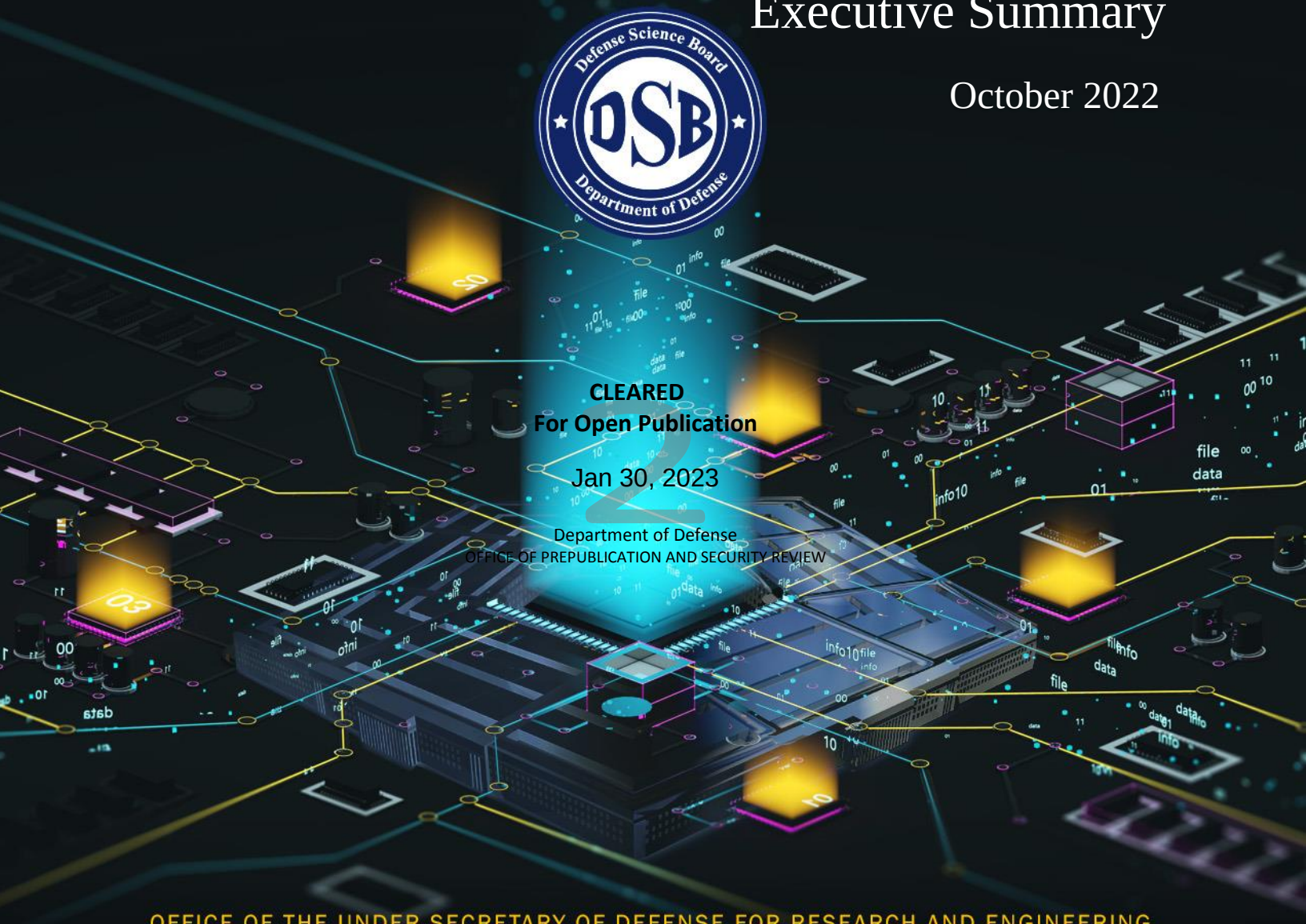
DEPARTMENT OF DEFENSE

DEFENSE SCIENCE BOARD

ENSURING MICROELECTRONICS SUPERIORITY

Executive Summary

October 2022



OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

DEFENSE SCIENCE BOARD

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301–3140

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

SUBJECT: Final Report of the Defense Science Board Task Force on Ensuring Microelectronics Superiority

I am pleased to forward the final report of the Defense Science Board Task Force on Ensuring Microelectronics Superiority, co-chaired by Dr. John Manferdelli and Dr. Robert Wisnieff.

