Air Force Global Horizons

Dr. Mica Endsley
USAF Chief Scientist

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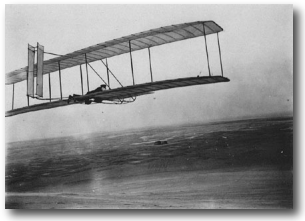
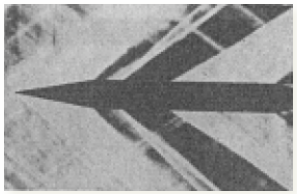
The Air Force is Critically Dependent on Science & Technology Advances


Powered flight

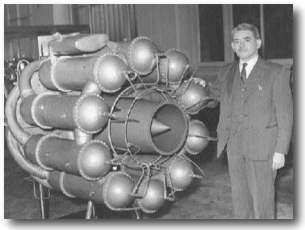

Supersonic flow


Communications


Global positioning

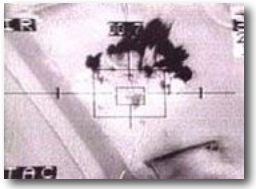

Stealth / LO

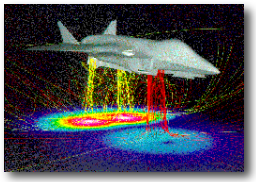

Long-endurance ISR


Gas turbine engine


Night attack


ICBMs


Precision strike


Computer simulations


High-power lasers

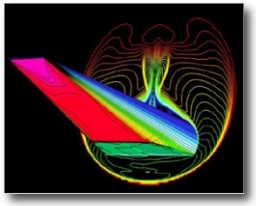

Aerial refueling

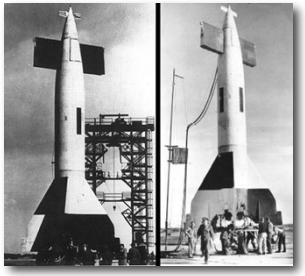

High-speed flight


Space ISR


Space launch


Directed energy


Hypersonics

