SYSTEMS ENGINEERING RESEARCH CENTER

CISA
Center for Integrated Systems in Aerospace

Investigating Approaches to Achieve Modularity Benefits in the Acquisition Ecosystem

Sponsor: DASD(SE)

By

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9th Annual SERC Sponsor Research Review

November 8, 2017

FHI 360 CONFERENCE CENTER

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Motivation

- 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…via a Modular Open Systems Approach (MOSA)
  - CHALLENGE: program managers need strategies and tools to be successful in a MOSA ecosystem

MOSA Initiative

- ODASD/SE Modular OPEN 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 to include MOSA in acquisition language → current guidance on law and policy vs technical implications*
  - 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

Need to <u>connect desired program outcome</u> to a MOSA goal

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 system 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?

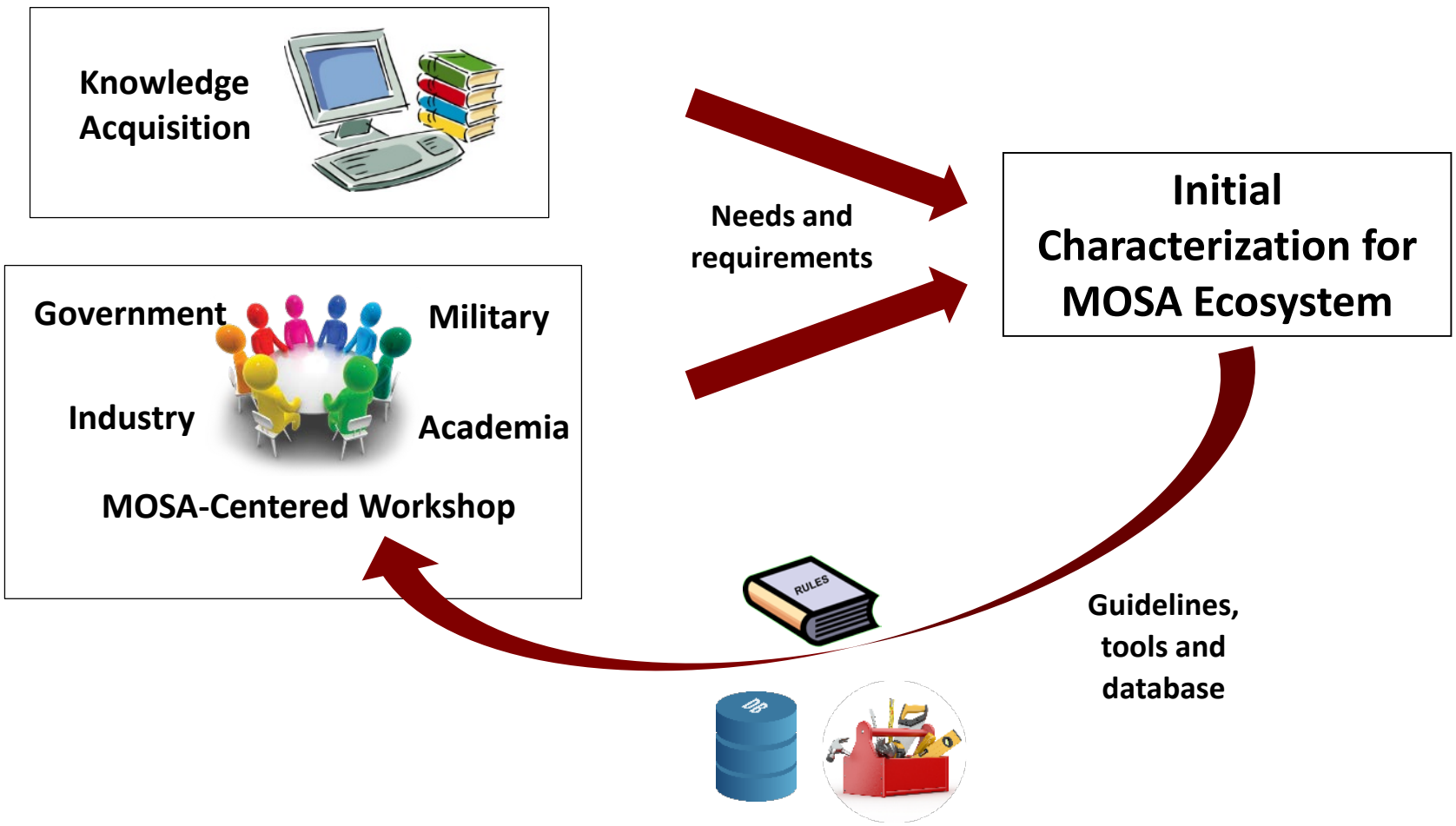
http://www.acqnotes.com/acqnote/careerfields/modular-open-systems-approach

