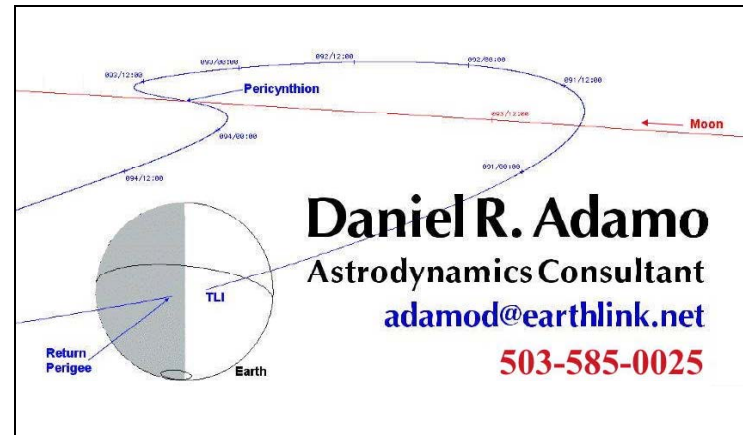


Questioning The Surface Of Mars As The 21st Century's Ultimate Pioneering Destination In Space



Small Bodies Assessment Group Meeting #13
Washington D.C.
1 July 2015

Questioning Mars As The Ultimate Pioneering Destination In Space

Background And Context

- Foreseeable human-initiated activity in space can be divided into two categories
 - Exploring (e.g. Lewis & Clark ca. 1805): survey foreign territory
 - + A major component of NASA's charter
 - + Can be conducted by humans directly or by robots under human control
 - + Virtual human presence is possible via tele-robotics stationed < 100,000 km away
 - + Mars never approaches Earth closer than 56 million km
 - Pioneering (e.g. Pilgrims ca. 1620): put down multi-generation roots in foreign territory
 - + NOT in NASA's charter
 - + MUST be conducted by humans in situ and ultimately return sustained profits
 - + Any examples to date are dubious and Earth-centered (e.g. communication satellites)
- Mars is widely accepted as the ultimate 21st century pioneering destination in space
 - Why would 202,586^{*} adults volunteer in 2013 for a one-way trip to the surface of Mars?
 - What are potential obstacles to pioneering the surface of Mars?
 - Might there be more accessible and hospitable pioneering destinations than Mars?

^{*} The number of applications actually completed and submitted to Mars One was reported in 2015 to be 4227.

Questioning Mars As The Ultimate Pioneering Destination In Space

History[†] Indicates Humans Pioneer For Compelling Reasons

- Escape from war, starvation, persecution, and pestilence
- "Don't fence me in" land grabs motivated by overcrowding, limited opportunities, and poverty

Reasons To Pioneer In Space Are Relatively Abstract

- No predictable threat to widespread survival on Earth is known for at least the next 100 years
- No "unobtainium" has been found in space yet

No Known Hostile Natives On The Way To Mars, But...

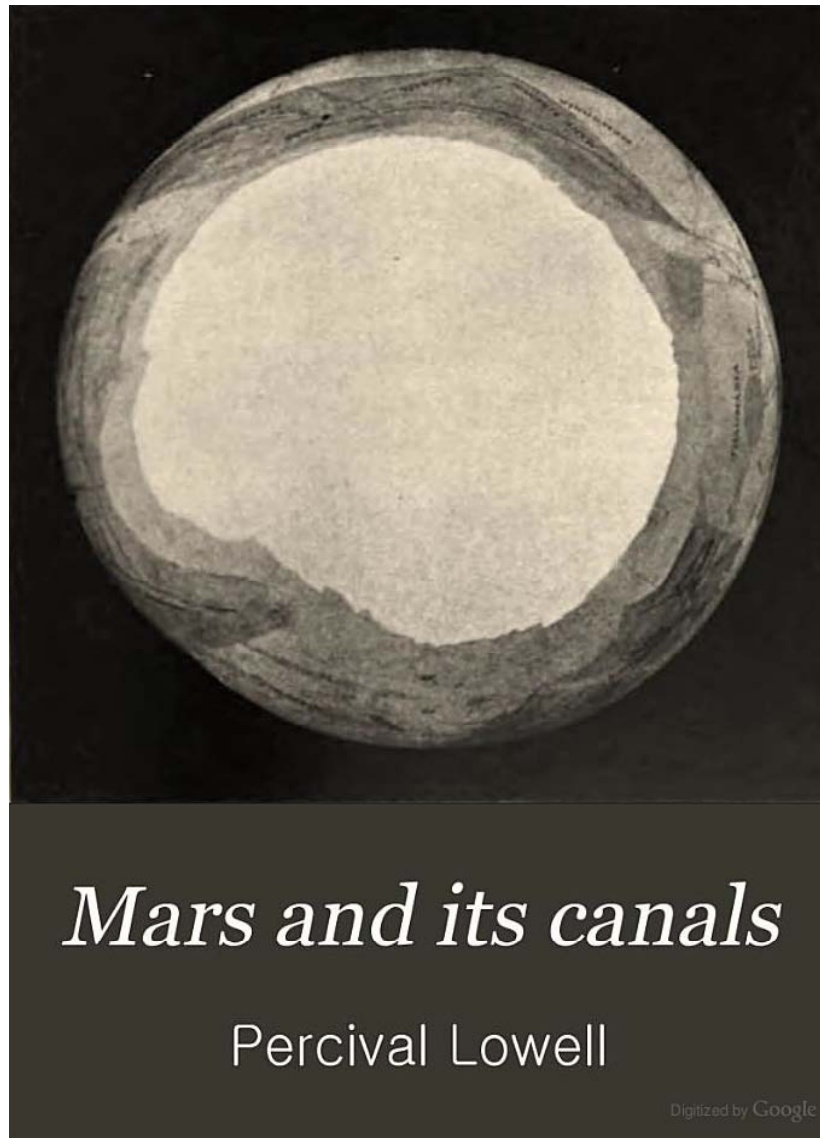
- Transport from and to Earth involves huge distances, delayed responses, and immense energies
- Threats from exposure to temperature extremes, vacuum, radiation, and reduced gravity
- Habitats tend to be cramped, stuffy, and insulated from outside scenery
- Diets with fresh produce may be problematic over protracted intervals

