Mars Entry, Descent, and Landing by Small THz Spacecraft via Membrane Aeroshell

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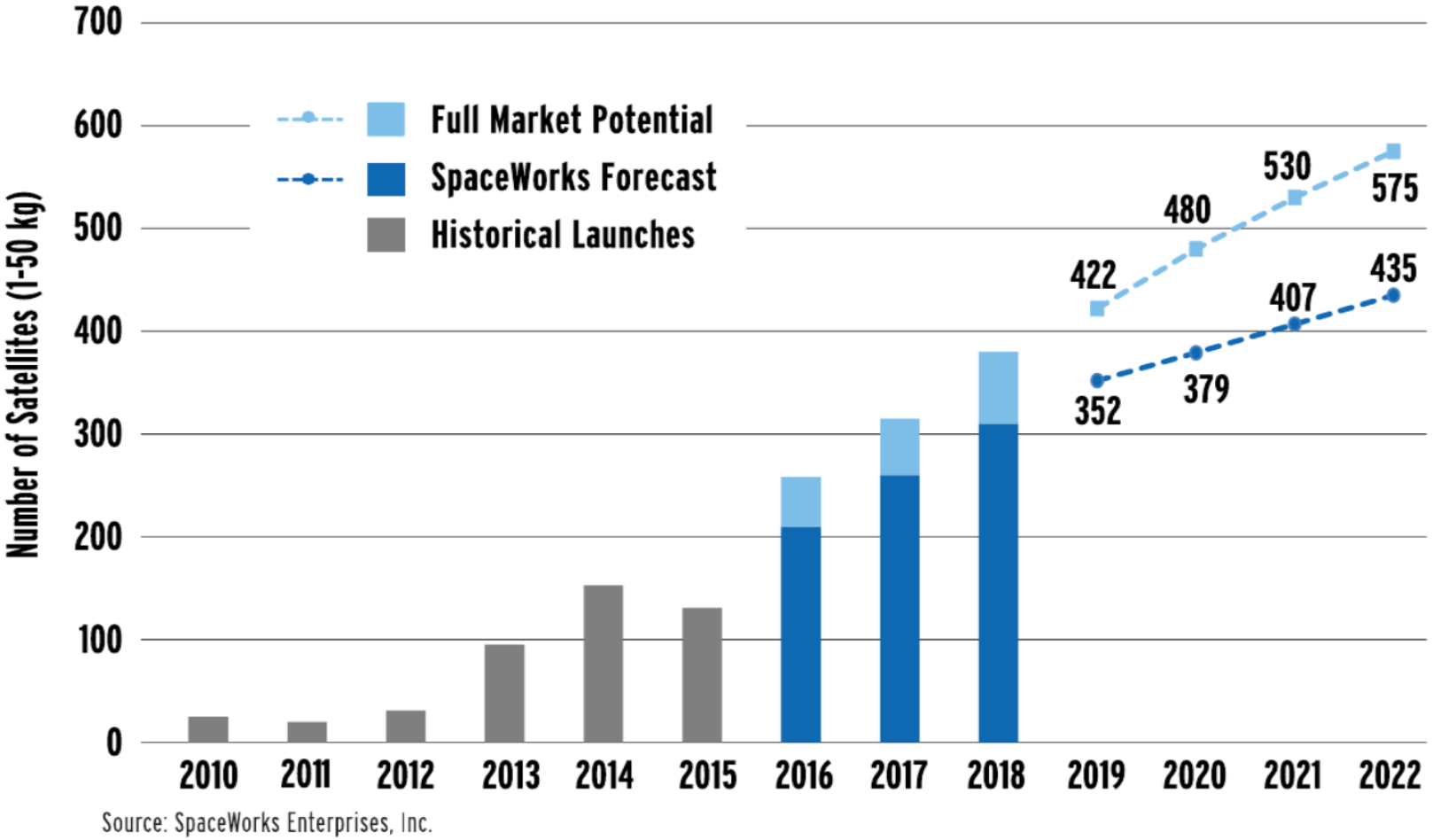
Background #1

