Air Force Space Command

AFSPC Long-Term S&T Challenges

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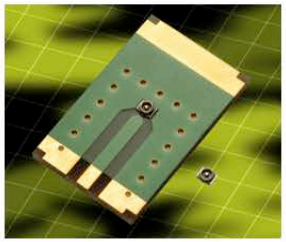
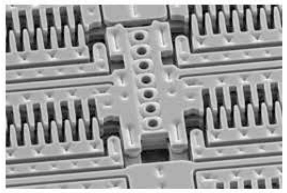
What New S&T Advances Will Create the Next Generation of USAF Capabilities?


Advanced sensors


Quantum computing

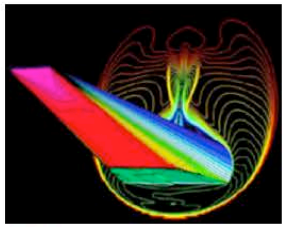

Microwave generators

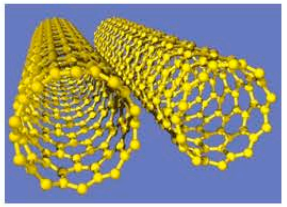

Micro-mechatronics

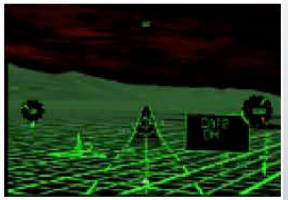

Whole-fusion knowledge


Blended wing-body


Autonomous refueling

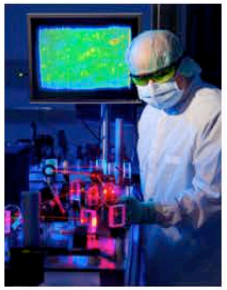

Advanced hypersonics

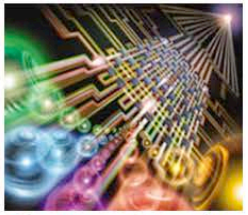

Nanotailored materials


Automotonic systems

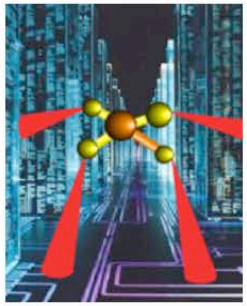

Hypersonic strike

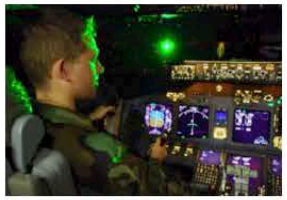

Morphing wings

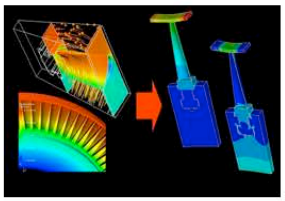

Surface adaptation

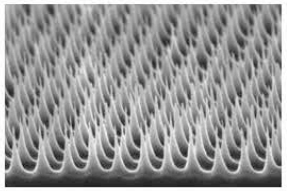

Convergent sensing


Advanced mobility


Cyber operations


Man-as-machine systems


Perpetual simulation


Nanostructured surfaces

Maintaining superior capabilities over its adversaries requires the Air Force to continually seek new science and technology advances and integrate these into fieldable systems

How We Get there: U.S. Air Force "Technology Horizons"

SecAF / CSAF Tasking Letter

THE SECRETARY OF THE AIR FORCE
CHIEF OF STAFF, UNITED STATES AIR FORCE
WASHINGTON DC

JUN 18 2009

MEMORANDUM FOR ALMAJCOM-FOA-DRU/CC
DISTRIBUTION C

SUBJECT: Technology Horizons Study

Air Force warfighting capabilities have a proud heritage of being born from the very best science and technology our Nation can create; indeed, the very history of the United States Air Force is closely intertwined with the development of advances in science and technology. Yet today, "flattening" of the world is making it increasingly challenging for the U.S. to maintain technology superiority over potential adversaries. A growing number of nations will soon have the ability to transform science and technology advances into militarily significant capabilities. Over the next decades, we will increasingly face potential adversaries having peer or near-peer capabilities. To remain the world's most capable Air Force, we must correctly anticipate the emerging science and technology advances that have the greatest military potential.

