National Aeronautics and Space Administration

Mars Exploration Program Status
Planetary Sciences Subcommittee of NAC
9 July 2009

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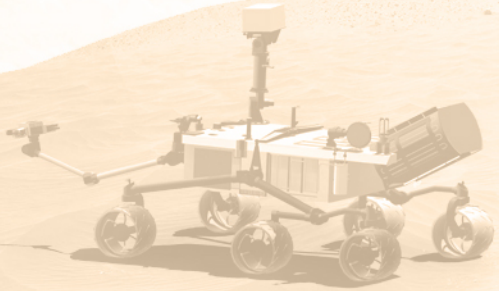
Mars Exploration Program, Director

Agenda

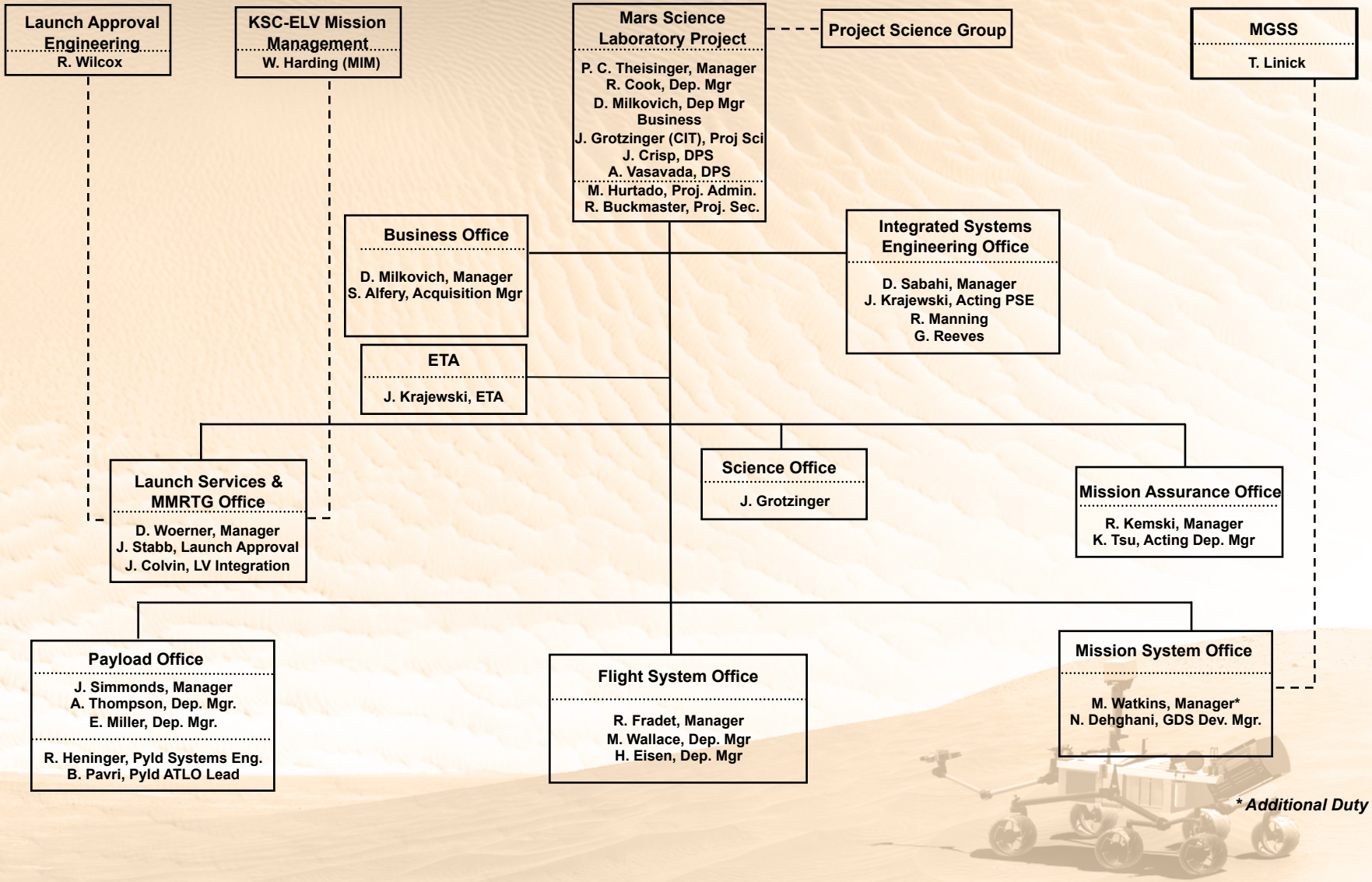
- MSL
  - Current Status and Progress
  - Budget Situation and Path Forward
- Future Program Planning
  - ESA and MART



