Defense Advanced Research Projects Agency

Peter Highnam, PhD
Acting Director

National Defense Industrial Association (NDIA)
Pacific Operational Science & Technology (POST) Conference

March 9, 2021

Distribution Statement A: Approved for public release; distribution unlimited

DARPA

PREVENT AND IMPOSE TECHNOLOGICAL SURPRISE

YEARS	GOVT. EMPLOYEES	BUDGET	PROGRAMS	YEARS OF AVG PM TENURE
63	194	$3.5B	250+	4

DEFEND THE HOMELAND

Cyber deterrence

Countering hypersonics

Bio threat detection and mitigation

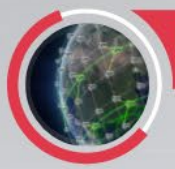
Defense against WMT

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

Distribution Statement A: Approved for public release

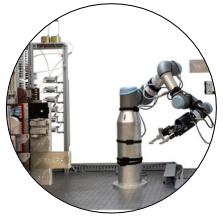
AI Next Campaign: $2B over five years to drive AI technologies

*90+ programs **applying** AI*

RF spectrum

SC2

Drug discovery

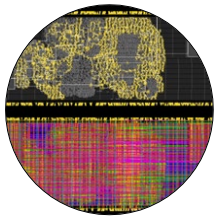


Make-It

Piloting

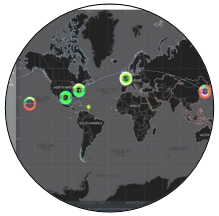
ALIAS

Chip design



IDEA

Cybersecurity



HACCS

Underground operations

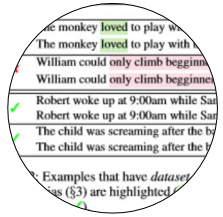
SubT

*27 programs **advancing** AI*

Explainability

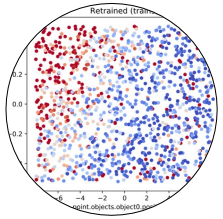
XAI

Reasoning



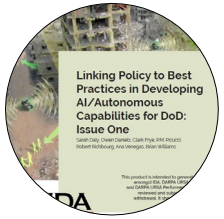
MCS

Robustness



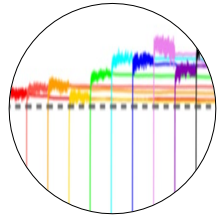
Assured Autonomy

Ethics



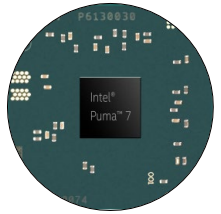
URSA

Generalizability



L2M

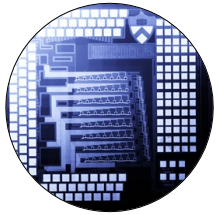
Extreme performance



HIVE

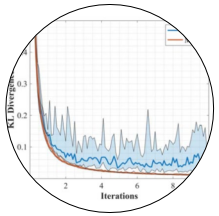
*18 topics **exploring** new frontiers in AI*

Electro-optical AI hardware



PEACH

Learning with limited data

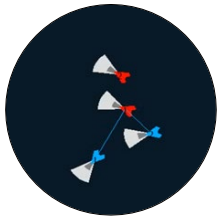


VIP

Insect brain-modeled hardware

µBRAIN

AI-based military game theory

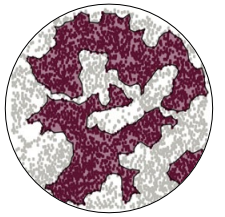


SI3-CMD

Physics-informed AI

AIRA

Controlling complex systems



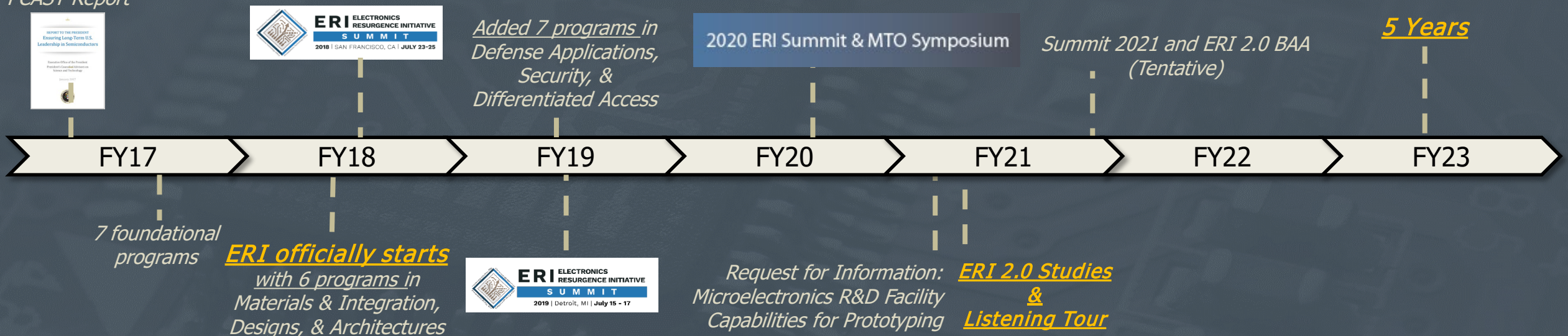
PAI

Distribution Statement A: Approved for public release; distribution unlimited

ERI: $1.5B over five years to drive microelectronics technologies

THE ELECTRONICS RESURGENCE INITIATIVE

Consisting of *20+* new and existing DARPA programs, ERI aims to forge forward-looking collaborations among the commercial electronics community, defense industrial base, university researchers, and the DoD to ensure far-reaching improvements in electronics performance well beyond the limits of traditional scaling



Universities

Arizona State University
Brown University
Cornell University
Georgia Tech
MIT
Princeton University
Purdue University
Stanford University
University of California
University of Illinois - UC
University of Michigan
University of Minnesota
University of Southern CA
University of Texas
University of Utah
University of Washington
Yale University