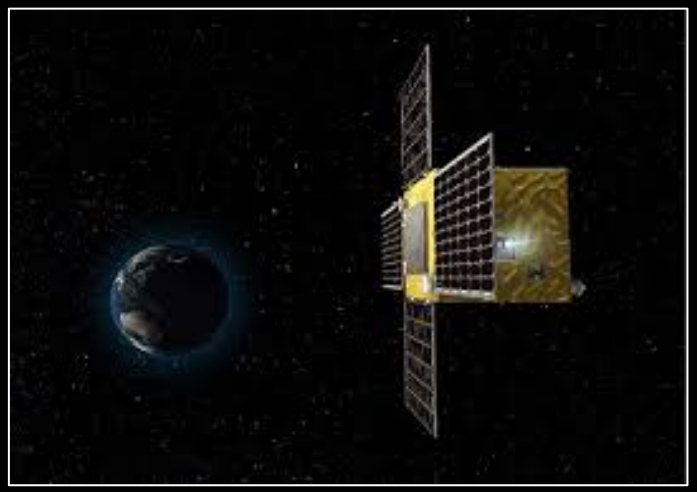
Micro Deep Space Explorers

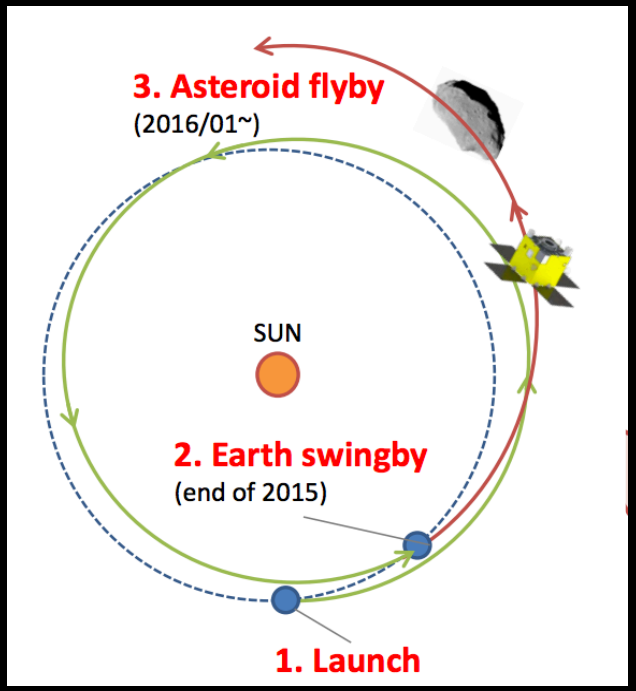
Nano/Microsatellite Launch History and Projection (1-50 kg)



PROCYON (Univ. of Tokyo & JAXA)

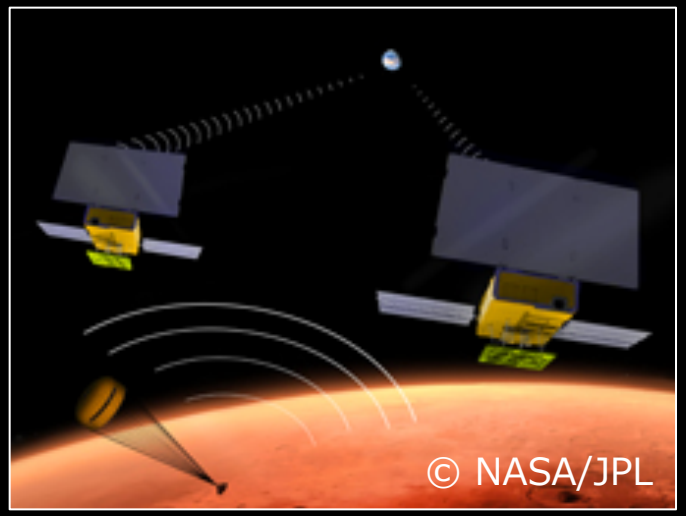
- World's first deep micro space probe
- Successfully demonstrated micro-spacecraft bus system for deep space exploration
- 65kg, 50cm cube

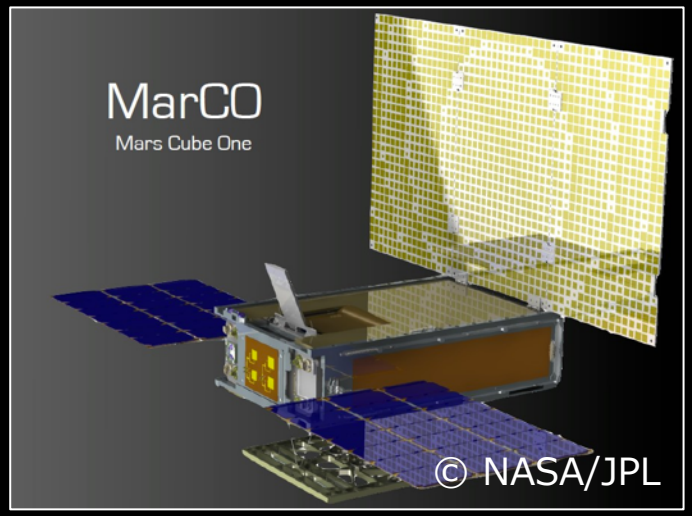




MarCO (NASA/JPL)

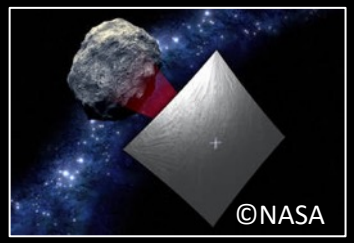
- Two 6U CubeSats which are planned to be launched to relay communication between InSight and Earth

