DARPA/DSO 101

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Acting Director
Defense Sciences Office

May 2017

February 7, 1958
NUMBER 5105.15

Department of Defense Directive

SUBJECT Department of Defense Advanced Research Projects Agency

I. PURPOSE

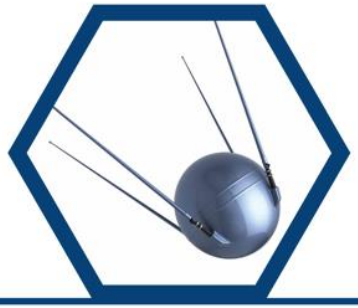
The purpose of this directive is to provide within the Department of Defense an agency for the direction and performance of certain advanced research and development projects.

B. Responsibility

The Agency shall be responsible for the direction or performance of such advanced projects in the field of research and development as the Secretary of Defense shall, from time to time, designate by individual project or by category.

DARPA Through the Decades...

Sputnik and the Birth of DARPA



1950s

The Beep Heard 'round the World

The 1950s were marked by both the fervor of the Cold War and a belief that American ingenuity and industry could overcome any technical challenge.

Cultural Context

1957

Sputnik and the Dawn of the Space Age

Everything changed on October 4, 1957, when the Soviets successfully launched Sputnik I. The world's first artificial satellite was no bigger than a beach ball, and took about 96 minutes to orbit the Earth. Though Sputnik was small in size, its launch caught the American public off guard. If the Soviets could put a satellite into space, what would stop them from putting a nuclear warhead into space next? The space race was on!


The New York Times.

SOVIET FIRES EARTH SATELLITE INTO SPACE; IT IS CIRCLING THE GLOBE AT 18,000 M. P. H.; SPHERE TRACKED IN 4 CROSSINGS OVER U. S.

1958
Peace sign

1958
Cassette tape

1959
Buddy Holly dies

1959
Cuban rebels take control of Havana

1958

The Urgent Origin of ARPA

The creation of the Advanced Research Projects Agency (ARPA) was among the first reactions to this apparent challenge.

On November 13, 1957, President Dwight D. Eisenhower addressed a wary nation on radio and television: "The world will witness future discoveries even more startling than that of nuclear fission. The question is: Will we be the ones to make them?"

The administration's answer was to create an agency imbued with the flexibility and nimbleness to drive the high-risk, high-reward technological investments that would position the United States as the first mover in new areas of science and engineering relevant to national defense.

On Feb. 7, 1958, Secretary of Defense Neil McElroy issued a directive and ARPA was formally born.

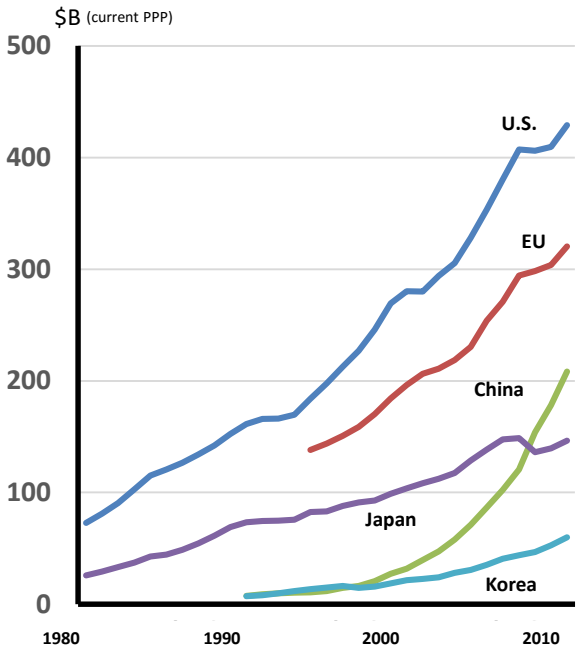
Success!

The new agency didn't waste time. ARPA's initial focus was on space, and on December 19, 1958, the agency achieved one of its earliest successes when President Eisenhower used the world's first communication satellite to address the nation.

