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# Network-Centric Operations Support: Lessons Learned, Status, and Way-Ahead

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# Outline

- Network Centric Warfare (NCW): Overview
  - Operational Objectives
    - Time-Sensitive Targeting (TST)
    - Information Dominance
  - Reference Models (e.g. OODA Loop)
  - Engineering-Support versus Business-Services
- Model-Based System-of-Systems Engineering (MBSE/SOSE)
  - Challenges
    - Multiplicity of Evolving Standards
    - Evolutionary Transformation from Systems to Services
  - Emerging Capabilities
    - Distributed Modeling/Simulation (M&S) and Virtual Environments
    - Model-Based Systems Integration (MBSI)
- Example Need and Use-Case: Maritime Ad-Hoc Mesh Networks
  - Multi-link RF Line-of-Sight (LOS) Network Nodes: Link Management
  - Content Delivery/Distribution Networks (CDN) Support
- Summary, Conclusions, and Future Work

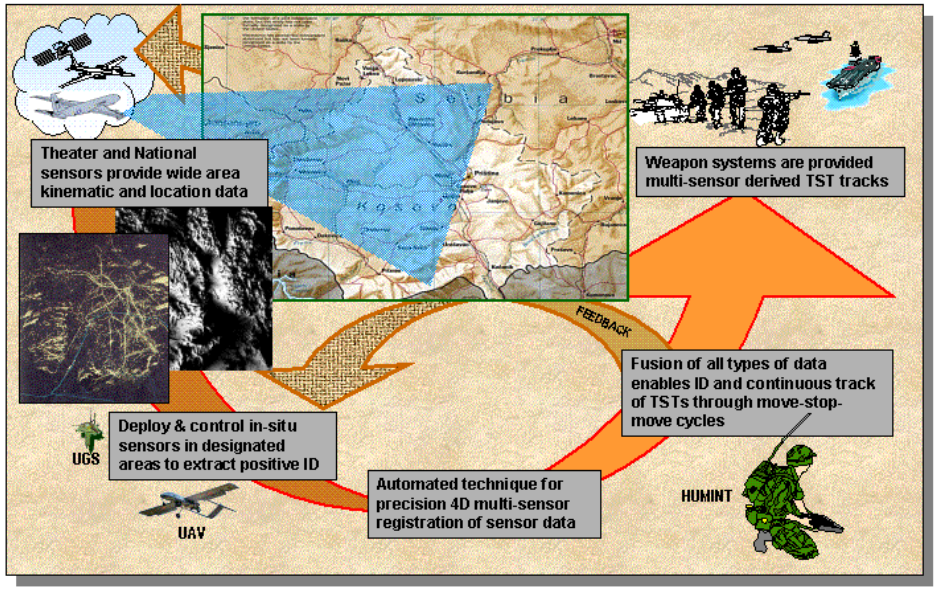
# NCW Overview: Operational Objectives
## *Time-Sensitive Targeting (TST) Examples*


Joint Fires - Network Centric Collaborative Targeting (JF-NCCT) Integration Study

DARPA IXO
Dynamic Tactical Targeting (DTT)

## TST Goals and Objectives

- *Real-time collaboration*
- *Self-synchronization*
- *Machine-to-machine networking*
- *Dynamic sensor management*
- *Geographically dispersed sensing*



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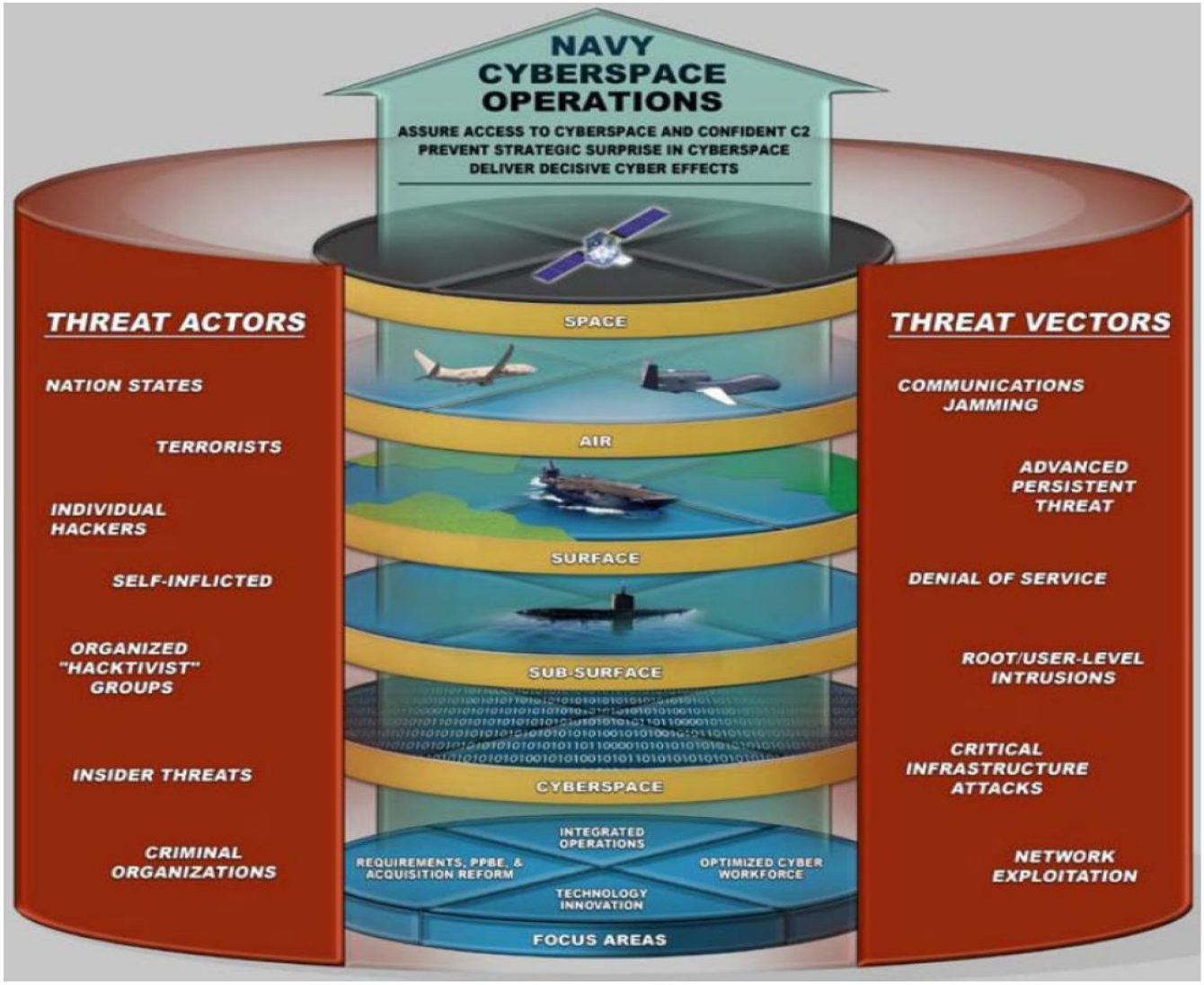
# NCW Overview: Operational Objectives

