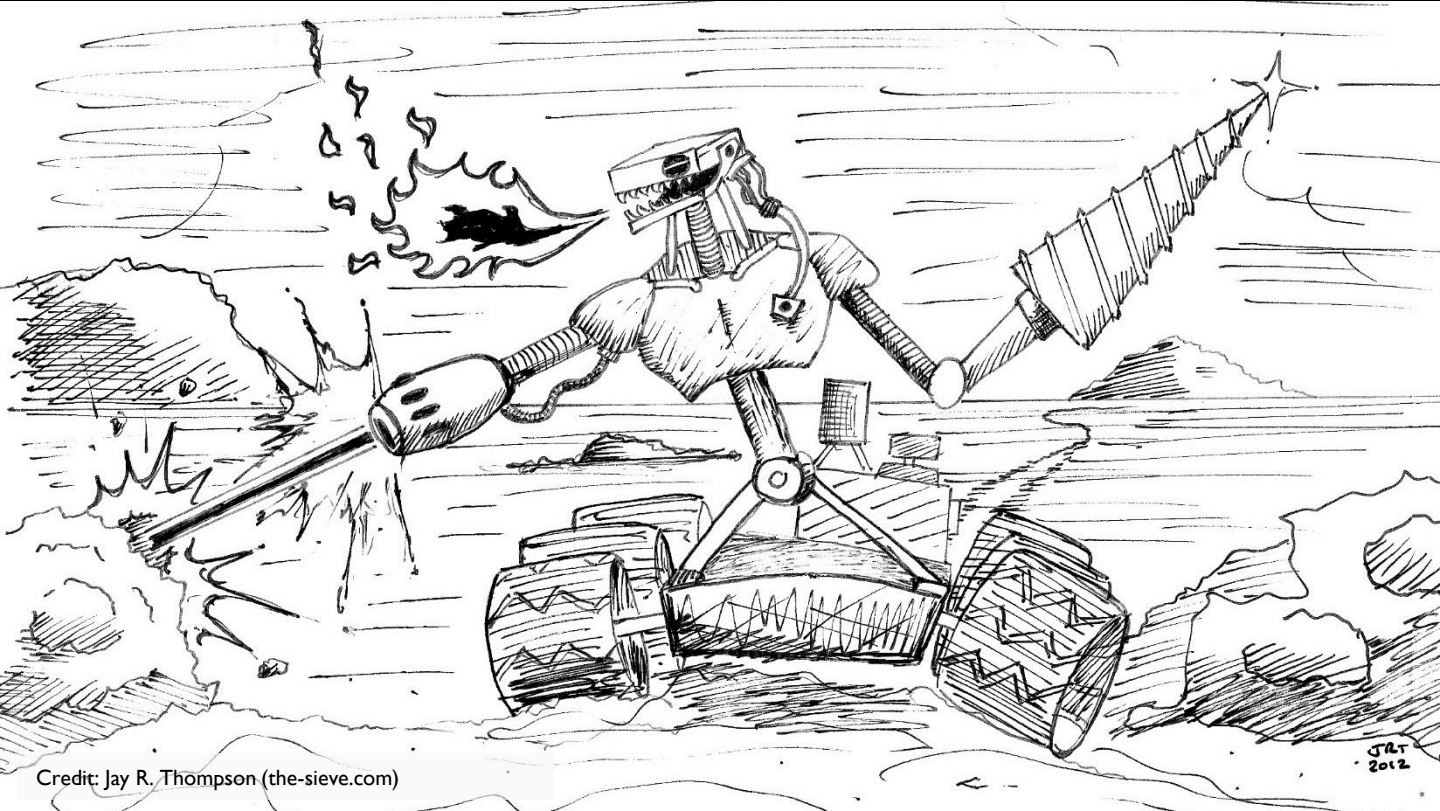
## Cameras

- Mast Camera (Mastcam)
- Mars Hand Lens Imager (MAHLI)
- Mars Descent Imager (MARDI)

## Spectrometers

- Alpha Particle X-Ray Spectrometer (APXS)
- Chemistry & Camera (ChemCam)
- Chemistry & Mineralogy Instrument (CheMin)
- Sample Analysis at Mars (SAM) Instrument Suite

