

Space Exploration Systems

Its Place in Lockheed Martin and Its Roles in Exploring the Solar System

2014 International Workshop on
Small Satellite and Sensor Technology for
Disaster Management (SSTDM)

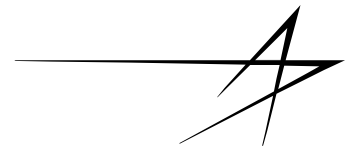
March 31 – April 2, 2014

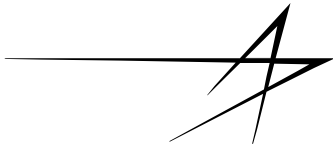
Indian Institute of Science (IISc)
Center of Nano Science and Technology Building
Bangalore, India



Wanda Sigur
Lockheed Martin Space Systems Company

Space Systems Company & NASA Video





Aeronautics

A collage of images related to aeronautics, including several fighter jets in flight, a transport aircraft, and a close-up of a jet's engine.

Information Systems & Global Solutions

A collage of images related to information systems and global solutions, including a control room with multiple computer monitors, a globe of the Earth, a meeting room, and a green digital interface with data points.

Missiles & Fire Control

A collage of images related to missiles and fire control, including a cruise missile in flight, a military truck, a helicopter, and a soldier in a desert environment.

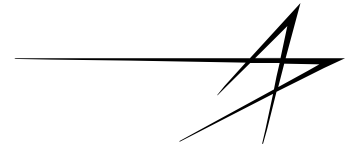
Mission Systems & Training

A collage of images related to mission systems and training, including a large aircraft carrier, a ship at sea, a large ship, and a person in a blue uniform working on a large piece of equipment.

Space Systems

A collage of images related to space systems, including a satellite in orbit, a rocket launch, a space station, and a satellite in orbit.

Ethics



Our Vision

- Powered by innovation, guided by integrity, we help our customers achieve their most challenging goals

Value Delivery

- Improving security, enhancing quality of life and expanding human knowledge through the application of space technology

Our Value Statements

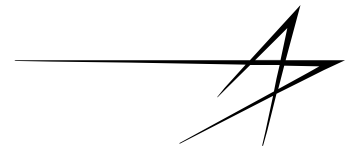
- Do what's right
- Respect others
- Perform with excellence



Photo courtesy of NASA



The Men and Women of Lockheed Martin

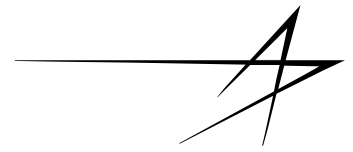


- 115,000 employees
- 60,000 scientists, engineers and IT professionals
- 500 + facilities across the U.S.
- And operating in 70 countries

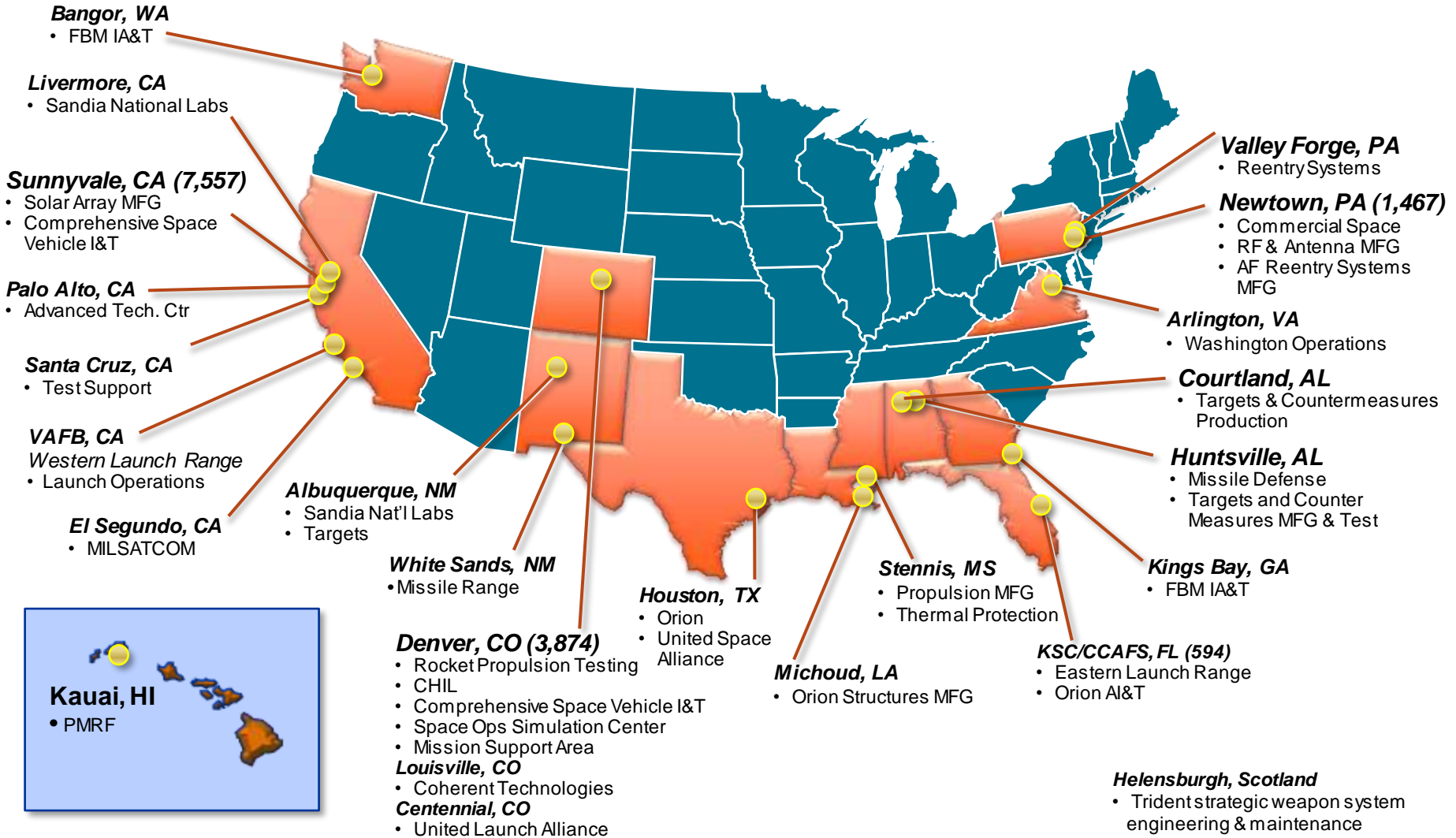
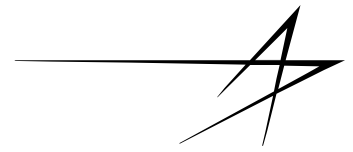