## *Information Dominance Example*




*Source of graphic (see paper)*

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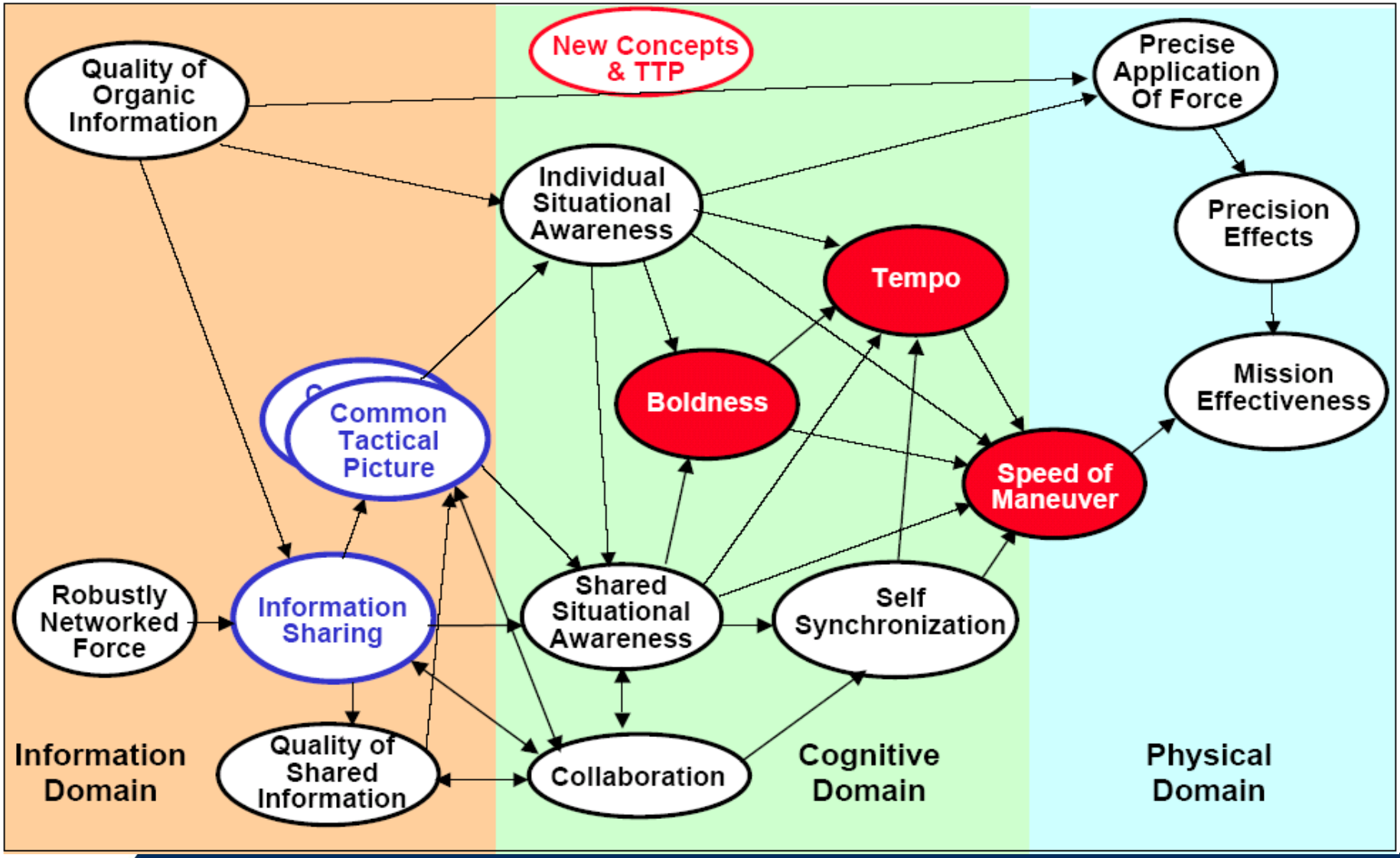
# NCW Overview: Reference Models
## (Info Sharing, Shared SA, Collaboration, Self-Synchronization)




Source: "Fighting The Networked Force," Network Centric Warfare 2005, John J. Garstka, 27 Jan 2005

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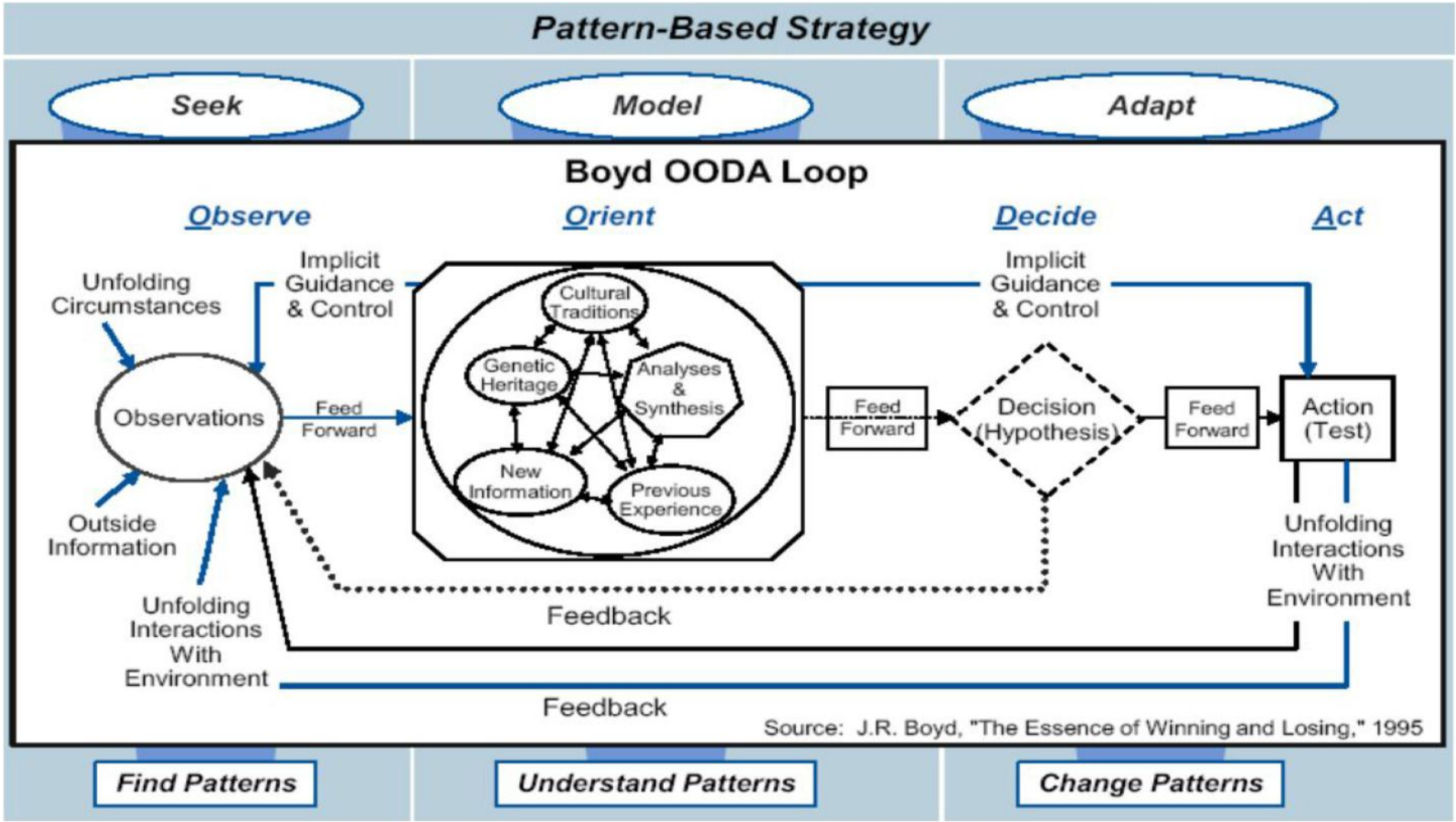
# NCW Overview: Reference Models

