ATROMOS

A Mars Companion Mission

Enabled by Advanced EDL Concepts

IPPW-5

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- Introduction
- Definition of ‘Companion’ Missions
- Attractiveness in future Mars programs
    - Adds ground element
    - Compartmentalizes risk
- 2-point Polar Science Network
- A proposed EDL concept
- Key technical development areas
- Summary

Introduction and Relevance

- Strong redirection towards Mars Sample Return (MSR)

  Cost > 2 x MSL
- Perhaps will result in less landing opportunities in 2010-2020
- Perhaps will discourage the development of advanced in-situ measurement and instruments

…Perhaps the provision of 'Companion' ground element would help create conduit for such development

Companion defined: Simple probe/EDL; cost <35M (MoO class)

Science Mission: Advance Mars Polar Science

Science Goals:

1. Acquire in-situ simultaneous measurements at the critical polar regions that will provide the ground truth for remote sensing instruments as well as characterize critical polar atmospheric transport processes and phenomena.

2. Use the entry data to permit atmospheric structure reconstruction at the unique polar locations.

3. Emplace small, robust 1.5 L science stations that would constitute a Network Science test-bed by providing pressure, relative humidity, temperature, opacity (TBD) and radiation dosimetry for the period of 90 sols (level I) or 1 Martian year (level II).

Science Mission

Technology Goals:

1. Develop the necessary technical elements to enable future '**Companion**' mission on future orbiters, or other larger Mars missions.

2. Develop and prove the critical technologies supporting a Network Science Mission proposed.

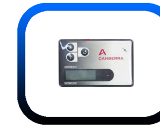
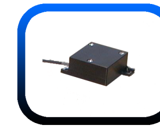
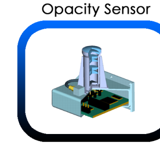
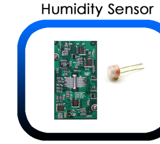
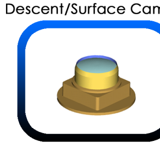
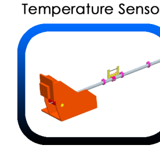
Polar Science Mission - Possible Instrument Suite:

Parameter	Accelerometer	Dosimeter	Descent Camera	Humidity Sensor	Pressure Sensor	Temperature Sensor	Opacity Sensor
Sensor type	Silicon capacitive	Si PIN diode	CMOS	Tunable diode laser	Thin-film capacitive	Thin-wire thermocouple	Photo diode
Heritage	Commercial	GeneSat-1	COTS	MPL, DS2	Phoenix	Phoenix	Netlander
Mass [g]	68	20	50	227	16		75
Volume [cc]	37.34	3	16	335	12.6		36.1
Power [mW]	75	100	280	2 - 3	43.2	50	25
Range	±25g	TBD	N/A	1 - 1000 ppm	0-30 mbar	100 - 400k	0 - 5
Resolution	80 mV/g	N/A	> 30m/ pixel	1 ppm	0.01 mbar	0.5k	0.01
Accuracy	±0.2g	N/A	N/A	3%	0.02 mbar	0.5k	±0/05 for 0-2 ±0.1 for 2-5

Tier I
- Pressure
- Temperature
- Acceleration
- Descent/Surface imaging

Tier II
- Dosimetry
- Humidity
- Opacity

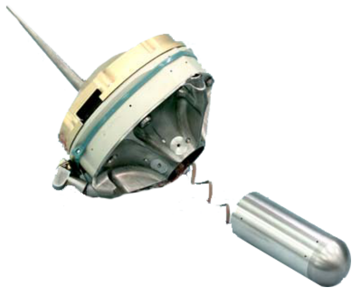
Accelerometers

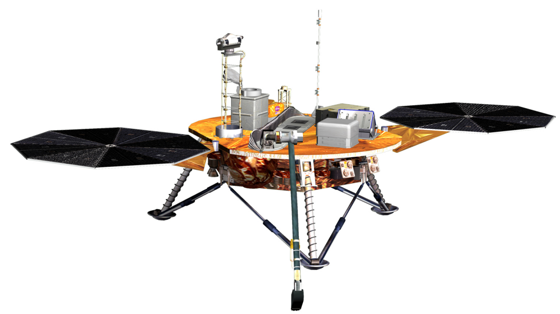
Dosimeter

Pressure Sensor

Opacity Sensor

Humidity Sensor

Descent/Surface Camera

Temperature Sensor


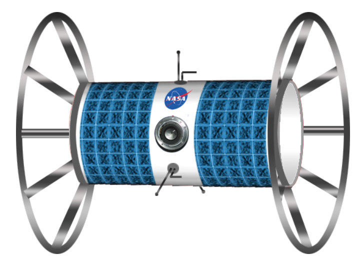
Polar Mission Comparison

	Type	Mass	Technical challenge	Power	Intended Duration	Surface Contamination	MET Capable
DS-2	Penetrator (Hard Lander)	3.67 kg	High	Batteries	8 Sols (Failed)	No	No
Phoenix	Soft Lander	100's kg	Medium	Solar Array	90 Sols (Launch '07)	Yes	Descoped?
Atromos	'Firm' Lander	**9kg**	**LOW**	Array s/ Robust MPG	**90-668 Sols**	**NO**	**YES**