Partners helping customers achieve their goals

Global Business Offices

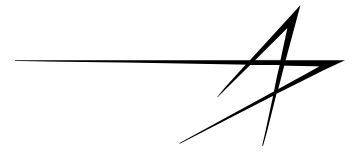


Space Systems Company Locations



Broad and deep competencies enlivened by a diverse program base

Space Systems Company Portfolio



Strategic & Missile Defense



Advanced Programs



Strategic Missiles



Missile Defense

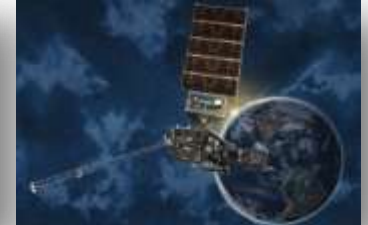
Civil Space



Human Exploration



Planetary Exploration



Weather & Environment

Military Space



Protected Comms



Narrowband Comms



Navigation



Weather



Early Warning

Special Programs



Commercial Ventures



Remote Sensing



Commercial SATCOM

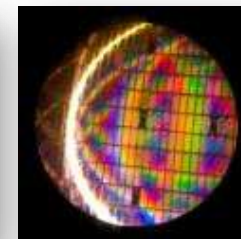


Wind Energy Management

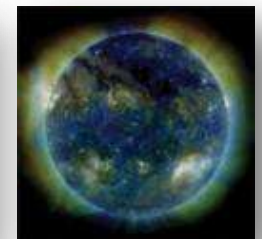
Advanced Technology



Optics, RF & Photonics

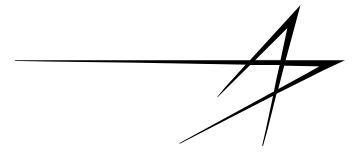


Adv. Materials & Nano Systems



Space Sciences and Instruments

Space Systems Mission Facts



Lift

- Over 100 consecutive successful Atlas launches
- Delivery to all orbit regimes

Payloads

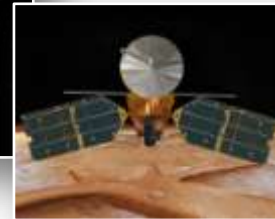
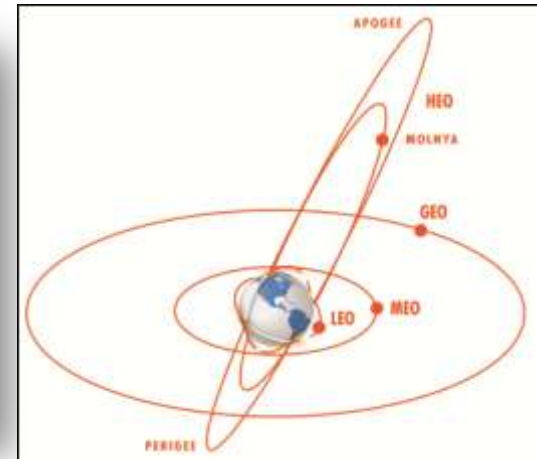
- More than 310 payloads over the last 50 years
- 84 payloads, 10 hosted payloads since 2000

Spacecraft

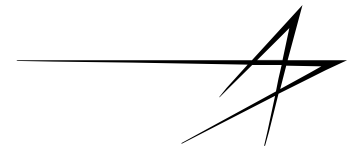
- Built over 800 satellites in 50 years
- 10 year 99% Mission Success rate

Missiles

- 144 successful Trident II D5 missile tests since 1989
- 10-for-10 THAAD intercepts since 2006



