Family of Systems (FoS) System Engineering Wave Model

Presented to
16ᵗʰ Annual Systems Engineering Conference

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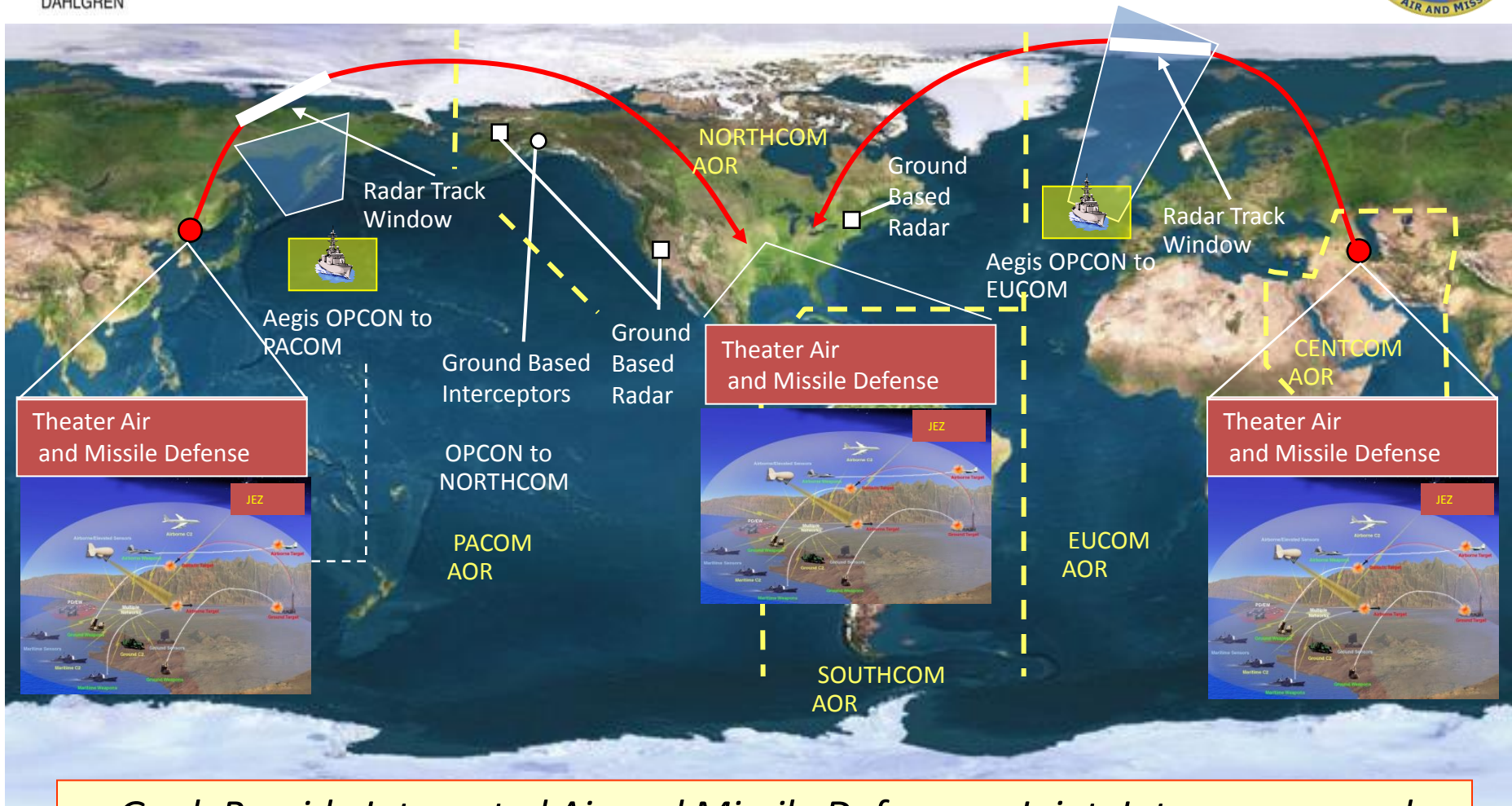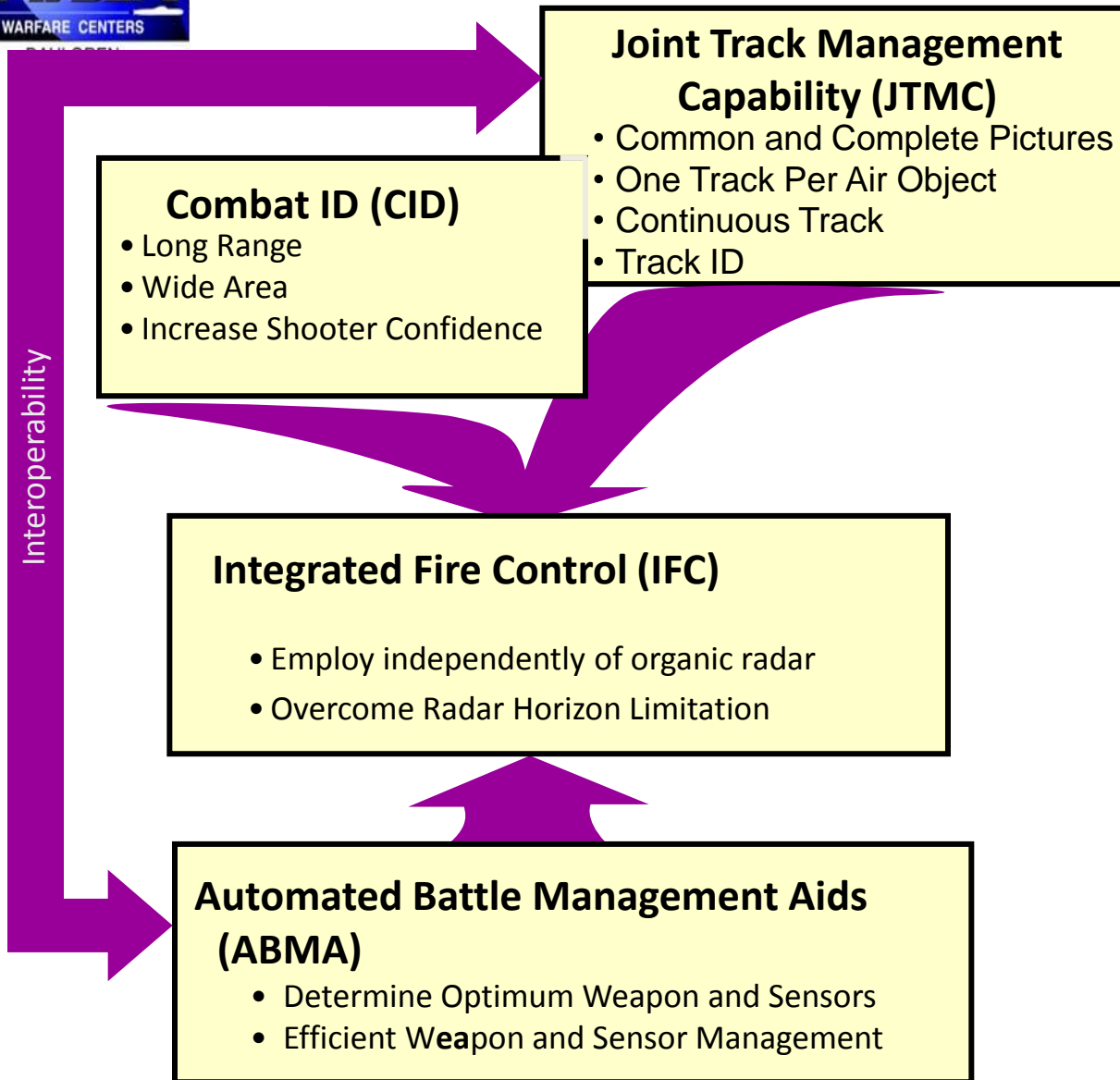
Presentation Agenda

