Jet Propulsion Laboratory
California Institute of Technology

What is at Stake in Space Exploration?

Had Queen Isabella Launched Robotic Ships: NASA Adventures in KM

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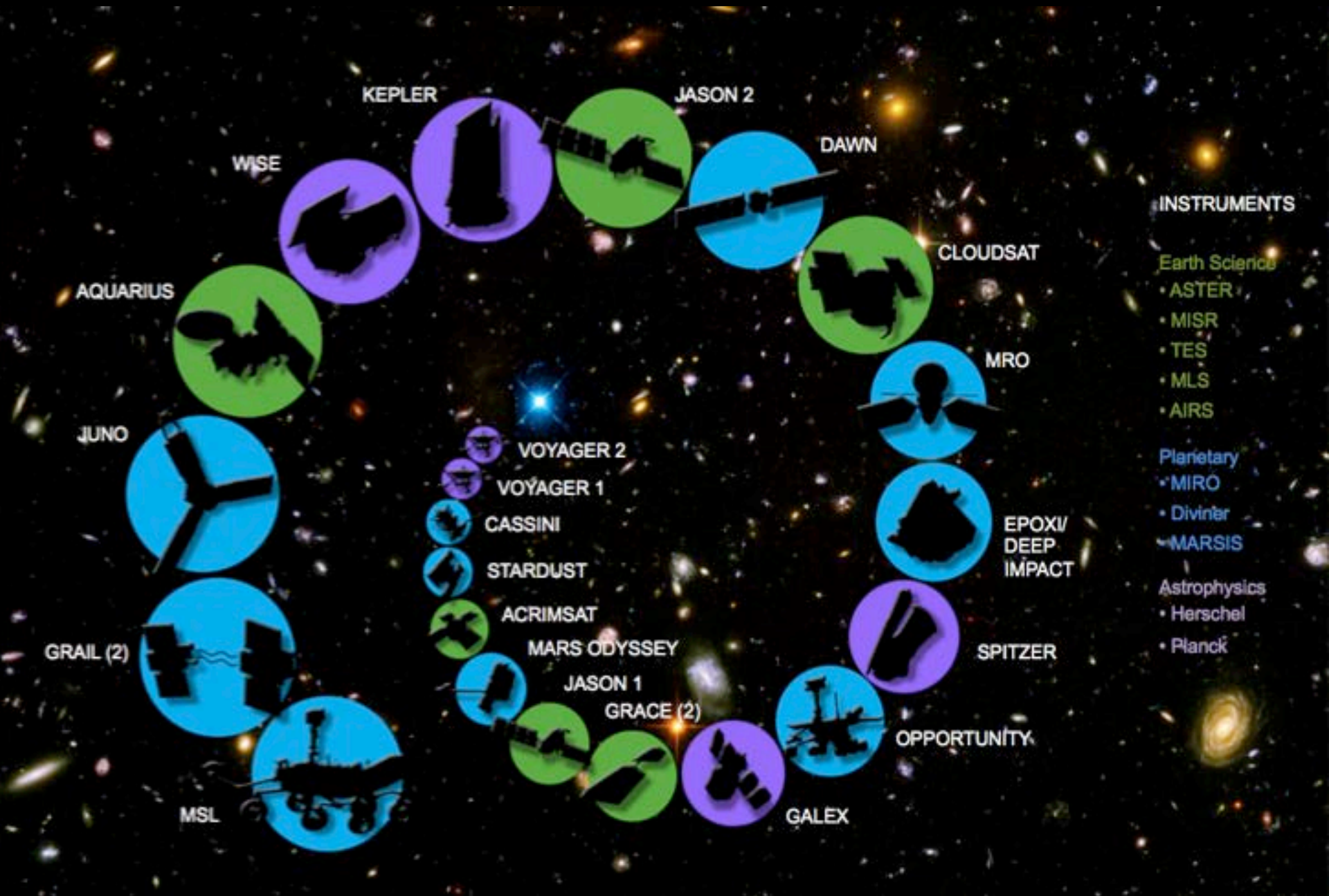
NASA/Caltech Jet Propulsion Laboratory

- World's preeminent center for the robotic exploration of deep space
- Some JPL "firsts":
  - In 1958, Explorer 1 was the first satellite launched by the United States
  - In 1965, we did the first flyby of Mars, the following year the first U.S. soft landing on the Moon
  - Voyager 1 and Voyager 2 accomplished the Grand Tour of the Solar System (1989). Last August, we determined that two years earlier, Voyager 1 left the heliosphere– left the solar system-- and is now operating in interstellar space
  - Galileo reached Jupiter (1995); Cassini to Saturn (2004)
  - Mars Pathfinder became the first planetary rover in 1997, and we now have two vehicles operating on Mars
  - In 2005, Deep Impact slammed a copper penetrator into a comet to determine its composition

47 JPL Missions Now in Development or Operation



What are the stakes in space exploration?