## *Boyd OODA-Loop Example*

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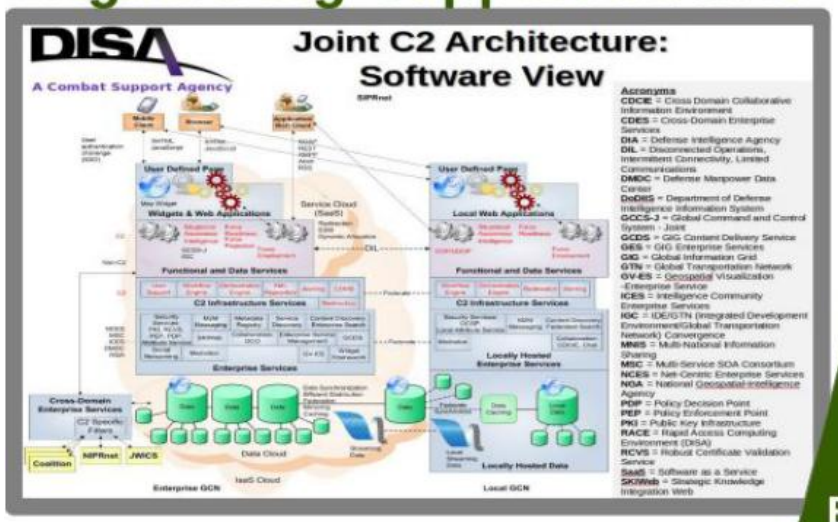
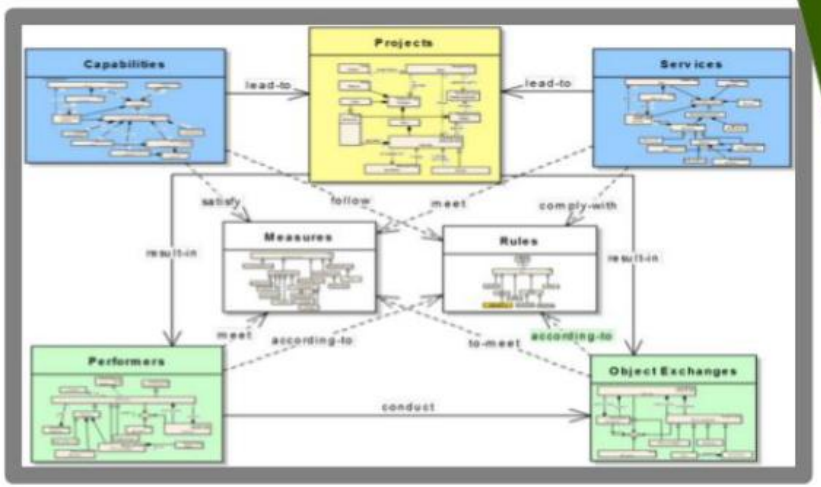
# NCW Overview: Challenges

## *Engineering-Support versus Business-Services*

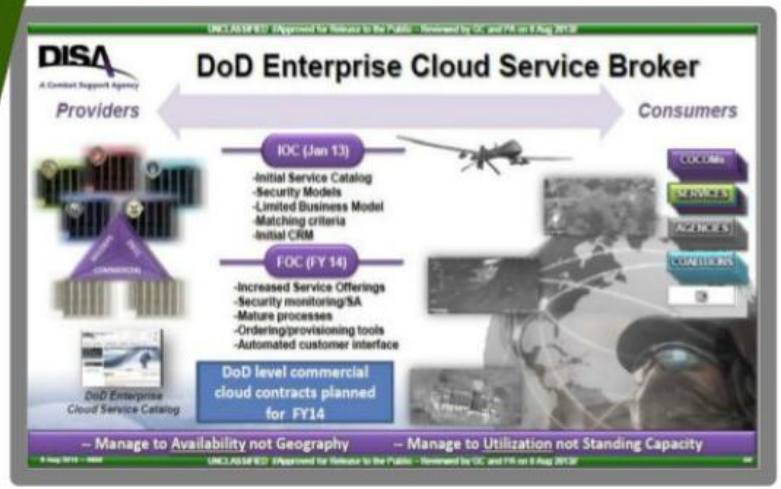
## Engineering-Support Models




Lifecycle/ Engineering Support Process

## Business-Services Models


*Sources of graphics (see paper)*

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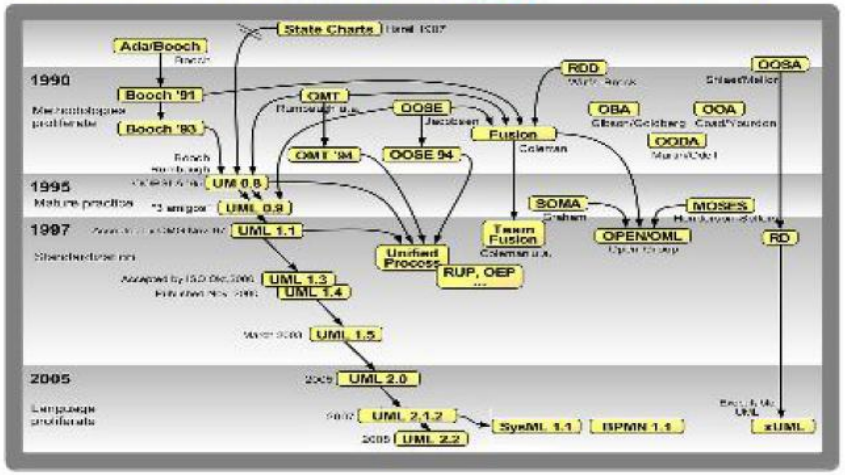
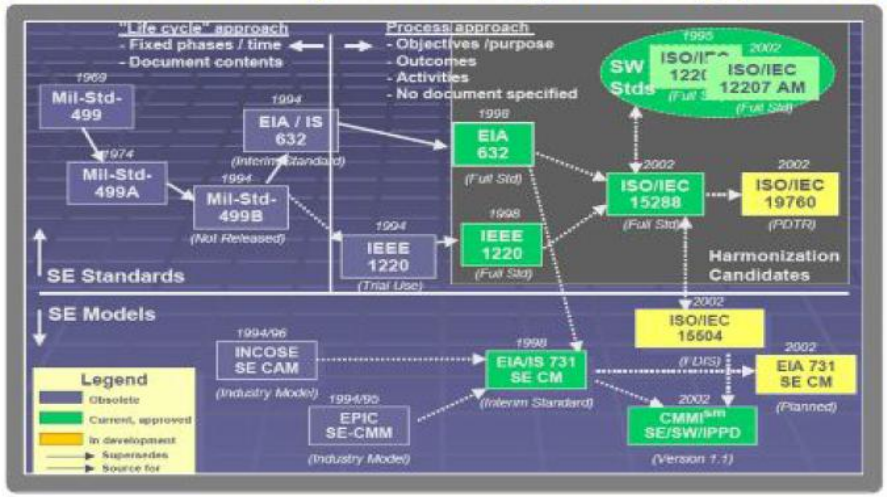
# MBSE/SOSE: Challenges

