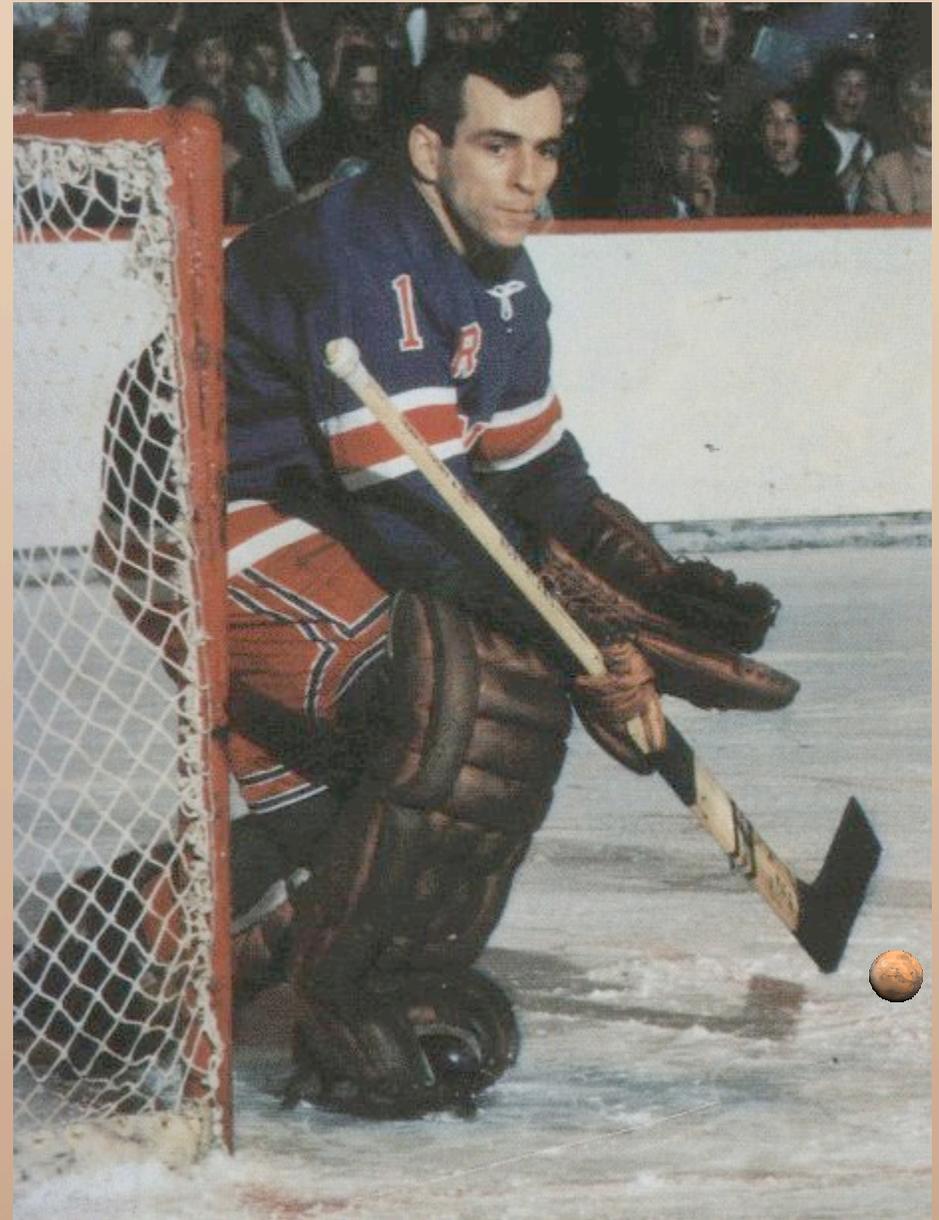


**Left to Explore on Mars:
*In the name of SCIENCE***

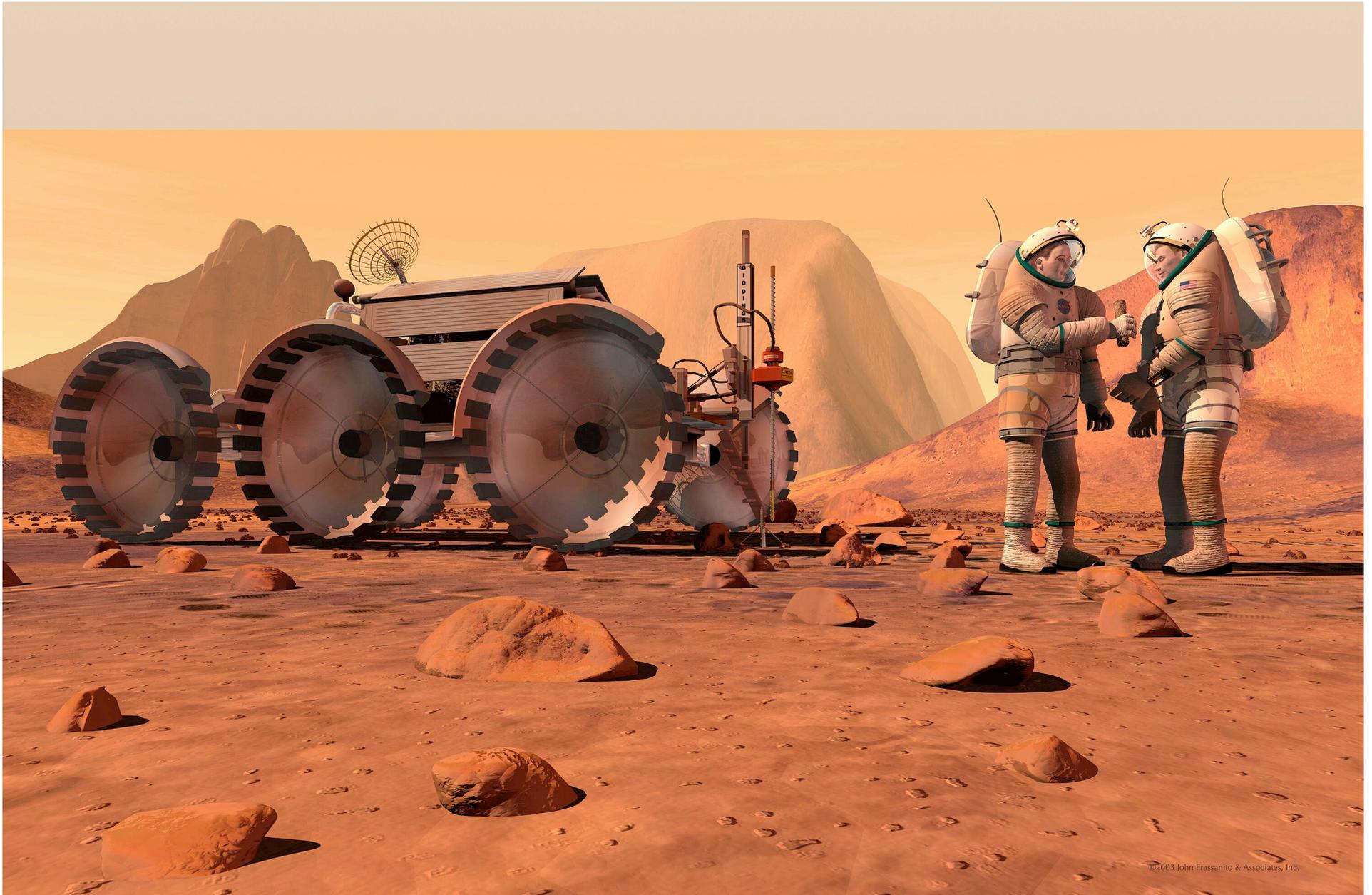
Dr. Jim Garvin (NASA)





**Learning to Explore...and the RISKS!
*Training for the heartbreaks of Mars?***

**LIVING AND LEARNING THE THE RISKS...
*And later mitigating them***



**Humans “on site” *in the name of Science...*
A question of Risk, Timing, and Pace?**

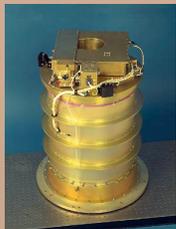


Learning to explore... "Mars on Earth" as a graduate student: Mauna Kea 1980

A human spaceflight “experience”: SLA on *Endeavour*!

