CCAS
Coalition for the Commercial Application of Superconductors

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Superconducting Technology for National Security

High End Computing (HEC) systems are becoming larger and yet increasingly less efficient in both power and programmability. Commercial systems fail to solve the most difficult critical problems in Cryptology, as well as in High Performance Aircraft Design and Test, Battlespace Modeling and Simulation, Nuclear Weapons Stockpile Stewardship, and Imagery Processing and Correlation. Digital Superconducting Rapid Single Flux Quantum (RSFQ) technology can be made available in the near term to enable new architectures and offers the most promising new technology to support the critical national security needs identified above. Major government-funded science applications in energy, medical and drug fields would receive equal benefit.

Scaling CMOS machines to petaFLOPS (10^{15}, a quadrillion, Floating Point Operations Per Second) requires large numbers of processors with immense switching networks and very high power infrastructure. For example, the specialized CMOS parallel vector processor NEC Earth Simulator (5120 processors with 40 teraFLOPS, peak) has a 50 x 60 m^2 footprint on three floors, plus a dedicated power plant (the processors alone require ~7MW). Although the recent 1 petaFLOPS (peak) Roadrunner system requires “only” ~2 MW, it is expected to perform real-world ocean and climate modeling at only about 2% of its peak benchmark performance, not quite as good as the Earth Simulator.

In 2002, the congressionally requested “Report on High Performance Computing for the National Security Community” described significant issues in the development of HEC systems for national security needs and recommended an Integrated High End Computing (IHEC) program addressing needs for new and innovative architecture, software, algorithm, and technology development. The Letter of Promulgation stated *“For many demanding applications in the U. S. national security, scientific, medical and industrial sectors, availability of higher-performance components in well-balanced HEC environments is essential. Alternatives to CMOS must therefore be found.”*

The report concluded that superconductivity offers an unparalleled combination of logic speed, low power, and circuit density, but that superconducting chip technology must be improved from present LSI levels to VLSI levels. The path is straightforward and the funds required are relatively modest when compared with the benefits, i.e., superconducting processors operating at 50 GHz and higher clock rates significantly reduce the number of processors; low power superconducting processors enable design of a small form factor processor unit (projected ~1 cubic meter) with much lower power needs than conventional HEC; and electronic data routing at optical bandwidths is possible through low power, compact superconducting packet switches, overcoming the critical performance limitations of conventional HEC systems.

With federal investment, estimated between $372 and $437 million over five years, RSFQ technology could be sufficiently matured to allow the introduction of superconducting electronics in new, heterogeneous extreme computing architectures customized for national security and advanced science applications described above. The National Security Agency's IHEC R&D Program, in collaboration with other federal agencies, national centers of excellence and industry partners would lead to the development and fielding of superconducting computing technologies and the migration of such technology into general purpose high end computing. Most importantly, this would help the United States retain its leadership in Cyberspace.

Currently the most powerful computing capability and the most advanced high speed chip technology no longer reside in the United States. This is an untenable situation with potentially major consequences. When national security is involved, second best is not good enough. The United States must regain leadership in this critical arena. The program to develop high performance superconducting computing technology must be supported and pursued without reservation.

The Coalition for the Commercial Application of Superconductors (CCAS) strongly endorses this technology development and demonstration. CCAS is a non-profit organization formed in 1987.

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