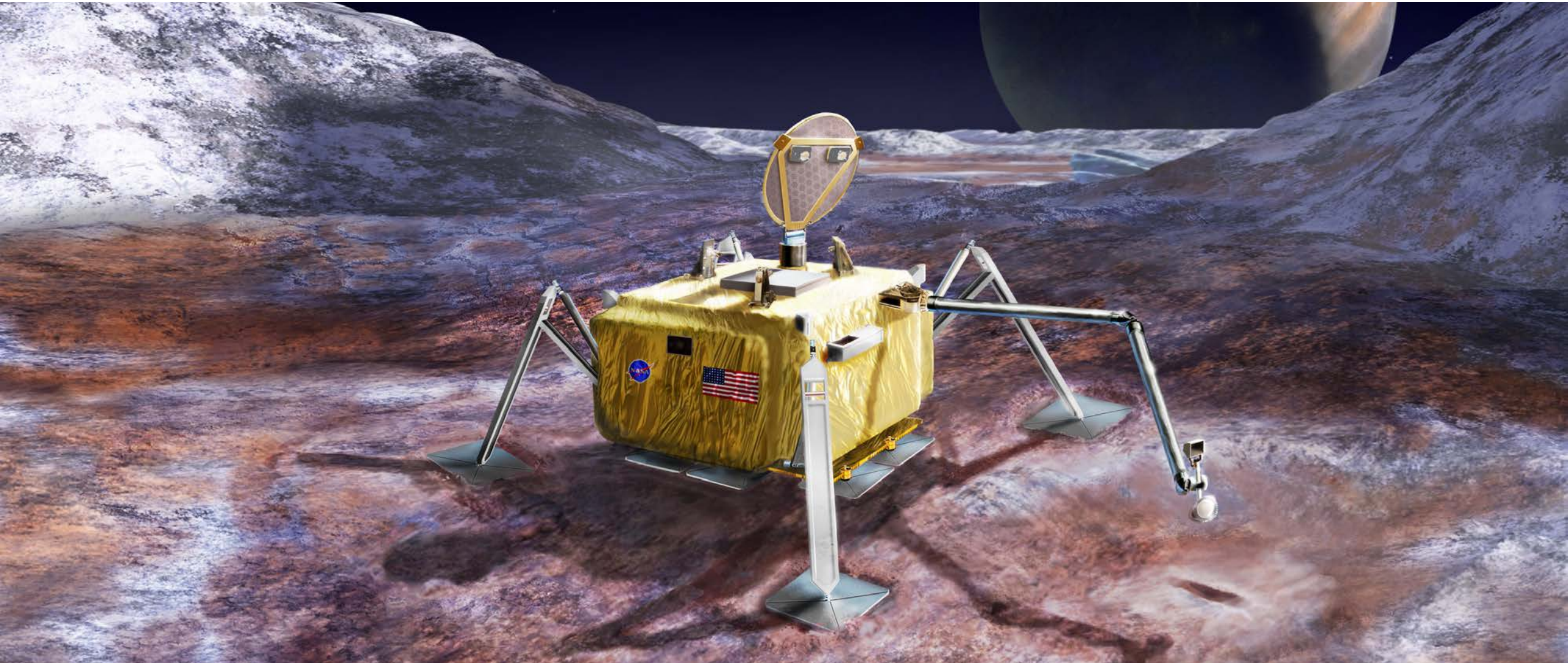


Europa Lander Mission Overview and Update

Steve Sell

15th International Planetary Probe Workshop, Boulder CO

June 2018

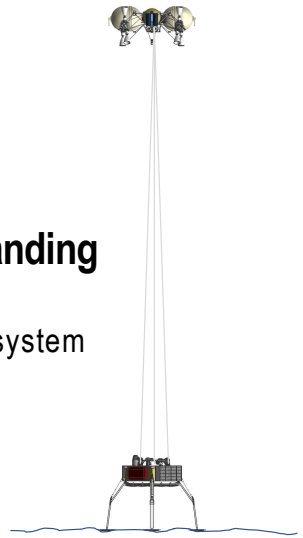
Jet Propulsion Laboratory
California Institute of Technology

