U.S. DEPARTMENT OF
ENERGY

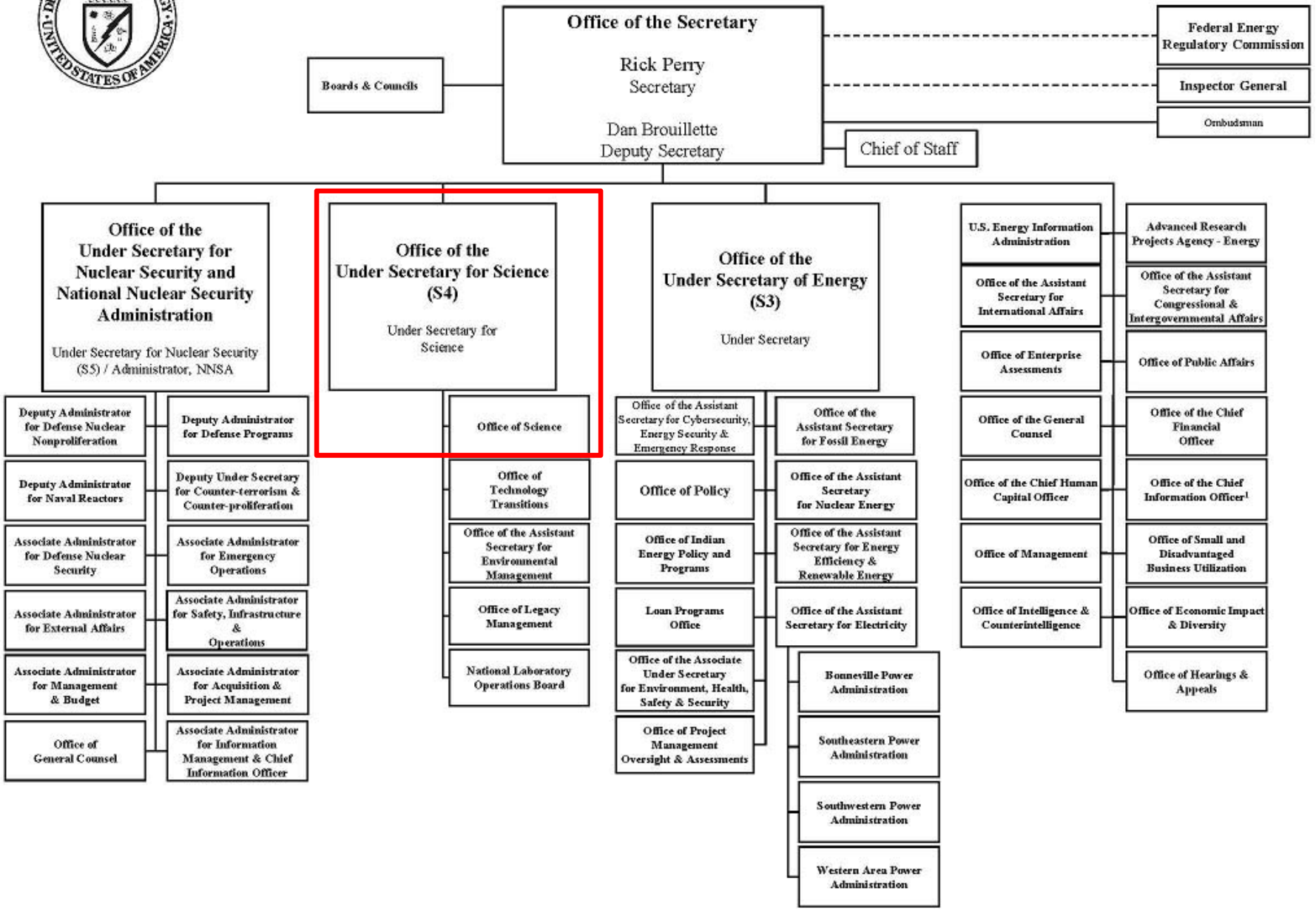
DOE Programmatic Activities in Advanced Computing Technologies

