

# MTO STATUS UPDATE

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MTO Performers, Program Managers, and SETAs:

As we head towards the New Year and announce ERI Phase II, it is worth reflecting on the past year and what has been achieved so far.

This summer was very active for MTO, with the highlight being the inaugural Electronics Resurgence Initiative (ERI) Summit we hosted from July 23rd-25th. The event brought the microelectronics community together for several days of discussions, presentations, and compelling keynotes from some of the industry's leading visionaries. There was so much information, excitement, and collaboration that one could have easily missed the larger picture. Therefore, I want to use this forum to synthesize what I heard and my own reactions.

We kicked-off the ERI Summit with an opening keynote from John Hennessy, chairman of Google parent company Alphabet, who described "a new golden age of computing" where faster general computing will accompany the end of Moore's Law. He foretold an era of domain-specific languages and SoCs, concluding his speech by stating, "information technology—computing to electronics—is the most important economic and security asset for any nation... (we must) combine software and hardware creativity to compete by running faster."

"Running faster" is a key phrase we have latched onto as the basis for ERI. The country has multiple tools at its disposal to compete, some are more restrictive while others are more promotional. At DARPA, our role is to serve as the accelerant for any formula of U.S. dominance in microelectronics that emerges, mirroring the advice from the PCAST report of which John Hennessy was a part.

Following Hennessy's keynote, Mike Mayberry, CTO of Intel, took to the stage and started his presentation by sharing much of Hennessy's optimism – but from a materials angle. Mayberry described an "era of heterogeneous compute," walking on stage with sunglasses to the lyric "the future's so bright, I gotta wear shades." Mike spoke of the importance of integration and materials developments, using an "islands and oceans" metaphor. He noted that general and commercial computing – or computing for the masses – are like an ocean, while specific-purpose products are like islands poised to rise out of an above that ocean. Mike then talked about the importance of the DARPA CHIPS program, which Intel is supporting. He described CHIPS, which focuses on the fine-grained integration of chiplets, as a mechanism for creating "islands from the oceans" and announced the open sourcing of an ultra-low power Intel I/O standard on that program. The standard will be used as a mechanism for smaller designs to aggregate into a larger capability – another means ideal for creating special purpose "islands." Mayberry highlighted a great opportunity, and analogy, for the DoD. The DoD operates in unique domains and has unique needs for security, performance, and reliability. We need to rise out of the "oceans" with specialized hardware that leverages the fact that much of our generalized computing is primarily created by U.S.-based companies. We must continue to find opportunities to team across the boundaries between commercial and national defense in order to rise above the oceans and run faster.

After Mayberry, Gary Dickerson, the CEO of Applied Materials, spoke about enabling the AI era. He described a future with as much as 10 ZB of data generated by 2022 and called for a 1,000x improvement in compute performance/watt. Dickerson noted that the foundation for this future will be materials engineering, commenting that "the AI big data era is the biggest opportunity of our lifetimes." In his opinion, new tools, materials, and physics will form the foundation for managing this data. With that in mind, he highlighted some of the work DARPA is collaboratively doing with Applied Materials to create new CeRAM for neuromorphic applications.

On the third day of the Summit, Bill Dally, chief scientist at NVIDIA, took to the stage to describe the "accelerator age" and stated unequivocally that "Moore's Law is dead." He started his presentation by demonstrating the importance of increasing GFLOPS for image and speech recognition, using an example that showed how increasing compute capability can help achieve results with significantly lower error. This clearly detailed a clear tie between trusting the results of AI systems with better processing. According to Dally, process technology isn't helping us anymore but accelerators could come to the rescue. To explain this theory, he used an example that showcased the importance of algorithm/architecture co-design for a typical algorithm, in this case a Darwin algorithm. While software alone can often help, simply recasting an algorithm in a hardware-friendly state actually hurt in his example. Instead, adding an accelerator to the hardware-friendly algorithm increased speed by 380x, and changing the memory channels and access provided an additional ~60x boost. His example showed that correct pipelining and changing of the hardware along with the software could allow for 15,000x benefits for the final co-designed result.

Dally further claimed that GPUs are particularly good for the accelerator age. However, the newest GPU design requires 8,000 engineering years – a mindboggling number that makes me think of other ambitious human endeavors, like the construction of mid-century cathedrals. To me, these cathedrals further highlight the need for collaboration. He ended by highlighting why NVIDIA has engaged in DARPA programs for the past eight years – most recently working with the agency as well as academic and defense performers on the CRAFT program to create fast accelerators using a high-level synthesis approach. Their work with DARPA has helped NVIDIA establish the communities needed to maintain leadership in their core areas.

