Air Force Research Laboratory

Integrity ★ Service ★ Excellence

"Back to the Future" – What History Tells Us About Contemporary ISR S&T Challenges

18 April 2012
(70 Years Later)
NDIA S&T Symposium
Charleston, SC

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Sensors Directorate
Air Force Research Laboratory

[1] Linked-in Profile

AFRL

Outline

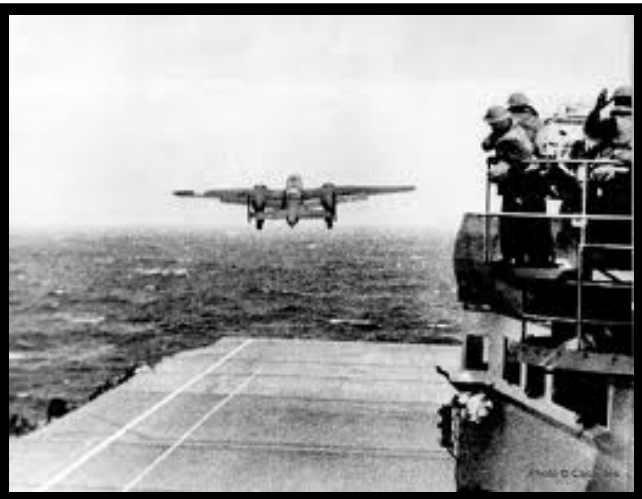
- A *Great Joint Day* In US Navy/US-AAF History
- ISR Historical Trend lines
- AFRL Vision/Organization /C^4-ISR Enterprise
- S&T Investment Strategy
- C^4ISR S&T "Core Technical Competencies"
- C^4ISR S&T Challenges for the Next Decade
- Summary

My Daily "Re-Bluing" USAF Air Force Art Painting[1]

[1] "Tokyo Bound" print by Nicolas Trudgian

Doolittle Raid on Imperial Japan

4/18/1942 – 70 years ago today!



