Integrating Air & Space, Command, Control, & Intelligence, Surveillance & Reconnaissance

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20 September 2005

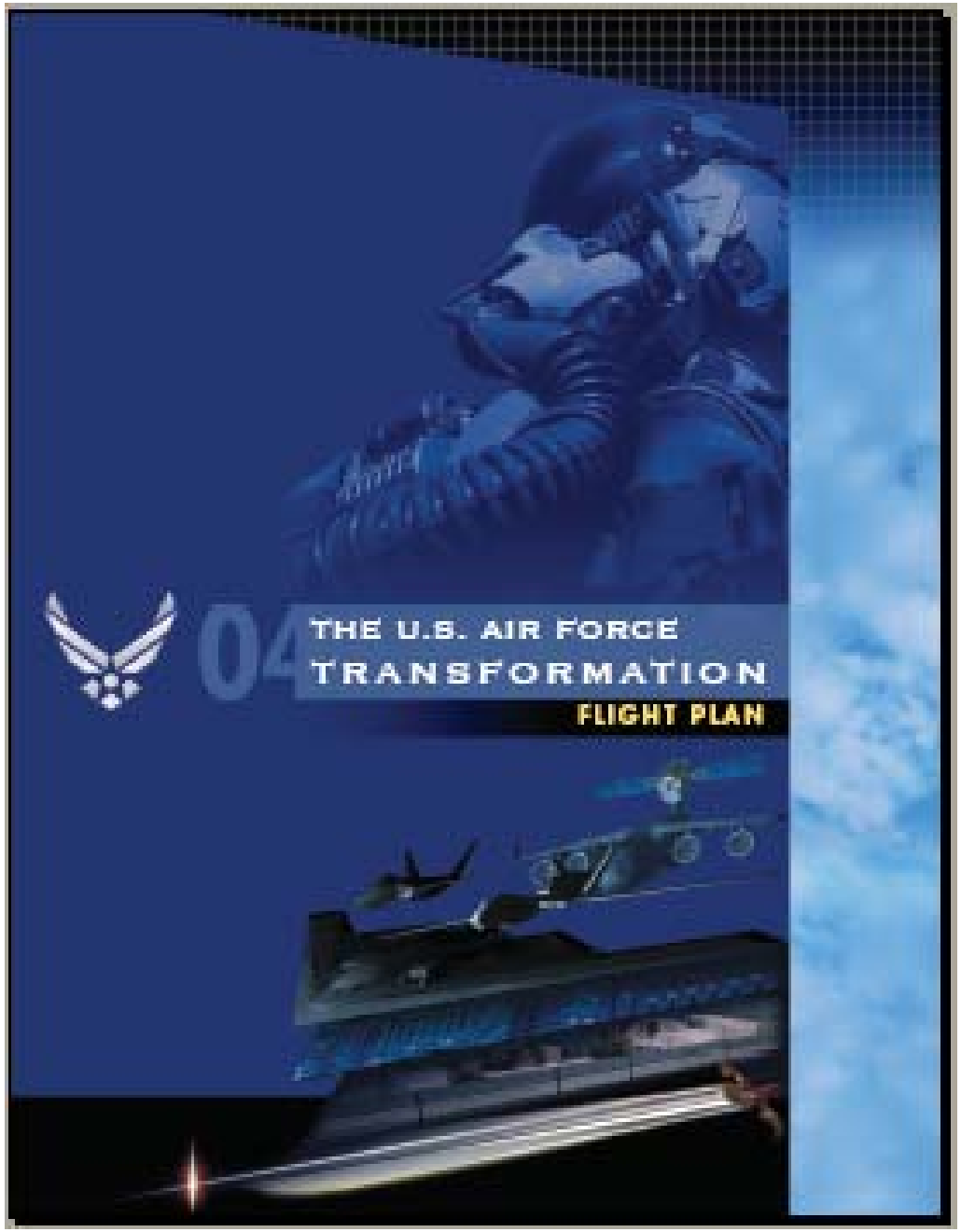
Ninth Annual High Performance Embedded Computing Workshop

