A Systems Engineering Perspective on Innovation

Col Luke Cropsey

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Context: Engineering Within DoD

Systems Engineers creatively apply scientific principles across a broad portfolio of weapons, sensors, command and control, logistics, and business systems:

- To design, develop, construct and operate complex systems
- To forecast their behavior under specific operating conditions
- To deliver their intended function while addressing economic efficiency, environmental stewardship and safety of life and property

- *US Department of Defense is the World's Largest Engineering Organization*
- *Over 108,000 Uniformed and Civilian Engineers*
- *Over 39,000 in the Engineering (ENG) Acquisition Workforce*

Innovation Defined

[in-*uh*-**vey**-sh*uh* n]

Noun

1. Something new or different introduced
2. The act of innovating; introduction of new things or methods

Dictionary.reference.com

- The process of translating an idea or invention into a good or service that creates value or for which customers will pay.
- To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need.
- Innovation involves deliberate application of information imagination and initiative in deriving greater or different values from resources, and includes all processes by which new ideas are generated and converted into useful products.

BusinessDictionary.com

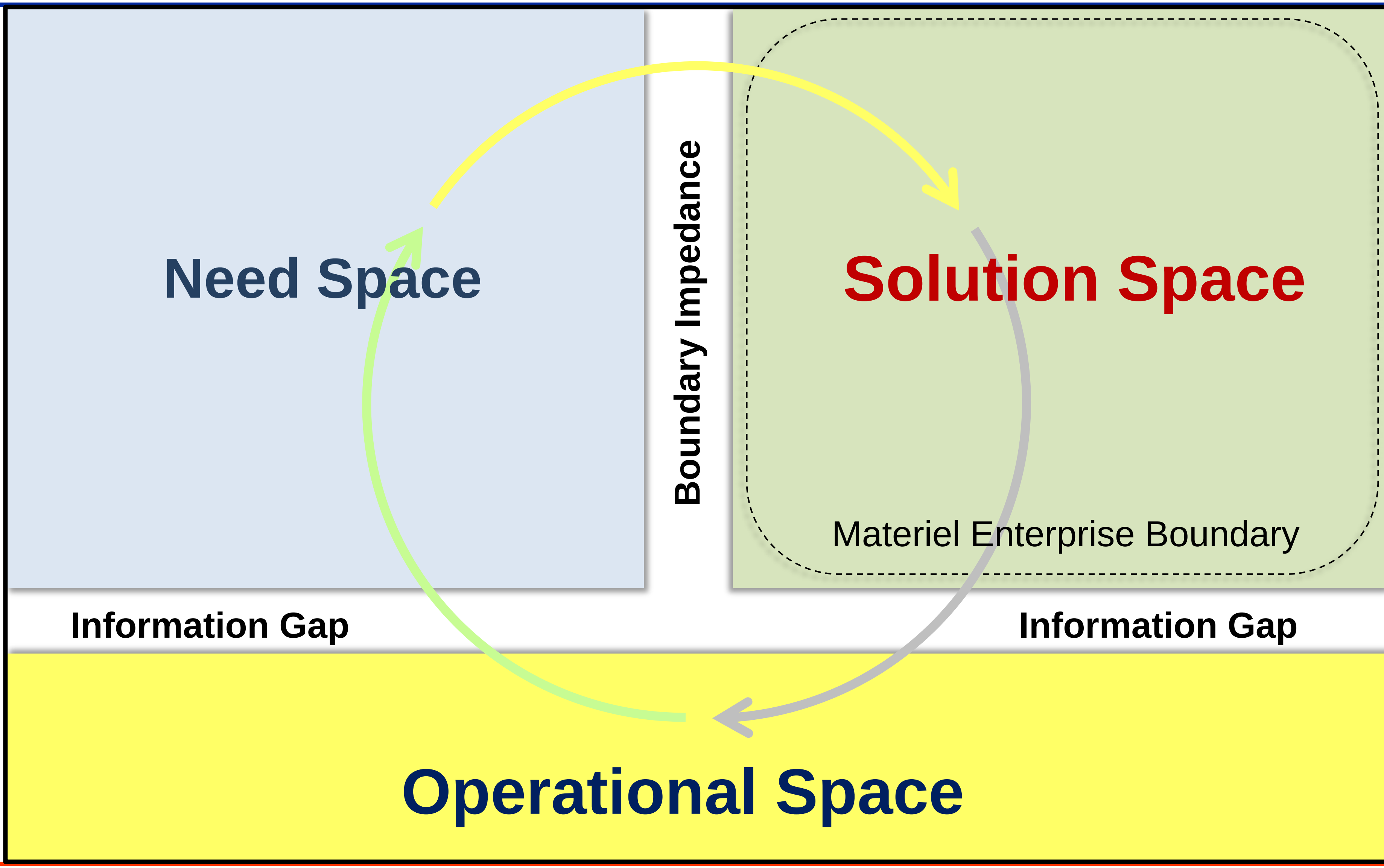
The ability to do something useful in a new and compelling way.

