Secure, Real-Time CORBA Requirements for Military Avionics

Presented to OMG/NSA Workshop
April 1997

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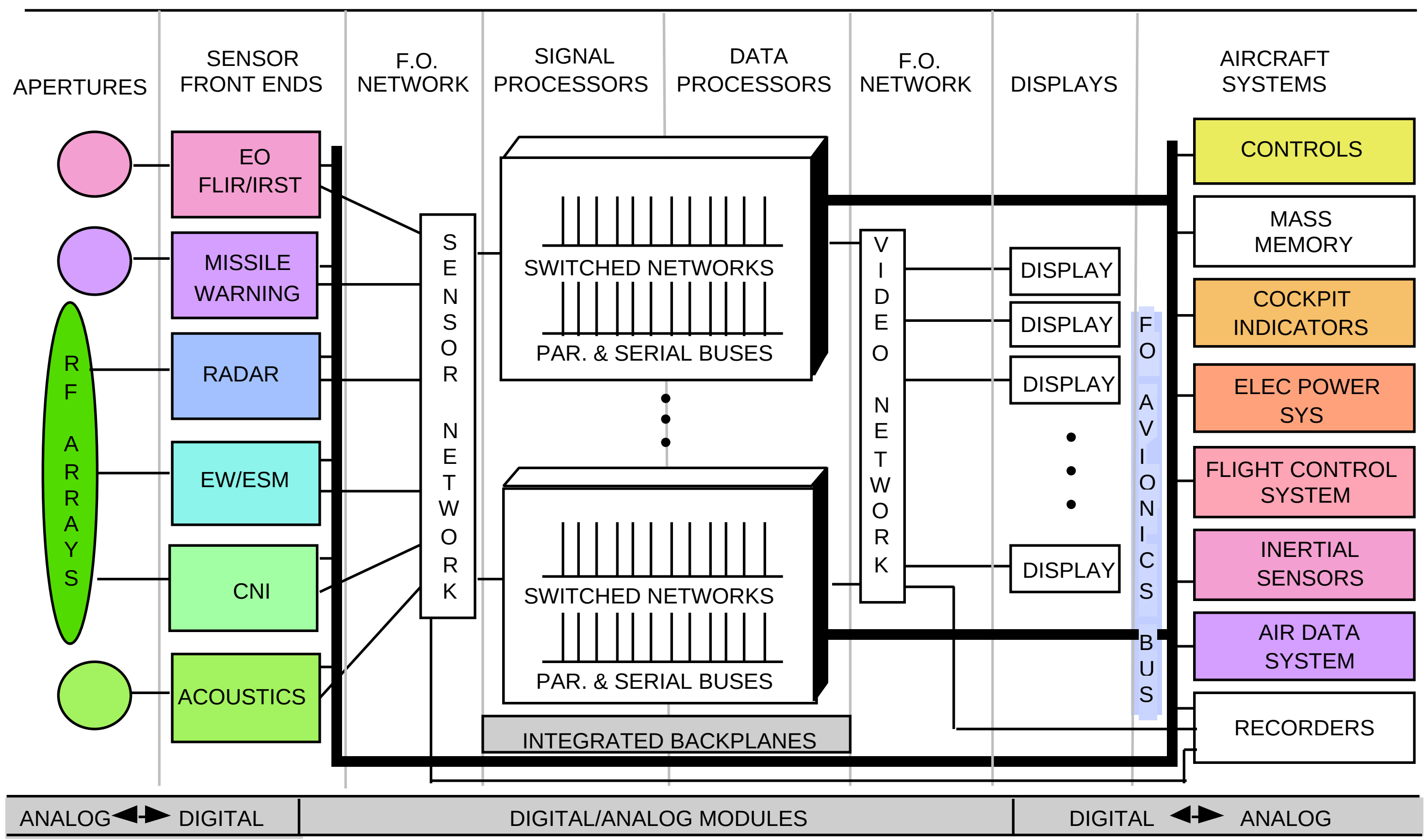
Outline

- Characteristics of Military Avionics Processing Environments
- Software Architecture Issues in Military Avionics Systems
- Real-Time Requirements
  - RT CORBA Functional Requirements
  - Real-Time Features of Avionics Operating Systems, POSIX and Ada95
  - Which Real-Time Requirements Implemented in the Application, OMG's OMA, OS, Hardware?
- Evolution of Avionics Processing Architectures
- Security Requirements
  - Information Security is a Recognized Requirement in Airborne Systems
  - Security Features of F-22 & Future Military Avionics Systems
  - Which Security Requirements Implemented in the Application, OMG's OMA, OS, Hardware?
- Technical Risk Reduction Plan for CORBA in Military Avionics

Characteristics of Military Avionics Processing Environments

- Real-Time: Periodic & Aperiodic Events; Hard Real-Time; Resource Management - QoS
- Processing: Serial & Parallel; Signal & Data
- Parallel Processing: Cache Coherent Shared Mem versus Message Passing Distributed Mem (e.g., Mercury)
- I/O: Multiple Buses; Not Typically TCP/IP; Streaming Data
- Adaptive Behavior: Increase or Decrease Processing Load in Response to Dynamic Environment (e.g., sensor resolution, EW, Fire Control, Radar Modes, ...)
- Security: Military & Intelligence Threats; Multi-Level; International
- Mission Critical: Lives Depend on Correct Operation (BIT, Fault Management, System Integrity)
- Embedded: Remote Operations; Field Replaceable Modules; Size, Weight and Power: 2X Increase => 10X $ Increase

Example Avionics Processing Architecture



This architecture is taken from the Joint Advanced Strike Technology Program Avionics Architecture Definition, Version 1.0 dated 9 August 1994

Software Architecture:
Issues in Military Avionics Systems

- **Evolution (Evolvability)**
- **Increased Situational Awareness**
  - **Increased Survivability and Lethality**
- **Aircraft LifeCycle Cost**
  - **Development**
  - **Maintenance**
  - **Upgrades (technology, function, cost reduction)**
- **Scalability at Runtime**

CORBA represents part of a solution to address many of these challenges.