Lincoln Laboratory

Massachusetts Institute of Technology

Overview

- Vision & Concept of Operations
- USAF Transformation Flight Plan → S&T
- The High Performance Embedded Computing (HPEC) Challenge
- HPEC Initiatives
- Summary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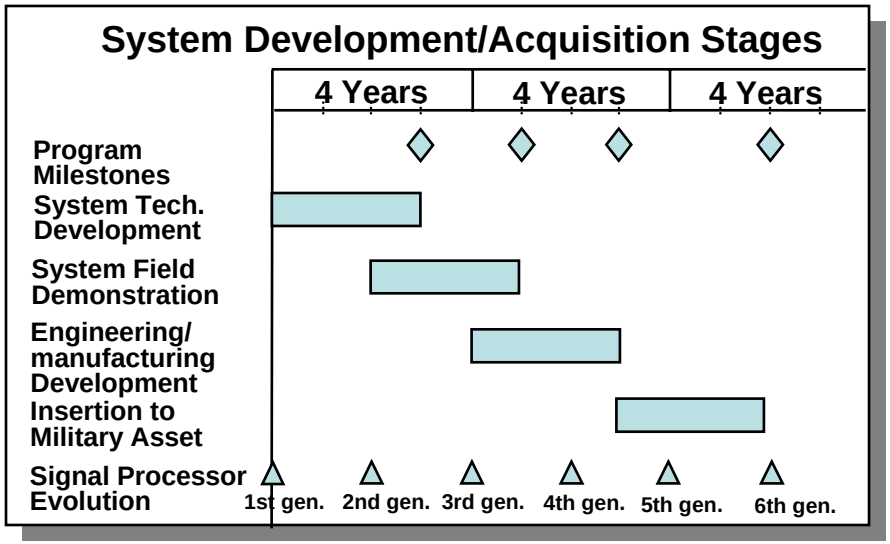
THE U.S. AIR FORCE
TRANSFORMATION
FLIGHT PLAN

Science & Technology Challenges

- Finding and Tracking
  - Control availability of latent sensory data/integrate with real time detection
  - Net large arrays of individual sensors
- Command and Control
  - Bio, nano, quantum computing
  - Intelligent dynamic software agents
  - High-level fusion tools and algorithms
  - Artificial intelligence, neural networks, fuzzy logic
- Controlled Effects
- Sanctuary
- Rapid Air and Space Responses
- Effective Air and Space Persistence

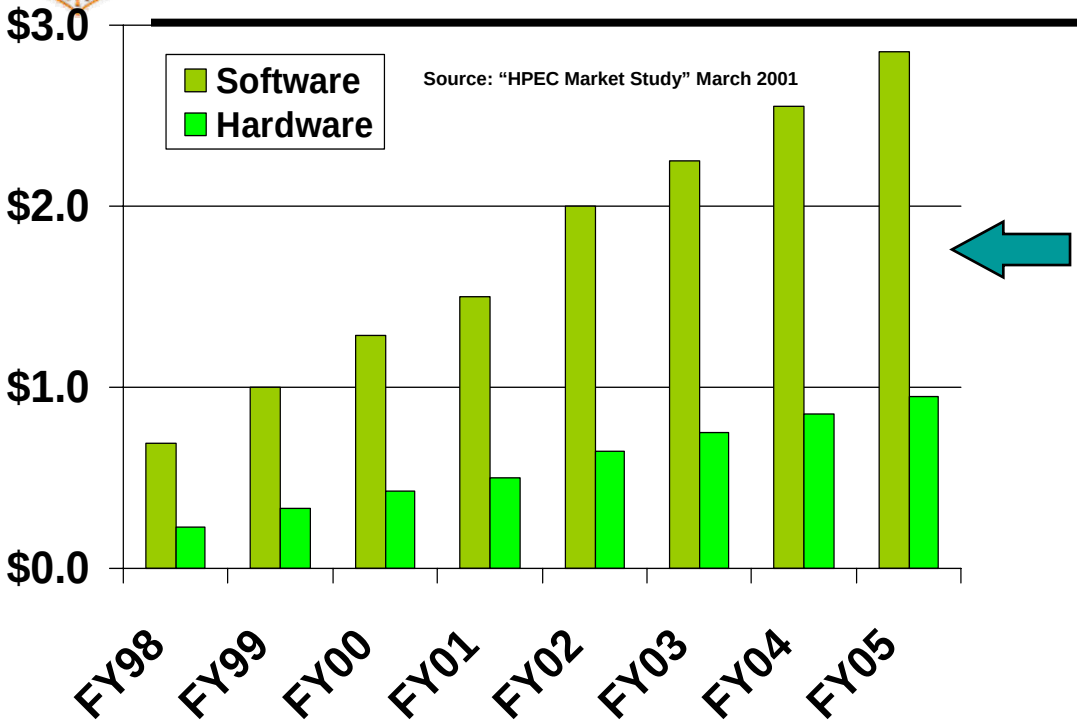
Issues with Current HPEC Development
Inadequacy of Software Practices & Standards

- **High Performance Embedded Computing pervasive through DoD applications**
  - **Airborne Radar Insertion program**
    - **85% software rewrite for each hardware platform**
  - **Missile common processor**
    - **Processor board costs < $100k**
    - **Software development costs > $100M**
  - **Torpedo upgrade**
    - **Two software re-writes required after changes in hardware design**



- Today – Embedded Software Is:
- Not portable
- Not scalable
- Difficult to develop
- Expensive to maintain

Why Is DoD Concerned with Embedded Software?



