EUROPA STI: EXPLORING COMMUNICATION TECHNIQUES AND STRATEGIES FOR SENDING SIGNALS THROUGH THE ICE (STI) FOR AN ICE-OCEAN PROBE. C. McCarthy[1], K.L. Craft[2], C. R. German[3], M. V. Jakuba[3], R. D, Lorenz[2], G. W. Patterson[2], A. Rhoden[4], [1]Lamont-Doherty Earth Observatory, Palisades, NY, mccarthy@ldeo.columbia.edu, [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, [3]Woods Hole Oceanographic Institution, Woods Hole, MA , [4]Southwest Research Institute, Boulder, CO.

Introduction: Several outer solar system moons, including Europa, are believed to harbor conditions conducive to life. Beneath its icy shell, Europa likely hosts a long-lived global ocean in contact with silicates and internal tidal heating. In order to sample Europa's ocean, however, or water pockets within its ice shell to look for signs of life pose significant challenges would need to be overcome. As Europa executes its 3.5 day elliptical orbit around Jupiter, its shape is distorted by Jupiter's gravitational pull and as the ice shell flexes with the tides, its surface can crack and slip, as evidenced by the pervasive tectonic features observed on its surface. A successful mission will require penetrating the ice shell with instrumentation *robust* to these forces, down to depths of kilometers to 10s of km, while maintaining communication with the surface.

Strategy: The recent *NASA Compass* concept study [1] discussed the use of tethers with coupled radio frequency (RF) repeater 'pucks' to enable communication between a descending probe (cryobot) and a surface lander. Tether lengths for such an architecture may need to exceed 15 km and, if employed, multiple RF repeaters will need to be deployed to ensure communication over that length. The largely unknown thermal, mechanical, and compositional properties of Europa's subsurface may pose significant risks to both tether deployment and lifetime and to RF system performance. Europa STI is working three tasks that will address key risks for communication between a descending subsurface probe within Europa's ice shell and a surface lander.

1. Characterization of strength & performance, of multiple tethers and their deployment (payout) mechanism in a laboratory setting that simulates Europa-like conditions.
2. Numerical modeling of potential thermo-mechanical environmental hazards within Europa's ice shell that could pose risks to probe-lander communication.
3. Evaluation of system performance of RF, acoustic, and optical free-space communication strategies in a variety of modeled Europa environments

The STI project is working to bringing one (or more) communication tether design to TRL 4/5 (through validation in a laboratory setting that simulates a relevant environment) and will evaluate the performance of multiple free-space communication architectures that could be coupled with, or alternatives for, tethers to a subsurface probe. Fiber optic micro-tethers currently exist that have lengths sufficient to traverse Europa's ice shell and have sufficiently low mass to allow delivery as part of a planetary mission. In recent work NUI [2] vehicles (Fig. 1) have used 20 km spools of bare fiber, 250 μm in diameter, to reach the deepest parts of Earth's ocean (11,000 m), and to reach from the ice-water interface to the seafloor beneath the ice-covered Arctic Ocean.

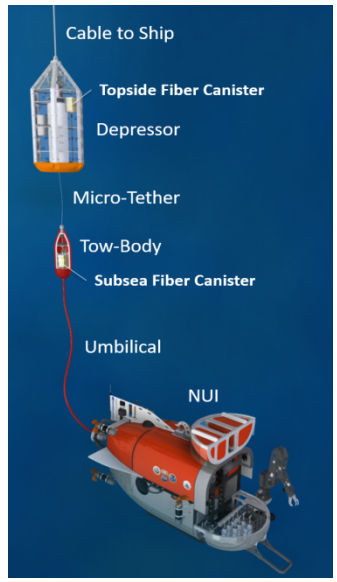

Fig 1. The NUI micro-tether system. Two fiber canisters containing 20 km each of bare fiber connect a depressor to a tow-body pulled behind the vehicle. Fiber pays out from either canister as needed to limit tension in the fiber as the vehicle or depressor move.

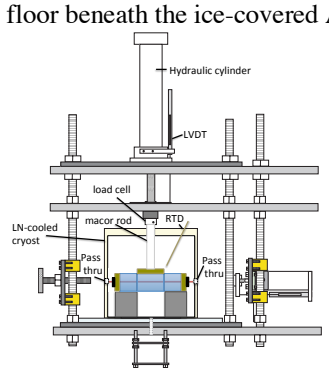

Fig 2. The Liquid Nitrogen (LN) cooled custom biaxial cryogenic deformation rig at LDEO. Each tether will be frozen into the ice (blue region) and loads will be applied.

Testing of the tethers will include shearing across icy faults for a range of tether types as a function of shear stress, velocity, temperature, and ice (impurity) composition in the test rig shown in Fig 2. Numerical models will be run to explore the fault rates and magnitudes expected in the different layers of Europa.

Europa STI will enable the search for extraterrestrial life and exploration of an ocean world, through evaluation of tethered and free space techniques as means of communication with a cryobot.

References: [1] Dombard, A. et al. (2018), *AGU Fall Meeting*, abstract# P52C-05. [2] Jakuba, et al. (2018), *J Field Robotics*, 25(11-12), pp.861-879.