System of Systems Challenges in the Capability Lifecycle – a Joint MoD / Industry Enterprise Approach

Malcolm Touchin
Principal Consultant, SEIC
Loughborough University
malcolm.touchin@baesystems.com
Tel +44 1509 635210
Mob +44 7793 424566

David Camm
DepHd Engineering – SEIG
DESSESEIG-Eng-DepHd@mod.uk
Tel +44 117 91 37810
Mob +44 7974 224358

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Agenda

- What is a System of Systems
- BAE Systems / MoD Partnership
- BAE Systems SoS Activity Model
- MoD System of Systems Approach (SOSA)
- Examples of SoS Application
- Benefits and Challenges

What is a System of Systems?

Ensuring the whole >> Sum of individual parts

System of Systems:

"A SoS is a set or arrangement of systems that results when <u>independent</u> and useful systems are combined* into a larger system that delivers unique capabilities"

– *modified from US DOD definition

SoS Engineering – not increased attention to detail rather an attention to overall coherence – controlling emergent properties at SoS level

BAE Systems and MoD Partnership

- SoS Issues
  - Independent recognition of SoS problem
- MoD / BAE Systems Partnering - Joint Development Framework
  - Alignment of Engineering Strategy
  - Engineering Skills Development
  - Product Safety
  - Roles and Responsibilities, such as Design Authority
  - Systems Engineering for TLCM
  - Product Environmental and Sustainability issues

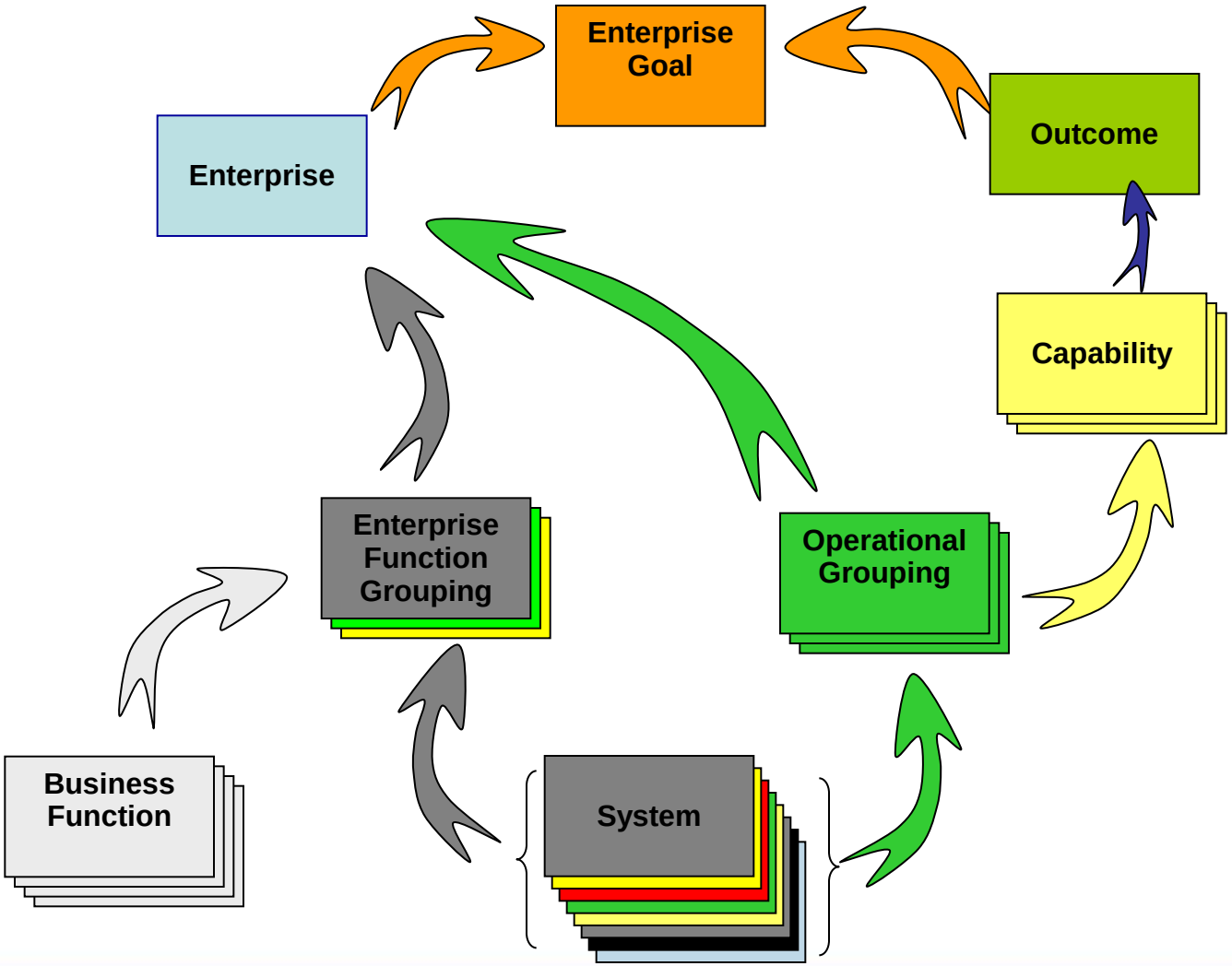
Rationale for BAE Systems' Approach

- Progression towards outcome based contracting
  - Customer need to develop in terms of capabilities
  - Some customers expecting capability but not explicitly contracting for it
  - Internal initiatives to explore non-traditional product areas (e.g. services, support)
  - Underlying affordability an inherent driver in all of these perspectives
- Other Influences
  - Increasing Customer awareness of the benefits of wider integration
  - Emerging research and approaches for System of Systems Engineering
  - Opportunities in other lines of development (e.g. training, infrastructure)
  - Emergence of enterprise opportunities spanning multiple businesses

