The Mars Exploration Program

Still Following the Water

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Director, Mars Exploration Program
NASA HQ

1st Mars Express Science Conference
February 24, 2005

Agenda

- Mars Exploration Program – The Current Decade
- Next Decade of Mars Exploration
- Strategic Roadmapping and Future Human Exploration of Mars
- International Partnerships

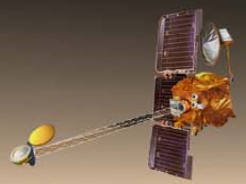
Mars Exploration Program - the Current Decade

Launch Year

OPERATIONAL

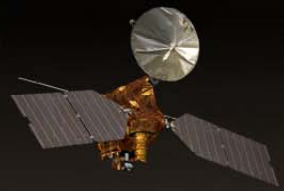
Mars Global Surveyor

ESA
Mars Express



Mars Odyssey

2005



Mars
Reconnaissance
Orbiter
(Italian SHARAD)

2007

2009

Mars Telesat

...Next Decade

Explore the Evolution of Mars

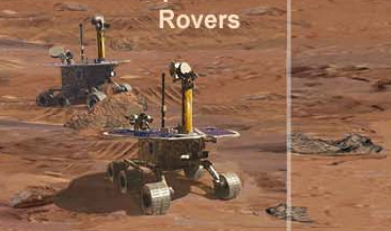
Search for Evidence of Past Life

Science pathways responsive to discovery

Search for Present Life

Explore Hydrothermal Habitats

Competed Scout Mission



Mars
Exploration
Rovers

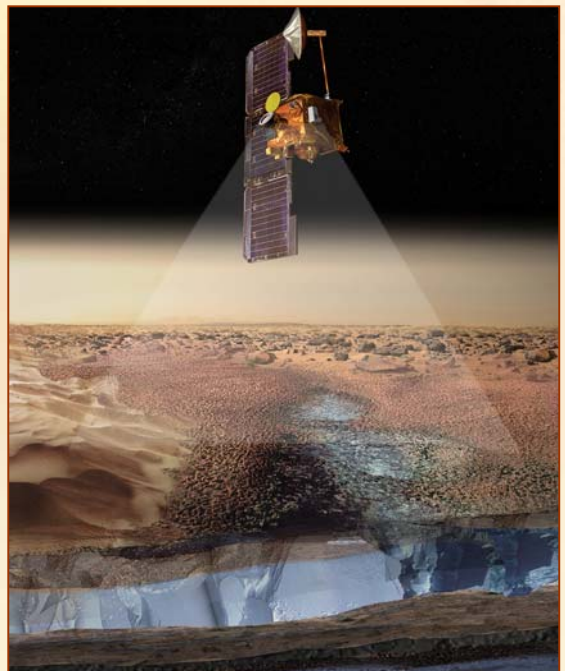
Phoenix

Mars Science
Laboratory

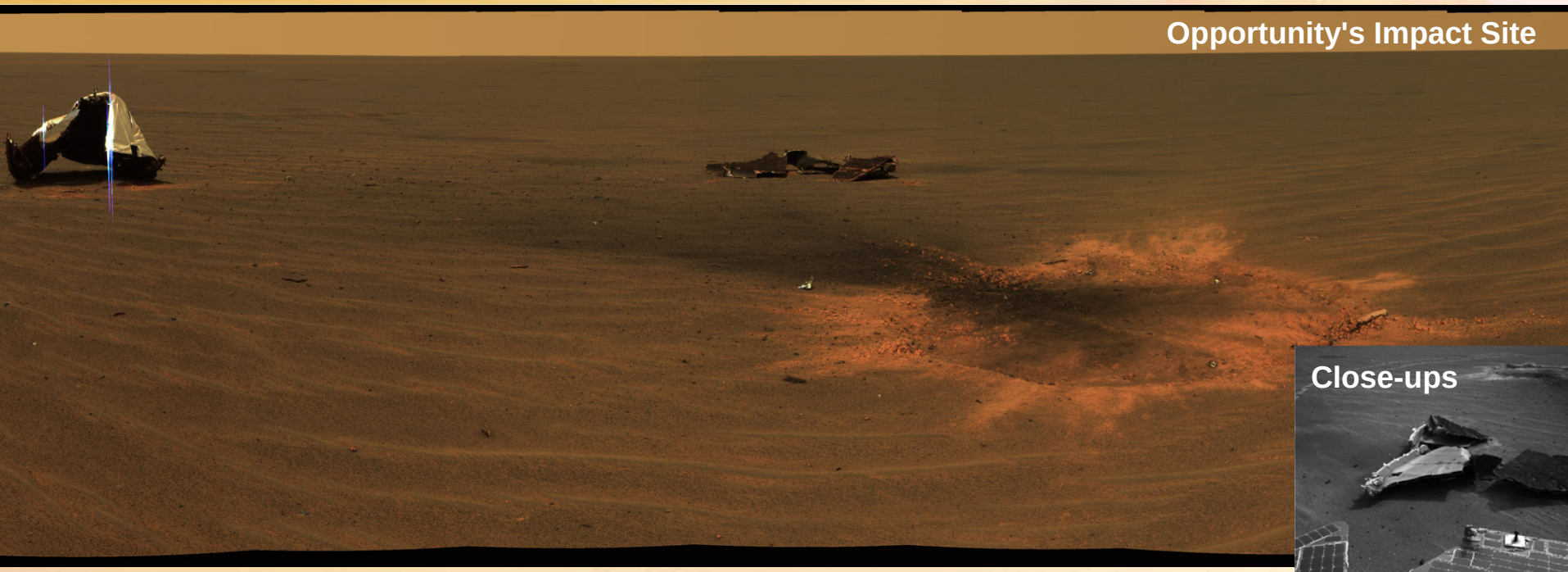
Operating Missions Highlights

- MGS' 3rd mission extension (10/04 – 09/06) proceeding well
- MGS has been productive longer than any other spacecraft sent to Mars and has returned more images than all past Mars missions combined

