

Preserving Technological Superiority

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Defense R&E Strategy

The United States depends on science, technology and innovative engineering to not only protect the American people but to advance our national interests and to prepare us to meet the challenges of an uncertain future.

Mitigate current and anticipated threat capabilities.

Affordably enable new capabilities in existing military systems.

Create technology surprise through science and engineering.

Investing in science and technology to support the Warfighter.

Innovation Influences Strategy

Leveraging innovation opportunities

Innovation enables Strategy

Time to Market

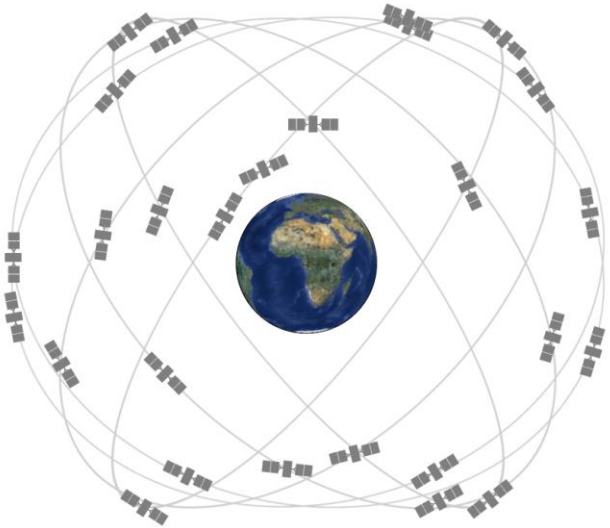
Laboratory to Field

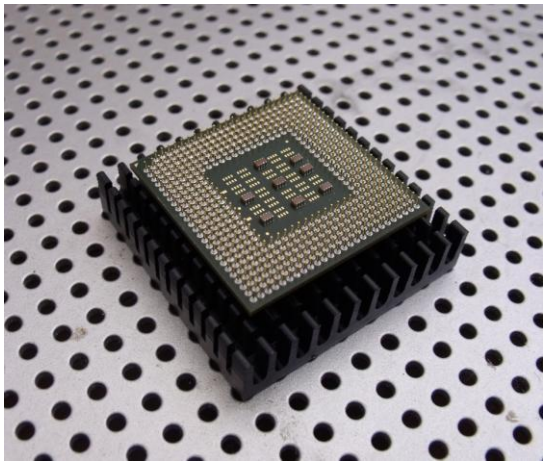
The DoD needs the ability to harness advanced technology from all possible sources.

Innovation Across the Defense Enterprise

- Creating operational advantage – **not just technology**
- Inventing new techniques and processes – **Opening opportunities**
- **Engaging in the art of the possible** – with allies and partners
- Driving **cost-effective capabilities** for the warfighter
- Developing long-term and sustainable **disruptive advantage**
- Collaborating internally (labs) and externally (e.g., industry, academia)

The U.S. has enjoyed a 40 year technological advantage





But the environment and the threats are changing….

- **Global access** to resources, technology and talent
- Competitor investments
- **Speed and pace of technical opportunity**
- Cost and cycle time

Previous "Offset" Strategies

"First Offset Strategy" – 1950s

Nuclear deterrence to avoid a large increase in defense expenditures to conventionally deter Warsaw Pact forces during the 1950s

"Second Offset Strategy" – 1970s

Development of precision-guided munitions to deter both conventional and unconventional aggression from Soviet Forces.

Capabilities from the 2nd offset strategy continue to enable U.S. technological superiority today.

3OS Technology Approach

Seeks to deny adversary objectives, and strengthen conventional deterrence by:

- **Leveraging autonomy and artificial intelligence**
  - Get inside an adversary's decision cycle
- **Greatly expanding manned-unmanned combat teaming**
  - Extend our attack surface
- **Re-amplifying our guided-munitions advantage**
  - With 'raid-breaking' capabilities
- **Creating new mass**
  - Disaggregating complex systems to deliver combine effect
- **Developing 'inside-out' and 'over-under' capabilities**
  - Leverage dispersal, sanctuaries, and speed
- **Developing new forms of distributed maneuver**
  - Combining kinetic, electronic warfare (EW), cyber

Five Key Areas

Autonomous Learning Systems

- Delegating decision to machines in applications that require faster-than-human reaction times
  - Cyber defense, EW, missile defense

Human-machine Collaborative Decision Making

- Exploiting the advantages of both humans and machines for better and faster ***human*** decisions
  - "Human strategic guidance combined with the tactical acuity of a computer"