Research Needed

MOSA Research Tasks with SERC have commenced: FY17 RT-163, FY 18 RT-185

- 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:
  - aid program managers in decision-making on modularization and achieving the intended benefits
  - Connect desired program outcomes to a MOSA goal

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

Benefits and Drawbacks

- **Benefits of Modularity**
  - Managing complex systems by breaking down into smaller pieces
  - Facilitates rapid evolution through changes at module level
  - Enables parallelisms (e.g. operations, development)
  - Accommodate future uncertainties

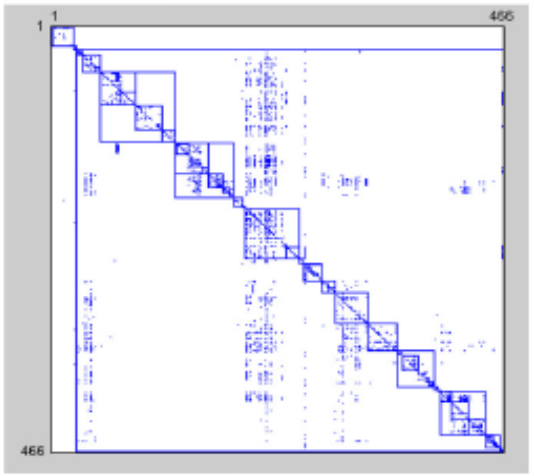
SECURITY ?

- **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

Case: Modularity and Organizational Structure

Open Source

Gnucash 1.8.4



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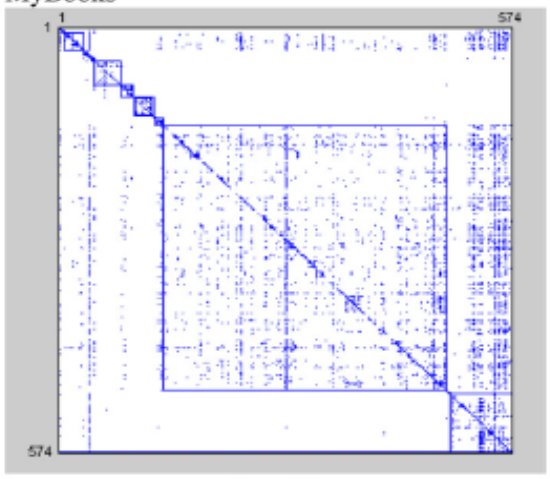
Dependency Density = 1.3672%
Propagation Cost = 7.7428%

Commercial

MyBooks



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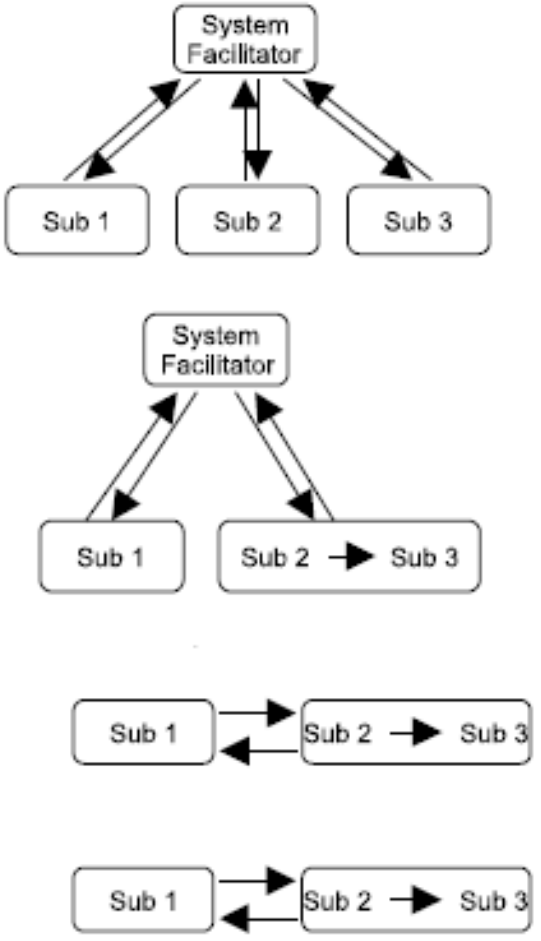