Conclusion: Mars Is Evidently A "Socio-Cultural" Destination

[†] "The only thing new in the world is the history you don't know." -Harry S. Truman

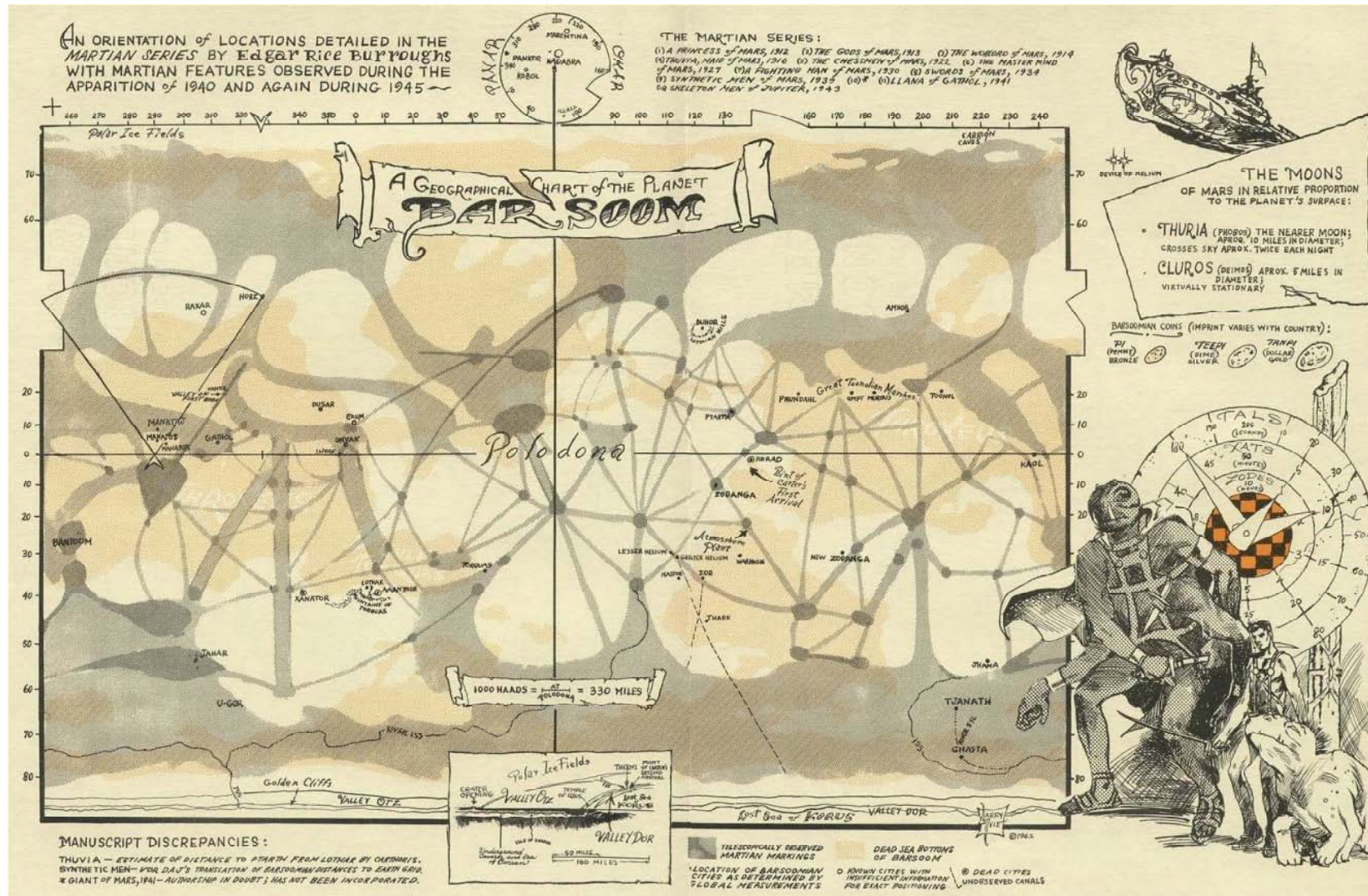
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Why Mars? Intelligent Life Has Built Canals There (Percival Lowell ca. 1906)



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Why Mars? Adventure and Romance (Edgar Rice Burroughs ca. 1912)



Cartography by Edward Ivie

Questioning Mars As The Ultimate Pioneering Destination In Space

Why Mars? The Martians Are Coming! (Orson Welles 1938 & H.G. Wells ca. 1898)

FROM MERCURY... TO MARS!

75TH ANNIVERSARY RADIO BROADCAST & LISTENING PARTY!!