System Evolvability
20 - 30 Year LifeCycle

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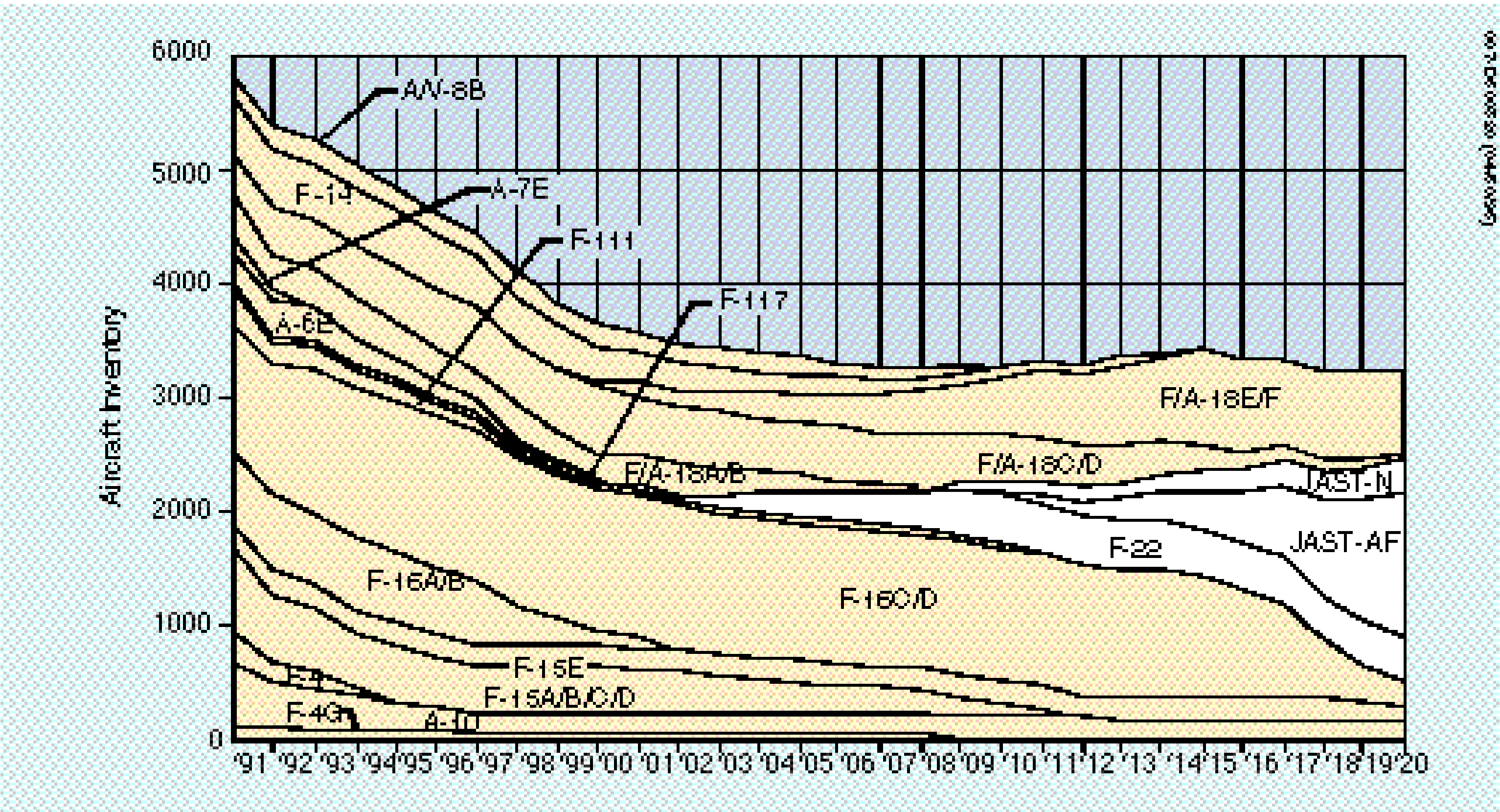
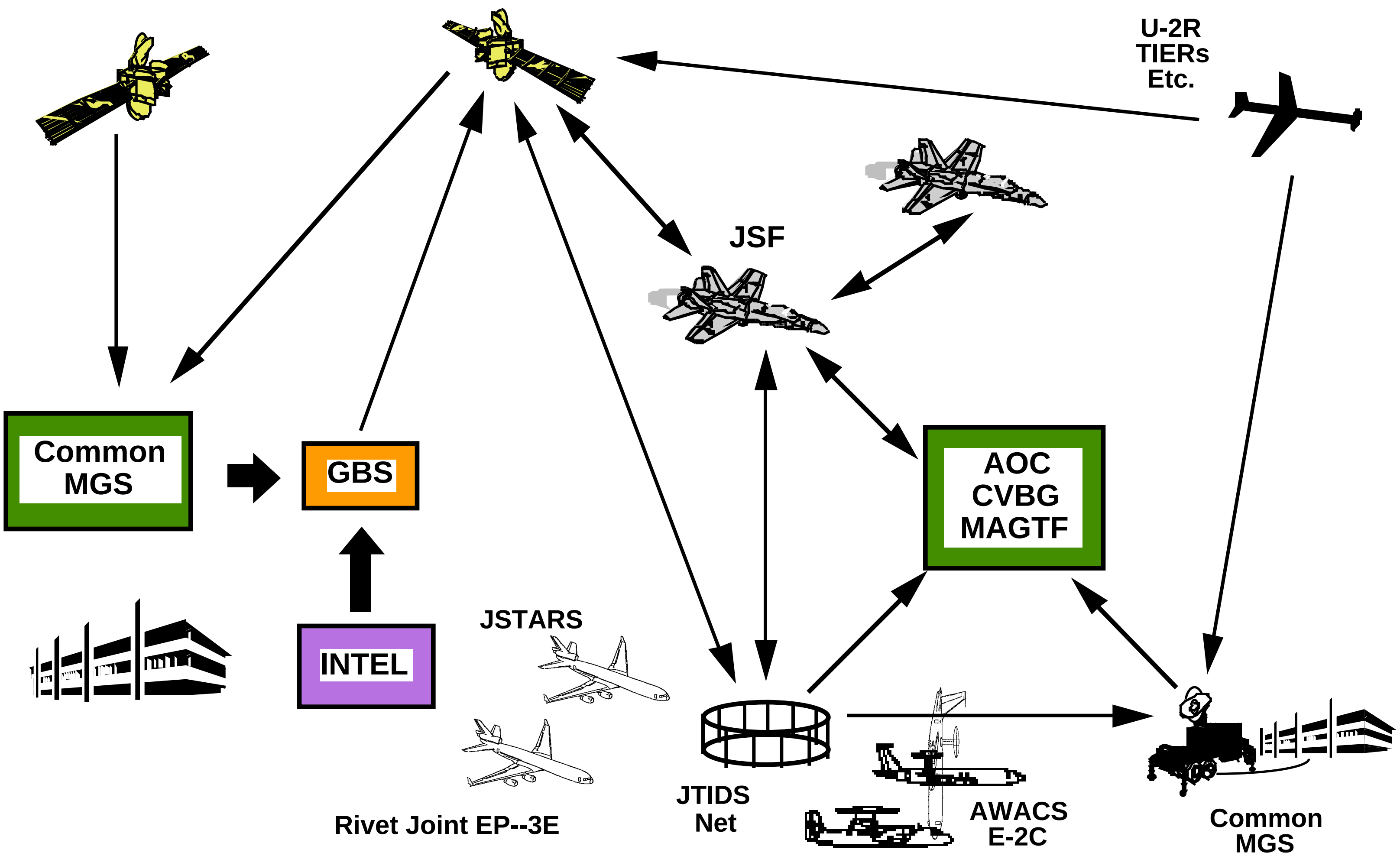
- **Why Upgrade: Parts Obsolescence; Changes in Functionality & Performance**
- **Cost-Effective Upgrades**
  - **Reengineer Legacy S/W, OO, Reuse, COTS**
  - **Revalidation strategies for cost, reliability, correctness (flight test)**



