ERI ELECTRONICS RESURGENCE INITIATIVE SUMMIT

& MTO Symposium

ELECTRONICS RESURGENCE INITIATIVE SUMMIT
& MTO Symposium
2020 | Seattle, WA | August 18-20

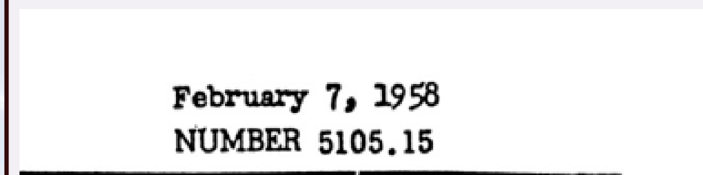
WORKING WITH DARPA

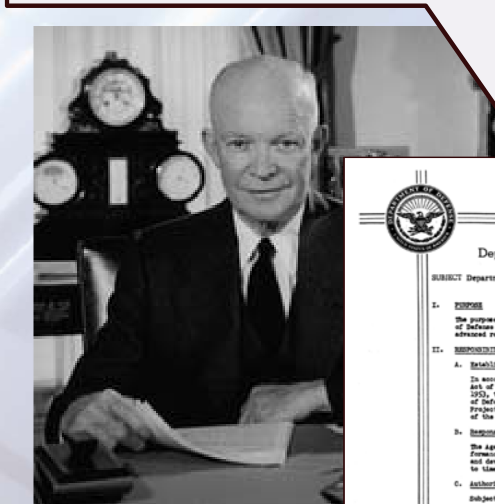
Dr. Mark Rosker, MTO Director
Dr. Dev Palmer, MTO Deputy Director

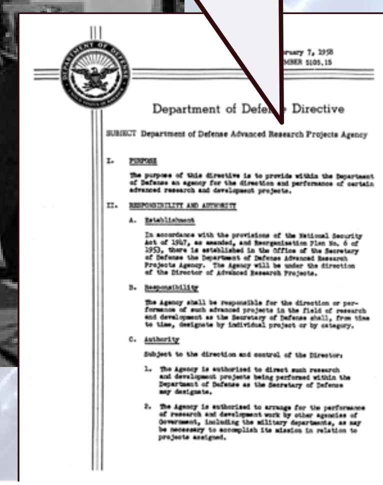
THE HISTORY OF DARPA

Nytimes.com

"The purpose of this directive is to provide within the Department of Defense an agency for the direction and performance of certain advanced research and development projects."







DARPA'S MISSION

BTO
BIOLOGICAL TECHNOLOGIES OFFICE
- Detect and characterize threats
- Rapid, scalable protection and countermeasures
- Warfighter overmatch
- Non-traditional platforms and capabilities

DSO
DEFENSE SCIENCES OFFICE
- Frontiers in math, computation & design
- Limits of sensing & sensors
- Complex social systems
- Anticipating surprise

I2O
INFORMATION INNOVATION OFFICE
- AI to the mission
- Advantage in cyber operations
- Confidence in the information domain
- Resilient, adaptable, and secure systems

MTO
MICROSYSTEMS TECHNOLOGY OFFICE
- Embedded intelligence / localized processing
- Spectral dominance
- Microsystem integration for functional density and security
- Disruptive microsystem defense applications

STO
STRATEGIC TECHNOLOGY OFFICE
- Mosaic Warfare: Joint all-domain lethality with continuous speed and adaptability
- Tools and infrastructure for interoperable, adaptive kill webs
- Sensors and non-kinetic effects

TTO
TACTICAL TECHNOLOGY OFFICE
- Tactical systems
- Platforms, systems, and technologies that enable new warfighting constructs
- Reimagine missions across maritime, ground, air and space domains

DARPA'S TECHNICAL OFFICES

Director (Acting), Peter Highnam
Deputy Director (Acting), David Honey

Biological Technologies

Director, Bradley Ringeisen
Deputy Director, Kerri Dugan

- Detect Novel Threats and Protect Force Readiness
- Physiological Interventions to Maintain Operational Advantage
- Warfighter Performance
- Operational Biotechnology for Mission Success

Defense Sciences

Director, Valerie Browning
Deputy Director, Philip Root

- Limits of Sensing & Sensors
- Complex Social Systems
- Anticipating Surprise
- Frontiers in Math, Computation & Design

Information Innovation

Director, William Scherlis
Deputy Director, Jennifer Roberts

- Proficient artificial intelligence
- Advantage in cyber operations
- Confidence in the information domain
- Resilient, adaptable, and secure systems