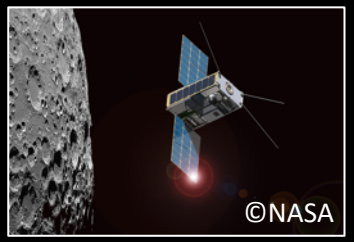


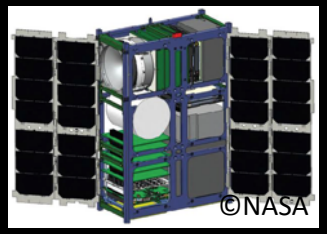


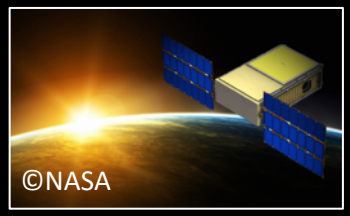
SLS-EM1 mission

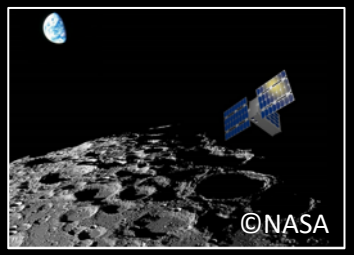
Orion and 13 CubeSats will be launched at the same time.

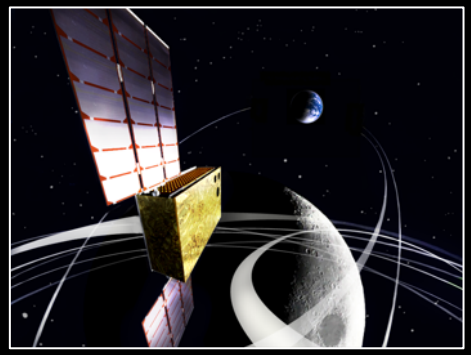


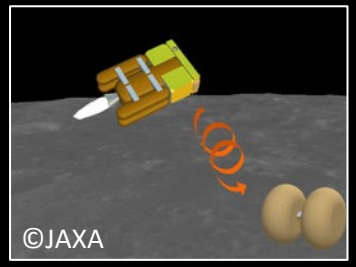


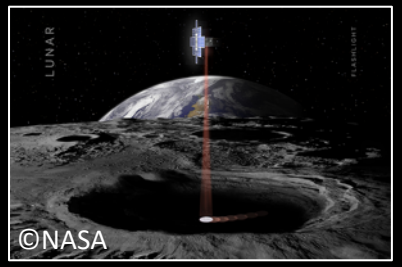












3 additional CubeSats are TBD

Background #2

Mars Entry, Descent, and Landing

What is your memorable Mars EDL mission?


© NASA/JPL-Caltech
3839 kg


© NASA/JPL-Caltech
890 kg


©ESA
4332 kg

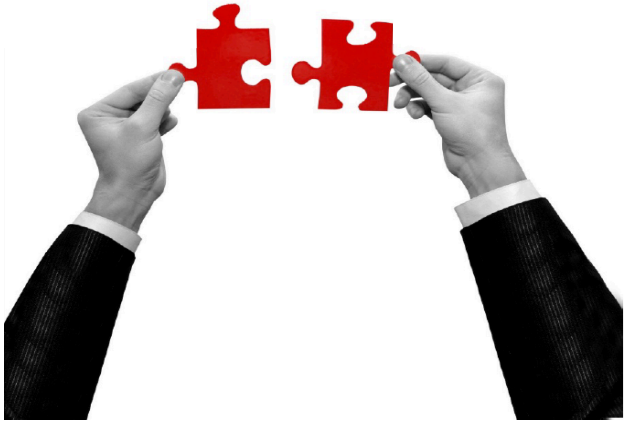

© NASA
2328 kg

Launch mass of conventional Mars EDL missions has been large.