Assisted Human Operations

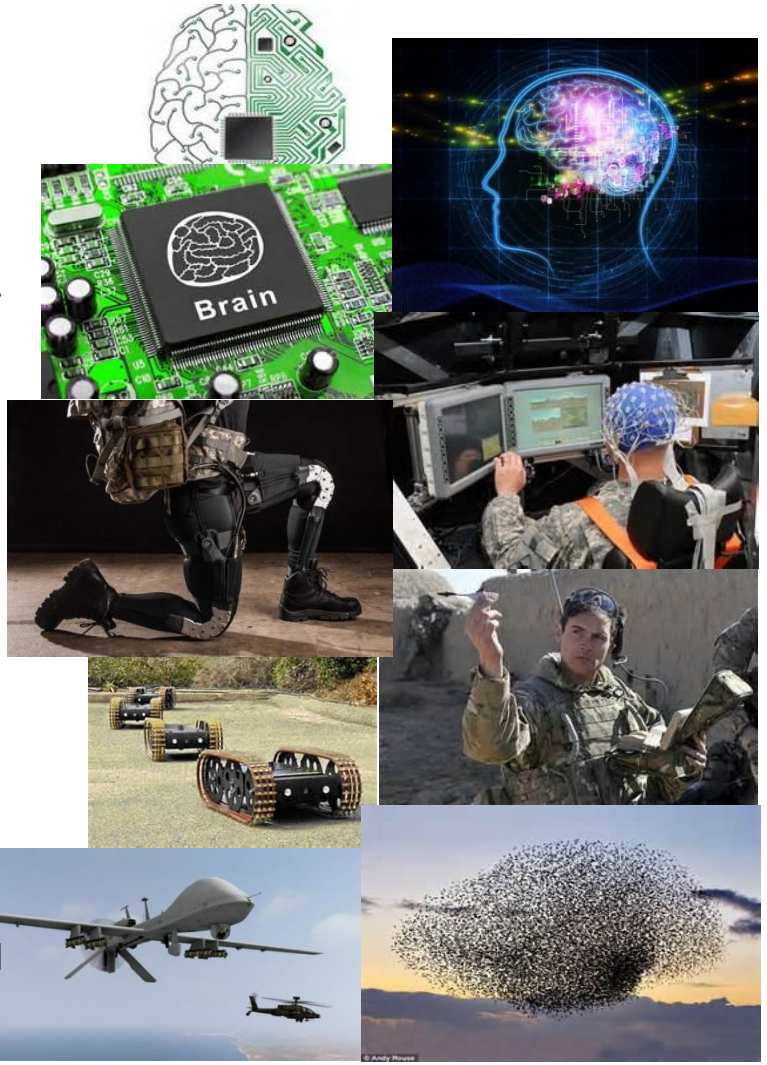
- Helping humans perform better in combat

Advanced Manned-unmanned System Operations

- Employing innovative cooperative operations between manned and unmanned platforms
  - "**Smart swarm**" operations and tactics

Network-enabled, Autonomous Weapons Hardened to Operate in a Future Cyber/EW Environment

- Allowing for cooperative weapon concepts in comms-denied environments



Five Challenges to the Systems Engineering Community

- Implementing agile systems engineering methods
- Safeguarding critical information
- Developing flexible system designs
- End-to-end mission engineering
- Rigorous development planning

