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Military Benefits of Superconductor Based Equipment

***Benefits of Superconductor Based Equipment*:** Superconductivity brings sensitivity, accuracy and performance advantages beyond the theoretical limits of conventional electronics technology. Additionally, in large scale superconducting systems, when all the necessary cryogenic components are included, size and weight reductions of 50-70% are achieved versus conventional equipment. Five examples of military applications development serve to demonstrate the dramatic benefits of superconductivity.

***Mine Protection*:** As steel hulled ships at sea move through the magnetic field of the earth they develop a low level magnetic charge which can be used as a homing signature in mine warfare. Most naval vessels are therefore equipped with large copper degaussing coils running around the ship which are used to "neutralize" the magnetic signature. Superconducting degaussing coils are 20% the weight of copper based coils as they carry higher currents at lower voltages which translates into smaller footprints and improved efficiency. High Temperature Superconductor (HTS) coils were retrofitted on the guided-missile destroyer USS Higgins (DDG 76) in 2008 and have performed extremely well in sea trials since that time. **Use of this demonstrated superior and potentially life-saving technology should be retrofitted on all current Navy vessels and incorporated into all new construction.**

***Electric Power Distribution*:** High Temperature Superconducting (HTS) power cables have significantly higher power density capability than copper counterparts, thus providing weight and size savings and making room for other war fighting equipment on board Navy vessels. Bridging various loads and sources of electric power with HTS cables will ensure uninterrupted power with minimal waste. HTS cables also offer tunable power density by adjusting the operating temperature. With investments in research and development, the HTS technology advancements that are under development for utility power grid applications can be extended to defense. **CCAS recommends that the Administration and the Congress continue funding ongoing programs and new proposals in HTS cables and related cryogenic technology development for military use.**

***Revolutionary Marine Ship Propulsion*:** Within the past 20 years ship designers have begun to adopt electric propulsion systems which are hailed as the most important design change since the adoption of the diesel engine in the 1920s. Among large commercial ocean going vessels, nearly 100% of all new ships are electrically propelled. This includes many large cruise ships such as the Queen Mary 2. In 2002, the U.S. Navy announced it would migrate towards an all-electric fleet. The large size and heavy weight of conventional copper-based electrical propulsion motors and generators have been a barrier to broad adoption of electric propulsion. For these reasons superconductor-based ship drive motors will revolutionize electrically propelled ships. HTS motors and generators are much smaller and lighter; operating prototypes are one-third the size and weight of their copper wound conventional counterparts and run quieter with less vibration. In Navy vessels

quieter and less vibration means a lower probability of early detection. In addition the elimination of rotor losses results in much higher efficiency, especially under partial load conditions, where many ships operate for the great majority of their operating hours. This translates into a longer cruising range and greater fuel economy. Smaller and lighter motor assemblies could also enable electric ships to use shallower ports and result in greater maneuverability. For Navy vessels the smaller propulsion motors provides additional space and weight allowances for high power combat radars and additional missiles. A prototype 36.5 MW HTS ship drive motor that has been fully lab tested is sitting in the Philadelphia Naval Yard awaiting incorporation into a Navy vessel. This is an equivalent power replacement for a conventional ship drive at one-third the weight and size. **The Administration and the Congress should fund, and U.S. Navy should implement, a demonstration of the benefits of this major HTS ship drive propulsion system that is so close to realization.**

***Radar*:** Superconductor electronics can dramatically enhance anti-ship missile defense radars. Emerging threats include sea-skimming missiles that reflect very small fractions of the radar signal. The challenges to radar receivers are that they must distinguish these small echoes from the huge background clutter of waves, rain, jammers and mountains on the shore in real time. Superconductivity enables the highest dynamic range digitizers and the smallest digits are essential to detect the most elusive threats. High dynamic range superconductor-based electronics provide the most advanced technology and simplify the receiver, thereby making these life-saving sensors and detectors affordable for a wide variety of Navy ships. **CCAS recommends that programs in support of such major technology advances and military advantages should be expanded as in combat situations settling for second best is not good enough.**

***Communications*:** Superconductors offer the unique advantages of ultra-low signal dissipation and distortion as well as intrinsic (quantum) accuracy. These advantages combine to enable what researchers with the US Army have called the “most significant change to satellite communications in 30 years”. Superconducting analog filters have been installed in over 10,000 cellular phone telephone base stations and, in an industry where reliability and uptime are essential, these filters have proven their advantages in increased range and enhanced call handling and processing capability. Military signal communications is conducted at much higher frequency and is primarily digital. The revolution under development, funded by the US Government and in part by commercial ventures, is to take advantage of the intrinsic linearity and quantum accuracy of superconductors to produce the world’s best analog-to-digital converter. This would enable the digitization of a wide band of signals without the need for much slower and error prone analog pre-processing. As a result, significant portions of the system, which usually add weight, volume, cost and distortion, would be completely eliminated. Software could then be used to manipulate digital data resulting in compatibility of all protocols and an effective exceptionally high speed, error-free “universal” system. Significant progress has been made and demonstrated in satellite communications links with the incorporation of a superconducting integrated circuit containing about 11,000 Josephson junctions on a chip smaller in size than half a penny. There is no other way to effect such high frequency, very high speed, all digital communications. **CCAS recommends continued support for this critical technology**.

CCAS members are involved in the end-use, manufacture, development and research of superconductor based systems, products and related technologies. CCAS members comprise large and small corporations, research institutions, national laboratories and universities.

***Additional Information*:** For additional information please contact Dr. Alan Lauder, Executive Director, CCAS, at 610-388-6901 or alauder@comcast.net