ELEC-E4210
History of Space Tech

Jaan Praks

Aalto University

Proloque

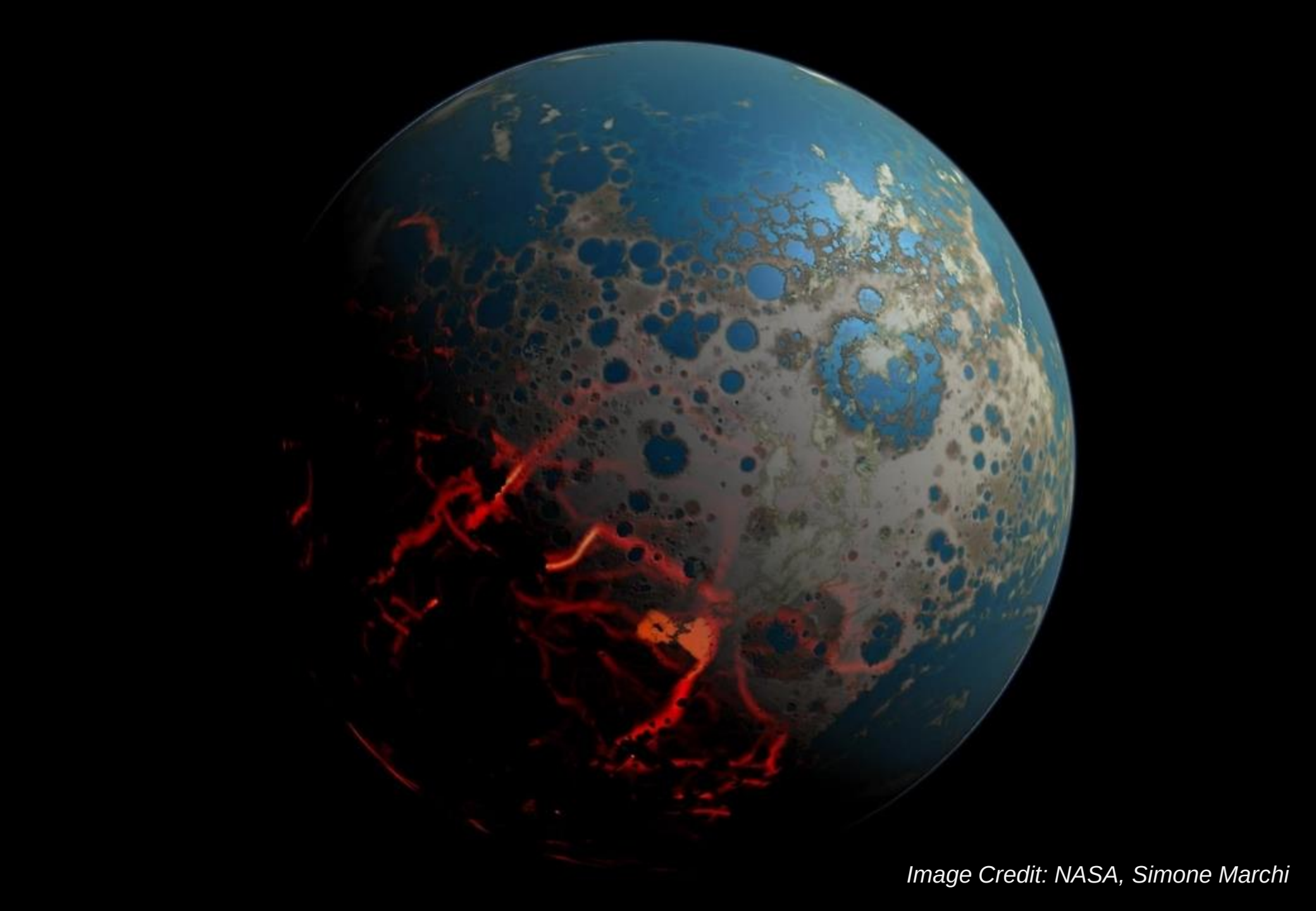
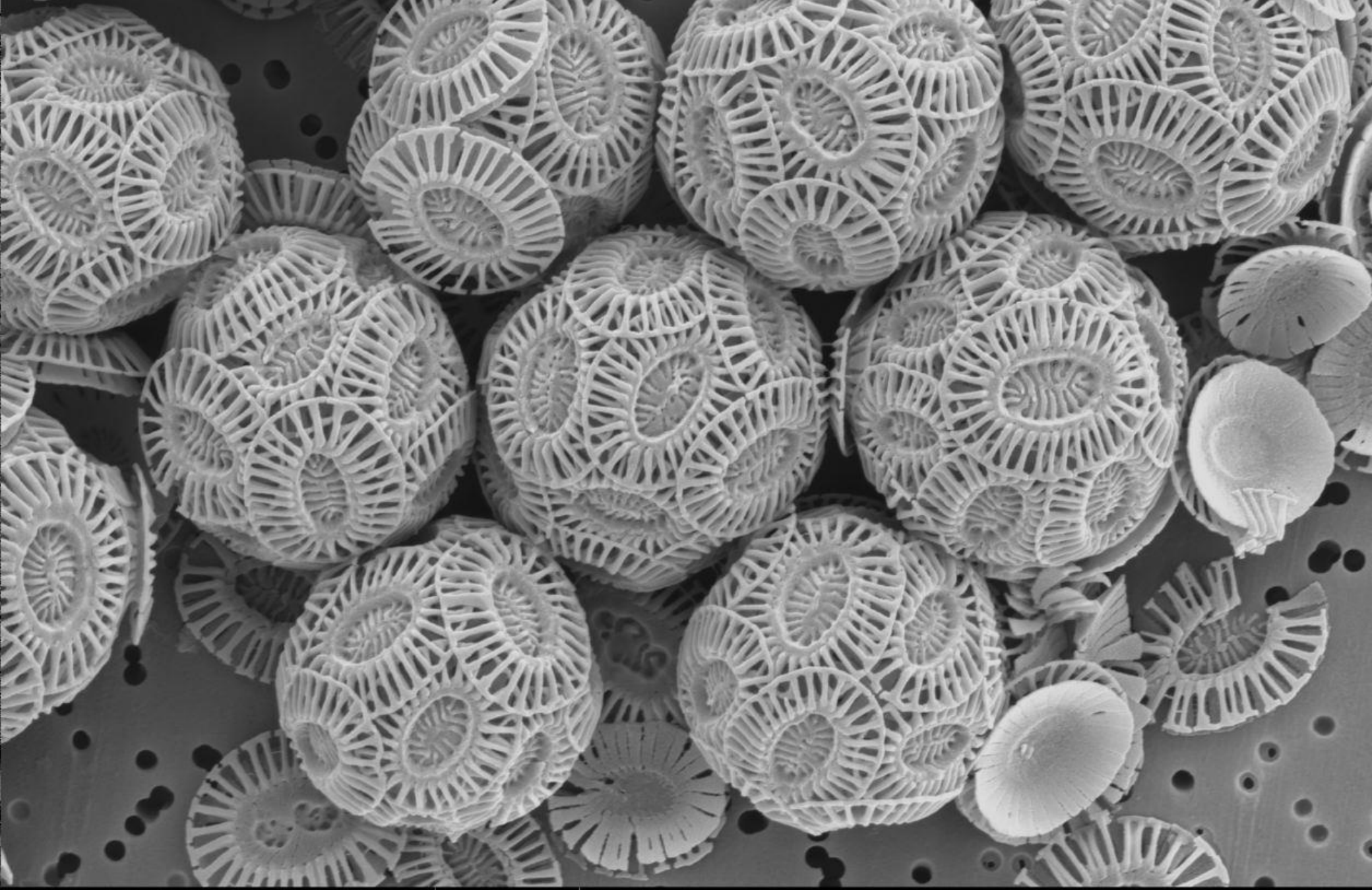


Image Credit: NASA, Simone Marchi

Terraforming the planet


pixabay

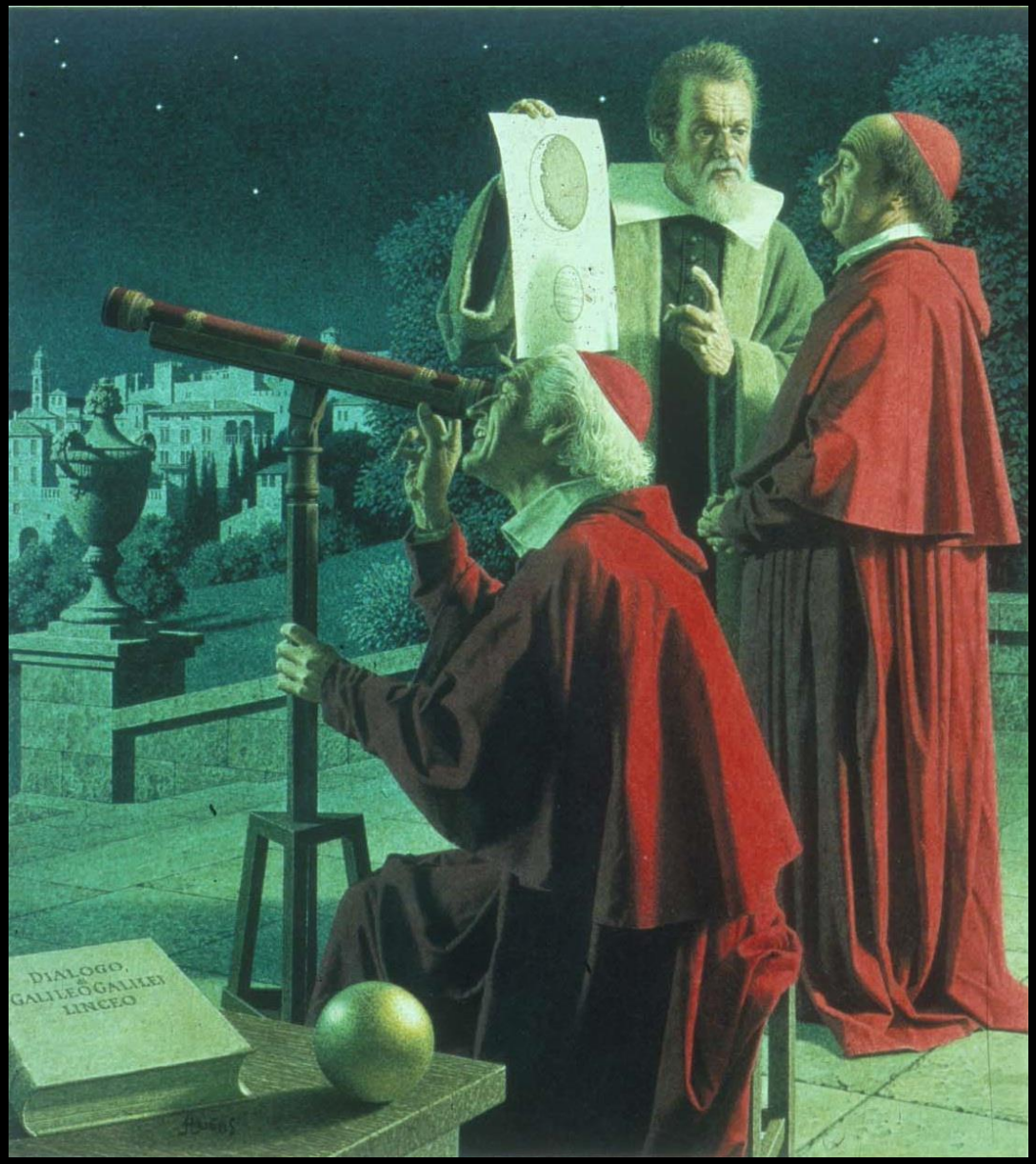

Acc.V Spot Magn Det WD
5.00 kV 3.0 6500x SE 10.0
2 µm
JRY 218

Animals step to dry land, each carrying around a small piece of sea.

Image Credit: NASA

Life continues to expand to new horizons

Influential innovations in space exploration



1609 Telescope

by Galileo

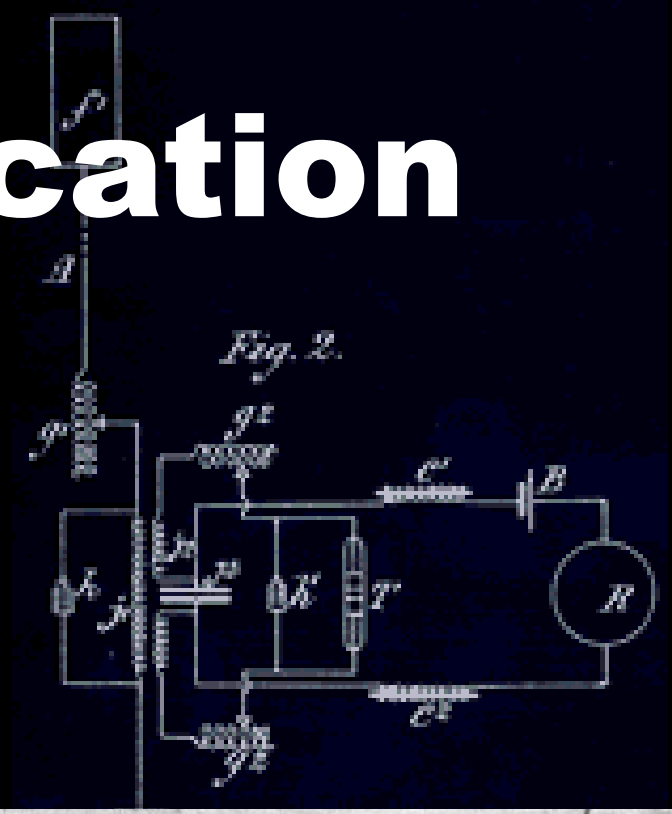
Telescope

Remained the most important space exploration tool till 1950’ties

Radio communication

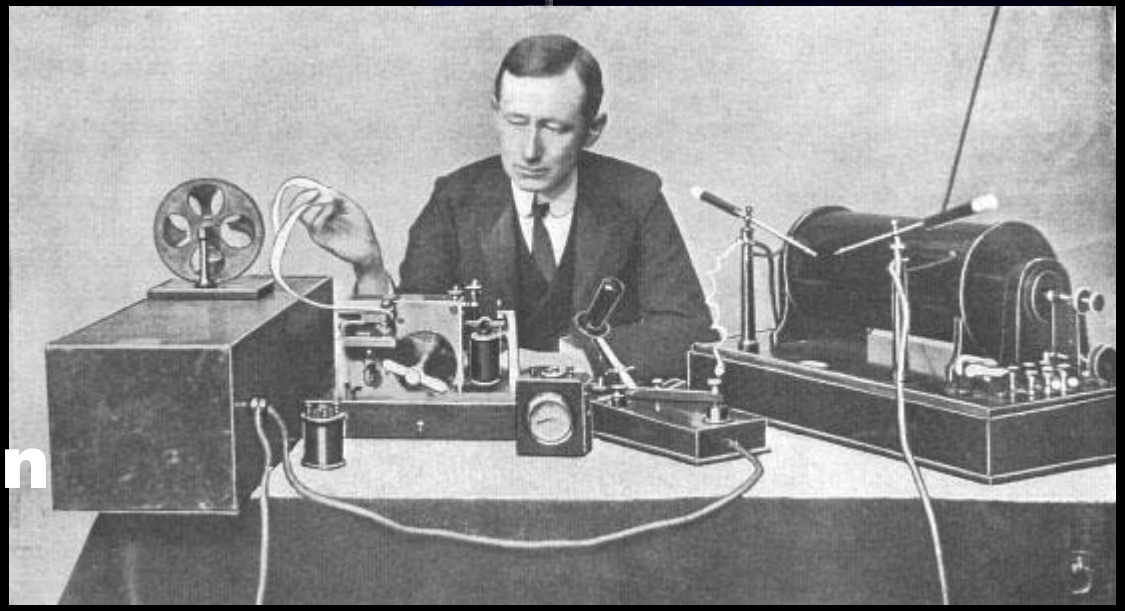
1873

Maxwell predicts EM waves



1888

Herzian waves demonstration



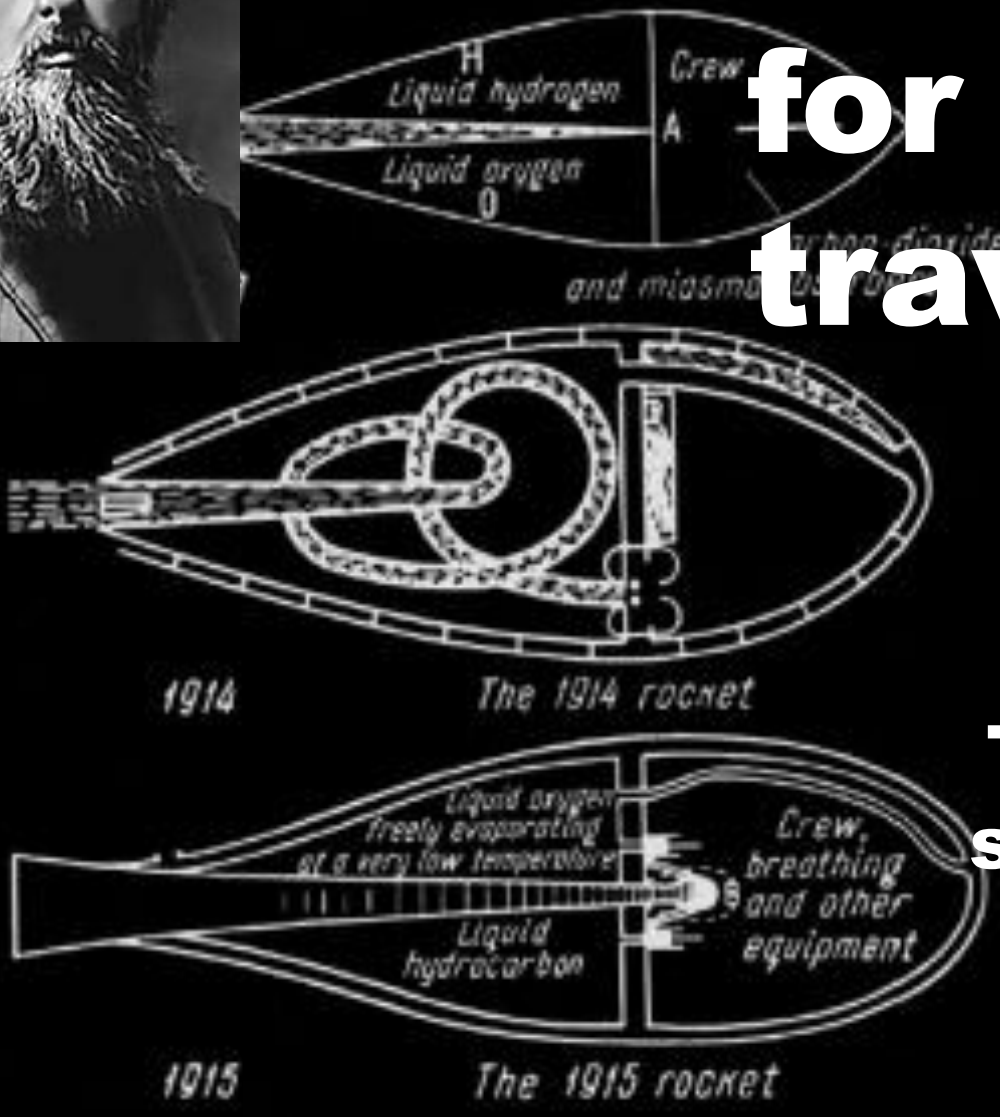
1900

Radio communication patents

Early Rockets

China in 1300

Propulsion for space travel



1903

Tsiolkovsky: idea of space research by a rocket device

1903

Исследование мировых пространств реактивными приборами
Konstantin Tsiolkovsky

1912

Robert Esnault-Pelterie's lecture on rocket theory
Robert Goddard analysis of rockets

1920

Robert Goddard: A Method of Reaching Extreme Altitudes
Idea of traveling to the moon

Link

1923

Hermann Oberth
Die Rakete zu den Planetenräumen

1924

Cosmic Rocket Trains
Konstantin Tsiolkovsky

1928

RAK-1 car by OPEL

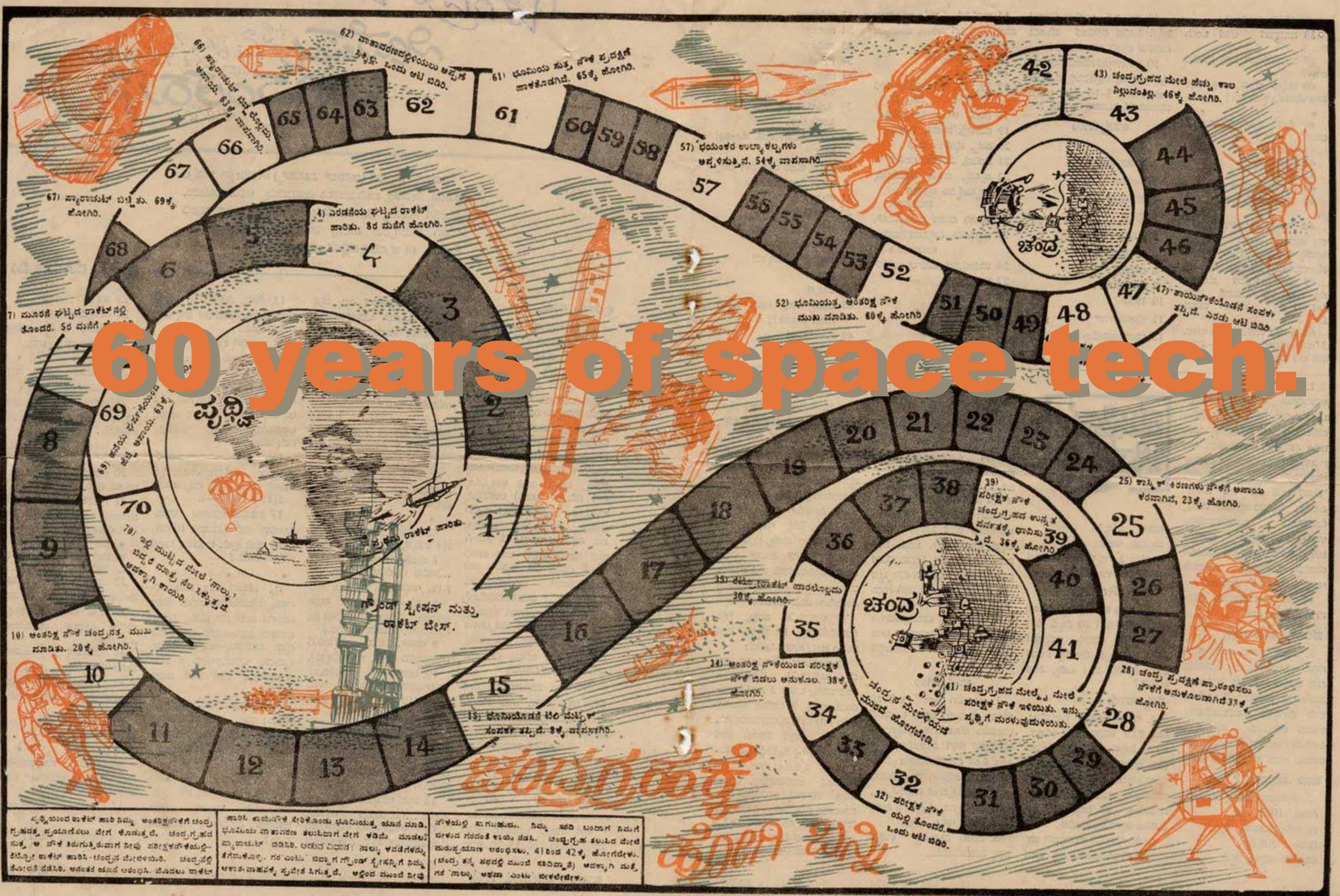
1931

Leningrad Gas Dynamics Laboratory

1932

Reichswehr starts rocket weapon research

60 years of space tech.



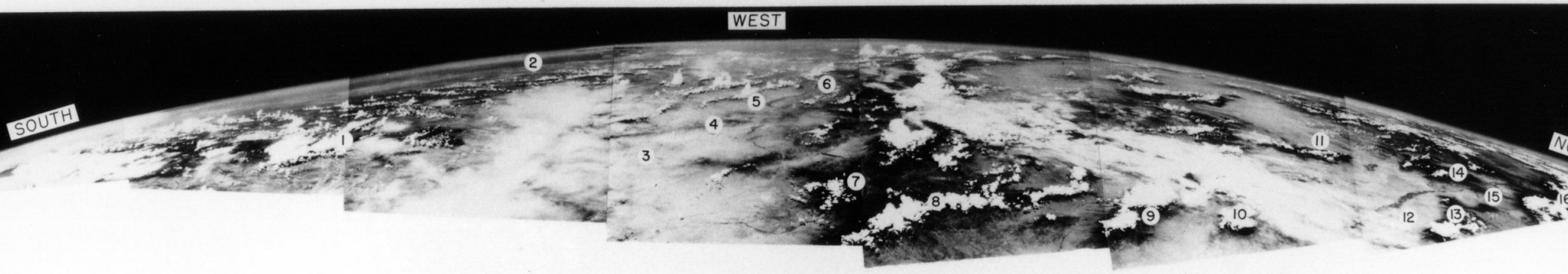
1944 German V-2

The first rocket reaches space

1945

Operation paperclip. Peenemünde rocket team is captured and transferred to US.

V-2 ROCKET-EYE VIEW FROM 60 MILES UP



1- MEXICO
2- GULF OF CALIFORNIA
3- LORDSBURG, NEW MEXICO
4- PELONCILLO MTS.
5- GILA RIVER
6- SAN CARLOS RESERVOIR
7- MOGOLLON MTS.
8- BLACK RANGE
9- SAN MATEO MTS.
10- MAGADALENA MTS.
11- MT. TAYLOR
12- ALBUQUERQUE, NEW MEX
13- SANDIA MTS.
14- VALLE GRANDE MTS.
15- RIO GRANDE
16- SANGRE DE CRISTO RANGE

KET FIRED AT WHITE SANDS PROVING GROUND, JULY 26,1948

DISTANCE FROM CAMERA TO HORIZON-700 MILES

WN APPROXIMATELY 800,000 SQ.MILES

DISTANCE ALONG HORIZON-2700 MILES

INSTRUMENTATION AND PHOTOGRAPHY BY APPLIED PHYSICS LA
THE JOHNS HOPKINS UNIVERSITY FOR THE BUREAU OF ORDNANC

The first spacecraft

1957 Sputnik

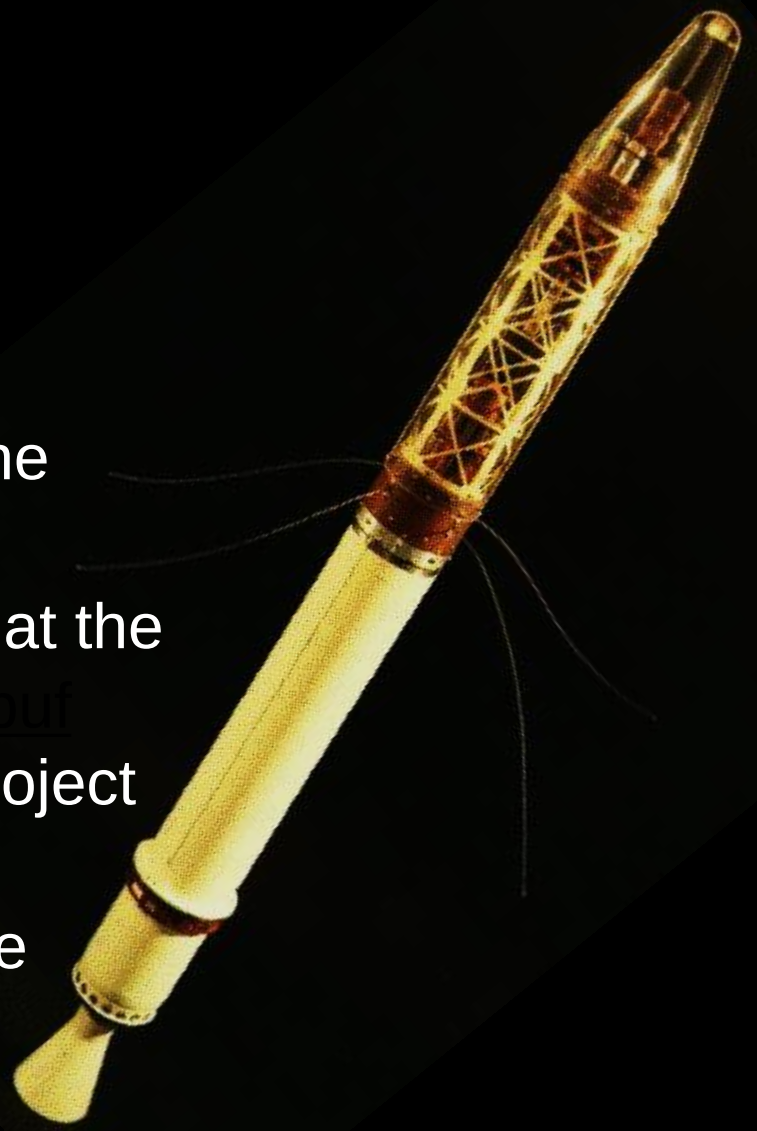
Combining rocket, satelite and radio


www.thefeverof57.com

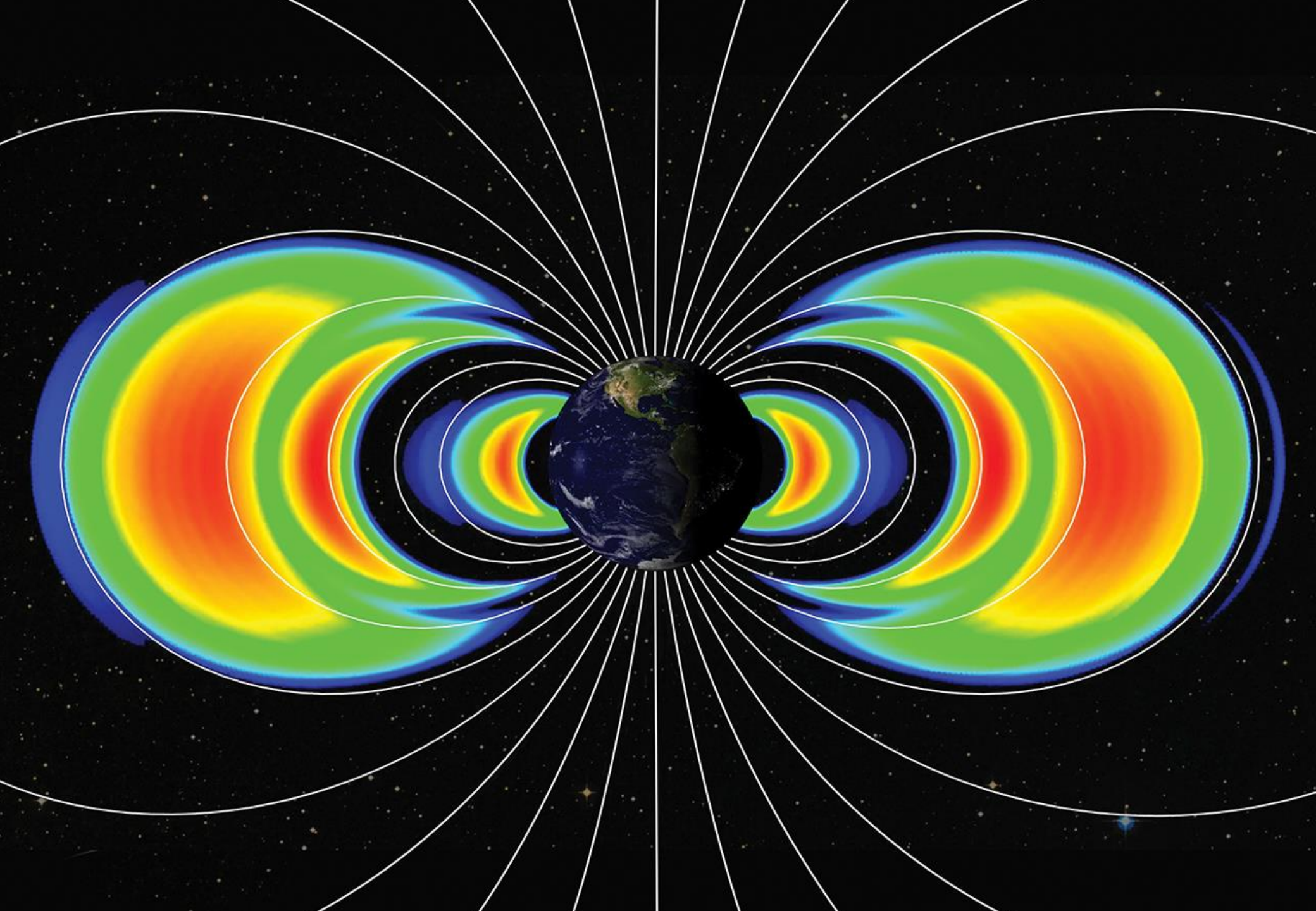
1958 Explorer-1

Detects Earth radiation belts

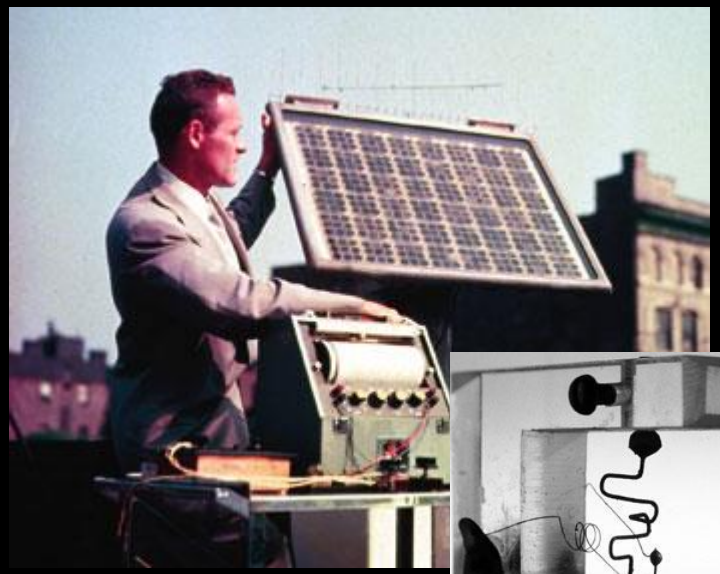
1954 Wernher von Brown and Redstone (mil)
1955 President Eisenhower declared that the nation will launch a satellite
Eisenhower suspended the Redstone project and selected project Vanguard (civilian)
1957 after Sputnik launch, the Redstone project was reviewed and
Explorer-1 was built in 84 days



William Hayward Pickering, James Van Allen, and Wernher von Braun



Satellite parts
from Bell labs



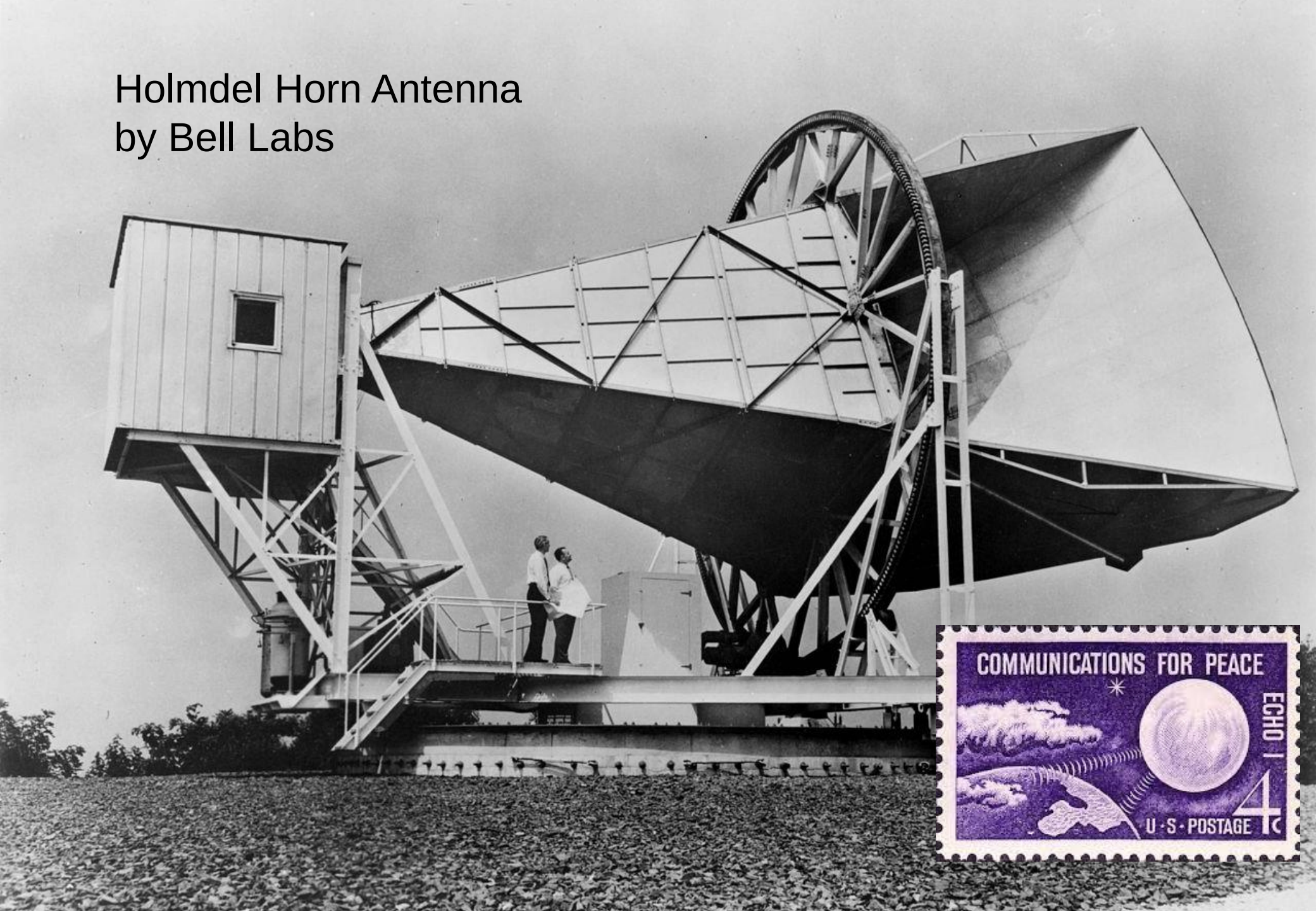
1947 Transistor
1947 Hamming codes
1948 Communication theory
1954 Photovoltaic Panel
1962 Communication satellites
1969 Charge-coupled Device CCD
1972 C-language, UNIX
1974 TTL logic

