Planetary Protection at NASA: Overview and Status

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NASA Planetary Protection Officer

8 December, 2015

2014 NASA Strategic Goals

Strategic Goal 1: Expand the frontiers of knowledge, capability, and opportunity in space.

Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.

Objective 1.2: Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity.

Objective 1.5: Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

NASA Planetary Protection Policy

- The policy and its implementation requirements are embodied in NPD 8020.7G *(NASA Administrator)*
  - Planetary Protection Officer acts on behalf of the Associate Administrator for Science to maintain and enforce the policy
  - NASA obtains recommendations on planetary protection issues (requirements for specific bodies and mission types) from the National Research Council's Space Studies Board
  - Advice on policy implementation to be obtained from the NAC Planetary Protection Subcommittee
- Specific requirements for robotic missions are embodied in NPR 8020.12D *(AA/SMD)*
  - Encompasses all documentation and implementation requirements for forward and back-contamination control
- NASA Policy Instruction 8020.7 "*NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions*" released in NODIS as of May 28, 2014

Role of PPS

- The scope of the PPS includes programs, policies, plans, hazard identification and risk assessment, and other matters pertinent to the Agency's responsibilities for biological planetary protection.
- This scope includes consideration of NASA planetary protection policy documents, implementation plans, and organization.
- The subcommittee will review and recommend appropriate planetary protection categorizations for all bodies of the solar system to which spacecraft will be sent.
- The scope also includes the development of near-term enabling technologies, systems, and capabilities, as well as developments with the potential to provide long-term improvements in future operational systems to support planetary protection.

Recent PPS Recommendations

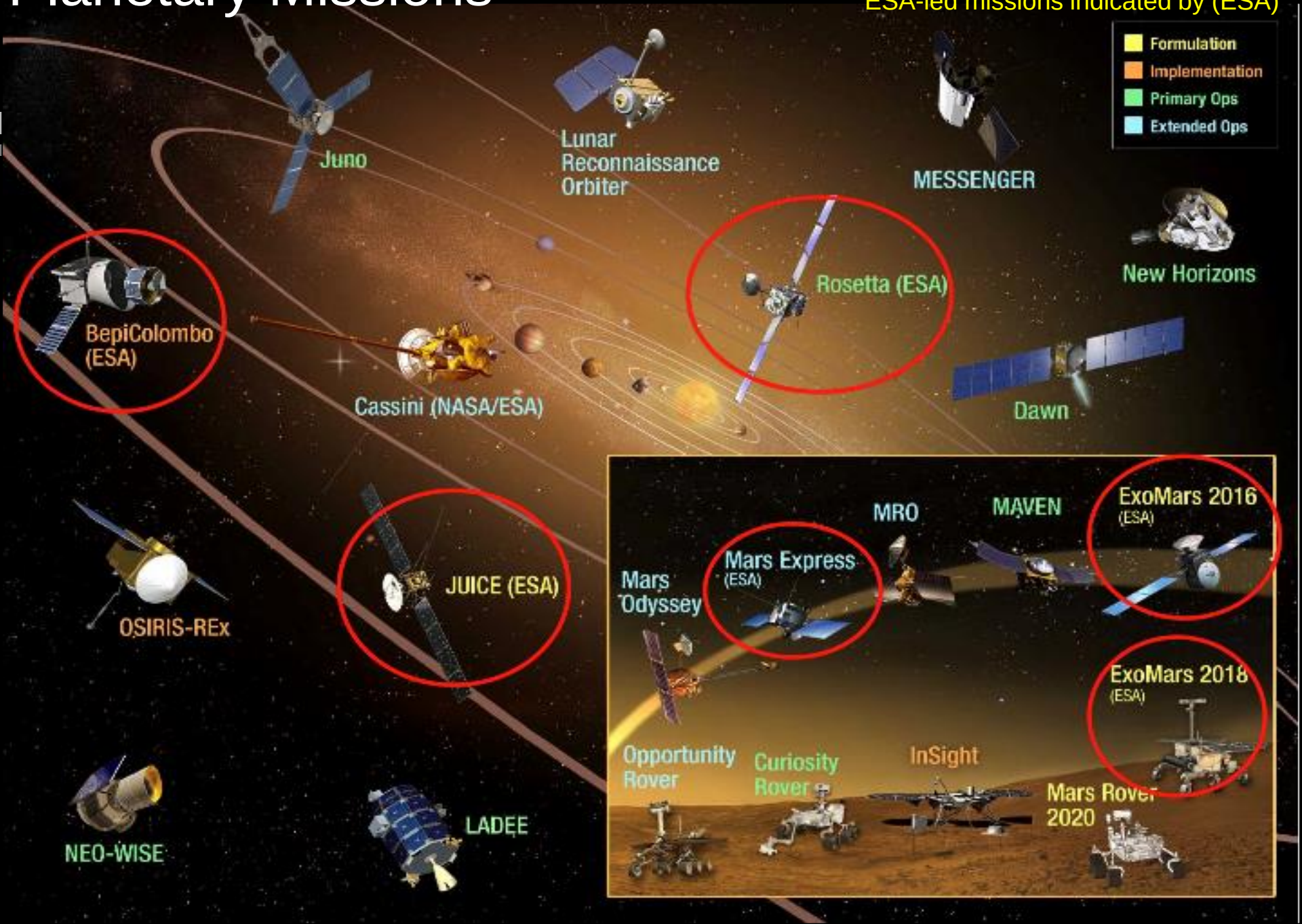
- Apr. 2013 meeting
  - Recommendations
    - Include PPO early in mission planning and design
- Nov. 2013 and May 2014 meetings
  - No formal recommendations; concerns from above reiterated
- Nov. 2014 meeting
  - Recommendations
    - Improve MSL Project Office – Planetary Protection Officer Communications
    - Ensure Planetary Protection input to NASA assessment of launch and reentry license applications to the DoT/FAA by Non-Governmental Entities
  - Observations and information
    - Pleased by improved communications with InSight, M2020, and HEO
    - Concerned that the reporting line of the PPO be consistent with responsibility to assure continued treaty compliance across programs in multiple directorates
    - Concerned that joint meetings with ESA were not held
- June 2015 meeting
  - Recommendations
    - M2020 receives Category V Restricted Earth Return