Activities Since Last PSS

- After the decision to slip the MSL launch to 2011:
  - MSL status presented to PSS in December 2008
  - Presented interim report to SMD in February, completed the re-plan activity, and started baselining the new implementation plan in March.
  - SRB Re-Baseline Review was held May 13 – 15, 2009, and the JPL CMC on May 27, 2009
- SMD DPMC on June 11, 2009 approved MSL to proceed to APMC
- APMC on June 18, 2009 approved MSL to continue, knowing that:
  - Current reserves are low (~13%) and budget challenges remain
  - Additional reserves may be necessary based on several different cost estimate models

New MSL Project Organization



** Additional Duty*

Issues Resolution Teams Established by the Systems Engineering Team

Fault Protection and redundancy	Actuator Recovery Team
Grounding, EMI/EMC	Surface Energy Augmentation
E-Bridle bridge	Actuators
Motion Control	Surface resources
Sample Transfer	CHEMCAM TEC
Functionality description, flight S/W, V&V	

- EM/testbed hardware being used extensively ahead of the flight hardware to mitigate risks before ATLO

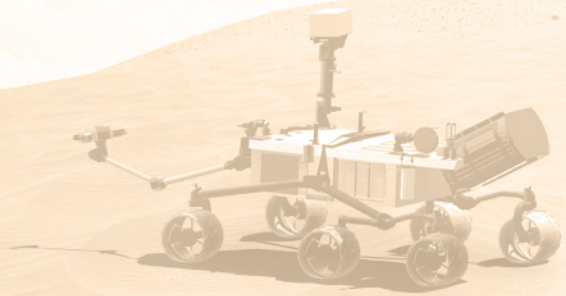
Project Overview and Status

- Key technical and management issues that delayed the 2009 launch are being addressed
  - System and Subsystem design assessment and closure
    - Broad based design assessment performed
      - Issues identified being worked off by the Integrated System Engineering Office (ISEO)
      - Focusing on:
        - » Redundancy/Fault Protection details
        - » Sample chain robustness
        - » Motion control validation
        - » Test infrastructure
  - Actuators
    - Focusing on:
      - Anomaly resolution (thermal backdrive torque, bi-stability)
      - Life test completion
      - Flight Unit Production
    - Project initiated an Actuator Evaluation and Recovery Task in March
      - "Path to flyability"--Analyses and tests that would permit flying existing Aeroflex WSA and LPHTA actuators
      - As an insurance policy, initiated a study of the feasibility of alternate supplier

Project Overview and Status - 2

- Avionics
  - Design Finalization, including resolution of open design issues; maturing of FPGA designs; and resolving Problem Failure Reports (PFR's)
  - Major progress in completion of test infrastructure and maturing of FPGA designs.
  - RCE FM 101 PFR diagnosis (including repeat of environmental testing)
  - PFR resolution in process
  - Start of hardware rework and deliveries scheduled for later in FY.

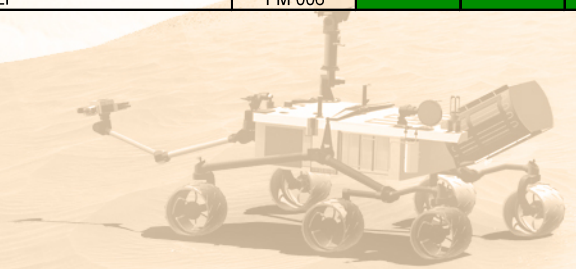
- FSW development and V&V implementation planning
  - Four month S/W development schedule; personnel assignments, including margin, in place
  - FSW capabilities and deliveries synchronized with ATLO needs,
  - Testbed schedule for V&V generated and synchronized with FSW deliveries – substantial margin exists.