- Extended mission through September 2006 approved. Goal is to look for climate change.
- Odyssey UHF Relay Campaign very successful
  - Now relaying nearly 100% of MER data



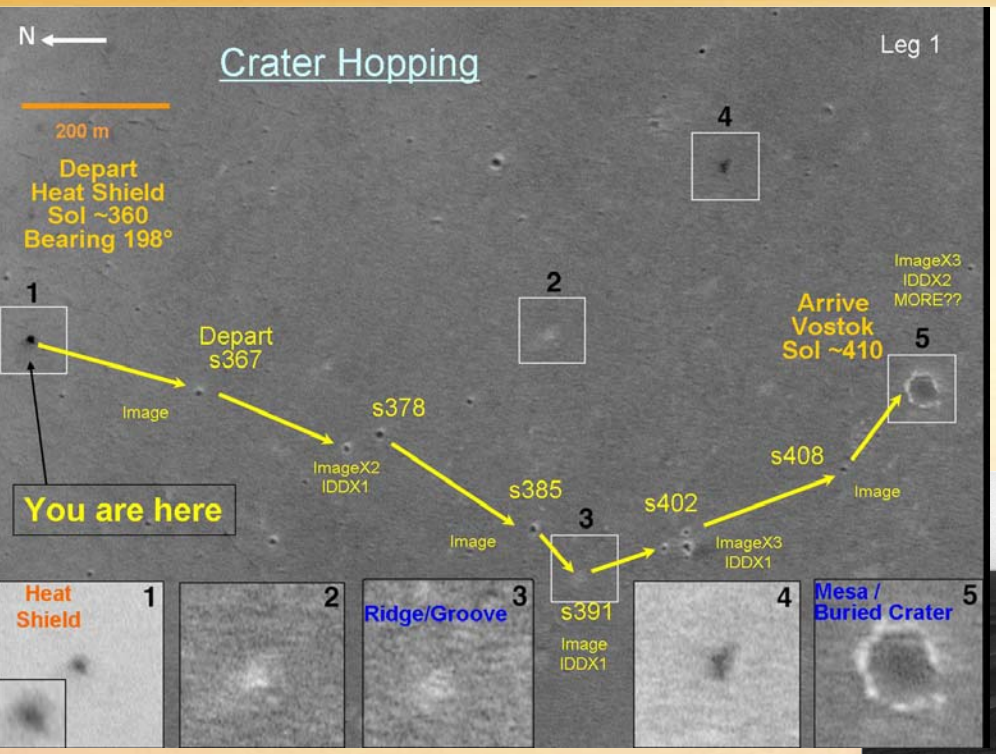
Rovers: the Trek Across Mars Continues

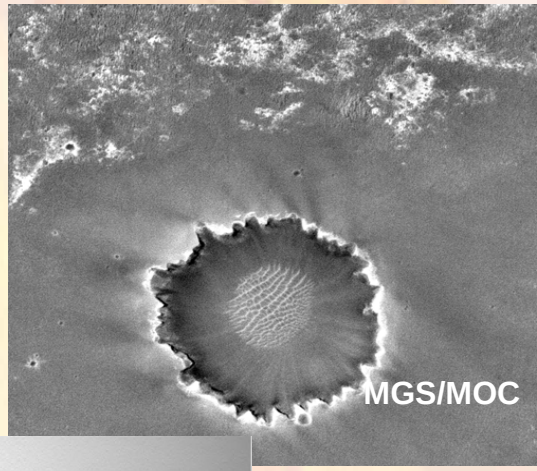


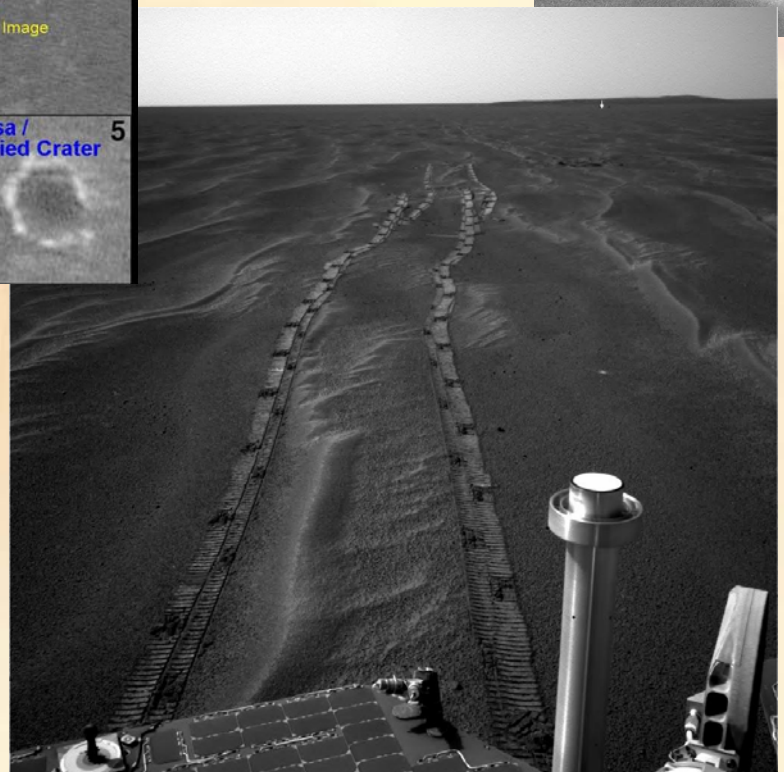
- ***Celebrated one (Earth) year on Mars in January!***
- **MER extended mission operations continue to go extremely well**
  - **Planning underway for next mission extension**