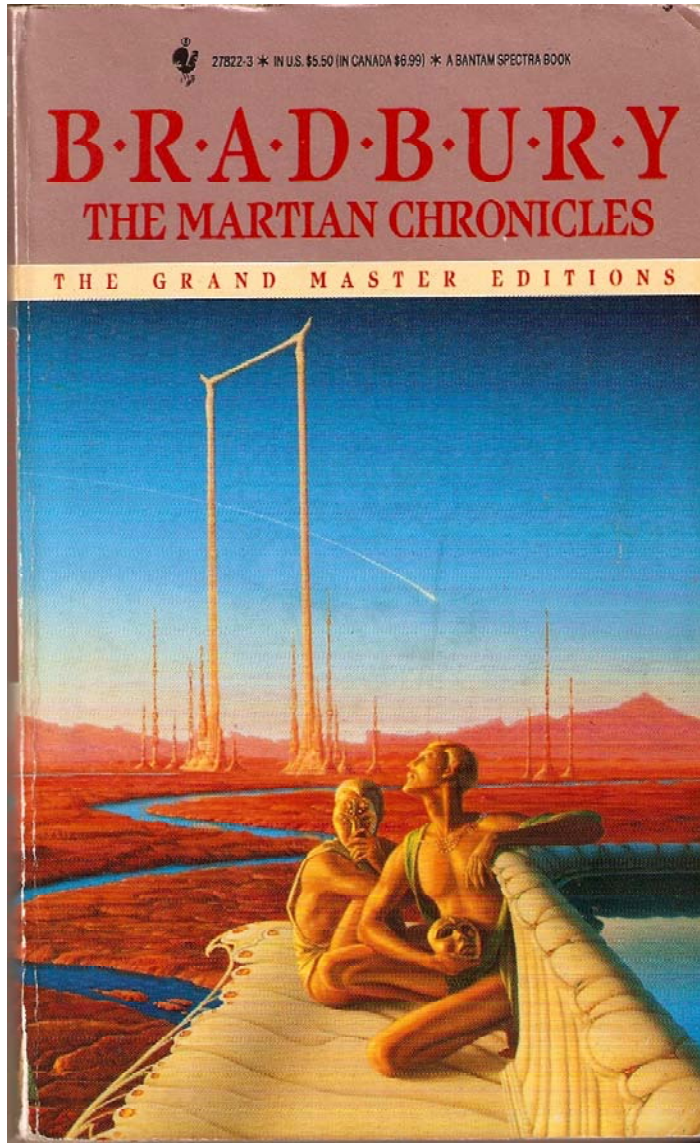
Friends and Fans! Come be part of the end of history by live-tweeting the 75th anniversary of Orson Welles and the Mercury Theater's infamous *Invasion from Mars*. Follow along at soundstudiesblog.com at 8pm eastern and 7pm central, Wed. Oct 30, 2013. Use the hashtag **#WOTW75** on Twitter and Facebook to react to the play in real time. We'll archive your responses. Organize your listening party now! The alien intelligences already draw their plans against us...

Sponsored by Sounding Out! The Sound Studies Blog.

H.G. WELLS' THE War OF THE Worlds

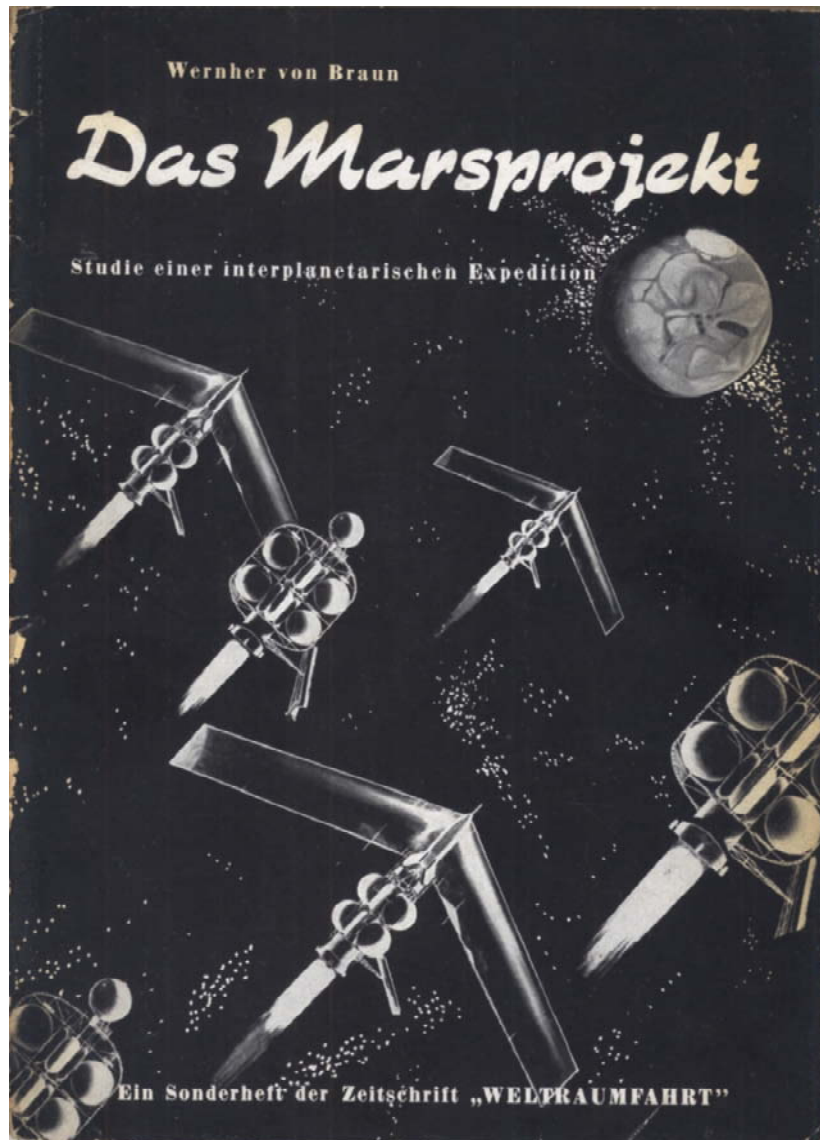
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Why Mars? It's Human Destiny (Ray Bradbury ca. 1950)