Delivering the Summit's final keynote, Wally Rhines, CEO of Mentor Graphics, showed a data-driven and compelling overview of the industry. He started by stating that "happy days are here again," pointing to 22% annual growth rate in IC revenues in 2017 and a 9.8% increase in R&D funding, bringing R&D spending to over \$50 billion annually. He also shared that the fear of consolidation within the industry is unfounded, noting that many recently announced deals did not actually go through and that actual consolidation was around average in practice. Further, venture capital investment in the fabless industry is back to 2009-2012 levels, driven largely by the AI and crypto-currency fields.

Despite the highs, however, Rhines described how everything is not as happy as it would seem. A significant amount of growth is coming from state-backed foreign funding. In the second quarter of 2018, China overwhelmingly paced the market, investing 2.8x more in venture capital funding than the United States. Further, there are now 1,300 fabless IC design enterprises in China.

What I took away from the ERI Summit was that the US electronics companies are in good hands, with impressive leadership. However care must be taken moving forward as we are at a critical juncture in the inflection of a technical field. We should never assume our unique position that we are in, since it is built on the backs of greats that have come before us. If you were able to join us, you felt the energy of this unique moment in time. If you weren't, I highly recommend that you view the slides and videos posted at [www.eri-summit.com/agenda](http://www.eri-summit.com/agenda) and on [YouTube](https://www.youtube.com/watch?v=...).

After the summit, we found ourselves asking: If Moore's Law is not the vector for enhancement, and specialization like this is, what DoD specializations are needed? If we are truly in an "oceans and islands" moment, with the burden of "running faster" on our shoulders, what domains and partnerships are needed to apply specialization? We are actively searching for these answers around data analytics on the HIVE program, but where this type of enhancement will come from for other DoD domains is less obvious. We are looking for the community's input on which domains/algorithms could be explored. In my opinion, the DoD is not properly prepared to participate in this era of specialization. One necessary outcome of ERI is for the community to help uncover ways of applying these enhancements for national defense to help us rectify that situation.

We announced [the next phase of ERI](#), Phase II, earlier this month which will focus on further enmeshing the technology needs and capabilities of the defense enterprise with the commercial and manufacturing realities of the electronics industry. The Photonics in the Package for Extreme Scalability (PIPES) program, the first to be announced as part of Phase II, aims to explore ways to bring the benefits of optical scaling directly to chips. Through the remainder of the year, we plan to announce additional programs that stemmed from ideas raised at the Summit and increase the connections between the various ERI programs.

Keep up the good work,

Bill Chappell

## Recent DARPA Public Affairs Releases

### [DARPA ERI Summit Expands to Include Workshops Regarding DARPA's Future Electronics Investments](#)

First announced in June 2017, DARPA's Electronics Resurgence Initiative (ERI) is a multi-year, upwards of \$1.5 billion investment in jumpstarting innovation and collaboration across the U.S. electronics community to address an array of long foreseen challenges to Moore's Law. To kickoff this community-wide effort, DARPA is hosting its first annual ERI Summit from July 23-25 in San Francisco, CA.

Date of Release: June 26, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### [Developing Microrobotics for Disaster Recovery and High-Risk Environments](#)

Imagine a natural disaster scenario that inflicts widespread damage to buildings and structures, critical utilities and infrastructure, and threatens human safety. Having the ability to navigate the rubble and enter highly unstable areas could prove invaluable to saving lives or detecting additional hazards among the wreckage.

Date of Release: July 17, 2018  
MTO Program: Short-Range Independent Microrobotic Platforms (SHRIMP)  
Program Manager: Dr. Ron Polcawich

### [Research Teams Selected to Lower Barriers to Modern System-on-Chip Design Announced](#)

A once highly manual process, circuit design has been transformed by the advent of electronic design automation (EDA) tools and modular design methodologies. Despite continuing advances in automation technologies, the demand for increasingly complex System-on-Chip (SoC) platforms has shown no sign of slowing.

Date of Release: July 24, 2018  
MTO Program: [Intelligent Design of Electronic Assets \(IDEA\)](#), [Posh Open Source Hardware \(POSH\)](#)  
Program Manager: Mr. Andreas Olofsson

### [DARPA Selects Teams to Unleash Power of Specialized, Reconfigurable Computing Hardware](#)

The general-purpose computer has remained the dominant computing architecture for the last 50 years, driven largely by the relentless pace of Moore's Law—the transistor-scaling that has allowed for a half-century of rapid progress in electronics.