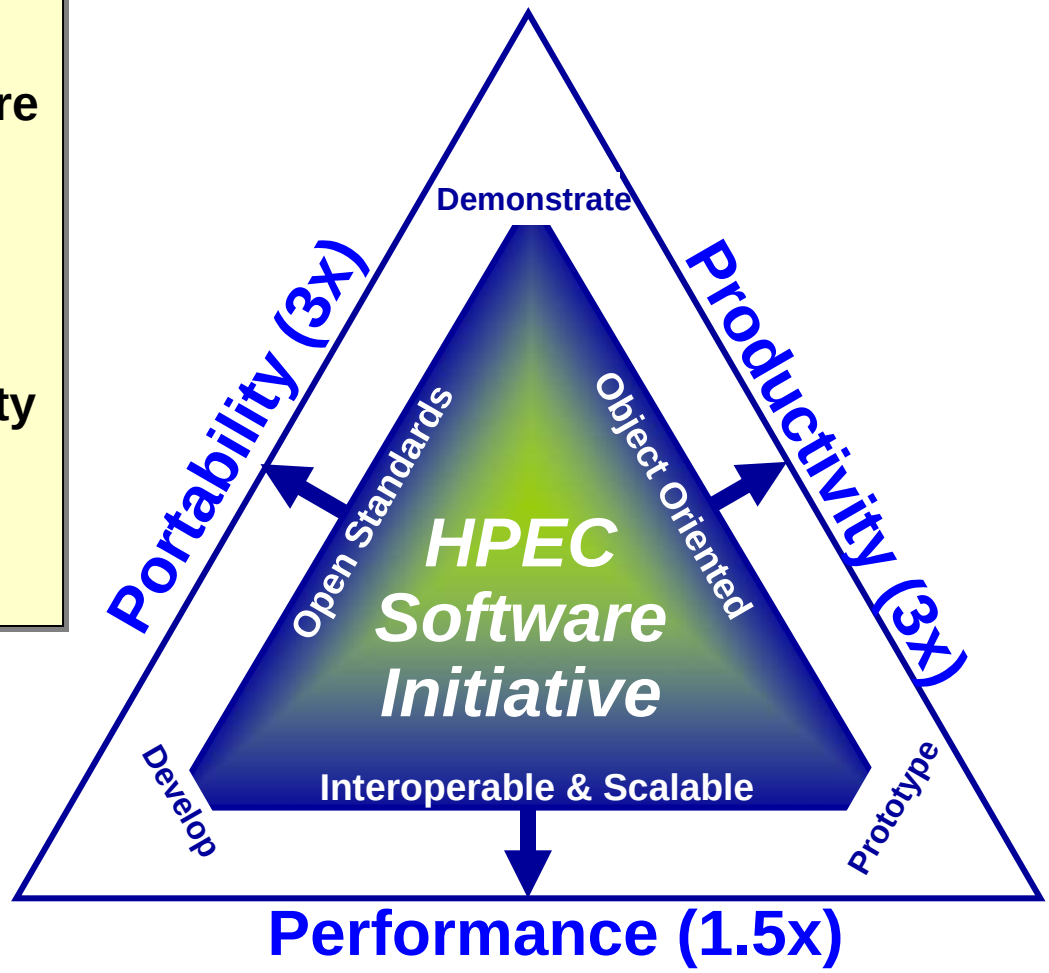
Estimated DoD expenditures for embedded signal and image processing hardware and software ($B)

- COTS acquisition practices have shifted the burden from "point design" hardware to "point design" software
- Software costs for embedded systems could be reduced by one-third with improved programming models, methodologies, and standards

High Performance Embedded Computing - Software Initiative

Program Goals

- **Develop and integrate software technologies for embedded parallel systems to address portability, productivity, and performance**
- **Engage acquisition community to promote technology insertion**
- **Deliver quantifiable benefits**