Civil Space



Expanding the frontiers of space exploration and Earth observation

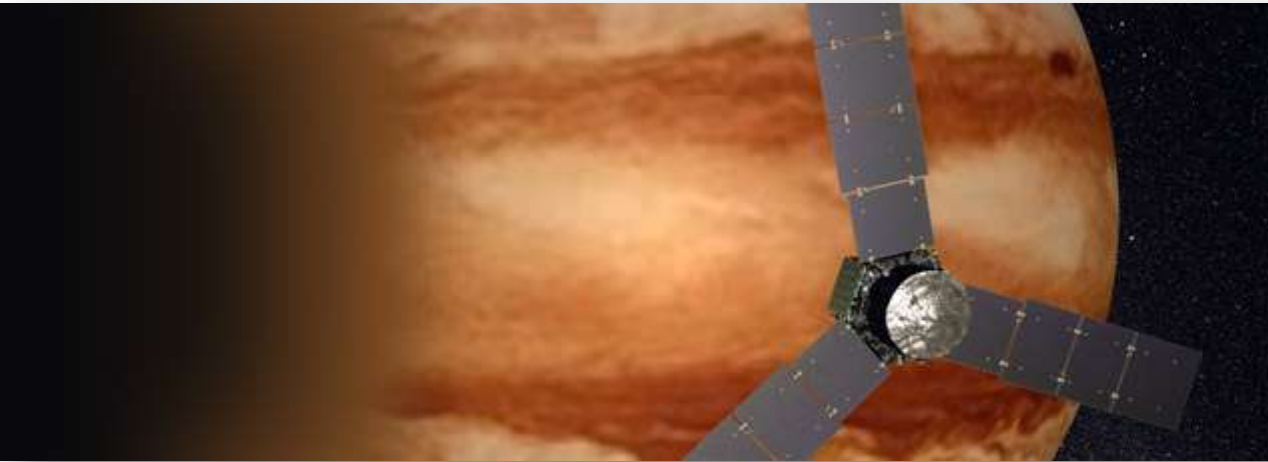


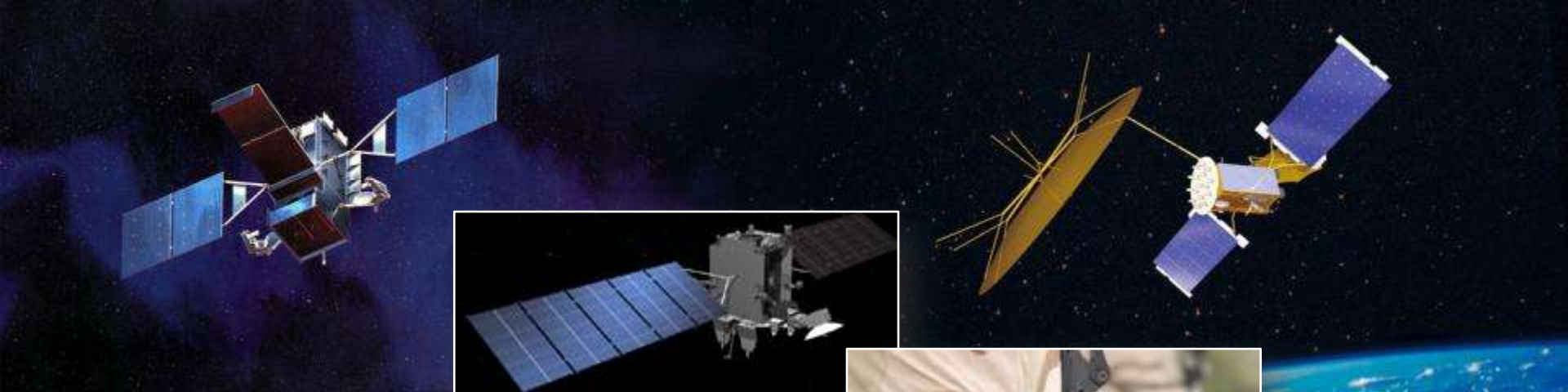
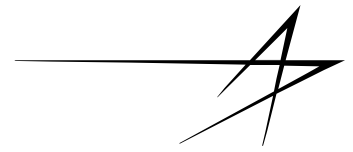
Image courtesy of NASA

- Human space exploration
- *Robotic deep space exploration*
- *Mars orbiters and landers*
- Weather and environmental sensing
- Advanced Programs – exploring new frontiers



Military Space

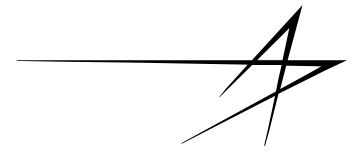
Delivering critical national security space capability



- Protected military communications
- Mobile military communications
- Global positioning systems
- Space-based surveillance

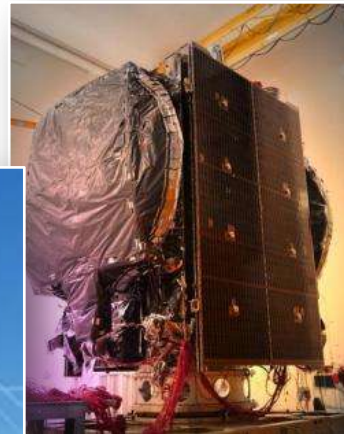


Commercial Ventures



Meeting the needs of the global commercial market for space-related products and services

- **Commercial satellite telecommunications**
- **Commercial remote sensing**
- **Wind energy management**
- **New technology and business model applications**



Lift

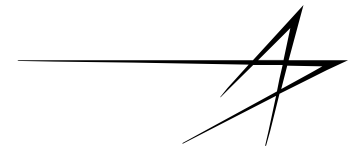


- Entrusted with our nation's most critical assets
- Launched an annualized value exceeding \$2.5B/year over the last five years
- Unmatched performance, accuracy and reliability

OVER 350 TITAN FLIGHTS | OVER 600 ATLAS FLIGHTS | 135 SHUTTLE FLIGHTS | 7 ATHENA FLIGHTS



World Class Facilities



Core infrastructure in place to execute space-based missions



Advanced Simulation



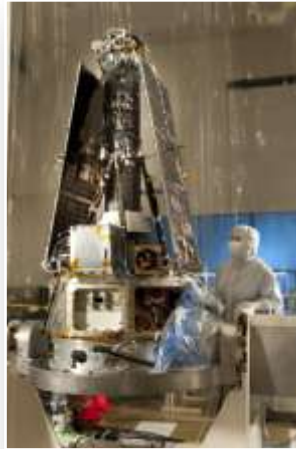
Environmental Test



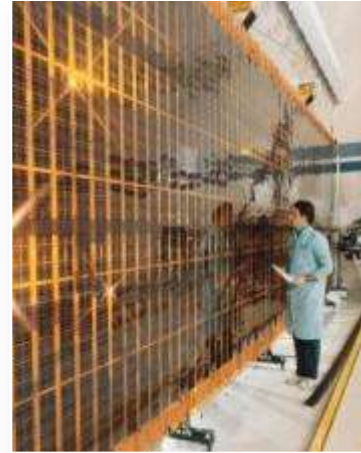
Virtual Design & Production



Clean Rooms



Payload Development



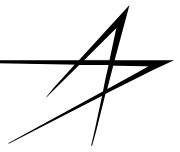
Manufacturing/Assembly



Satellite Integration

Decades of industry and government investment

Full-Cycle Model Based Enterprise (MBE)



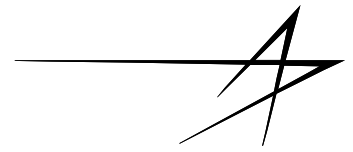
Understanding and exploring complex systems before they are built

- Rapid development to improve responsiveness, productivity, quality and affordability
- Visual evaluation of design concepts over the entire product lifecycle
- Validate, integrate and operate test designs through wholly immersive simulations
- Comprehensive visual work instructions