First steps on sat com

Bell Labs and NASA

1960 Echo 1A
1964 Echo 2

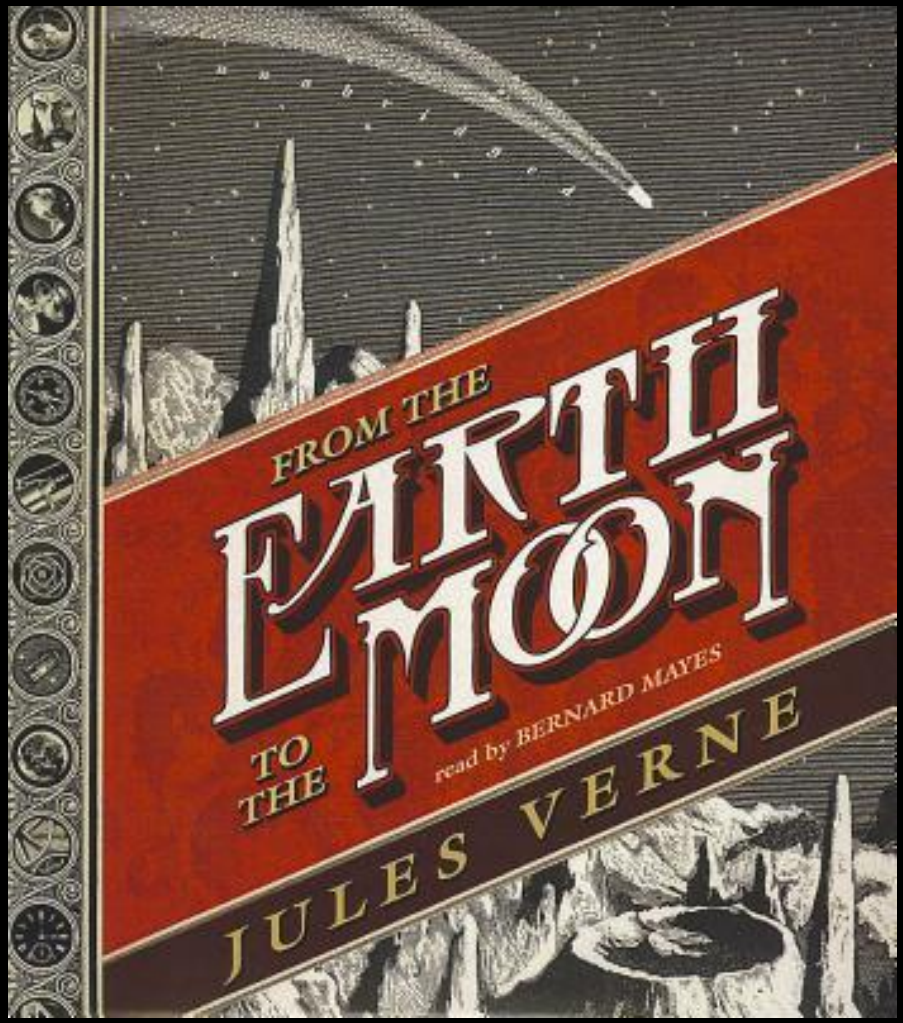
Holmdel Horn Antenna
by Bell Labs



Telstar

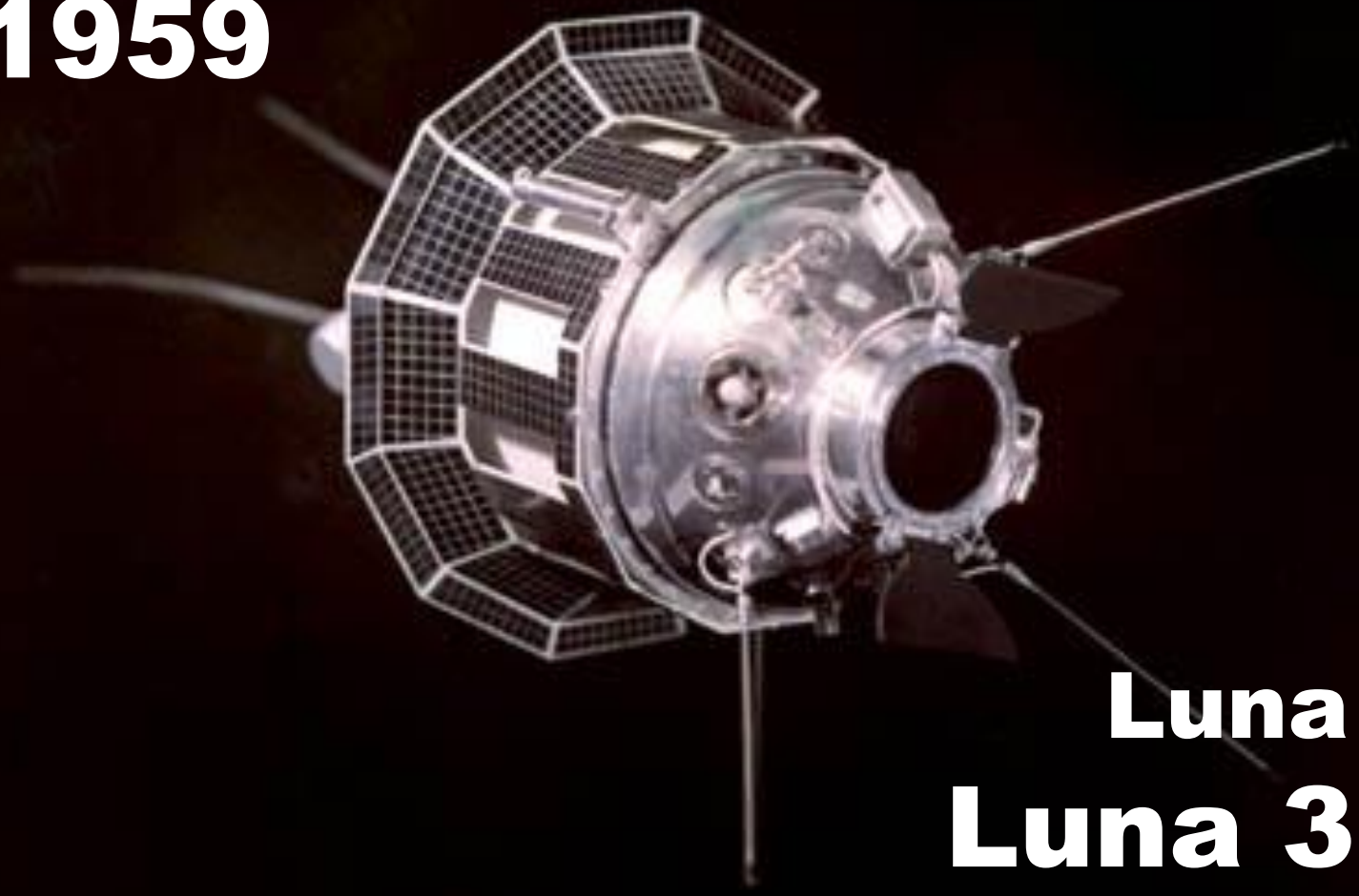
Launch 1962
Power: 15 W
Mass: 77 kg
Three Ground stations
Relay for one TV channel
and 600 phone calls
(for 20 min com session)

Race to the Moon


FROM THE
EARTH
TO THE
MOON
read by BERNARD MAYES
JULES VERNE


AIRMONT
CLASSICS SERIES CL78
H. G. WELLS
THE
FIRST MEN
IN THE
MOON
Introduction by Robert A. W. Lo
Complete
and Unabridged

1959



Luna 2 (USSR)

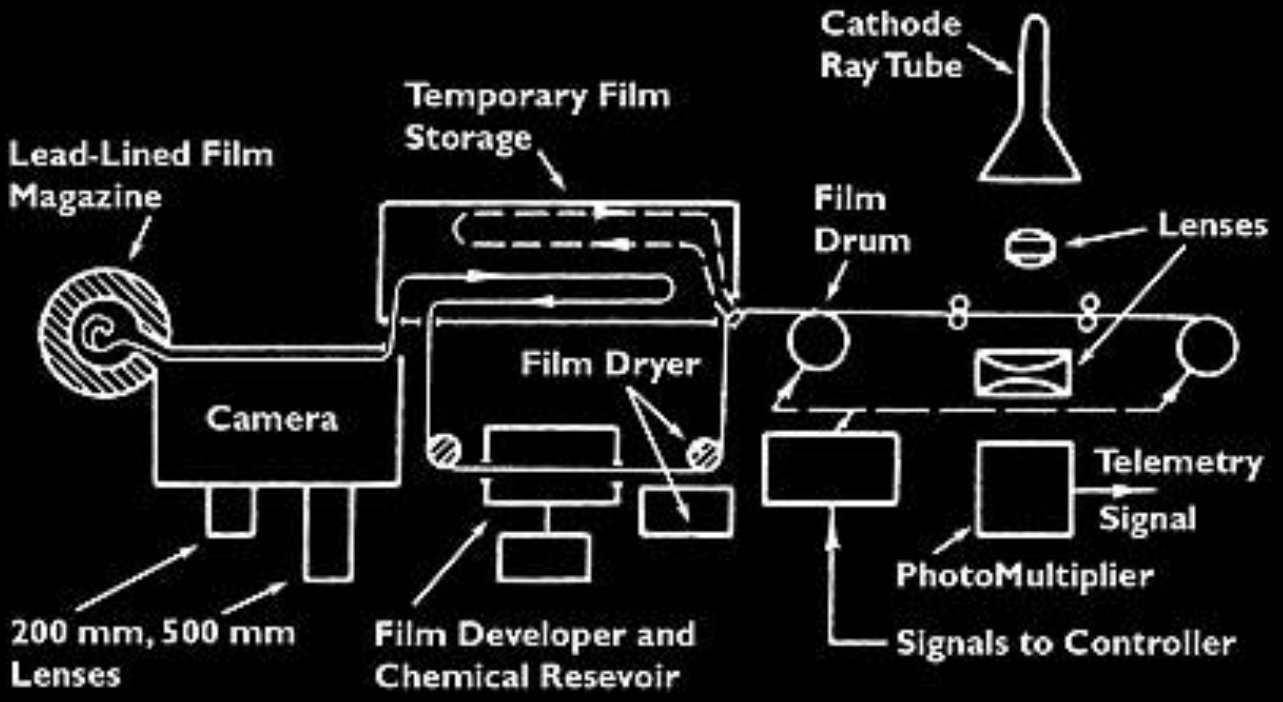
Luna 3 (USSR)

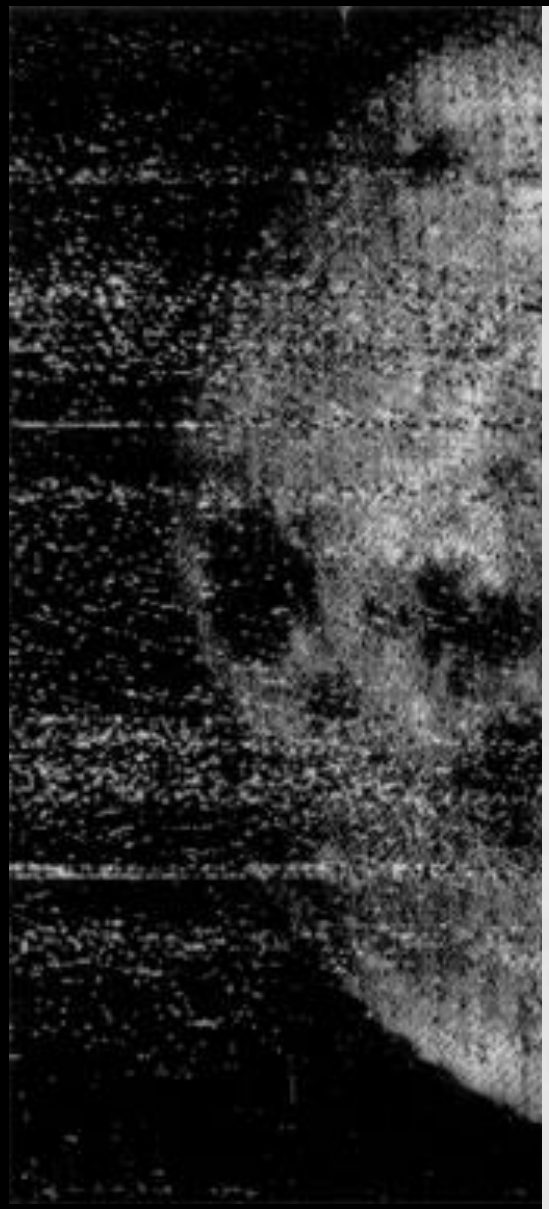
1959

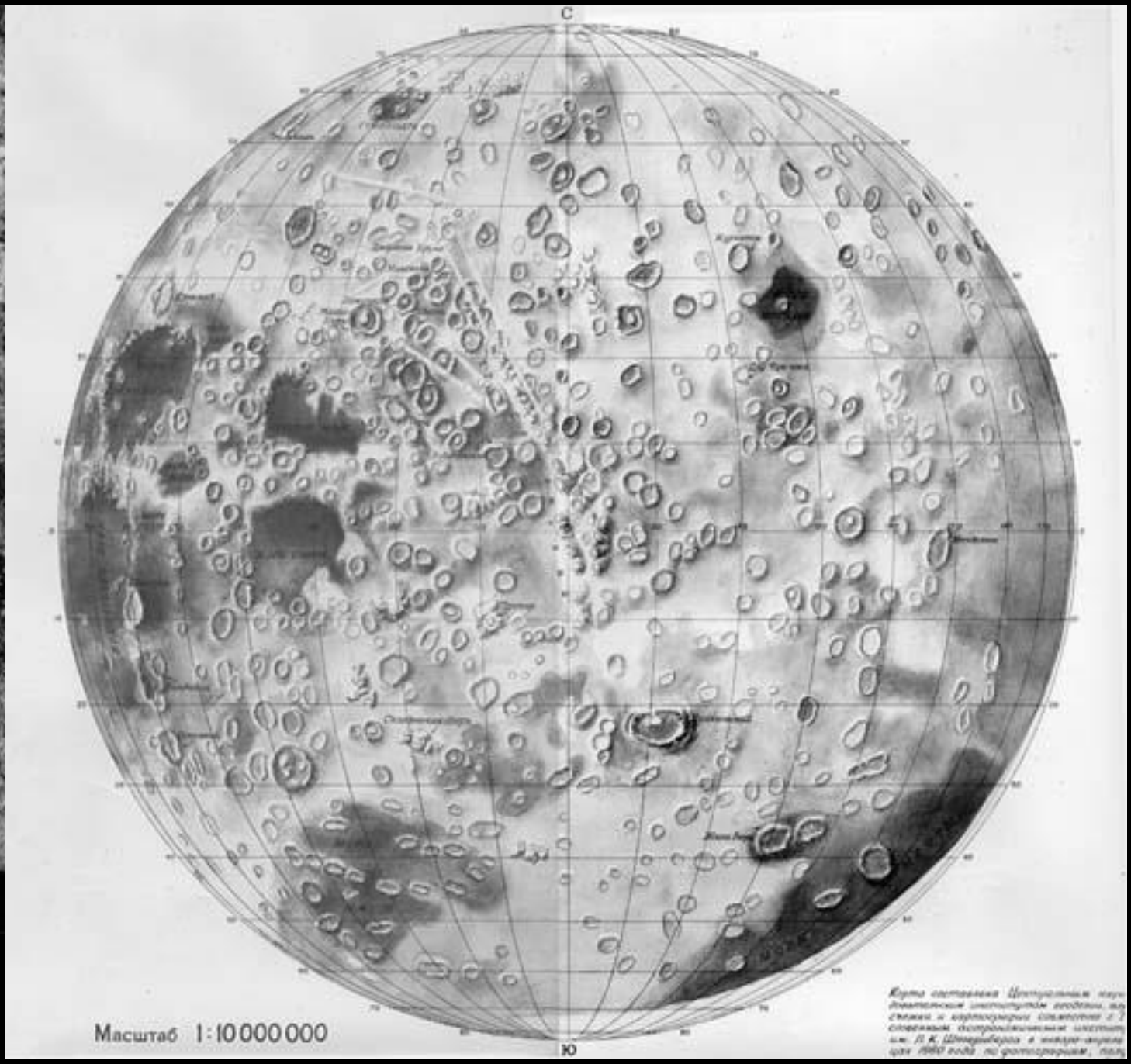
First images of the far side of the Moon

AFA-E1 Phototelevision system

"*Yenisey*" Phototelevision System, Prototype for AFA-E1





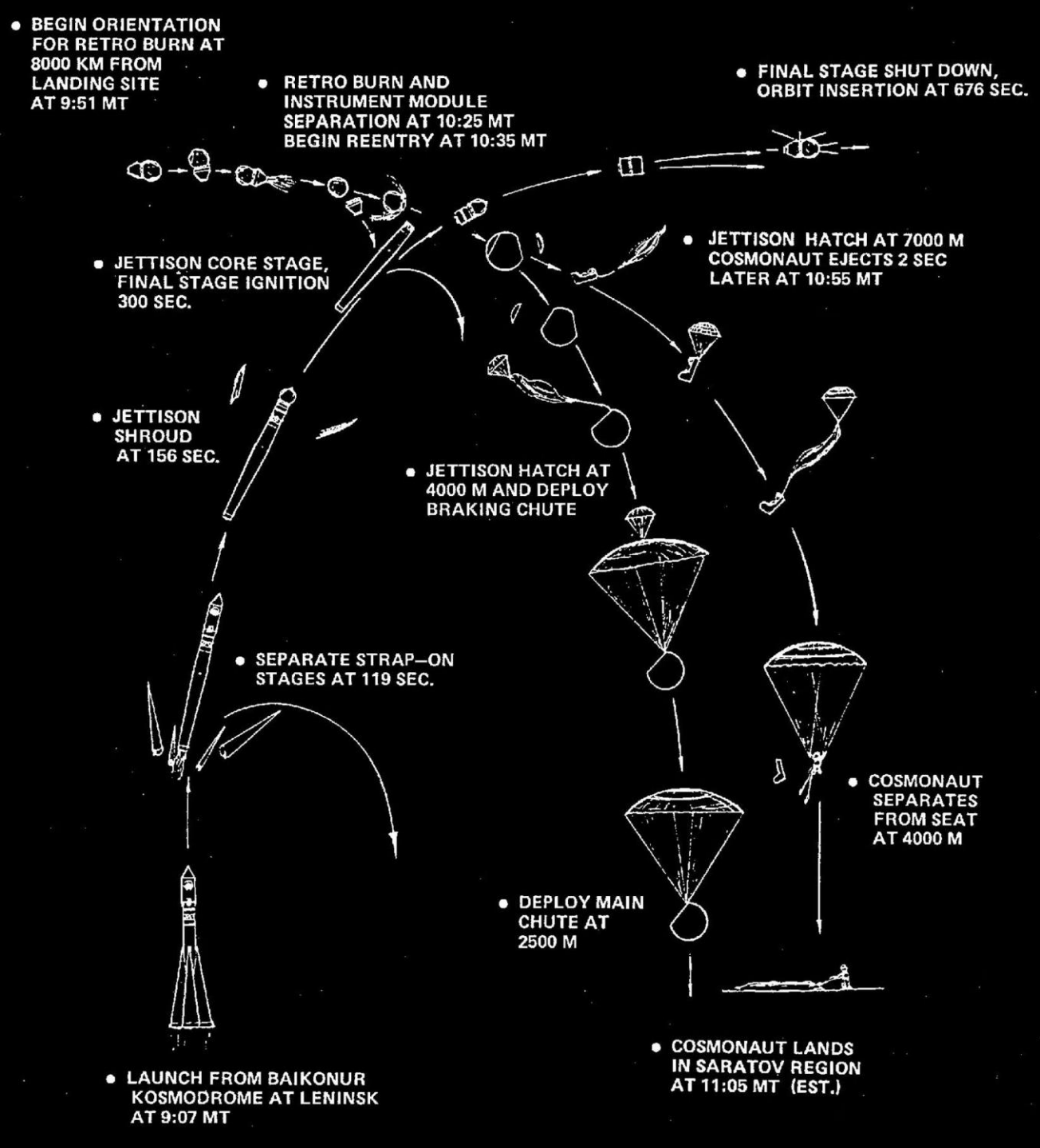


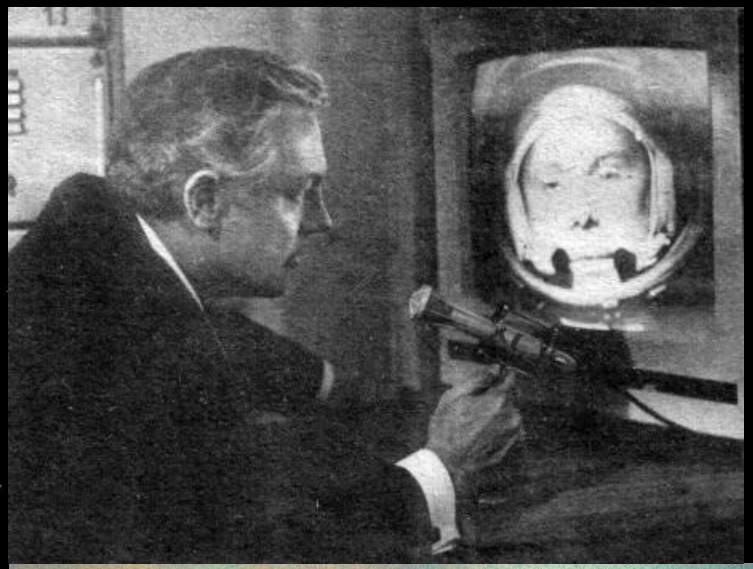
Карта составлена Центральным научно-исследовательским институтом геодезии, аэросъемки и картографии совместно с Государственным астрономическим институтом им. П. К. Штернберга в масштабе 1:10 000 000 по фотографиям, полу

First man in space

1961

Yuri Gagarin obits the Earth as the first man in space


• BEGIN ORIENTATION FOR RETRO BURN AT 8000 KM FROM LANDING SITE AT 9:51 MT
• RETRO BURN AND INSTRUMENT MODULE SEPARATION AT 10:25 MT BEGIN REENTRY AT 10:35 MT
• FINAL STAGE SHUT DOWN, ORBIT INSERTION AT 676 SEC.
• JETTISON CORE STAGE, FINAL STAGE IGNITION 300 SEC.
• JETTISON HATCH AT 7000 M COSMONAUT EJECTS 2 SEC LATER AT 10:55 MT
• JETTISON SHROUD AT 156 SEC.
• JETTISON HATCH AT 4000 M AND DEPLOY BRAKING CHUTE
• SEPARATE STRAP–ON STAGES AT 119 SEC.
• COSMONAUT SEPARATES FROM SEAT AT 4000 M
• DEPLOY MAIN CHUTE AT 2500 M
• COSMONAUT LANDS IN SARATOV REGION AT 11:05 MT (EST.)
• LAUNCH FROM BAIKONUR KOSMODROME AT LENINSK AT 9:07 MT

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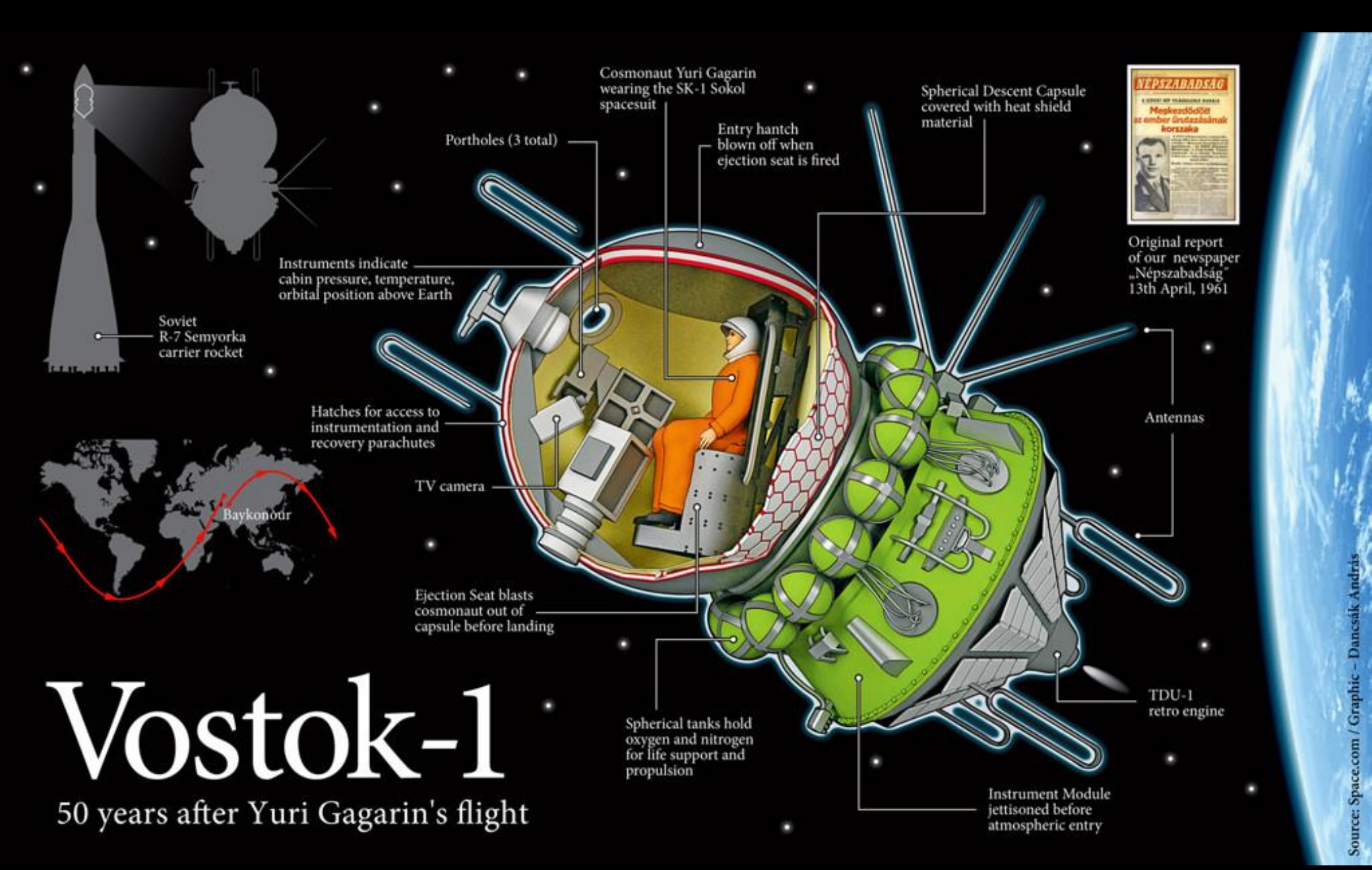


Vostok-1

50 years after Yuri Gagarin's flight


www.videocosmos.com

1962

John F. Kennedy

"..this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth."

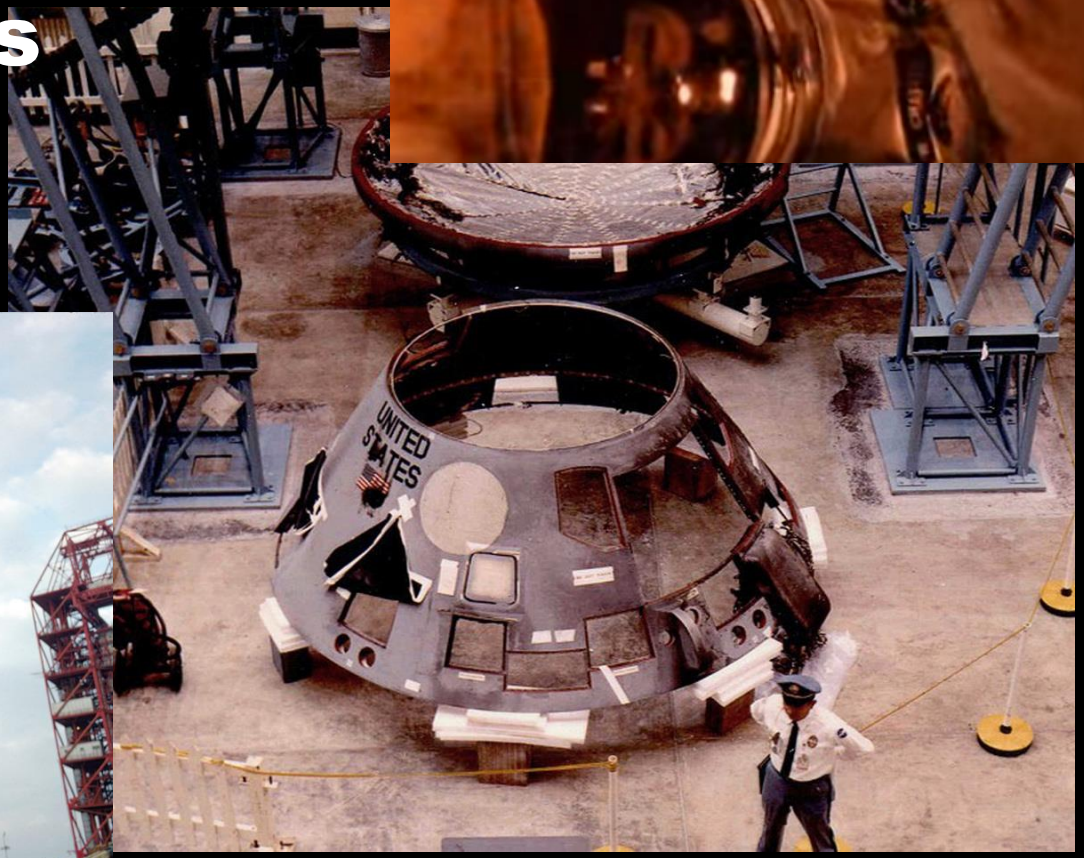
Apollo program

1958 Project Mercury
1962 - 1966 Project Gemini
1961 – 1972 Project **Apollo**

- Six spaceflights to the Moon
- 12 men to the surface of the Moon

Apollo-1 fire 1967

Three astonauts lost their lives



1968

Apollo 8

1969

Apollo 11

1967

Apollo 1
Fire during launch test claims lives of Apollo's first crew.

Virgil I. "Gus" Grissom; Edward H. White, II; and Roger B. Chaffee

1968

Apollo 7
Apollo's first successful manned launch into space.

Donn F. Eisele, Walter M. Schirra, and R. Walter Cunningham

1968

Apollo 8
Astronauts escape the bounds of Earth's gravitational field.

James A. Lovell, Jr.; William A. Anders; and Frank F. Borman, II

1969

Apollo 9
NASA's first manned mission of the lunar module.

James A. McDivitt, David R. Scott, and Russell L. Schweickart

1969

Apollo 10
NASA's final dress rehearsal for lunar landing is a success.

Eugene A. Cernan, John W. Young, and Thomas P. Stafford

1969

Apollo 11
First manned Moon landing and Armstrong's famous first step.

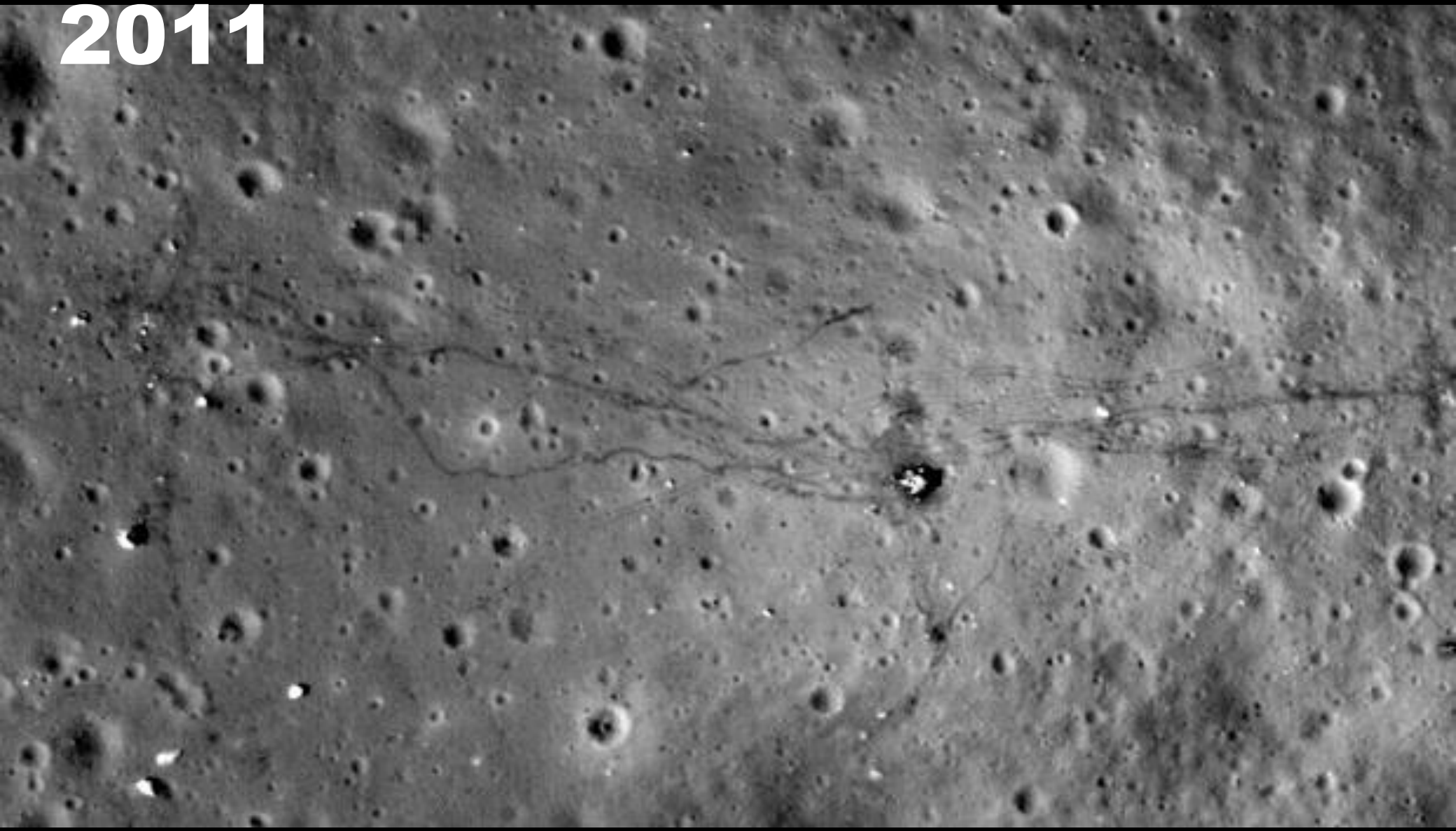
Neil Armstrong; Michael Collins; and Edwin E. "Buzz" Aldrin, Jr.