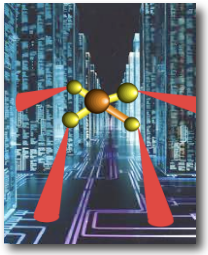

Rocket flight


Long-range radar


5th-gen fighters


Blended wing-body

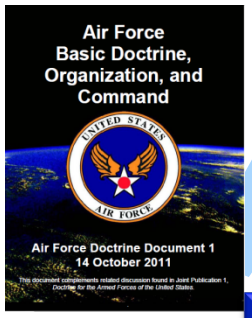

Unmanned systems


Cyber operations

Global Horizons

Study Methodology

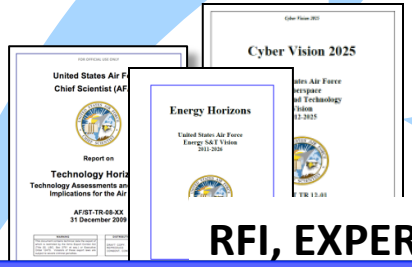
STRATEGY



REQUIREMENTS AND PLANS

COCOM and MAJCOM Requirements

CFMPs, STIPLs



RFI, EXPERT SUMMITS

GLOBAL PRIVATE SECTORS

Global Horizons

United States Air Force
Global S&T Vision
2013-2027

AF/ST TR 13-01
1 August 2013

Independent Senior Expert Review

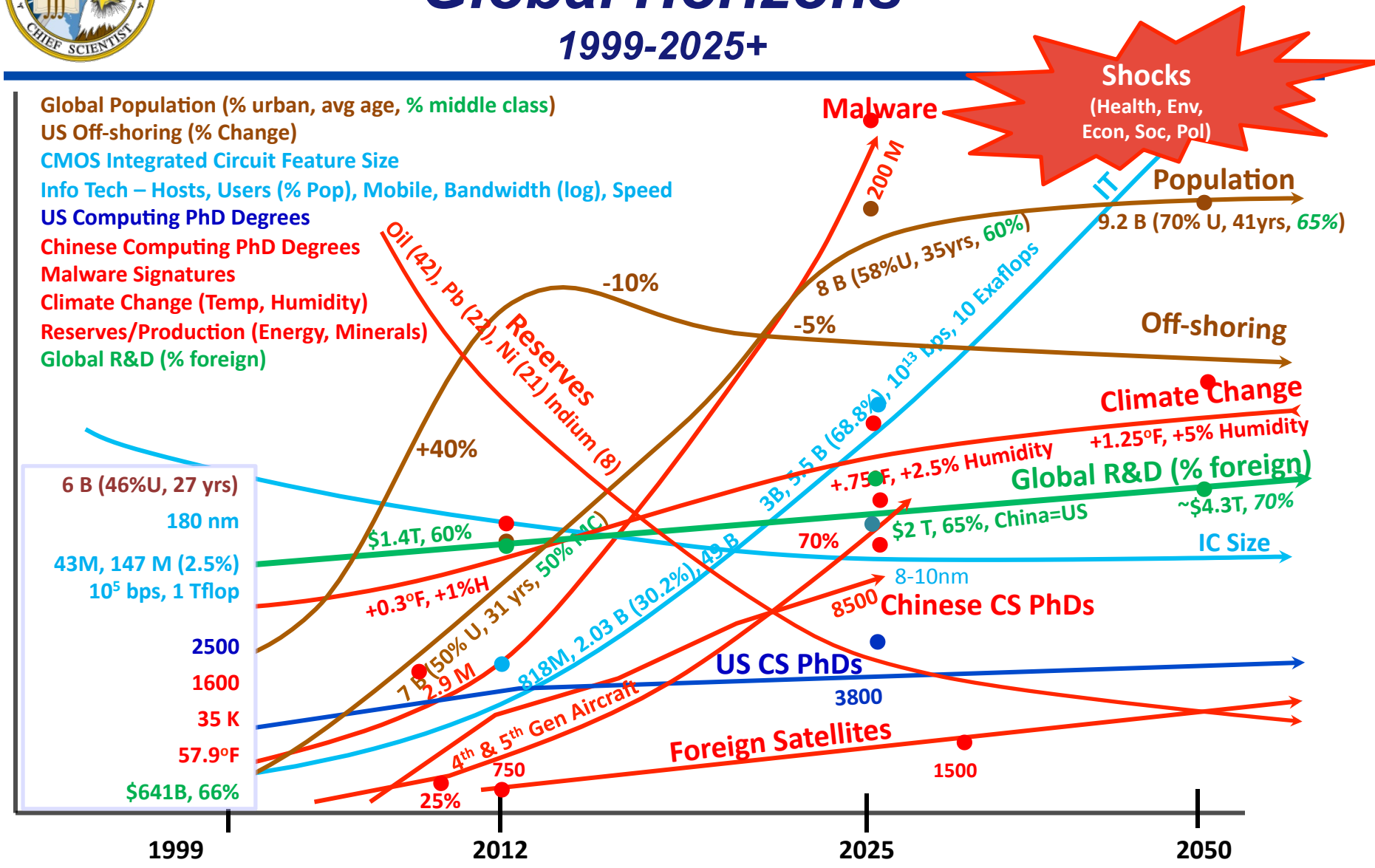
Global Threats and Opportunities

CORE FUNCTION	GLOBAL SECTOR
Air	Trans
Space	Mfg
Cyber	Comm/IT
C2ISR	Energy
Enabling	Health
Support	Ed/Train

Global Vigilance, Reach and Power dependent upon contested Global Domains and Globalized Industrial Sectors