Commercial

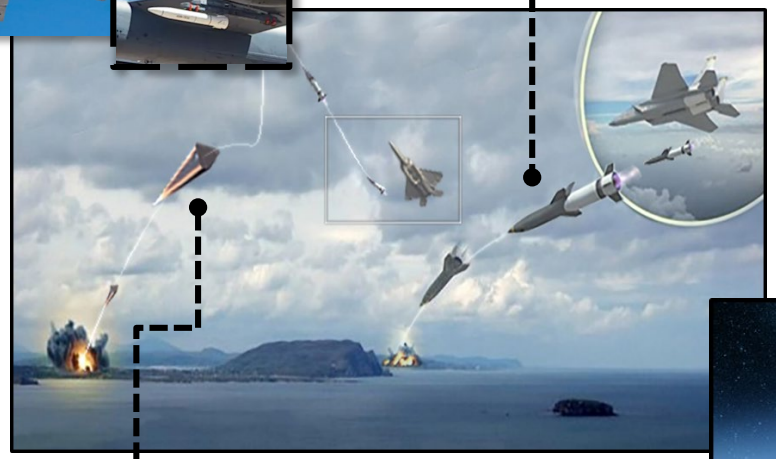
Applied Materials
ARM
Cadence
Ferric Semiconductor
GlobalFoundries
IBM
Intel
Micron
NVIDIA
Qualcomm
Samsung
Skywater
Synopsys
STR
TSMC
Xilinx

Defense

Army Research Lab
Boeing
General Dynamics
General Electric
HRL Laboratories
Lockheed Martin
NIST
Northrop Grumman
Oak Ridge National Lab
Raytheon
Sandia National Labs

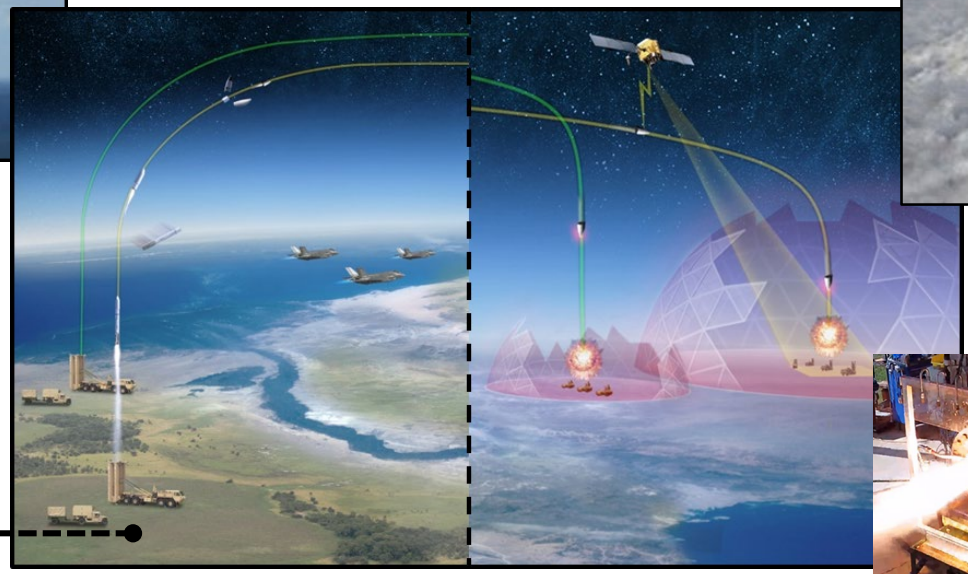
Air-launched and ground-launched hypersonics