Ongoing Office Activities

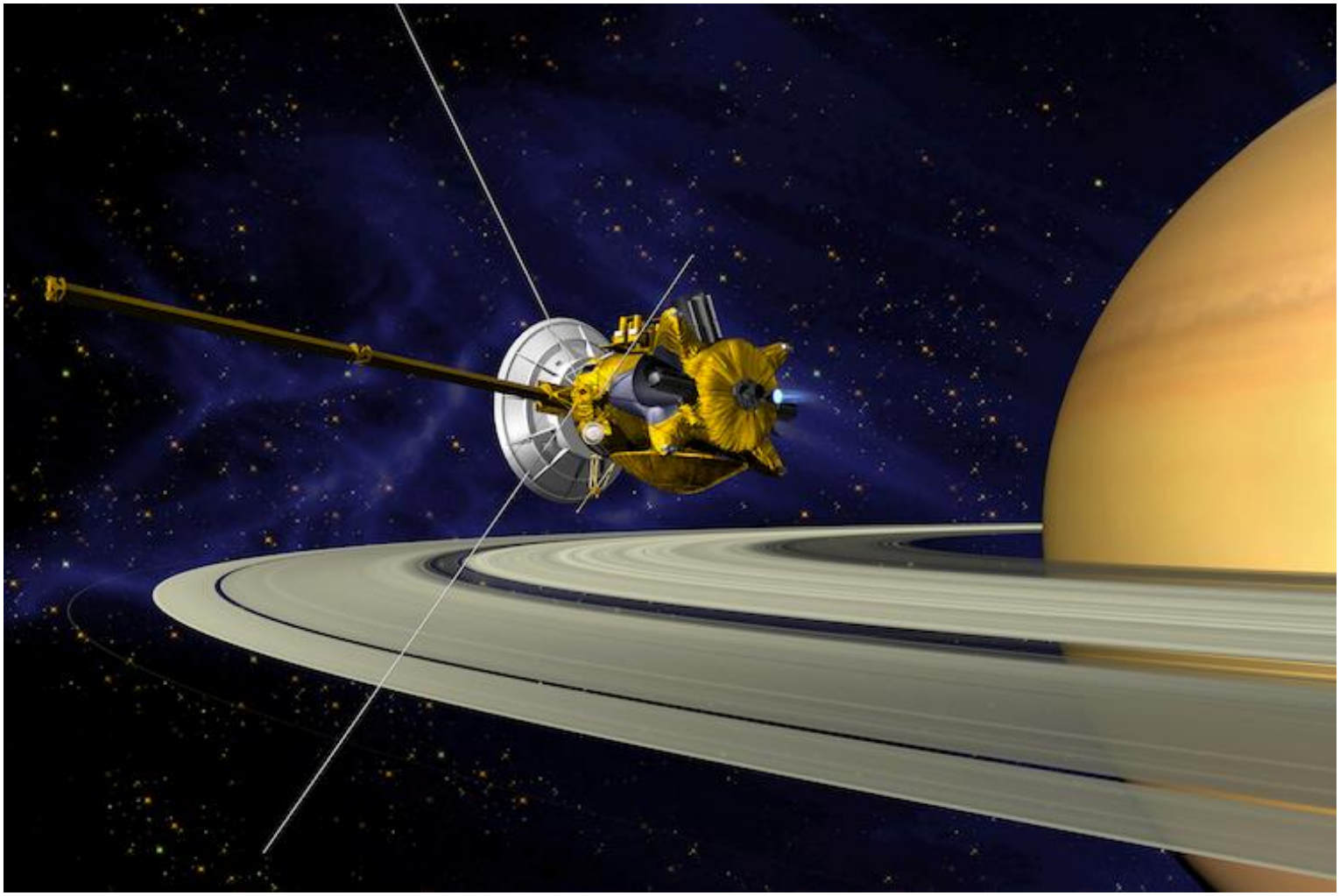
- SMD lead on responses to MSL Lessons Learned initiated
  - Ensure appropriate requirements flowdown ongoing
  - Revise/coordinate planetary protection documentation L. Bromley
  - Expand training options ongoing
- Continue cross-directorate coordination
  - Exploring opportunities for interaction with SMA
  - Planetary Protection Coordination Group
- Internal SMD activities
  - Ensure appropriate separation of implementation activities in PSD from regulatory/oversight activities of PPO
  - Develop and support Office of Planetary Protection operating plan
    - support needed
    - Include planetary protection in Launch Services Contract
  - Work closely with missions, active and in development B. Pugel
    - MSL, M2020, InSight; MAVEN, MOM, MRO
    - Cassini, Dawn, New Horizons, Juno,
    - Europa Concept, Discovery and New Frontiers AOs
    - missions supporting HEO – e.g. ARM

Planetary Missions

Nearly all NASA missions have multiple-agency contributions; ESA-led missions indicated by (ESA)



Cassini-Huygens Extended Mission



New Frontiers Program

1st NF mission
New Horizons:

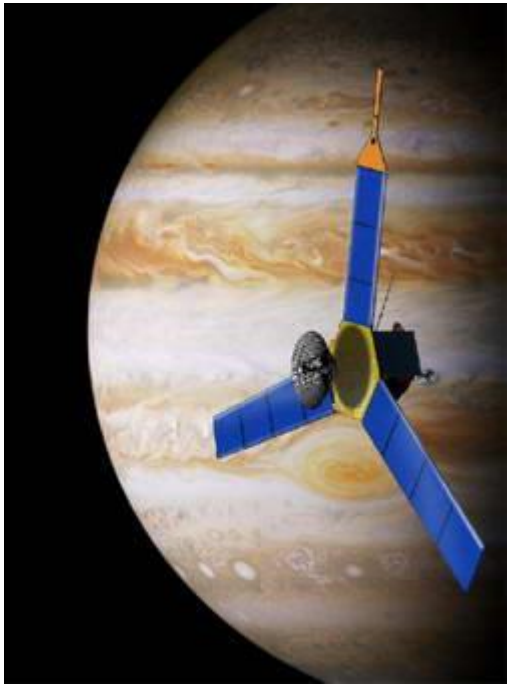
Pluto-Kuiper Belt Mission

Launched January 2006
Arrival July 2015

Category II

2nd NF mission
JUNO:

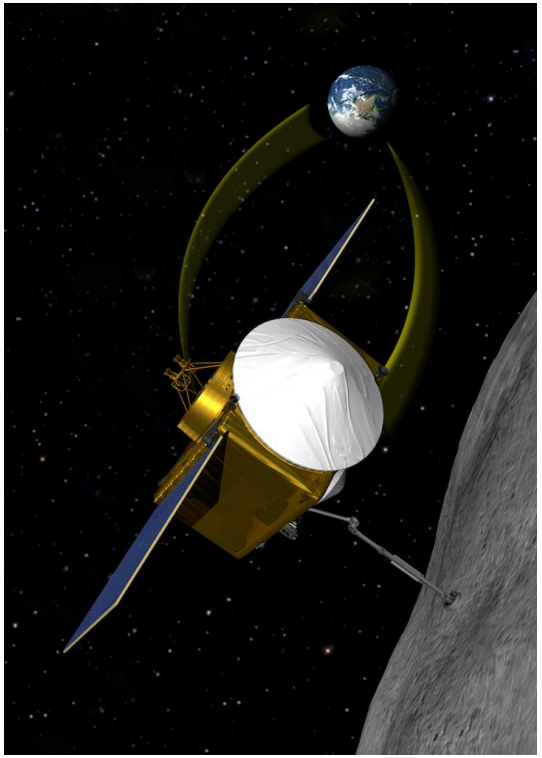
Jupiter Polar Orbiter Mission



August 2011 Launch
Arrival 2017

Category III

3rd NF mission
OSIRIS-REx
Asteroid Sample Return



September 2016 Launch
Arrival 2019

Category V Unrestricted

Discovery: New Phase A Selections

Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (DAVINCI)
– chemical composition of Venus' atmosphere during a 63-minute descent

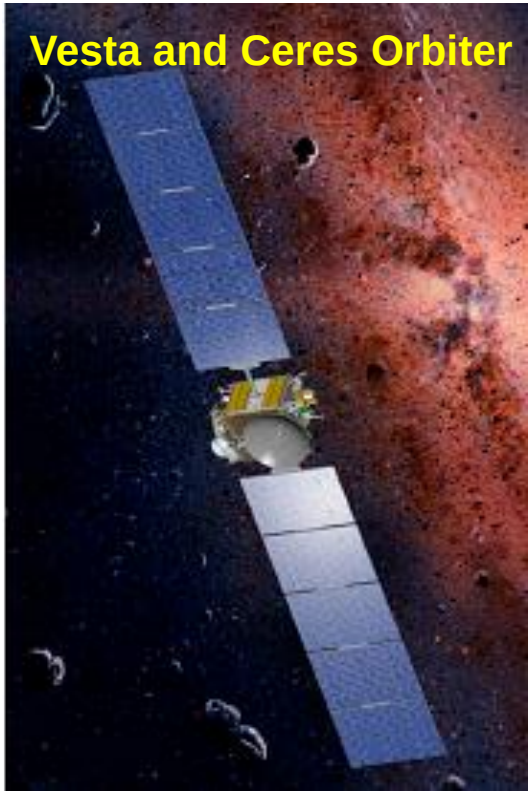
Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy mission (VERITAS)
– produce global, high-resolution topography and imaging of Venus' surface

Psyche
– explore the origin of planetary cores by studying the metallic asteroid Psyche

Near Earth Object Camera (NEOCam)
– discover ten times more near-Earth objects than all NEOs discovered to date

