



**Inputs to Moon to Mars (M2M) Objectives  
Workshop #1 Houston, TX  
June 28-29, 2022**

**Update July 13, 2022**



# An Independent Nonprofit Nonpartisan Educational Membership Organization Dedicated to the Creation of a Spacefaring Civilization

**Our Vision: “People living and working in thriving communities beyond the Earth and the use of the vast resources of space for the dramatic betterment of humanity.”**

- 6000 members in over 40 chapters
- Sponsors annual International Space Development Conference with Technical, Business, Policy, Legal, and other Tracks
- STEM activities influence new generations
- Online forums and Position Papers on space-related topics
- Collaborated with NASA Advanced Innovative Concepts (NIAC) in organizing and running the 2021 Space Settlement Workshop
- A founding Member of the Alliance of Space Development which represents 16 non-profit space interest organizations
- Participates in developing a “Citizen’s Space Agenda” for regular discussions with Members of Congress
- Produces the award-winning monthly ad Astra magazine with a circulation of 52,000





# Team for 2022 M2M Objectives Workshop #1

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**John K. Strickland**, Member NSS Board of Directors, NSS Roadmap Committee Chair; President, Austin NSS Chapter; Author: *Developing Space & Settling Space* (Apogee Books, 2021)

**David Chevront**, NASA JSC (Retired); Commercial Space Business and Technology Advisor; NSS Policy Committee Member

**Dr. Gregory Stanley**, Ph.D., Chemical Engineering; President, Performity LLC; Vice President, NSS North Houston Chapter

**Dr. Fredrick (Rick) Jenet**, Ph.D., Physics; Expanding Frontiers, Founder and Executive Director; CTO Lunar Station Corp.; South Texas NSS Chapter Founding Board Member

**Advisor: Dave Huntsman**, NASA (Retired); Board Member, Alliance for Space Development; Independent Space Consultant



# National Space Society Goals

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**Developing Space:** Making the vast resources of space available to all

**Clean Energy from Space:** Enabling everyone to benefit from space solar power

**Communities in Space:** Supporting the establishment of space settlements, making us an interplanetary species

**Defending Earth:** Protecting humanity from dangerous space objects

***NSS does NOT expect NASA to develop the space economy and settlements itself, but NASA should actively seek to enable industry to do so***

***NSS believes that by enabling commercial capabilities in space, NASA will be able to achieve greater science returns at lower cost and less time***

# Commends NASA's Work on M2M Objectives

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- Recognized including private industry, but need sooner and in more innovative ways
- Going for *Economic Sustainability* is the key (versus *Fiscal Budget* “sustainability”)
- Issue: Definitions of “Develop” and “Demonstrate” suggests Industry cannot Lead
  - Language is “NASA Designs..., NASA Deploys...” - Infers Industry only follows
  - Inconsistent with actions already taken by NASA to allow Industry leadership
    - HLS, Commercial Crew, Commercial Cargo, Commercial Spacesuit
- Recommendations:
  - Increase & front-end load NASA efforts to include and encourage private sector
  - *Economic Sustainability* by including private industry earlier & more often
  - R&D should solve industry's needed business ‘tipping points’ sooner - not later.
    - e.g., ISRU oxygen/propellant demos soonest to enable earliest industry development - with resultant benefits to both USG and overall economy
  - NASA could achieve the same outcome of these objectives in other ways
    - Purchase propellant, air, water, food, data
    - Lease hab volume; comm, nav, timing, power

# Missing Objective: Enable Space Development NSS-01

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- Space Development, as an extension of Space Exploration, means:
  - Economic sustainability of space efforts - the only type of ‘sustainability’ that’s lasting in the end; a virtuous cycle that can support sustainable Moon-to-Mars operations
  - Expands the economic sphere of Earth to Moon, Mars - and beyond
- Synergistic growth/feedback in human/robotic space activities for business and commerce with Earth activities and industries.
- More emphasis on operations for access to resources on planetary and lunar surfaces
- Sufficient characterization of extent and economics of mineral resources - prospecting, more than ‘science’ - to classify as reserves, as defined by the USGS, and required to secure private investment in terrestrial mining operations - Same is needed for ISRU
- Substantial private investment can augment Federal budgets, enable more space science, and create wealth which feeds back into the terrestrial economy

# Examples of enabling commercial capabilities

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## **Exhibit 1: Lunar Crew, Cargo Lander, and CLPS:**

**Current first HLS lunar lander selection was only possible because NASA did *not* feel hamstrung by the basic assumptions listed going into this Workshop**