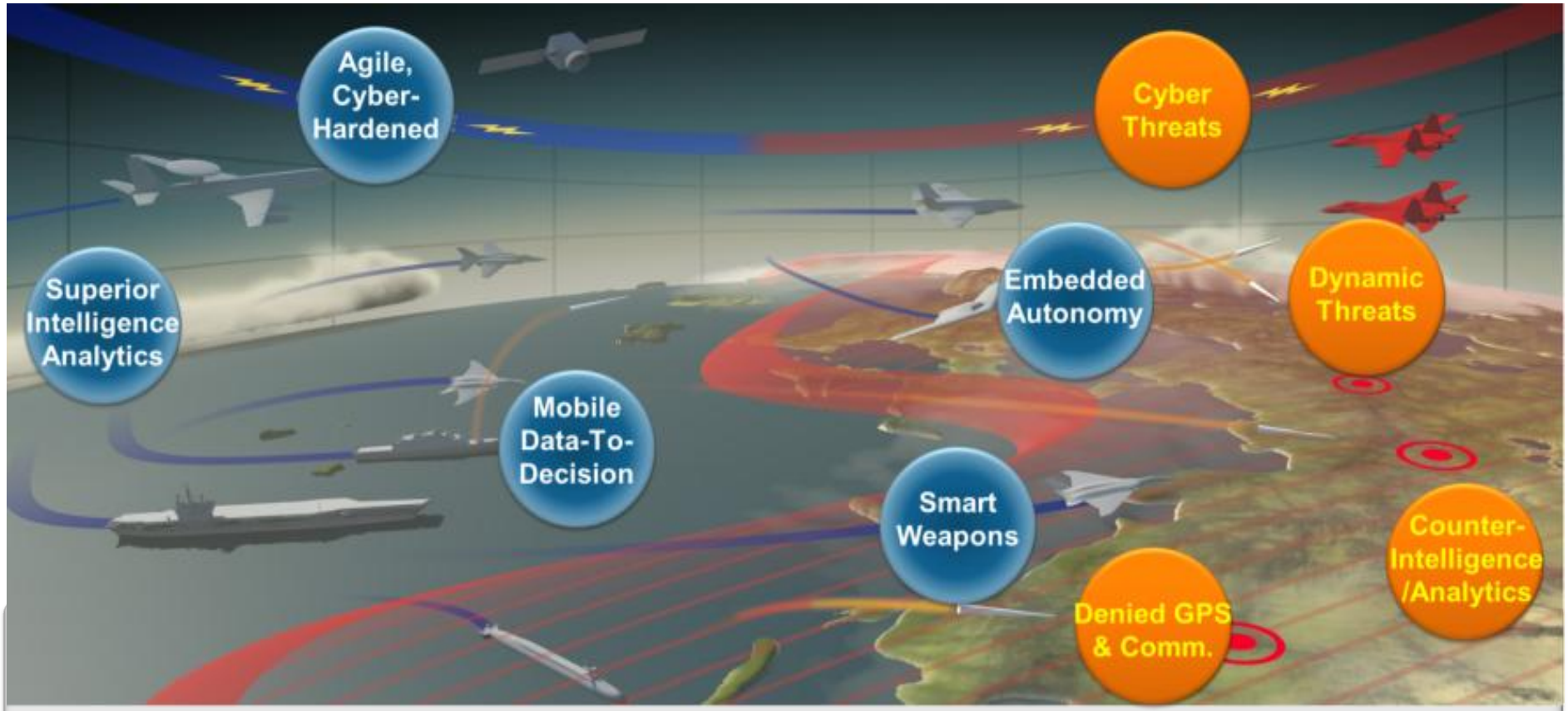
Future Challenges

Autonomy/AI

Synthetic Biology

Why Do We Need Autonomy/AI?

—to counter sophisticated threats—



- Increase the speed and accuracy of decisions
- Enable new tactics and operational concepts requiring persistence and endurance
- Reduce the risk of casualties to both civilians and US troops
- Enable operations in Cyber/EW environments
- Enable use of unmanned platforms when comms to those platforms are denied
- Enable ability to operate platform if human operators are injured or killed

Four Autonomy/AI Area within the DoD

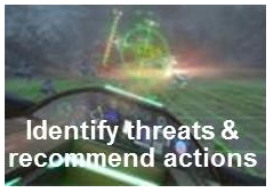
- **Machine Perception, Reasoning, and Intelligence**
  - Perception, reasoning, and intelligence allows for entities to have existence, intent, relationships, and understanding in the battle space relative to a mission.
- **Human / Autonomous System Interaction and Collaboration**
  - The keys to maximizing the human-agent interaction are: instilling confidence and trust among the team members; understanding of each member's tasks, intentions, capabilities, and progress; and ensuring effective and timely communication. All of which must be provided within a flexible architecture for autonomy; facilitating different levels of authority, control, and collaboration.
- **Scalable Teaming of Autonomous Systems**
  - Collaborative teaming is a fundamental paradigm shift for future autonomous systems. Such teams are envisioned to be heterogeneous in size, mobility, power, and capability.
- **Test, Evaluation, Validation, and Verification**
  - The creation of design based verification and validation (V&V) methods and novel developmental and operational test and evaluation (T&E) techniques that focus on the unique challenges of autonomy, including state-space explosion, unpredictable environments, emergent behavior, and human-machine communication.

The DoD S&T Autonomy Roadmap

Autonomy can transform the DoD by expanding operational capabilities with improved safety, effectiveness and manpower efficiencies.