Microelectronics technology is the critical enabling hardware for legacy conventional and strategic systems, as well as critical emerging technologies with military applications, such as artificial intelligence, autonomous systems, and quantum information science. Sustaining U.S. military advantage across all warfighting domains and across the spectrum of competition and conflict therefore requires the Department of Defense (DoD) to ensure access to trusted and assured microelectronics for sustainment of legacy systems, as well as to state-of-the-art microelectronics for current and future acquisition programs.

The global semiconductor industry has increasingly become an object of geopolitical competition, particularly between the United States and China. Moreover, since this Task Force began its important work, the coronavirus pandemic has exacerbated the risks to the globalized supply chain for microelectronics and for other critical areas of supply.

Recent congressional and executive actions on supply chains, and on semiconductors specifically, underscore the need for DoD attention. The DoD urgently needs a holistic and technologically-informed microelectronics strategy to guide and focus its efforts across the Department and to ensure that it is postured to support whole-of-government efforts in this area. This report contains actionable recommendations for DoD entities in support of these efforts.

I endorse the findings and recommendations of this report and urge the Department to adopt them expeditiously.

Eric D. Evans

Dr. Eric Evans
Chairman, Defense Science Board

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DEFENSE SCIENCE BOARD

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301–3140

MEMORANDUM TO THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Ensuring Microelectronics Superiority

Attached is the final report of the Defense Science Board Task Force on Ensuring Microelectronics Superiority. During its study period, the Task Force surveyed the current global microelectronics supply chain, the Department's current and projected future microelectronics requirements, and potential policy options for the Department to mitigate threats and ensure access to trusted and assured microelectronics.

During the Task Force's deliberations, the coronavirus pandemic served to underscore the fragility of certain critical supply chains, for the nation as a whole as well as for the Department. Indeed, commercial sectors such as the automotive industry are still enduring the effects of the semiconductor supply shock. At the same time, seismic tremors in the global semiconductor market are beginning to register, such as some re-shoring activity by major semiconductor manufacturers and announcements of unprecedented mergers and acquisitions. Additionally, national-level attention from both the executive and legislative branches in the form of executive orders and legislation are demonstrating the growing consensus that the United States must take action to ensure microelectronics superiority vis-à-vis its competitors.

As the March 2021 *Interim National Security Strategic Guidance* notes, the United States must "ensure that our supply chains for critical national security technologies…are secure." Moreover, in the February 2021 "Executive Order on America's Supply Chains," the President observed, "More resilient supply chains are secure and diverse – facilitating greater domestic production, a range of supply, built-in redundancies, adequate stockpiles, safe and secure digital networks, and a world-class American manufacturing base and workforce." The findings and recommendations contained in this report, if adopted by the Department, will ensure it moves decisively to support a more resilient and secure microelectronics supply chain, and that the Department is postured to support future whole-of-government efforts in this critical issue of national security.

Dr. John Manferdelli
Co-Chair

Dr. Robert Wisnieff
Co-Chair

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DSB Final Report on Ensuring Microelectronics Superiority

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DSB Final Report on Ensuring Microelectronics Superiority
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The Defense Science Board (DSB) Task Force on Ensuring Microelectronics Superiority was tasked with considering how the United States can maintain a strong industrial base to provide increasingly more sophisticated and reliable microelectronics capability to defense systems. Specifically, the Task Force aimed to address the following questions from the terms of reference:

- What approaches can guarantee capacity that can respond to varying national security needs, such as node sizes, recipes, heterogeneous integration of best-of-breed, and variable volume on demand?
- How can the DoD assure access to trustworthy, state-of-the-art, high-performance components – commodity, custom, semi-custom, and hybrid? Further, how can access to radiation hard components for strategic and space applications be assured?
- How can the DoD assure access to trustworthy components to service DoD legacy systems? Is it possible to identify engineering principles and methods to insert state-of-the-art microelectronics in DoD systems and reduce perpetual dependence on obsolete parts?
- What is needed to ensure that the U.S. leads high-performance microelectronics for decades to come? What aspects of policy and workforce must be considered?
- What is needed to accelerate leap-ahead research and development and innovation for microelectronics?
- Can public/private partnerships advance DoD microelectronics trustworthiness needs?
- How should the national security microelectronics community be resourced and organized for maximum impact?

