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## DEVELOPMENT OF PROBE TECHNOLOGIES TO REACH EUROPA OCEAN

**Abstract**

Europa is a primary target in the search for past or present life because it is potentially geologically active and likely possesses a deep global ocean in contact with a rocky core underneath its outer ice shell. Galileo spacecraft observations and theoretical models predict that the ice shell is 3-30 km thick and overlays an ocean 100 km deep.

To reach the subsurface ocean where life may be most prevalent, a probe would need to penetrate the ice shell while moving the excavated material aft. This can be achieved by melting the material

(thermal penetration) and cutting the material (mechanical penetration). Mechanical systems break the icy material efficiently but transport ice chips inefficiently. Thermal systems have an effective chip removal approach but a power intensive ice-melting step. The Search for Life Using Submersible Heated (SLUSH) drill is a hybrid thermo-mechanical drill probe system that combines the most efficient aspects of these two techniques.

SLUSH is 5 m long, 57 cm diameter probe with a heated drill bit in front, antitorque cutters on the side, and several tether bays on top. The probe is partially flooded to achieve negative buoyancy. Critical subsystems are inside a pressure vessel. SLUSH utilizes a mechanical drill to break the ice and a reactor to partially melt the fragments, enabling the efficient transport of material behind the probe. The resulting slush behaves like liquid despite being partially frozen, significantly reducing the power required for melting the full volume of ice. Further, because the mechanical approach generates higher penetration rates than melting, SLUSH can reach the ocean in a much shorter time than a pure melt probe. Once SLUSH passes through the top cryogenic ice and penetrates deeper into warmer ice, it can use a purely thermal approach to melt through this warmer ice without the need for mechanical cutting. SLUSH incorporates the Kilopower reactor for both thermal and electrical needs.

The probe is physically connected to a surface lander by a communications tether, housed in several spool bays that are left behind in the ice once the spool is depleted. This allows each tether section to be purpose-designed. For example, the top section, which may see 150 kPa shear stresses on a diurnal cycle, will be reinforced with Kevlar and or Vectran. Leaving the spools behind also shortens the probe length as it descends, making penetration more efficient.