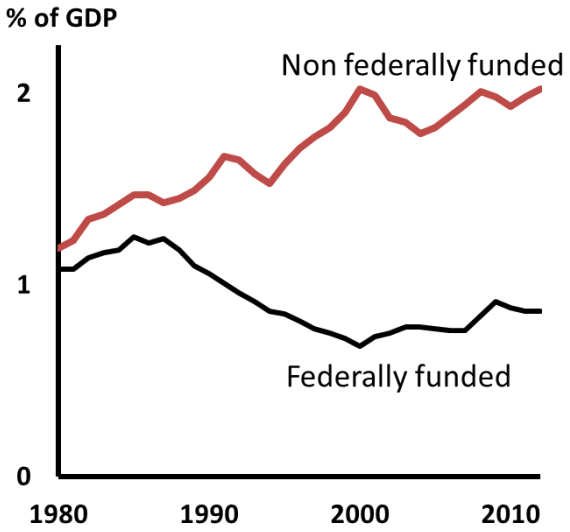
"This is the President of the United States speaking. Through the marvels of scientific advance, my voice is coming to you from a satellite traveling in outer space. My message is a simple one: Through this unique means I convey to you and all mankind, America's wish for peace on Earth and good will toward men everywhere."

– President Dwight Eisenhower

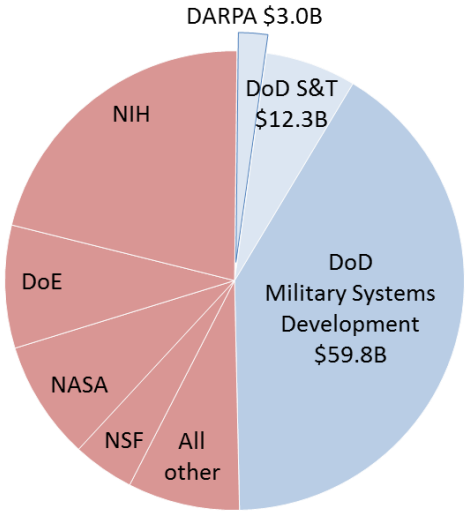
R&D Expenditures



Global



National



Federal R&D
FY 2016 President's Budget Request
$146B

Federal

DARPA and the Defense Sciences Office

DARPA

- Founded in 1958 in the wake of Sputnik
- 50 years of supporting breakthrough technologies for national security

DARPA: Create and prevent strategic surprise

DSO

- "DARPA's DARPA": Create opportunity from scientific discovery
- Invest in multiple, often disparate, scientific disciplines; reshape existing fields or create entirely new disciplines
- Harvest and accelerate the development of promising breakthroughs and technologies to address national security challenges

DSO: The Nation's first line of defense against scientific surprise

DARPA Technical Offices

DEFENSE SCIENCES OFFICE

BTO — BIOLOGICAL TECHNOLOGIES OFFICE

- Biological Complexity at Scale
- Neurotechnologies
- Engineering Biology
- Restore, Maintain and Improve Warfighter Abilities

DSO — DEFENSE SCIENCES OFFICE

- Math, Modeling & Design
- Physical Systems
- Human-Machine Systems
- Social Systems

I2O — INFORMATION INNOVATION OFFICE

- Empower the Human within the Information Ecosystem
- Guarantee Trustworthy Computing and Information