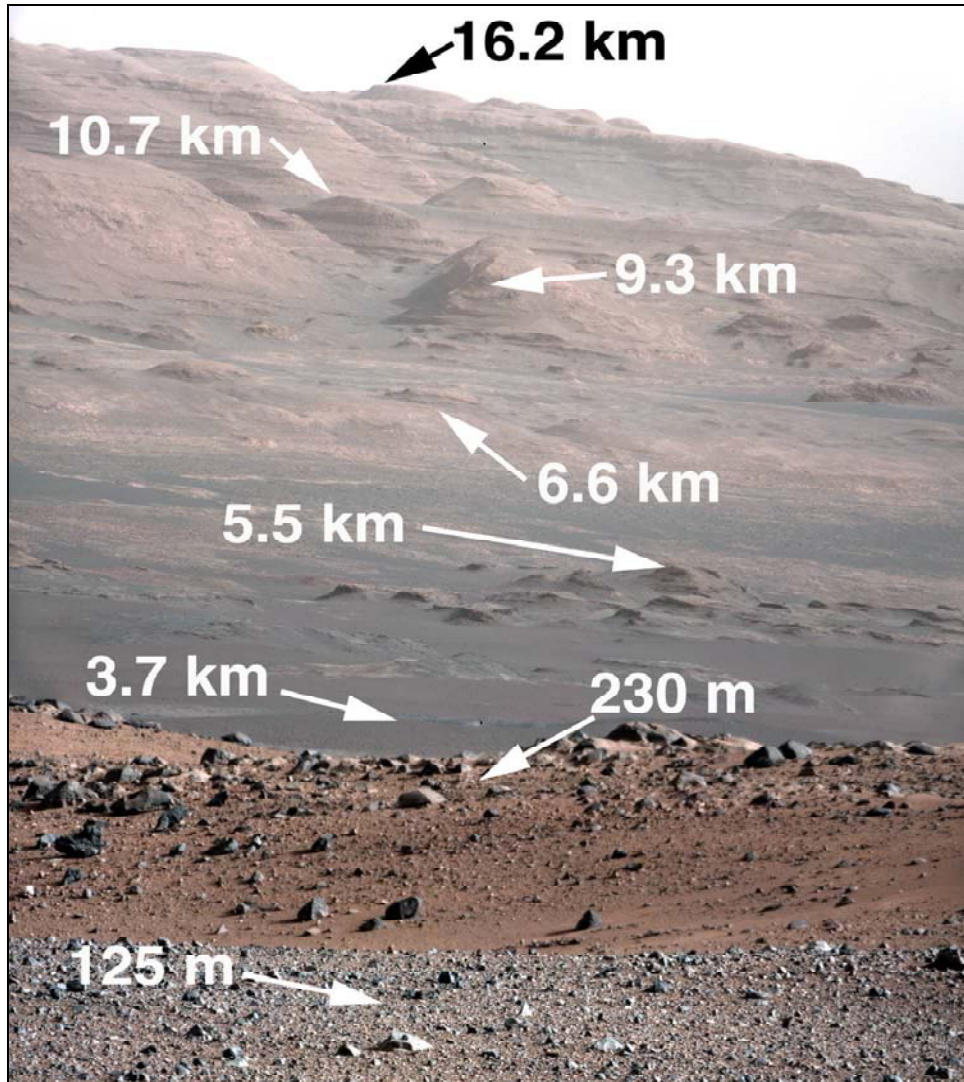
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Why Mars? We Have The Technology (Wernher von Braun ca. 1952)



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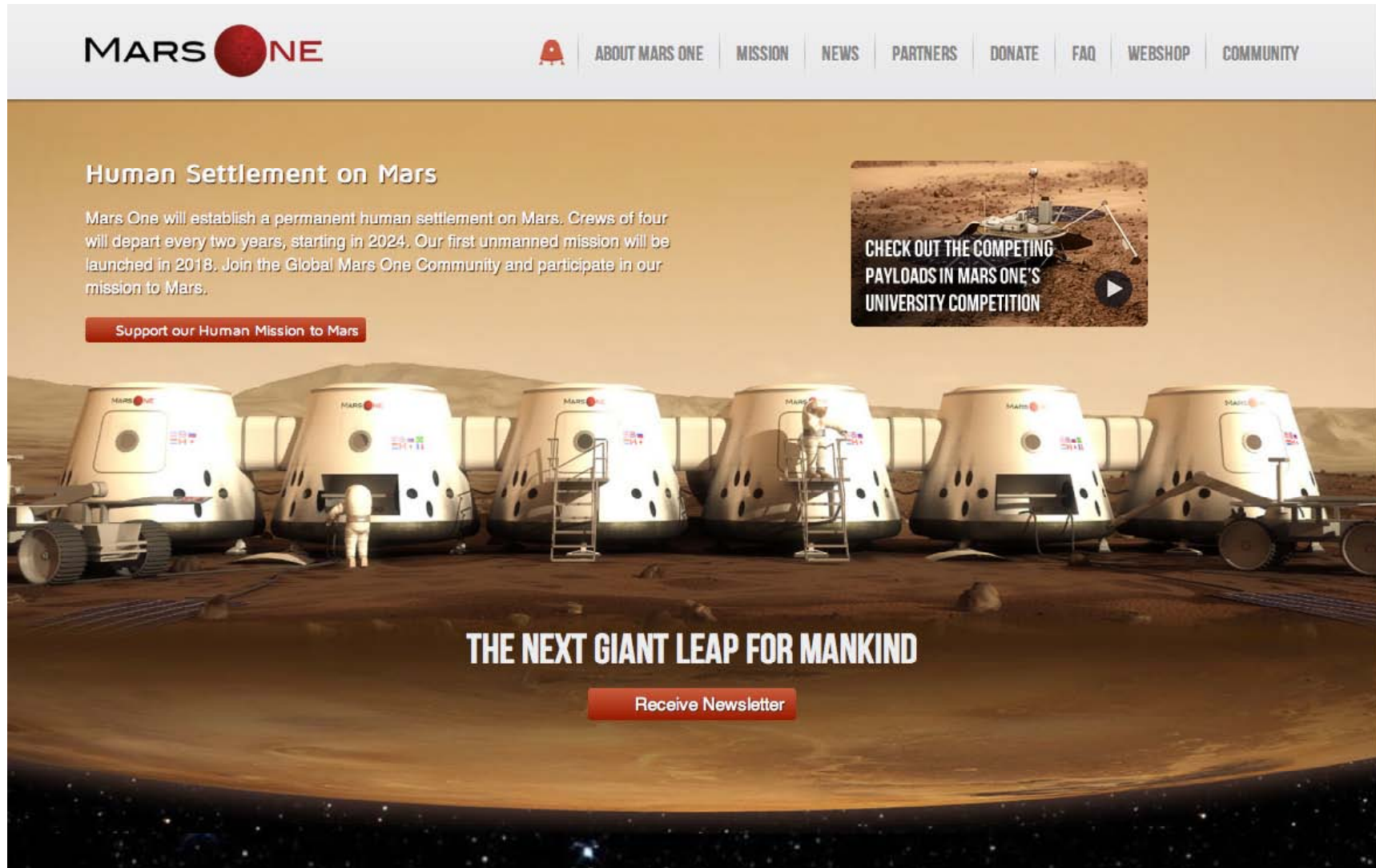
Why Mars? It Looks Like Home, And The Views Are Spectacular (NASA ca. 2012)