16 B-25B "Mitchell" Army Bombers Launched from USN Aircraft Carrier *USS Hornet* ~650 NM from Mainland Japan

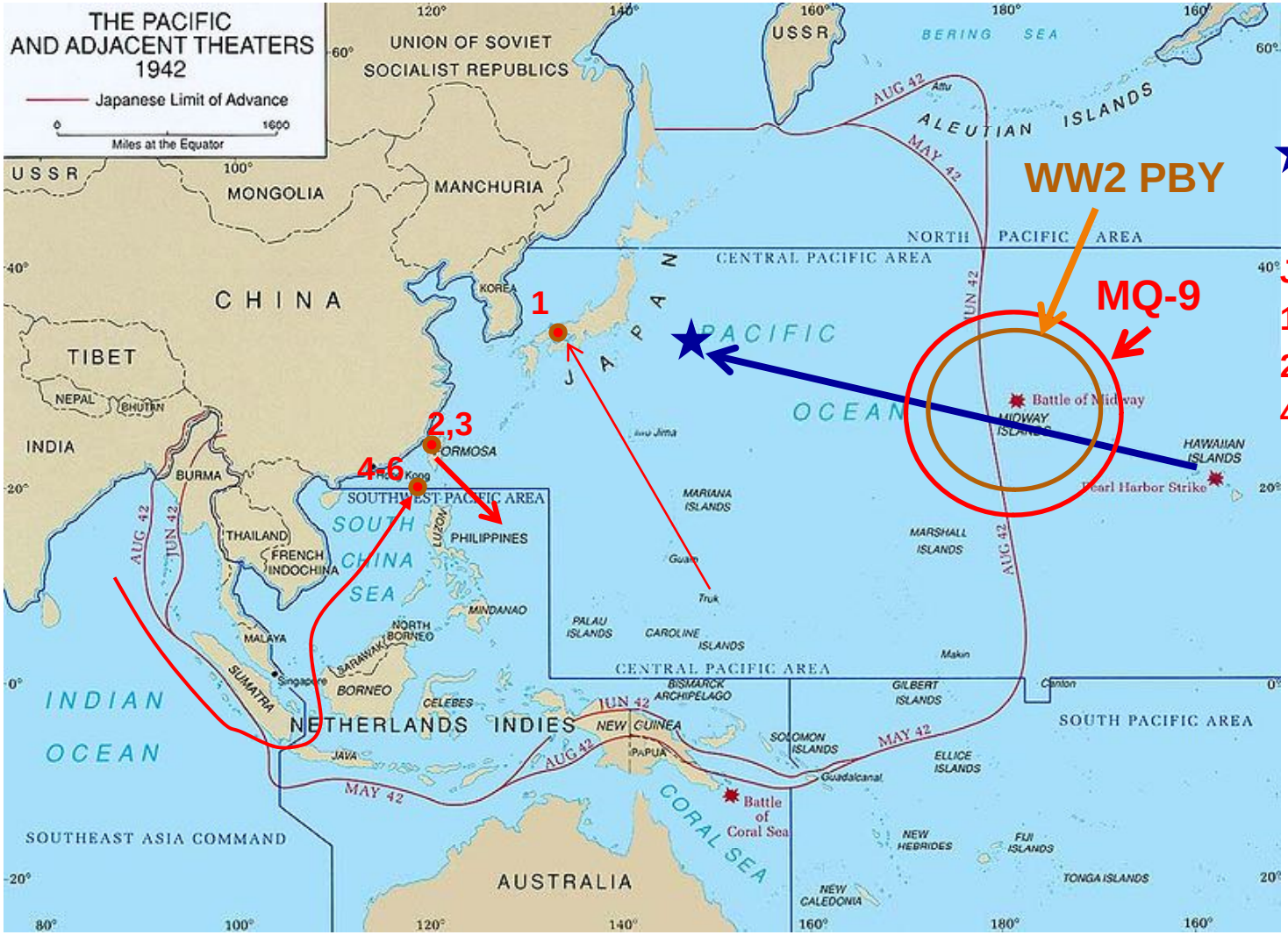
Wright Field Engineering Patch

These aircraft were modified by "Wright Field" Engineering Directorate to take off a carrier in <500 ft! (Now WPAFB)

Pacific ISR Sources 4/18/1942

- Sparsely Deployed Submarines
- "Coast watchers" throughout Indonesia, Micronesia, Solomon Islands, etc.
- Very limited long range photo-recon A/C
- " Purple" Diplomatic Intercepts
- "Ultra" Naval Code Intercepts (~10%)
  - Joe Rochefort's Code Breakers reporting to Adm Nimitz
- "Tactical" reports from UK East Asiatic Fleet
  - Pummeled the week before in the Indian Ocean by ~3-4 Japanese Fleet Carriers (31 March-10 April) [1]

Actual Japanese Carrier Deployment day of Doolittle Raid (4/18/42) [1]



★ **Hornet, Enterprise (Doolittle/Halsey)**

Japanese Fleet Carriers

1 Kaga (Drydock)

2,3 Shokaku, Zuikaku

4,5,6 Akagi, Hiryu, Soryu

Another day, outcome *may* have been different!

[1] Japanese Carrier Tabular Record of Movement, "Kido Butai!-Stories And Histories of the IJN's Carrier Fleet" (http://www.combinedfleet.com/cvlist.htm)

Notable Pacific Theater ISR Failures and Successes (41-45)