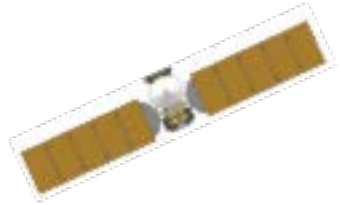
When we last spoke…

Launch
- SLS Block 1B
- Oct. 2025

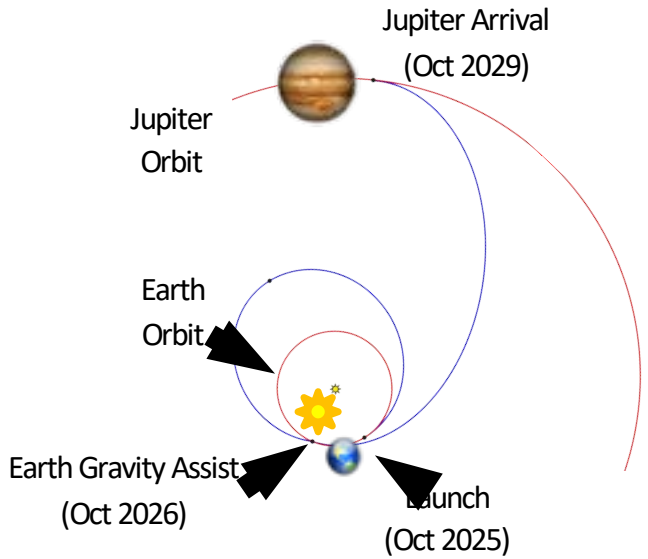
Cruise/Jovian Tour
- Jupiter orbit insertion Apr 2030
- Earliest landing on Europa: Dec 2031

Deorbit, Decent, Landing
- Guided deorbit burn
- Sky Crane landing system
- 100-m accuracy





Carrier Relay Orbit
- 24 hour period
- >10 hours continuous coverage per orbit
- 2.0 Mrad radiation exposure



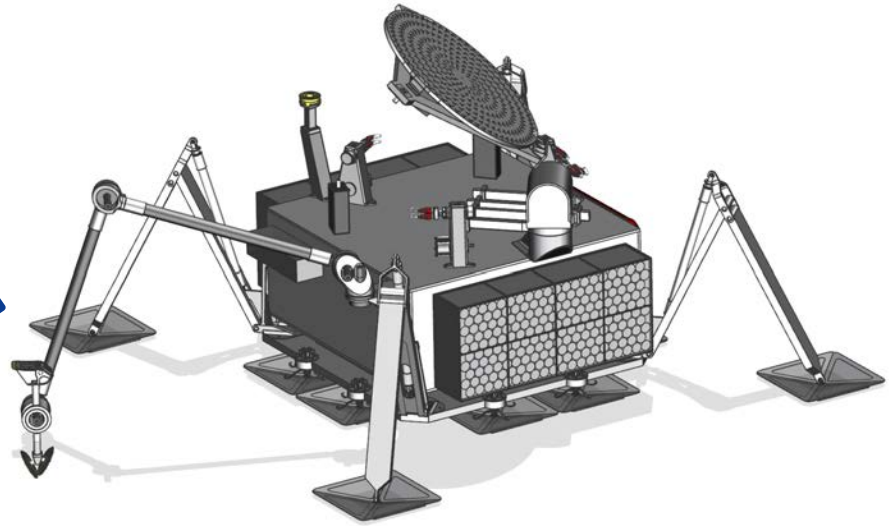
Surface Mission
- 20+ days
- 5 samples
- Relay comm through Carrier or Clipper (backup)
- 3–4 Gbit data return
- 45 kWh battery
- 1.5 Mrad radiation exposure

Post-MCR Design Options

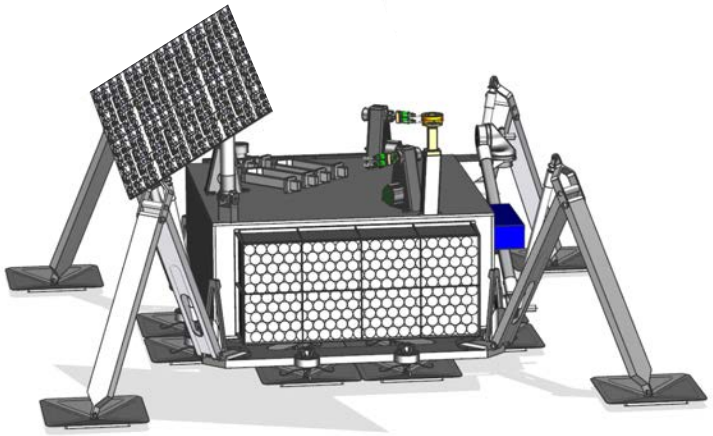
After Mission Concept Review in June 2017, team pursued three variants of the Europa Lander Mission concept to explore reduced cost

- Evolved MCR design
  - Uses the Carrier spacecraft as a communications relay with relaxed visibility and communications cadence
  - Carrier maneuvers to stable orbit after surface mission ends
- Direct To Earth
  - Communication path is direct from the Lander to Earth without using the carrier spacecraft for relay
  - Carrier becomes non-operational once Lander separates and is therefore abandoned in stable orbit