- **Description of Joint Integrated Air and Missile Defense (IAMD)**

- System Engineering Challenges of Integrating Cross Service

- FoS System Engineering Wave Model

Integrated Air and Missile Defense 2025

Goal: *Provide Integrated Air and Missile Defense – Joint, Interagency, and Coalition solutions required across multiple COCOMs*

Future Employment Concepts/Enablers

Joint Track Management Capability (JTMC)
- Common and Complete Pictures
- One Track Per Air Object
- Continuous Track
- Track ID

Combat ID (CID)
- Long Range
- Wide Area
- Increase Shooter Confidence

Integrated Fire Control (IFC)
- Employ independently of organic radar
- Overcome Radar Horizon Limitation

Automated Battle Management Aids (ABMA)
- Determine Optimum Weapon and Sensors
- Efficient Weapon and Sensor Management

Interoperability

Optimal Use of Joint Forces

JTMC - CID
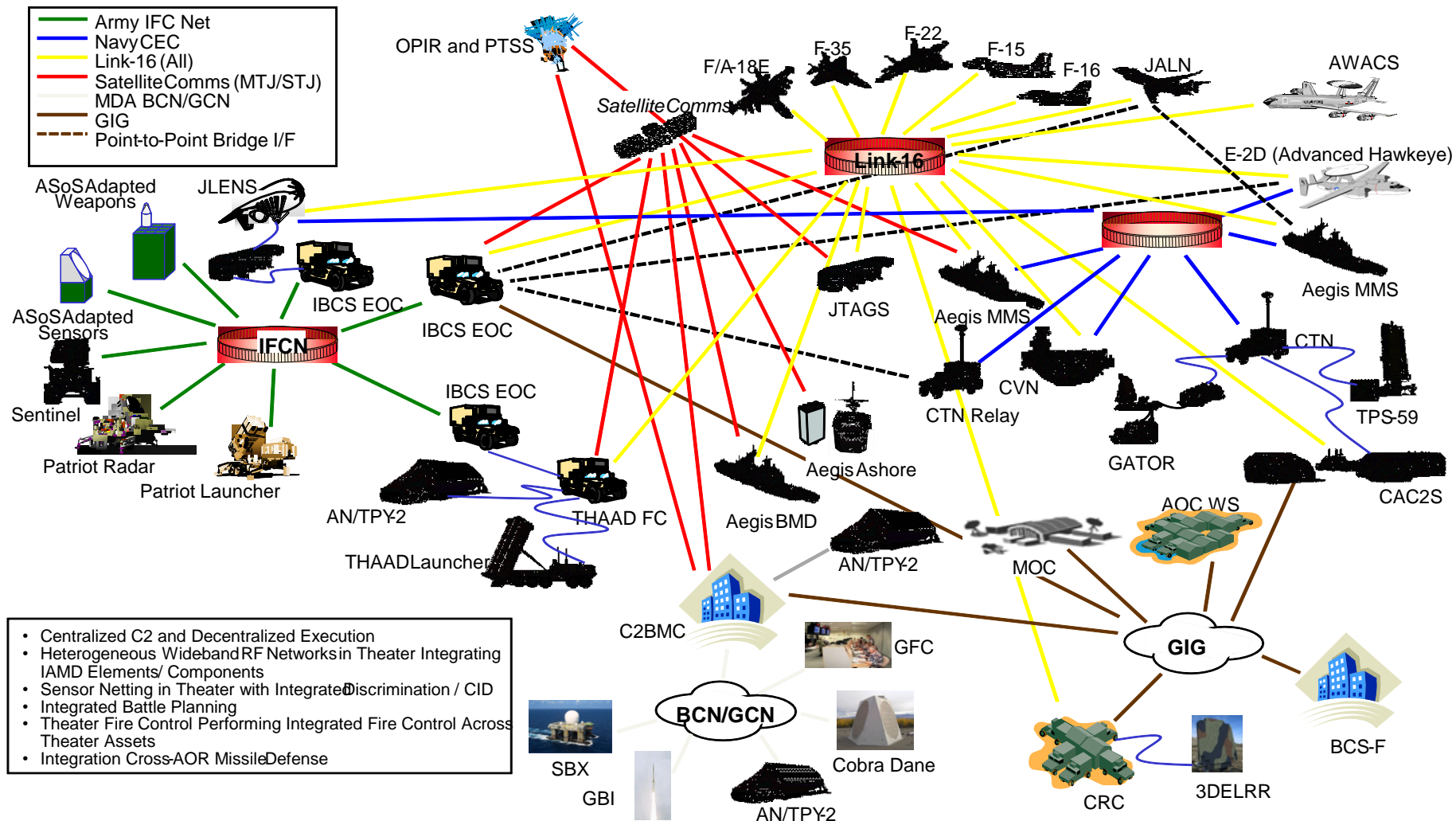
"Confidence to Engage"
Throughout the Battlespace