Gap in understanding and ability to address the problem space

BAE Systems Activity Model

Capability and Functional Groupings



Planning | Delivery | Generation and Operation | Disposal/Retirement

Capability

System of Systems

Systems

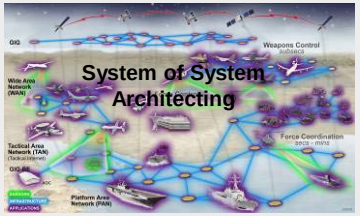
Component

Concept and Technology Development

Capability Determination & Planning

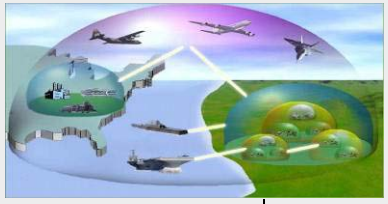
Capability Analysis

Operations



System of Systems Architecting & Analysis

Operational Package Integration & Deployment



Element Integration

System Architecting, Design, Build & Integration

Element Sustainment & Engineering

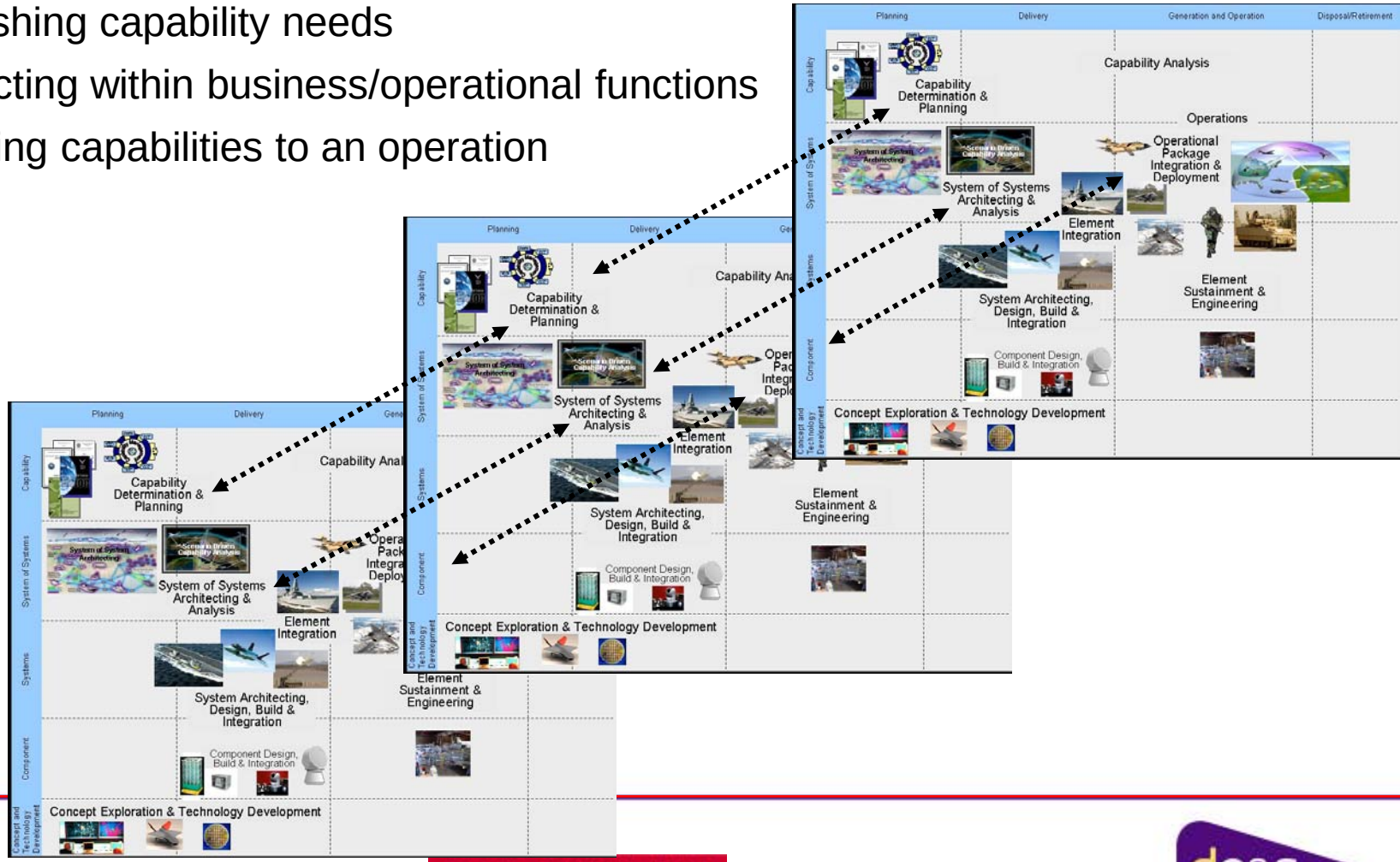
Component Design, Build & Integration

Concept Exploration & Technology Development

Managing a Range of Capabilities

Most enterprises need to co-ordinate across many capabilities, when, for instance:

- Establishing capability needs
- Architecting within business/operational functions
- Deploying capabilities to an operation



BAE SYSTEMS

Using the Model

The model is a framework within which the full set of activities needed to realise a given operational capability, and their interrelationships, can be derived and visualised. This allows:

- Identification of priorities for change
- Taking different perspectives, e.g. PESTLE*, to support trade-off decisions
- An holistic, Enterprise-wide view to ensure that activities are optimised to achieve the desired outcomes
- Suppliers to:
  - Identify business opportunities and risks
  - Establish appropriate contracting and partnering arrangements

(*PESTLE – Political, Economic, Social, Technological, Legal, Environmental)

Model Application

- Overall (Defence) Enterprise - inform understanding of operational capabilities needed at the Enterprise level
  - By either Government or Prime Contractor
  - UK MoD-specific model in development
- BAE Systems – develop (industrial) capabilities needed to make effective contributions to the Enterprise
  - Compare needs with current capabilities
  - Identify business changes
- Supply Chain – determine need for supporting capabilities

