System of Systems Implications for Operational Test

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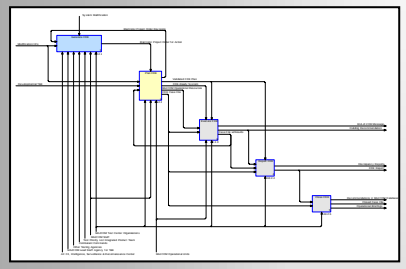
Are we test planning differently in this DoD network-centric, system of systems environment?

Are we? Should we? Can we? How?

Agenda Roadmap

Policy



Process

Practice

7.1 Observations from Policy, Process, and Case Study Analysis

- *Observation 1: A Shift to Integrated, Capabilities-Based T&E Philosophy.* DoD and AF T&E policy reveals a philosophical shift from traditional platform-centric acquisition and testing to an integrated, capabilities-driven approach.
- *Observation 2: Seamless Verification Still Has Seams.* The prevalence of systems-of-systems and the evolution toward net-centric architectures demand T&E processes that are not only integrated throughout the lifecycle of a particular weapon system but are also integrated across entire sets of operational capability.
- *Observation 3: Apparent Lifecycle Seams Are Mitigated by Cooperation in the T&E Community.* Seamless verification, while a recent term, is not a new goal; the T&E community has a long-standing commitment to cooperative testing activities to achieve testing integrity and efficiencies in time, money, and resources.
- *Observation 4: Seams among Interdependent Systems Are Real.* While an ITT may provide a management structure for integrated testing across a system's lifecycle, ITTs aren't currently structured to integrate testing among interdependent systems.
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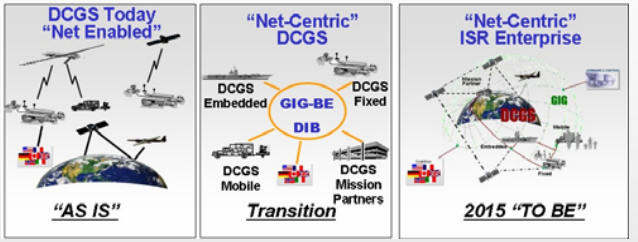
AF DCGS



Net-Centric Ops

7.3 Implications of Net-Centric Operations for T&E

- *Implication 1: Co-evolution is Critical.* As the heralds of net-centricity emphasize, the DoD's transition from Industrial Age (platform-centric) to Information Age (net-centric) operations must include the co-evolution of supporting processes like T&E.
- *Implication 2: End-to-End Is Out and Net-Readiness Is In.* The emergence of net-centric architectures is making end-to-end assessments impractical. End-to-end assessments simply aren't scalable in a net-centric environment.
- *Implication 3: SOS T&E Requires SOS Acquisition and Sustainment.* SOS T&E should complement a strategic planning, budgeting, requirements development, and acquisition system fundamentally oriented toward generating net-centric mission capabilities instead of individual systems.

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- *Recommendation 1.* Designate primary and alternate personnel (blue suit or contractor) to work AF DCGS T&E issues exclusively. ACC/A2YD will continue to serve as a critical "seam-bridger" between AF DCGS in sustainment and AF DCGS in modernization, and A2YD needs someone looking full time at T&E issues that span the system's lifecycle as well as its SOS partners.
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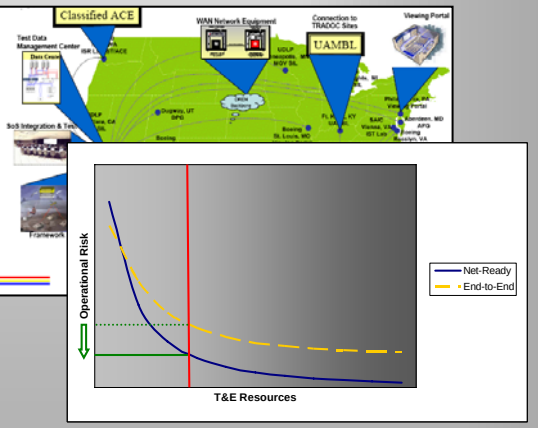
User

Now

T&E

Future

Attributes



Analysis Observations Implications Recommendations

Background

- Operational concern:
  - Air Combat Command is “enterprise manager” for AF Distributed Common Ground Station (DCGS)
  - Test events being planned without coordination
  - T&E plans not validated
  - Missing opportunities to “piggy-back” test objectives

- Problem: AF not yet transitioned from system-centric to SOS approach to T&E
- Focus: ACC Force Development Evaluation (FDE) Process
- Methodology:
  - Policy and Guidance Review (Policy)
  - As-Is FDE Process (Process)
  - SYERS-2A Case Study (Practice)

“System of Systems” T&E

Cliché? No, a real problem

… a real research area

DAU Acquisiton Guidebook:

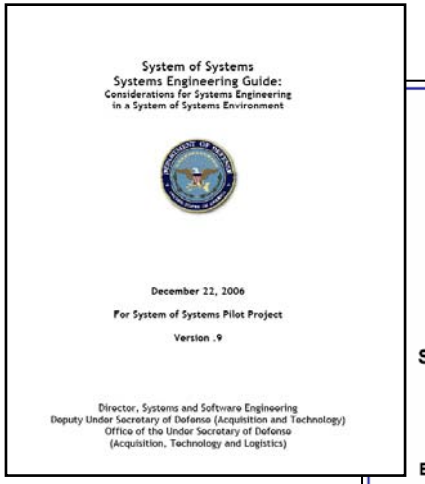
Defines System of Systems (SoS) as a set or arrangement of interdependent systems that are related or connected to provide a given capability.

SoS Characteristics (Maier 1996,1998)

1. Operational Independence
2. Managerial Independence

Other Characteristics

- Evolutionary Development
- Emergent Behavior
- Geographic Distribution

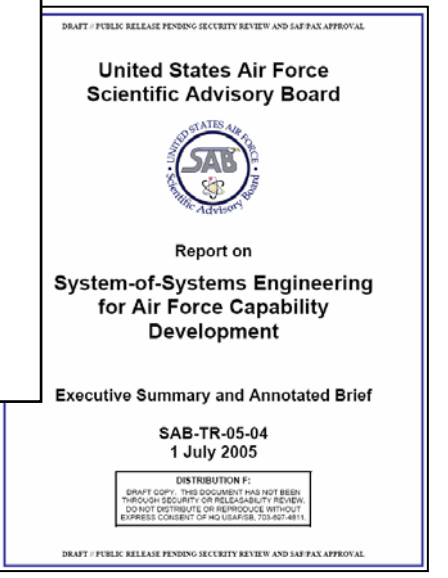

System of Systems
Systems Engineering Guide:
Considerations for Systems Engineering in a System of Systems Environment

December 22, 2006

For System of Systems Pilot Project

Version .9

Director, Systems and Software Engineering
Deputy Under Secretary of Defense (Acquisition and Technology)
Office of the Under Secretary of Defense
(Acquisition, Technology and Logistics)


DRAFT // PUBLIC RELEASE PENDING SECURITY REVIEW AND SAF/PAX APPROVAL

United States Air Force
Scientific Advisory Board

Report on

System-of-Systems Engineering for Air Force Capability Development

Executive Summary and Annotated Brief

SAB-TR-05-04
1 July 2005

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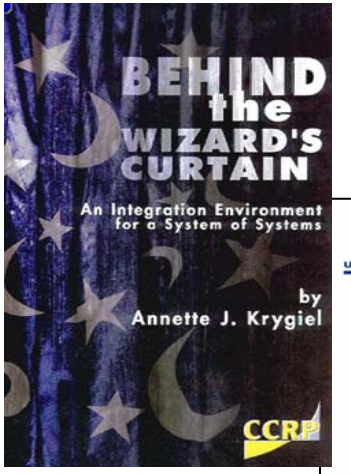