Microsystems Technology

Director, Mark Rosker
Deputy Director, Dev Palmer

- Embedded Microsystem Intelligence / Localized Processing
- Electromagnetic Spectrum Dominance
- Microsystem Integration for Functional Density & Security
- Disruptive Defense Microsystem Applications

Strategic Technology

Director, Timothy Grayson
Deputy Director, Kenneth Plaks

- Mosaic Warfare: Joint All Domain Adaptive Kill Webs
  - Comms, Interoperability, Command & Control
  - Sensors and non-kinetic effects
- Cognitive Warfare

Tactical Technology

Director, Michael Leahy
Deputy Director, Thomas Beutner

- Tactical Systems
- Platforms, Systems, and Technologies that Enable New Warfighting Constructs
- Reimagine missions across Maritime, Ground, Air and Space Domains

PREVENT AND IMPOSE TECHNOLOGICAL SURPRISE

PEOPLE

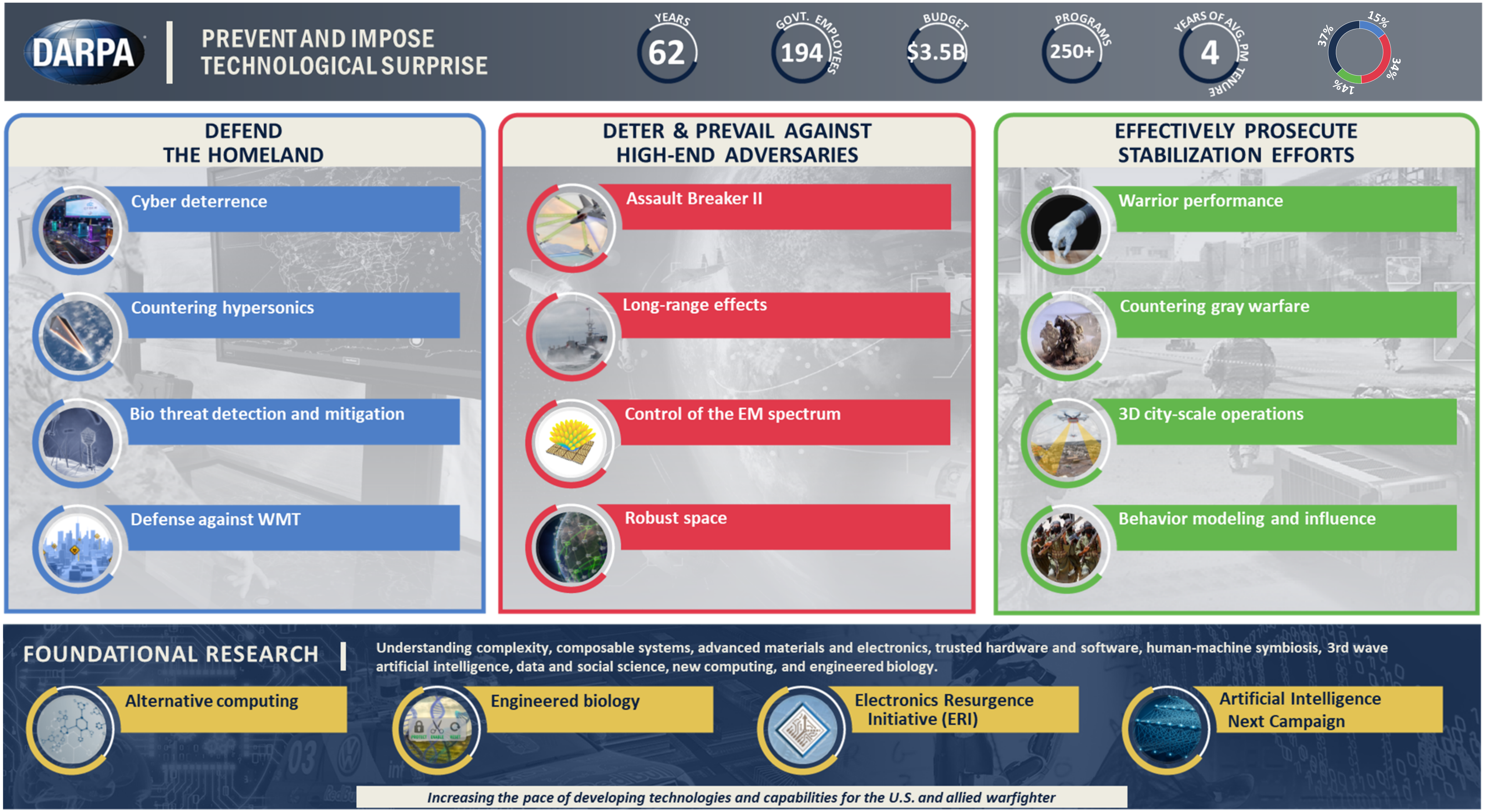
- Exceptional technologists
- Limited tenure
- Autonomy