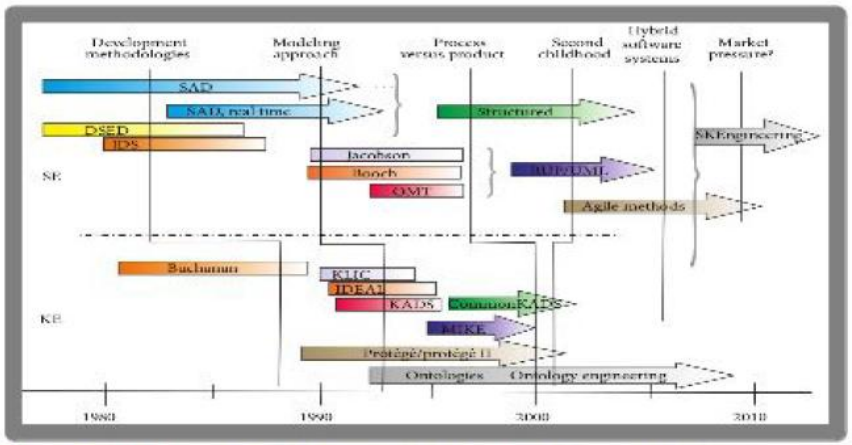
## *Multiplicity of Evolving Standards*

### Software Engineering (e.g OMG/UML)

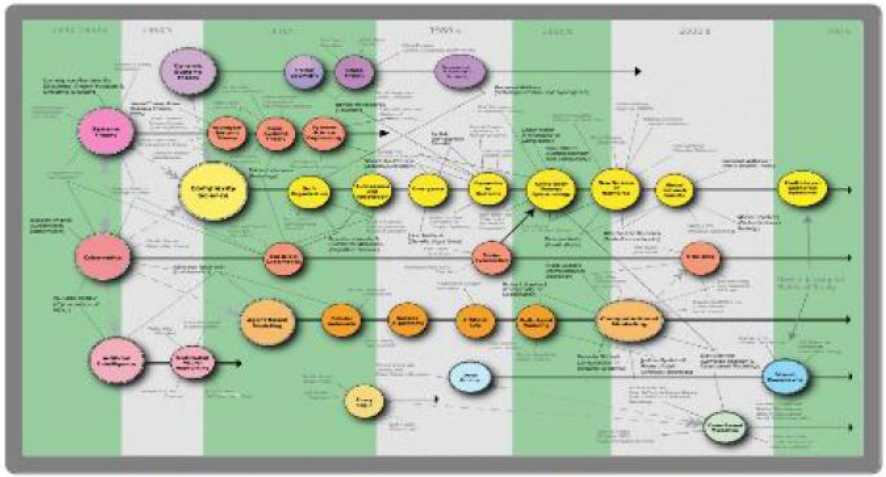



### Model-Based Systems Engineering (MBSE)




### Enterprise Architecture (EA) & Information and Communications Technology (ICT)



### Complex Systems & Computational Modeling

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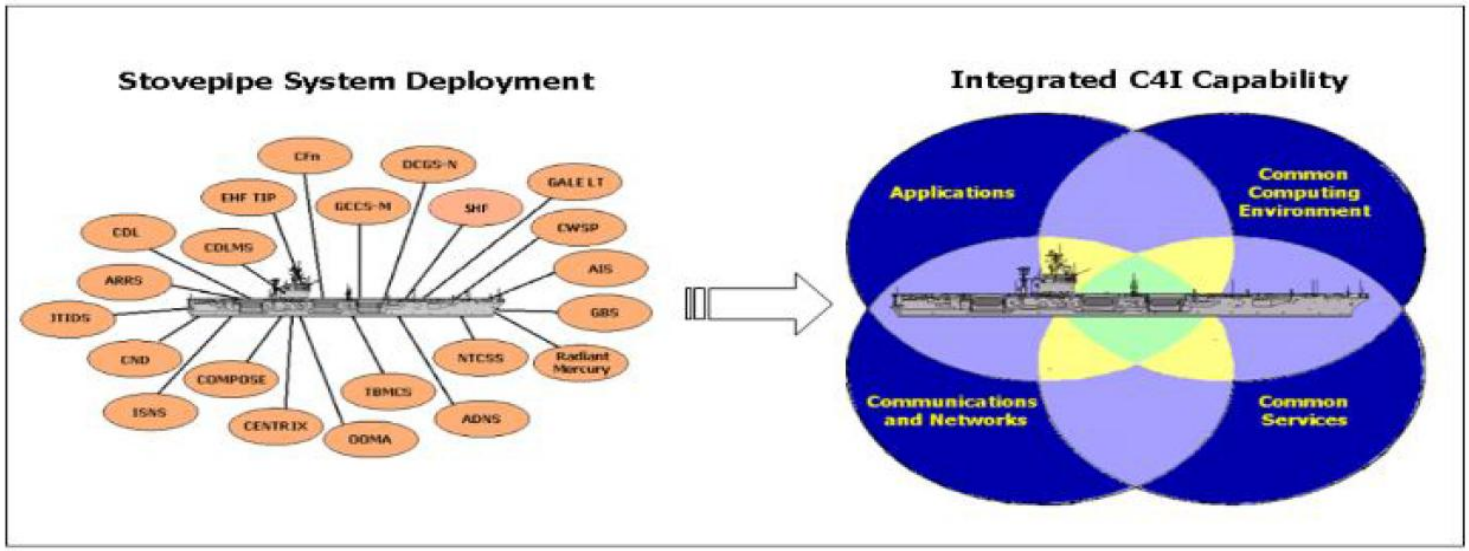
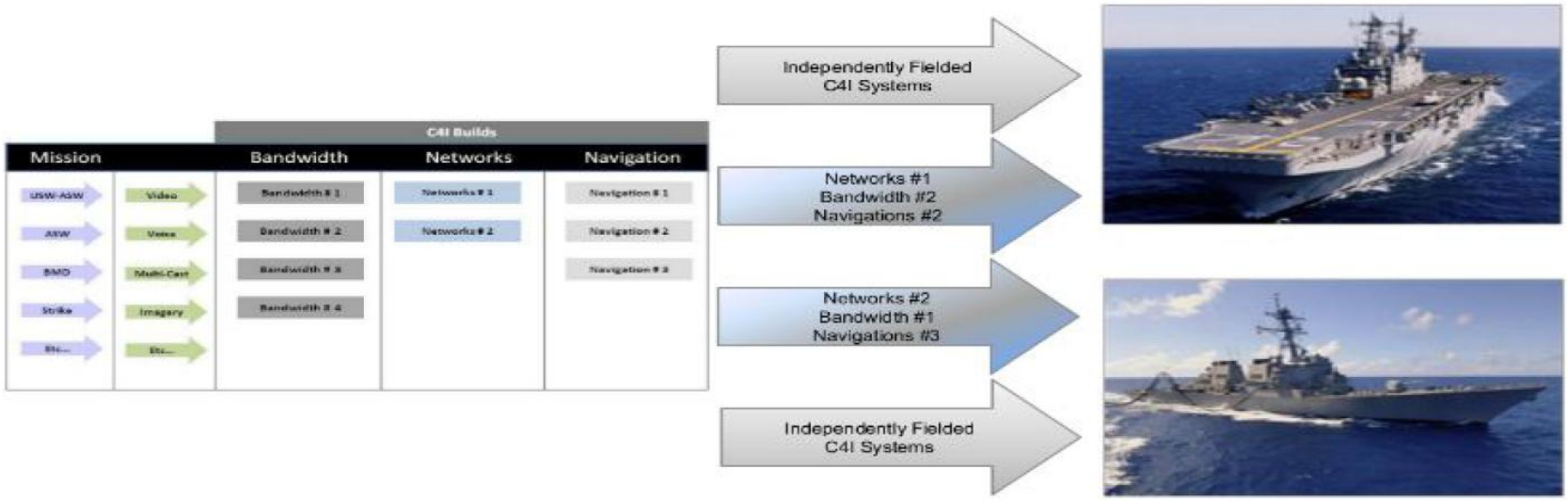
# MBSE/SOSE: Challenges