**Learning the risks of
Scientific Exploration:**

**Investigating
the previously
unmeasured
from
SPACE
to
get to Mars**



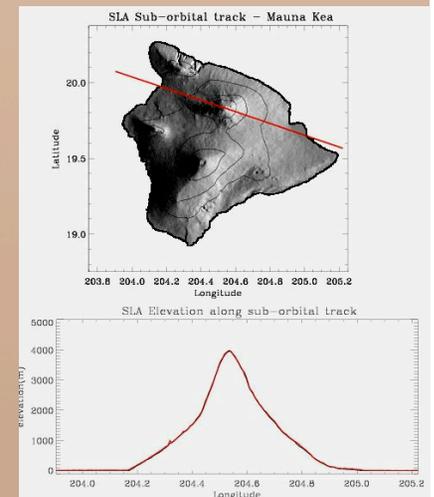
SLA-01



STS-72 *Endeavour*, carrying SLA-01 in January 1996



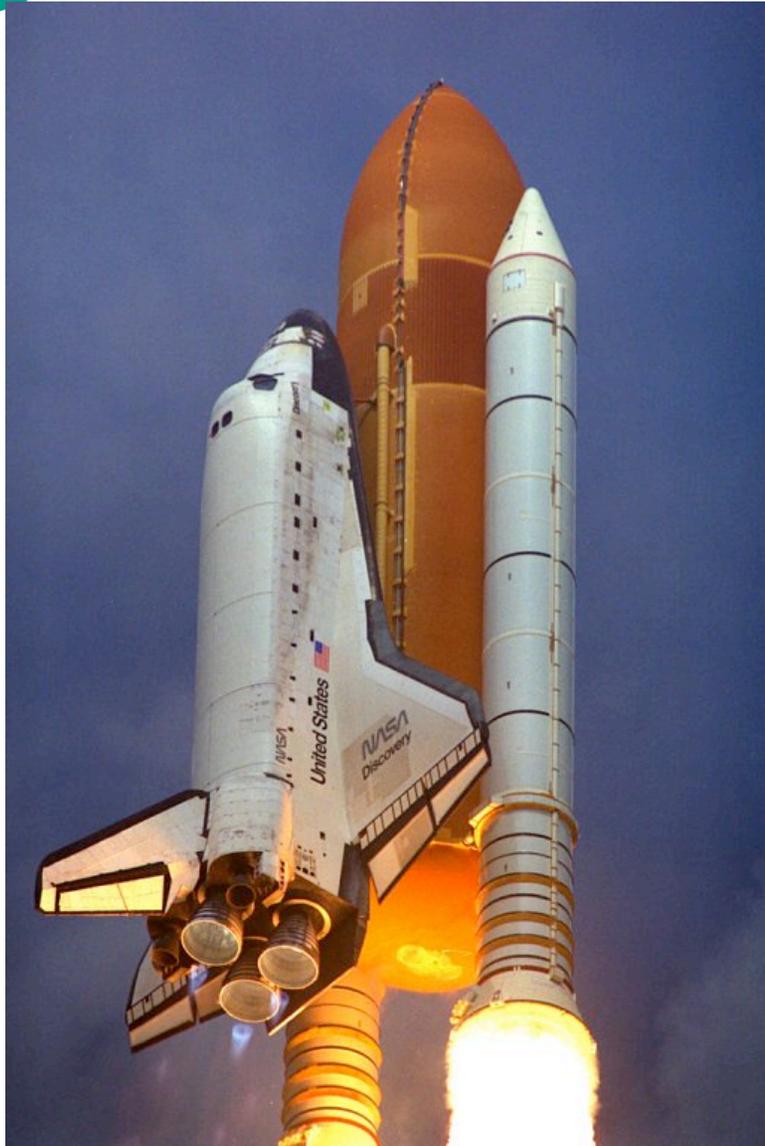
1st light!



1st data: Mauna Kea



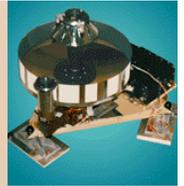
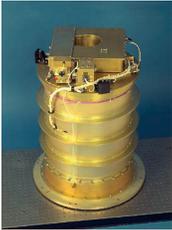
HUMAN SPACEFLIGHT AS AN ENABLER: SLA on STS-72 and 85



STS-85 Discovery (SLA-02)



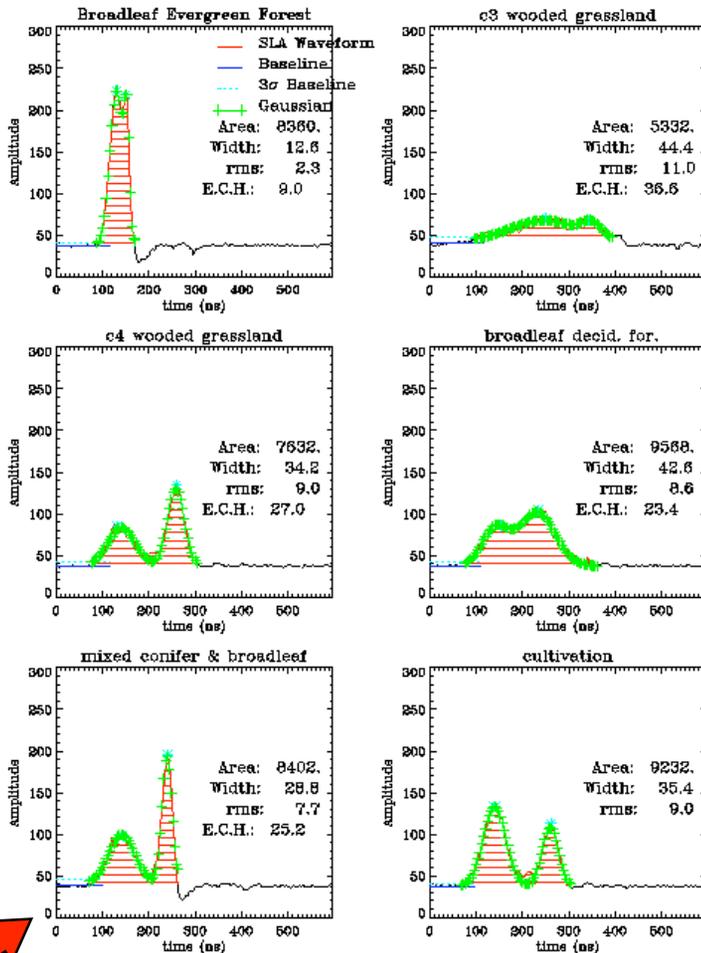
Our SLA Team



Shuttle Laser Altimeter

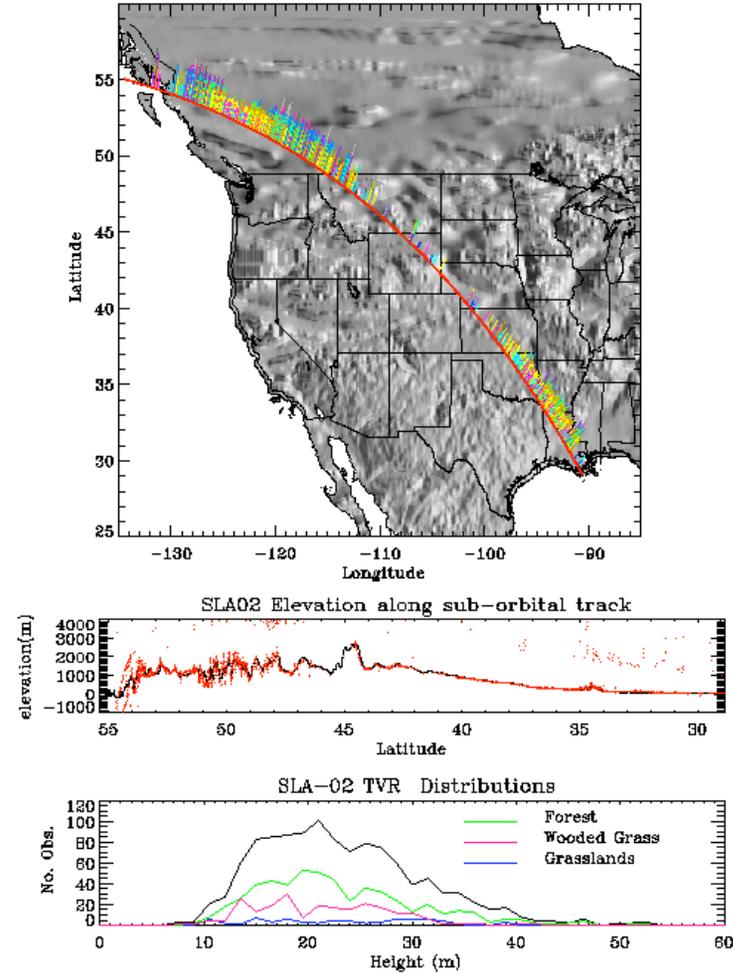
From Exploration RISK came DISCOVERY!

SLA-02 Waveforms



TREE HEIGHTS FROM SPACE!
(25m tall trees observed)