1969

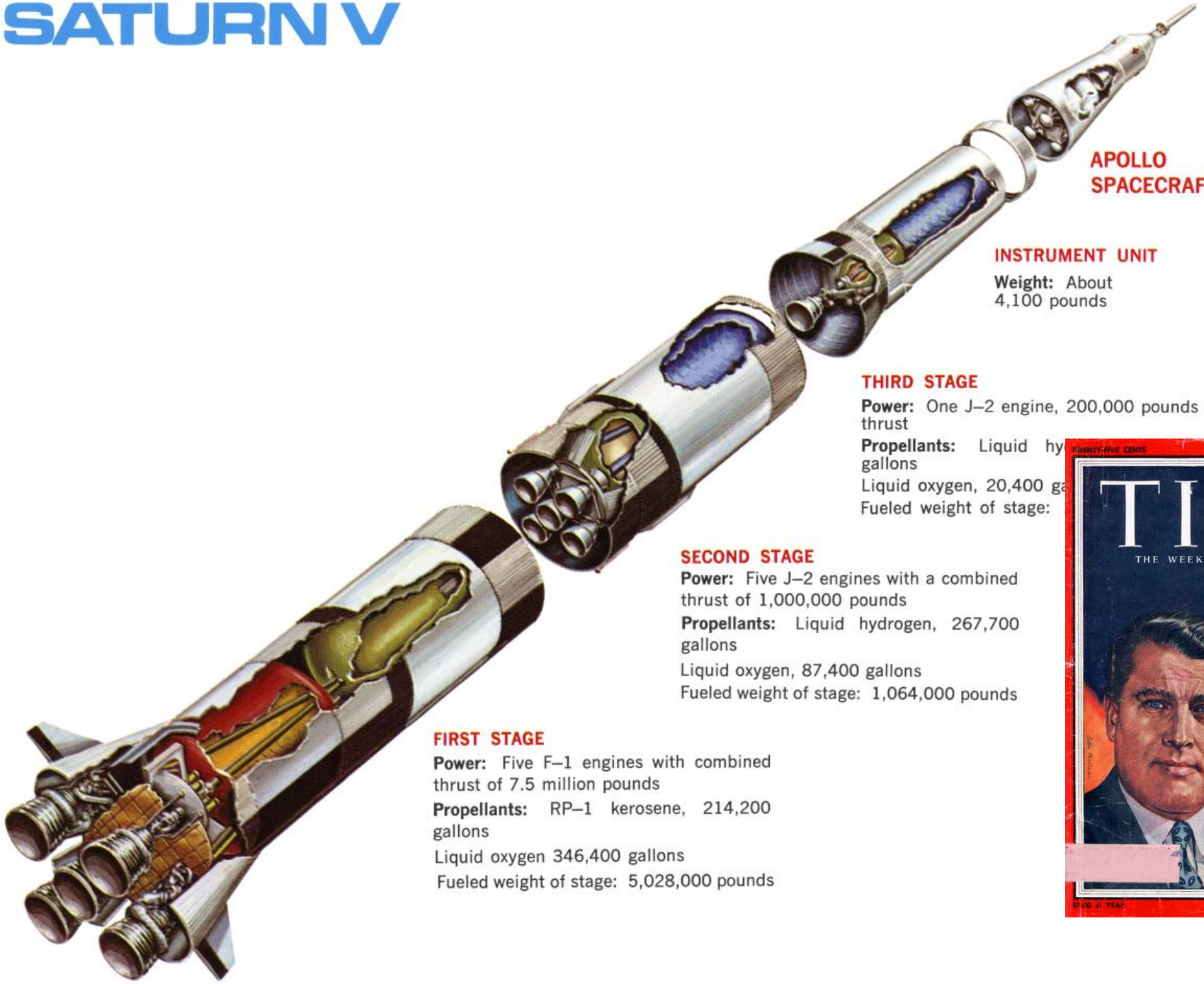
Apollo 12

1970

Apollo XIII
Apollo 13 aborts mission after


2011

SATURN V



APOLLO SPACECRAFT

INSTRUMENT UNIT

Weight: About 4,100 pounds

THIRD STAGE

Power: One J–2 engine, 200,000 pounds thrust

Propellants: Liquid hy
gallons
Liquid oxygen, 20,400 ga
Fueled weight of stage:

SECOND STAGE

Power: Five J–2 engines with a combined thrust of 1,000,000 pounds

Propellants: Liquid hydrogen, 267,700 gallons

Liquid oxygen, 87,400 gallons

Fueled weight of stage: 1,064,000 pounds

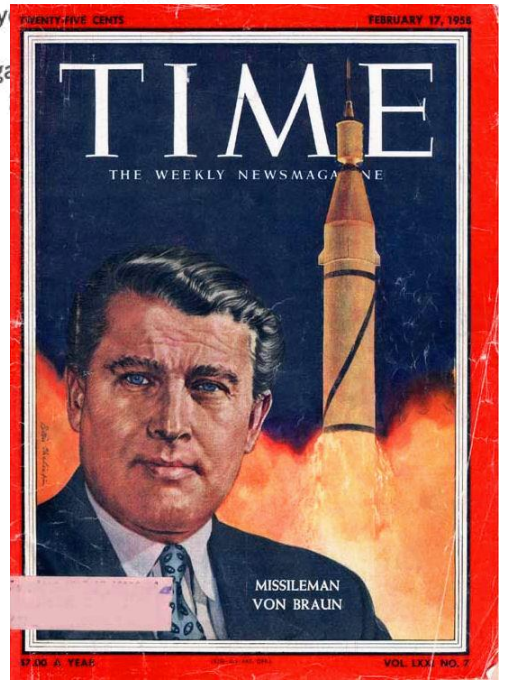
FIRST STAGE

Power: Five F–1 engines with combined thrust of 7.5 million pounds

Propellants: RP–1 kerosene, 214,200 gallons

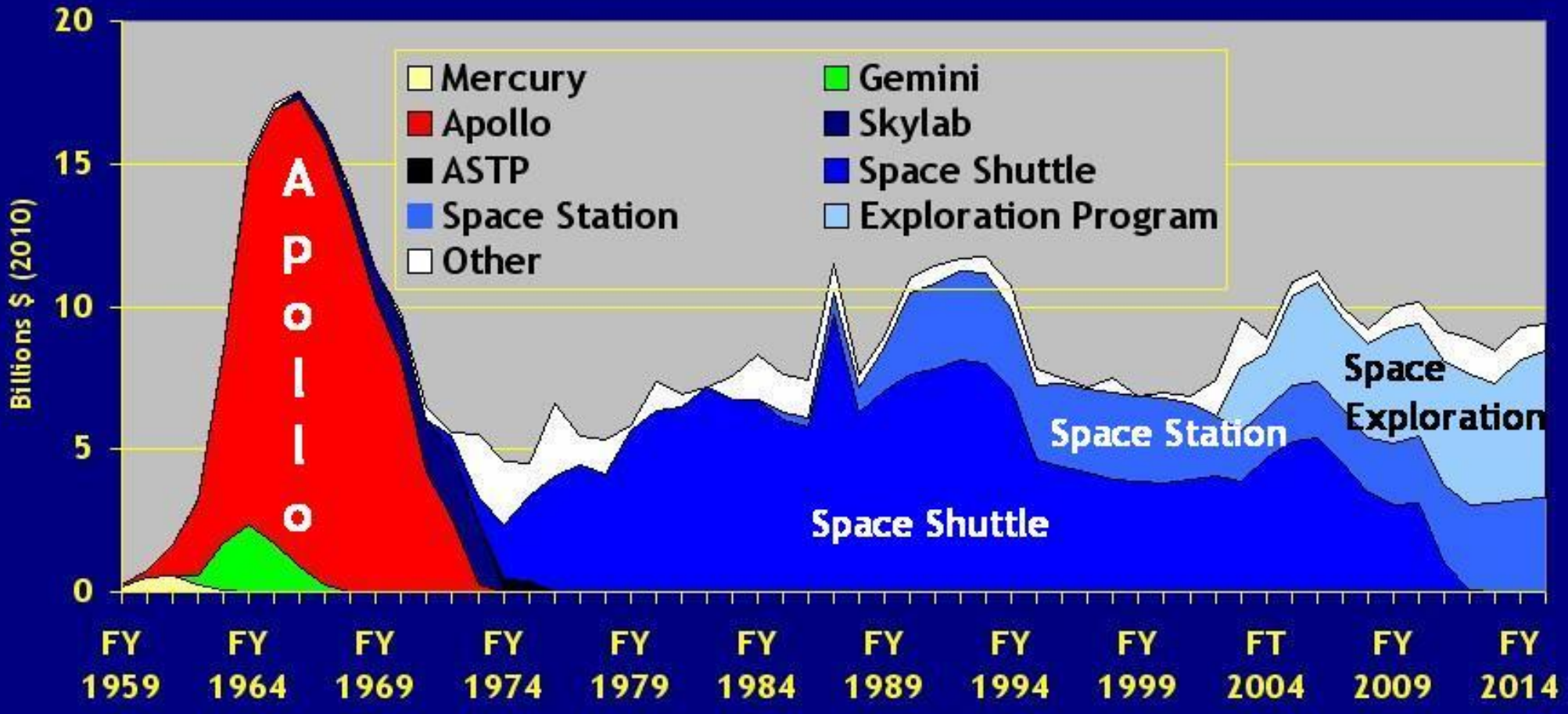
Liquid oxygen 346,400 gallons

Fueled weight of stage: 5,028,000 pounds



Saturn V – the biggest rocket ever built

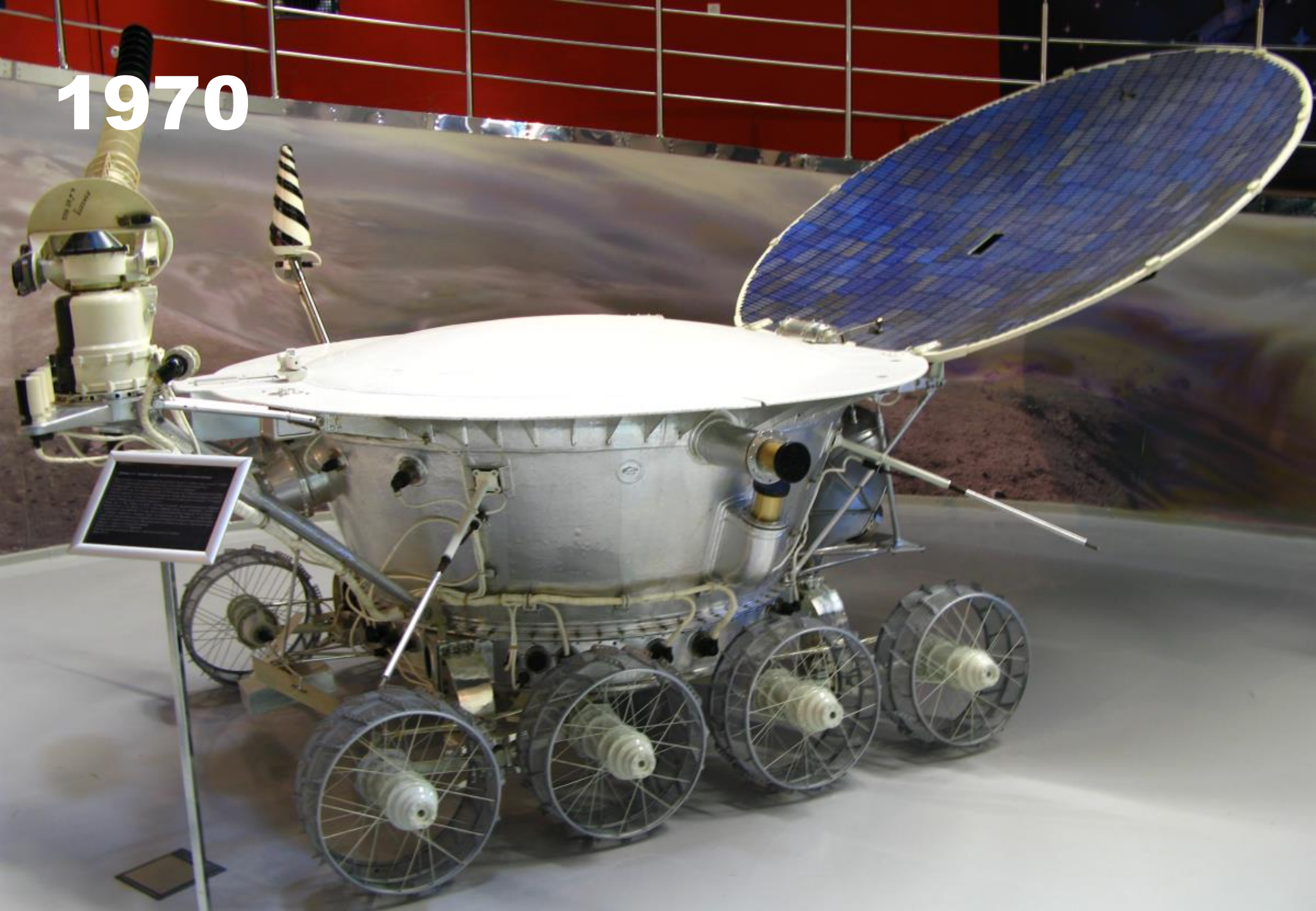
U.S. Piloted Programs Funding, 1959-2015 (2010$)

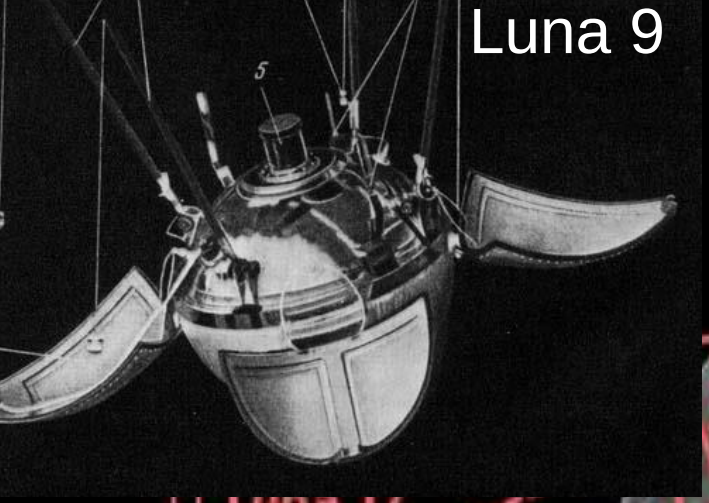


N1 – Russian Saturn V contender

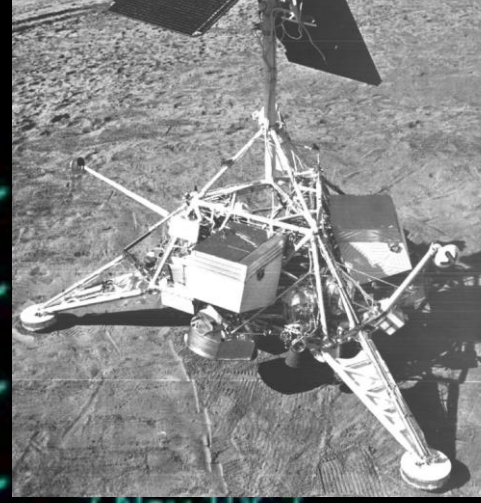
Ракета-носитель

Development program
for Soviet moon mission.
All four test flights failed.
Rocket was poorly tested
due to lack of resources.


1970



Luna 9



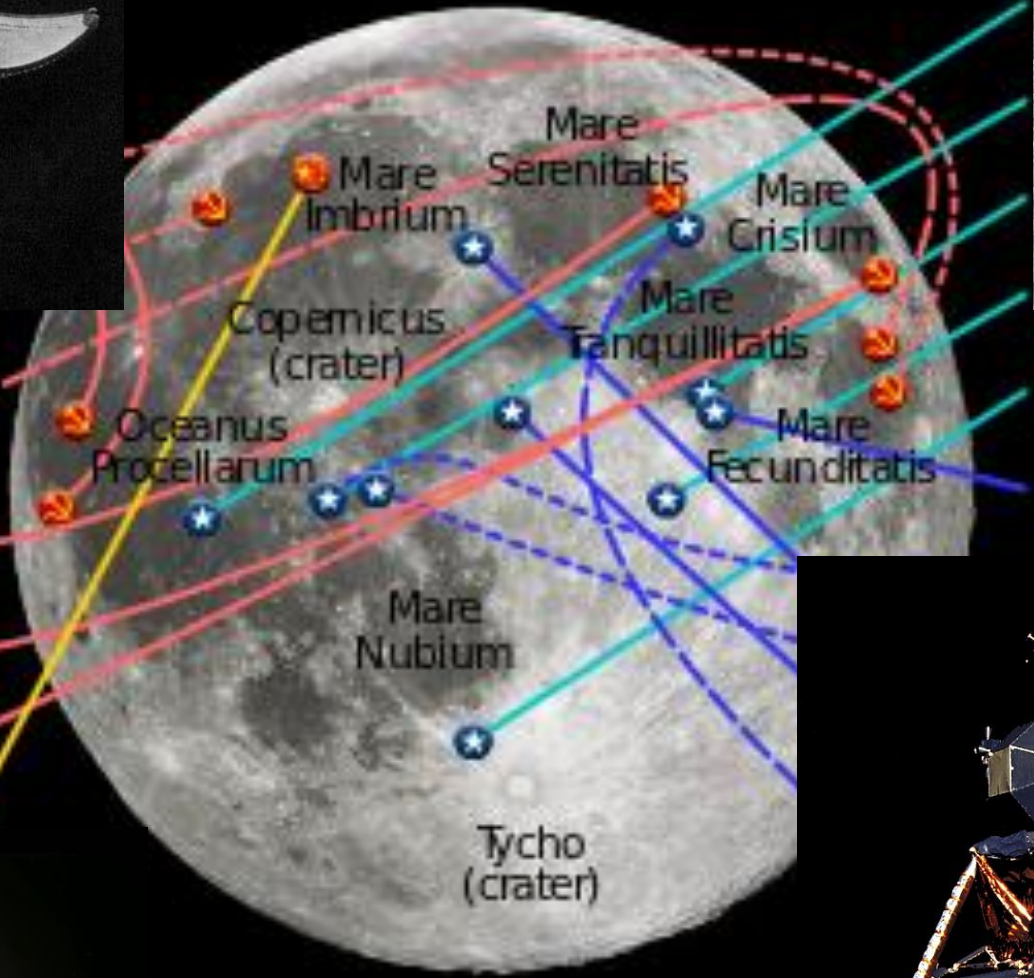
11. **Luna 17**
17 Nov 1970

14. **Luna 20**
21 Feb 1972

17. **Luna 21**
15 Jan 1973

18. **Luna 23**
6 Nov 1974

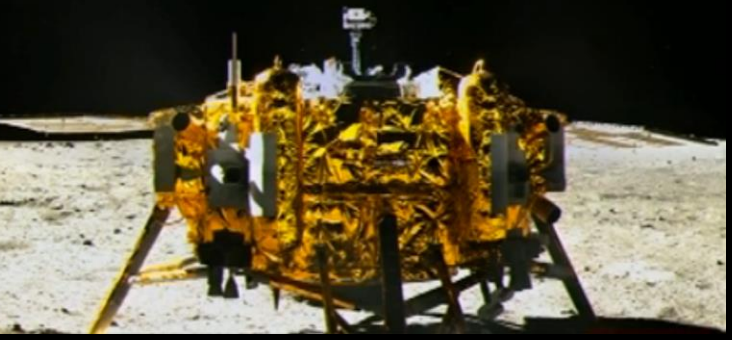
19. **Luna 24**
19 Aug 1976

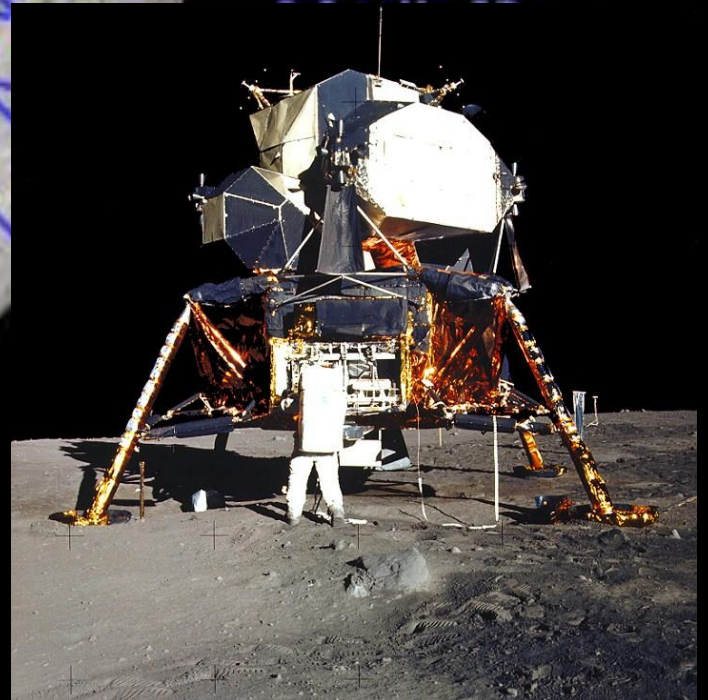


7 Nov 1967

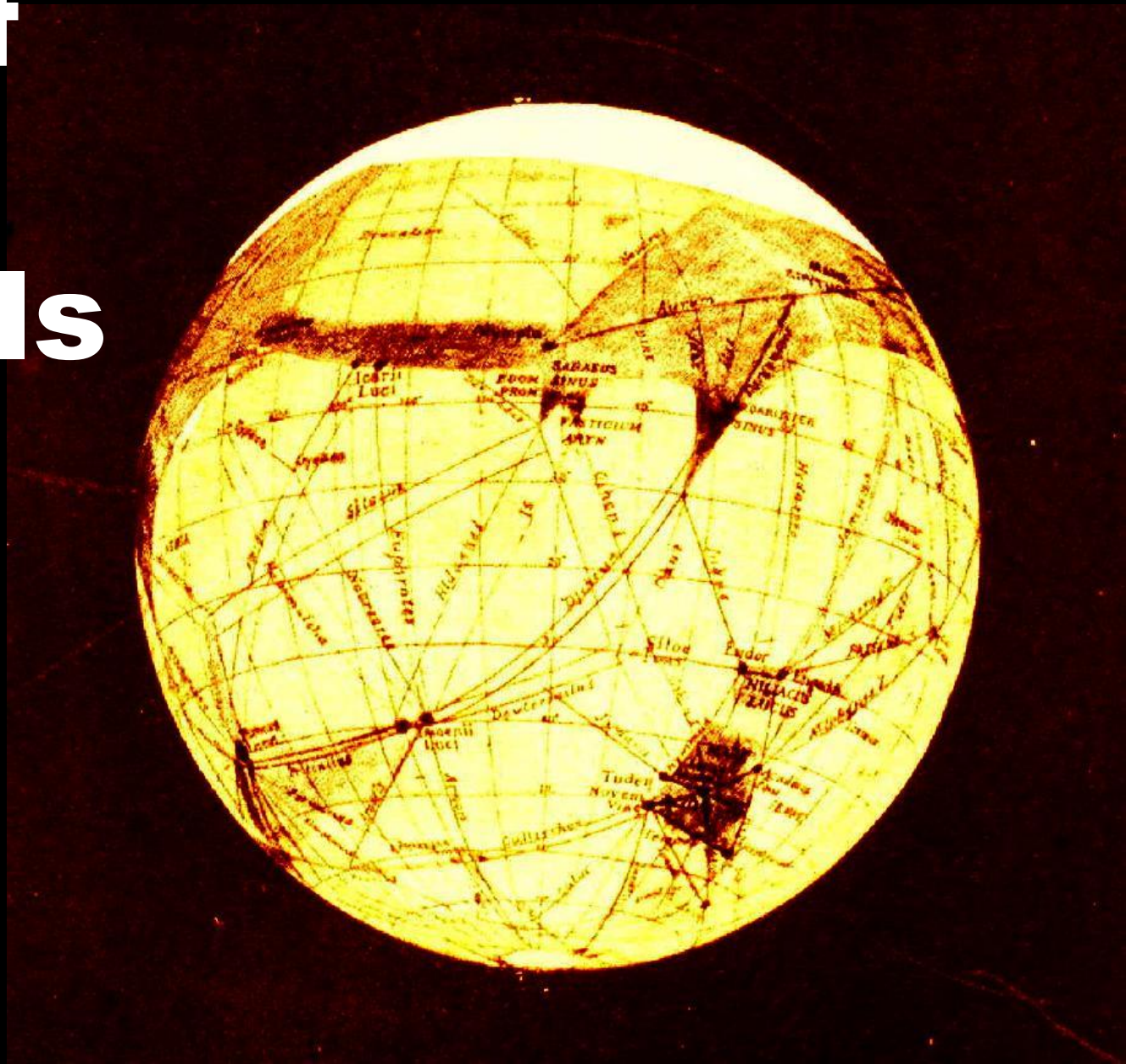
7. **Surveyor 7**
10 Jan 1968

8. **Apollo 11**
20 Jul 1969





Story of MARS Channels



Mars ”Channels”

1877 - Schiaparelli observes Mars with telescope and describees the picture with ”channels”. Draws first maps of Mars.

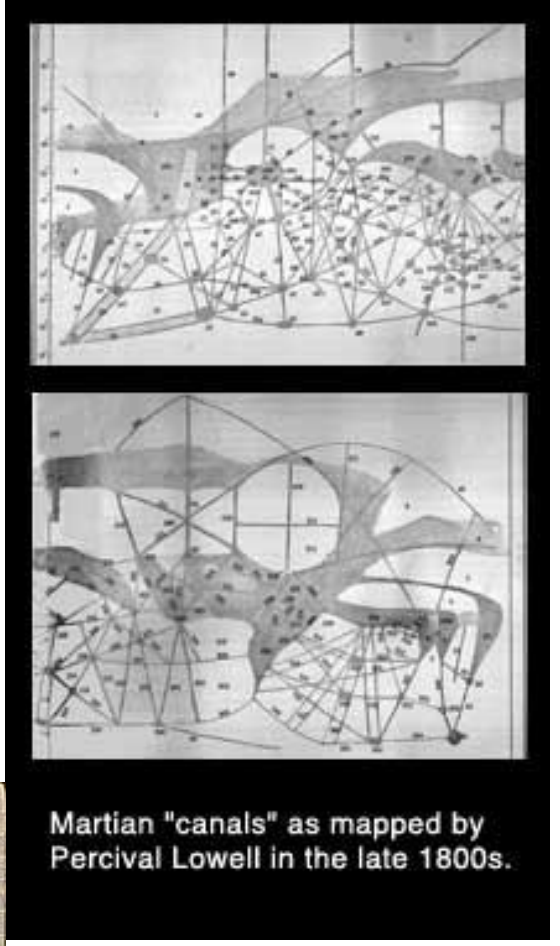
1895 - Percival Lowell publishes book ”Mars” where he is discussing the possibility that “channels” are made by a civilization.

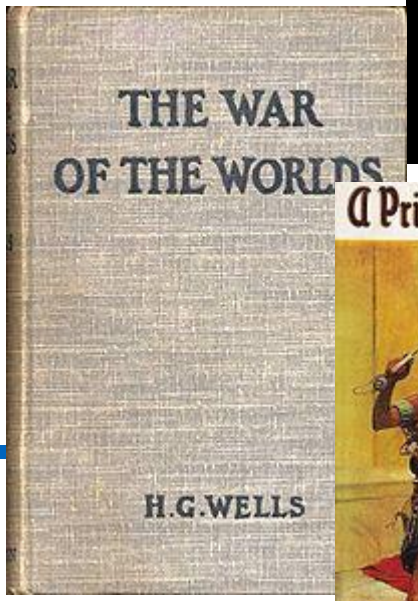
1896 - Percival Lowell: Intelligence on Mars

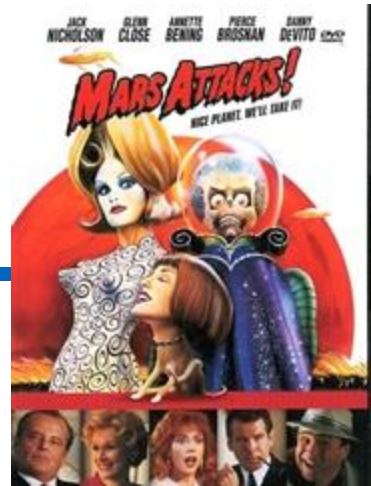
1897 – H.G. Wells, *The War of the Worlds*