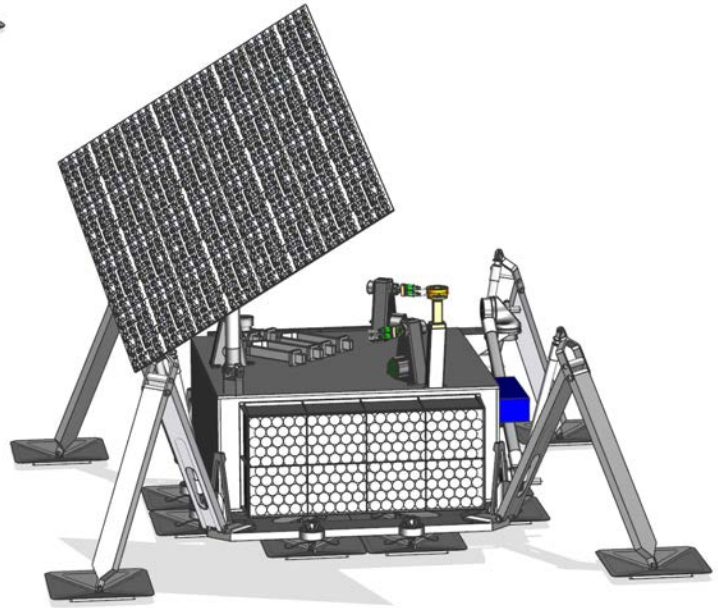
Considered Options



MCR Relay Lander



Evolved MCR Design



Direct-to-Earth Lander (DTE)

Artist's Concepts

Key Technical Changes from MCR Design (1/2)

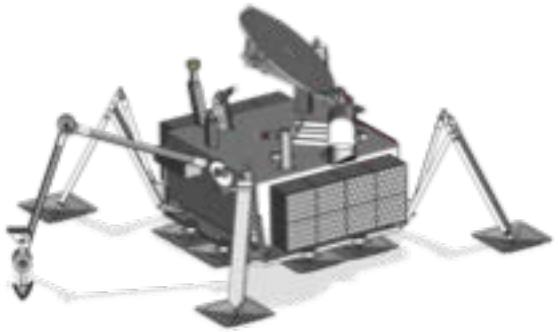
- Changes applicable to all options (Relay and DTE Options)
  - Use re-packaged Clipper avionics on Lander for power savings
  - Re-distributed power functionality more optimally for much lower sleep power
  - Perform longer tour to save ΔV
    - Marginally increases radiation exposure, but reduces prop needed in tour
    - Landing delayed up to 1 year, depending on landing site

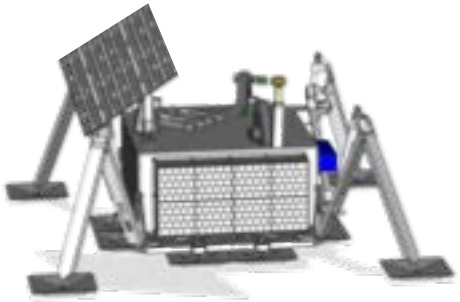
Key Technical Changes from MCR Design (2/2)

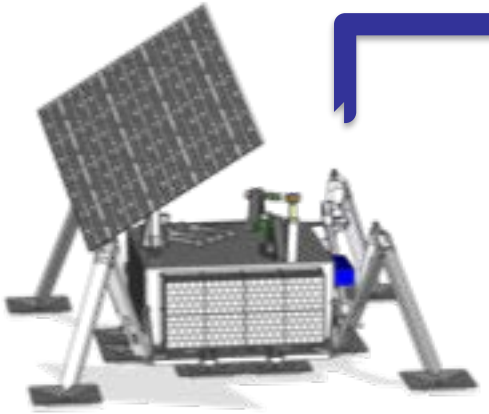
- Changes applicable to Relay Option
  - Relaxed post-touchdown communication duration requirement from 15 min to “a few seconds”
  - Relaxed TD-to-first-overflight requirement from 24 hours to up to ~3.5 days (delay is landing site dependent)
  - Added minimal DTE capability to allow health, status, backup communications with Lander during times where carrier isn’t visible
  - Carrier maneuvers to stable orbit after surface mission, but does not survive for extended future use
  - Surface communications cadence is variable depending on landing site (was forced to be 24 hour cycles in MCR design)

- Changes applicable to DTE Option
  - Primary communication is Direct-to-Earth from Lander
    - Requires high-precision antenna pointing (~0.5 deg) for communications to work
    - High-power radio amplifiers, large antenna added to Lander for DTE communications
  - Carrier is dependent on the Lander to operate
    - System is maneuvered to stable orbit prior to Lander separation
    - Abandoned in stable, non-operational state at Lander separation