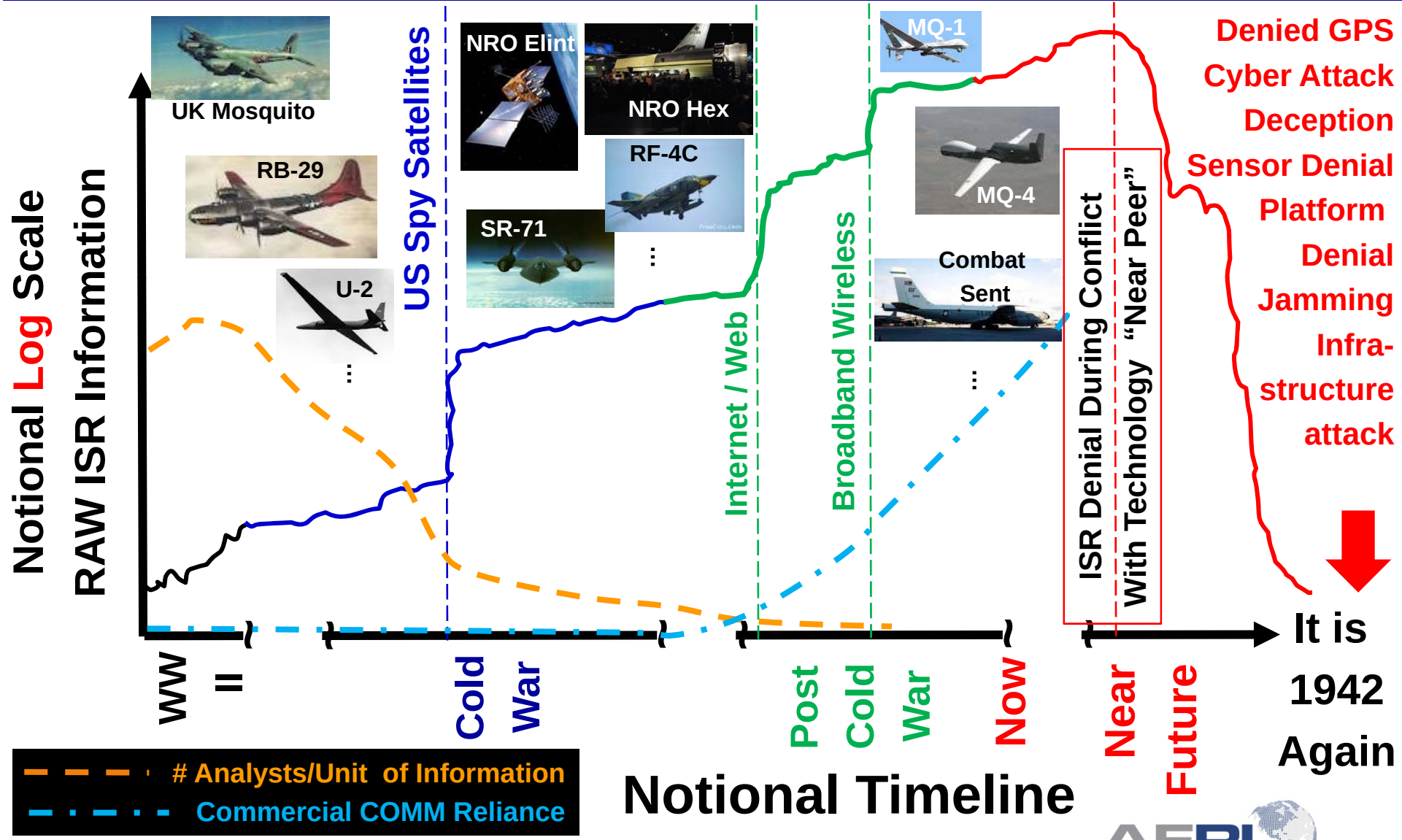
- **Failures**
  - **Pearl Harbor, Clark Field (Philippines) [2]**
  - **1st Battle of Savo Island off Guadalcanal (9 Aug 1942)**
  - **Battle of Samar off Philippine Landings (25 Oct 1944) [1]**
  - **Island Defense Estimates (Tarawa, Peliliau, Iwo Jima – repeat offenders all)**
- **Successes [2]**
  - **Coral Sea (7 May 1942)**
  - **Midway (5-6 June 1942)**
  - **Shooting Down Adm Yamamoto (4/18/1943)**

Adm. Nimitz characterized the Pacific Theater challenge as "the tyranny of distance" -- PACOM is still a HUGE AOR today!