	Spirit	***Opportunity***
Design Life:	**90 sols**	**90 sols**
Mission to Date:	**408 sols**	**387 sols**
Planned Distance:	**600 m**	**600 m**
Distance to Date:	**4070 m** (as of sol 387)	**2200 m** (as of sol 358)
Total Images:	**31,699**	**29,093**

Opportunity: The Goal….Victoria Crater

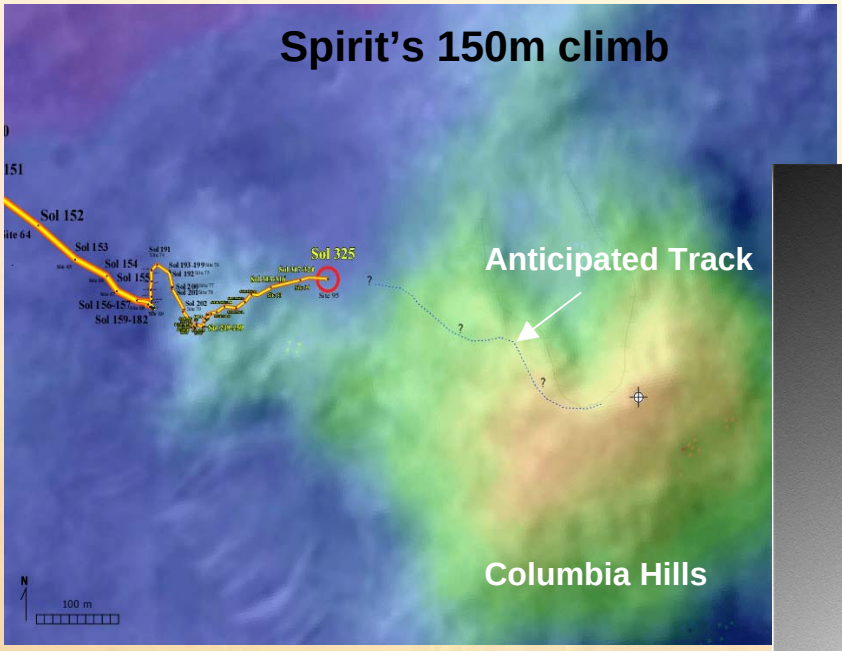


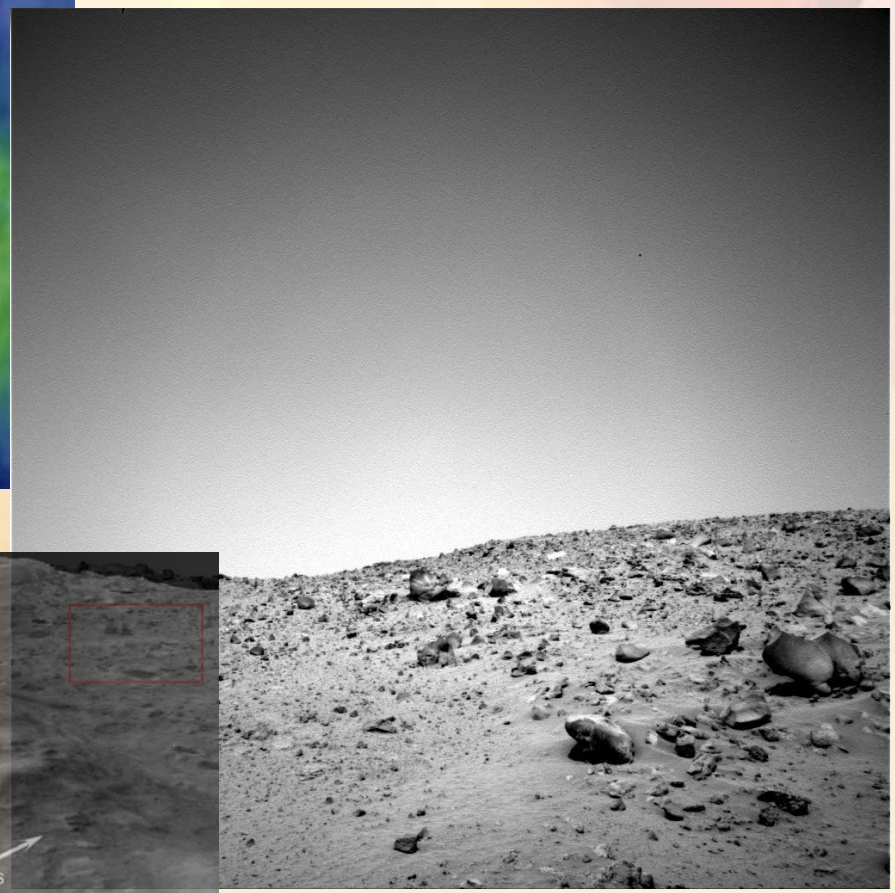


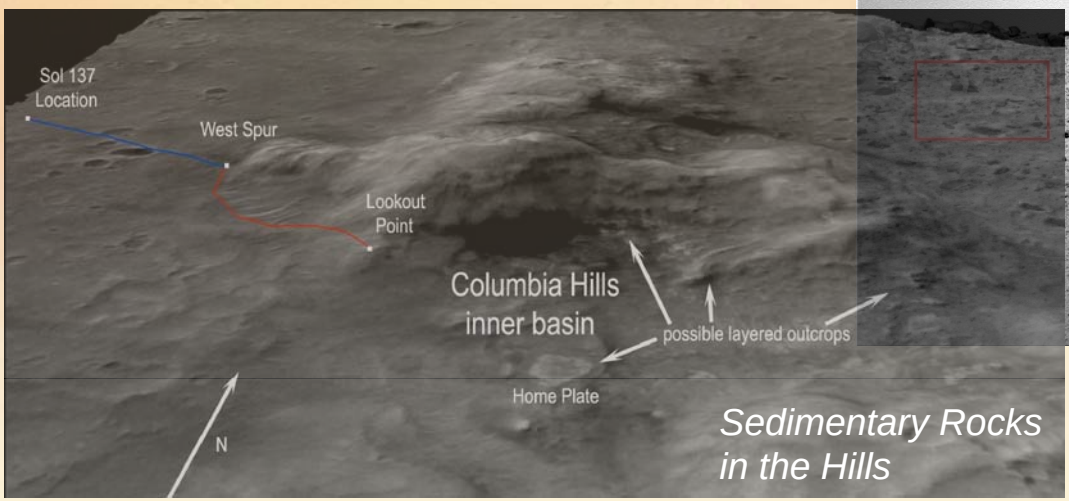


Deeper into the Martian record "books"?

Spirit: “The Road Less Traveled”