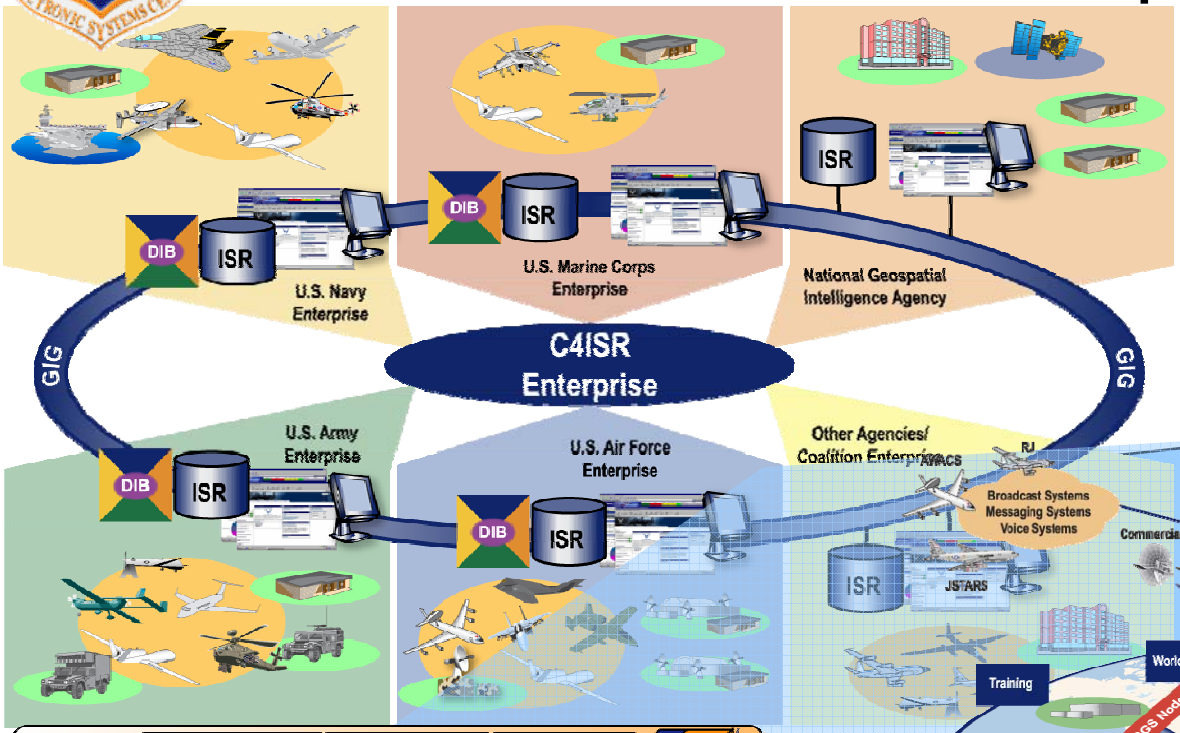
Portability: reduction in lines-of-code to change port/scale to new system

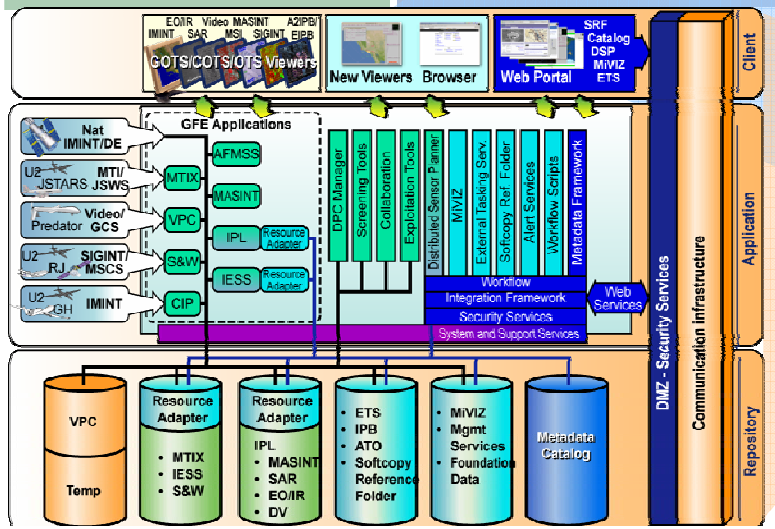
Productivity: reduction in overall lines-of-code