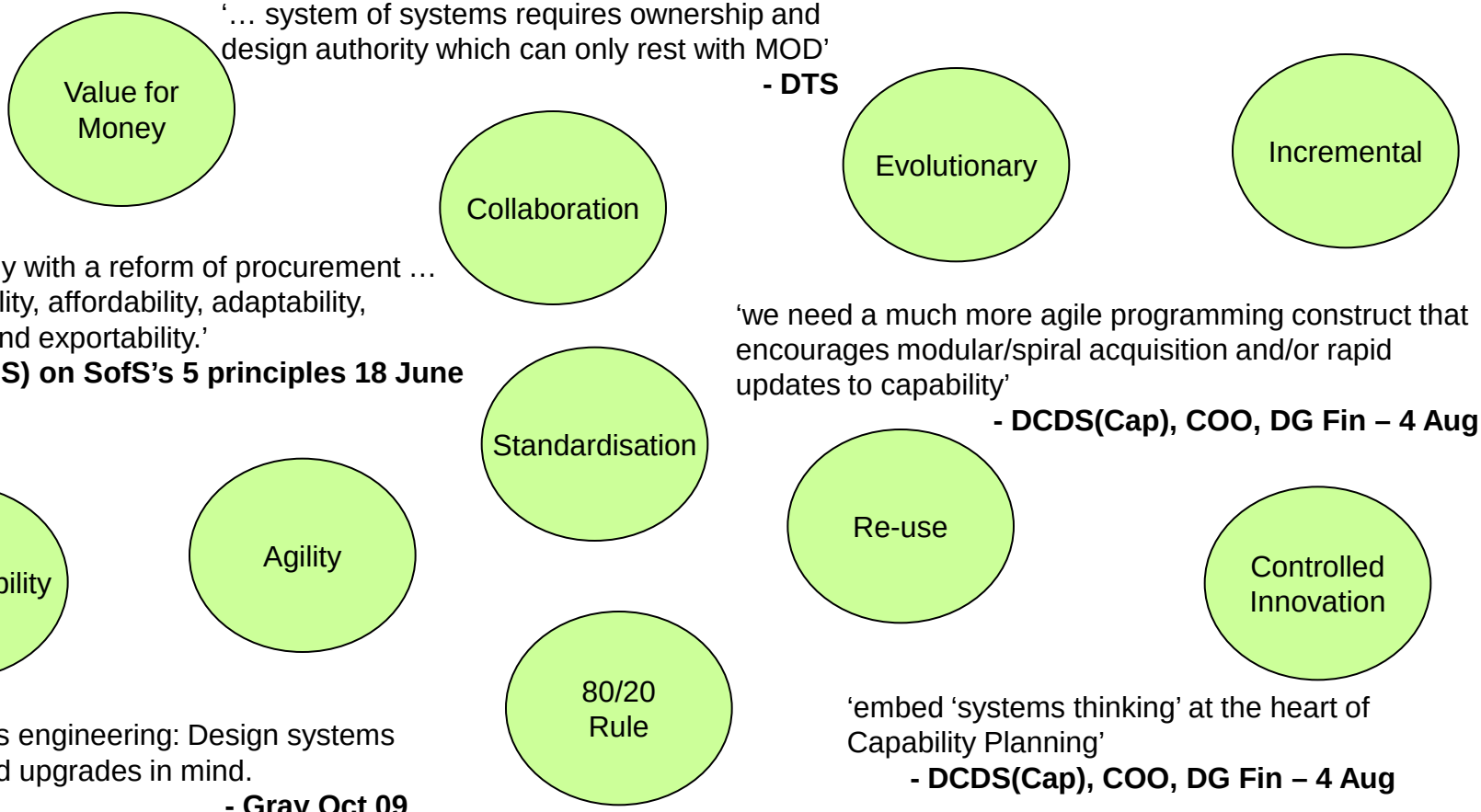
Activity Model Summary

- Provides critical insight into the complexities of capability integration
- Informs scheduling and management of risks
- Promotes understanding of :
  - All activities necessary to realise overall capability
  - How to shape activities and interactions to support overall purpose
  - Who is responsible for each activity/interaction
- Allows identification of:
  - What each organisation needs to do
  - What changes are needed
  - Who should collaborate with whom

The model underpins an enterprise approach in which all parties co-operate to achieve a common aim

MoD System of Systems Approach

MoD SOSA Drivers Key Themes



What are the Issues ?

To provide the right capabilities and support to the right people at the right time.

Front Line

MOD

- Systems incoherent
- Interoperability fixed late in life
- Too many get well packages
- Sub-optimal VFM
- Unable to deliver agile procurement opportunities
- Poor TLCM decisions
- Uninformed trades
- Non-agile & upgradeable solutions