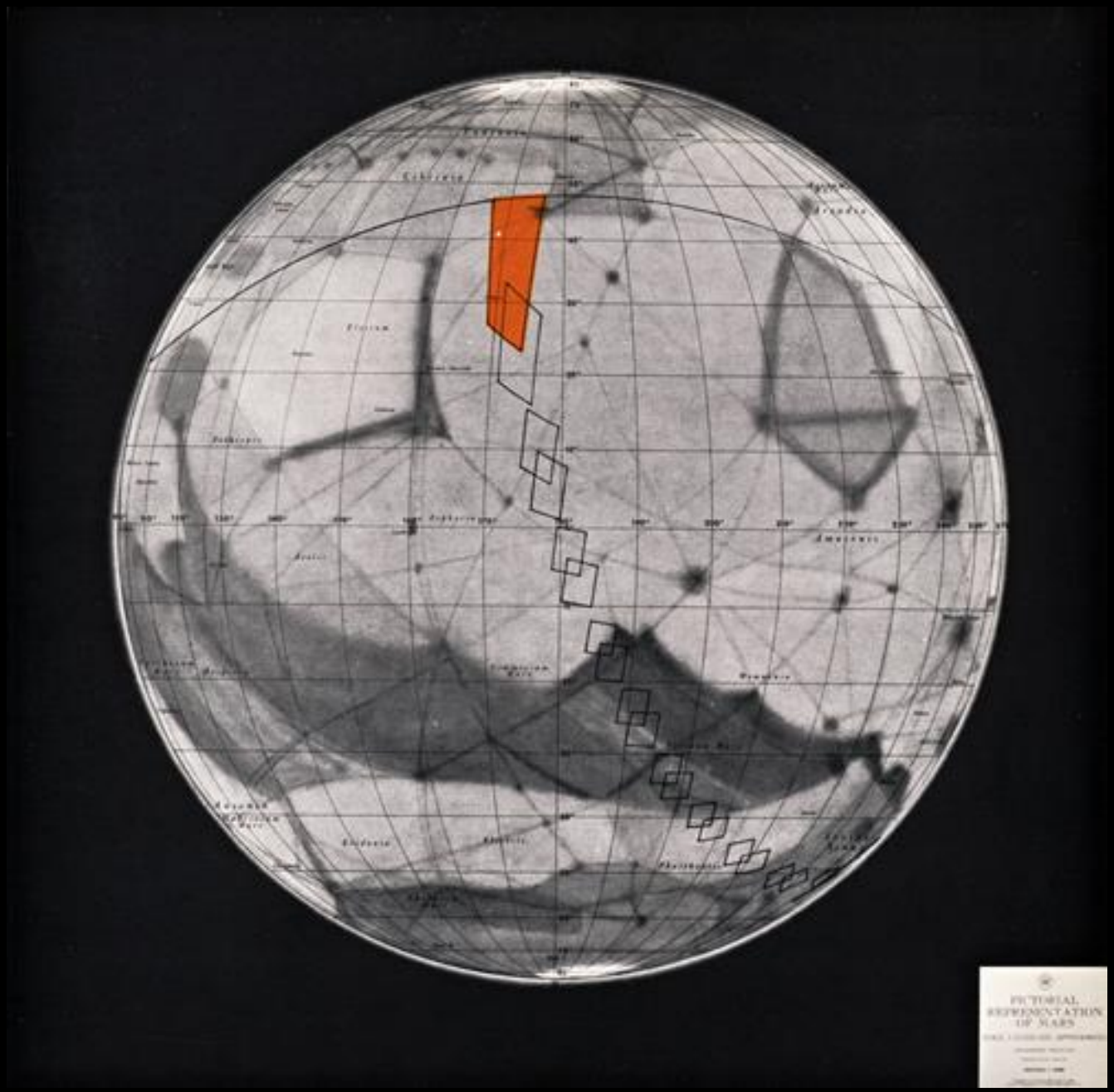
1912 – Princess of Mars

1938 - Orson Welles, radio play ***The War of the Worlds***

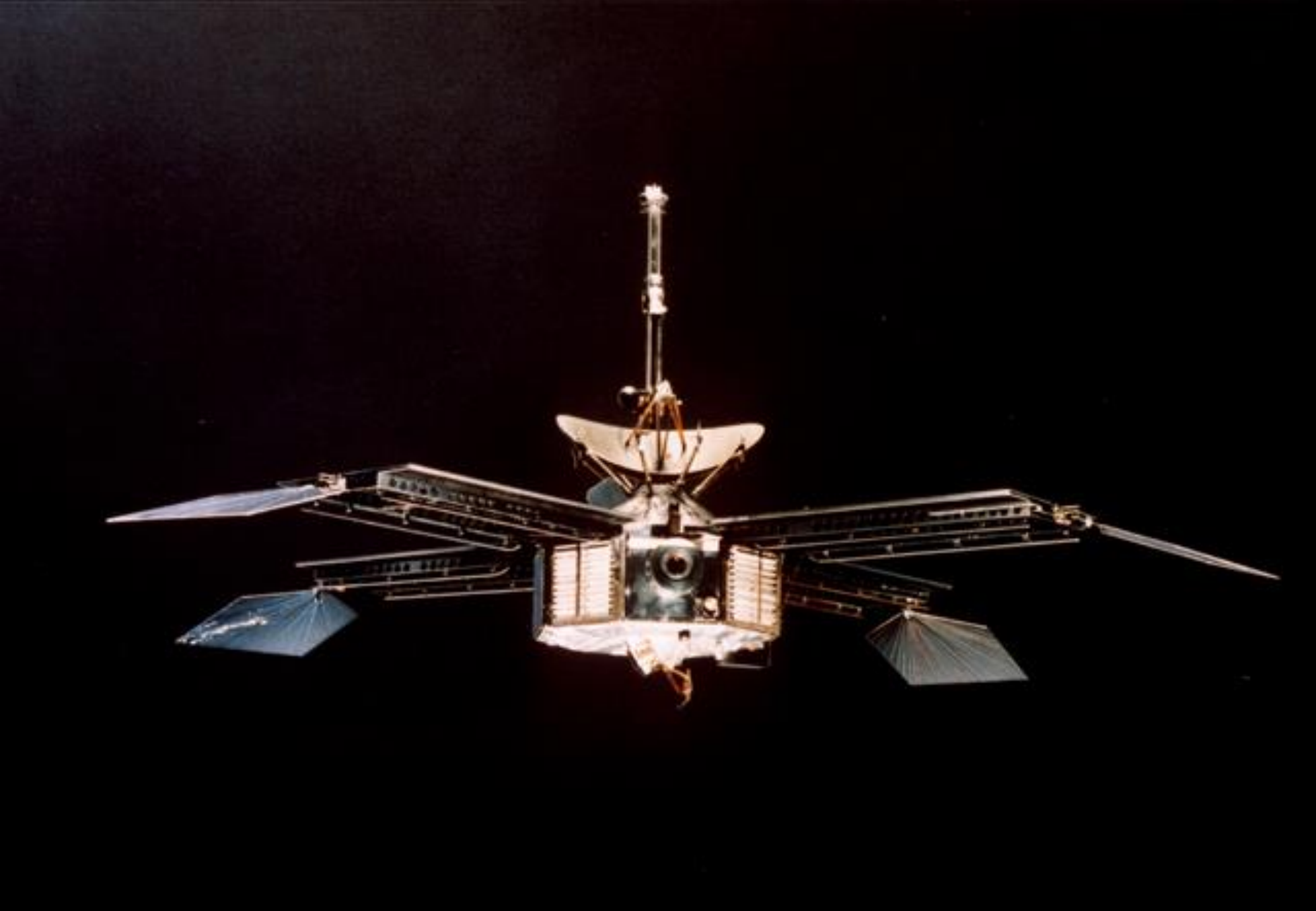


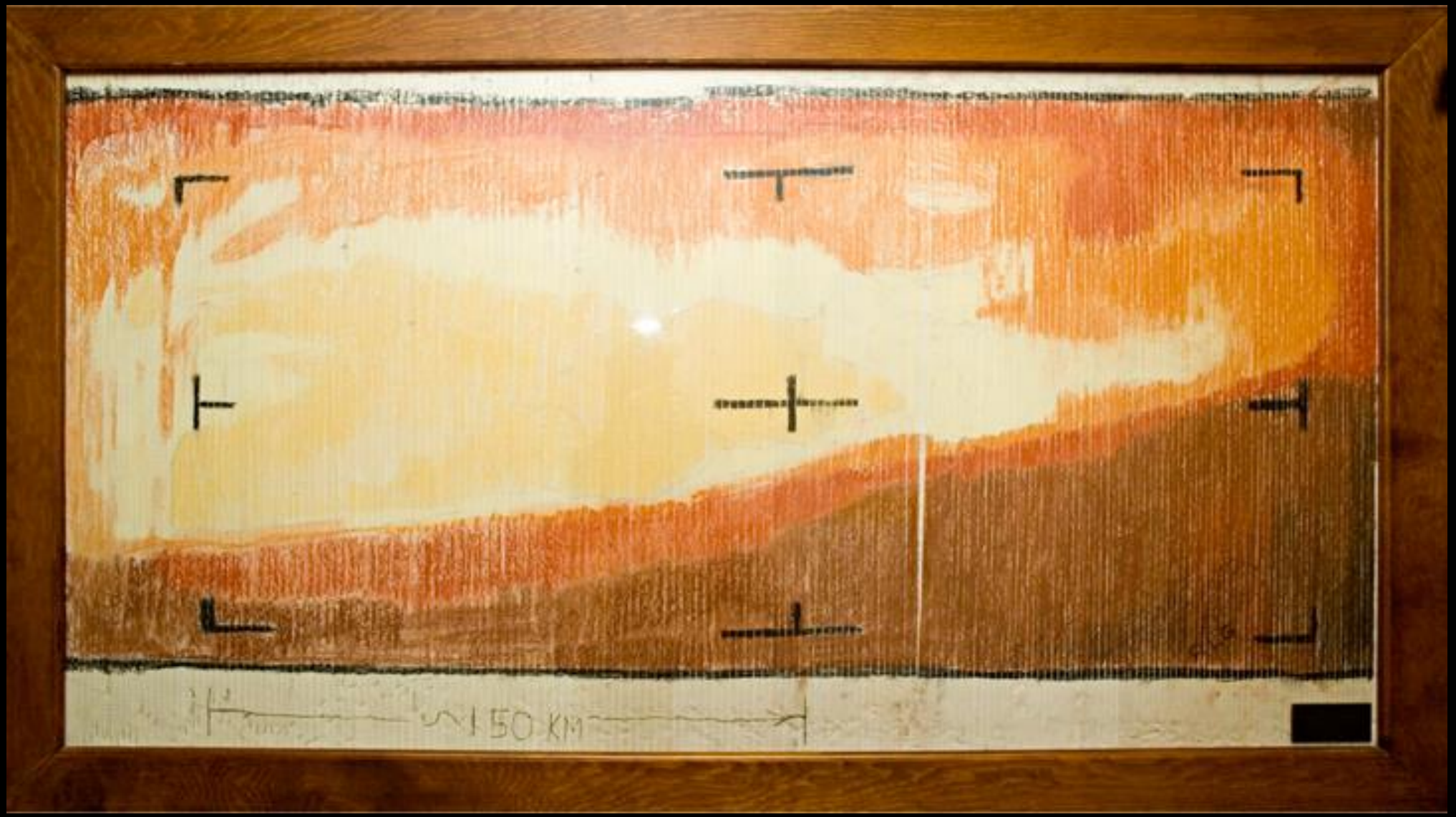





PICTORIAL
REPRESENTATION
OF MARS

1964




~150 KM

Edge of Frame

DN

50-45 DARK

45-40

40-35

35-30

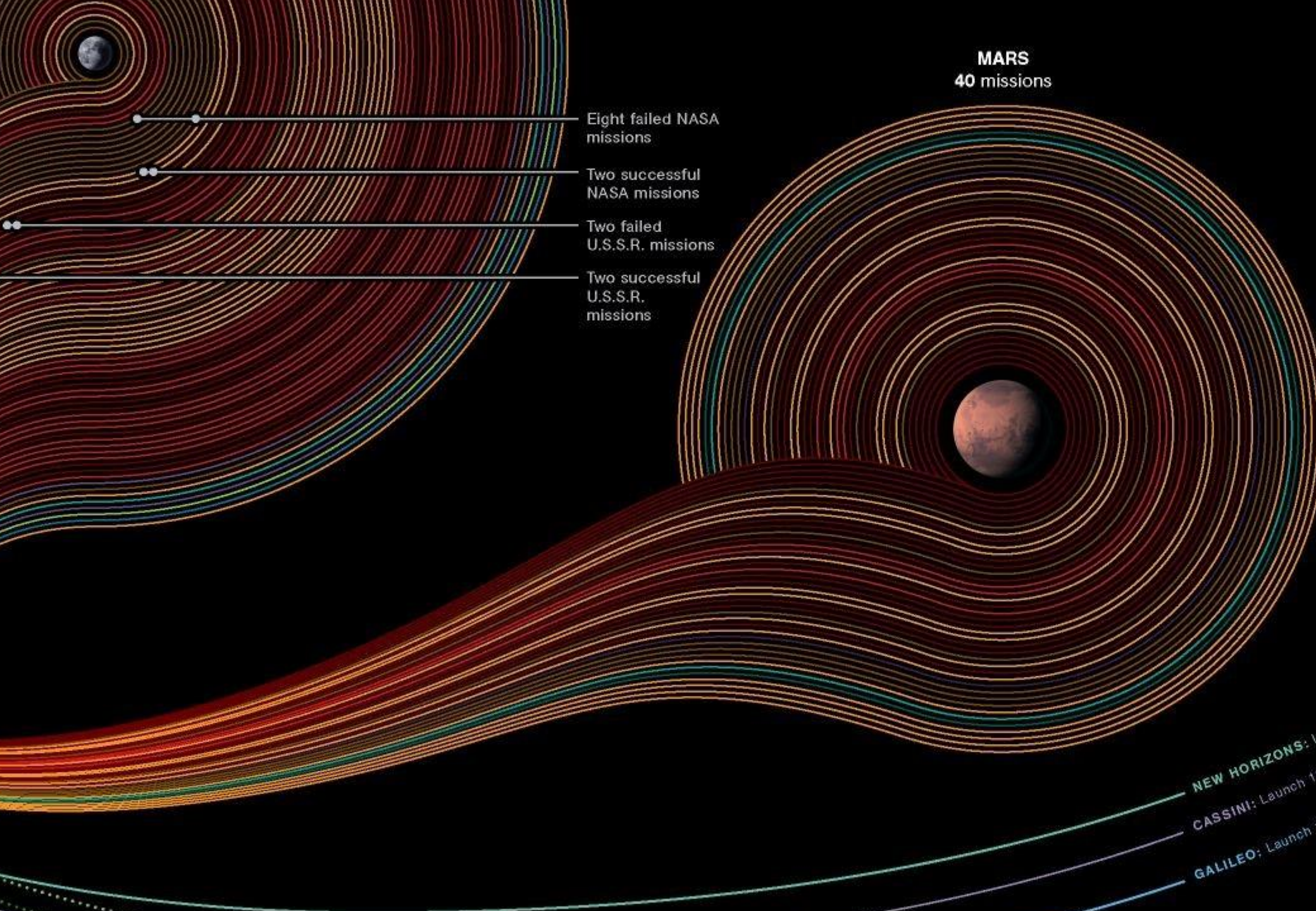
30-25

25-20 LIGHT


Edge of Mars
Clouds Over Mars

Total amount of data returned by Mariner 4 mission was 634 kB...

and it changed our view to the world.


MARS
40 missions
Eight failed NASA missions
Two successful NASA missions
Two failed U.S.S.R. missions
Two successful U.S.S.R. missions
NEW HORIZONS:
CASSINI: Launch
GALILEO: Launch

Mars Missions this Decade

Operational 2001-2013

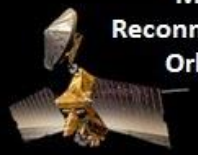
2016

2018

2020

2022

Odyssey



Mars Reconnaissance Orbiter

MAVEN Aeronomy Orbiter

ESA Trace Gas Orbiter (Electra)

ESA Mars Express

Follow the Water | *Habitable Environments* | *Seeking Signs of Life* | *Future*

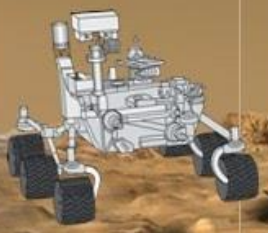
Opportunity

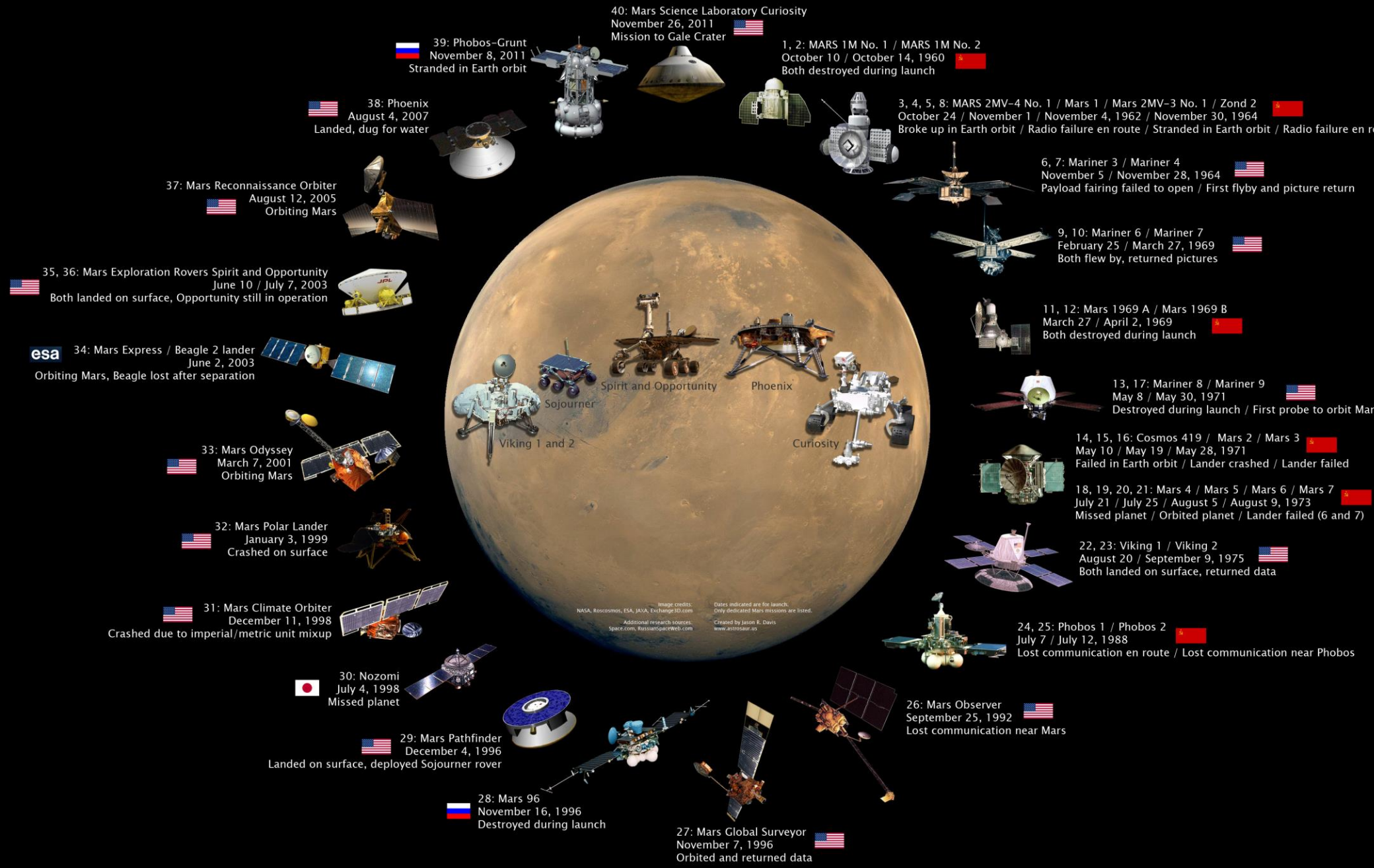
Curiosity – Mars Science Laboratory

InSight

ESA ExoMars Rover (MOMA)

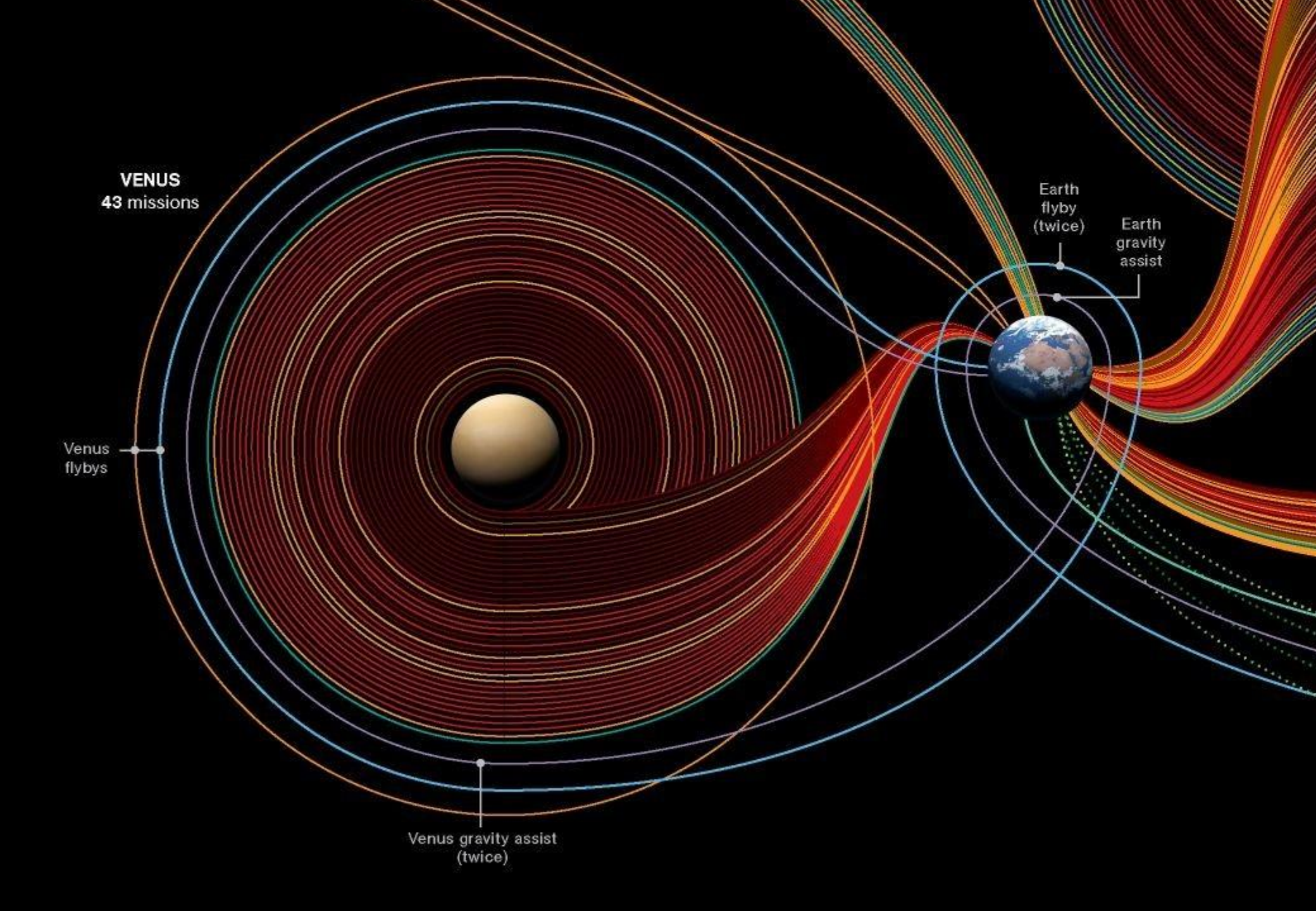
2020 Science Rover

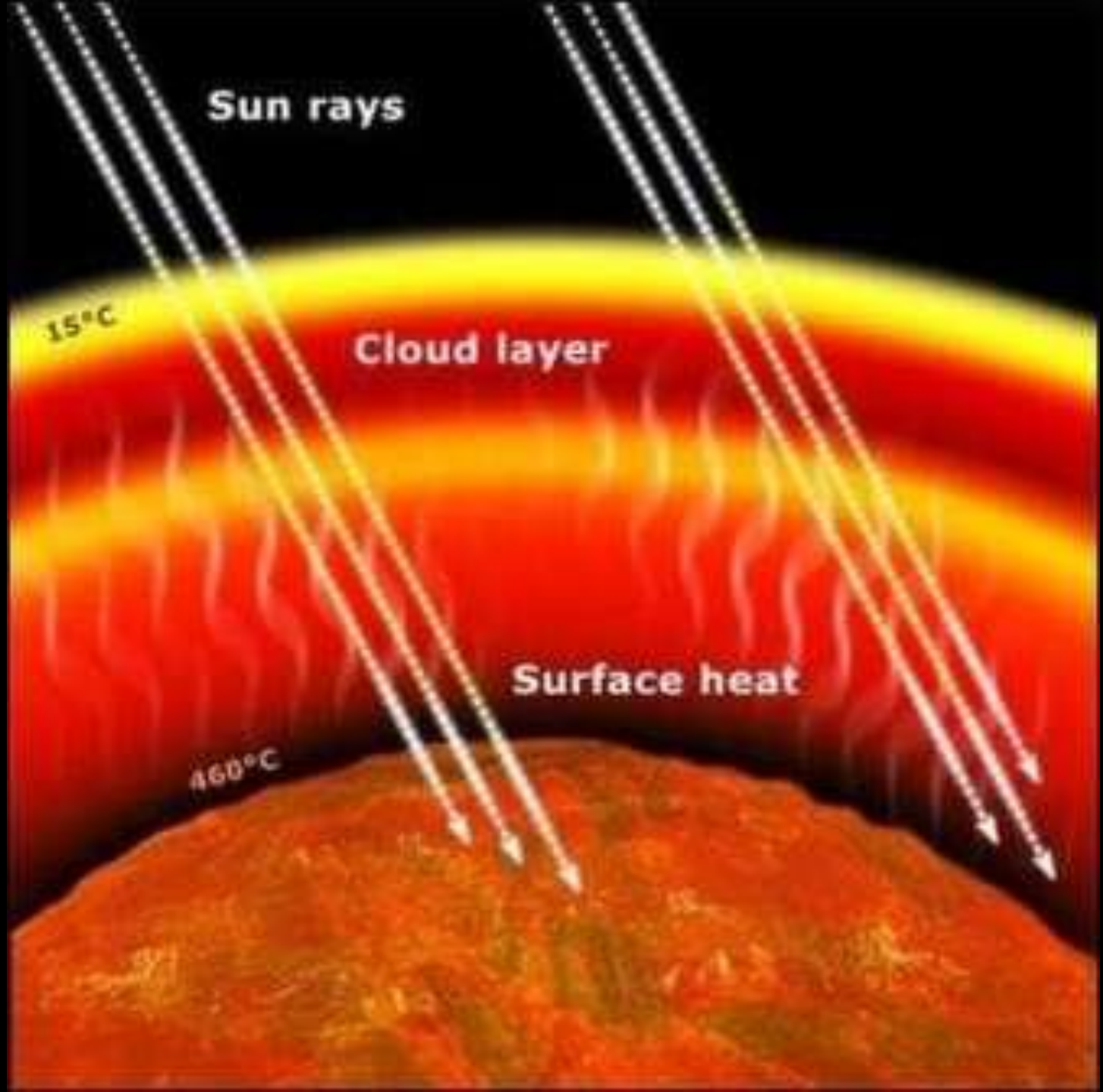



40: Mars Science Laboratory Curiosity
November 26, 2011
Mission to Gale Crater
39: Phobos-Grunt
November 8, 2011
Stranded in Earth orbit
1, 2: MARS 1M No. 1 / MARS 1M No. 2
October 10 / October 14, 1960
Both destroyed during launch
38: Phoenix
August 4, 2007
Landed, dug for water
3, 4, 5, 8: MARS 2MV-4 No. 1 / Mars 1 / Mars 2MV-3 No. 1 / Zond 2
October 24 / November 1 / November 4, 1962 / November 30, 1964
Broke up in Earth orbit / Radio failure en route / Stranded in Earth orbit / Radio failure en r
37: Mars Reconnaissance Orbiter
August 12, 2005
Orbiting Mars
6, 7: Mariner 3 / Mariner 4
November 5 / November 28, 1964
Payload fairing failed to open / First flyby and picture return
35, 36: Mars Exploration Rovers Spirit and Opportunity
June 10 / July 7, 2003
Both landed on surface, Opportunity still in operation
9, 10: Mariner 6 / Mariner 7
February 25 / March 27, 1969
Both flew by, returned pictures
11, 12: Mars 1969 A / Mars 1969 B
March 27 / April 2, 1969
Both destroyed during launch
esa
34: Mars Express / Beagle 2 lander
June 2, 2003
Orbiting Mars, Beagle lost after separation
Spirit and Opportunity
Phoenix
Sojourner
Viking 1 and 2
Curiosity
13, 17: Mariner 8 / Mariner 9
May 8 / May 30, 1971
Destroyed during launch / First probe to orbit Mar
14, 15, 16: Cosmos 419 / Mars 2 / Mars 3
May 10 / May 19 / May 28, 1971
Failed in Earth orbit / Lander crashed / Lander failed
33: Mars Odyssey
March 7, 2001
Orbiting Mars
18, 19, 20, 21: Mars 4 / Mars 5 / Mars 6 / Mars 7
July 21 / July 25 / August 5 / August 9, 1973
Missed planet / Orbited planet / Lander failed (6 and 7)
32: Mars Polar Lander
January 3, 1999
Crashed on surface
22, 23: Viking 1 / Viking 2
August 20 / September 9, 1975
Both landed on surface, returned data
31: Mars Climate Orbiter
December 11, 1998
Crashed due to imperial/metric unit mixup
Image credits:
NASA, Roscosmos, ESA, JAXA, Exchange3D.com
Additional research sources:
Space.com, RussianSpaceWeb.com
Dates indicated are for launch.
Only dedicated Mars missions are listed.
Created by Jason R. Davis
www.astrosaur.us
24, 25: Phobos 1 / Phobos 2
July 7 / July 12, 1988
Lost communication en route / Lost communication near Phobos
30: Nozomi
July 4, 1998
Missed planet
26: Mars Observer
September 25, 1992
Lost communication near Mars
29: Mars Pathfinder
December 4, 1996
Landed on surface, deployed Sojourner rover
28: Mars 96
November 16, 1996
Destroyed during launch
27: Mars Global Surveyor
November 7, 1996
Orbited and returned data

Venus

Russian Venera program


VENUS
43 missions
Earth
flyby
(twice)
Earth
gravity
assist
Venus
flybys
Venus gravity assist
(twice)


Sun rays
15°C
Cloud layer
Surface heat
460°C

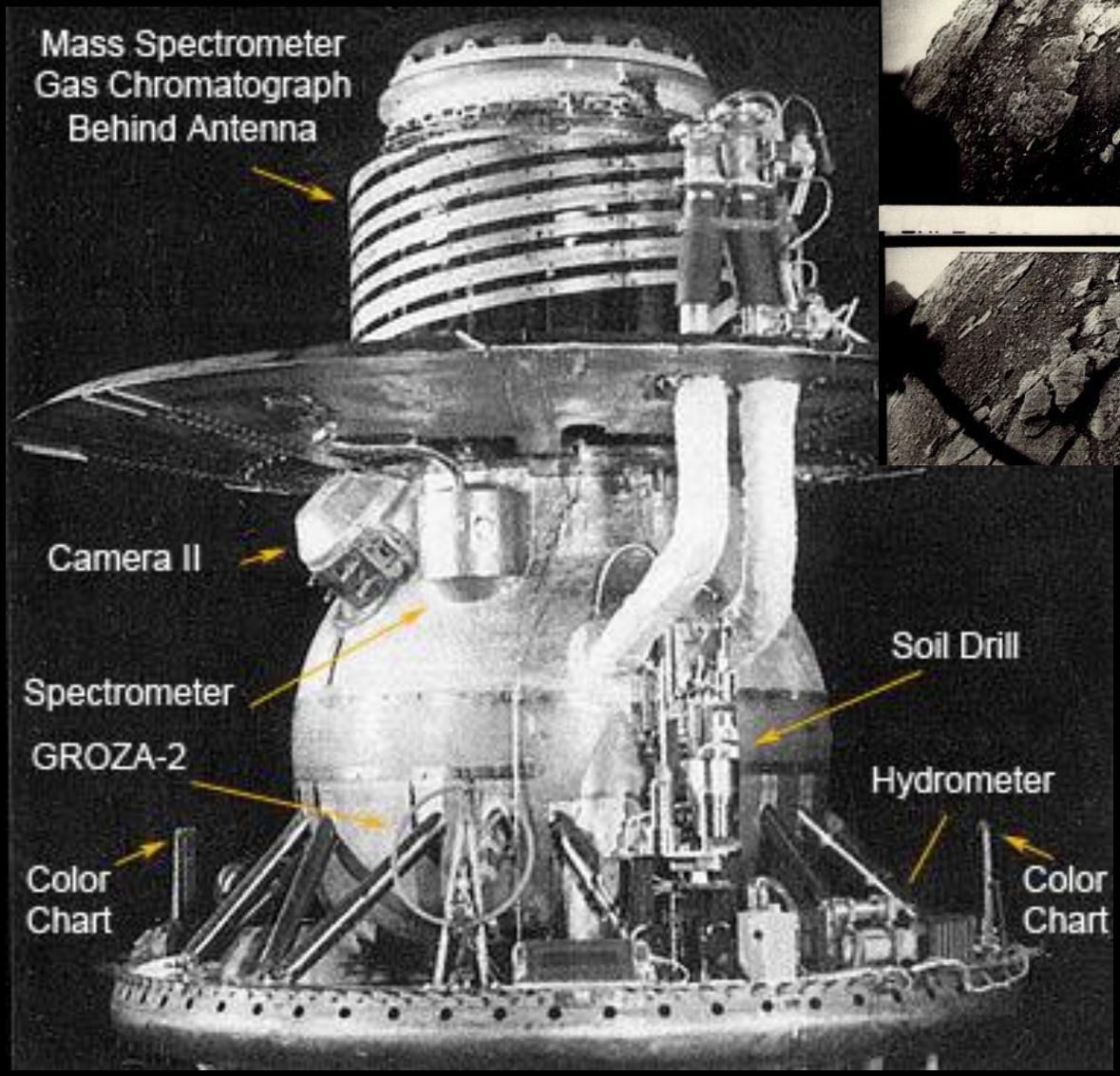
1961 Russian Venera program (1961 – 1985)

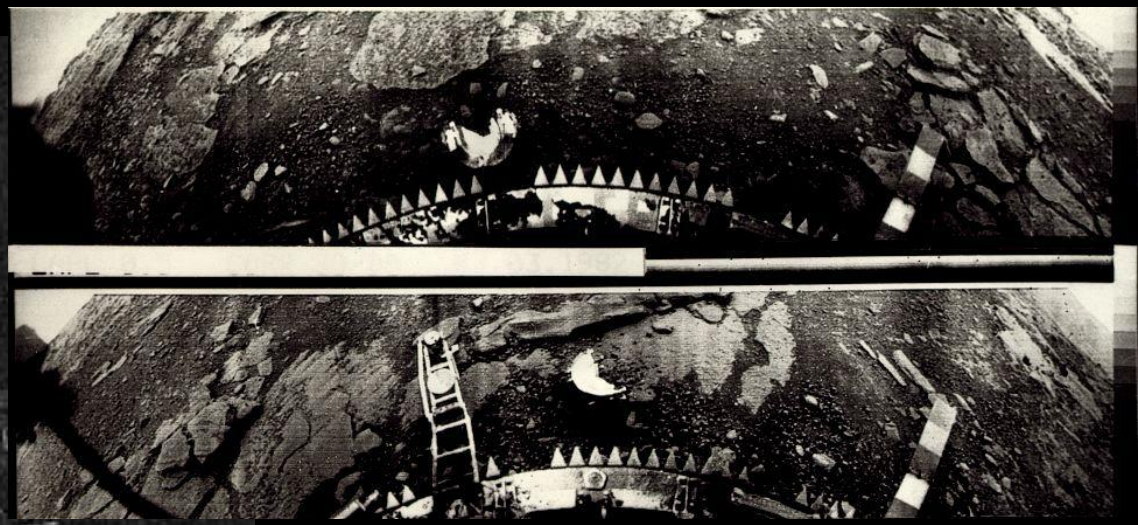
Launch date	Official name*	Mission	Comments
Feb. 4, 1961	Heavy sputnik	Impact	Stranded in Earth orbit
Feb. 12, 1961	Venera-1	Impact	Failed on its way to Venus
Aug. 25, 1962	-	Landing	Fourth stage failure in the orbit
Sept. 1, 1962	-	Landing	Stranded in the low Earth orbit
Sept. 12, 1962	-	Flyby	Fourth stage failure in the low orbit
Feb. 19, 1964	-	Flyby	Did not reach orbit due to third stage failure
March 27, 1964		Landing	Stranded in the low Earth orbit
April 2, 1964		Landing	Failed on its way to Venus
Nov. 12, 1965	Venera-2	Flyby	Passed 24,000 km from Venus
Nov. 16, 1965	Venera-3	Landing	First reached the planet
Nov. 23, 1965	Kosmos-96	Flyby	Failed to leave low Earth orbit
June 12, 1967	Venera-4	Landing	First to reach atmosphere of Venus and transmit data
June 17, 1967	Kosmos-167	Landing	Failed on the Earth orbit
Jan. 5, 1969	Venera-5	Landing	-
Jan. 10, 1969	Venera-6	Landing	-
Aug. 17, 1970		Landing	Transmitted data from the surface
Aug. 22, 1970	Kosmos-359	Landing	-
March 27, 1972	Venera-8	Landing	Transmitted data from the surface for 50 minutes
March 31, 1972		Landing	Failed to leave Earth orbit
June 8, 1975		Orbit/landing	Landed; transmitted first black and white images of the surface
June 14, 1975		Orbit/landing	Landed; transmitted black and white images of the surface
Sep. 9, 1978	Venera-11	Landing	Landed; failed to return photos
Sept. 14, 1978	Venera-12	Landing	Landed; failed to return photos
Oct. 30, 1981	Venera-13	Landing	Landed; returned color photos
Nov. 4, 1981	Venera-14	Landing	Landed; returned color photos
June 2, 1983	Venera-15	Orbit	Radar mapping from orbit
June 7, 1983	Venera-16	Orbit	Radar mapping from orbit
Dec. 15, 1984	Vega-1	Venus landing/Halley Comet flyby	Landed on Venus/ flew by Halley Comet
Dec. 20, 1984	Vega-2	Venus landing/Halley Comet flyby	Landed on Venus/ flew by Halley

Venera program highlights

- **1967** Enter first time to the atmosphere of another planet
- **1970** First soft landing on another planet
- **1975** First images from another planet surface
- **1983** First high resolution radar maps from another planet