9 SoS Integration Lessons

U.S. AIR FORCE

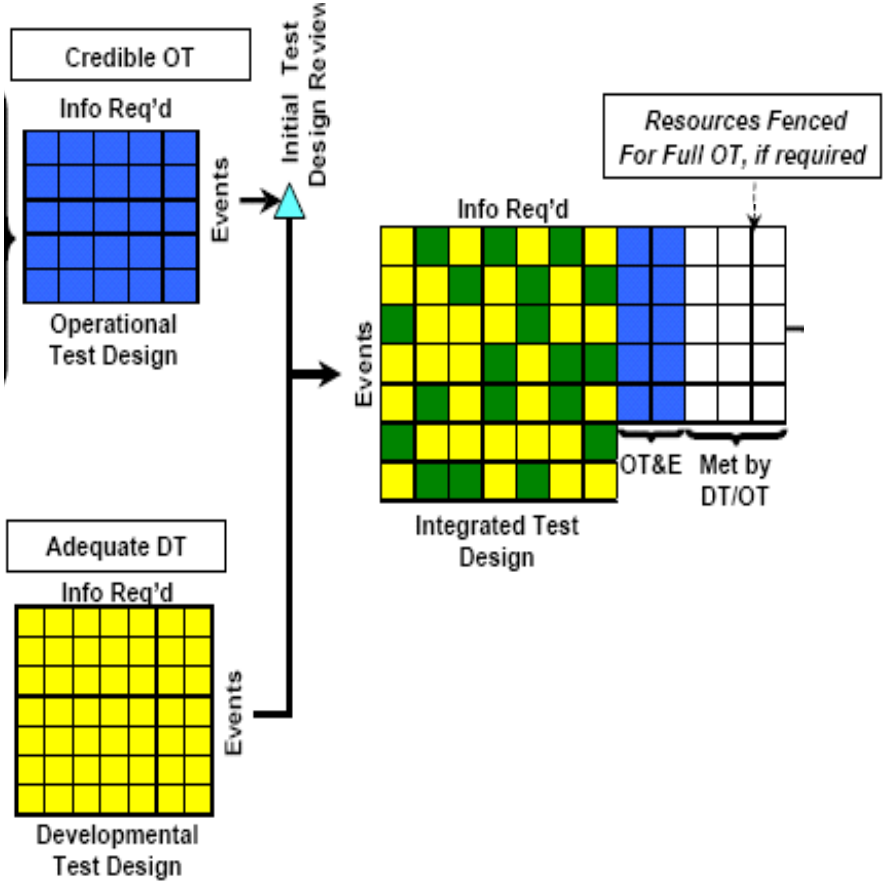
1. Activities need to precede SoS integration
   - Architecture, system interface tests, Architecture compliance
2. Early, incremental and iterative integration
3. Robust testing strategy
4. Plan for substantial difficulties and significant time and resources
5. Use of a single facility facilitates integration of SoS components
6. Address the leadership of the integration
7. Need for common processes and infrastructure
   - Engineering boards, tracking requirements, SoS issue ID, …
8. Effective common processes
   - daily planning, timely dissemination of info, status meetings
9. Prototyping the SoS provides early insight in the ops requirements

Test Policy/Guidance Review

- Public Law, DoD Policy
- AF Guidance
  - AF Policy Directive (AFPD) 99-1: T&E Process
  - AF Instruction (AFI) 99-103: Capabilities Based T&E
    - “Seamless Verification”
    - Integrated Test Team (ITT)
    - Common T&E Data Management (Open Database)
- Air Combat Command Instruction (ACCI) 99-101
- Other
  - Defense Acquisition Guide (DAG)
  - International Council on Systems Engineering (INCOSE)
  - ANSI/EIA-632

Test Policy/Guidance Review

- Air Combat Command Instruction (ACCI) 99-101: Test and Evaluation
  - Electronic Project Order (EPO)
  - Test Priority List (TPL)
- Others
  - AF T&E Guidebook
  - 53rd WG Test Team Handbook



DT + OT = Integrated Lifecycle Test Focus

SoS Test Guidance

- Defense Acquisition Guide (DAG) – Chapter 9

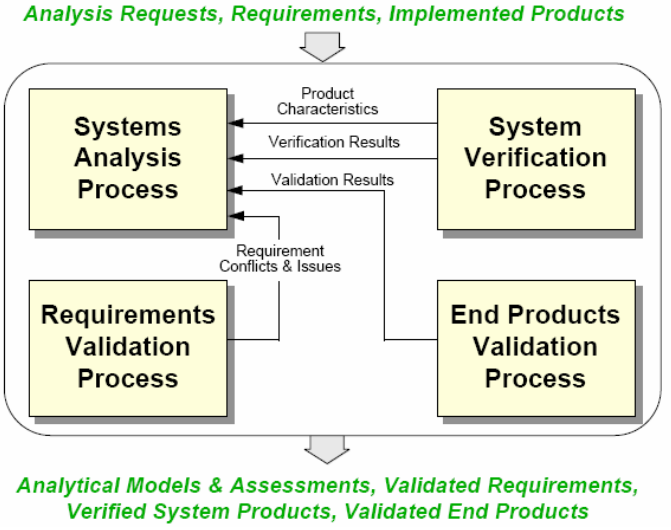
  An important aspect is to develop a strategy for testing each system in the context of the system-of-systems, or family-of-systems architecture within which it is required to operate.

  The shift away from point-to-point system interfaces to network-centric interfaces brings implications for the T&E community.

SoS Test Guidance Review

- INCOSE, Systems Engineering Handbook (ver 2a)
  - System Integration with External Interfaces
  - ICDs, Interface working Groups
  - Review test procedures and plans which verify these interfaces

- ANSI/EIA-632, Processes for Engineering a System
  - Technical Evaluation: Analysis, Verfication and Validation
  - Application Context
    - Enterprise Factors
    - Enterprise Support
    - External Factors
    - Other Enterprise Projects