IFC
Extended Battlespace, Multiple Engagements, Stressing Threat

ABMA
Efficient Engagements
Manage Inventory (Magazine)

Suggested 2025 JIAMD SV-1/2
(Source: MSSET AWG Working Draft)

Legend:
- Army IFC Net
- Navy CEC
- Link-16 (All)
- Satellite Comms (MTJ/STJ)
- MDA BCN/GCN
- GIG
- Point-to-Point Bridge I/F

Labels in diagram: OPIR and PTSS, Satellite Comms, F/A-18E, F-35, F-22, F-15, F-16, JALN, AWACS, Link-16, E-2D (Advanced Hawkeye), ASoS Adapted Weapons, JLENS, Aegis MMS, IBCS EOC, JTAGS, Aegis MMS, ASoS Adapted Sensors, IFCN, IBCS EOC, CVN, CTN Relay, CTN, TPS-59, Sentinel, IBCS EOC, Aegis Ashore, GATOR, CAC2S, Patriot Radar, AN/TPY-2, THAAD FC, Aegis BMD, AOC WS, Patriot Launcher, THAAD Launcher, AN/TPY-2, MOC, GIG, C2BMC, GFC, BCN/GCN, Cobra Dane, BCS-F, SBX, GBI, AN/TPY-2, CRC, 3DELRR

Notes box:
- Centralized C2 and Decentralized Execution
- Heterogeneous Wideband RF Networks in Theater Integrating IAMD Elements/ Components
- Sensor Netting in Theater with Integrated Discrimination / CID
- Integrated Battle Planning
- Theater Fire Control Performing Integrated Fire Control Across Theater Assets
- Integration Cross-AOR Missile Defense

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Joint IAMD System Engineering
(OSD Direction in RMD-700, JAN 2011)

JIAMDO Developed Joint Operational Family of System Needs / Requirements

- JIAMD Operational Views
- IAMD ICD
- JIAMD Roadmap
- IAMD PCL
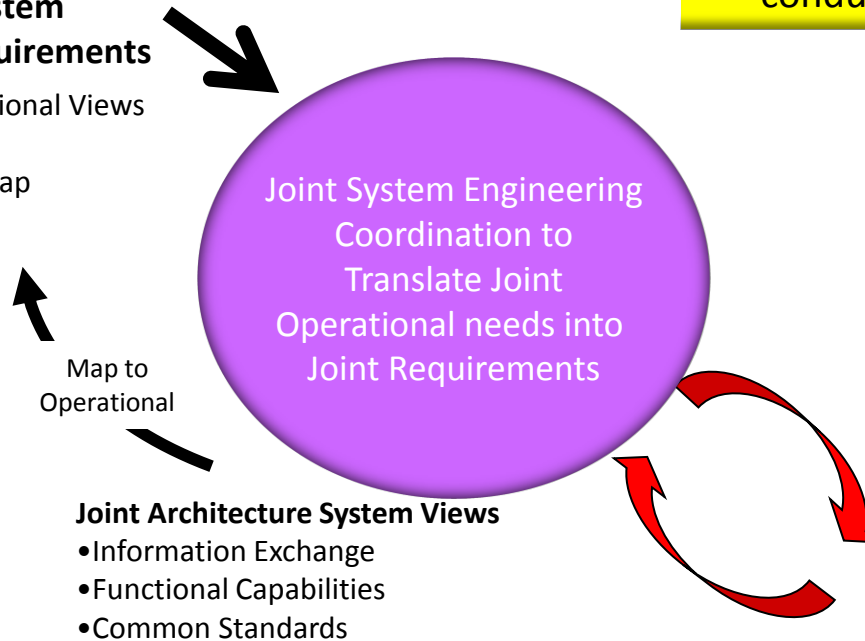
Establish System Engineering Team

- Long term intent is to provide a forum for conducting Joint engineering

Joint System Engineering Coordination to Translate Joint Operational needs into Joint Requirements