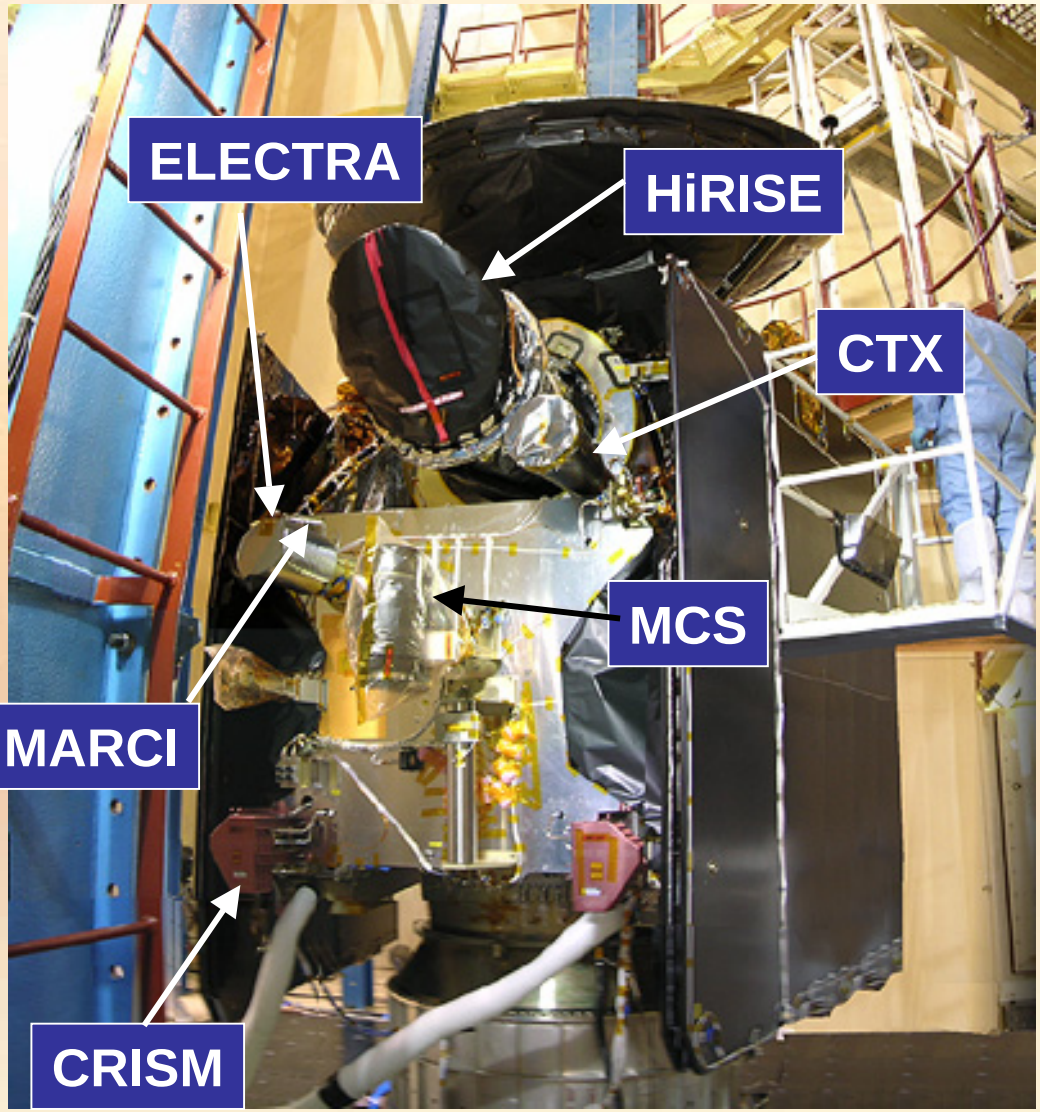


2005 Mars Reconnaissance Orbiter (MRO)

Outstanding progress being made as MRO continues in Environmental Testing

- All instruments delivered and integrated
- S/C completed acoustic and shock testing in January
- System level mechanical testing completed
- Thermal vac started February 10
- Pre-Ship Review: March 30
- Ship to KSC: April
- Launch Window: August 10-30

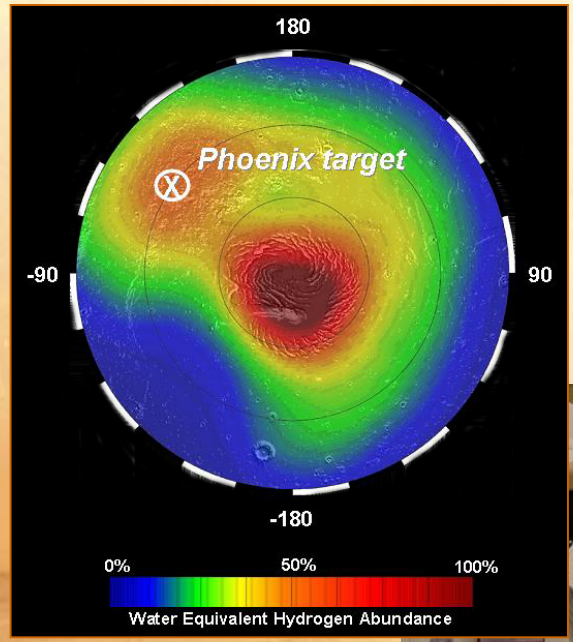
MRO Almost Ready to Go

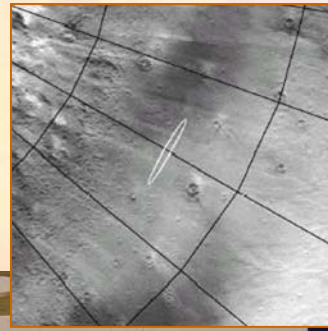


2007 Competed Scout Mission: Phoenix