## **Exhibit 2 & 3: Commercial Cargo, Commercial Crew:**

**Neither of which would have existed - particularly in the time scale they came to exist - if the assumptions laid out for this Workshop had also been applied to Low-Earth orbit sustainable development. It was *only* NASA's willingness to think and act differently that changed the space world - for the better**

## **Exhibit 4: Commercial Spacesuits:**

**NASA turned to commercial providers to meet ISS and Lunar Mission schedule needs**

## **Exhibit 5: Lunar Regolith Purchase Contract:**

**NASA awarded 4 contracts for In-Situ delivery of regolith set the precedence that Lunar resources can be extracted and sold in compliance with the Outer Space Treaty**

## Recommendation / Guiding Principles

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- NASA's Lunar/Mars Objectives ***must*** take advantage of already proven ways of doing 'business' faster/better, e.g., earlier & broader use of PPP
  - *Change the basic paradigm* of industry's role on needed tech development - to one where *industry's needs help determine which tech is developed first. (NACA-mode)*
  - If not modified, there will likely be ***no*** *economically* sustainable Lunar-Mars development in the near decades.
- Move from: "NASA (must) control and develop space systems initially....."
  - To: *Each step in the process/architecture is nominally selected if it can rapidly lead to lower costs of doing business to accomplish the follow-on necessary steps*
  - Not just for NASA, but primarily for the industries that must make it '*affordable & sustainable*' in the real sense that matters

- Failure to consider early objectives to create economic benefits through space development will significantly increase long-term costs and schedules
- IF current assumptions about these objectives remain baselines, economically sustainable human Lunar/Mars operations will **not** occur at all;
- We will - again - enter the usual cycle of long-term spending increases, schedule slips, and potential Program Cancellation that does not lead to the end goals we all seek
  - i.e. we will **NOT** get there from here, unless every effort is made to engage industry
- *Example:* After years/decades of knowing that ISRU, or 'living off the land' would fundamentally 'change the game',
  - NASA continues to de-prioritize schedule-wise operational ISRU to years (and years) after start of lunar surface operations
    - All the while wondering ...
      - Why does space still cost so much?
    - To the extent that key ISRU experts are dying off!
  - Moving such key, true tipping point tech demos to be front-loaded in the architecture - directly involving industry in doing so - to enable such capabilities sooner, not later, changes the game for all that follows



(9/16/1965 -  
6/25/2022)

*A moment to Brad Blair\**

\* <https://space.nss.org/national-space-society-mourns-the-passing-of-brad-blair/> *Brad planned to review ISRU comments in this report*

# Internal NASA documents show an extremely drawn out lunar program with no lunar base this decade. (Credit: Eric Berger, Ars Technica 6-20-2022)

	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034
<u>Baseline</u>	<u>Artemis I</u>		<u>Artemis II</u>	<u>Artemis III</u>		<u>Artemis IV</u>	<u>Artemis V</u>	<u>Artemis VI</u>	<u>Artemis VII</u>	<u>Artemis VIII</u>	<u>Artemis IX</u>	<u>Artemis X</u>	<u>Artemis XI</u>
	SLS Block 1		SLS Block 1	SLS Block 1		SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B
	Orion		Orion	Orion		Orion	Orion	Orion	Orion	Orion	Orion	Orion	Orion
	Uncrewed test flight around Moon		Crew test flight around Moon	Crew flight to lunar surface		Gateway hab module (I-HAB)	ESPRIT module LTV (rover)	Airlock for Gateway	Pressurized rover	Lunar surface logistics	Lunar surface habitat	Lunar surface logisitcs	Lunar surface logistics
<u>Cadence</u>	<u>Artemis I</u>			<u>Artemis II</u>	<u>Artemis III</u>	<u>Artemis III.5</u>		<u>Artemis IV</u>		<u>Artemis V</u>	<u>Artemis VI</u>	<u>Artemis VII</u>	<u>Artemis VIII</u>
	SLS Block 1			SLS Block 1	SLS Block 1	SLS Block 1		SLS Block 1B		SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B
	Orion			Orion	Orion	Orion		Orion		Orion	Orion	Orion	Orion
	Uncrewed test flight around Moon			Crew test flight around Moon	Crew flight to lunar surface			Gateway hab module (I-HAB)		ESPRIT module Pressurized rover	Airlock for Gateway	Lunar surface logisitcs	Lunar surface habitat
<u>Content</u>	<u>Artemis I</u>			<u>Artemis II</u>	<u>Artemis III</u>	<u>Artemis IV</u>			<u>Artemis V</u>	<u>Artemis VI</u>	<u>Artemis VII</u>	<u>Artemis VIII</u>	<u>Artemis IX</u>
	SLS Block 1			SLS Block 1	SLS Block 1	SLS Block 1B			SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B	SLS Block 1B
	Orion			Orion	Orion	Orion			Orion	Orion	Orion	Orion	Orion
	Uncrewed test flight around Moon			Crew test flight around Moon	Crew flight to lunar surface	Gateway hab module (I-HAB)			LTV (rover) ESPRIT module	Airlock for Gateway	Pressurized rover	Lunar surface logisitcs	Lunar surface habitat