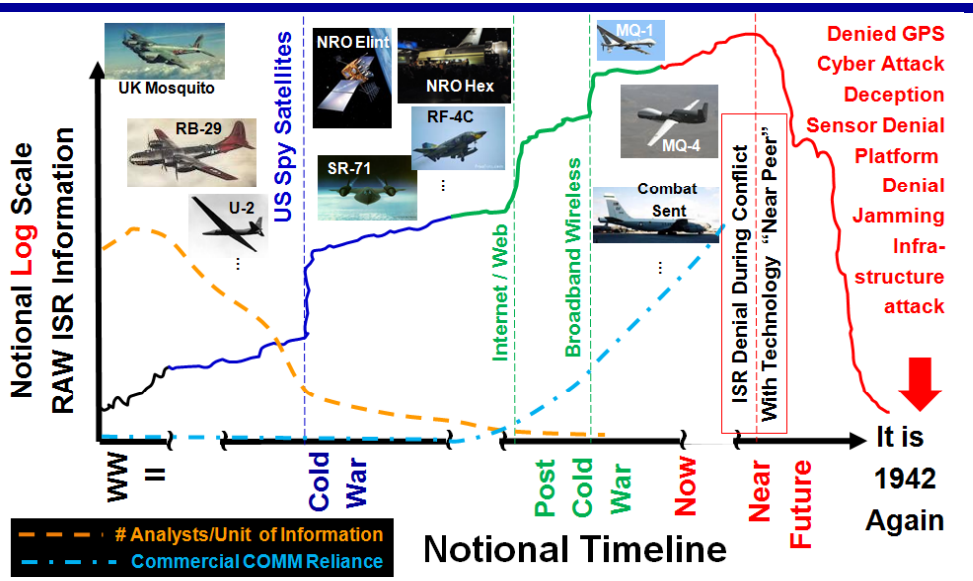
[1] Last Stand of the Tin Can Sailors, James D Hornfischer, Bantam Books Press, 2004

[2] "And I Was There"- Pearl Harbor and Midway Breaking te Secrets, Edwin T. Layton, Roger Pineau, John Costello, Naval Institute Press, 1985

ISR/COMM Challenge Timeline



Future C⁴-ISR S&T Challenge



DoD must be prepared to *effectively and efficiently* operate C⁴-ISR enterprise across a wide spectrum of conflict scenarios**

** Law Enforcement too!

- During "peacetime"/low intensity irregular warfare, ISR Data "overload", deception, attribution & time sensitivities remain key challenges
- During "contested" confrontations, C⁴ Denial, data starvation, deception, lack of attribution, infrastructure vitality, cyber, and decision timelines are key technical challenges