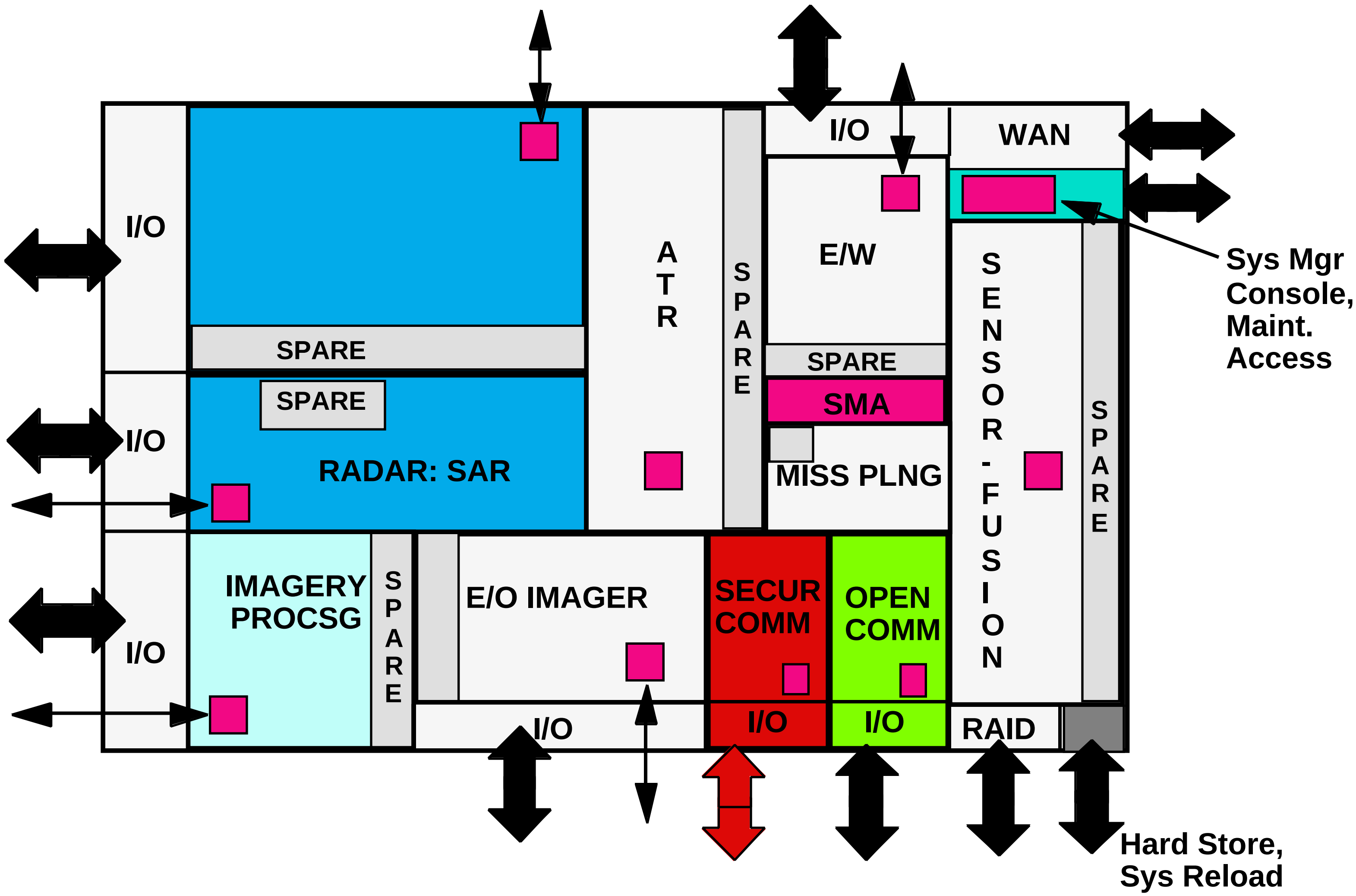
Increased Situational Awareness (Survivability & Lethality)