The Atromos Program will develop a low risk, long duration polar measurement capability. It will provide a new EDL paradigm for a unique class of Companion and Network missions

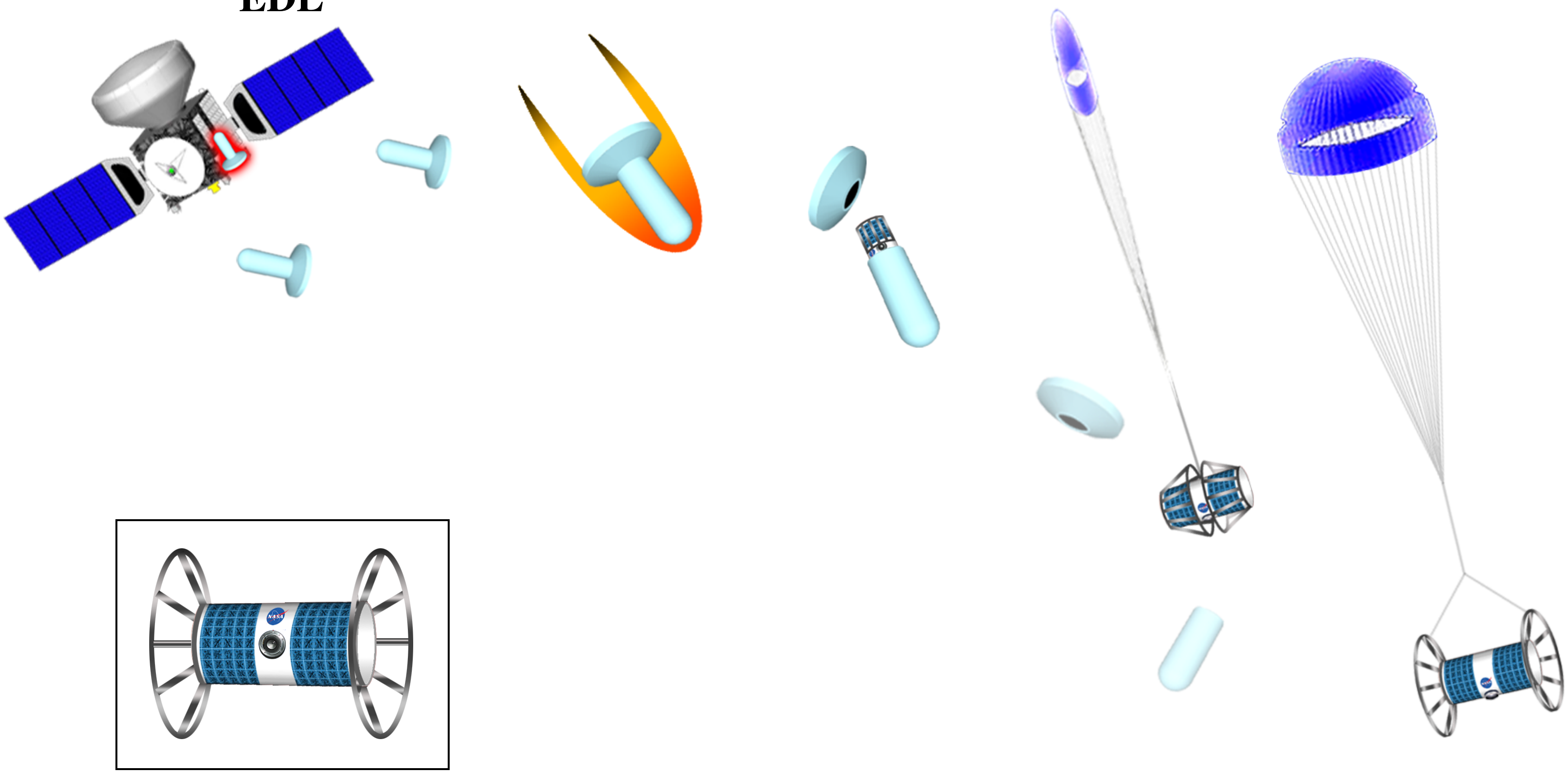




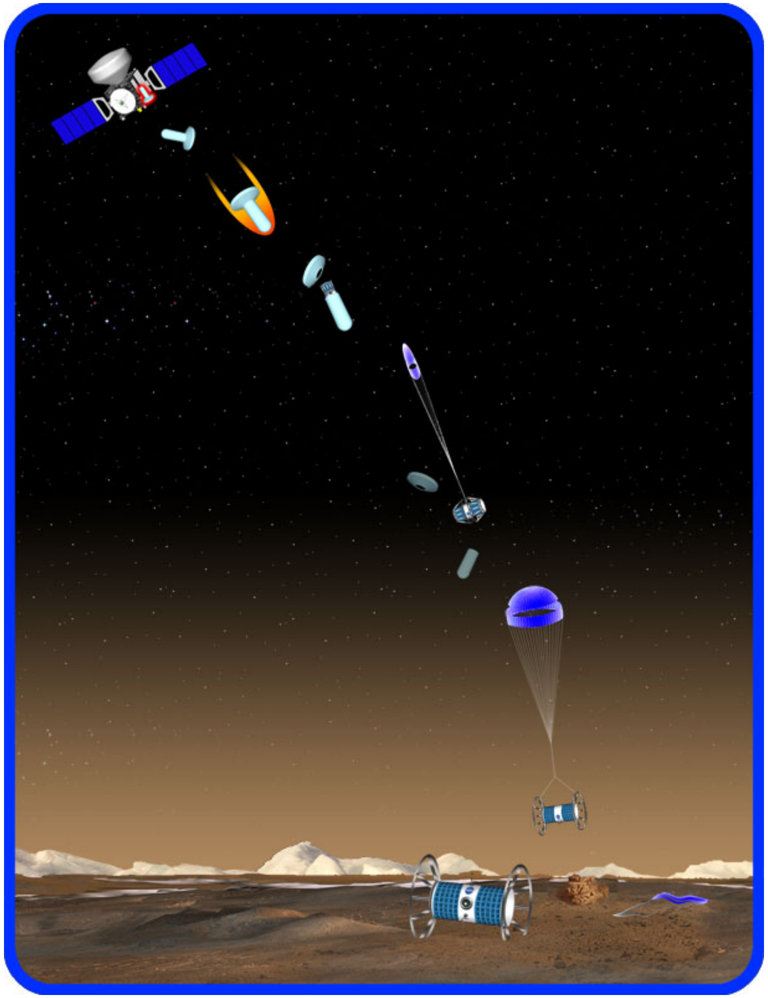


Mission Overview