During the course of its study, the Task Force engaged a comprehensive array of stakeholders inside and outside the Department of Defense, including elsewhere in the U.S. Government, in academia, and in the private sector.

Given the increasing interest inside and outside of the U.S. Government in the microelectronics supply chain issue, the Task Force earnestly hopes the findings and recommendations of the study will be well-received and help the United States continue to ensure microelectronics superiority now and into the future.

The full report of the Task Force, including its findings and recommendations, is classified. Please contact the Defense Science Board office for appropriate distribution.

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Appendix A: Task Force Terms of Reference

RESEARCH AND ENGINEERING

THE UNDER SECRETARY OF DEFENSE
3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3030

OCT 3 0 2019

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference - Defense Science Board Task Force on Ensuring Microelectronics Superiority

Microelectronics components are critical enablers that underpin all of the major technology areas expected to give U.S. forces their qualitative edge. Future military systems that will rely on microelectronics include air, space, land and sea vehicles, cyber-electromagnetic maneuvering and command and control systems, artificial intelligence, and autonomous systems as well as quantum information sciences and other evolving technologies. However, a January 2017 report by the President's Council of Advisors on Science and Technology noted:

> "The global semiconductor market has never been a completely free market: it is founded on science that historically has been driven, in substantial part, by government and academia; segments of it are restricted in various ways as a result of national-security and defense imperatives; and it is frequently the focus of national industrial policies. Market forces play a central and critical role. But any presumption by U.S. policymakers that existing market forces alone will yield optimal outcomes — particularly when faced with substantial industrial policies from other countries — is unwarranted. In order to realize the opportunities that semiconductors present and to effectively mitigate major risks, U.S. policy must respond to the challenges now at hand."

The need for innovative microelectronics, as well as the ability to sustain the trustworthy and assured microelectronics supply for legacy Department of Defense (DoD) systems, is a challenge for the Department. The ability to meet many of the modernization priorities in the National Defense Strategy will rest on a secure microelectronics foundation both the technological capabilities, and a reformed acquisition and supply chain management process to ensure the delivery and verification of hardware and software that will be integrated into weapons systems.

In order to achieve the benefits needed for the U.S. military to maintain its superiority over potential future adversaries, the Defense Science Board Task Force on A Strategy for Ensuring U.S. Leadership in Microelectronics and Securing the Technological Advantage of the U.S. Military will consider how the United States can maintain a strong industrial base to provide increasingly more sophisticated and reliable microelectronics capability to defense systems.

The Task Force will examine the following questions:

DOPSR20-S-0254

- What approaches can guarantee capacity that can respond to varying national security needs, such as node sizes, recipes, heterogeneous integration of best-of-breed, and variable volume on demand?

- How can the DoD assure access to trustworthy, state-of-the-art, high-performance components: commodity, custom, semi-custom, and hybrid? Further, how can access to radiation hard components for strategic and space applications be assured?

- How can the DoD assure access to trustworthy components to service DoD legacy systems? Is it possible to identify engineering principles and methods to insert state-of-the-art microelectronics in DoD systems and reduce perpetual dependence on obsolete parts?

- What is needed to ensure that the U.S. leads high-performance microelectronics for decades to come? What aspects of policy and workforce must be considered?

- What is needed to accelerate leap-ahead research and development and innovation for microelectronics?

- Can public/private partnerships advance DoD microelectronics trustworthiness needs?

- How should the national security microelectronics community be resourced and organized for maximum impact?

I will sponsor the study. Dr. Victoria Coleman, Dr. John Manferdelli, and Dr. Robert Wisnieff will serve as the tri-Chairman of this study. Ms. Nicole Petta will serve as the Executive Secretary. Mr. Kevin Doxey will serve as the Defense Science Board Secretariat.

The task force members are granted access to those DoD officials and data necessary for the appropriate conduct of their study. The Under Secretary of Defense for Research and Engineering will serve as the DoD decision-maker for the matter under consideration and will coordinate decision-making as appropriate with other stakeholders identified by the study's findings and recommendations. The nominal start date of the study period will be within three months of signing this Terms of Reference, and the study period will be between 9-12 months. The final report will be completed within six months from the end of the study period. Extensions for unforeseen circumstances will be handled accordingly.

The study will operate in accordance with the provisions of Public Law 92-463, "Federal Advisory Committee Act," and DoD Instruction 5105.04, "DoD Federal Advisory Committee Management Program." It is not anticipated that this study will need to go into any "particular matters" within the meaning of title 18, United States Code, section 208, nor will it cause any members to be placed in the position of action as a procurement official.