Cropped Mars Science Laboratory *Curiosity* annotated image PIA16104 from NASA/JPL

Questioning Mars As The Ultimate Pioneering Destination In Space

Why Mars? We'll Be Pioneering There In 2024 2027!



Reference <http://www.mars-one.com> (accessed 19 Nov 2014)

Questioning Mars As The Ultimate Pioneering Destination In Space

What's Wrong With This Picture?



- Radiation exposure: above-surface habitats, space suits, and unpressurized rovers provide inadequate shielding to support 500-day duty tours, let alone multi-generation pioneering
- Reduced gravity: there is no evidence supporting multi-generation human adaptation to 38% of Earth's gravity after evolving millions (billions?) of years on Earth
 - "Terraforming" to appreciably increase Mars gravity defies reason in the 21st century
 - Habitat in a "Tilt-A-Whirl" centrifuge cannot reproduce constant Earth gravity on the surface of Mars (constant Earth gravity is only achievable under nearly weightless ambient conditions)

Questioning Mars As The Ultimate Pioneering Destination In Space

What Off-Earth Location Offers These Hospitable Ambient Living Conditions

Human Pioneers On The Surface Of Mars Would Envy?

- Atmospheric pressure near 66% of Earth's at sea level \Rightarrow radiation protection equivalent to living at 3500 m (11,500 ft) altitude on Earth
- Temperature near 37° C (98.6° F)
- Gravity near 89% of Earth's at sea level

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Magellan Venus orbiter atmospheric data presented at <http://www.datasync.com/~rsfl/vel/1918vpt.htm> (accessed 19 Nov 2014).

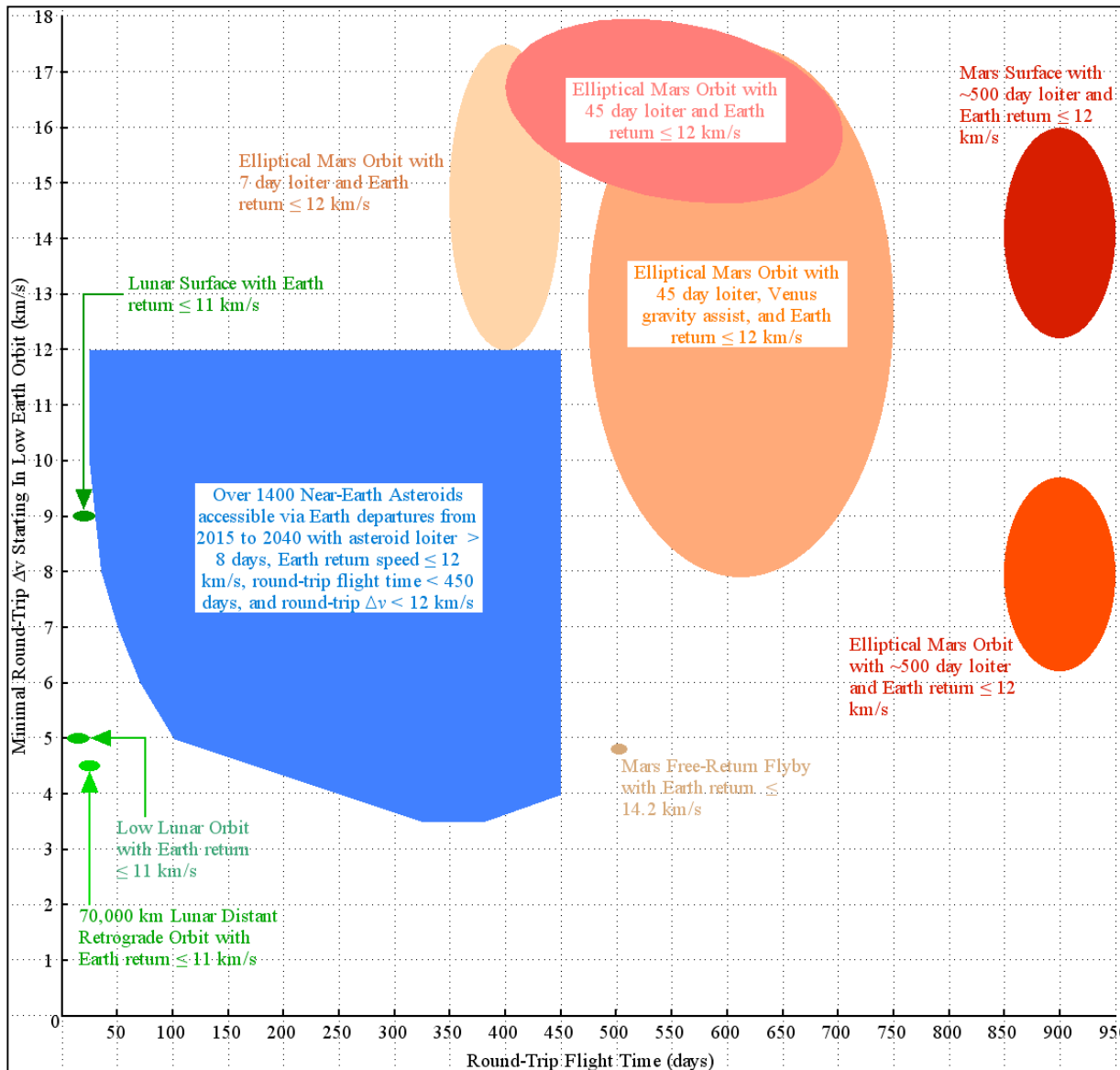
Answer: A Floating Habitat 52.5 km (32.6 mi) Above The Surface Of Venus