Setting the Conditions

- **The Cropsey Hypothesis**
  - Innovation is most likely to occur when dissimilar bodies of information come into contact with each other
  - That contact has to be of sufficient duration and intensity for knowledge to transfer from one body of information to another
  - Insight results when the new knowledge enables a change in perspective or mental models that was previously unseen or not obtainable
- **Challenges**
  - Information is "sticky[1]"
  - People naturally seek to reduce their local uncertainty[2]
  - "Not Invented Here" syndrome
  - Science is universal, Technology is local[3]

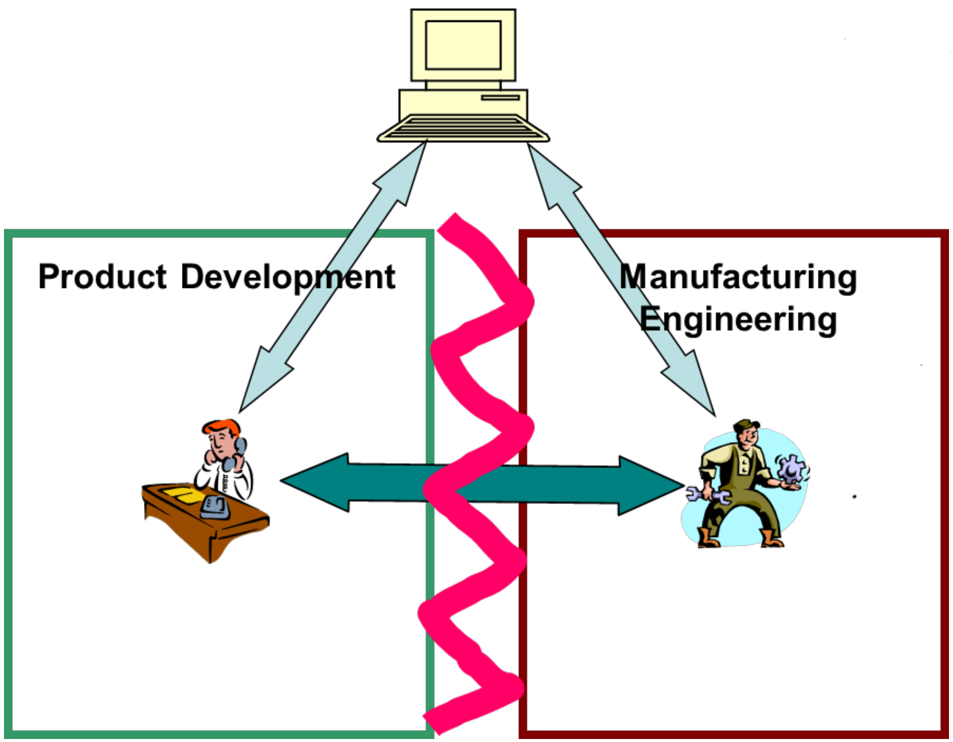
Source: von Hippel[1], Katz[2], and Allen[3]