1982 Venera 13

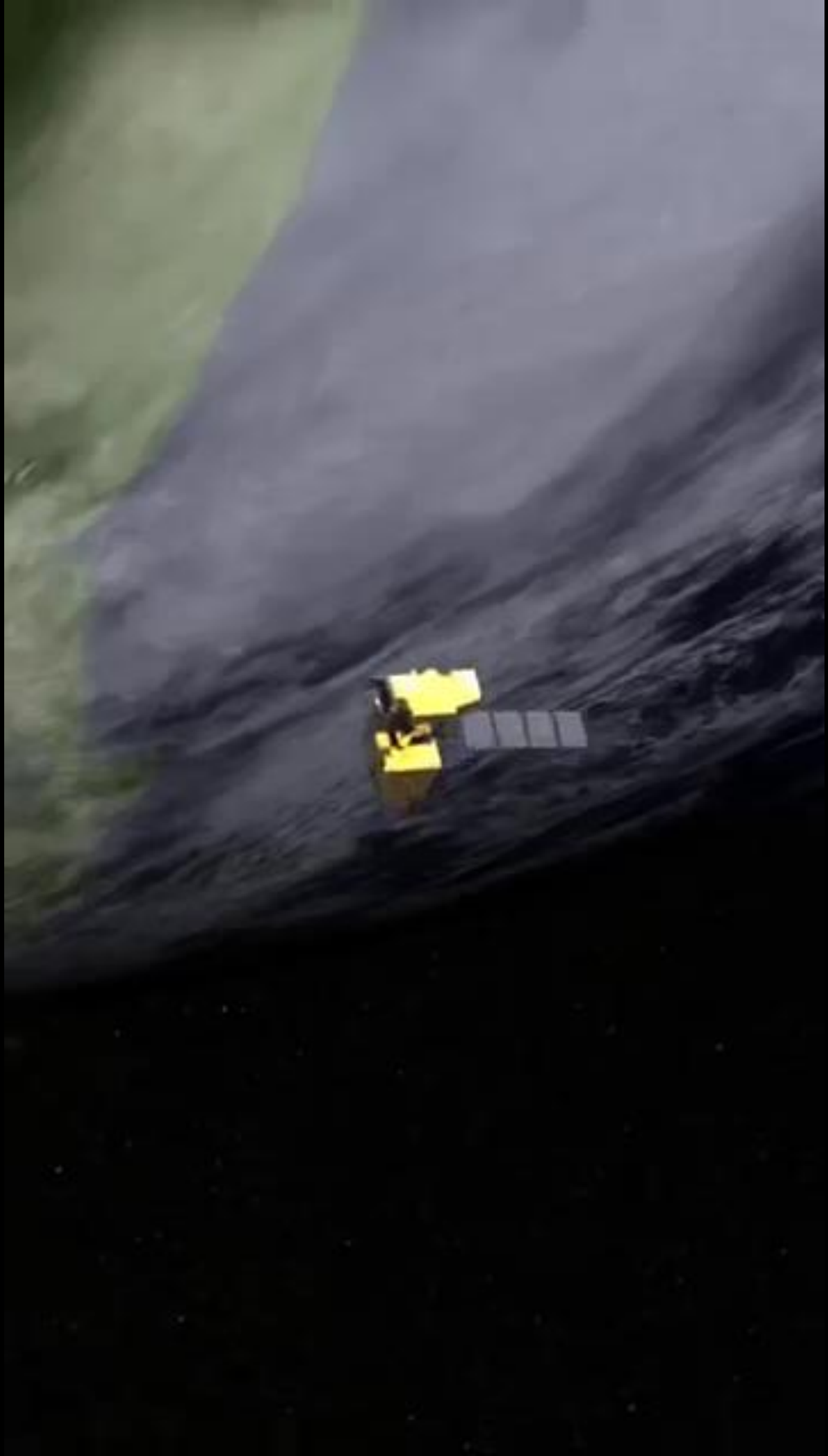





Don P. Mitchell

USGS
science for a changing world

1972 Landsat

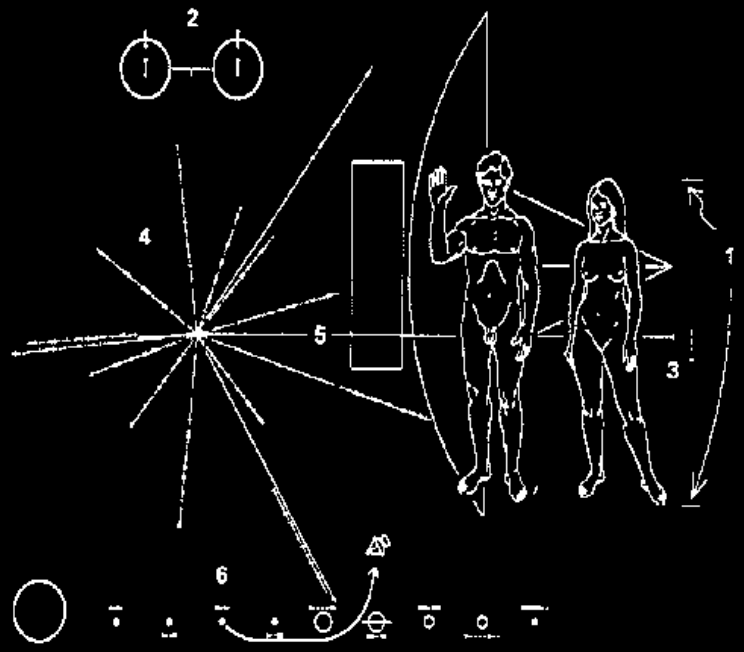


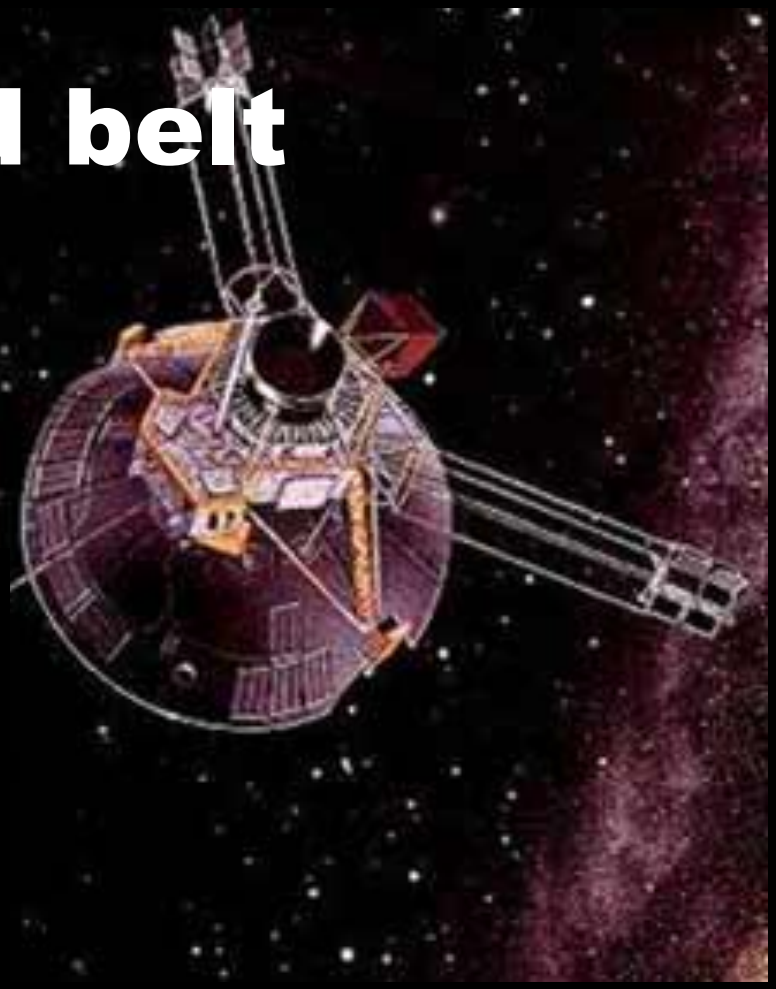
1972

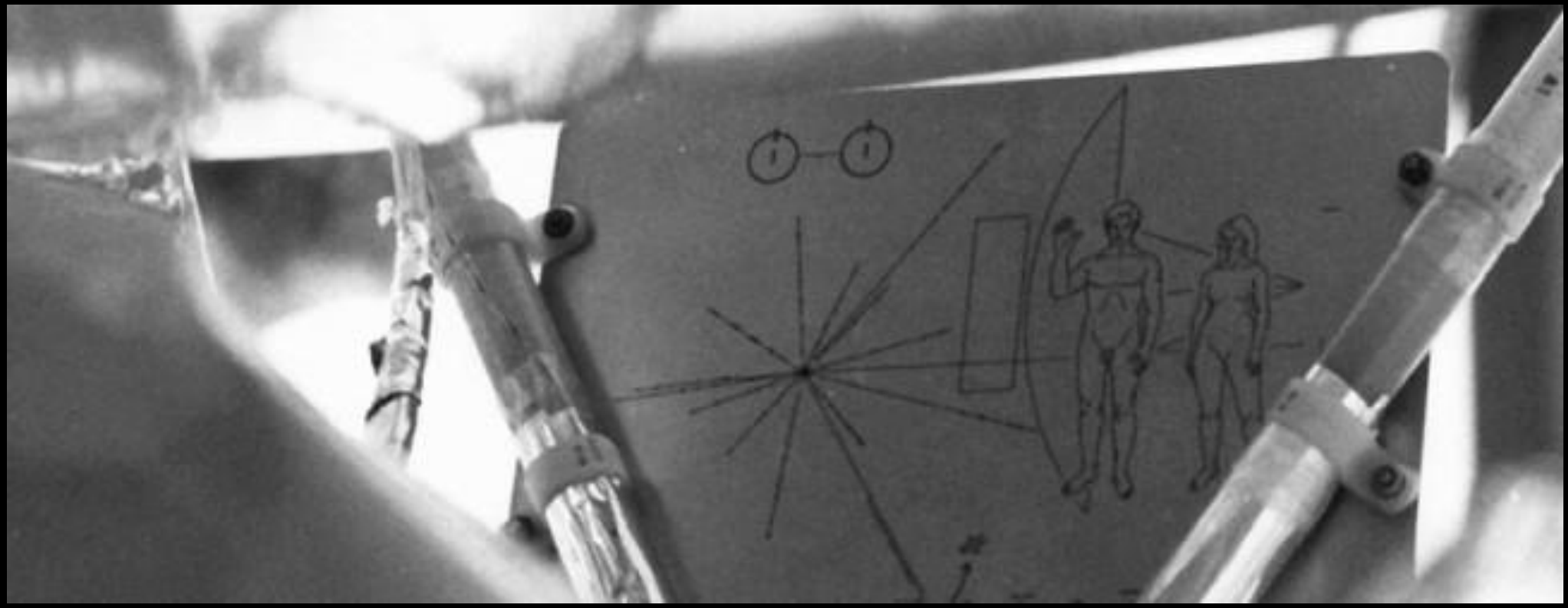
Passing the asteroid belt

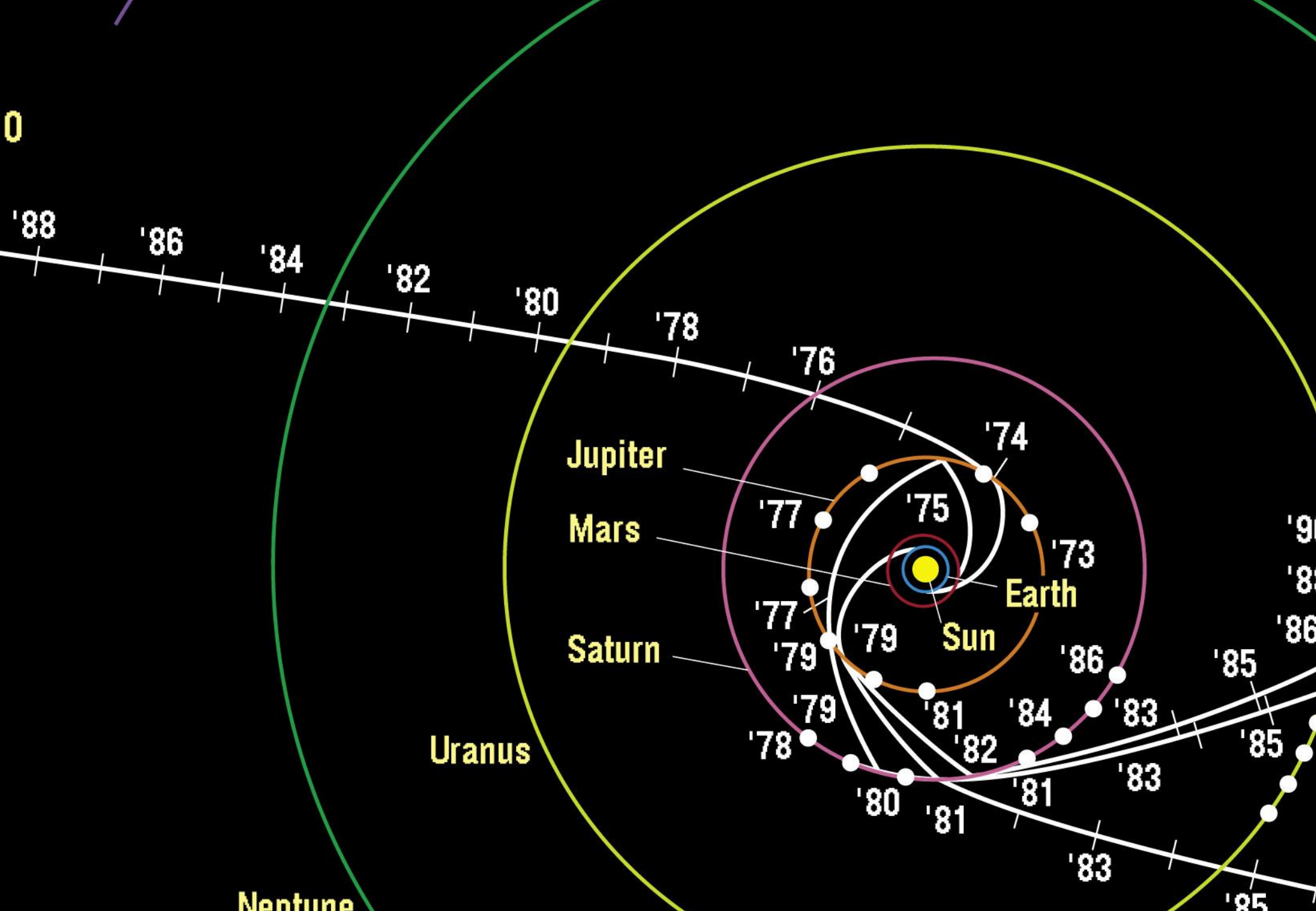
Pioneer 10

Pioneer 11





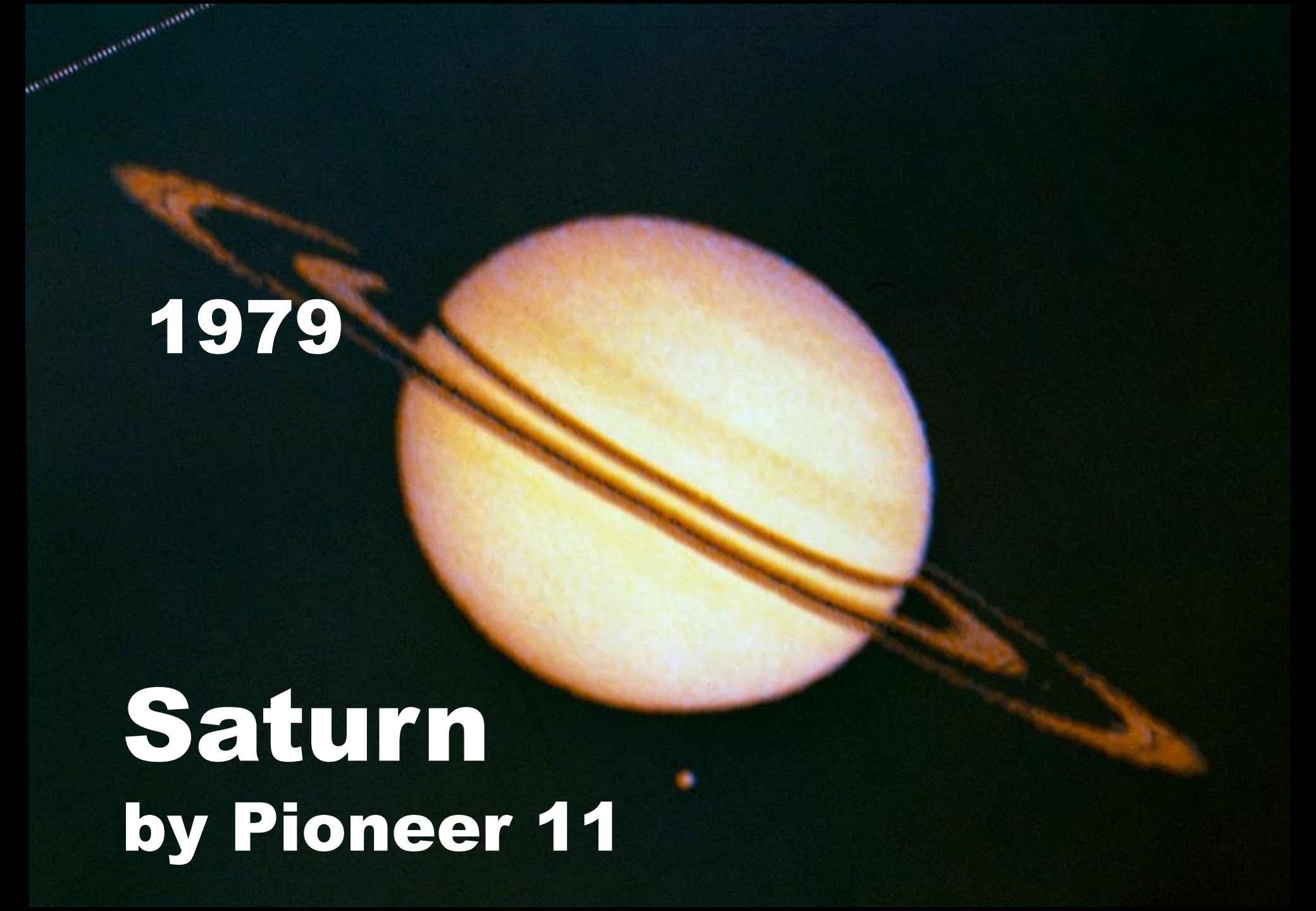



0
'88
'86
'84
'82
'80
'78
'76
'74
'73
'75
'77
'77
'79
'79
'79
'78
'80
'81
'81
'82
'83
'83
'84
'86
'85
'85
Jupiter
Mars
Saturn
Uranus
Neptune
Earth
Sun

1973

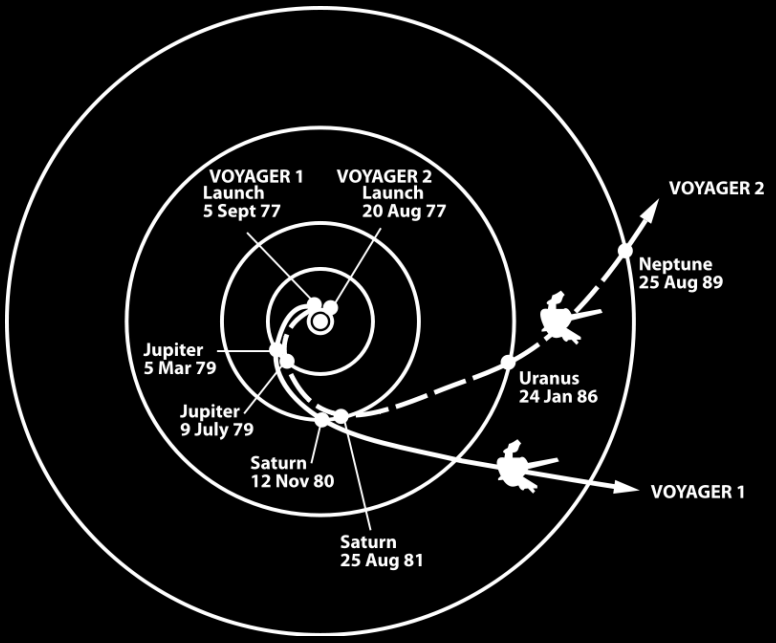
Jupiter

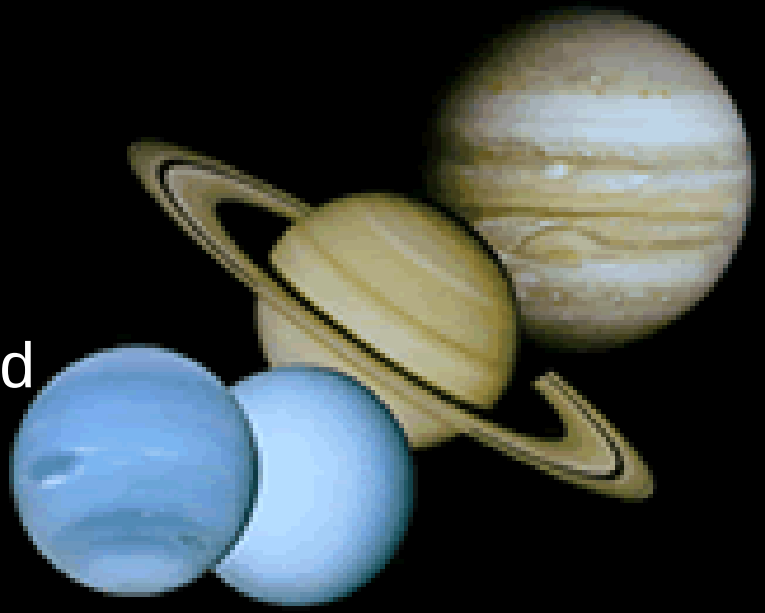
a. *Pioneer 10*, December 1973


1979
Saturn
by Pioneer 11

Grand Tour project

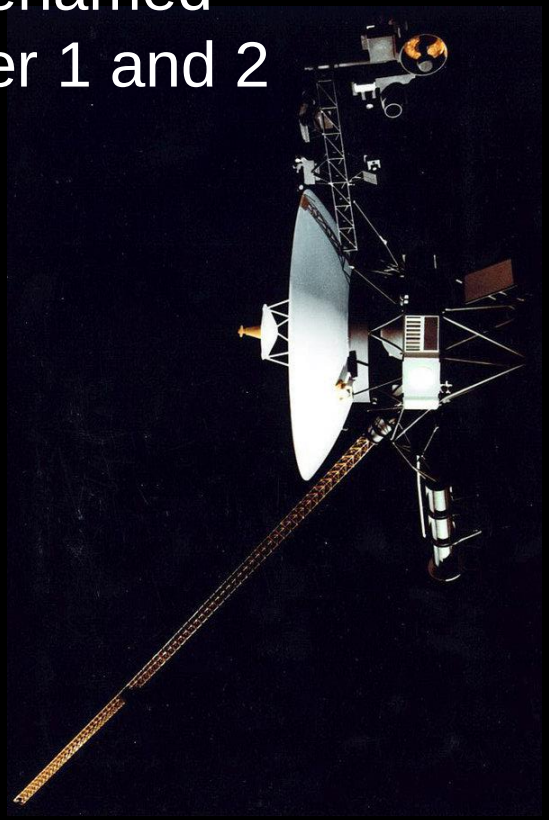
- **1964** Gary Flandro at JPL notes that Jupiter, Saturn, Uranus and Neptune are aligned in the end of 1970s.
- **1969** NASA creates Outer Planets Working Group
- **1971** Grand Tour was canceled and replaced by tow **Mariner Jupiter-Saturn** spacecraft



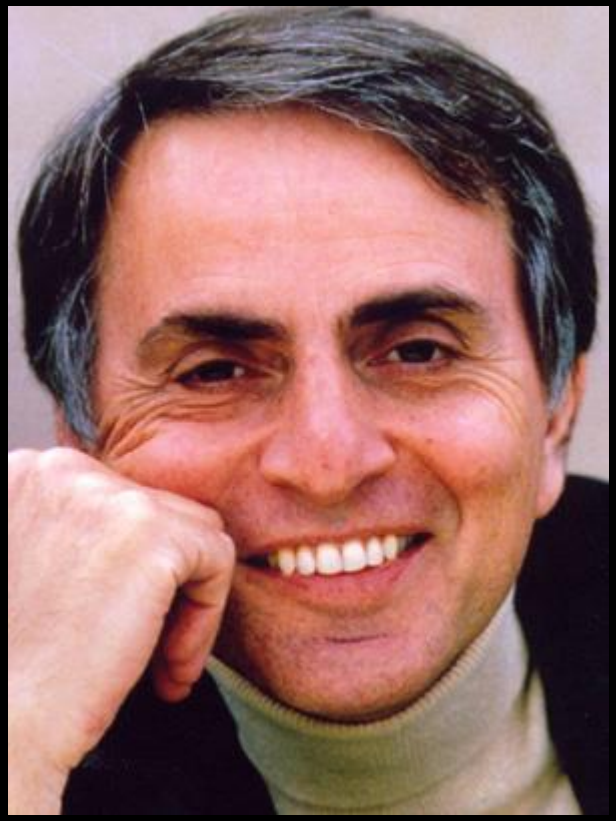


Voyager 1 & 2

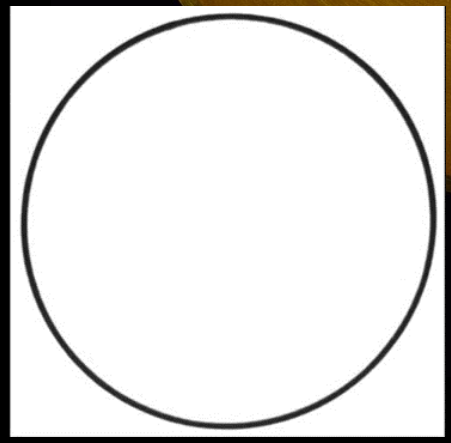
6 months before the launch the spacecraft were renamed Voyager 1 and 2

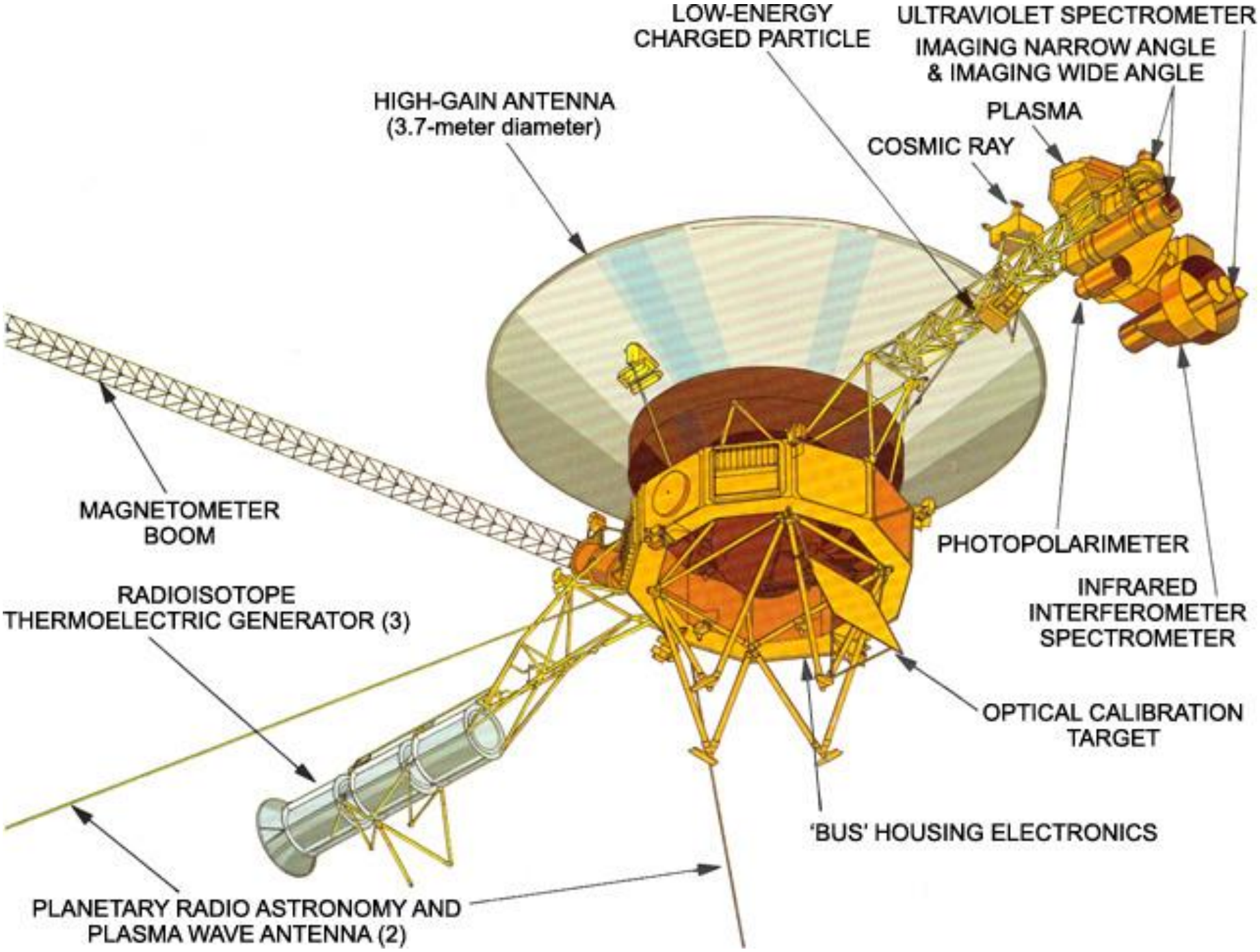


Voyager Golden Record



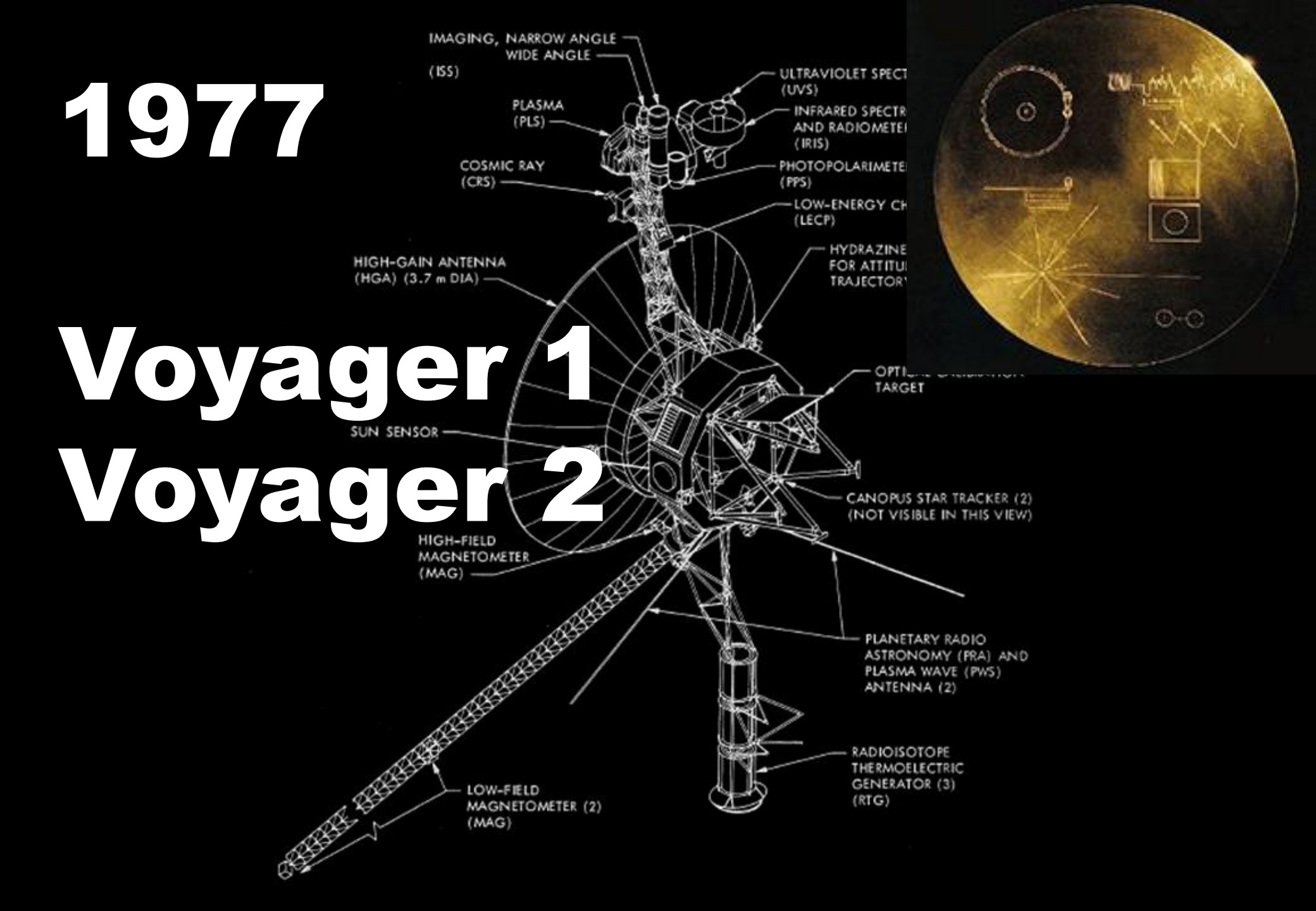
Carl Sagan (1934-1996)




LOW-ENERGY CHARGED PARTICLE
ULTRAVIOLET SPECTROMETER
IMAGING NARROW ANGLE & IMAGING WIDE ANGLE
HIGH-GAIN ANTENNA (3.7-meter diameter)
PLASMA
COSMIC RAY
MAGNETOMETER BOOM
PHOTOPOLARIMETER
INFRARED INTERFEROMETER SPECTROMETER
RADIOISOTOPE THERMOELECTRIC GENERATOR (3)
OPTICAL CALIBRATION TARGET
'BUS' HOUSING ELECTRONICS
PLANETARY RADIO ASTRONOMY AND PLASMA WAVE ANTENNA (2)