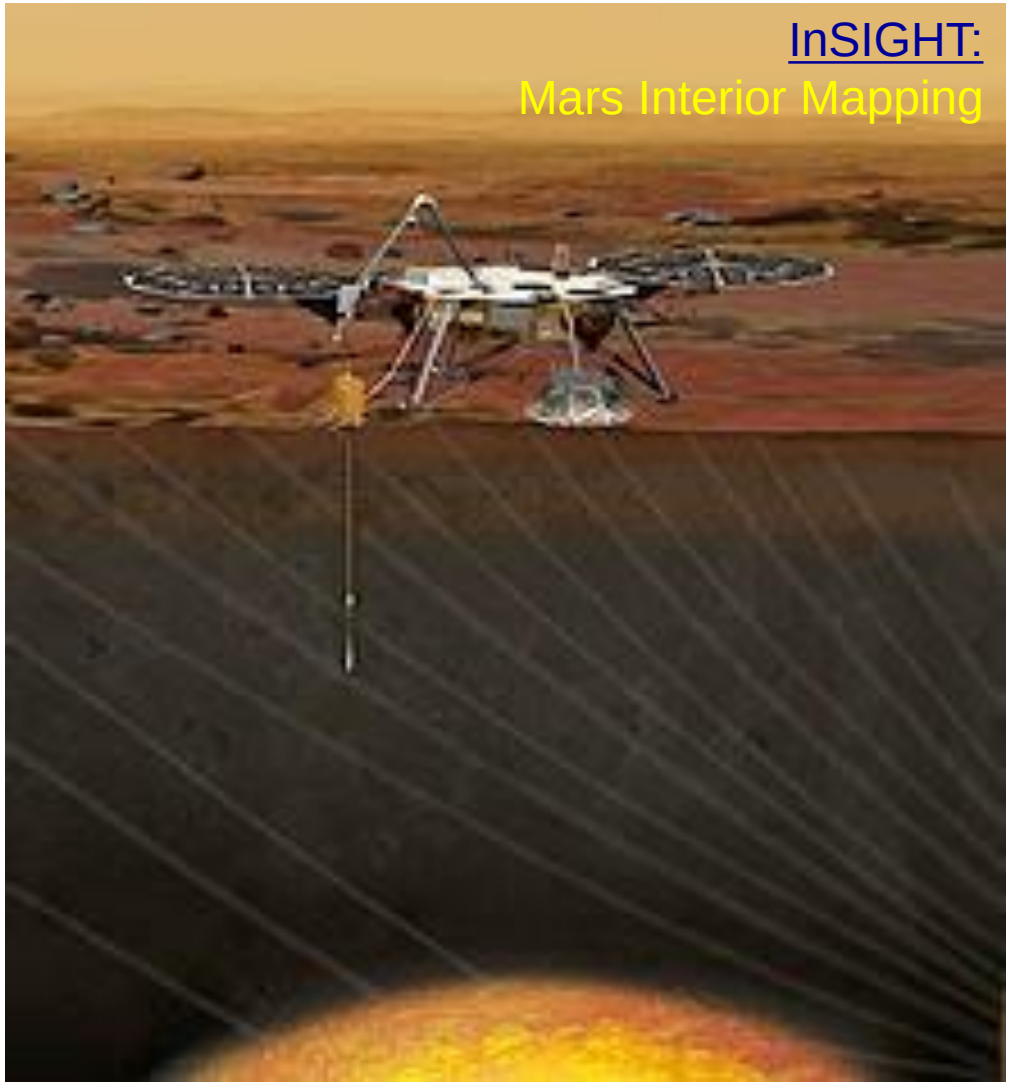
Lucy
– perform the first reconnaissance of the Jupiter Trojan asteroids

Dawn:



Category II: will not impact Ceres due to orbital mechanics constraints

2012 Discovery Selection



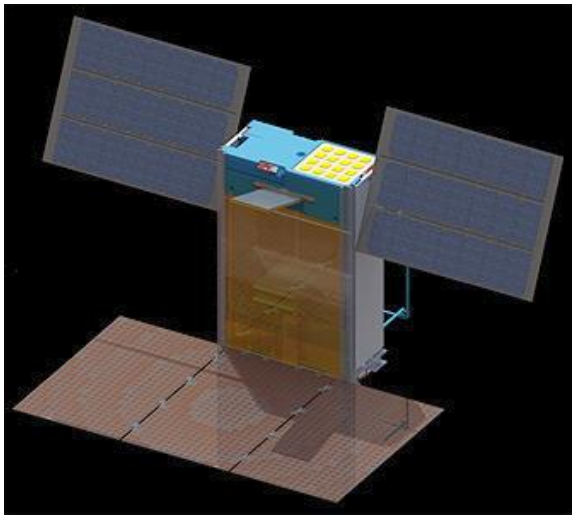
Category IVa

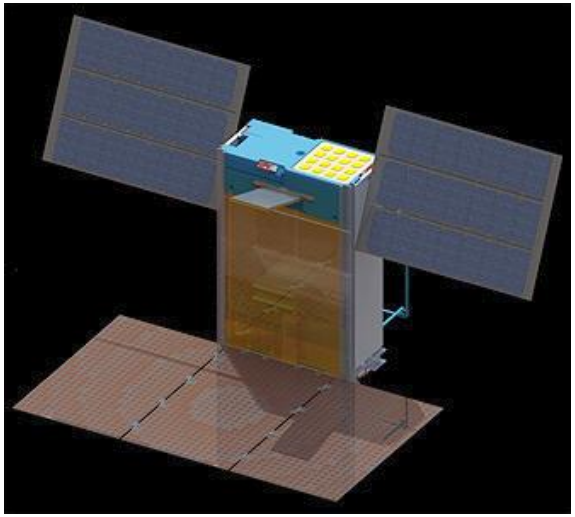
Launch March 2016

- Demonstrate, by observation and analysis, that mole will not access Mars special regions

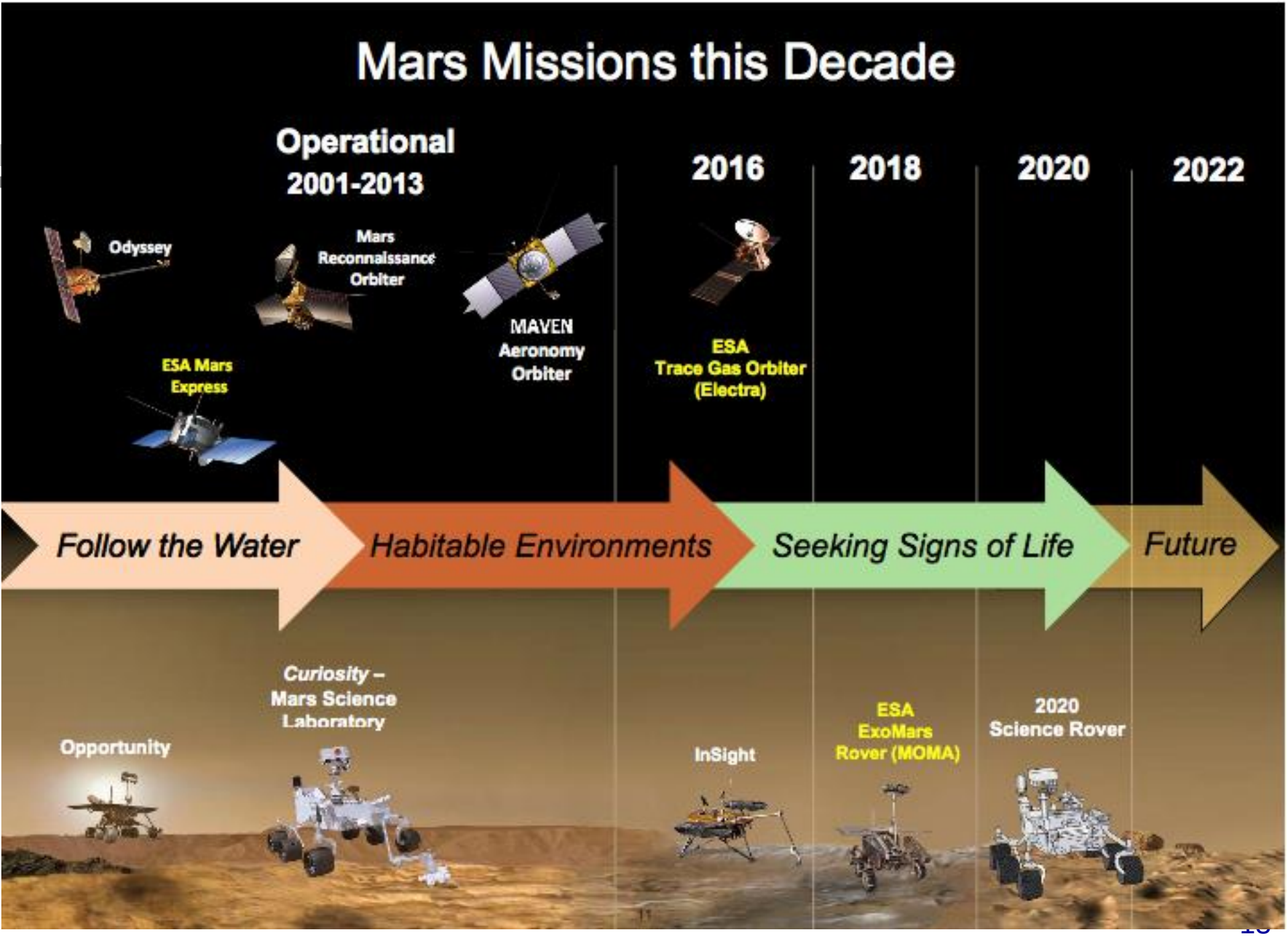
- Pre-ship review completed, spacecraft travelling from L-M Denver to VAFB in mid-December