Performance: computation and communication benchmarks

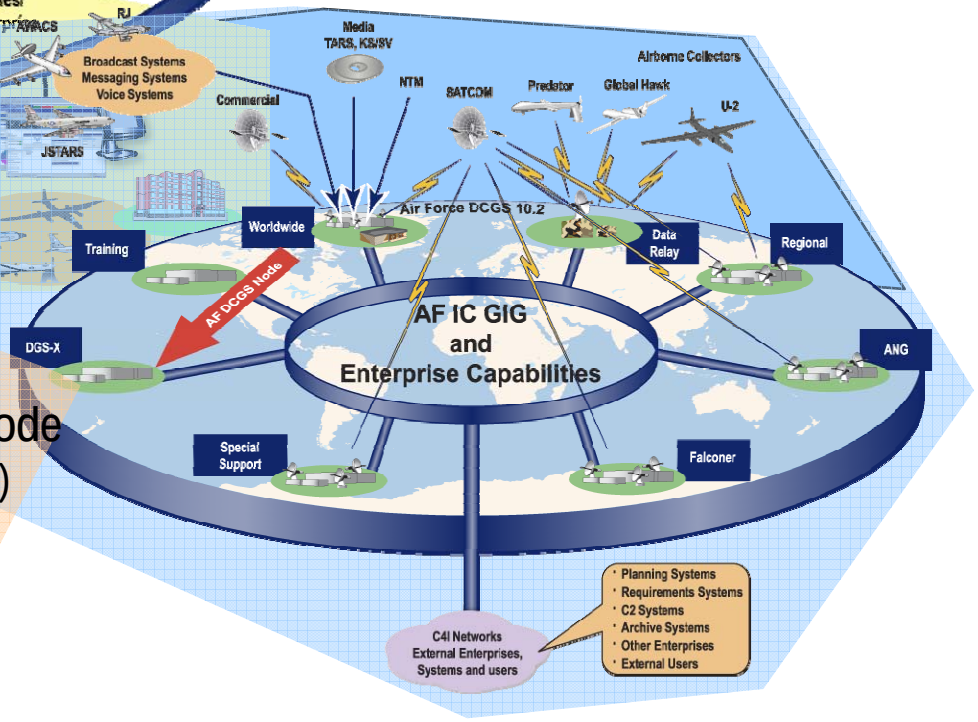
AF DCGS Interoperability Supports Global C4ISR Enterprise Vision

From a
Single DCGS Node
To a
DCGS Enterprise
To the
Global C4ISR Enterprise





DCGS
10.2 Node
(DGS-X)



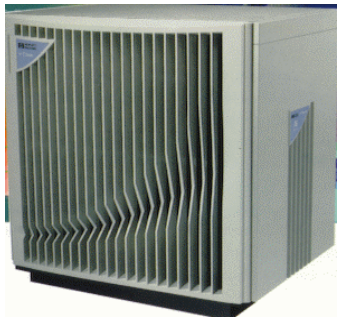
Common Imagery Processor
- Demonstration Overview -

Common Imagery Processor

- **Demonstrate standards-based platform-independent CIP processing (ASARS-2)**
- **Assess performance of current COTS portability standards (MPI, VSIPL)**
- **Validate SW development productivity of emerging Data Reorganization Interface**
- **MITRE and Northrop Grumman**

Embedded Multicomputers

APG 73 SAR IF



Shared-Memory Servers

Single code base *optimized* for *all* high performance architectures provides future *flexibility*

Commodity Clusters
Massively Parallel Processors

Swathbuckler: Wide-Swath High Resolution SAR Image Formation

Goal:

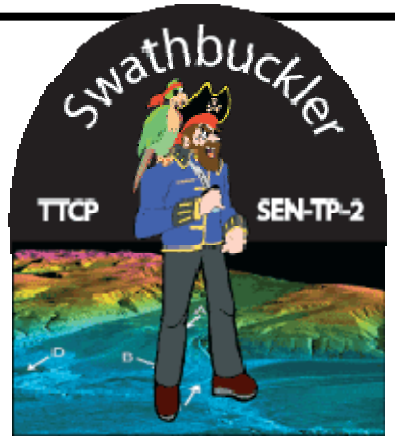
- **Demonstrate affordable, continuous (22100 km²/hr) real-time, wide-swath (37 km), high-resolution (15 cm range pixels) SAR image formation, storage, and exploitation.**

Approach:

- **Canadian test aircraft with SAR radar and algorithms, frontend hardware, test flights**
- **US (AFRL) HPC with parallel software, algorithm optimization, information management and dissemination**
- **UK FPGA programming**
- **AUS conops and EO image enhancement**