Air Force Test Policy

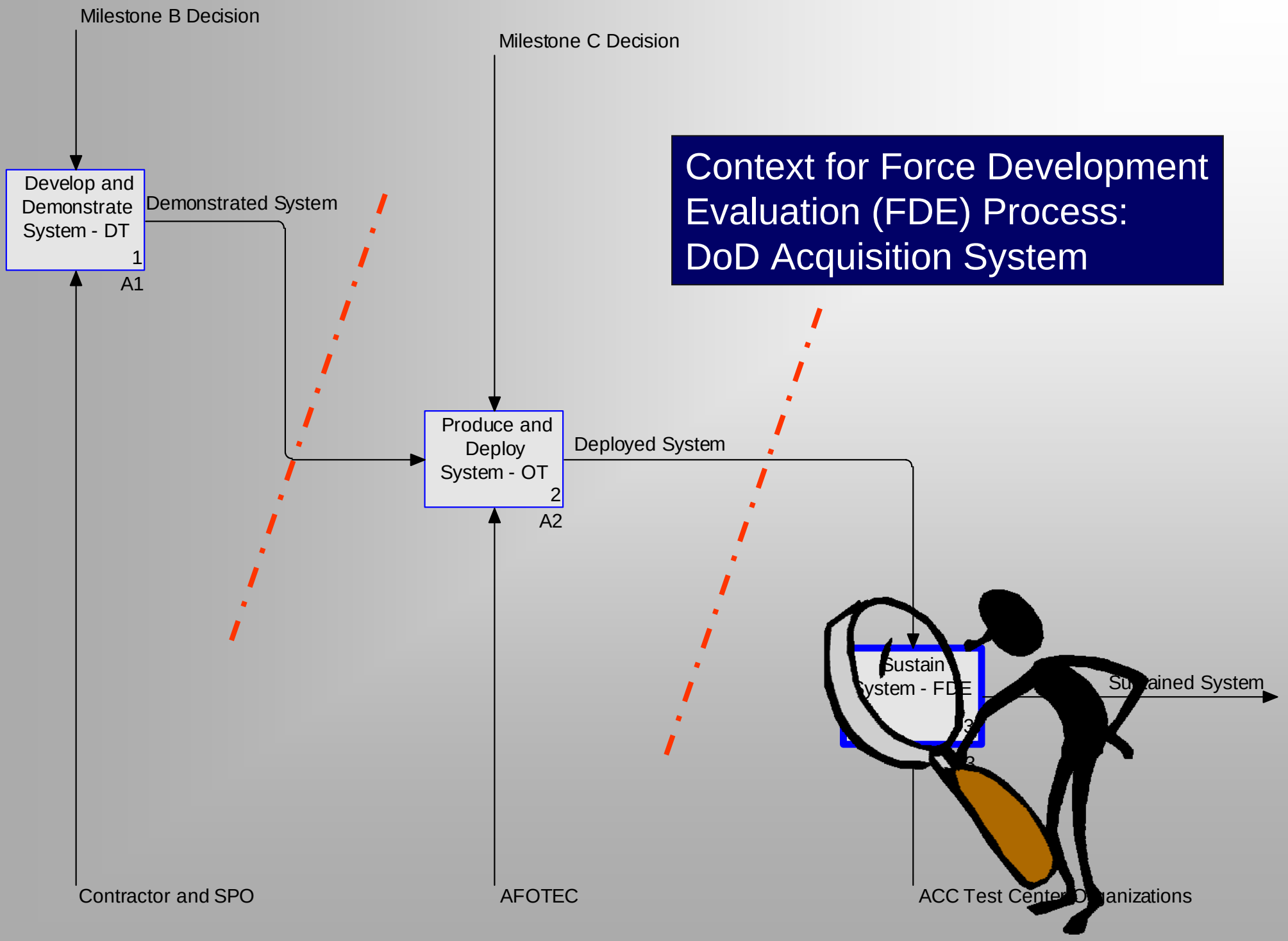
- ***Observation 1:***

  A Shift to Integrated, Capabilities-Based T&E

- ***Observation 2:***

  Seamless Verification Still Has Seams

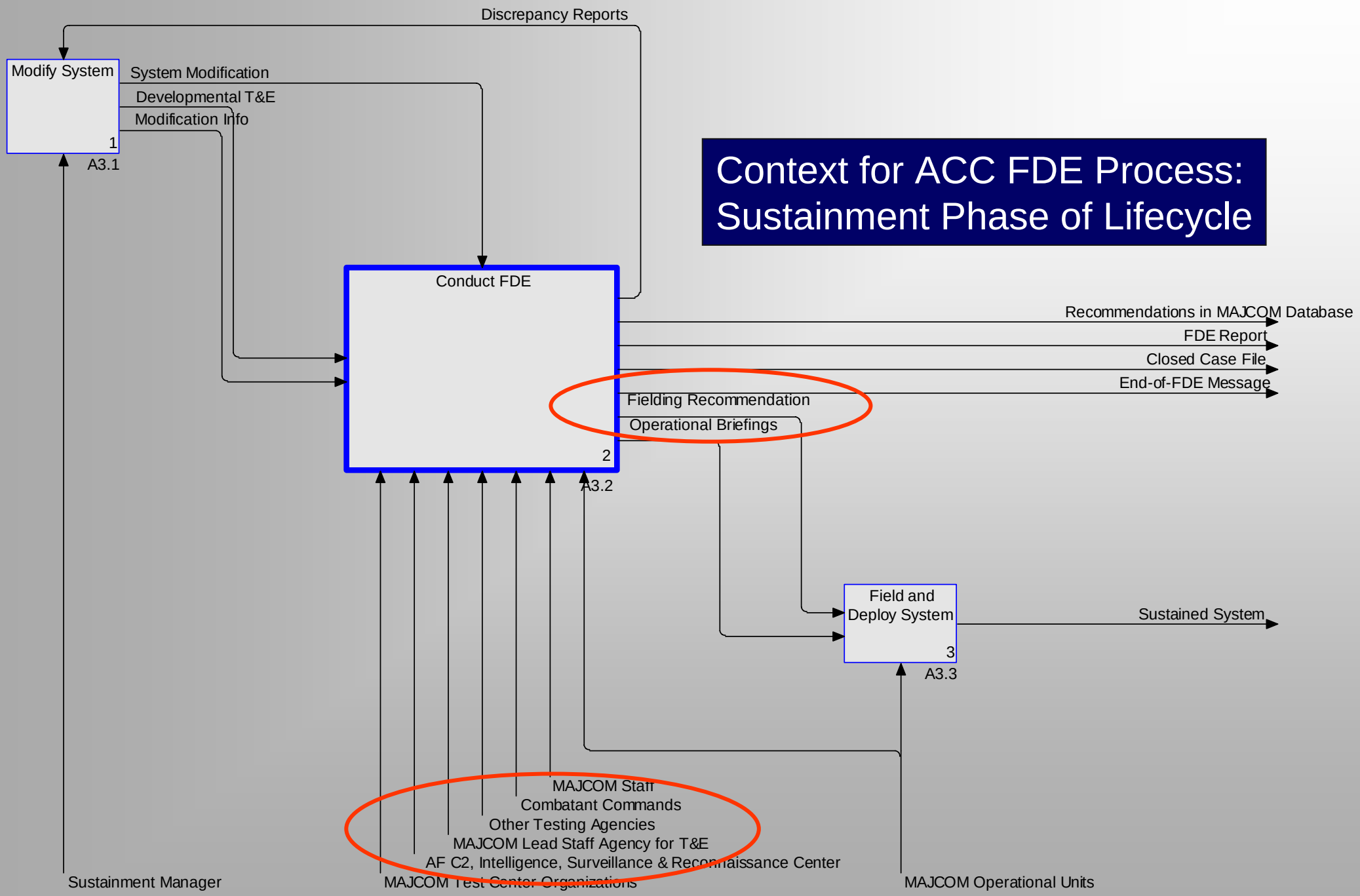
Context for Force Development Evaluation (FDE) Process: DoD Acquisition System



Force Development Evaluation (FDE)

- A Subset of Operational Test and Evaluation (OT&E)

- *Demonstrate the operational effectiveness and suitability of a system as evolutionary upgrades are made to sustain its relevance*


Context for ACC FDE Process: Sustainment Phase of Lifecycle
Discrepancy Reports
Modify System
System Modification
Developmental T&E
Modification Info
1
A3.1
Conduct FDE
Recommendations in MAJCOM Database
FDE Report
Closed Case File
End-of-FDE Message
Fielding Recommendation
Operational Briefings
2
A3.2
Field and Deploy System
Sustained System
3
A3.3
MAJCOM Staff
Combatant Commands
Other Testing Agencies
MAJCOM Lead Staff Agency for T&E
AF C2, Intelligence, Surveillance & Reconnaissance Center
MAJCOM Test Center Organizations
Sustainment Manager
MAJCOM Operational Units