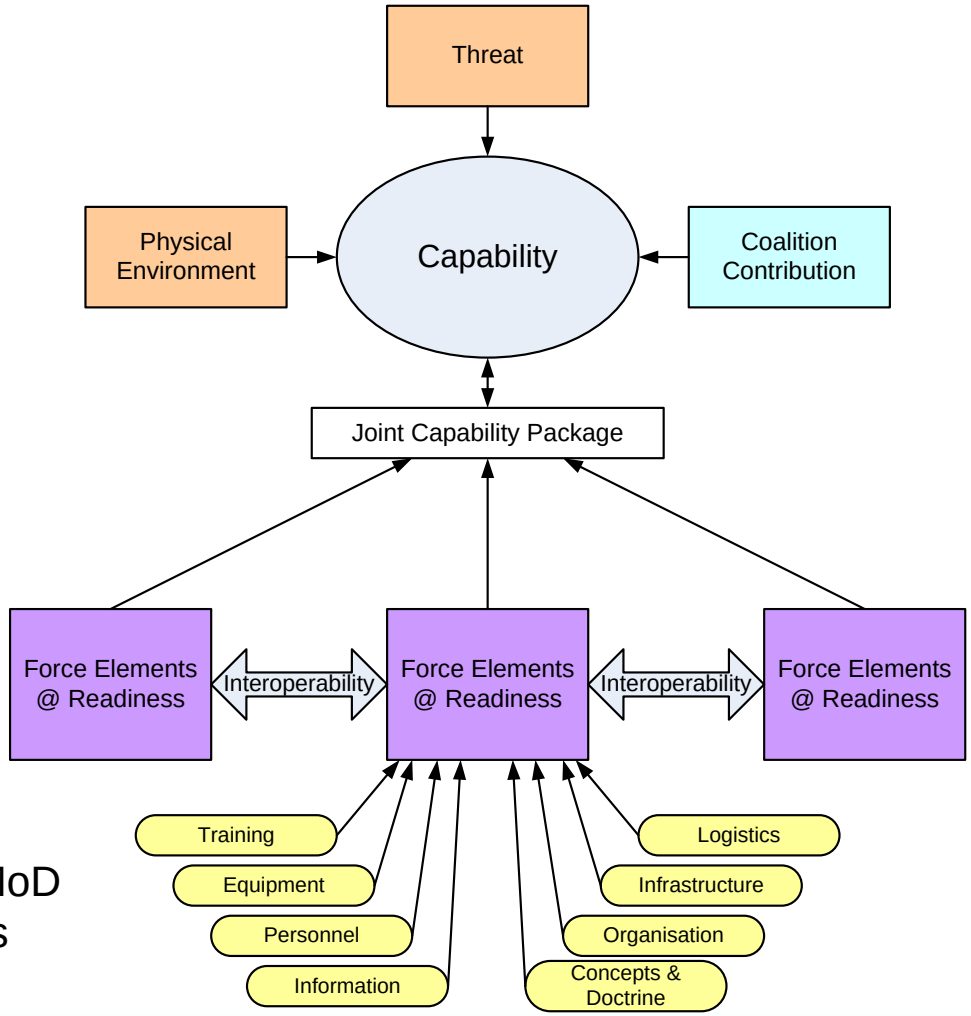
Industry

- Unclear requirement & success understanding
- Wasted effort
- Incoherent Strategies
- Mis-targetted Private Venture funding
- Missed innovation opportunities
- Offering Innovation Inappropriately
- Untimely Sharing of Information
- Missing Opportunities
- Limited Collaboration

Force Elements Contribution to Capability

MoD Aspiration

Equip … properly with a reform of procurement … based on capability, affordability, adaptability, interoperability and exportability



- Complexity challenge increasing
- SoS Technical & Business risk belongs to MoD
- Cost of late project requirements & changes
- Residual problems faced on front line

No single system delivers capability

Capability is delivered by interacting systems

The SOSA Vision

Current Situation

- Lack of common context
- Lack of common vision
- Culture of buying new
- Bespoke solutions
- Non-agile/upgradeable solutions
- Shortage of export opportunity
- 'Big-bang' acquisition
- Incoherent strategies & policy
- Equipment non-interoperable
- Solution diversity & duplication
- Red-card assurance

SOSA

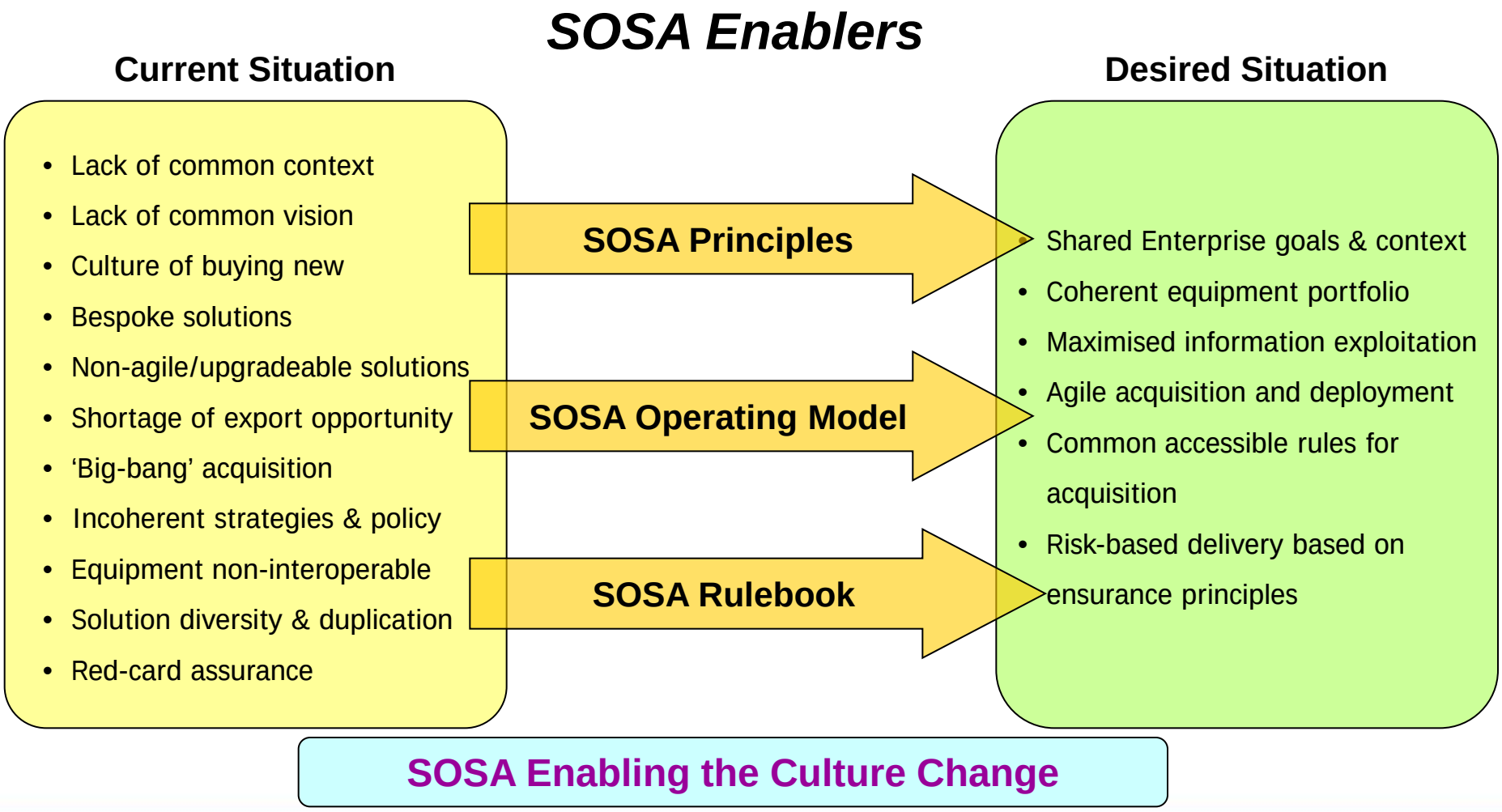
"Enabling enhanced capability through achieving commonality, reuse and the interoperability of independently procured systems"