## *Transformation from Systems to Services*

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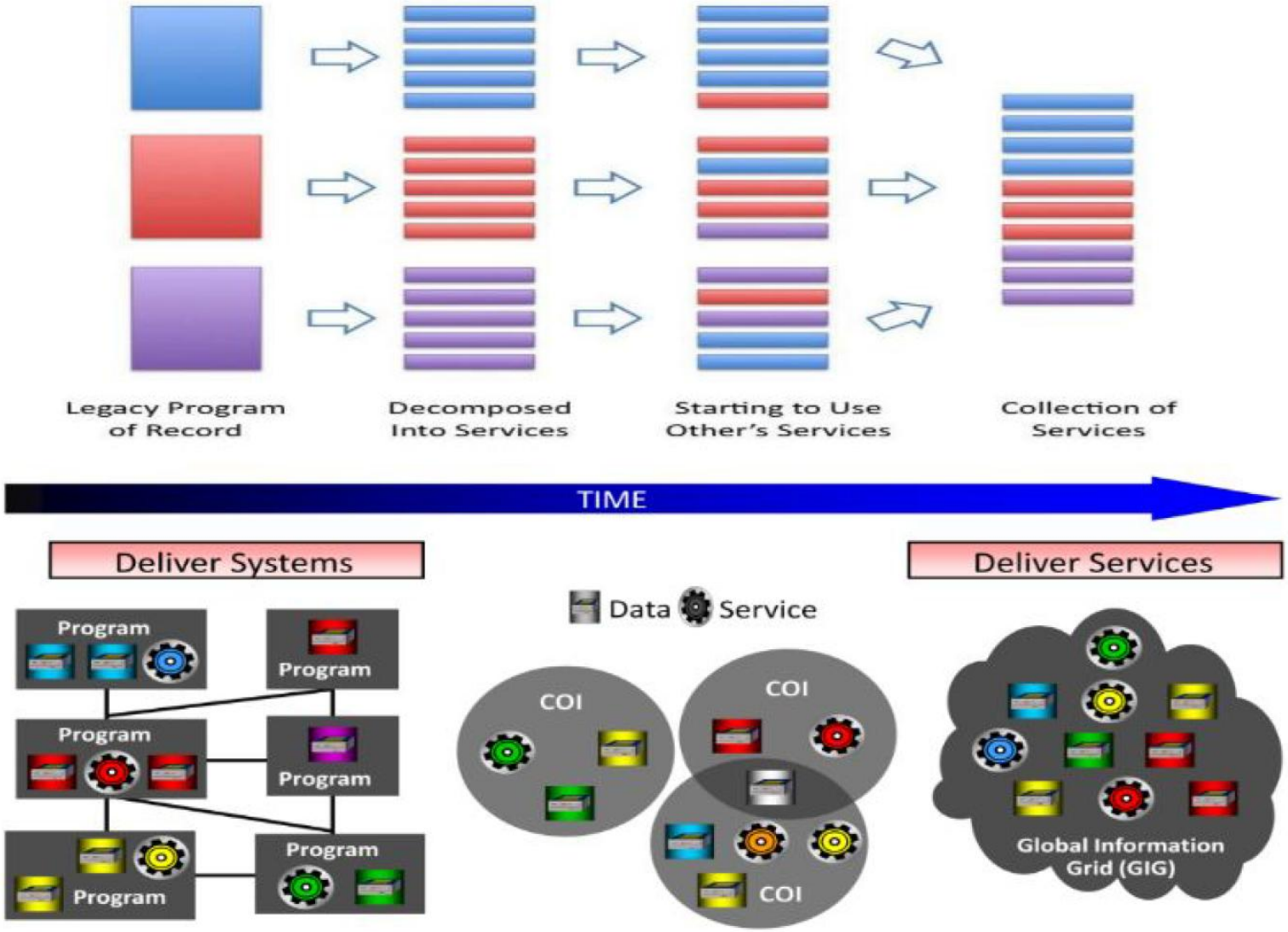
# MBSE/SOSE: Challenges

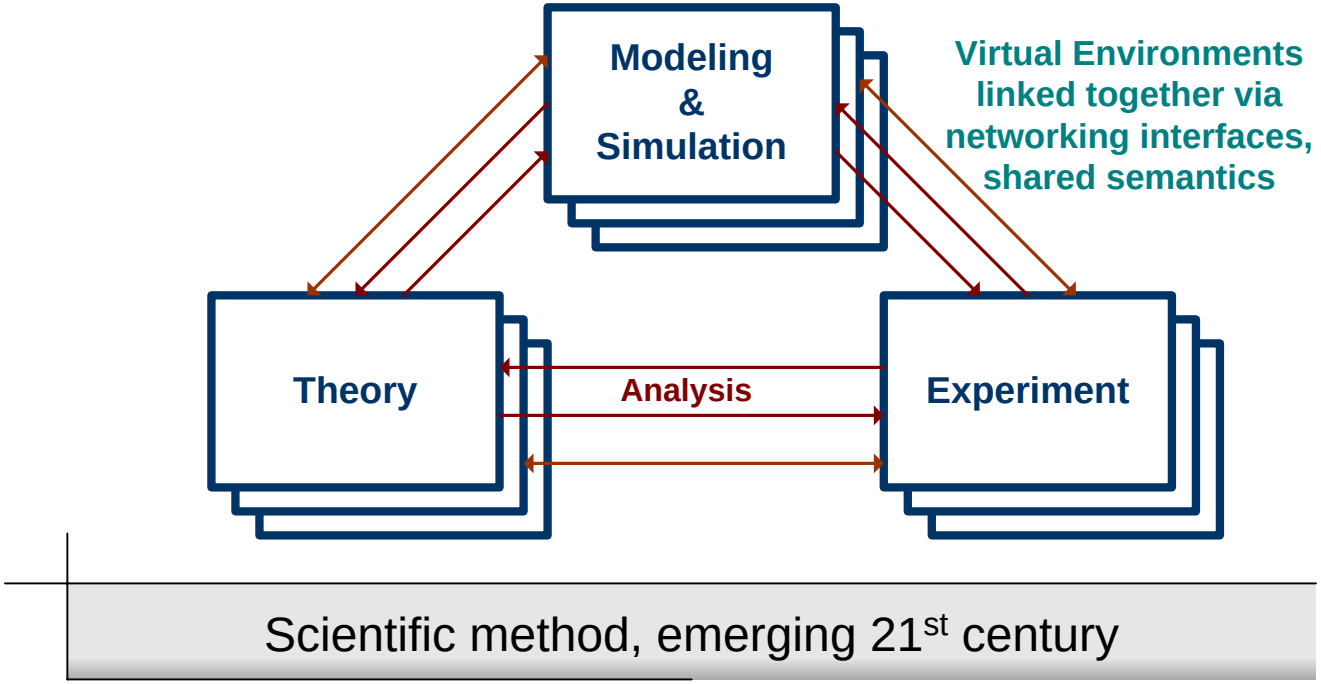
## *Transformation from Systems to Services (continued)*




*Source of graphic (see paper)*

# MBSE/SOSE: Emerging Capabilities

## *Distributed M&S and Virtual Environment*




**Naval Postgraduate School (NPS) Autonomous Unmanned Vehicle (AUV) workbench (Brutzman 2007, Brutzman and Daly 2007, Weekley *et al.* 2004, NPS Autonomous Unmanned Vehicle (AUV) Workbench)**

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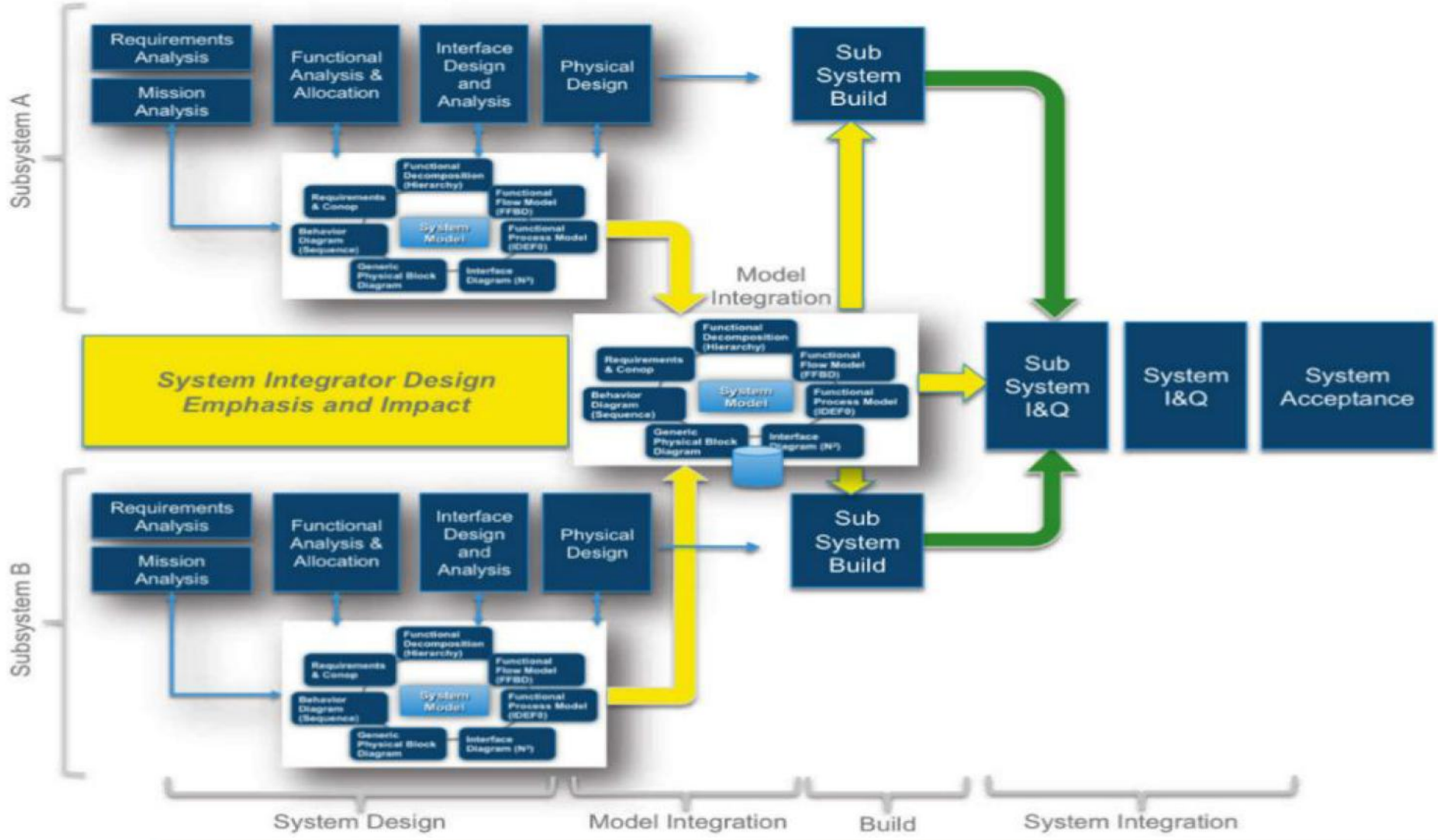
# MBSE/SOSE: Emerging Capabilities