AFRL Organization

Commander

Maj Gen Neil McCasland

Executive Director

Mr. Joe Sciabica

Vice Commander

Col Daniel Morin

Chief Technology Officer

Dr. Jennifer Ricklin

Air Force Office of Scientific Research

Propulsion

Air Vehicles

Information

711th Human Performance Wing

Munitions

Sensors

Space Vehicles

Materials and Manufacturing

Directed Energy

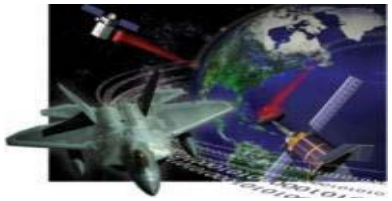
Sensors TD

TDs Reporting ISR to Sensor's CL for ISR/C²

Organizing AFRL C^{4}ISR S&T And Identifying Tech Challenges

Core Technical Competencies
Relevant C4ISR S&T Portfolios

Cyber Science & Technology

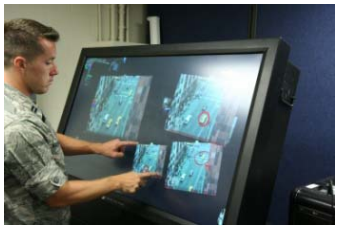


Autonomy, C2 Planning & Decision Support

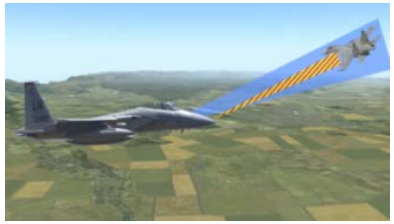
Processing & Exploitation

COMPASE Center

Layered Sensing Exploitation



Decision Making

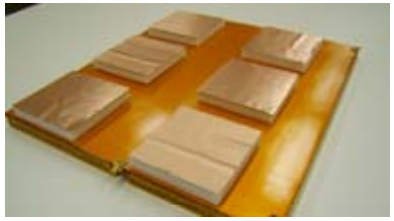


Net-Enabled Spectrum Warfare

C4ISR

Training

Connectivity & Dissemination



Enabling Sensor Components/Devices

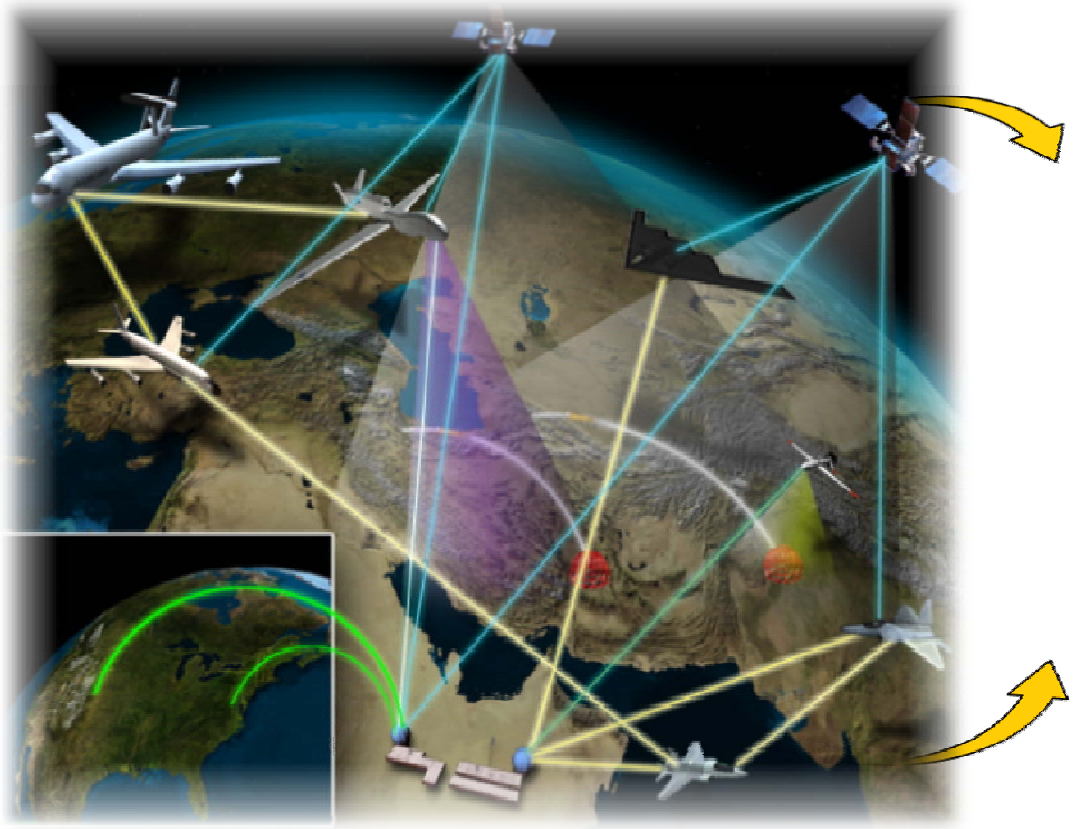
Electro-Optical Sensing

Radio Frequency Sensing

AFRL

C4ISR S&T Centered within Information & Sensors Directorates[1]

C4ISR is characterized by the appropriate combination of sensors/platforms, infrastructure and exploitation capabilities across warfighting domains to generate operator situation awareness and directly support decision making and delivery of tailored effects.



SECDEF S&T Priorities

1. Data-to-Decisions
2. Engineered Resilient Systems
3. Cyber Science and Technology
4. Electronic Warfare/Electronic Protection
5. Counter Weapons of Mass Destruction
6. Autonomy
7. Human Systems

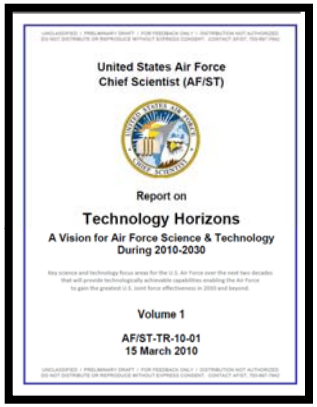
OSD Disruptive Basic Research Areas

1. Metamaterials and Plasmonics
2. Quantum Information Science
3. Cognitive Neuroscience
4. Nanoscience and Nanoengineering
5. Synthetic Biology
6. Computational Modeling of Human and Social Behavior