Michael D. Griffin

Appendix B: Task Force Membership

Chairs

Dr. John Manferdelli
VMware

Dr. Robert Wisnieff
IBM

Dr. Victoria Coleman*
University of California, Berkeley

Members

Dr. Dean Collins
DRC Consulting

Dr. Joshua Fryman
Intel Corporation

Mr. Paul Hoeper
Defense Science Board

Mr. Chris Inglis*
U.S. Naval Academy

Dr. William Jeffrey
Institute for Defense Analyses

Dr. Craig Keast
MIT Lincoln Laboratory

Mr. Jay Lewis
Microsoft

Dr. Louise Sengupta
Northrop Grumman

Mr. Henry Tong
Qualcomm

Dr. John Zolper
Raytheon

Executive Secretary

Ms. Nicole Petta, OUSD(R&E)

DSB Representative / Designated Federal Officer

Mr. Kevin Doxey, Defense Science Board

Government Advisors

Mr. Brett Hamilton
Naval Surface Warfare Center Crane

Dr. Gerald Borsuk
Naval Research Laboratory

Ms. Kaila Raby
Sandia National Laboratory

Mr. Jeff Krieg
National Security Agency

Dr. Carl McCants
Office of the Director of National Intelligence

Dr. Dev Palmer
DARPA

Dr. Matthew Kay
OUSD(R&E)

Dr. Christine Michienzi
OUSD(A&S)

Support Staff (SAIC)

Ms. Brenda Poole Mr. Austin Dahmer Ms. Erin Chase

*Indicates previous member of the Task Force. Member either left for government service during the course of the study, or is now in government service.

Appendix C: Briefings Received

4–5 February 2020

Discussion with the DUSD(R&E)
Deputy Under Secretary of Defense for Research and Engineering

Red Team Overview
Naval Research Laboratory

OSD Plan to Assure Strategic Advantage in Microelectronics
Office of the Under Secretary of Defense for Research and Engineering

Threat Briefing
Intelligence Community

Threat Briefing
Naval Surface Warfare Center, Crane

15 April 2020

Radiation Hardening
Naval Surface Warfare Center, Crane

Heterogeneous Packaging
Naval Surface Warfare Center, Crane

OUSD(R&E) Update
Office of the Under Secretary of Defense for Research and Engineering

TSMC Government Relations
Department of State

27 May 2020

Electronic Design Automation
Synopsys

Electronic Design Automation
Aerospace and Defense Solutions

Microelectronics Supply Chain
Department of Commerce

18 June 2020

Focus on the Demand Side: Volume Manufacturing is Key
Harvard Business School

Fabrication Independence at Qualcomm
Qualcomm

Industry Perspectives
Semiconductor Industry Association

Leveraging Semiconductor Supply Chain to Regain U.S. Leadership in Computing
Mundie & Associates

Supply Chain Assurance at Intel
Intel Corporation

23 July 2020

FabMetrics
Modern Technology Solutions, Inc.

Microelectronics Study—Public-Private Partnership (Availability & Sustainability)
CTC Aero, LLC

Intellectual Property Portability
Arm Ltd.

Microelectronics Education & Workforce Development
Office of the Under Secretary of Defense for Research and Engineering

CMOS Fabrication Process
WaferTech

9–10 September 2020

Threat Briefings
Intelligence Community

Discussion with Frank Kendall
Former Under Secretary of Defense for Acquisition, Technology, and Logistics

Fab Process
Intel Corporation

Radio Frequency Integrated Circuits
Clark Street Associates

Workbench
Microsoft Corporation

Trusted Foundry
Office of the Director of National Intelligence

Results of Fabrication Costs Study
Semiconductor Industry Association

Fab Process
Intel Corporation

21–22 October 2020

Threat Briefing
Naval Surface Warfare Center, Crane

Threat Briefing
Intelligence Community

IBM's Experiences Moving State of the Art Designs from one Fab to Another (e.g., GF-Samsung)
Benefit of Doing Personalization after Assembly of a Die
Approaches that have been Developed to Make Tampering Detectable

Approaches Developed to have a Chain of Custody through the Design and Fabrication Process
IBM

18–19 November 2020

Enhanced Security
Task Force Government Advisors

Intelligence Management Perspective
Department of the Air Force

Domestic Advanced Packaging Facility
Intel Corporation