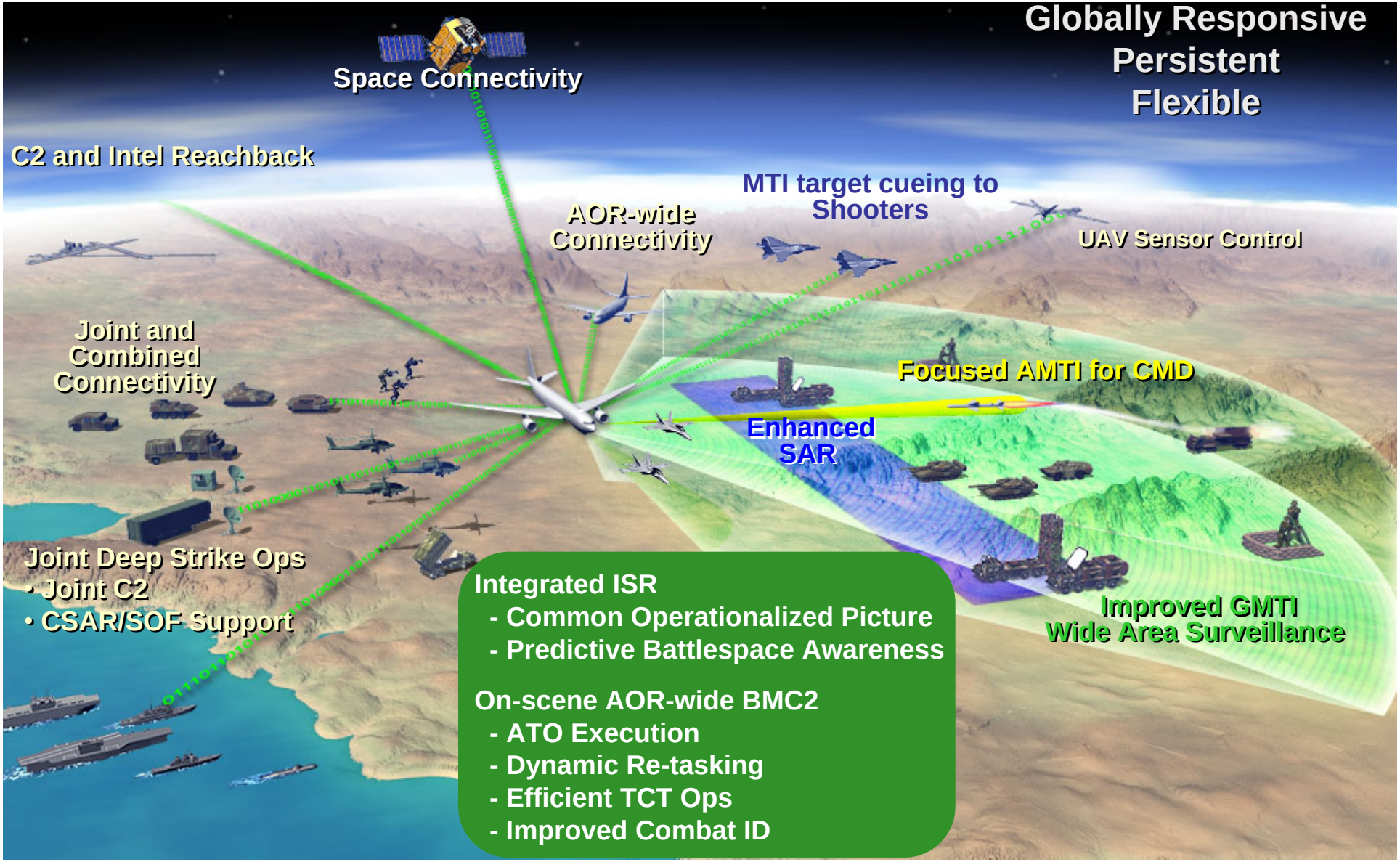
Military Impact:

- **Affordable, High-resolution SAR area coverage**
  - **3.5x Global Hawk coverage: 477K km²/day vs 138K km²/day**
  - **18x Global Hawk pixels: 0.37x0.15 m² vs 1m²**
- **>10 TB data collected for ATR algorithm development**