Decreasing Aircraft Life Cycle Costs

- **API Standards Increase Portability**
- **OO Software Architectures Increase System Modularity**
- **CORBA Increases Portability of Objects & Interoperability Between Objects**
- **Increased Potential for Reuse and for Use of COTS Components Lowers Development and Incremental Upgrade Costs**
- **Software: Jovial, Ada83, other --> Jovial, Ada95, COTS, Legacy Reuse, other**
- **Increased Use of COTS Standards: Portability, Interoperability, Scalability**
- **Increased Use of COTS Hardware & Software Components**
- **Fewer Hardware Module Types**

Run-Time Scalability



Real-Time CORBA
Required In Military Avionics

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- **All Real-Time SIG (ORBOS) Activities Necessary in Military Avionics**
  - Fault Tolerance WG
  - Flexible Bindings WG
  - Embedded ORB WG
  - Multiple Protocols WG (low latency transport, RT IOP, UDP GIOP, ...)
  - Time Services WG
  - End-to-end Timelinenss Predictability WG
  - Scheduling WG
  - Run Time Performance Metrics WG (Metrics SIG - initial RFI real-time market)
- **Real-Time Parallel Processing for CORBA Needed in Military Avionics**
  - Parallel ORB Supporting SPMD Applications on MIMD Parallel Processor
  - No OMG SIG/WG on Parallel Processing Platform
  - Tandem Has Parallel ORB for Fault Tolerance on Proprietary Non-Stop Processor
  - MPI DeFacto Standard in HPCC Community - RT MPI as RT SIG RFI Response
  - DARPA HPC++

Real-Time OS + CORBA + Security in Military Avionics

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- JSF, DISA (AJPO), and USAF Wright Lab funded Hughes to evaluate and determine the suitability of the POSIX and AOS APIs, and Ada 95 features for real-time embedded software
  - Areas of Interest: availability, performance, security, and supportability tradeoffs
  - Delta Document Comparing RT POSIX (IEEE 1003.5b/D5), AOS, Ada 95
    - 165 page Delta Doc on OMG Server: orbos/97-03-02, orbos/97-03-03
- Examining CORBA + Security Implications for AOS/POSIX/Ada95 in Military Avionics

SAE Requirements

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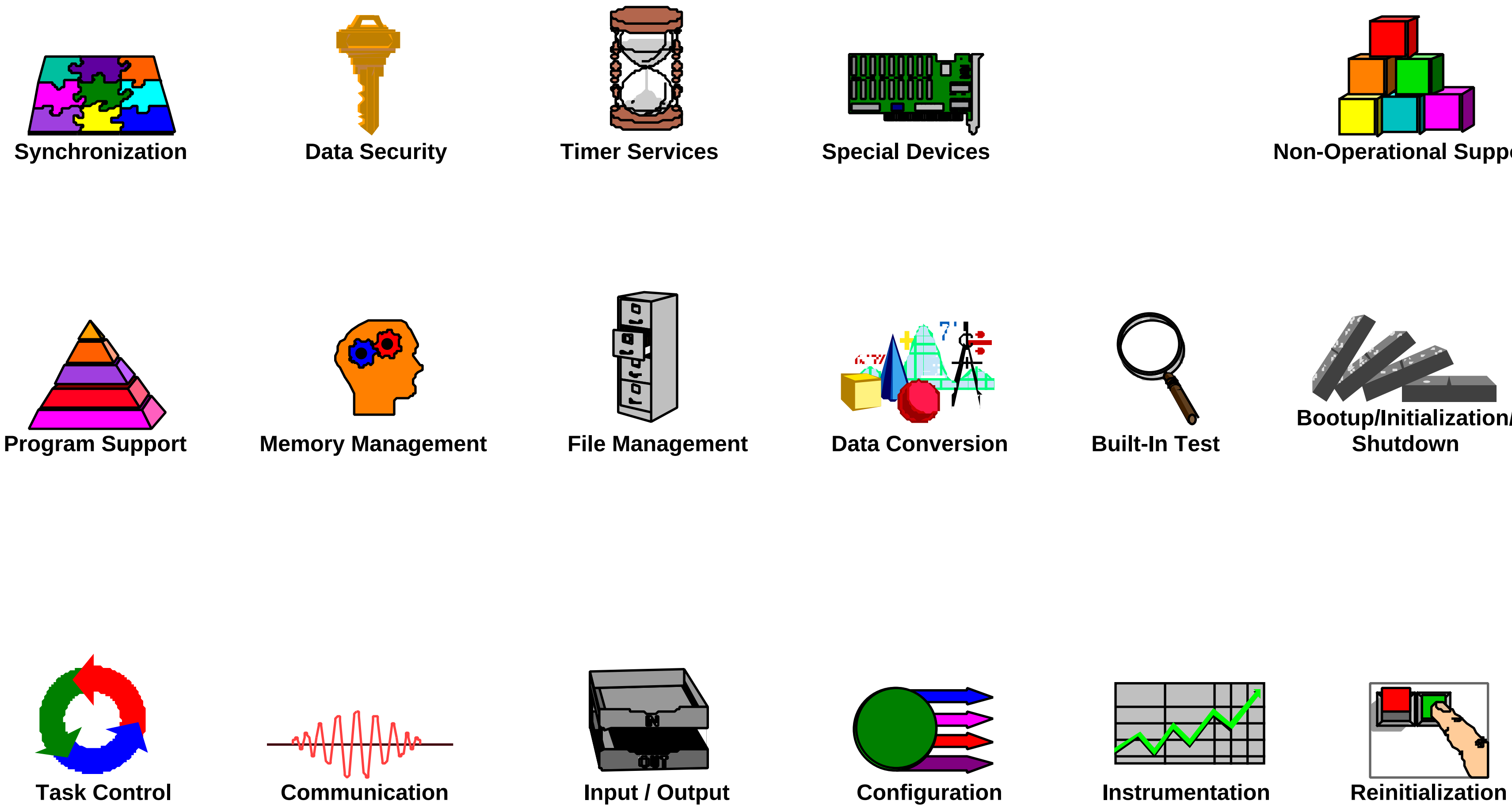
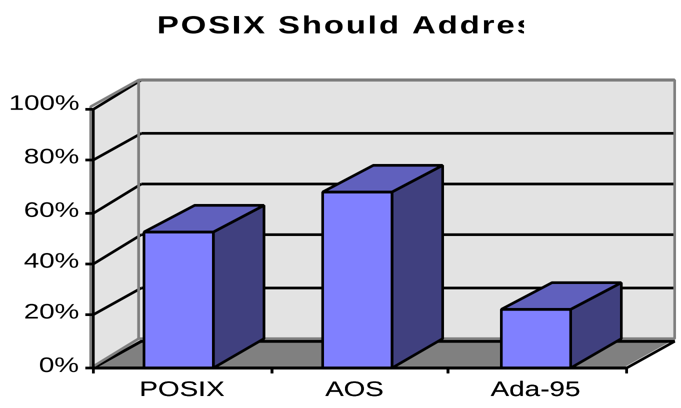


