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# MARS EXPLORATION PLANNING

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## Mars Exploration Planning

SOLAR SYSTEM EXPLORATION

- Mars Observer
- MESUR
- Small Rovers and Sample Return Missions

## Mars Exploration Planning

SOLAR SYSTEM EXPLORATION

➢ Mars Observer

MESUR

Small Rovers and Sample Return Missions

# Mars Observer: Mission Rationale

While Knowledge of Mars is Extensive, It Contains Significant Gaps. More Importantly, There Are a Number of First Order Scientific Questions That Can be Best Addressed From an Orbital Platform. The Geoscience/Climatology Orbiter Will Provide New Observations and Complement Existing Measurements, and Provide an Improved Basis for Future Intensive Investigations.

SSEC Report

# Mars Observer

- Low Altitude Polar Orbit
- 1 Martian Year Mission Duration
- Simple Repetitive Geological/Climatological Mapping Mission
- Spacecraft Based on Derivative of Earth Orbital Spacecraft
- Experiments Selected Concurrent with Spacecraft

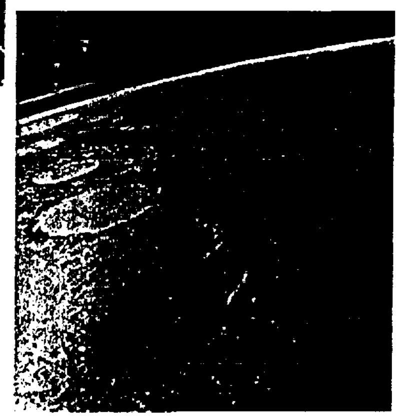
SCIENCE OBJECTIVES

# MARS OBSERVER WILL . . .

DETERMINE THE GLOBAL ELEMENTAL AND MINERALOGICAL CHARACTER OF THE SURFACE MATERIAL

DEFINE GLOBALLY THE TOPOGRAPHY AND GRAVITATIONAL FIELD

DETERMINE THE TIME AND SPACE DISTRIBUTION, ABUNDANCE, SOURCES, AND SINKS OF VOLATILE MATERIAL AND DUST OVER A SEASONAL CYCLE



