



Boeing Technology
Phantom Works

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Embedded Systems at Boeing Challenges and Opportunities

Component-based Engineering for Embedded Systems

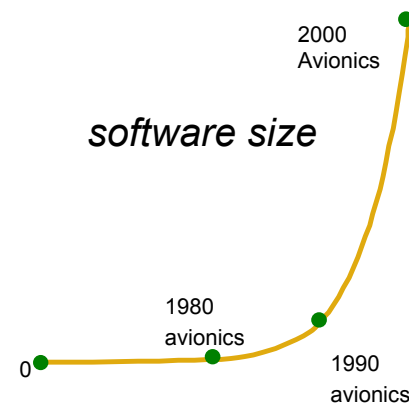
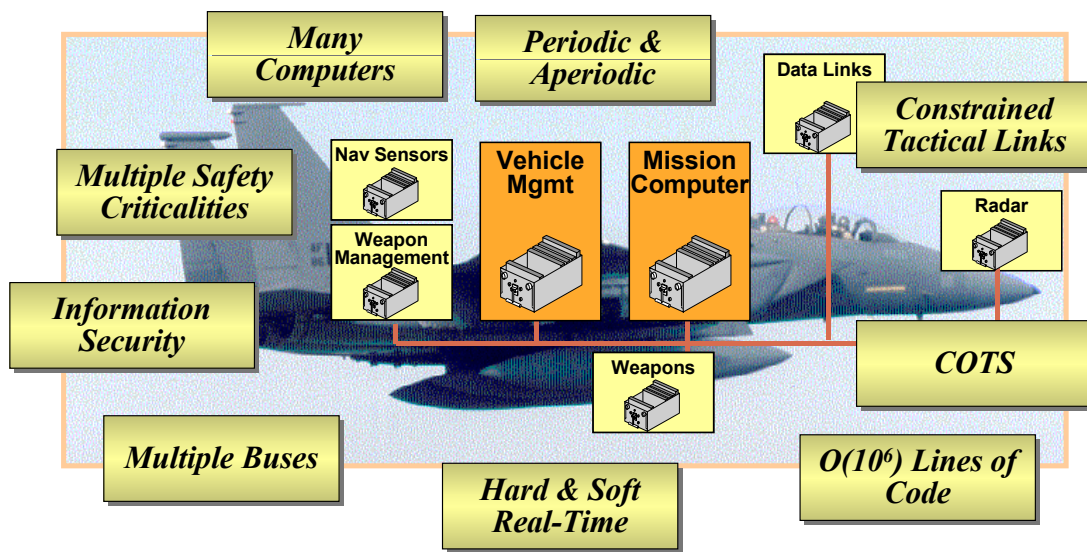
7 July, 2005

Embedded Systems Technology Challenges

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NCO Thrust

- **Operational Complexity of Large-scale Embedded Systems Is Growing Exponentially**
 - New capabilities: autonomous UAVs, Mixed Initiative, broadband aircraft networking,
 - Extended capabilities: real-time mission replanning...
 - Highly dynamic operating environments