SLA-02 Sub-orbital track - W. US TVR



SLA-02 - W. U.S. - Total Vertical Roughness

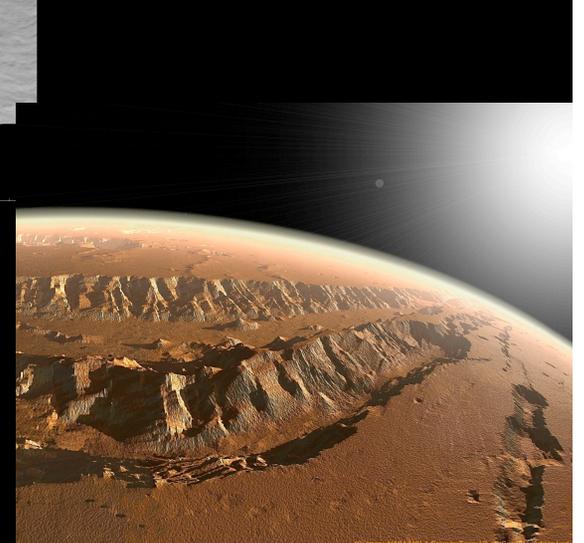
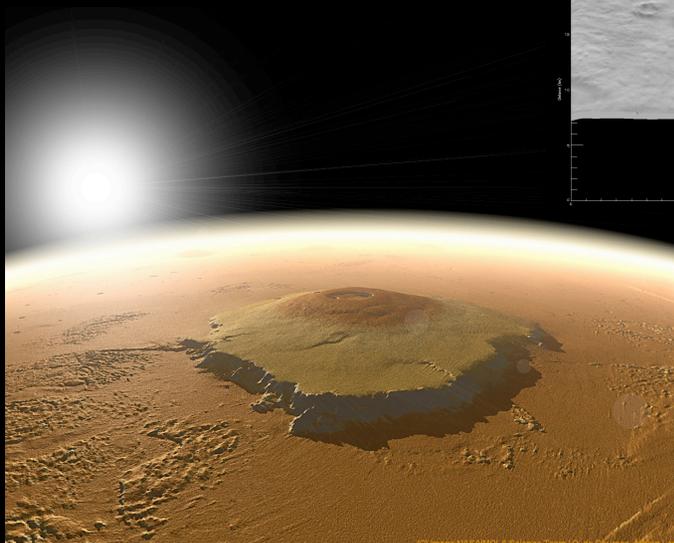
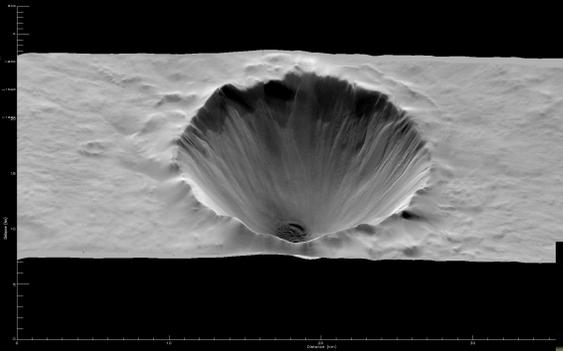
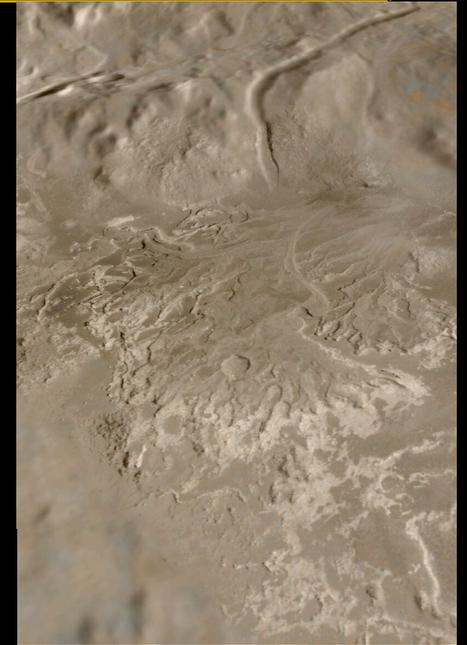
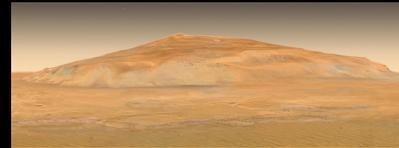
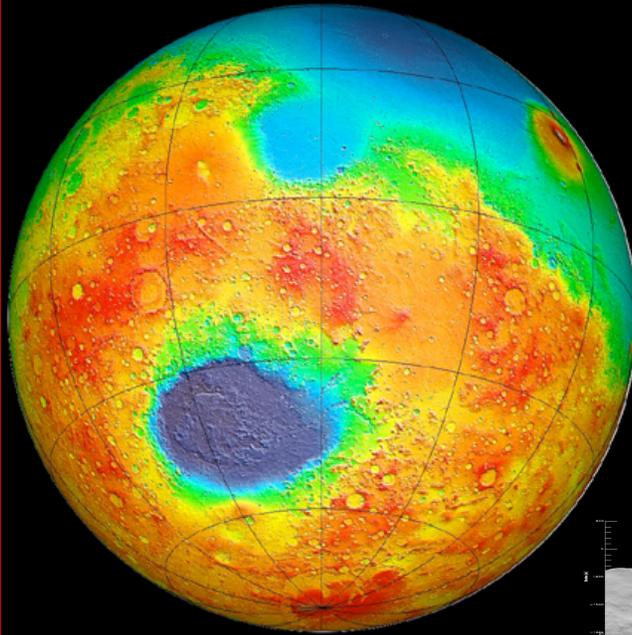
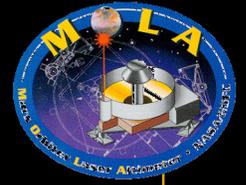
Garvin

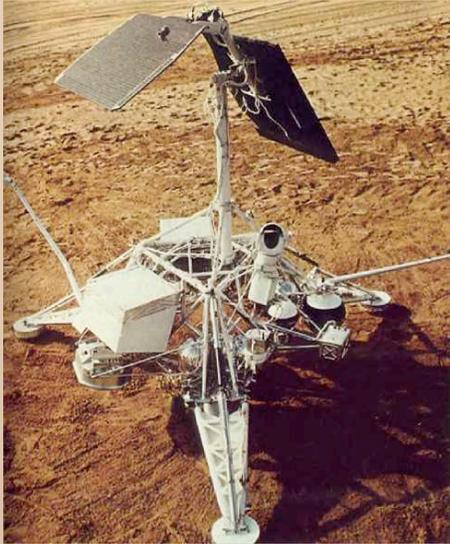
Applying the SLA Lesson to Mars (and MGS/MOLA)



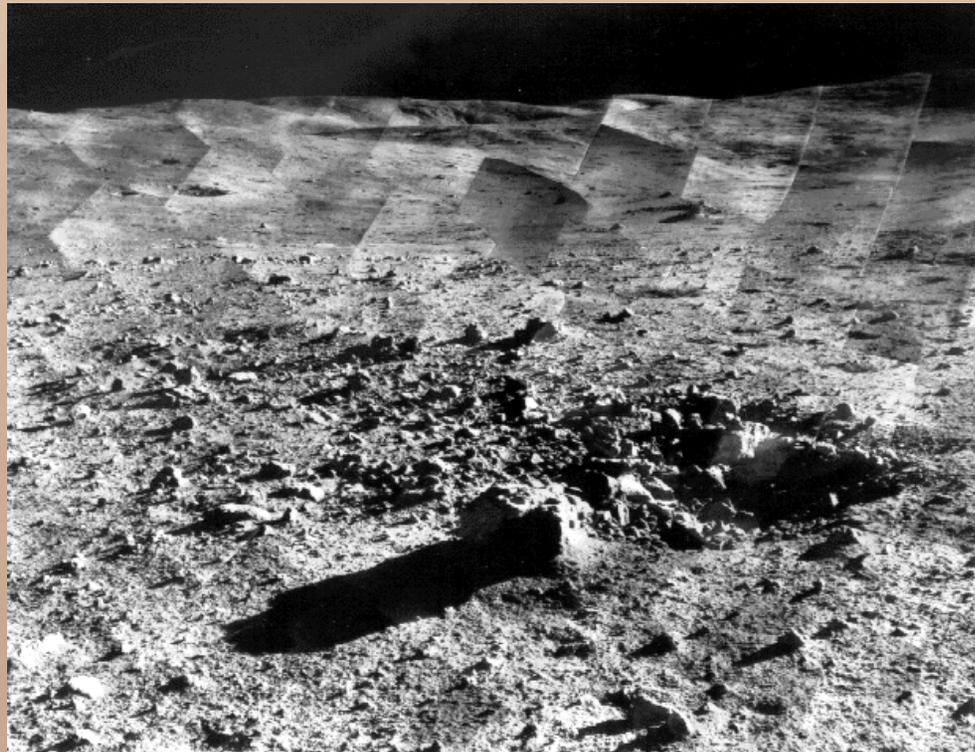
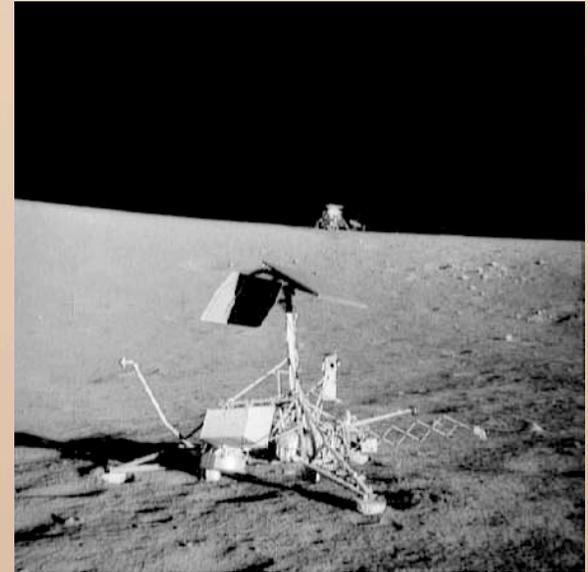


Mars in 3D: The Risk of Trying Something New: MOLA





Our First Vicarious Steps...to the Moon!

