Toward Efficient and Effective Contracting Structures and Processes for Systems-of-Systems Acquisition

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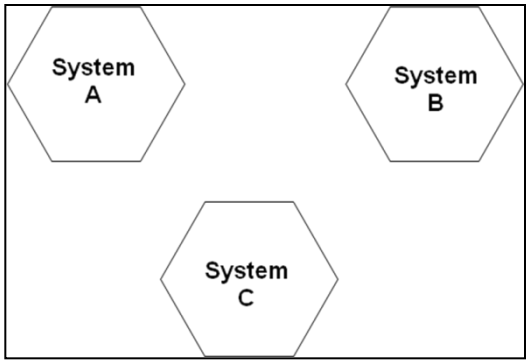
Overview

- Research Objectives
- Scenario
- Recent SoS Acquisitions
- Current Systems Engineering Findings
- SoS Acquisition
- Current SoS Acquisition Findings
- Conclusion

Research Objectives

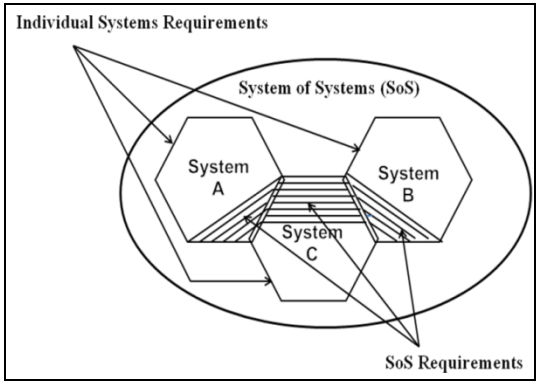
- Assess impacts of SoS systems engineering on SoS acquisition
- Determine contracting and organizational options to enable successful SoS acquisition

Scenario



Three Separate Systems Being Developed

- Realistic , reflecting some current DoD SoS acquisition programs
- Three separate, autonomous, individual systems
  - Currently being acquired
  - Managed by a government program office and a contractor

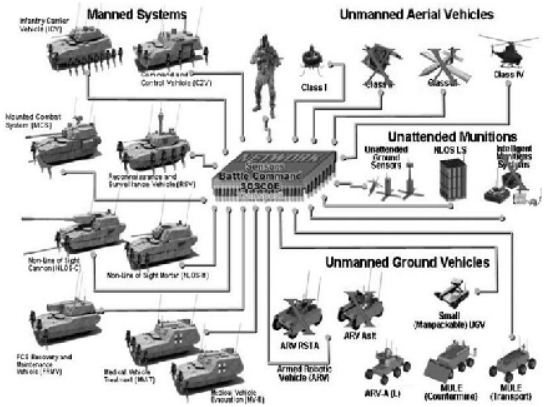


Addition of SoS Requirements

- During the course of acquisition of each individual system
  - New mission arising
  - Required SoS consisting of the three systems
- New requirement: each individual system as part of the SoS acquisition program

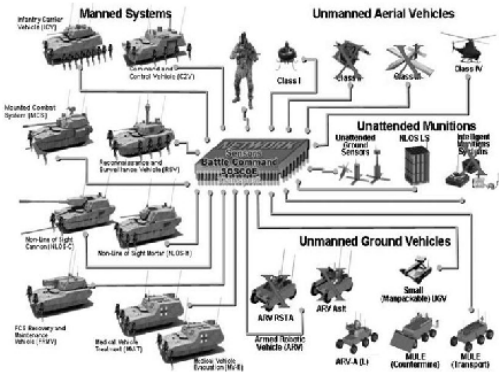
Recent SoS Acquisitions & Challenges

- Recent SoS Acquisitions
  - US Army's Future Combat System
  - US Coast Guard's Deep Water System
  - Homeland Security's SBInet
- Technical, budget, and schedule challenges beyond usual norm for system acquisitions
  - Similar acquisition approach: contract to a large system integrator (LSI)
  - Development responsibility passed from Government to industry
  - Lack of front-end overarching SoS architecture