EXPLORE THE STRUCTURE AND ASPECTS OF THE CIRCULATION OF THE ATMOSPHERE

ESTABLISH THE NATURE OF THE MAGNETIC FIELD

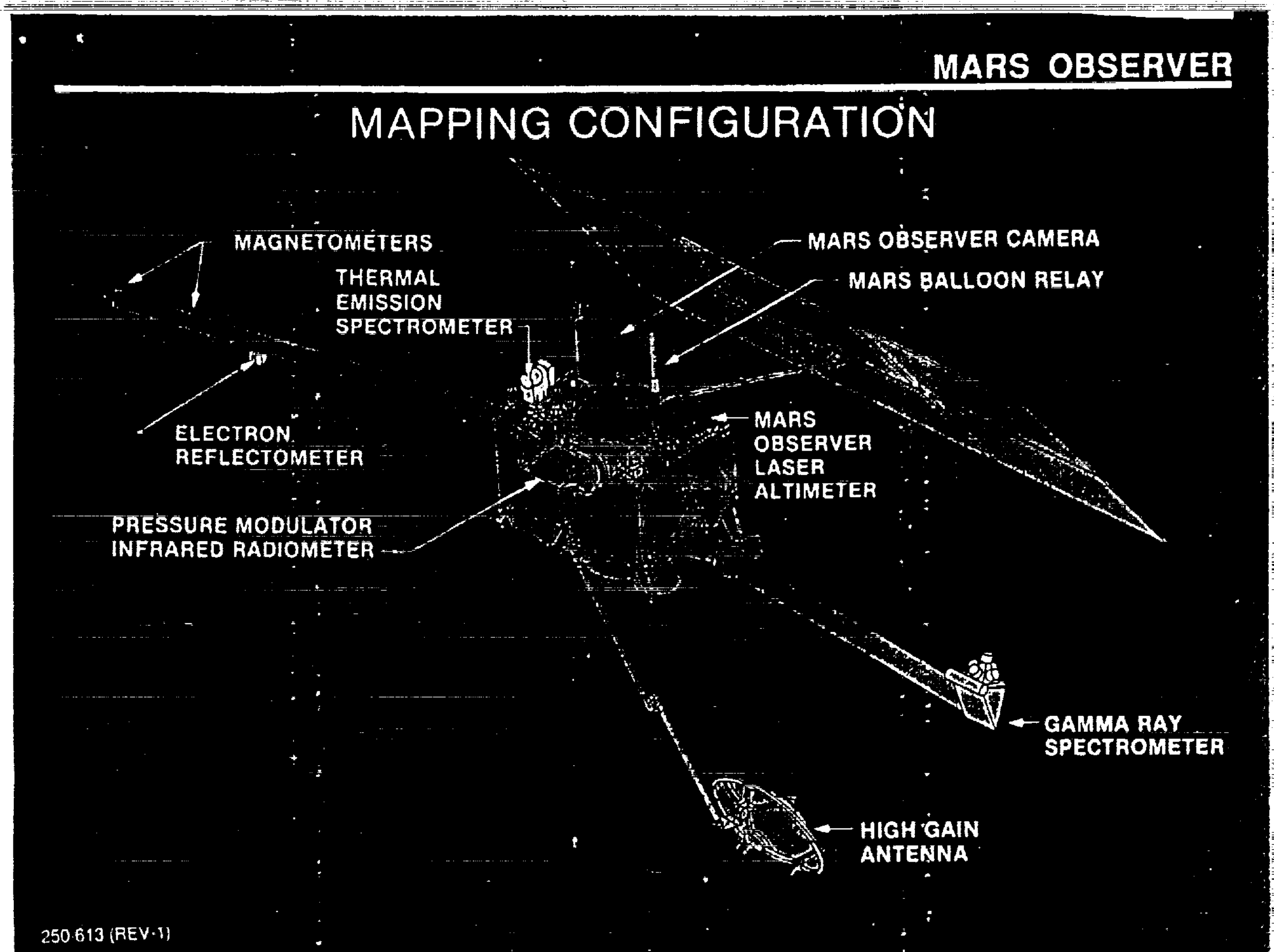
# Mars Observer

## Science Instrument Measurement Objectives

| | |
|---|---|
| Gamma Ray Spectrometer | Elemental Composition of Surface |
| Magnetometer | Intrinsic and Local Magnetic Field |
| Mars Observer Camera | Global Synoptic Views, Selected Moderate and Very High Resolution Images of Surface and Atmosphere |
| Pressure Modulator Infrared Radiometer | Profiles of Temperature, Water, Dust, and Radiation Budget Measurements |
| Radar Altimeter | Topography, Microwave Radiometry |
| Radio Science | Gravitational Field; Atmospheric Refractivity Profiles |
| Thermal Emission Spectrometer | Surface Mineralogy; Atmospheric Dust and Clouds: Radiation Budget |

# Mars Observer Status

- Spacecraft Assembly and Test Nearing Completion
- Five of 7 U.S.-Supplied Instruments Delivered and Integrated
  - Remaining 2 to be Delivered in February
  - Gamma-Ray Spectrometer Electrically Integrated with Spacecraft and Functional Testing Completed
    - Excellent Instrument Performance
  - Thermal Emission Spectrometer Successfully Completed Acceptance Tests and Was Delivered
  - Pressure Modulator Infrared Radiometer (PMIRR) Integrated Systems Testing Successfully Completed



# Mars Observer Status

- Instrument and Spacecraft Integration and Test Schedules Remain Challenging
  - Mars Balloon Relay Delivered and Integrated
  - Mars Observer Camera Electronics Completed and System Performance Testing Underway
- All Titan III Major Design Reviews Completed
  - TOS Completed and in Storage
  - Launch Complex Behind Schedule, but on Recovery Plan