Approximate Mass Comparison







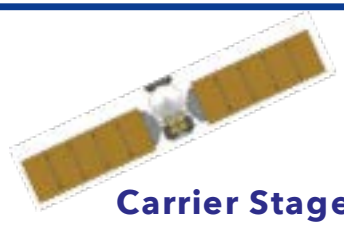
Artist's Concepts

	Dry Launch Mass	
Concept	kg	%Δ
MCR	5700	0%
Evolved Relay	4200	-26%
DTE	4140	-27%

Europa Lander Direct-to-Earth Mission Concept

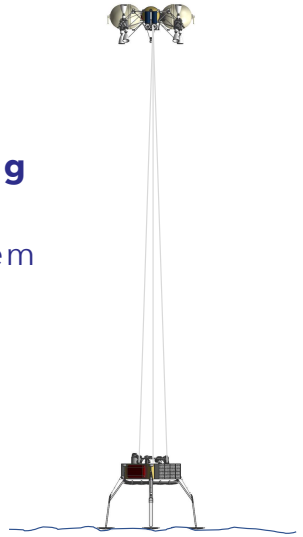
Launch
- SLS Block 1B
- Nov 2026

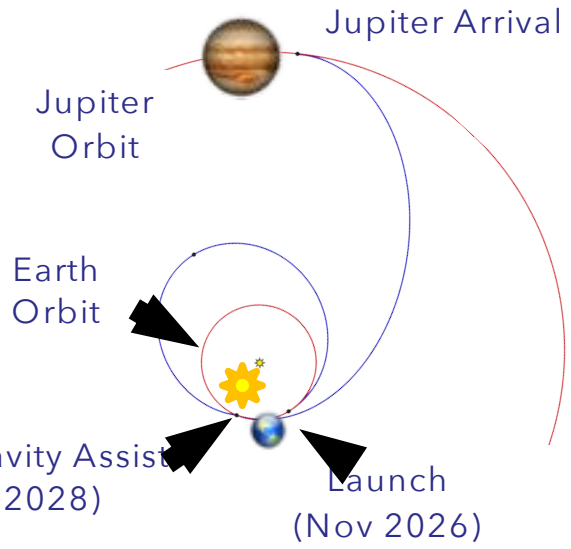
Cruise/Jovian Tour
- Jupiter Orbit Insertion: Sep 2031
- Europa Landing: 2033



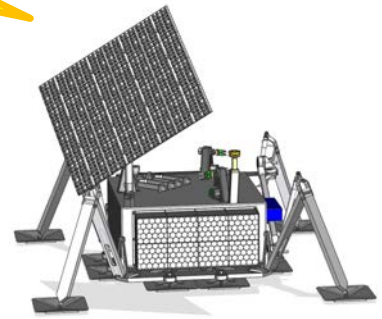
Carrier Stage
- 2.0 Mrad radiation exposure
- **Elliptical disposal orbit**

Deorbit, Descent, Landing
- Guided deorbit burn
- Sky Crane landing system
- 100-m accuracy
- **DTE tones only**





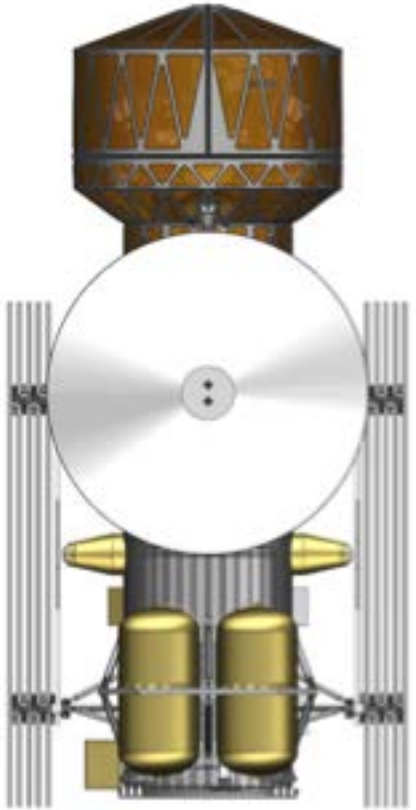
Surface Mission
- **Biosignature Science**
- 20+ days
- **3 samples from 1 trench**
- **Direct to Earth Comm or Clipper (backup)**
- **1.5 Gbit data return**
- 50 kWh battery (Useable)
- 2.0 Mrad radiation exposure



