SYSTEMS ENGINEERING RESEARCH CENTER

CISA
Center for Integrated Systems in Aerospace

Investigating Approaches to Achieve Modularity Benefits in the Acquisition Ecosystem

Sponsor: DASD(SE)

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Background

- Current DoD acquisition challenges
  - —to affordably address emerging threats
  - —component obsolescence
  - —loss of critical suppliers, and planned technology upgrade for tightly coupled, highly integrated systems
- DoD acquisitions strategy : Better Buying Power 3.0 (BBP 3.0)
  - — Implement best practices to improve productivity, affordability, capabilities, reduce unproductive states across DoD acquisitions
  - —Includes encouraged use of modularization strategies to achieve desired end benefits
  - — Strategy: Modular Open Systems Approach (MOSA)

MOSA Initiative

- ODASD/SE Modular Systems Approach (MOSA)
  - Open System Architecture (OSA)
    - Business side of acquisition process - data rights, IP, legal matters
    - Most MOSA work currently under auspices of OSA efforts – need to extend to technical as well
    - Requirement under law on including MOSA in acquisition language
  - Modularity (in DoD)
    - Viewed as technical approach in defense acquisitions
    - Complex system decomposition: physical and functional architecture
    - Largely separated from OSA tenets that are more business oriented
    - Modular open systems leverages business driven benefits of adopting Open Architecture standards for development

MOSA Goals

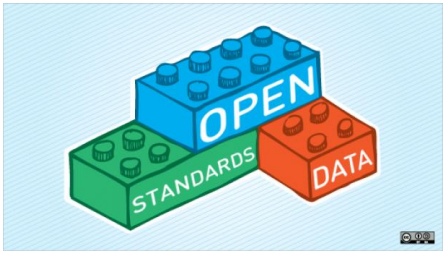
- **Cost savings/cost avoidance**
  - —Savings via reduced burden on acquisition processes,
- **Allow technology refresh**
  - —Rapid updates of modules individually easier than addressing total monolithic complex system
- **Interoperability of systems/components**
  - —Open standards use ensures compliance in interoperability
- **Increase competition between suppliers**
  - — Leverage open standards and modularity to engage more business units for development (e.g. SBIRs etc)
- **Incorporate innovation**
  - — Innovation can be more readily focused at localized modular level

MOSA Guidelines

- **Establish an enabling environment**
  - PM to generate business practices, technology development, test and evaluate, etc. needed for development of open systems

- **Employ modular design**
  - Four main characteristics: cohesive, encapsulated, self-contained, highly binned

- **Designate Key Interfaces**
  - Module interfaces defined to enable designers and configuration managers



- **Use Open Standards**
  - Utilization of community accepted standards that are well defined/matured

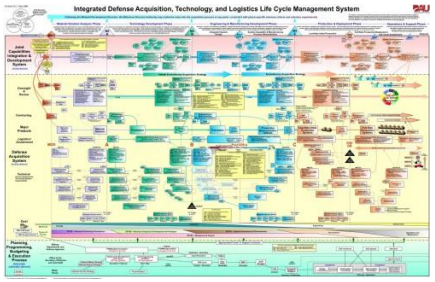
- **Certify Conformance**
  - Use rigorous assessment mechanisms, interface control management and proactive conformance testing.

How to bring business and technical elements together in an ecosystem?