## *Model-Based Systems Integration (MBSI)*

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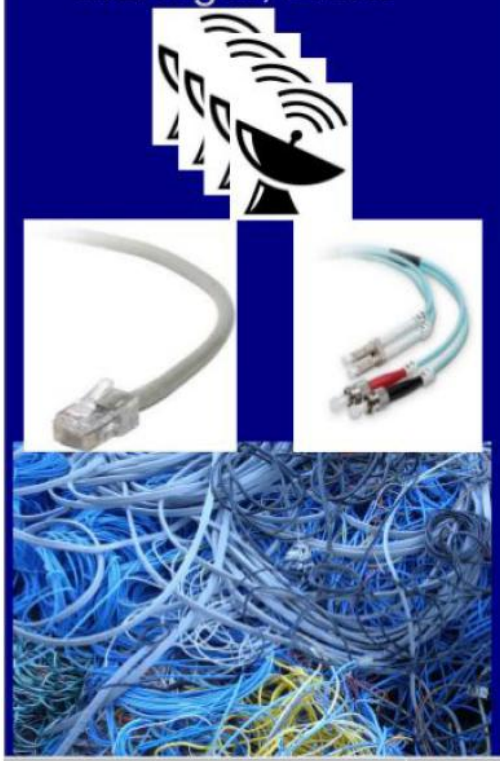
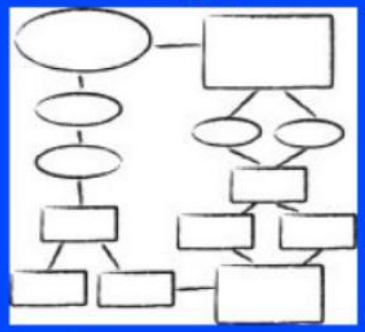
# MBSE/SOSE: Example Need and Use-Case

## *Link-Management for Maritime Ad-Hoc Mesh Networks*

**Physical Layer**
RF LOS Link manager, Links



**Logical Layer**
Connectivity manager, RF LOS relays



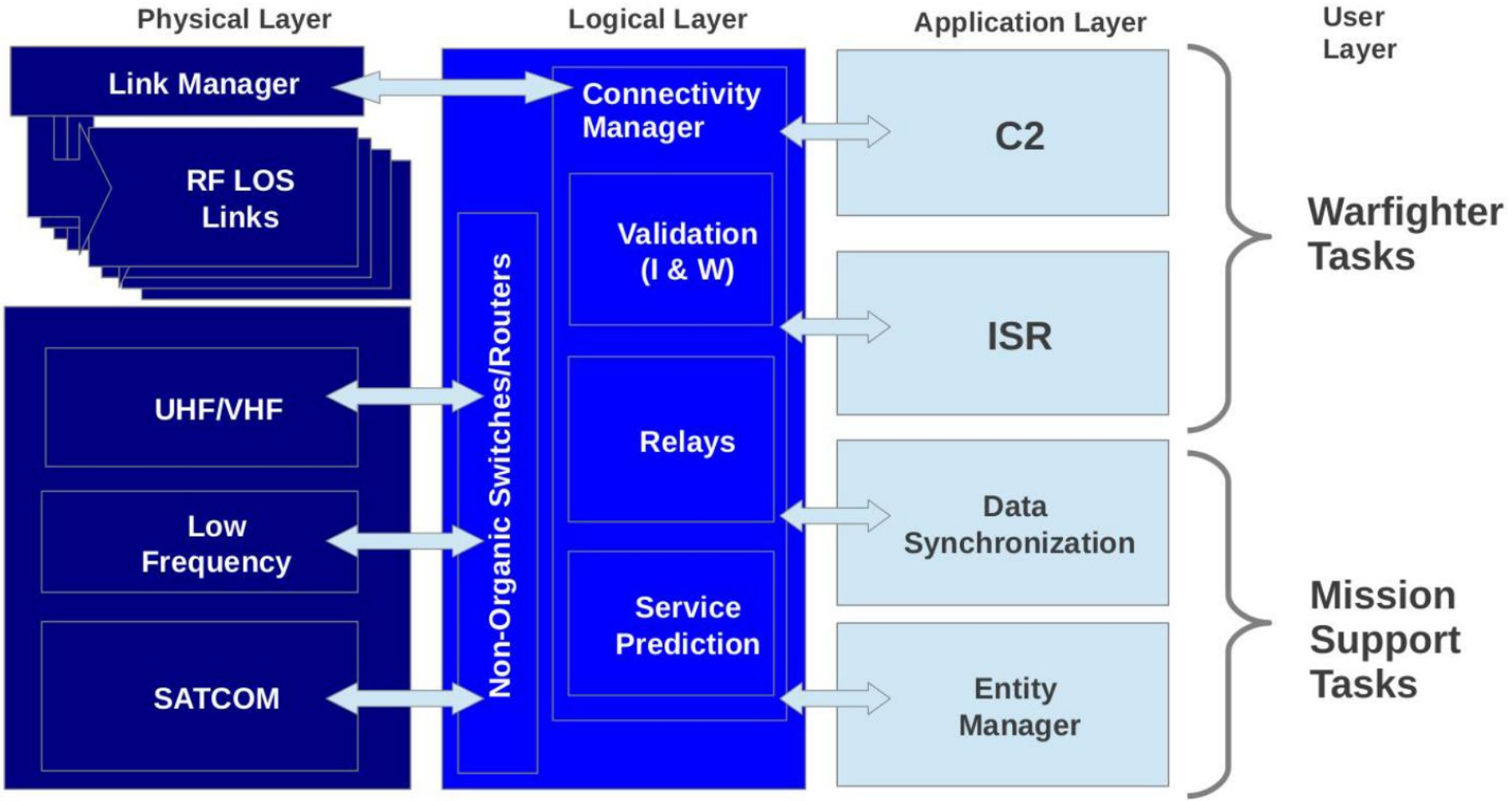

**Application Layer**
Relays, vehicles, user interface

**User Layer**
Operations, Workflow

| 1: Physical | 2: Link | 3: Network<br>4: Transport | 5: Session | 6: Presentation<br>7: Application | "Layer 8"<br>(Individual, End-User) |
|---|---|---|---|---|---|