- This location lies near the middle of a sulfuric acid cloud deck extending from 30 to 75 km above the surface of Venus, but the view from a subsurface Mars habitat would be no better
- If multi-generation survivability off-Earth is our primary consideration, the atmosphere of Venus is arguably a better pioneering destination than the surface of Mars from what little we know about human adaptation to off-Earth environments

See the High Altitude Venus Operations Concept (HAVOC) at <http://sacd.larc.nasa.gov/branches/space-mission-analysis-branch-smab/smab-projects/havoc/> (accessed 23 Dec 2014)

Questioning Mars As The Ultimate Pioneering Destination In Space

Many Small Bodies Are Easier To Access Than The Surface Of Mars



Shaded areas are approximate for illustrative purposes

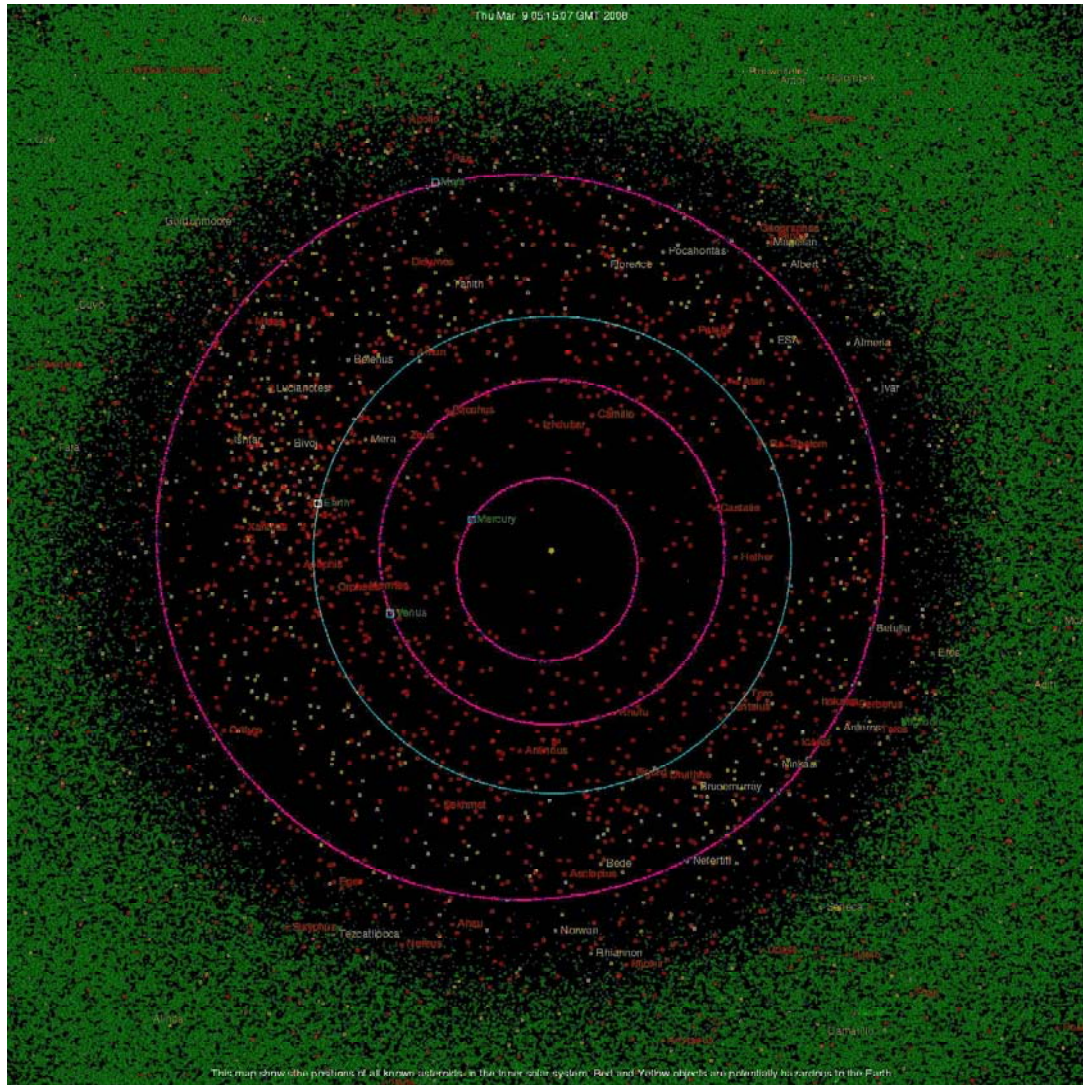
Moon missions assume minimal loiter time at the destination

Asteroid and Mars destinations may be highly inaccessible at times

Adapted from a chart by NASA/Brent Barbee posted at http://www.lpi.usra.edu/sbag/science/NHATS_Accessible_NEAs_Summary.png (accessed 14 Jan 2015)

Questioning Mars As The Ultimate Pioneering Destination In Space

Small Bodies, Including Near-Earth Asteroids (NEAs) More Accessible Than The Surface Of Mars, Were Virtually Unknown Through Most Of The 20th Century



Sun-centered plot by the U.K. Spaceguard Centre shows all asteroids known on 9 March 2008