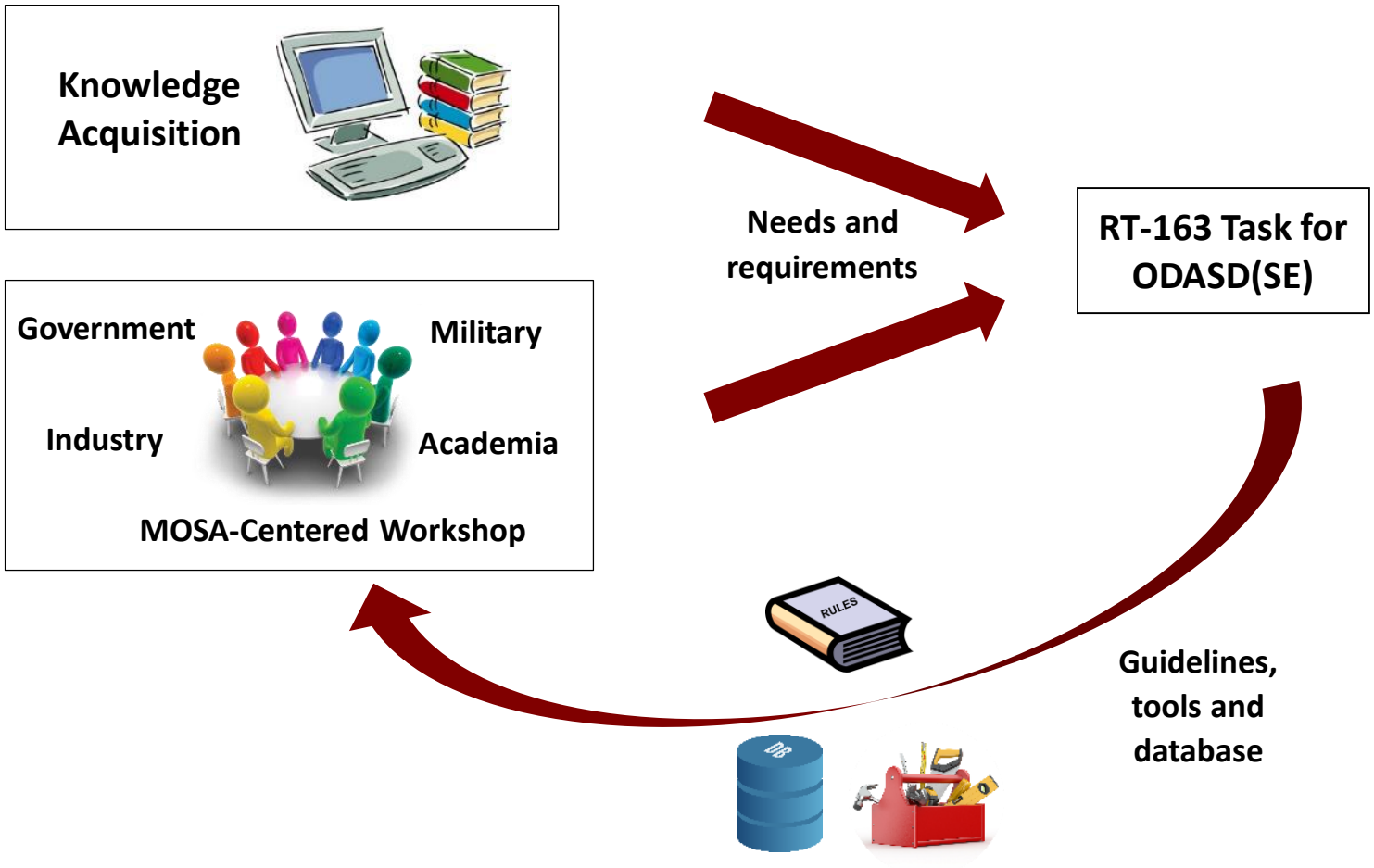
** http://www.acqnotes.com/acqnote/careerfields/modular-open-systems-approach

Research Needed [RT-163]

- Investigate development of systems to **exploit modularity** to enhance defense acquisitions and military capabilities.
- Explore **concept of an ecosystem** that facilitates adoption of modular solutions to achieve benefits (business + technical ends)
- Investigate how to **encourage modularity** to gain its benefits – conducive modular patterns, decompositions, methods, factors, catalysts etc.
- Provide **guidance and insights** to aids program managers in decision-making on modularization and achieving the intended benefits
- Work under RT-163 currently ongoing



RT-163 Research Approach



Modularity – An Intuitive Perspective

- **Definition:** *A general set of principles that help with managing complexity through breaking up a complex system into discrete pieces, which can then communicate with one another through standardized interfaces* [Langlois, 2002]