Map to Operational

Joint Architecture System Views
- Information Exchange
- Functional Capabilities
- Common Standards

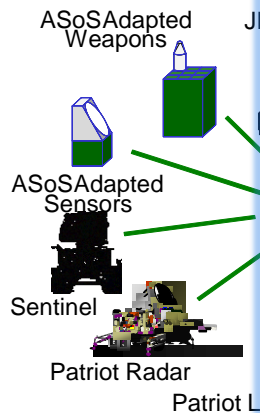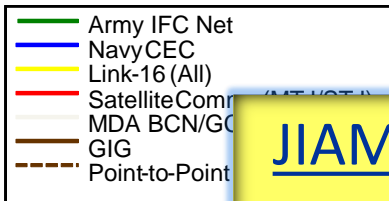**Service & MDA System (SOS) Level Requirements & Recommendations**
(ECPs, CDDS, Specs...)

1   2   3 . . .   N
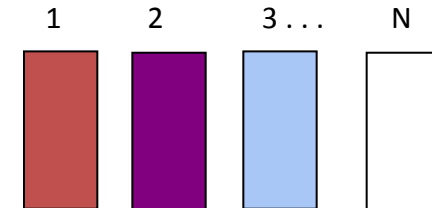
Service PEOs and MDA Implement Recommendations

Suggested 2025 JIAMD SV-1/2
(Source: MSSET AWG Working Draft)

Legend:
- Army IFC Net
- Navy CEC
- Link-16 (All)
- SatelliteComm
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- GIG
- Point-to-Point

OPIR and PTSS

F-22 F-35 F-15 F-16 F/A-18E JALN AWACS

ASoSAdapted Weapons

ASoSAdapted Sensors

Sentinel

Patriot Radar

Patriot L...

(Advanced Hawkeye)

...s MMS

TPS-59

CAC2S

- Centralized C2 and De...
- Heterogeneous Wideb...
  IAMD Elements/ Comp...
- Sensor Netting in Thea...
- Integrated Battle Plann...
- Theater Fire Control Performing Integrated Fire Control Across Theater Assets
- Integration Cross-AOR MissileDefense

SBX
GBI
AN/TPY-2
Cobra Dane
CRC
3DELRR
BCS-F

JIAMD System Engineering Challenges Cross Service

- Integrate all Services and all JIAMD Capabilities

- Leverage off the JIAMD capabilities within the Services

- Integrate Service Unique Intra Networks and Command and Control Constructs

- Coordinate Service Unique Integration Approaches (e.g., System-to-System vice System-of-System)

- Coordinate Physics based System to System engineering while Integration is System-to-C2 SOS, C2-to-C2, etc.
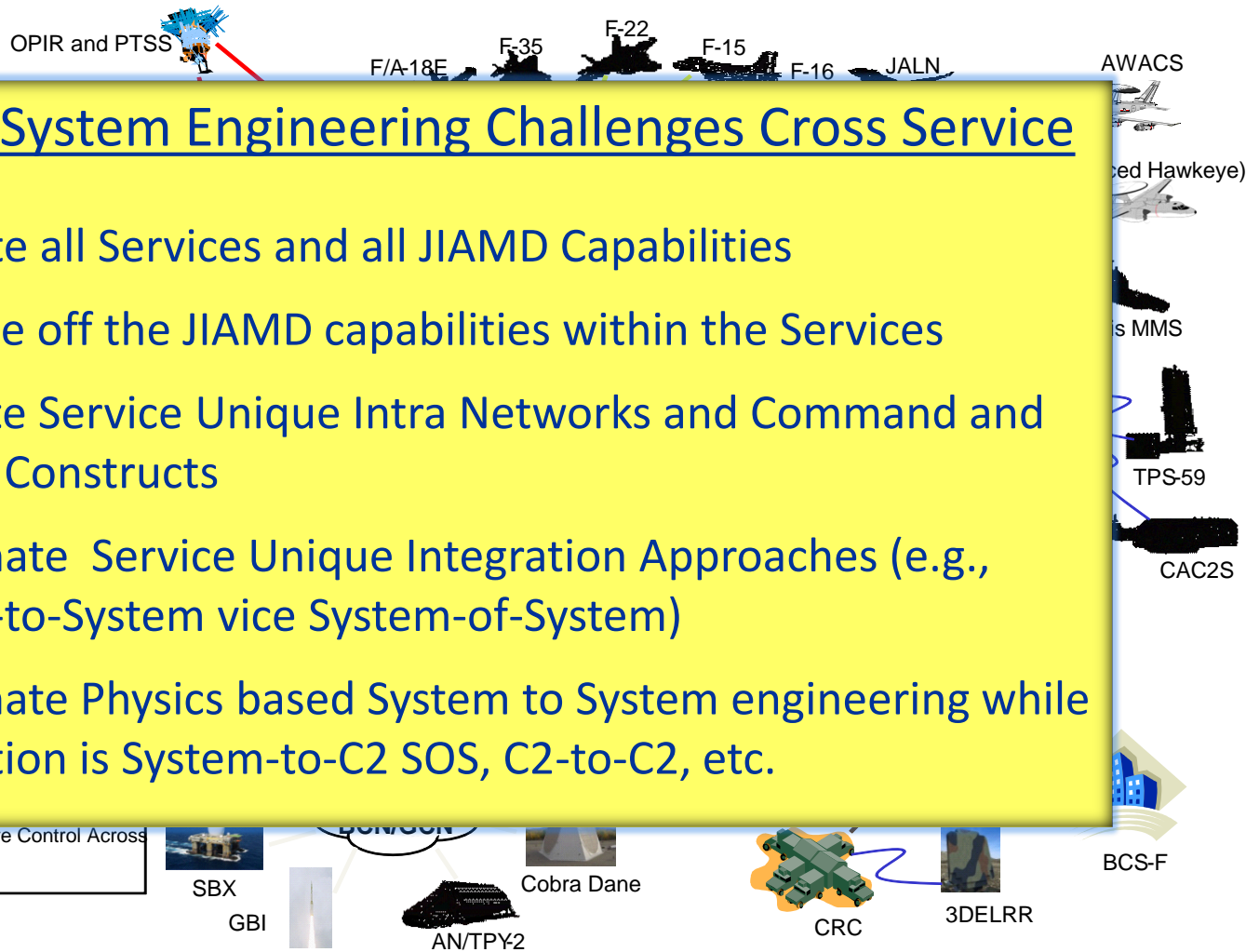
Systems of Systems (SoS) versus Family of Systems (FoS)