[1] With significant ISR Contributions in Space Vehicles and Human Performance TDs

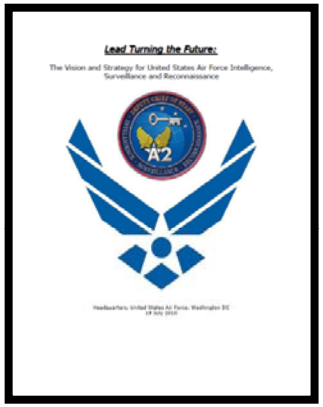
C⁴ISR Technology Program Plan In-Work: Due June 2012 (for FY13)

AFRL CORPORATE INVESTMENT STRATEGY



AF/ST Tech Horizons

AF S&T Strategy & Plan



AF Core Function Master Plans

Available Now -- FY12

Information Directorate, Sensors Directorate

Annual Technology Program Plan

FY13 C4ISR Technology Program Plan [1]

FOUR GRAND CHALLENGES

- Inherently Intrusion-Resilient Cyber Networks
- Trusted Highly-Autonomous Decision Making Systems
- Fractionated, Composable, Survivable, Autonomous Systems
- Hyper-Precision Aerial Delivery in Difficult Environments

- Cyberspace Superiority
- Global Integrated ISR
- Command and Control
- Special Operations
- Air Superiority
- Space Superiority
- Global Precision Attack
- Agile Combat Support

[1] Available for DoD/Contractors ~15 June 2012

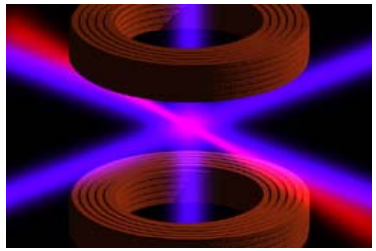
A2/AD *Suggested* "Definition"

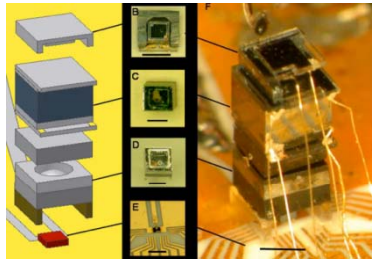
- **Permissive -low risk, (domain) superiority/supremacy achieved**
- **Contested –med risk, (domain attacks) neither fully integrated or mitigated**
- **Anti-Access -high risk for many (domain assets), not all; pervasive enemy activity; high *domain capability losses* until *domain superiority* is achieved**
- **Anti-Access -affects all domain usage/movements supporting aggressive warfighter theater operations**
- **Area Denial -affects domain usage/movements limiting ability of warfighter to operate *within* a theater**

Domain = Air, Space, Cyberspace, (Land, Sea)

Selected Technologies to Re-enable Operations in Contested Environments

- S&T advances are needed in three key areas to enable increased freedom of operations in contested or denied domain environments
- Technologies for increased cyber resilience
  - e.g., massive virtualization, highly polymorphic networks, agile hypervisors
- Technologies to augment or supplant PNT in GPS-denied environments
  - e.g., cold-atom (Bose-Einstein condensate) INS systems, chip-scale atomic clocks
- Technologies to support dominance in electromagnetic spectrum warfare
  - e.g., dynamic & cognitive spectrum access, spectral mutability, advanced RF apertures
- **Basic and early applied research are needed to support long term development of future A2-AD capabilities – not just a few S&T "quick fixes"**

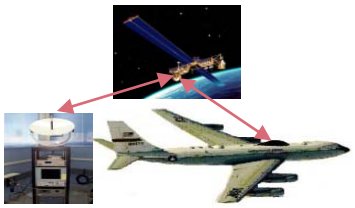




Radio Frequency Sensing

Legacy

FOPEN Radar



TIMEX

Geodesic Dome Phased Array

Technical Challenges

- Passive RF sensing for congested & contested environments
- Robust GPS & alternative position / navigation / timing technologies
- Persistent RF sensing in contested, high clutter environments
- Exploiting & countering diverse RF waveforms
- Open architectures for RF systems
  - Sensing + EW/EA/EP