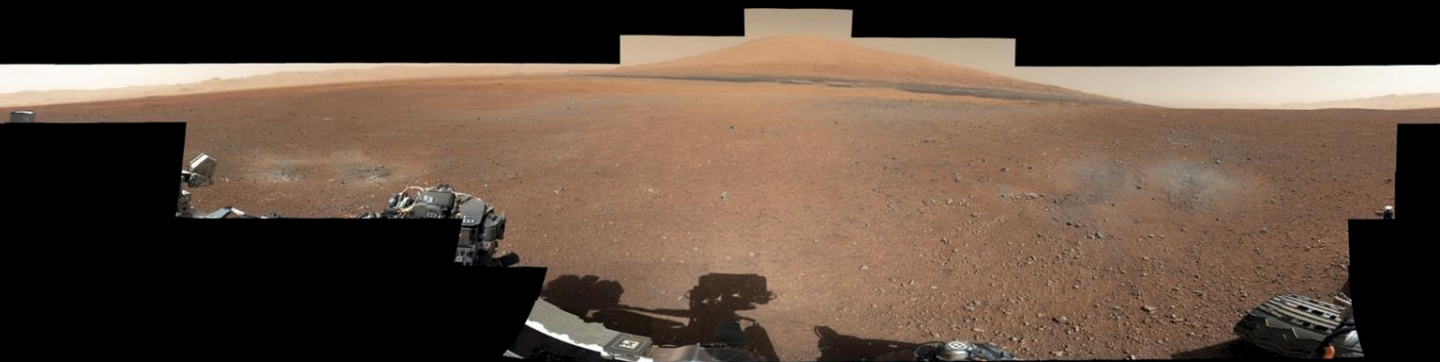
And others!



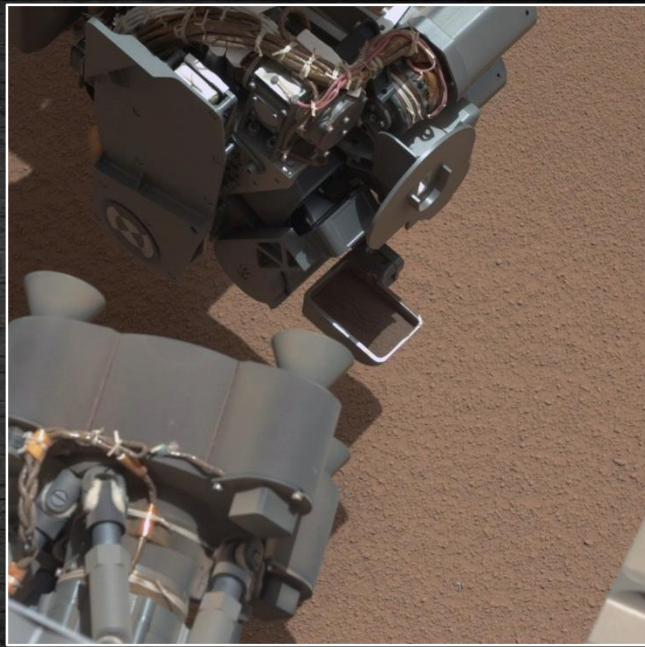
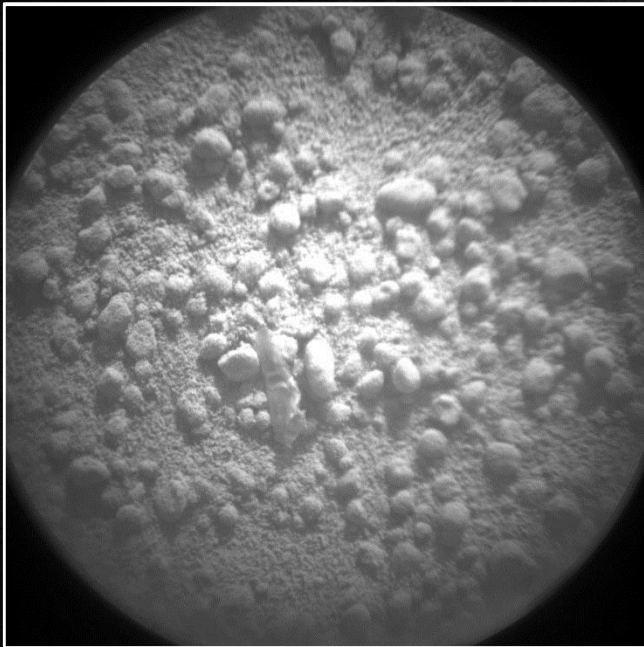
Credit: Jay R. Thompson (the-sieve.com)