John Clark, Chief Engineer at NG Corp states -

- SoS: The sum of the whole is greater than the sum of the individual parts:
  - The parts are integrated (i.e., have interfaces)
  - The parts may or may not be members of a common domain (such as a product line, for example: surface ship radars)

- FoS: The sum of the whole is equal to the sum of the individual parts:
  - The parts are not integrated
  - The parts are members of a common domain

"System of Systems Engineering and Family of Systems Engineering from a Standards Perspective," by John O. Clark which appeared in the IEEE International Conference on System of Systems Engineering, 2008. SoSE '08. Copyright © 2009 by IEEE

Definitions Cont.

CJCS, 2007(1) states:

- FoS a set of systems that provide similar capabilities through different approaches to achieve similar or complementary effects.

- Fundamentally different than SoS because FoS lacks the synergy of a SoS

- FoS does not acquire qualitatively new properties as a result of grouping – may not be connected into a whole

Challenges/Approach

Challenges

Acquisition management problem not technical
- Driving FoS requirements into to PoR
- Getting buy-in from Services and systems

SE process
- Applying to FoS

Approach

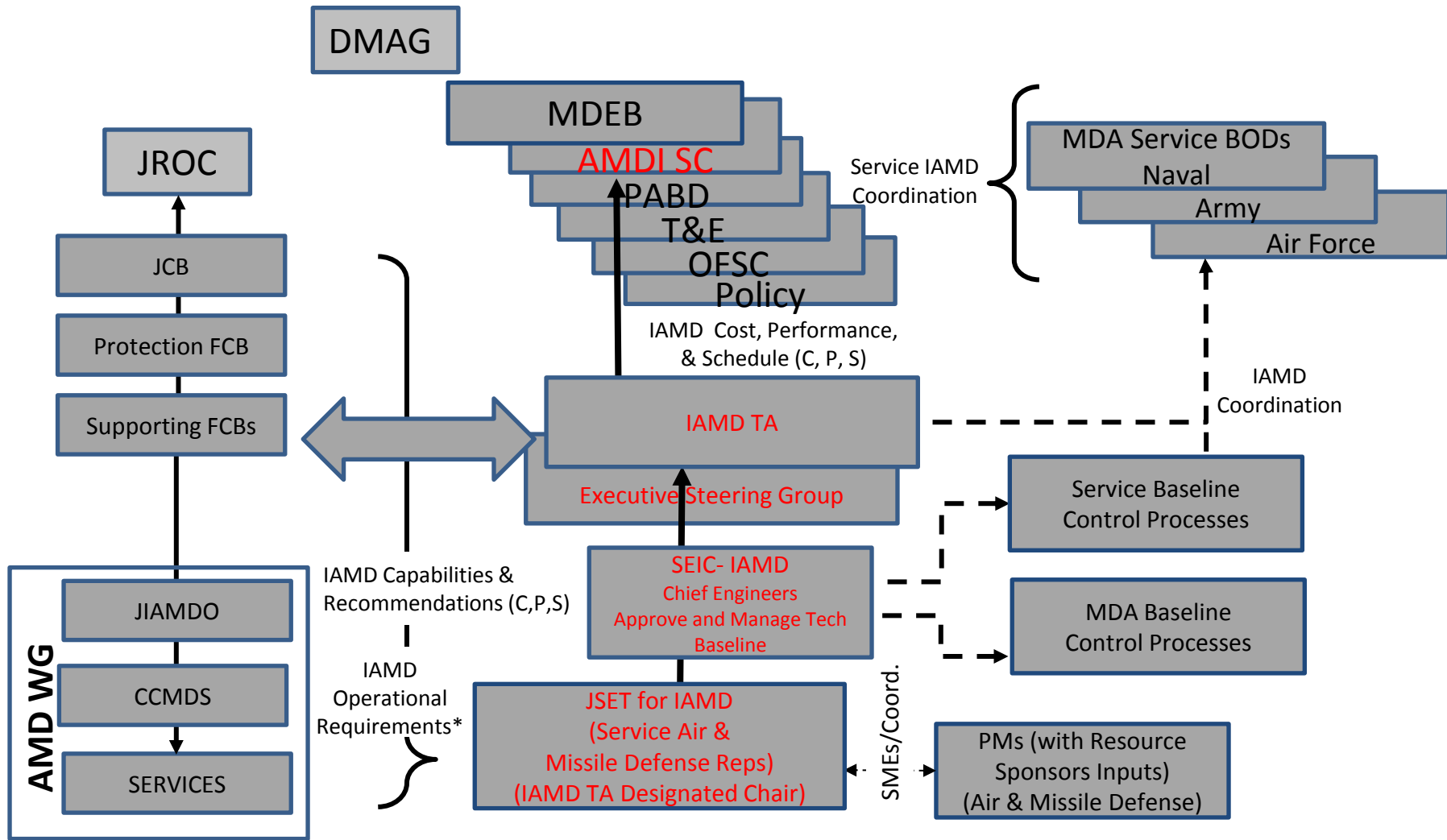Establish a Governance that all members agree to
- Acquisition management
- Program management
- Directive