The Air Force Chief Scientist will conduct a study across the air, space, and cyberspace domains to develop a forward-looking assessment on a 20-year horizon of potential offensive and defensive capabilities and counter-capabilities of the Air Force and its future adversaries. This study will bring together scientists, engineers and operators from inside and outside the Air Force to develop a 10-year technology forecast, followed by a further 10-year forecast of new militarily significant capabilities that can be derived from those technologies. Using this "10+10 technology-to-capability" forecasting process, the study will seek to identify potential "leapfrog" and "game-changing" capabilities that could substantially alter future warfighting environments and affect future U.S. Joint capability dominance.

We believe this study can provide important insights in this pivotal time and we encourage support of its objectives. We expect that Air Force leaders at all levels may find the results useful in today's decision making as we work to ensure that our Air Force remains the world's most capable in 2030 and beyond.

Michael B. Donley
Secretary of the Air Force

Norton A. Schwartz
General, USAF
Chief of Staff

Terms of Reference (TOR)

USAF Chief Scientist Office

Technology Horizons and Capability Implications for the Air Force

Terms of Reference

Background

The rapid "flattening" of the world from a technology perspective is allowing science and technology advances made anywhere to be exploited globally for developing militarily significant new capabilities. Many countries already have, or soon will have, the ability to translate worldwide technology advances into new offensive and defensive capabilities in the air, space, and cyber domains, and across domain boundaries. International markets in military systems will diffuse these capabilities rapidly and broadly. As a result, over the next two decades the U.S. will face a growing number of nations having near-peer or peer capabilities, and may find it increasingly difficult to maintain the technology superiority over potential adversaries that it has had in the past. Correctly anticipating those science and technology advances that will have greatest potential military significance – and the capabilities and counter-capabilities that may be derived from them – can help avoid technology surprise and ensure U.S. capability dominance.

This study will seek to identify key advances in science and technology that are likely to occur over the next 10 years that could in the following 10 years be developed into significant military capabilities. The use of this "10+10 technology-to-capability" forecasting process distinguishes this study from others in the Air Force and elsewhere that aim to understand various aspects of the opportunities and threats that emerging technologies present. Using this process, the study will develop a forward-looking yet realistic assessment on a 20-year horizon of potential offensive and defensive capabilities and counter-capabilities of the Air Force and its possible future adversaries.

Study Products

Briefing to SAF/OS & AF/CC in December 2009. Publish report in February 2010.

Charter

The study will:

- Conduct a "next-decade" (2020) assessment of technology advances that will be key to future air, space, and cyber domain capabilities, and to potential cross-domain capabilities.
- Provide a "following-decade" (2030) assessment of U.S. and adversary capabilities that could be developed from these technology advances, focusing on potential "leapfrog" and "game-changing" capabilities that may substantially alter future warfighting environments.
- Determine counter-capabilities that the Air Force will need in 2030 to be effective against these potential new adversary capabilities.
- Identify the underlying technologies that the Air Force will need in 2020 in order to develop the counter-capabilities it needs in 2030.
- Identify the science and technology research efforts that the Air Force must start today to develop the technologies it needs in 2020 to obtain the counter-capabilities it needs in 2030.