Beyond Moore's Law Computing

Dr. Robinson Pino
Advanced Scientific Computing Research
Office of Science

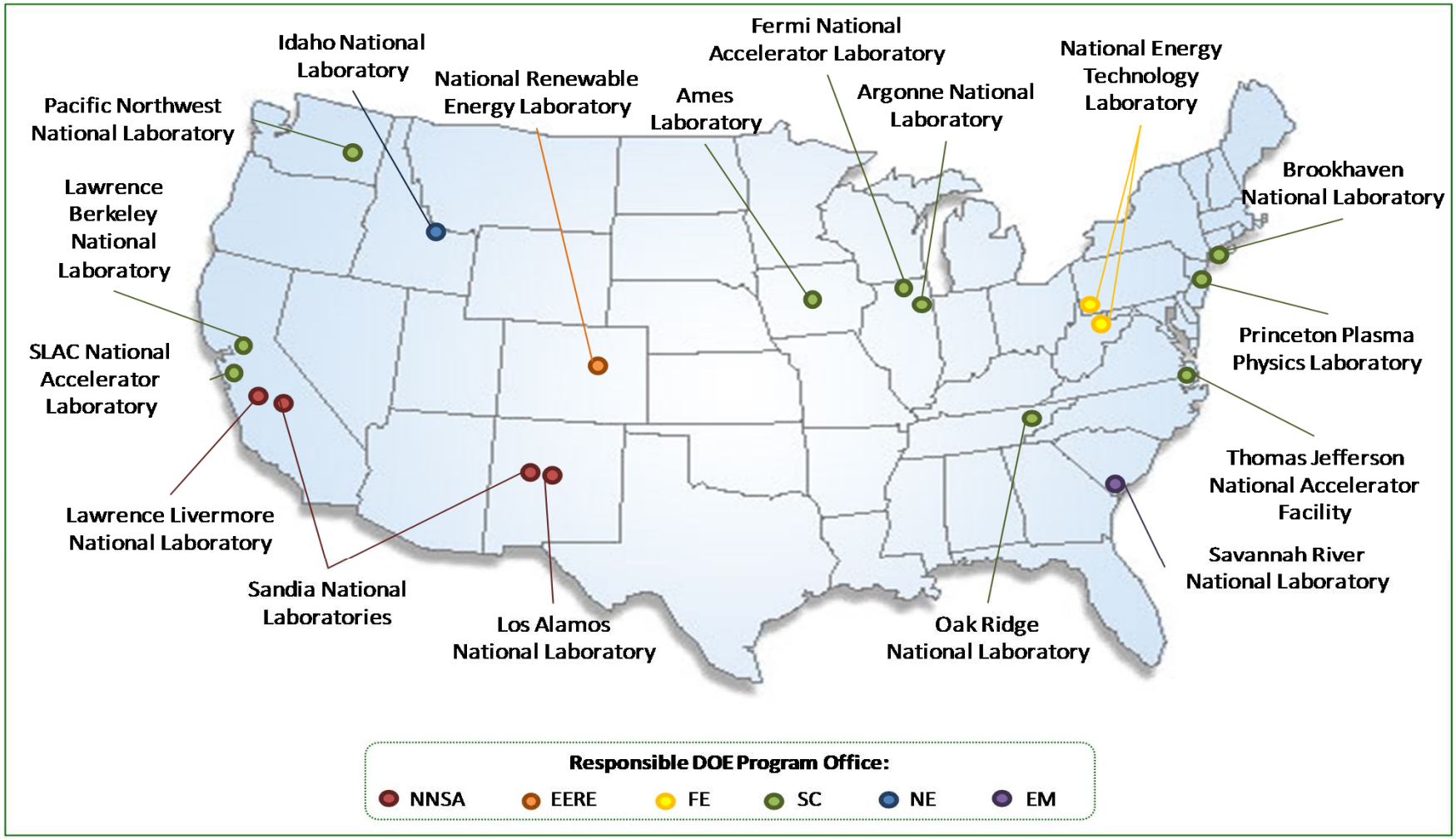
July 25, 2018

DEPARTMENT OF ENERGY



May 2018

DOE's 17 National Laboratories



Quick-Facts about the DOE Office of Science

Advanced Scientific Computing Research (ASCR)