PROCESSES

- No in-house labs
- Metrics-based
- Programs have end-dates

CULTURE

- Drive for off-scale impact
- Risk tolerant
- Honor in public service


DARPA
PREVENT AND IMPOSE TECHNOLOGICAL SURPRISE
YEARS 62
GOVT. EMPLOYEES 194
BUDGET $3.5B
PROGRAMS 250+
YEARS OF AVG. PM TENURE 4
15%
34%
14%
37%
DEFEND THE HOMELAND
Cyber deterrence
Countering hypersonics
Bio threat detection and mitigation
Defense against WMT
DETER & PREVAIL AGAINST HIGH-END ADVERSARIES
Assault Breaker II
Long-range effects
Control of the EM spectrum
Robust space
EFFECTIVELY PROSECUTE STABILIZATION EFFORTS
Warrior performance
Countering gray warfare
3D city-scale operations
Behavior modeling and influence
FOUNDATIONAL RESEARCH
Understanding complexity, composable systems, advanced materials and electronics, trusted hardware and software, human-machine symbiosis, 3rd wave artificial intelligence, data and social science, new computing, and engineered biology.
Alternative computing
Engineered biology
Electronics Resurgence Initiative (ERI)
Artificial Intelligence Next Campaign
Increasing the pace of developing technologies and capabilities for the U.S. and allied warfighter

MTO

MICROSYSTEMS TECHNOLOGY OFFICE

C4ISR

Electronic Warfare

Directed Energy

MICROSYSTEMS TECHNOLOGY OFFICE

MTO's core mission is the development of high-performance, intelligent microsystems and next-generation components to enable dominance in national security C4ISR, EW, and DE applications

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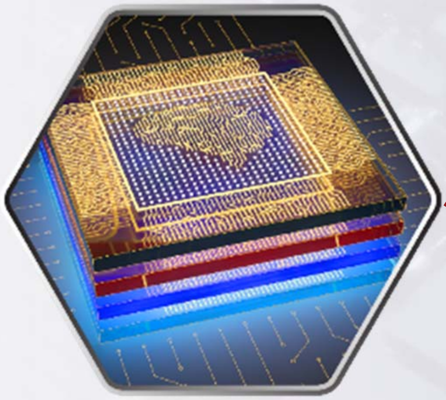
The effectiveness and survivability of these systems depends critically on microsystems

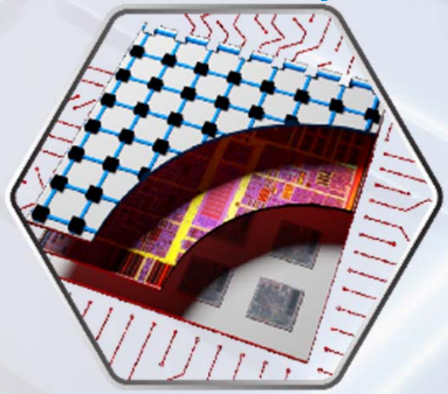
C4ISR: Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance

MTO
MICROSYSTEMS TECHNOLOGY OFFICE

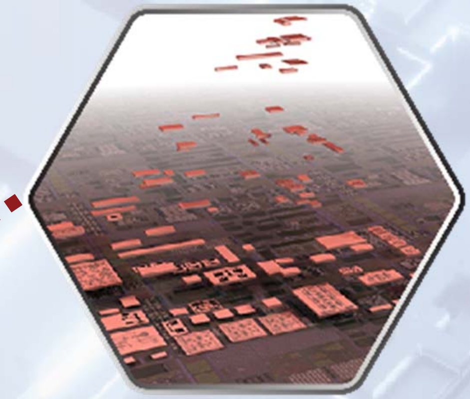
Embedded Microsystem Intelligence / Localized Processing



