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M1Or4A-05: [Invited] Advanced Cryogenic Cooling Concepts for Superconducting Technologies on Electric Transport Platforms

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There is growing interest in superconducting technologies for large electric transport platforms such as electric aircraft and ships to eliminate greenhouse gas emissions from the transportation sector. Superconducting technologies have high efficiency and power density, which are necessary to achieve the electrification of large transport platforms. Liquid hydrogen (LH2) fueled platforms offer the synergy to reduce the complexity of superconducting technologies by using the liquid fuel at 20 K as a cryogenic heat sink. Many government-funded research programs and the efforts by aircraft manufacturers are developing technology components necessary to realize the dream of zero-emission aircraft and ships. Significant investments are also being made to establish LH2 production, storage, and distribution infrastructure. High power density propulsion motors, generators, and power distribution systems are under development. It has been recognized that thermal management, electrical insulation, and safety are critical to success with LH2-fueled electric aircraft. Fuel cells and hydrogen-burning generators are options for electrical power generation using hydrogen. The low efficiency of fuel cells represents significant thermal loads that are difficult to manage on an aircraft or ship. The low volumetric energy density of LH2 coupled with limited space available for fuel storage requires that the thermal loads be curtailed to the levels supported by the mass of LH2 necessary for fuel needs.

The paper will briefly review various research and development efforts on electric ships and aircraft. It will discuss the absence of comprehensive research facilities required to develop the technologies, the need for broad collaborations and joint developments to quickly design and validate initial design options, and build and test prototype propulsion, power distribution, and cryogenic systems, and international efforts to establish such regional technology support centers.

The Center for Advanced Power Systems (CAPS) and the FAMU-FSU College of Engineering have established testbeds for high temperature superconducting (HTS) power distribution systems, cryogenic electrical insulation systems, cryogenic fluid circulation systems, advanced AC loss measurement systems at LH2 temperature relevant to developing electric aircraft and ships. The paper will describe the facilities and examples of collaborative development efforts. The paper will discuss the facilities, ongoing research, and opportunities for collaboration.

The paper will briefly discuss the R&D efforts of the NASA-funded University Leadership Initiative project, Integrated Zero-Emission Aviation (IZEA), in superconducting technologies and cryogenic thermal management.

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