EDL

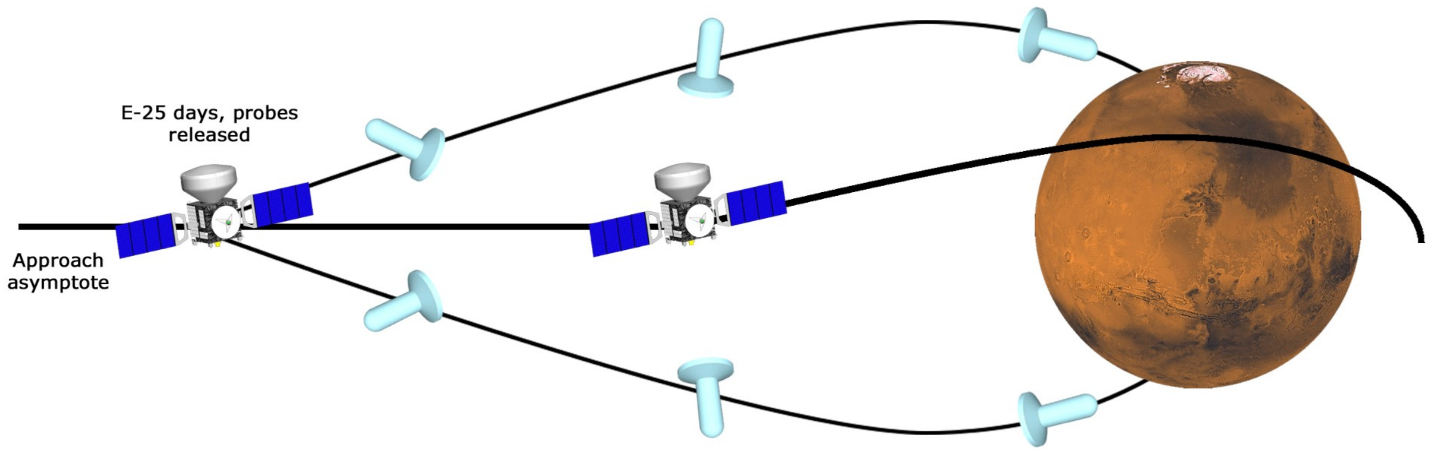


Science: perform hourly measurements of key climatology measurements; store until uplink opportunity avails (data rate 32 kbits/s; 2W RF power)



Entry/Descent/Landing sequence at polar region
3 pyrotechnic events with no airbag