A Simplified Model

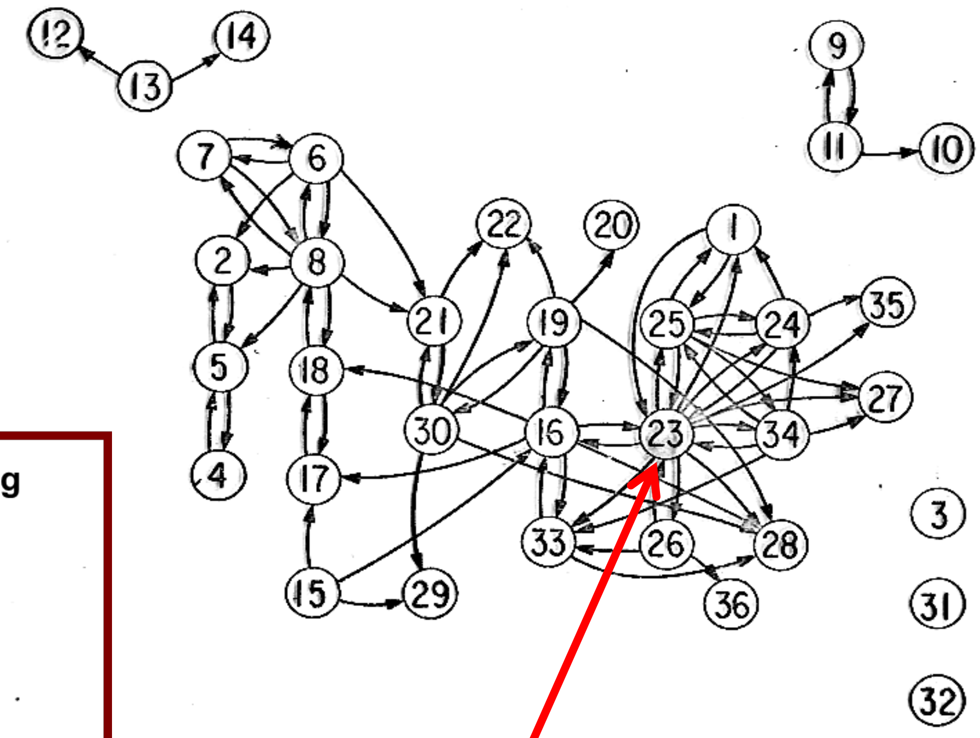


Bridging the Information Gap

Common Model to reduce communication ambiguity



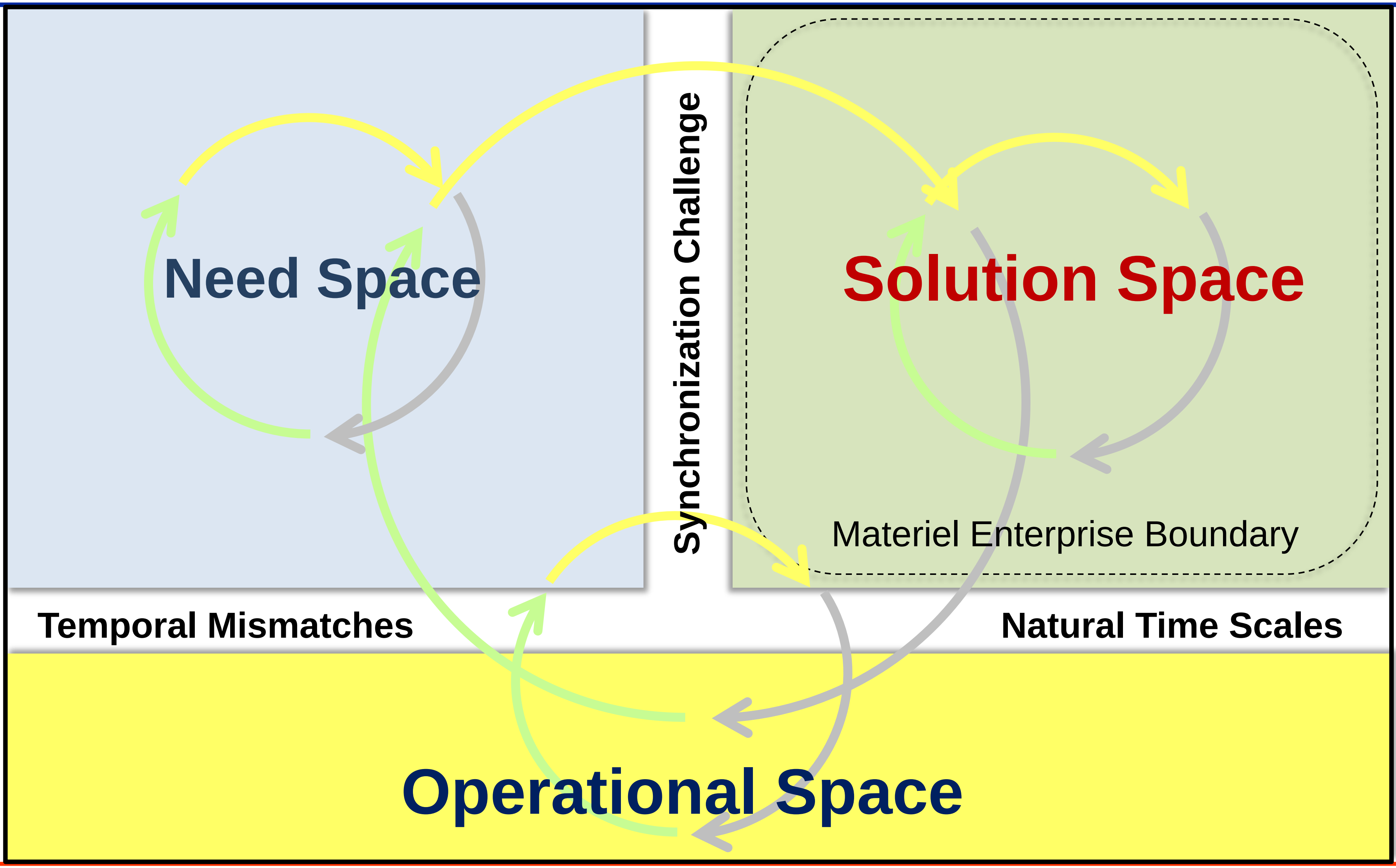
Interpersonal communication network in a small lab