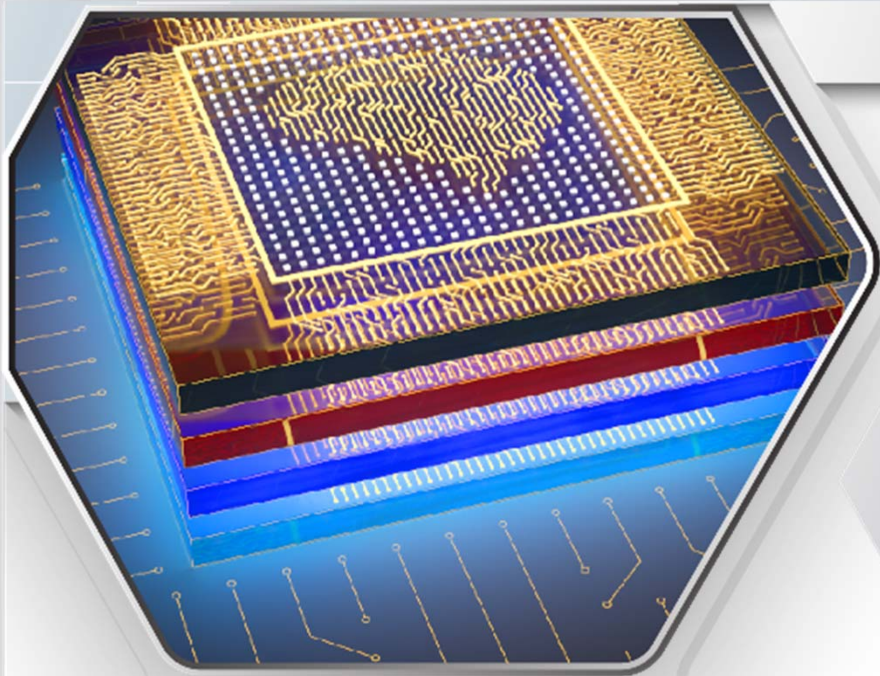
Microsystem Integration for Functional Density & Security



Next Gen Front-End Technologies for Electromagnetic Spectrum Dominance



Disruptive Defense Microsystem Applications



Embedded Microsystem Intelligence / Localized Processing

- Increasing information processing density & efficiency
- Making decisions at the edge faster
- Reducing the glut of digitized sensor data

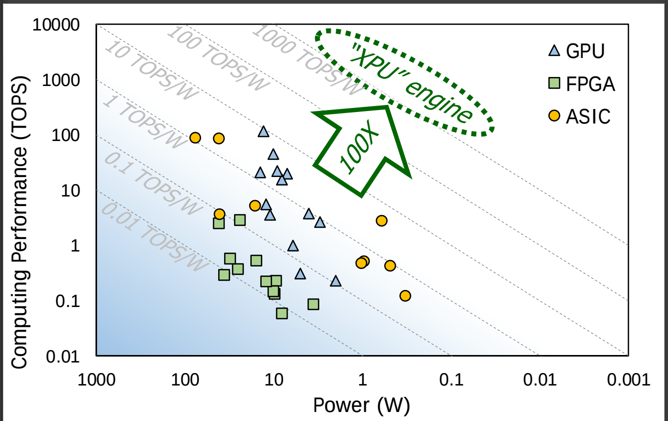
ERI Topics

Non-ERI Topics

EMBEDDED MICROSYSTEM INTELLIGENCE / LOCALIZED PROCESSING: KEY CHALLENGES

Increasing information processing density & efficiency

Problem: Current processors cannot be scaled to DoD needs



Potential Approaches

- Low temperature computing
- New computing materials
- New computing algorithms

Making decisions at the edge faster

Problem: Conventional algorithms and associated platforms not sufficiently fast for emerging threats