Basic Energy Sciences (BES)

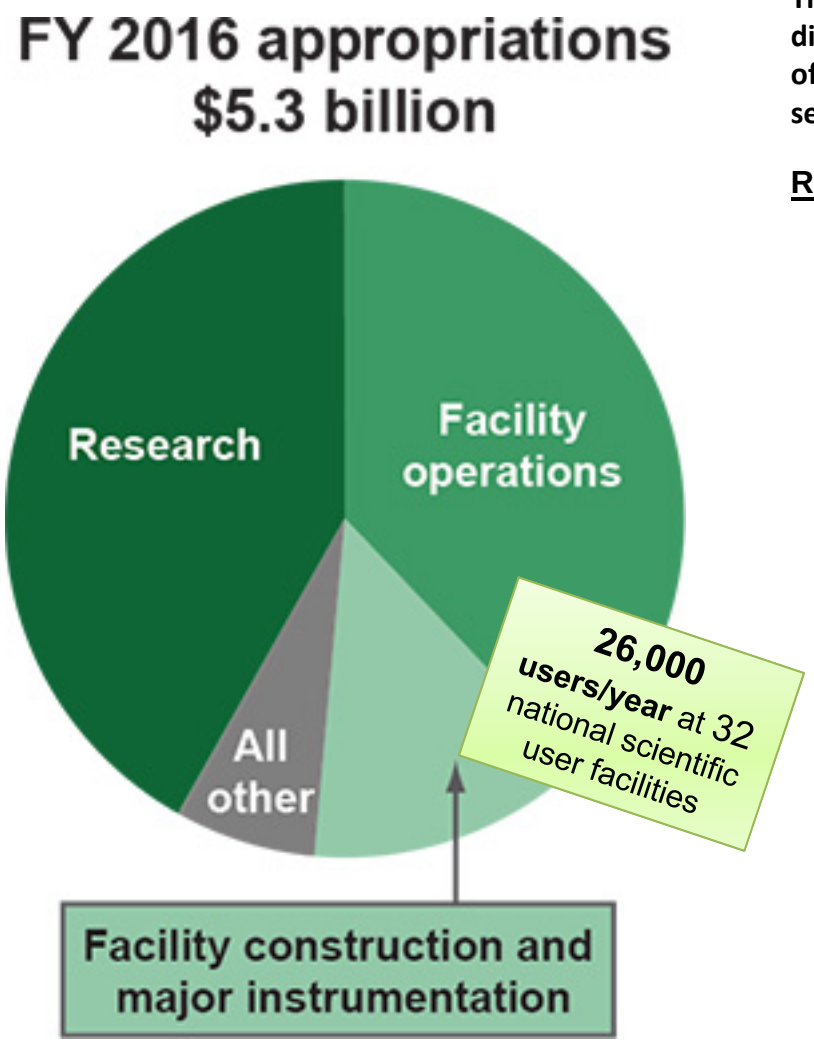
Biological and Environmental Research (BER)

Fusion Energy Sciences (FES)

High Energy Physics (HEP)

Nuclear Physics (NP)

DOE Office of Science – At a Glance

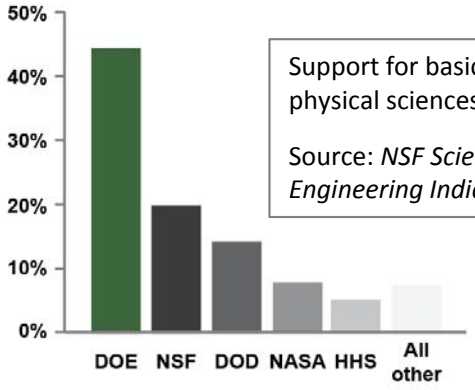


Source: http://science.energy.gov/about/

The mission of the Office of Science is the delivery of scientific discoveries and major scientific tools to transform our understanding of nature and to advance the energy, economic, and national security of the United States.

