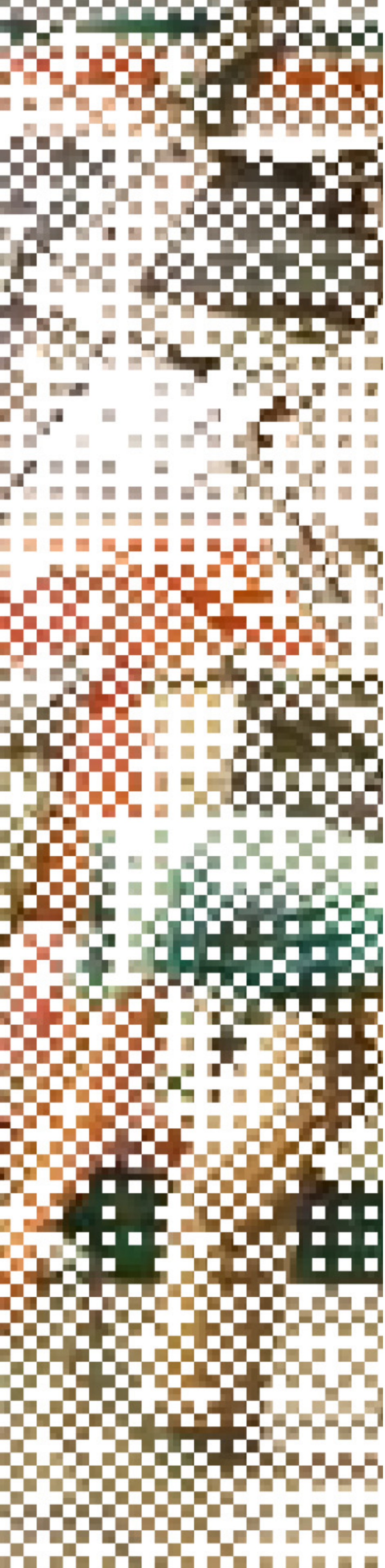

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Reforming the National Semiconductor Technology Center

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SUMMARY

The semiconductor industry faces mounting challenges as traditional chip fabrication processes approach their physical limits. Novel materials, devices, and computing paradigms could drive future progress, but gaps in the US semiconductor innovation ecosystem—namely, access to prototyping lines, expensive equipment and tooling, and scarce capital—make commercialization challenging. The CHIPS and Science Act established the National Semiconductor Technology Center (NSTC) as a public-private partnership to address these gaps. To date, however, the NSTC has adopted a cautious, consensus-driven approach.

To realize the NSTC's potential, three reforms are needed:

- The administration and Congress must commit to ensuring that the NSTC succeeds beyond the organization's initial five-year appropriation. Cutting semiconductor R&D programs now would jeopardize US competitiveness in next-generation chip technologies and future AI systems.

- The NSTC must prioritize disruptive innovation by maintaining an independent, moonshot-focused research agenda and positioning the NSTC investment fund as an anchor investor, augmented by a fund-of-funds to stretch capital further.
- Prevent industry capture by tweaking the NSTC's financial and intellectual property (IP) structure, incentivizing greater participation by startups and academic researchers.

PROBLEM STATEMENT

In 1965, Intel co-founder Gordon Moore famously predicted that cramming more transistors onto flat silicon wafers would result in regular doublings of computing power. This remarkable prediction, which later became known as Moore's Law, sparked the personal computing revolution and gave rise to the digital world. Today, however, traditional chip fabrication is reaching its atomic limits, resulting in ballooning technical complexity, rising costs to design and fabricate chips, and increasing industry concentration. What Moore termed the "day of reckoning" has arrived.

The core technical problem facing the semiconductor industry today is heat dissipation. When chips perform computations, they release excess energy as heat. For decades, the power consumption of a chip scaled down alongside Moore's Law, allowing for remarkably energy-efficient computing. But this linkage broke in the mid-2000s. The result has been a massive spike in energy consumption, made much worse by the recent explosion in compute demand for large-scale AI systems. Novel materials, devices, and compute paradigms exist which could improve AI energy efficiency by several orders of magnitude; picture the creation of energy-efficient supercomputers that could fit in a closet, not a warehouse. This novel hardware could power future large-scale AI systems and offer outsized geopolitical leverage to the first nation to develop them.

The CHIPS and Science Act established the NSTC as a forward-looking innovation hub that would drive true breakthroughs. Former Commerce Secretary Gina Raimondo explained that the NSTC would "ensure the US leads the way in the next generation of semiconductor technologies—everything from quantum computing, materials science, and AI to the future applications we haven't even thought of yet." But in the two and half years since the passage of the CHIPS Act, the NSTC has moved too slowly, opting for an industry-led, consensus-driven approach. The organization must move faster, and it must prioritize disruptive innovation.

SOLUTION

To ensure that the NSTC reaches its full potential, policymakers should reach for a scalpel, not a sledgehammer. Starting over would waste valuable time. Several promising initiatives are already underway—especially expanded access to prototyping, packaging, and tooling—which will lower barriers to entry for startups. However, additional resources and targeted reforms will be needed across three areas.

First, sustained congressional funding will be necessary to keep the NSTC financially viable. Past successful research consortia discussed below received steady government funding for their first decade of work, and Congress should ensure that its existing investment in the NSTC does not go to waste by issuing a second five-year appropriation. The corollary to sustained government investment is fiscal discipline; the NSTC must limit the number of technology verticals it attempts to pursue and regularly trim research programs that do not yield results.