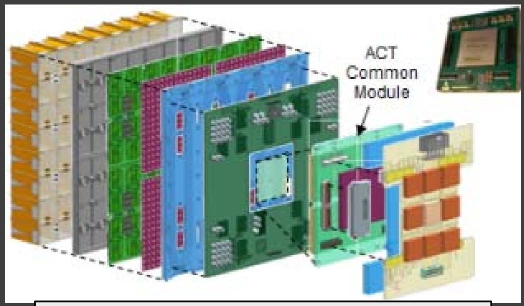
STRIPES.com

Potential Approaches

- Artificial intelligence / machine learning for decision making at the edge

Reducing the glut of digitized sensor data

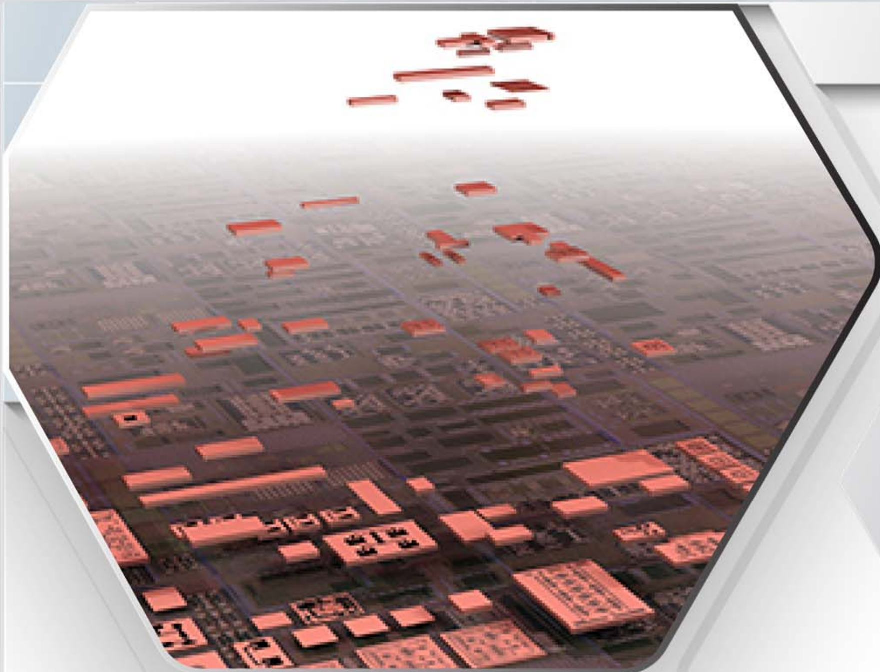
Problem: Volume of data captured in static sensor architectures overwhelms processing capability



ACT Signal Processing Challenge:
51.2 GSPS/element * 10 bit/Sample * 2 Pol * 512 elements = **524 Tbps**

Potential Approaches

- New reconfigurable architectures with more on-chip functionality
- Scalable algorithms



Next Gen Front-End Technologies for Electromagnetic Spectrum Dominance

- **Reducing SWaP-C of front-end elements**
- **Increasing tactical range**
- **Enabling robust operation in congested spectrum**

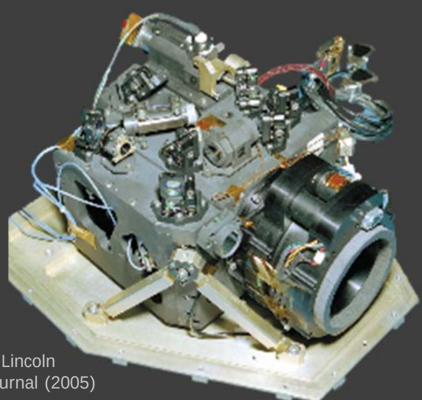
ERI Topics

Non-ERI Topics

NEXT GEN FRONT-END TECHNOLOGIES FOR EM SPECTRUM DOMINANCE: KEY CHALLENGES

Reducing SWaP-C of front-end elements

Problem: Bulky electronics and optics undermine ability to miniaturize sensors and systems



Marino et al., Lincoln Laboratory Journal (2005)

Potential Approaches

- Wafer-scale electronics and optics
- Chip-scale sensors
- Advances in quantum sensors

Increasing tactical range

Problem: Range of EW, DE, and C4ISR is limited by inherent properties of current electronic materials and transmitter efficiency

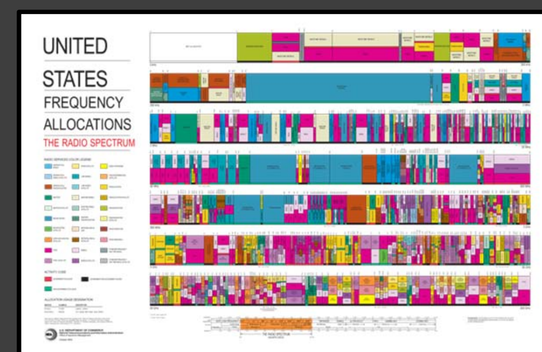
MIT

Potential Approaches

- Emerging electronic materials
- New PA architectures / circuit design techniques