Who is this person?

Source: Tom Allen[3]

Temporal Disharmonic

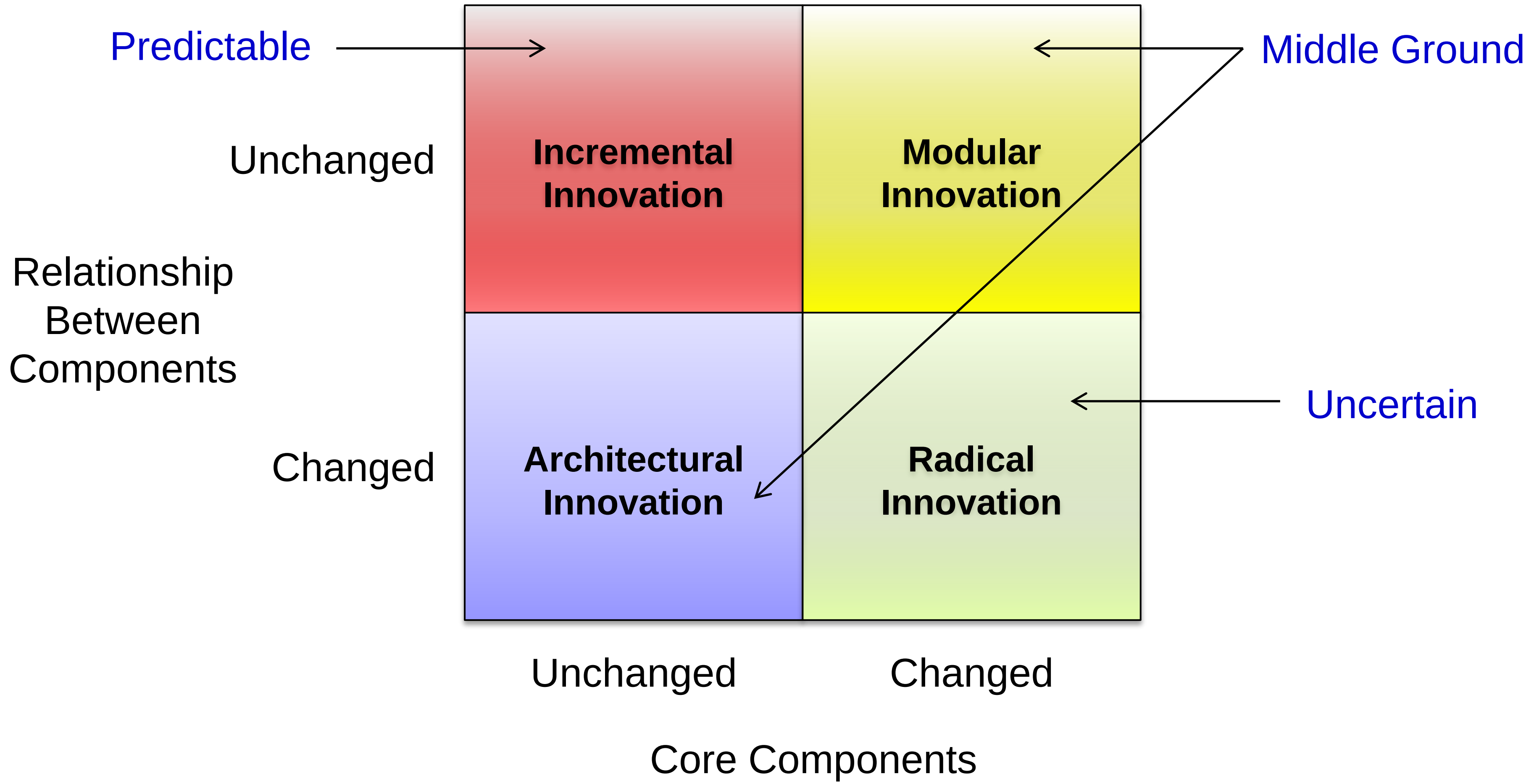


Types of Innovation

Relationship Between Components		Core Components: Unchanged	Core Components: Changed
	Unchanged	**Incremental Innovation**	**Modular Innovation**
	Changed	**Architectural Innovation**	**Radical Innovation**

Source: Henderson[4]

Matching Clock Speeds



Source: *Henderson*[4]

The Technology Life Cycle

	Early ferment	Dominant design emerges	Incremental innovation	Maturity	Eclipse or renewal
Demand Opportunity	Lead users, early adopters - high payoff, low switching costs	Early mainstream - usability, cost more important	Mainstream customers - soft factors, aesthetics	Saturation, segmentation, customization	Find ***new needs*** or ***new customers***
Business Ecosystem	Many entrants - diverse business models	Decisive battles for leadership	Intensifying competition, early consolidation	Fierce competition, consolidation around majors and minors	
Technological Infrastructure	Make it work - innovate on ***performance***, diverse integrative designs	Select optimal architecture, drive down ***costs***, focus on ***ease of use***	Provide broader offer, rationalize **portfolio**, build complementary ***assets***	Develop ***broad portfolio***, build ***platforms***	Search for ***new options***

Source: Davies[5]

Putting it All Together

- **Need to bridge the information gap, both internally and externally**
- **Need common models for knowledge transfer between "sticky information" communities**
- **Need system architectures that account for a wide variety of subsystem time scales**
- **Need a variety of innovation efforts focused at different points in the technology life cycle**