Embedded HPC Challenge Problem exceeding 200 GFLOPS

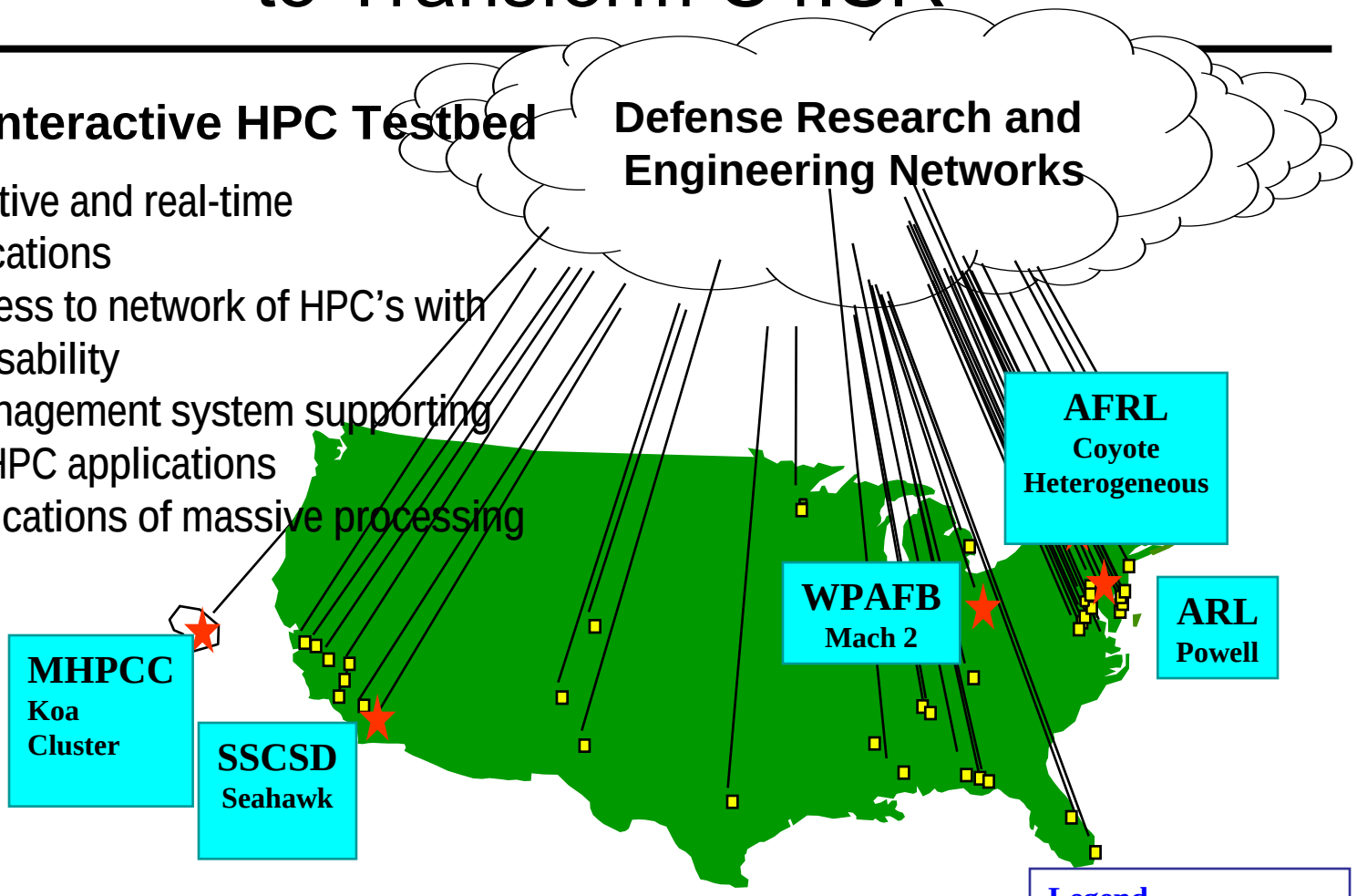
E-10A Key Capabilities



High Performance Computing to Transform C4ISR

Distributed Interactive HPC Testbed

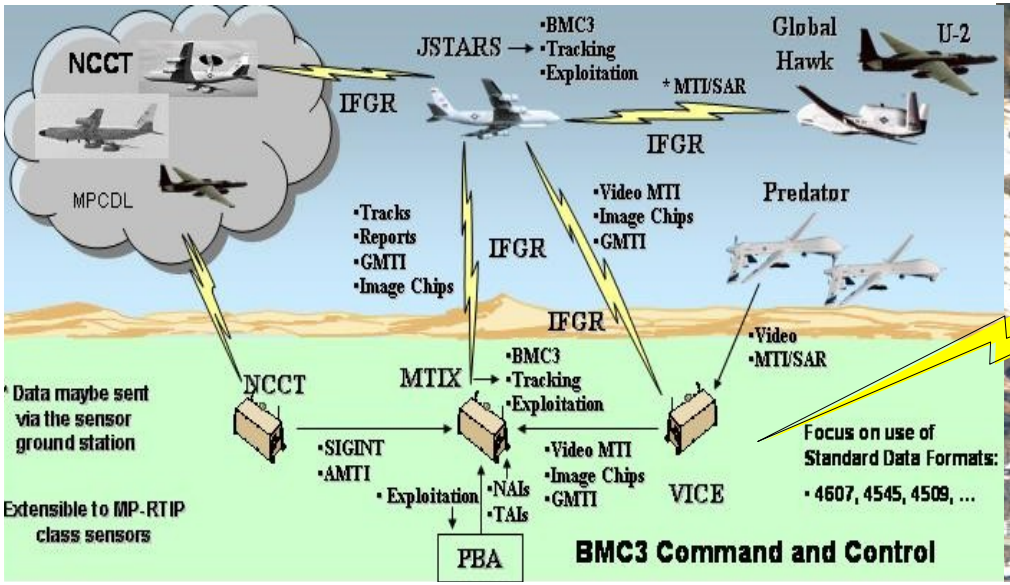
-Support interactive and real-time C4ISR applications
-Web-based access to network of HPC's with enhanced usability
-Information management system supporting distributed HPC applications
-Horizontal applications of massive processing power



- ✓ **Distributed HPC's**
- ✓ **Accessed by authorized users anywhere on the DREN and Internet**
- ✓ **Interactive and time critical problems**