Desired Situation

- Shared Enterprise goals & context
- Coherent equipment portfolio
- Maximised information exploitation
- Agile acquisition and deployment
- Common accessible rules for acquisition
- Risk-based delivery based on ensurance principles

SOSA brings structure and cohesion to strategy and policy

The SOSA Enablers

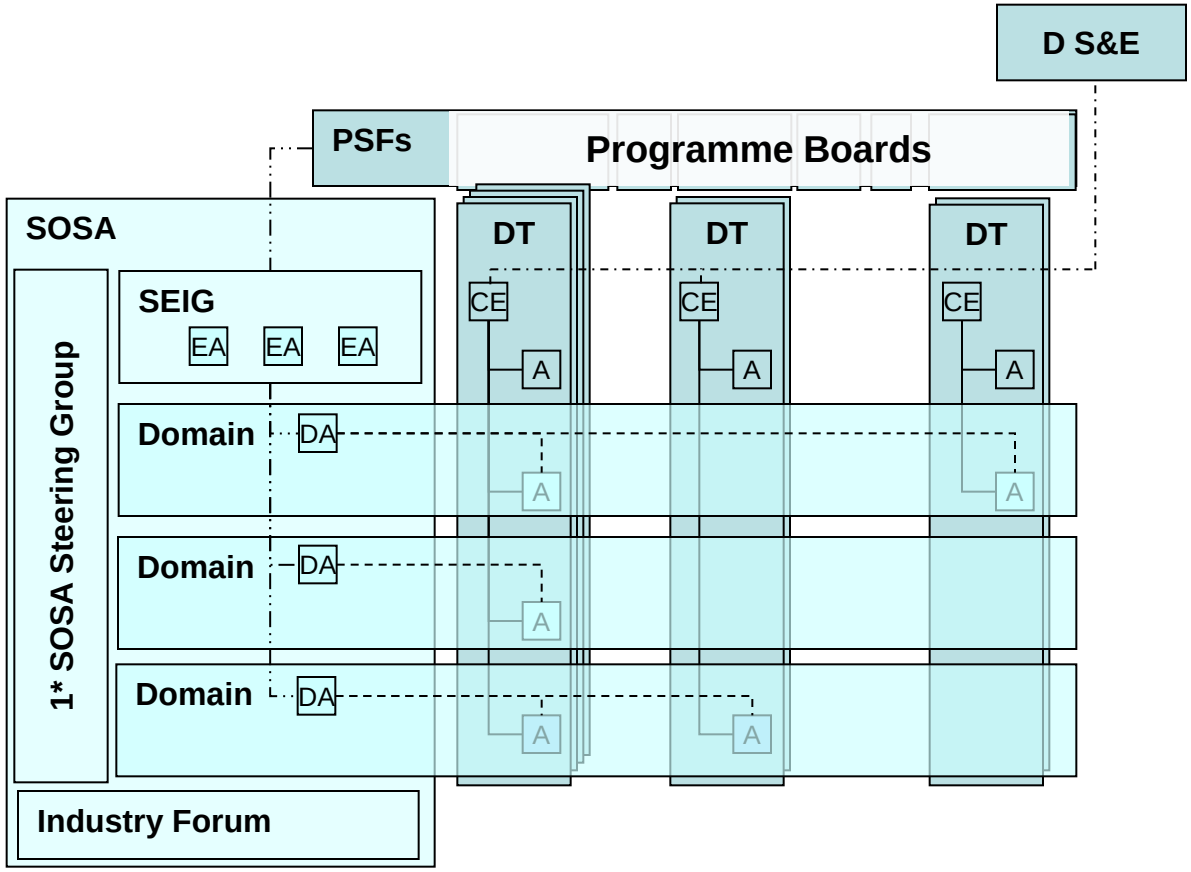


SOSA Principles – Design Principles for the Acquisition of Capability