Research

- Support for 43% of the U.S. Federal support of basic research in the physical sciences; 30% of computer science and math;
- ~20,000 Ph.D. scientists, grad students, engineers, and support staff at >300 institutions, including all 17 DOE labs;
- U.S. and world leadership in high-performance computing and computational sciences;
- Major U.S. supporter of physics, chemistry, materials sciences, and biology for discovery and for energy sciences.



Support for basic research in the physical sciences by agency.

Source: *NSF Science and Engineering Indicators 2012*

Scientific User Facilities

- The world's largest collection of scientific user facilities (aka research infrastructure) operated by a single organization in the world, used by >30,000 researchers each year.

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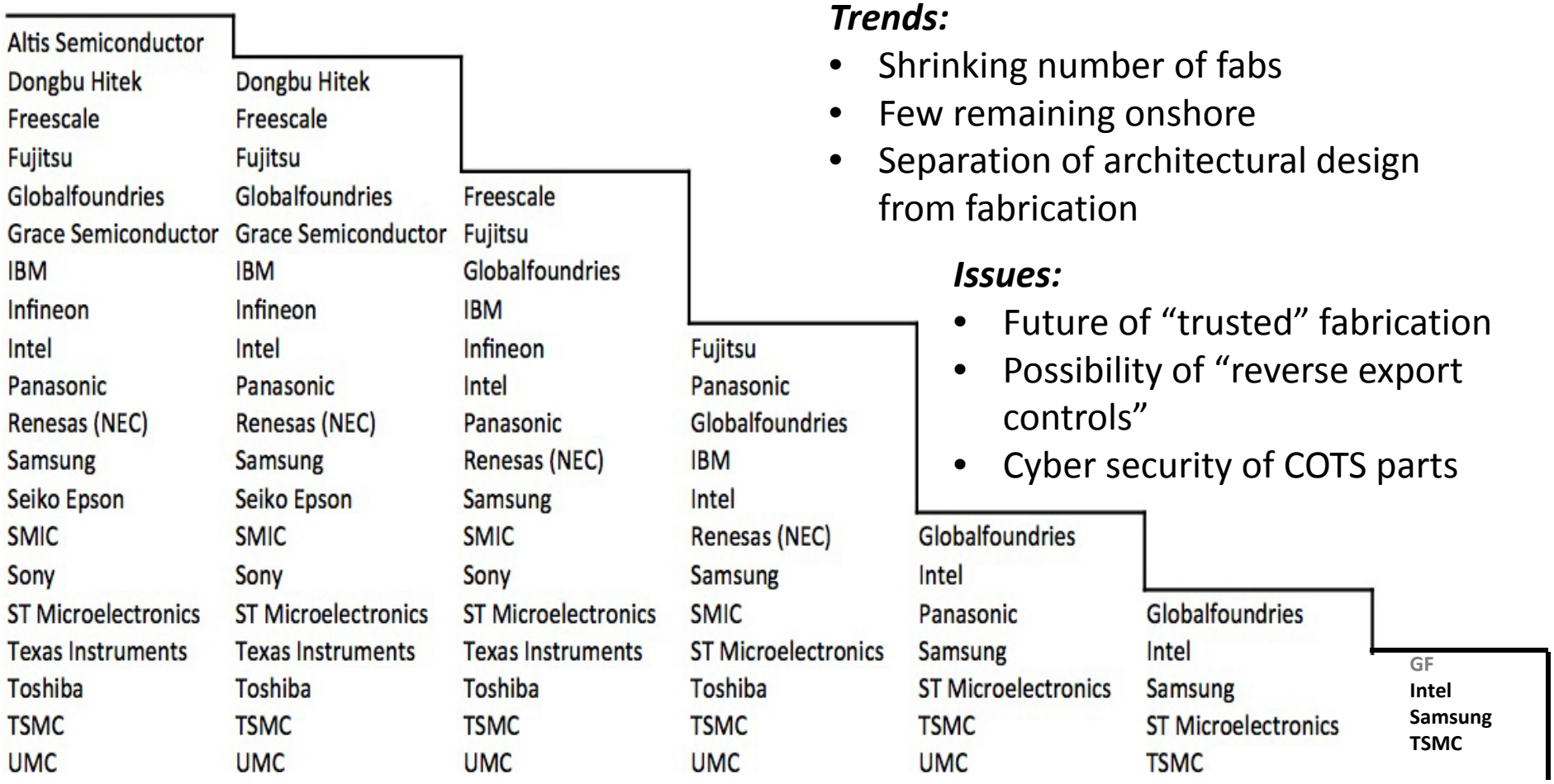
Consolidation of semiconductor manufacturing