Future Combat System (FCS)

- Program restructured
  - Existing manned ground vehicles to replace new manned ground vehicles, networked with unmanned aerial vehicles
  - Four of eighteen core systems cancelled
- Cost growth
  - From $91.4 B to $160.9 B ($203.3 - $233.9 B by independent estimation)
- SE pitfalls
  - Late, poorly defined, or omitted requirements for networks and software
  - Only 2 of program ‘s 44 technologies fully matured bv late 2006
  - Critical technologies not fully mature until Army ‘s production decision in 2013



Deepwater

- Program cancelled
  - Awarded to Integrated Coast Guard Systems (ICGS) -- NG and LM
  - SoS = updated legacy ships + new national security cutters + offshore patrol cutters + fast response cutters + updated aircraft + new manned and unmanned aircraft + new C4ISR system
  - Program cancelled, close to $100M spent
  - Coast Guard to modernize existing 110-foot Island class patrol boats pending the delivery of replacement Deepwater craft
- Cost issues
  - Estimated cost: $19-24 B
  - About $100M spent at time of program cancellation
- SE pitfalls
  - Serious problems with C4ISR system
- US Coast Guard
  - Pursuing Deepwater acquisition programs as individual programs
  - Phasing out & terminating ICGS contract in January, 2011
  - Being systems integrator for all Coast Guard Deepwater assets
  - Increasing its in-house system-integration capabilities

SBInet

- Program problems
  - Awarded to Boeing Integrated Defense Systems in 2006
  - Cameras, radars, lighting and other sensors networked through a communication system including satellite nodes and links to detect illegal crossings of US-Mexico
  - Prototype of final solution currently in use on just one part of the border
  - Funding cut off by DHS pending further review

- Cost issues
  - Estimated cost: $2.5B
  - Expected cost of $6.7B to be adjusted to $8B
- SE issues
  - Flawed testing process, performance issues, and poor management
  - Test plans poorly defined and plagued by "numerous and extensive last-minute changes to test procedures" (GAO)
  - Testing poorly performed
  - Failure to prioritize solving problems with the system and to conduct further tests

Current SE Findings: SoS SE Required for SoS Acquisition Success

- Need for effective, sustainable global SoS systems engineering effort , including development of an over-arching architecture before start of acquisition process
- Prior to milestone A, and prior to Material Solution Analysis phase, assessment of
  - Elucidation of user needs and requirements
  - Elucidation of data ownership issues impacting contractual relationships
  - Assessment of availability of all systems and technology readiness
- Requirement for a capable SE organization either organic to or external to the SoS acquisition program office, but with strict authority over the SE organization by the SoS acquisition program office during entire SoS acquisition

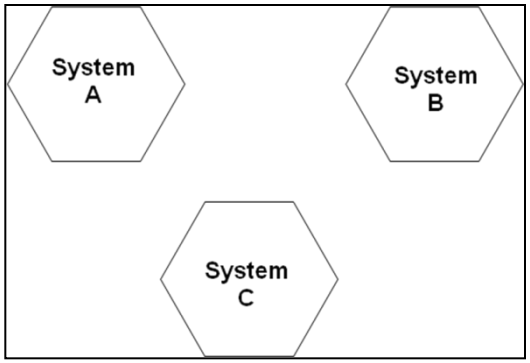
Current SE Findings: Need for Front-end SoS Architecture

- SoS systems engineering team with high level skills in place to
  - Assure knowledge-based acquisition
  - Develop accurate SoS architectural representations
- Approaches to SoS Architecting
  - Object-oriented representation of SoSs, using Systems Modeling Language (SysML)
  - SoS testing considered similar to integration testing of object-oriented software systems, based on operations analysis threads

SoS Acquisition

- Systems acquisition
  - Disciplined management approach for systems acquisition
  - Involving all system lifecycle phases & activities
  - Using established program management approach
- SoS acquisition
  - Significant differences between systems and systems of systems
  - Application of acquisition management approach plus some new concepts
  - Need for understanding of issues associated with SoS acquisition