Second, Natcast—the nonprofit consortium running the NSTC—is in the process of standing up an investment fund, as authorized by Congress. Yet key decisions about how the fund operates have yet to be made. For example, in the semiconductor industry, investment arms of large chip companies typically lead funding rounds for startups they believe will complement their existing research agenda. But the NSTC fund could play a key role by leading its own funding rounds, serving as an anchor investor and crowding in capital for projects that do not necessarily benefit one existing firm. In addition, the investment fund should compensate for its relatively modest size of $500 million by distributing a portion of its capital as a fund of funds.

Third, the NSTC's internal R&D agenda should prioritize disruptive innovation by commercializing breakthroughs rather than subsidizing industry-led research. Natcast should model its research program off the Defense Advanced Research Projects Agency (DARPA)'s approach, hiring program managers from industry and academia on a revolving basis to execute an internal research agenda free from industry bias.

Congressional

- Congress should fund the NSTC for an additional five years after the initial appropriation expires in 2027. Successful semiconductor-focused public-private partnerships have relied heavily on public funding for the first decade of their lives, which prevented industry capture, as explained below.
- The House Committee on Energy and Commerce and Senate Committee on Commerce, Science, and Transportation should require mission agencies to issue annual reports on public funding for microelectronics-related research. Policy makers need updated estimates of current spending on strategic technologies to make funding decisions, but properly cataloguing relevant R&D programs has proved difficult. Policymakers could model this initiative on successful efforts to estimate federal AI R&D, which aligned with national-level strategic planning.

Executive

The White House should issue an executive order on the CHIPS R&D program to do the following:

- Protect programs and staff related to microelectronics R&D and immediately rehire key CHIPS R&D Office staff. NIST recently dismissed two-thirds of the staff responsible for overseeing CHIPS R&D programs. Small savings through staff reductions could jeopardize the efficient allocation of $11 billion in R&D funding.

- Accelerate provision of tooling, facility access, and prototyping to Natcast member companies. Delays in standing up the NSTC have cost valuable time, but ensuring access to existing infrastructure and tooling could compensate while new R&D facilities are built, and fast-tracking permitting and construction of R&D facilities could make up for lost time.
- Institute a regular review period for NSTC research programs. Literature on public-private partnerships suggests that successful efforts ruthlessly prune projects, without penalizing program managers for risk-taking.
- Direct the NSTC investment fund to lead funding rounds and solicit fund-of-funds proposals from qualified venture investors. These actions would allow the fund to crowd in additional private capital while drawing on the expertise of existing deep-tech investors, increasing the odds of success.

JUSTIFICATION

Federal research funding has historically moved the needle at critical points in the semiconductor industry's development, offering outsized benefits to the US economy. Since 1978, every dollar invested by the federal government into semiconductor research has increased US GDP by approximately $16.50. These returns are the result of a series of breakthroughs in the chip industry which were catalyzed by federal R&D spending. For example, DARPA's Very Large-Scale Integrated Circuits (VLSI) program was pivotal to overcoming the Moore's Law scaling challenges of the 1970s and 1980s. Other examples of breakthroughs that received federal support include Extreme Ultraviolet Lithography (EUV) tools and FinFET, the chip industry's first 3D transistor.

Balancing the goals of government with the interests of industry has been key to the success of R&D programs, both in the US and abroad. As a research consortium funded with both government and industry contributions, the NSTC has been established as a public-private partnership, but the success of these programs hinge on designing the right funding models and IP-sharing structures. The Interuniversity Microelectronics Center (Imec) in Belgium provides the closest example for the structure the NSTC needs. Imec is best known for its role in developing EUV tools; today, the center offers researchers access to facilities for developing new, full-stack, complementary metal-oxide-semiconductor (CMOS) paradigms. Imec's facilities also offer pilot wafer runs for startups in sensors and telecommunications.

Imec's early budget independence was key to its success. For the first decade of its existence, Imec received over half of its funding from the Flemish government. Even as it transitioned away from subsidies, Imec refused to become an outsourced research service for industry. Avoiding reliance on a membership-based funding structure proved crucial: Imec's Industrial Affiliation Program established IP as participants' "currency" for contribution and reward, offering open IP sharing for early-stage R&D while tightening sharing for mature research. This arrangement incentivizes established firms to contribute to Imec long-term while allowing startups and researchers to reap early-stage benefits.

Pursuing a membership fee funding structure would likely relegate NSTC to being an outsourced research service for industry. Instead, NSTC must pursue ambitious projects whose IP results will incentivize established firms (and Congress) to sustain its funding. Constructing unique prototyping facilities which industry or academia alone cannot provide is an example of such ambitious projects. ■

FURTHER RESOURCES

- Arrian Ebrahimi and Jordan Schneider, "How to Make the NSTC a Moonshot Success," Institute for Progress, 2024
- Brady Helwig and PJ Maykish, "National Action Plan for U.S. Leadership in Compute & Microelectronics," Special Competitive Studies Project, 2023
- John Shalf, "The Future of Computing Beyond Moore's Law," Philosophical Transactions of the Royal Society, 2020
- Hassan Khan, "Scaling Moore's Wall: Existing Institutes and the End of a Technology Paradigm," Carnegie Mellon University, 2017

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