Trends:

- Shrinking number of fabs
- Few remaining onshore
- Separation of architectural design from fabrication

Issues:

- Future of "trusted" fabrication
- Possibility of "reverse export controls"
- Cyber security of COTS parts

National Strategic Computing Initiative

Executive Order - July 29, 2015

EXECUTIVE ORDER

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CREATING A NATIONAL STRATEGIC COMPUTING INITIATIVE

By the authority vested in me as President by the Constitution and the laws of the United States of America, and to maximize benefits of high-performance computing (HPC) research, development, and deployment, it is hereby ordered as follows:

The NSCI is a whole-of-government effort designed to create a cohesive, multi-agency strategic vision and Federal investment strategy, executed in collaboration with industry and academia, to maximize the benefits of HPC for the United States.

National Strategic Computing Initiative

INTENT

- **National**
  - "Whole-of-government" / "whole-of-Nation" approach
  - Public/private partnership with industry and academia
- **Strategic**
  - Leverage beyond individual programs
  - Long time horizon (decade or more)
- **Computing**
  - HPC = most advanced, capable computing technology available in a given era
  - Multiple styles of computing / all necessary infrastructure
  - Scope: everything necessary for fully integrated capability
    - Theory and practice, software and hardware
- **Initiative**
  - Above baseline effort
  - Link and lift efforts

STRATEGIC THEMES

- Create systems that can apply exaflops of computing power to exabytes of data
- **Keep the U.S. at the forefront of HPC capabilities**
- Improve HPC application developer productivity
- Make HPC readily available
- **Establish hardware technology for future HPC systems**

www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

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A Nanotechnology-Inspired Grand Challenge for Future Computing

OCTOBER 20, 2015 AT 6:00 AM ET BY LLOYD WHITMAN, RANDY BRYANT, AND TOM KALIL

Summary: Today, the White House is announcing a grand challenge to develop transformational computing capabilities by combining innovations in multiple scientific disciplines.

In June, the Office of Science and Technology Policy issued a Request for Information seeking suggestions for *Nanotechnology-Inspired Grand Challenges for the Next Decade*. After considering over 100 responses, OSTP is excited to announce the following grand challenge that addresses three Administration priorities—the National Nanotechnology Initiative, the National Strategic Computing Initiative (NSCI), and the BRAIN initiative:

Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain.

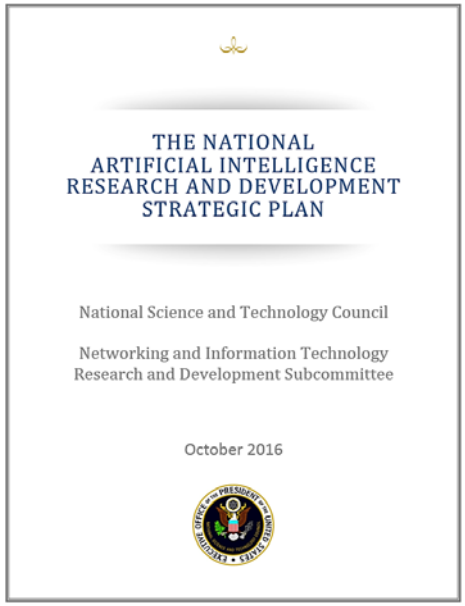
https://www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