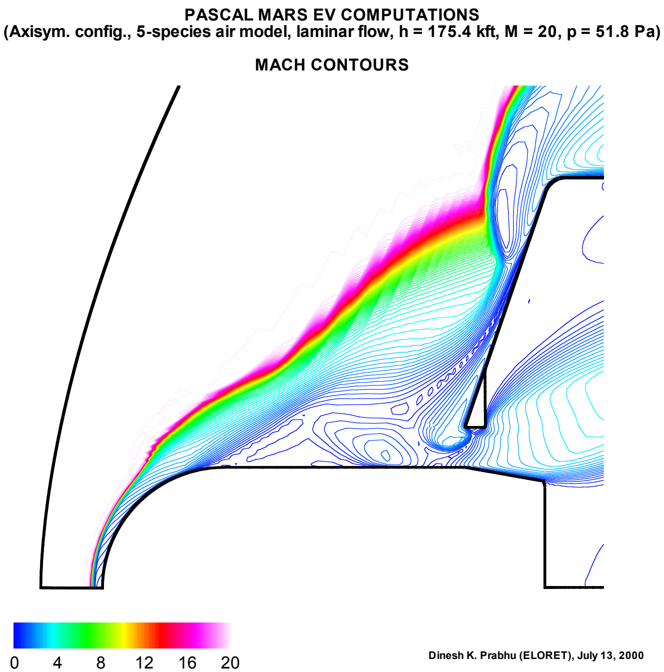
Orbit Mechanics and Mission Opportunity

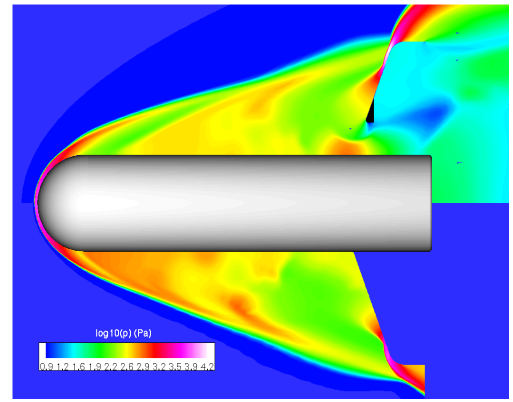


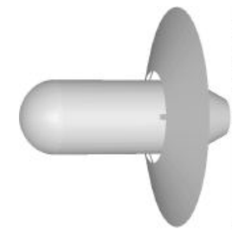
<u>Example:</u>
Type 1 Opportunity
ExoMars Mission
Ariane V launch

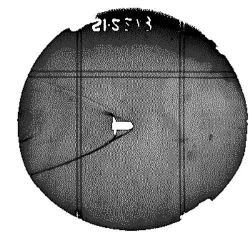
Technical Development (1)

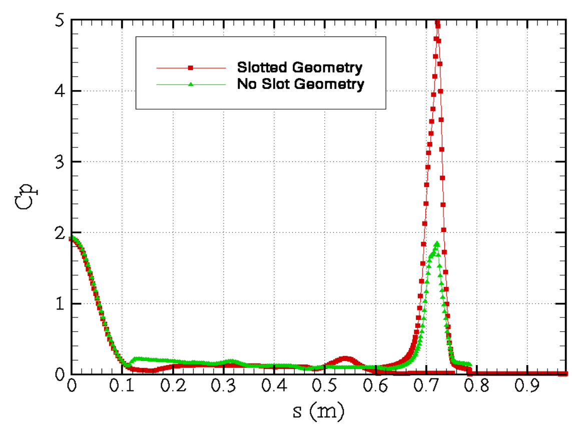
The SCRAMP Probe

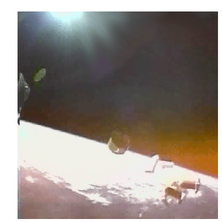












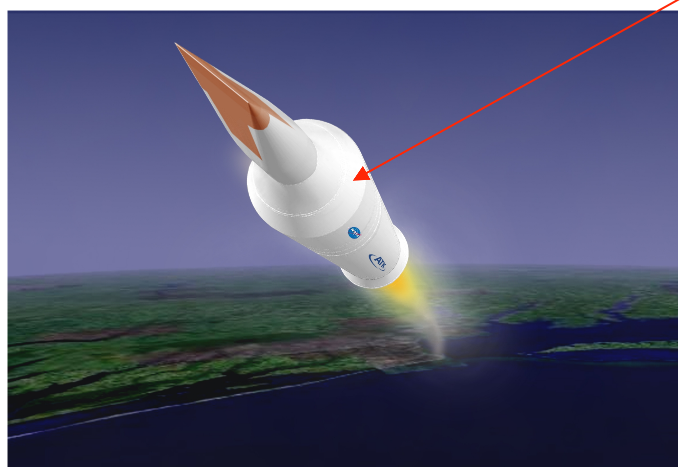
Solid development path continues…

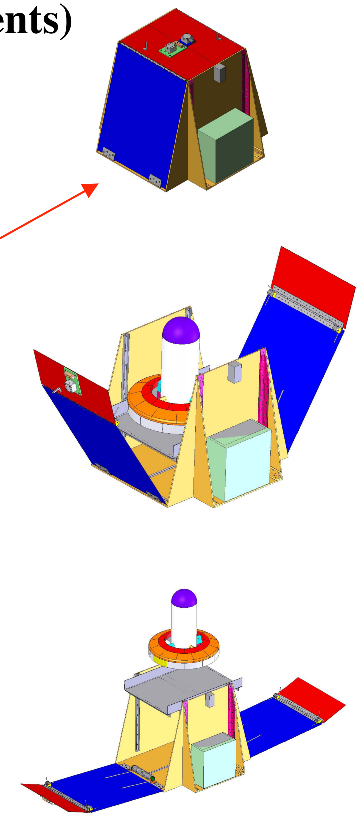
Different than 2002 Pascal (AESOP 70°NSC)