Enabling robust operation in congested spectrum

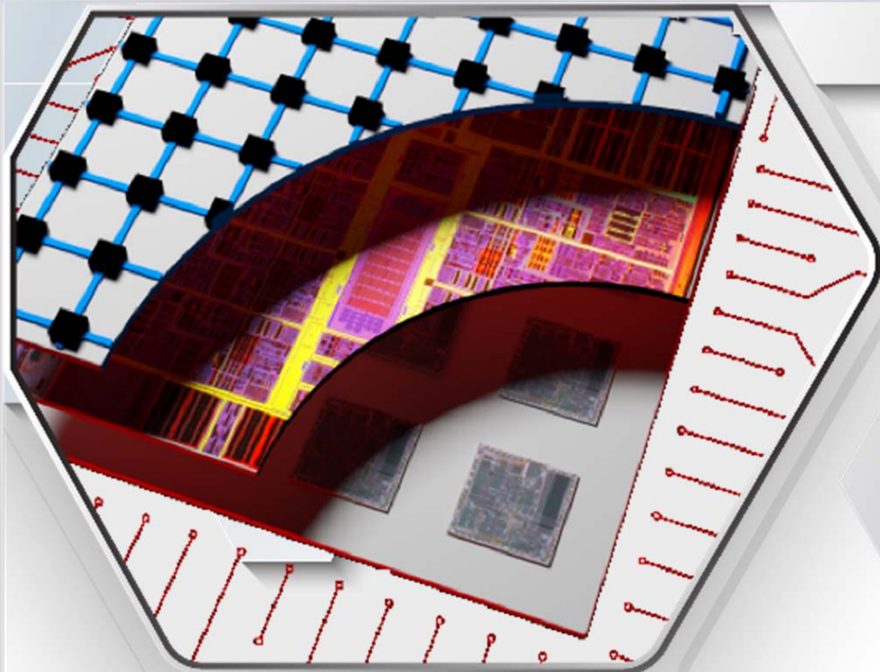
Problem: RF components are insufficiently adaptable or robust to operate in increasingly congested spectrum



SpectrumIN.com

Potential Approaches

- New materials / devices integrated directly onto RF MMICs
- Real-time adaptive technologies for navigating crowded RF environments



Microsystem Integration For Functional Density & Security

- Overcoming the inherent throughput limits of 2D electronics
- Mitigating the skyrocketing costs of electronics design
- Overcoming security threats across the entire hardware lifecycle

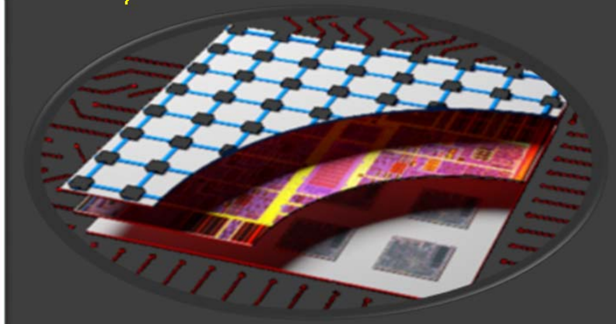
ERI Topics

Non-ERI Topics

MICROSYSTEM INTEGRATION FOR FUNCTIONAL DENSITY & SECURITY: KEY CHALLENGES

Overcoming the inherent throughput limits of 2D electronics

Problem: 2D computing with traditional interconnects between processor and memory limits throughput and drives energy consumption

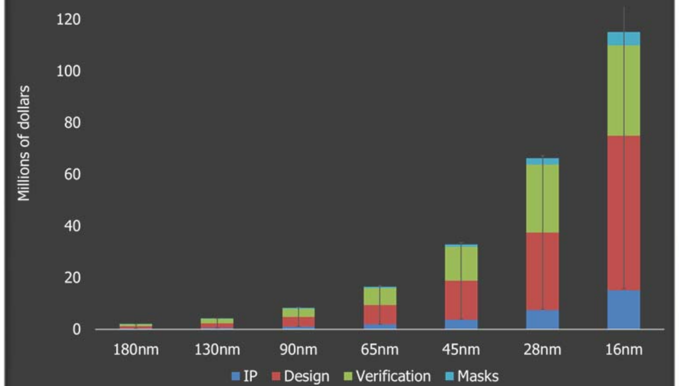


Potential Approaches

- 3-dimensional electronics
- Integration of photonics with optics
- New materials *e.g.,* nanotubes
- Heterogeneous electronics with Si-like back-end processing

Mitigating the skyrocketing costs of electronics design

Problem: Increasingly complex circuit architectures are making design costs prohibitive for commercial industry and DoD

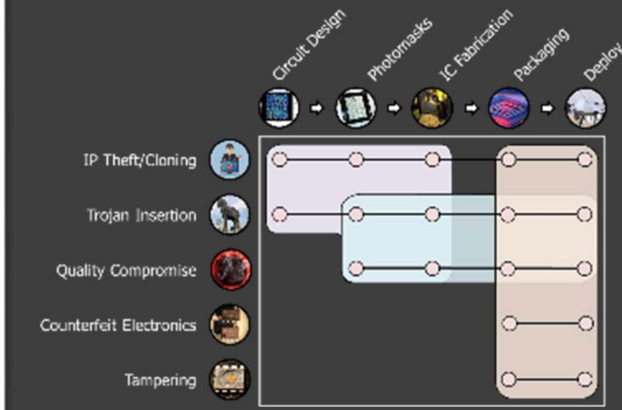


Potential Approaches

- Design tools and hardware with machine learning capability
- Trusted open source tools
- Modular circuit design with relevant standards and interconnects