Global Horizons

1999-2025+

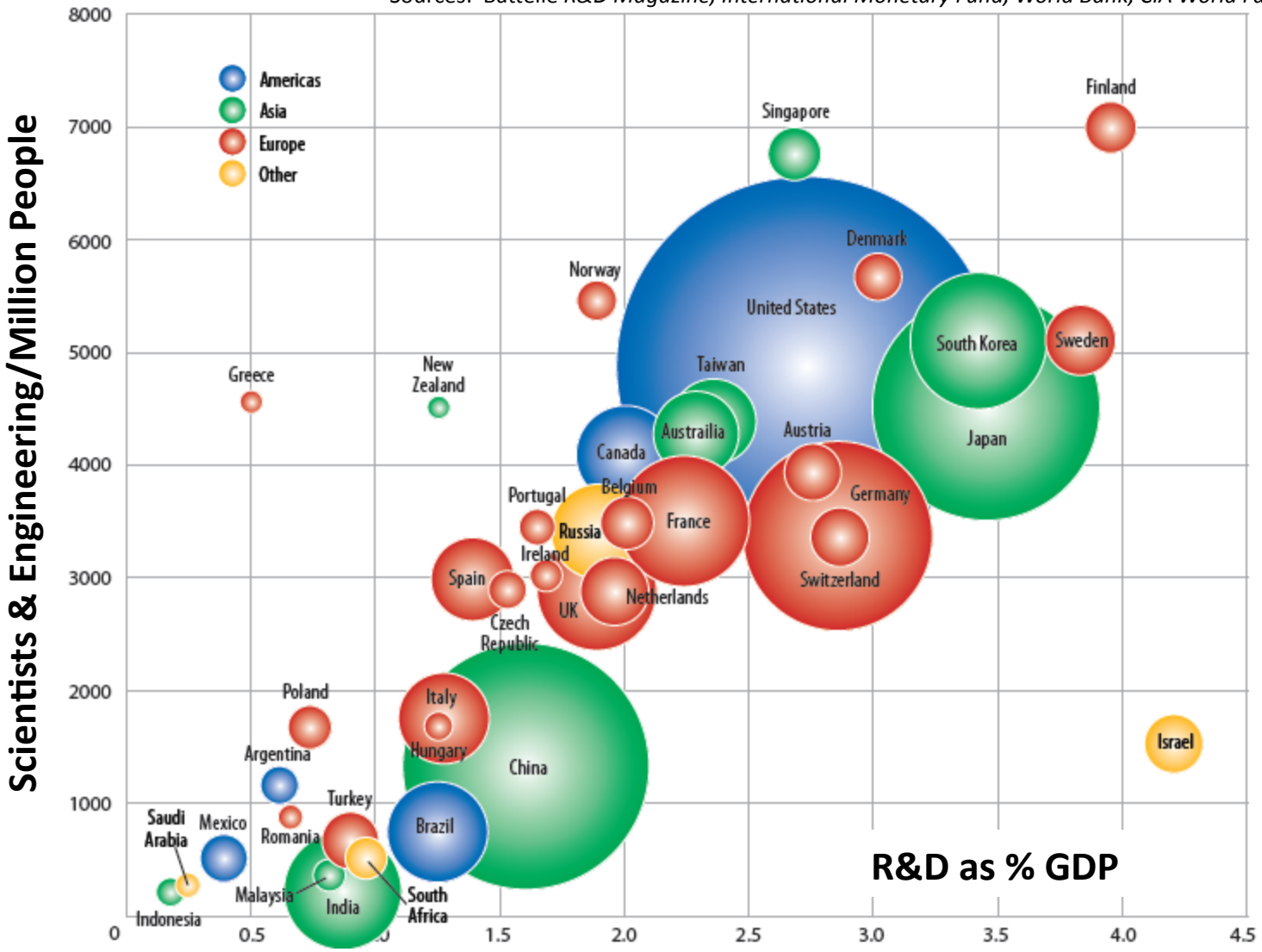


CMOS – Complimentary Metal-Oxide Semiconductor; IC – Integrated Circuit
World Trade Organization (WTO), International Monetary Fund (IMF)
PhD Degrees in Computer Science/Computer Engineering/Computational Mathematics

Global R&D (2011)

Size of circle is relative amount of Annual R&D

Sources: Battelle *R&D Magazine, International Monetary Fund, World Bank, CIA World Factbook, OECD*