Scenario



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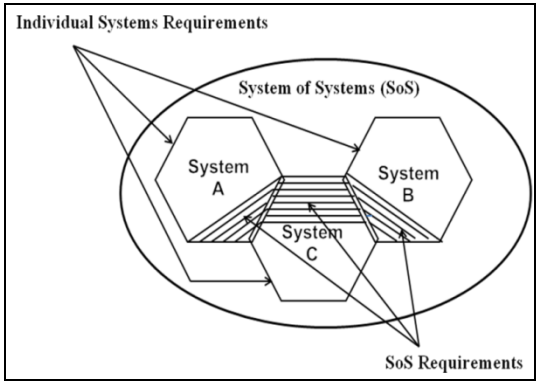

Addition of SoS Requirements

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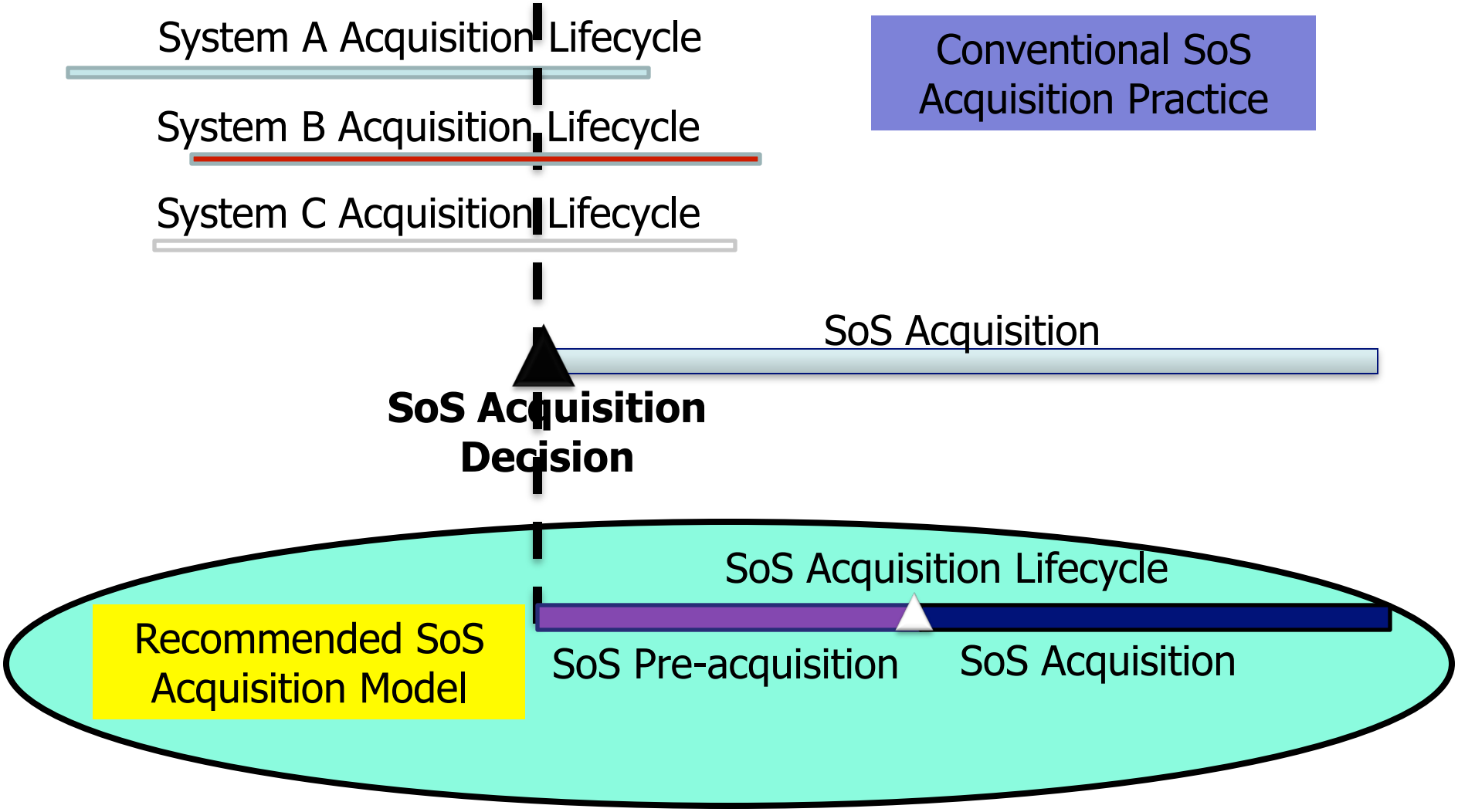
Current Findings: SoS Acquisition Models