1977

Voyager 1
Voyager 2



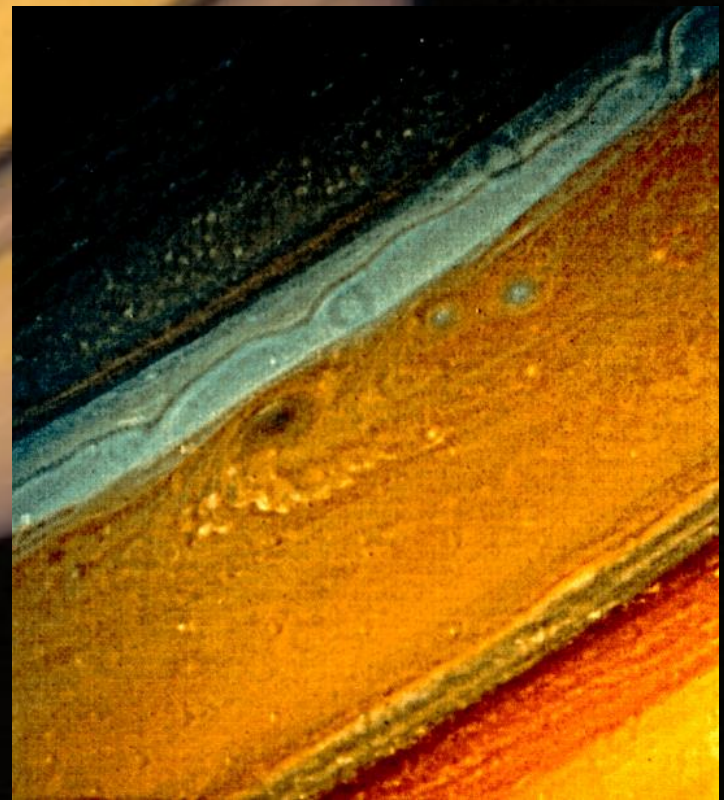
1979

Jupiter
by Voyager 2

1980

Saturn

by Voyager 2



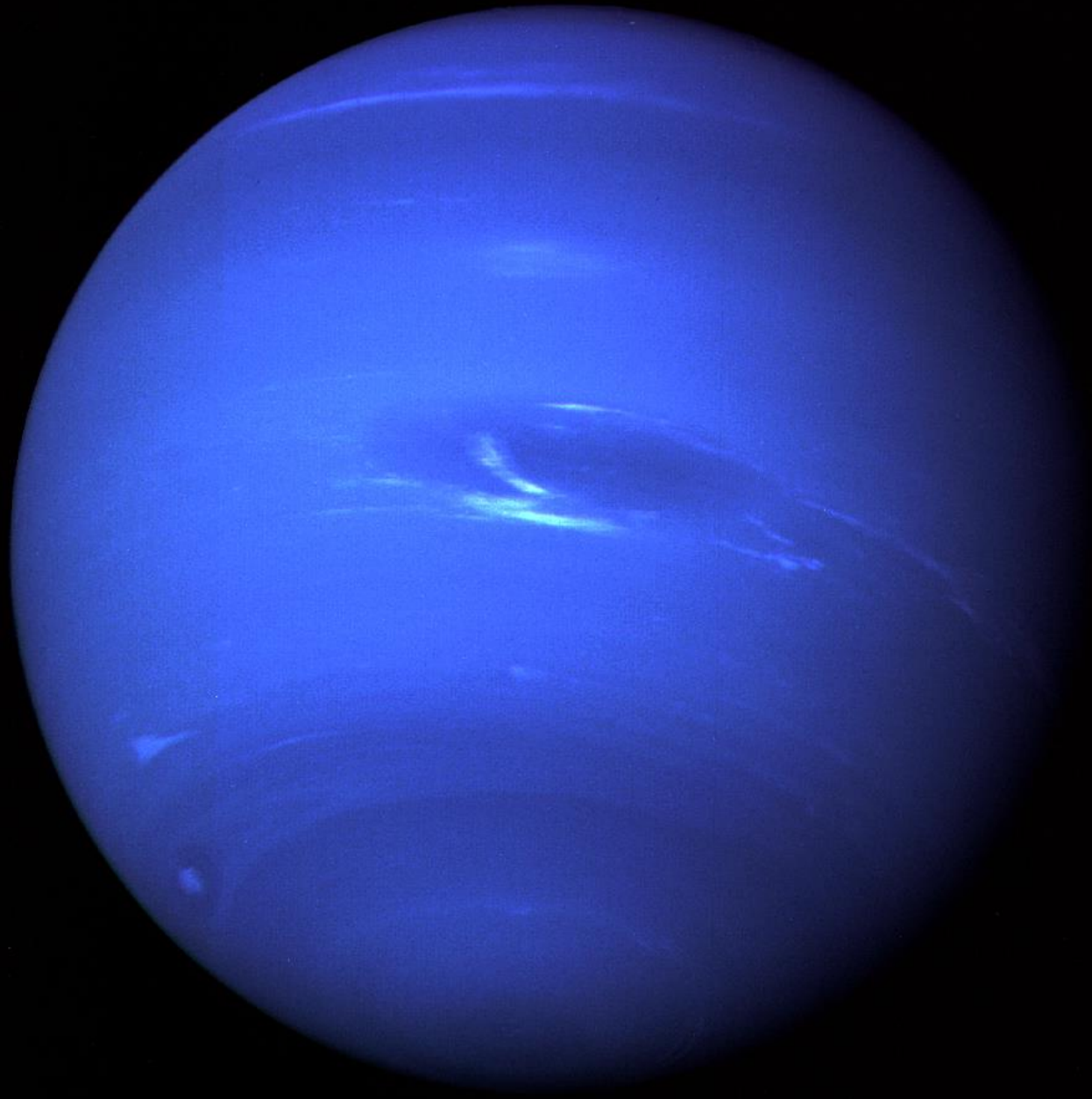
1986

Uranus

By Voyager 2


1986
Miranda
by Voyager 2

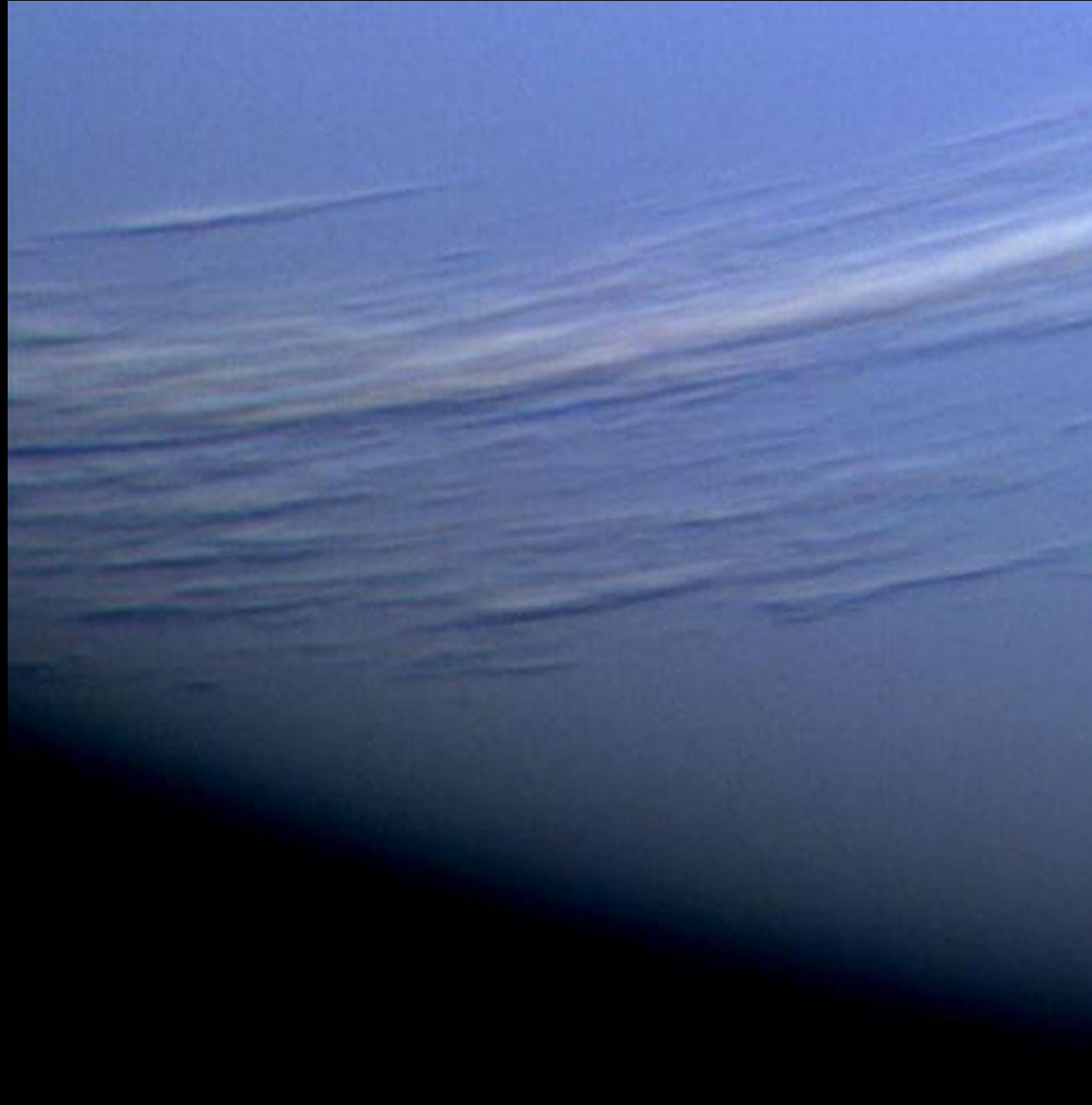
1989



Neptune

by Voyager 2

1989



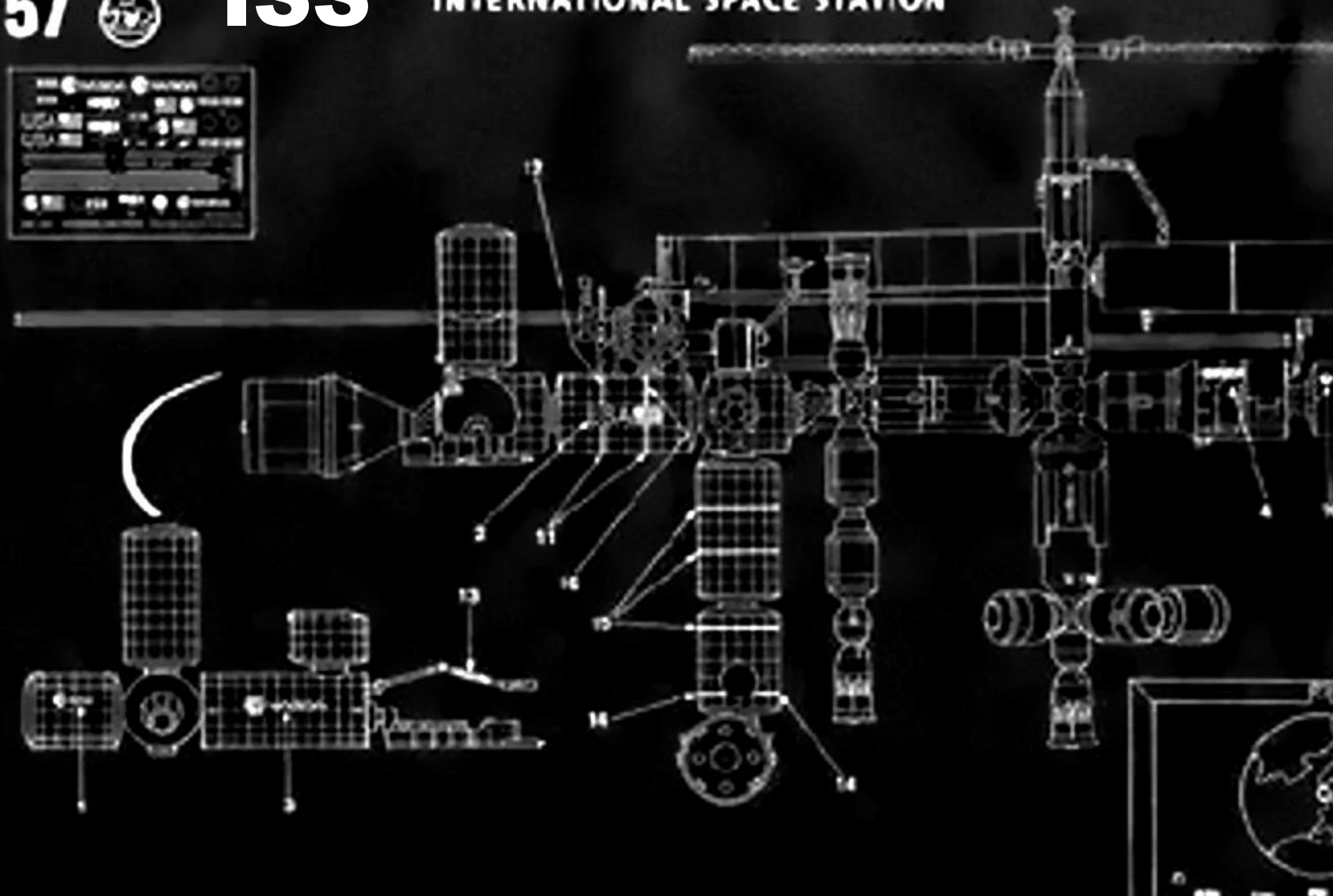
Neptune

by Voyager 2


1989
Triton

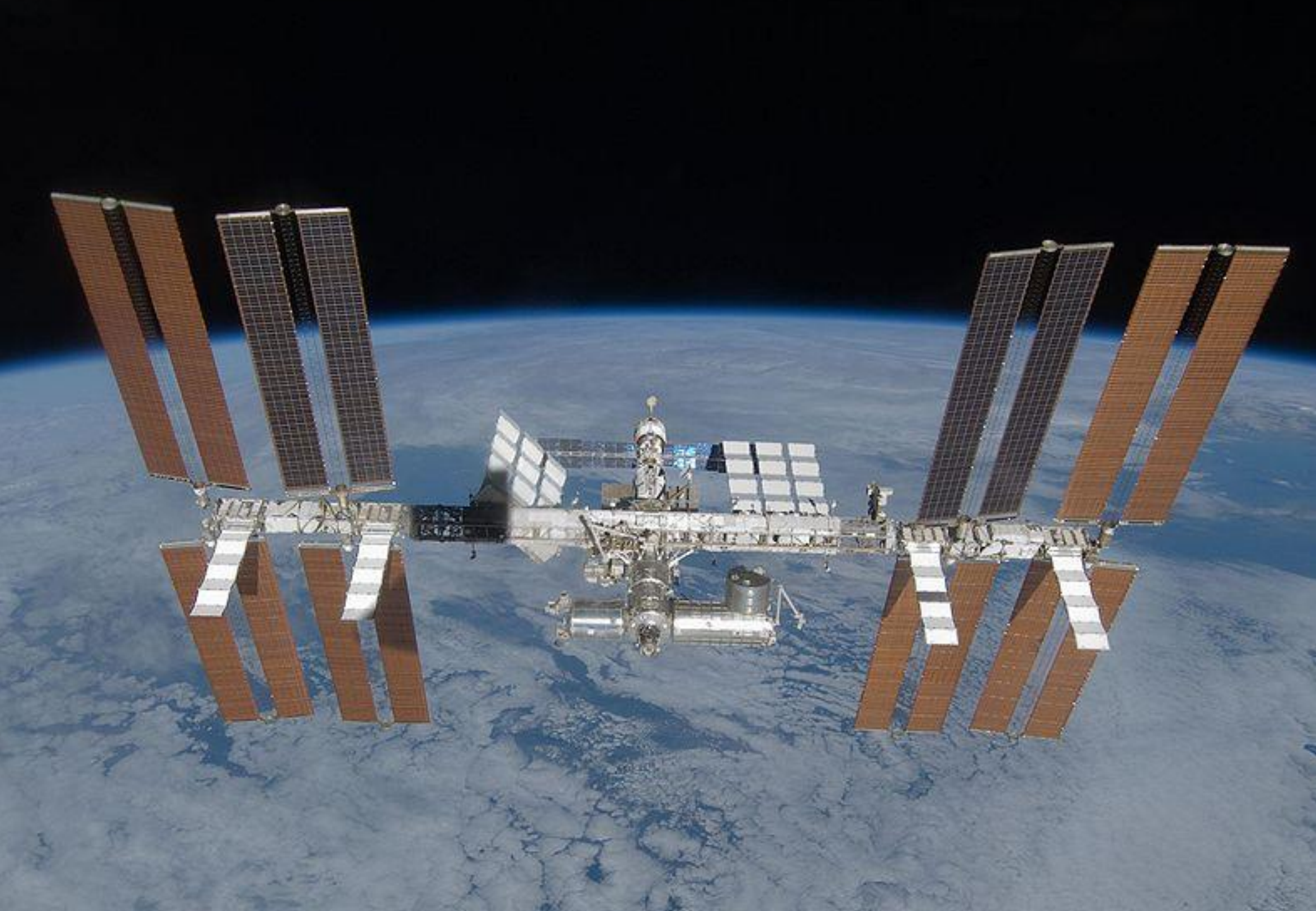

1990
Pale
Blue Dot

57 ISS INTERNATIONAL SPACE STATION



1998 International Space Station

ISS, Humans live in space.
360 km
27 743.8 km/h
7.7 km/s



Galileo

Mission to Jupiter

Jupiter on 7 Mar 2001

Cassini Jupiter flyby (Dec 2000)

Cassini trajectory to Saturn

GEM extension (proposed) Jan - Dec 2000

Earth/Moon 1 8 Dec 1990

Earth/Moon 2 8 Dec 1992

Venus 10 Feb 1990

Launch 18 Oct 1989

Galileo Europa Mission (orbits 12-25) Dec 1997 - Dec 1999

1989

Ida and Dactyl 28 Aug 1993

Gaspra 29 Oct 1991

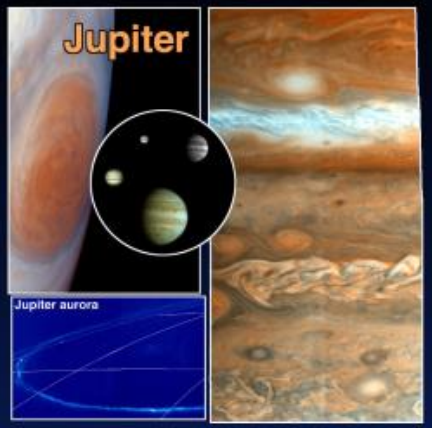
Shoemaker-Levy 9 observations Jul 1994

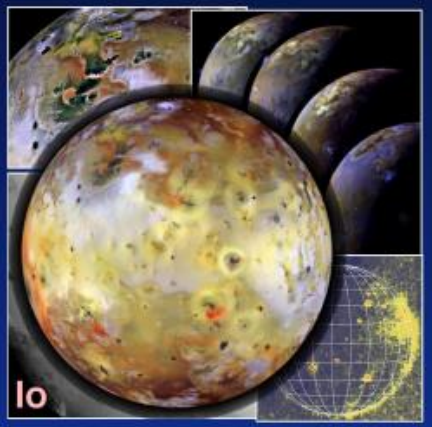
Jupiter in Jul 1994

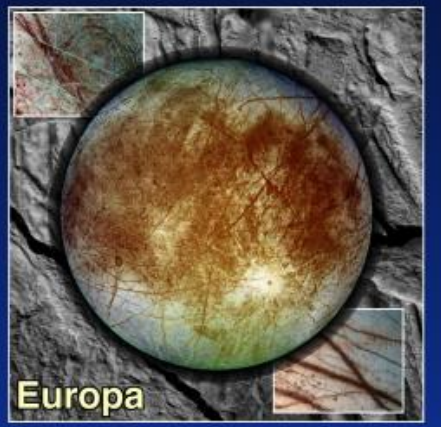
Galileo primary mission (orbits 1-11) Jun 1996 - Dec 1997

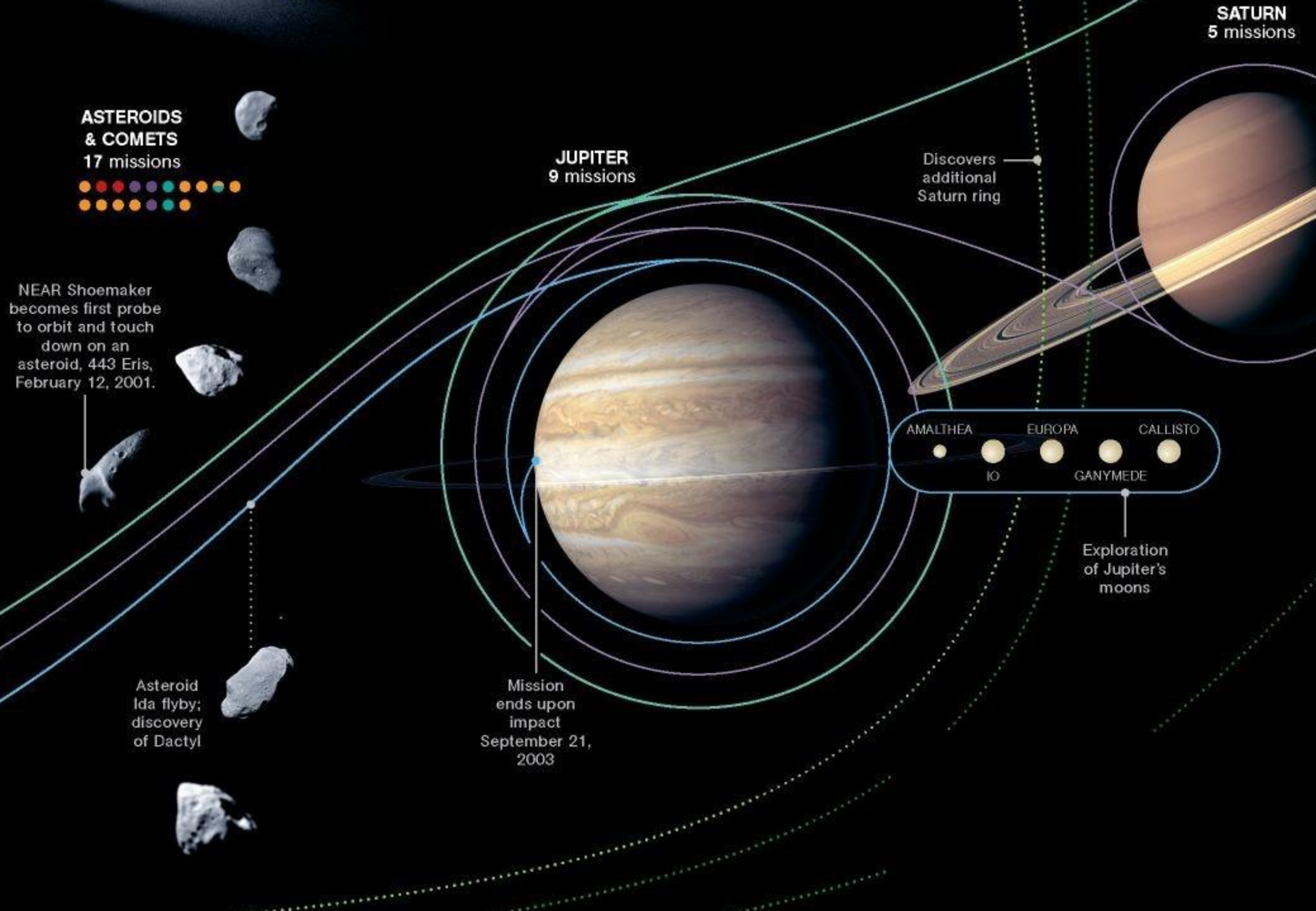
Probe release 13 Jul 1995

Probe mission Jupiter orbit insertion







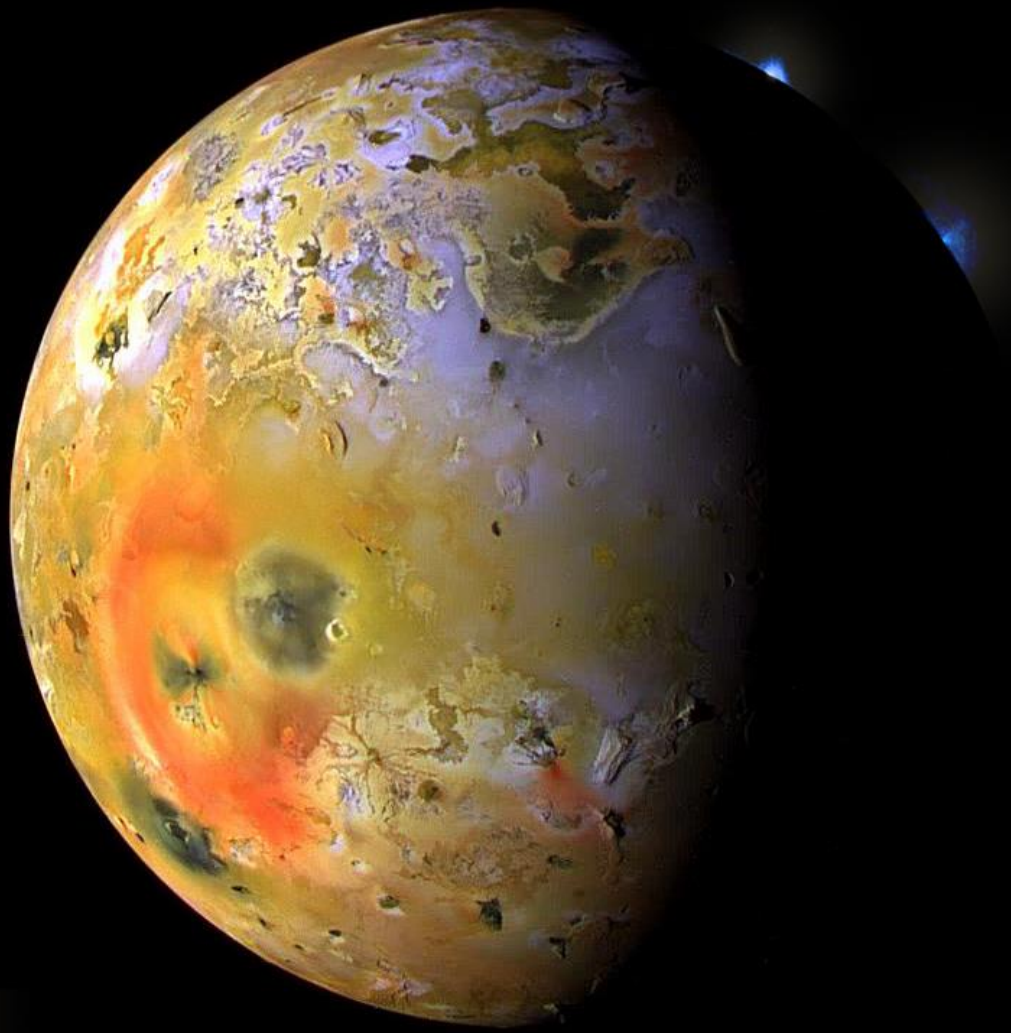

SATURN
5 missions
ASTEROIDS
& COMETS
17 missions
JUPITER
9 missions
Discovers
additional
Saturn ring
NEAR Shoemaker
becomes first probe
to orbit and touch
down on an
asteroid, 443 Eris,
February 12, 2001.
AMALTHEA
EUROPA
CALLISTO
IO
GANYMEDE
Exploration
of Jupiter's
moons
Asteroid
Ida flyby;
discovery
of Dactyl
Mission
ends upon
impact
September 21,
2003

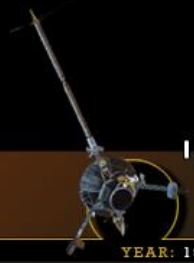
IO WITH JUPITER BACKDROP

YEAR: 2001
MISSION: CASSINI
TARGET: JUPITER / IO

The moon Io captured against Jupiter and crossing into Jupiter's night side.

1997





IO

YEAR: 1997
MISSION: GALILEO
TARGET: JUPITER / IO

Io is the most geologically active place in our Solar System. In this image a handful of active volcanos are present. The 3 plumes on the dark edge were added from other references. Their scale is accurate but placement is fictional.

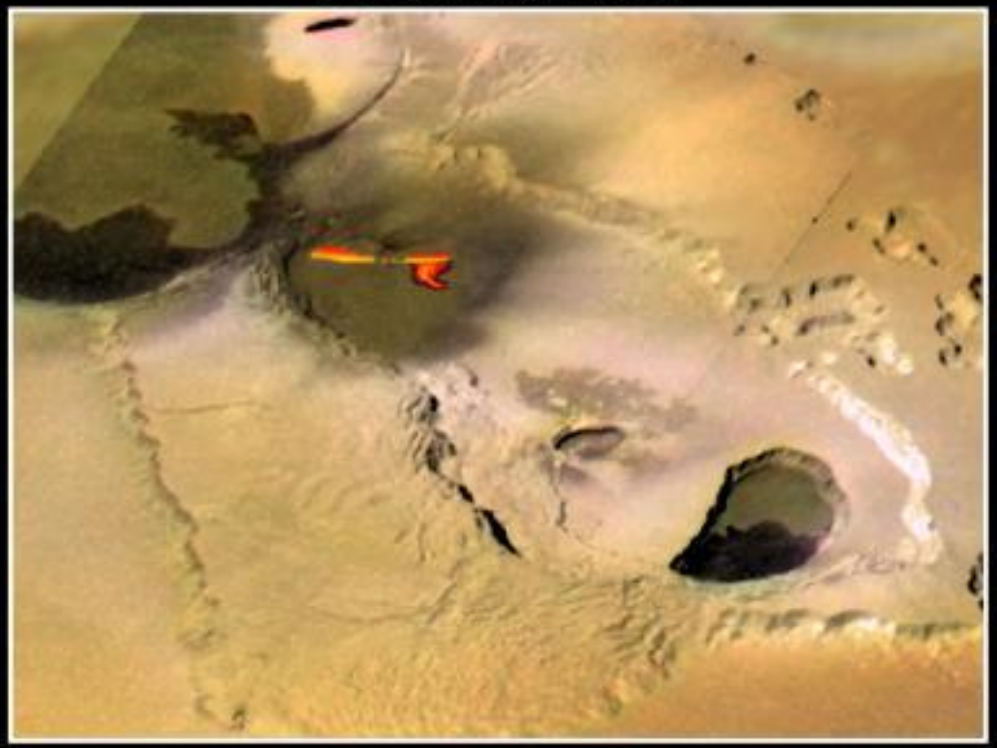
Io — Tvashtar Catena

I25 (26 Nov 1999)

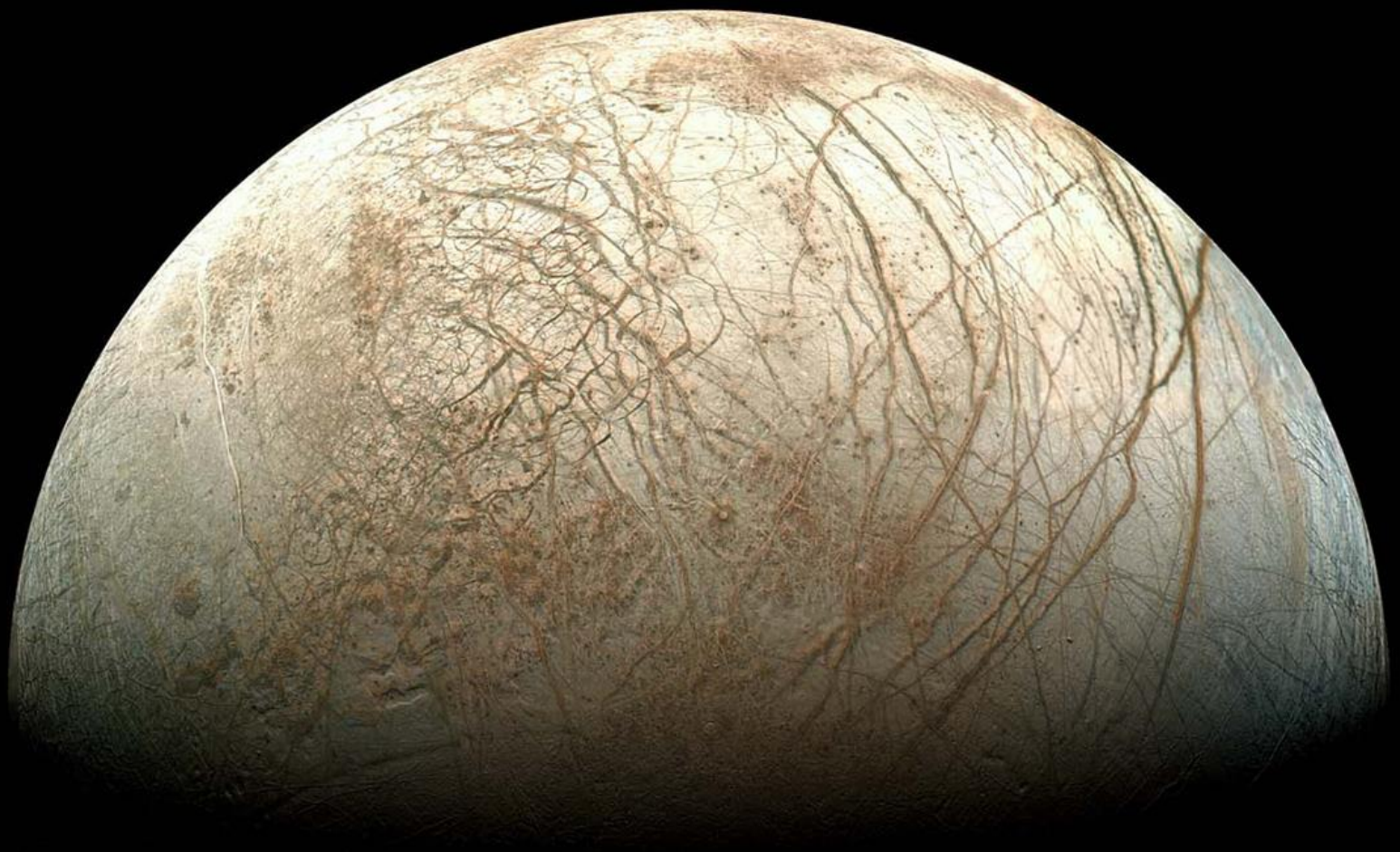
+ C21 low-resolution color
+ fire fountain sketch

I27 (22 Feb 2000)

visible wavelength data
+ IR data of active lava flow



COLOR COMPOSITE BY: Ted Stryk

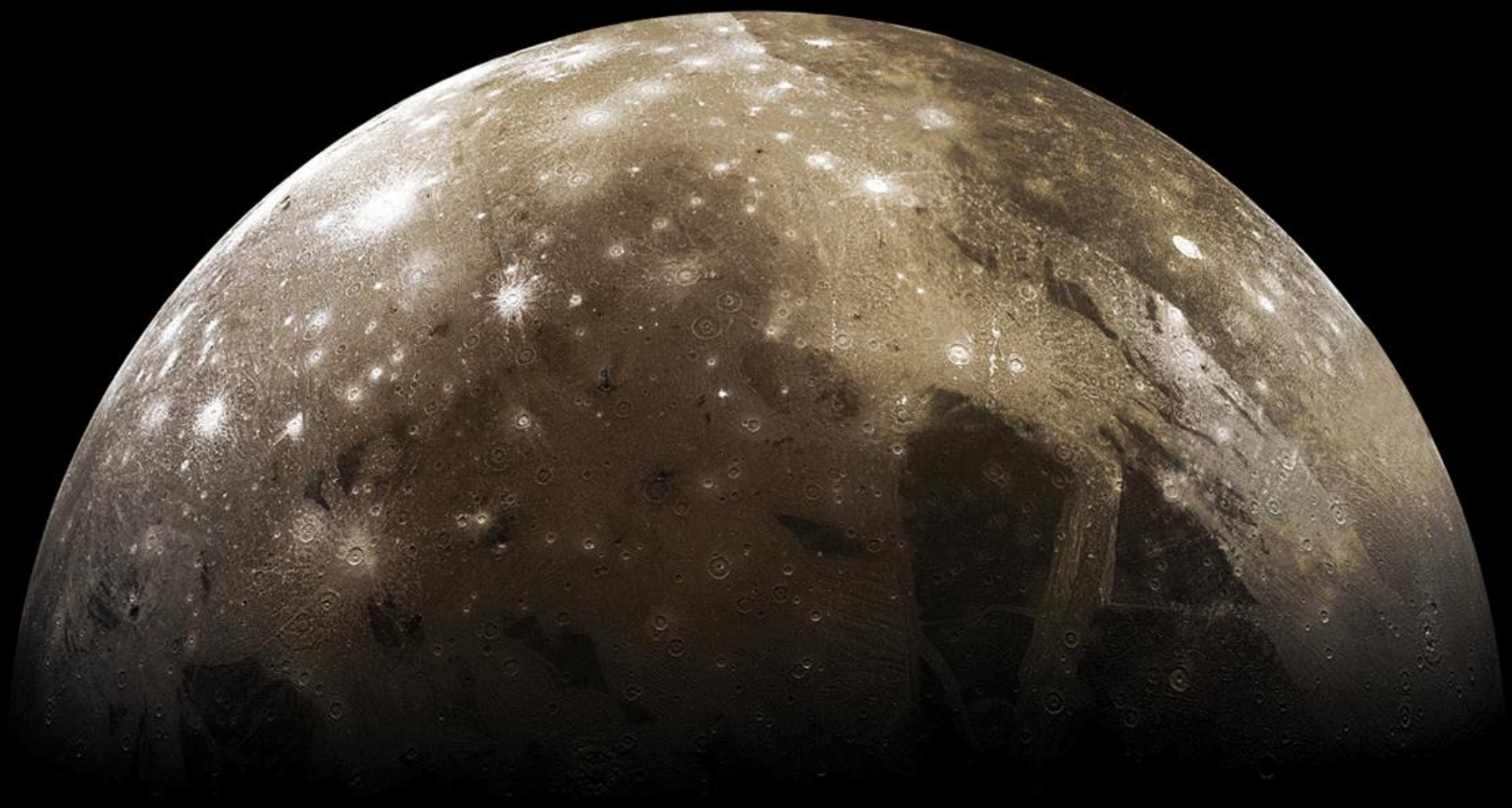


EUROPA AT HALF PHASE

YEAR: 1996
MISSION: GALILEO
TARGET: JUPITER / EUROPA

Europa at half phase and one of the most detailed images of Europa's cracked ice shell. It is these markings that provide some of the evidence pointing to its internal watery ocean.

COMPOSITE BY: Ted Stryk

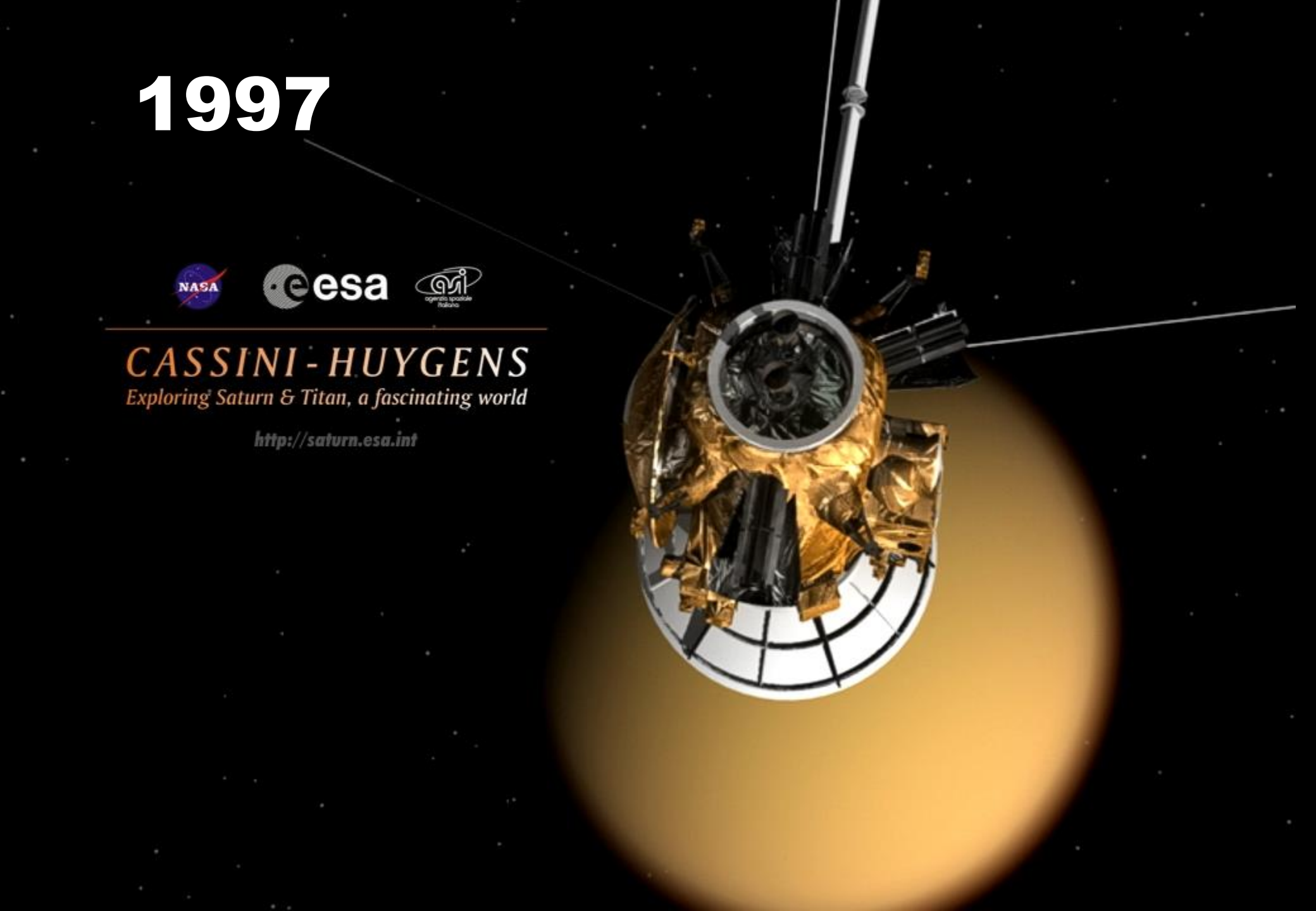


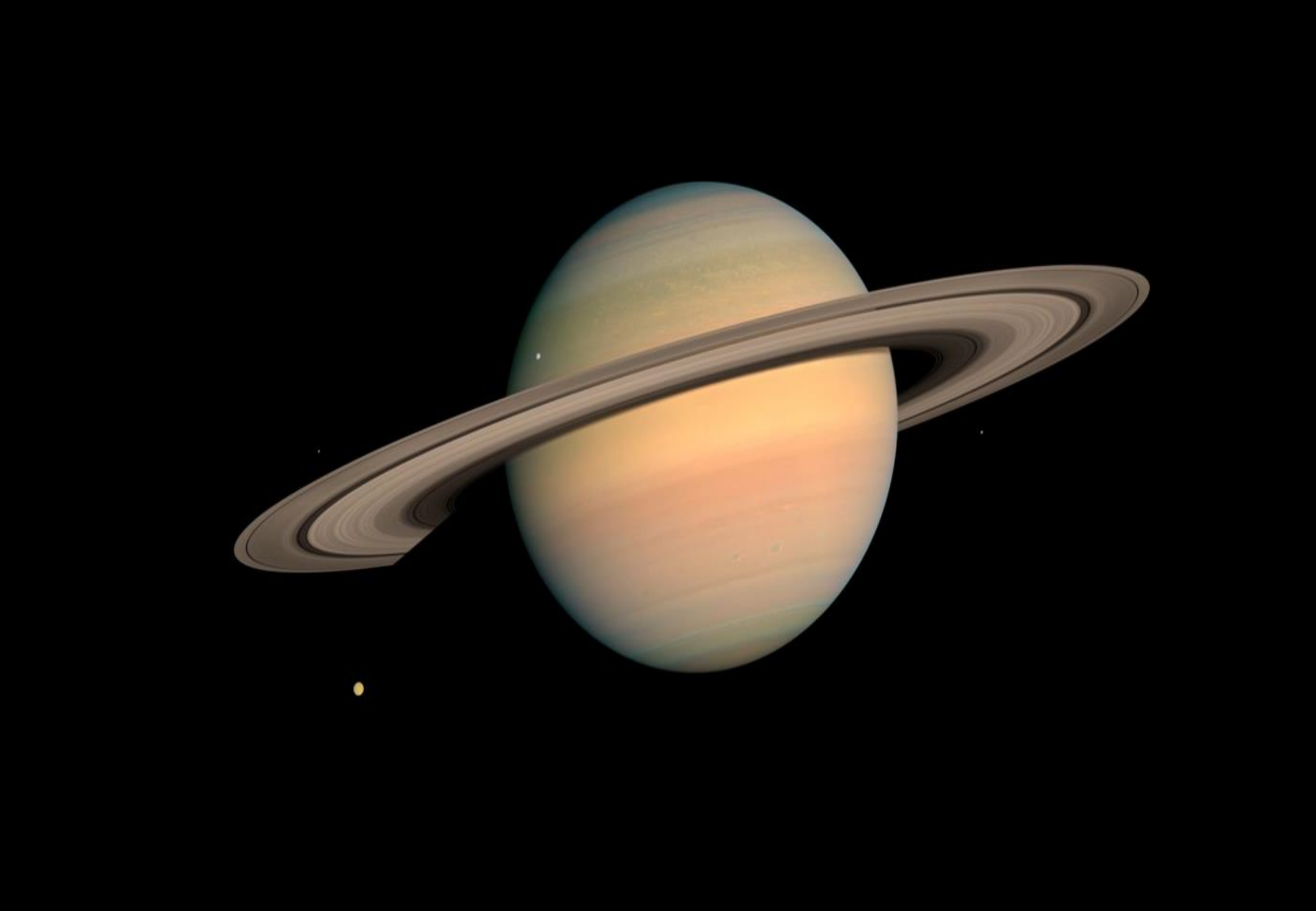
GANYMEDE AT HALF

YEAR: 1996
MISSION: GALILEO
TARGET: JIPITER / GANYMEDE

Ganymede at half phase shows off its tectonic patterning and texturing.