Two moons of Mars and one NEA known in 1900

13 NEAs known 1 Jan 1950

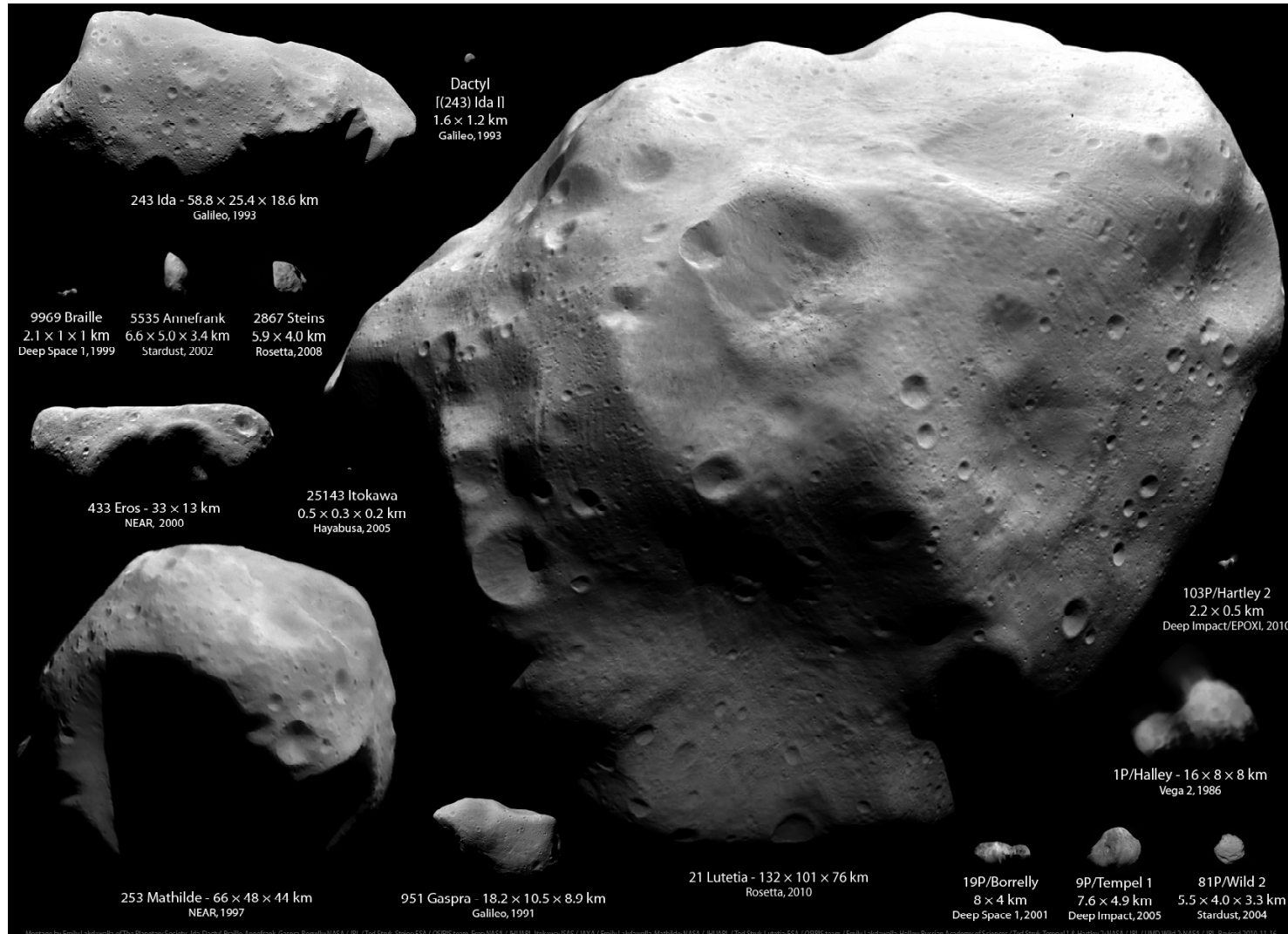
877 NEAs known 1 Jan 2000

11,451 NEAs known 1 Oct 2014

Reference <http://neo.jpl.nasa.gov/stats/> for NEA tallies (accessed 4 Oct 2014)

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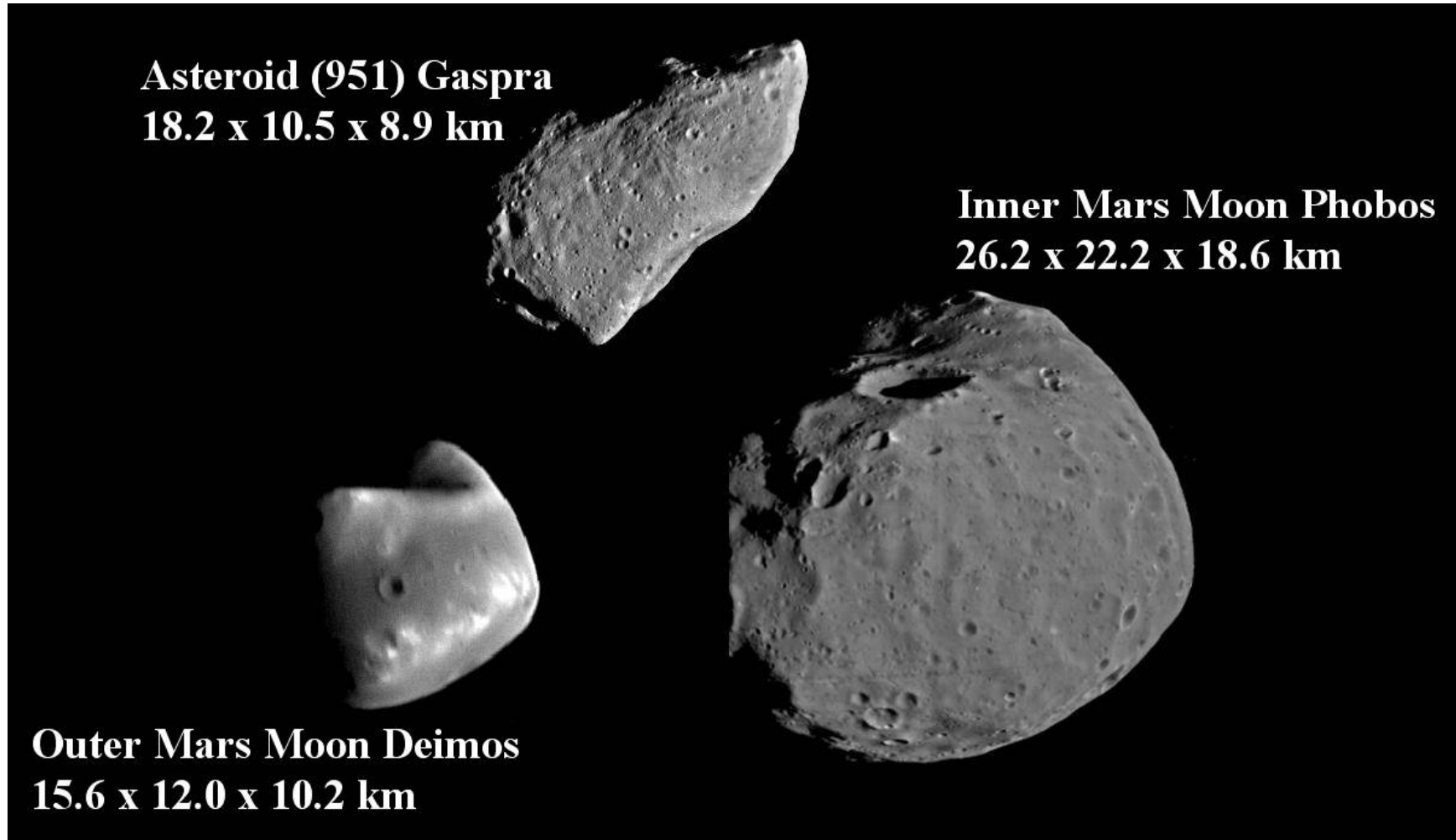
Small Bodies (Asteroids, Comets, And Moons Of Mars) Are Prolific & Various