Expand SE Process
- V model to W model
- Expand SoS Wave model

Joint IAMD Technical Authority Process and Governance (IAMD MOU)

DMAG

MDEB
AMDI SC
PABD
T&E
OFSC
Policy

JROC

JCB

Protection FCB

Supporting FCBs

Service IAMD Coordination

MDA Service BODs
Naval
Army
Air Force

IAMD Cost, Performance, & Schedule (C, P, S)

IAMD TA

IAMD Coordination

Executive Steering Group

IAMD Capabilities & Recommendations (C,P,S)

Service Baseline Control Processes

AMD WG

JIAMDO

CCMDS

SERVICES

IAMD Operational Requirements*

SEIC- IAMD
Chief Engineers
Approve and Manage Tech Baseline

MDA Baseline Control Processes

JSET for IAMD
(Service Air & Missile Defense Reps)
(IAMD TA Designated Chair)

SMEs/Coord.

PMs (with Resource Sponsors Inputs)
(Air & Missile Defense)
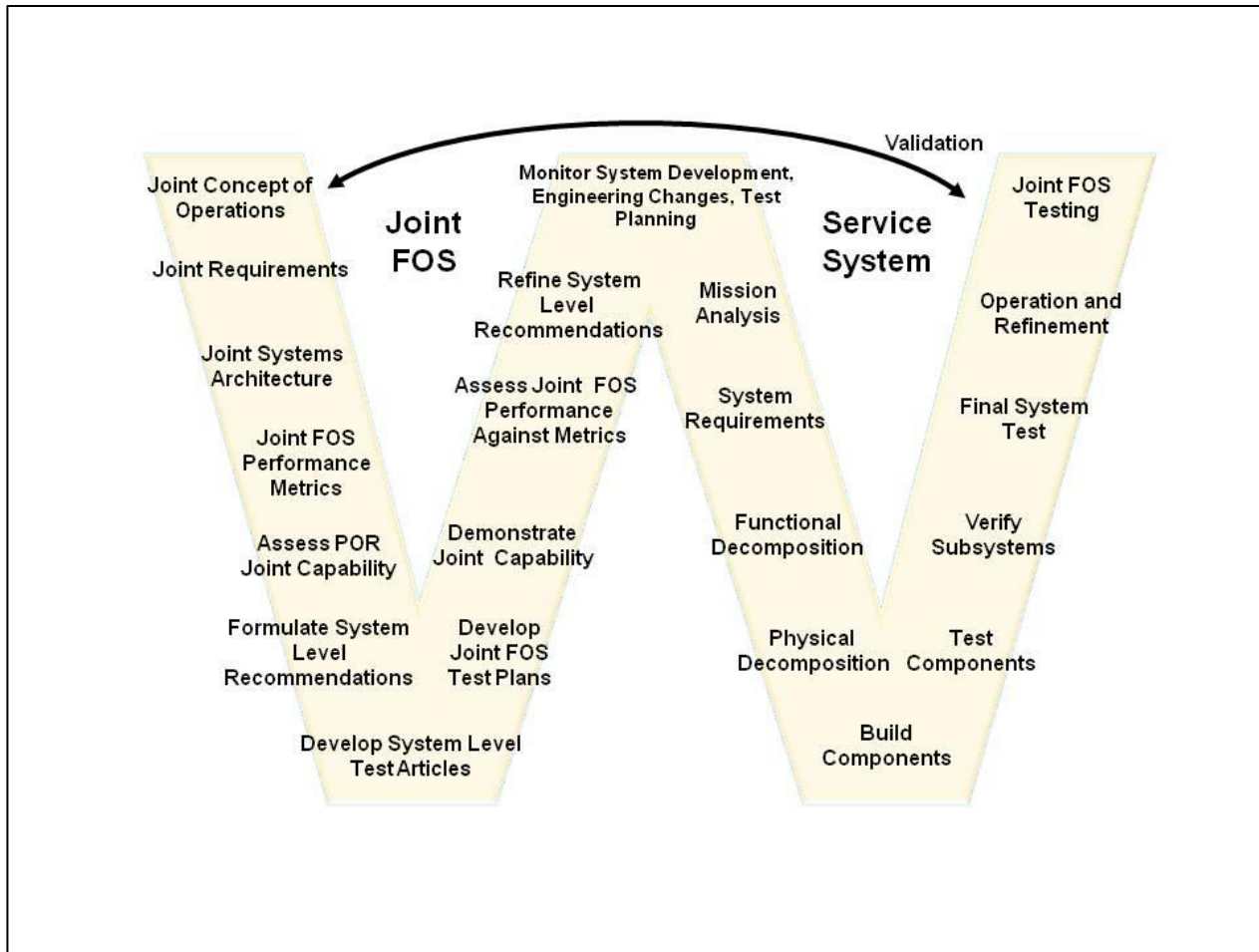
*JCIDS, WIP, Ops Arch, Ops Concepts
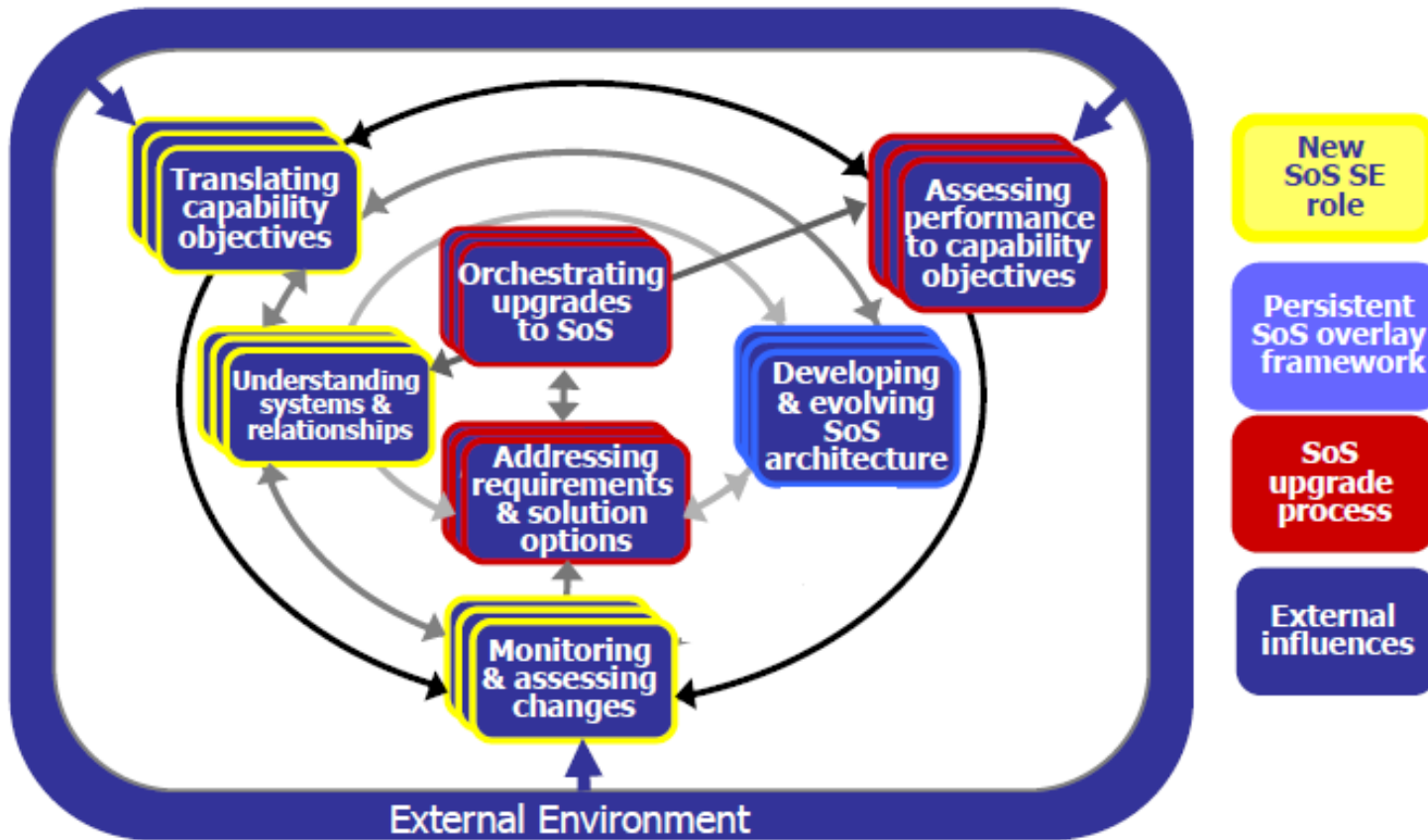
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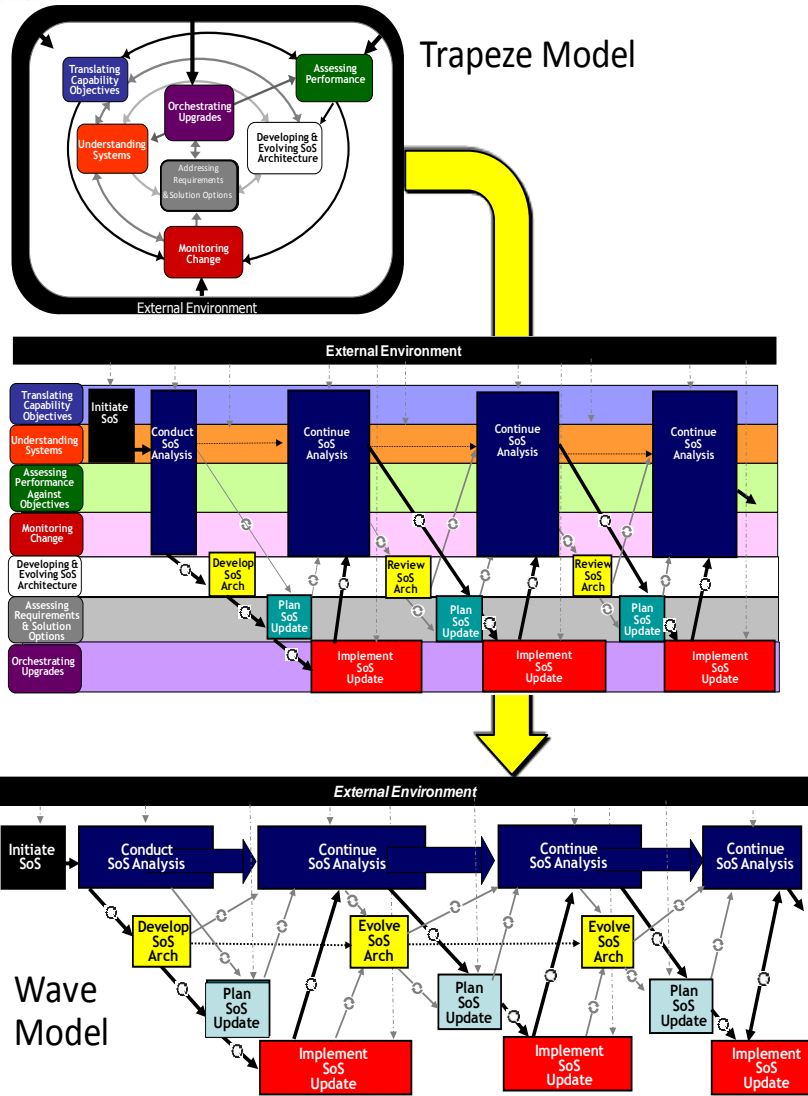- **FoS System Engineering Wave Model**