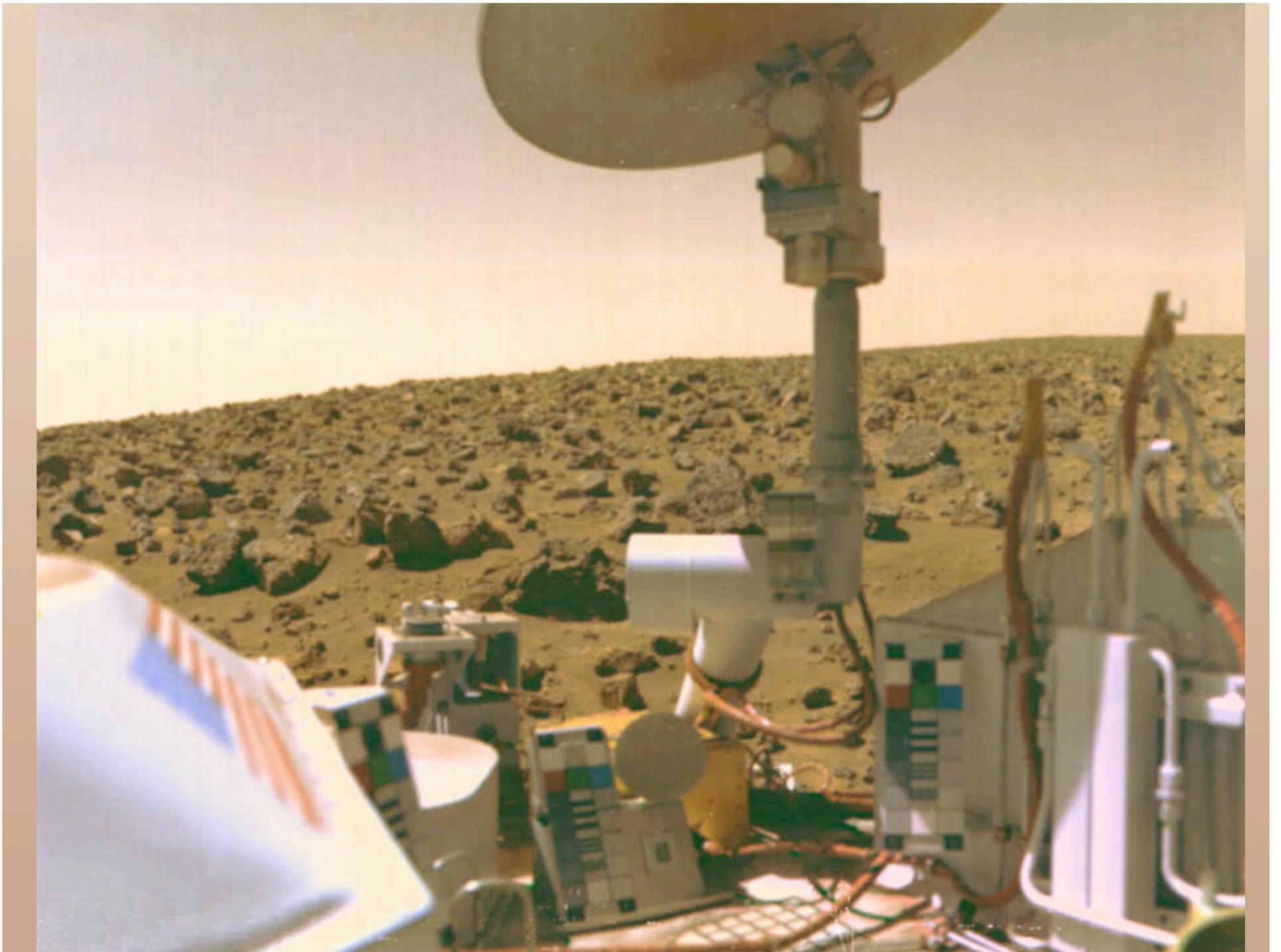


**ROBOTS as
forerunners...**

Our 1st Steps

First “footprints” on Mars... The RISKS OF THE UNKNOWN...





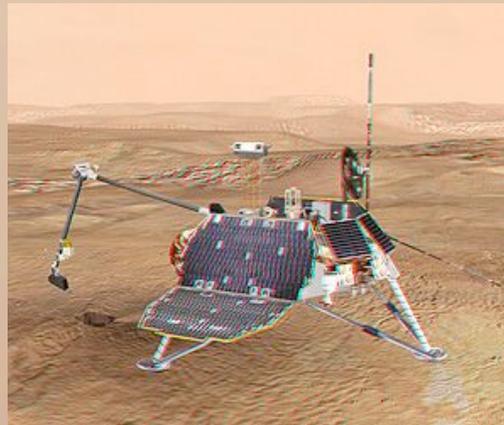


Mars 96 Clamshell lander: Lost in LEO in Nov. 1996



Mars Observer: Lost during MOI in Sept. 1993

LEARNING FROM FAILURES... To get it RIGHT



Mars Polar Lander: Lost upon landing Dec. 1999

**Mars
Global Surveyor:**
26000 orbits!



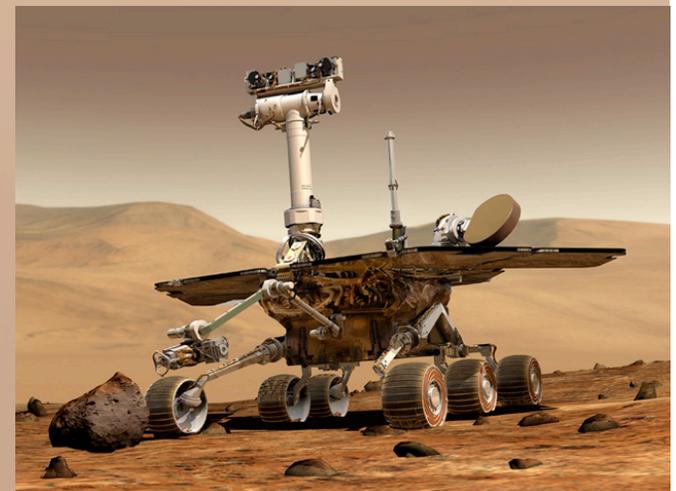
SUCCESS: MER Rovers on Mars Exploring!



Beagle 2: lost during EDL, Christmas 2003



Phoenix: to land in 2008
(recovering lost science)



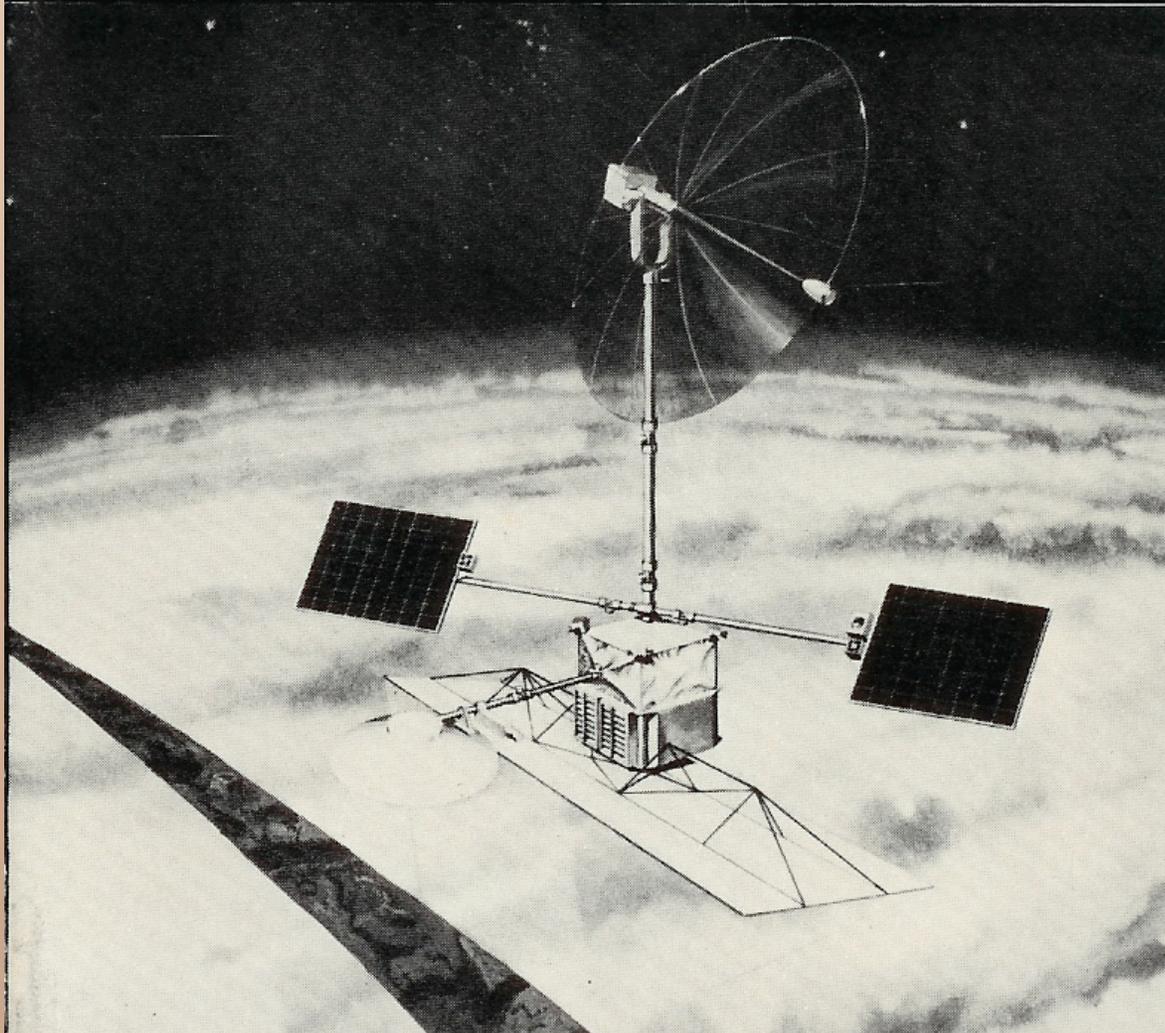


The RISKS of BUILDING new things to measure “new” things...MRO 2005

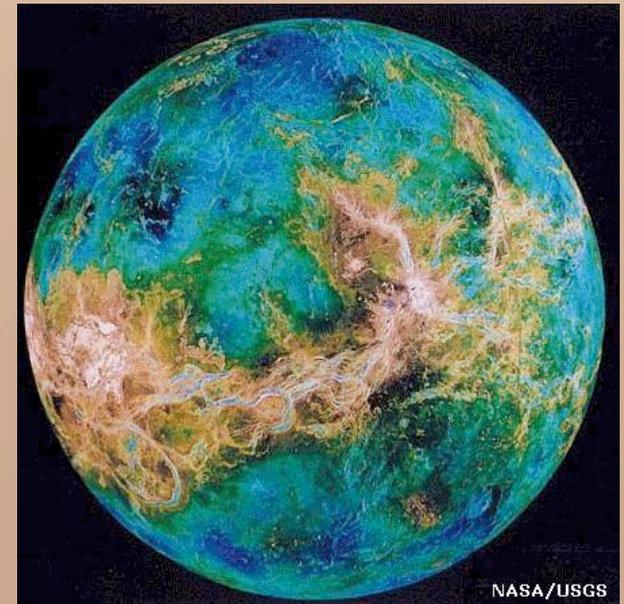
Evolution in Exploration:
From "Vision" in '79
To Reality in the '90's

VOIR

VENUS ORBITING
IMAGING RADAR



Magellan: Mapped Venus!

