A Systems Engineering Perspective on Innovation

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18th Annual NDIA Systems Engineering Conference
Springfield, VA | October 27, 2015
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-shuh 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

Need Space

Solution Space

Boundary Impedance

Materiel Enterprise Boundary

Information Gap

Information Gap

Operational Space
Bridging the Information Gap

Common Model to reduce communication ambiguity

Interpersonal communication network in a small lab

Who is this person?

Source: Tom Allen

Product Development

Manufacturing Engineering
Temporal Disharmonic

Need Space

Temporal Mismatches

Operational Space

Solution Space

Natural Time Scales

Materiel Enterprise Boundary

Synchonization Challenge

Operational Space

Temporal Disharmonic

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Temporal Mismatches

Operational Space

Solution Space

Natural Time Scales

Materiel Enterprise Boundary

Synchonization Challenge
Types of Innovation

- Incremental Innovation: Unchanged
- Modular Innovation: Changed
- Architectural Innovation: Changed
- Radical Innovation: Unchanged

Source: Henderson

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Matching Clock Speeds

- Incremental Innovation
- Modular Innovation
- Architectural Innovation
- Radical Innovation

Unchanged
Changed

Predictable
Middle Ground
Uncertain

Relationship Between Components

Core Components

Source: Henderson⁴
# The Technology Life Cycle

<table>
<thead>
<tr>
<th>Demand Opportunity</th>
<th>Early ferment</th>
<th>Dominant design emerges</th>
<th>Incremental innovation</th>
<th>Maturity</th>
<th>Eclipse or renewal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead users, early adopters - high payoff, low switching costs</td>
<td>Early mainstream - usability, cost more important</td>
<td>Mainstream customers - soft factors, aesthetics</td>
<td>Saturation, segmentation, customization</td>
<td>Fierce competition, consolidation around majors and minors</td>
<td>Find new needs or new customers</td>
</tr>
</tbody>
</table>

| Business Ecosystem | | | | |
|---------------------| Many entrants - diverse business models | Decisive battles for leadership | Intensifying competition, early consolidation | | |

| 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*
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
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References