- Prior work by McCormack et al on mirroring effect/Conway's Law (propagation costs, IP modularity)
- Honda work on information passing → impacts end design

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

Case: Modularity and Supply Chain

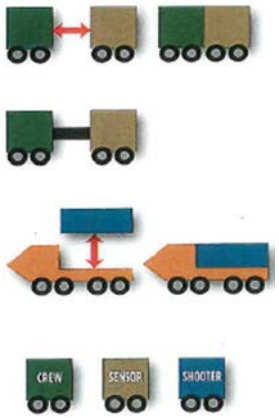
- Daimler designs closely knit and carefully designed integrated component

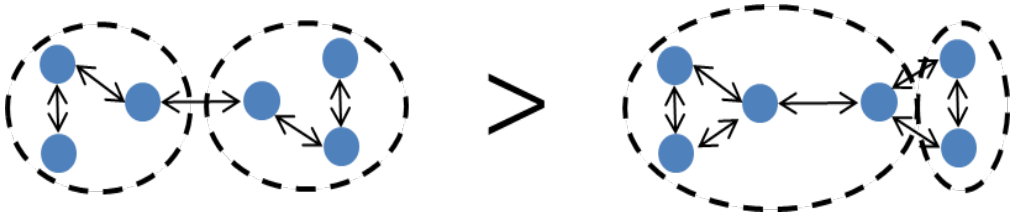
- Chrysler design focus on modular designs
  - Autonomous suppliers design, supply and innovate based on standards

- Merger of Daimler-Chrysler was overall deemed detrimental
  - Mixing JIT supply chain with Daimler supply chain proved challenging and costly

Case: Modularity Measures

- Choice of measure (metric) for modularity? How is one system more modular/open than another?
- 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
- Need to focus on metrics that inform attainment of MOSA benefits for program goals





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

MOSA Workshop

- MOSA workshop held in Washington DC [Government, Academia, Industry attendees] 5th October 2016
  - 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

RT-163 produced an Initial MOSA Guidance Document for PMs

- Guidance Categories
  - *What to Measure and Why*
  - *Useful Strategies Exist at Different Acquisition Lifecycle Phases*
  - *Caution! Emergent phenomenon in benefits and risks*
  - *Ouch! Technical and programmatic pain points*

- Preliminary 'living' document informed by prior research effort
  - Current refinement efforts:
    - Further exchanges with key collaborators and contributors from government, industry, academia
    - Directed knowledge acquisition and canvassing of case studies based on prior efforts

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 t
- **Provide feedback mechanisms**, to help stakeholders understand the consequence of their actions and that of others (e.g. decision support framework)
- **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**

Focus of current SERC RT-185 Effort

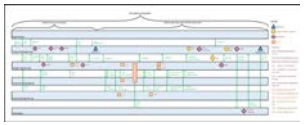
Concept Decision-Support Framework

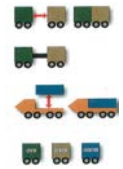
SME Knowledge Base

Literature/ Case Study Knowledge Base

Decision Support Framework

Impact on Acquisition Processes





Program Manager Queries

PM Decision Feedback

Acquisition Process relevant outputs

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Thank you

This material is based upon work supported, in whole or in part, by the U.S. Department of Defense through the Systems Engineering Research Center (SERC) under Contract HQ0034-13-D-0004-0063. SERC is a federally funded University Affiliated Research Center managed by Stevens Institute of Technology.

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