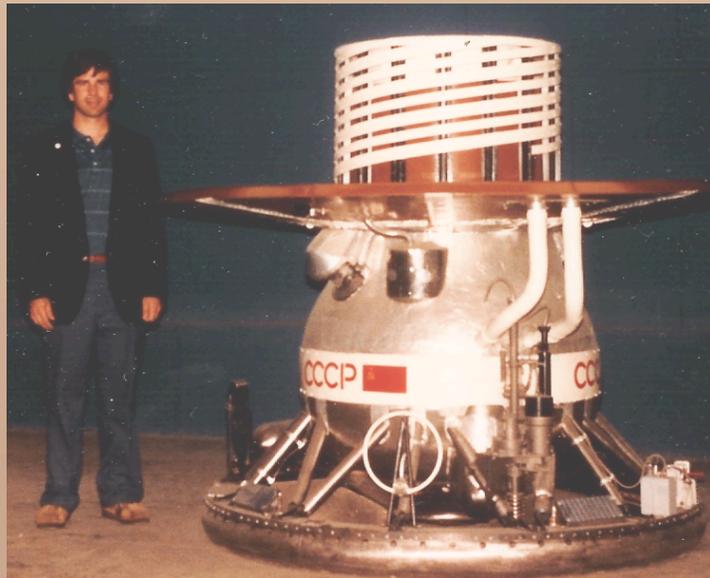


NASA/USGS

UNIQUE ENVIRONMENTS
REQUIRE UNIQUE EXPLORATION SOLUTIONS



The Surface of VENUS... Risky but worth it ...



Soviet Venera 13 (1982)

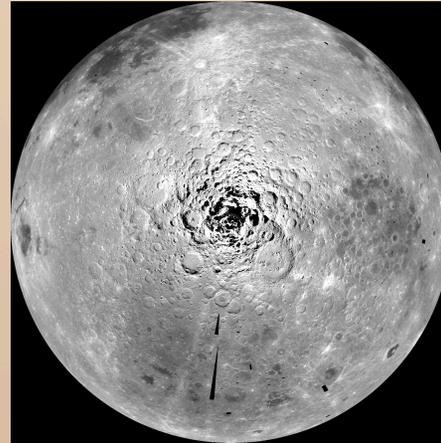


Russian Panoramas of the surface of Venus
obtained by the Venera spacecraft.