SE W Model

SE Model for SoS Based on 7 Core Elements of SoS SE

Taken from Dr. J. Dahmann, MITRE Corp, Systems Engineering for Systems of Systems, NDIA SE Conference, Oct 2008,

Trapeze Model to Wave Model


Trapeze Model

Wave Model

- **Trapeze Model**
  - Core elements of SoS SE and relationships
  - A good 'conceptual' view of SoS SE
  - Not as useful in charting an implementation approach

- **Wave Model**
  - 'Unwinds' the trapeze model
  - A view of SoS SE as a sequence of major implementation steps
  - More intuitive for an implementer

*Taken from Dr. J. Dahmann, MITRE Corp, An Implementers' View of Systems Engineering for Systems of Systems, 2011 IEEE Systems Conference

FoS WAVE MODEL
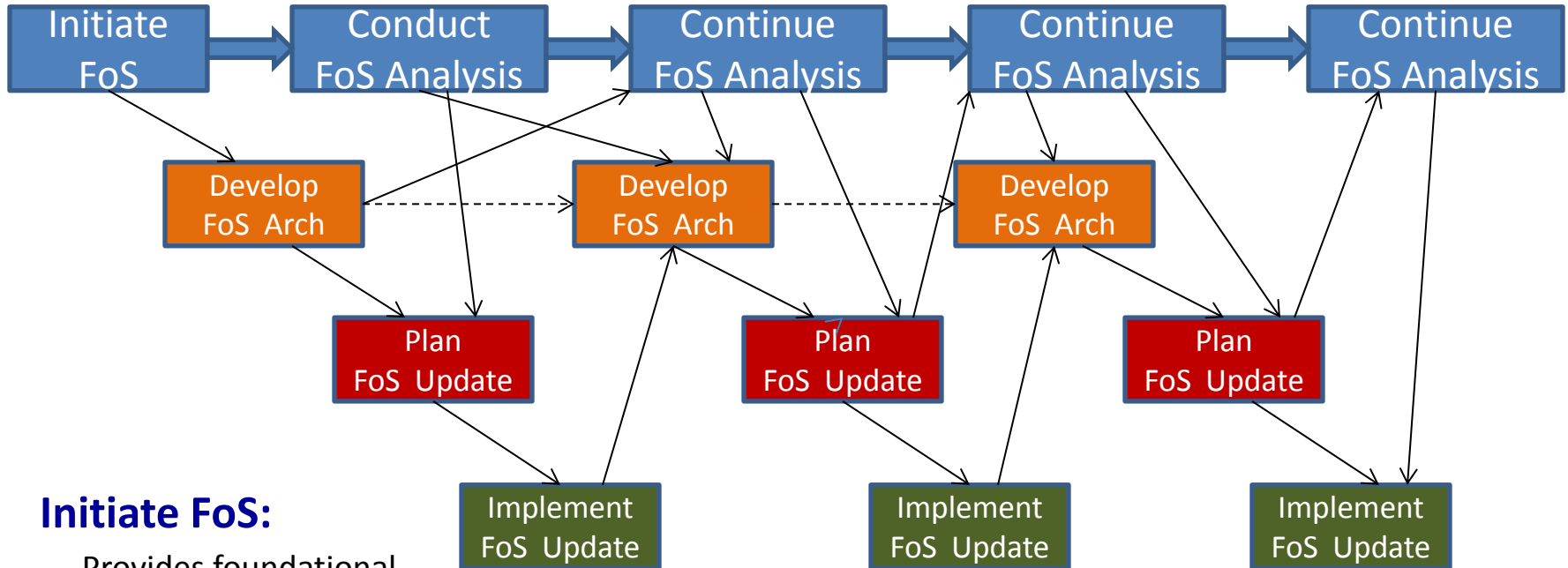
- **Initiate FoS:**
  Provides foundational information to initiate the FoS

- **Conduct FoS Analysis:**
  Provides analysis of the 'as is' FoS and basis for its evolution

- **Develop FoS Architecture:**
  Develops/evolves the persistent technical framework for FoS evolution and a migration plan identifying risks and mitigations

- **Plan FoS Update:**
  Evaluates FoS priorities, backlog of FoS changes, and options to define plans for the next FoS upgrade cycle

- **Implement FoS Update:**
  Oversees system implementations and plans/conducts FoS level testing, resulting in a new FoS baseline

- **Continue FoS Analysis:**
  Ongoing FoS analysis revisits the state of and plans for the FoS as the basis for FoS evolution

CONCLUSION

- Joint IAMD challenges the SE approach
- Modified the SoS Wave Model, developed by Dr. Dahmann, to accommodate the challenge of integration cross services
- Developed approach to FoS SE

Questions