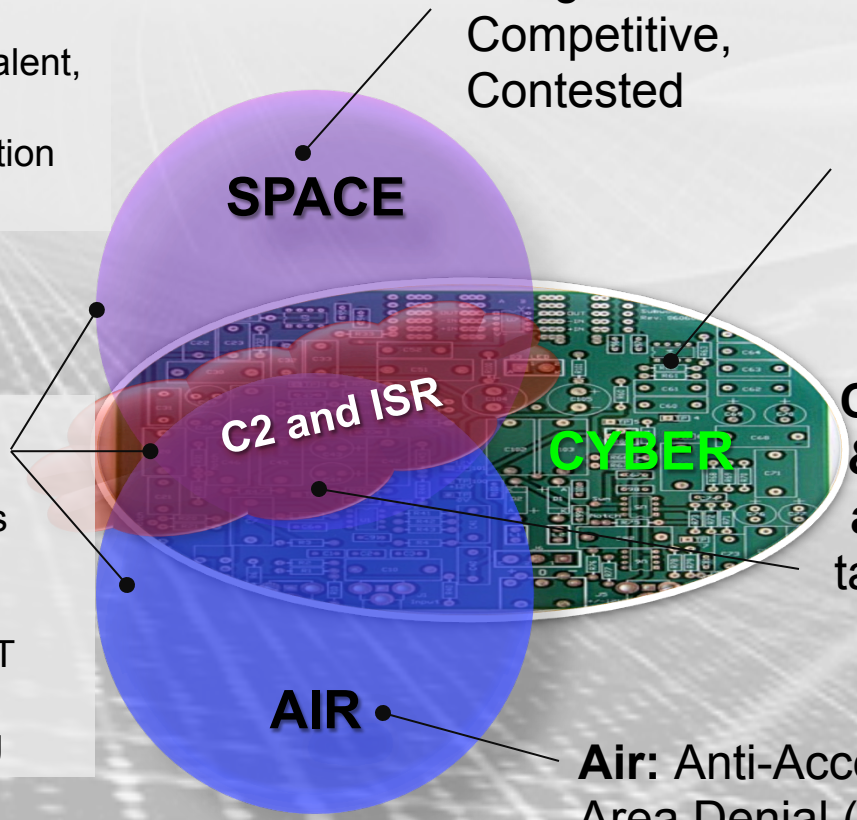
Global Environment

Global Forces

- Demographics
- Climate
- Resources (Natural, Talent, Treasure, Time)
- Globalization/Proliferation
- Conflict

Global Sectors

- Manufacturing and Materials
- Transport and Logistics
- Energy and Utilities
- Health and Pharma
- Communications and IT
- Financial Services
- Education and Training



Space: Congested, Competitive, Contested

Cyberspace: threatened by malicious insiders, supply chain attacks, and advanced persistent threats to deceive, degrade, disrupt, destroy

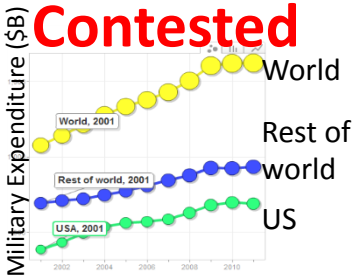
Command and Control (C2) & Intelligence Surveillance and Reconnaissance (ISR) targeted as a center of gravity threatening integrated and resilient global operations

Air: Anti-Access, Area Denial (A2/AD)

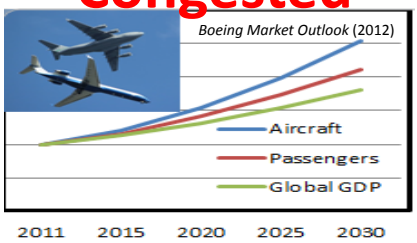
Global Vigilance, Reach and Power dependent upon contested Global Domains and Globalized Industrial Sectors

Air Challenges and Opportunities

Contested



Congested



Constrained

Maturing affordable game changing S&T across the Air Domain allows us to remain ahead of near-peer threats, operate with efficiency and impunity in A2AD environments, and evolve Air Doctrine with new technologies.

Theme	Near (FY13-17)	Mid (FY18–22)	Far (FY23–27)
High Speed Systems/ Directed Energy	Weapons (L) High Power Microwave missile (L) Target identification (pulsed lasers) (L)	***High Speed Systems*** ISR platforms (L) ***Directed Energy*** Mounted a/c self protect (CW electric lasers) (L)	Reusable, responsive platforms (L) Integrated a/c self protect; speed-of-light strike (L)
Autonomy/Distributed Decision Making/ Fractionated Systems	Distributed mission planning (L) Sense and avoid (L) Automat/Autonomous formation flight (L)	***C2 and Communications*** Automated terminal area operations (F*) ***Platform and Operations*** Cooperative and autonomous control (L)	Human/machine cognitive communications (F*) Human/machine teaming (F*)
Advanced Aircraft Adaptive Architecture	Enhanced analysis for V&V (F*) Certification of composite structures (F*) Large composite structures (F*)	***Processes*** System-of-system certification (F*) ***Products*** Modular aircraft architectures (F*) Plug-and-play avionic interface (L)	Automated assembly and quality assurance (F*) Universal weapon system interface (L)
Small Munitions/Long Range Missiles	Cooperative control & selectable effects (L) Self-realizing and adaptive guidance (L)	***Small munitions*** Multi-purpose, multi-mode effects packages (L) ***Long Range Missiles*** Sensor/seekers, apertures, payload, guidance (L)	Optimized internal carry design (L) Real-time adaptive software (L)
Energy Efficient Aircraft and Propulsion Design	ADVENT/AETD/ESSP (L) Thermal management/adaptive cycles (F*) Laminar flow control (F*) Conformal antennae (F*)	***Propulsion and Power*** HEETE (L) On-demand integrated subsystems (L) ***Airframe/Aerodynamics*** Lightweight, unitized structure (F*) Adaptive structure and active flow control (F*)	Adaptive HEETE (L) Hybrid systems/distributed propulsion (F*) Supersonic tailless designs (L) N+1 generation efficient aircraft configurations (F*)