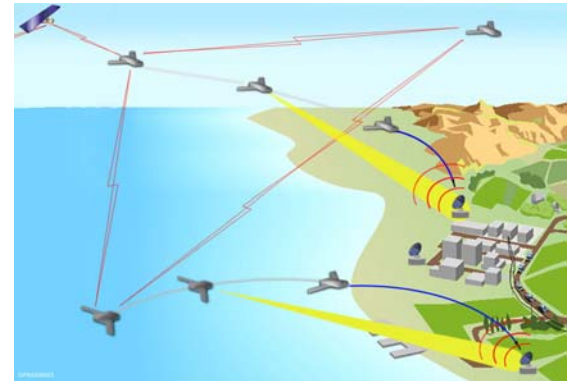
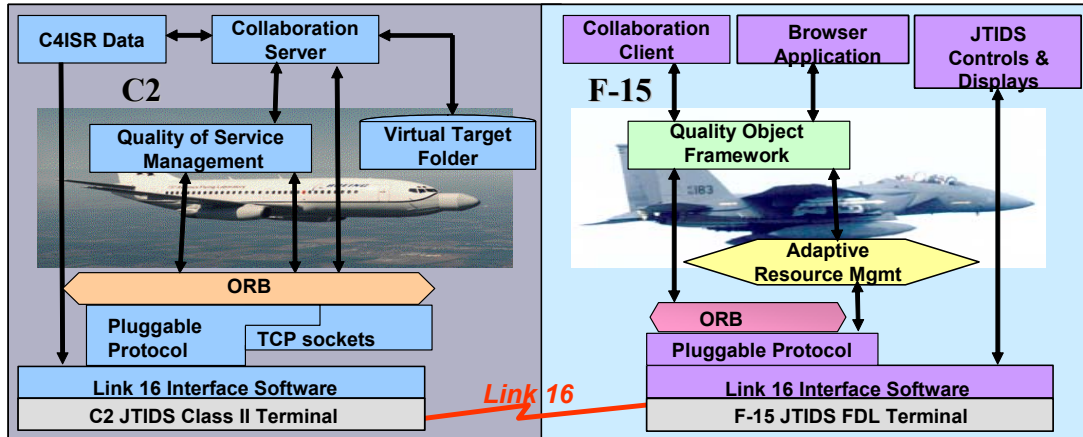


- Avionics S/W challenges
- Networking challenges
- Information Management challenges
- Application challenges
- Verification, Validation and Certification challenges
- Software Engineering challenges

Avionics Software Challenges: Dynamic System Behavior

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NCO Thrust



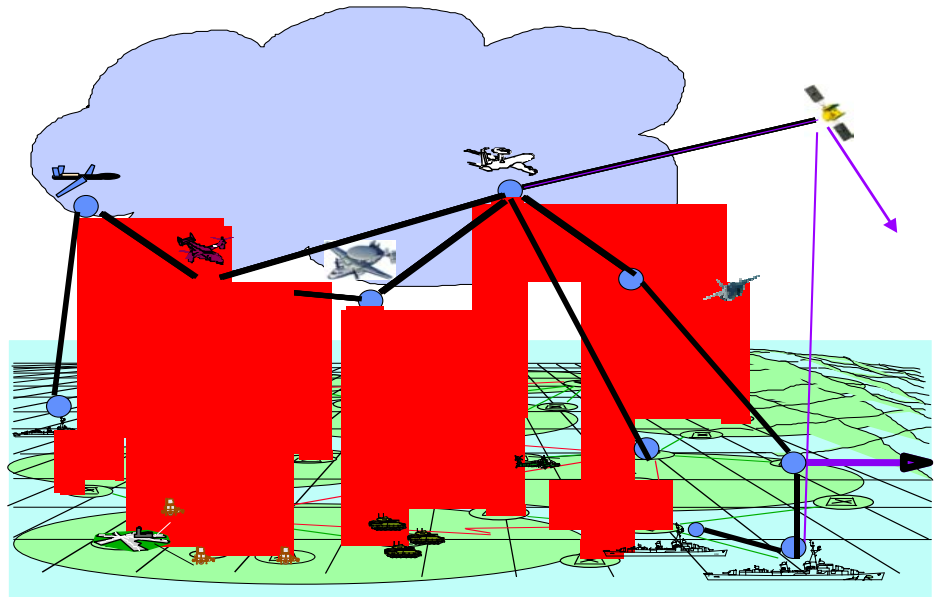
- **New applications require dynamic behaviors**
 - Mixture of hard and soft real-time tasks
 - Active resource management and dynamic scheduling
 - Mode changes with component configuration changes
 - Dynamic changes to system membership
 - Swarms
 - NCO
 - Power conservation
- **Component/System Models Favor Static Systems**
 - CCM
 - OCP
- **Meet Embedded/Real-Time constraints in a dynamic setting**
 - Need to handle during system execution things that were typically dealt with “out of band” at startup

Networking Challenges

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NCO Thrust

- **Smart routers**
 - Help deal with massive amounts of data
- **QoS in “open” networks**
 - Latencies
 - Predictability
 - Guaranteed delivery
- **Bandwidth**
 - Wireless
 - Mobile
 - Satellite
 - Airborne
- **Heterogeneous/Federated networks**
- **Inherently unreliable networks**