MTO — MICROSYSTEMS TECHNOLOGY OFFICE

- Electromagnetic Spectrum
- Tactical Information Extraction
- Globalization

STO — STRATEGIC TECHNOLOGY OFFICE

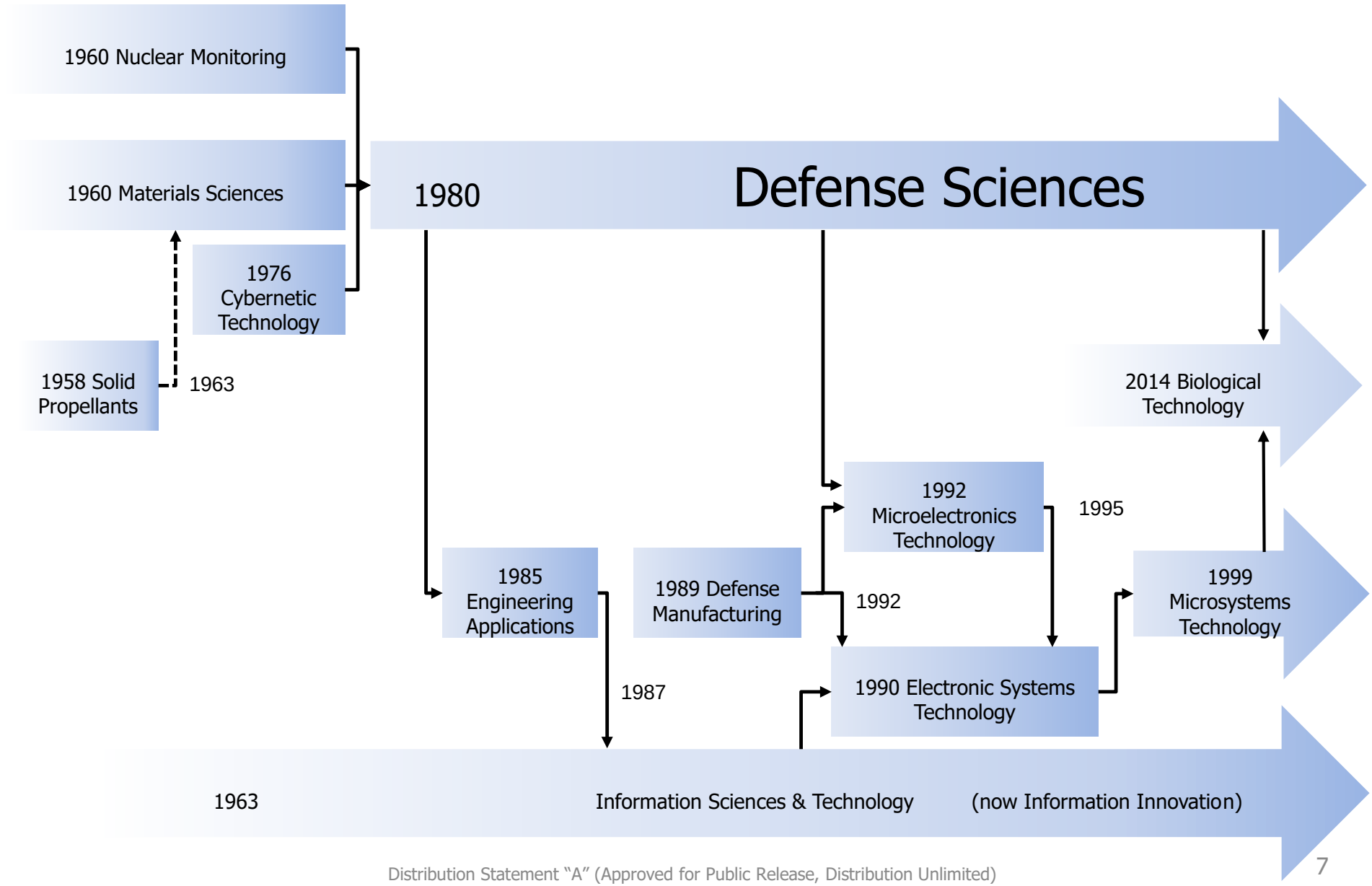
- System of Systems (SoS)
- Battle Management/Command and and Control (BMC2)
- Communications and Networks (C&N)
- Electronic Warfare (EW)
- Intelligence Surveillance, and Reconnaissance (ISR)
- Positioning, Navigation, and Timing (PNT)