MarCo CubeSat Secondary Payload

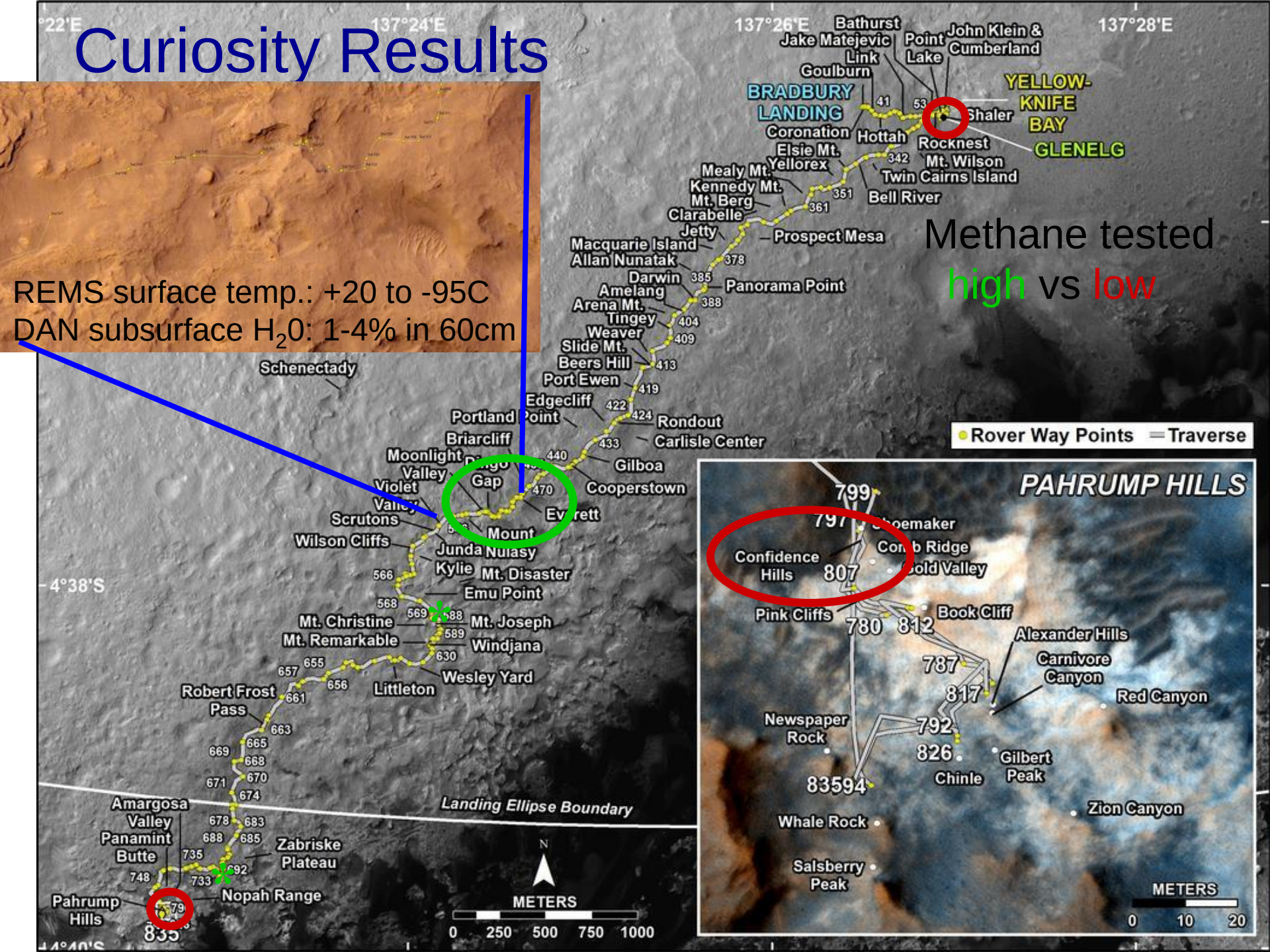




- Two Cubesats to follow InSight to Mars and provide communications during EDL.
- Nominal mission is a flyby: Cubesats continue in heliocentric orbit.
- Cubesat launcher is mounted at the base of the upper stage: requires Mars impact avoidance at $<1x10^{-4}$, or Burn-up and Break-up analysis.
- Good communication between all payloads and the launch vehicle providers are essential, to ensure that planetary protection requirements on the primary payload are not violated.

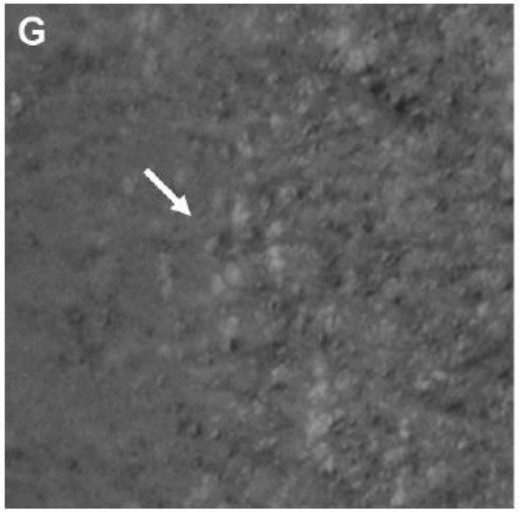

Mars Missions this Decade
Operational
2001-2013
2016
2018
2020
2022
Odyssey
Mars Reconnaissance Orbiter
MAVEN Aeronomy Orbiter
ESA Mars Express
ESA Trace Gas Orbiter (Electra)
Follow the Water
Habitable Environments
Seeking Signs of Life
Future
Opportunity
Curiosity – Mars Science Laboratory
InSight
ESA ExoMars Rover (MOMA)
2020 Science Rover