HAWC Hypersonic Air-breathing Weapon Concept

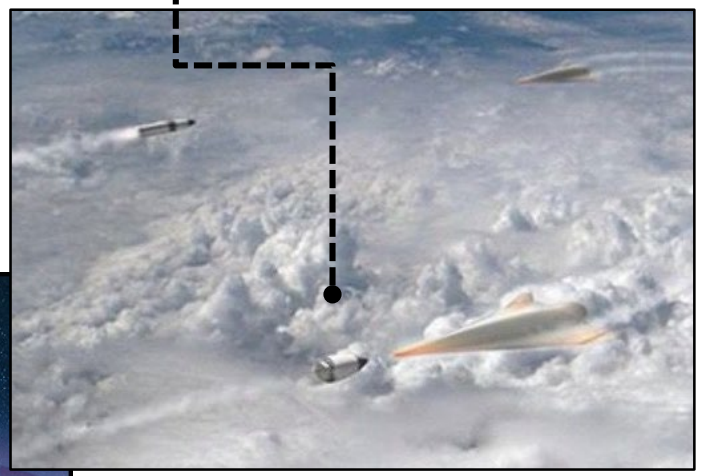


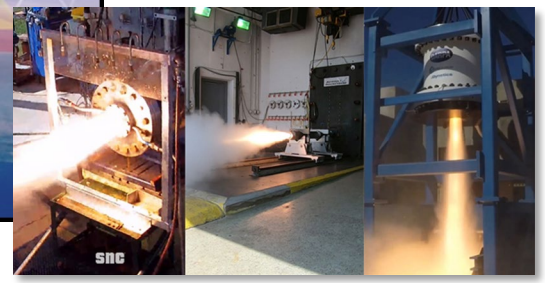
TBG Tactical Boost Glide

OpFires Operational Fires



Glide Breaker *Countering hypersonics*



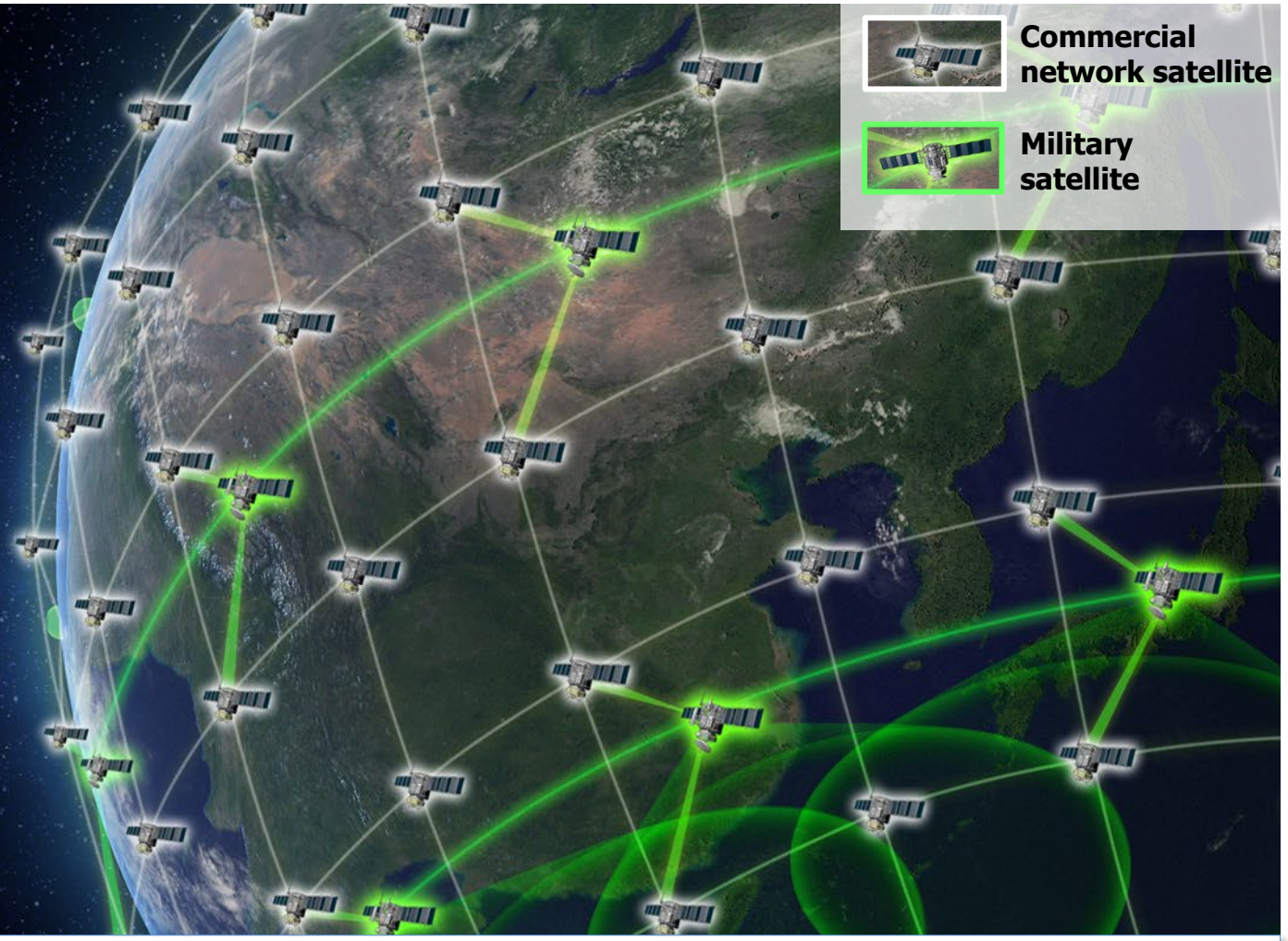


Robust space – Blackjack

Military space – Pivot to Low Earth Orbit

Leverage:
Commercial LEO mega-constellation
- Global "Space Internet"
- High-speed crosslinks
- Launch and ground infrastructure in place

Develop:
Co-orbiting military demo constellation
- Rapid tech refresh
- Resilience
- Global persistence
- Autonomous ops
- Low-cost COTS bus
- Rapid response to future threats



Blackjack: Demonstrate a space order of battle architecture that cannot be easily defeated by a near peer, and enables one-to-two-year technology refresh cycles vs. current 10-year cycles

Defense Advanced Research Projects Agency

Recently

Anticipated the needs of the COVID-19 fight

3 vaccine development processes de-risked

moderna	2013-2019
inovio	2013-2019
medicago	2009-2013

Jim Langevin @JimLangevin · May 21

.@RepStefanik & I make the case in @thehill that federal investment in science, technology & innovation through support for agencies like @Darpa is a necessity & can help lead us out of the COVID-19 pandemic & protect us against similar future crises.