- We turn to space for answers about the possibility of extraterrestrial life, origins of the universe, and even for clues on how we can better protect our own planet
- Science return: learning about our neighborhood, and
- Maybe it is worthwhile doing something just <u>because</u> it's difficult

The Great Pyramids of Giza

Four Business Cases

- Examples of potentially high stakes involved in space exploration

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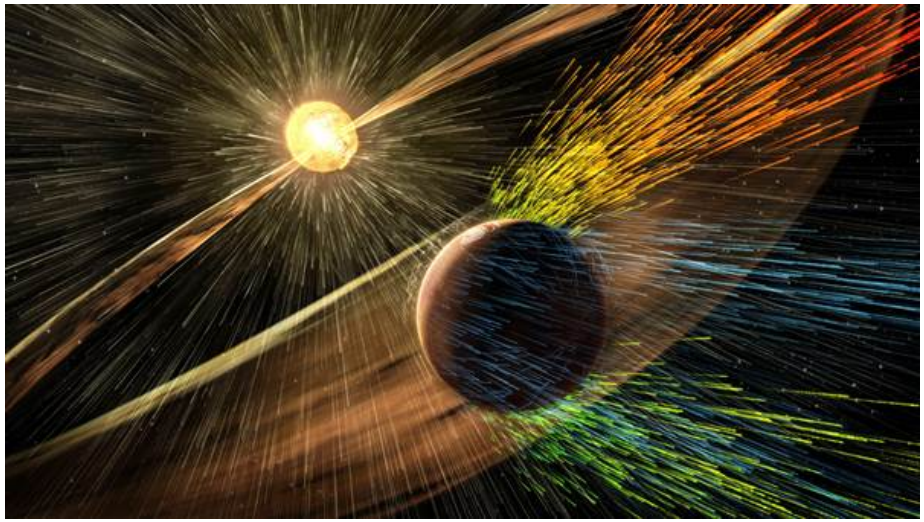
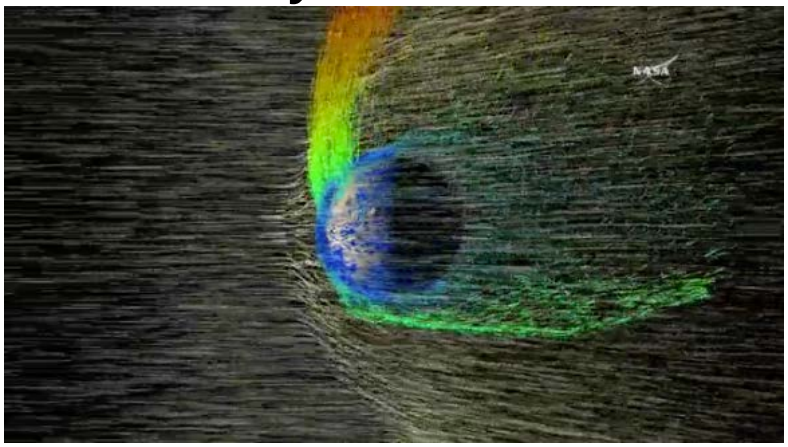
High Stakes
Business Case #1:

Goodbye Earth's Atmosphere

- Mars Atmosphere and Volatile Evolution (MAVEN)
- Objective: Explain the loss of volatile compounds from the Martian atmosphere to space.
- Result: data from a March 2015 solar mass ejection show loss of Mars' atmosphere continuing even today