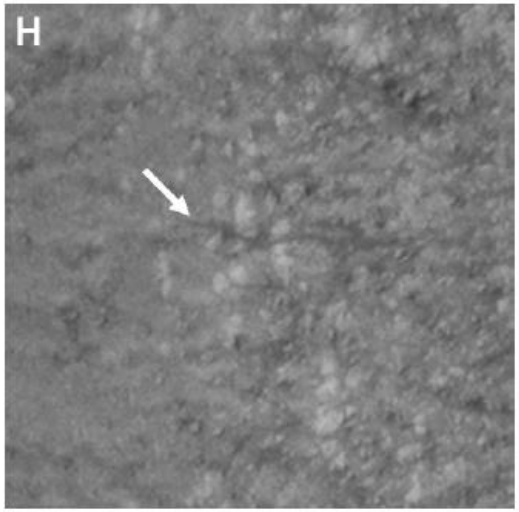
Curiosity Results



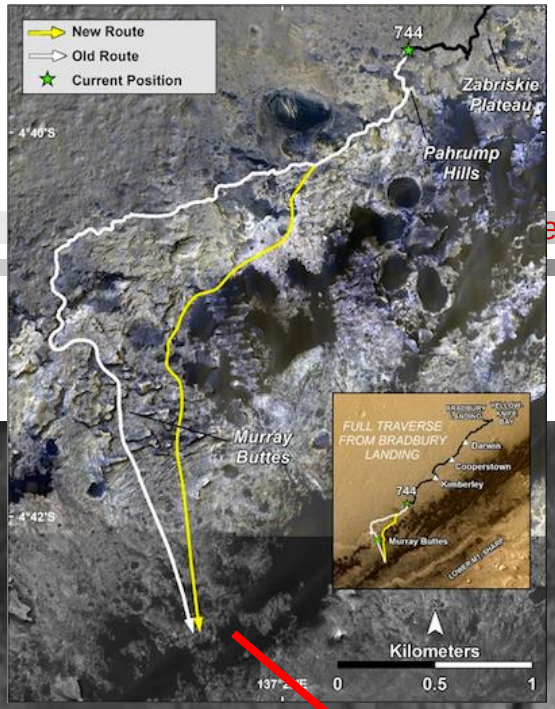
Curiosity
New Traverse

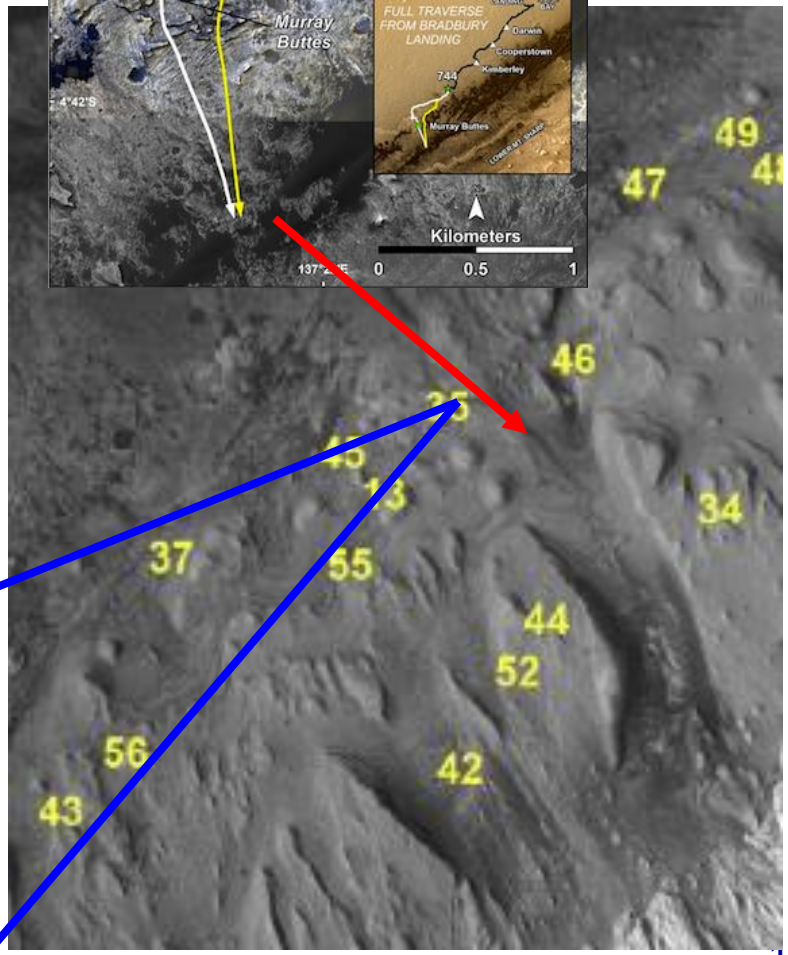
Many Dark Streaks, Possible RSLs....

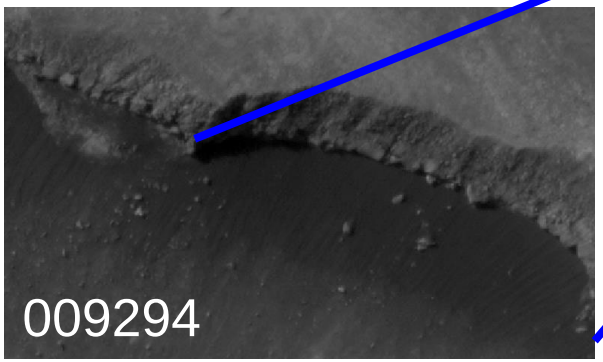




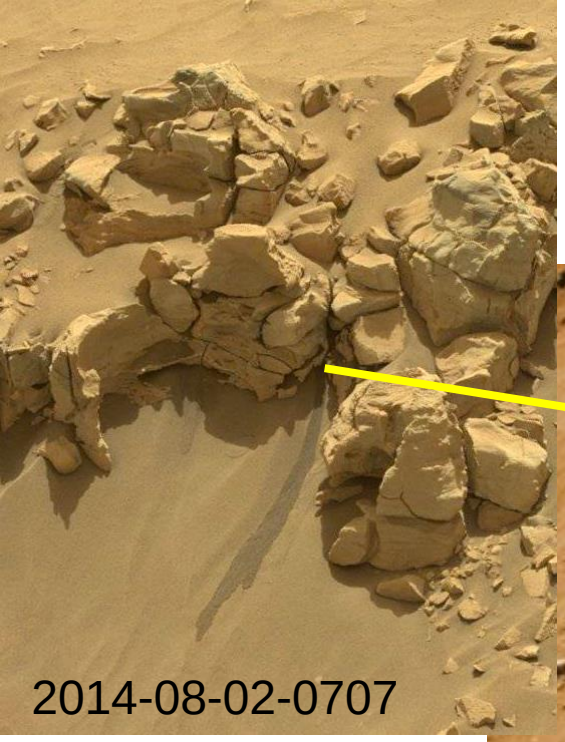
CM Dundas & AS McEwen, (2015) Icarus 213–218