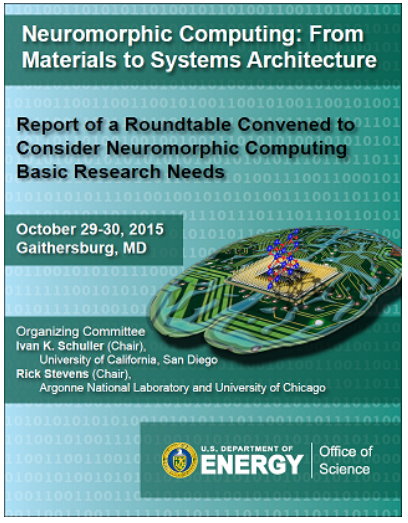
Success = Game-Changing Capabilities

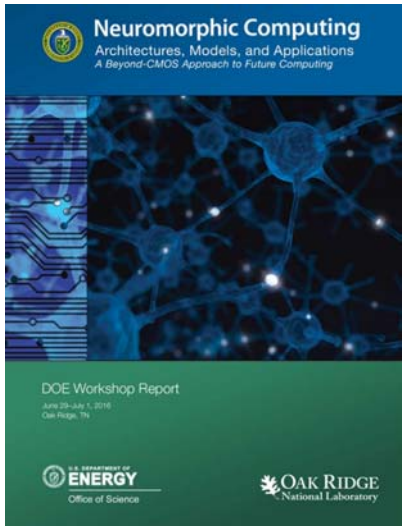
- **Emerging computing architecture platforms, neuromorphic, quantum, …**
  - Significantly accelerate algorithm performance and concurrency while reducing energy consumption by over six orders of magnitude (from megawatts to watts)
- **Intelligent big data sensors: Autonomous and Reprogrammable**
  - Increased flexibility and communication with other networked nodes while maintaining security and avoiding interference with the things being sensed
- **Machine intelligence for scientific discovery**
  - Enable rapid extreme-scale data analysis and be able to deal with unlabeled data sets
  - Capable of understanding and making sense of results, thereby accelerating innovation
- **Cybersecurity**
  - Prevent/minimize unauthorized access, identify anomalous behavior, ensure data and software code integrity
  - Provide contextual analysis for adversary intent or situational awareness; i.e., deter, detect, protect, and adapt

DOE Office of Science Programmatic Activities

- Foundational technology for:
  - ✓ Autonomous operations
  - ✓ Sense-making
  - ✓ Reconfigurable in situ analysis
- Plenty of opportunity to make substantial contribution in the area of information processing and *understanding*
- Neuro-inspired architectures in software-hardware offer a path for much needed technological evolution
- It is truly a multi- and cross-disciplinary effort in materials, physics, chemistry, biology, mathematics, engineering, computer science, neuroscience, etc., to ensure success in this field







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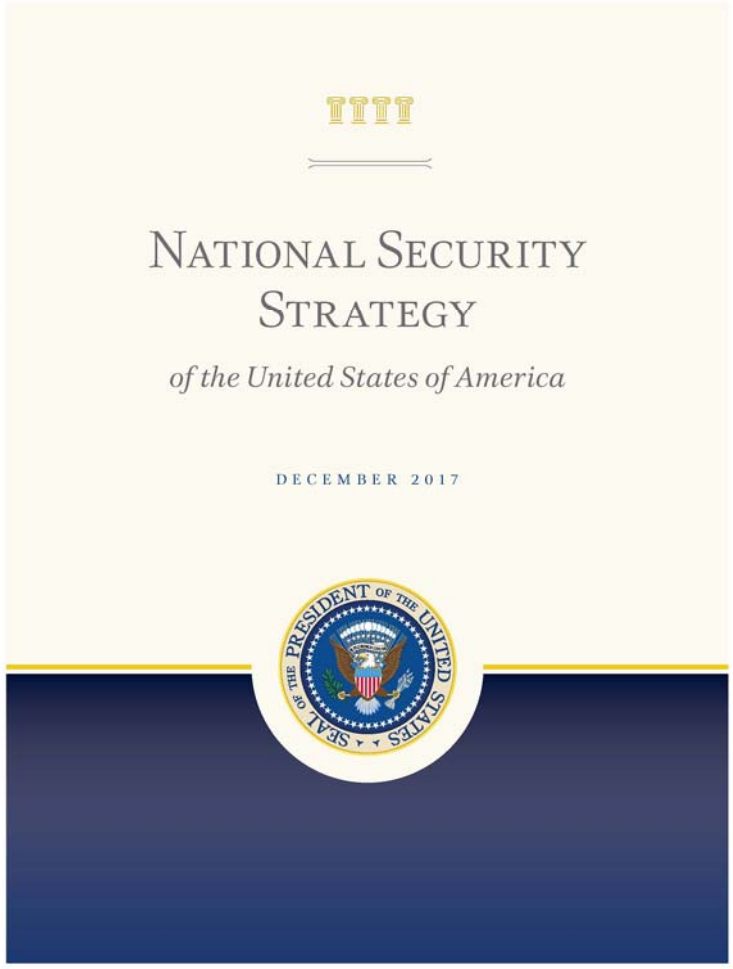
Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain.