- **Types** of modularity [Baldwin 2006]
  - Modularity in Design
    - Product divided into modules independently with minimal interactions
  - Modularity in Production
    - Mass production driven that promotes flexibility and parallelism
    - Efficient innovations in production phases (e.g. vehicle production)
  - Modularity in Operations
    - Shared components for increased operational flexibility
    - Interchangeable components for different missions

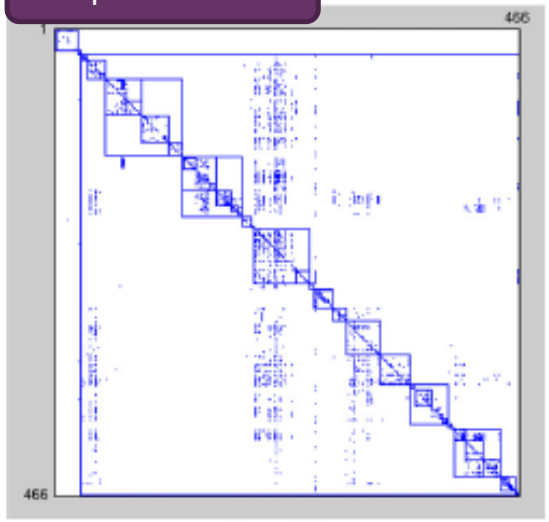
Modularity

- **Benefits of Modularity**
  - Managing complex systems by breaking down into smaller pieces
  - Facilitates rapid evolution through changes at module level
  - Enables parallelisms (operations, development)
  - Accommodate future uncertainties
- **Potential Drawbacks**
  - Duplicated subsystems at local levels
  - Limited innovation due to compartmentalization
  - Many choices of measure for modularity
  - Unseen impacts on complex system due to changes at module level

SECURITY ?

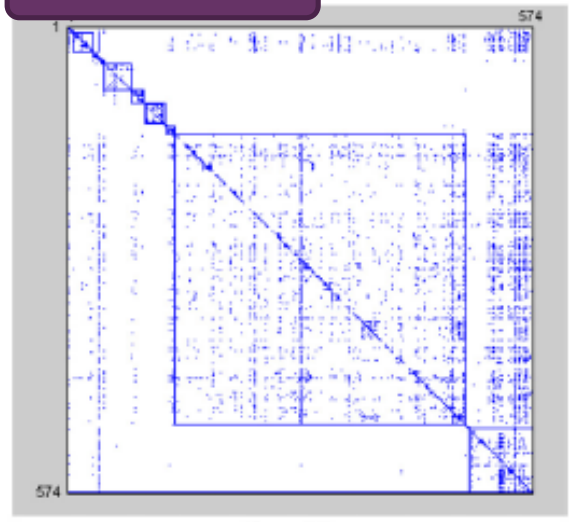
Case: Modularity and Organizational Structure

Open Source



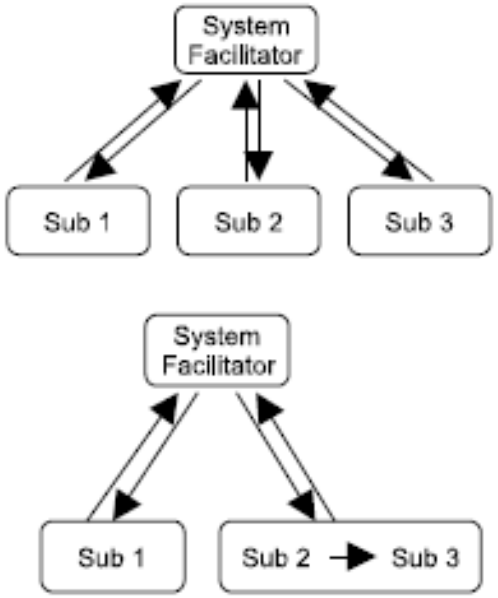
Size = 466
Dependency Density = 1.3672%
Propagation Cost = 7.7428%