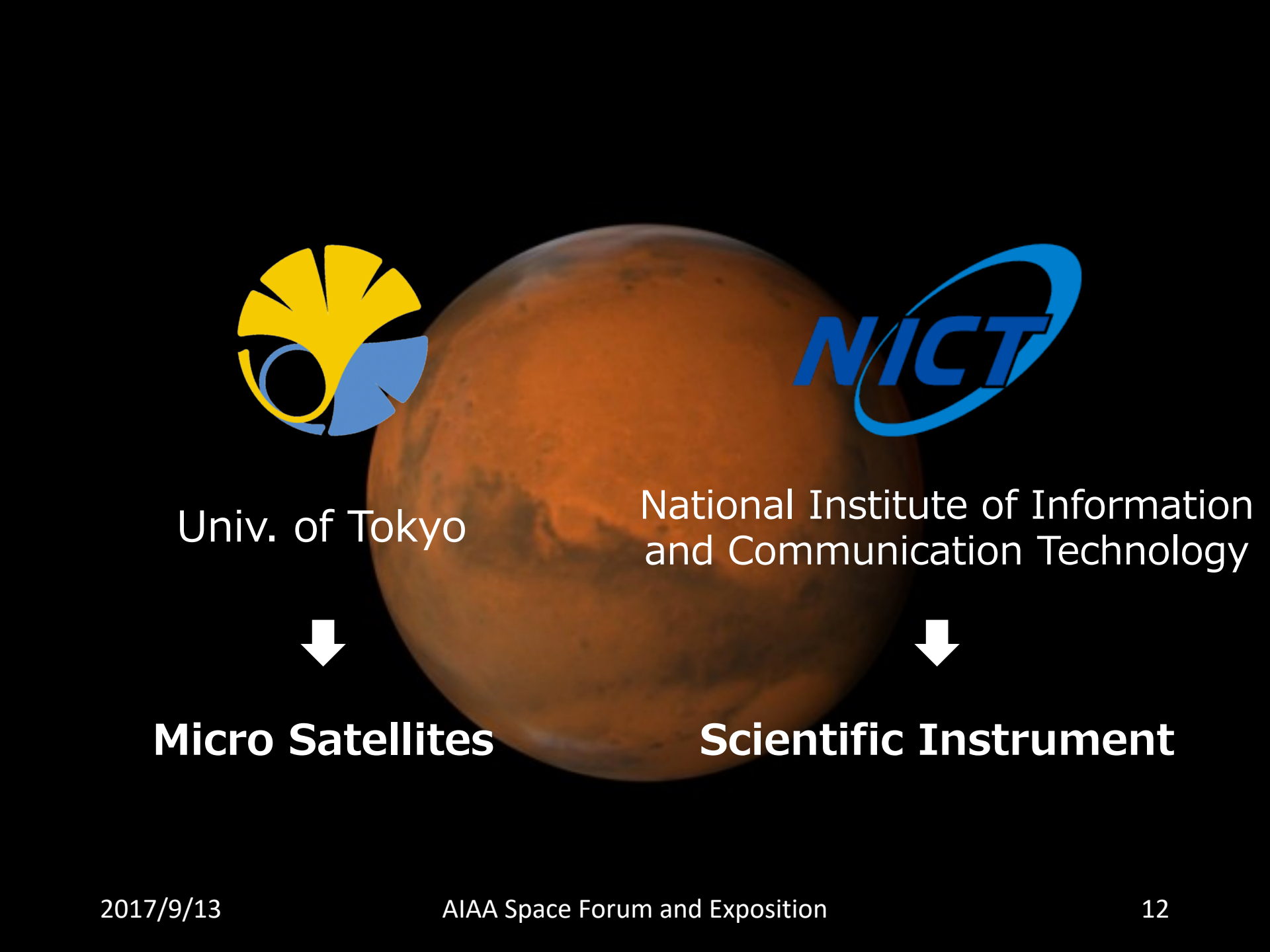
If we reduce the launch mass, many scientists could launch their own Mars landers

Our proposal

Microsatellites **Mars EDL**



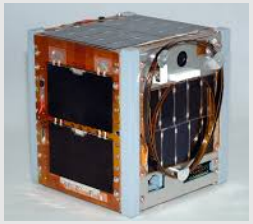
Lower the threshold of Mars EDL


Univ. of Tokyo
National Institute of Information and Communication Technology
Micro Satellites
Scientific Instrument