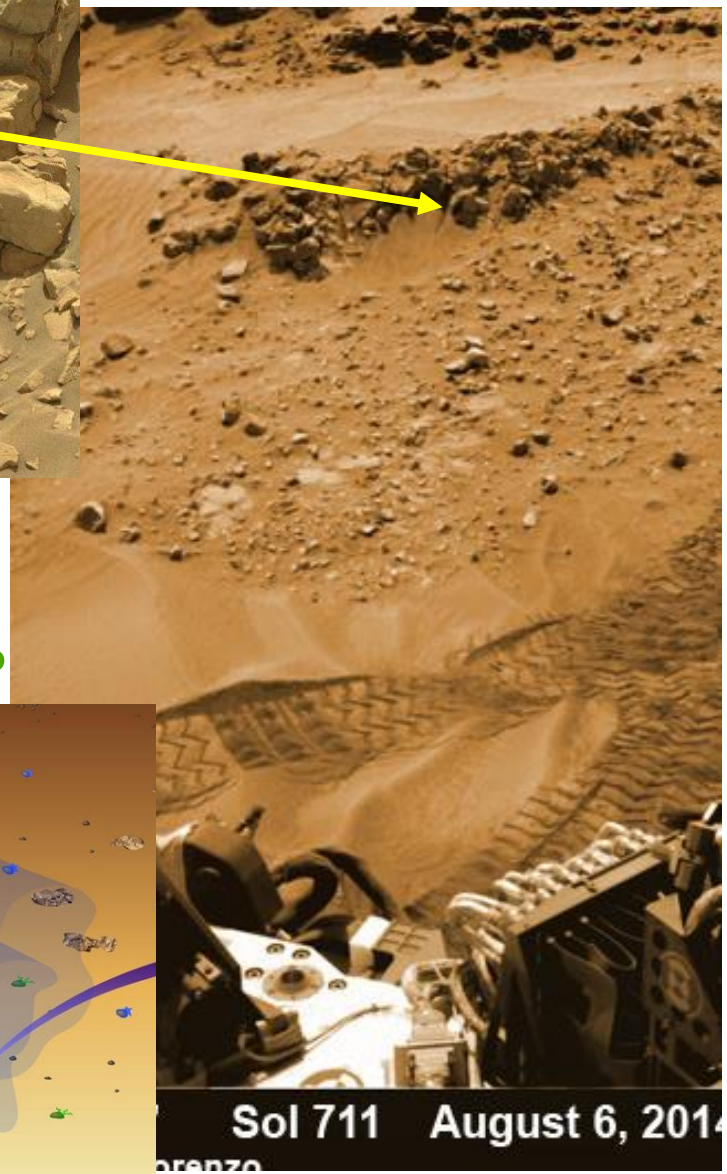


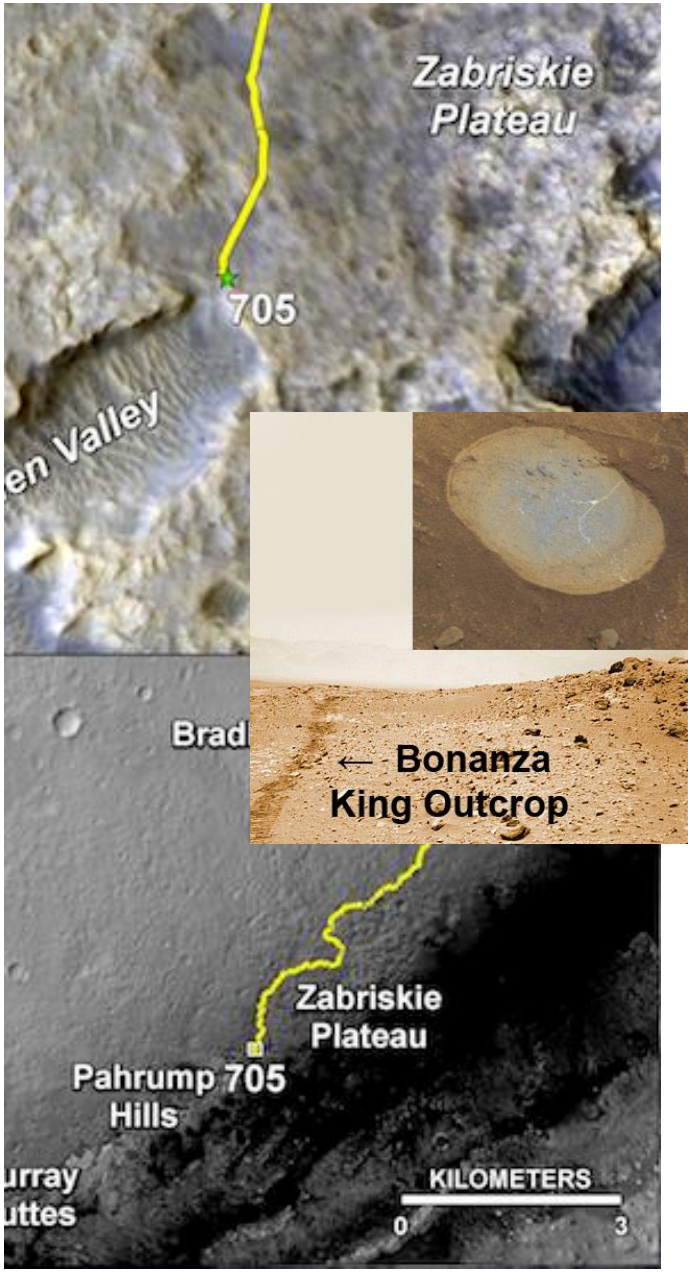




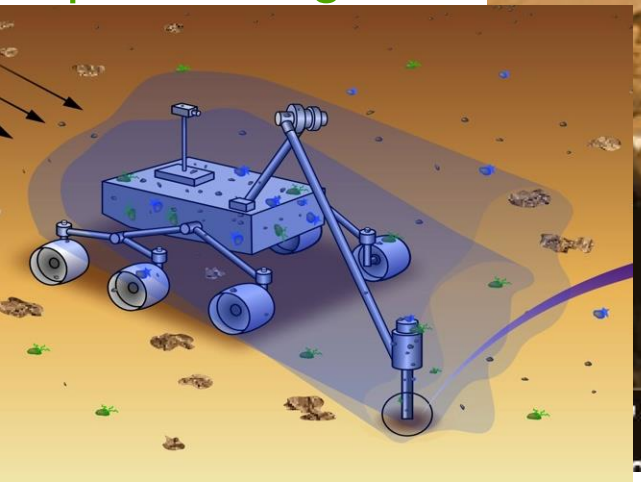
Curiosity at Bonanza King Outcrop





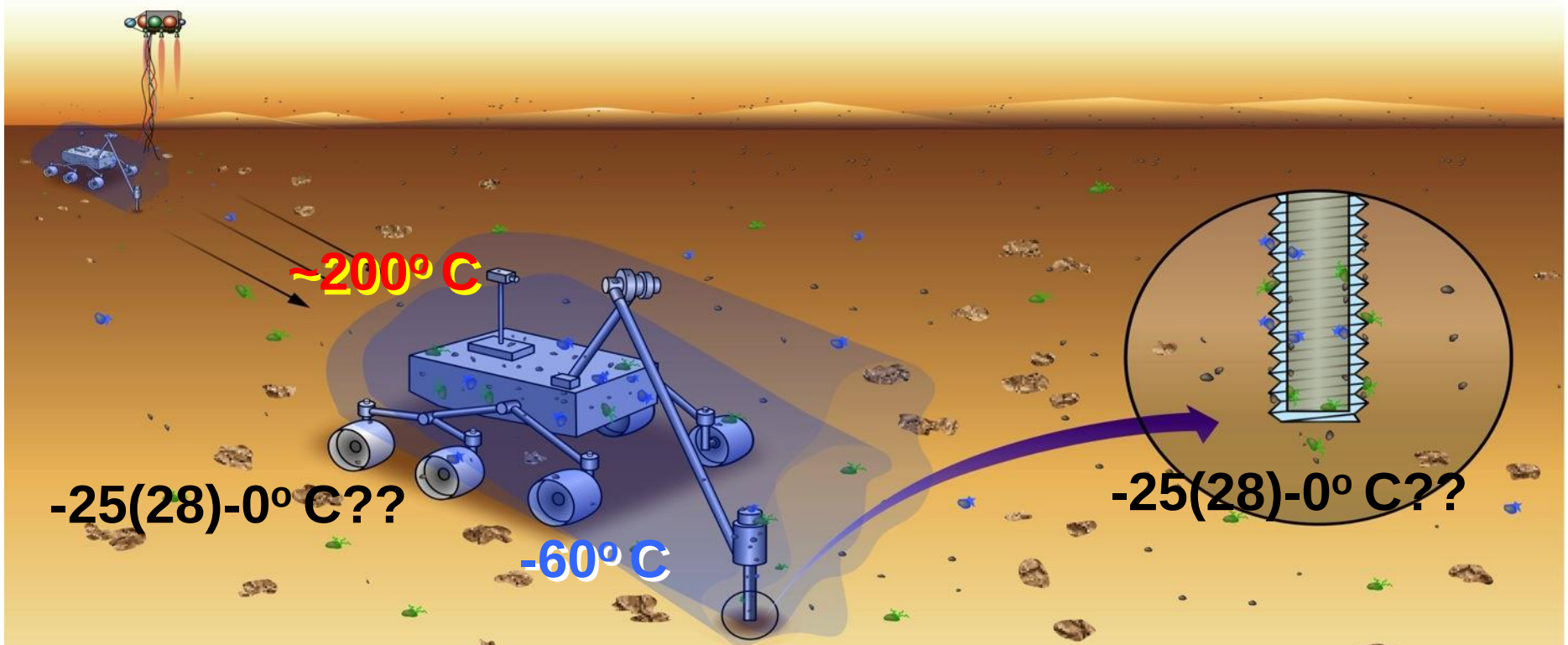


30 Microbes into Special Regions?




Curiosity views Bonanza King outcrop Sol 719 August 14, 2014
Credit: NASA/JPL/Marco Di Lorenzo/Ken Kremer
← Bonanza King Outcrop
Sol 711 August 6, 2014

Identifying Spacecraft-Induced Special Regions?