Network Centric Connectivity

- Machine to Machine
- Machine to Decision Makers
- Decision Makers to Weapon Systems
  - Provide flexible, rapidly configurable systems and operations
  - Create capability on demand
  - Facilitate distributed operations
  - Provide customized applications allowing for dynamic flexibility

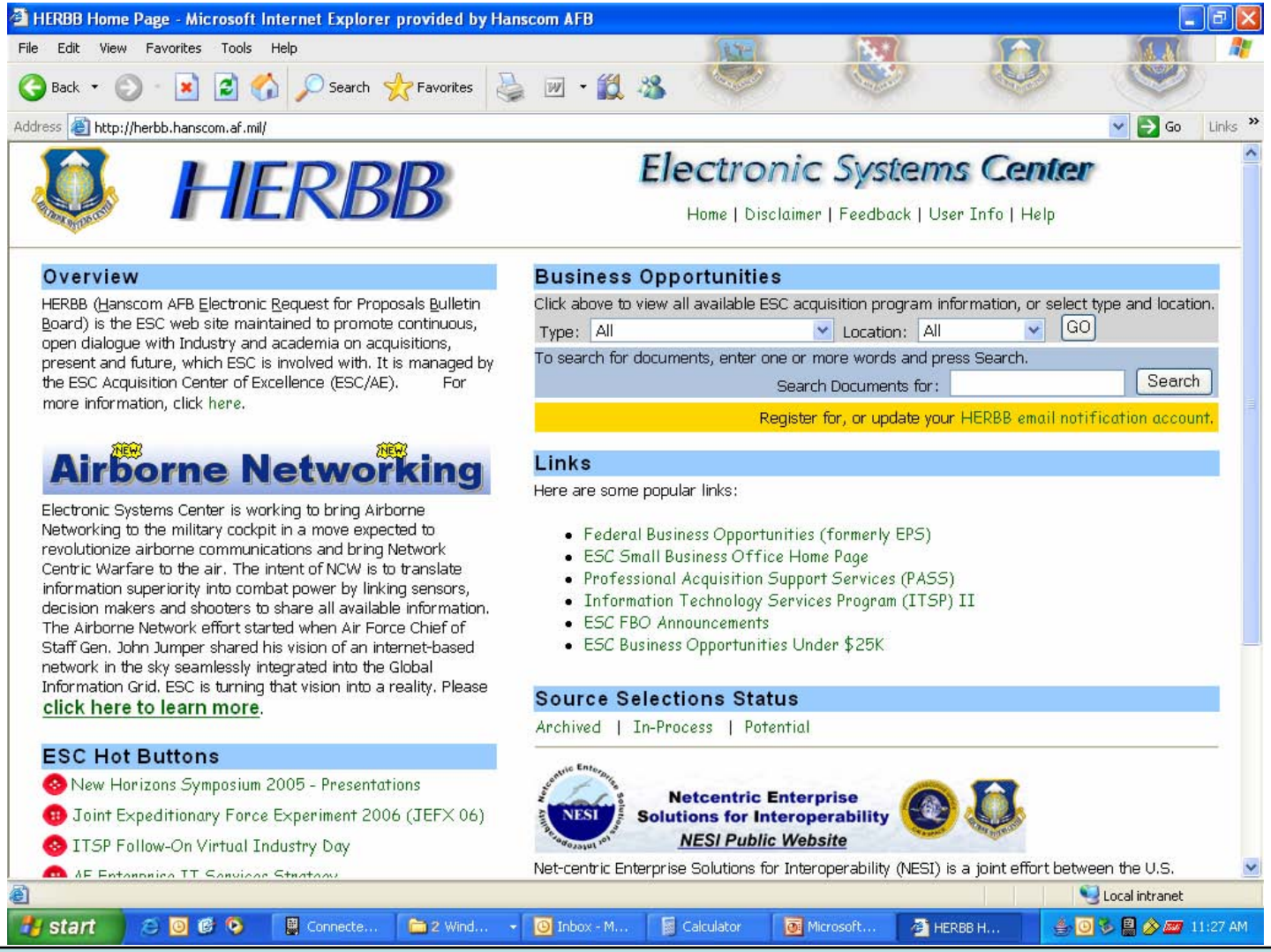


C2ISR and CS Capability Integration Points of Contact

- Capabilities Integration Directors
  - C2/ISR Systems – Ray Modeen, 781-266-9627
  - Battle Management – Marie Francesca, 781-377-9007
  - Network Centric – Col David Madden, 781-377-2389
  - Ops Support – E. Steve Wright, 334-416-5860

- HERB Site Address → http://herbb.hanscom.af.mil/

HERBB Website



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Where You Can Help

- Capabilities – Focused Tech Investment
- Openness → Technologies & Business Strategies
- Tech Transition to the Field…