32 drugs screened using human organ chip technology

1ST open-source, interactive map of virus:host molecular interaction

8 antibodies selected for manufacturing (8,000+ discovered)

AstraZeneca AbCellera Duke UNIVERSITY Lilly VANDERBILT UNIVERSITY

Partnered with the Services and Interagency

NIH BARDA DEFENSE HEALTH AGENCY WRAIR JPEO-CBD NAVAL MEDICAL RESEARCH CENTER U.S. NAVY plus-ups ASPR CONGRESS

1ST blood sample received in the U.S. AbCellera

3 EUAs enabled (8 others targeted)

10 military & commercial aircraft tested

38 APIs produced using flow synthesis, providing the first implementation of flexible, scalable, and portable production toward a diversified, resilient pharmaceutical supply chain

EUA: Emergency Use Authorization
API: Active Pharmaceutical Ingredient

UNCLASSIFIED

Engineered Living Materials (ELM)

Engineer living building materials that grow on-site, self-repair, and respond predictably to their environment.

UNCLASSIFIED
Distribution Statement A. Approved for public release; distribution unlimited

UNCLASSIFIED

Test Case 5

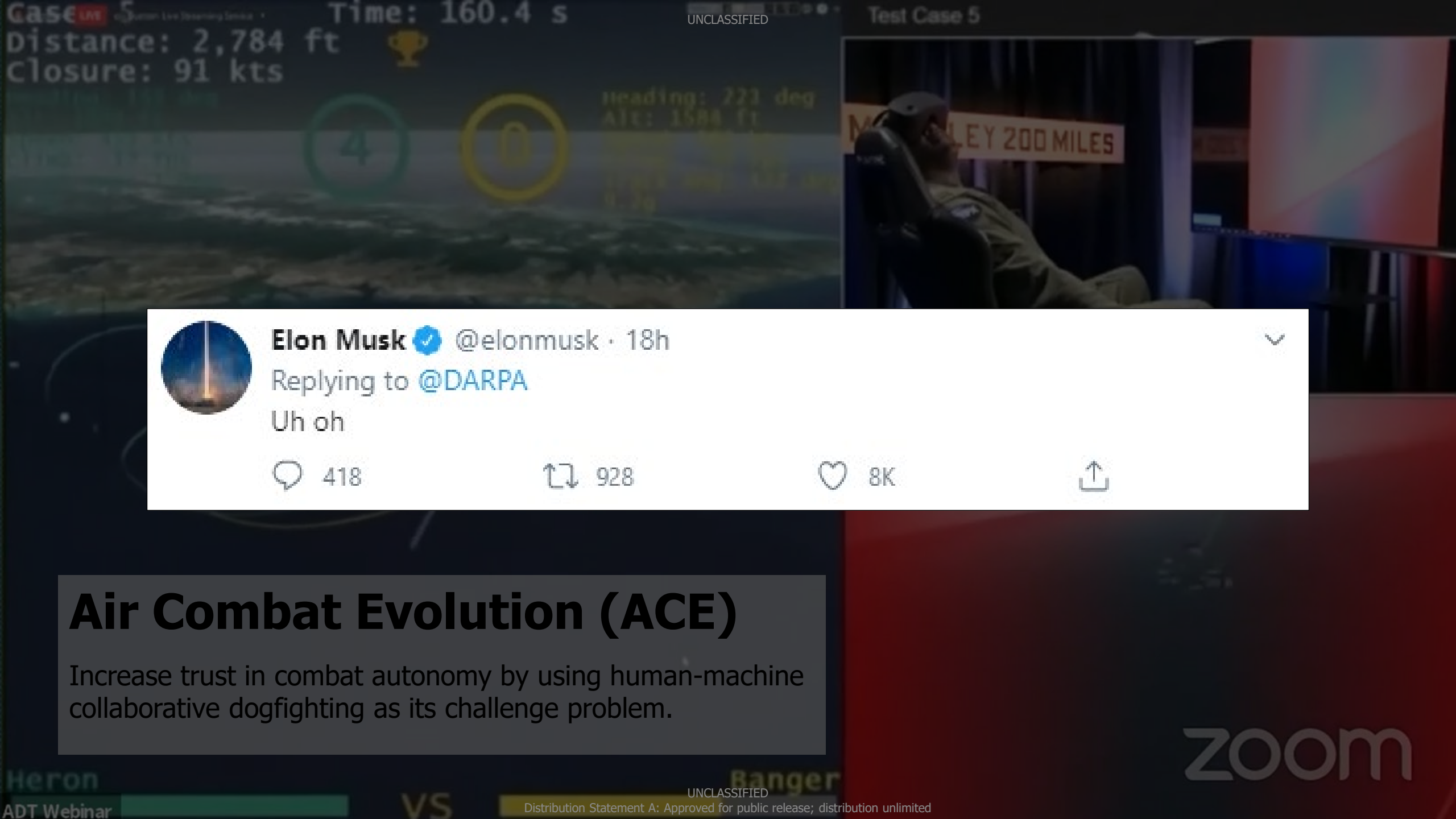
Air Combat Evolution (ACE)