Overarching Themes for Vectoring Air Force S&T During 2010-2030

From decreased emphasis on this …	*To increased emphasis on this …*
1. *From …* **Platforms**	*To …* **Capabilities**
2. *From …* **Manned**	*To …* **Remote-piloted**
3. *From …* **Fixed**	*To …* **Agile**
4. *From …* **Control**	*To …* **Autonomy**
5. *From …* **Integrated**	*To …* **Fractionated**
6. *From …* **Preplanned**	*To …* **Composable**
7. *From …* **Single-domain**	*To …* **Cross-domain**
8. *From …* **Permissive**	*To …* **Contested**
9. *From …* **Sensor**	*To …* **Information**
10. *From …* **Strike**	*To …* **Dissuasion**
11. *From …* **Cyber defense**	*To …* **Cyber resilience**
12. *From …* **Long system life**	*To …* **Faster refresh**

“Technology Horizons” Major Findings

- **Key capability areas**
  - **Highly-adaptive autonomous systems**
  - **Human performance augmentation**
  - **Increased cyber resilience**
  - **PNT in GPS-denied environments**
  - **Electromagnetic spectrum warfare**
  - **Processing-enabled intelligent sensors**
  - **Directed energy for tactical strike/defense**
  - **Next-generation high-efficiency gas turbine engines**
  - **Persistent space situational awareness**
  - **Rapidly composable small satellites**
- **“Technology Horizons” report lists technology areas associated with each capability area**

Grand Challenges for Air Force S&T

#1: Inherently Intrusion-Resilient Cyber Networks

Autonomous scalable technologies enabling large, nonsecure networks to be inherently resilient to attacks entering through network or application layers, and to attacks that pass through these layers

#2: Trusted Highly-Autonomous Decision-Making Systems

Broad principles, theoretical constructs, and algorithmic embodiments for autonomous decision-making in applications where inherent decision time scales far exceed human capacity

#3: Fractionated, Composable, Survivable, Autonomous Systems

Survivable system architecture based on fractionation with redundancy using collaborative control and adapative autonomous mission planning

#4: Hyper-Precision Aerial Delivery in Difficult Environments

Low-cost, air-dropped, autonomously guided, precise delivery under GPS-denial for altitudes and winds representative of steep mountainous terrain

AF Space Command Capability Needs

AFSPC Vision: **Global Access, Persistence and Awareness for the 21st Century**

AFSPC Mission: **Provide Resilient and Cost-Effective Space and Cyberspace Capabilities for the Joint Force and Nation**

Space

- Nuclear, Survivable Comm
- Launch Detection/Missile Tracking
- PNT
- SSA and BA
- Defensive Space Control
- Assured Space Access/Spacelift
- Space C2
- Satellite Ops
- Protected, Tactical Comm
- Offensive Space Control
- Unprotected Comm
- Space to Surface ISR
- Terrestrial Environmental Monitoring
- Nuclear Detonation Detection
- Responsive Spacelift

Cyber

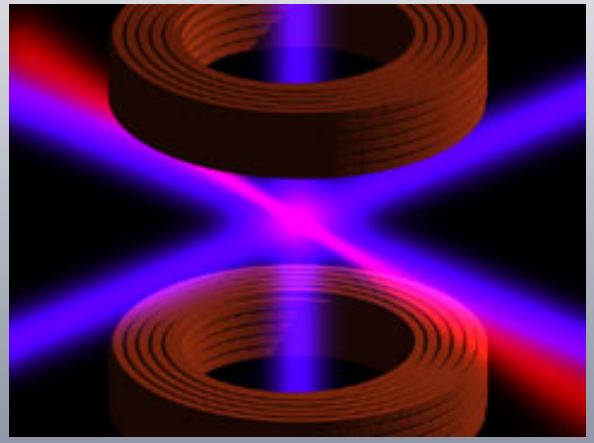
- Proactive Defense
- Defensive Counter Cyberspace
- Cyberspace ISR & Situational Awareness
- Persistent Network Operations
- Data Confidentiality & Integrity Systems
- Cyberspace Operations Center
- Offensive Counter Cyberspace for Global Reach & Access
- Net Extension & Resiliency
- Influence Operations

AFSPC Long-Term S&T Challenges

- **Eliminate Cyber restrictions as a limitation in SA, C4, PNT and CyberOps**
- **Provide Full-Spectrum Launch capability at a dramatically lower cost**
- **Provide Real-time, Predictive, Cross-Domain, Assured Situational Awareness**
- **Establish Resilient Space and Cyber Systems**