Date of Release: July 24, 2018  
MTO Program: [Domain-specific System on Chip \(DSSoC\)](#)  
Program Manager: Dr. Tom Rondeau

### [Bringing Photonic Signaling to Digital Microelectronics](#)

DARPA program seeks to unleash the performance of modern multi-chip modules by integrating optical signaling at the chip-level

Date of Release: November 1, 2018  
MTO Program: Photonics in the Package for Extreme Scalability (PIPES)  
Program Manager: Dr. Gordon Keeler

### [DARPA Announces Next Phase of Electronics Resurgence Initiative](#)

Expanded program portfolio seeks to increase access to DoD-specific electronics manufacturing capabilities, enhance hardware security, and ensure ERI investments translate to DoD applications

Date of Release: November 1, 2018  
MTO Program: [Electronics Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

## Other MTO Media Coverage

### [DARPA pursues smart RF radios](#)

The US Defense Advanced Research Projects Agency (DARPA) is seeking ways to exploit autonomy and artificial intelligence (AI) to improve spectrum management and address the growing appetite for radio frequency (RF) communication in the military and civil domains.

Media Source: Jane's 360, June 5, 2018  
MTO Program: [Spectrum Collaboration Challenge \(SC2\)](#)  
Program Manager: Mr. Paul Tilghman

### [Getting into hot water](#)

The Defense Advanced Research Projects Agency's Intrachip/Interchip Enhanced Cooling (ICECool) project was awarded to IBM in 2013. The company and GIT are hoping to develop a way of cooling high-density 3D chip stacks, with actual products expected to appear in commercial and military applications as soon as this year.

Media Source: Datacenter Dynamics, June 21, 2018  
MTO Program: [Interchip Enhanced Cooling \(ICECool\)](#)  
Program Manager: Dr. Ken Plaks

### [DARPA Unveils \\$100M EDA Project](#)

The U.S. will pour \$100 million into two research programs over the next four years to create the equivalent of a silicon compiler aimed at significantly lowering the barriers to design chips.

Media Source: EE Times, June 27, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\); Intelligent Design of Electronic Assets \(IDEA\), Posh Open Source Hardware \(POSH\)](#)  
Program Manager: Mr. Andreas Olofsson

### [Google's DeepMind taught AI teamwork by playing Quake III Arena](#)

Google's DeepMind today shared the results of research and experiments in which multiple AI systems were trained to play Capture the Flag on Quake III Arena, a multiplayer first-person shooter game.

Media Source: Venture Beat, July 3, 2018  
MTO Program: [Lifelong Learning Machine \(L2M\)](#)  
Program Manager: Dr. Hava Siegelmann

### [Chipmakers look to machines to help the struggle with cost](#)

At the manufacturing level, Moore's Law has run into severe difficulties, though the numerical games played by different manufacturers has made it look as though the trend of a doubling in chip density every two years is on track.

Media Source: Engineering & Technology, July 3, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Mr. Andreas Olofsson

### [DARPA Plans a Major Remake of U.S. Electronics](#)

The defense department's research wing is pouring \$1.5 billion into projects that could radically alter how electronics are made

Media Source: IEEE Spectrum, July 16, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)

### **DARPA Plans Bugbot ‘Olympics’ to Foster Breakthrough in Tiny Machines**

The U.S. military has been studying “insect cyborgs” since 2006, but has struggled to build tiny machines that can do useful things without a power cord. On Tuesday, the Defense Advanced Research Projects Agency launched a new effort to leapfrog the static state of micro-robot technology.

Media Source: Defense One, July 18, 2018  
MTO Program: Short-Range Independent Microrobotic Platforms (SHRIMP)  
Program Manager: Dr. Ron Polcawich  
Related Coverage: [Popular Mechanics](#), [Live Science](#), [Digital Trends](#), [PC Mag](#)

### **DARPA Unveils Research Partners**

Chip giants IBM, Intel, Nvidia, and Qualcomm and a little-known foundry called Skywater were among eight companies announced as prime contractors in four research projects announced by the U.S. Defense Advanced Research Projects Agency.

Media Source: EE Times, July 24, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple  
Related Coverage: [IEEE Spectrum](#), [HPC Wire](#), [Tech Crunch](#), [National Defense](#), [IEEE Spectrum](#), [ZDNet](#), [GOVCON Wire](#), [Electronics Weekly](#), [Washington Technology](#), [SIGNAL](#)

### **Intel contributes royalty-free data bus for research agency’s ‘chipelets’ initiative**

You’ve heard of chips. But how about chipelets? Intel is providing a royalty-free license for an advanced data transfer technology for a new government-sponsored electronics research program.