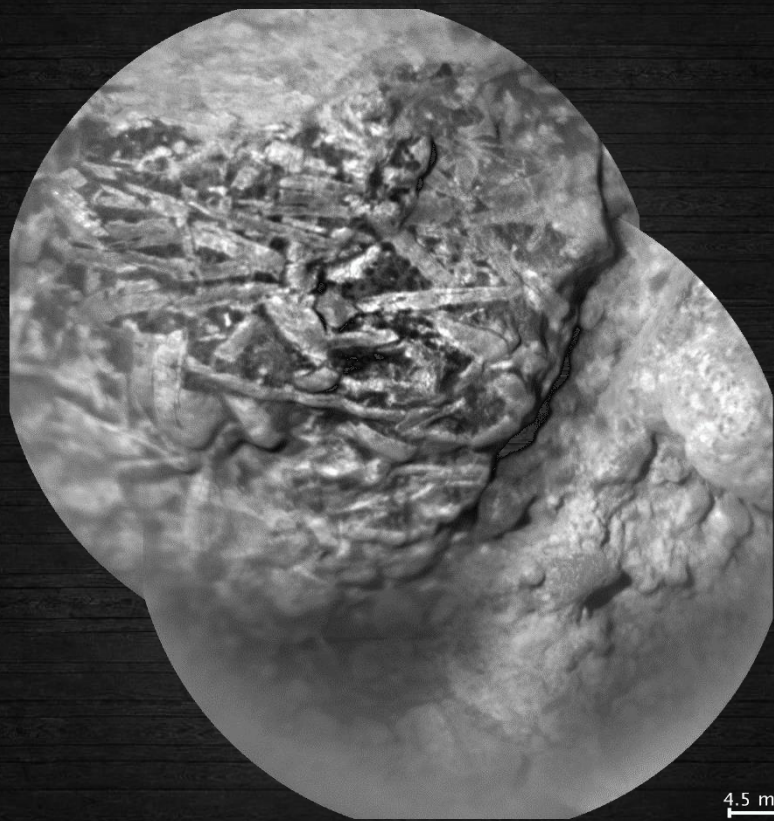
JRT  
2012



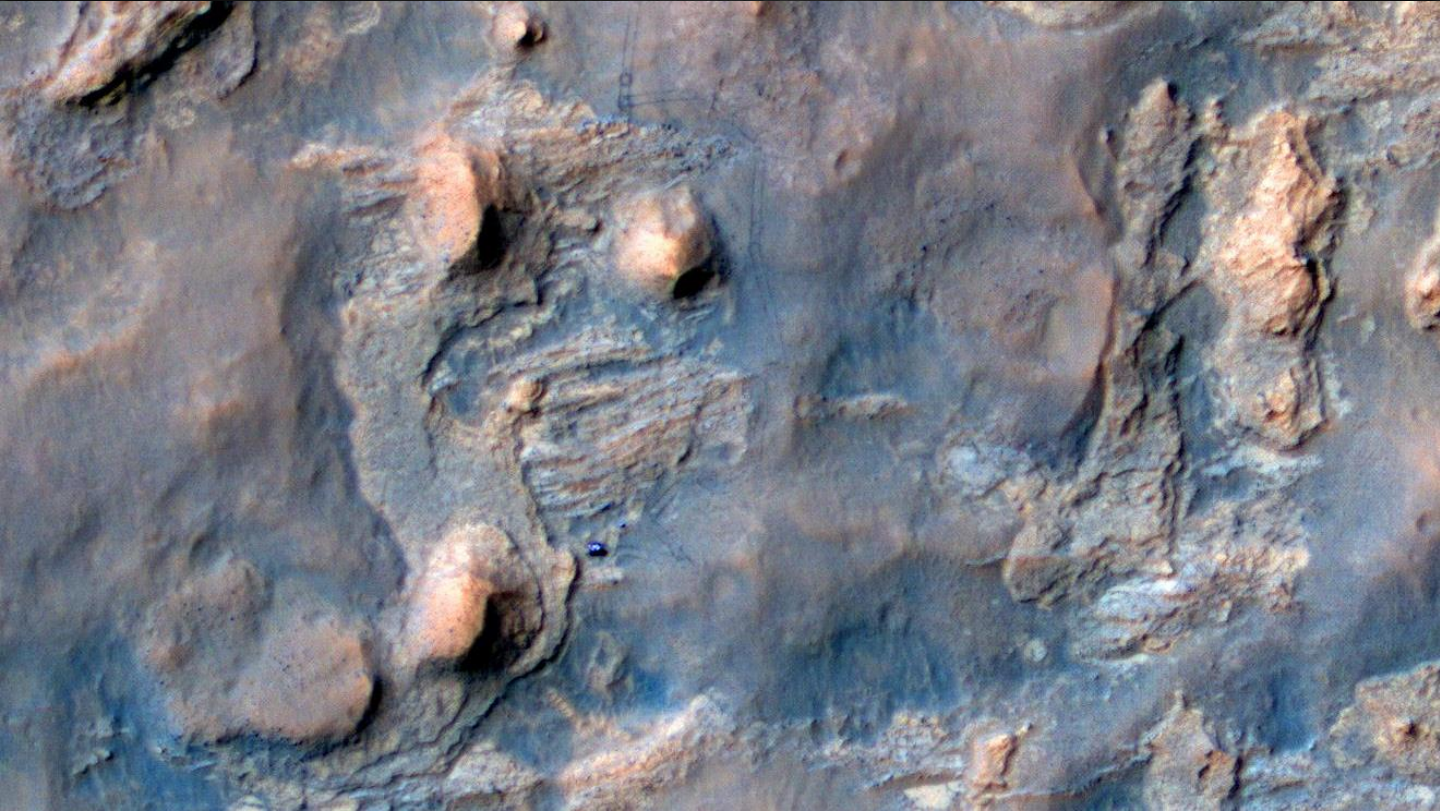








4.5 mm







Earth

moon

# Curiosity

- Minimum mission duration of 1 Martian year
- Currently driven over 3 miles
- Lots more to come!





Thank you