Small Sats of Univ. of Tokyo

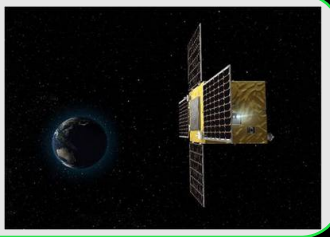
XI-IV, XI-V

- World's first CubeSat
- 10cm cube, 1kg



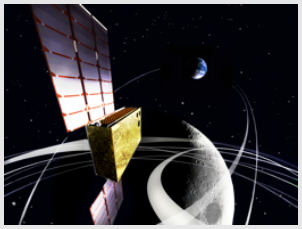
PROCYON

- World's first micro deep space explorer
- 50cm cube, 65kg



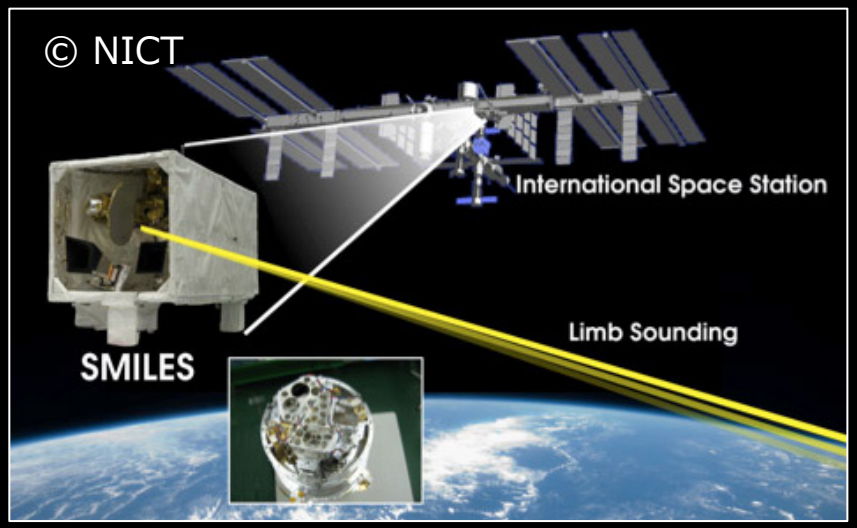
EQUULEUS

- Planned to be launched by SLS in 2019
- 6U (10cm x 20cm x 30cm), 14kg

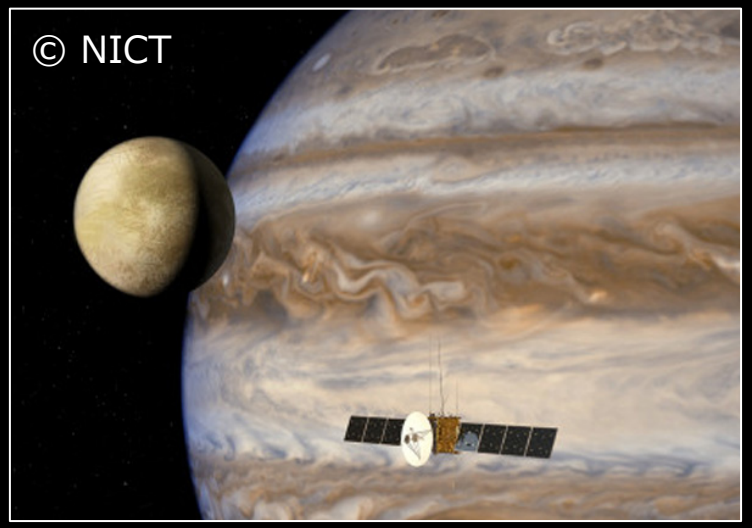


Geoscience of NICT

NICT possesses strong heritage on THz sensing.



Earth THz observation from ISS

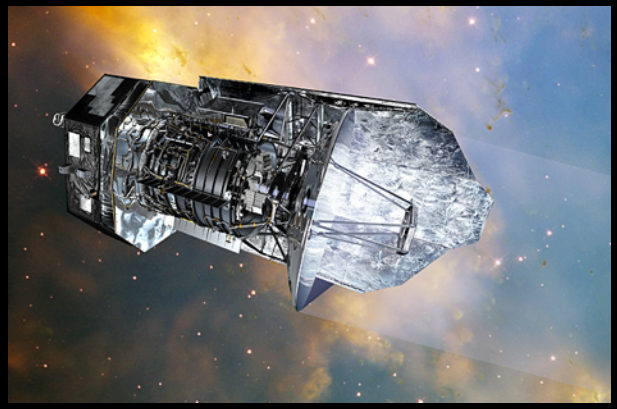


Jupiter or Europa observation via THz sensor on JUICE

Then, what kind of Mars landing mission will we do via a micro satellite?

Background

Observation by Herschel Space Observatory via Terahertz (THz) wave suggests the large amount of oxygen near the Mars surface.

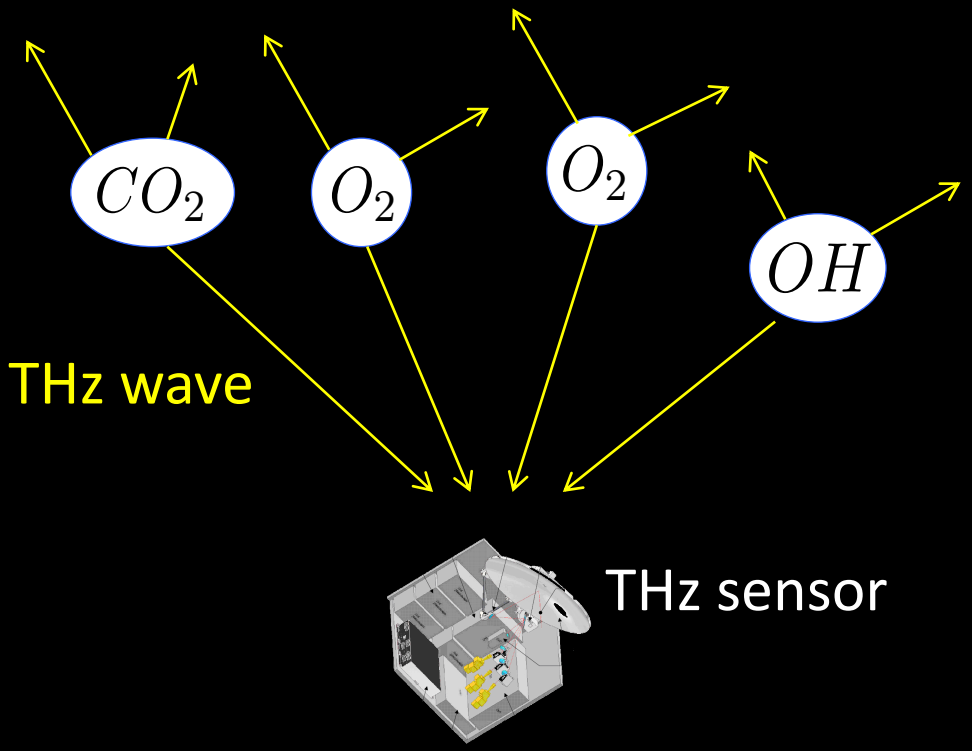


This observation contradicts the conventional theory (Chemical transport model)

Is there any source which generates oxygen near the Mars surface?