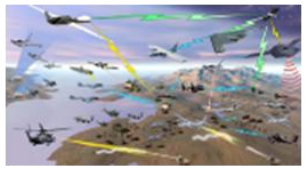
Operating Safely & Efficiently

Machine-Assisted Operations



Logistical Operations

Man-Unmanned Teams



Near-Term
Present - 2020

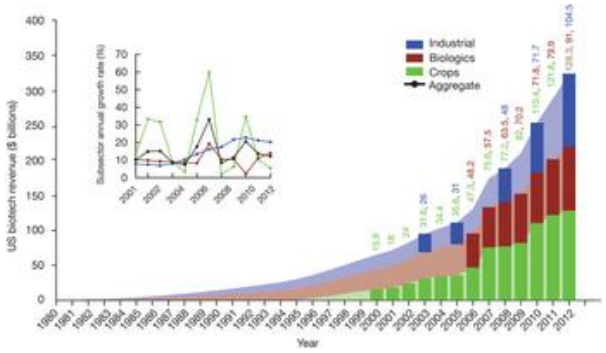
Mid-Term
2020-2030

Far-Term
2030+

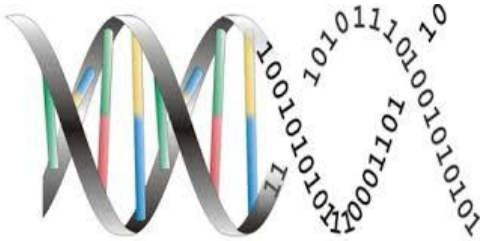
Present: Biotechnology

DIY Bio – Community labs are being established all over the country. These user facilities lower the financial and intellectual barrier to entry and opportunities for oversight.

The use of monocultures essential for large scale agriculture presents a potential vulnerability to an engineered pathogen.



Biotechnology is a substantial and rapidly growing contributor to the U.S. economy. Estimated contribution for 2012 is >$320B.

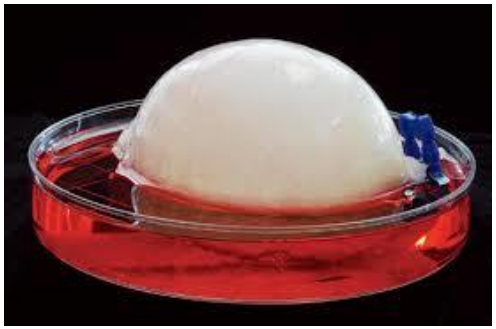


Big data and informatics tools, including artificial intelligence, are being applied to the biodesign space resulting in faster and more robust systems.

Crops are being engineered to improve yield, increase drought tolerance, limit the need for pesticides, and enhance nutrition to feed the growing global population.

Commercial production of chemicals ranging from flavors and fragrances to fuels is being shifted from petroleum to bio-based processes.

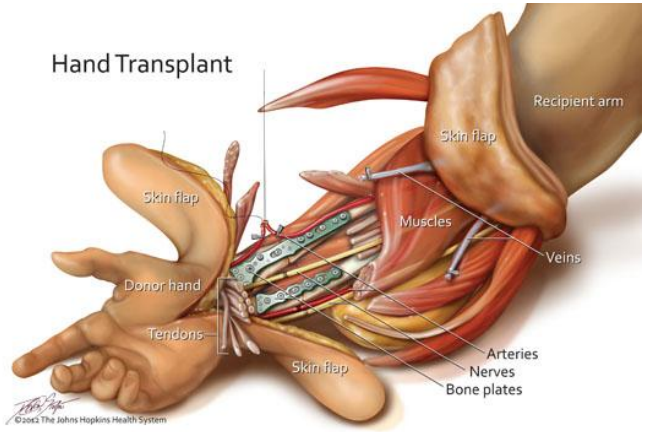
Present: Biotechnology



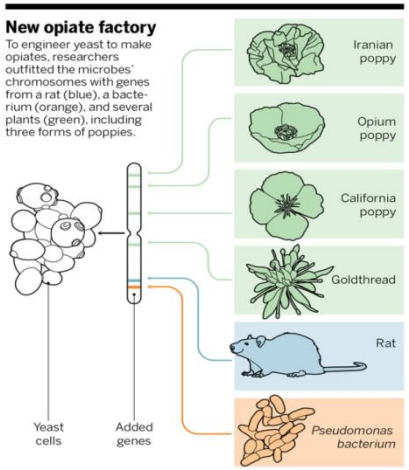
Simple human tissues and organs are being grown in culture from stem cells and implanted in people.

This thumb drive-sized sequencer connects to a laptop, rapidly reads DNA, and identifies genetic material in uncharacterized samples.