Problems: slow to re-orient; CM constraints; mortar; mass inefficiency due to structural outer-ring; complex EDL

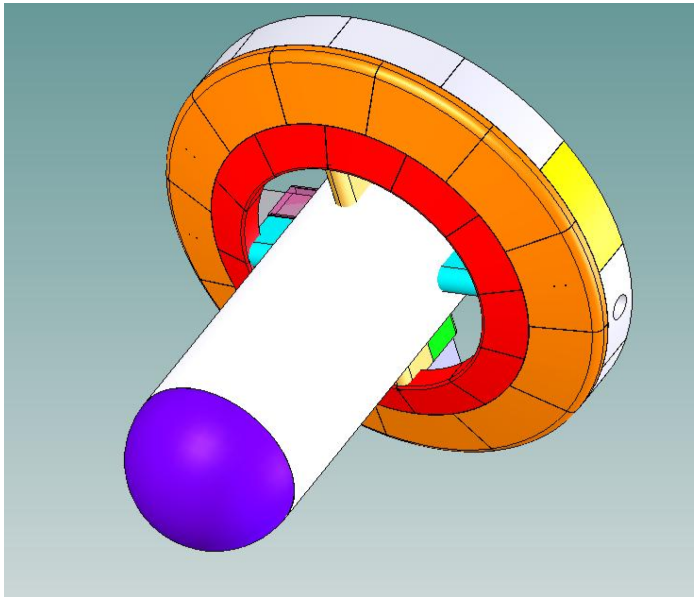
SOAREX VI (Sub-Orbital Aerodynamic Re-entry Experiments)

SCRAMP Advanced Flight Test

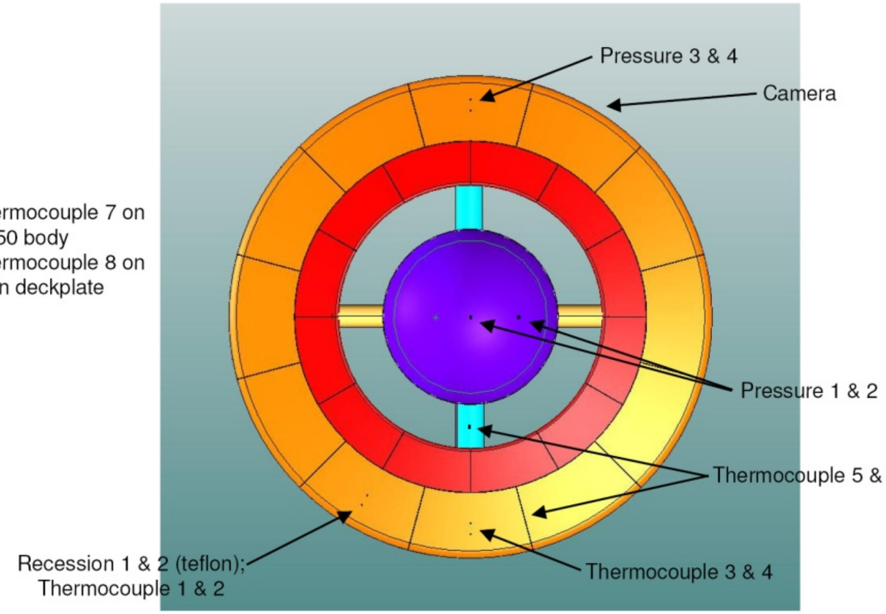




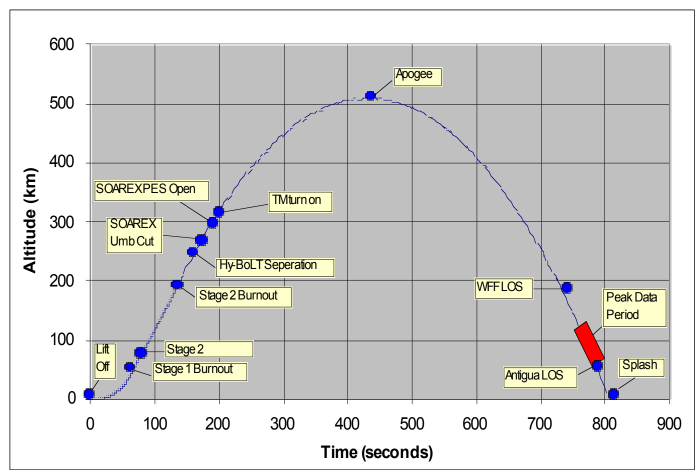
Launch date 11-30-07
Reentry velocity at 4+ km/s (Mars orbit entry)
SCRAMP probe is well instrumented (shock studies; dynamics of improved design)
SOAREX VII would launch in 2 yrs with a 6 km/s velocity (Mars direct entry)