# Maximize Partnerships & Competition from the get-go

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- ***Maximizing competition & ensuring serious players***
  - Having ‘skin in the game’
  - Incentivizes lower follow-on costs for each next phase
- **Conduct annual Scenario-Based Workshops**, overseen by a *non-HSF* Center with *expertise in emerging commercial capabilities*
  - Such as NASA Ames Research Center, Space Portal Office
    - Direct Interfaces w/commercial space, DIU & Venture Capital
  - Usage of Commercial Space Scenario Strategy Planning
    - Originally developed by Shell Oil Co. in 1970’s
    - Assesses new capabilities that could emerge and to utilize it
  - Could develop scenarios independent of HSF
  - Provide an ‘on-ramp’ for new tech/capability inclusion & assessment, as well as *new ways to engage industry*

# Other Issues and Concerns (Part 1)

## NSS-02

- **Issue:** No explicit objectives exist, either for increasing reuse of vehicles, or corresponding increase in flight frequency
- **Recommendation:** Make both increasing reuse of vehicles and greatly increased flight rates *explicit Objectives* of the Lunar/Mars effort
  - Increasing economies of scale
  - Increase levels of safety by maintaining skill sets at increasingly higher levels over time and increase vehicle reliability and redundancy levels as flight rates increase

## NSS-03

- **Issue:** Lack of objectives for early use of ISRU for structural or radiation shielding materials
- **Recommendation:** Need early development and use of ISRU processes, related to LI-3, LI-4, OP-3, OP-11 such as excavating, mining, beneficiating, smelting, and fabricating metal and other structural materials on the Moon, to allow early use of the materials at a lunar base
  - Add an objective supporting ISRU for Mars for similar applications on the Moon
  - Include ISRU resource scouting and prospecting at lunar sites besides just polar & only for water
  - Need many small mass-produced “ground truth” rovers (both volatiles and other materials)

## Other Issues and Concerns (Part 2)

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### NSS-04

- **Issue:** Objectives TH-9, TH-10 are stated only in terms of maximizing science return
- **Recommendation:** Science objectives must be prioritized in way that enables sustainable operations soonest (e.g., science that enables development)
  - Infrequent missions also minimize long-term science return; therefore frequency/reuse must be given an explicit priority, *even for science*.

### NSS-05

- **Issue:** Missing objectives for expanded recycling and agriculture for the Moon, Mars, and space transit to Mars, to minimize expensive resupply from Earth (Not covered by BPS-2)
- **Recommendation:** Add new objective to expand recycling and agriculture for the Moon, Mars, and space transit to Mars

### NSS-06

- **Issue:** Objective mentioning “returning large cargo mass” from Mars: TH-12, ES-8
- **Recommendation:** We do **not** need the capability to return large cargo mass for sample return or for any other reason, from Mars, as compared to enabling important scientific and practical investigations to be carried out on the surface

# Other Issues and Concerns (Part 3)

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## NSS-07

- **Issue:** No objective exists to fully utilize payload capabilities of HLS to support a robust lunar base
- **Recommendations:**
  - Add an objective to fully utilize mass and volume payload capability Earth-to-Orbit and Trans-Lunar Injection to match the baseline HLS landing capability
  - Recommendation: Modify objective TH-3 to take full advantage of payload sizes of the HLS
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## NSS-08

- **Issue:** No objective exists for research and experimentation with artificial gravity to determine optimum levels of gravity for transit to Mars and acceptable human performance after landing.
- **Recommendation:** Add an objective for research and experimentation with artificial gravity, including Lunar and Mars gravity levels