Overcoming security threats across the entire hardware lifecycle

Problem: Persistent hardware threats limit the ability to access and utilize advanced electronics technology



Potential Approaches

- EDA based technologies
- Inspection based technologies
- Supply chain based technologies

Disruptive Defense Microsystem Applications

- Revolutionizing communications (5G and beyond)
- Reducing latency in EW
- Generating / directing high power radiation
- Delivering accurate position and timing without GPS

ERI Topics

Non-ERI Topics

DISRUPTIVE DEFENSE MICROSYSTEMS APPLICATIONS: KEY CHALLENGES

Revolutionizing communications (5G and beyond)

Problem: Ensuring network availability and security

Medium.com

Potential Approaches

- Digital arrays
- Low power element-level beamforming
- Advanced techniques for secure comms

Reducing latency in EW

Problem: Adaptive threats challenge ability to detect and counter

Navalnews.com

Potential Approaches

- Neural networks for RF signal recognition
- Embedded machine learning for cognitive EW systems

Generating / directing high power radiation

Problem: Advanced threats require high power countermeasures

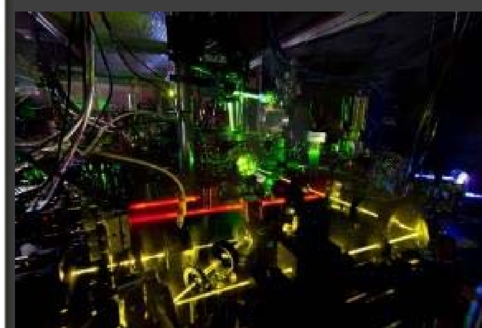
Navalnews.com

Potential Approaches

- Ultra-efficient, high power laser diodes
- Compact, high power laser arrays
- High power microwave systems

Delivering accurate position and timing w/o GPS

Problem: Low SWaP-C solutions required for GPS-denied environments



DARPA

Potential Approaches

- Modern atomic physics for low SWaP clocks
- Advanced MEMS for inertial guidance
- Integrated photonic chips for clocks/gyros

HOW TO ENGAGE WITH US

REMEMBER THE “P” IN OUR NAME

DEFENSE
ADVANCED
RESEARCH
PROJECTS
AGENCY

“A **project** consists of a concrete and organized effort motivated by a perceived opportunity when facing a **problem**…”

What **problem** are you trying to solve?

THE HEILMEIER CATECHISM

We recommend that DoD adopt such a structured methodology for its decision making. Whether or not the figure of merit or the criteria are exactly adopted is not the point. What is important is that decision makers at all levels should ask the questions which are summarized in the investment strategy catechism:

- What are we trying to do?
- How is it done today and what are the limitations of current practice?
- What is new in my approach and why do I think I can be successful?
- Assuming success, what difference will it make to the user or in a mission area context?
- How long will it take; how much will it cost; what are the "midterm" and "final" exams?

The answers to these questions should be of great value in the resource allocation process.

Sincerely

George H. Heilmeier

Source:
1981 Defense Science Board Summer Study

FUNDING VEHICLES AT DARPA

Kind	Typical Award ($M)	Typical Duration (Months)	How	Purpose	Where to Begin
Program	0.5 to >50	48	BAA[1]	To solve a specific national security problem	Directly engage a PM interested in this technical area
Seedling	0.2 to 1	6-12	"Office-wide" BAA[2]	To provide key information to allow a PM to define a Program	
Microsystem Exploration (µE)	1	18	PA[3]	To provide foundational work in an area of potential interest for a future Program	
SBIR/STTR	Phase 1: 0.225 Phase 2: 1-1.5	Phase 1: 10 Phase 2: 24-36	BAA[4]	To stimulate technological innovation lead by small businesses and research institutions	
Young Faculty Award[5]	0.5	24	BAA[6]	To develop the next gen of scientists and engineers and encourage focus on DoD and National Security issues	

[1] http://www.darpa.mil/work-with-us/opportunities
[2] http://www.darpa.mil/work-with-us/office-wide-broad-agency-announcements
[3] https://beta.sam.gov/opp/765d3278dd11489c9ad662a414cc5400/view
[4] https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program
[5] Available to junior faculty positions in academia and equivalent positions at non-profit research institutions
[6] https://www.darpa.mil/work-with-us/for-universities/young-faculty-award