Direct To Earth Chosen as Architecture

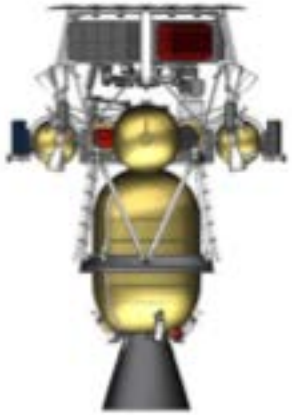
- After careful review, the Direct To Earth architecture was chosen as the Europa Lander Mission concept to continue
  - Was the lightest of the options explored
  - Reduced complexity in the surface mission could lead to less risk of cost growth later
    - Only operating one spacecraft at a time
  - Lifetime at Europa for Carrier reduced
    - Much lower radiation total dose

Baseline System Vehicles



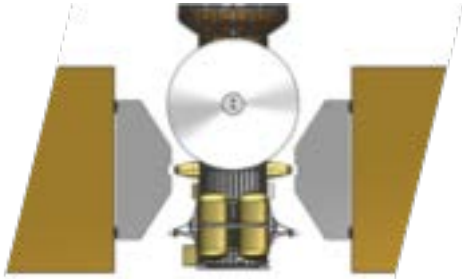
Cruise Vehicle (CV)

Launch Mass: 14 mt

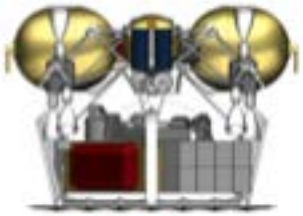


Deorbit Vehicle (DOV)

+

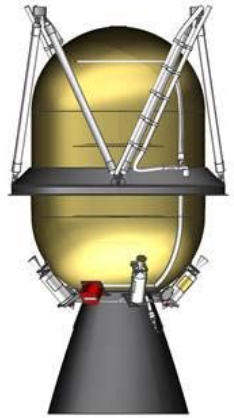


Carrier Stage (CS)



Powered Descent Vehicle (PDV)

+



Deorbit Stage (DOS)

Descent Stage (DS)

+

Lander

Artist's Concepts

Baseline Launch Assembly

Ejected Bio-Barrier X2

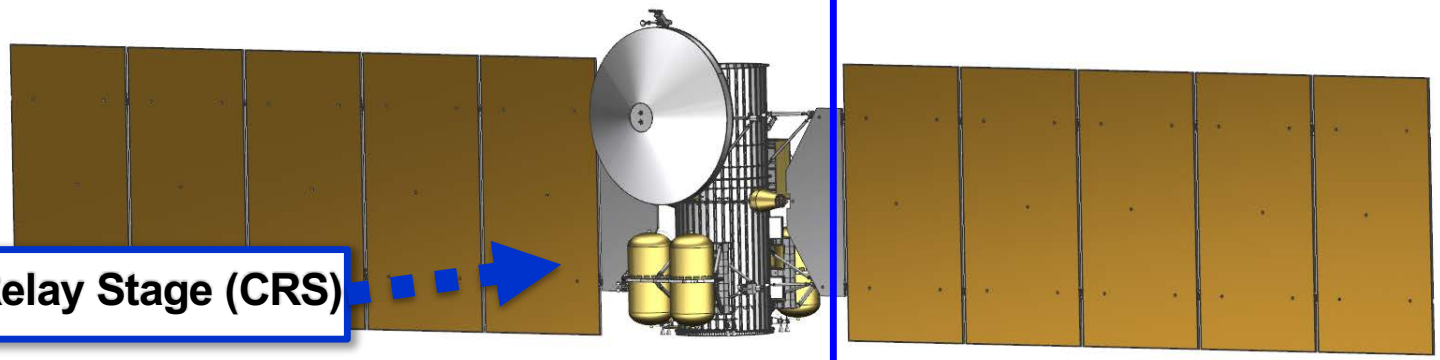
Lander

Descent Stage (DS)

De-Orbit Stage (DOS)

Fixed Bio-Barrier

Carrier & Relay Stage (CRS)