# Mars Exploration Planning

## Mars Observer

## ➢ MESUR

## Small Rovers and Sample Return Missions

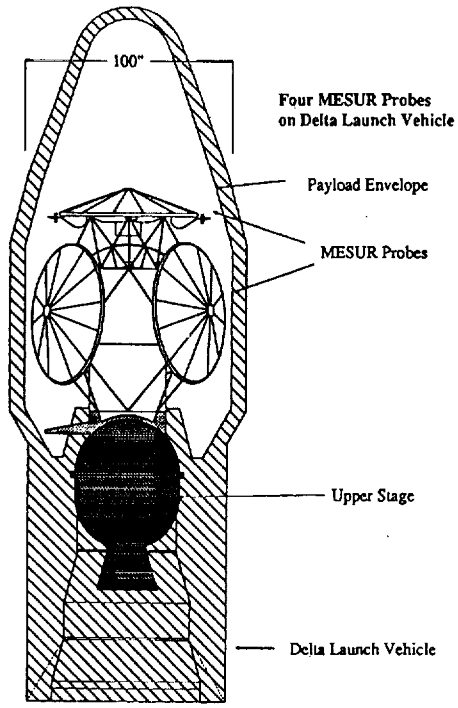
# MESUR Philosophy

- "Grow" a Survey Network Over a Period of Years (a Series of Launch Opportunities)
- Develop a Level of Effort Which is Flexible and Responsive to a Broad Set of Objectives
- Focus on Science Return While Providing a Solid Basis for SEI (e.g., Site Selection Data)
- Minimize Cost and Complexity Wherever Possible

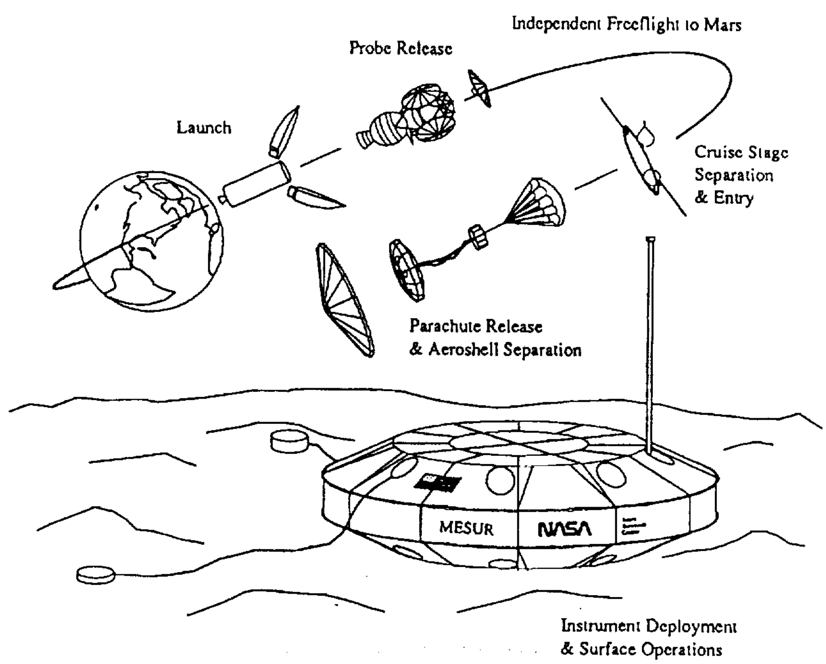
# Baseline Mission Profile

- 16 Landers
- Delta II Launches at Every Opportunity
  - 2001, 2003, 2005
  - 4 Probes per Launch
- Small Free-Flyer Spacecraft, Spin Stabilized
  - Probes Designed as Cruise Stage, Entry System, Lander
  - Design Based on Pioneer & Viking Heritage
    - "Hard" Landing of <40 g's
    - RTGs
  - Communications Orbiter
    - Launch 2003