TTO — TACTICAL TECHNOLOGY OFFICE

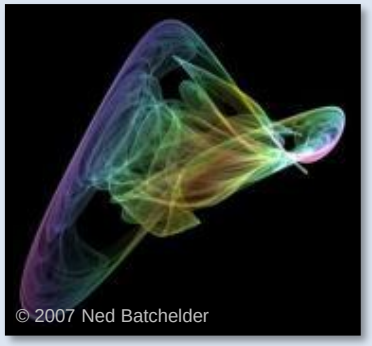
System Focus Areas:
- Ground
- Maritime
- Air
- Space

Crosscutting Themes:
- Agile development
- Cooperative Autonomy
- Unmanned Systems
- Power and Propulsion

DSO Office History

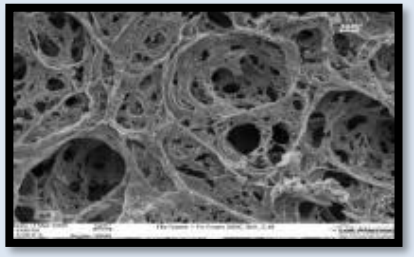


Focus Areas



Math, Modeling & Design

Physical Systems



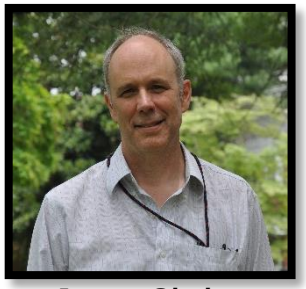
Human-Machine Systems

Social Systems

Program Managers

Fariba Fahroo
Mathematics

Anne Fischer
Chemical Systems



James Gimlett
Physics

Jan Vandenbrande
Math, Design, & Production Automation

John Paschkewitz
Systems, Design, & Materials

Michael Fiddy
Inverse Problems in Electromagnetics

John Main
Material System Innovation

Adam Russell
Behavioral/Social Sciences

Ale Lukaszew
Physics/Materials

Predrag Milojkovic
Imaging & Optics

Reza Ghanadan
Complexity Science

Vincent Tang
Applied Physics

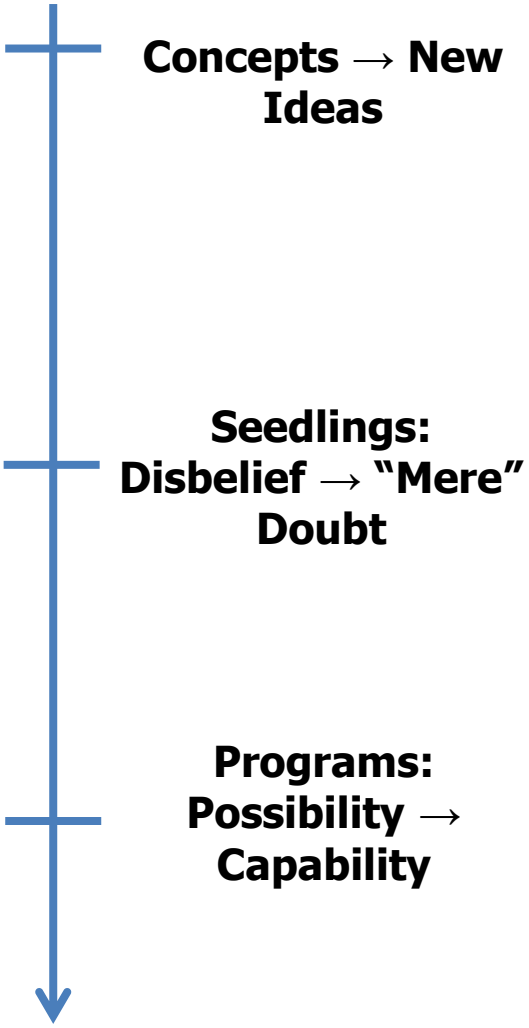
Three Ways to Engage with DSO

Talk to a Program Manager (PM)

- Email/phone/face to face throughout the year

Submit ideas to the DSO Office-Wide BAA (BAA-16-46)