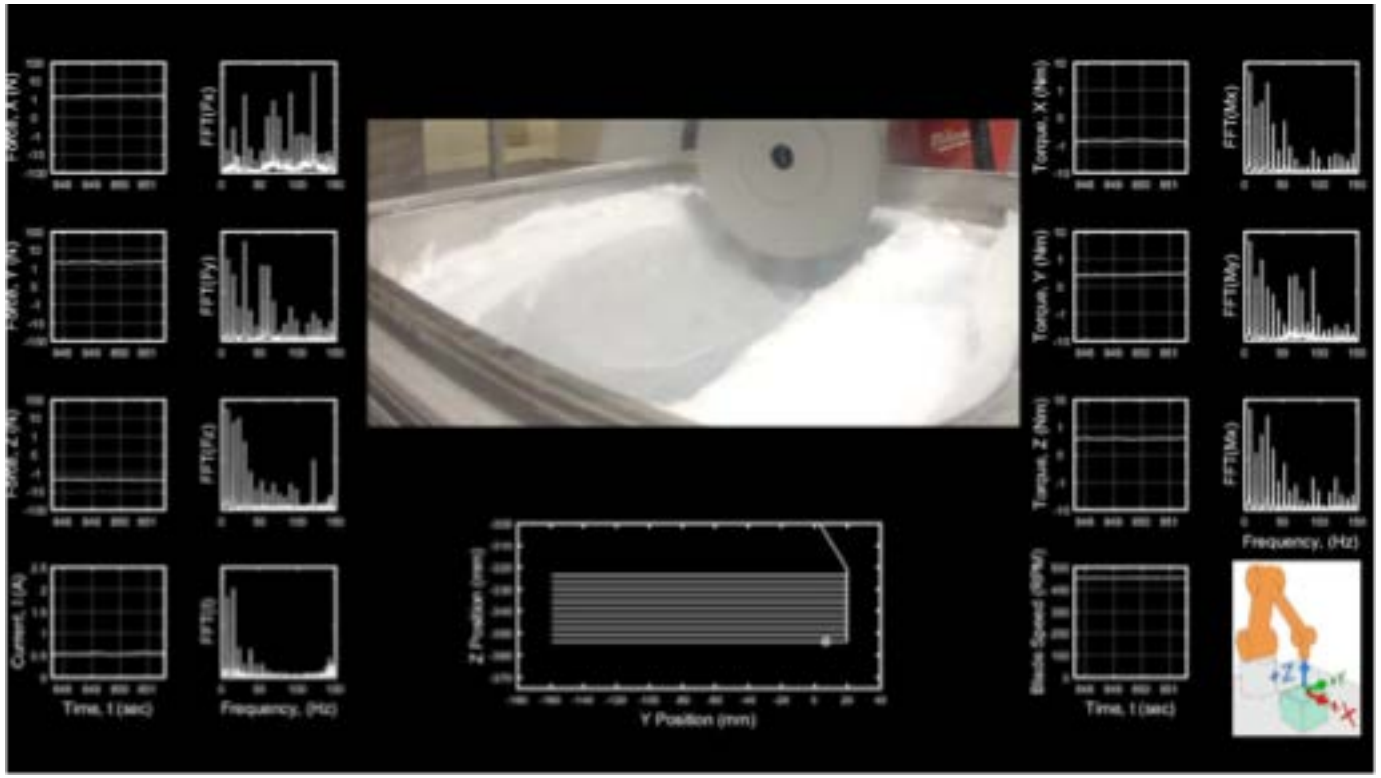
Powered Descent Vehicle (PDV)

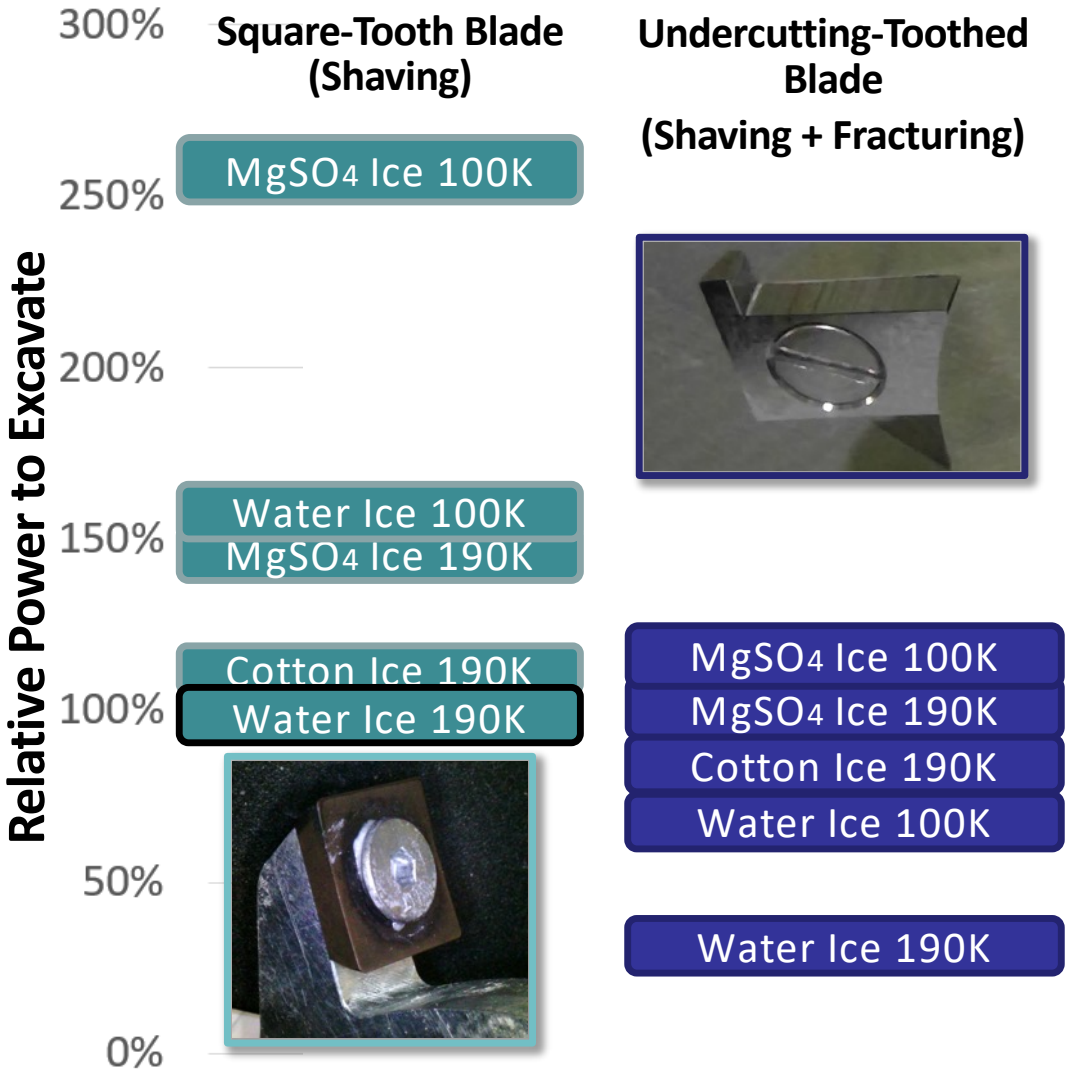
De-Orbit Vehicle (DOV)