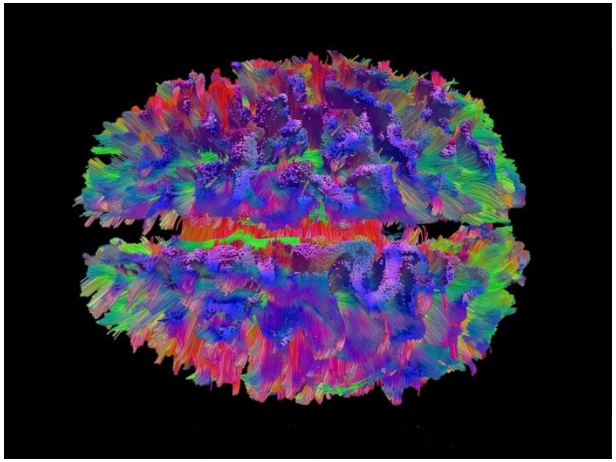
Chinese scientists are using gene editing tools to engineer animals to have desired physical traits.



DoD researchers have pioneered systems for hand transplantation that restore significant functionality.

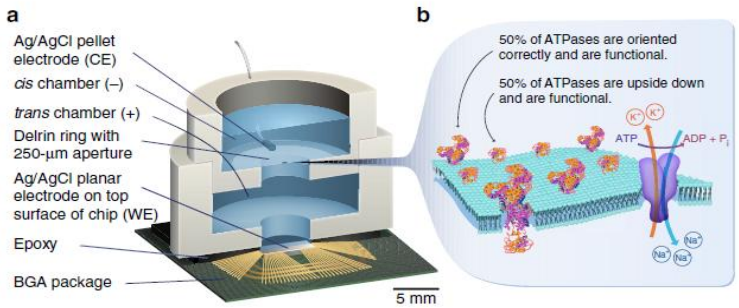


US researchers used gene editing tools to engineer yeast that make opiates via biochemical processes.

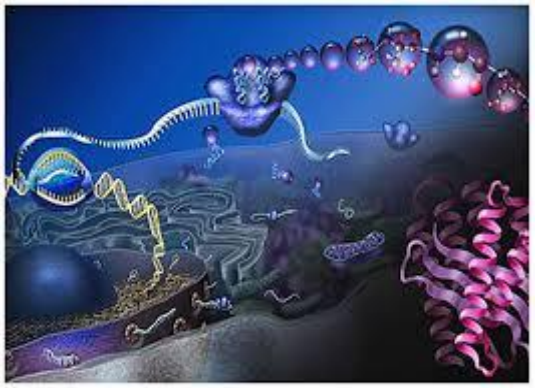


DoD researchers are using new non-invasive imaging techniques to map neural pathways and understand TBI.

Future Trends: Biotechnology

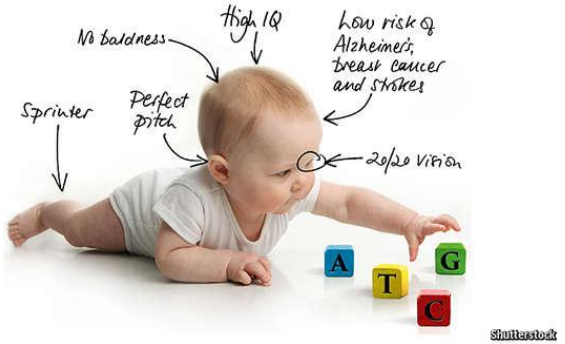


Coupling of artificial biological systems to integrated circuits will enable reliable low-level environmentally generated power for persistent electronic devices.



