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Mars Exploration Rover Surface Operations

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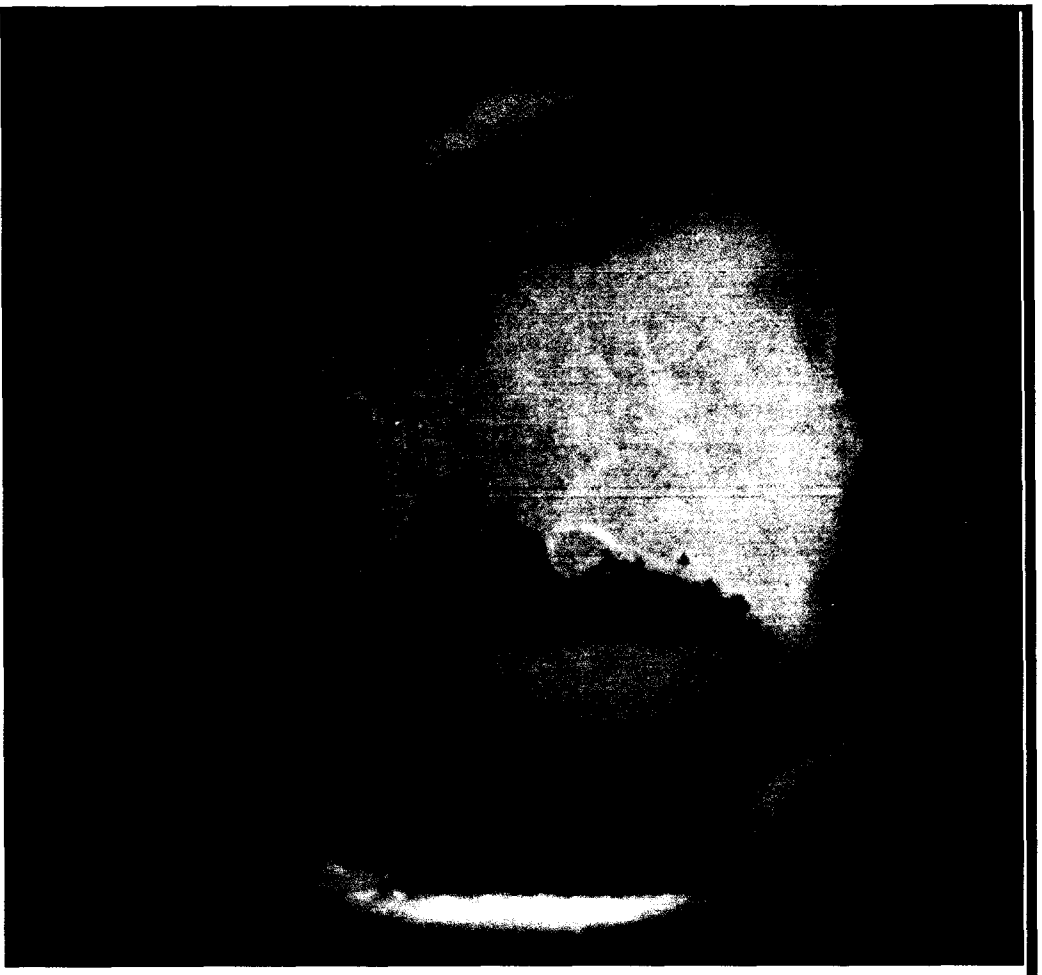
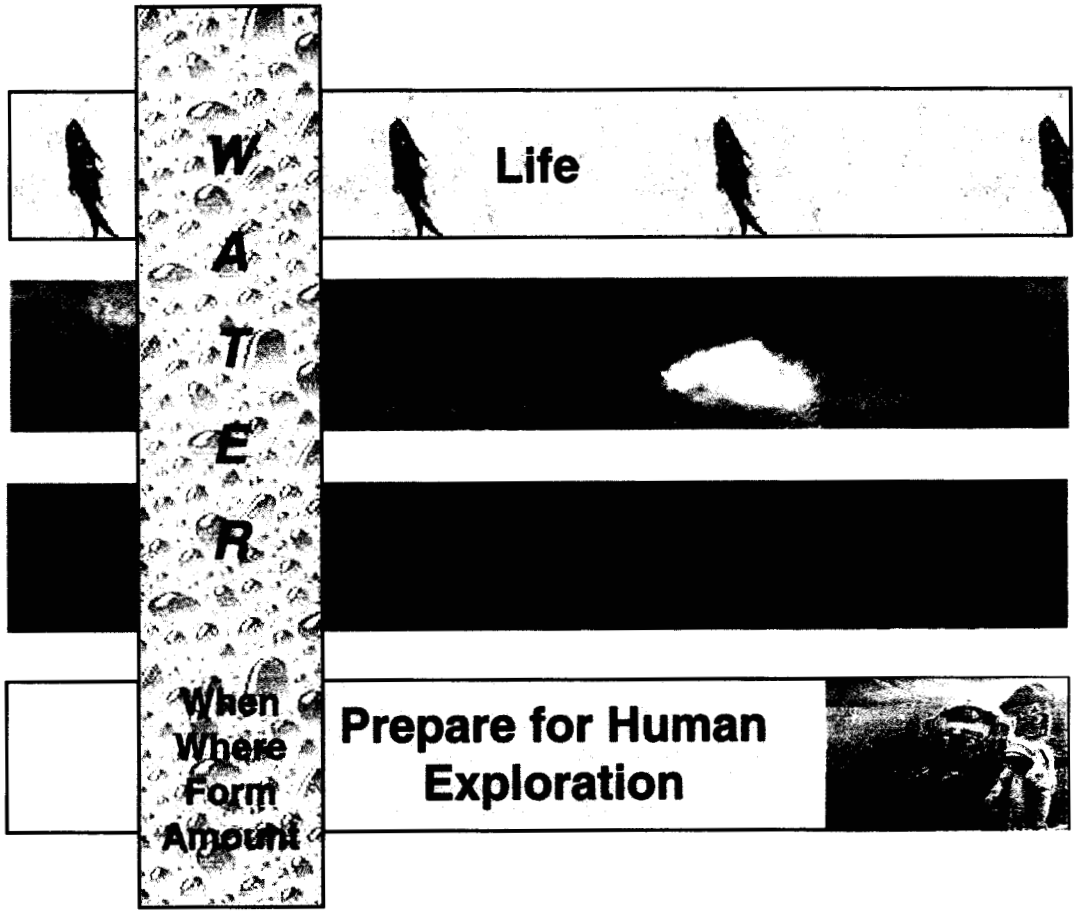


53rd International Astronautical Congress
The World Space Congress - 2002
10-19 Oct 2002/Houston, USA

The Mars Science Strategy: "Follow the Water"



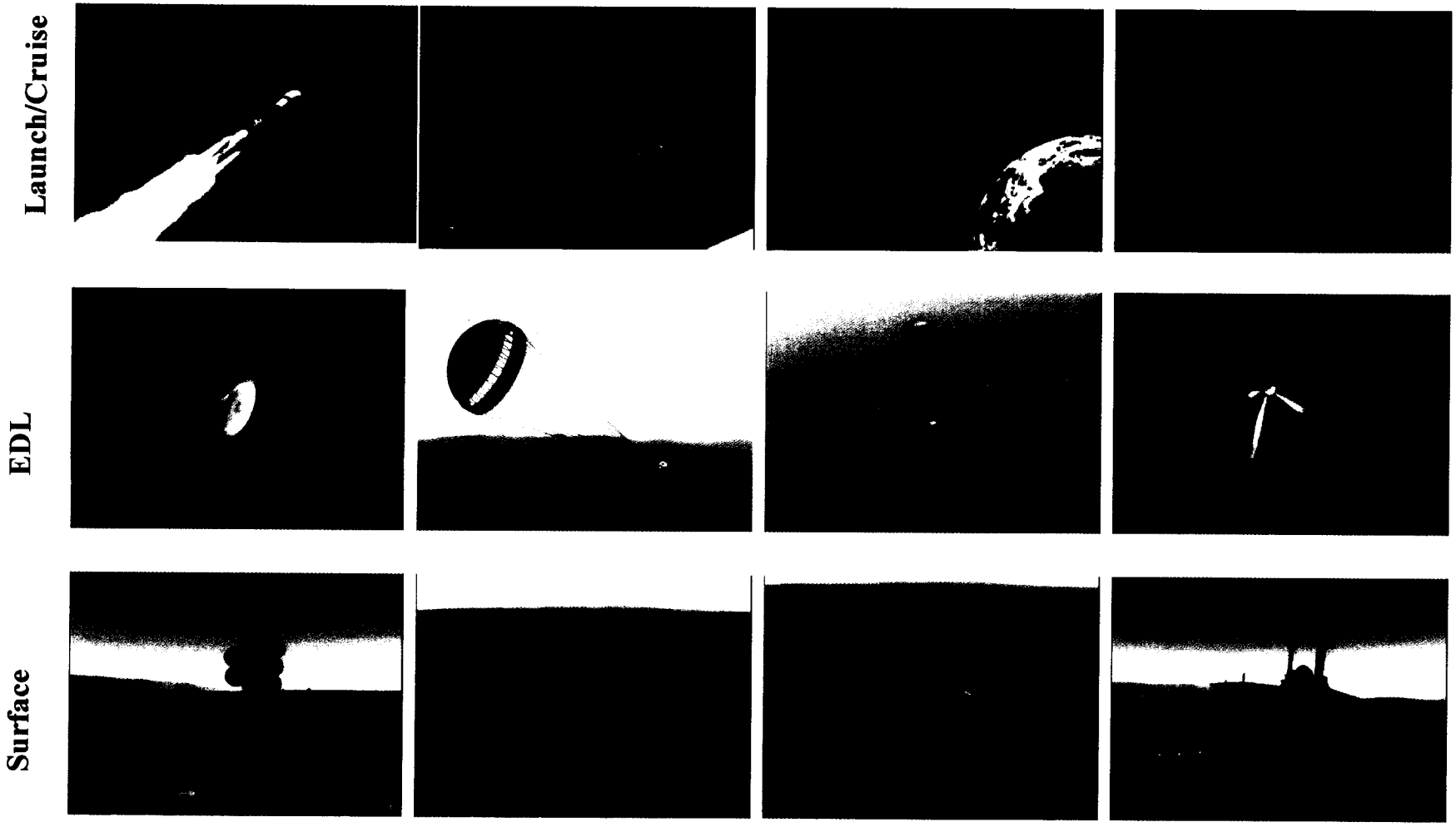
Understand the potential for life elsewhere in the universe

Characterize the present and past climate and climate processes

Understand the geological processes affecting Mars' interior, crust, and surface

Develop the knowledge & technology necessary for eventual human exploration

Mission Overview (1)



Images From Mission Animation by Dan Maas

Mission Overview (2)

- **MER-A and MER-B: 18-day Launch Periods (Type I Transfer Trajectories)**
  - **MER-A**
    - **Delta II 7925 launch vehicle: (max $C_3 \leq 9.3$ km^2/s^2, spacecraft injected mass $\leq$ 1063 kg)**
    - **Launch period: May 30, 2003 through June 16, 2003**
    - **Constant arrival date: January 4, 2004 (Ls = 328°)**
  - **MER-B**
    - **Delta II 7925H launch vehicle: (max $C_3 \leq 16.8$ km^2/s^2, spacecraft injected mass $\leq$ 1063 kg)**
    - **Launch period: June 25, 2003 through July 12, 2003**
    - **Constant arrival date: January 25, 2004 (Ls = 339°)**
- **Interplanetary Cruise / Mars Approach**
  - **Total of 6 TCMs: L + 15days, L + ~75days, E - ~60days, E - 8days, E - 2days, E - 6hours**
  - **Navigation Using Independent, Complementary Data Types**
    - **Doppler, Range, ΔVLBI (ΔDOR)**
  - **Cruise and Approach Phase Activities**
    - **Post-launch spacecraft checkout / calibration**
    - **Science / instrument checkout**
    - **ACS / navigation calibration and characterization and ΔVLBI performance tests**
    - **EDL M-FSK tone tests**
    - **Spacecraft attitude adjustments to maintain Earth/Sun pointing**
    - **Test and training activities (Operational Readiness Tests: Approach, EDL, and Surface operations)**
  - **EDL Preparation**
    - **Activation of EDL flight software**
    - **EDL Turn-to-Entry attitude at Entry - 70 minutes**
    - **Cruise stage separation**