Possible mechanisms for creating Special Regions:

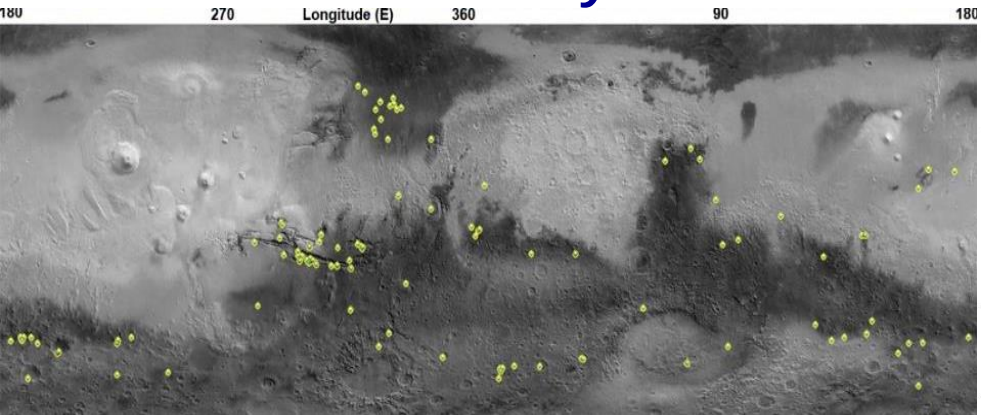
- Off-nominal impact delivers RTG to surface: MSL scenario
- Rover heats ground during nominal operations, inducing hydrated minerals to release water vapor into a closed environment: the Teakettle Problem
- Temperature gradient on rover from RTG to unheated surfaces creates special region when 100% relative humidity air condenses at night

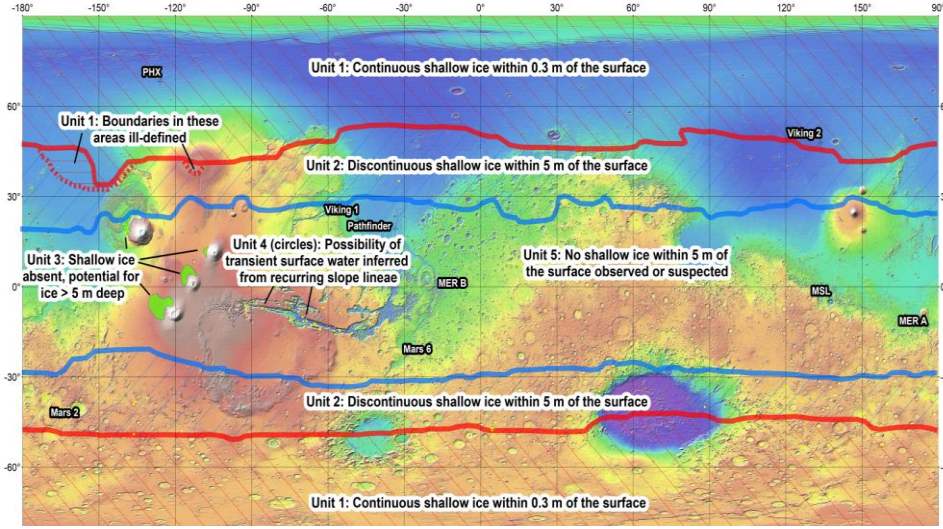
RH: ??%

M2020: Planetary Protection Category V, Restricted Earth Return

- Individual mission category, not part of a campaign: Partial categorization letter provided to project, date 7 May 2015
- Payload includes a subsurface sampling system and caching hardware to collect and enclose samples for possible future return to Earth
- Payload has the capability to perform near-surface measurements of organic 'biosignature' compounds in situ, with at least ppm sensitivity
- Outbound leg of the M2020 mission shall be required to comply with requirements for Planetary Protection Category IVb implemented at subsystem level, as a mission to Mars that will not access Special Regions, but that will conduct "scientific investigations of possible extraterrestrial life forms, precursors, and remnants”
- Clarified sections of NPR 8020.12:
  - 5.3.2.2.b implemented at subsystem level, requirements for in situ instruments investigating 'precursors or remnants' of life
  - 5.3.2.3.c and 5.3.2.5.c, requirements for avoiding access to or creation of special regions
  - 5.3.3.2 and 5.3.2.7, requirements for Category V Restricted Earth Return

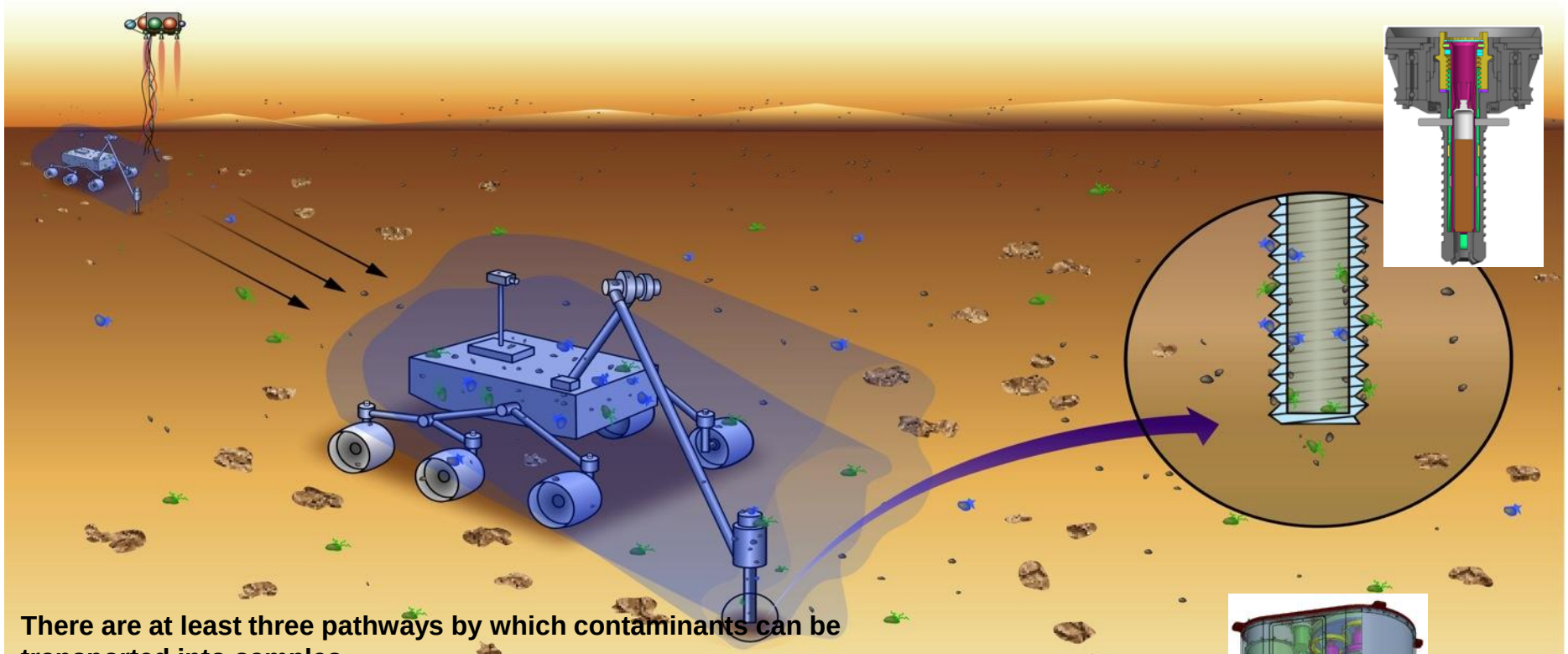
Planetary Protection





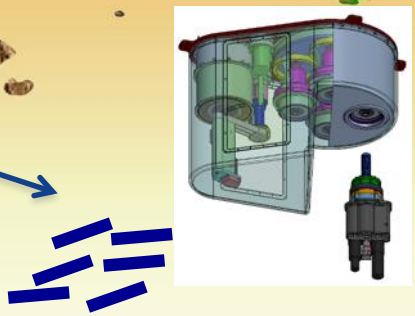
- Sites between the blue lines clearly meet the “no ice within 5 m of the surface” requirement
- Sites between the blue and red lines may be acceptable, but must be evaluated on a case by case basis
- Small yellow dots show potential special regions that need to be avoided based on current knowledge, see purple diamonds on RSL figure for better view of these.
- The potential to create or access special regions after an off-nominal impact of the RTG into hydrated minerals is still under investigation.
- Note all current top 9 sites appear to avoid currently known or suspected special regions
  - In future years, the remaining top landing sites will be examined carefully to assure compliance