Cruise Vehicle (CV)

Artist's Concepts

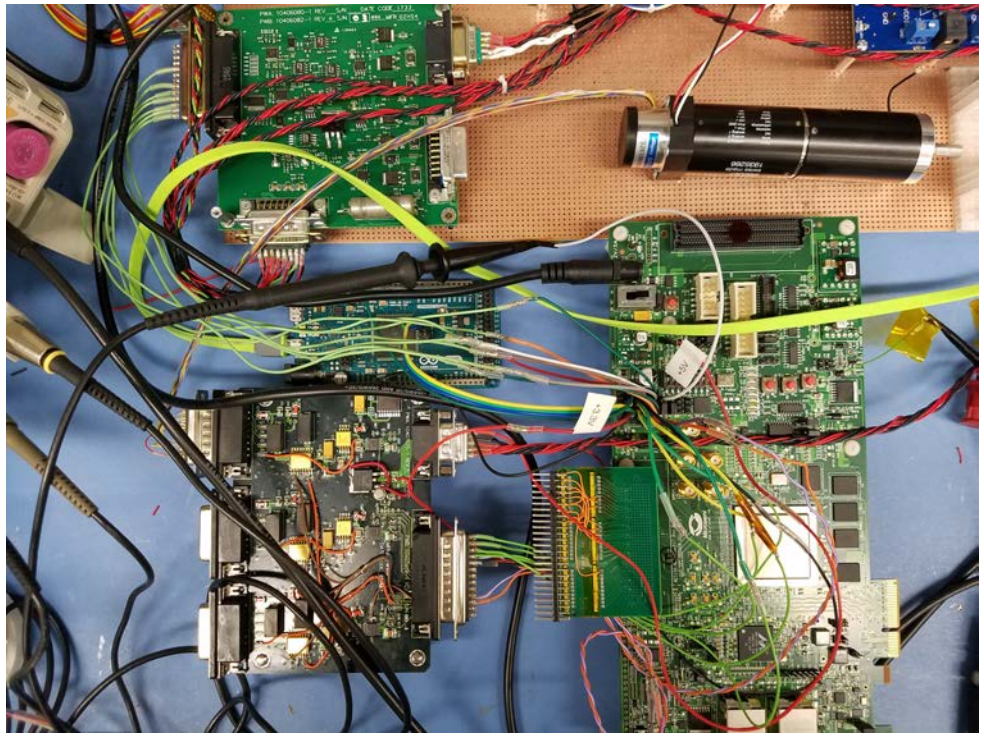
Excavation testing



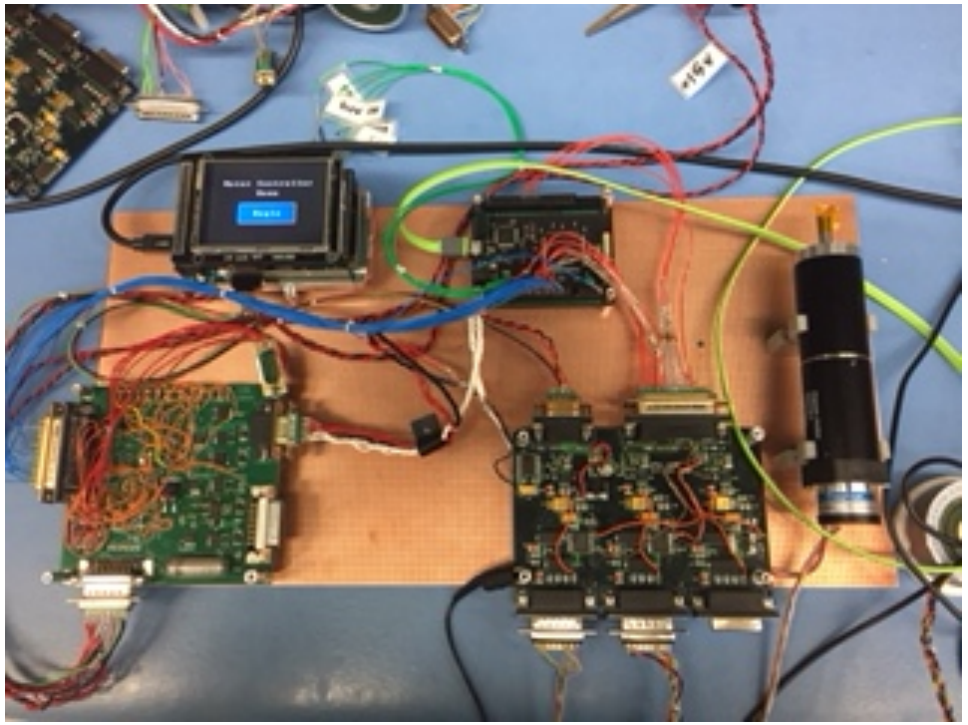


End to End Motor Control Testbed

- Completed construction of second copy of our end to end motor control testbed.
- Testbed incudes FPGA, Resolver, Motor Driver and Current sense module breadboards or modules

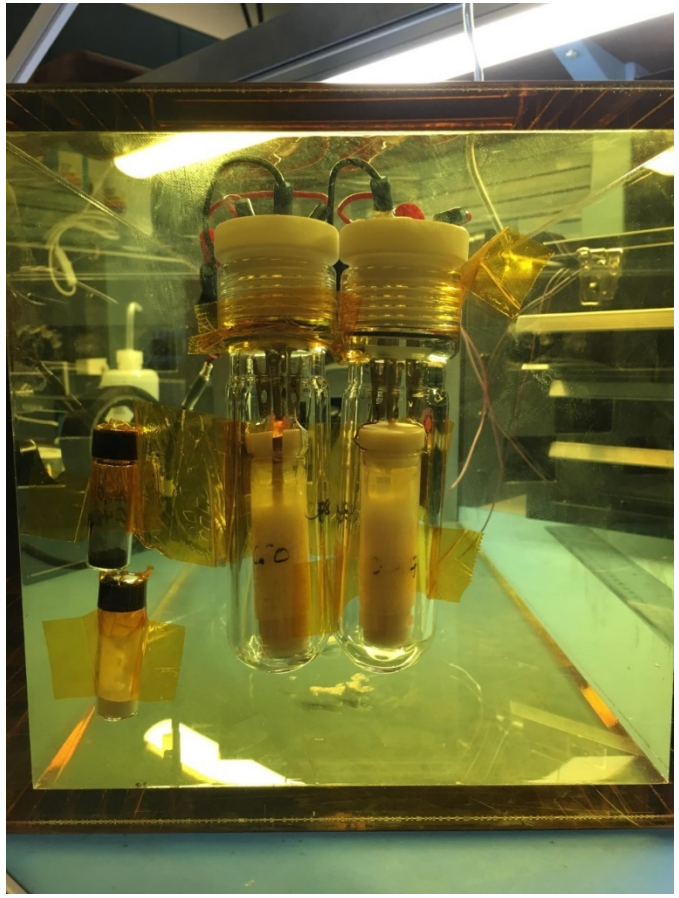


Testbed #1



Testbed #2

Battery Development



Irradiated three electrode cells, for evaluation radiation effects on anode and cathode

View of cathode and separator, as jellyroll is unwound during DPA

Current Status

- Team is underway working the DTE mission concept and is headed for a Δ-MCR this Fall
- NASA has released ICEE-2 call for development of Instrument Concepts compatible with the Europa Lander Mission Concept
  - Step 1 Proposals due June 22, 2018
- Sampling team testing blades, techniques for sampling cryogenic ice
- DTE antenna panel has been tested
- Radiation testing on Solid Rocket Motor Propellent underway
- Battery environmental testing underway
- Prototype motor controller testbed constructed

Cryo Sampling Test Camber

Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov