EUROPA STATION: DEVELOPING A CONCEPT FOR HIGHER FIDELITY ANALOG-ENVIRONMENT TESTING OF CANDIDATE OCEAN WORLD TECHNOLOGIES. W. C. Stone[1]; V. Siegel[1]; K. Richmond[1]. [1]Stone Aerospace (3511 Caldwell Lane, Del Valle, Texas, billstone@stoneaerospace.com; vickie.siegel@stoneaerospace.com; Kristof.richmond@stoneaerospace.com).

Introduction: We are developing a preliminary concept for an Antarctic field camp facility to advance development and testing of fully-integrated robotic systems required for missions to explore the subsurface of icy Ocean Worlds. The facility we propose – Europa Station – would be a multi-year technology development program and scientific field camp in Antarctica allowing for full-scale, long-term testing and validation of space-capable technologies to penetrate kilometers of ice, to break through into a liquid water environment, and to explore that environment for signs of life. This same technology will also dramatically enhance scientific access to subglacial lakes in Antarctica. We are in initial planning stages for a community workshop to further assess the merits and define the details of this idea, with the aim of submitting a report to OPAG and contributing a white paper to the upcoming Decadal Survey process.

Flight planning and space qualification of instruments are already underway for the Europa Clipper flyby mission. Advanced concept definition for a lightweight Europa lander is also moving forward. The next phases of technology development will need to test a basic autonomous ice-penetrating vehicles (known as “cryobots”) followed by a cryobot-deployed autonomous underwater vehicle (AUV) to explore the sub-ice ocean. While AUVs are familiar to most scientists today, cryobots have only seen significant development in the last decade as a result of NASA-funded research.

How does Europa Station address the need?: There are six critical environments in which sub-ice technology for Ocean World exploration will have to successfully operate:

1. The Starting Problem, in which a penetrator must transition from the high-vacuum, ultra-cold environment on the ice surface, to starting and entering a borehole, through the eventual borehole closure behind it;
2. Brittle Ice Cruise transiting through ultra-cold, brittle cryogenic ice (temperatures <100K);
3. Areas requiring identification of obstacles (impact debris, salt intrusions, etc.) or targets (brine layers or water-filled cracks and voids) and maneuvering around or towards them as needed;
4. Ductile Ice Cruise transiting through more temperate ice (temperatures above 233K);
5. Breakthrough into the subsurface ocean; and
6. Moving through the ocean to explore, characterize, and sample in the search for life.

Europa Station will provide operational environments 3, 4, 5 and 6, while laboratory environmental chambers can be used to investigate environments 1, 2, and 3.

Europa Station Implementation. The Antarctic ice sheet overlying unexplored subglacial lakes represents the closest Earth analog for testing advanced Europa missions. The 4 km thickness of Antarctic ice can be viewed as the last 4 km of ice on Europa before ocean breakthrough. As such, the ice sheet provides an extraordinary opportunity for mission simulations, testing of life search protocols and algorithms, and assessing the reliability of various concepts when subjected to long-term operations such as will be experienced on multi-year missions to Europa. We envision Europa Station to be located in the Antarctic interior at a location where a minimum of 2,500 m and up to 4,000 m of ice overlies a suitable subglacial lake.

New power transmission technologies (e.g., using high power lasers and fiber optics as well as high voltage AC power transmission, novel insulators, and conducting-fluid-based thermal power conversion) make it possible to create self-contained cryobots of reasonable size with relatively small field logistics footprints. Spooling micro tethers from the vehicle allows the borehole to refreeze behind the vehicle. Because onboard spoolers can work in both directions, it becomes possible for the vehicle to melt its way back to the surface at will, thus eliminating one of the greatest restrictions surrounding present Antarctic drilling technologies. Furthermore, planetary protection requirements have led to studies that show that a self-contained cryobot, if pre-sterilized, will not forward-contaminate deeper ice.

These factors: novel power transmission; small logistics footprint; bi-directional travel; and presterilization not only allow for expedited Antarctic testing of future space systems, they also open a doorway to routine and persistent subglacial lake access in Antarctica. The development and testing of such vehicles at Europa Station would significantly benefit both NASA planetary mission technology development and NSF polar science.