Electro-Optical Sensing

Legacy

Passive IR/EO

IR/EO Ladar

Angel Fire/Blue Devil Blk 1

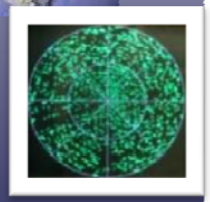
Technical Challenges

- Long-Range EO/IR detection and identification
- Missile Warning Detection
- Compensation for laser and EO/IR atmospheric scattering, turbulence, absorption
- Tunable midwave IR coherent laser sources for Active LADAR sensing
- Sensors to distinguish with high accuracy between natural and man-made materials

Network Enabled Spectrum Warfare

Legacy

Aircraft self-protection



Electronic attack

Technical Challenges

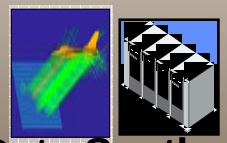
- Technology proliferation increases ambiguities regarding threat system capabilities.
- Ability to sense, learn, react/adjust to feedback from dynamic EM Spectrum use
- Delivers effects across disparate, heterogeneous payloads for spectrum dominance.
- Mitigating cyber vulnerabilities that threaten USAF mission systems
- Assure PNT availability when/where needed

Layered Sensing Exploitation

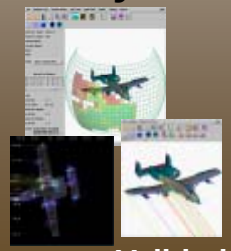
Legacy

TACSAT-3

CAD Build



Data Synthesis

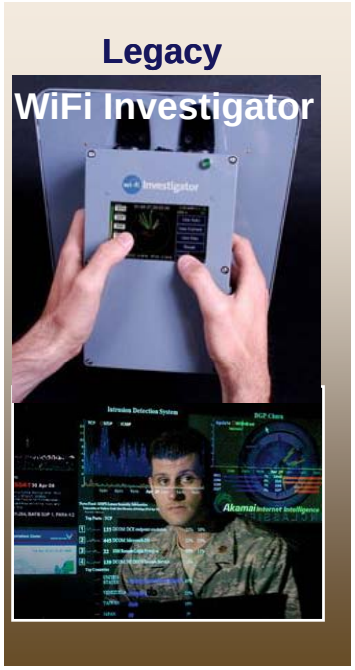


Signature Validation

Technical Challenges

- **Processing, Exploitation, Dissemination (PED) process improvement**
- **Detecting, identifying and tracking targets in large, populated, denied areas, spatially & spectrally diverse environments**
- **High Performance Computing improvements to allow real-time exploitation of computationally intensive data sets**
- **Focus on acquisition of Capability versus Platforms (Performance Driven Sensing)**
- **Apply Autonomy and Automation to our PED processes to improve human operator effectiveness**
- **Develop Tools that can exploit "huge" datasets from wide area RF/EO Sensing Systems of the future**

Cyber Science and Technology



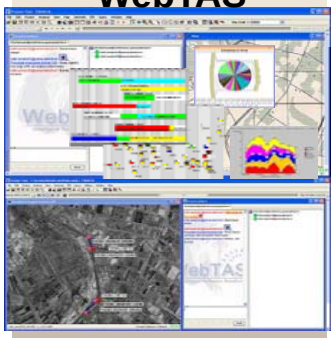
Technical Challenges

- **Mission awareness, evasion, execution and effects assessment**
- **Cyber agility to disrupt/deny adversary attack planning**
- **Cyber resiliency to fight through and recover from attack**
- **Trustworthy systems from un-trusted h/w and s/w components**

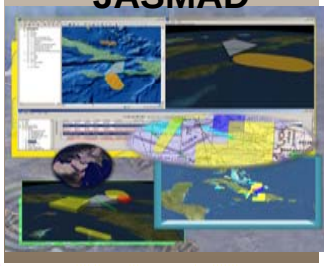
Autonomy, C2 Planning, and Decision Support