FDE Process Observations

- ***Observation 3:***

  Apparent Lifecycle Seams are Mitigated by Cooperation in the T&E Community

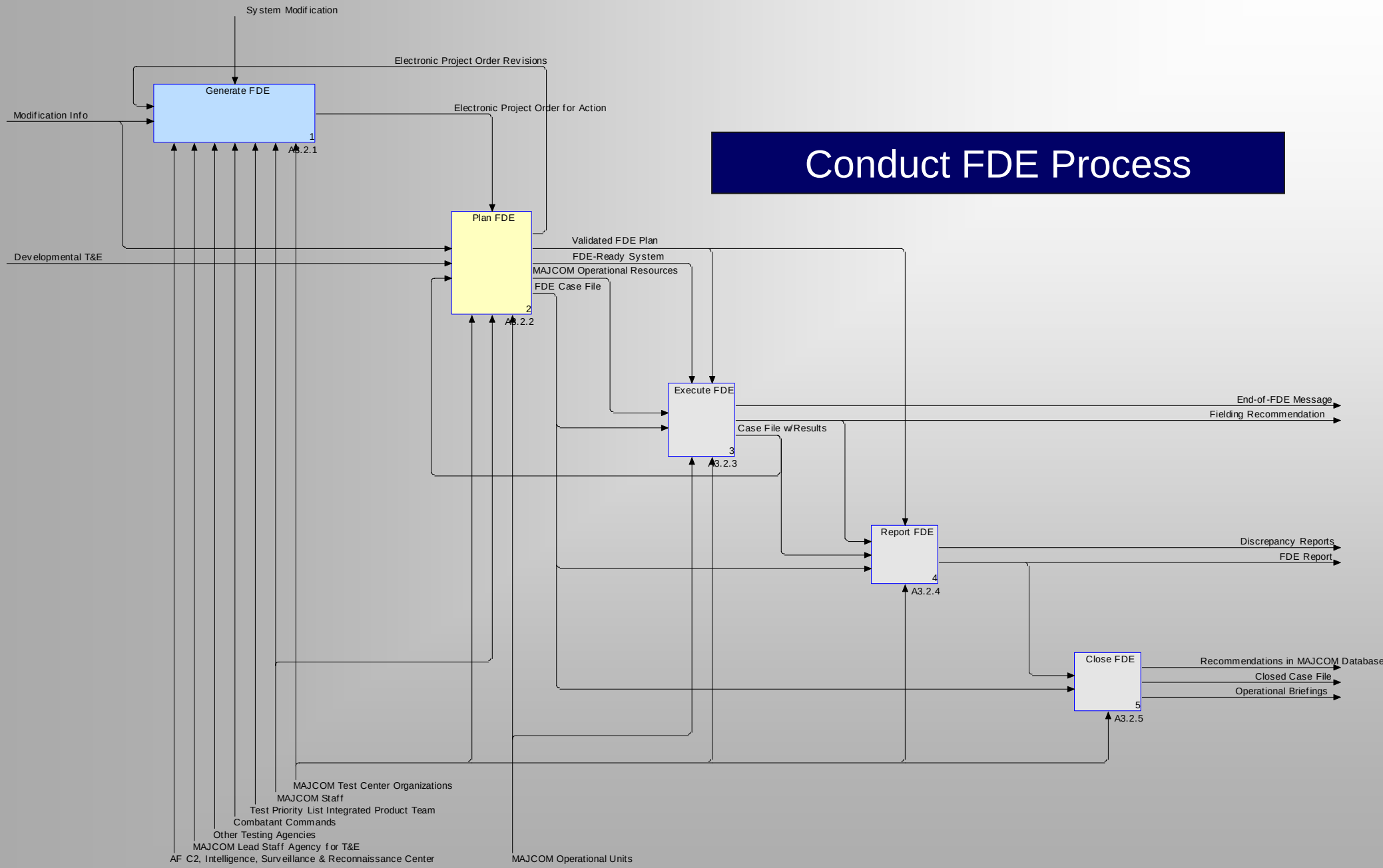
- ***Observation 4:***

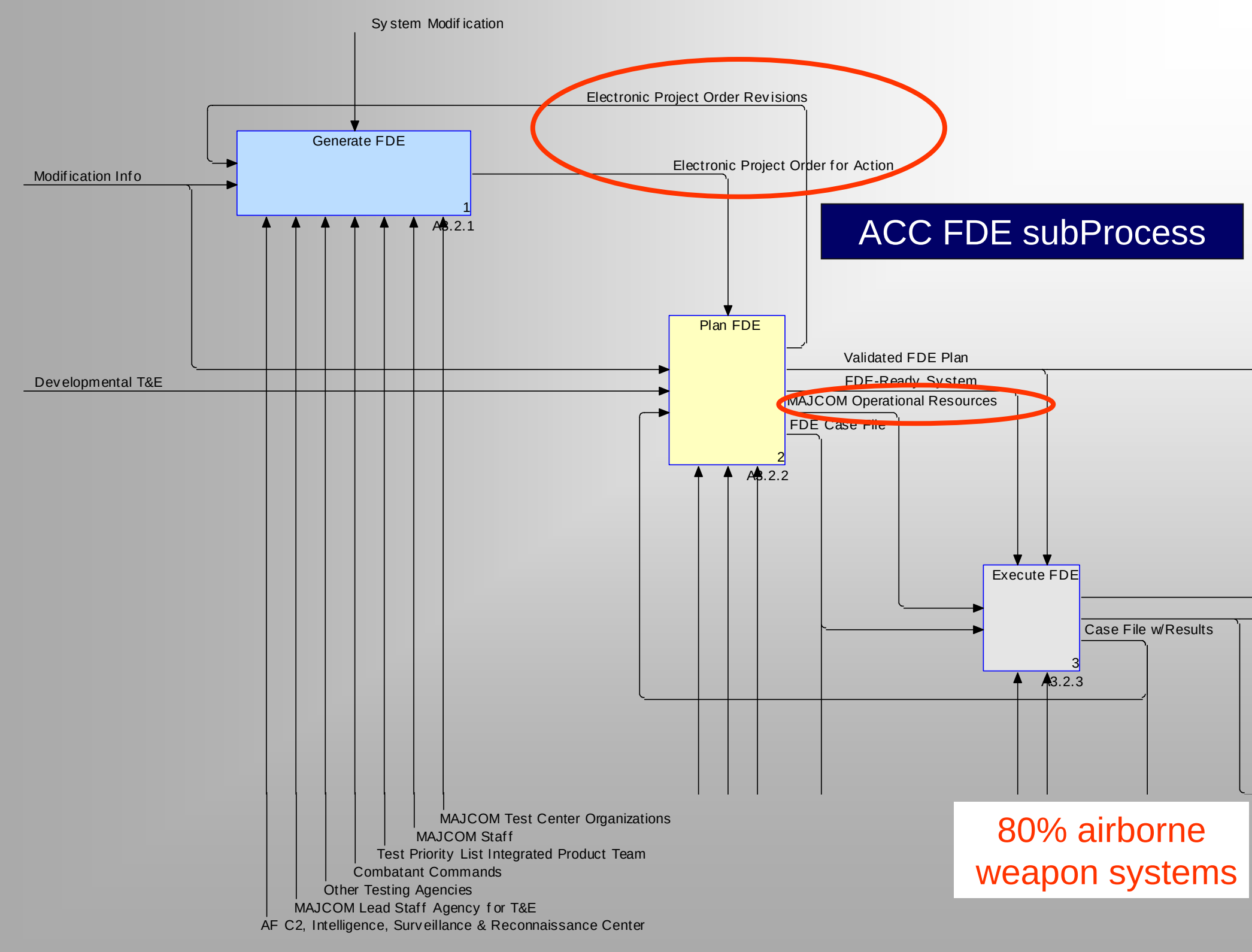
  Seams Among Interdependent Systems are Real

- ***Observation 5:***

  Integration is NOT Built Into the Process

Conduct FDE Process




System Modification
Electronic Project Order Revisions
Generate FDE
Modification Info
Electronic Project Order for Action
1
A3.2.1
ACC FDE subProcess
Plan FDE
Validated FDE Plan
Developmental T&E
FDE-Ready System
MAJCOM Operational Resources
FDE Case File
2
A3.2.2
Execute FDE
Case File w/Results
3
A3.2.3
MAJCOM Test Center Organizations
MAJCOM Staff
Test Priority List Integrated Product Team
Combatant Commands
Other Testing Agencies
MAJCOM Lead Staff Agency for T&E
AF C2, Intelligence, Surveillance & Reconnaissance Center
80% airborne weapon systems

FDE Process Observations

- ***Observation 6:***

  FDE Process Accommodates SOS Testing But Doesn't Deliberately Force it

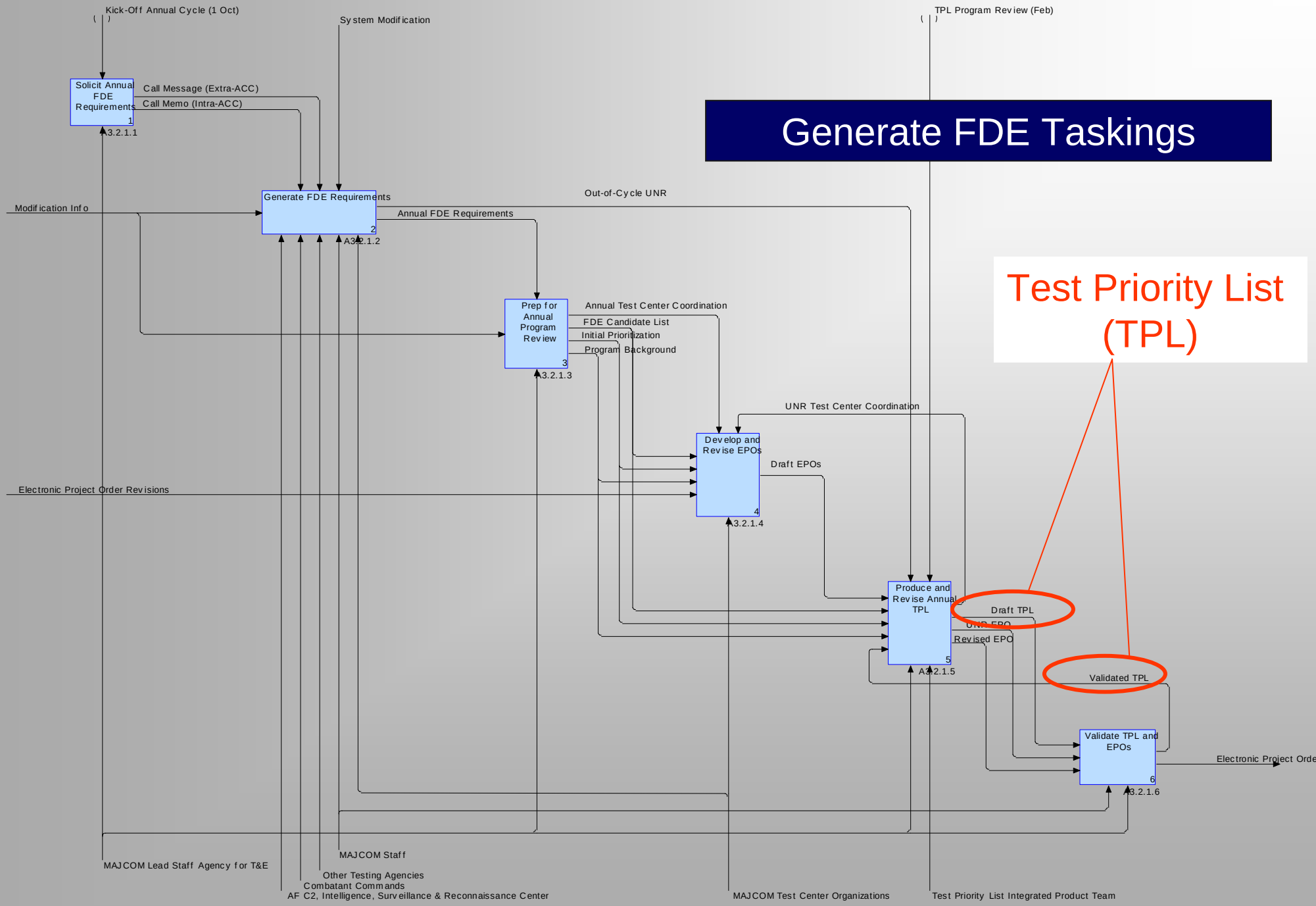
- ***Observation 7:***

  Resource Constraints Limit ACC's Ability to Develop SOS FDEs

- ***Observation 8:***

  Process is Beginning to Embrace Non-Traditional Weapon Systems

Generate FDE Taskings



Test Priority List (TPL)