Real-Time POSIX Should Address



Requirements:

•Program Support
•Data Security
•Memory Management
•Input Output
•Data Conversion
•Fault Management
•Non-Operational Support

Number of Requirements:

•108 Total Requirements

Findings:

•Significant POSIX Deficiencies were Found in:
- •Program Support
- •Data Security
- •Memory Management
- •Input Output
- •Data Conversion
- •Fault Management
- •Non-Operational Support

Recommendation:

•Present The Missing Requirements to The Real-Time Working Group.

•Get a Consensus on The Needed Requirements.

•Implement The Agreed-on Requirements.

•Migrate Any Requirements That have not Been Agreed-on to Category 4.

•Recommend The Implementation of Ada Bindings of Any Relevant Requirements.

The Trend in APIs

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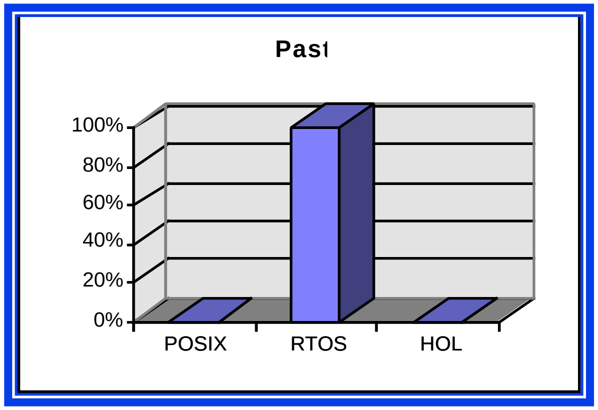
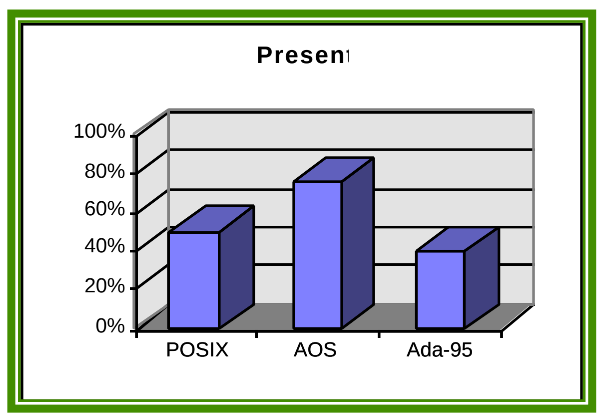
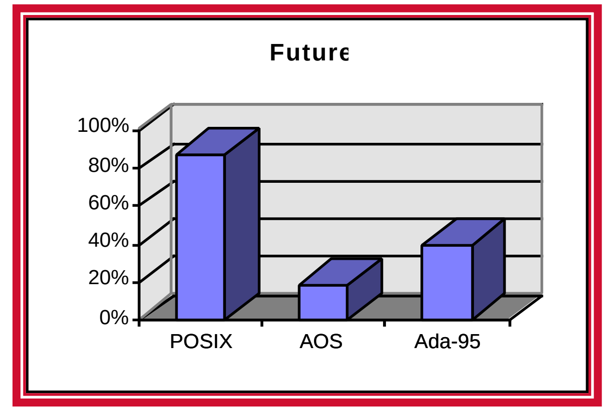


Ada + POSIX

- Real-Time Functionality Lacking in OS, POSIX, and Ada
- Considerable Overlap in OS, POSIX, and Ada





Ada + POSIX

- High Order Functionality in Ada
- General OS Functionality in POSIX
- Hardware Specific Functionality in RTOS

Evolution of Avionics Processing Architectures

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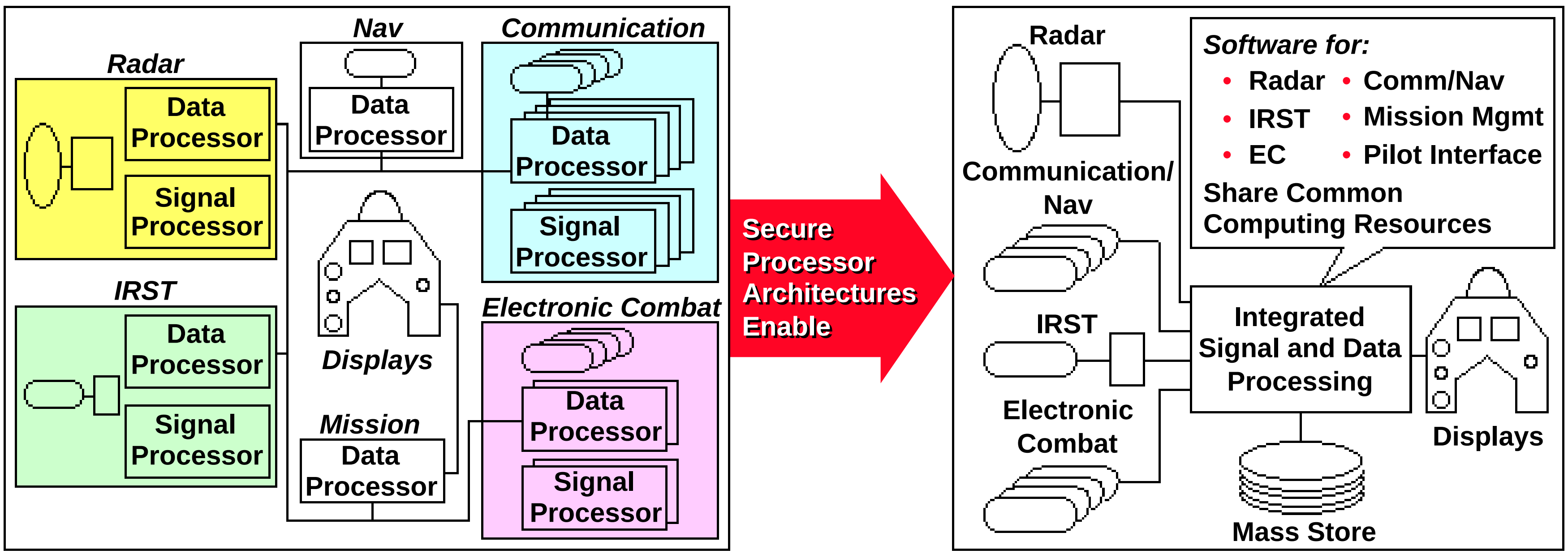
Federated System Properties:

- Single Application Within Each Physical Boundary
- Single Applications Developer Per Unit
- Debugging Scope Is Limited to Application

Integrated Avionics Properties:

- Multiple Applications Sharing Many Common Resources
- Multiple Applications Developers
- Multiple Applications Debugging



Data Security Importance:

- Protect Classified Information From Leaking

Data Security Approach:

1. Each Unit At Application High
2. "Natural" Red/Black Separations

Data Security Importance:

- Protect Classified Information
- Prevent Illicit Interactions Between Applications

Data Security Approach:

1. "Built-in" Robust Hardware and Software Separation Mechanisms: Trusted Computing Base (TCB)
2. Assurance Through Trust Engineering Discipline

Air Vehicle Interfaces Extend Beyond the Operational Environment

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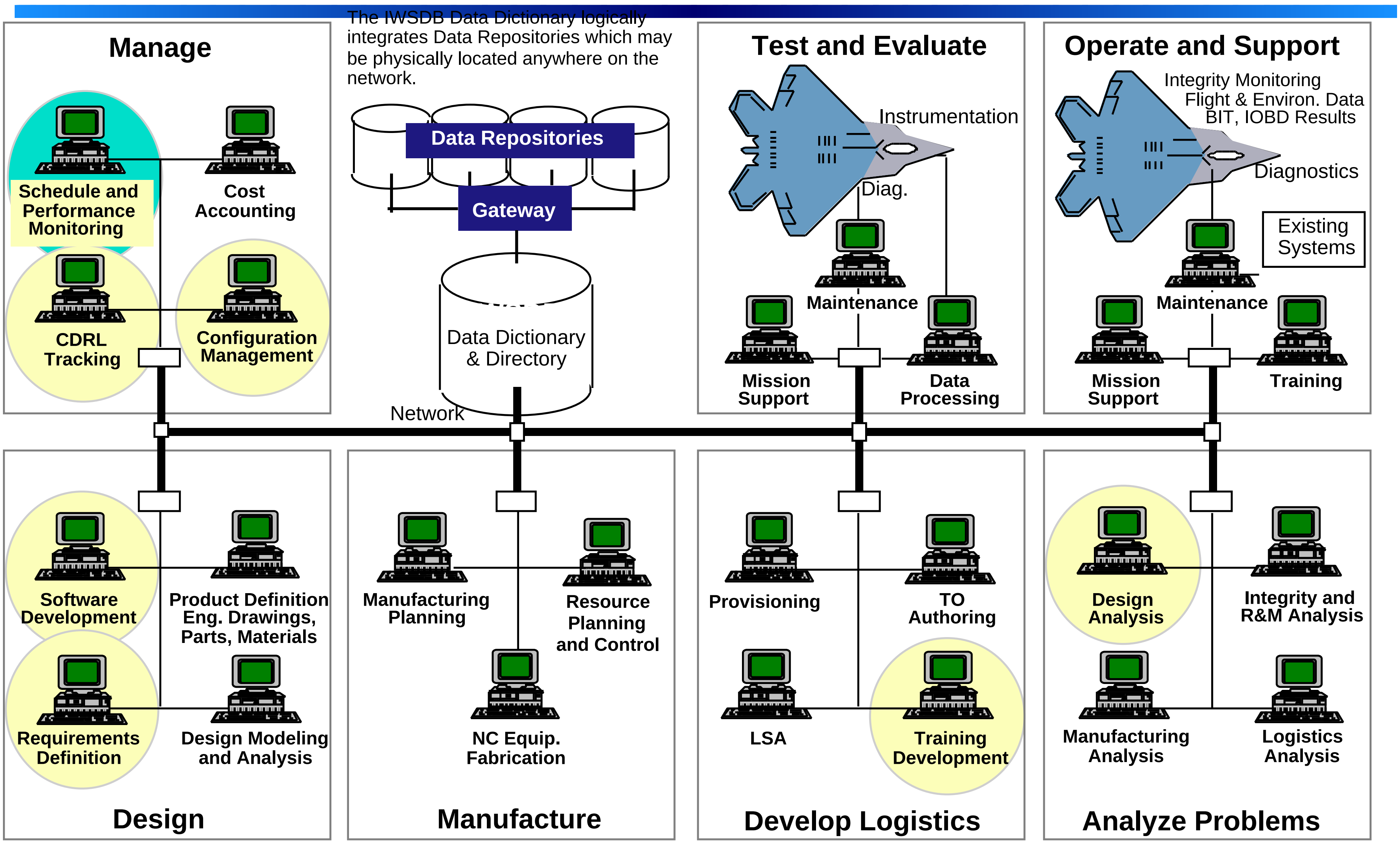