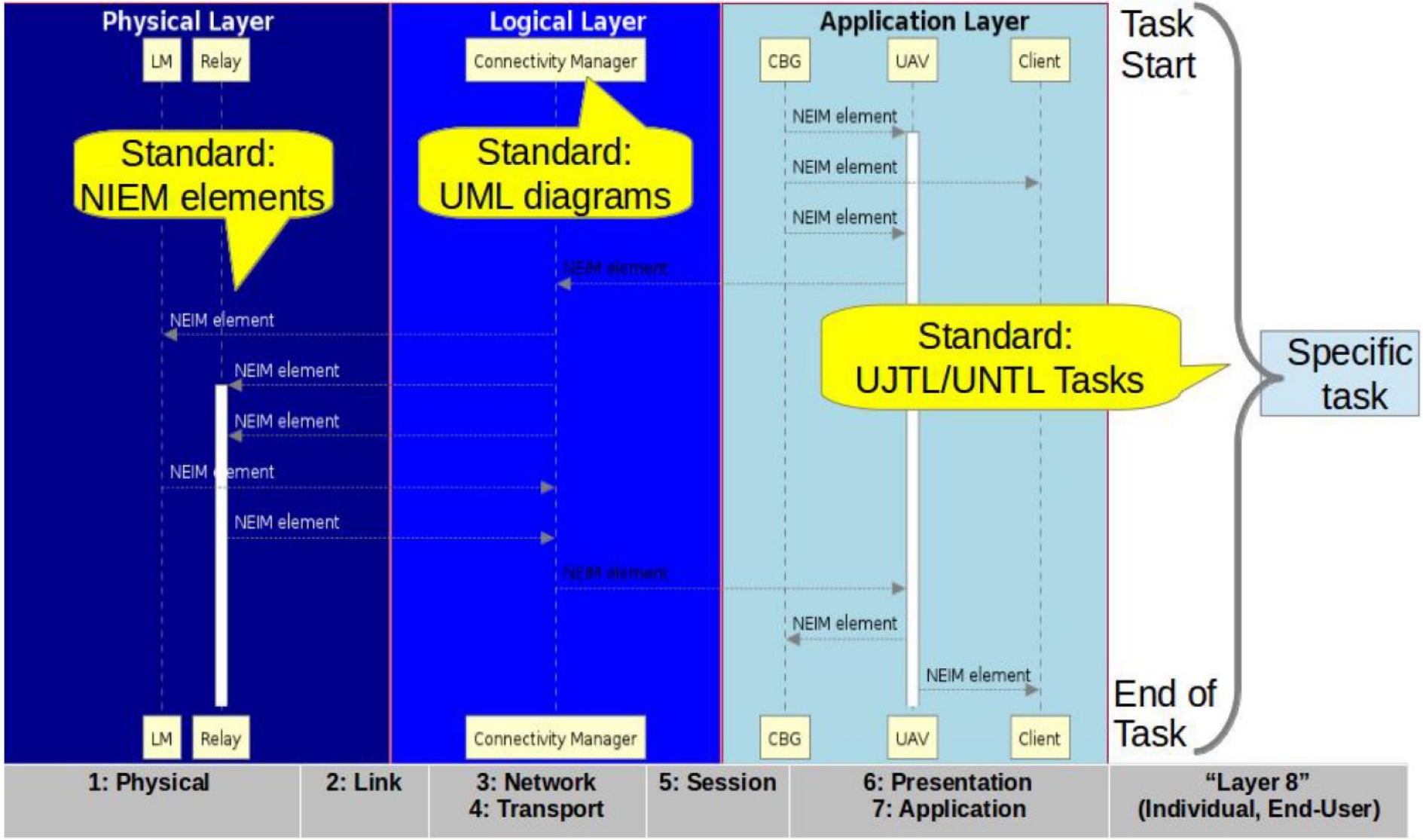
# MBSE/SOSE: Example Need and Use-Case

## *Link-Management (continued)*



# MBSE/SOSE: Example Need and Use-Case

## *Link-Management (continued)*



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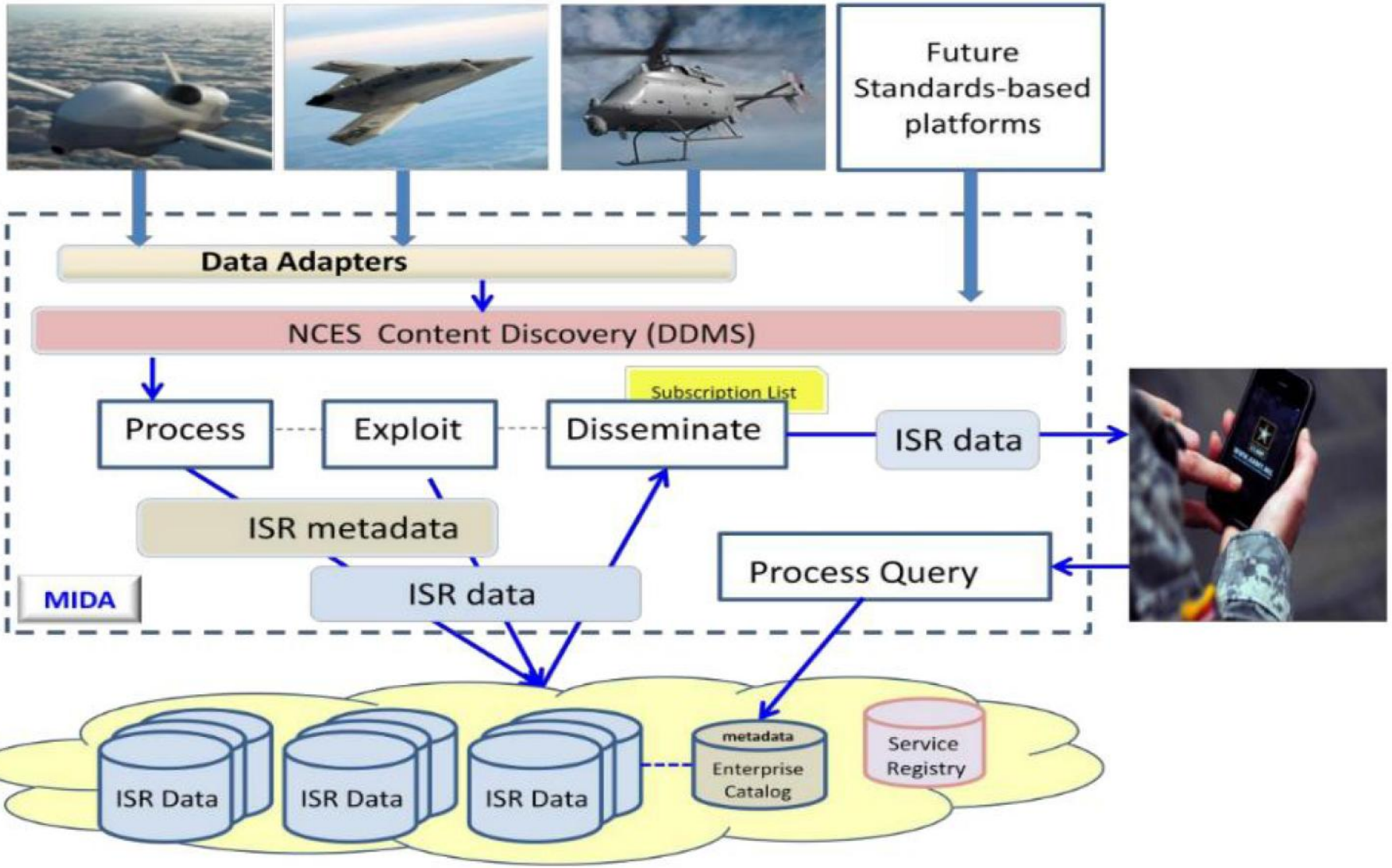
# MBSE/SOSE: Example Need and Use-Case