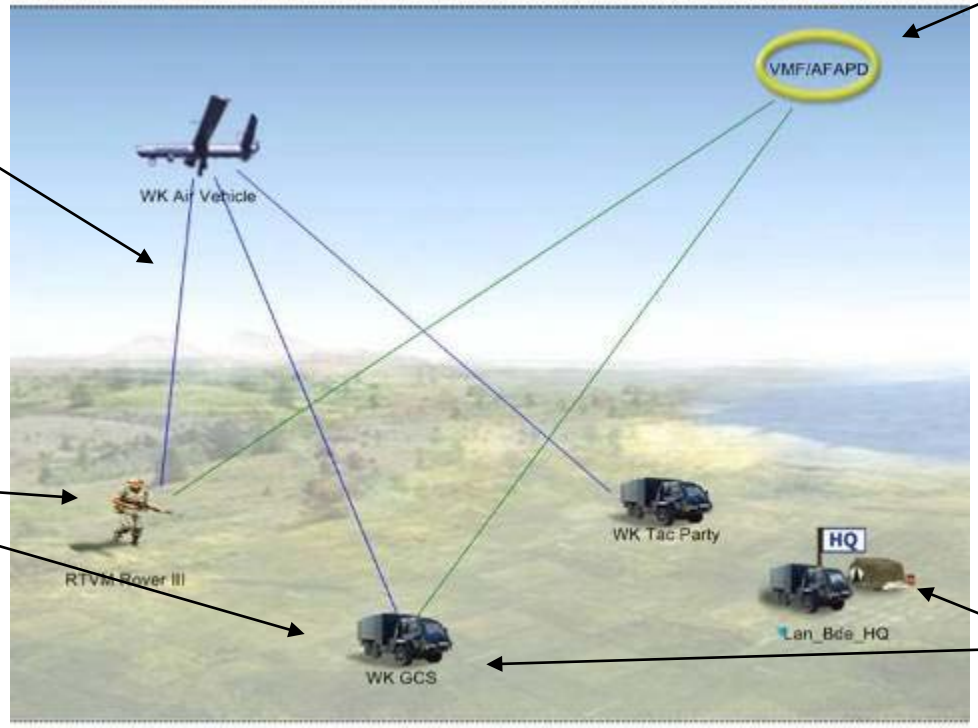
D i f R

- Designing for Flexible Interoperability
- Conforming to Open Standards
- Information as an asset

SOSA – SEIG, PSFs, Domains, Delivery Teams Working Together – SOSA Operating Model



Domains Example – UAV ISTAR System



TDL
-VMF

Spectrum

ISTAR
- Common GS

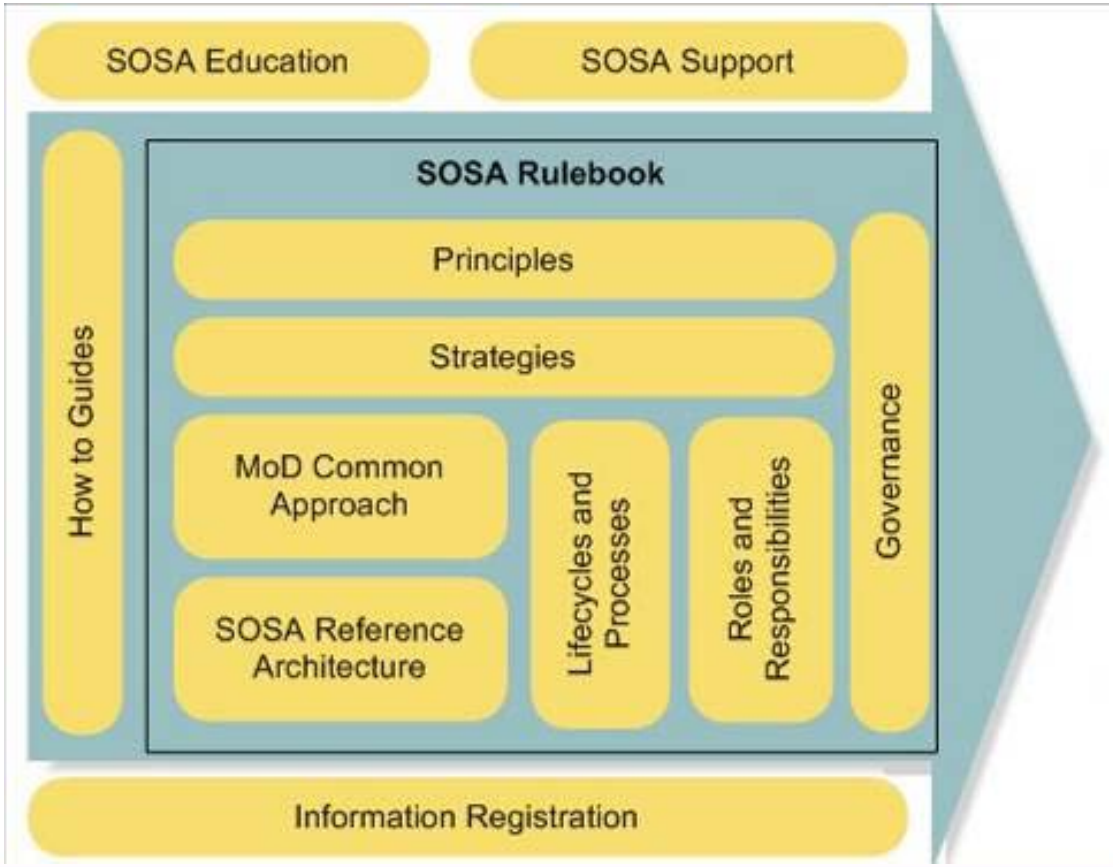
C4 / Network
- Bde HQ Comms
- DII in GS
- Apps Integration
- Network Joining