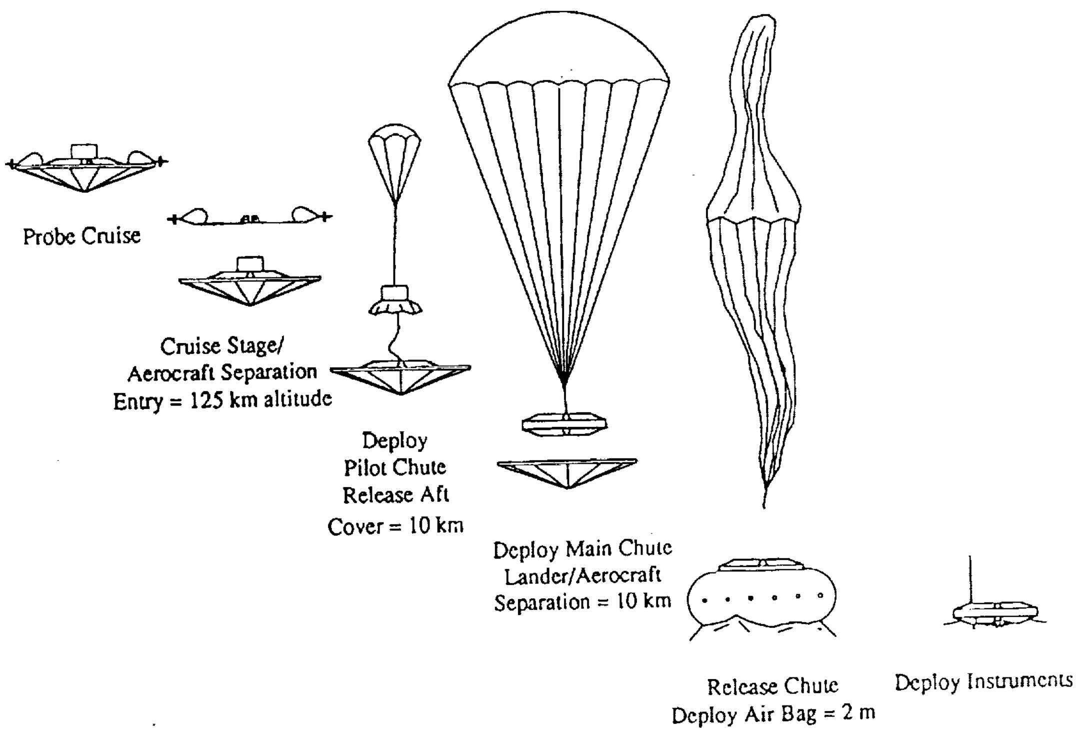
# Launch Configuration




# MESUR Mission Summary



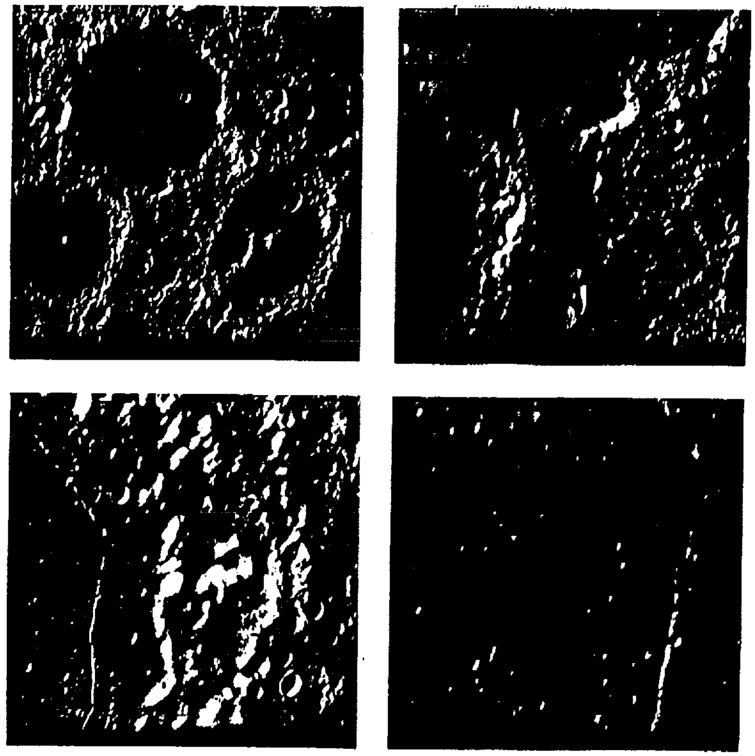
# MESUR Descent and Deployment




# Detailed Mission Objectives and Assumptions from MarsSWG

- Descent and Surface Imagery (Multiband)
  - Nested Images Desirable but Not Required
- Landing Accuracy on the Order of 100 km
  - Knowledge of Relative Lander Position to 1 km
- Entry Science Performed
  - Atmospheric Structure Experiment

# RANGER DESCENT IMAGING



# Descent Imaging Concerns

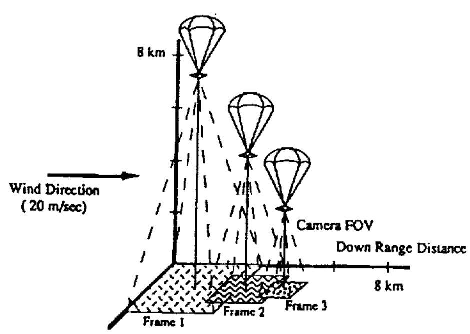
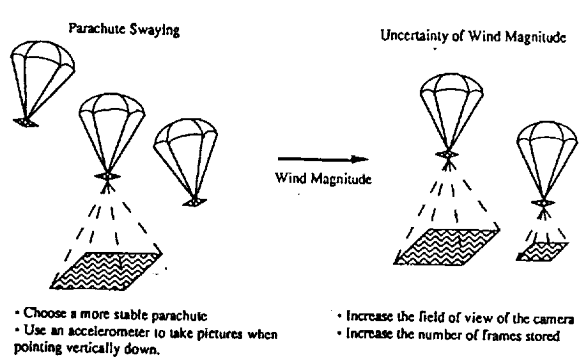



Figure V-2. Descent Imaging Concept




- Choose a more stable parachute
- Use an accelerometer to take pictures when pointing vertically down.