Overall Integration Status

		SN	Elect Int	Funct Test	Mech Int
ROVER					
AVS	RCE-A	FM 101			
AVS	RCE-B				
AVS	RPAM-A	FM 102			
AVS	RPAM-B	FM 103			
AVS	RMCA				
AVS	RPA	FM 101			
AVS	RPFA				
AVS	RBAU	NF 001			
RPS	MMRTG	Qual			
GNC	NavCams-A [pair]				
GNC	NavCams-B [pair]				
GNC	HazCams, front-A [pair]				
GNC	HazCams, rear-A [pair]				
GNC	HazCams, rear-B [pair]				
GNC	RIMU-A (LN200)	FM 404448			
GNC	RIMU-B (LN200)	FM 404471			
MECH	RVR Chassis	FM 101	N/A	N/A	
MECH	RVR Heat Exchanger	FM 004	N/A	N/A	
MECH	Mobility				
MECH	Remote Sensing Mast				
MECH	Robotic Arm Assembly				
MECH	PADS Drill				
MECH	CHIMRA				
MECH	SAM Inlet Covers Assembly				
MECH	Chemin Inlet Cover Assembly				
MECH	Pyro Circuits				
PLD	MSSS DEA	EM-MARDI			
PLD	MastCam Heads				
PLD	MAHLI Camera Head				
PLD	MARDI Camera Head	FM 00001			
PLD	ChemCam				
PLD	APXS				
PLD	CheMin				
PLD	SAM				
PLD	RAD				
PLD	DAN				
PLD	REMS				
PLD	Cal Targets				
TEL	RVR X-band	Numerous			
TEL	High Gain Antenna System				
TEL	UHF-A (Electra)	EM001			
TEL	UHF-B (Electra)				
THM	RIPA (Rover IPA)	FS* 001			
THM	Rover Shunt Radiator (RSR)				
THM	Thermal Circuits	N/A			