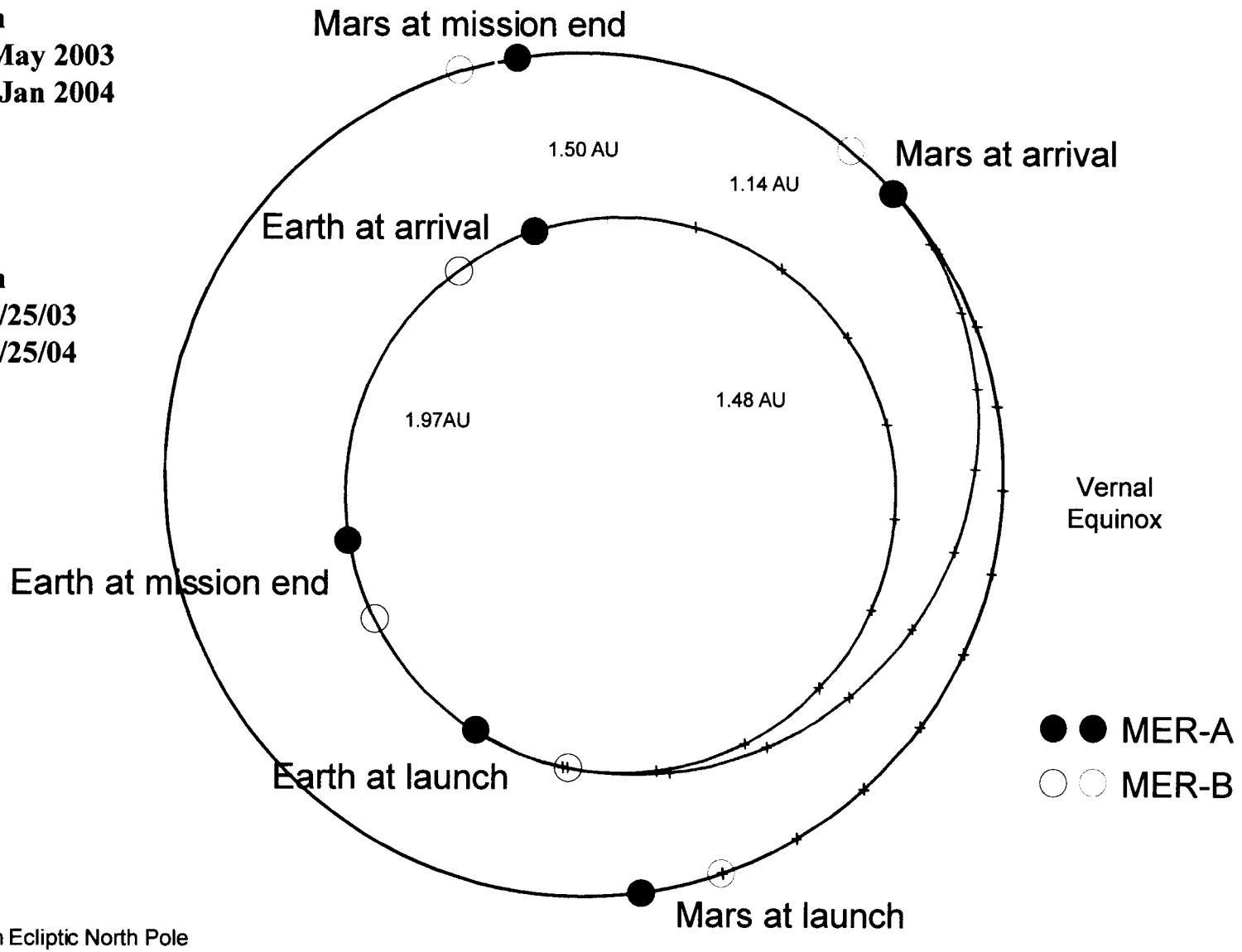
Mission Overview (3)

- **Entry, Descent and Landing (EDL)**
  - **Posigrade Entry**
  - **MPF-derived EDL System**
    - **Flight system capability: 825 kg entry mass, surface altitude ≤ -1.3 km relative to MOLA areoid**
  - **EDL Communications**
    - **Real-time X-band DTE (Direct-to-Earth) communications during EDL (Doppler and M-FSK tones)**
    - **MGS capture of MER telemetry transmitted via UHF-band link during EDL**
- **Surface Mission**
  - **Landing site latitude range:** MER-A: 15° South to 5° North. MER-B: 10° South to 10° North
  - **Science**
    - **Imaging science: Pancam, Mini-TES, engineering cameras**
    - **In-situ science: APXS, Mössbauer, Microscopic Imager, Rock Abrasion Tool**
      - **Instrument placement using Instrument Deployment Device (IDD)**
  - **Operations Strategy**
    - **Daily DTE / DFE (Direct-from-Earth commanding) each morning, daily DTE session each afternoon**
    - **Data return via X-band DTE link and UHF-band link with MGS and Mars Odyssey**
    - **Scenario margins in: activity duration, comm opportunities, DSN coverage, energy, and environments**
  - **Key Mission Success / Mission Return Criteria (per mission)**
    - **90 sols of surface science operations (after the landing sol)**
    - **600 meter odometer traverse (system qualified to 1000 meters)**
    - **~ 4 distinct locations (including landing location)**
    - **~ 6 targets: one soil, five rock (one of which is abraded with RAT)**
    - **~ 3 Gbits total data return (~ 4 Gbits for MER-A)**

Interplanetary Trajectory

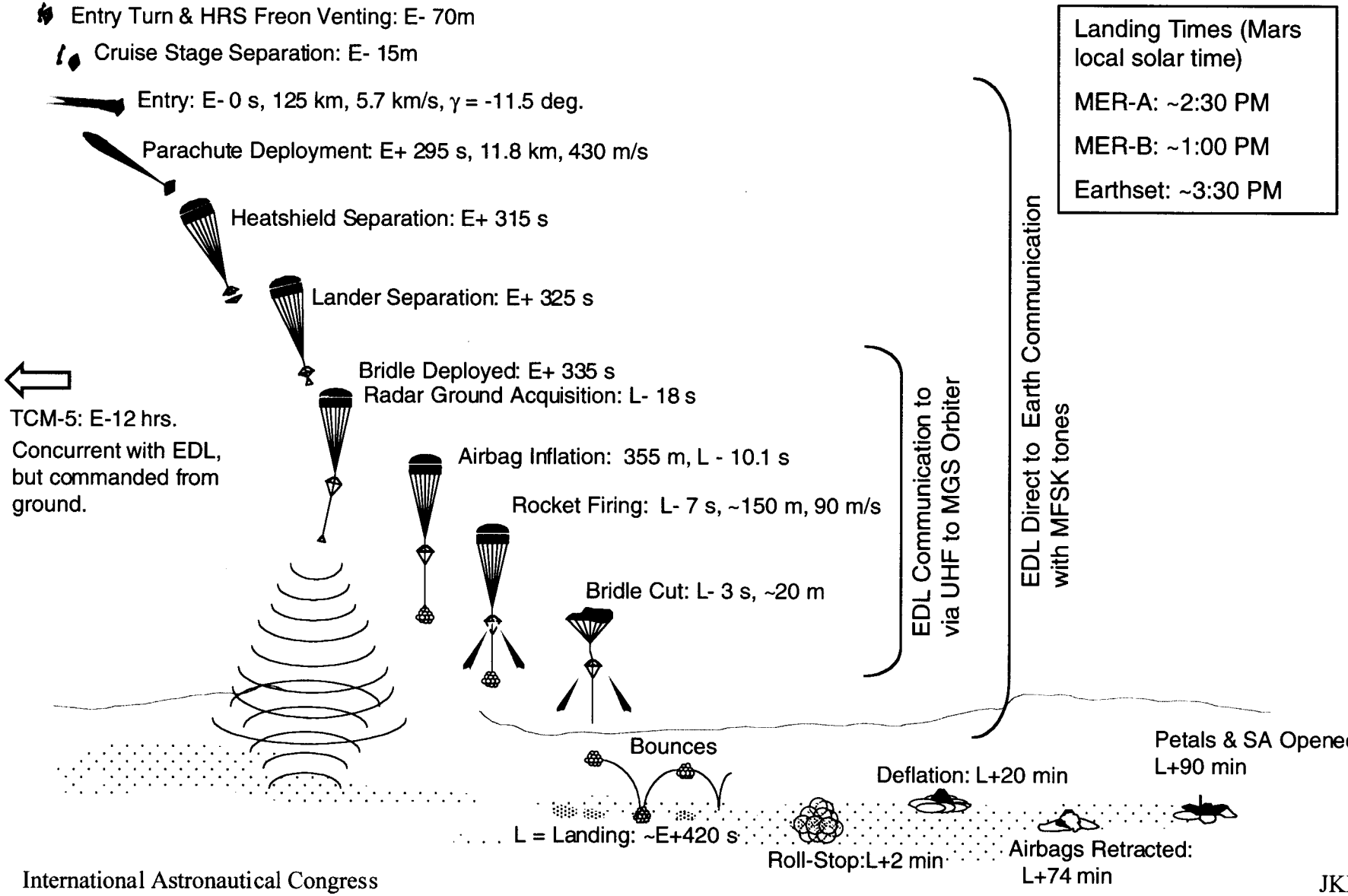
MER-A Open
Launch 30 May 2003
Arrival 4 Jan 2004