MICROSYSTEM EXPLORATION **(μE)**

μE

MTO has introduced a new class of programs: "Microsystems Exploration (μE)"
Continuously open Program Announcement: DARPA-PA-19-04

From Program Announcement to contract in 90 days
Up to $1M over 2 phases (including cost share)
Streamlined proposal templates

Microsystems Exploration will accelerate microelectronics innovation

MICROSYSTEM EXPLORATION **(µE)** TOPICS

Safeguards against Hidden Effects and Anomalous Trojans in Hardware (SHEATH)

PM: Keith Rebello | DARPA-PA-19-04-01

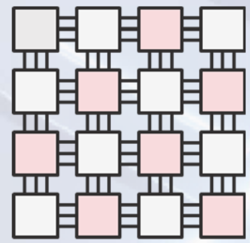
Fusion of non-invasive, rapid inspection techniques for DoD electronics

Special Notice Released July 18, 2019

83 days to contract

Performant Automation of Parallel Program Assembly (PAPPA)

PM: Sandeep Neema (I2O) | DARPA-PA-19-04-02



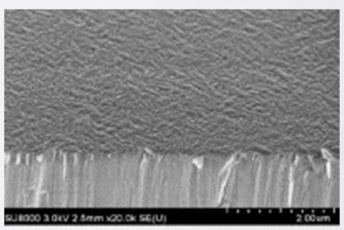
Compiler technologies to improve the programming productivity of massively parallel and heterogeneous processing systems

Special Notice Released September 3, 2019

89 days to contract

Tunable Ferroelectric Nitrides (TUFEN)

PM: Ron Polcawich | DARPA-PA-19-04-03



Sc-doped AlN

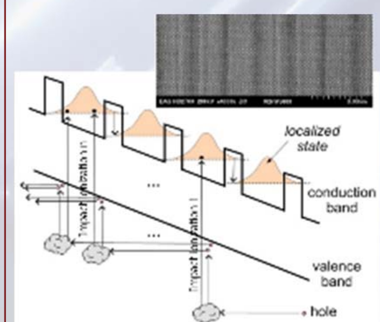
Tunable ferroelectric nitrides using manufacturable devices and process techniques

Special Notice Released November 12, 2019

98 days to contract

Gain Enhancement by Novel Impact Ionization (GENII)

PM: Whitney Mason | DARPA-PA-19-04-04



High gain, low noise avalanche photodiodes (APD)

Special Notice Released February 19, 2020

84 days to contract

= ERI

TALK TO A PROGRAM MANAGER

- Start with: www.darpa.mil
- Identify (if you can) the right PM
- Then, contact them (web page, email, visit)
- Available for technical discussions

https://www.businessinsider.com/best-way-to-increase-mental-strength-2014-10

Some Advice

- PMs are motivated by finding new and highly disruptive problems that will be the basis of new programs
- Generally, you should discuss ideas that might lead to new programs, not present your approaches for ongoing programs

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- PMs will be thinking about the Heilmeier catechism… so you should, too
- PMs are most receptive when you do their homework for them
- Listen to them!

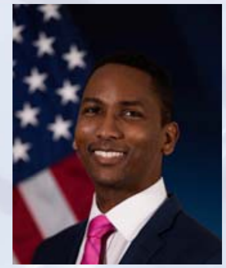
MTO PROGRAM MANAGERS

Mark Rosker
MTO Director

Dev Palmer
MTO Deputy Director

Wendy Smith
MTO ADPM

Miriam Prantner
MTO PA



Richard-Duane Chambers
ERI Chief of Staff

PMs from Other Offices with MTO Programs
- Sandeep Neema, I2O
- Tom Rondeau, STO
- Ted Senator, DSO
- Walter Weiss, I2O

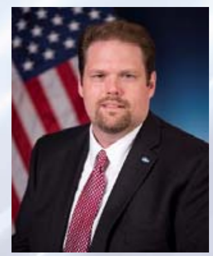
David Abe
HPM/Vacuum electronics

John Burke
Quantum sensing/PNT

YK Chen
AI/Communications

John Davies
Cognitive EW

Ben Griffin
MEMS/High T materials



Tim Hancock
RF Electronics

Bryan Jacobs
Algorithms

Tom Kazior
Devices/Integration

Gordon Keeler
Photonics

Ali Keshavarzi
Novel CMOS Devices

Serge Leef
EDA/Security

Whitney Mason
IR Imaging

Ron Polcawich
Microrobotics/PNT

Keith Rebello
Hardware security

James Wilson
Integration

Jason Woo
CMOS / Processing

ERI ELECTRONICS RESURGENCE INITIATIVE

SUMMIT

& MTO Symposium

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