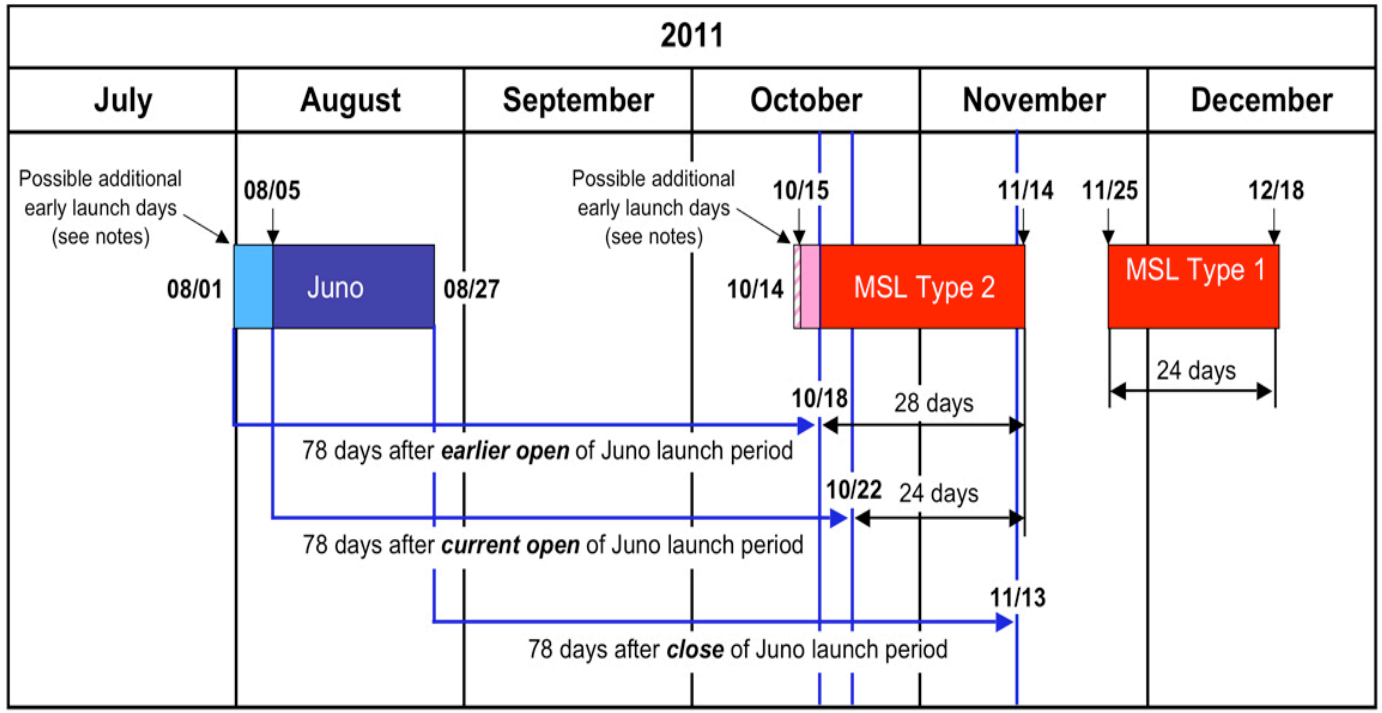
		SN	Elect Int	Funct Test	Mech Int
DESCENT STAGE					
AVS	DPAM-A	FM 104			
AVS	DPAM-B	FM 105			
AVS	DPA	FM 101			
AVS	BLRA	EM 101			
AVS	DMCA				
AVS	PWTB				
AVS	PYTB				
GNC	DIMU				
GNC	TDS	FM 002			
MECH	Pyro Circuits	N/A			
MECH	BUD				
MECH	DS Structure		N/A	N/A	
PROP	Descent RCS	Various			
PROP	Descent MLE	Various			
TEL	DS X-Band	Numerous			
THM	Thermal Circuits	N/A			
CRUISE STAGE					
AVS	CPAM-A	FM 106			
AVS	CPAM-B	FM 107			
AVS	CPA	FM 101			
AVS	CSA	Numerous			
GNC	DSE-A	FM 003			
GNC	DSH-A (x4)	Numerous			
GNC	DSE-B	FM 004			
GNC	DSH-B (x4)	Numerous			
GNC	SSA	FM 009			
MECH	CS Structure		N/A	N/A	
PROP	Cruise RCS				
THM	CIPA (Cruise IPA)	Test 001			
THM	Cruise Shunt Radiator (CSR)				
THM	Thermal Circuits	N/A			
AEROSHELL					
Mech	Backshell		N/A	N/A	
Mech	Heatshield		N/A	N/A	
MEDLI	MEDLI	FM 006			



New Technical Issues

- Rover power system design does not meet present mission requirements, requiring additional battery capacity, and possibly solar array
  - Increased energy requirements to keep actuators above safe operating temperature
  - Almost double energy requirement to operate/conduct SAM instrument science/sample analysis scenarios
- The SAM instrument has not completed its environmental qualification program, and the wide range pump has not demonstrated life qualification (hours of operation and start/stop) requirements.

MSL Launch Period Options



Juno ⇒ Atlas V 551 (LC 41)

MSL ⇒ Atlas V 541 (LC 41)

Juno launch period notes:
Opening launch period four days earlier is contingent on release of at least 50% of launch vehicle margin.

MSL launch period notes:
1. Launch dates earlier than 10/15 currently violate launch vehicle separation attitude constraints.
2. Earliest launch date for target spec is 10/14.
3. Type 1 launch period is unaffected by Juno launch date.

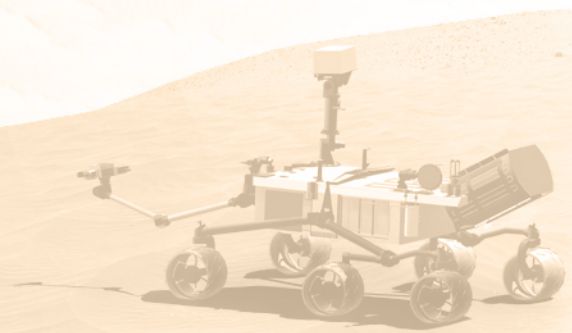
Budget Status and Impacts

- MSL overall budget needs remain around $400M at PMC, but reserves were unacceptably low (~13% cost-to-go)
- Expect a requirement for additional resources to restore reserves to adequate levels ($15-115M), predicted by several different cost models
  - Amount to be determined this calendar year after more progress has made on technical issues
- Impacts must be contained in Planetary Division
  - The Mars Program will repay non-Mars “loans”
- Impacts to cover low- to mid-range budget needs, in order:
  - Reduce or eliminate Mars Program APA in FY10 and FY11
  - Reduce US portion of Mars-16/18/20 missions
  - Reduce Discovery future and New Frontiers mission lines (no impact to current schedules)
- Impacts increase to cover mid- to upper-range budget needs, in order:
  - Further reduce US portion of Mars-16/18/20 missions
  - Delay LADEE and ILN missions
  - Delay New Frontiers 3 phase B selection