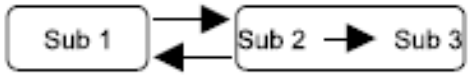
Commercial



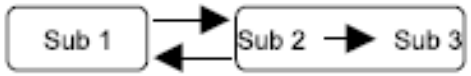
Size = 574
Dependency Density = 1.8903%
Propagation Cost = 47.1394%

- Prior work by McCormack et al on mirroring effect/Conway's Law (propagation costs, IP modularity)





- Honda work on information passing → impacts end design



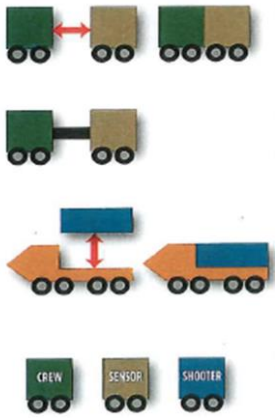
From McCormak et al., "Exploring the Duality between Product and Organizational Architectures: a Test of the Mirroring Hypothesis", 2012

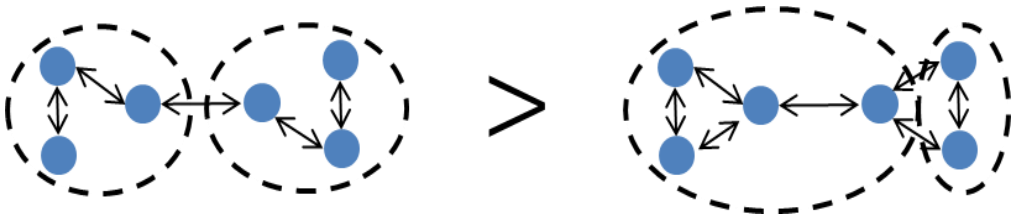
Case: Modularity and Supply Chain

- Daimler designs closely knit and carefully designed integrated components
- Chrysler design focus on modular designs
  - —Autonomous suppliers design, supply and innovate based on standards
- Merger of Daimler-Chrysler was overall deemed detrimental
  - —Mixing JIT supply chain with Daimler supply chain proved challenging and costly

Case: Modularity Measures

- How to choose a measure (metric) for modularity? How is one system more modular than another? Openness?
- TARDEC choice of vertical vs. horizontal modularity metric observed to drive effectiveness of approach
- Openness – Navy Open Architecture Assessment Tool (OAAT) to measure level of openness