Information Management Challenges

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NCO Thrust

- **Dealing with massive amounts of data under embedded systems constraints**
 - Data mining
 - Associating meta-data with data
 - Using meta-data
 - Turning data into information into knowledge into wisdom
 - Filtering
- **GIG/JBI Issues**
 - Making the GIG work

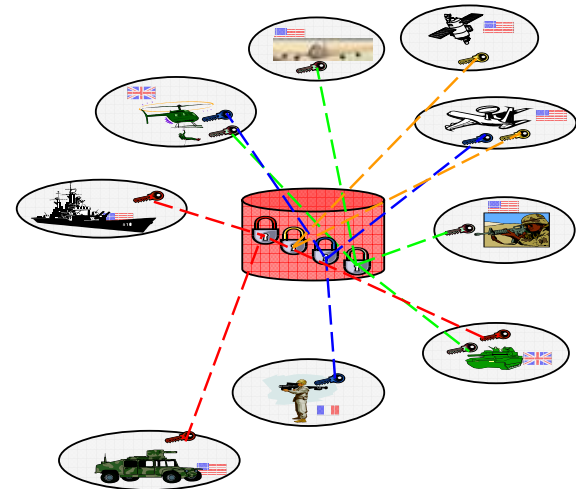


Information Assurance and Security Challenges

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NCO Thrust

- **Operations in coalition environment**
- **Dealing with security in a dynamic world**
 - Traditional security solutions impose static structure and partitioning
 - Preventing covert channels under cover of reconfiguration
- **Anti-tamper avionics software**

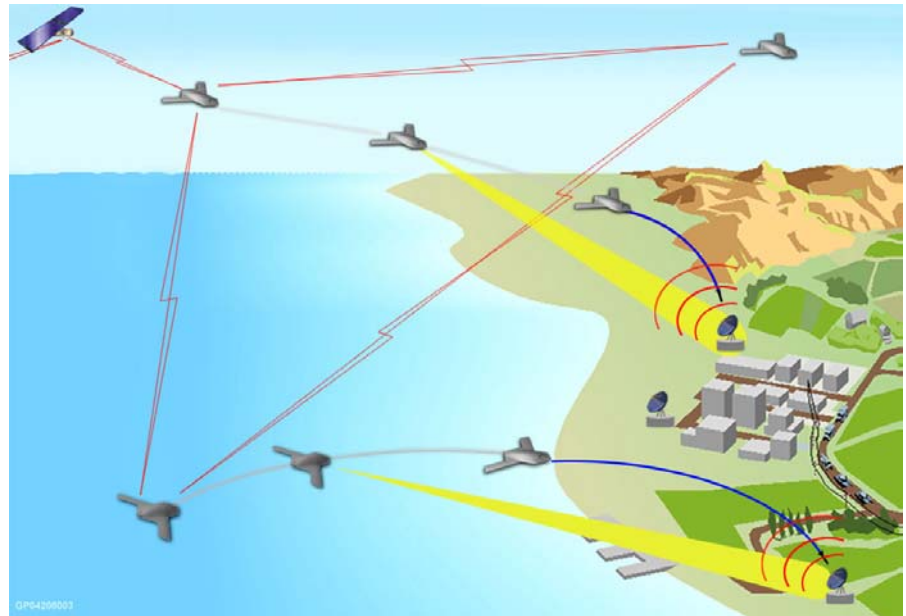


Multi-entity Embedded System Challenges

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NCO Thrust

- **Dynamic replanning and response to uncertainty**
- **Resource and task allocation**
- **Mixed initiative operations**
 - Allocation of initiative to human operator or automata
- **Fault-Tolerance**
- **Heterogeneous platforms**