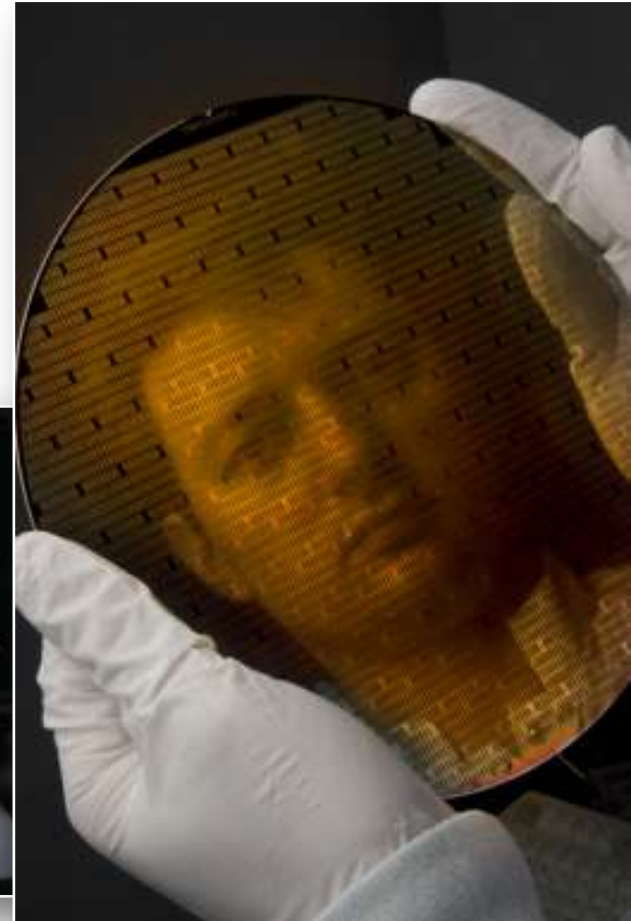
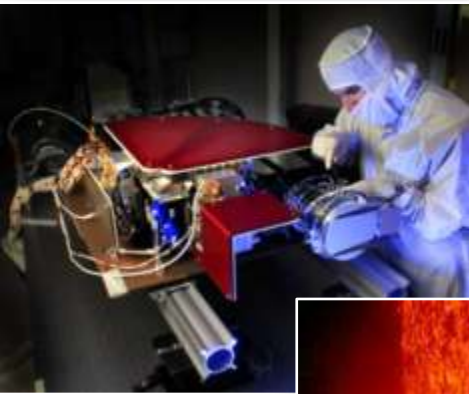


Advanced Technology Center

Harnessing technologies that enable the future

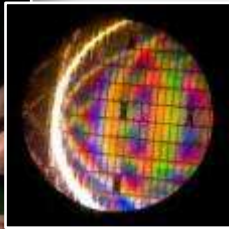
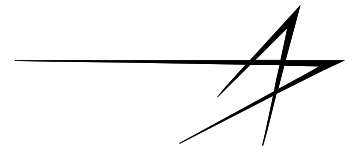


- Focus on customers' demanding requirements
- Expertise across numerous technologies
- Integrated multidisciplinary approach
- Solar and space physics instrumentation



Advanced Technology Development

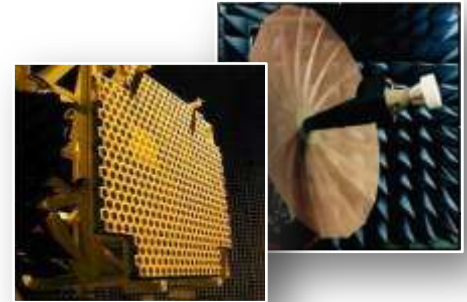
Innovative technologies that enable current and future missions



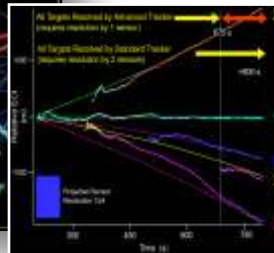
Nanotechnology



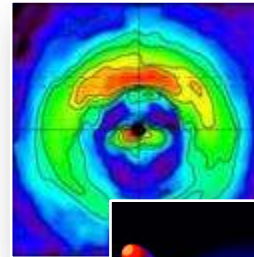
Optics & Electro-Optics



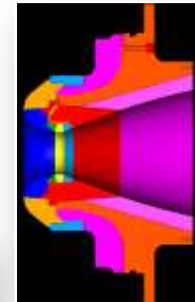
Telecommunications



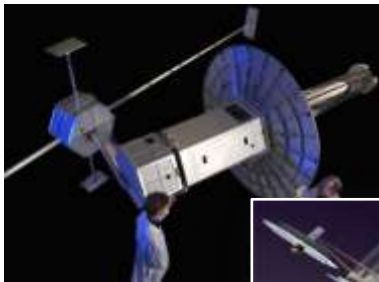
Modeling & Simulation



Phenomenology




Materials



Precision Pointing & Control



Continual investment in leading edge technologies



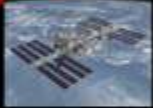
*Lockheed Martin's
Solar System Exploration*

“If you want a nation to have space exploration ambitions, you've got to send humans.”

Neil deGrasse Tyson

How Hard Could It Be?

If Earth was the size of a Classroom Globe, ISS is $\frac{1}{4}$ " away



International Space Station (ISS)
460 km

& the moon is at 50 yd ...

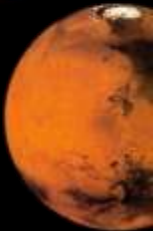


Moon
384,000 km
x 635



Asteroids
5,000,000 km
x 10,870

Mars is 10 mi away.!



Mars
55,700,000 km
x 121,100

Low-Earth Orbit
(LEO)

Cis-Lunar Space

Environment to test and prove exploration capabilities and operations

Deep Space

Human journeys of exploration and discovery, taking us farther into space than ever before

Stepping Stones

A series of exploration missions building incrementally towards the long term goal of exploring Mars.

Each mission will address science objectives relating to the formation of the solar system and the origins of life.

2023
Deimos scout



2031 – 2035
Red Rocks: explore Mars from Deimos



2024, 2025, 2029
Plymouth Rock: Humans explore asteroids like 1999 AO10 and 2000 SG344