In situ investigation of volatiles, organic molecules, and modern climate

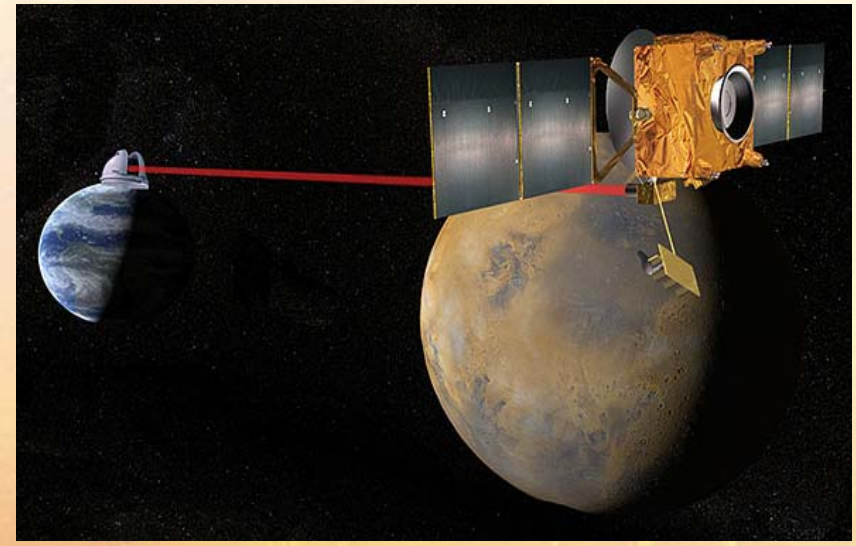
- **SSI – stereo imaging**
- **RAC – robotic arm sample images**
- **TEGA/MS – sample chemical composition**
- **MECA – habitability measurements**
- **MET/LIDAR – meteorology**
- **MARDI – landing site imagery**





- **Payload PDRs Completed in November**
- **Heritage Reviews Completed in December**
- **Mission-level PDR March 2005 (delayed 30 days)**
- **Confirmation Review April 2005**
- **Launch August 2007**

