SLUSH: Search for Life Using Submersible Heated Drill

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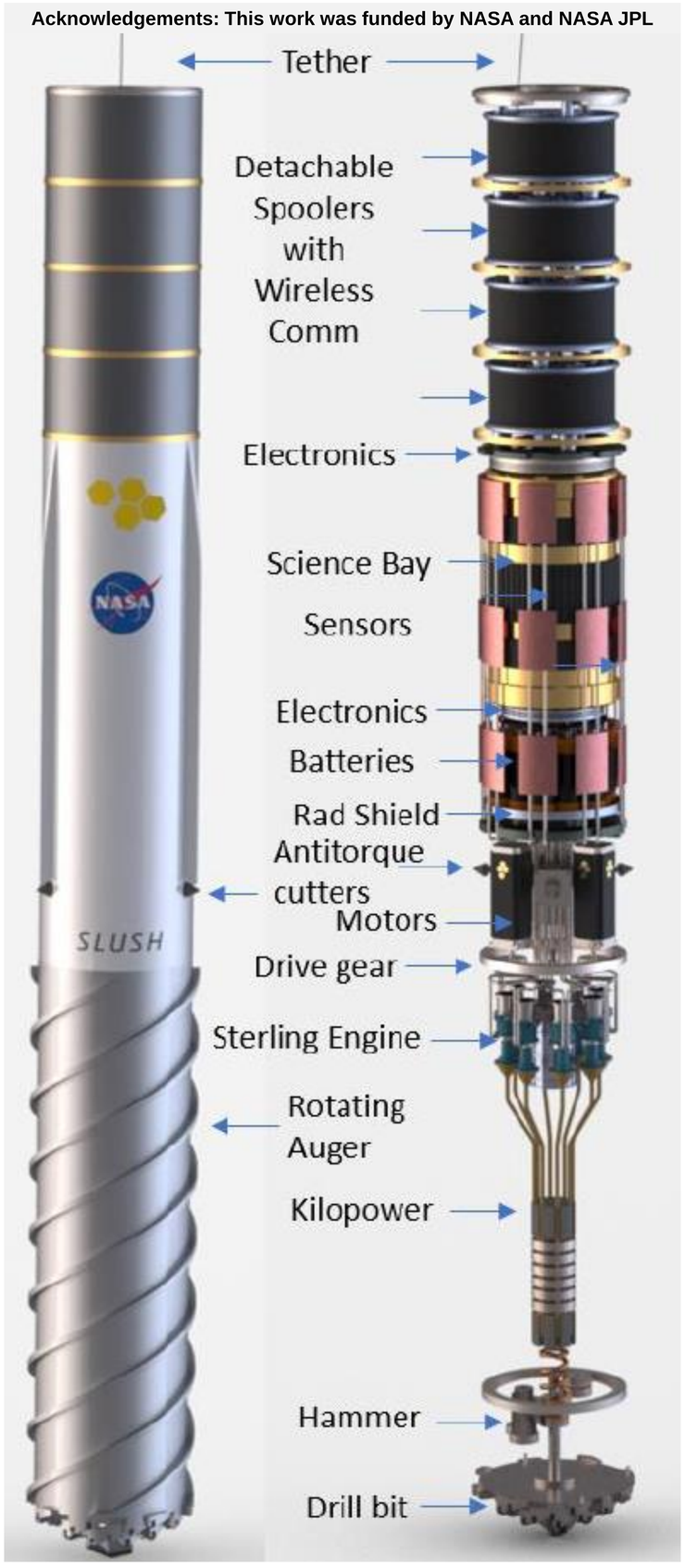
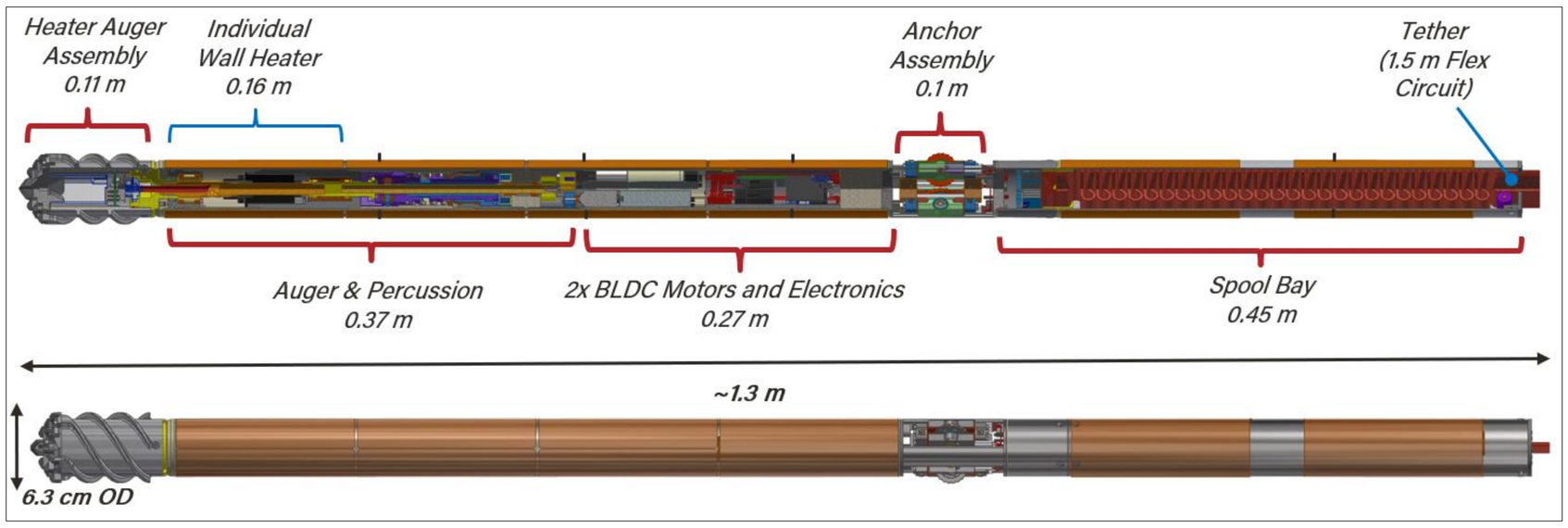
Ten Second Summary