Scientific objective

Observe the profile of molecules against height using THz receiver equipped with a Mars lander



Premise & Assumption

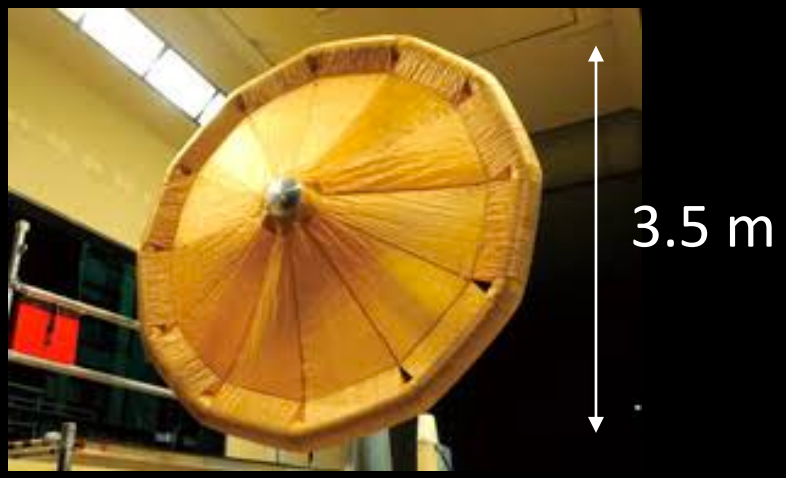
- Our Mars lander will be launched as a secondary payload of a Mars lander or orbiter

  → The launch mass should be less than 150 kg

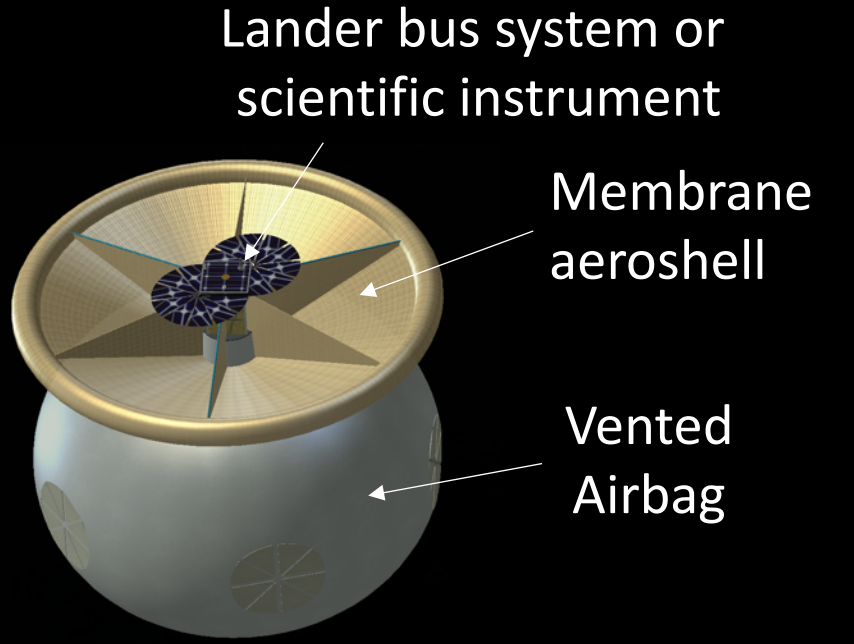
- Scientific device mass is quite small (< 10kg)

Our Mars Landing Project

- Our Mars EDL system consists of only two components
  - Membrane aeroshell (inflatable structure)
  - Vented airbag
- Launch mass: < 80 kg