- Increase the field of view of the camera
- Increase the number of frames stored

## Detailed Mission Objectives and Assumptions from MarsSWG

- Meteorology Measurements
  - Long Station Life (Simultaneous Measurements for 1-3 Mars Years)
  - Large Number of Widely Dispersed Stations (15-20)
  - Pressure, Opacity, Temperature, Winds and Humidity if Possible


## Detailed Mission Objectives and Assumptions from MarsSWG


- Seismology Measurements
  - Short Period Seismometer, Single 3-Axis, as Broad Band as Possible
  - Surface Emplaced Seismometer
  - Long Station Life (>1 Mars Year)

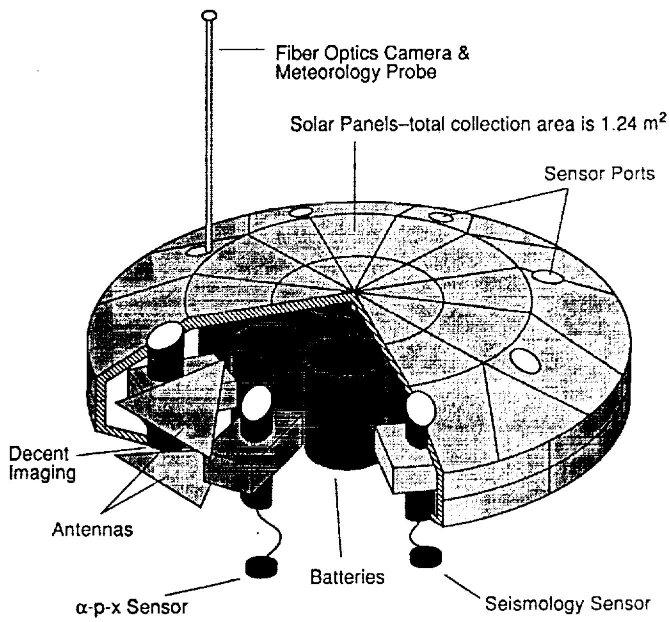
# Detailed Mission Objectives and Assumptions from MarsSWG

