



# Autonomous Agents for Space Exploration

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# A Challenge for Autonomy: Europa Cryobot





# Unknowns and Impact on Operations



- Thickness and composition of ice-cap
  - energy expended to penetrate surface
  - data volume and type collected
  - ability to communicate while below cap (reliability, rate)
  - effectiveness of melting strategies (fast v. slow)
- Properties of underground ocean
  - energy and time cost to move/explore
  - effectiveness of sensors (reliability, range, discriminability)
  - ability to communicate
  - predictability of above

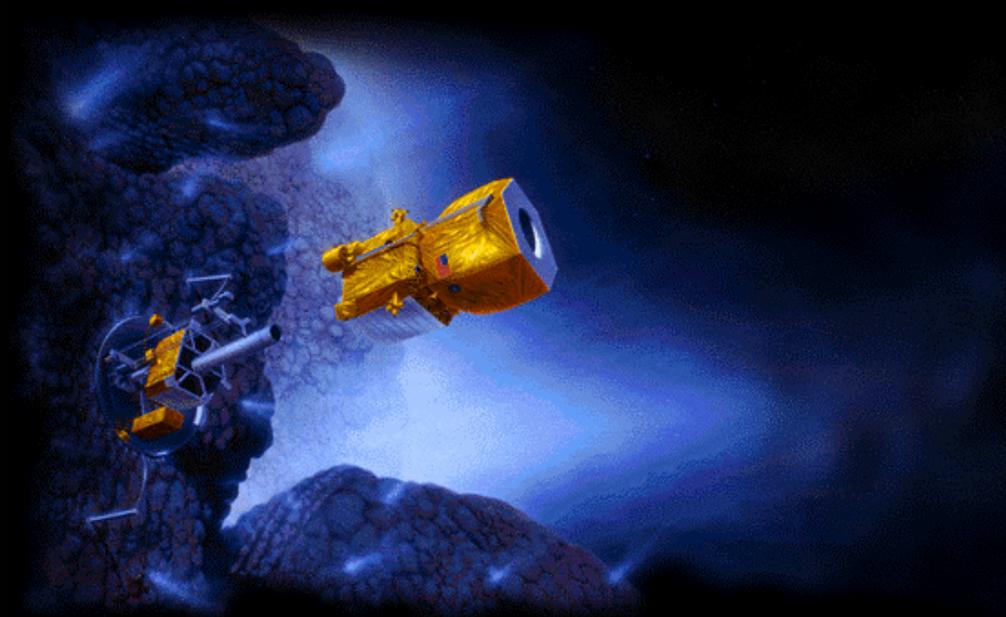


# Comet Lander



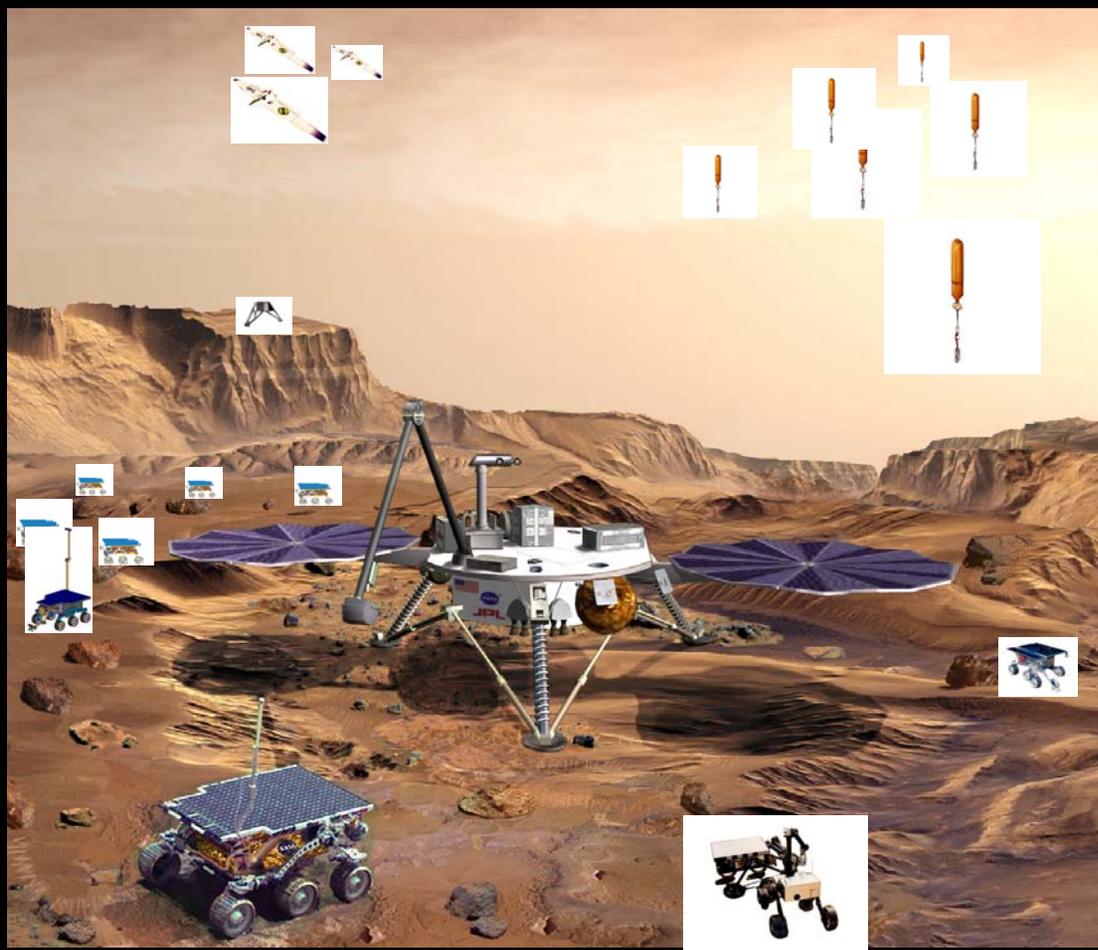
## Examples of Unknowns and Impact on Operations

- Hardness of surface
  - time to drill to specified depth
  - power consumption of drilling activities
- Outgassing properties of comet under solar illumination
  - affects lighting for pictures
  - may affect communications links





# Mars Robotic Outpost



- Long-term environmental changes (general warming trend)
- Medium-term environmental changes (seasons)
- Shorter-term environmental changes (storms)
- Hardware degradation
- Communications performance
- Mobility
- Sensor effectiveness

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## Adaptive, self-organizing Exploration Agents

- conduct extended (decades long) environmental and geological Martian survey



# Outline

- Motivation for Space Autonomy
- Autonomous Science on EO 1
- Future Autonomous Science Missions
- Learning Autonomous Agents, Multi-agents