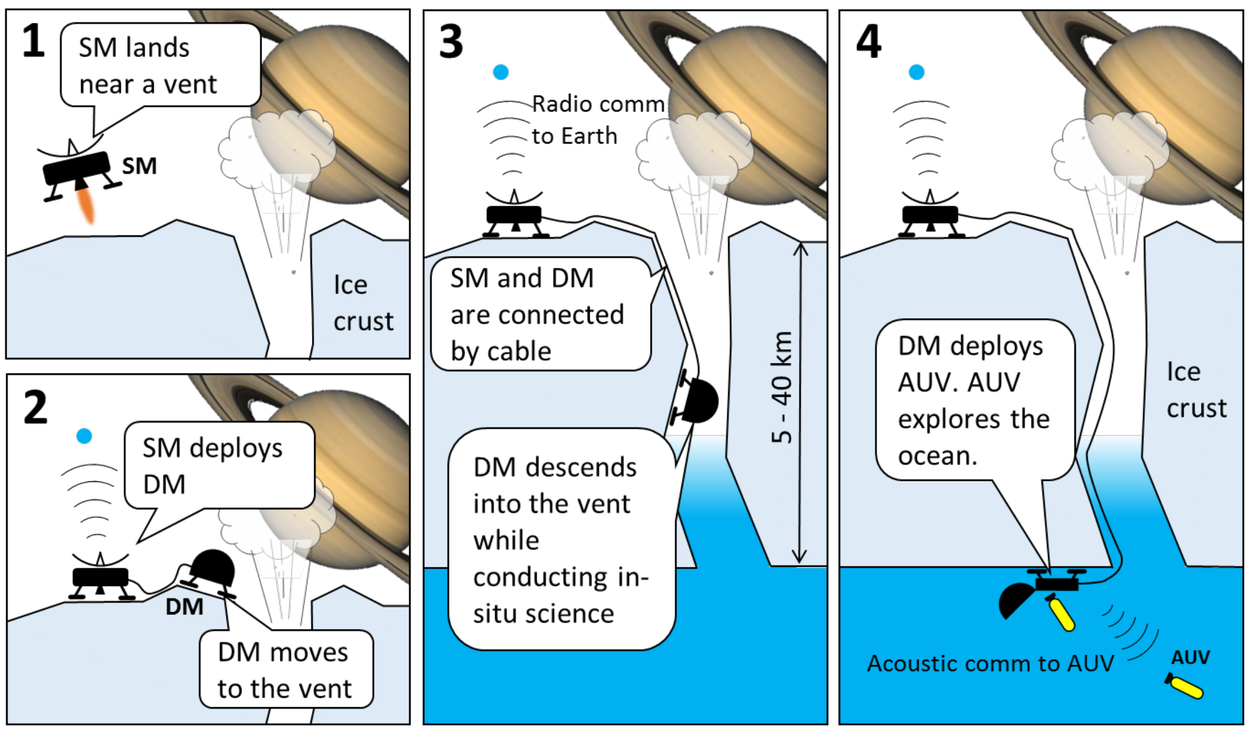
# Journey to the Center of Icy Moons

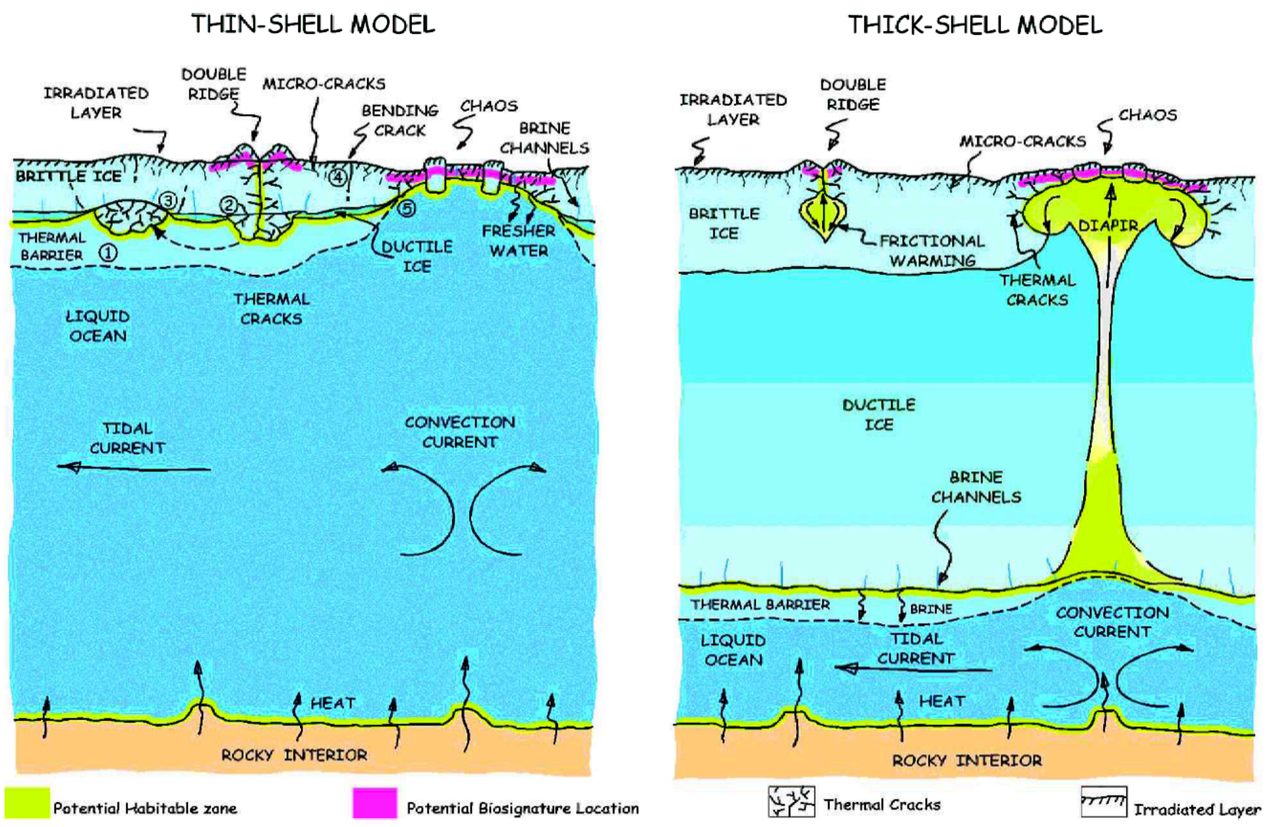
Masahiro Ono, Mitch Ingham, Tara Estlin, Aaron Parness, Karl Mitchell, Kalind Carpenter, Kevin Hand
Jet Propulsion Laboratory, California Institute of Technology