- Geochemistry Measurements
  - Instruments Placed on Surface
  - Elemental Composition Instrument ($\alpha$-p-x) Deployed at Each Station
  - Thermal Analyzer and Simple Evolved Gas Analyzer

# Strawman Lander Science Payload

- Atmospheric Structure Experiment
  - Determination of Winds
- Descent/Surface Imager (CCD/CID Array)
- Meterology Package
  - Atmospheric Pressure
  - Atmospheric Opacity
  - Temperature, Humidity, and Winds (at 1m Above Lander)
- Surface Composition ($\alpha$-p-x)
- Seismometer
- Impact Accelerometer
- Thermal Analysis Instrument (e.g., DSC)

# MESUR Lander




# MESUR Strawman Science Payload

| INSTRUMENT | MASS (kg) * | POWER (W) | DATA | DIMENSIONS (cm) | LATITUDE DEPENDENCY | HERITAGE | MAX. 'g' LOAD (peak) | OPERATIONS DUTY CYCLE |
|---|---|---|---|---|---|---|---|---|
| METEOROLOGY PACKAGE Note (1) | 0.66 * | 0.021 | 10 kbits per day | Not Available | | NEW | <40 | continuous - wind, temp point measurements, humidity, pressure |
| 3-AXIS SEISMOMETER (Sensor package) | 1.5 * Note 2 | 2 | 10 Mbits/day | | | NEW | | continuous |
| ATMOSPHERIC STRUCTURES INSTRUMENT, Note (1) | 1.5 | 6.2 | 65 bps | 4 x (5-10) long (5 sensors) 10 x13 x 13 (elec box) | Note (1) | Galileo, PV, Viking | <500 | 5.5 minutes |
| ELEMENTAL COMPOSITION INSTRUMENT, (alpha/proton/x-ray) | 0.6 * | 0.5 | 100 kbits for 3 spectra | need elect dimensions (4.5 x 3.2) | primarily site dependent | NEW, Viking | <40 | 600 minutes |
| IMAGERS: | | | | | | | | |
| DESCENT | 0.22 * | 4 | 12 Mbits to store 12 images | 6 x 6 x 3 (head) 10 x 10 x 3 (internal elec) | | NEW | <40 | continuous during descent |
| SURFACE | 1.36 * | 21 | 25Mbits per 360 deg scan | 10 x 15 x 6 (camera/drive) 1000 x 1 dia (Mast) 3 x 2 x 5 (Head) | | NEW | <40 | 10 minutes |
| COMMON ELECTRONICS | 0.26 | Note 3 | | included w/ imagers | | NEW | | included w/ imagers |
| THERMAL ANALYZER & EVOLVED GAS ANALYZER ANALYSER | 2 | 12 | 3M bits per sample | 12 x 12 x 12 | primarily site dependent | NEW | <40 | 60 minutes (4 samples per martian year) |
| TOTAL | 8.10 | | | | | | | |

Notes:
* mass estimate does not include deployment hardware
(1) may share common sensor
(2) mass estimate for sensor only
(3) mass estimate included in descent and surface imagers mass estimate

# Mars Exploration Planning

Mars Observer

MESUR

➢ Small Rovers and Sample Return Missions

## Science Drivers: Sample Return Mission

- Return Martian Samples to Earth Laboratories for Analysis
  - Highest Priority Science Objective for Mars
- Geology of Mars
  - Based on Geologic Mapping from Viking Images (Defined Units kms Scale)
- Defined 10 Different Units
  - Need ~10 Different Types of Samples Returned