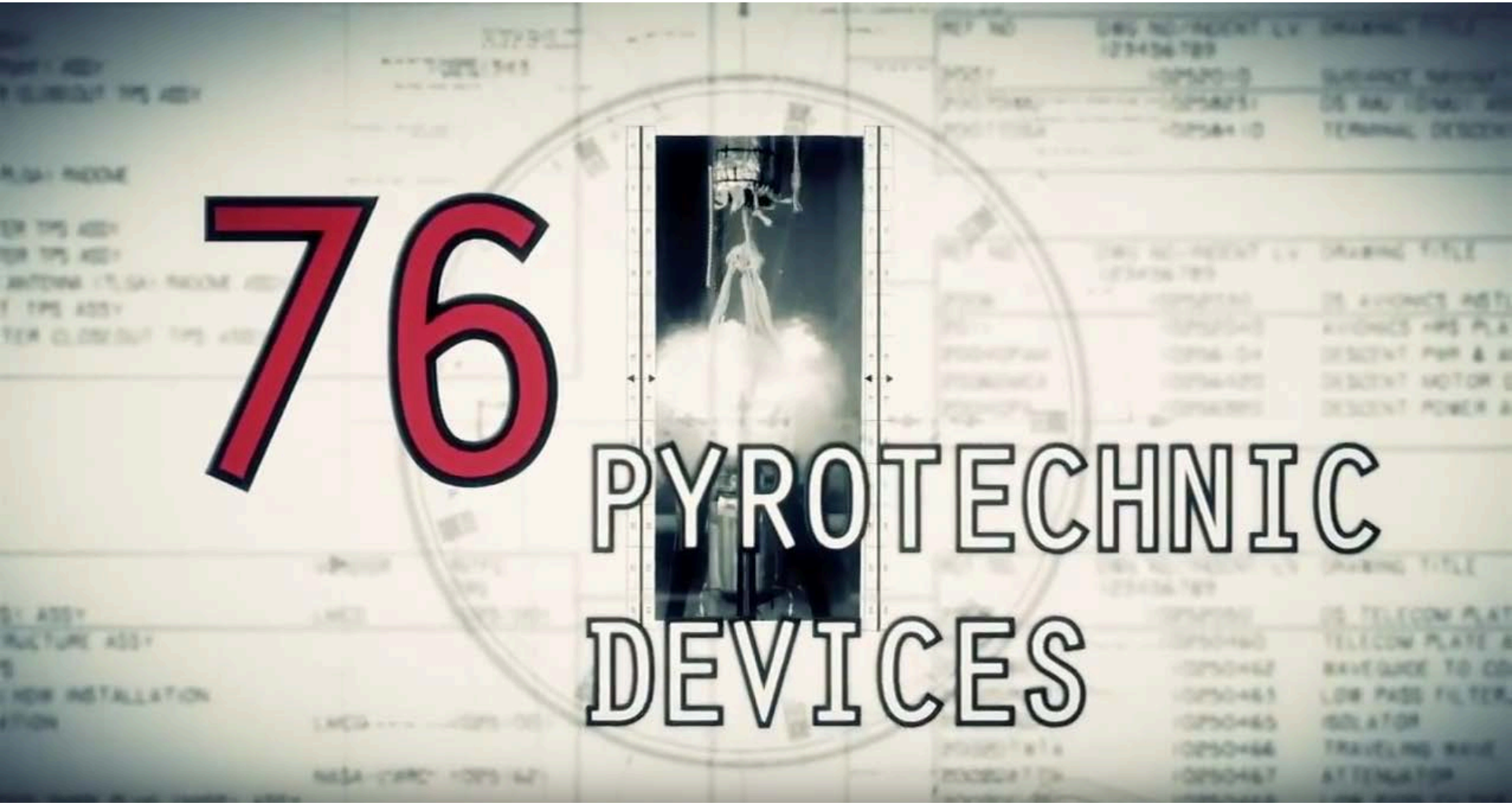




Mars Science Laboratory (MSL) “Curiosity” Rover

- Has operated on Mars for 4 years
- The size and mass of a Mini Cooper
- Nuclear-powered
- Learning more about Mars’ past and Earth’s possible future

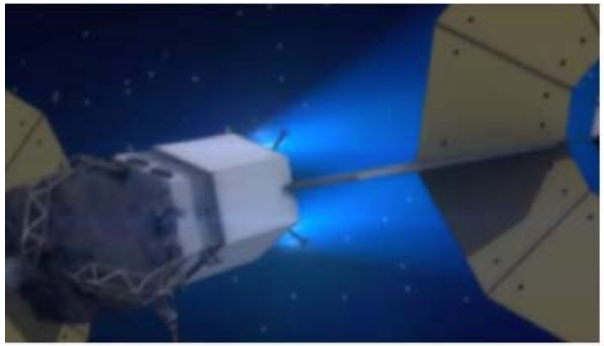
The “7 Minutes of Terror”