SLUSH (Search for Life Using Submersible Heated Drill) is a thermo-mechanical probe designed to penetrate the ice shell of Europa. The probe combines the best of two common drilling techniques: a rotary-percussive drill to break apart the ice formation and melting to remove the cuttings. Unlike traditional melt probes, SLUSH melts just a fraction of the ice cuttings to form "slush", which behaves like a liquid but is still partially frozen and enables a significant reduction in power draw. The mechanical approach also generates faster penetration rates and allows the probe to drill through non-icy formations.

Baselined Specs:
Power: 10's kW (Selected source: Nuclear Fission)
Penetration rate: 0.57 m/hr
Mass: <200 kg
Dimensions: 5 m long, 57 cm diameter (driven by power source)



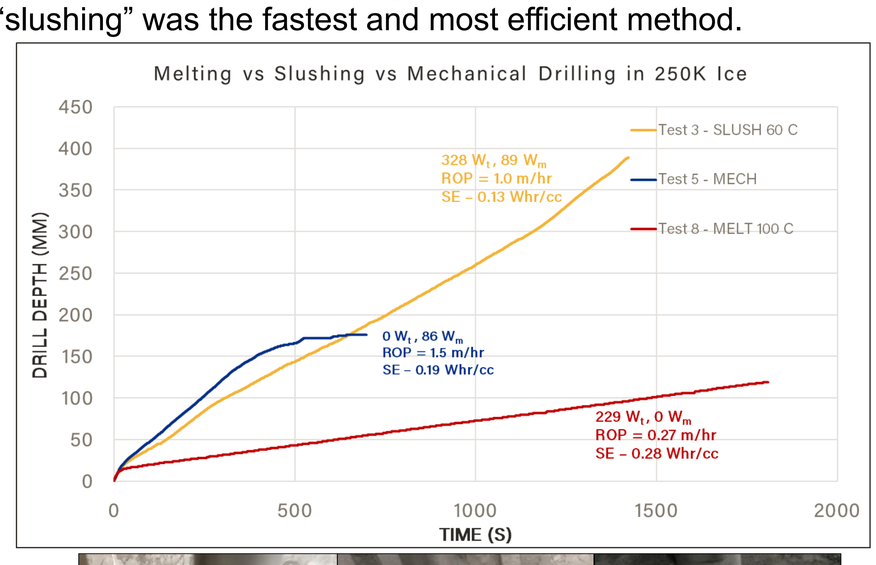
Prototype Probe Development



Honeybee Robotics is developing a stand-alone probe to demonstrate "slushing" as a viable approach to penetrate Europa's thick (~15 km) ice shell. The probe will be tested in ice at temperatures found on Europa (250 K - 100 K) to at least 2x its length. It will have all the critical functionality to demonstrate thermo-mechanical drilling, generation of "slush", and refreezing above the probe. Once validated, the probe can be scaled to a larger design capable of carrying science payloads to study terrestrial glaciers in preparation for a future deep drilling mission.