Media Source: Venture Beat, July 24, 2018  
MTO Program: [Common Heterogeneous integration & IP reuse Strategies \(CHIPS\)](#)  
Program Manager: Mr. Andreas Olofsson

### **Nvidia, DARPA Announce Collaboration as the Era of Moore’s Law Closes**

The chip manufacturer announced that it was teaming up with Defense Advanced Research Projects Agency, which is an arm of the U.S. Department of Defense, for a four-year contract worth around \$23 million.

Media Source: The Street, July 25, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Mr. Andreas Olofsson

### **Chipmakers look past Moore's law, and silicon**

Silicon computer chips have been on a roll for half a century, getting ever more powerful. But the pace of innovation is slowing.

Media Source: Science Mag, July 27, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple  
Related Coverage: [Science Mag](#), [Extreme Tech](#)

### **Moore’s Law, China vs. Team USA**

The U.S. Department of Defense is pushing for a \$2.2 billion program to fund a broad range of electronics efforts.

Media Source: EE Times, July 27, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **DARPA has an ambitious \$1.5 billion plan to reinvent electronics**

The US military agency is worried the country could lose its edge in semiconductor chips with the end of Moore's Law.

Media Source: Technology Review, July 30, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple  
Related Coverage: [Financial Times](#), [Jane's 360](#), [GovernmentCIO Media](#)

### **ASU Researchers Lead DARPA Effort to Design the Computational Architecture of the Future**

An Arizona State University research team seeks to create a new framework for designing and building advanced computing platforms that will circumvent the power constraints that exist in a growing range of technologies.

Media Source: Research & Development Magazine, July 30, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Dr. Tom Rondeau, Mr. Wade Shen  
Related Coverage: [Jane's 360](#)

### **Applied Materials and ARM partner on CeRAM for neuromorphic applications**

Semiconductor manufacturing equipment maker Applied Materials Inc. has been selected by DARPA to work with ARM Ltd. and research firm Symetrix Corp. to develop a switch that functions like the neuron and synapses of the human brain, based on Correlated-Electron RAM (CeRAM) technology.

Media Source: EE News, August 1, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **UC San Diego nets \$11.3M grant to cut costs, risks of designing cutting edge chips**

The University of California San Diego has been awarded an \$11.3 million grant from a government defense agency to develop tools aimed at making it less risky and more affordable to design advanced semiconductors.

Media Source: EE News, August 1, 2018  
MTO Program: [Intelligent Design of Electronic Assets \(IDEA\)](#)  
Program Manager: Mr. Andreas Olofsson

### **The Continuing Evolution of Moore's Law**

Moore's Law is dead-Long live Moore's Law! This was the essence of the debate at DARPA's Electronic Resurgence Initiative Summit in San Francisco.

Media Source: EE Times, August 2, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **DARPA Selects Research Projects for Next-Gen Processing Technology**

DARPA (Defense Advanced Research Projects Agency) has announced the academic and industry research groups selected to develop new computing technologies to drive computing performance post Moore's Law.

Media Source: Inside HPC, August 5, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **The Foundry at the Heart of DARPA's Plan to Let Old Fabs Beat New Ones**

3D tech could give a performance boost so big that chips built at SkyWater Technology's 90-nm foundry could beat those built using today's most advanced 7-nm tech.

Media Source: IEEE Spectrum, August 6, 2018  
MTO Program: [Domain-specific System on Chip \(DSSoC\)](#)  
Program Manager: Dr. Tom Rondeau

### **Advancing computing in a post-Moore's Law world**

When the Defense Advanced Research Projects Agency launched the Electronics Resurgence Initiative last year, it aimed to use new computer architectures, design and materials to continue computing advances even as Moore's Law seems to be reaching its limit.

Media Source: GCN, August 6, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **UMass professor receives grant from DARPA to teach computers 'visual common sense'**

DARPA, which has been behind many of the largest technological breakthroughs of the 20th century--including the Internet, GPS, and air force stealth technology--has funded numerous research projects at UMass Amherst over the years.

Media Source: Mass Live, August 8, 2018  
MTO Program: [Lifelong Learning Machine \(L2M\)](#)  
Program Manager: Dr. Hava Siegelmann

### **Algorithms Outpace Moore's Law for AI**

Moore's Law continues to change the world. But algorithmic advances have been every bit as critical for driving electronics.

