2018 Workshop on Autonomy for Future NASA Science Missions

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Ocean Worlds

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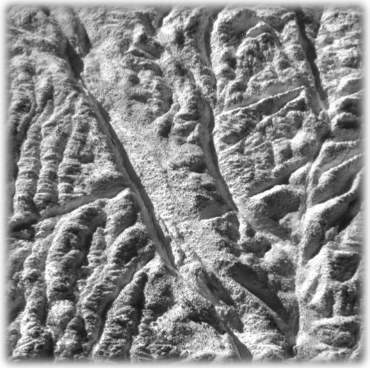
Concept 1: Autonomy for Surface Lander

Lander autonomy challenges

- Communication constraints
  - Data volume and time delays
- Limited lifetime – weeks expected
- Unknown environment

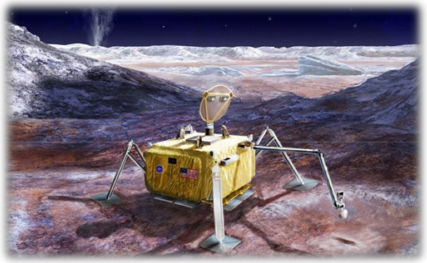


Enceladus (Cassini)

Key autonomy needs

1. Resource management of thermal, power and data, including when to sleep and wait for ground command
2. On board fault detection and response
3. Sample site selection
   - Visually and physically assess surface onboard to identify highest priority (safety, likelihood of success, and science value) sample locations.
4. Sample collection
   - Autonomously collect and analyze samples. Optimize energy usage/loss by deciding when to try another site or approach if current try is not working.

Europa (Galileo)



Europa Lander Concept

Concept 2: Autonomy for Mobility in 3D – Not 2D Terrain

Land safely near an active vent. Limbed robot traverses to the vent and descends 10s of meters, collecting fresh venting sample. Chemical analysis onboard or return sample to the lander.

Goal is a fully autonomous multi-km traverse across the 3D extreme terrain to access the highest quality and highest priority samples. Gridded maps and obstacle avoidance aren't enough. Unlike the 2D *Flatlander* worlds navigated by self-driving cars or JPL-driven Mars rovers, in these 3D places the entire landscape is the obstacle and can not be avoided.

Key Enabling Autonomy Capabilities:

- **Perception, SLAM, and Path Planning on extreme 3D terrain with roughness at the scale of the robot (penitentes, vents, caves)**
- **Force-in-the-loop control of limbed robotic systems**
- **Terrain analysis, learning, and prediction**
- **Multi-day autonomy in extreme environment**

Concept 3: Autonomy for Long-Lived Cryobot

Cryobot autonomy challenges are due to communication constraints

- **The Cryobot may uses 6-8 communication transceivers for subsurface to surface com limiting interactions with controllers**
- **Due to the low accessibility from Earth and continuous high risk operations, the Cryobot requires significant autonomy**

Key autonomy needs

1. **The Cryoprobe head may utilizes drilling and water jetting to augment melt heat from an RTG source**
   - **Considerable control needed based on feedback when descending**
2. **Nominal operations: Resource management of thermal, power and data**
   - **Management must react to environment**
3. **Hazard detection and avoidance**
   - **Sensor perception in ice, perception and prediction**
4. **On board fault detection and response**
   - **Multi-year autonomy in extreme environment**
5. **Opportunistic science to due to changes in the**