2017
Asteroid scout



2018 – 2023
L2 Farside: Explore the Moon's far side from Earth-Moon L2 point



2017
SLS test flight



2016
Asteroid survey

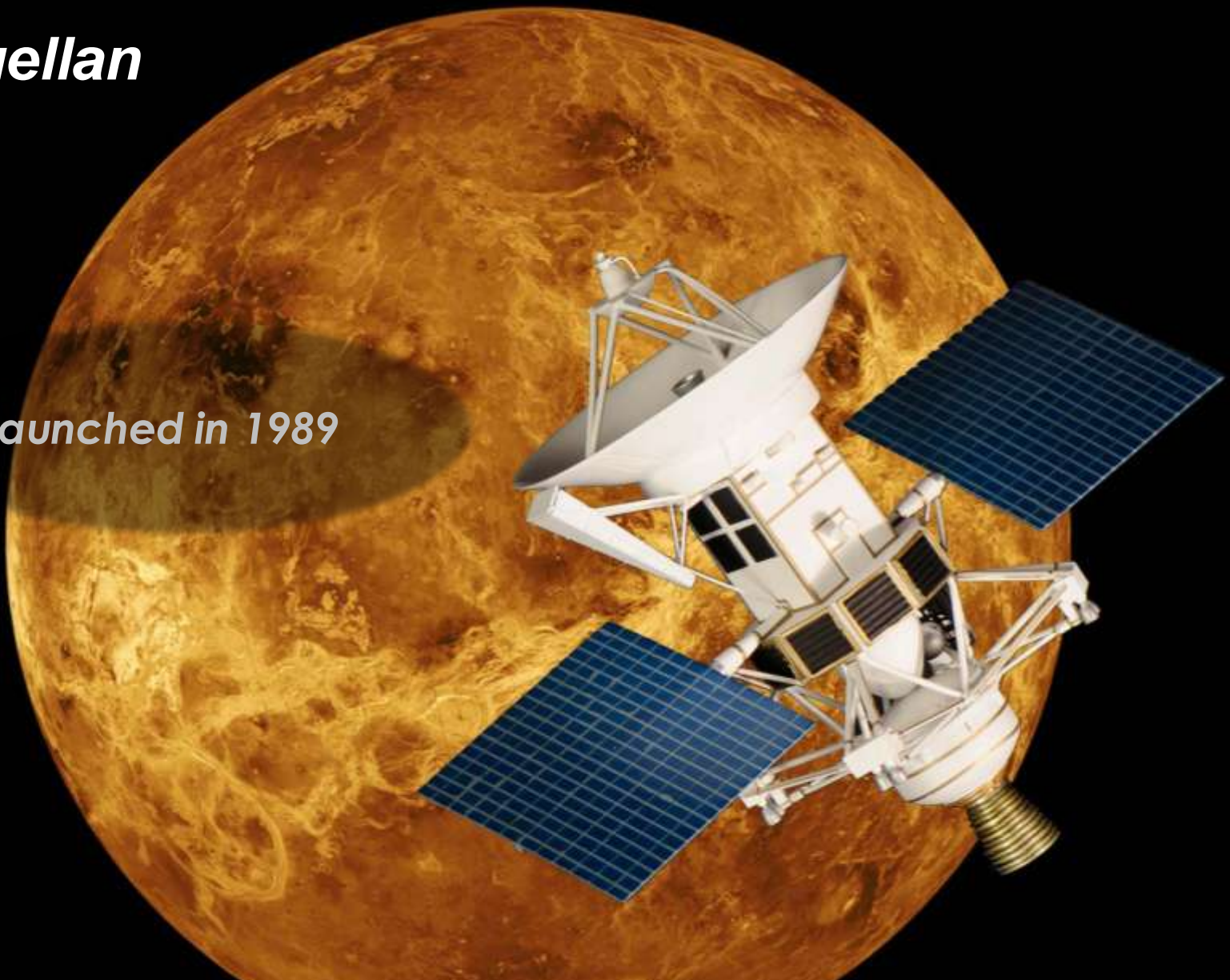


2013 – 2020
Human Systems extended duration tests on ISS

Magellan

Launched in 1989

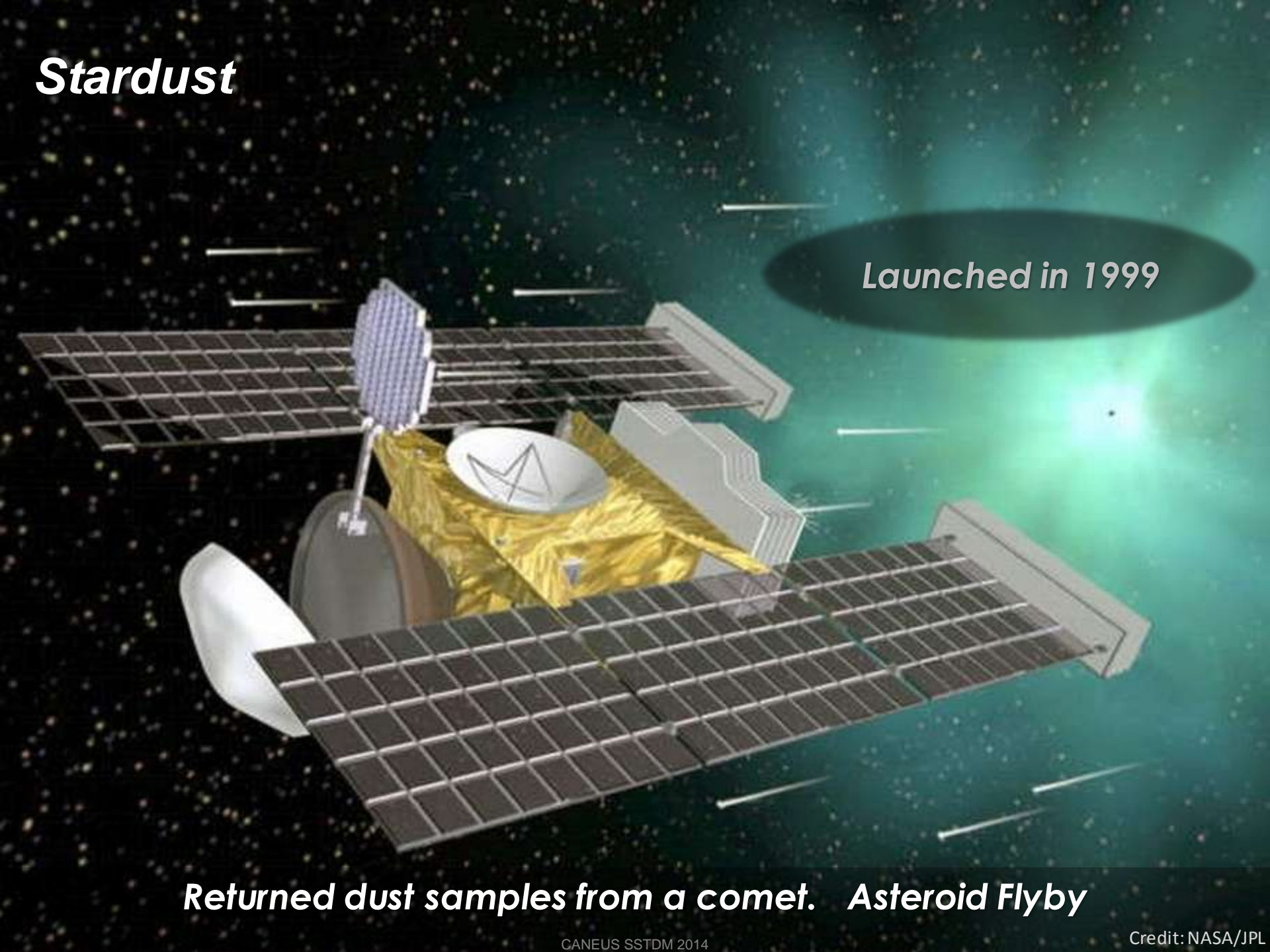
Produced most detailed surface & gravity maps of Venus ever captured. Tested Aerobraking