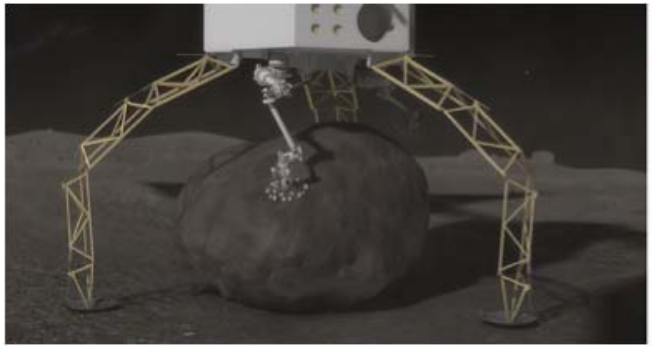


High Stakes
Business Case #2:

Planetary Defense

- **JPL proposed Asteroid Redirect Robotic Mission (ARRM).** JPL plans to rendezvous with an asteroid, grab it or a piece of one, and tow it into near-Earth orbit



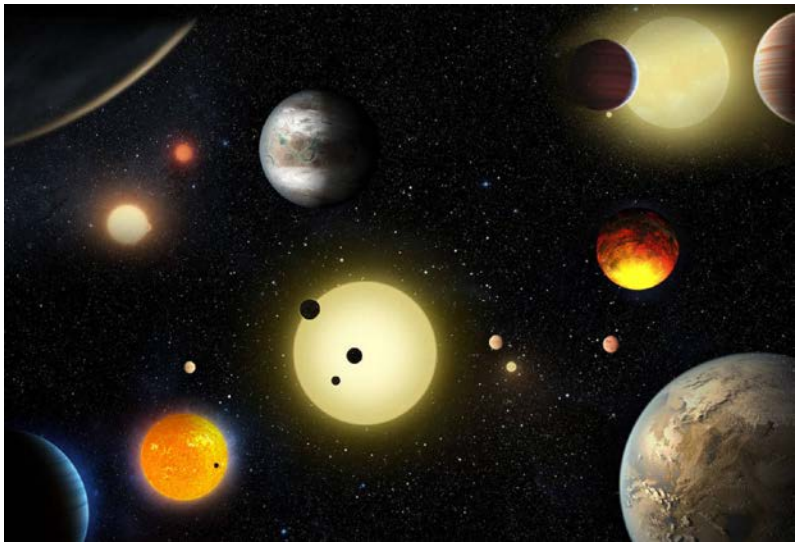


- ARRM would include a “gravity tractor” demo– a possible technique for diverting a hazardous Earth-bound asteroid

High Stakes
Business Case #3:

Other Earths

- **JPL Kepler Mission.** The spacefaring observatory has discovered 21 planets like Earth (i.e., Earth size and located in the “habitable zone”) orbiting distant stars



- Are we alone?

High Stakes
Business Case #4:

Return on Investment

How We Made the Case for KM at JPL

1. Today, corporate investment in intellectual capital may exceed that in physical capital (equipment and facilities)
2. Restoring knowledge that we fail to retain is costly
   - Also risky, because the heritage knowledge had already been proven in ground test and spaceflight
3. Uniquely, JPL can't obtain lost knowledge from elsewhere
   - Who else designs Mars landings, autonomous spacecraft?
4. Critical expertise may be lost due to employee turnover
   - NASA engineers over age 50 outnumber <35 by four to one
5. Value of a "quick win" likely exceeds cost of KM program
6. Because NASA told us to…