* AF should follow industry, unless a specific AF application

Air Domain Highlights

- **Key Challenge will be Contested Environment (A2/AD)**
  - **Future adversaries will have 5th Aircraft, UAVs & systems to undermine our ability to operate with impunity**
    - **Anti-GPS**
    - **Comms Attacks (Voice/Datalink)**
    - **Attacks on C2 (Cyber)**
    - **Anti-UAV, IADS, etc…**
  - **Drives our focus to new capabilities to regain our critical edge**
    - **Assured Comms**
    - **Precision Navigation & Timing (PNT) – Cold Atom**
    - **Long range precision strike**
      - **Hypersonics**
      - **Directed energy Weapons**
        - **Precise targeting, disrupt/destroy electronics, sensing, blind/destroy sensors**
        - **Precision effects, fast response, low collateral damage, deep magazine, low costs**
        - **High power microwave – non-lethal effects to disperse crowds and disrupt electronics**

Cold-Atom Inertial Navigation Systems For GPS-Denied Environments

Position Uncertainty for 3 Scenarios

36 h loiter

20,000 m

20 m

1-3 m

Flight half-way around world

1000 m

1-3 m

1 m

GPS

Cold Atom INS

Laser-based INS

Ballistic missile flight

500 m

1-3 m

0.1 m

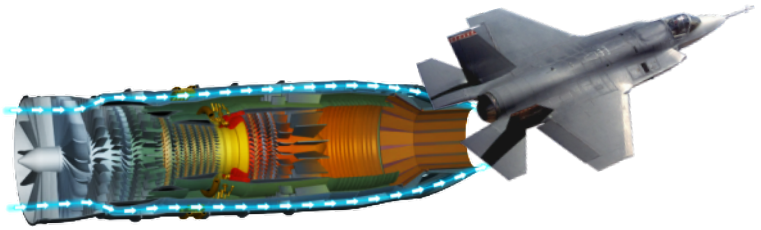
Cold atom INS: potentially provide orders of magnitude better performance than laser-based INS, and accuracy comparable to GPS for GPS-denied environments

AFRL Game Changing Technologies

Fuel Efficiency

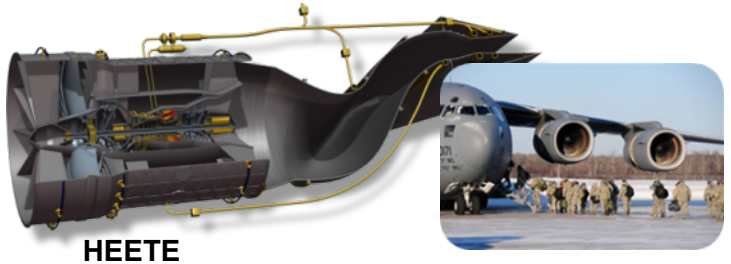
Providing Enhanced Range & Persistence

- For Combat Air Force: Adaptive Versatile Engine Technology (ADVENT) & Adaptive Engine Technology Development (AETD)



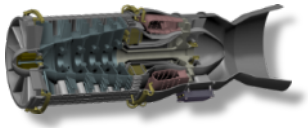
ADVENT & AETD

- For Mobility/ISR: Highly Energy Efficient Turbine Engine (HEETE)



HEETE

- Integrated Propulsion Power and Thermal (INPPAT)
- Supersonic Turbine Engine for Long Range (STELR)



STELR

- Efficient Small Scale Propulsion (ESSP)

ESSP

- Legacy Fleet: Aerodynamic efficiencies / drag reduction – microvanes/winglets/laminar flow

RPAs Role in Future Operations

- RPAs will be potentially called upon to do a larger set of missions
  - ISR
  - Precision strike
  - Refueling
  - Transport
  - Long-range bombing