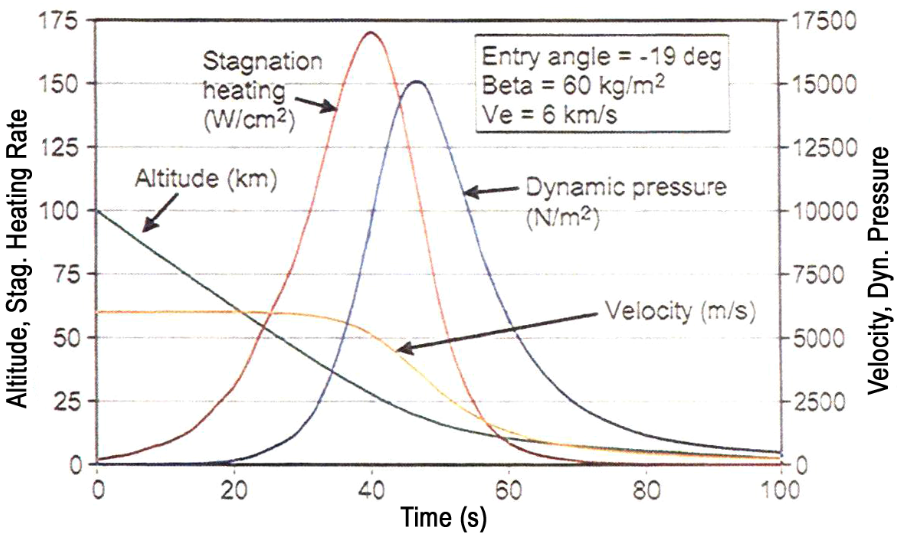
- Thermocouple 7 on GP50 body
- Thermocouple 8 on main deckplate

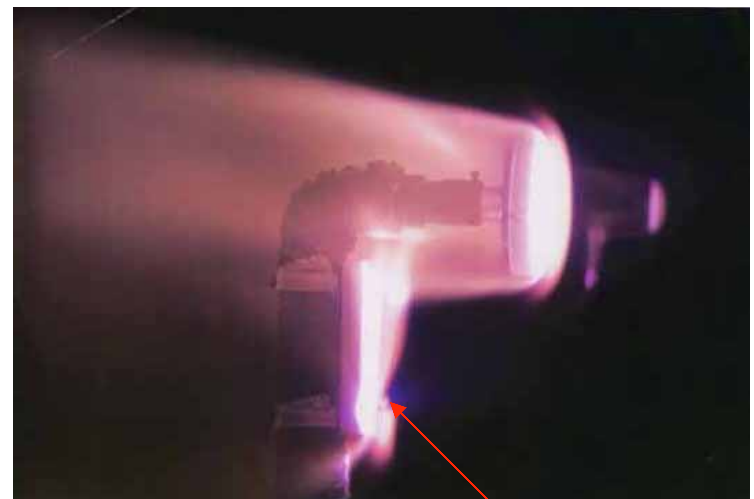


SOAREX VI instrumentation & trajectory



Arc-jet shock-impingement tests



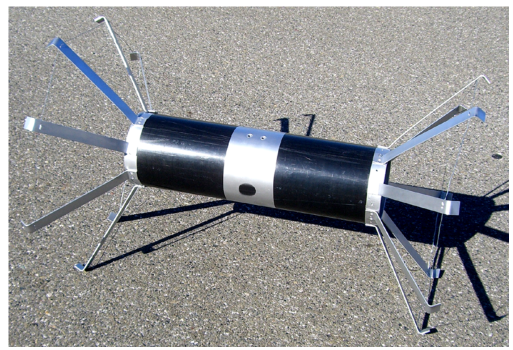
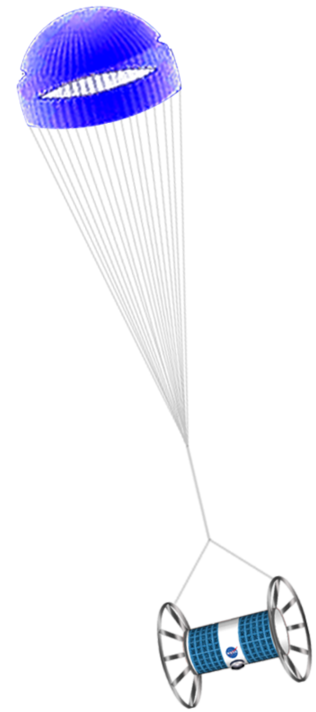


Shock interaction region (HX x 6)

Creation of similar shock-shock heating for 4km/s and 6 km/s conditions

Technical Development (2)