## Concept




- Intelligent robotic system to descend into a cryovolcano vent and explore the subsurface ocean of icy moons
- Surface Module (SM) provides communication link and power to DM by a tether
- Descent Module (DM) uses versatile mobility combining rappelling, hopping, and hovering, driven by resilient autonomy
- Autonomous underwater vehicles (AUVs) are deployed in in subsurface ocean
- AUVs talks to DM by acoustic communication
- Optimistic estimation of vent dynamic pressure: ~0.5 Pa

## Science




(Figueredo et al. 2003)

- Explore three primary habitable zones: vent, ice ceiling, and sea floor
- Immediate opportunities to discover life and/or biosignatures, even without reaching the subsurface ocean
- Perform in-situ science of relatively large (up to 1 µm) dust grains, which cannot reach orbital altitude
- Discovery of a second origin of life would allow us to "distinguish the contingent from the necessary" (Sagan, 1974)
- Potentially answer humanity's fundamental question: "Are We Alone?"

## Technologies

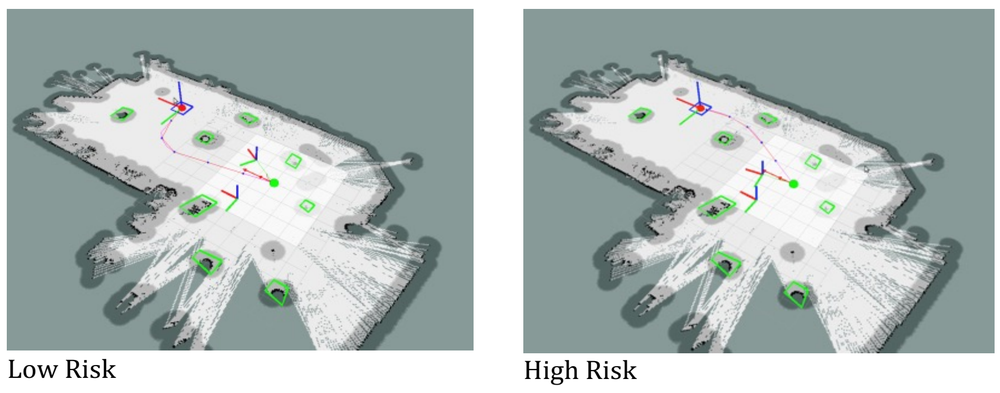
### Hardware

Left: LEMUR 3 climbing robot. Top-right: VolcanoBot rappelling down a volcanic fissure. Bottom-right: proposed ice gripper with claws.

Leverage JPL's existing hardware technologies:

- Vertical climbing with microspine grippers (Parness)
- VolcanoBot (Mitchell/Parness)
- Ice gripper (Carpenter)

### Software



Low Risk High Risk

Risk-aware route planning in simulation (top) and on a rover (bottom)

- Advanced autonomy is needed due to the lack of orbital reconnaissance and limited comm.
- JPL's Resilient Spacecraft Executive (Ingham/Ono/Estlin) demonstrated risk-aware planning capability on a rover testbed

©2016 California Institute of Technology. U.S. Government sponsorship acknowledged.