Current Findings: Contracting Options

- Three possible options for incorporating SoS requirements into the individual acquisition programs (Scenario programs A, B, and C)
- First option: Two separate contracts
  - Incorporation of SoS requirements in a contract distinct from existing contract
  - Each contractor working under two different and separate contracts
- Second option: Replacement of existing contract
  - Termination of original individual system contract
  - Negotiation for new single contracts for individual system and SoS components
- Third option: Modification of existing contract
  - Modification of existing contracts, incorporating SoS requirements
  - Each contractor with a single contract

Current Findings: Preferred Contracting Option

- Preferred Option: Modifying Existing Contract
- Rationale
  - Preferred over "two separate contracts"
    - Risk of conflict of two contracts
    - Significant resources required for administering two separate contracts
    - Management of two separate contracts complicating organizational structures
  - Preferred over "replacement of existing contract"
    - Contractor likely to stop acquisition effort during negotiation, thereby impacting project schedule and cost
- Some issues with modifying existing contract
  - Time and resources still needed
  - Added SoS requirements potentially a major portion of total requirements
  - Modified contract potentially used to correct contractual weaknesses discovered after existing contract in place

Current Findings: Organizational Structure Options

- Impact of SoS acquisition contracting options on SoS acquisition organizational structure
  - Government-contractor relationship
  - Government-government relationship
- Three organizational structure options for SoS acquisition program management
  - First option: Designate one individual program as lead
  - Second option: Establish a separate government program office
  - Third option: Contractor selected as LSI

Current Findings: Preferred Organizing Option

- Preferred Option: Establishing a separate government program office
- Rationale:
  - Preferred over "Designate one individual programs as lead"
    - Avoidance of potential conflicts of interest and bias in favor of individual program over SoS needs
  - Preferred over "Contractor selected as LSI"
    - Potentially involving contractor performing some critical requirements, determination and acquisition decision-making of SoS program
    - Out-sourcing of inherently government functions related to SoS acquisition program
    - Government's potential loss of systems engineering core competency and capability for managing SoS programs
- Some issues with "separate government program office" option
  - Need for clearly defined policies governing reporting and responsibility relationships among different government program managers
  - Individual system program managers reporting to more than one master
  - Relationships among peer individual system program managers

Current Findings: Integrating Acquisition Management Processes

- High integration level needed in the acquisition process of each individual system and SoS
  - Evolving technical requirements of individual systems to interface with each other
  - Use of lead systems integrator or prime systems contractor overseeing subcontractors
- Integration of SoS contract requirements
- High-level of uncertainty and thus high-level of risk in SoS acquisition programs
- Critical challenges in integrating cost, schedule, and performance elements within individual contracts

Current Findings: Integrating Acquisition Management Processes (cont'd)

- Diverse responses to increased uncertainty and risk of SoS acquisition programs
  - Increasing specificity of contract elements
    - Performance requirements
    - Contract type
    - Incentive
    - Delivery schedule
    - Other terms and conditions
  - Increasing flexibility of contract elements
    - Not in detailed product or performance specifications of contracts
    - More in processes established for development of specifications, testing and acceptance criteria, and cost
- Preferred approach: Strike a proper balance between contract element specificity and flexibility through an integrated management system
- Best practice: Establish management system integrating planning, monitoring and control, and feedback elements of SoS acquisition program