Membrane aeroshell



Landing phase

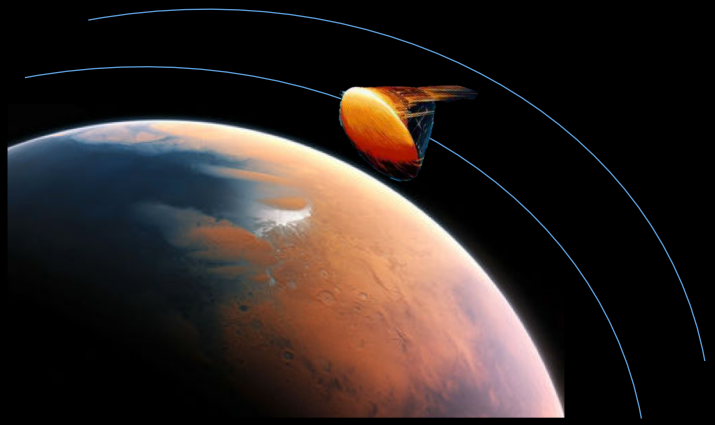
Our Mars EDL approach

No heat shield
No parachute
No powered descent

Mars Entry via Membrane Aeroshell

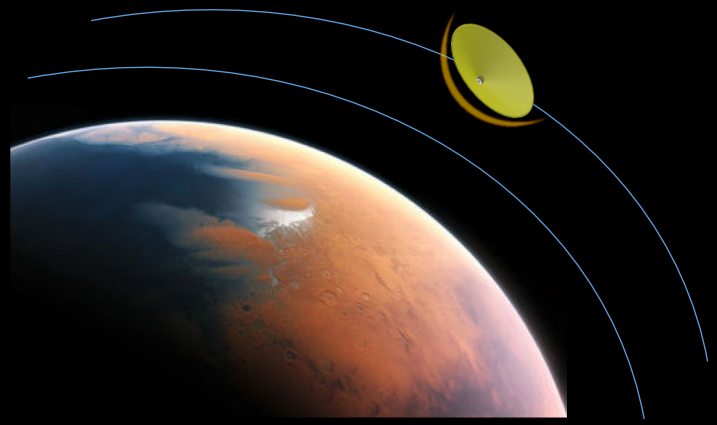
Conventional heat shield

Entry to the dense atmosphere at high velocity



Membrane aeroshell

Decelerate in the thin, upper atmosphere



We can construct light and simple Mars entry system.

Mars Entry via Membrane Aeroshell

- Membrane aeroshell is proved to be effective for Earth entry in EGG spacecraft released from ISS [1].

[1] http://www.isas.jaxa.jp/topics/001003.html

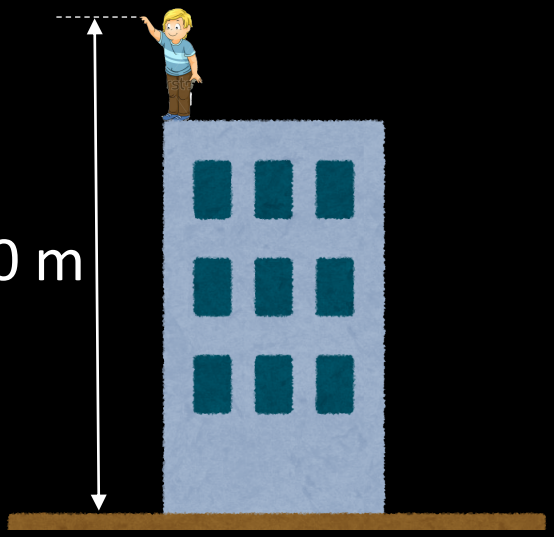
Mars Descent

Terminal velocity can be obtained by:

$$\frac{1}{2}\rho V^2 S C_D = mg$$

⬇ Our lander's configuration

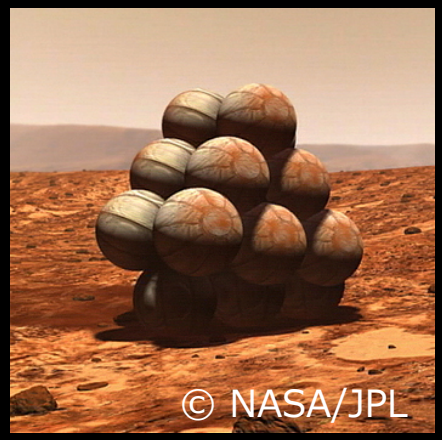
$$V \approx 40 m/s$$



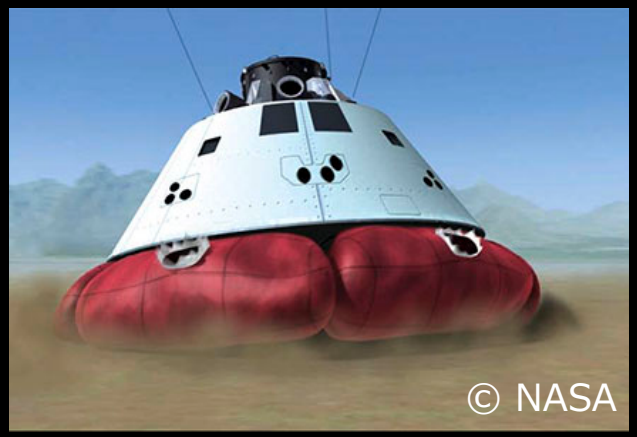
Mars Landing

- Terminal velocity of 40m/s is too large.
- Additional mechanism for landing is needed