The Path Forward

- MSL Project's Baseline readjusted w/additional $400M in President's 2010 budget
- Updated Status to PSS (this meeting)
- Submit MSL Project Cost and Schedule Analysis Report ("Breach Report") to Congress by the end of July
  - Development = $1,631M (68% development overrun); LCC = $2,286M
  - Report states that additional reserves may be needed ($15M to $115M range)
- HQ/SMD will continue tracking progress through weekly meetings and metrics (resolution of technical issues, reserve burn rates, PFR closure rates, workforce profile, etc.)
- Conduct a "Readiness to Proceed" Review in November 2009—actuators, avionics, power, etc.
  - Project must stabilize these key technical issues for meaningful CTG estimates
  - Include updated cost estimate
- After "Readiness to Proceed" Review, assess the need for added funding reserves
  - APMC approval required
  - Bring back to PSS for review

Future Program Planning



ESA and NASA are Forming a Joint Mars Exploration Initiative

- Joint studies began the first week of January, 2009
- Joint ESA-NASA Engineering Working Group (JEWG)
  - Developed cooperative architecture options for shared mission responsibilities
- Joint Instrument Definition Team (JIDT)
  - Defined minimum investigation capabilities for orbital science, to focus EWG studies
  - Focused on orbital measurements: Trace Gas Detection and mapping, aerosols, surface mapping
- Joint Executive Board
  - JEWG and JIDT reported to an Executive Board made up of senior ESA and NASA Managers
    - NASA: McCuistion, Meyer
    - ESA: Coradini, Ellwood
  - In-depth analyses and meetings occurred, January –June 2009
  - The Board's determined that multiple options for mission portfolios are budgetarily and technically feasible, but additional analyses are required to determine the most feasible
  - June 2009 ESA-NASA Bi-lateral meeting endorsed the determination and authorized additional studies encompassing a broader range of mission portfolio studies

Study Principles Established for an ESA/NASA Collaboration

NASA Principles

1. Partnership must address NASA/MEP/NRC, as well as ESA, science goals

2. NASA-ESA establish a strategic partnership for Mars exploration in 2016/18/20 and beyond, with immediate focus on ExoMars and 2016-18

3. Plans must be budgetarily and technically realistic
3a. Develop two plans: what we can afford to do, and the "best" partnership

4. Shared science and science efforts on all missions, including sharing science data

5. Substantial collaboration will create dependencies, and must build on both party's strengths and strategic interests

6. Missions should be segmented with clean interfaces (ITAR requirements must be complied with as well)

7. US does EDL in at least one opportunity of 2016-18 (NASA core competency)
8. US has a surface system in at least one opportunity of 2016-18 (NASA core competency)
9. US provides an ELV in no more than one opportunity of 2016-18

10. Shared opportunities require shared credit for outreach, public relations and national/organizational prestige

11. Missions must show identifiable progress toward Mars Sample Return

***NOTE:* Red/italics items do not have a specific cross-reference**

ESA Principles

> 4. ESA science priority for ExoMars—Exobiology

> 1. ESA-NASA establish a strategic partnership for Mars exploration in 2016/18/20 and beyond, with immediate focus on ExoMars and 2016-18

> 2. Shared science and science efforts on all missions, including sharing science data

> 5. ESA technology tenants for ExoMars-EDL, rover, drilling, sample preparation and distribution

> 7. Missions should be segmented with clean interfaces

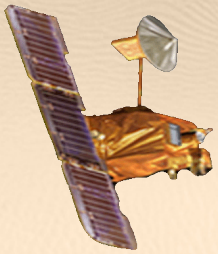
6. Lead agency to be defined for each mission. For ExoMars (2016), ESA would like to be the lead agency