Stardust

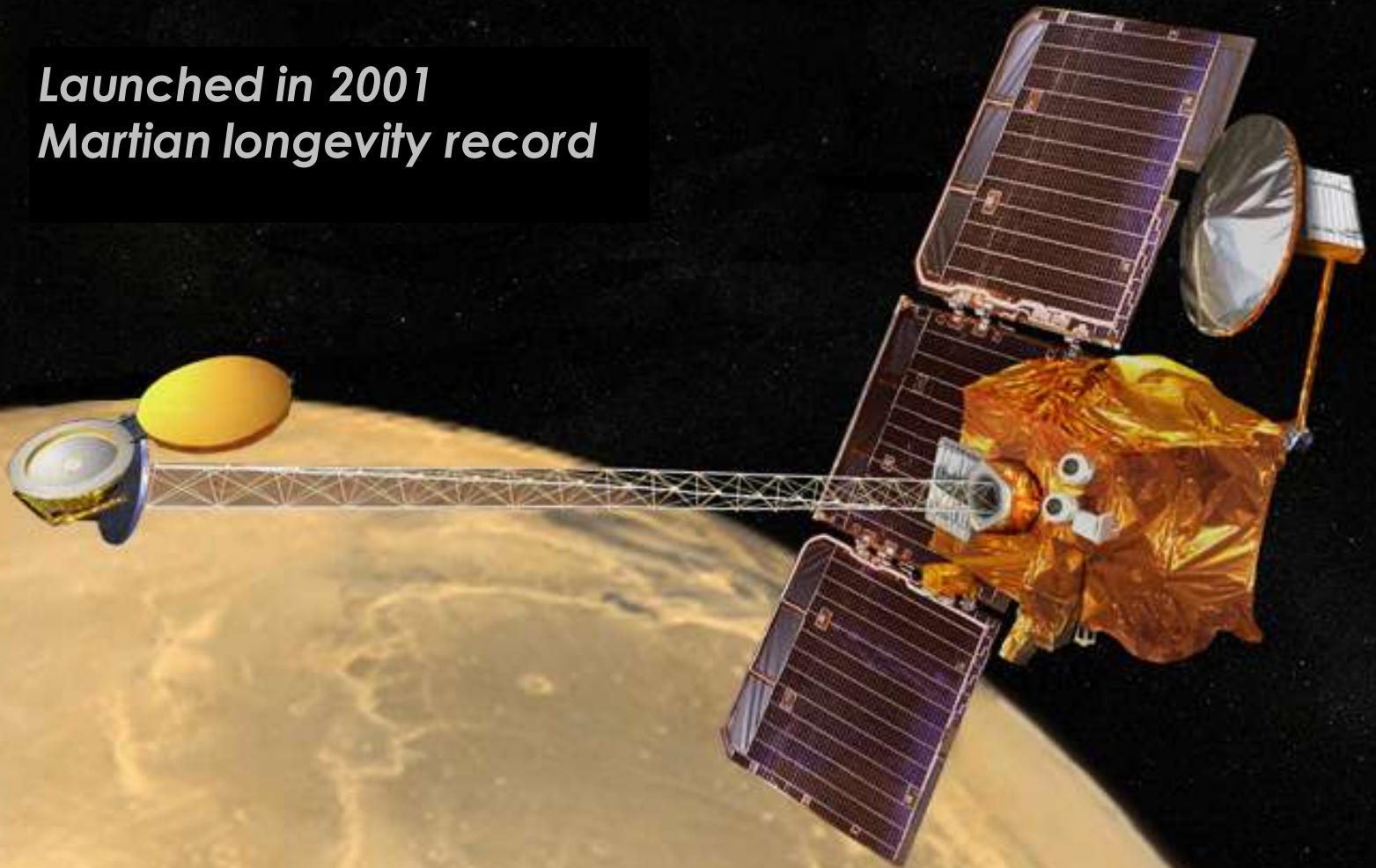
Launched in 1999

Returned dust samples from a comet. Asteroid Flyby



Mars Odyssey

*Launched in 2001
Martian longevity record*



Provided Distribution of elements and radiation map. Landing site characterization. Search for water & Support for Mars rovers

Mars Reconnaissance Orbiter



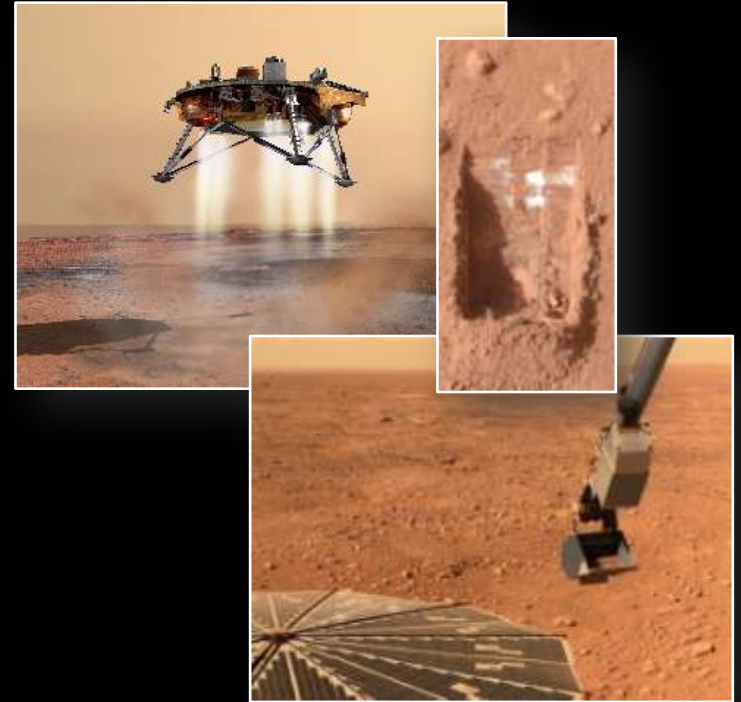
Launched in 2005
Data relay since Jul 2008