MER-B Open
Launch 6/25/03
Arrival 1/25/04

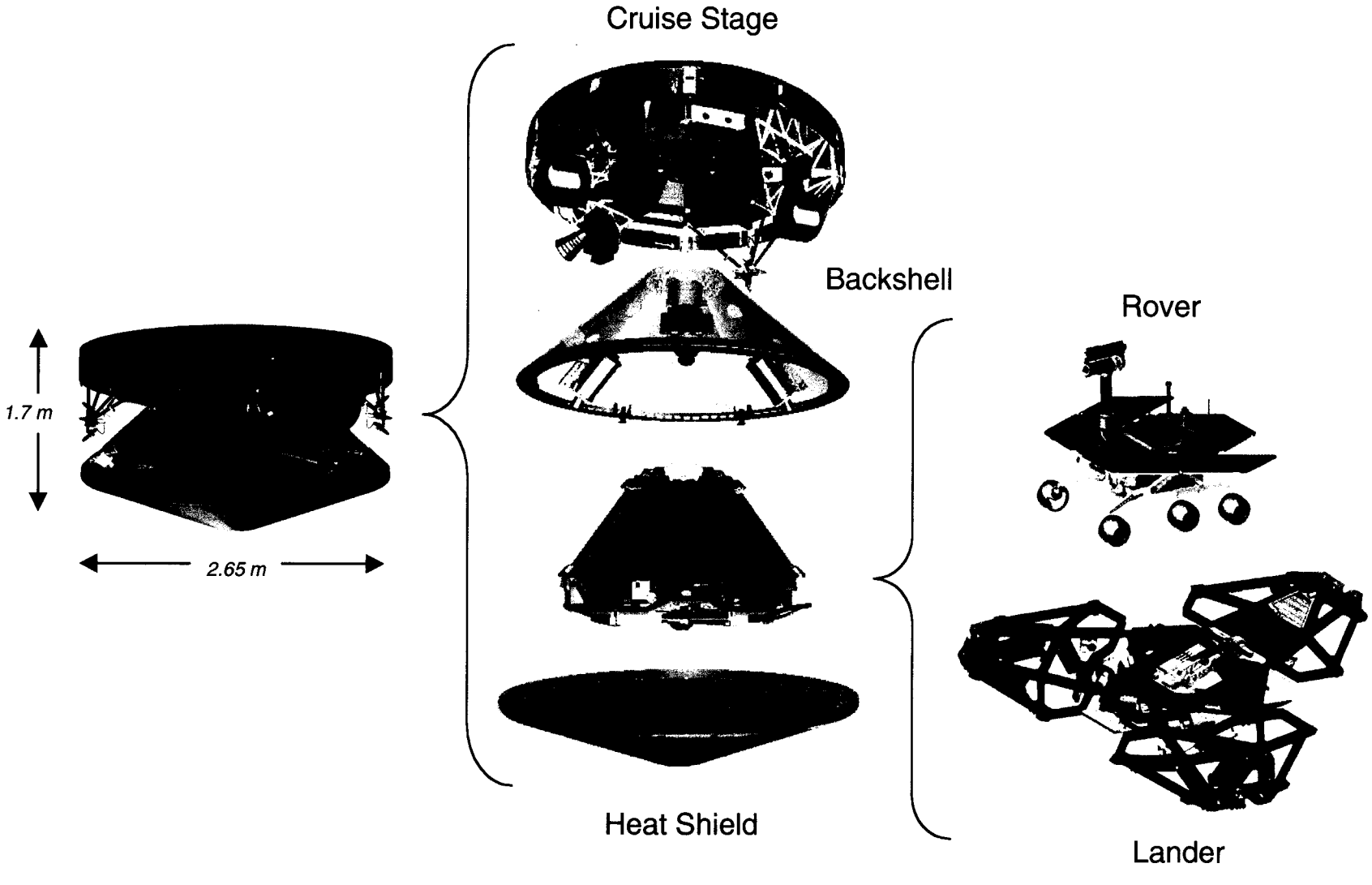


View from Ecliptic North Pole
20 day tick marks

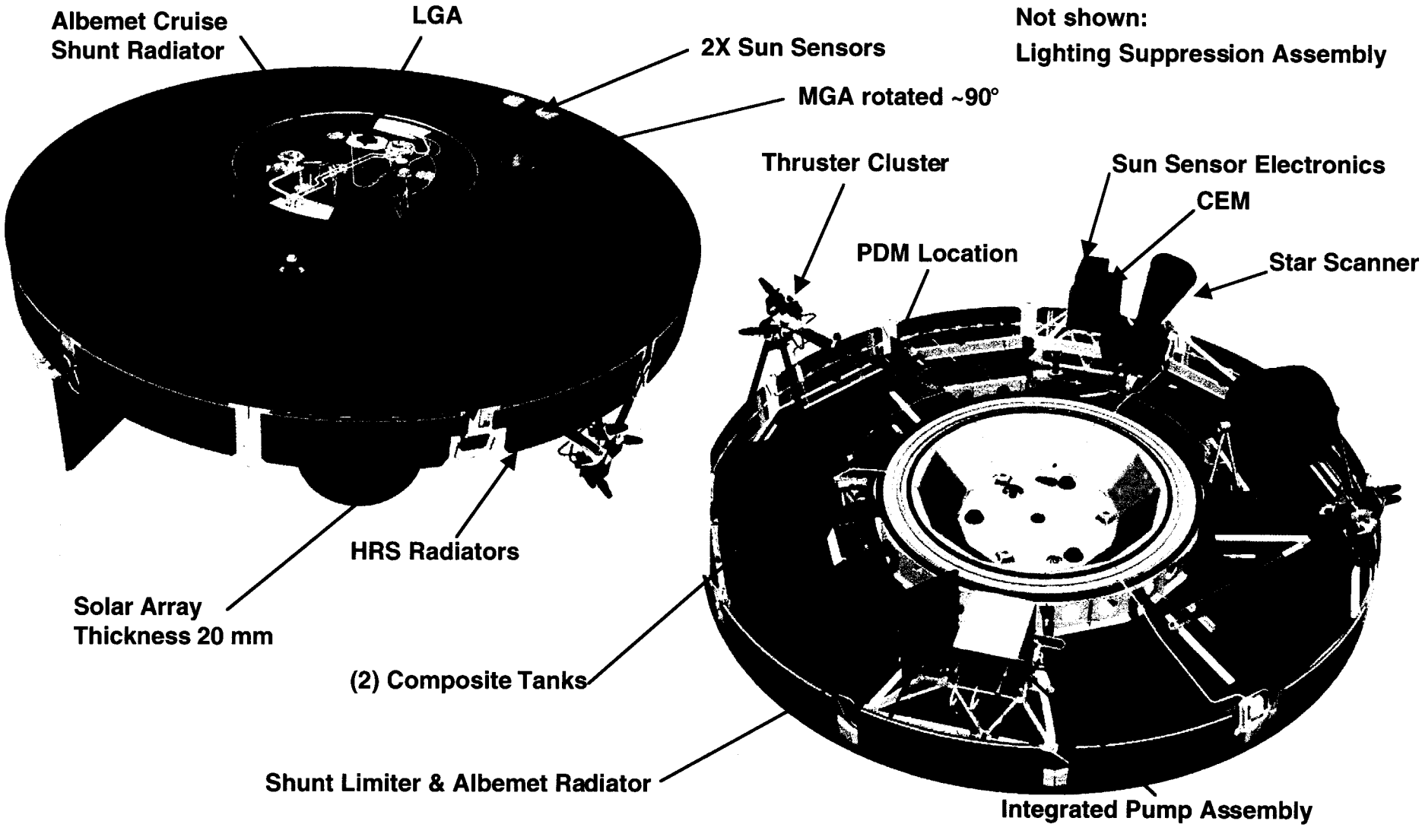
Entry, Descent & Landing (EDL) Scenario



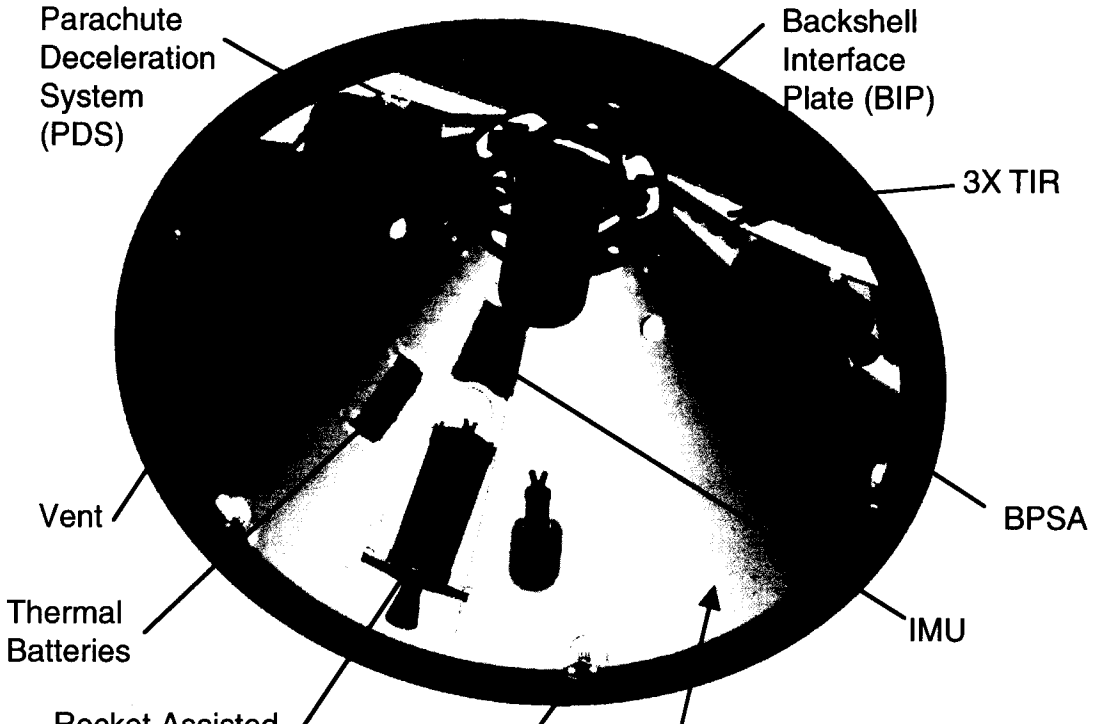
