JPL – Bringing Wonder to the World
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JPL – Across the Universe

~5000 Employees
~4000 technical
~30% BS/BA
~35% MS
~35% PhD
~$1.5B annual budget

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JPL Mission Statement

As part of the NASA team, JPL enables the nation to explore space for the benefit of humankind by developing robotic space missions to:

Explore our own and neighboring planetary systems.

Search for life beyond the Earth’s confines.

Further our understanding of the origins and evolution of the universe and the laws that govern it.

Make critical measurements to understand our home planet and help protect its environment.

Enable a virtual presence throughout the solar system using the Deep Space Network and evolving it to the Interplanetary Network of the future.

Apply JPL’s unique skills to address problems of national significance.

Inspire the next generation of explorers.

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Over twenty spacecraft and ten instruments across the solar system (and beyond).

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A Few Recent Science Highlights

- DSN captures new images of the largest asteroid passing Earth
- Dawn Image shows oblique view of Vesta’s South polar region
- Herschel finds oceans of water in disk of nearby star
- The MLS observed the first ever Arctic ozone hole
- NEOWISE discovered significant numbers of Near Earth Objects
- Cassini Chronicles Life of Saturn’s Giant Storm
- WISE discovers the first-ever Y-class Brown Dwarf
- Research Leads to First Complete Map of Antarctic Ice Flows

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Deep Space Network – Connecting Us to Space
Voyager Mission

- Two spacecraft, launched in 1977 to explore Jupiter and Saturn
  - Five year lifetime requirement
- Now in their 35th year
- Voyager 1 and 2 are now in the "Heliosheath" - the outermost layer of the heliosphere where the solar wind is slowed by the pressure of interstellar gas.
- Voyager Interstellar Mission (VIM): to extend the NASA exploration of the solar system beyond the neighborhood of the outer planets to the outer limits of the Sun's sphere of influence, and possibly beyond.

- Operations challenges:
  - Legacy ground system
  - Dated flight system with few people with intimate knowledge
  - Long round trip light-time (33+ hours for Voyager 1, 27+ hours for Voyager 2)
Rewrote the planetary science and astrophysics books
- observed nine erupting volcanoes on Io: first evidence in the solar system of active volcanism on a body other than Earth
- Discovered moons, rings, magnetic fields, atmospheres, storms etc of Jupiter, Saturn, Uranus and Neptune
- Found first direct evidence of the heliopause
- Provided estimate for the location of the termination shock

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• Explore the Jupiter System
• International Mission
  – Galileo orbiter: NASA's JPL
  – Propulsion System: Germany
  – Probe: Ames Research Center and Hughes Aircraft Company
  – More than 100 scientists worldwide
• Jupiter:
  – Giant Gas planet comprised mostly of Hydrogen and Helium
  – Galileo Galilei discovered original 4 moons (Io, Europa, Ganymede and Callisto)
  – Now over 63 moons known
  – Small ring system
  – Average distance from Sun: 5.2 AU
• Operations challenges
  – Maneuver/encounter rich trajectory in system with 3-body effects
  – Unexpected behaviors in radiation environment
  – Failed Antenna caused mission redesign due to lower data return capability
  – Mission design modified to protect possible ocean on Europa

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Galileo Science Highlights

- Discovered evidence of sub-surface saltwater oceans on Europa, Ganymede and Callisto
- First direct probe measurements of the clouds and atmosphere of Jupiter
- Conducted long term observations of the Jovian system including atmosphere, rings, moons and magnetosphere.
- Revealed the intensity of volcanic eruptions on Io

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Robust successes on Mars

- Mars Exploration Rover Opportunity
- Mars Reconnaissance Orbiter and Odyssey continue to reveal Mars secrets while preparing to support Mars Science Laboratory operations
Phoenix makes it official: There is water on Mars
(Clean your glasses if you think Phoenix saw a Mars polar bear)
Dawn uses Ion Engines to orbit Vesta

Crater wall with sinuous features

Artist rendition of Dawn spacecraft gathering spectral data from Vesta

Image Credit: NASA/ JPL-Caltech/ UCLA/ MPS/ DLR/ IDA

Credit: McREL

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Cassini-Huygens Studies the Saturnian System
Cassini RADAR passes show Ethane/Methane lakes with strong resemblance to Lake Powell above
Titan: A mystery unveiled but not solved

Cassini Radar Image
500 meter resolution
Broad fluvial channels

Huygens Descent Image
50 meter resolution
Small-scale sapping

Huygens Landed Image
5 cm resolution
Fluvial outflow

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Challenges for Deep Space Missions

- Budget constraints require more and more cost efficiencies
  - Smaller teams
  - Streamlined processes and multi-mission systems
- Maintaining the operational rigor and flight team expertise throughout the operational mission.
  - Lessons Learned from operational and command file errors being incorporated back into the current and planned mission set.
Earth Orbiting Missions

- Operations Challenges
  - International cooperation
  - Downlinking and processing large data volumes
  - Fast data access for immediate use

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Why Do I Do This?

- Science knowledge

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Why Do I Do This?

- Science knowledge
- Engineering challenge
Why Do I Do This?

• Science knowledge
• Engineering challenge
• People

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Challenges Ahead

• **Cyber Defense**
  – On-board embedded systems
  – Ground systems
  – Use of web-based distributed systems

• **Reaching distant stars**
  – Increased autonomy
  – Data return

• **Understanding our own Earth**
  – Coordinated measurements by multiple agencies and multiple nations
  – Collecting, distributing and analyzing immense data volumes