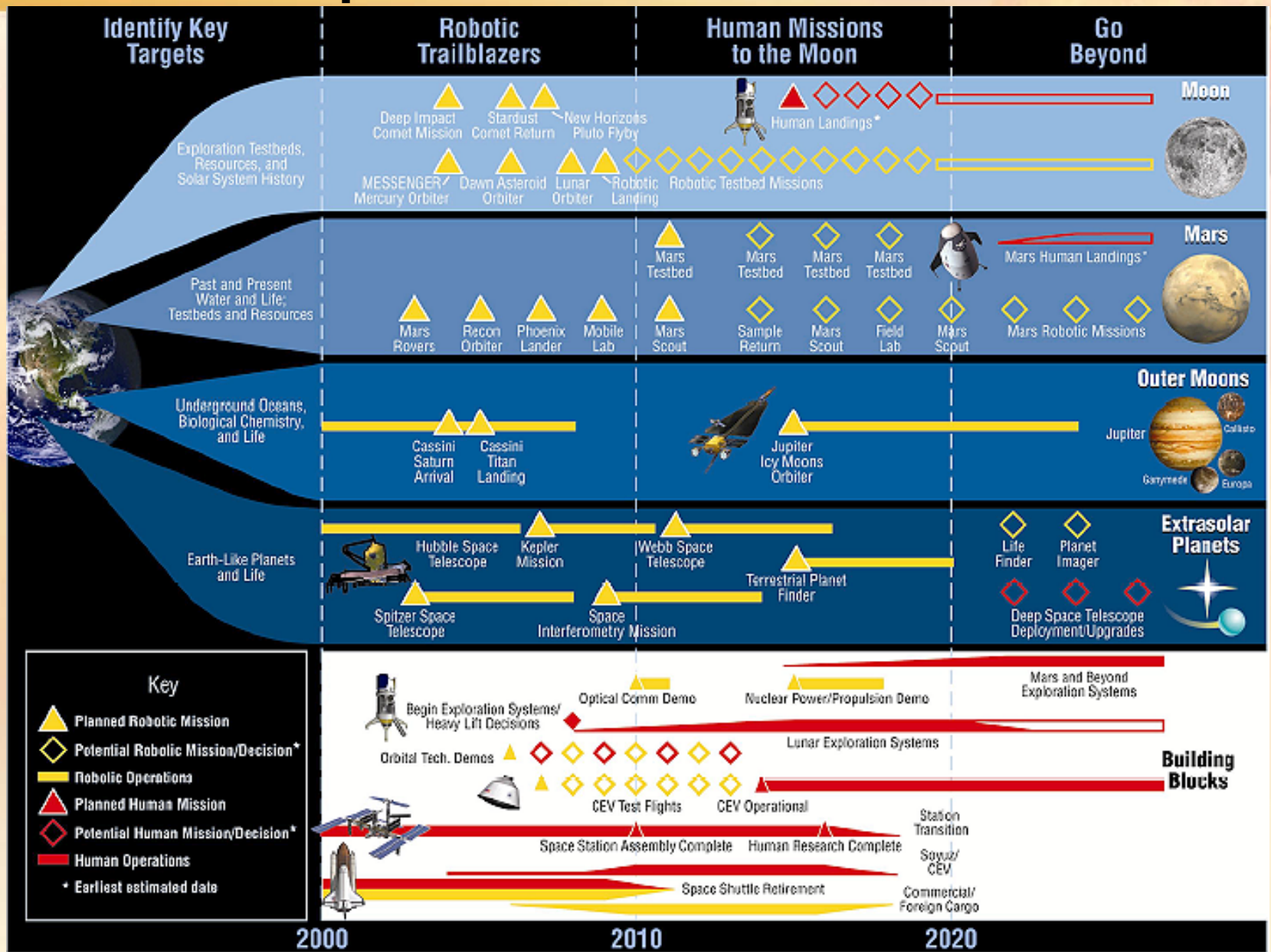
2009:
Mars Telecom Orbiter and Mars Science Laboratory



	MER	MSL
Landed Mass	174 kg	~600 kg
Designed Driving Distance	600 m	5000-10,000 m
Mission Duration	90 sols	687 sols
Power/Sol	400 - 950 w/hr	~2400 w/hr
Instruments (#/mass)	7/~5.5 kg	9/65 kg
Data Return	50-150 Mb/sol	100-400 Mb/sol 500-1000 Mb/sol (with MTO)
EDL	Ballistic Entry	Guided/Precision Entry

- S/C RFP released November 2004; contract award expected in March/April 2005
- Science AO under development; planning to release internal draft AO by mid-March
- Launch October 2009

Mars Exploration Program's Integral Role in Human Exploration



Agency Roadmaps

1. Undertake robotic and human exploration of the Moon to further science and to enable sustained human and robotic exploration of Mars and other destinations. (Agency Objective 4)

2. **Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration. (Obj 5)**

Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions, and after successfully demonstrating sustained human exploration missions to the Moon. (Obj 6)

3. Conduct robotic exploration across the solar system to search for evidence of life, to understand the history of the solar system, to search for resources, and to support human exploration. (Obj 7)

4. Search for Earth-like planets and habitable environments around other stars. (Obj 8)

5. Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit. (Obj 10)

6. Focus research and use of the International Space Station on supporting space exploration goals, with emphasis on understanding how the space environment affects human health and capabilities, and developing countermeasures. (Obj 12)

7. Return the Space Shuttle to flight, complete assembly of the International Space Station, and transition from the Space Shuttle to a new exploration-focused transportation system. (Obj 11)

8. Explore our Universe to understand its origin, structure, evolution, and destiny. (Obj 9)

9. Explore the dynamic Earth system to understand
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or life

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Mars Robotic *and* Human Exploration Requirements

11. Provide advanced aeronautical technologies to meet the challenges of next-generation systems in aviation, for civilian and scientific purposes, in our atmosphere and in the atmospheres of other worlds. (Obj 3)

12. Use NASA missions and other activities to inspire and motivate the nation's students and teachers, to engage and educate the public, and to advance the scientific and technological capabilities of the nation. (Obj 14)

13. Develop a comprehensive national plan for utilization of nuclear systems for the advancement of space science and exploration. (No Agency Obj)