# Science Drivers: Sample Return Mission

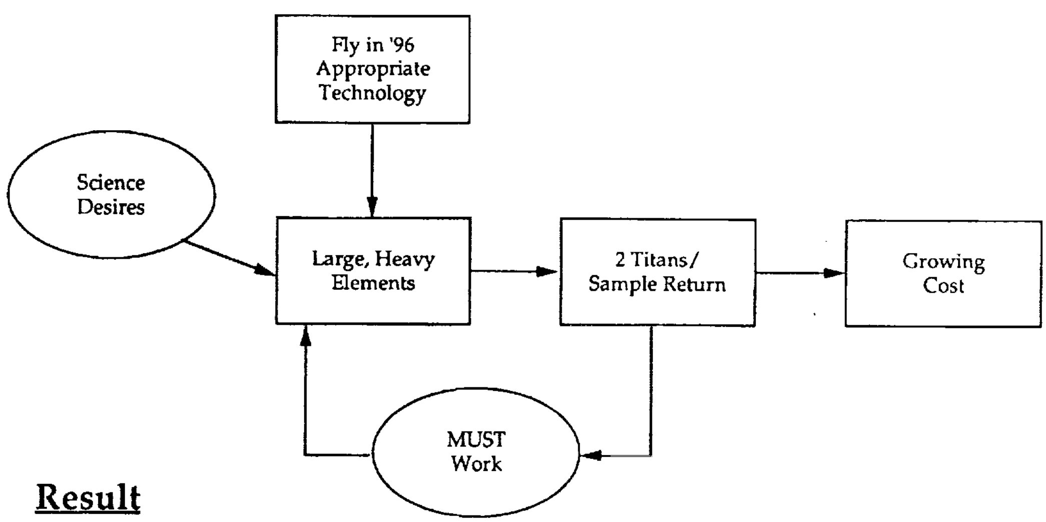
Heavily Cratered Material → Early History of Planets

Volcanic Rocks → Age and Composition of Planet

Sedimentary Rocks → Climatologic and Biologic (?) Conditions

Drift Material, Soil, Salts, Ice, Atmosphere → Volatile Inventory

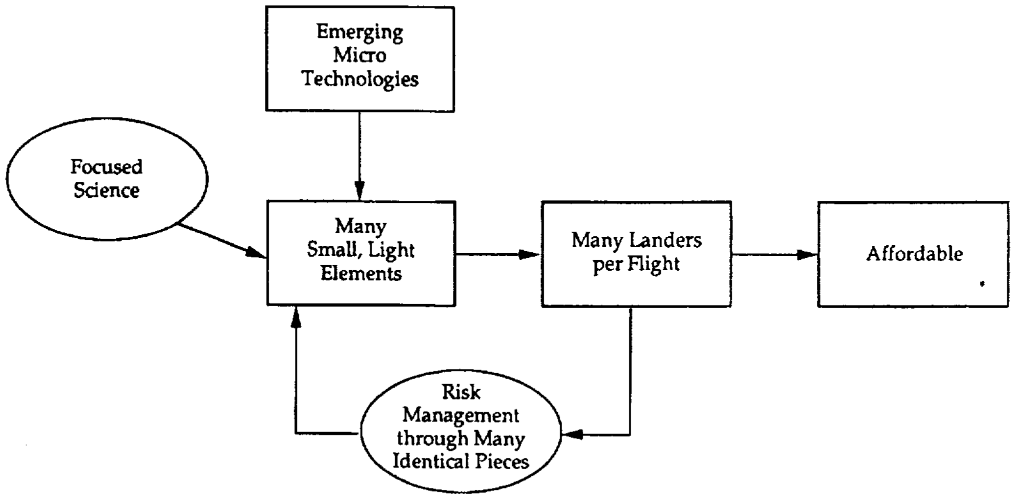
MSRS "Old Think"




Result

- Many interacting elements, complex operation
- Extremely Capable Rover
- Two Titan 4 Launches for One Sample Return
- Risk management through very high reliability, single items
- Cost ~$10B

## Micro Technology Based Approach "New Think"




**Result**

- Much smaller pieces - few on a Delta or Atlas
- Risk Management through many tries
- Cost goal ~$1.5 - 2 B