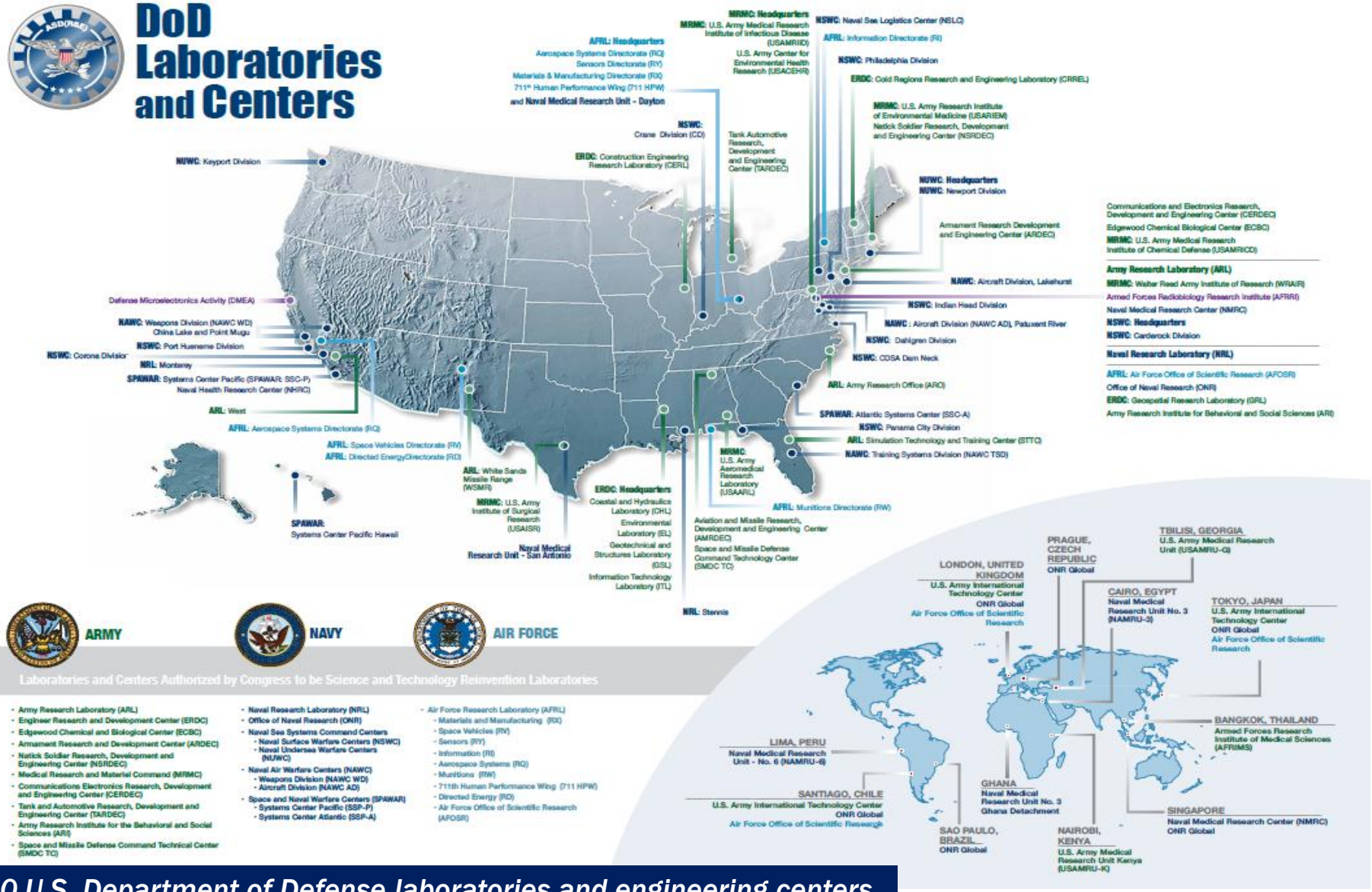
Gene editing and functional biology will enable intelligent design of organic nanomachines and cellular factories that manufacture at the molecular level.

Advances in DNA synthesis will unlock its data storage capacity (~700 terabytes/gram), allowing for physical archives of critical digital data that cannot be hacked.