Science Risk in Exploration: **Lessons for Mars**



Earth from Space



Lunar South Pole



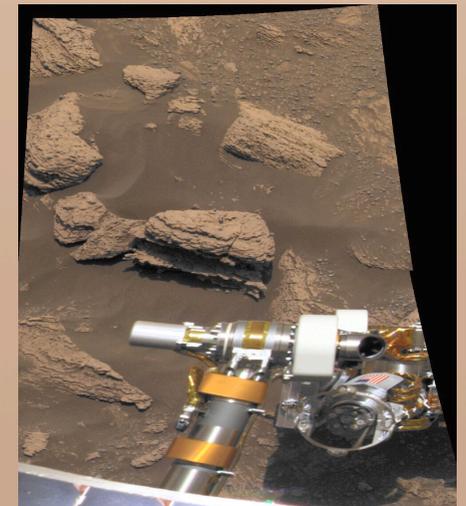
Mars



Dry Valleys, Antarctica

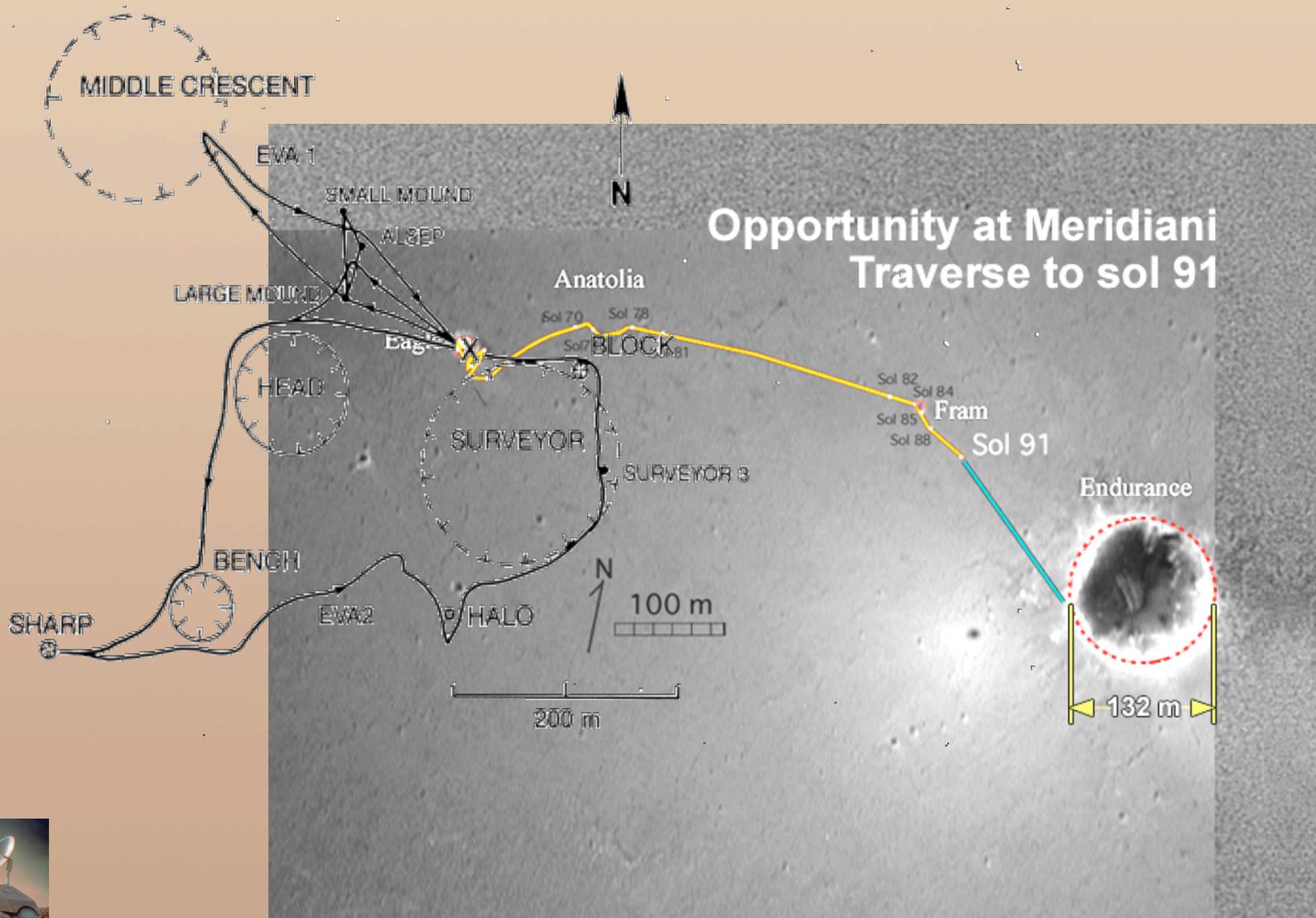


Human Sampling the Moon



MER Sampling Mars

APOLLO 12

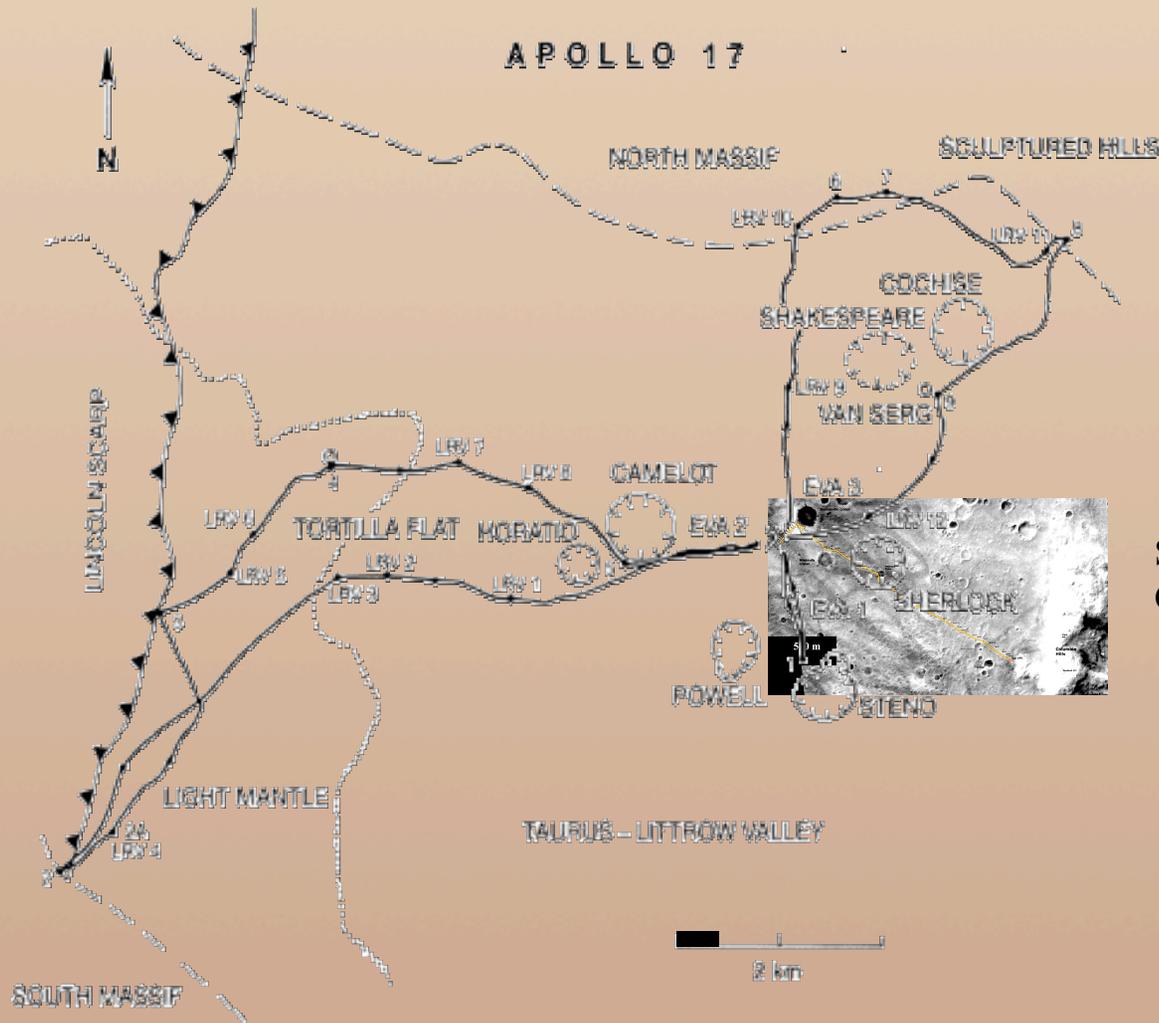


Opportunity at Meridiani
Traverse to sol 91



Today: 800+ meters in 91 days with MER Rover *versus* 2300+ meters in 2 EVA's on Apollo 12 in 1969 (kg's of rocks)