Increase trust in combat autonomy by using human-machine collaborative dogfighting as its challenge problem.

zoom

UNCLASSIFIED
Distribution Statement A: Approved f tribution unlimited

UNCLASSIFIED



Elon Musk @elonmusk · 18h

Replying to @DARPA

Uh oh

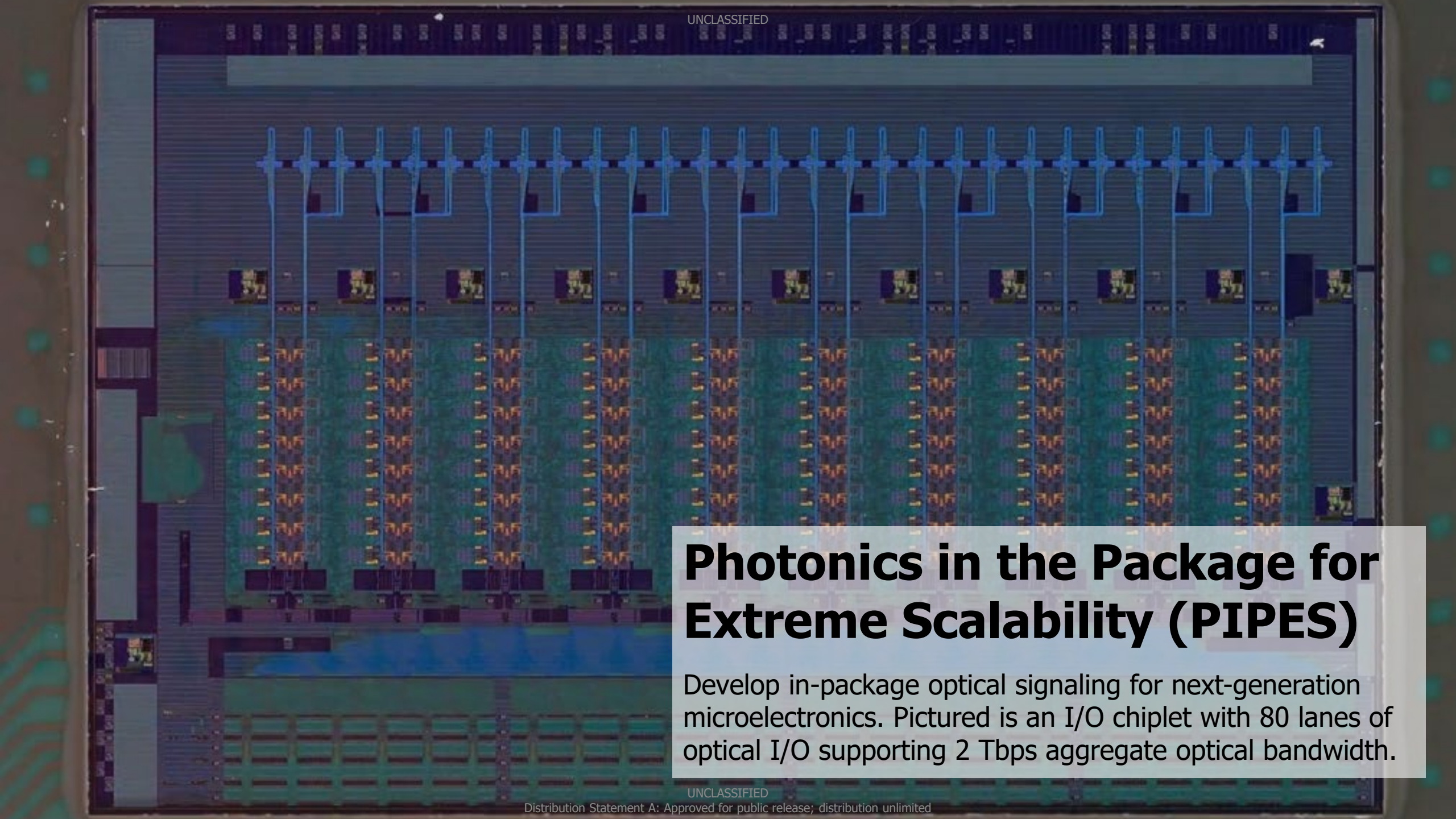
418 928 8K

Air Combat Evolution (ACE)

Increase trust in combat autonomy by using human-machine collaborative dogfighting as its challenge problem.

UNCLASSIFIED
Distribution Statement A: Approved for public release; distribution unlimited

UNCLASSIFIED



Photonics in the Package for Extreme Scalability (PIPES)

Develop in-package optical signaling for next-generation microelectronics. Pictured is an I/O chiplet with 80 lanes of optical I/O supporting 2 Tbps aggregate optical bandwidth.