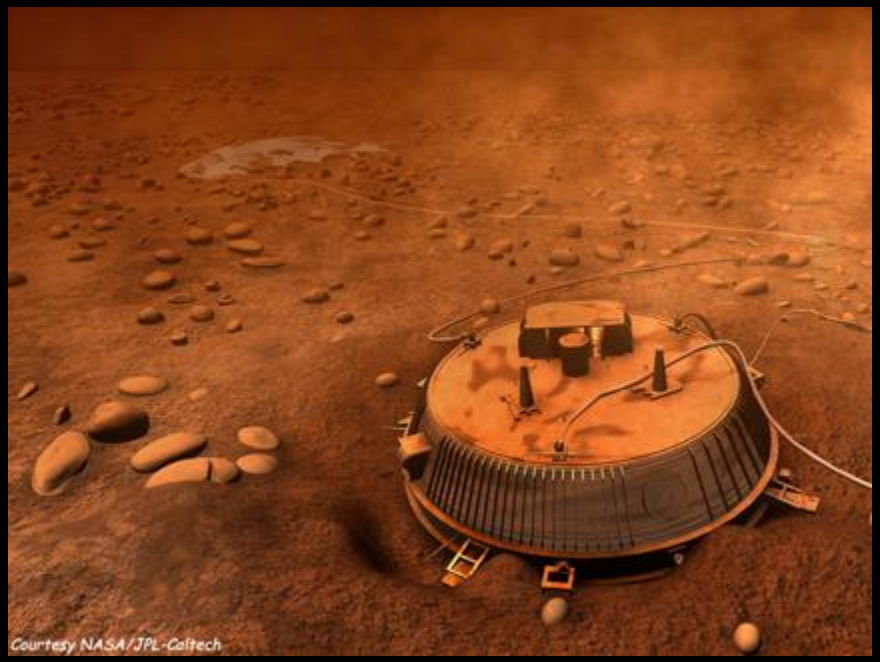
1997


NASA
esa
asi
agenzia spaziale italiana
CASSINI - HUYGENS
Exploring Saturn & Titan, a fascinating world
http://saturn.esa.int



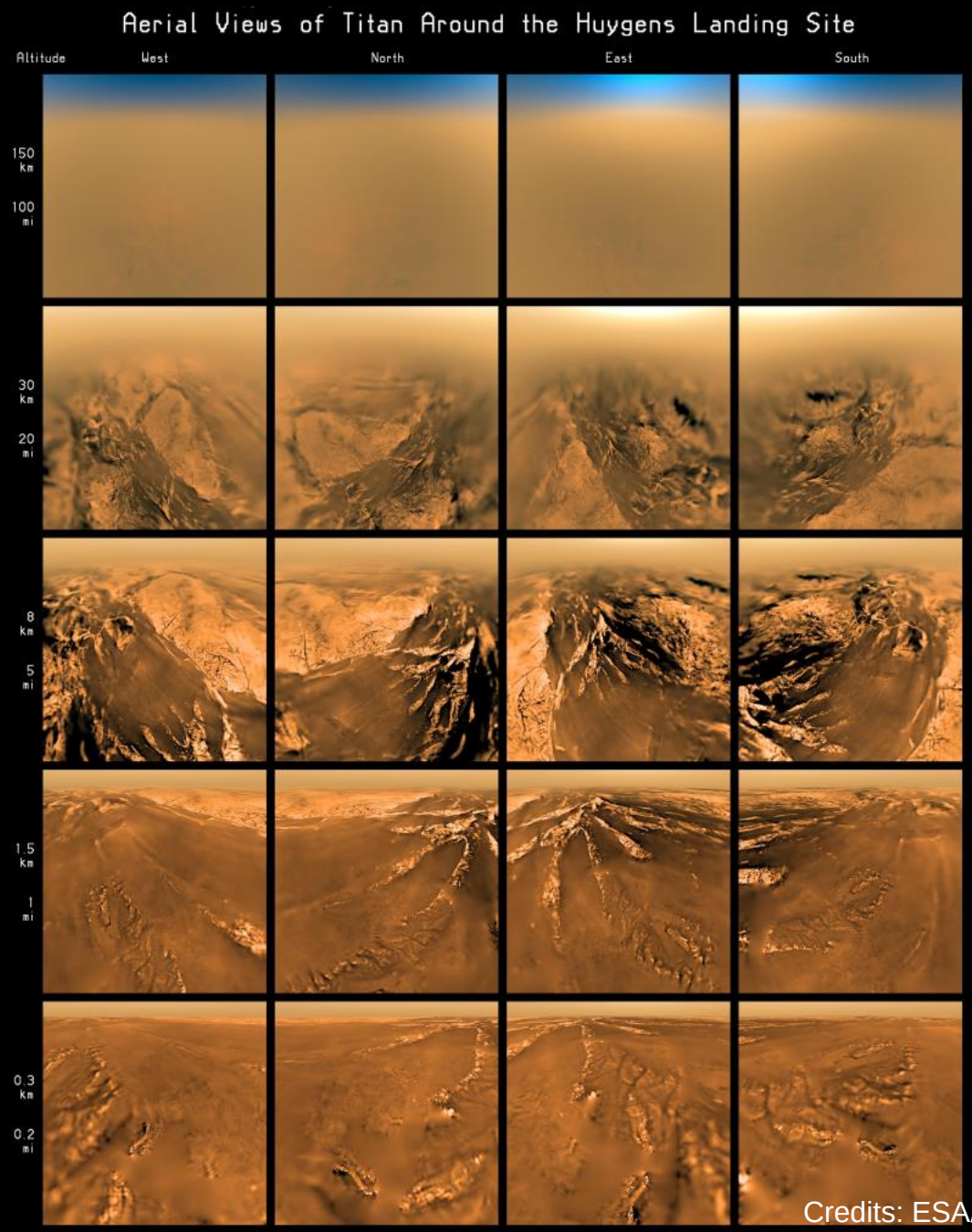
2005

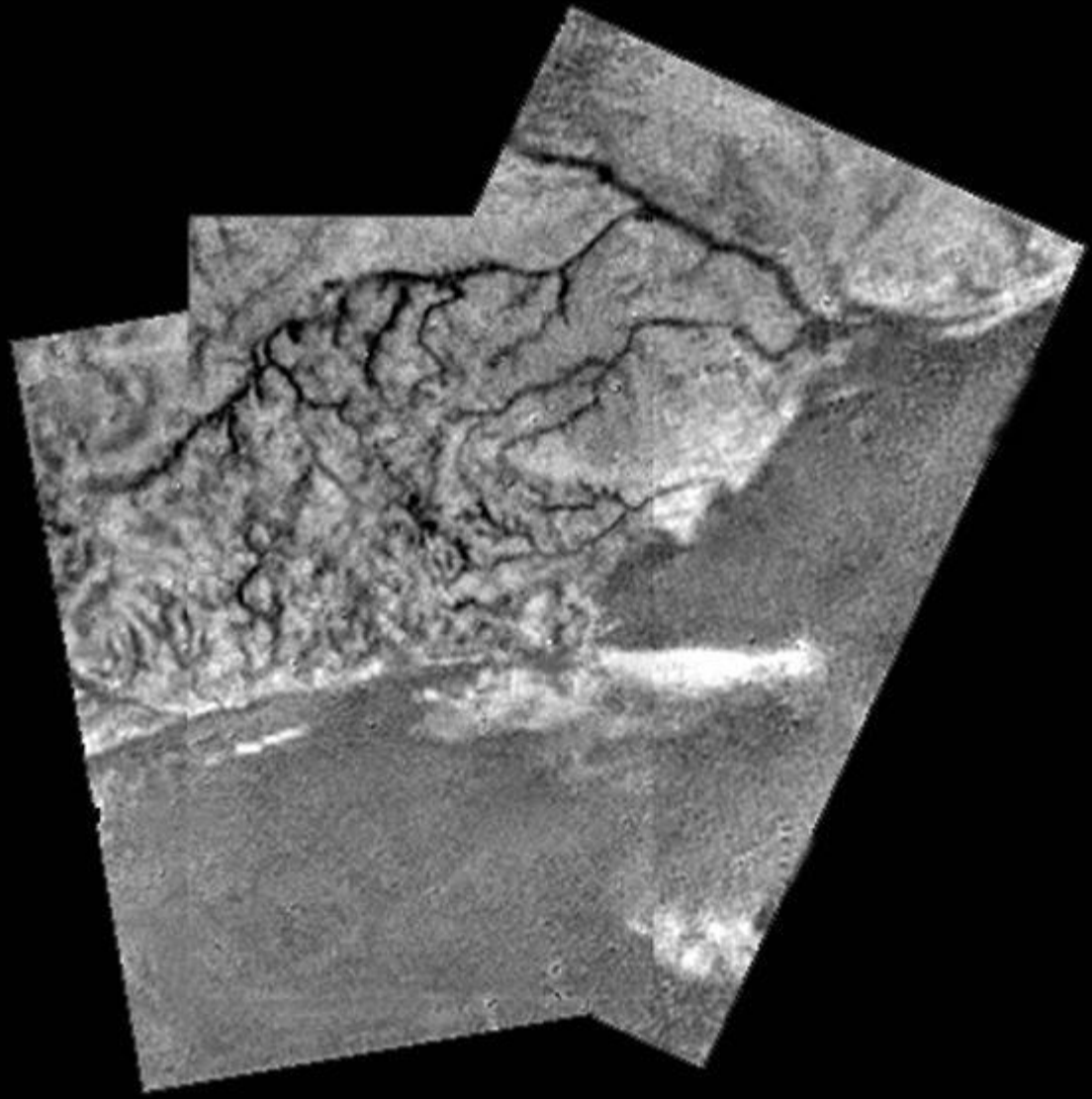
The Huygens spaceprobe descends to the surface of Saturn's moon Titan in this diagram depicting the mission sequence. Digital, 2004, for Scientific American. © 2005 by Don Dixon.



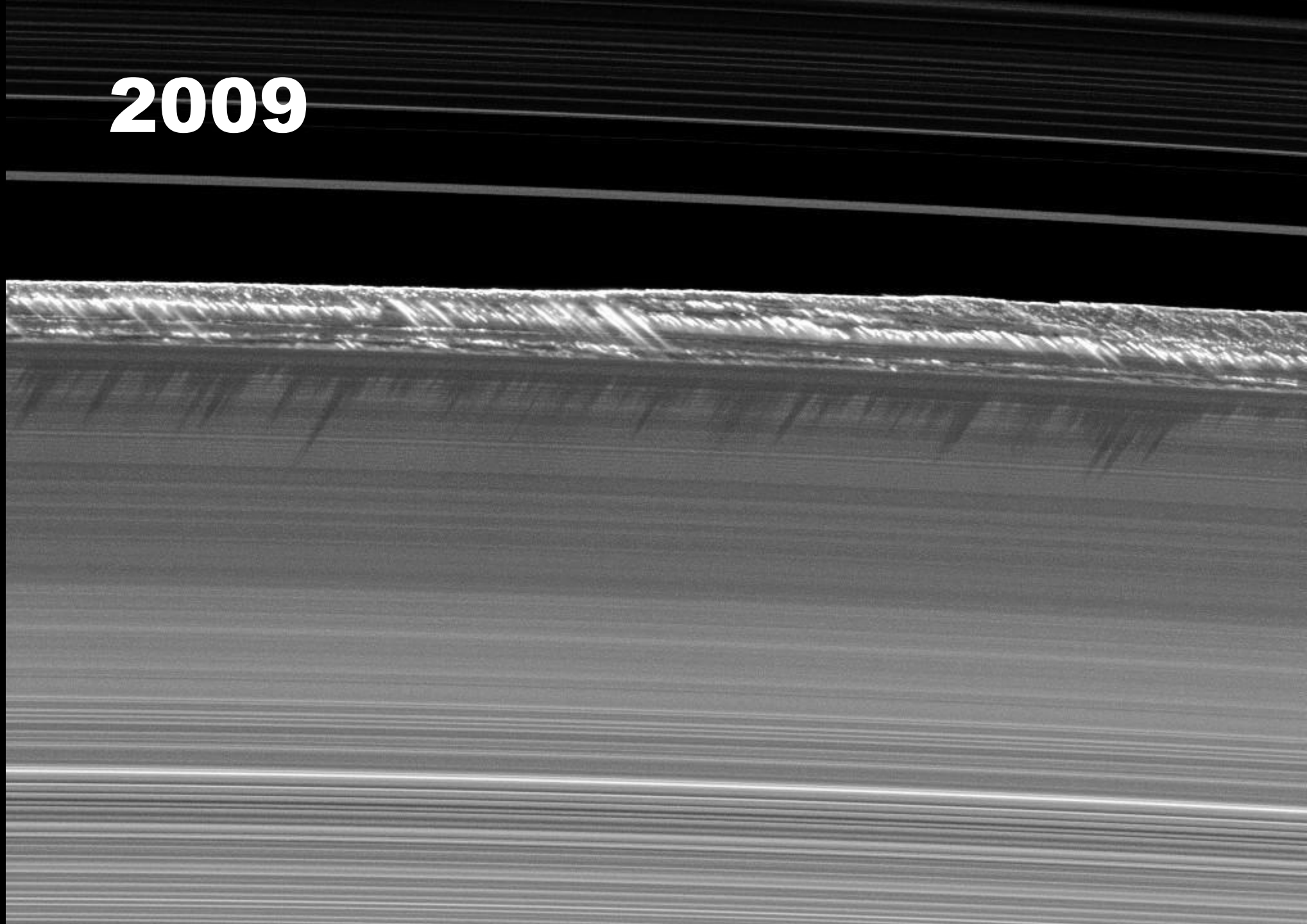
Titan

Saturn moon


Aerial Views of Titan Around the Huygens Landing Site
Altitude
West
North
East
South
150 km
100 mi
30 km
20 mi
8 km
5 mi
1.5 km
1 mi
0.3 km
0.2 mi
Credits: ESA/NASA/JPL/University of Arizona

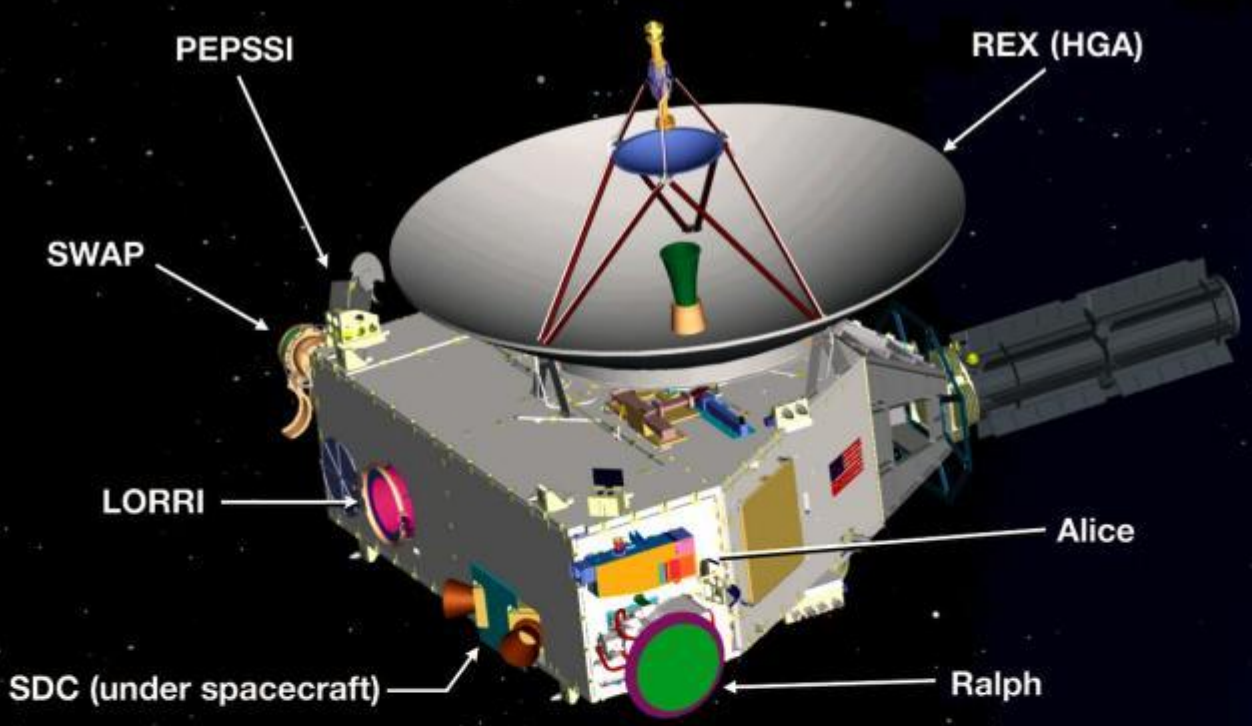


2009



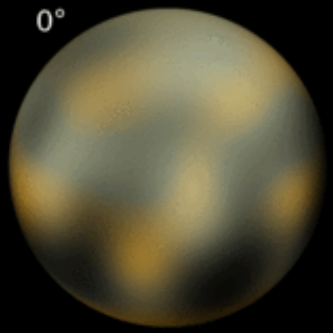
2006

New Horizons

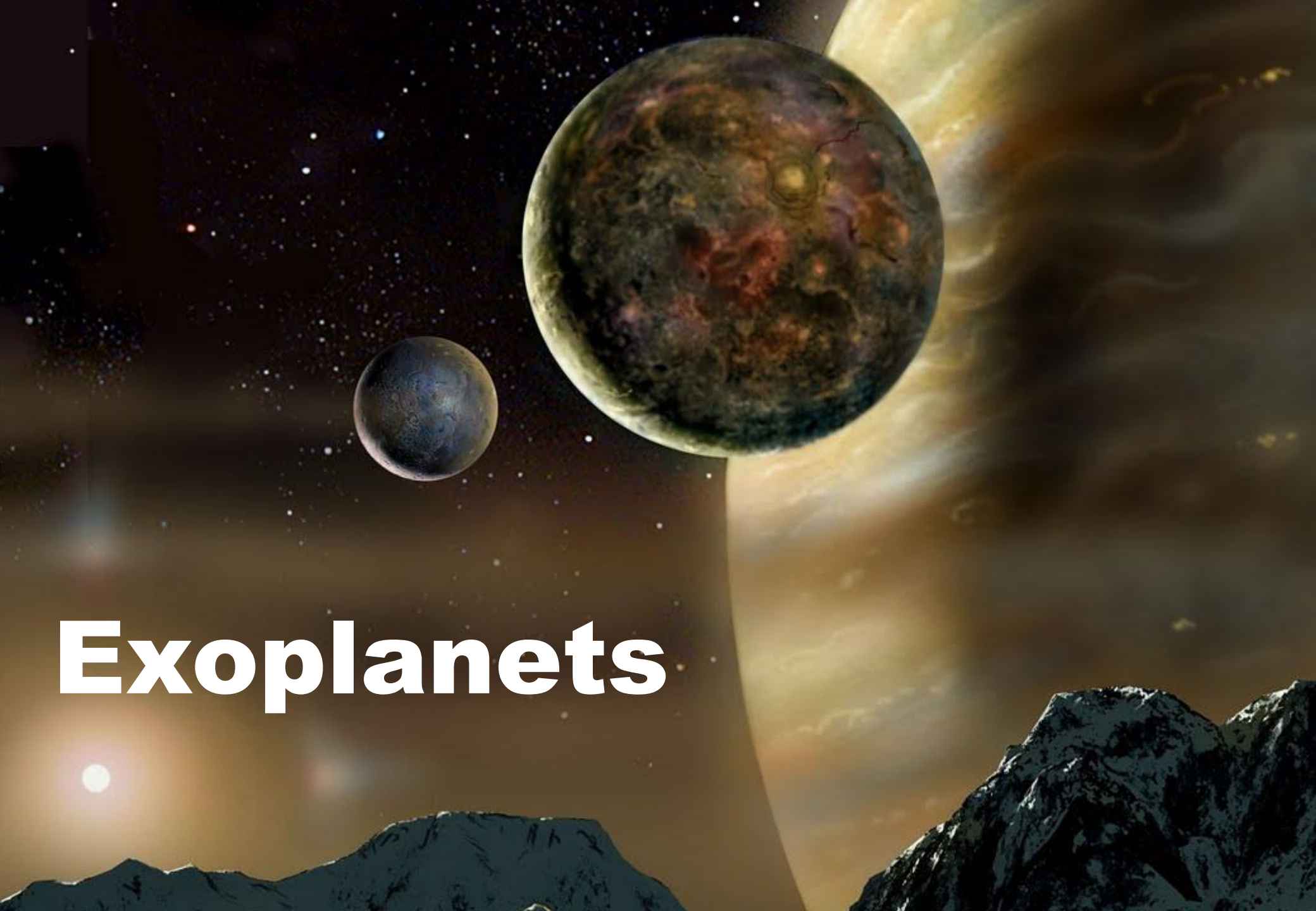


Science Payload

- Ralph: Visible and infrared imager/spectrometer; provides color, composition and thermal maps
- Alice: Ultraviolet imaging spectrometer; analyzes composition and structure of Pluto's atmosphere and looks for atmospheres around Charon and Kuiper Belt Objects (KBOs)
- REX (Radio Science EXperiment): Measures atmospheric composition and temperature; passive radiometer
- LORRI (LOng Range Reconnaissance Imager): Telescopic camera; obtains encounter data at long distances, maps Pluto's far side and provides high resolution geologic data
- SWAP (Solar Wind Around Pluto): Solar wind and plasma spectrometer; measures atmospheric "escape rate" and observes Pluto's interaction with solar wind
- PEPSSI (Pluto Energetic Particle Spectrometer Science Investigation): Energetic particle spectrometer; measures the composition and density of plasma (ions) escaping from Pluto's atmosphere
- SDC (Student Dust Counter): Built and operated by students; measures the space dust peppering New Horizons during its voyage across the solar system



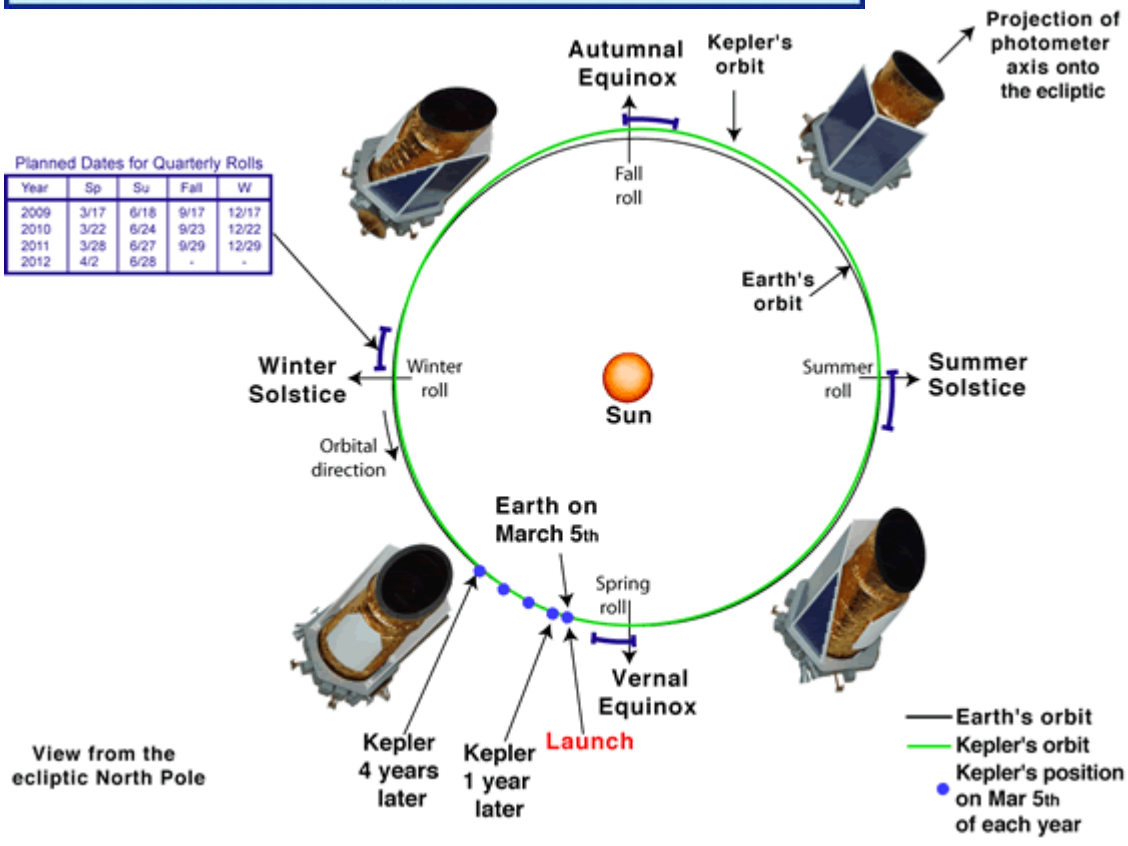

New Horizons
Pluto
2015

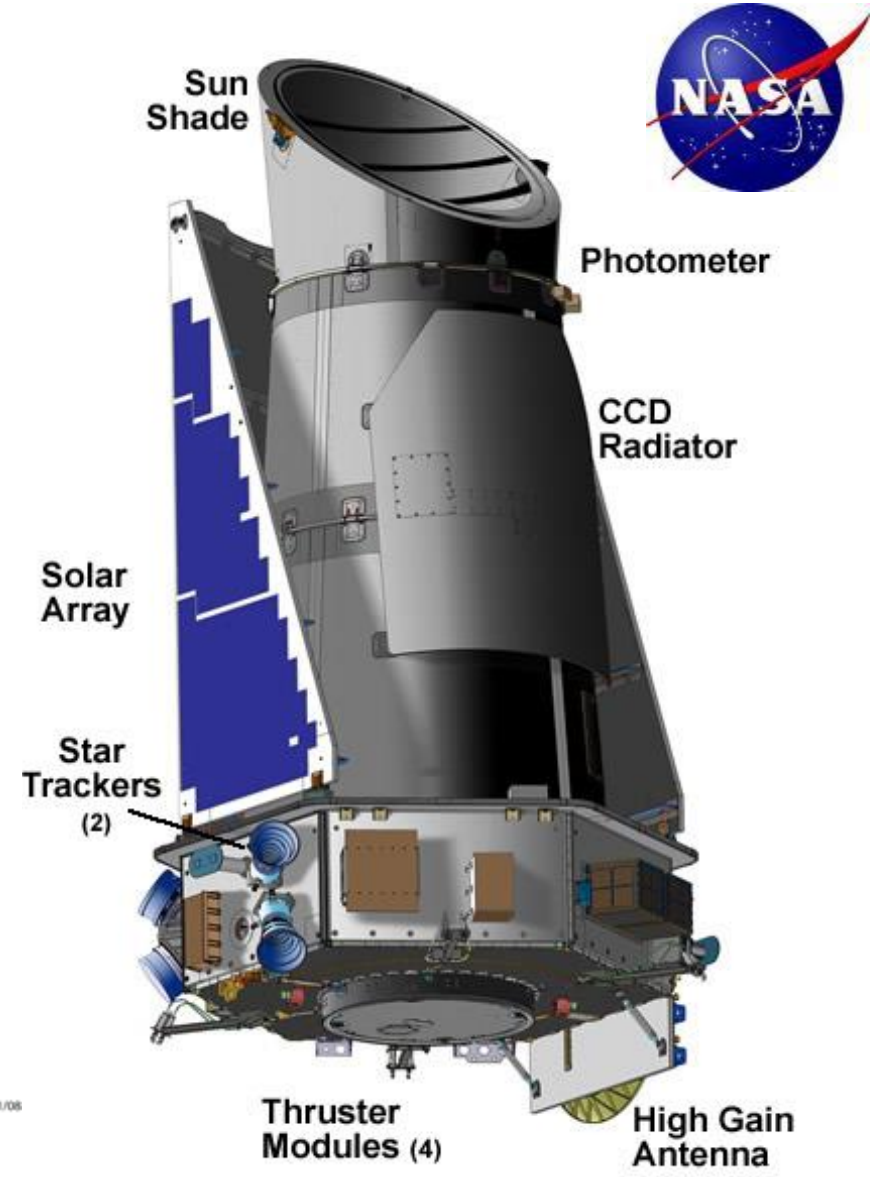

Exoplanets

er

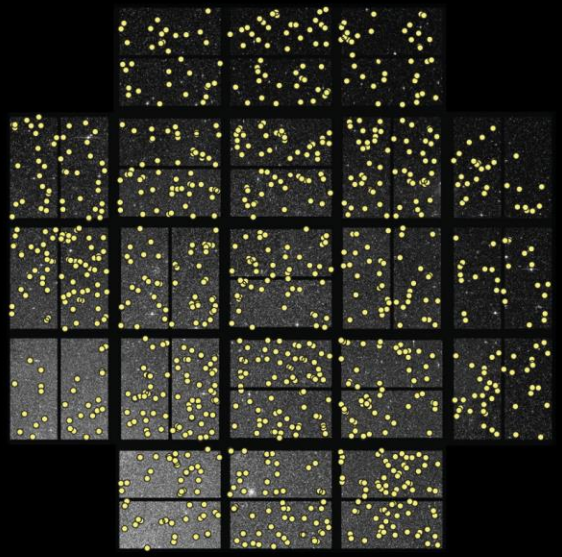
Planned Dates for Quarterly Rolls

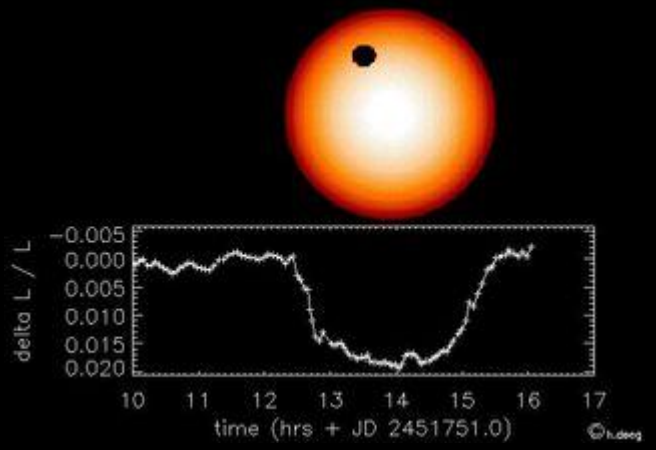
Year	Sp	Su	Fall	W
2009	3/17	6/18	9/17	12/17
2010	3/22	6/24	9/23	12/22
2011	3/28	6/27	9/29	12/29
2012	4/2	6/28	-	-

