

## Research Task / Overview

### Fundamental questions

#### 1. Why are we interested in modularity?

- Benefits of modularity

#### 2. How to use modularity to achieve desired outcomes?

- How to relate outcomes to modular strategies?
- How much and what type of modularity is “good”?

#### 3. What approaches towards modularity?

- Modularity and open systems
- Principles to obtain “good modularity”
- Good practice and modular ecosystem

### Limitations of the *status quo*

- Standards not clearly defined
- Multiple stakeholders with conflicting priorities require better understanding of benefits and enablers of modularity
- Modular concepts applied only at a local level

## Current effort

The US Department of Defense (DoD) proposed the Modular Open Systems Approach (MOSA) initiative to balance business objectives, for example open systems, with technical means to meet the challenges of increasing complexity, component obsolescence, and planned technology insertion for tightly coupled systems

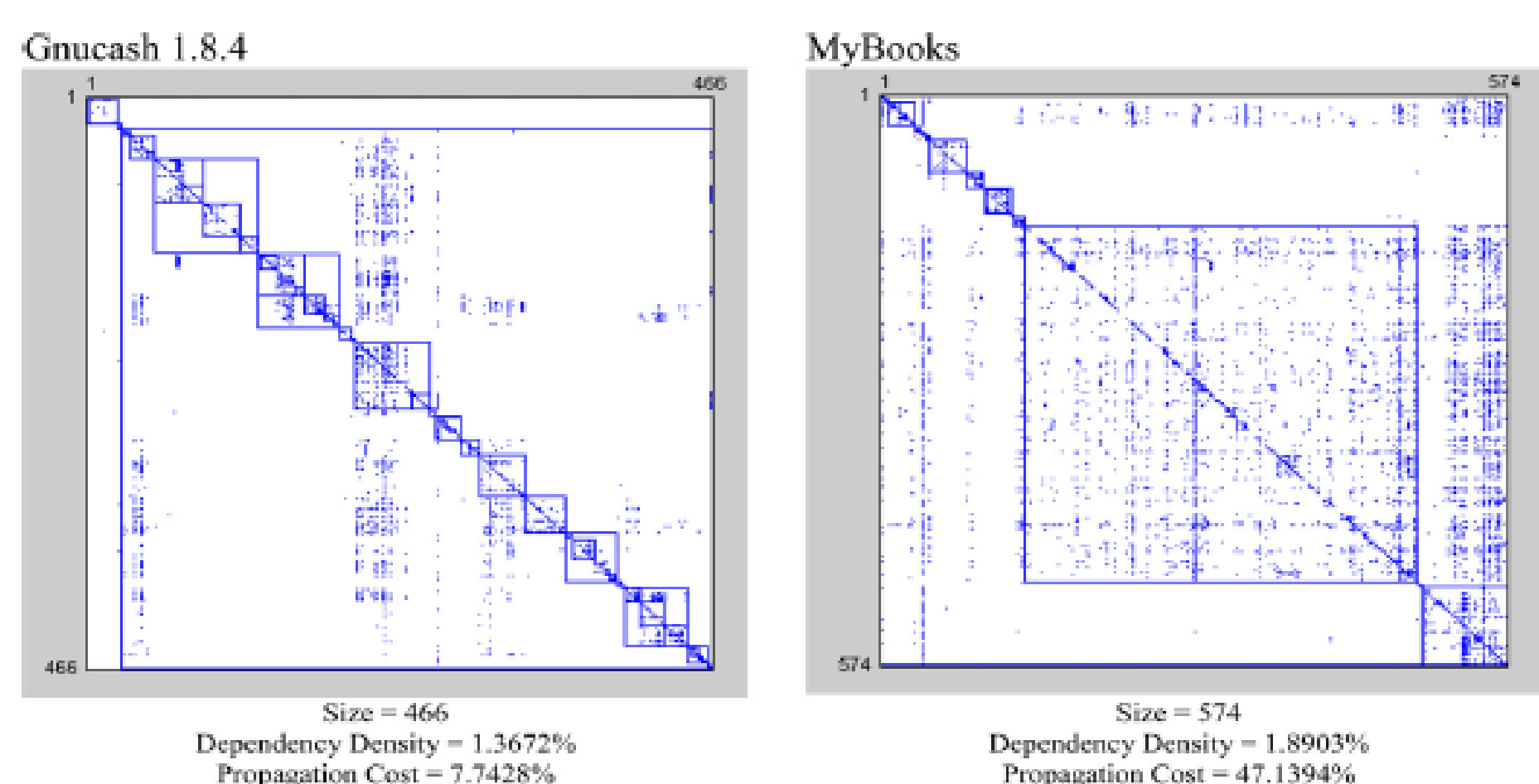
### Advantages of modularity

Examples from biology show some of the advantages of modularity:

- Facilitates rapid evolution in dynamically changing environment
- Favors hierarchical organization and specialization of modules

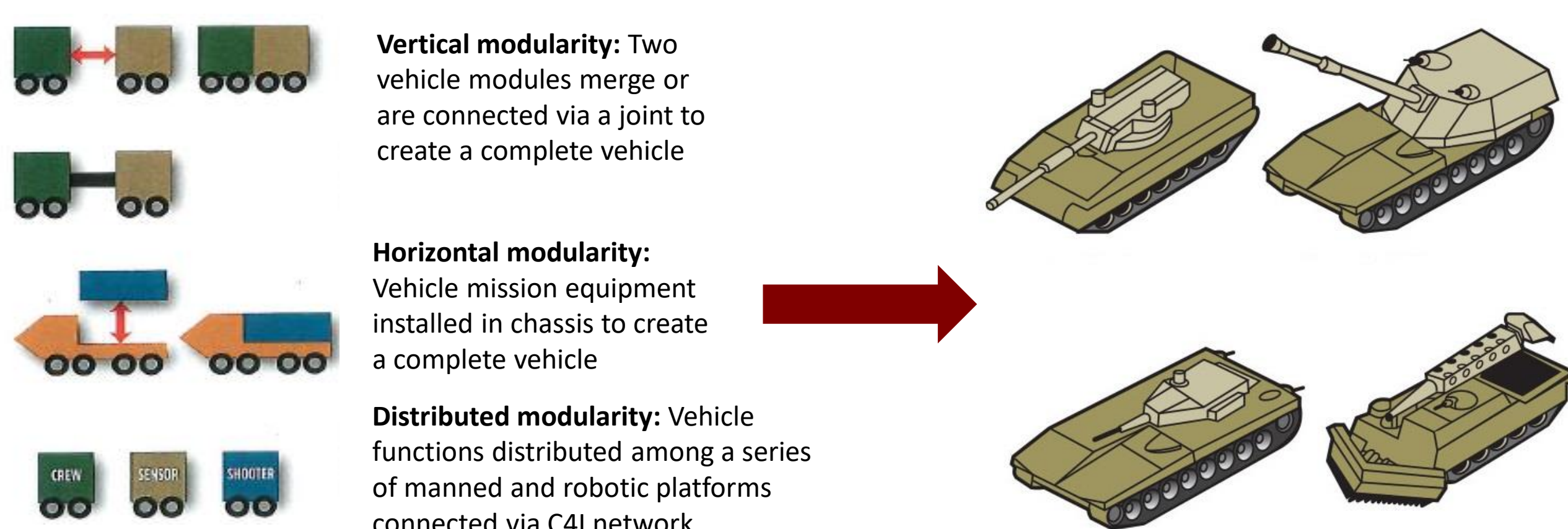
Examples in software development show an inverse correlation between modularity and propagation cost

- Modularity is facilitated by open systems (e.g. open source software)



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

Different types of modularity have been proposed and used in military application, to facilitate efficient reconstitution of subsystems to address different mission requirements



From Iler, “Modular Vehicle Concept Studies”, 2009, and GAO, “Armored Systems Modernization”, 1991

### Modular Open Systems Approach benefits

The US DoD identified five main benefits of MOSA:

1. Enhance competition
2. Facilitate technology refresh
3. Incorporate innovation
4. Enable cost savings/cost avoidance
5. Improve interoperability

## Considerations about modularity

- Modularity should not be seen as an output (hard to measure it), but as means to achieve functional architectures
  - Be sure to have “feedback” measures to inform choices
- MOSA is a means to the end we care about, which is the 5 benefits
  - 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
- Essentially, “good modularity” is same as good architecting
  - In this context the complex ecosystem in which doing good architecting (or good modularization) is harder
  - Encourage greater intentionality in adequate amount and style of modularity



A workshop on modularity gathered representative of industry, government, military, and academia to discuss experiences, considerations, and goals for modularity

## Goals, objectives and future research: requirements for a modular ecosystem

- 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 assess consequences of modularization choices, under uncertainty
  - Holistic level tools (e.g. MBSE)
  - Measure the consequences on 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
- Map case studies to appropriate parts of the overall acquisition lifecycle, in order to develop “principles” and guidelines with case studies tagged

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