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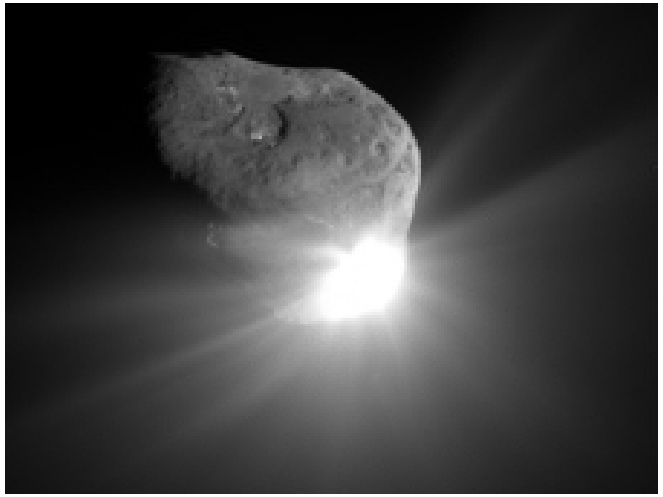
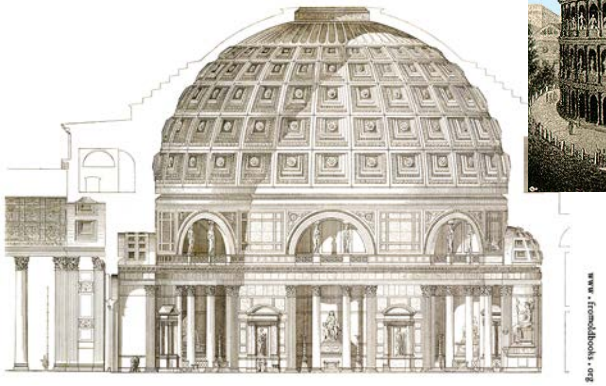
The Focus is on Critical Knowledge

- **JPL systems**: high unit value, often one-of-a-kind, that must operate with precision in an extremely hostile environment
  - **Deep Impact** (2005): An optically navigated flying copper “bullet” ran head-on into a comet while being tracked by the mother ship, all autonomously



Knowledge Management

- Corporate knowledge is often treated as if it has little value
- Key corporate knowledge may be lost unless leadership supports active measures to capture and retain it

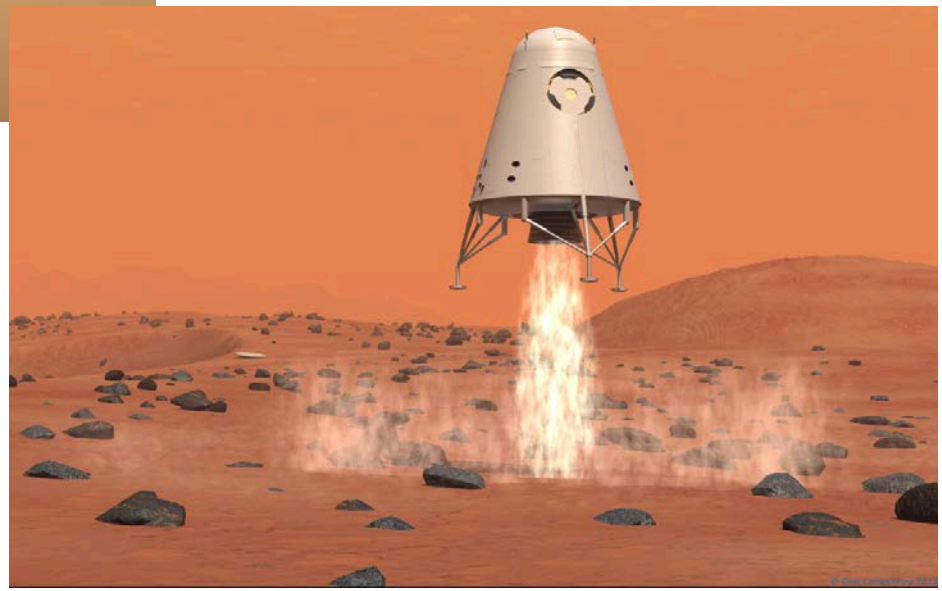


The ancient Romans used pozzolan concrete to build large structures --until the technology was lost for 1000 years

Lost Knowledge: Throttleable Thrusters

Mars Science Laboratory: launched in 2011

Hovering "sky crane" ↑ required the recovery of "lost" knowledge that had been used 36 years earlier on →