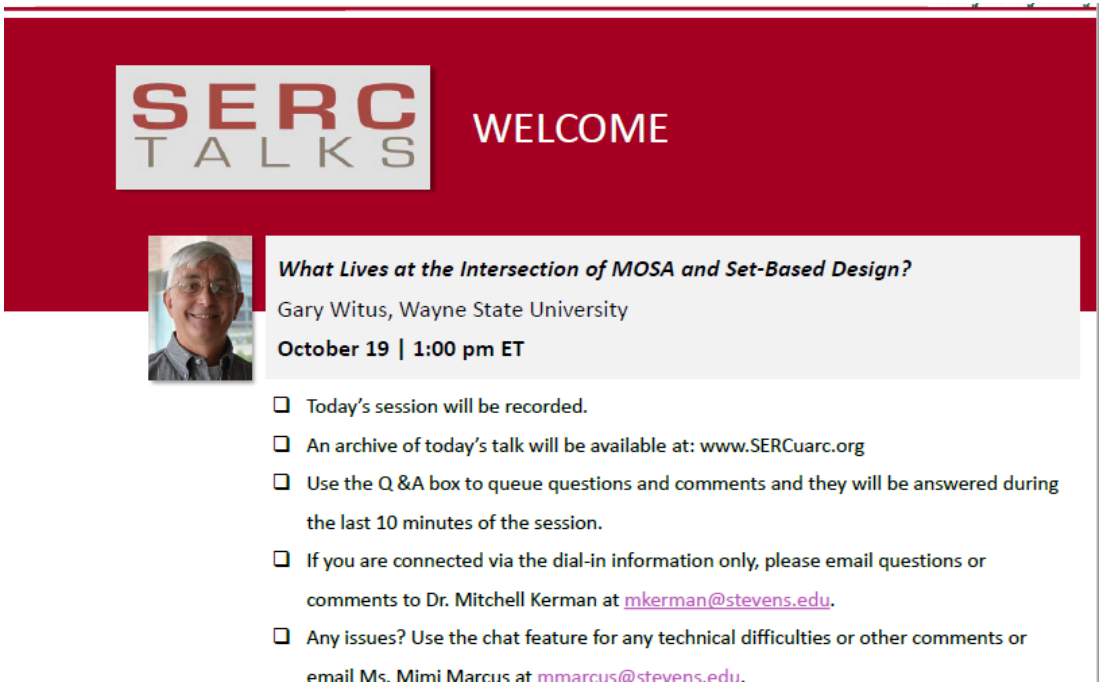


Dasch,J., Gorisch, D., "Survey of Modular Military Vehicles: Benefits and Burdens", Defense Acquisition Research Journal, January 2016, Vol 24 No1.:2-27

Special Note: SERC Talks

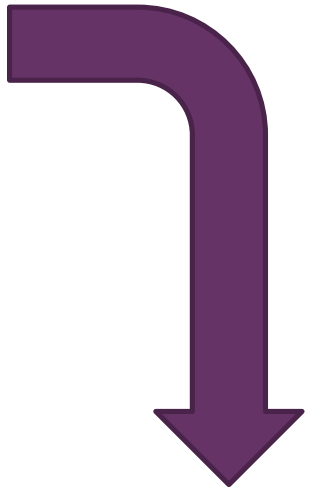
- Dr. Gary Witus - great insights on “Intersection of MOSA and Set-Based design”
- Highlights challenges and workflow considerations in MOSA strategies
- Includes TARDEC

  ATD case study



Modularization Challenges

Need Ecosystem concept…to avoid temptation think of modularization as more of a physical/functional decomposition with implicit business element (openness)



Daimler-Chrysler Case Study

- Operational Compatibility

McCormack Study &Conway's Law

- Organizational Compatibility

TARDEC Case study

- Choice of metric for modularization

Etc.

Need holistic view on MOTIVATION and IMPACT of strategies

MOSA Workshop

- MOSA workshop held in Washington DC [Government, Academia, Industry attendees]
  - 31 attendees [13 Gov, 6 Industry, 12 Academia]

- Purpose to focus on exploring key question/have in depth discussions on:
  - **Defining, quantifying** and **assessing** modularity
  - **Generating candidate strategies**, cognizant of current barriers
  - Synthesizing key list of **stakeholder needs**/concerns in MOSA ecosystem
  - **Mapping beneficial elements** of modularization strategies to appropriate acquisition processes
  - Generate **repository** of useful case studies/anecdotes

Some MOSA Workshop Outcomes

- Modularity should not be seen as an "output" but **as means to achieve end benefits**
- Need **"feedback measures"** to inform choices
- Care for multiple stakeholders and their needs
- To show "compliance", **evaluate** the degree to which programs show that their approaches are good **in terms of the of the estimated benefits**
- **"good modularity" is same as "good architecting"** – can be hard for complex systems development
- Encourage greater intentionality in adequate amount and style of modularity

Ecosystem Needs & Future Work

- **Establish the long-term business strategy, drivers and objectives for each stakeholder,** and their time horizons for MOSA-generated benefits
  - Keep into account competing interests
- Provide **tools to categorize and assess consequences** of modularization choices, under uncertainty
  - Holistic level tools (e.g. **MBSE**) to capture main viewpoints
  - Measure the consequences of available data, for example on the 5 benefits
- **Provide feedback mechanisms**, to help stakeholders understand the consequence of their actions and that of others
- **Develop a database of case studies,** based on best practices, tacit knowledge, anecdotes, that is well mapped to the acquisition process
- **Map case studies to appropriate parts of the overall acquisition lifecycle, in order to develop "principles" and guidelines with case studies tagged**

Thank you

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