Preserving Technological Superiority

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Assistant Secretary of Defense for Research and Engineering

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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

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
“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.
30S 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 effects
- 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/Al

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
- Air Collision Avoidance
- Work-centered PED cell
- FY14 CNO USV Swarm Demo
- Autonomous Mobility Applique System

Machine-Assisted Operations
- Identify threats & recommend actions
- Longer Range
- Fuse sensor data and cue analyst
- Logistical Operations

Man-Unmanned Teams

Near-Term
Present - 2020

Mid-Term
2020-2030

Far-Term
2030+
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 noninvasive 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.

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

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

Color Population
- 5000+: 3,665
- 1001-5000: 1,988
- 501-1000: 688
- 101-500: 1,417
- 1-100: 2,192

Foreign Countries: 1,502
U.S. Territories: 243
Other: 2342

HI: 1,980
MA: 803
RI: 1,823
CT: 271
NJ: 3,524
DE: 39
MD: 9,616
DC: 2,812
### Engineering Workforce Breakout

**as of 31 March 2016**

#### Engineering (Non-Construction)

<table>
<thead>
<tr>
<th>Civilian Occupational Series &amp; Description</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0801 - GENERAL ENG</td>
<td>16,493</td>
</tr>
<tr>
<td>0802 - ENG TECHNICAL</td>
<td>10,691</td>
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<tr>
<td>0806 - MATERIALS ENG</td>
<td>840</td>
</tr>
<tr>
<td>0818 - ENG DRAFTING</td>
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<tr>
<td>0830 - MECHANICAL ENG</td>
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<tr>
<td>0840 - NUCLEAR ENG</td>
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<td>0850 - ELECTRICAL ENG</td>
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<tr>
<td>0854 - COMPUTER ENG</td>
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<tr>
<td>0855 - ELECTRONICS ENG</td>
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<tr>
<td>0856 - ELECTRONICS TECHNICAL</td>
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<tr>
<td>0858 - BIOENG AND BIOMEDICAL ENG</td>
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<tr>
<td>0861 - AEROSPACE ENG</td>
<td>4,287</td>
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<tr>
<td>0871 - NAVAL ARCHITECT</td>
<td>866</td>
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<tr>
<td>0873 - MARINE SURVEY TECHNICAL</td>
<td>118</td>
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<tr>
<td>0881 - PETROLEUM ENG</td>
<td>1</td>
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<tr>
<td>0893 - CHEMICAL ENG</td>
<td>807</td>
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<tr>
<td>0895 - INDUSTRIAL ENG TECHNICAL</td>
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<tr>
<td>0896 - INDUSTRIAL ENG</td>
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<tr>
<td>0899 - ENG AND ARCH STUDENT TRAINEE</td>
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#### Acquisition Engineering Career Field

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<tr>
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<tr>
<td>0801 - GENERAL ENG</td>
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<td>0830 - MECHANICAL ENG</td>
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<td>0861 - AEROSPACE ENG</td>
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<td>0854 - COMPUTER ENG</td>
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<td>0850 - ELECTRICAL ENG</td>
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<tr>
<td>1515 - OPS RESEARCH ANALYST</td>
<td>659</td>
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<tr>
<td>1310 - PHYSICIST</td>
<td>553</td>
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<tr>
<td>0893 - CHEMICAL ENG</td>
<td>499</td>
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<tr>
<td>OTHER (INCLUDING ACTIVE DUTY MILITARY)</td>
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<td>GRAND TOTAL</td>
<td>41,325</td>
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#### DoD-Wide

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<th>Component</th>
<th>Military</th>
<th>Civilian</th>
<th>Total Count</th>
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<tr>
<td>Army</td>
<td>0</td>
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<td>9,063</td>
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<tr>
<td>DoN</td>
<td>224</td>
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<td>21,243</td>
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<tr>
<td>Air Force</td>
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<td>8,949</td>
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<tr>
<td>4th Estate</td>
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<tr>
<td>GRAND TOTAL</td>
<td>1,627</td>
<td>39,698</td>
<td>41,325</td>
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#### Data Sources:
**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