Information Security is a Recognized Requirement in Airborne Systems

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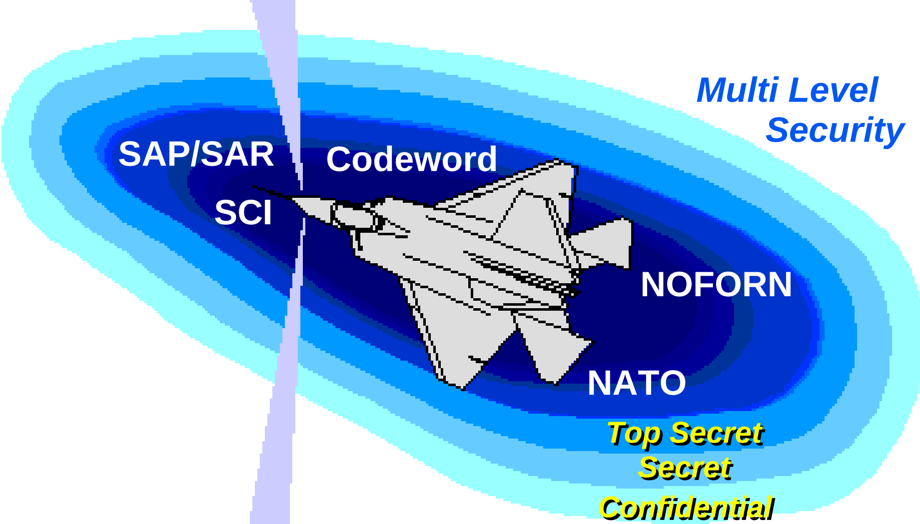
Off-Board Information

- National Assets
  - COMINT
  - ELINT
  - IMINT
- Threat Assets
  - HUMINT
  - Surveillance Information



On-Board Information

- Mission Plan
- Threat/Target Information
- Aircraft Capabilities and Technology
- Databases
- Electronic Keys

Example Security Threats in Airborne Systems

- Insider Threat (developers, maintainers)
- Disclosure
- Eavesdropping
- Penetration
- Traffic Analysis
- Masquerading (Spoofing,Malicious Logic)
- Emissions Attack
- Reverse Engineering (Tech/Alg)
- Penetration (Maintenance)
- Falsification
- Obstruction (Overload)

Applications

- F-22
- Joint Strike Fighter
- Upgrades to Existing
  - RECCE
  - JSTARS
  - E2C
  - F15
  - Comanche
- Data Fusion
- Sensor Fusion
- Situation Awareness
- RealTime Intell
- Integrated Avionics
- Off-Board Sensors
- SATCOM

JSF Secure Avionics Architecture Concept

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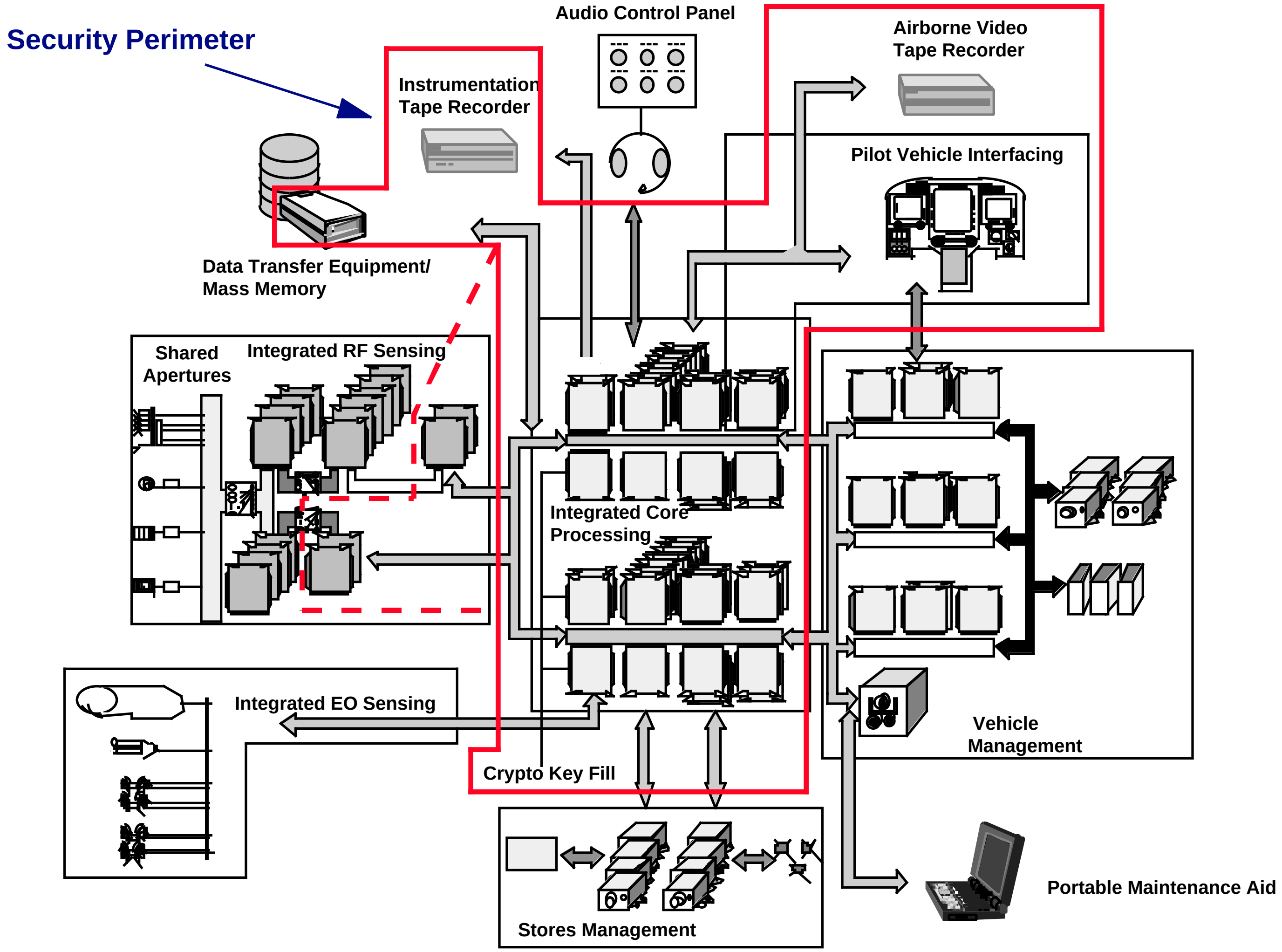