- **Need someone with the expertise to do better than random collisions to spark innovative solutions!**

SE Considerations

- **Model Based Systems Engineering**
- **Engineered Resilient Systems**
- **Open Systems Architecture**
- **Modular Architecture**
- **Tradespace Exploration**

What design considerations need to be embedded into the system architecture to enable innovation on a wider range of platforms and product life cycle stages?

Relevant BBP 3.0 Efforts

- Increase the use of prototyping and experimentation
- Emphasize technology insertion and refresh in program planning
- Use Modular Open Systems Architecture to stimulate innovation
- Reduce cycle times while ensuring sound investments
- Strengthen organic engineering capabilities
- Improve our leaders' ability to understand and mitigate technical risk

Systems Engineering: Critical to Defense Acquisition










Defense Innovation Marketplace

http://www.defenseinnovationmarketplace.mil

DASD, Systems Engineering

http://www.acq.osd.mil/se

For Additional Information

Col Luke C. Cropsey

Deputy for Systems Engineering Plans & Policy

ODASD, Systems Engineering

703-695-7848 | luke.c.cropsey.mil@mail.mil

References

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3. **Allen, Thomas J. (1984).** ***Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the R&D Organization*****. Cambridge, MA: MIT Press**
4. **Clark and Henderson (1990).** ***Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms.*** **Administrative Science Quarterly, 35: 9-30**
5. **Davies, Michael (2009).** ***Technology Strategy for System Design and Management.*** **MIT Course Number 15.965: MIT Open Courseware**