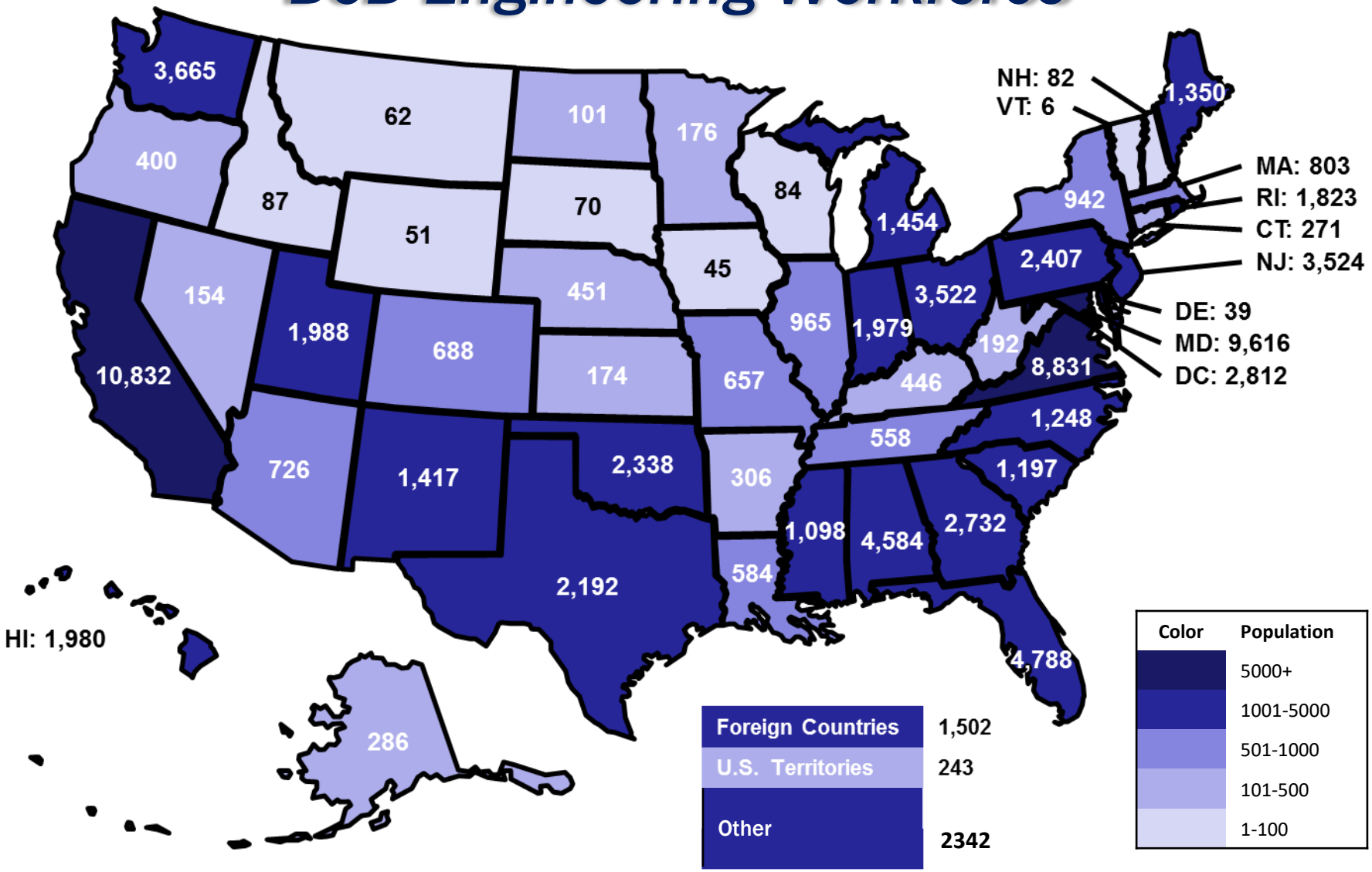
Gene editing will progress beyond preventing heritable disorders and could enable directed engineering of humans with selected traits.

DoD Laboratories and Centers



60 U.S. Department of Defense laboratories and engineering centers provide expertise and insight to enhance our warfighter's capability .

Geographic Distribution of DoD Engineering Workforce



Data Source: FedScope, 30 September 2015

Engineering Workforce Breakout

as of 31 March 2016

DoD-Wide

Defense Acquisition Workforce

Engineering (Non-Construction)

Civilian Occupational Series & Description	Count
0801 - GENERAL ENG	16,493
0802 - ENG TECHNICAL	10,691
0806 - MATERIALS ENG	840
0818 - ENG DRAFTING	2
0830 - MECHANICAL ENG	11,129
0840 - NUCLEAR ENG	2,430
0850 - ELECTRICAL ENG	3,458
0854 - COMPUTER ENG	3,486
0855 - ELECTRONICS ENG	16,413
0856 - ELECTRONICS TECHNICAL	5,574
0858 - BIOENG AND BIOMEDICAL ENG	99
0861 - AEROSPACE ENG	4,287
0871 - NAVAL ARCHITECTURE	866
0873 - MARINE SURVEY TECHNICAL	118
0881 - PETROLEUM ENG	1
0893 - CHEMICAL ENG	807
0895 - INDUSTRIAL ENG TECHNICAL	993
0896 - INDUSTRIAL ENG	1,044
0899 - ENG AND ARCH STUDENT TRAINEE	1,197
GRAND TOTAL	**79,928**

Engineering (Non-Construction)

Component	Count
Army	19,025
DoN	41,687
Air Force	15,381
4th Estate	3,835
GRAND TOTAL	**79,928**

Acquisition Engineering Career Field

Civilian Occupational Series & Description	Count
0855 - ELECTRONICS ENG	10,730
0801 - GENERAL ENG	7,869
0830 - MECHANICAL ENG	5,976
1550 - COMPUTER SCIENTIST	3,496
0861 - AEROSPACE ENG	2,907
0854 - COMPUTER ENG	2,523
0850 - ELECTRICAL ENG	1,423
1515 - OPS RESEARCH ANALYST	659
1310 - PHYSICIST	553
0893 - CHEMICAL ENG	499
OTHER (INCLUDING ACTIVE DUTY MILITARY)	4,690
GRAND TOTAL	**41,325**

Acquisition Engineering Career Field

Component	Military	Civilian	Total Count
Army	0	9,063	9,063
DoN	224	21,019	21,243
Air Force	1,403	7,546	8,949
4th Estate	0	2,070	2,070
GRAND TOTAL	1,627	39,698	41,325