Respond to DSO program BAAs



How we think: The Heilmeier Catechism

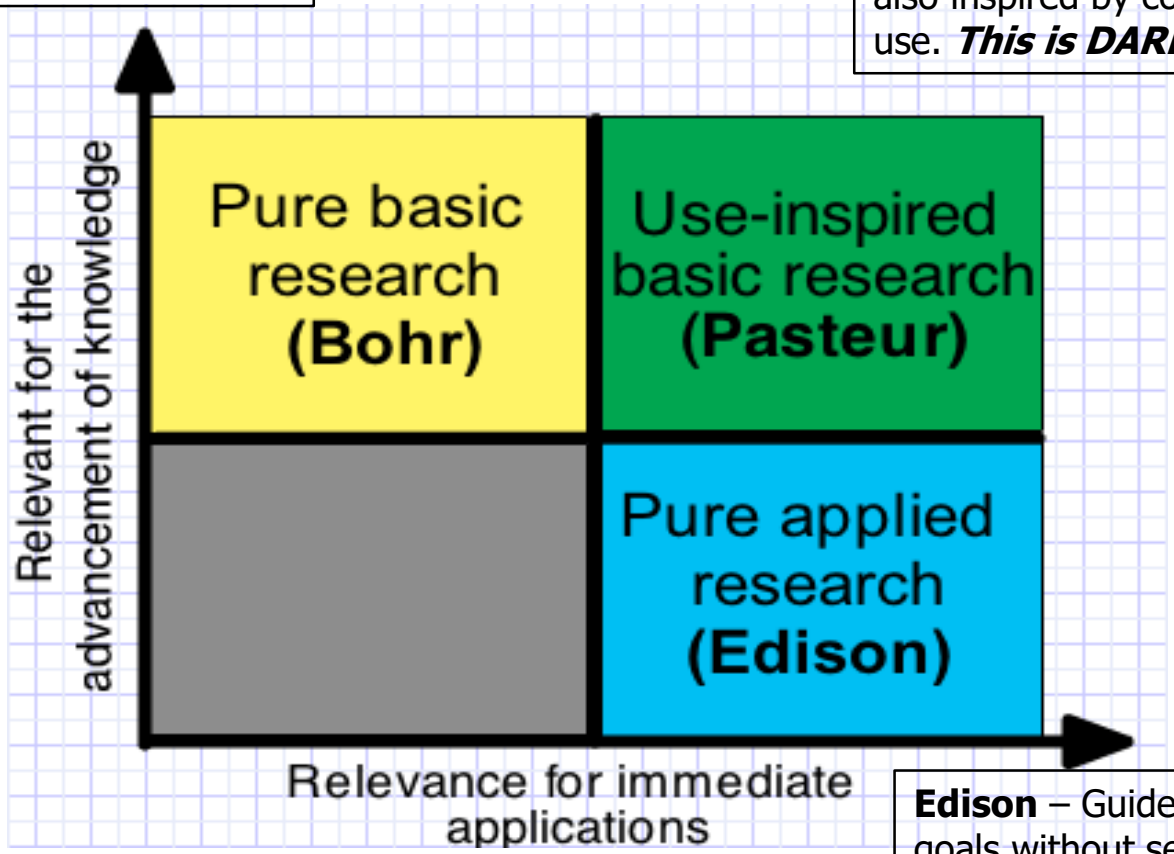
Important questions to consider when approaching DARPA with ideas:

- What are we trying to do? (no jargon!)
- How does this get done at present?
- What is new about your approach?
- If we succeed, what difference do we think it will make?
- How long do we think it will take?
- Can we transition (to the DoD or others)?
- How much will it cost?

Pasteur's Quadrant: DARPA's Power Lane

Bohr – Guided solely by the quest for understanding without thought of practical use.

Pasteur – Includes Basic Research that seeks to explain the frontiers of understanding, but is also inspired by considerations of use. ***This is DARPA***.