Humans on site can change the pace of discovery



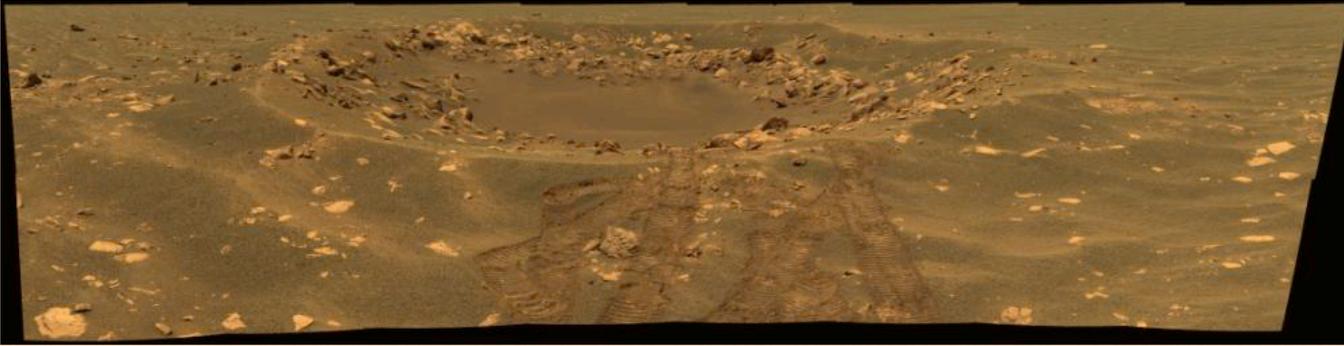
Spirit traverse to Columbia Hills

Apollo 17 traverses

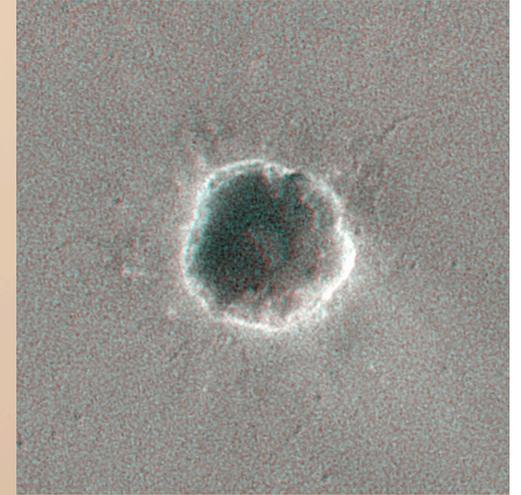


Opportunity traverse to Endurance crater

36 km during 22 hrs in 1972 vs 3.5 km in 200 days in 2004



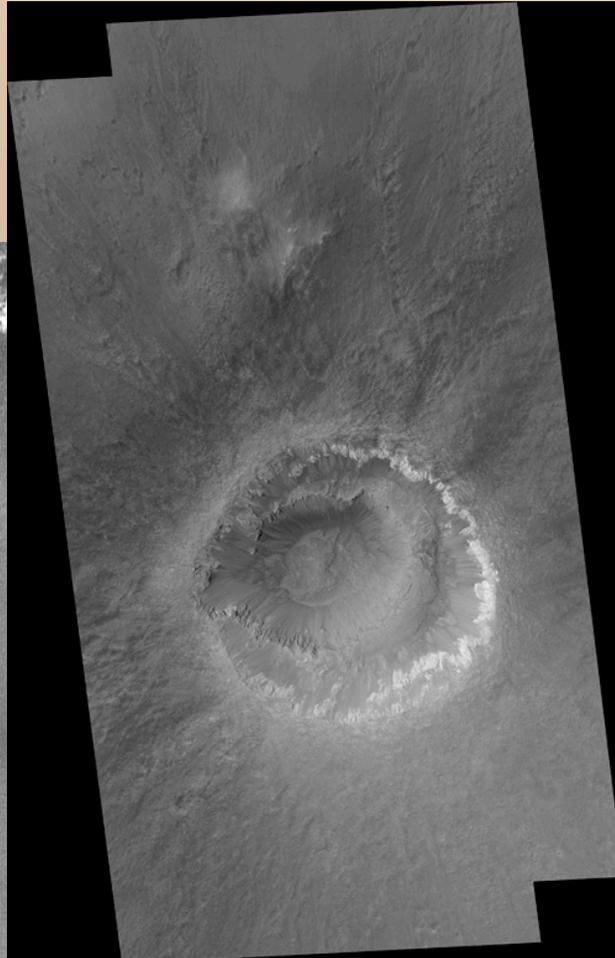
Fram



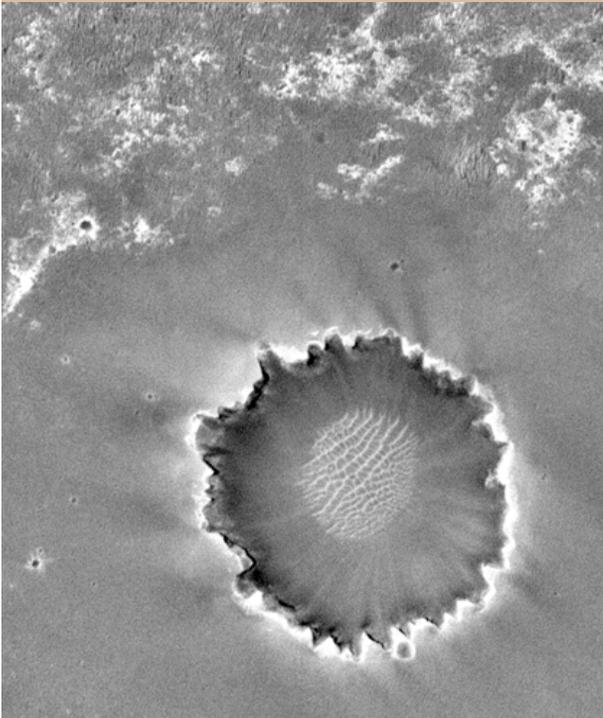
Endurance

**The Risk in going "Down" into Craters...
People vs Machines?**

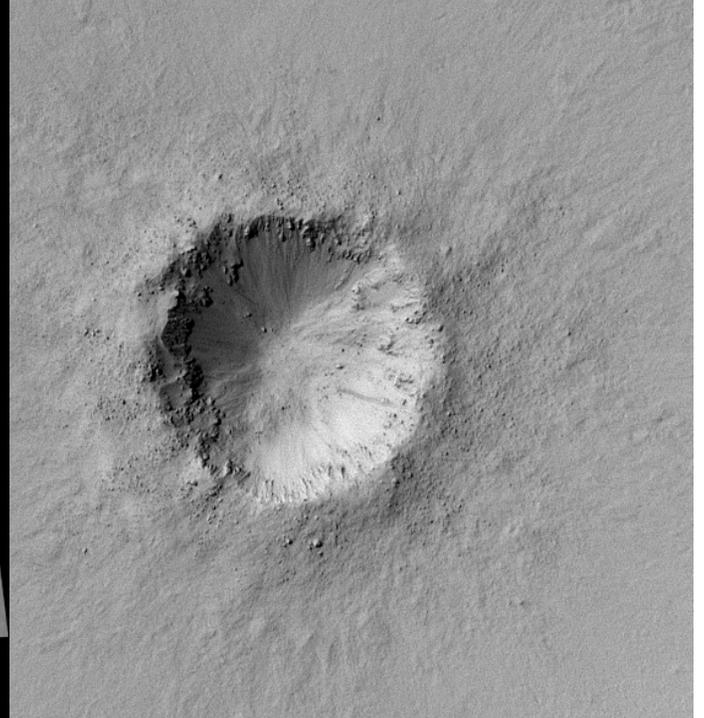
Meridiani Crater

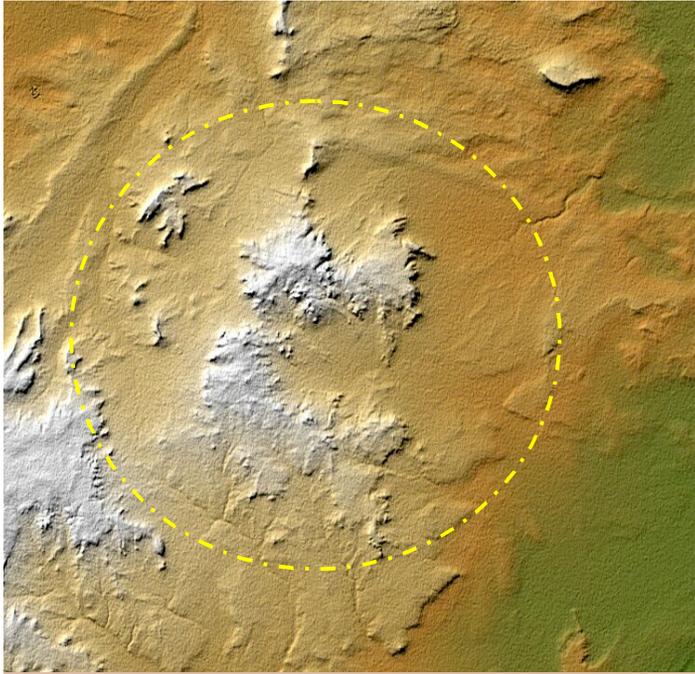


Victoria



Simple Mars crater

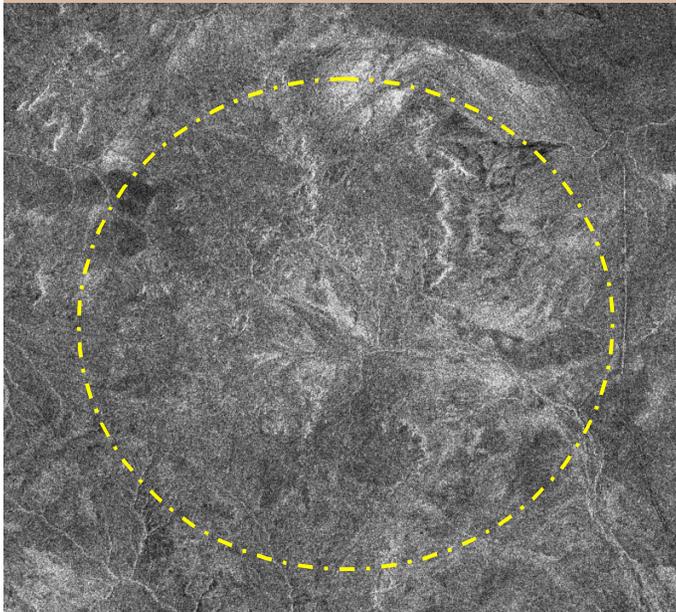




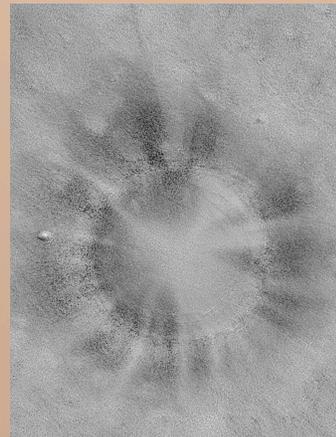
SRTM



Being there!



RADARSAT (CSA)



Mars (MGS)

**Reducing Risk in Exploration via
Remote Sensing (as RECON)**

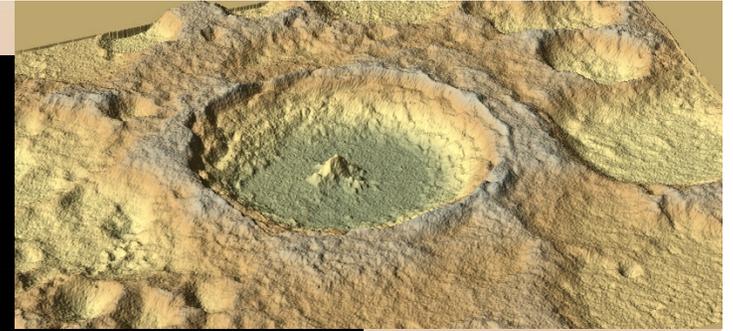
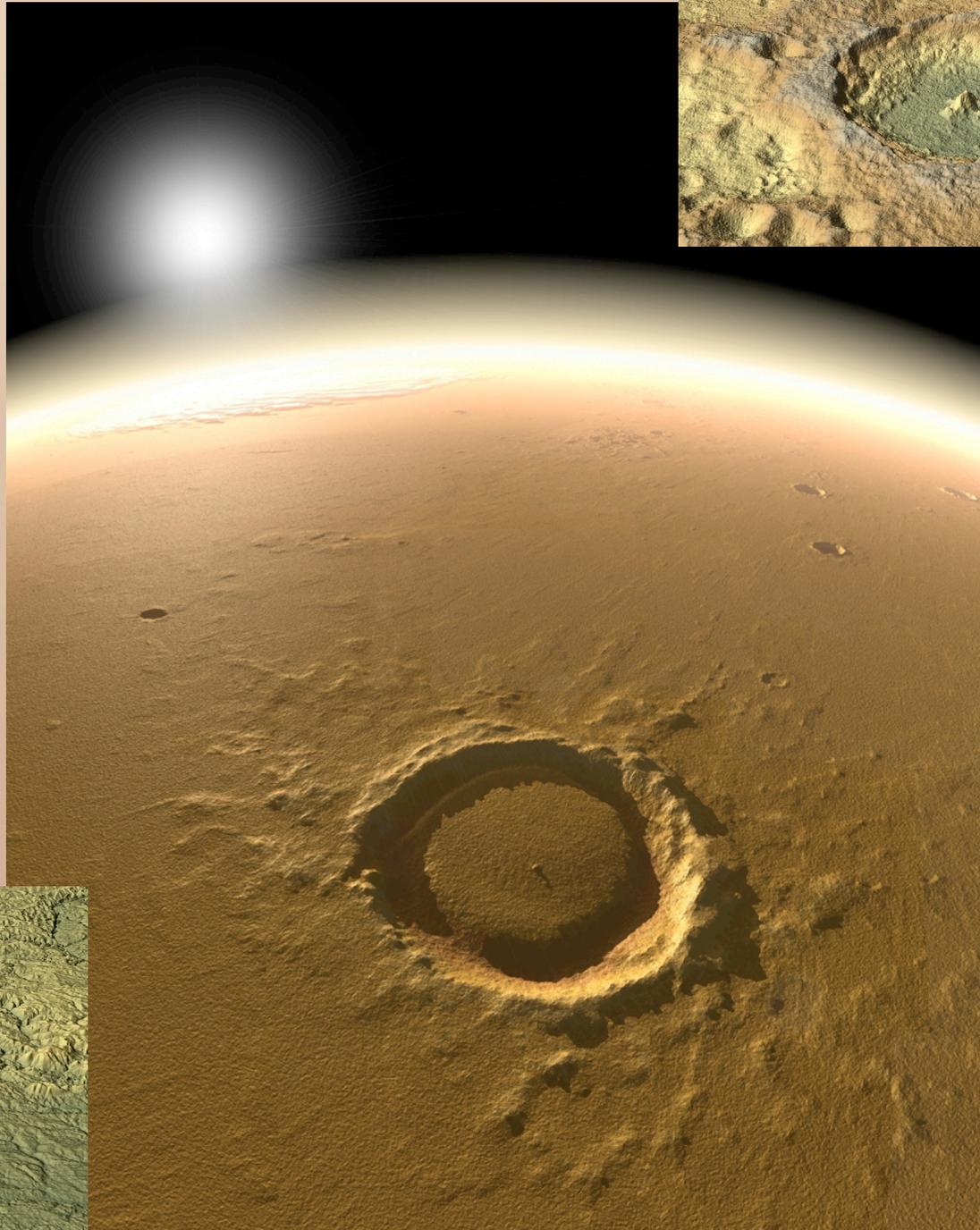
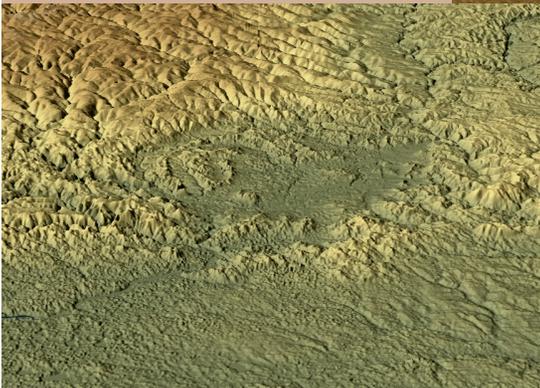
**My Zhamanshin Experience
(Soviet Akad. Nauk Expedition, 1989)**

870,000 years ago, a 20,000 Megaton Explosion

Getting to compelling places...on Mars!

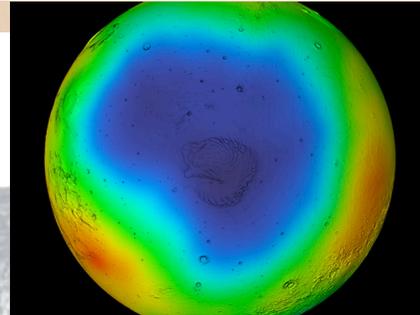
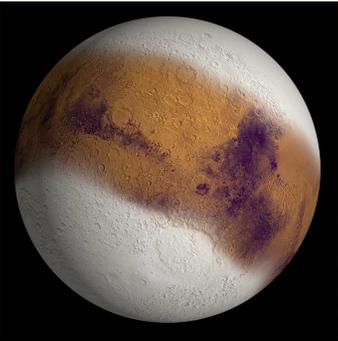
The Risk of NOT Exploring:
Cosmic Collisions

Popigai, Earth



Tycho, Moon
(Arecibo DEM)

Korolev, Mars
(MOLA ray trace)



Exploring the Edge of an Icecap? Where we may have to go...on Mars

Iceland c/o Jim Rice



SEEING AN ERUPTION UNDER ICE ON EARTH – Preparing for Mars?