FDE Process Observations

- ***Observation 9:***

  Increasing Load on the FDE Process

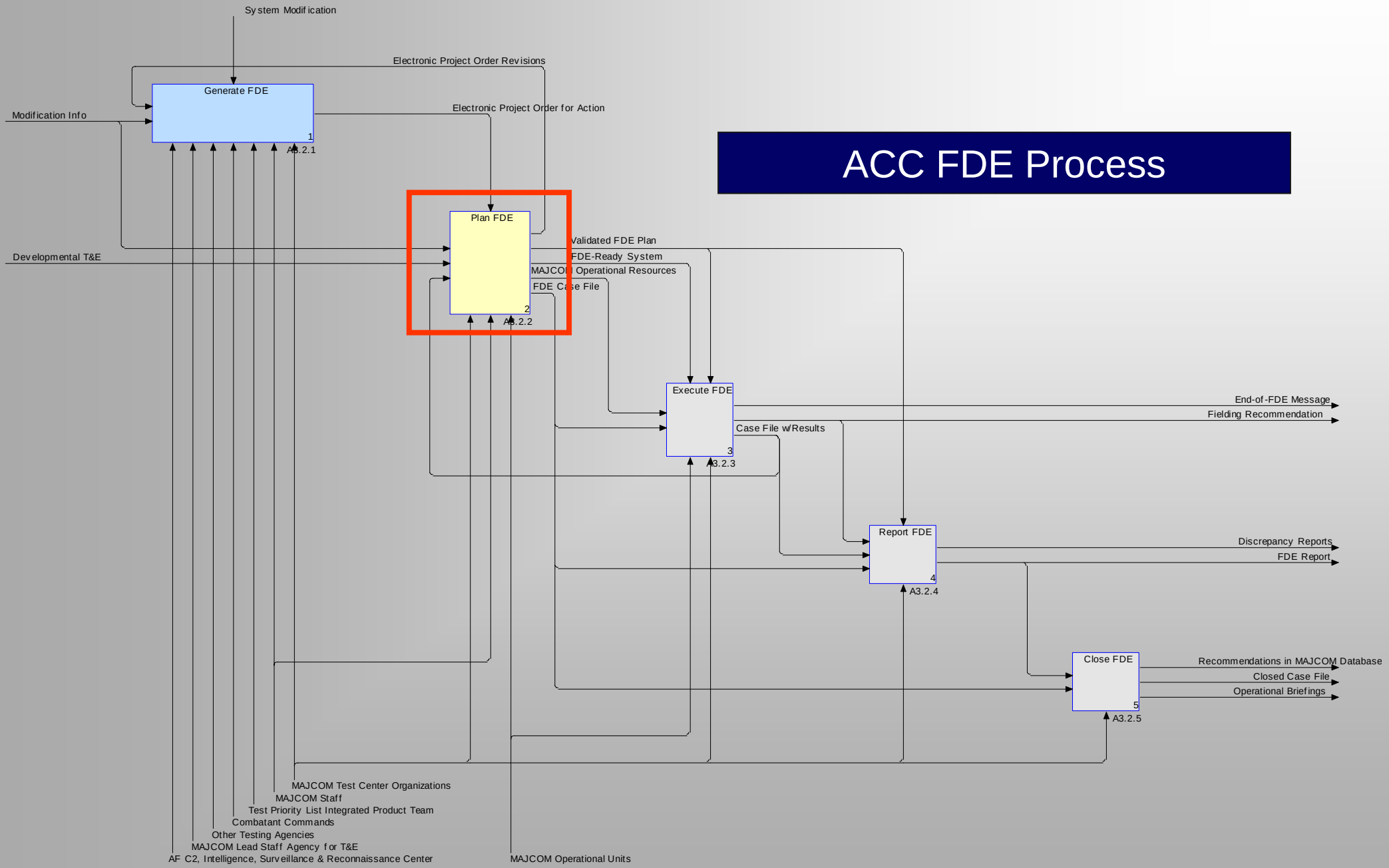
DoD T&E Summit 2004, Dr. Glenn Lamartin:

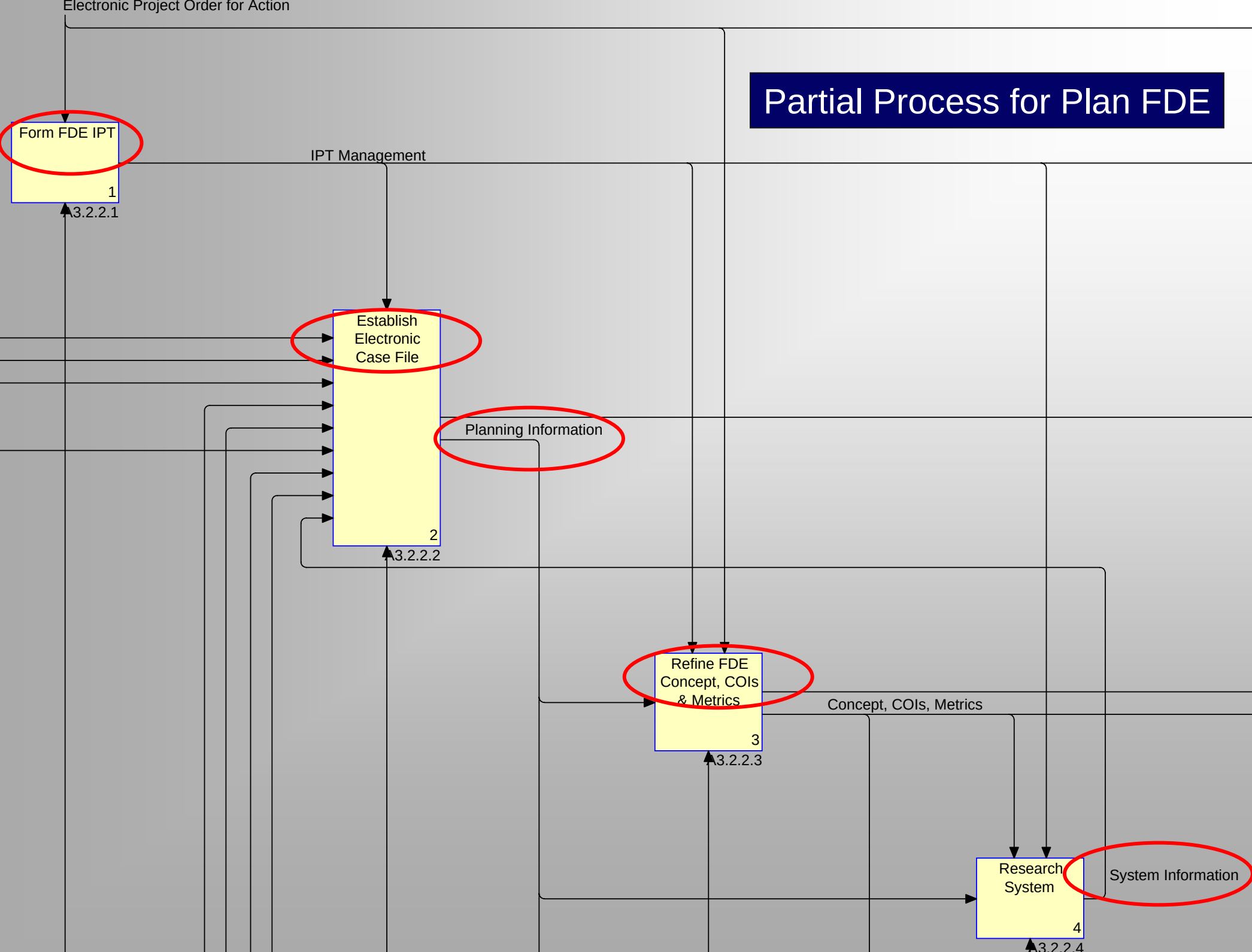
- *From platforms to capabilities & SOS solutions*
- *Increasing complexity and interdependencies of systems*
- *Exponential growth in interfaces (network participants)*
- *Increased requirements for T&E (Evolutionary Acq)*

NCW, Alberts, Garstka and Stein

> "Testing systems will become far more complex since the focus will not be on the performance of individual systems by on the performance of the federation of systems"

ACC FDE Process




Partial Process for Plan FDE
Electronic Project Order for Action
Form FDE IPT
1
A3.2.2.1
IPT Management
Establish Electronic Case File
2
A3.2.2.2
Planning Information
Refine FDE Concept, COIs & Metrics
3
A3.2.2.3
Concept, COIs, Metrics
Research System
4
A3.2.2.4
System Information

FDE Process Observations

- ***Observation 10:***

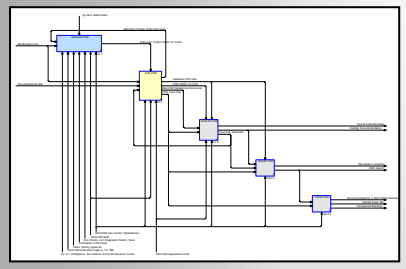
  Test Center Project Manager (PM) is the Key Actor in FDE Planning

- ***Observation 11:***

  Lack of AF-Level Guidance on T&E Information Management

Agenda Roadmap

Policy



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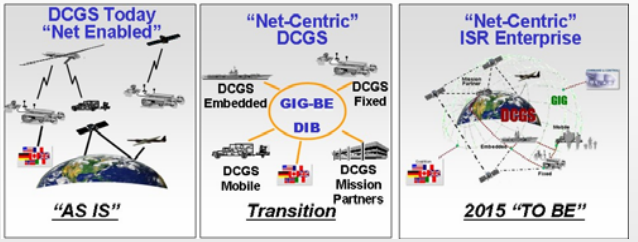