***Pasteur's Quadrant, Basic Science and Technological Innovation*, Donald E. Stokes, 1997**

Edison – Guided solely by applied goals without seeking a more general understanding of the phenomena of a scientific field.

Characteristics of a DARPA Program

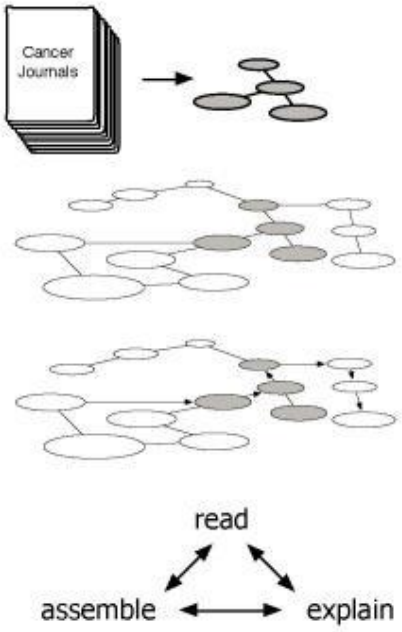
- Revolutionary ideas that may lead to new national security capabilities (not extensions or incremental gains)
- Initiated on ideas articulated to the director by program managers
- Project centric – not investigator centric
- Multi-year research portfolios to encourage "diverse" teams
- Flexible, rapid review and contracting
- Actively managed by the Program Manager
- Driven by quantitative technical goals and milestones
- DARPA programs start quickly and END—having an on-going program in a domain does not imply we will continue to invest in that area
- "Old problems" CAN be revisited if there is a compelling reason, e.g., if a technological breakthroughs or great ideas have emerged
- We are looking for focus, commitment and dogged persistence in our performers; and a willingness to take on DARPA-worthy problems

DSO Recent Programs

Improv	Scope emerging threats to military personnel, technology, and operations posed by commercially available technology and products	BAA release: 3/11/2016
Next Generation Social Science (NGS2)	New experimental methods, models, and practices for conducting research into complex social systems	BAA release: 3/18/2016
Intense and Compact Neutron Sources Phase Two (ICONS2)	Revolutionary increases in neutron source intensity and reductions in device size, weight, and power (SWaP) for in-the-field neutron radiography and analytical techniques.	BAA release: 4/28/2016
Accelerated Computation for Efficient Scientific Simulation (ACCESS)	Computational architectures that will achieve the equivalent of petaflops performance in a benchtop form-factor and be capable of what traditional architectures would define as "strong" scaling for predictive scientific simulations of interest	BAA release: 5/6/2016
Transformative Design (TRADES)	Develop/exploit new mathematics to incorporate advanced materials and manufacturing techniques into the design of solid parts and structures	BAA release: 5/11/2016
Extreme Optics and Imaging (EXTREME)	Optical systems capable of extreme performance and/or capabilities, which utilize Engineered Optical Materials (EnMats)	BAA release: 8/24/2016
Young Faculty Award (YFA)	Identify and engage rising stars in junior faculty positions in academia and equivalent positions at non-profit research institutions and expose them to Department of Defense (DoD) and National Security challenges and needs	RA release: 9/29/2016
Gamifying the Search for Strategic Surprise (GS3)	Apply a unique combination of online game and social media technologies and techniques to engage a large number of experts and deep thinkers in a shared analytic process to rapidly identify, understand, and expand upon the potential implications and applications of emerging science and technology	SN release: 11/30/2016
Agile Teams (A-Teams)	Discover, test and demonstrate generalizable mathematical abstractions for the design of agile human-machine teams and to provide predictive insight into team performance	BAA release: 12/5/2016
RadioBio	Establish if purposeful communication via electromagnetic waves between biological systems exists, and if it does, will determine what mechanisms are involved and what information is being transferred	BAA release: 2/15/2017
Molecular Informatics	Explore new approaches to store and process information with molecules	BAA release: 3/31/2017
Ground Truth	Use artificial but plausible simulations with known causal rules (aka "ground truth") as testbeds to validate social science modeling methods	BAA release: 4/28/2017