> 9. Shared opportunities require shared credit for outreach, public relations and national/organizational prestige

> 3. Missions must show identifiable progress toward Mars Sample Return

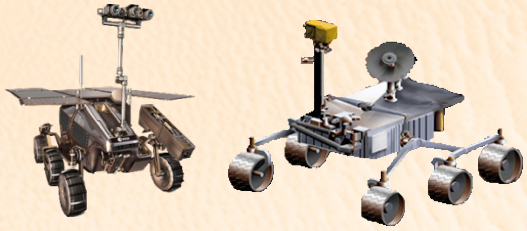
8. Need a communications data relay orbiter for 2016 opportunity which could be used as a science opportunity as a secondary objective

Leading Elements for Future Architectures



Trace Gas & Telecomm Orbiter

- Detect a suite of trace gases with high sensitivity (ppt)
- Characterize their time/space variability & infer sources
- Replenish orbiter infrastructure support for the Program

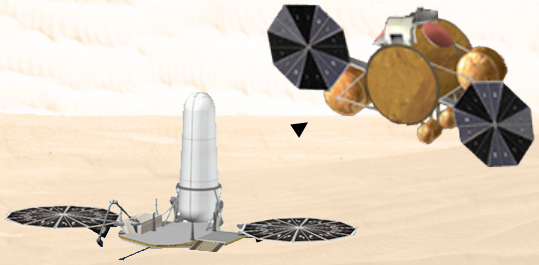


Rovers

- Explore Mars habitability in the context of diverse aqueous environments provided by a new site
- Begin process of preparing samples for return

Geophysical Surface Science

- Determine the planet's internal structure and composition, including its core, crust and mantle
- Collect simultaneous network meteorological data on timescales ranging from minutes to days to seasons



Mars Sample Return

- Make a major advance in understanding Mars, from both geochemical and astrobiological perspectives, by the detailed analysis conducted on carefully selected samples of Mars returned to Earth

Joint ESA-NASA Mars Exploration Initiative

- The Initiative's mission portfolio will span 2016 through 2020 opportunities, with goal of Mars Sample Return in the 2020's
- Follow-up on the recent methane discovery, and emplacement of long-term telecommunications relay capability, are important (a NASA-priority)
- Completion of the ExoMars mission is important (an ESA-priority)
- Studies begin this week for 2016-2020 mission queue:
  - Astrobiology is the overall scientific focus
  - Geological, geophysical and geochemical sciences are a high priority
  - Surface systems are expected to predominate mission types
  - Sample return technologies will factor prominently in mission design, such as
    - Precision sample handling
    - Sample preparation and caching
    - Precision landing
- A new series of intense studies are being initiated under these premises
  - Results timed to provide more detail on mission queue to the Decadal's Mars Panel in September, and the ESA Council Meeting in October

MART, and Their Assessments

- The Mars Architecture Review Team (MART) is a Program-level team established to assess MEP architecture's, science "compliance", risks and alternatives—sort of an "Program-level SRB"
  - Reports to the NASA Mars Program Director
  - No scientific evaluation or competition with community recommendations (NRC, PSS, MEPAG)
  - No development of architectures to accomplish science—that's an inherently governmental activity
  - Two meetings have occurred to provide input on possible architectures for a bi-lateral Mars Program with ESA

- Findings to date focused on US accommodation of the current ExoMars mission on the 2016 NASA orbiter mission, and follow-on 2018 opportunity
  - Astrobiology focus well supported by the suite of missions; 2016 trace gas/methane orbiter is a high priority for later landers (and comm.)

MART, and Their Assessments

- Accommodation of 1200kg ExoMars Decent Module Composite represents an unacceptable level of technical risk for both Agencies
- Architecture options of acceptable risk are beyond either agency's budgets
- NASA's 2018 lander mission is ill-defined WRT critical science and technology
- Recommended options to consider that could reduce cost and risk to acceptable levels, such as spreading ExoMars elements across multiple opportunities, or a NASA-led orbiter in 2016 followed by the lander(s) in later opportunities.
- Reiterated a *ESA/NASA Guiding Principle* of the cooperation, that all missions need feed-forward to returning samples in the future

- The plan is to internationalize MART to support the joint ESA/ NASA Mars Initiative