Current Findings: Contracting Options & Organizational Structure Options Linkages

- Organizational option coupled with a contracting options
  - Enabling resolution of SoS acquisition issues
  - Facilitating & effectively managing SoS acquisition effort
- Modifying existing contracts & establishing separate government program office potentially effective for SoS acquisition
- Government program office responsible for SoS acquisition to be the requirements agency
  - SoS government program office to communicate SoS requirements to each system program office
  - Collaboration among SE and contract management personnel across programs
- Potential drawback of linkage between two preferred contracting and organizing options
  - Conflict potential between SoS government program manager and individual system government program managers
- Alleviation of potential conflict through understanding of and adherence to roles and responsibilities and contract order-of-precedence clause

Current Findings: Contracting Options & Organizational Structure Options Linkages (cont'd)

- Possible combinations of contracting and organizational options to potentially resolve SoS issues, thereby enabling satisfaction of SoS acquisition success criteria
- Modification of existing contracts combined with either separate government program or lead systems integrator option

	Contracting Option			Organizing Option			Acquisition Success Criteria		
Issues	Two separate contracts	Replacing contract	Modified contract	Designated individual program	Separate government program	Lead Systems Integrator	Performance	Schedule	Budget
Initial agreement .			√		√	√	X		
SoS control					√	√	X		
Organizing			√		√	√	X	X	X
Staffing, team building, and training			√		√				X
Data requirements			√		√		X	X	
Interfaces			√		√	√	X	X	X
Risk management			√		√	√	X	X	X
SoS testing			√		√	√	X	X	X
Measures of effectiveness			√		√	√	X	X	X
Emergent behavior			√		√	√	X		

Conclusion

- Research ‘s goal: Determine contracting and organizational options to enable successful SoS acquisition and assess impacts of SoS systems engineering on SoS acquisition
- Suggestions at this point in this research:
  - Sustainable systems engineering effort with extensive span of control by SoS acquisition systems engineers during both pre-acquisition and acquisition
  - Front-end overarching SoS architecture to be established prior to acquisition
  - Modifying contract being preferred option
  - Organizing option to be coupled with contracting option to enable resolution of SoS acquisition issues and facilitate and effectively manage SoS acquisition effort
- Future work:
  - Current findings to be applied to a case study
  - Incorporation of collaboration theory in organizing options
  - Treating external factors adversely affecting SoS acquisition

BACK-UP SLIDES

SoS Acquisition Issues*

- Initial agreement
  - Decision makers initially getting agreement that an SoS meets some desirable objective
  - Issue in particular with the SoS involving systems from different organizations or services
  - Contingent on quantifying the benefits and risks of the new SoS
- SoS control
  - Who will control the SoS?
  - How will it be controlled?
  - Partner's potential loss of measure of control over its own systems in order to enable overall SoS control
- Organizing
  - Key issue as to how to organize for development and operation of an SoS
  - e.g., How are processes that interface with SoS processes established and monitored?
- Staffing, team building, and training
  - How an SoS will be staffed and operated?
- Data requirements
  - Concerning sharing of classified and/or proprietary design information among SoS partners
  - Recognition and weighing of losses of systems' operational superiority based on shared classified or proprietary design information against SoS benefits