Some Emerging Opportunities

- **Harnessing IT & computation to accelerate innovation**
  - Can we re-think the relationship between man and machine and how, together, they can engage in creativity, design and scientific discovery?
- **The exploiting the central role of data**
  - Where do we need new methods of representation?
  - Can we harvest knowledge, including legacy knowledge, to extend our collective expertise?
  - Examples: SIMPLEX (DSO), Big Mechanism (I2O)
- **Expanding the reach of modeling and simulation**
  - What are the implications of desktop supercomputers and access to massive quantities of computation?
  - Can we improve models of physics and environments? How to handle interfaces across physics/energy domains?
  - What abstractions are needed to design and model systems with behavioral embodiments that span orders-of-magnitude in length (e.g., $1x10^{-6}$m (μm) to 10^2 m) and time ($1x10^{-15}$ s (fs) to decades ($1x10^{9}$))?
- **Complexity**
  - How can we master complexity? How can we harness complexity?

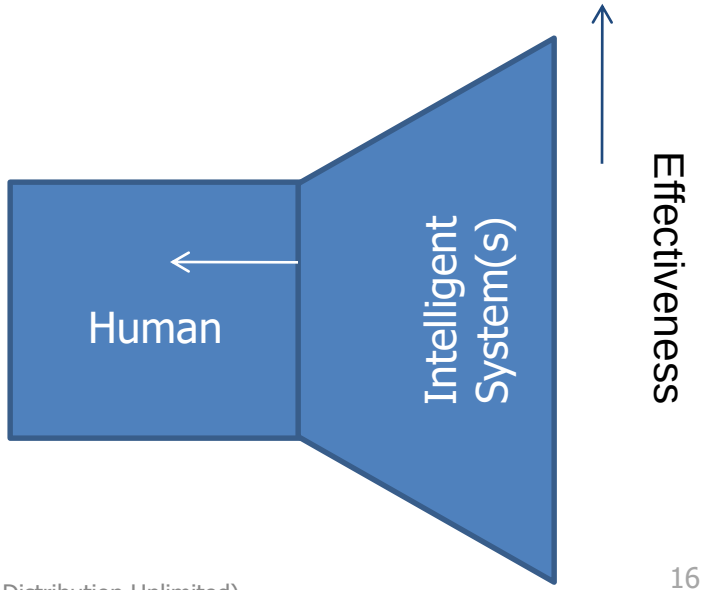


A DSO Perspective: Scientific Foundations of Autonomy

- Can we enhance the relationship between humans and machines?
- Accelerate engineering innovation and scientific discovery
- Improve the performance machines and their effectiveness
- Extend human capabilities by advancing software, devices and systems

Man-Computer Symbiosis
J. C. R. Licklider (head of IPTO 1962)
IRE Transactions on Human Factors in Electronics, volume HFE-1, pages 4-11, March 1960

Engelbart, Douglas C (October 1962). "**Augmenting Human Intellect: A Conceptual Framework**". *SRI Summary Report AFOSR-3223, Prepared for: Director of Information Sciences, Air Force Office of Scientific Research*. SRI International.



How to get DARPA Notifications from FedBizOpps

- Go to https://www.fbo.gov/
- Click on Register Now under the Vendors/Citizens section
- Fill in requested information
- Create user name and password
- Click Submit
- A verification email will be sent to complete the registration process
- Once you click on that link, you will log in and be on the My FBO page
- Click on Opportunities; click Advanced Search; scroll to Specific Agency/Office field and type Defense Advanced Research Projects Agency; identify specific criteria if desired and finally click Search
- All opportunities for DARPA will appear
- At the top of the page, hit Save Search Agent - name the search
- Under Search Agents you can schedule a run for daily, weekly or monthly inputs - you will get automatic notifications based on what you select
- For specific opportunities of interest, hit the Watch List button on that page - these will be added to your Watch List and email updates should be sent to you

www.darpa.mil