UNCLASSIFIED
Distribution Statement A: Approved for public release; distribution unlimited

UNCLASSIFIED

DARPA wants you to HACK Our SSITH Hardware

FETT

FINDING EXPLOITS TO THWART TAMPERING

Three Months of Open Hacking

587 Ethical Hackers

Over 13,000 hours hacked

Only 10 Vulnerabilities Found

UNCLASSIFIED
Distribution Statement A: Approved for public release; distribution unlimited

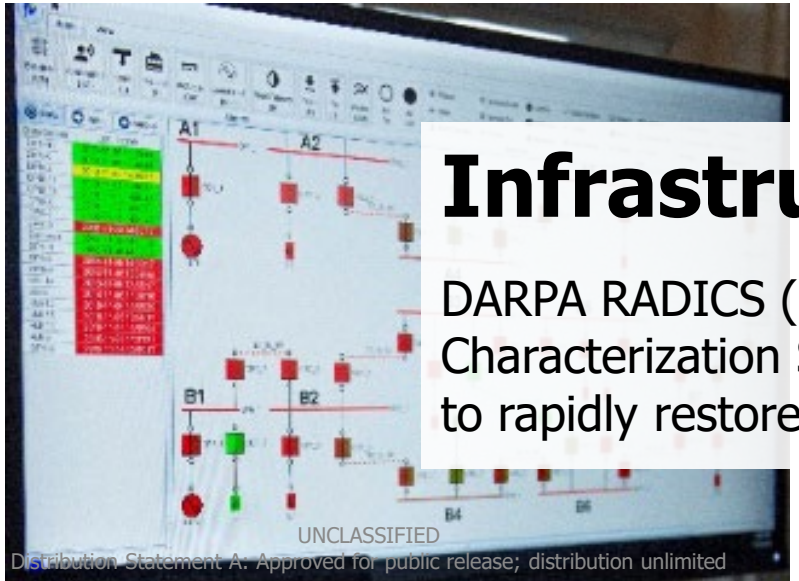
UNCLASSIFIED

Subterranean Challenge (SubT)

Revolutionize how we operate in the underground domain by developing novel approaches to rapidly map, navigate, and search underground environments during time-sensitive combat operations or disaster response scenarios.

UNCLASSIFIED
Distribution Statement A: Approved for public release; distribution unlimited

UNCLASSIFIED



Infrastructure resilience

DARPA RADICS (Rapid Attack Detection, Isolation and Characterization Systems) delivered novel technologies to rapidly restore the electrical grid after cyberattack.

UNCLASSIFIED
Distribution Statement A. Approved for public release; distribution unlimited

DARPA launches entrepreneurial initiative to propel over 150 cutting-edge national security innovations to market

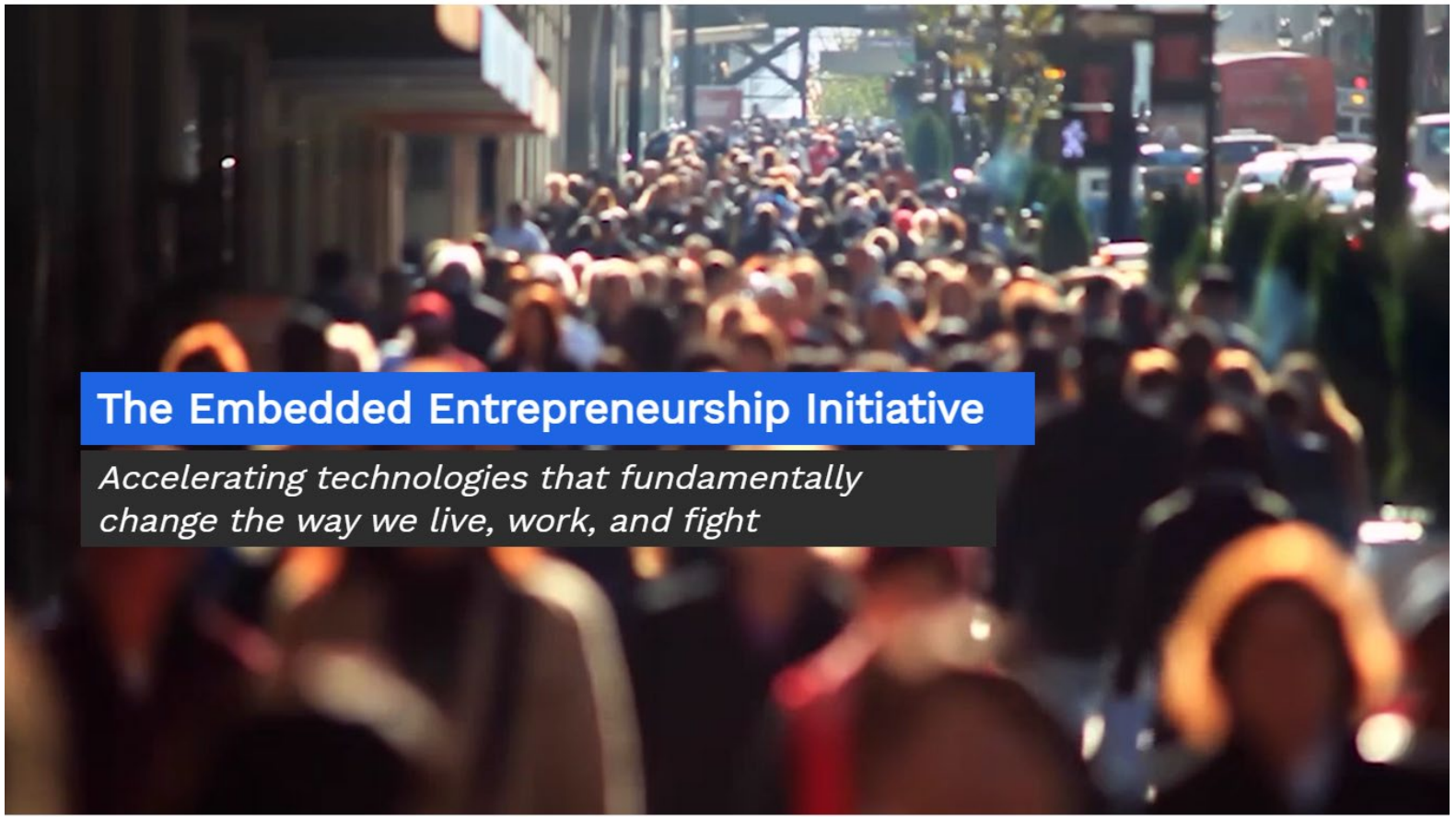
What: U.S. entrepreneurs paired with researchers to provide U.S. investment and business advice