Overarching
- Info Assurance
- GeoSpatial
- SoS Safety
-Human Factors

Logs
-Comply with JSC & SSE

Rulebook Framework and Structure

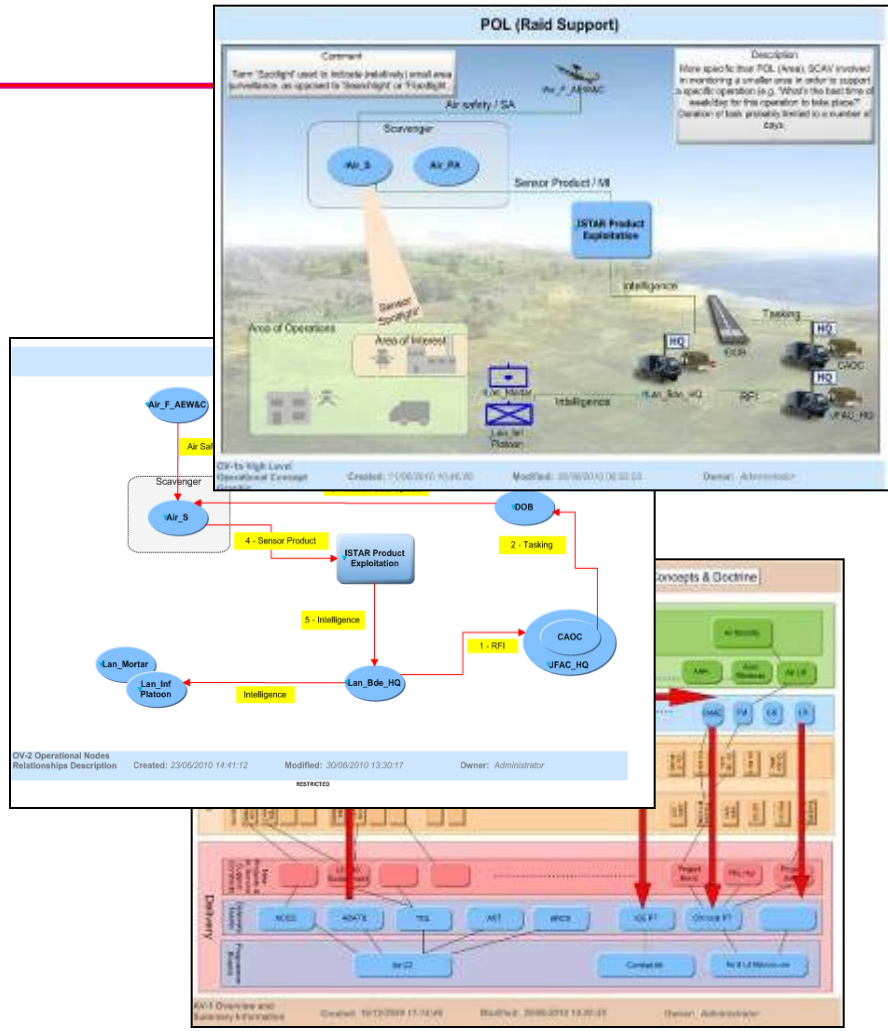
The Rulebook has been designed to capture and expose the relationships between the various SOSA components. E.g. SOSA Principles are developed into themes which are then linked to rules.



Examples of SoS Application

Scavenger Case Study

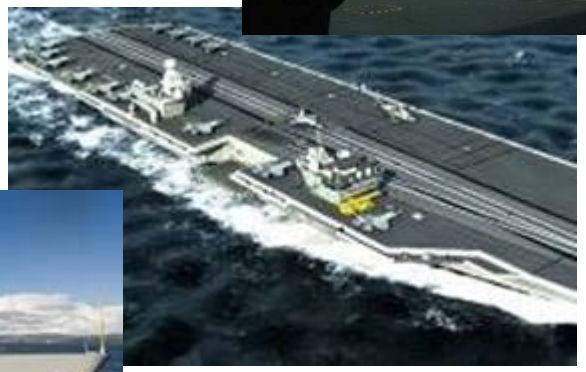
- Purpose
  - Support development of Scavenger context
  - Develop constraints and interoperability requirements
- Approach
  - Use CONEMP, DSG 08, HLOC, FASOC 2009 and Allied Joint Doctrine for Air and Space Operations (AJP 3.3A), and is consistent with the concepts espoused in the FMOC, FLOC and FEMOC
  - Synthesise
    - Coherent Context
      - Validate with stakeholders
    - Corner Case Mission Threads



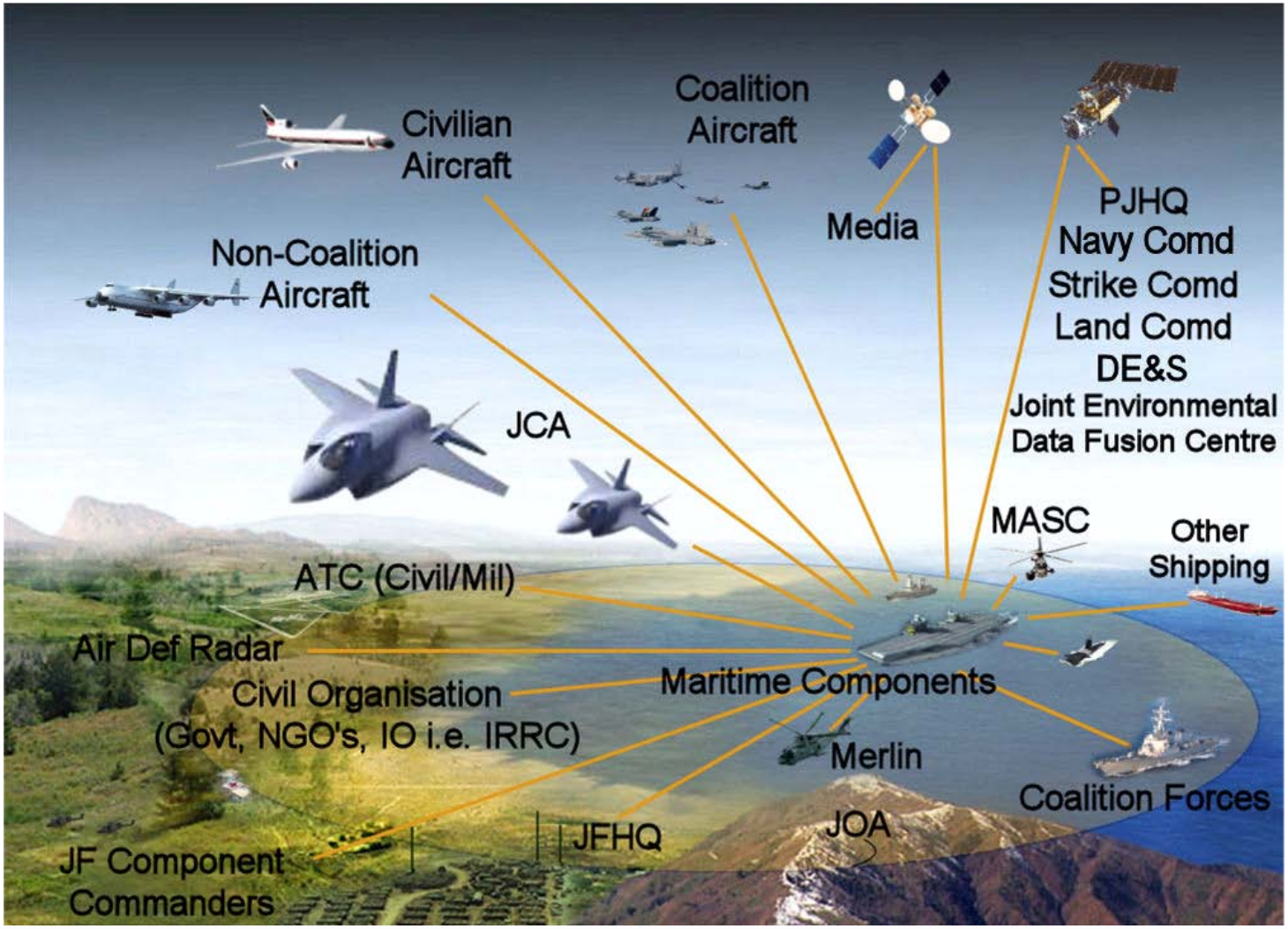
Benefit – Complete & coherent requirements specification developed from a through life perspective enabling SoS integration during delivery not operations