M2020: Evolving Concepts for Sampling



There are at least three pathways by which contaminants can be transported into samples:

- Direct contact – microbial and molecular contaminants are transferred from the hardware surfaces to samples by direct contact.
- Particle transport – Microbes and molecular contaminant-containing particles are dislodged from spacecraft hardware surfaces by wind or by mechanical forces and are then carried by wind to the sampling ground or into the sample tube.
- VOC transport – outgassed volatile organic compounds from nonmetallic parts will diffuse or be carried by wind to condense on the sampling ground, sample contacting hardware, and samples.



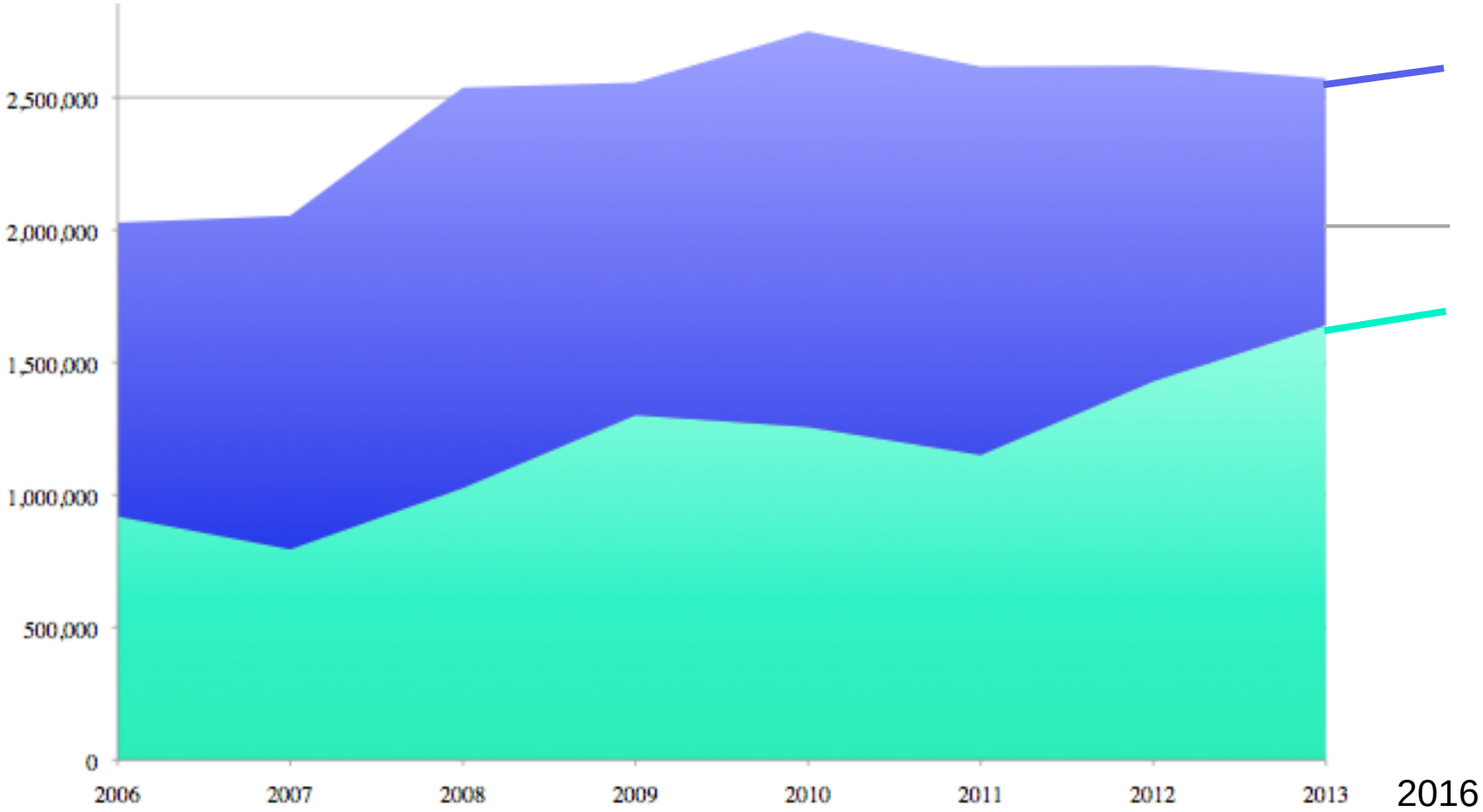
Deposit cache or individual sample tubes

Other Activities

- Media Attention
  - Articles on planetary protection in New York Times; New Yorker; many others
  - Radio interview: WMCLive with Robin Morgan
- Planetary Protection Coordination Group
  - charter circulated for comment
  - currently in concurrence
- Strengthening interfaces with HEO and STMD
  - identifying Center points of contact beyond HQ
- Planetary Protection Research in ROSES
  - PPR research program selected 6 proposals from ROSES14
  - ~20 proposals received for ROSES15

Planetary Protection Budget

PPR proposals to ROSES 2015 under review
Programmatic support being pursued



PPR Solicitation

- Characterize the limits of life in laboratory simulations of planetary environments or in appropriate Earth analogs.
- Model planetary environmental conditions and transport processes that could permit mobilization of spacecraft-associated contaminants to locations in which Earth organisms might thrive
- Develop or adapt modern molecular analytical methods to rapidly detect, classify, and/or enumerate the widest possible spectrum of Earth microbes carried by spacecraft
- Identify and provide proof-of-concept on new or improved methods, technologies, and procedures for spacecraft sterilization that are compatible with spacecraft materials and assemblies.

2014 Selections

- **Dry Heat Inactivation of Embedded Spores (W. Schubert, JPL)**
- **Microorganism Survivability in High-velocity Impacts (D. Austin, (BYU)**
- **Potential Growth and Survival of sulfate reducing bacteria on the martian surface (V. Chevrier, U. Arkensas)**
- **Life at Low Water Activity with Salts Relevant to Mars and Icy Satellites (F. Chen, JPL)**
- Evaluating Microbial Hardiness and Archiving of Isolates from NASA's Next Generation Lander (S. Smith)
- PCR activated cell sorting (PACS)-based molecular detection of spores and other microbial communities (A. Abate, USCF)
- Germination-induced Molecular Detection of Spores and Other Heat-tolerant Microbial Communities (K. Venkateswaran, JPL)

2012 and prior Selections

- **Laser Induced Plasma Shockwave Cleaning for Planetary Protection (F. Chen, JPL)**
- **Metabolism, Growth, and Genomic Responses of *Serratia liquefaciens* under Simulated Martian Conditions (A. Schuerger, KSC/U. Florida)**
- **Ultraviolet Susceptibilities of Microbes in Water Ice to Address Forward Contamination on Mars and Other Icy Worlds (D. Winebrenner, U. Washington)**
- Metagenomics approach to predict functional capabilities of microbes in clean room facilities (P. Vaishampayan, JPL)
- *Advanced microbial census and sterilization research for planetary protection (A. Feldman, APL)*
- **Cleaning to Sterility Using CO2 Composite Spray (2011, S. Chung, JPL)**

Questions?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