Who: DARPA in partnership with IQT Emerge

Why: Ensure DARPA tech transitions to use for U.S. national security

Results to-date:

- **14** venture rounds closed
- **$110M** in U.S. venture capital raised
- **$0** foreign investment raised
- **12** joint development agreements and licensing deals with corporations
- **>100** top-tier U.S. investors in DARPA's Transition Working Groups

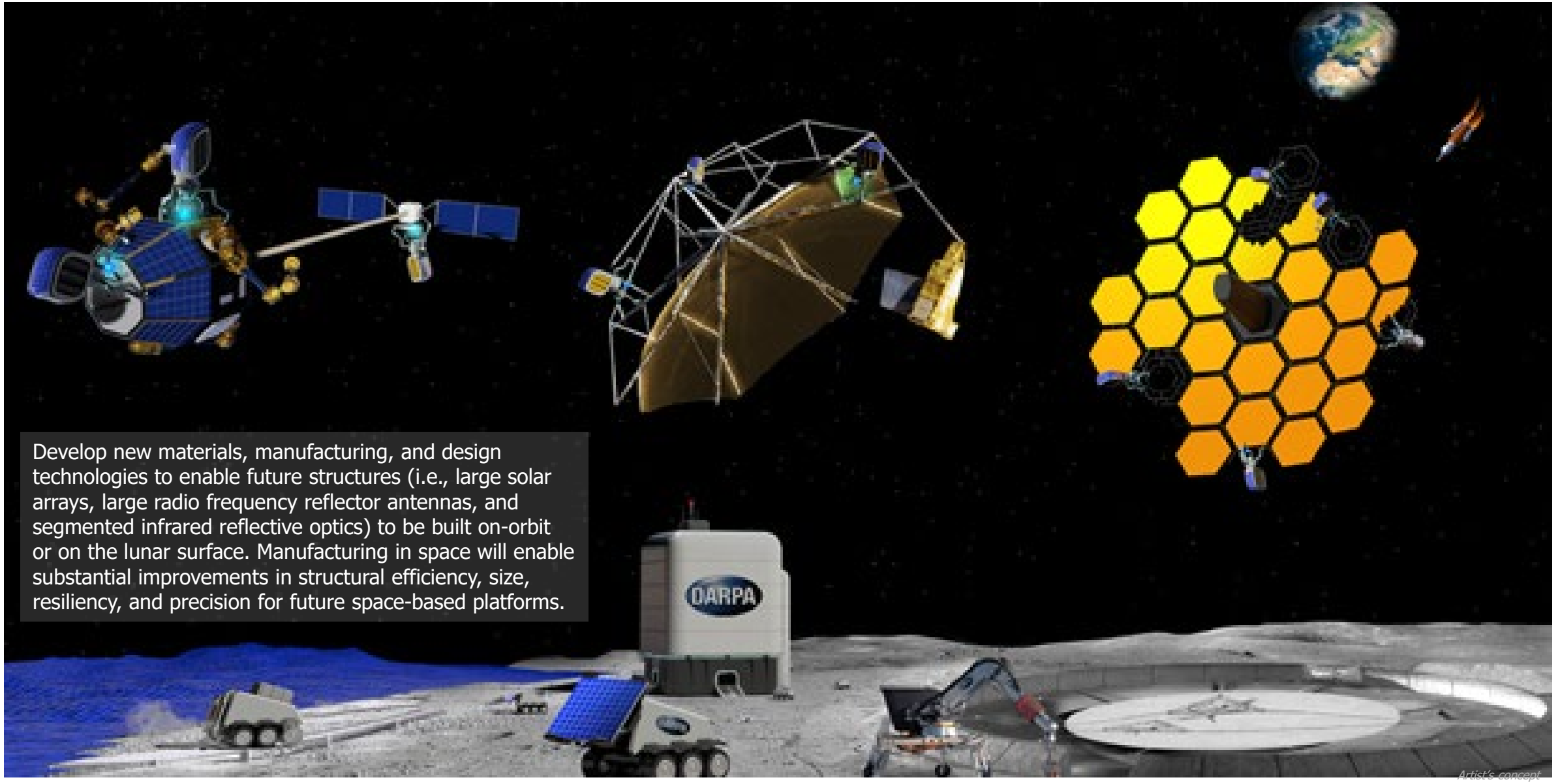


https://eei.darpa.mil/

Defense Advanced Research Projects Agency

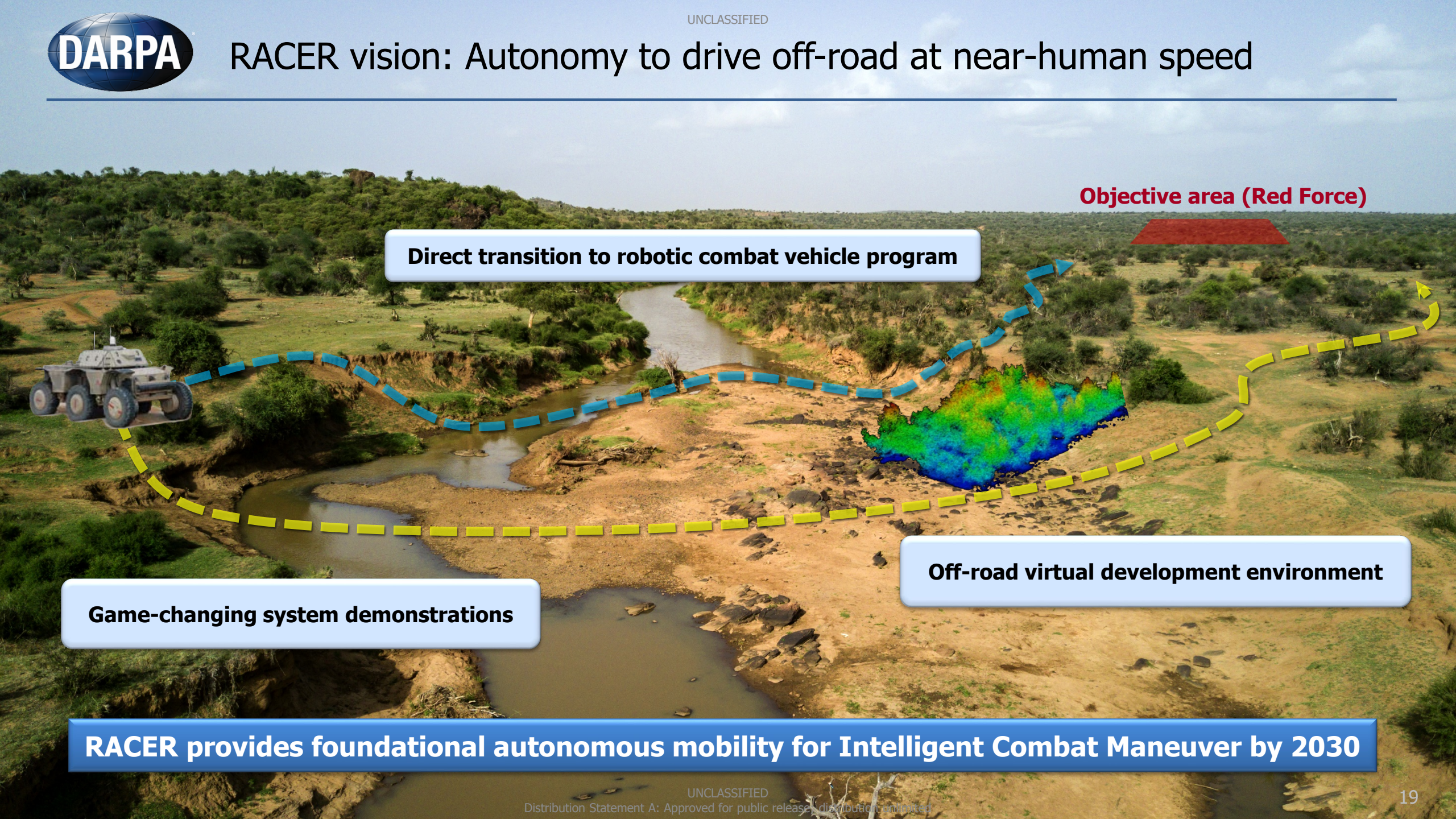
More recently

Novel Orbital and Moon Manufacturing, Materials, & Mass-efficient Design (NOM4D)



Develop new materials, manufacturing, and design technologies to enable future structures (i.e., large solar arrays, large radio frequency reflector antennas, and segmented infrared reflective optics) to be built on-orbit or on the lunar surface. Manufacturing in space will enable substantial improvements in structural efficiency, size, resiliency, and precision for future space-based platforms.

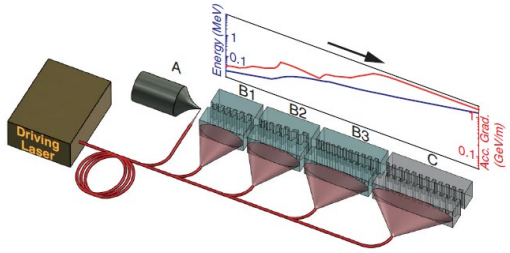
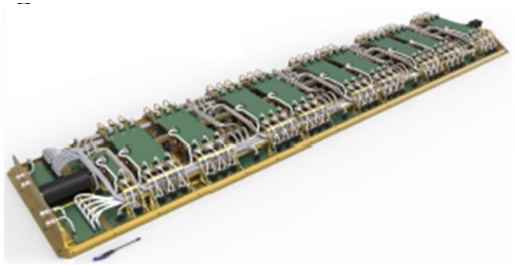
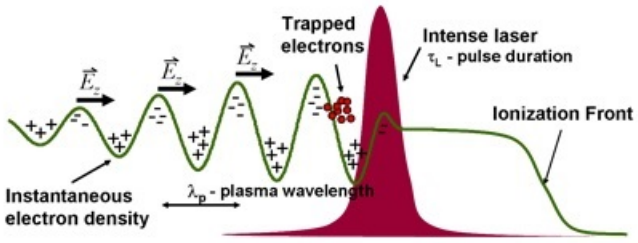
RACER vision: Autonomy to drive off-road at near-human speed



RACER provides foundational autonomous mobility for Intelligent Combat Maneuver by 2030

Advanced Concept Compact Electron Linear-accelerator (ACCEL)

Candidate technologies

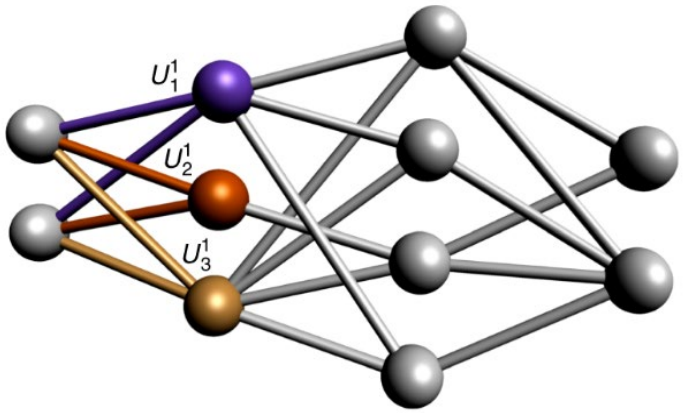
Conventional RF-driven Linear Accelerators (LINACs) 	Dielectric Laser Accelerators 
Conventional RF-driven LINAC with Gallium Nitride Amplifiers 	Wakefield Accelerators 

Develop, build and demonstrate a compact, ruggedized electron accelerator for multiple applications

Enhanced Night Vision in eyeglass form (ENVision)