SPIDR/EDL

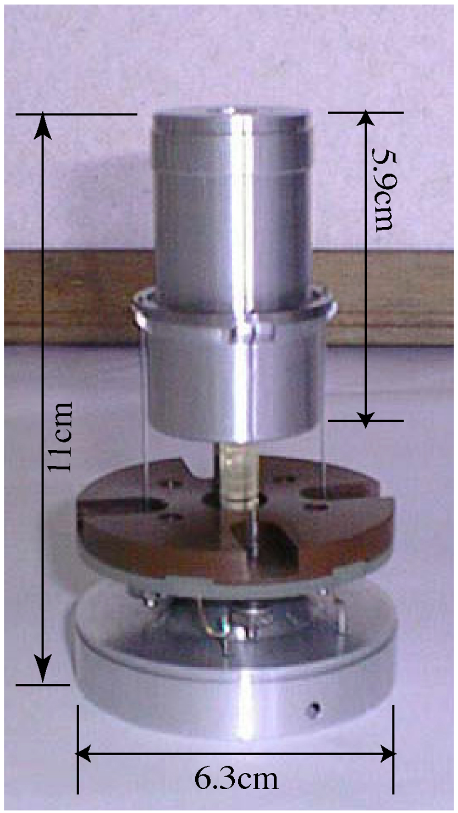




As 'mechanical airbag'
Compression distance .5 - .75 L; at 30 m/s decel. , load reduced to <300 g's
Concept is 'testable' (i.e., no pyro devices, etc.)
Mechanical model guides design

Contrast with single airbag design: Difficult to test; hard to remove Science Station from bag after use

Technical Development (3)

Robust-Milliwatt Power Generator (R-MPG)

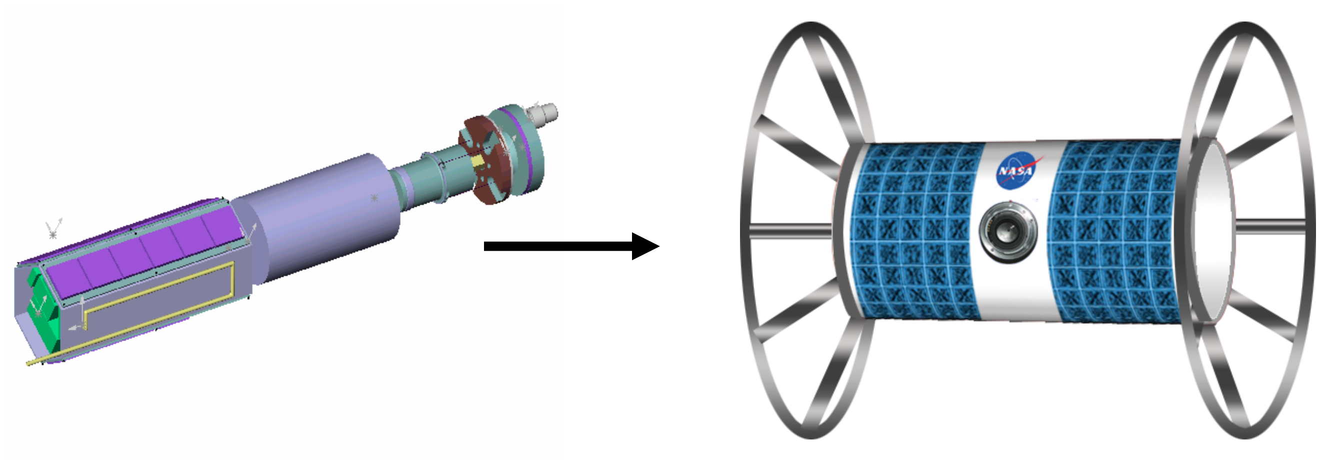


Adding a Kapton collar will intruduce a thermal short and reduce the BOL power output to 20mW

…but will allow current technology to be used and permit unit to survive omni-directional impact.

Technical Development

Station Design (Physical)



PowerTube Approach

Internal evacuated tube/central channel for R-MPG placement

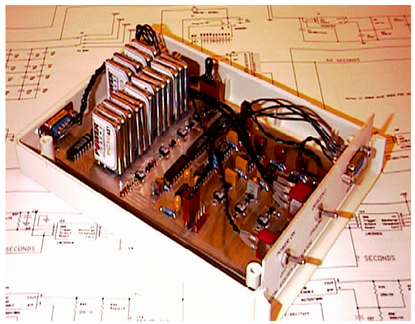
LWRHU integrated at launch site

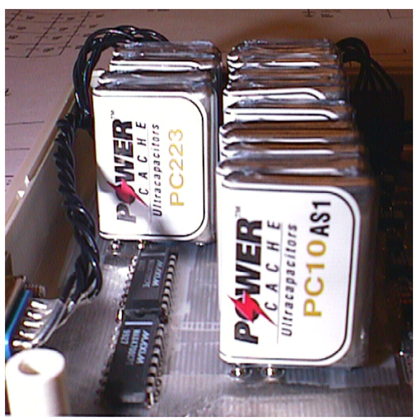
Doubly redundant power (full illumination at 6mW/cm^2)