Spacecraft Configuration

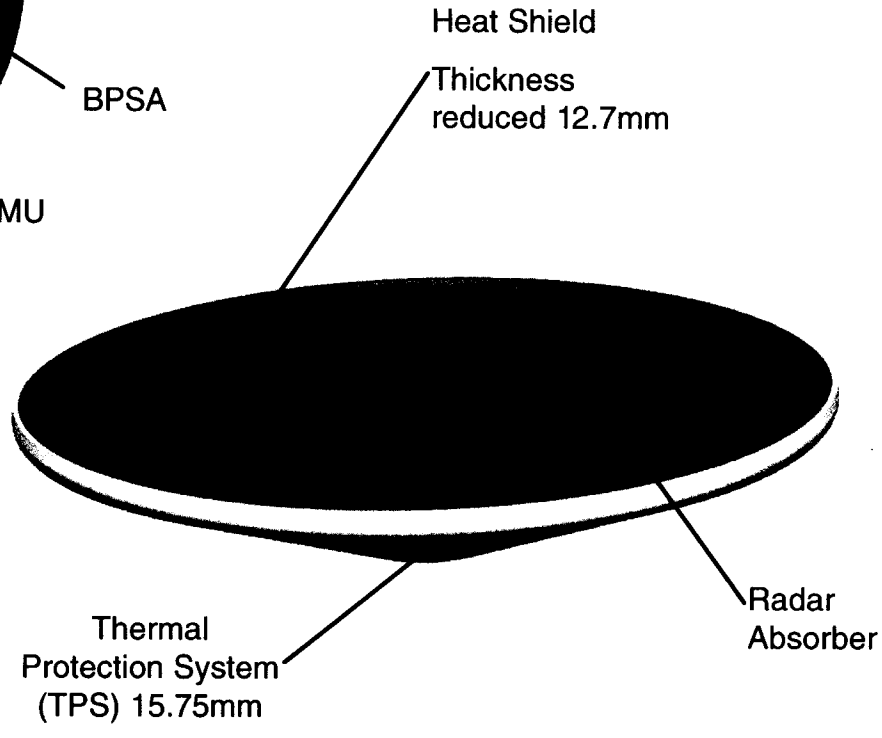


Cruise Stage Configuration

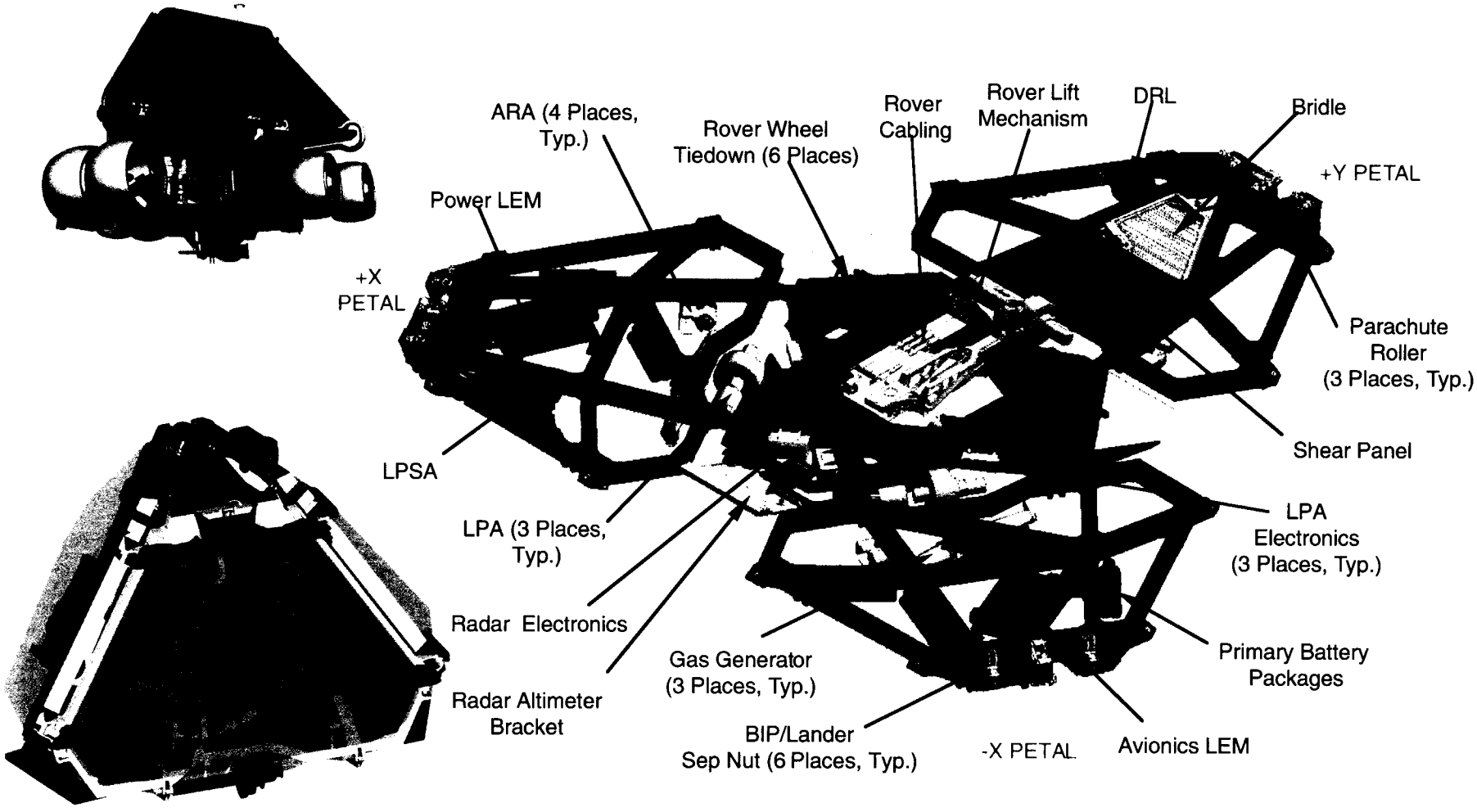


Aeroshell Configuration

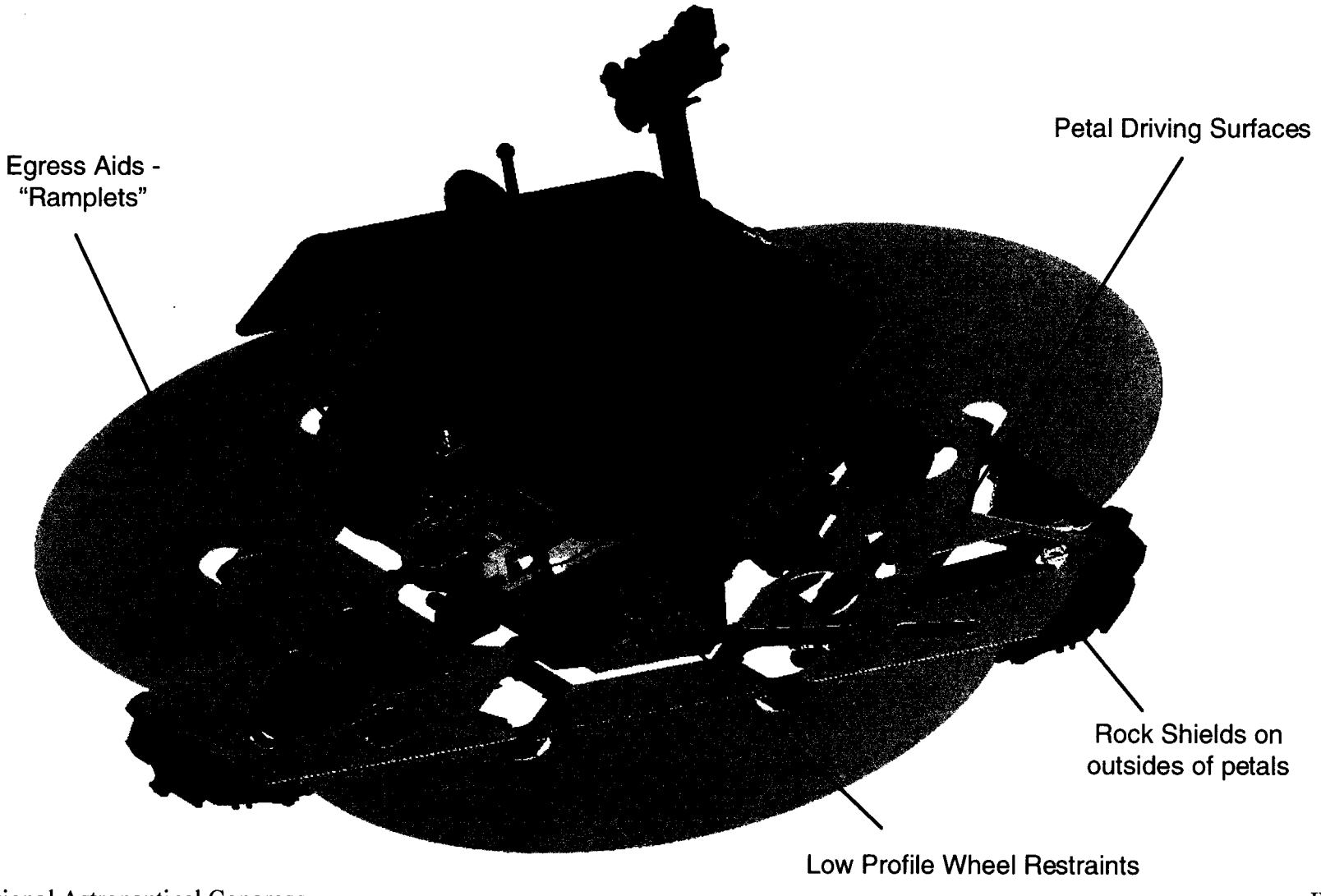




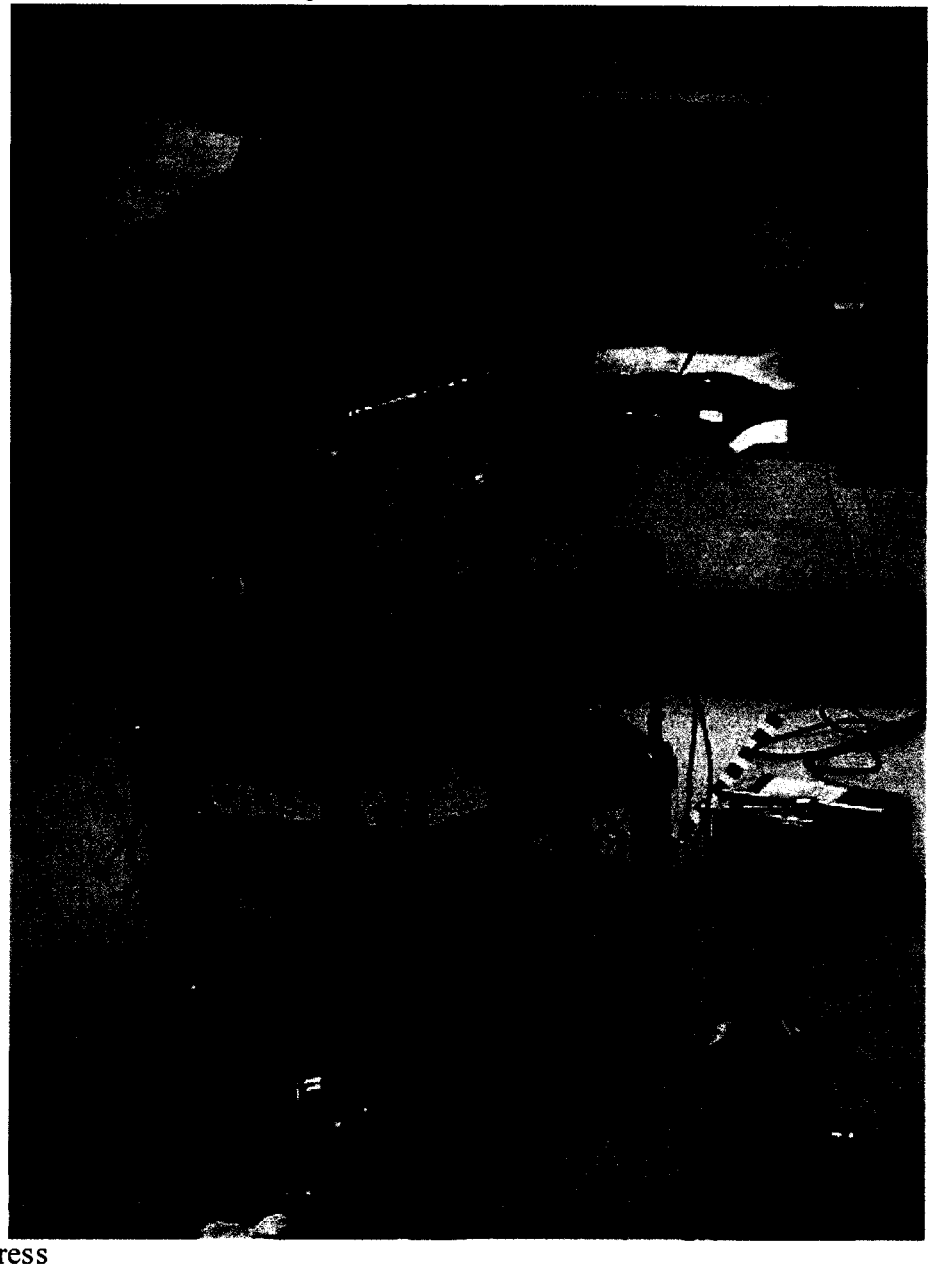
Lander Configuration