Search for Past Life Pathway
"Point of Departure" Architecture

Scout & Mars Testbed

Mars Testbed

Mars Testbed

2006 President's Budget

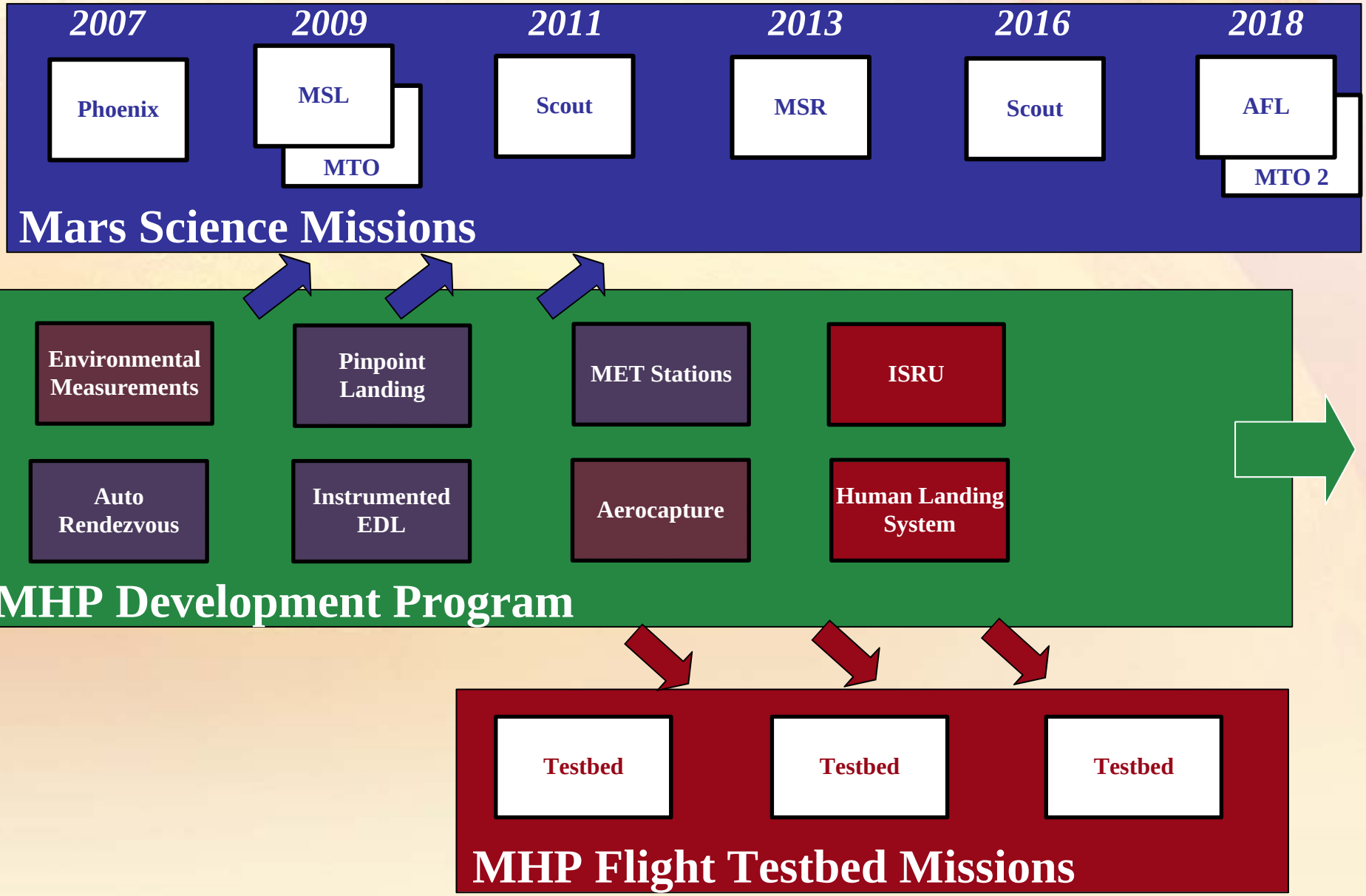
Mars Human Precursors Requirements

- Requirements study for human precursor missions
  - Measurements
  - Technology/Infrastructure
  - Near term mission architecture