- RPAs will need to be able work as a part of mixed manned-unmanned aircraft team
- Requires systems to
  - Better support integrated operations
  - Better ability to work autonomously
  - Better ability to work in conjunction with other UAVs
  - Better ability to work with manned oversight/coordination

Need Advanced Remote Cockpits to Support RPA Pilot SA

- **Challenges to pilot situation awareness**
  - Time lags
  - Intermittent/Noisy data
  - Limited transmission of situationally relevant information
    - Visual (soda straw, size/distance)
    - Auditory
    - Tactile/Kinesthetic
    - Olfactory
  - Poor user interfaces for many systems
  - Little support for team tasks
    - Mission Context
    - Information Needs
    - Needed Imagery
  - Automation
    - Out-of-the-loop problems
    - Understandability of actions/intentions

Mishaps involving significant human factors shortcomings

- **Pioneer - 59% (55 of 93)**
- **Predator - 76% (16 of 21)**
- **Global Hawk - 25% (1 of 4)**

AF Scientific Advisory Board Report, 2003

Autonomy Is An Underlying Theme Across Many Air Force Missions

Remotely Piloted Vehicles

C2&ISR

Space

Cyber Operations

Logistics

Space Highlights

- Modern operations are highly dependent on space assets to provide comms, precision navigation and superior battlefield SA.
- Space will be congested, contested and competitive
- Need to be able to defend space assets to maintain our advantages, be agile to attacks and changing operational needs, and rapidly insert new capabilities
  - Highly distributed and disaggregated space assets
    - More agile, reliable, and defensible posture
  - Low-cost, small satellites
    - Flexible, quick, easy, inexpensive launch
  - Improved space situation awareness
    - Tracking 10's of thousands of objects
    - Understanding their impact on our operations
  - Additive manufacturing
    - Long term promise for rapid response and parts in space

Cyberspace Highlights

- **Mission assurance and empowerment**
  - Enhanced cyber situational awareness for air, space, and cyber commanders enabled by automated network and mission mapping
  - Early vulnerability detection and enemy behavior forecasting enabled by advanced cyber ranges, including high fidelity, real-time modeling and simulation
  - Develop offensive cyber capabilities to augment kinetic operations during wartime scenarios to affect strategic, operational and tactical missions
- **Agility and Resilience**
  - Effective mix of redundancy, diversity, and fractionation for survivability
  - Reduction of attack surface, critical mission segregation, and attack containment
  - Autonomous compromise detection and repair (self healing) and real-time response to threats
  - Transition from signature based cyber sensors to behavior understanding to enhance high performance attack detection
  - Active defense requires rapid maneuver enabled by dynamic, reconfigurable architectures (e.g., IP hoping, multilevel polymorphism)

Cyberspace Highlights

- **Optimized human-machine systems**
  - Measurement of physiological, perceptual, and cognitive states to enable personnel selection, customized training, and (user, mission, and environment) tailored augmented cognition.
  - High performance visualization and analytic tools to enhance situational awareness, accelerate threat discovery, and empower task performance.
  - Autonomy appropriately distributed between operators and machines, enabled by increased transparency of autonomy and increased human “on the loop” or supervisory control.
- **Software and hardware foundations of trust**
  - Operator trust in systems (e.g., sensors, communications, navigation, C2) enabled by trusted foundries, anti-tamper technologies, and supply chain assurance, as well as effective mixes of government, commercial off the shelf, and open source software
  - Formal verification and validation of complex, large scale interdependent systems
  - Advanced vulnerability analysis, automated reverse engineering, real-time forensics tools
  - High speed encryption, quantum communication, and quantum encryption for confidentiality and integrity

C2ISR Highlights

- **Data transformed into higher levels of SA**
  - Swimming in sensors, drowning in data
  - Integrate data and provide rapid "at a glance understanding of information" using cognitive engineering tools
- **Integrated networked operations (connect 4th gen and 5th gen aircraft), sensors, command centers across air,space, cyber, sea, ground**
  - Secure, resilient, agile, and high capacity air-space-and-surface network to enable joint and multinational global C2 and ISR.
  - Fully integrate weapon systems and PCPAD across air, space, and cyberspace to achieve synchronized effects
  - Provide processing to provide the right information to each user based on goals/decision needs
  - Cognitive modeling to provide better funneling of information under limited bandwidths
- **Effective human/automation teams**
  - Develop flexible autonomy and all-source fusion technologies for enhanced analysis and planning capabilities for C2 and ISR.