Software Engineering Challenges

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NCO Thrust

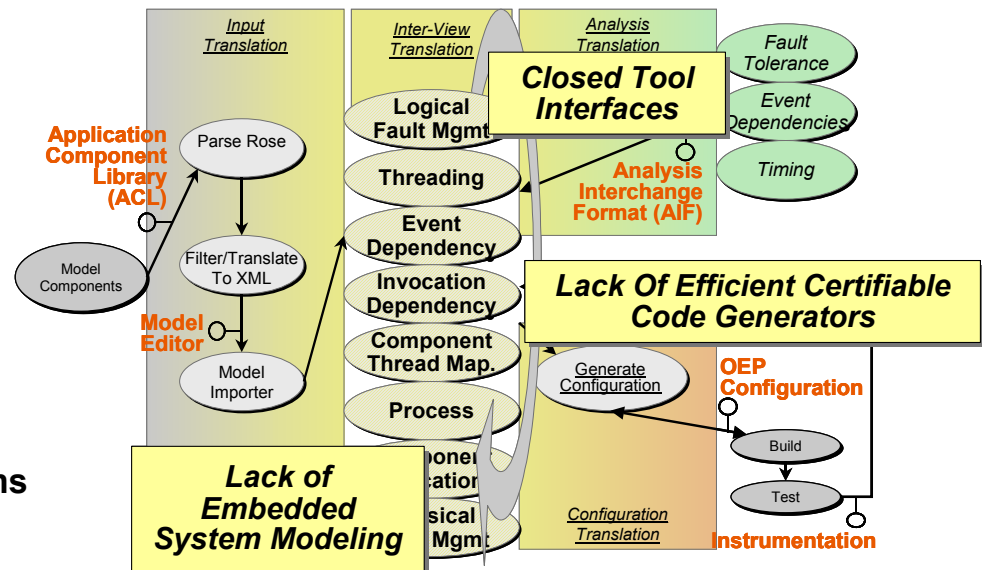
- **Creating component models/development environments for “legacy” systems**
 - **May not always be able to select the component model first**
 - Have instead an existing infrastructure to create a component model and development environment for
 - Define component model consistent with legacy platform
 - Abstractions appropriate for
 - Component based development
 - Existing infrastructure
 - Functional and non-functional requirements
 - **Generate development environment**
 - Modeling tools
 - Code generators
 - Infrastructure adapters
 - Testing/analysis tools
- **Data collection**
 - **Analysis techniques require data that**
 - Does not currently exist
 - Frequently difficult to obtain
 - Too often impractical to create directly
 - **Ex: timing and state transition data for legacy system/components**

Avionics Software Challenges: Integration

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NCO Thrust

- **Component/System integration is still hard**
 - **The MoBIES problems are still out there**
 - **Component integration satisfying QoS**
 - **Real-time**
 - **Concurrency**
 - **Distribution**
 - **Constrained by**
 - **Large, distributed development teams**
 - **Product line based reuse**
 - **Legacy systems, platforms and processes**
 - **With Efficient/Effective**
 - **Performance analysis, prediction and testing**
 - **Testing and iterative development**



Verification, Validation and Certification Challenges

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NCO Thrust

- **V&V and Certification is expensive, and getting more expensive, for fielded systems**
- **Future advanced manned and un-manned systems may not fit naturally under current V&V and Certification regimes**
- **Need approaches for efficient V&V and Certification for emerging technologies for them to be deployable**
 - **Multi-entity Systems**
 - **Human interaction with Autonomy.**
 - **Fused Sensor Systems**
 - **Adaptive Systems that change with environmental stimulus**
 - **Mixed Criticality- Functions dependent on information with varying confidence.**



Summary – Common Embedded System Challenges

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NCO Thrust

- **Dynamism**
 - System of systems with changing participants
 - Changing modalities of individual systems
 - On-line code generation
- **Heterogeneity**
 - System of systems
 - Heterogeneous/federated networks
 - Heterogeneous collaborations
 - Ad hoc coalitions
 - COTS/GOTS components in an overall system
- **Fault Tolerance**
 - Unreliable networks
 - High confidence
 - Mission effectiveness in the presence of failures
 - IVHM
- **Scalability**
 - Massive data flows
 - Systems of lots of systems
 - Ever larger endsystems
- **Certification and V & V**