## NSS-09

- **Issue:** BPS-1 and BPS-2 do not address means to mitigate or solve effects of lunar environment and do not address Mars environment effects (low gravity, dust, etc.)
- **Recommendations:**
  - Modify BPS-1 and BPS-2 to replace “Understand” with “Understand and mitigate or solve”
  - Modify BPS-1 and BPS-2 to include Mars environment

NSS-10

- **Issue:** No Objective was found to identify Mars locations with access to sufficient near surface water ice deposits for ISRU production of propellant for crew return.
- **Recommendation:** An objective should be added to find crew landing sites on Mars with very large near surface ground ice resources

NSS-11

- **Issue:** The undefined “Human Mars Demonstration Mission”, which we de facto take to mean the first human Mars mission, risks locking into expensive mature technologies for short missions rather than investing in rapidly maturing economically sustainable technology such as ISRU for subsequent missions (MI-1 and MI-2)
- **Recommendations:**
  - Define “Human Mars Demonstration Mission, including stay time
  - Ensure adequate objectives exist for early implementation of economically sustainable operations at scale, for subsequent missions
  - A top priority of the earliest human missions (and preceding robotic missions, to the extent possible) must be to install and test the entire ISRU propellant process at scale, including mining, separation processes as needed, transport & handling, manufacturing, propellant storage, and refueling the rocket. The ISRU facilities could be used by subsequent missions

# Other Issues and Concerns (Part 5)

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## NSS-12

- **Issue:** HS Goal is limited to Moon and Cis-Lunar Space; Consequently it is unclear if HS-1 will address the environment or informing mitigation of hazards for crew transportation to Mars
- **Recommendation:** Expand HS Goal and HS-1 Objective to address environment between Moon and Mars. Additionally, expand scope of OP-6 to address space weather effects on crew health

## NSS-13

- **Issue:** OP-3 addressed lunar ISRU only. ISRU is needed on Mars but is not included in this or other objectives
- **Recommendation:** Expand OP-3 to include ISRU for Mars or add another objective for this
  - Provide early support for ISRU at Mars, including searches for mineral sites and basic geological information to enable an economically sustainable Mars surface base

## NSS-14

- **Issue:** Missing objectives for propellant production, storage, and handling systems
- **Recommendation:** Add new objectives for complete integrated propellant production systems, including mining, material handling, processing, energy sources, storage, and handling



# Issue Cross Reference to NASA M2M Objectives

NSS Issue	TH	LI	MI	OP	ES	LPS	HS	BPS	AS
NSS-01	All	All	All	All	All	All	All	All	All
NSS-02	TH-1, 2, 5, 6, 11, 12	LI-3, 4	MI-3	OP-1, 2, 3, 5, 8	ES-8				
NSS-03	TH-1, 2, 3, 4, 5, 6, 7, 9, 10	LI-1, 2, 3, 4	MI-1, 2	OP-3, 11	ES-1, 3, 4, 7	LPS-1			
NSS-04	TH-9, 10			OP-3, 11					
NSS-05		LI-Missing	MI-Missing	OP-Missing				PBS-2	
NSS-06	TH-12				ES-8				
NSS-07	TH-Missing, TH-3 update?								
NSS-08	TH-Missing			OP-Missing				BPS-Missing	
NSS-09								BPS-1, 2	
NSS-10			MI-Missing	OP-11 Missing		LPS-Missing			
NSS-11			MI-1, 2						
NSS-12				OP-6			HS-1, 2, 3		
NSS-13				OP-3, 11					
NSS-14		LI-Missing	MI-Missing	OP-Missing					

# Conclusions

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- Key Objectives NSS Supports:
  - Economic sustainability must become an explicit, upfront goal that drives decision-making
  - Environmental sustainability must also be considered on Moon and Mars, not just on-orbit
  - Continually increasing reusability of all elements as a goal, leads to continually increased flight rates, both of which are required for economic sustainable space development, including crew safety
  - ISRU sooner, not later, is mandatory for an economically sustainable lunar/Mars program
  - Front-end loaded R&D focused on solving industry tipping points for economic sustainability with heavy industry input/involvement
  - Earlier use of Public-Private Partnerships (PPP) along proven successful model
- Commercial space industry can attract private capital to supplement, extend, and accelerate NASA's ability to meet its M2M goals
  - NASA Objectives must make it clear that industry's and investor's concerns are addressed
  - Industry and competition provide value and cost-effective solutions for real sustainability
- Strong citizen support of NASA at meetings with Congress, especially those engaging private industry through Commercial initiatives and International Partners via the Artemis Accords