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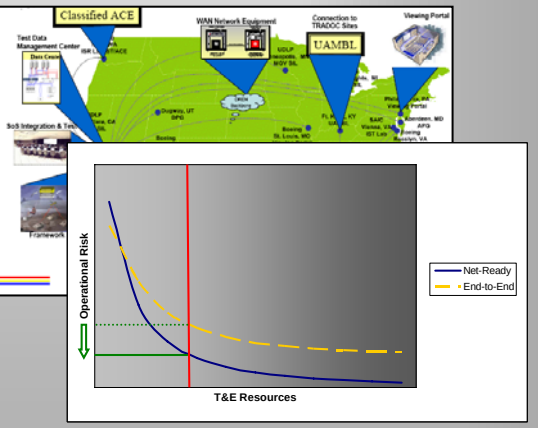
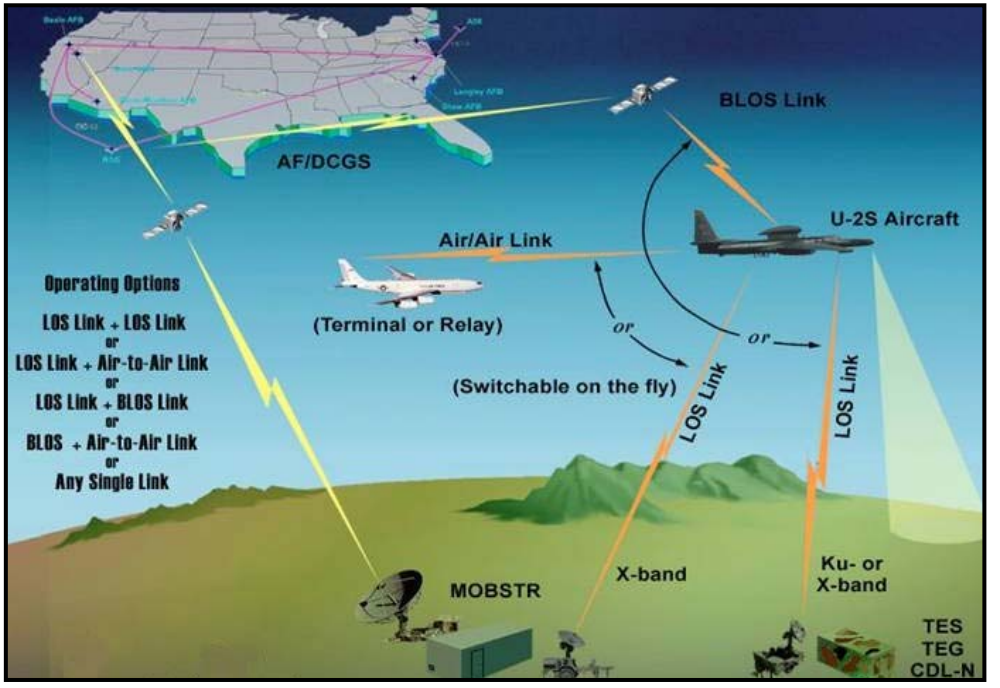
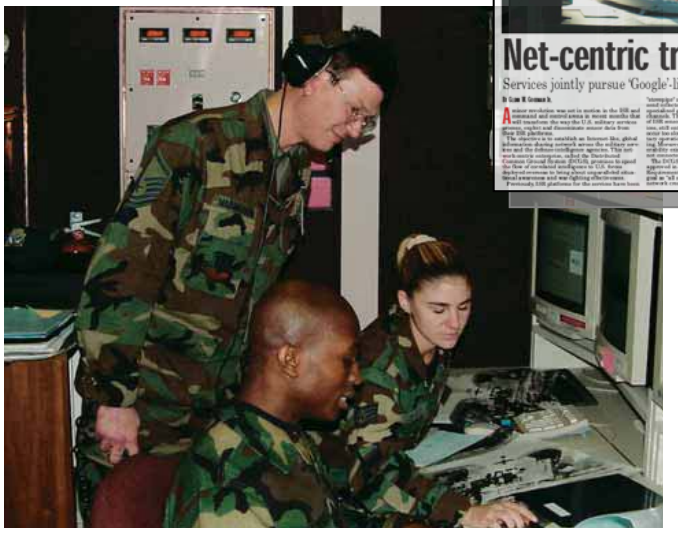


Analysis Observations Implications Recommendations

Sensor Case Study

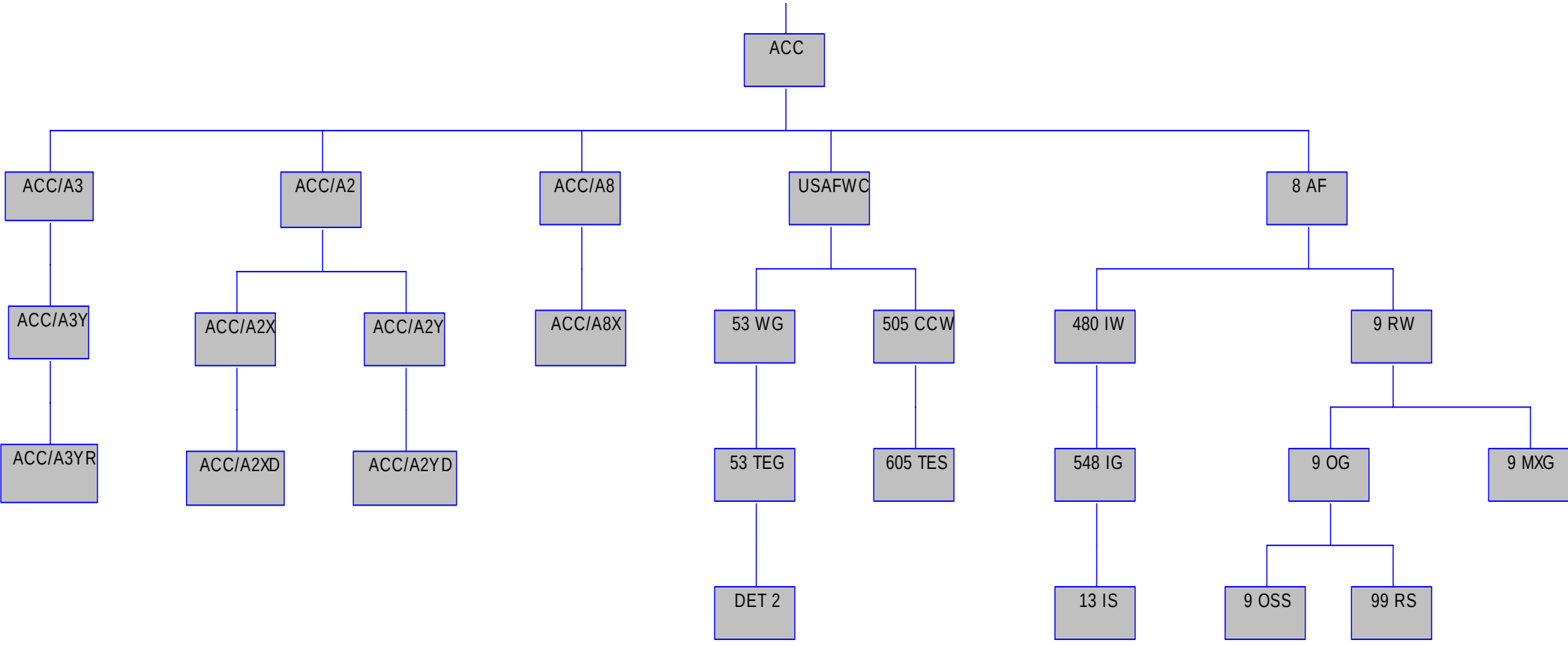
- Platform: U-2S - high altitude surveillance & reconnaisscance
- Sensor: SYERS-2A - multispectral (EO/IR) imaging sensor
  - Upgrade to airborne processor with ATM interface
- Data Link: Dual Data Link 2 (DDL 2-LOS and BLOS configurations
- Ground Station: AF DCGS - dispersed ground systems supporting first-phase analysis of U-2, Predator, Global Hawk and other sensors via secure WAN





Numerous Stakeholders

… an insightful OV-4



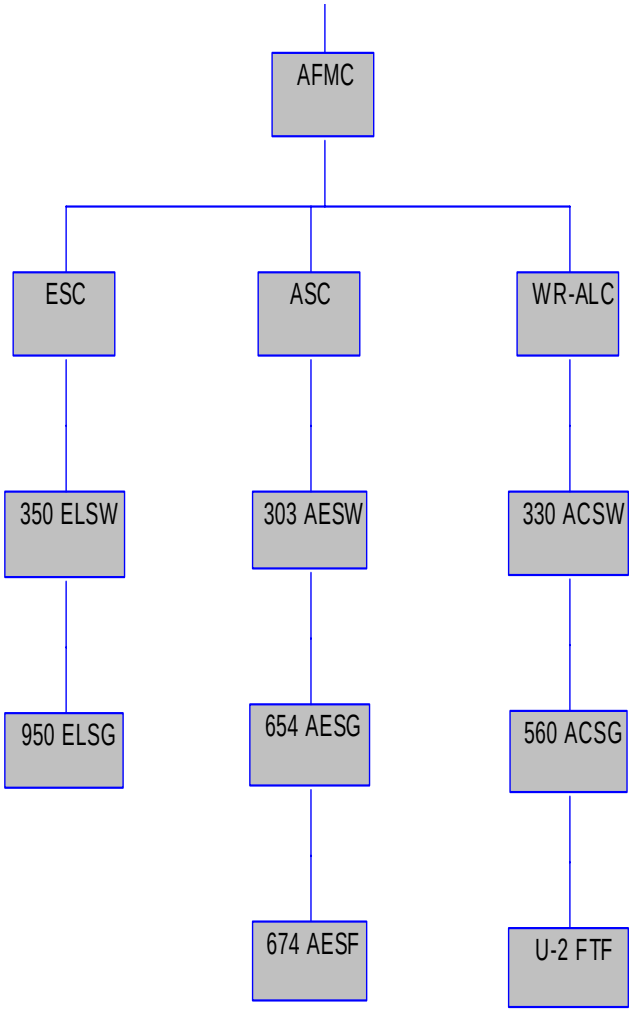
Enterprise Management
Requirements
Test Resourcing
Test Coordination