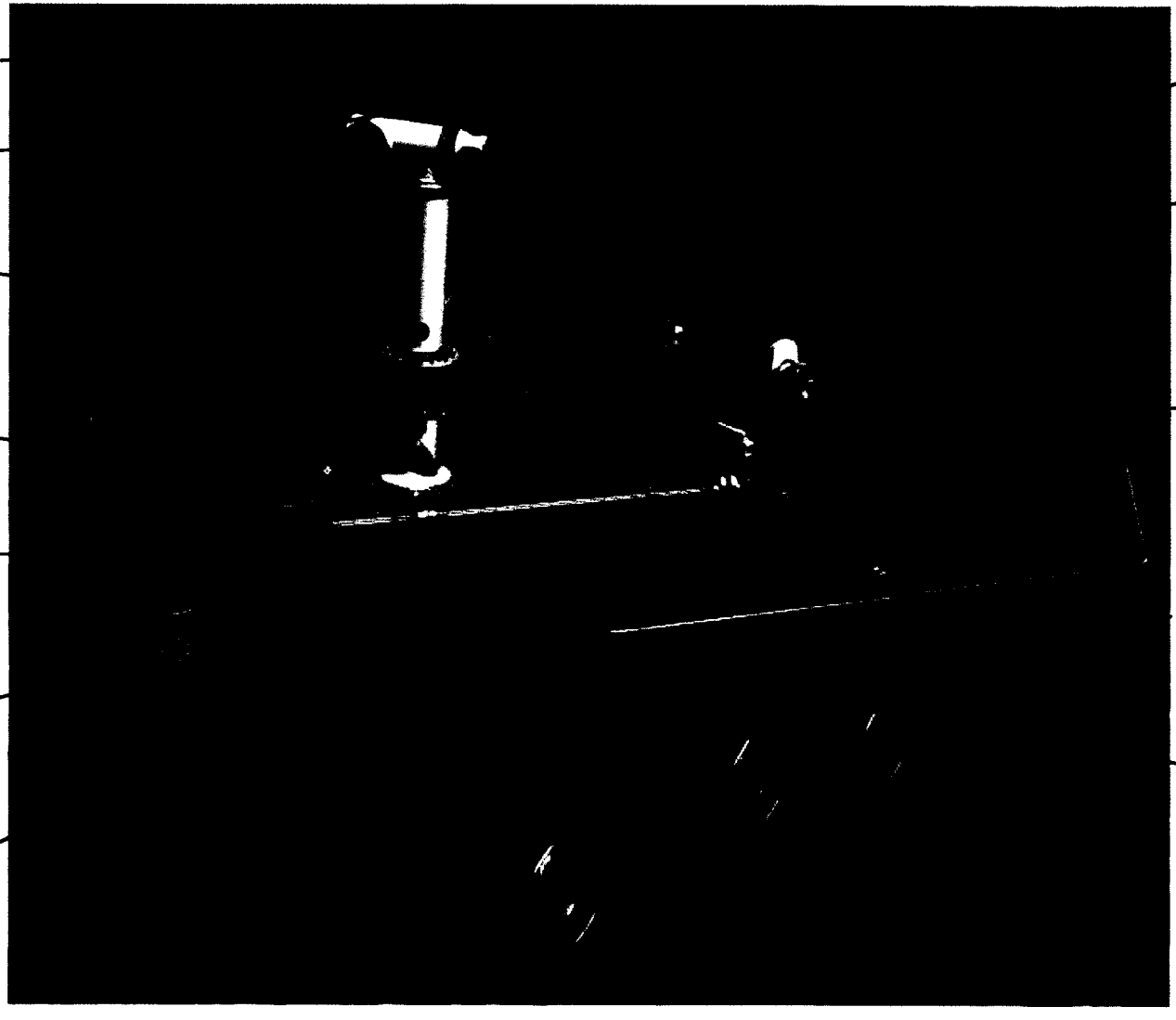
Deployed Rover on the Lander



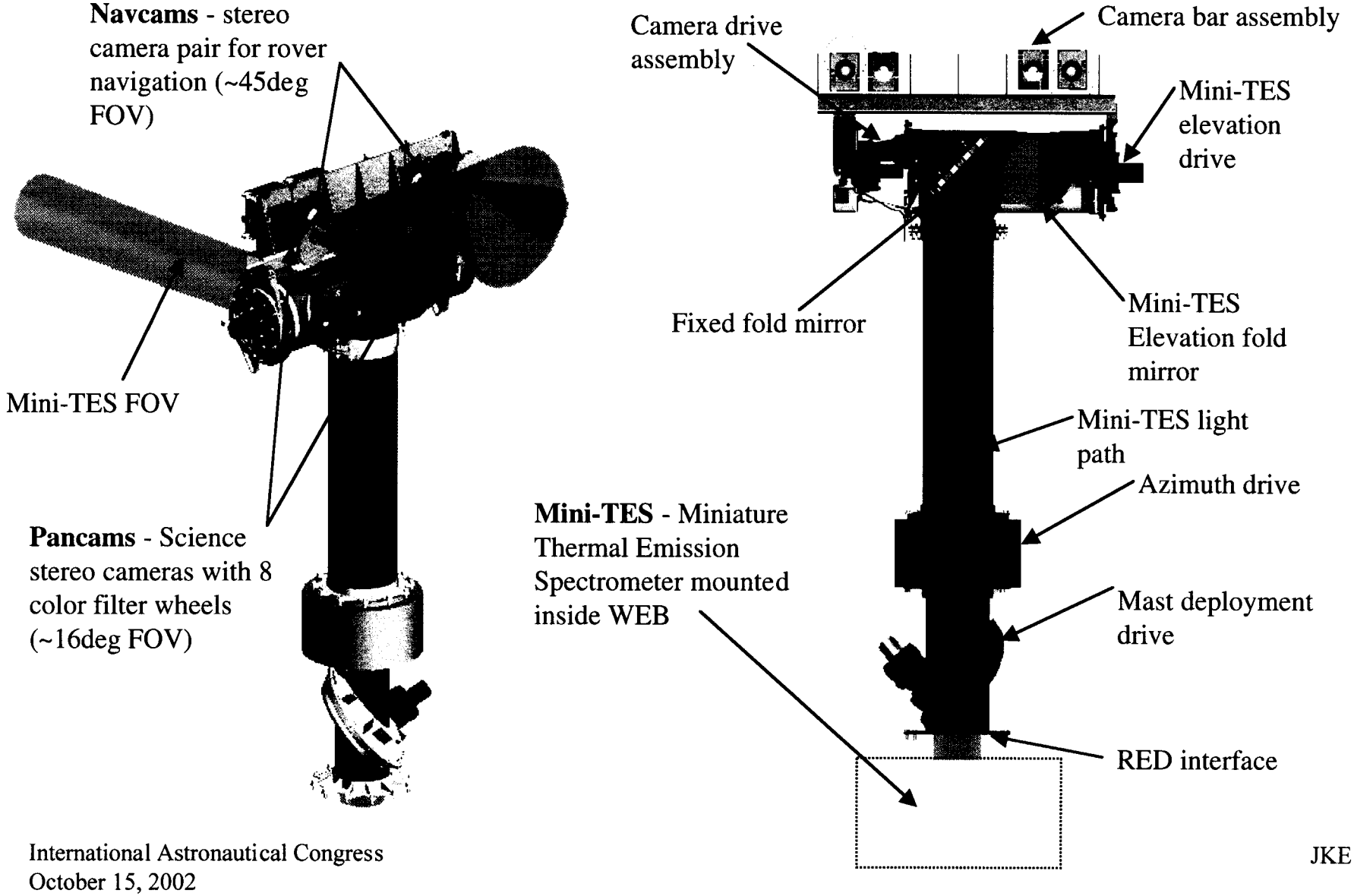
Flight Rover ready for installation on Lander



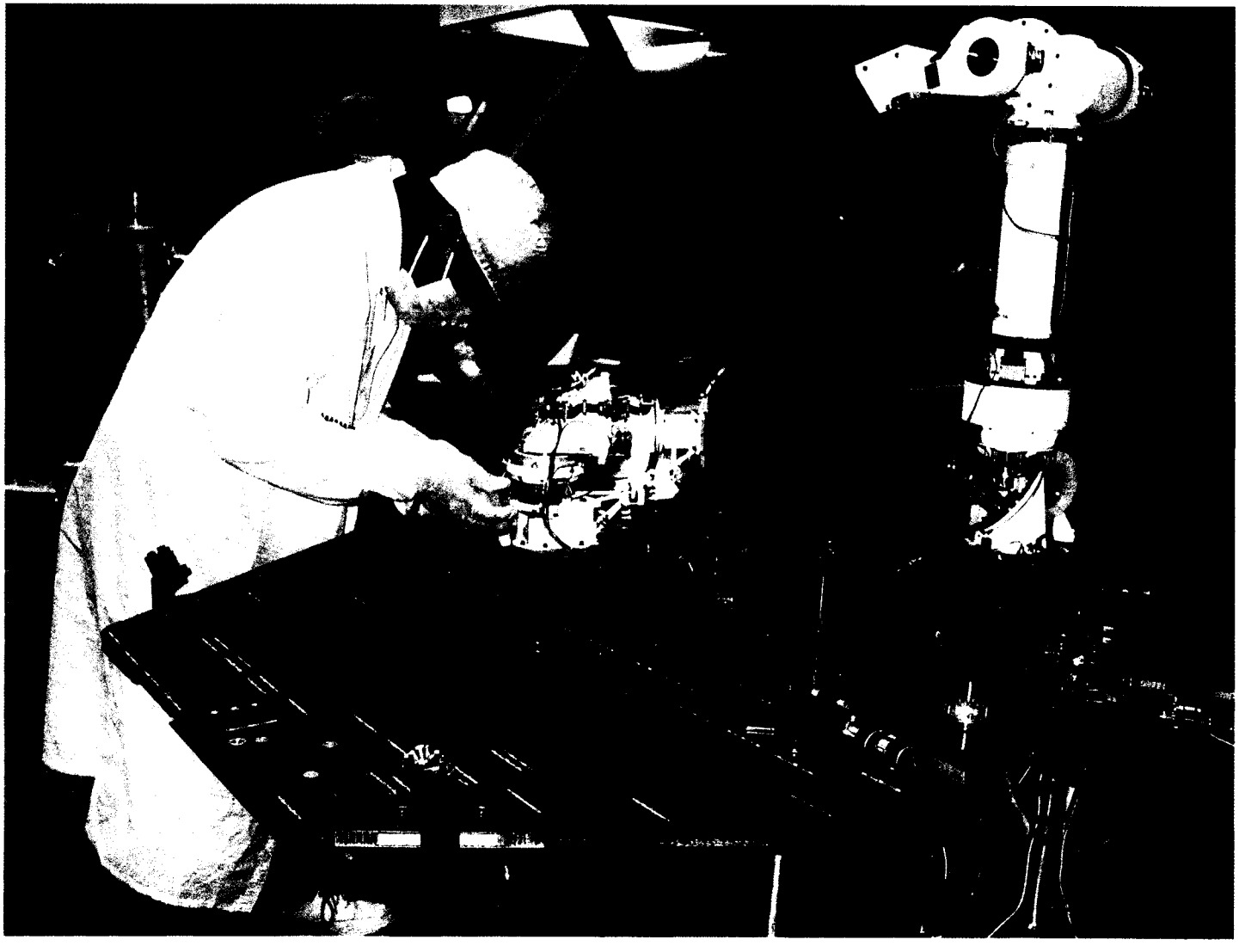
Rover Configuration



Remote Sensing Instruments & Pancam Mast Assembly (PMA)