# Key Concepts to "New Think"

- Take Advantage of Emerging Micro Technologies
  - Most Develop Outside NASA, Particularly for SDI
  - Includes Integrated Electronics, Power, Processors, Propulsions, Software...
- Focused Science
  - Limited Access from Lander and Constrained Landing Regions
  - Less Capable Rover
  - Less Elaborate Sampling
  - Less in-situ Science
  - No Traverse Science
  - Less Stringent Sample Preservation

# Key Concepts to "New Think"

- Simplify Missions to Absolutely Essential Elements
- Commit to Many Small Landers
  - Accept that Some Fraction (~20%?) Will Fail
  - Manage Risk by Increased Number of Independent Landers
  - Mission Success Achieved with a Fraction (<1) of Landers Successful

# Comparison of Approaches

- Returned Samples
  - Both ~8-10 Different Sample Types
  - Similar Total Mass
  - MRSR Samples from 2 Areas
  - Small SR Samples from Diverse Areas

# Comparison of Approaches

- Rovers/Landers
  - MRSR
    - Large Complex Rover
    - Many in-situ Instruments on Rover
    - Traverse Science
    - Sample Packaging/Preservation on Rover
  - Small SR
    - Small Simple Rover
    - No Traverse Science
    - Most in-situ Instruments on Lander
    - Sample Preparation on Lander
    - Different Instruments on Different Landers

# Small SR

- Satisfies All Major Science Objectives
- Simple Approach
- Flexible
- Less Expensive
- Failure Tolerant

# Key Technologies

- Mini RTGs
- Advanced Propulsion Systems
- Small Rover 'Behavior' Control
- Micro Sensors and Instruments
- In-situ Instruments
- Micro Spacecraft Subsystems
- Long Life Electronics

# Small Rover Mission Strategies

- Many Landing Options (Propulsive Lander to Ranger-Style Impact Capsule)
- Use Beacons and INS to Guide Rovers
- Reliability Through Redundancy
- Many Small Rovers Mean Smaller Traverses and Shorter Required Lifetimes
- Many Landings Allow Rovers to be Targeted at Individual Geologic Units

# Mission Options

- Direct Return from Surface to Earth Entry
  - No Sample Transfer After MARV Lift-off
  - JPL Design Emphasis
- Mars Orbit Rendezvous
  - Sample Transfer MAV to ERV/SRC in Mars Orbit
  - Previous JSC Design Emphasis
- Earth Orbit Rendezvous
  - Sample Transfer MARV to ERV/SRC in Earth Orbit
  - Martin Marietta Corporation Design Emphasis

# Micro MAV Sample Return Options

| Option | Direct Return | Mars Orbit Rendezvous | Earth Orbit Rendezvous |
|---|---|---|---|
| Design | Current JPL | Old JPL/JSC | Current MMC |
| MARV Mass | 380 kg | 62 | 311 |
| MARV Delta-V | 6339 m/s | | 7235 |
| Sample Mass | 0.5 kg | 0.5 | 0.5 |
| Other Elements | SRC+Lander+Aeroshell+ Minirover | Lander+Aeroshell+ Minirover | Lander+Aeroshell+ Minirover |
| Flight System Mass | (6 elements) 790 kg | (5 elements) 238 | (5 elements) 715 |
| Aeroshell Diameter | 3.6 m | 2.0 | 3.7 |
| Beta | 46 kg/m2 | 46 | 41 |
| Launch Vehicle | Atlas IIAS (4) | Delta 7925 (4) | Atlas IIAS (4) |
| C3 | 11.1 km3/s2 (2009) | 17.7 (2005) | 11.1 (2009) |
| Flight Systems per Launch | 2 | 2 | 2 |
| Mass Margin | 20% | 85% | 33% |
| Other Launched Elements | CO+Delta (2) | R/CO+Atlas (2) SRC+ERV+Delta (4) | CO+Delta (2) SRC+ERV+Delta (3) |

# Interactions with SEI

- New Associate Administrator Named
- Huntress/Griffin Agree on Science Objectives and Priorities for Moon and Mars
- Who Will Implement Moon/Mars Missions?
- Discussions Continue