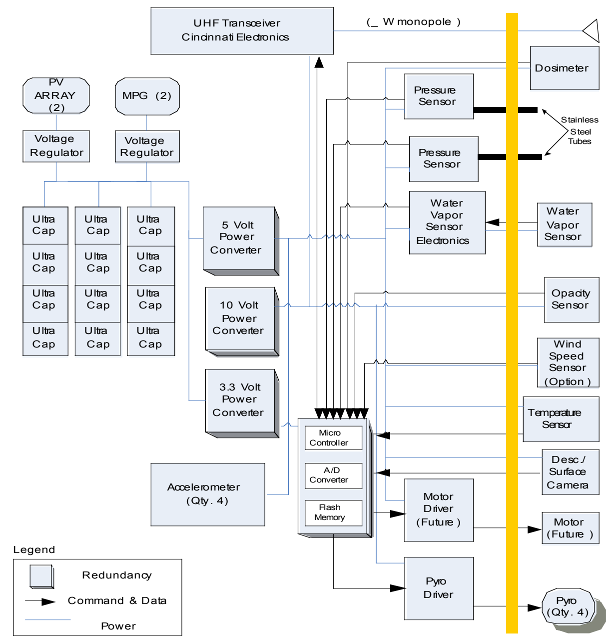
At this rate, 4 cm^2 charge > R-MPG

Technical Approach

Station Design Block Diagram/ Power Breadboard







Ultra caps at 180C; each can run station for 16 hrs. (80% discharge)

Science Station Mass/Power Budgets

Component	Nominal Mass (Kg)	Reserve	Allocated Mass (Kg)
Science Sensors (including associated electronics)	0.8	16%	0.93
Electrical Subsystem (power, comm., C&DH)	0.43	23%	0.53
MPG (Robust) x2	0.52	28%	0.67
Structure	2.32	17%	2.71
Mechanism/SPIDR	1.1	20%	1.32
Total	**5.17**	**21%**	**6.16**

Component	EDL Avg Pwr (mW)	Surface Avg Pwr (mW)
Pressure Sensor	0	24
Temperature Sensor	0	50
Humidity Sensor	0	50
Accelerometer	75	0
Camera	2400*	2400**
Pyro Events	0.0004	0
Transceiver	4.1	1.36
CPU	0.82	7.86

* = Camera does not function continuously during EDL
** = Camera takes only one picture per sol

**** Note: Avg. surface power requirement = 15-28 mW**

Station TM/Antenna trades

Scenario	Trans Time (sec)	Data/Trans (bytes)	Monthly Tx Capacity (bytes)	Monthly Data Collection (bytes)	Trans Time/ AC Data & Images (mos)
Long Tx	240	960,000	4,182,857	260,280	0.8
Short Tx	90	360,000	1,568,571	260,280	2.5
Burst Tx	30	120,000	522,857	260,280	12.2

Data Rate	EIRP	Space Loss	Polarization Loss	Received Losses	G/T	Eb/ No	Margin (dB)	Boltzman's Constant
32 kbps	5.81	-143	-1	-1	-30	2.85	9	228.6

Science Station Development:

All heritage instruments (TRL>9)

TM subsystem TRL>9 (Transceiver available; 1/4 W antenna)

Pioneer parachute design (oversize from Network Study; small DGB)

Ultracaps/micro-processor/memory

**** THE RISK IN THE INITIAL APPROACH IS IN THE DEVELOPMENT OF THE EDL AND S/C INTERFACE**

Technical Development Summary (1-3)

TOP RISK AREAS and Mitigation:

- ** SCRAMP Probe
  - Suborbital test program (SOAREX VI/VII)
    - RP1 Basic SCRAMP
    - RP2 'Super' SCRAMP (option)
    - RP3 Long downrange probe recovery
    - RP4 Long downrange atm. structure
- ** Science Station/SPIDR
  - Early drop testing (key: testability!)
- ** Robust MPG (R-MPG)
  - Commence impact/power generation tests
  - NOTE: 3.85M in RHU EIS/launch approval etc.
  - This may be part of EIS of larger project.

Current/Proposed Flight Development

Current: 2007 SOAREX VI sub-orbital flight (October launch)

4 km/s; instrumentation core development

Long-downrange problems (TM, atm. structure; recovery)

Future: 2009 SOAREX VII

6 km/s TPS and EDL validation for Mars

Test S/C key interface

2011 'Simple' Atromos

Mars EDL; TM and limited data only

2013 Initial Atromos science mission

Science Station; high TRL instrument core

2016 Advanced Atromos Stations

Advanced Companion or Network Mission

Summary

- Argument for Mars Companion Missions further outlined
- Two-point Polar Science Network proposed
- New EDL strategy is outlined
    - Simple S/C interface; simple separation events
- Key development areas:
    - SCRAMP Probe (GROUND TESTS; SOAREX VI/VII)
    - Station/SPIDR (TESTABILITY; IMPACT TO 35m/s)
    - Robust MPG (Kapton collar; 20mW BOL and TEST…)
- Development strategy presented with gradually increasing complexity