Ikonos, Sept.02

The risk of getting there...

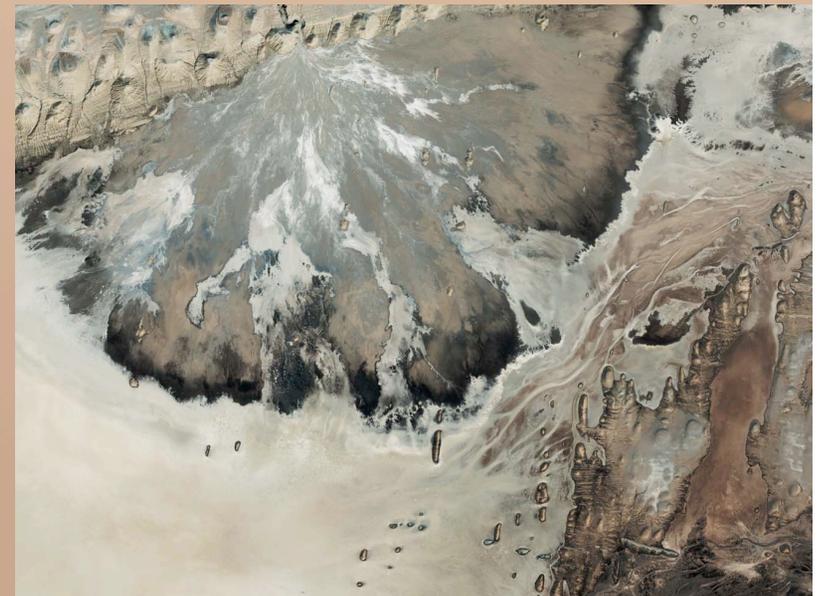


Earth (Ikonos): Iran



Mars (MGS/MOC)

WHERE WE MUST GO, SOMEDAY...



**Birth,
Nov. '63**



**Today,
at 41 yrs old...
25% gone!**

**My SURTSEYAN
EXPERIENCES...**

**Science Risk
“before its gone”**



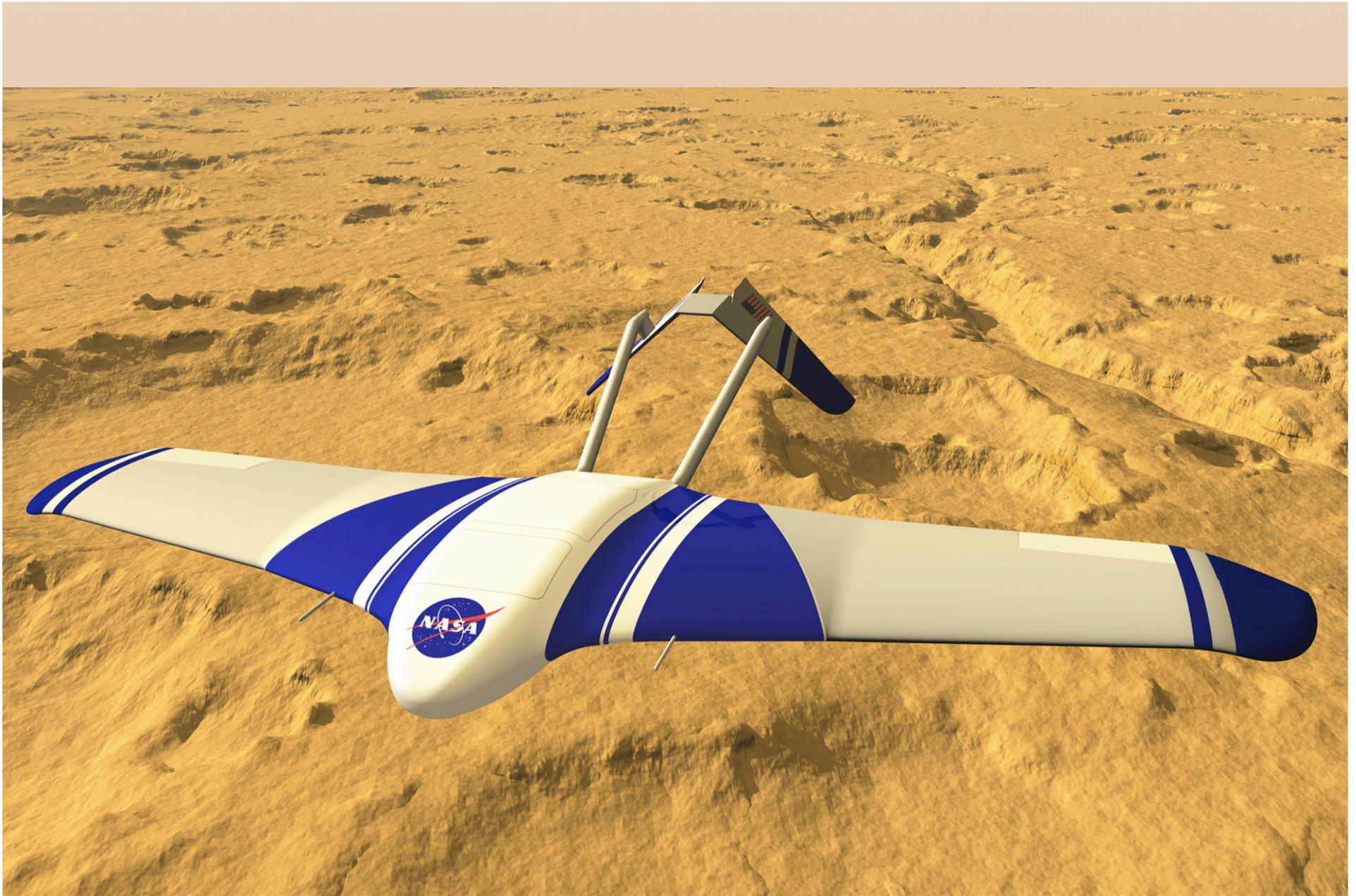
Mars



GOING INTO NEW TERRITORIES... anticipating “science gold”

Garvin,
Surtsey “gully”
Iceland

How must we explore gullies on Mars?



New Exploration Vantage Points enable NEW SCIENCE... But at risk...
The Value of Robotic Forerunners/Precursors...

ARES, Mars
Scout (Levine, LaRC)

DISCOVERY

Climate History



Sample Selection



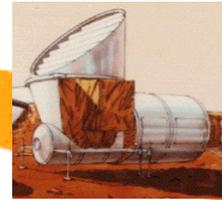
Ancient Water



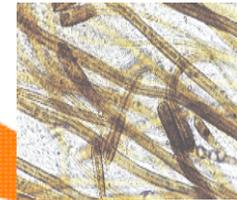
Validate Paleo-Life



Resources



Extant Life?



ROBOTICS ROBOTICS ROBOTICS HUMANS ROBOTICS & HUMANS

EXPLORATION



Reconnaissance



Site Selection



Sample Selection



Return Sample



Field Studies

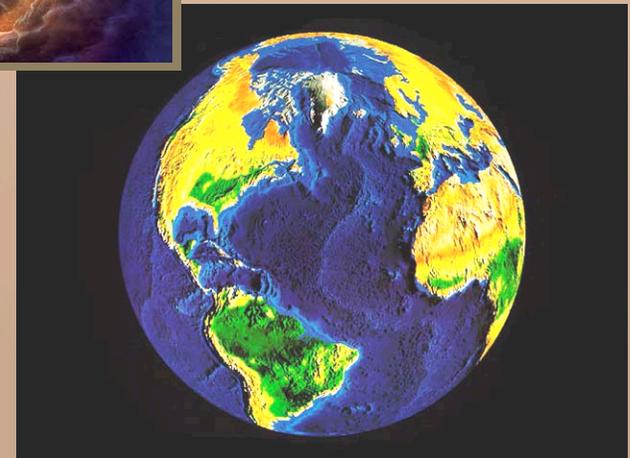
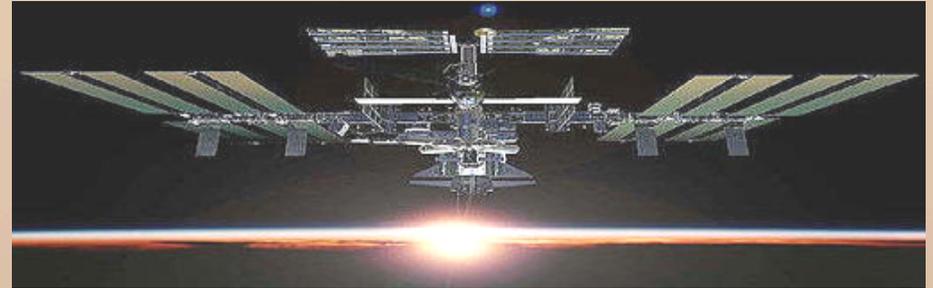


Deep Drilling

Exploring Mars



So *Where Are We Going* with **Humans**?



EXPLORING for Science | HOPE !



Ladder to the Moon
Georgia O'Keefe, 1958

Daring to Explore!
Inspiring the question:
"WHY NOT?"



**Vision provides a
powerful tool to
mitigate RISK**