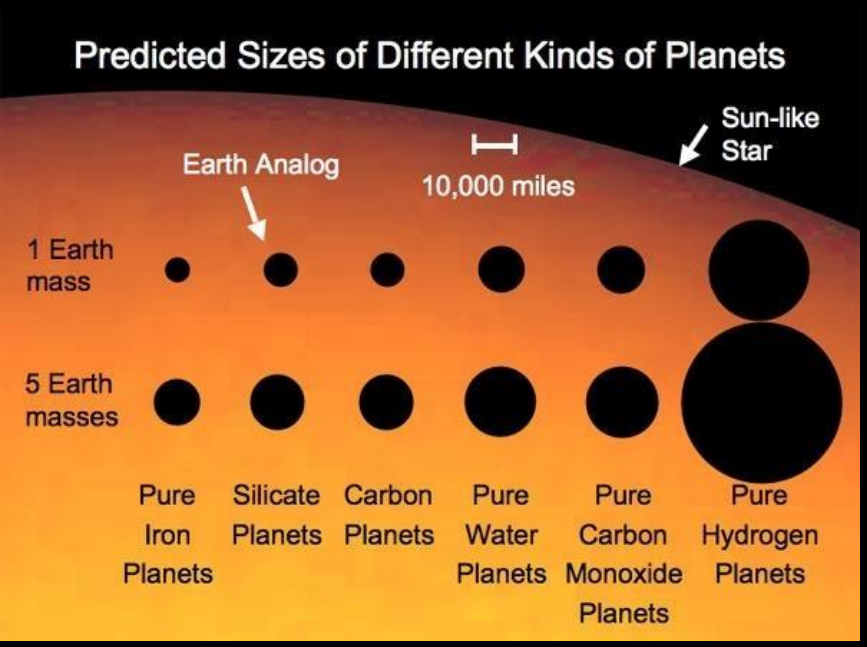




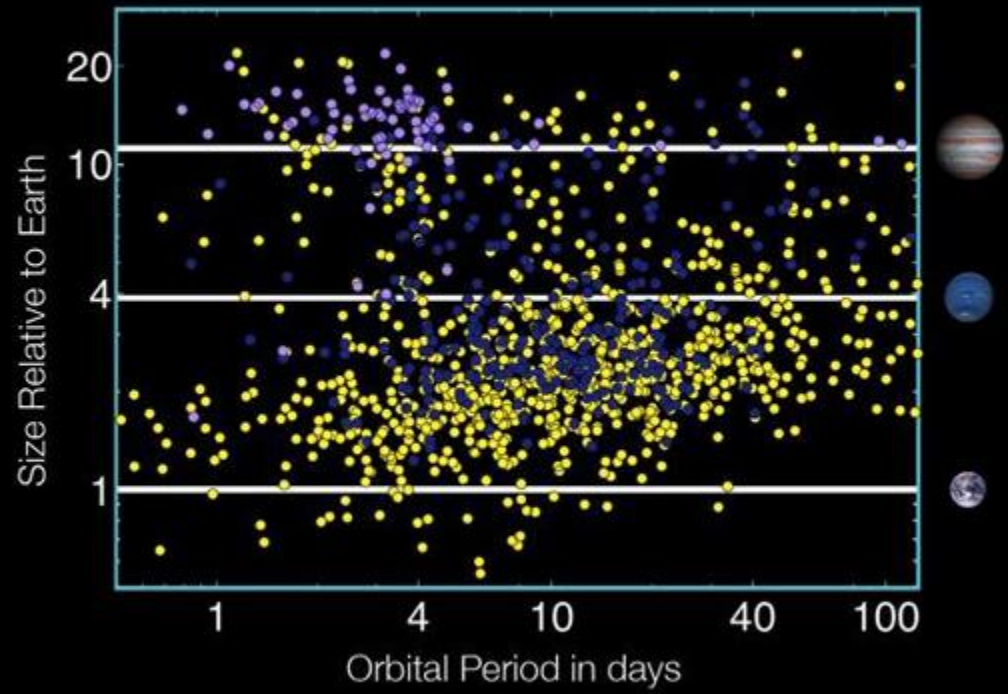
Kepler's 1,000+ Planet Candidates





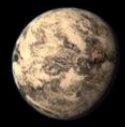


Kepler Candidates as of February 1, 2011

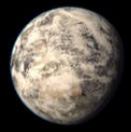


Current Potentially Habitable Exoplanets

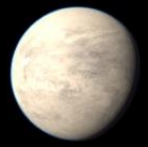
Ranked in Order of Similarity to Earth



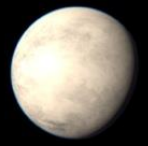
01. Gliese 667C c



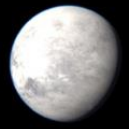
02. Kepler-62 e



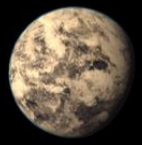
03. Kepler-283 c



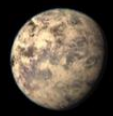
04. Kepler-296 f



05. Tau Ceti e*

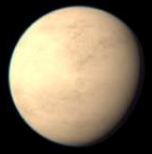


06. Gliese 180 c*

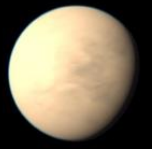


07. Gliese 667C f

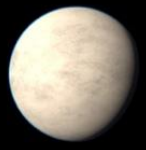
08. Gliese 581 g*



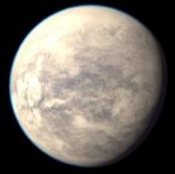
09. Gliese 180 b*



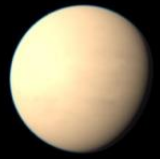
10. Gliese 163 c



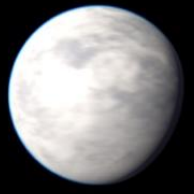
11. HD 40307 g



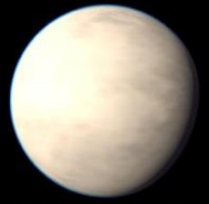
12. Kepler-61 b



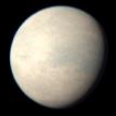
13. Gliese 422 b*



14. Kepler-22 b

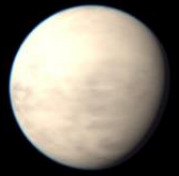


15. Kepler-298 d

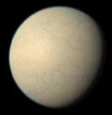


16. Kepler-62 f

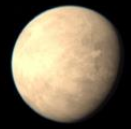
17. Kepler-186 f



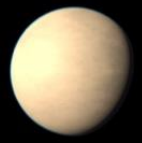
18. Kepler-174 d



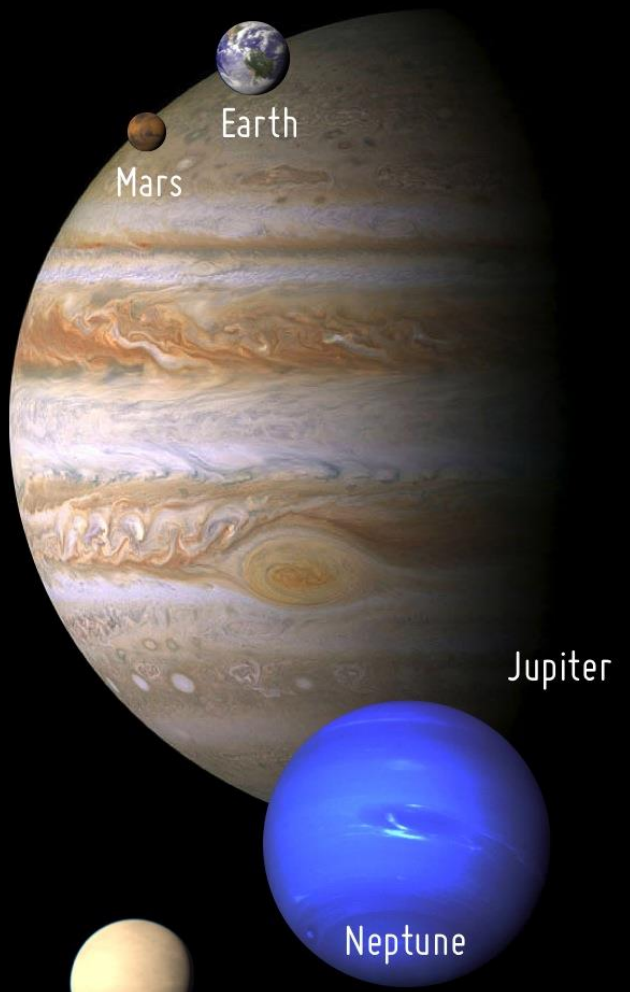
19. Gliese 667C e



20. Gliese 682 b*

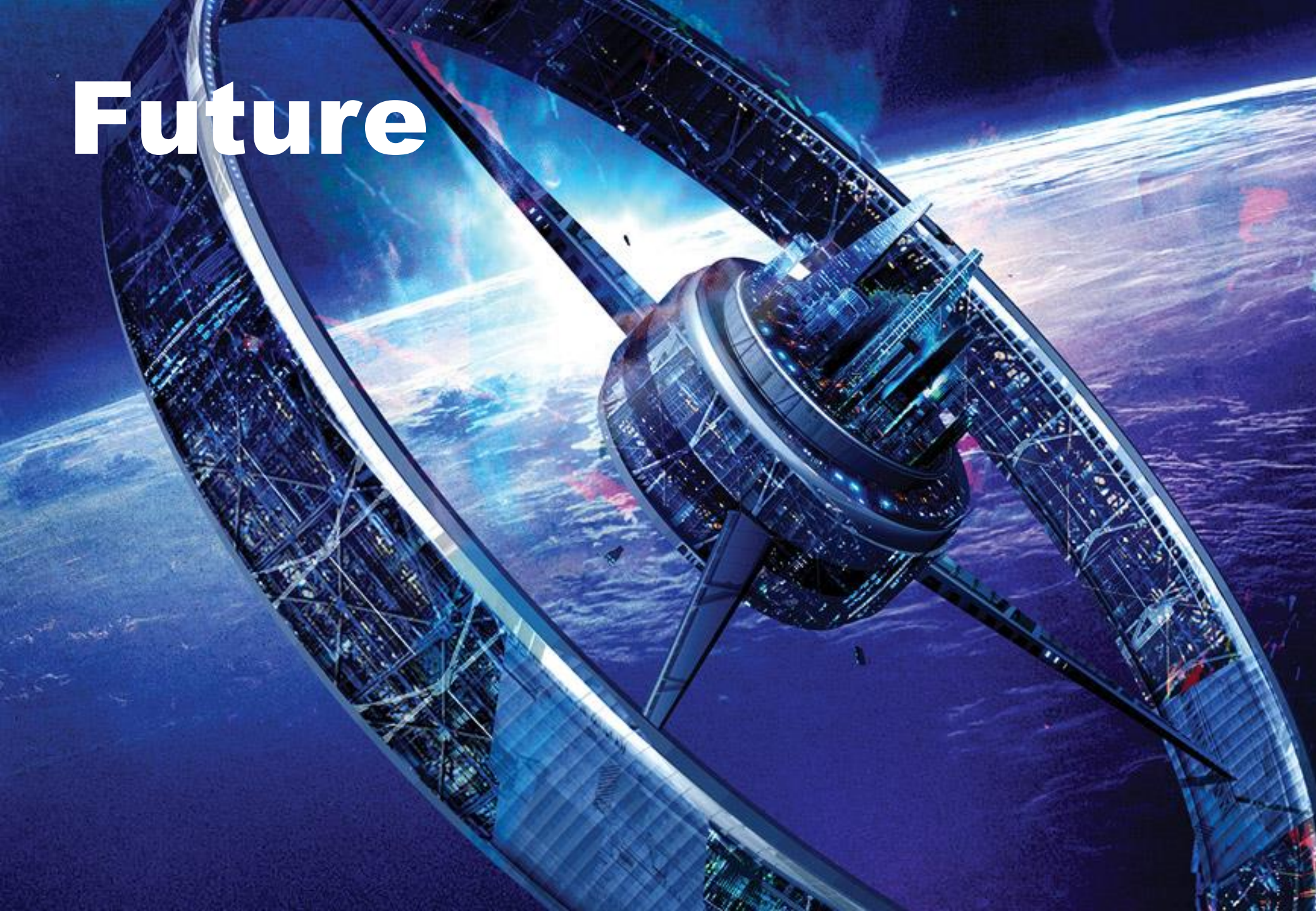


21. Gliese 581 d

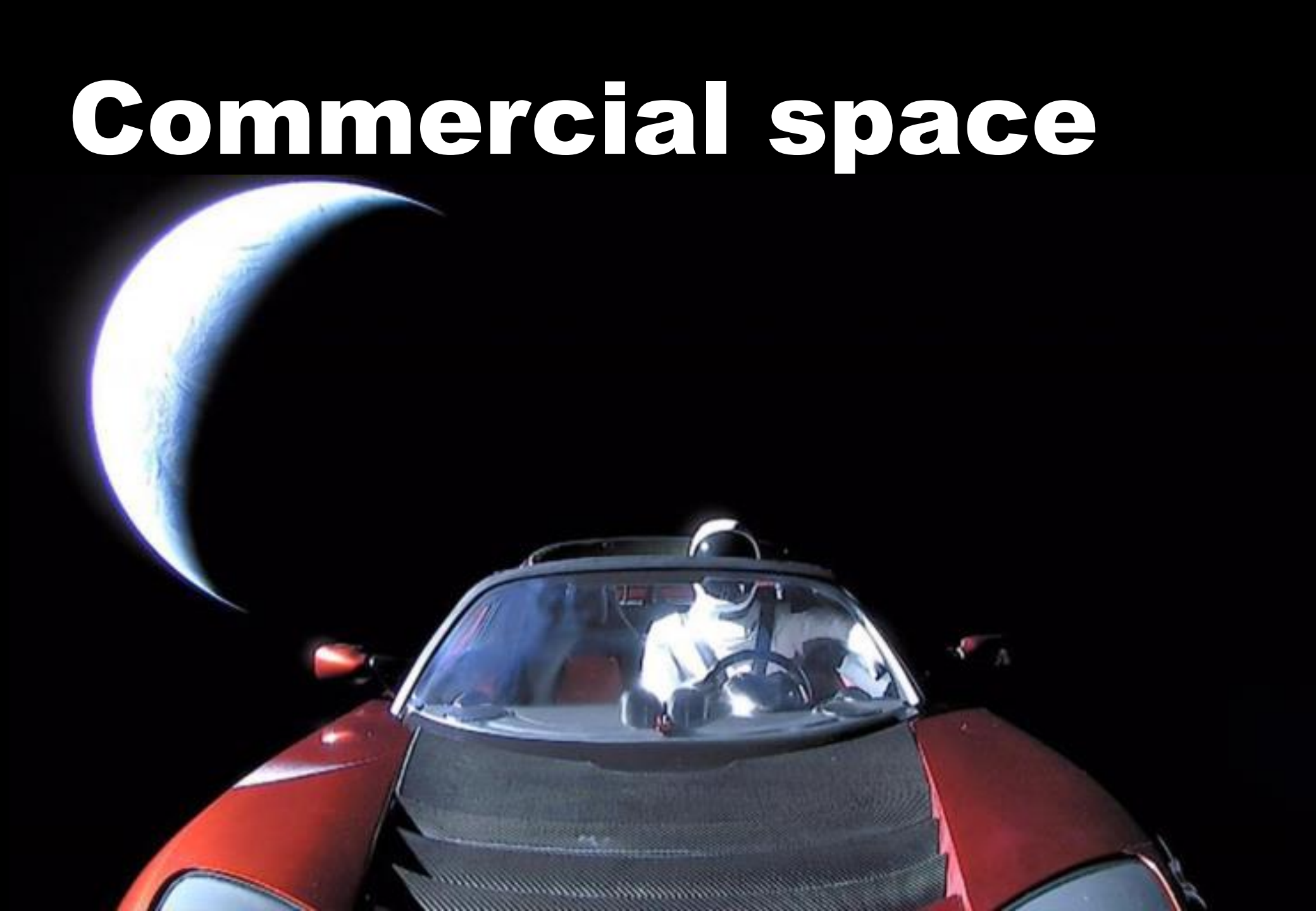


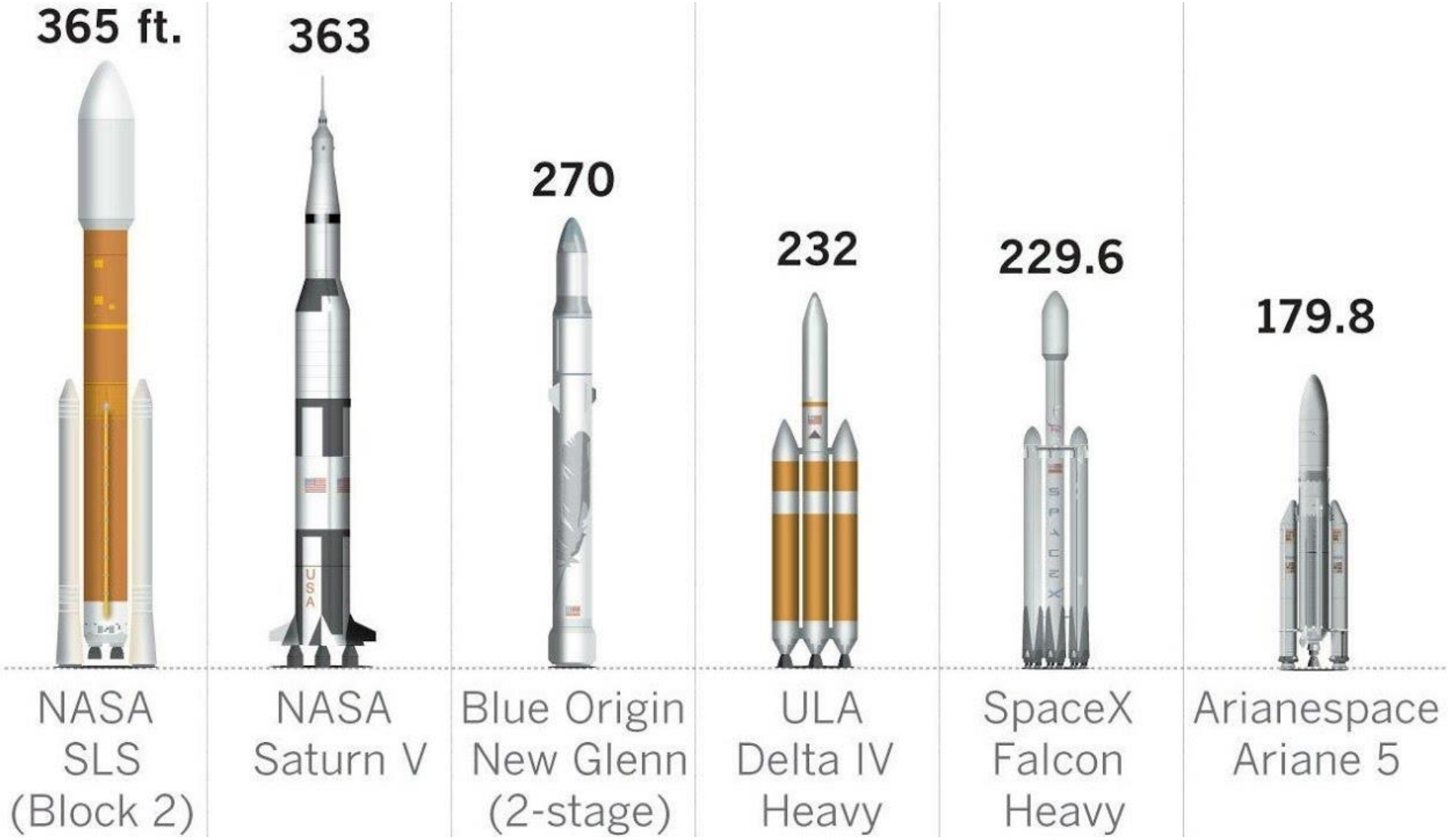
*planet candidates

CREDIT: PHL @ UPR Arecibo
(phl.upr.edu) April 17, 2014


Future

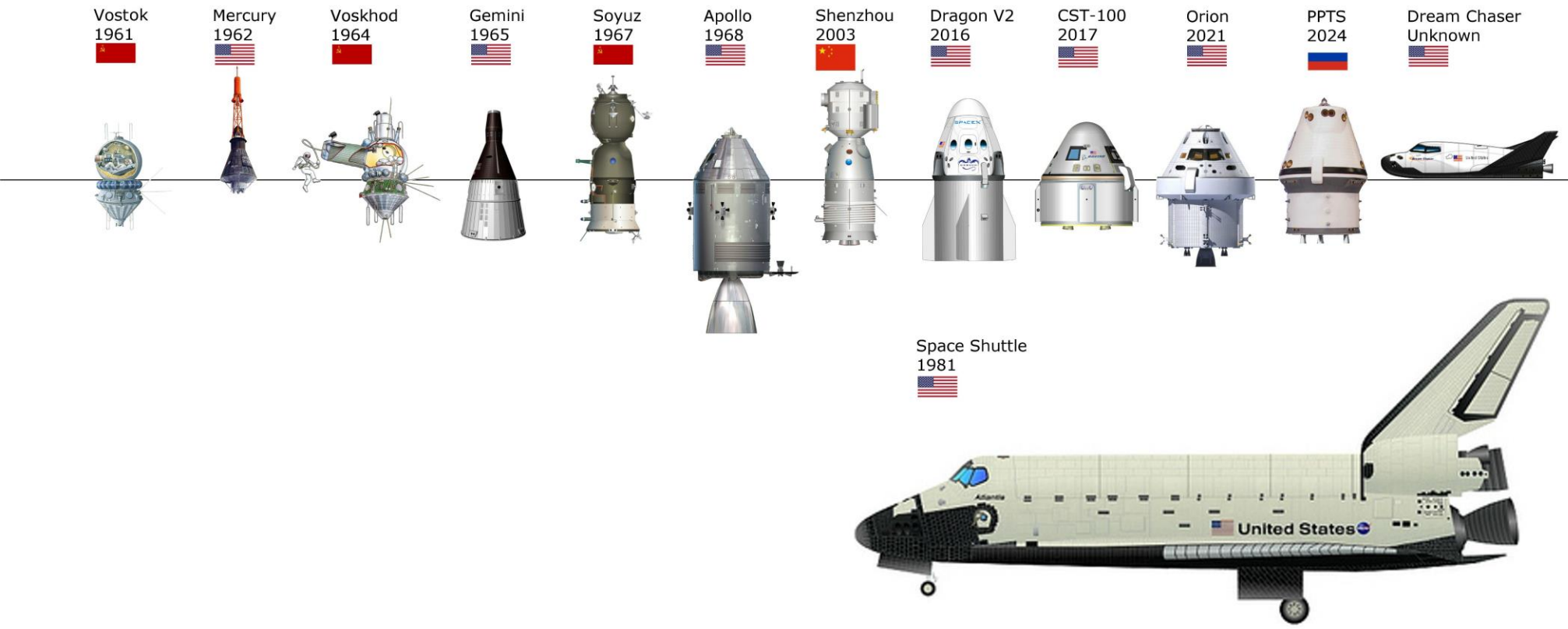
Commercial space

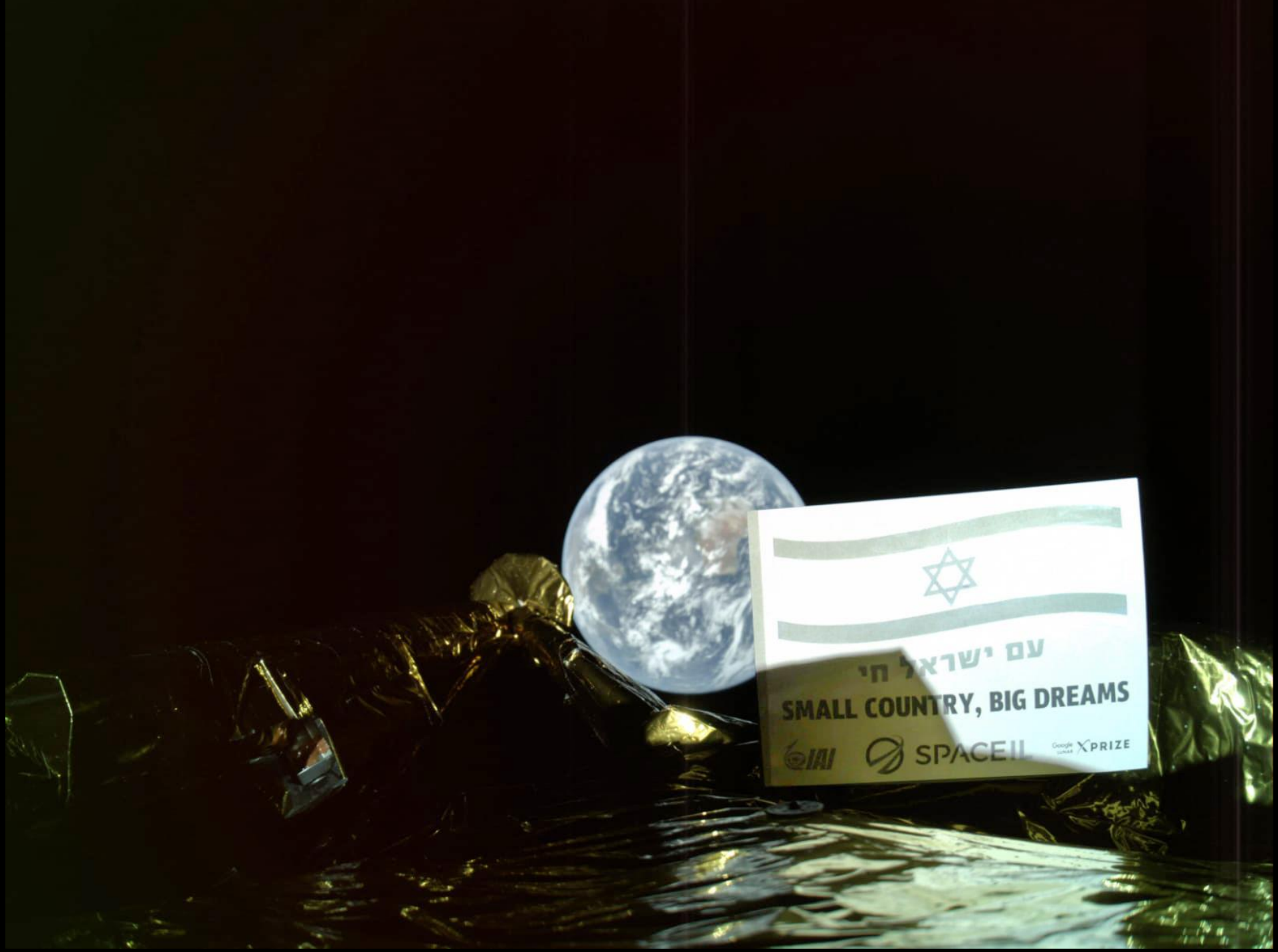



365 ft.
363
270
232
229.6
179.8
USA
SPACEX
NASA SLS (Block 2)
NASA Saturn V
Blue Origin New Glenn (2-stage)
ULA Delta IV Heavy
SpaceX Falcon Heavy
Arianespace Ariane 5

Manned Reentry Vehicles

0 2 4
meters

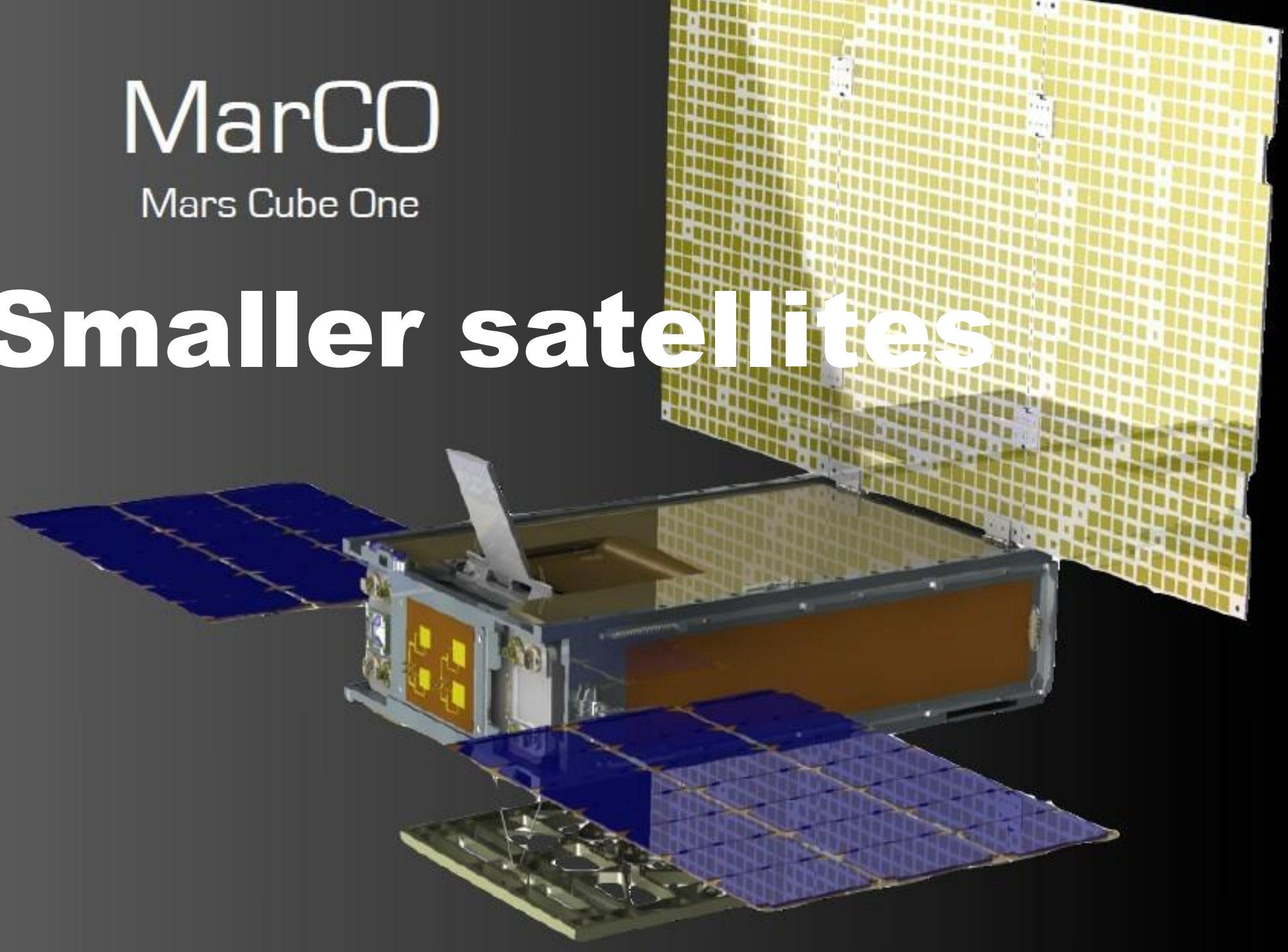



עם ישראל חי
SMALL COUNTRY, BIG DREAMS
IAI
SPACEIL
Google LUNAR XPRIZE

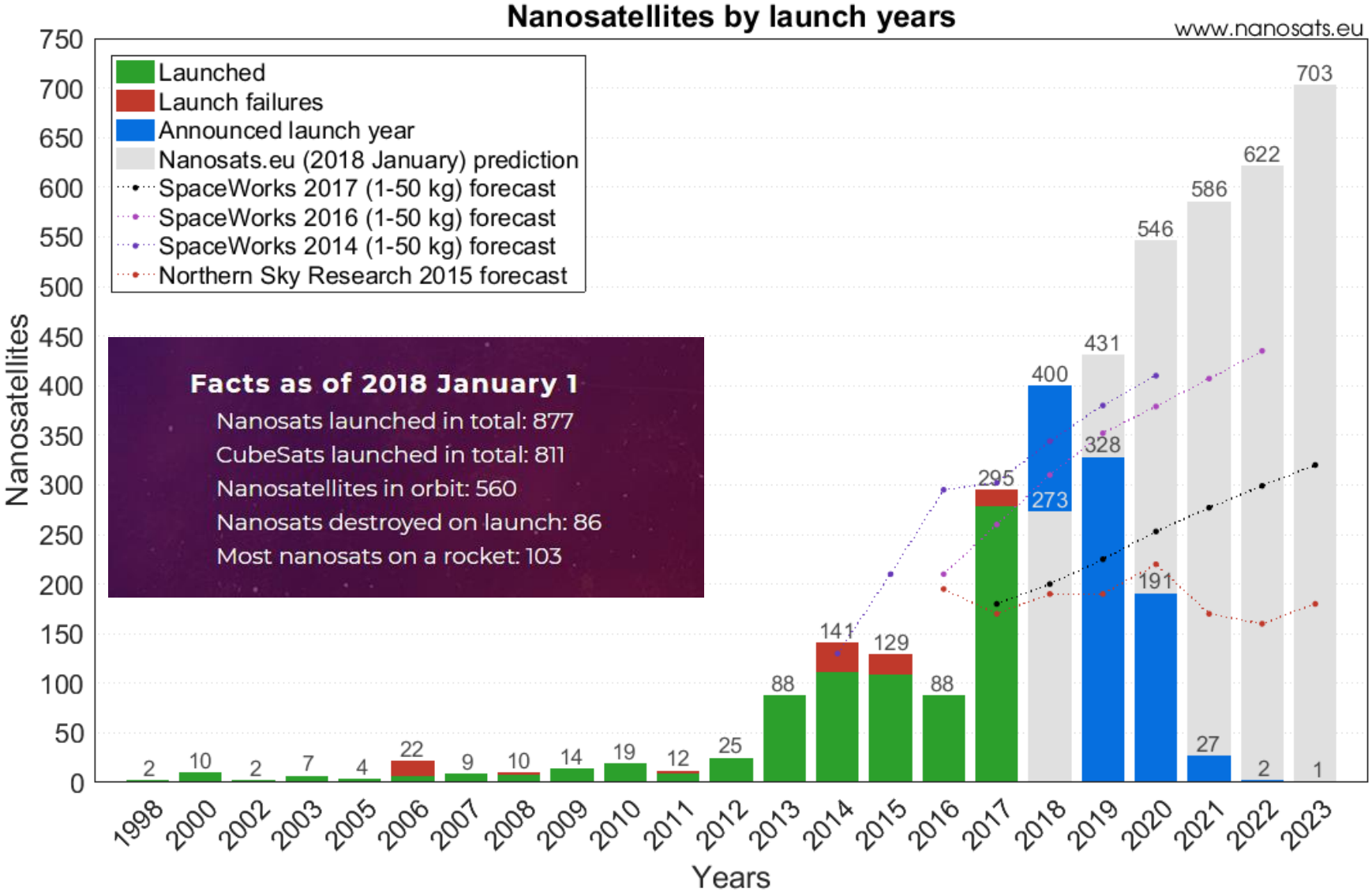
MarCO

Mars Cube One

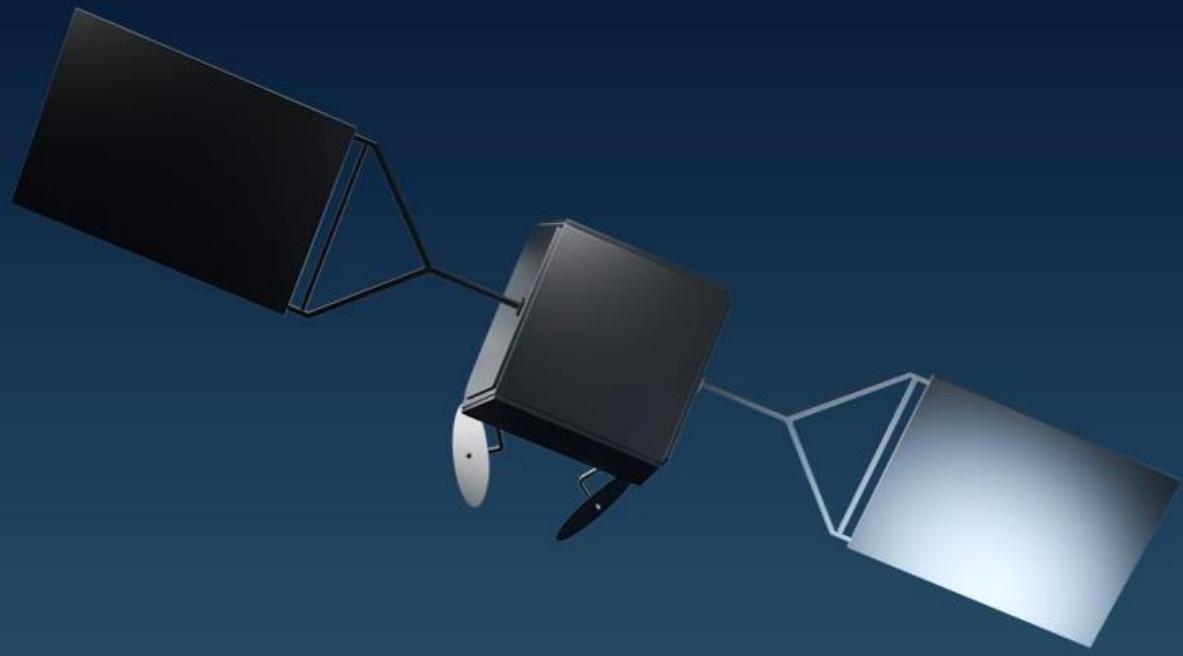
Smaller satellites



Aalto University
School of Electrical
Engineering



Constellations



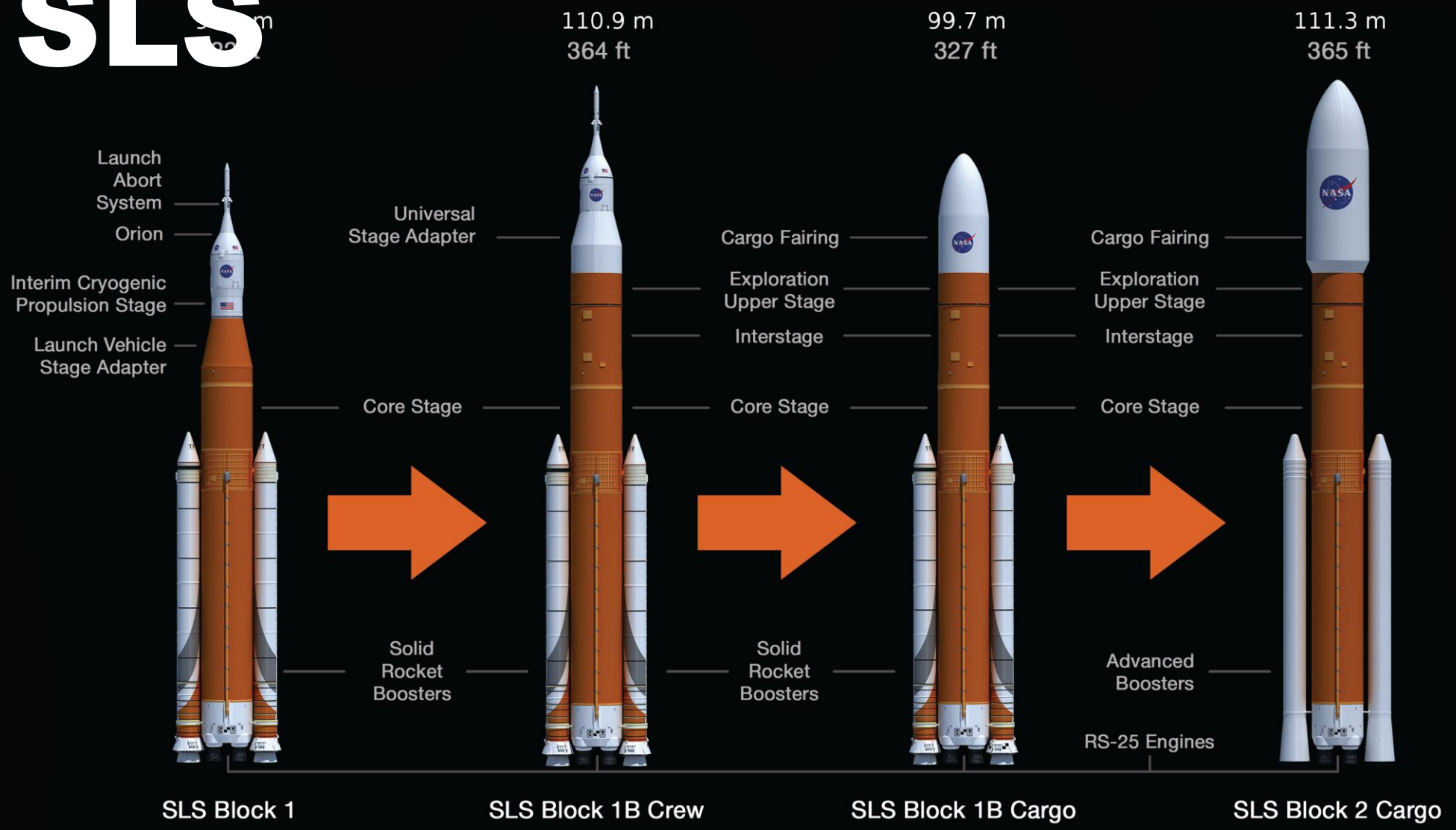

Space tourism

space nation

ANNIN TILANNE 183 %


MARS ONE
@MarsOneProject
#MarsOne

SLS

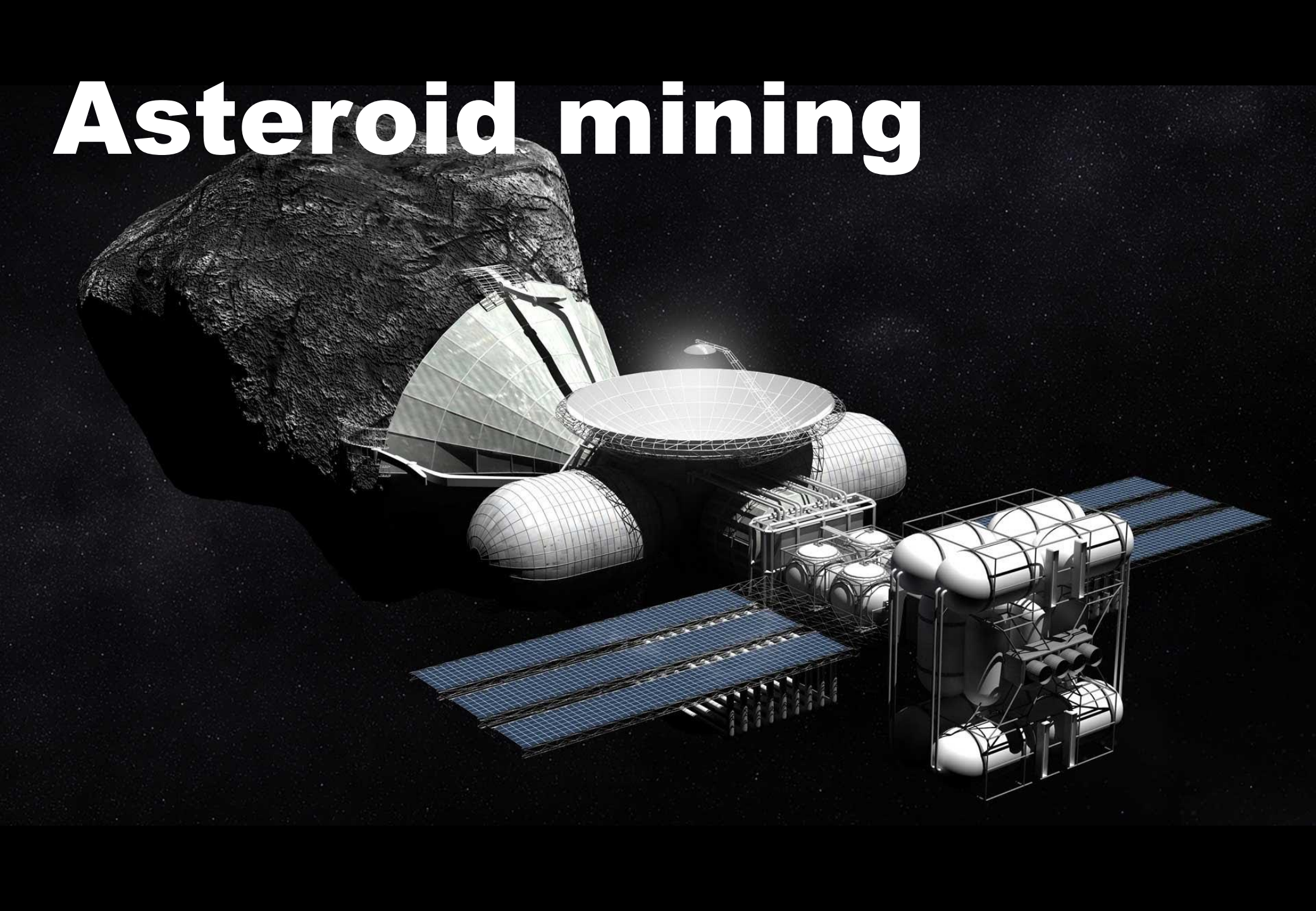

110.9 m
364 ft
99.7 m
327 ft
111.3 m
365 ft
Launch Abort System
Orion
Interim Cryogenic Propulsion Stage
Launch Vehicle Stage Adapter
Universal Stage Adapter
Cargo Fairing
Exploration Upper Stage
Interstage
Core Stage
Solid Rocket Boosters
Advanced Boosters
RS-25 Engines
SLS Block 1
SLS Block 1B Crew
SLS Block 1B Cargo
SLS Block 2 Cargo

Skylon rocket plane

Planetary colonisation

Aalto University

Asteroid mining



Search for extraterrestrial life continues

Interstellar missions