Media Source: IEEE Spectrum, August 21, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **Intel details future of chip design at Hot Chips 2018**

Forward-looking: What do Intel foundries and Legos have in common? Not much, right now. But if Intel delivers on a future of mix 'n' match pieces of silicon, then we'll see multiple silicon IP blocks patched together with Intel's proprietary technology.

Media Source: Tech Spot, August 21, 2018  
MTO Program: [Common Heterogeneous Integration & IP Reuse Strategies \(CHIPS\)](#)  
Program Manager: Mr. Andreas Olofsson  
Related Coverage: [Semiconductor Engineering](#), [Next Platform](#), [Venture Beat](#)

### **DARPA wants photonic integrated circuits for new generation of military gyroscopes and clocks**

The U.S. Defense Advanced Research Projects Agency (DARPA) Microsystems Technology Office is soliciting research proposals for the development of a new class of atom-based systems using integrated photonics and trapped atoms to enable high-performance, robust, portable clocks and gyroscopes.

Media Source: Military & Aerospace Electronics, September 12, 2018  
MTO Program: The Atomic-Photonic Integration (A-PhI)  
Program Manager: Dr. John Burke

### **Colosseum: A Battleground for AI Let Loose on the RF Spectrum**

Over the last four decades, the use of wireless technology has become so pervasive, both militarily and commercially, that we have come to rely upon its never-ending, and seemingly unbounded, ability to carry more and more information.

Media Source: Microwave Journal, September 13, 2018  
MTO Program: [Spectrum Collaboration Challenge \(SC2\)](#)  
Program Manager: Mr. Paul Tilghman

### **DARPA contract aims to design circuits in months, not years**

The Defense Advanced Research Agency announced an \$8 million contract modification for the University of Southern California's Information Sciences Institute to work on a program that develops circuits that be quickly adapted rather than wholesale reinvented.

Media Source: C4ISRNET, September 19, 2018  
MTO Program: [Circuit Realization at Faster Timescales \(CRAFT\)](#)  
Program Manager: Dr. Linton Salmon

### **Interview: DARPA- Spectrum Collaboration Challenge**

Paul Tilghman, Program Manager – Microsystems Technology Office at US government agency DARPA, tells Mobile World Live why he's working with the GSMA on a multi-year Spectrum Collaboration Challenge.

Media Source: Mobile World Live, September 24, 2018  
MTO Program: [Spectrum Collaboration Challenge \(SC2\)](#)  
Program Manager: Mr. Paul Tilghman

### **DARPA Pieces Together Combat Technology Mosaic**

Researchers lay the tiles for the future fight.

Media Source: SIGNAL Magazine, October 1, 2018  
MTO Program: [Spectrum Collaboration Challenge \(SC2\)](#), [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Mr. Paul Tilghman

### **Bee-sized bots set to dominate future battles for cities**

In future battles, new American warriors may be the size of a baseball, the size of a bumble bee – even the size of a grain of sand.

Media Source: Fox News, October 26, 2018  
MTO Program: Short-Range Independent Microrobotic Platforms (SHRIMP)  
Program Manager: Dr. Ron Polcawich

### **To Keep Pace with Moore's Law, Chipmakers Turn to 'Chiplets'**

Instead of carving new processors from silicon as single chips, semiconductor companies assemble them from multiple smaller pieces of silicon—known as chiplets.

Media Source: Wired, November 6, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#)  
Program Manager: Multiple

### **US Chip Initiative Aims For 'Moore's (Law) Inflection'**

As DARPA engages directly with chip makers and university researchers, it is attempting to transform the semiconductor industry largely guided by Moore's Law scaling.

Media Source: HPC Wire, November 8, 2018  
MTO Program: [Electronic Resurgence Initiative \(ERI\)](#), Photonics in the Package for Extreme Scalability (PIPES)  
Program Manager: Dr. Gordon Keeler

### **DARPA eyes microelectronics optical interconnects for high-performance embedded computing boards**

U.S. military researchers are asking the microelectronics industry to find ways of using optical interconnects on high-performance embedded computing boards to enhance bandwidth, power efficiency, channel density, and link reach.

Media Source: Military & Aerospace Electronics, November 8, 2018  
MTO Program: Photonics in the Package for Extreme Scalability (PIPES)  
Program Manager: Dr. Gordon Keeler

### **DoD Places Spectrum on a War Footing**

The U.S. Navy has formally elevated electronic warfare and the underlying electromagnetic spectrum to the status of a “warfighting battle space” equivalent to its sea, air, land, space, and cyber operations.

Media Source: EE Times, November 14, 2018  
MTO Program: [Spectrum Collaboration Challenge \(SC2\)](#)  
Program Manager: Mr. Paul Tilghman