Legacy

WebTAS



JASMAD



Technical Challenges

- Anticipate future adversarial activity and action
- Synchronize actions across air, space, and cyberspace
- Trusted autonomous systems for rapid, complex operations
- Agility in a dynamically changing battlespace
- Continuous operational assessment

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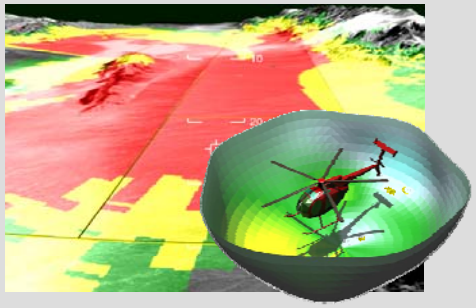
Decision Making CTC
(Human Effectiveness Directorate)

- Supervisory Control Interfaces

- Tactical Situation Display for immersive mission planning

- Dynamic Acoustic Models



- Control Interfaces for Autonomous Systems

- Ability to manipulate order of batter in novel ways

- Advanced, Multi-modal Tactical Interfaces

Training CTC
(Human Effectiveness Directorate)

Research, demonstrate and transition leading-edge human performance methods and technologies that provide Airmen the knowledge, skills, and experiences necessary to dominate the decision environment

- **Continuous Learning**
- **Cognitive Modeling**

A New FY13 Business Reality

- **DoD Shifting National Defense focus to Anti-Access/Area Denial operations**

- **Rapid Budget Changes unlike previous S&T planning cycles – put-backs are "directive"**
  - **Large increases in some areas**
  - **Large decreases/elimination of other areas**
  - **"Zero" sum game or less**
  - **Sequestration ????**

ISR Coordination and Collaboration

- **AFRL's C^4ISR Portfolio developed with critical S&T and mission partners**
  - **Mission: ACC GIISR CFMP, HAF/A2, AFISRA, AFSCP, NORTHCOM, SOUTHCOM, etc.**
  - **S&T: Academia, Industry, Cross DoD Services, Intelligence Community, DARPA, IARPA, etc.**
- **Sensors Director – "Capability Lead" SES for ISR/C^2 within AFRL (Dr Michael Deis)**
  - **Coordination is "never done" at AFRL– we always strive to improve, learn, and share broadly.**
  - **Collaboration opportunities are always welcomed and sought**

Summary

- **Major contributions to USAF ISR, Cyber, and Spectrum warfare enterprise**
- **Developing technology for the evolving A2-AD environment**
  - **S&T Enterprise is engaged from basic research through advanced development**
- **FY13 AFRL C^{4}ISR Tech Program Plan Available June 2012 for DoD and DoD Contractors (Distribution D Document)**
  - **Dist List: robert.ehret@wpafb.af.mil**

A successful C^{4}ISR S&T portfolio depends on a productive partnership between academia, our industrial partners, and defense laboratories

Questions?

20 of 50 surviving B-25s

70 Years Later

Dayton, Ohio

April 18, 2012

Final "Doolittle" Reunion

This Briefing is controlled at an overall level of

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Dist A, 88 ABW/PA Case 12-2151, 10 April 2012

AFRL

A2/AD In definition (AFDD)

- **Permissive -low risk, air superiority/supremacy achieved (Draft AFDD 3-52)**
- **Contested –med risk, enemy IADs neither fully integrated or attrited (Draft AFDD 3-52)**
- **Anti-Access -high risk for many, not all; pervasive enemy activity; high losses until air superiority is achieved (Draft AFDD 3-52)**
- **Anti-Access -affects movements to a theater**
- **Area Denial -affects maneuver *within* a theater**

OPINION – These are too narrow and wording favors the USAF air domain interests. One can "change Domains" (Cyber, Space, land, sea) and swap "IADS" out, and define a broader, domain-agnostic definitions

AFRL S&T Guidance Flow

"Grand Challenges" for Air Force S&T From USAF 2010 "Tech Horizons" [1]

#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**

Air Force S&T Plan
Increased S&T Emphasis Areas

RED: AFRL C^{4}ISR Enterprise Areas of Increased Emphasis

AFRL Mission