Future Landing site examination. High data rate communications relay.
20 – 30 cm resolution

Phoenix

Launched in 2007
"Follow the water"



Confirmed ice in soil & atmospheric snow. Successful robotic arm digging & science operations

Mars Science Laboratory

*Launch in 2011
Successful landing in
Gale Crater*



*Study Mars' climate & geology, and collect data for a human
mission to Mars*

MAVEN

(Mars Atmospheric and Volatile Evolution)

Launch in 2013
Mars orbit insertion Sep 2014

Objective:

Determine:

- **Contribution of solar activity to atmospheric loss**
- **Loss of volatiles to space effect on Mars climate**
- **Current state of atmosphere**

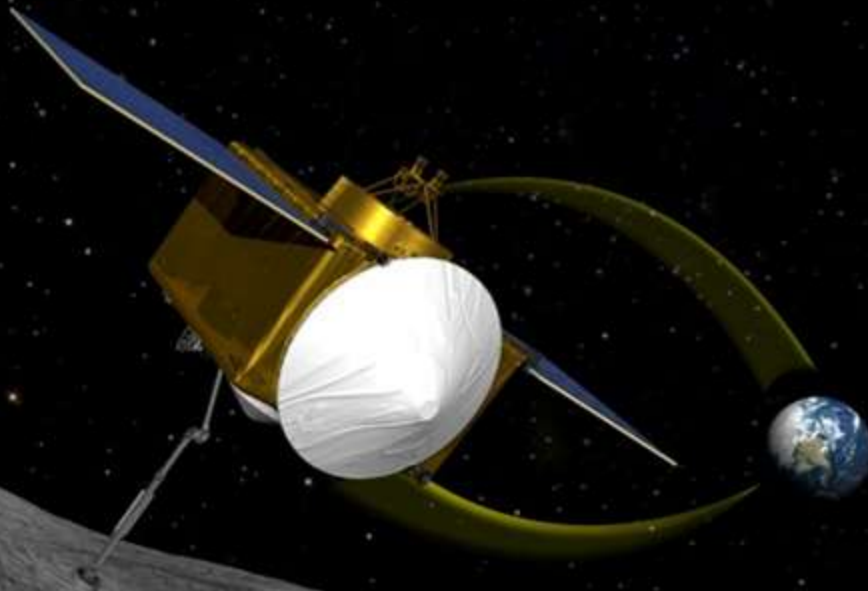
OSIRIS-Rex

(Origins Spectral Interpretation Resource Identification Security Regolith Explorer)



1999 RQ36
Bennu

Objective:
Return 60 grams of
Bennu asteroid
regolith

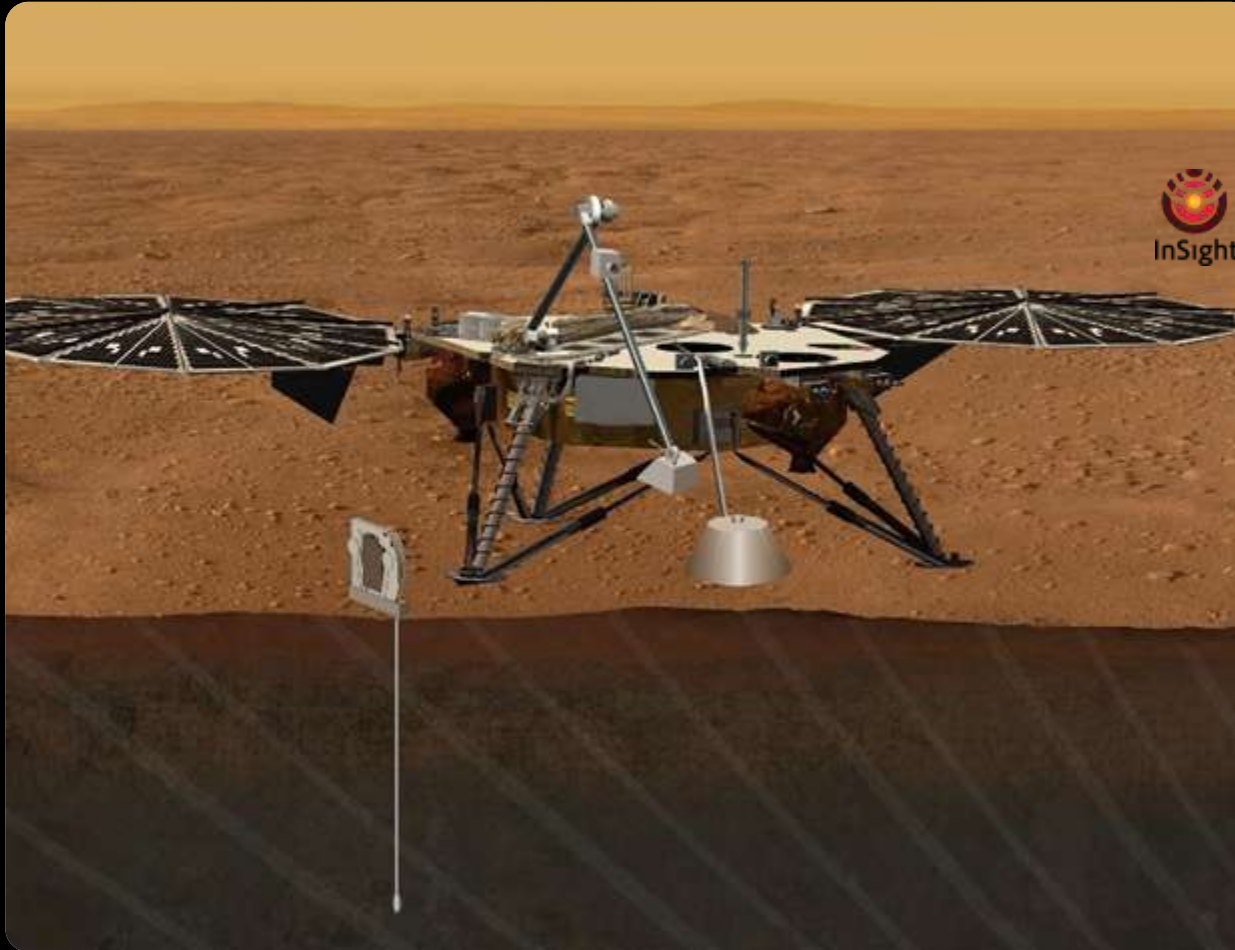


Schedule:

<i>Launch</i>	Sep 2016
<i>Rendezvous</i>	Jan 2020
<i>EDL</i>	Sep 2023

InSight

(Interior Exploration using Seismic Investigations, Geodesy and Heat Transport)



Objective:
Understand the formation and evolution of terrestrial planets through the interior structure and processes of Mars.

