

**TO MARS VIA ITS MOONS PHOBOS AND DEIMOS (Ph-D Project)**

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**National space program needs a single overarching goal**

Manned exploration of Mars from Martian Moons has unique scientific content – not a publicity stunt.

First step should be the **Ph-D Project**, with a base on Deimos. It can be **Faster**: 10- 15 years; **Better**: than a series of unmanned probes or than a manned base on Mars surface; **Cheaper** than either alternative – and within current NASA budget.

A Manned Mission to the Moons of Mars (MMMM) addresses Fundamental Science Goals:

**1. How do planets develop? Comparative Planetology**

What happened to Mars oceans?

To magnetic field?

Mars volcanism and mountain building

**2. Climate history**

Was Mars wet and warm?

Climate change as spin axis moved

Do climate cycles exist as on Earth?

Can models explain climate changes

**3. Origin of Life**

Existence of fossil life forms?

Existence of hidden life beneath surface or near ice caps?

Biochemistry and morphology --similar to terrestrial life forms?

**FASTER.....**

Simple Orbit transfer from Earth orbit to Mars orbit. No unsafe landings.

Deimos provides shielding against meteor streams, cosmic rays, solar flares

**BETTER.....**

Unmanned rovers controlled in real time – no time delay

Tele-robots return data/samples to Deimos

Immediate evaluation permits sequential exploration --- with results in hours instead of years

Complete scientific laboratory setup --- natural vacuum for instruments

Sortie to Phobos for sample collection

Manned sortie to Mars surface --- for follow-up of scientific results; and to set up prototype automatic propellant factory

**CHEAPER.....**

Assemble gradually in Earth orbit -- 30 tons, mostly propellant

Pre-position “Slow Freight “ on Deimos -- via cheapest route

Test Manned Habitat and crew in LEO

When ready, send by fastest route – study propulsion vs. transit time trade-offs

Desirable technology developments --- (now in pipeline)

---Heavy-lift vehicle (“Space Truck”)

---Nuclear reactor electric power supply

No showstoppers. Build on ISS experience.

Cost Estimate: \$30 billion over 15 years -- within present NASA budget

**Advantages of PhD Mission**

Manned-Robotic Cooperation vs. Manned Planetary Base

1. No delta-vee penalty (2 x 2.38 km/sec on Moon) (2 x 5.0 km/sec on Mars)

Hence: Less need for propellants (and for their transport)

2. No need for high-thrust engine -- since del-vee = thrust x time

No Landings—only Orbit Maneuvers

Hence: Use existing engine (smaller, less weight, better mass ratio)

3. Better science 4. Safer 5. Cheaper and sooner

We need further trade-off studies: Minimizing transit time vs. additional del-vee

“Lifeboat” mission (*Chang-Diaz*): 100 days to Mars, 30 d at/near Mars, 100 d to return

**Follow-ons:**

Mars base: Propellant production

Detailed exploration & experiments

Habitation & colonization: Terraforming & agriculture

Phobos/Deimos as cheap sources for material for space construction