# Back-up

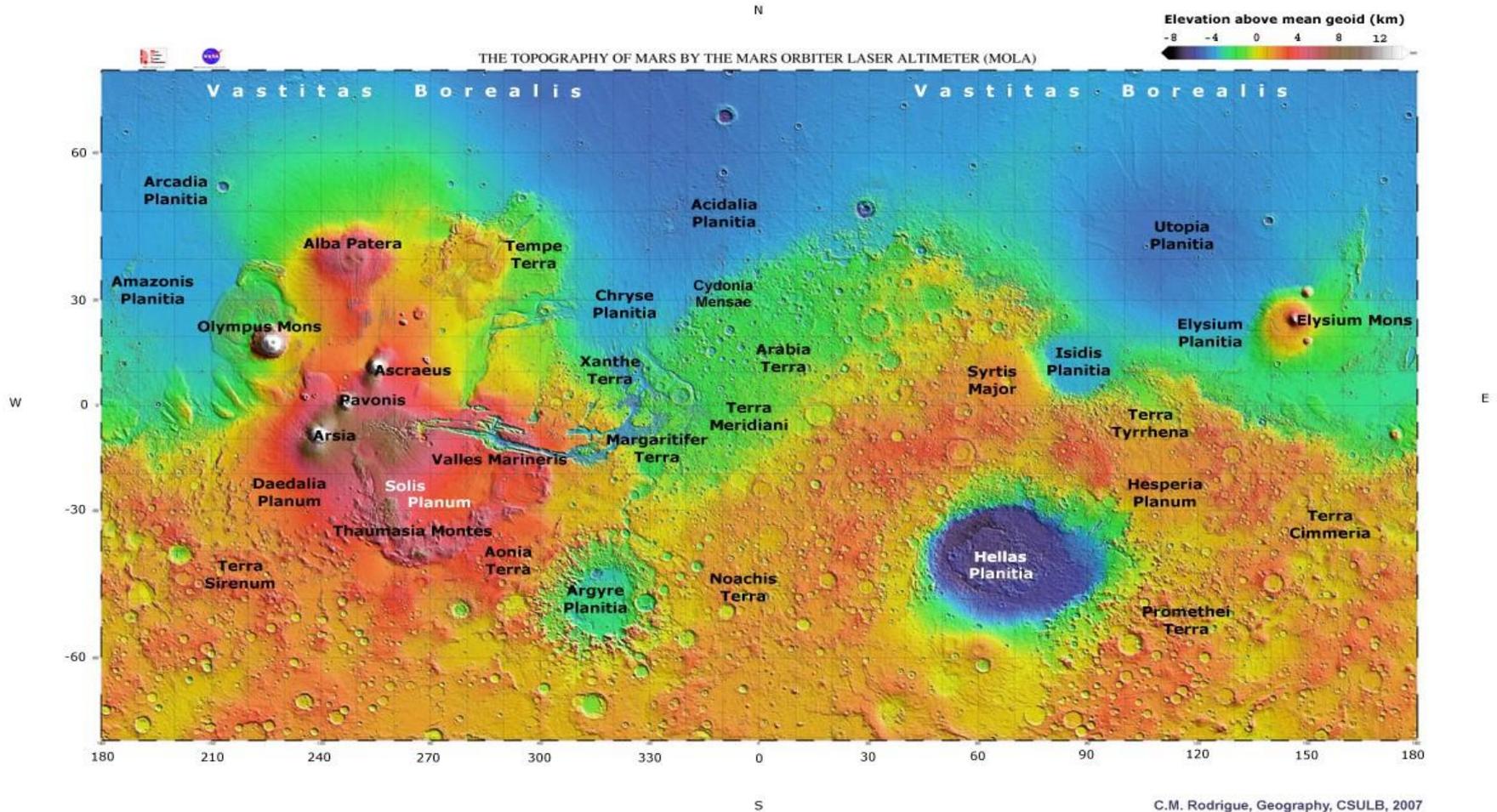
- Mankind needs a very large, clean source of base load electricity, in the 25 Terawatt range, that is not intermittent and produces no greenhouse gases, such as Space Solar Power
- We need a source of minerals to augment those on the Earth
- We need more living space for a growing population to reduce pressure on the Earth's habitats
- We need to be able to divert threatening asteroids and comets
- We need a place of refuge for Humanity and Life itself in case of a catastrophe on the Earth and to avoid loss of Life itself as the Sun grows old
- Life itself almost demands that we, as the **only** agent that can leave Earth, help spread life beyond the Earth, even to the stars