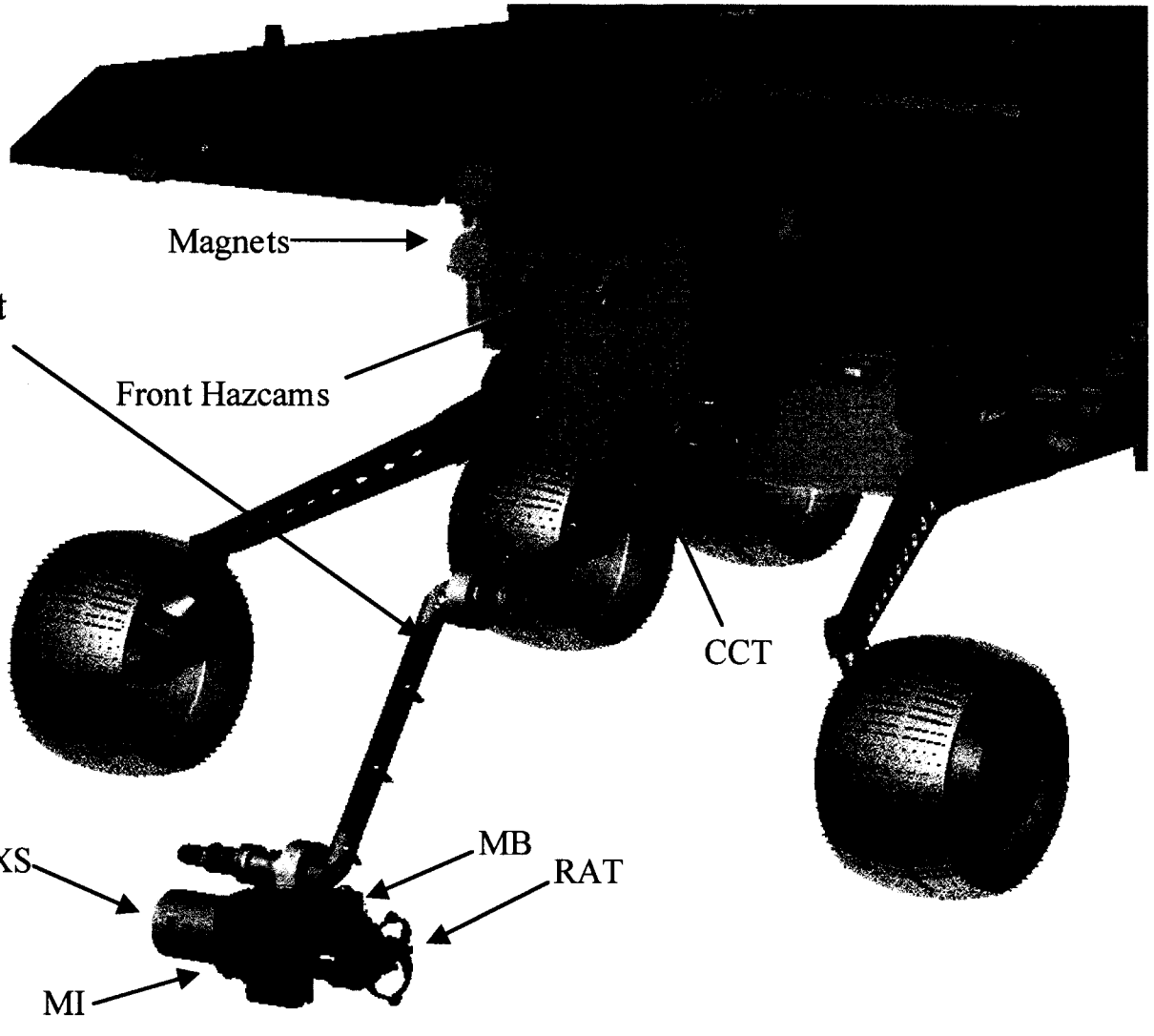


Flight PANCAM Mast and Remote Sensing Instruments



Instrument Positioning System

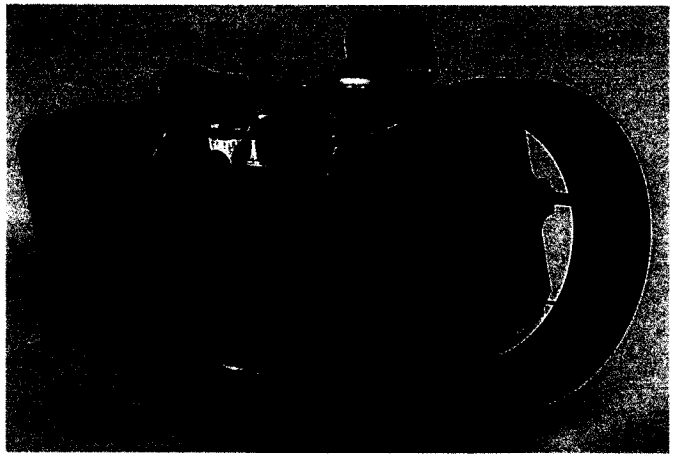
Instrument Deployment Device (IDD) - 5 DOF Robotic Arm with 4 instrument turret at end



Flight Deployment Device

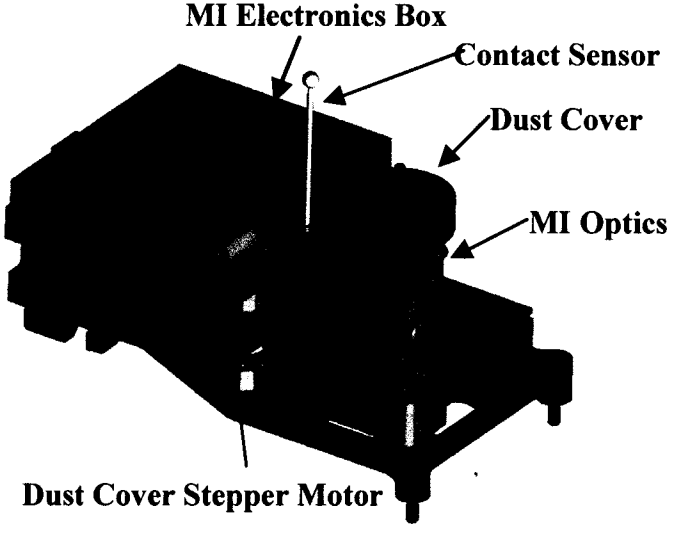
In-Situ Instruments

Alpha Particle X-Ray Spectrometer (APXS)

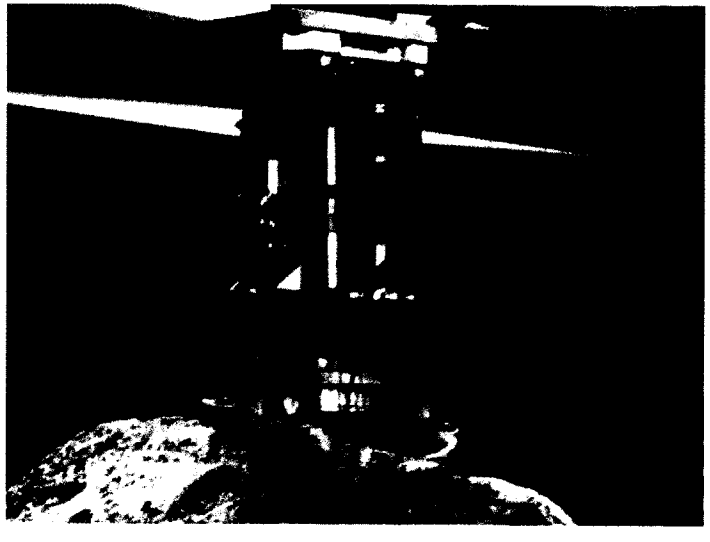


Mössbauer Spectrometer (MB)

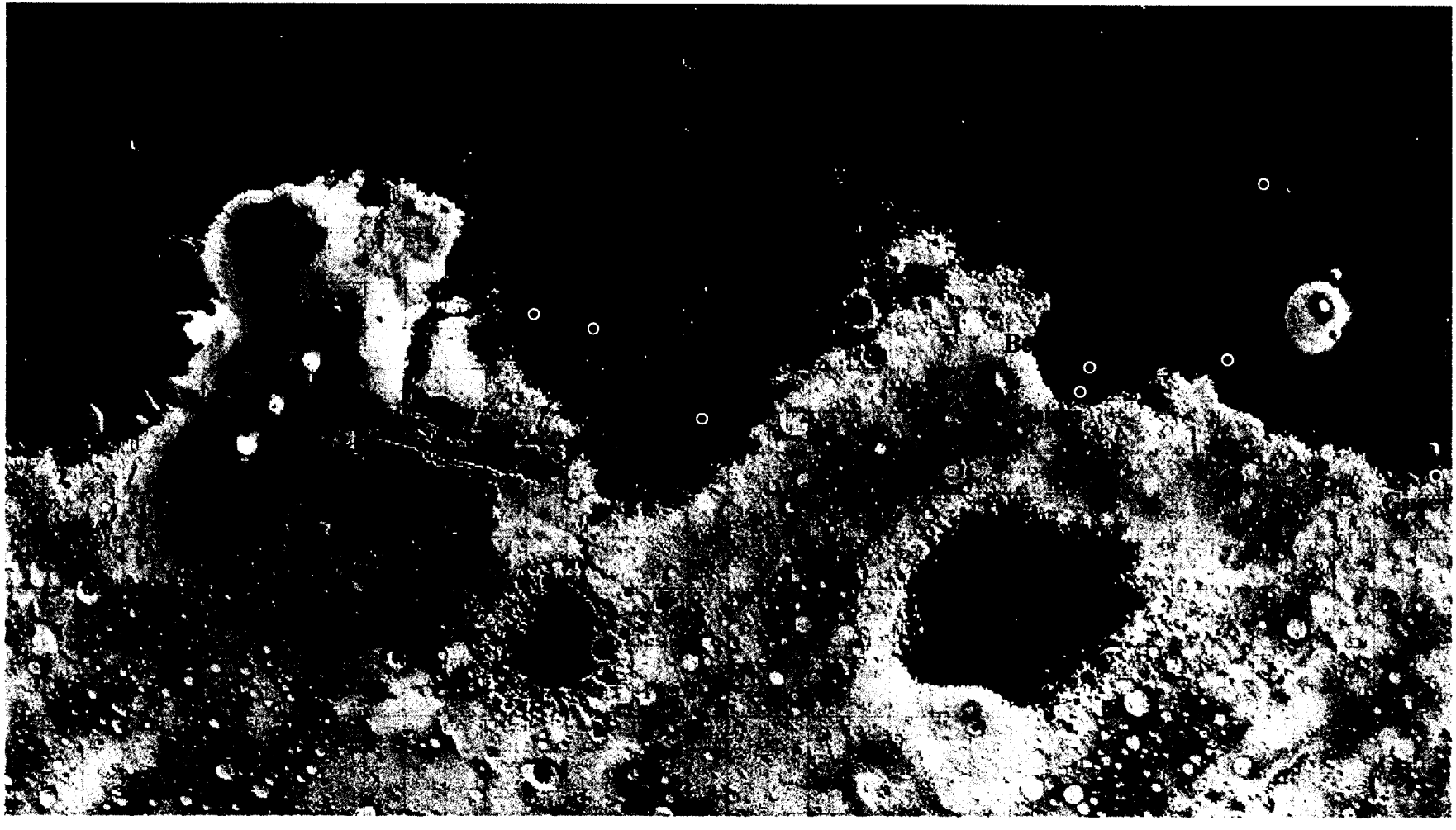
Microscopic Imager (MI)



Rock Abrasion Tool (RAT)