Thruster



Non-vented Airbag

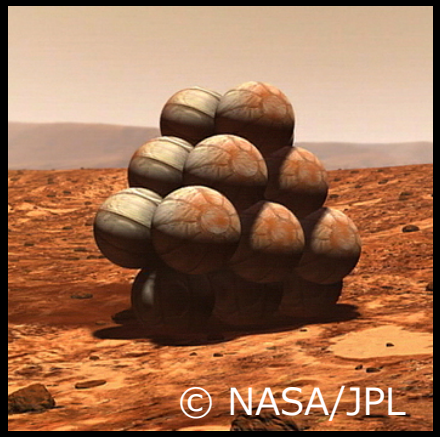


Vented Airbag

Mars Landing

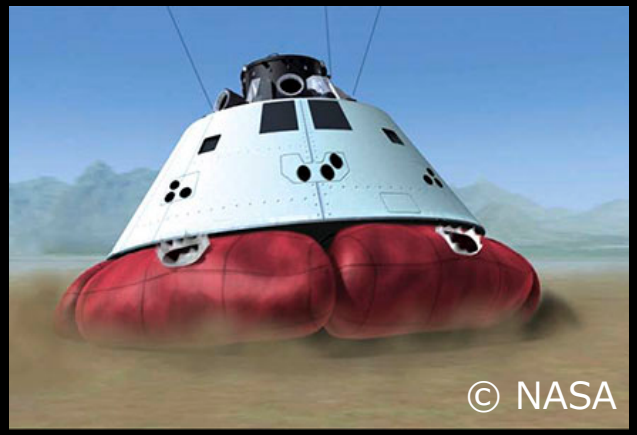
Thruster

- Robust to wind
- Flight proven
- Large mass
- Safety review



Non-vented Airbag

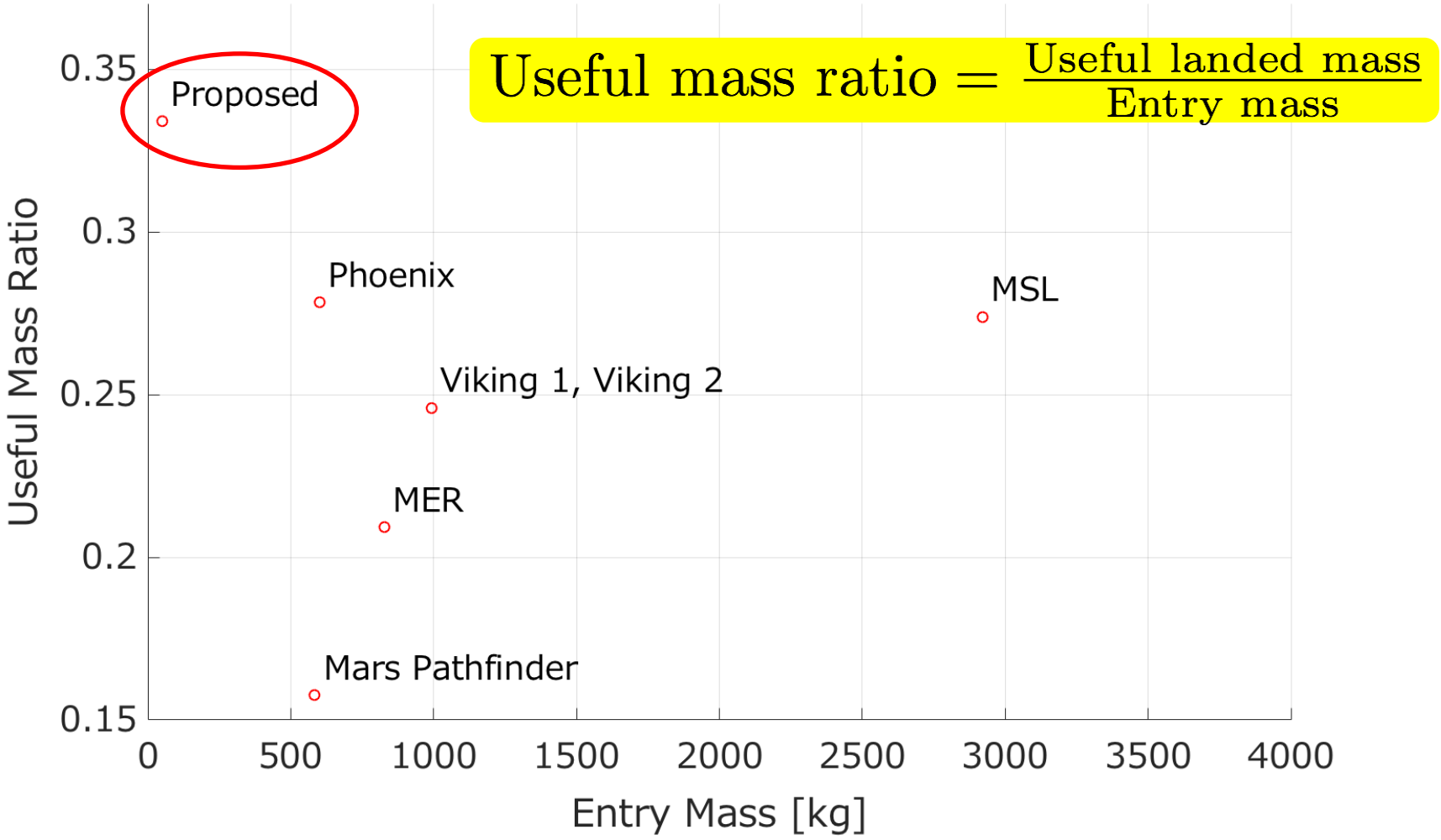
- Robust to rocks
- Large mass
- Sensitive to wind



Vented Airbag

- Robust to rocks
- Small mass
- Not flight proven

Justification of our proposal



Conclusion

1. Propose a concept of Mars landing mission by micro-spacecraft
2. Propose a novel Mars EDL system which consists of membrane aeroshell and vented airbag
3. Our proposal could have a potential of lowering the threshold of Mars EDL mission

Thank you very much!

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