Test Planning
Test Execution
Airborne and C2

Operations
Air and Ground

…Numerous Stakeholders

… an insightful OV-4



DCGS Sustainment (O&M)

U-2 Sustainment (O&M)

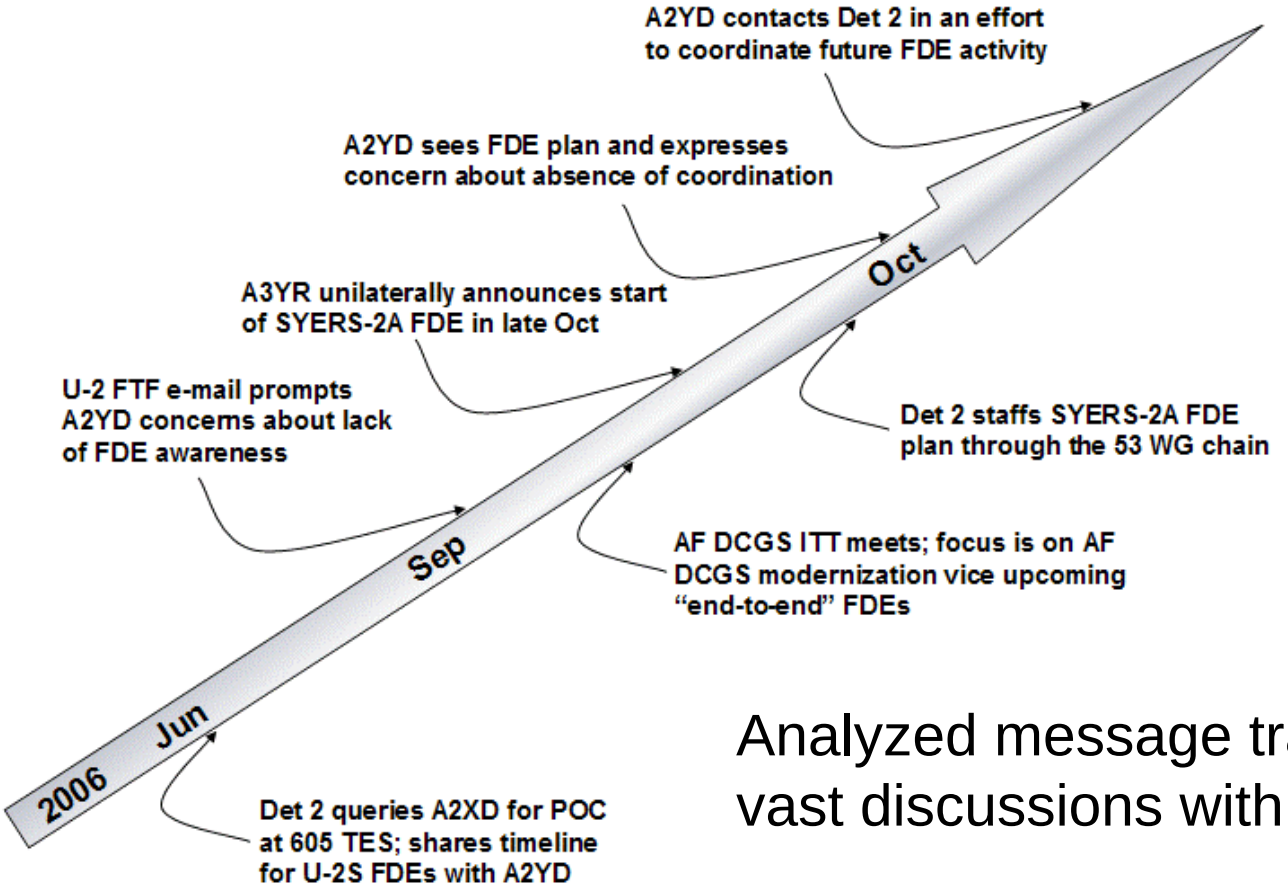
DCGS System Program Management
New Acquisition and Modernization

U-2 System Program Management
New Acquisition and Modernization

Flight Test Facility

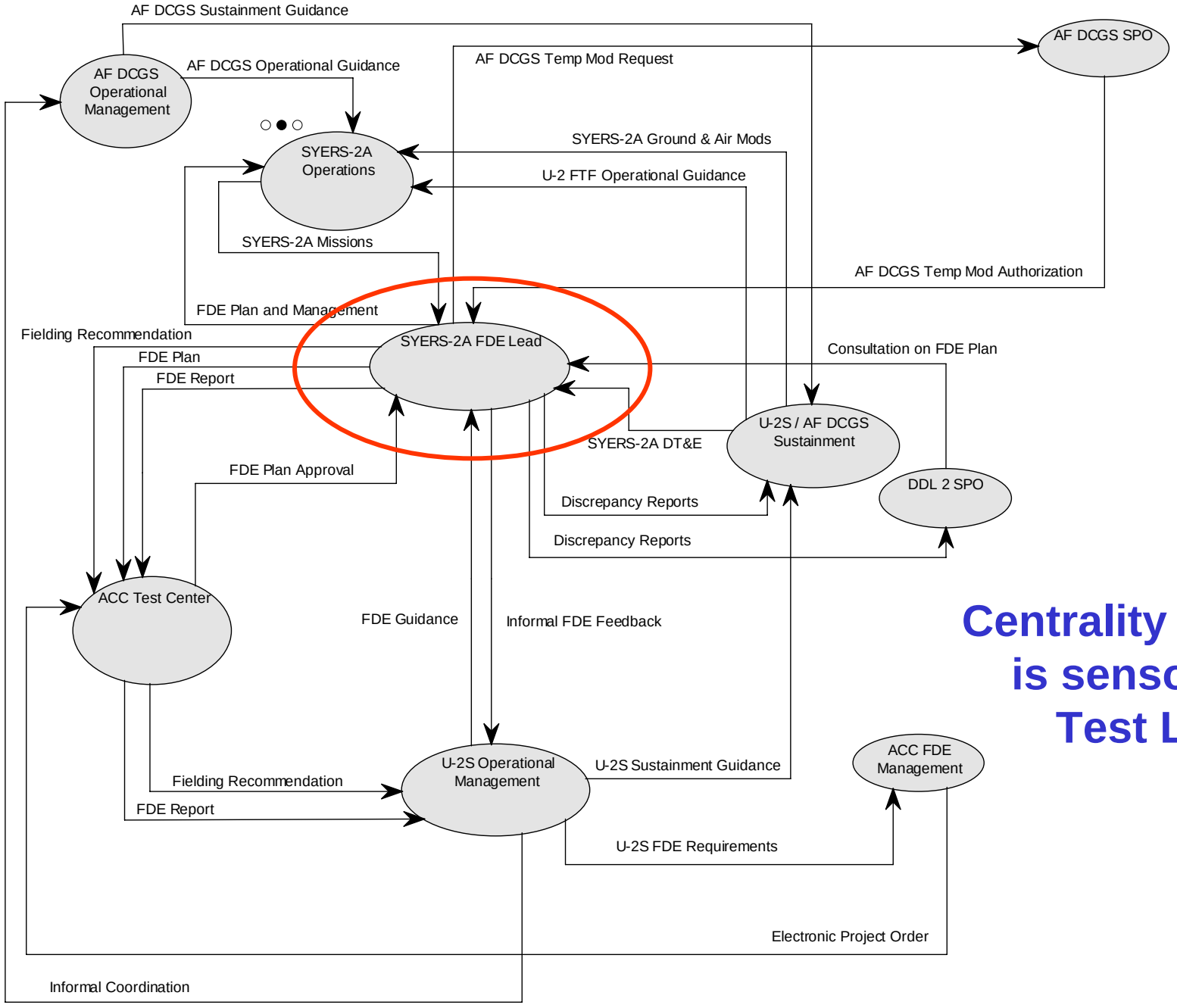
Sequence of Events

Test Objective: “Verify SYERS-2A sensor end-to-end operations and to demonstrate full airborne/ground segment functionality with DLL2 in available configurations and operational representative architectures”



Analyzed message traffic, documents, and vast discussions with SME/ POCs

Complex Interactions



Centrality of graph is sensor FDE Test Lead

Case Study Observations

- ***Observation 12:***

  Program Priorities Dominate Even Among Interdependent Systems

- ***Observation 13:***

  System-Centric Management

- ***Observation 14:***

  System Focus for the Fielding Decision

- ***Observation 15:***

  Some Coordination Tools Left Unused

- ***Observation 16:***

  Ability to Define the "Ends" Disappearing as Net-Centric Reality Emerges

Agenda Roadmap

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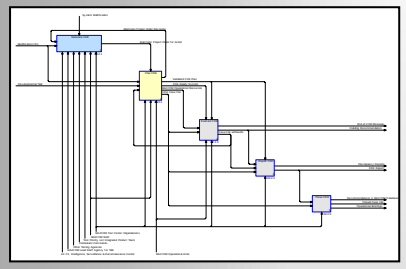

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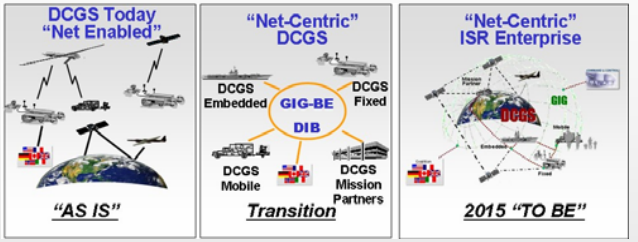
- *Observation 6: ACC's FDE Process Accommodates SOS Testing but Doesn't Deliberately Push in That Direction.* The process relies on the insight and foresight of action officers on ACC staff and FDE project officers at Test Center Organizations to properly scope FDEs to approximately demonstrate the full capabilities ACC is offering the warfighter.