Schedule:

<i>Launch</i>	Mar 2016
<i>Rendezvous</i>	Sep 2016
<i>EOM</i>	Sep 2018

Exploration Systems

- Space Launch System (SLS)
- Orion Program
- Ground System Development



Deep Space Exploration Vehicle

A composite image illustrating deep space exploration. In the upper left, a satellite with solar panels orbits in space. The background is a vast field of stars. A large, orange, spherical planet, likely Mars, dominates the center-right. In the foreground, a lunar lander with two large, circular antennas sits on the surface of the moon. An astronaut in a full space suit is walking on the moon's surface in the lower right.

The Orion MPCV will be capable of sustaining a crew of astronauts on deep-space missions –

from 6 days (lunar flyby) to up to 900 days (Mars exploration) when paired with additional propulsion and habitation systems.

Orion

Launch Abort System

- Protection for the CM
- Jettison after first stage flight

Objective:
Take humans safely
beyond LEO ...

... and return them
safely back to Earth



Crew Module

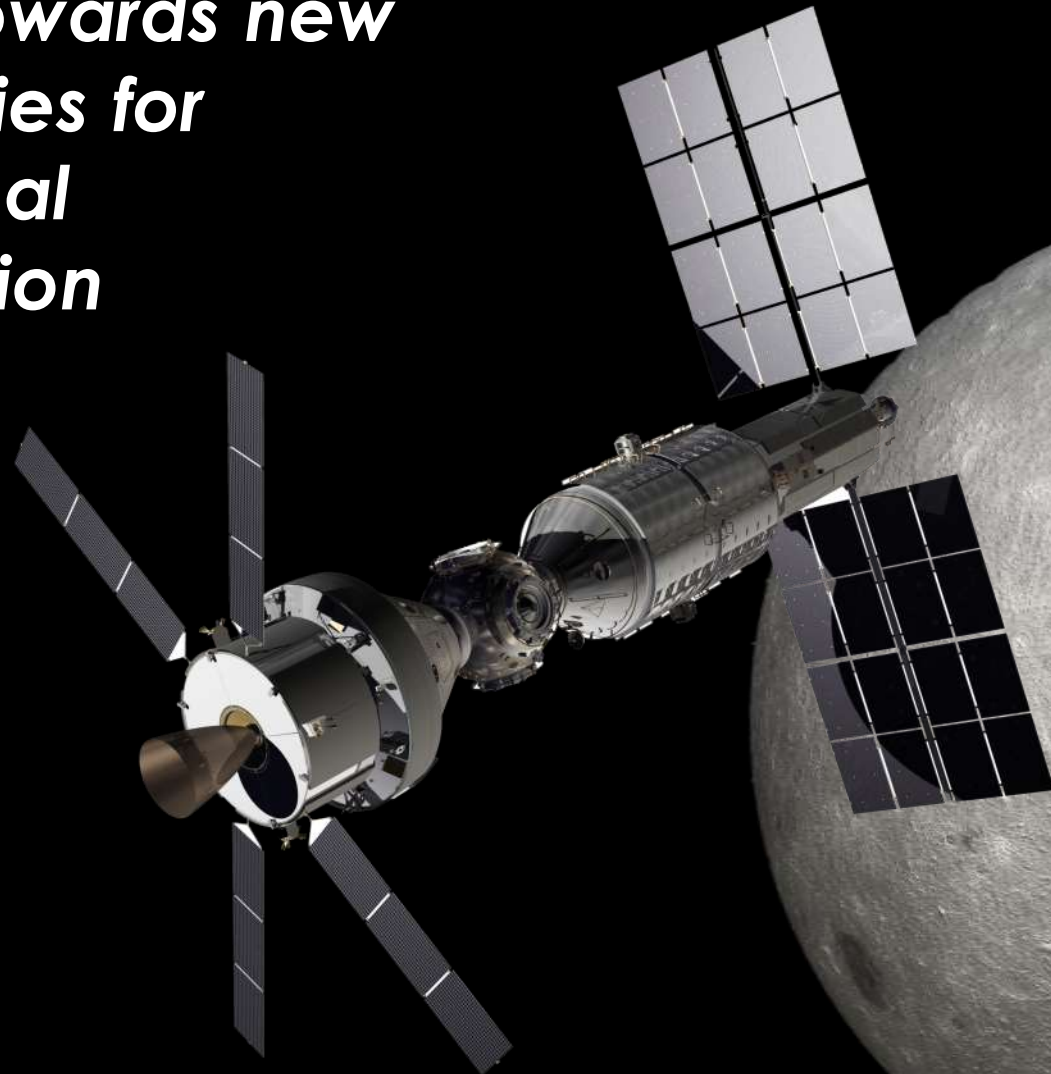
Service Module

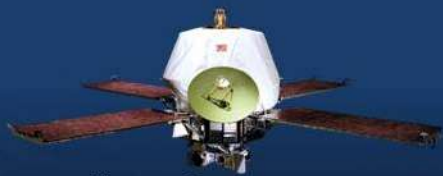
Space Launch System



Objective:
Lift Crew & Cargo for
Human Exploration

Working towards new opportunities for international collaboration



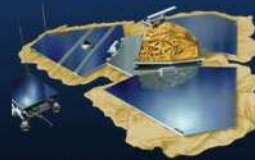


MARINER 9



VIKING I / II

MARS GLOBAL SURVEYOR



MARS PATHFINDER



MARS ODYSSEY



MARS EXPLORATION ROVERS



LUNAR PROSPECTOR



GRIL



JUNO



GENESIS



MAGELLAN



GALILEO



STARDUST