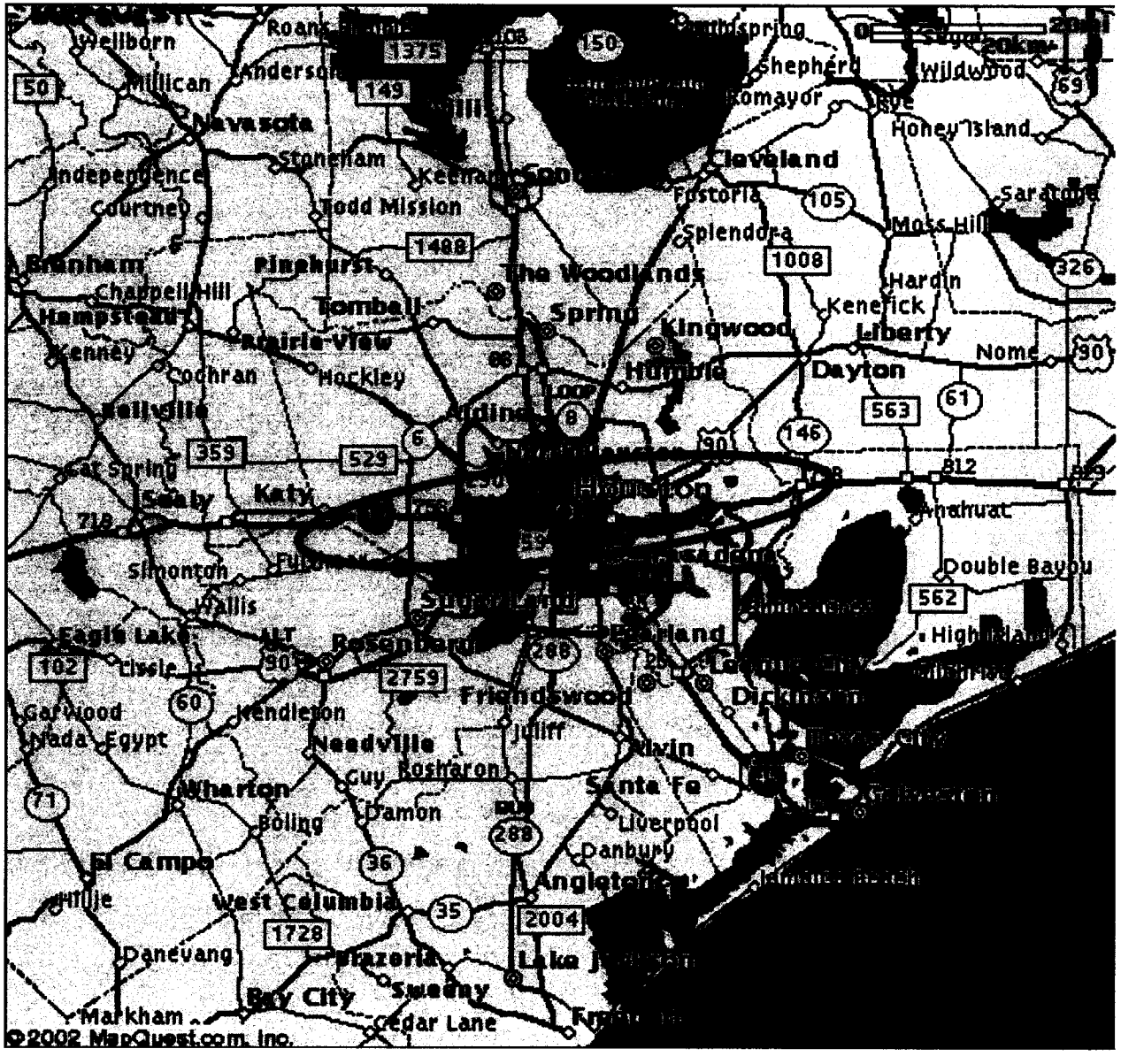
Possible Landing Sites



Typical Landing Error Ellipse

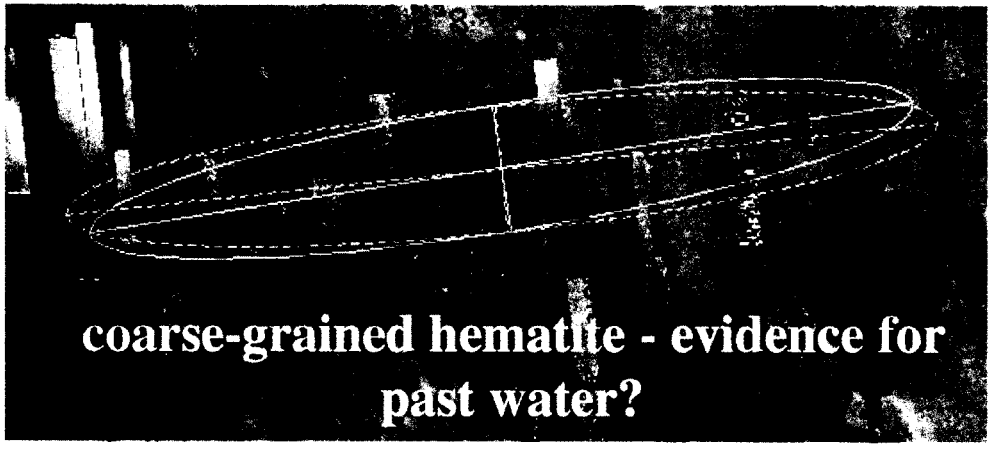
20 km by 100 km

99% Probability



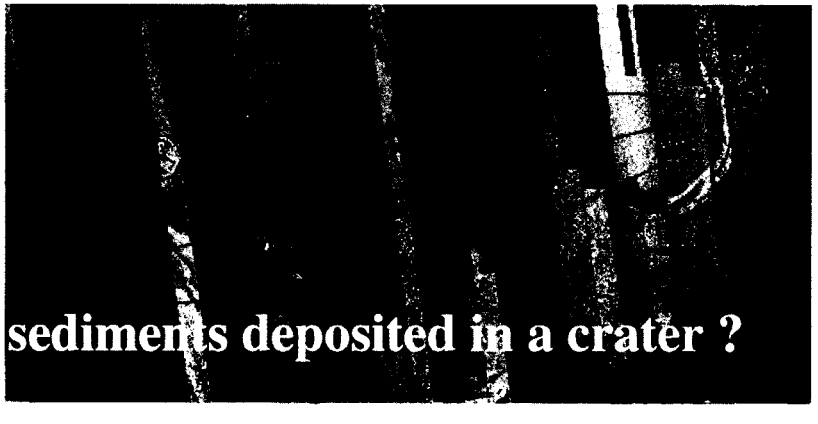
The Four Candidate Landing Sites for MER:

as of September 2002

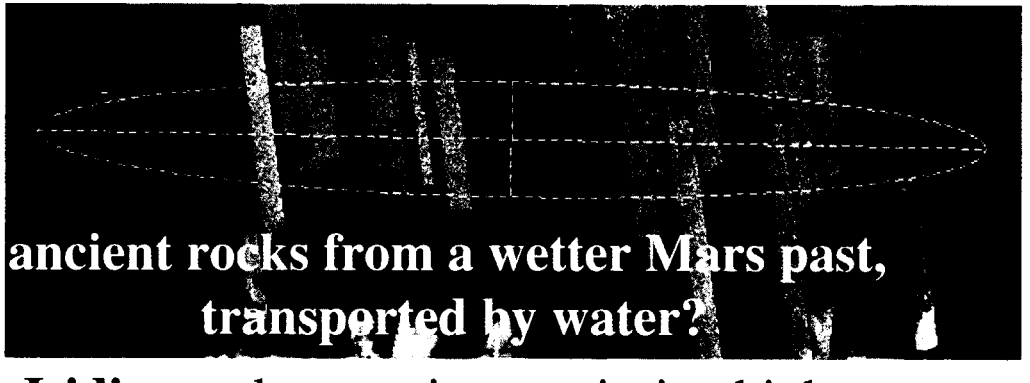


Hematite: safest site (low rock abundance, winds and slopes), high science priority

Elysium: 2nd-safest site, low science priority



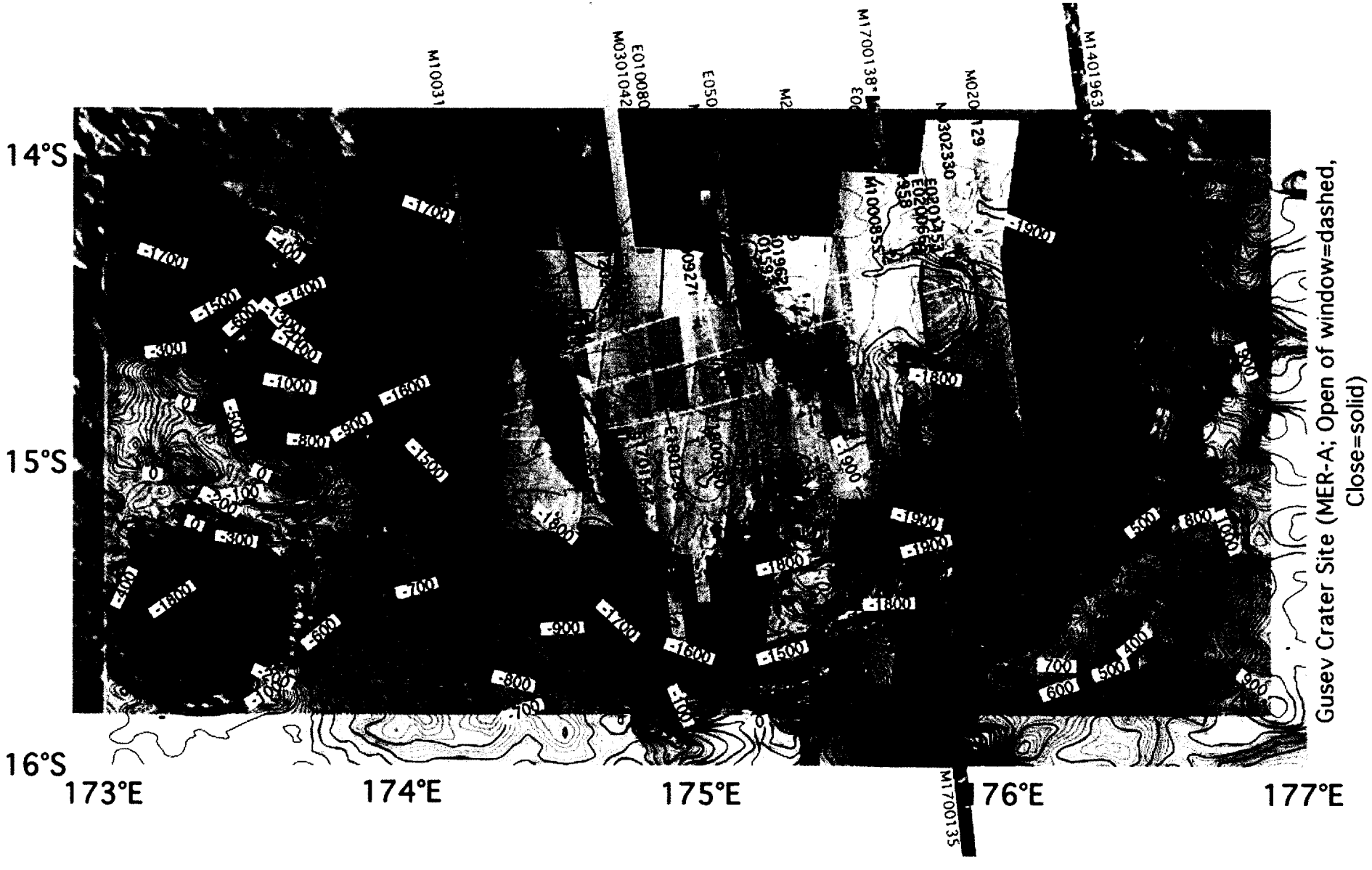
Gusev: high science priority, high wind shear, moderate slopes



Isidis: moderate science priority, high horizontal winds and wind shear, high rock abundance, low slopes