Application to Carrier Strike

- Carrier Strike (CS) Capability entails operating JSF from either a forward base or the Queen Elizabeth Class Aircraft Carrier(s)
- Elements include:
  - Aircraft Carrier
  - Joint Tailored Air Group, comprising fixed and rotary wing aircraft
  - Escort and support vessels
  - Embarked Headquarters
- In-service date now 2020



Carrier Strike Context



Systems of Systems Relevant to CS

- Co-operating military platforms
  - Ships
  - Aircraft
  - Support vessels
- The QE Class as a complete operational entity
  - Platform
  - Fully trained Crew
  - Operational procedures
  - Infrastructure
- Sets of systems within a DLoD
  - C2
  - Communications
  - ISTAR
  - Logistics
- Specific mission threads
  - Sortie generation
  - Self defence

Planning | Delivery | Generation and Operation | Disposal/Retirement

Capability

System of Systems

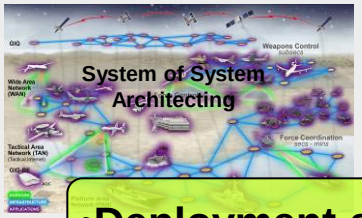
Systems

Component

Concept and Technology Development

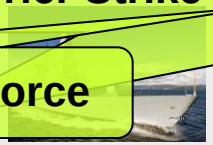
Capability Determination & Planning

- **Owned by CS SRO**
- **C2 informed by experiments and trials**
- **Information issues from MoD Pathfinder**

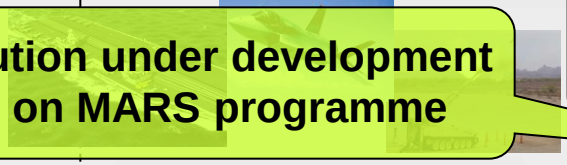


- **Interoperability captured in Mission System architecture**
- **JSF use of MoDAF to address NR KPP**
- **Pathfinder study highlighted mismatches in CIS**
- **Carrier Strike Architecture now being developed**

- **Deployment as a Carrier Task Force**



Element Integration

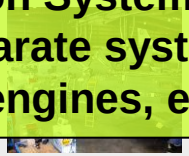


- **Support solution under development**
- **Dependence on MARS programme**

- **Ship architecture defined by GA**
- **Mission System described using MoDAF**
- **Ships and aircraft now being built**

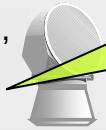
System Architecting, Design, Build & Integration

Element Sustainment & Engineering



- **Mission System comprising some 60 separate system procurements**
- **Main engines, etc.**

Component Design, Build & Integration



Concept Exploration & Technology Development

- **Concept exploration through experiments and trials**
- **Technology - flight deck comms, electromagnetic catapults**

Conclusions from Carrier Strike Example

- Offers an holistic view of the overall development programme
- Highlights gaps in current activities
- Further analysis should inform action plan
- Understanding key entities is crucial

Benefits and Challenges

What Good Looks Like (to BAE Systems)

- SoS Engineering embedded as normal business across the Defence Enterprise
- At Corporate level
  - Processes
  - L&D
  - Non-engineering functions
  - Organisation
- At Business Unit level
  - Reflected in Business Unit plans
  - Culture adjusted
  - Customers bought in

What Good Looks Like (to MoD)

- Ensuring that system coherence and interoperability are ‘designed-in’
  - Reduction in get well packages
  - Increased VFM
  - Greater capability for front line
- Better TLCM decisions
  - Informed trades
  - Common understanding of planning and delivery interdependencies
- Delivery of agile procurement opportunities
  - JCB Roles & Responsibilities calls up application of SOSA principles
- Better Communication
  - Common Language
  - Requirements
  - Main Building to DE&S to Industry
- Reuse
  - Knowledge
  - Expertise
  - Best Practice
- Ability to understand cross boundary issues and responsibilities
- Better targeting of R&D and Private Venture activities
  - Common ‘aiming point’
  - MoD & Industry

Summary

- Activity model provides critical insight into the complexities of capability integration
  - BAE Systems' model now fairly mature
  - MoD version under development
  - Information/entity structures still need clearer definition
- Informing UK MoD SoSA implementation
- Underpinning BAE Systems' alignment with significant emerging business opportunities
- Exemplified by Scavenger and Carrier Strike case studies

Challenges for the Defence Community

- Cultural / Behavioural Change
  - Collaborative Model
    - Domains empowered
  - Project goals subordinated to Enterprise goals
    - Performance incentivised accordingly
- Enterprise Level Products and Processes
  - Artefact sets required as Body of Knowledge
  - Enterprise processes not mature
- Education
  - SOSA Awareness
    - Staff churn
  - Educating SE and SOSE

Questions