Air Vehicle Interfaces with Security Characteristics

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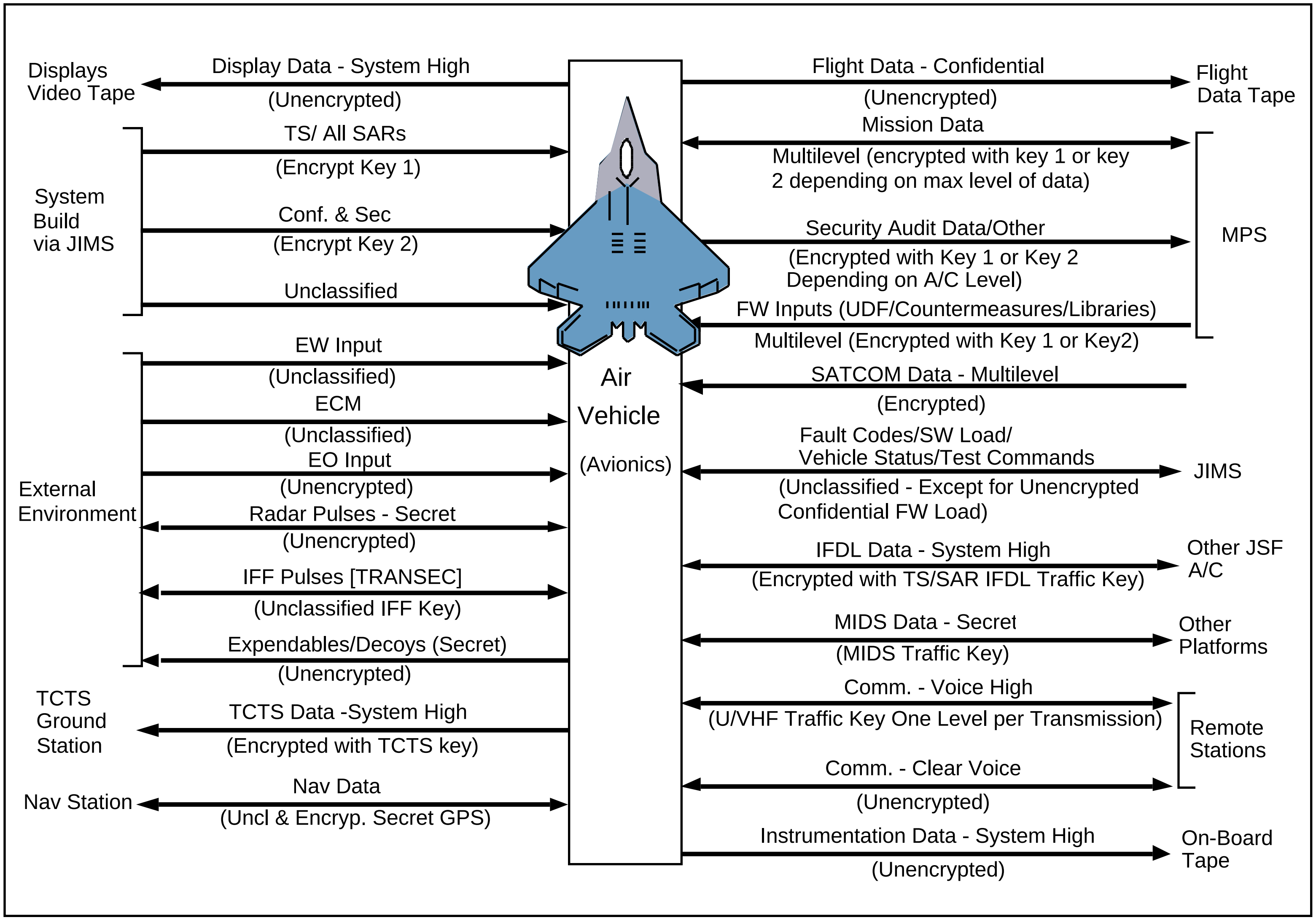

Technical Risk Reduction Plan for CORBA in Military Avionics

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- Real-Time, Secure CORBA
  - Performance Assessment of COTS ORBs (execution time & memory usage)
  - Real-Time, Trusted ORB Supporting MLS Using Standard RTOS API (e.g., AOS)
- Increased Experience Using CORBA With Ada95 on Real-Time, Embedded COTS Processor (e.g., OIS/Iona Orbix/Ada on PPC)
- Profiles of COTS ORBs - Use Only The Necessary Fuctionality
- Extensible ORBs (e.g., I/O)
- Parallel, Real-Time, Secure CORBA Applications
  - DeFacto Parallel Processing API Standards (i.e., MPI, Embedded MPI, Real-Time MPI) for Scalability
  - Real-Time, Secure OS Experience in COTS Parallel Processors (e.g., DARPA PROSE for Intel TeraFlops)
  - Secure, RT CORBA for SPMD Applications on COTS Embedded Parallel Processors (e.g., Mercury, CSPI, Sky)
- Demonstrate Scalable, Real-Time, Secure Military Application Software Using CORBA on Embedded Processors

Summary

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- CORBA Provides Same Benefits to Commercial and Military Systems
  - Standard APIs Increase Application Portability
  - Heterogeneous Languages, COTS Components, Reuse
  - Interoperability Between Distributed Objects
- Military Avionics Systems Require Solutions That Address Combinations of
  - Security + Real-Time + Embedded + Fault Tolerance + Scalability
- CORBA Needs to Provide
  - Flexibility in Security Policy and Models
  - Well-Defined and Acceptable Levels of Assurance in ORBs
  - Security Architecture That Clearly Defines OS/ORB Roles