# Provisional Ground Ice Image Set

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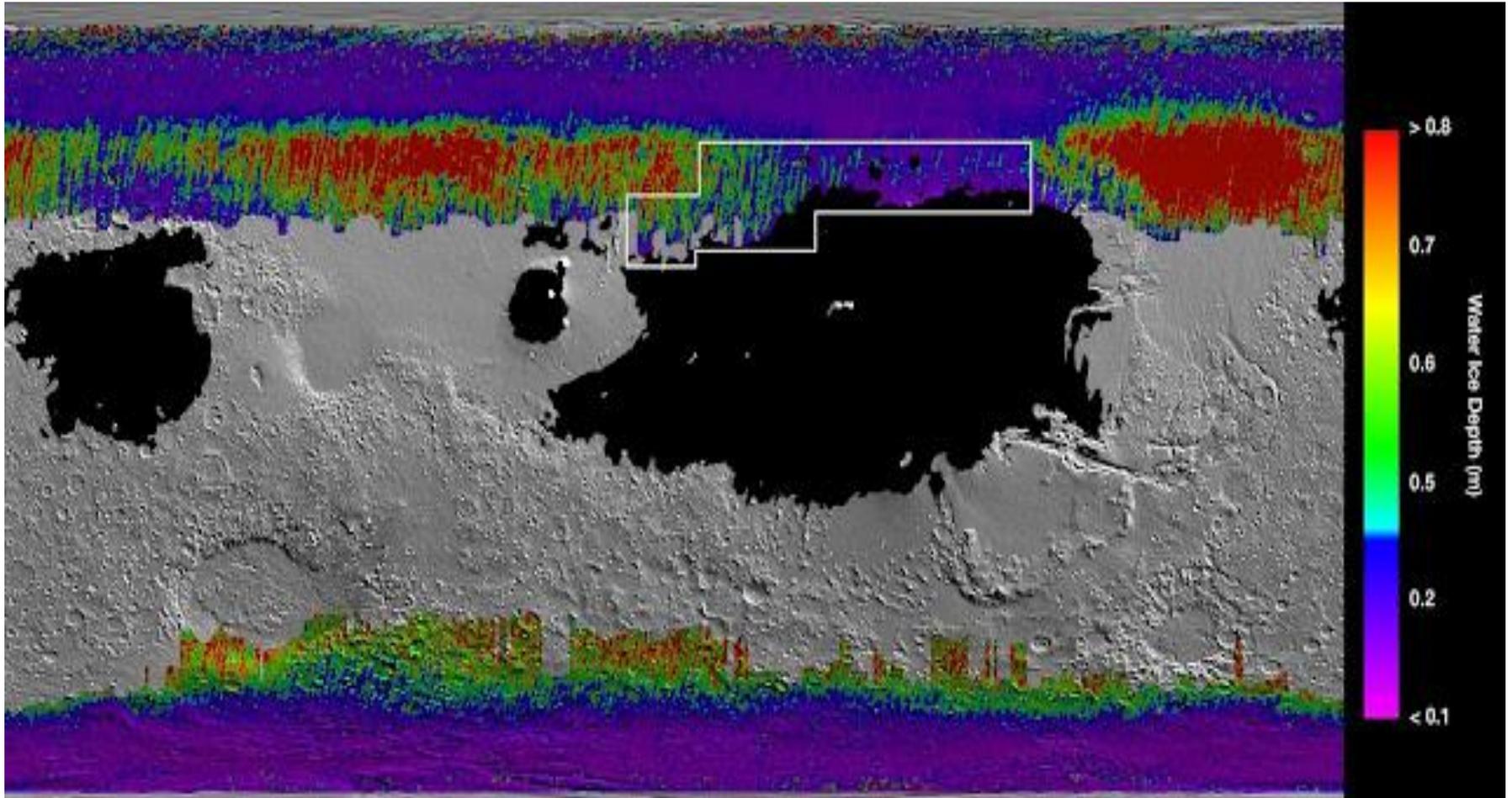
The following images illustrate the issues of Mars near surface ground ice detection

# Topographic Map of Mars from MOLA instrument



# NASA's Treasure Map For Water Ice On Mars 12-10-2019

[NASA's treasure map for water ice on Mars - The Archaeology News Network](#)



# Scientists Discover Clean Water Ice Just Below Mars' Surface 2018

[Scientists Discover Clean Water Ice Just Below Mars' Surface | WIRED](#)