AF DCGS



Net-Centric Ops

7.3 Implications of Net-Centric Operations for T&E

- *Implication 1: Co-evolution is Critical.* As the heralds of net-centricity emphasize, the DoD's transition from Industrial Age (platform-centric) to Information Age (net-centric) operations must include the co-evolution of supporting processes like T&E.
- *Implication 2: End-to-End Is Out and Net-Readiness Is In.* The emergence of net-centric architectures is making end-to-end assessments impractical. End-to-end assessments simply aren't scalable in a net-centric environment.
- *Implication 3: SOS T&E Requires SOS Acquisition and Sustainment.* SOS T&E should complement a strategic planning, budgeting, requirements development, and acquisition system fundamentally oriented toward generating net-centric mission capabilities instead of individual systems.

7.2 Recommendations for AF DCGS

- *Recommendation 1.* Designate primary and alternate personnel (blue suit or contractor) to work AF DCGS T&E issues exclusively. ACC/A2YD will continue to serve as a critical "seam-bridger" between AF DCGS in sustainment and AF DCGS in modernization, and A2YD needs someone looking full time at T&E issues that span the system's lifecycle as well as its SOS partners.
- *Recommendation 2.* Develop a strong working relationship with A8X. The ACC FDE process is the "only game in town," and A2 needs to have a seat at the table as the process adapts to SOS and net-centric realities.
- *Recommendation 3.* Ensure A2 is on the October Call for Tests.
- *Recommendation 4.* Ensure A2 is part of coordination chain for the final TPL and all TPL/EPO revisions.
- *Recommendation 5.* Use the ACC FDE process. Work all AF DCGS FDE requirements through ACC/A8C and ensure the 605 TES is using EPOs to participate in AF DCGS T&E events.

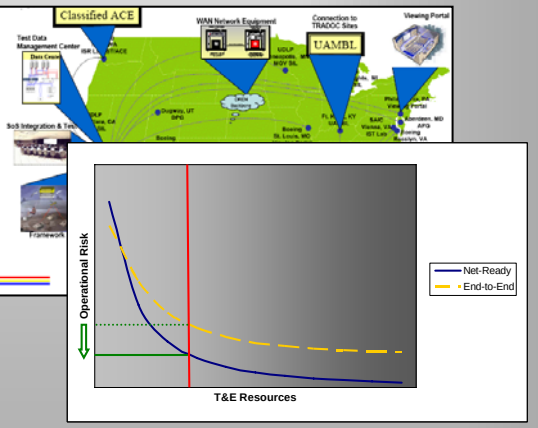
User

Now

T&E

Future

Attributes



Analysis Observations Implications Recommendations

Implications for T&E

Implication 1: Co-evolution Is Critical

Exposure to new information technologies and their capabilities is potentially dangerous unless it is accompanied by changes in a number of key dimensions.

- Alberts, *Information Age Transformation*

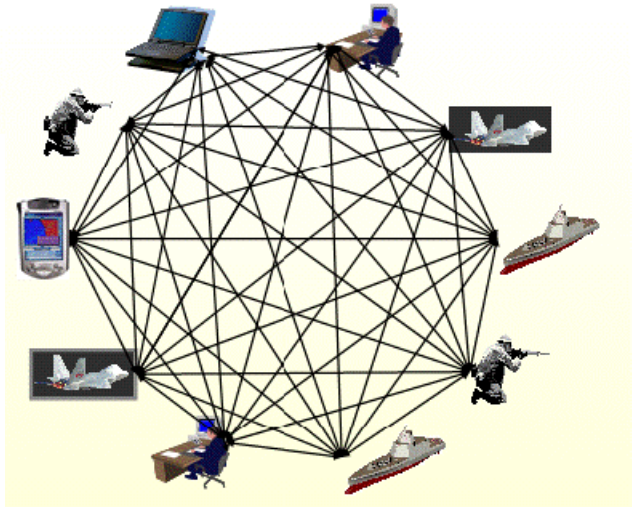
Doctrine

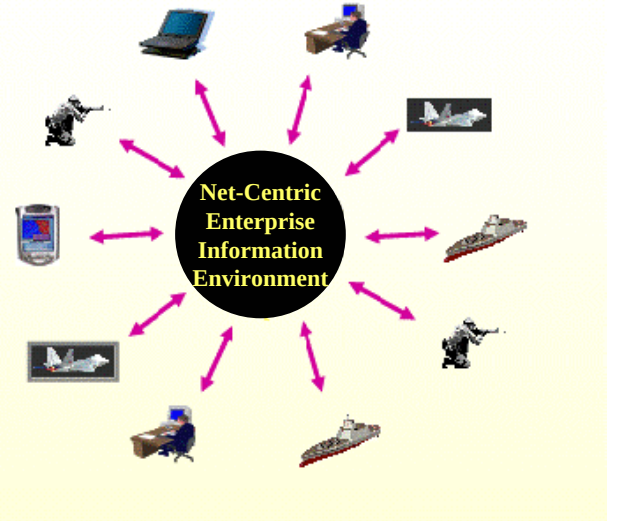
Training & Education

<u>Test & Evaluation</u>

Implications for T&E

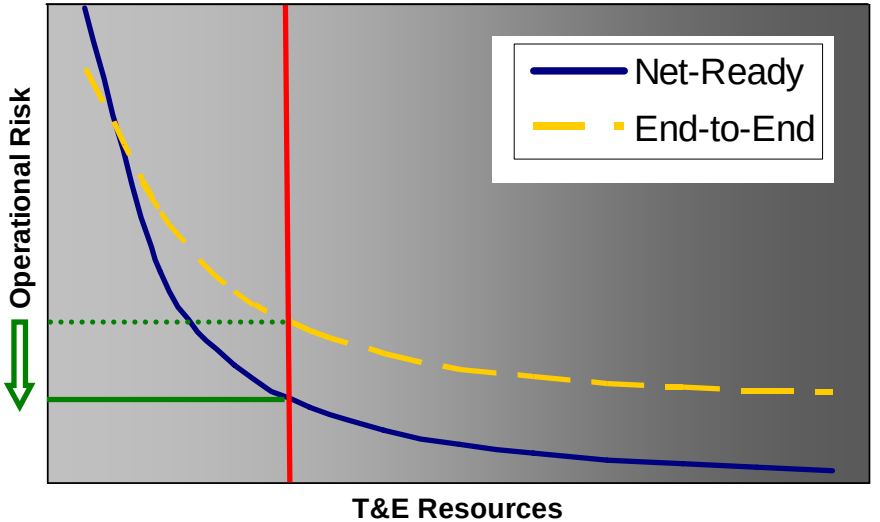
Implication 2: End-to-End Is Out, Net-Ready Is In





Focus of test and evaluation needs to shift from the performance of individual entities to their ability to add value to the networked force.

- Alberts, *Information Age Transformation*



Implications for T&E

Implication 3: SOS T&E Can't Work Alone

SOS T&E should complement a strategic planning, budgeting, requirements development, and acquisition system fundamentally oriented toward generating enterprise/mission capabilities instead of individual systems.

Recommended Characteristics for future SoS FDE

1. Scope to Validate Operational Capabilities
   - How? Use DoDAF Products/ M&S to understand complex relationship of systems and capabilities
2. Use Net-Readiness Objectives to Validate SoS Interoperability
   - How? Use DoD Net-Centric Data Strategy:

Visible	Trusted
Agile	Responsive
Accessible	Understandable

3. Prioritize According to Operational Risk
4. Employ appropriate Integration Environments

Conclusion

- Policy and guidelines now reflect the changing IT landscape of system of systems.
  - Integrated T&E and Seamless Verification
- Leaders have predicted this changing landscape will directly impact T&E activities
- Lessons can be learned from enterprise case studies
- Many organizations/ enterprises may rely on the heroics of system-level test managers to handle this added SOS focus

Changes to Integration, Test and Evaluation in a network-centric SoS environment is imperative