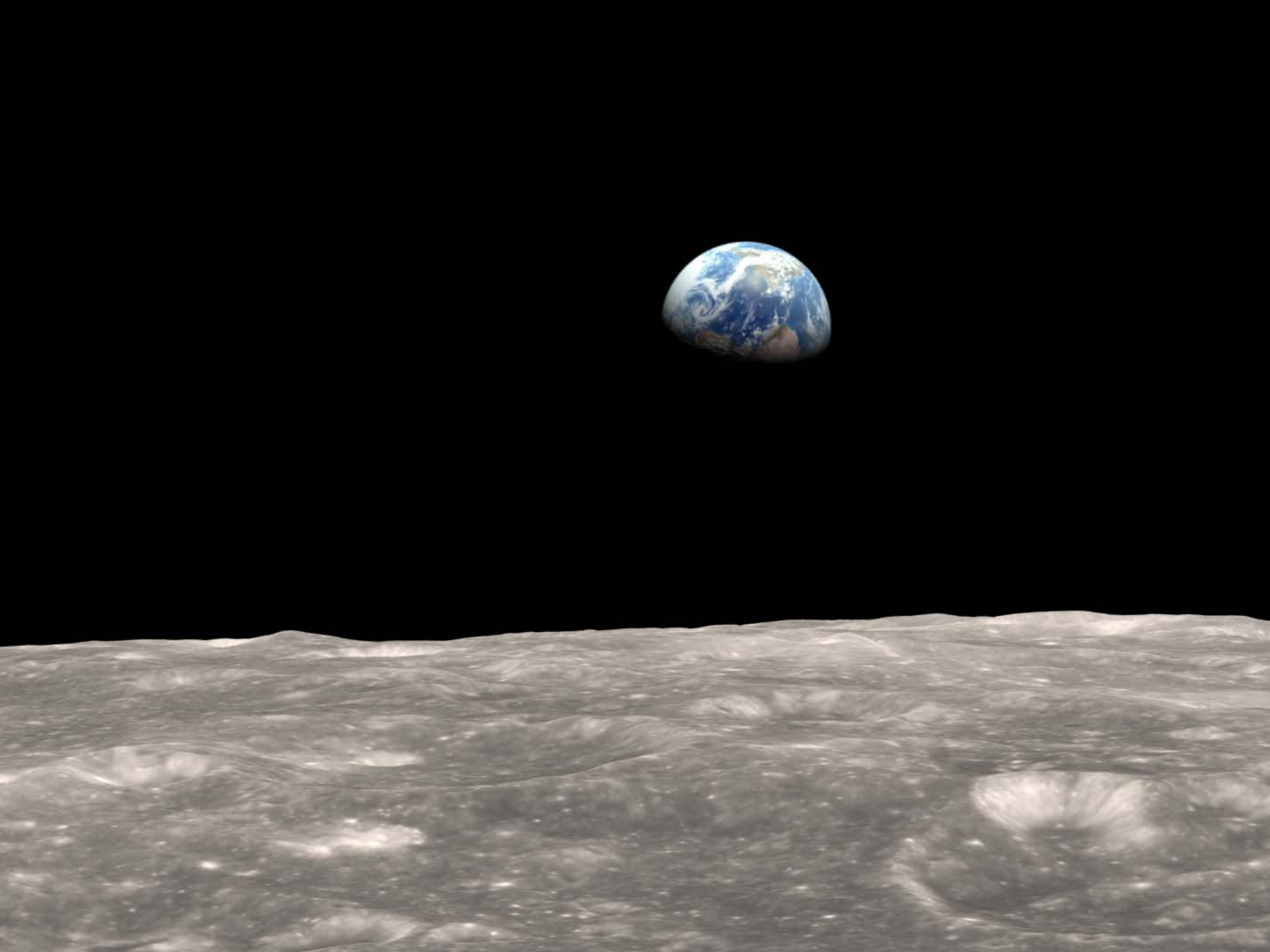


Mars Viking: launched in 1975

Effective Knowledge Management Practices

- Obtain your leadership's commitment to knowledge husbandry
- Prepare a knowledge management strategic plan
  - Identify (1) what knowledge is critical, (2) gaps in capturing/retaining/sharing it, and (3) activities needed to address the gaps
- Adopt industry-wide knowledge management "best practices"
  - Institute a formal **lessons learned** process
  - Encourage your subject matter experts to **mentor** junior staff
  - Investigate tools (e.g., case studies, video capture, Pause & Learn)
  - Collect metrics to show continuous improvement
- Serve as a knowledge champion by advocating knowledge husbandry and reuse within your organization
- And lastly…

Make good use of what your company knows



Dare Mighty Things

"Far better is it to **dare mighty things**, to win glorious triumphs, even though checked by failure...than to rank with those poor spirits who neither enjoy much nor suffer much, because they live in a gray twilight that knows not victory nor defeat."

- Theodore Roosevelt, 26th President of the United States

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