Reversible/Quantum Machine Learning and Simulation (RQMLS) AIE

Low-Entropy Machine Learning



Nature Communications **11**, 808 (2020) © Nature

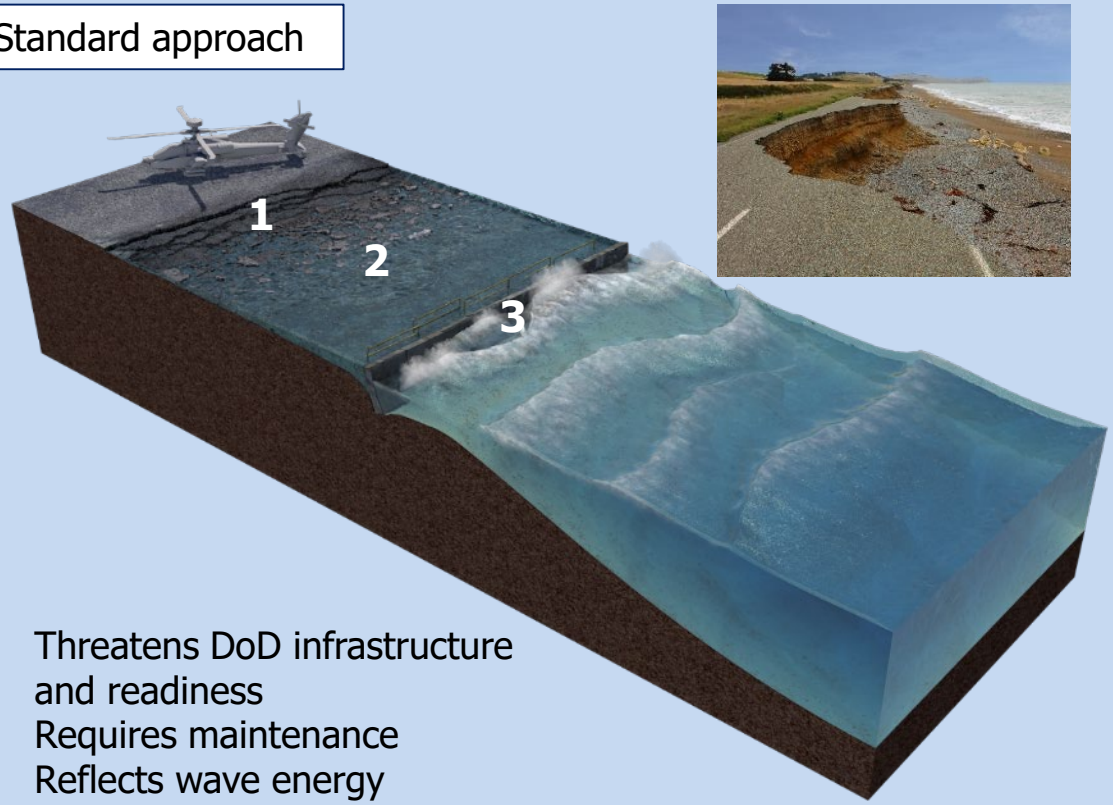
The Landauer Limit
Quantum annealers can nearly reach the theoretical limit of information processing efficiency

Degrees of Freedom
The number of degrees of freedom in a quantum annealer scale exponentially with system size

Can quantum annealers accelerate Machine Learning applications?

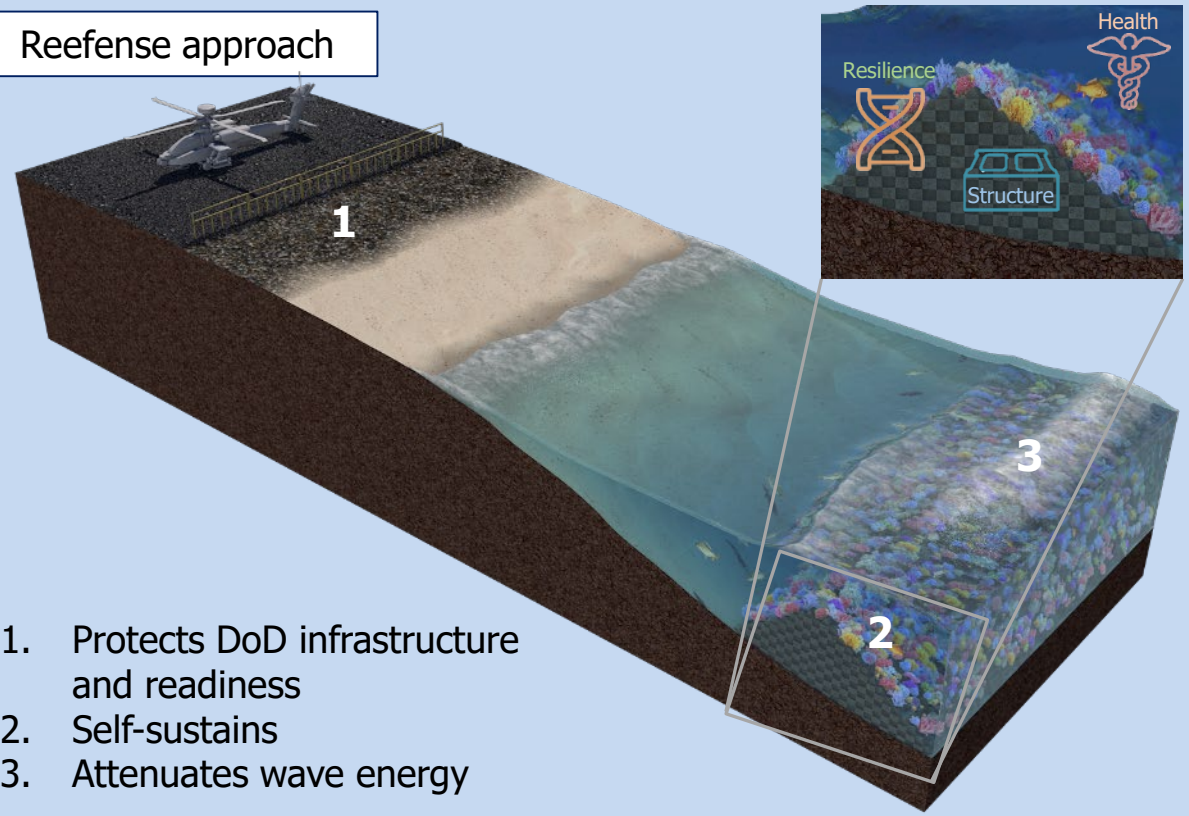
Reefense

Standard approach



1. Threatens DoD infrastructure and readiness
2. Requires maintenance
3. Reflects wave energy

Reefense approach



1. Protects DoD infrastructure and readiness
2. Self-sustains
3. Attenuates wave energy

Vision: Develop hybrid biological and engineered reef-mimicking structures to mitigate wave and storm damage that increasingly threaten DoD personnel and infrastructure

DARPA

PREVENT AND IMPOSE TECHNOLOGICAL SURPRISE

YEARS	GOVT. EMPLOYEES	BUDGET	PROGRAMS	YEARS OF AVG PM TENURE
63	194	$3.5B	250+	4

DEFEND THE HOMELAND

Cyber deterrence

Countering hypersonics

Bio threat detection and mitigation

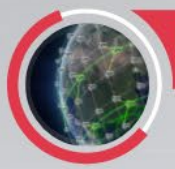
Defense against WMT

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

Distribution Statement A: Approved for public release

www.darpa.mil