Data Sources:
Engineering (Non-Construction) – Defense Civilian Personnel Data System, 31 March 2016
Acquisition Engineering Career Field – USD(AT&L) Defense Acquisition Workforce Data Mart, 31 March 2016

Better Buying Power 3.0

Achieving Dominant Capabilities through Technical Excellence and Innovation

Achieve Affordable Programs
- Continue to set and enforce affordability caps

Achieve Dominant Capabilities While Controlling Lifecycle Costs
- Strengthen and expand "should cost" based cost management
- Anticipate and plan for responsive and emerging threats by building stronger partnerships of acquisition, requirements, and intelligence communities
- Institutionalize stronger DoD level Long Range R&D Program Plans
- Strengthen cybersecurity throughout the product lifecycle

Incentivize Productivity in Industry and Government
- Align profitability more tightly with Department goals
- Employ appropriate contract types, but increase the use of incentive type contracts
- Expand the superior supplier incentive program
- Ensure effective use of Performance-Based Logistics
- Remove barriers to commercial technology utilization
- Improve the return on investment in DoD laboratories
- Increase the productivity of corporate IRAD

Incentivize Innovation in Industry and Government
- Increase the use of prototyping and experimentation
- Emphasize technology insertion and refresh in program planning
- Use Modular Open Systems Architecture to stimulate innovation
- Increase the return on and access to small business research and development
- Provide draft technical requirements to industry early and involve industry in funded concept definition
- Provide clear and objective "best value" definitions to industry

Eliminate Unproductive Processes and Bureaucracy
- Emphasize acquisition chain of command responsibility, authority, and accountability
- Reduce cycle times while ensuring sound investments
- Streamline documentation requirements and staff reviews
- Remove unproductive requirements imposed on industry

Promote Effective Competition
- Create and maintain competitive environments
- Improve DoD outreach for technology and products from global markets
- Increase small business participation, including through more effective use of market research

Improve Tradecraft in Acquisition of Services
- Strengthen contract management outside the normal acquisition chain – installations, etc.
- Improve requirements definition for services
- Improve the effectiveness and productivity of contracted engineering and technical services

Improve the Professionalism of the Total Acquisition Workforce
- Establish higher standards for key leadership positions
- Establish stronger professional qualification requirements for all acquisition specialties
- Strengthen organic engineering capabilities
- Ensure development program leadership is technically qualified to manage R&D activities
- Improve our leaders' ability to understand and mitigate technical risk
- Increase DoD support for STEM education

CONTINUE STRENGTHENING OUR CULTURE OF:
COST CONSCIOUSNESS, PROFESSIONALISM, AND TECHNICAL EXCELLENCE

Focus on Prototyping

Strategic Use of Prototyping

- Evaluate new concepts, guide development, and demonstrate capability
- Sustain and support unique capabilities
- Stimulate design teams
- Contribute to new methods and manufacturing
- Promote open standards and competition

New Applications

- Accelerate technologies, products, and concepts
- Test Tactics, Techniques and Procedures

Sea Hunter

Competition for Talent

- **Need** to continue to **attract** the **best** and **brightest** to **national security service**
- Direct **competition for talent**

- **Eliminate barriers** to service
- **Increase recognition** of unique and relevant technical work **and innovative thinking**
- **Leverage all** sources of **talent**

The Future of the Ecosystem: STEM

Shaping our future force to ensure technological superiority

National Defense Education Program

- Provide education and outreach programs and activities that build the pipeline
- Promote increased participation of underserved groups
- Communicate the value of STEM investments as a critical enabler to the DoD mission

Science, Mathematics, and Research for Transformation (SMART) Scholarship Program

Scholarship-for-Service program designed to produce the next generation DoD S&T Leaders

- Education support covering
  - Full tuition and related education expenses
  - Stipends
  - Health Insurances and book allowances
- Summer Internships (multi-year participants)
- Post-Graduation career opportunities

Military Child Pilot Program

Establishing a department-wide, coordinated effort to create, implement and assess the pilot program to improve the education for military dependents

- Enhance the preparation of dependents of members of Armed Forces for careers in science, technology, engineering, and mathematics
- Develop innovative STEM educational programs for military children, leveraging capabilities of private sector, other federal agencies, and DoD laboratories

DoD R&E Enterprise
Pursuing Sustained Technical Advantage










DoD Research and Engineering Enterprise
http://www.acq.osd.mil/chieftechnologist/

Defense Innovation Marketplace
http://www.defenseinnovationmarketplace.mil

Twitter: @DoDInnovation