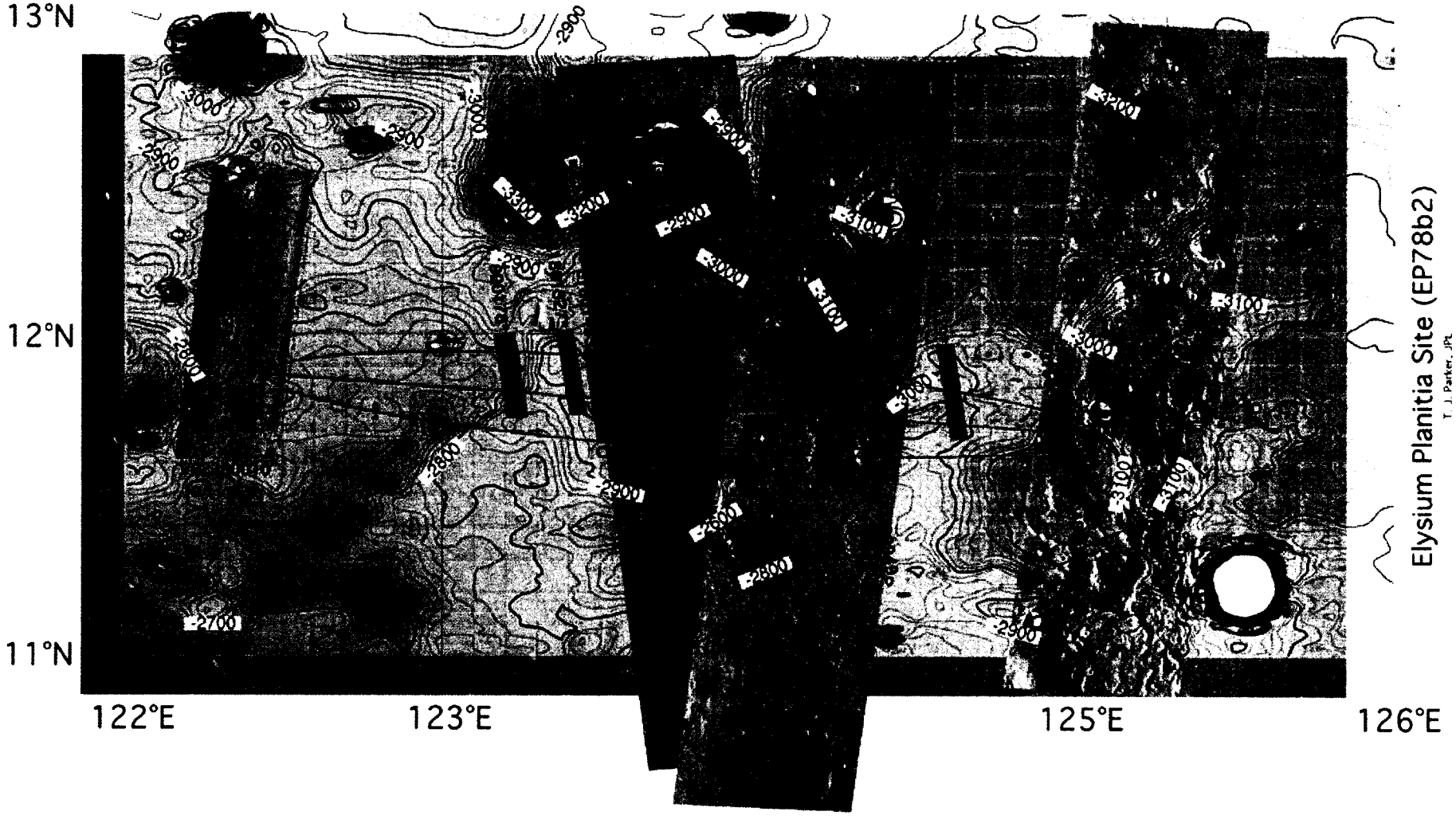
Grey Strips = MOC coverage. Ellipses are 100 to 150 km long

Gusev Crater

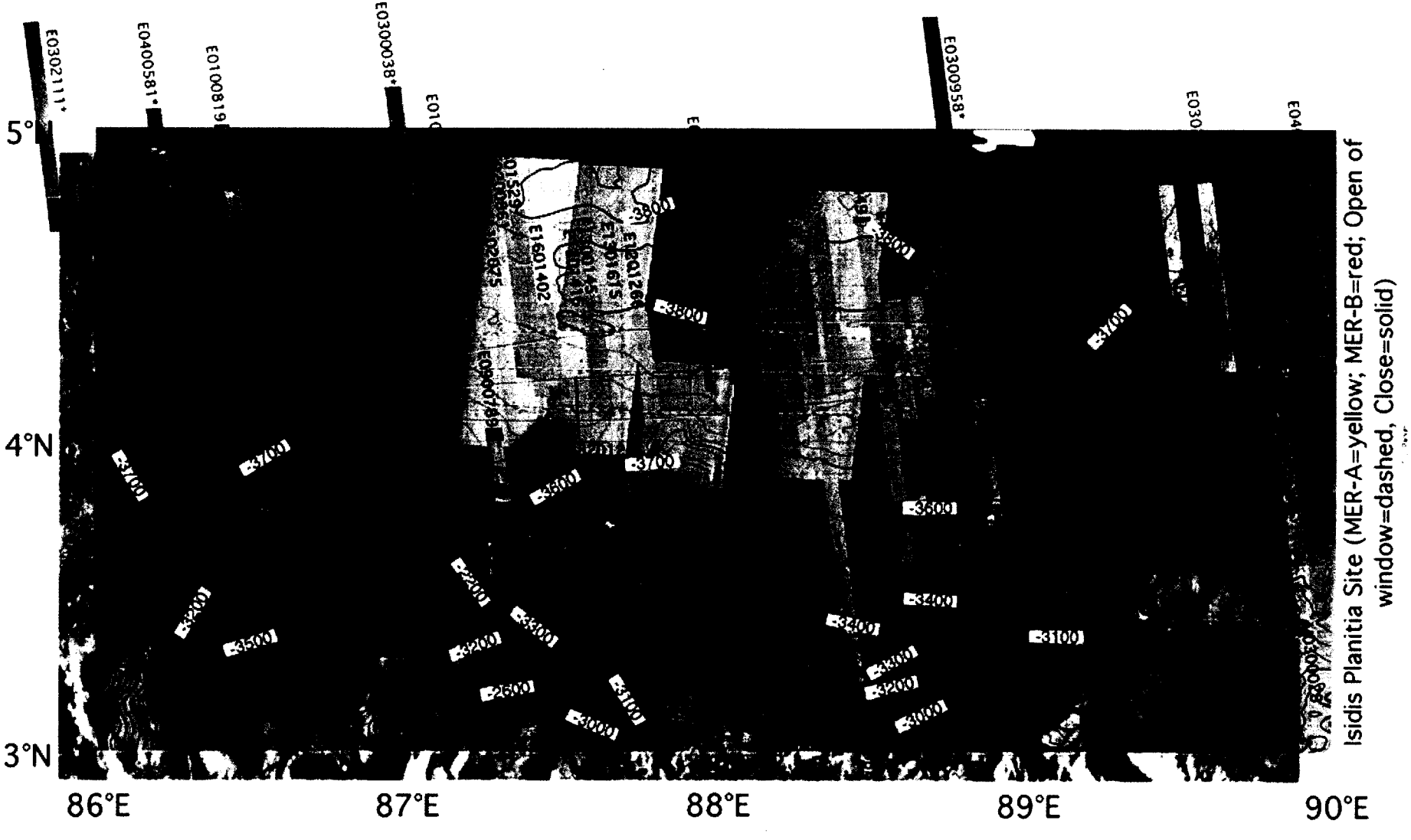


Meridiani Hematite

Elysium Planitia

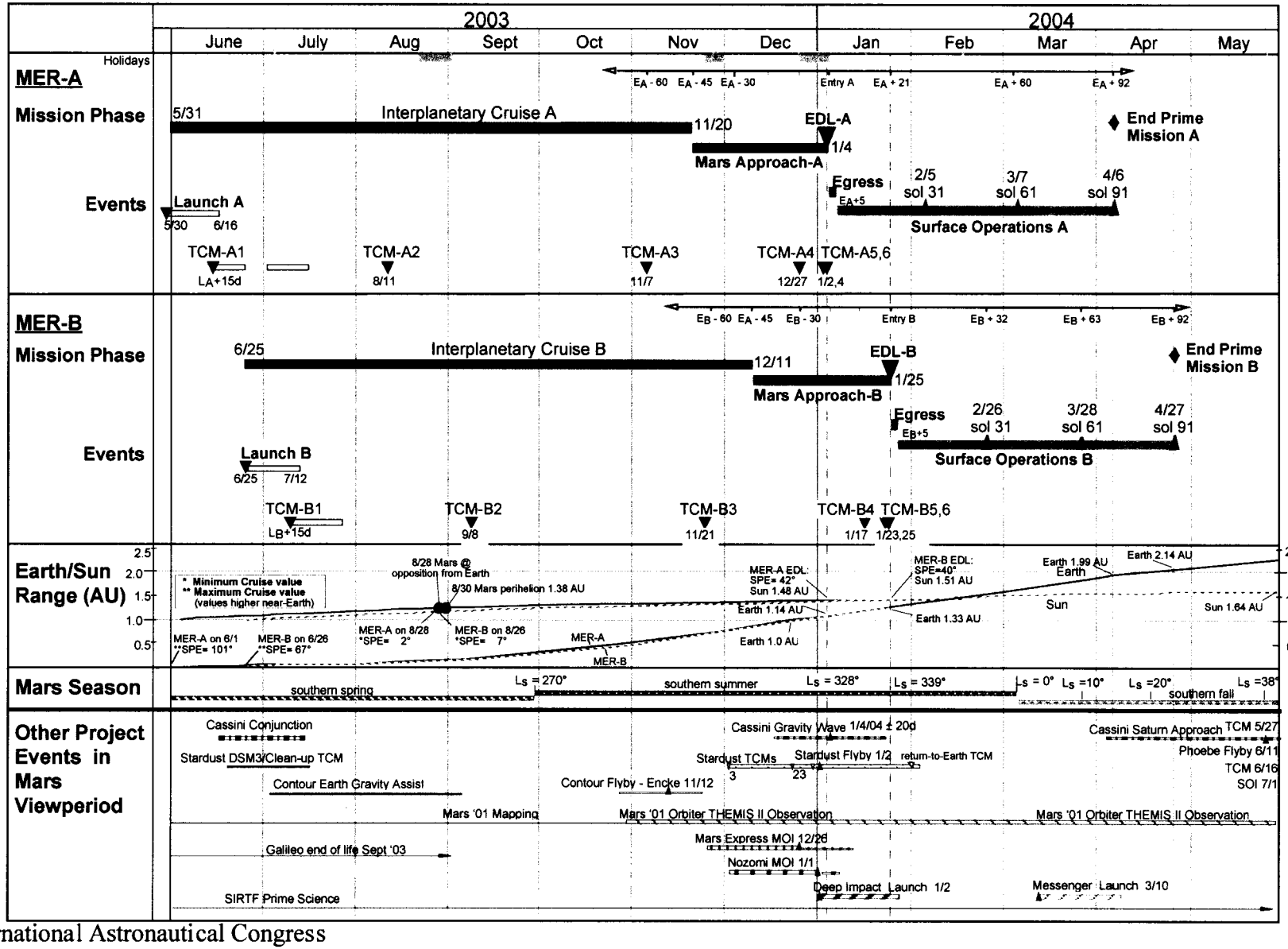


Isidis Planitia



Backup

Mission Timeline



Mars is Hard!!

- **The international community has sent 33 missions to Mars**

	USA	USSR/Russia*	Successful	Failure
Orbiters/Flyby	**12**	**-**	**8**	**4** (2 LV)
	-	**15**	**4**	**11** (5 LV)
Landers	**6**	**-**	**3**	**3**
	-	**8**	**0****	**8** (2 LV)
Totals	**18**	**23**	**15** **37%**	**26** **63%**

* **Japanese Nozomi mission is expected to arrive in Dec 2003**

** **Mars 3 in 1971 apparently transmitted for 20 sec after landing but no significant information was returned**