Ice Testing

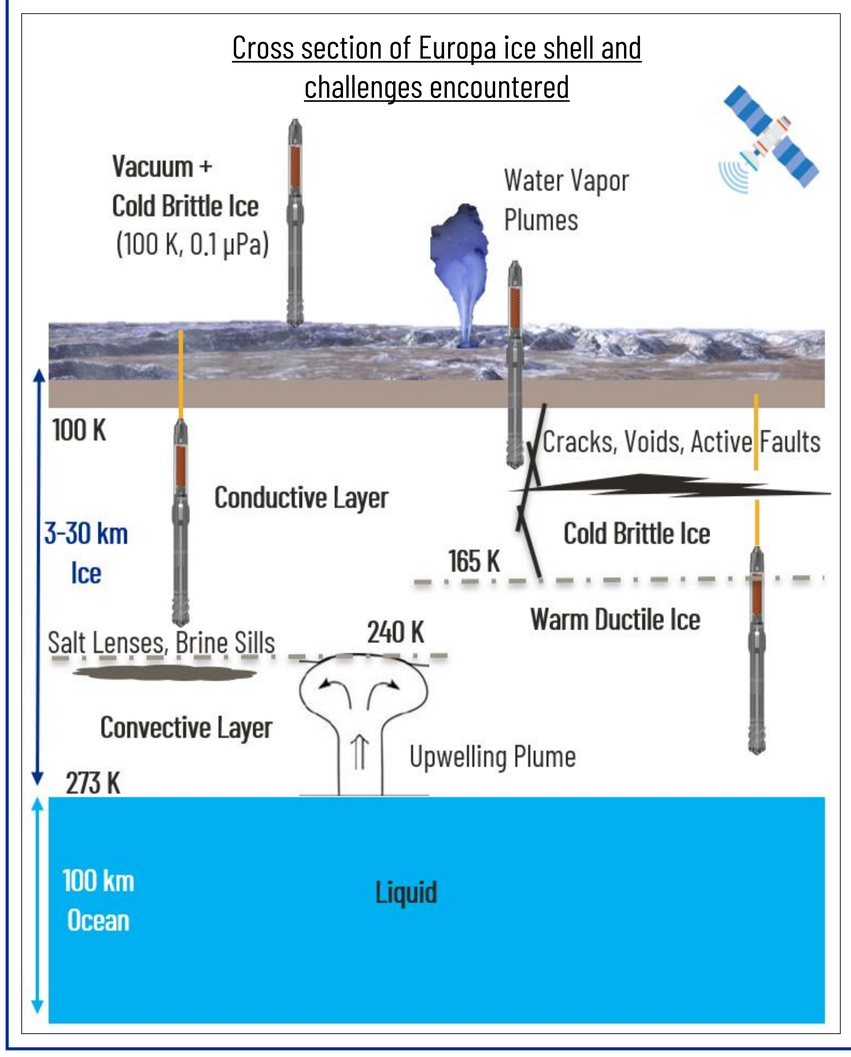
Using a heated rotary-percussive drill design, testing in "warm" (250 K) and cryogenic (100 K) ice was conducted to study differences in drilling methods. Pure melting was measured to be slower and inefficient, while pure mechanical drilling was prone to getting jammed. Using the "slushing" approach, the drill bit and auger were able to penetrate ice several times its length and demonstrated refreezing without getting stuck. In 250 K ice, "slushing" was the fastest and most efficient method.




Drilling 100 K ice using LN2 bath


Slushing 3x drill length & demonstrating borehole closure

Relevance to Europa



Europa is a primary target in the search for life because it is geologically active and possesses a liquid ocean below its surface. To reach the ocean where life may be most prevalent, a probe would need to penetrate the thick, icy shell. SLUSH must be capable of drilling through cold, brittle ice at the surface in a vacuum environment; warmer, ductile ice; salt layers; and voids. Thermo-mechanical drilling, with a moderated nuclear fission reactor as the power source, makes it possible to overcome the thermal and environmental challenges on the way to the ocean.