

## Today's Class: Robotic & Human Exploration of Mars

Reading for next class on Mars: Sections 9.1, 9.2, 9.4, and 10.4 of Cosmic Perspective.



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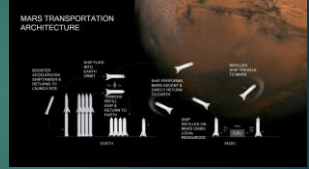
## Space in the News

Presented by Spencer Lynch

### Elon Musk says SpaceX's 1st Starship trip to Mars could fly in 4 years

Article by Hanneke Weitering

- ▶ Elon Musk says SpaceX could be ready to launch uncrewed mission second Mars transfer window in 2024.
- ▶ Will use Starship vehicle which is also supposed to go to the moon in 2022 and ferry space tourists in 2023.
- ▶ Current Starship prototype only has reached altitude of 500 ft.



**Question:** How feasible would it be for SpaceX to send the Starship to Mars by 2024 and how would a successful mission affect the space tourism industry?

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Reading Class Exercise: If all the ice in Mars' polar caps were melted, how deep an ocean would it make?

- a) about 1 cm
- b) about 10 cm
- c) about 1 m
- d) about 10 m
- e) about 100 m

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## Today's Class

- NASA's Goals for understanding Mars
- Search for Water & Life
- The Curiosity Rover
  - Goals
  - Results so far
- Human Expeditions to Mars

With thanks to Professor Brian Hynek for sharing slides!

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## Goals for NASA & Mars

### NASA's goals:

- To advance and communicate scientific knowledge and understanding of Earth, the Solar System, and the universe.
- To advance human exploration, use, and development of space.
- To research, develop, verify, and transfer advanced aeronautics and space technologies

### Mars-specific top level goals:

- 1) Determine whether life ever arose on Mars
- 2) Characterize the climate of Mars
- 3) Characterize the geology of Mars
- 4) Prepare for human exploration

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### Recent Mars Exploration (in the 21<sup>st</sup> century)

- **Mars Odyssey** – arrived 2001
  - Discovered huge regions of ground ice, interesting minerals
- **Mars Express (ESA)** – arrived 2004
  - High-resolution stereo imaging (~20 m), subsurface radar
- **2 Mars Exploration Rovers (Spirit & Opportunity)** – arrived Jan 2004
  - Chemical/mineralogical spectrometers, imagery.
- **Mars Reconnaissance Orbiter**
  - 25 cm resolution imaging, sounding radar
- **Mars Phoenix Lander (RIP Nov, 2008)**
  - Dug down to the ice table at a high latitude site.
- **Mars Science Laboratory (Curiosity)**
  - Launched Nov. 26, 2011, arrived Aug 6, 2012
- **InSight** - Interior Exploration using Seismic Investigations, Geodesy and Heat Transport: study of deep interior of Mars.
  - Launched May 5, 2018, arrived Nov. 26, 2018.

\* Blue = ongoing operations. Astronomy 2020 – Space Astronomy & Exploration

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### NASA's Exploration Plan: "Follow the Water"

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### Case for a Warm and Wet Mars I: Rivers

- Dense river valley networks observed across the ancient terrains of Mars.
- Viking data suggested groundwater formation under cold-dry conditions.
- Recent data provide evidence for active, long-lived hydrologic cycle.

Mars river valley

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### Comparison of Viking and recent data

Hynek and Phillips, 2003

Mars river channel from Viking data

Mars Global Surveyor data and newly recognized river valleys

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### Case for a Warm and Wet Mars II: Deltas

- Deltas require a standing body of water.
- Over 50 known deltas on Mars.
- Ages seem to be coeval with valley network formation.

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### Daily News

NATIONAL GEOGRAPHIC

#### Ancient Mars Had Vast Ocean, New Evidence Shows

Ocean Level

ratio

-2540

0.357

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## Mars Science Laboratory - Curiosity

Launch: Nov. 26, 2011 on an Atlas V rocket. Landed: Aug. 6, 2012.

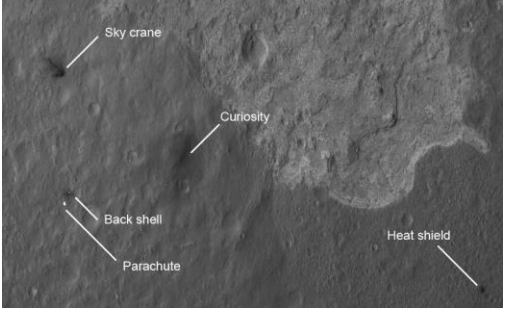
Two Earth years of planned operations while traveling at least 20 km, but mission has been extended by NASA!



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## Images from Mars Orbit



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### Main goals are to characterize a site that:


- was a habitable environment.
- is likely to have preserved biosignatures.
- can be related to the "Big Picture"



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## Primary Findings

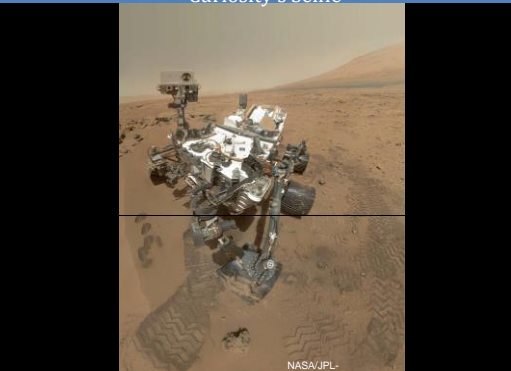


- Measurements of **radiation levels** during the flight.
  - Astronaut safety.
- Analysis of **atmospheric composition** on entry.
  - Evidence of original atmosphere loss process.
- Major objective of finding evidence of a past environment well suited to **support microbial life**.
  - Key elemental ingredients, chemical energy source, and water not too acidic or too salty.
  - Liquid water: rounded pebbles mixed with hardened sand in conglomerate rocks.
- Curiosity was able to accomplish a first for measurements on another planet: **determining the age of the rock**.
  - Drilled material was 4.2 billion years old.

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## Curiosity's Selfie



NASA/JPL-Caltech/MSSS

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## Sand dunes are also hazardous



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## Human Trip to Mars


- 2.5 year mission right out of the gate.
- Mining the water to create rocket fuel.
- Think *The Martian* as far as challenges go.



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## MARS IS HARD



THERE & BACK		
- The ability to launch a very powerful rocket	- Deep space navigation	- Rendezvous and docking
- High-reliability spacecraft systems	- Life support systems	- High speed re-entry
- Size requirements of crew capsule	- Validation of performance of SLS and Orion in the deep space environment (hotter, colder, radiation)	

HAPPY & HEALTHY		
- Air, water, food	- Bone loss	- Radiation
- Waste containment	- Psychological impact	- Ocular degeneration
- Low- / no-gravity	- Medical emergencies	- Hygiene

WELL EQUIPPED & PRODUCTIVE		
- Sample handling	- Advanced training	- Situational awareness
- Microgravity operations	- and tools	- and decision making
- Space suits	- Mission planning	- Crew relationships

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## SpaceX Plans for Mars Missions - Starship



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