## *Content Delivery/Distribution Networks (CDN)*

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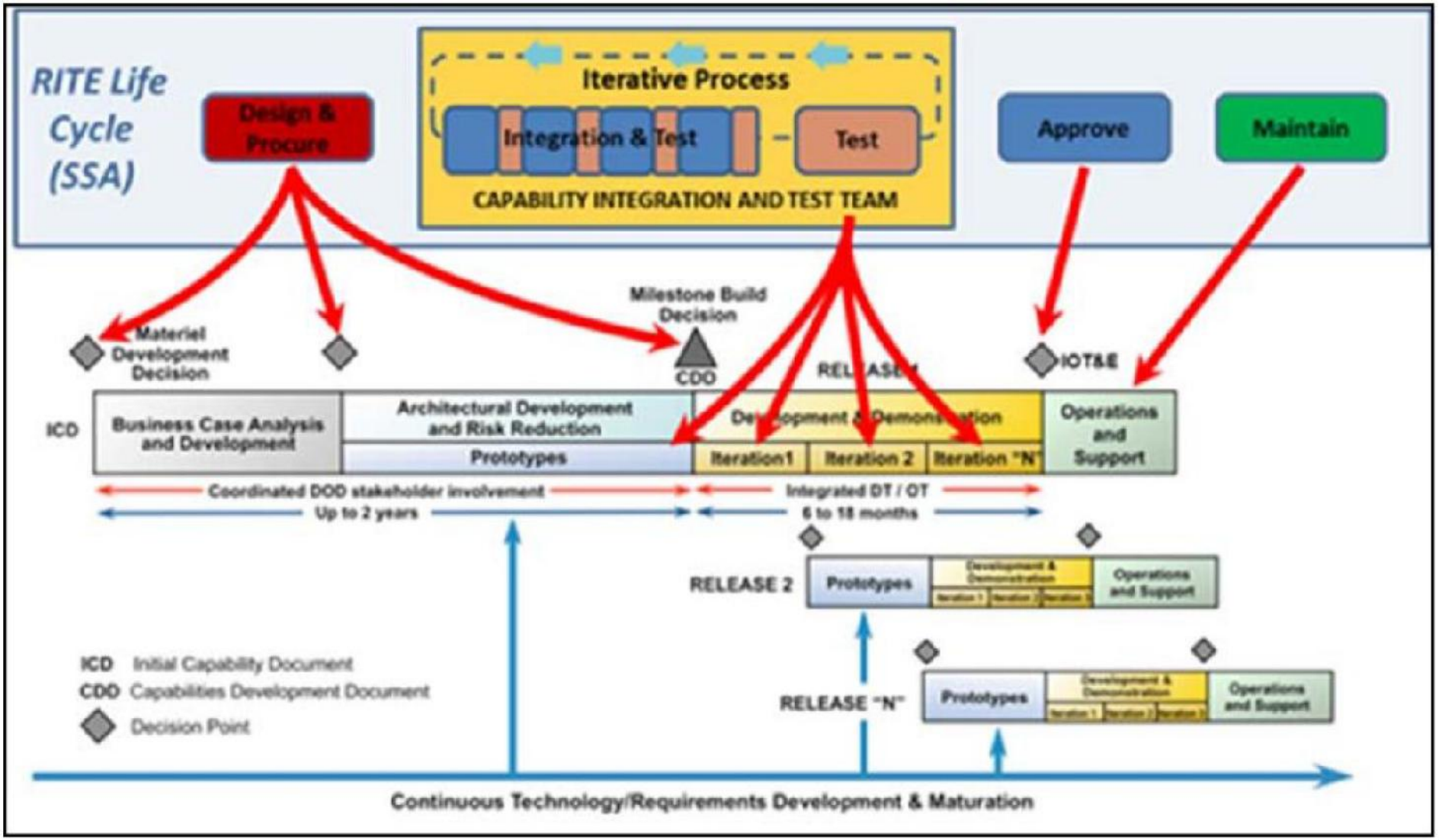
# Conclusions and Future Work: Agile/Incremental MBSE/SOSE Example

## *Rapid Integration and Test Environment (RITE)*




*Source of graphic (see paper)*

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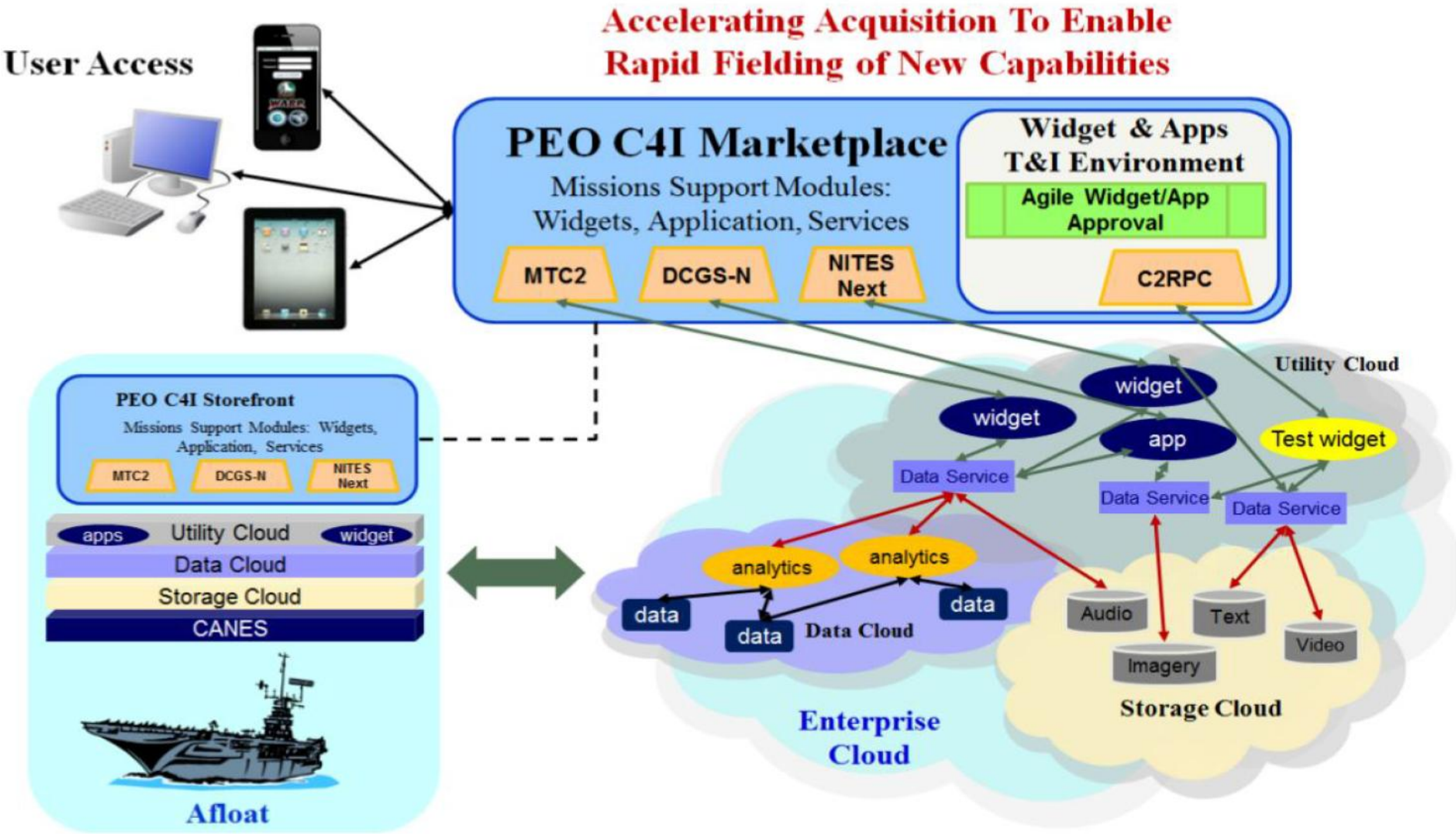
# Conclusions and Future Work: Agile/Incremental MBSE/SOSE Example

## *Cloud-Based Frameworks and Reusable Widgets*




*Source of graphic (see paper)*

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# Questions, Comments, and Dialog