National Security Strategy – December 2017

Pillar II: Promote American Prosperity
"Economic security is national security."

Lead in Research, Technology, Invention, and Innovation:

The US will build on the ingenuity that has launched industries, created jobs, and improved the quality of life at home and abroad. To maintain our competitive advantage, the US will prioritize emerging technologies critical to economic growth and security, such as data science, encryption, autonomous technologies, gene editing, new materials, nanotechnology, advanced computing technologies, and artificial intelligence.



Request for Information (RFI)
Assured Supply for Microelectronics Manufacturing

- The USG recognizes the need to proactively engage with industry to make these efforts successful in delivering microelectronics technologies and providing value to the industrial base.
- The USG is executing a plan to provide semiconductor and microelectronics leadership now and into the future with a whole-of-government effort.
- Public-Private Partnerships (PPPs) are a critical part of this plan.
- Responses must be received no later than 0600 EST on 6 August 2018.

https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=02409cc9f08b5c8a4c5765409382e5b5

Request for Information (RFI) - Current and Future Workforce Needs to Support a Strong Domestic Semiconductor Industry

- The National Institute of Standards and Technology (NIST) on behalf of the Department of Commerce and the National Security Council is seeking information on the scope and sufficiency of efforts to educate, train, and attract the workforce necessary to meet the demands of the current and future semiconductor industry, in support of the President's National Security Strategy.

- Responses to this RFI will inform recommendations to the National Security Council on steps the Administration can take to strengthen the technical workforce that supports the semiconductor and related industries.

- Comments must be received by 5:00 p.m. Eastern time on August 15, 2018.

https://www.federalregister.gov/documents/2018/07/16/2018-15077/current-and-future-workforce-needs-to-support-a-strong-domestic-semiconductor-industry

SEMICON WEST Panel: Federal Strategy for Semiconductor and Microelectronics Innovation, Wednesday, July 11, 2018

- Federally funded R&D, along with acquisition of leading-edge technology and systems, play key roles in driving innovation in the semiconductor and microelectronics industry. This panel will discuss Federal R&D and acquisition priorities aimed at ensuring the United States remains the global leader in this industry.

- http://www.semiconwest.org/programs-catalog/panel-federal-strategy-semiconductor-and-microelectronics-innovation

Basic Research Needs for Microelectronics Workshop

- **Co-sponsored by ASCR, BES, HEP**
- **October 23 –25, 2018**
- **CHARGE:**
  - To conduct a thorough assessment of critical scientific challenges, fundamental research opportunities, and priority research directions that require further study as a foundation for future advances in microelectronics for computing, communications, and sensing.
  - Particular emphasis will be placed on areas that are aligned with the missions and needs of the Offices of Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES), and High Energy Physics (HEP).
  - This workshop should exclude topics directly related to Quantum Computing.

Summary

- **High pay-off research, development, and Innovation**
- **Opportunity for:**
  - ✓ **Enhanced technology roadmap**
  - ✓ **Innovation - materials, architectures, modeling/simulation/software, applications**
  - ✓ **New ideas and approaches**
- **Enable a path for continued algorithm, software, and hardware technological evolution**
- **Multi- and cross-disciplinary efforts in materials, physics, chemistry, biology, mathematics, engineering, computer science, neuroscience, etc.**

Thank you!

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http://science.energy.gov/