Future C2 & ISR

Integrated
Networked
Operations

Trusted
Resilient
Software &
Cyberspace

Effective
Human &
Automation
Teams

Data Transformed
Into Higher Levels
Of Situation Awareness

Built on a platform for rapid innovation, prototyping and testing

Mission Support Recommendations

- **Experiment with new cross-domain Digital Design Tools**
  - **Identify pilot programs to integrate System of System concept trades & digital design tools**
  - **Verify claims the new tools reduce development time by at least 25% and save program costs**

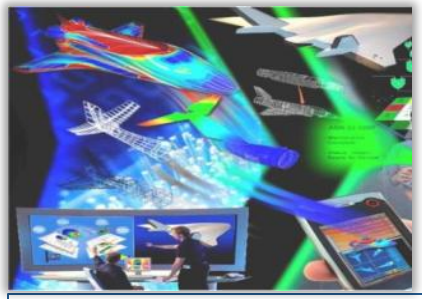
- **Reinvigorate a technology demonstration prototype program**
  - **Reallocate resources to increase the number of technology demonstrations**
  - **Explore feasibility and utility of creating small, independent rapid prototype teams comprised of Product Centers, Labs, Users, Academia, and Industry**
  - **Leverage external technical talent through Open Challenges and produce novel technologies and solutions at a fraction of the time and cost to conventional processes**

System Design, Material, & Manufacturing Highlights

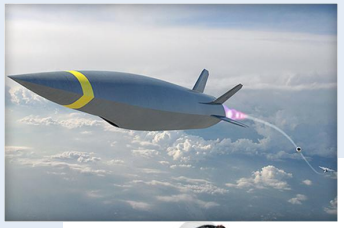
- **Open system architectures**
  - Plug-n-play, modular, standardized components
  - Standardized interfaces
  - Critical for technological agility
    - Threats change, technology changes
    - Need to be able to rapidly modernize
- **More efficient systems**
  - Design for maintainability
  - Design for operability (human-system integration)
  - Energy efficiency
- **Seamless thread from design to manufacturing to maintainability**
  - Rapid prototyping test environments
  - Significant build up of modeling and simulation tools
  - Digital thread
    - connectivity of test data/models to provide integrated information on a system
  - Digital twin
    - life time model of system to make maintenance & logistics customized
- **Additive manufacturing**

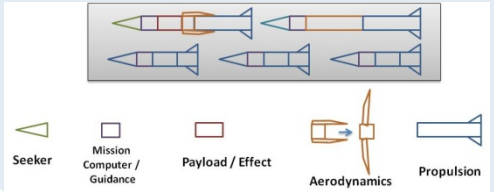
Agile Manufacturing for Rapid & Affordable Fielding

Affordable Capability…… New Systems /sub-systems

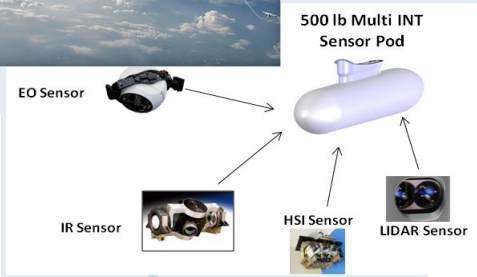


Networked Collaborative Design: 60% less time



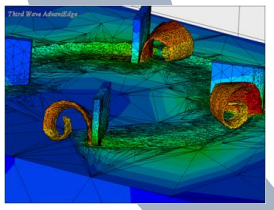


Flex Weapons

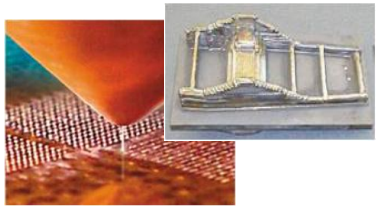


Open Architecture ISR Pod

From S&T to the Field: Faster @ Less Cost



Model-Based/ Virtual Mfg: 50% less time



Direct Digital & Additive Mfg: Small lot production

Auto/Digital Inspection: 20% less time

Automated Assembly: 30% less time

Air Force Global Horizons

- **Sets Air Force Science and Technology Vision 2013-2027**

http://www.af.mil/Portals/1/documents/news/GlobalHorizons.pdf

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Air	Transportation
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Cyber	Comm/IT/Finance
C2&ISR	Energy
Support Tech	Pharma & Health
Enabling S&T	Education &Train


UNITED STATES AIR FORCE
CHIEF SCIENTIST