Eliminate Cyber restrictions as a limitation in SA, C4, PNT, CyberOps

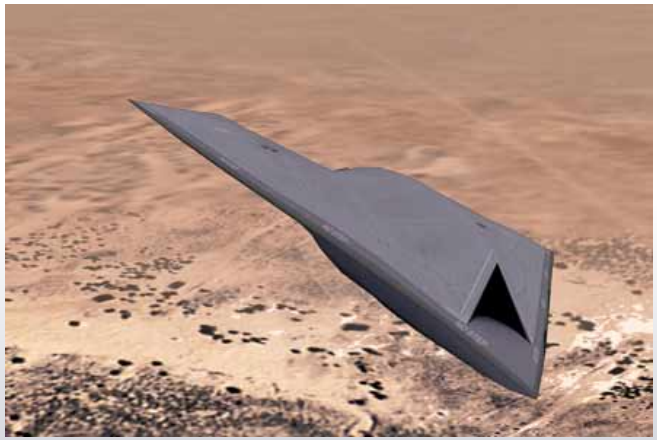
- Enable assured, autonomous, reconfigurable data collection and knowledge dissemination
  - Includes space sensors and cyber networks
- Overcome limitations in data rate, geographic access and multi-level security
  - Denied areas (canyons, caves), foreign countries/systems, etc
- Eliminate jamming, space and terrestrial environmental effects, spectrum management considerations



Augment legacy systems with smaller, fractionated, reconfigurable, networked systems

Provide Full-spectrum Launch capability at a dramatically lower cost

- **Enable rapid, routine, affordable (>10x) and responsive access to space**

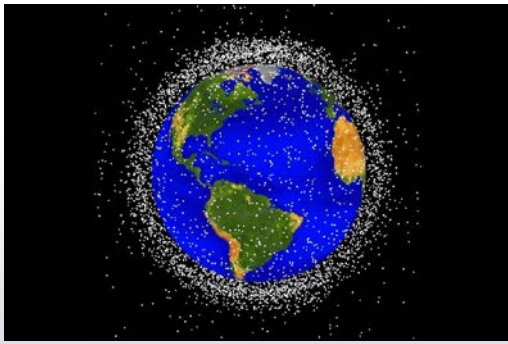


- **Augment large launches with mid-size and smaller, on-demand launchers and nontraditional launch**
  - **Enable routine space access and surge capability**
    - **Deliver dozens of space systems to different orbits in days**
    - **Enable rapid, efficient access to orbits from LEO to super-synchronous deep space orbit of any inclination**

Evolve launch to be a commodity, so some classes of satellites can be designed for short lifetimes

Provide Real-time, Predictive, Cross-domain, Assured Situational Awareness

Enable autonomous space and cyber situational awareness to provide relevant, actionable knowledge



Paradigm shift: task Information, not Sensors

- Low-latency between collect and access = real time SA
- High-frequency updates = dynamic SA
- Time-resolved data = forensics and attribution
- Fusing disparate, non-traditional data = prediction and intent

Enable autonomous tasking integrated with person-on-the-loop technologies

Establish Resilient Space and Cyber Systems

- **Invent autonomous and scalable technologies to enable intrusion resilient networks**
  - Enable network intrusion tolerance ("operating through") rather than traditional network defense
    - Includes our integrated space systems
  - Exploit virtualization with human-machine interfaces
- **Enable rapid reconstitution and reconfiguration for our space and cyber systems**
  - Exploit fractionated, composable, virtual, and self-configuring technologies

Enable person-on-the-loop technologies scalable to arbitrarily large networks

Conclusion

- **Future space and cyberspace capabilities will become even more vital to national security and Joint operations**
- **Innovation is crucial for accomplishing our mission**
- **USAF Technology Horizons is the roadmap**
  - **Science and Technology Opportunities will allow Full-Spectrum Solutions**
- **High-Level, Long-Term S&T Grand Challenges provide a focus for R&D**
  - **Not being prescriptive allows for innovative solutions**