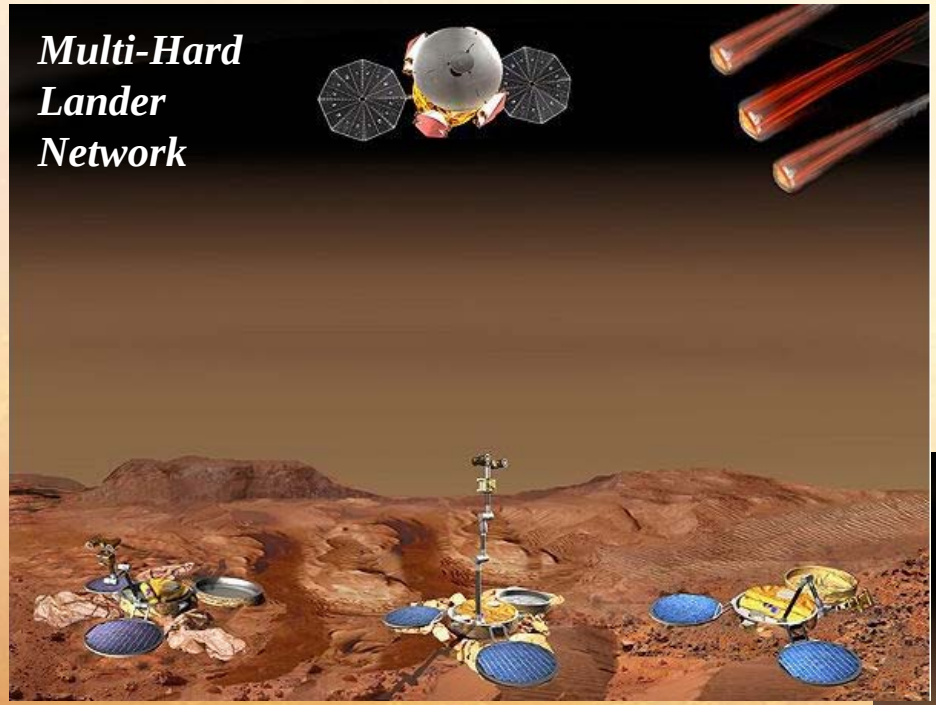
- Results categorized into:
  - Early Phase (2011-2016)
  - Mid Phase (2018-2022)
  - Late Phase (2024-2030)
  - …and broken out by priority

	MHP SSG Investigation	MHP SSG Measurement Category
	DUST - ENGINEERING EFFECTS	Characterize surface soil (Early)
		Characterize suspended dust (Early)
		Characterize dust from storm (Mid)
		Soil from different locations (Mid)
	ATMOSPHERE (EDL/TAO)	Upper, middle & lower - EDL (Early)
		Surface parameters over time (Early)
		Long-term orbital remote sensing (Early)
		EDL/TAO ascent/descent probes (Late)
	BIOHAZARDS	Draft Test Protocol (Mid)
		Organics at future landing site (Late)
	ISRU WATER	Equatorial water ground truth (Early)
		Ice deposits: 40-55 deg latitude (Early)
		Polar near-surface water/ice (Early)
		Other locations/depths (Mid)
	DUST TOXICITY	Toxicity - at least one site (Mid)
		Surface dust/water reactions (Mid))
		Dust grains shape (Mid)
		Toxic effects in human surrogates (Mid)
	ATM. ELECTRICITY	Electrical properties at surface (Mid)
		Electrical properties at surface with MET (Mid)
	FORWARD PLANETARY PROTECTION	Environmental effects on organics (Mid)
		Aeolian effects on organics (Mid)
		Organic contamination by landed HW (Mid)
		Surface-subsurface organic transport (Mid)
	RADIATION	Charged particles at surface (Mid)
		Neutrons (Mid)
		Radiation shielding ability of soil/regolith (Mid)
		Simultaneous orbital SEP events w/surface (Mi
	SURFACE TRAFFICABILITY	Vertical soil density profile (Mid)
		Internal angle of friction (Mid)
		Soil Cohesion (Mid)
		Precision imaging of sites (Mid)
	DUST STORM METEOROLOGY	Surface dust storm weather (Mid)
		Long-term weather from orbit (Mid)
	AEROCAPTURE	70 deg sphere cone shape (Early)
		New shape robotic scale (Mid)
		New shape human scale (Late)
	ISRU DEMOS	ISRU Atmospheric Processing (Early)
		ISRU Regolith-Water Processing (Early)
		ISRU Human-scale dress rehearsal (Late)
	PINPOINT LAND.	10m - 100m accuracy (Mid)
	COMM. INFRAST.	Continuous & redundant in situ comm (Late)
	MATERIALS	Materials degradation over time (Mid)
	APPROACH NAV	Accurate, robust, autonomous (Mid)

Integrating MEP and MHP



Testbed Missions will be Needed



- Take advantage of the Science Program to meet several of the human precursor needs
- Testbed Missions (early next decade) that concentrate on the "gap" requirements, by priority

- Target a major subscale (but human-scalable) landing and ISRU demo late next, or early 3rd, decade

International Partnerships

- Extensive International cooperation has been successful in the Mars Program
  - MGS – France, Austria
  - Odyssey – Russia, France
  - MER – Germany, Denmark
  - MRO – Italy, UK
  - MEX – US on ESA s/c
  - Phoenix – Switzerland, Germany, Denmark, Canada
  - MSL – Spain, France, Russia, Canada, Germany
- The Mars Exploration Program intends to continue these partnerships

Science Mission Directorate (SMD) International Conference

- An opportunity to continue our dialog on collaboration

- Workshop Goals
  - Present NASA/SMD's sceince priorities, especially in light of the National Vision for Space Exploration
  - Identify areas for mutually beneficial collaboration in science
  - Build on existing and ongoing relationships, as well as dialog from the Exploration Workshop in November 2004

- Agenda
  - Day 1—Plenary Sessions
  - Day 2—Breakout Sessions (Mars is Session #1)

March 8-10, 2005
University Of Maryland Inn and Conference Center
http://www.tisconferences.com/smd

In Conclusion….

- NASA's Mars Exploration Program is healthy, continuing to make new discoveries
- NASA strategic roadmapping activities have the potential to yield new scientific opportunities, as well as new challenges
  - Human Exploration precursor technology and mission needs are being integrated
- Mars Science will have additional opportunities with the NASA Vision and Aurora
  - We must work together—human exploration and science—through …
    - strategic collaborations,
    - tactical contributions,
    - ….and especially robust commitments