*Osmundson *et al.*, 2008

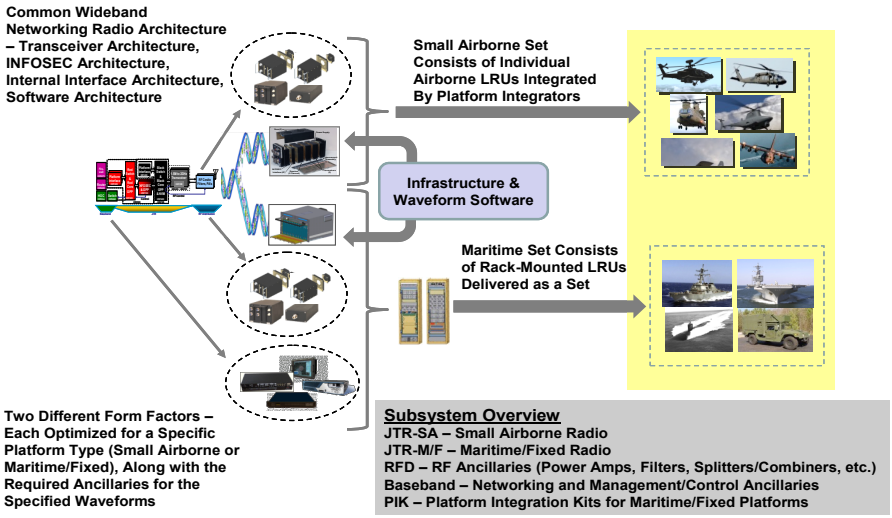
SoS Acquisition Issues*

- Interfaces
  - Identified and managed
  - Common language, grammar and usage
  - Configuration management to assure common agreements
  - Required information security levels identified
  - Provisions made to assure meeting of security requirements
- Risk management at the SoS level
  - Related to mitigation of SoS risks
  - Needed knowledge of component system risks and variations in individual system outputs
- SoS testing
  - Resolution of concerns about operational behavior and SoS threads be tested
- Measures of effectiveness
  - Understanding of individual component systems' measures of performance
  - Related to issues of data requirements and interfaces
- Emergent behavior
  - Resulting from unknown interactions among constituent systems or from its wnvironment interaction
  - To be collectively understood, analyzed, and resolved

*Osmundson *et al.*, 2008

Joint Tactical Radio System (JTRS)

- Software defined radio to allow accommodating multiple radio waveforms
- A system of airborne-maritime fixed site radios, ground mobile radios, handheld man pad small form fit radio, network centric enterprise services, GIG bandwidth extension, and legacy networks
- Lockheed-Martin as the Prime Systems Contractor

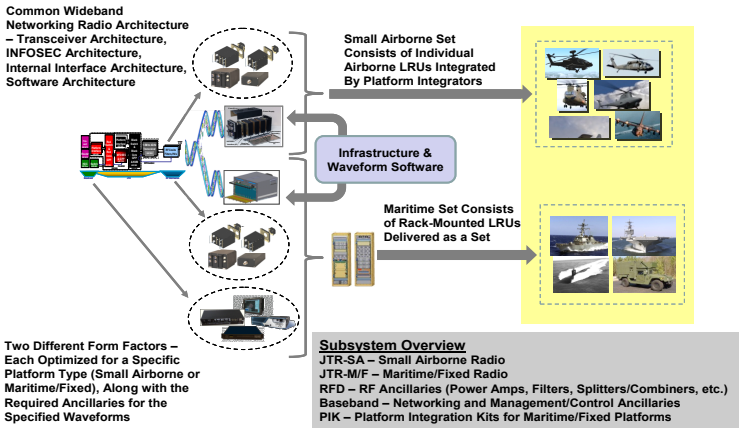


JTRS airborne-maritime fixed (AMF) delivery model (JTRS 2009)

(Nathans 2007)

JTRS Challenges

- Restructured in 2006
- Experiencing cost and schedule overruns and performance shortfalls
  - Due primarily to immature technologies, unstable requirements, and aggressive schedules
- Postponements of scheduled CDR
- Some recently identified issues
  - Unacceptable relying on platform processor for performing network management functions
  - Some difficulty meeting NSA information assurance requirements
  - Requirements not accepted by subcontractors at lower levels
  - Some waveforms not ready to be ported to JTRS
  - Failure of Platform Integration Kit (PIK) to integrate onto some platforms; some platforms' refusal to use PIK
  - Software design and architecture not fully defined ; definition would need to include operationally relevant system threads that demonstrate end-to-end capability
  - Extension of JTRS program schedule ; likely cost increase



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