To-scale montage by Emily Lakdawalla

Questioning Mars As The Ultimate Pioneering Destination In Space

Small Bodies (Asteroids, Comets, And Moons Of Mars) Are Prolific & Various



To-scale montage at <http://photojournal.jpl.nasa.gov/catalog/PIA00078> (accessed 6 October 2014); annotated ellipsoid dimensions are diametric

Questioning Mars As The Ultimate Pioneering Destination In Space

**Hypothesis: More Successful Pioneering Can Be Done At Less Risk And Expense
On Small Bodies Than On The Surface Of Mars**

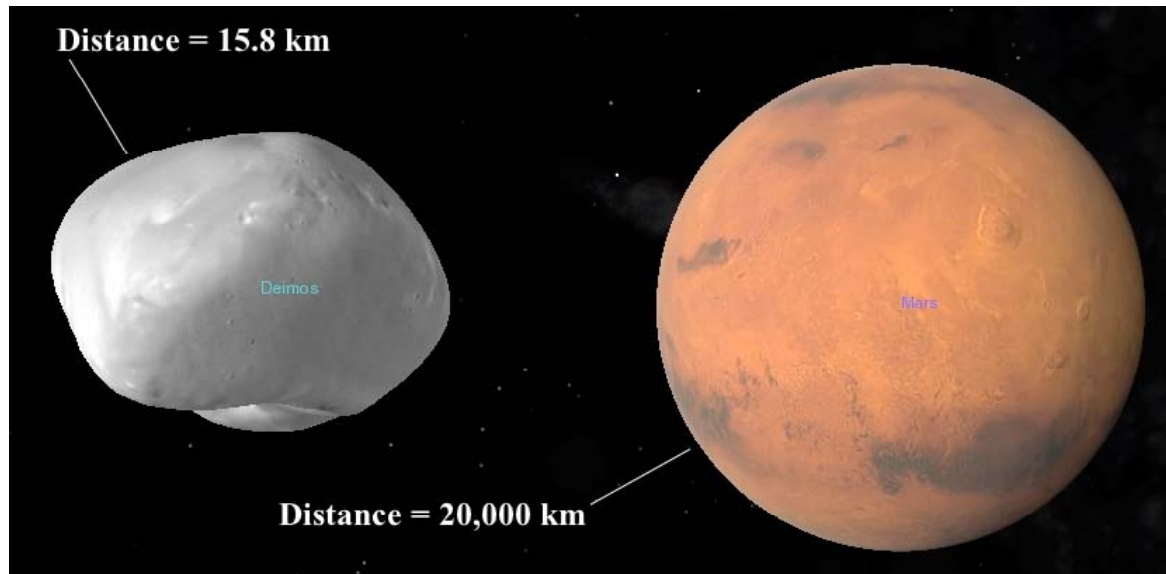
Pioneering Obstacle	Surface Of Mars Solution	Small Body Solution
Radiation Exposure	Subsurface Habitat	Subsurface Habitat
Reduced Gravity	?	Rotating Habitat
Access Logistics	Interplanetary Transport Plus Mars-Specific Lander	Interplanetary Transport
Marketable Exports	?	?
Export Logistics	Mars-Specific Launcher Plus Interplanetary Transport	Interplanetary Transport

NOTE: Mars-specific landers and launchers will be expensive to develop, produce, and operate. They will also undergo stressful flight regimes not conducive to prolonged reuse.

Questioning Mars As The Ultimate Pioneering Destination In Space

An Informed Space Pioneering Plan For The 21st Century

- Continue to explore the surface of Mars robotically from Earth (if current or fossilized life is there, it will be easier to detect and less likely to perish if humans are not present)
- Continue to search for and explore small bodies
- Study human adaptation to reduced gravity in low Earth orbit with rotating habitats
- Develop routine interplanetary transport for humans and cargo
- Establish rotating subsurface habitats on strategic small bodies
- Explore Mars with tele-present humans in subsurface Deimos habitats
- Pioneer on Mars only if it's possible to thrive there economically and biologically



Rendering by *Celestia* 3D space simulation software available for download at <http://www.shatters.net/celestia/> (accessed 19 Nov 2014)