The Drive for Innovation in Systems Engineering

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Defense Research & Engineering Strategy

Mitigate current and anticipated threat capabilities

Enable new or extended capabilities affordably in existing military systems

Create technology surprise through science and engineering

Focus on Technical Excellence

Deliver Technologically Superior Capabilities

Grow and Sustain our S&T and Engineering Capability

Evolving Capability

- **Up until World War II, almost all munitions missed the mark**
  - Massing of forces needed to achieve effects
- **Strategic government investments created an "offset" providing technological advantage**
  - Atomic weapons, precision guided munitions allow reliable targeting
  - Massing of forces no longer absolute necessity
- **Current innovations are driven by industry**
  - Broadly available technology creates a need for velocity

Systems Are Changing

From:

- Systems built to last
- Heuristic-based decisions
- Deeply integrated architectures
- Hierarchical development organizations
- Satisfying requirements

- Automated systems
- Static certification
- Standalone systems

To:

- Systems built to evolve
- Data-driven decisions
- Layered, modular architectures
- Ecosystems of partners, agile teams of teams
- Constant experimentation and innovation

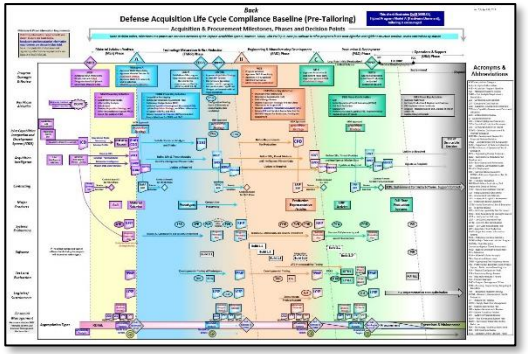
- Learning systems
- Dynamic, continuous certification
- Composable sets of mission focused systems

Systems Engineering Needs to Change

Credit: Derived from David Long, Former INCOSE President

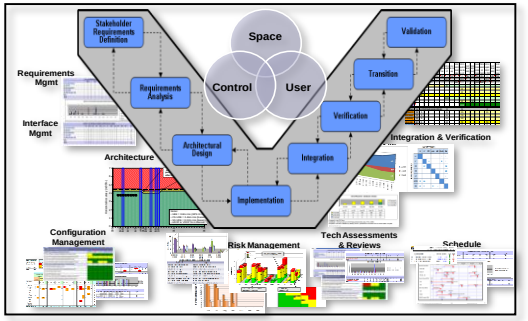
Industrial Age Acquisition and Engineering Processes

- **Taylor's scientific management**
  - Empirical methods to synthesize workflows to improve economic efficiency
  - Inspires industrial and systems engineering, business process management, lean six sigma, operations research



- **Optimizing engineering & production drives need for stable requirements, well-defined processes**

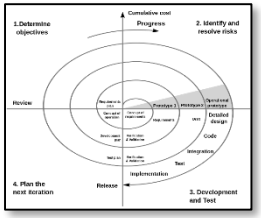
- **Optimizing methods to *change* engineering & production requires increasing the cycles of learning:**
  - To identify necessary changes
  - To incorporate those changes into systems



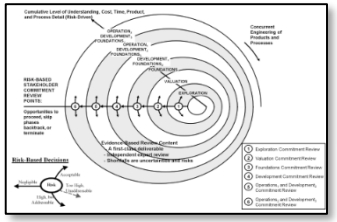
Initiatives to Accelerate Change

- **National Defense Authorization Act (NDAA) for Fiscal Year 2017 Acquisition Agility Act**
  - Modular Open Systems Approaches
  - New authorities for prototyping, experimentation & rapid fielding
  - Defining requirements likely to evolve due to evolving technology, threat or interoperability needs
- **Reorganization of USD(AT&L) – NDAA FY2017**
  - Creates separate organizations for acquisition and for innovative technologies
- **Middle Tier Acquisition Policy – NDAA FY2016**
  - Creates alternate acquisition path for rapid prototyping and fielding
- **Engineered Resilient Systems – 2011**
  - Research and development of deep tradespace analysis methods to address the nature of evolving missions and threats
- **Joint Urgent Operational Needs processes – 2004**

Methods for Managing Software-Intensive Acquisitions

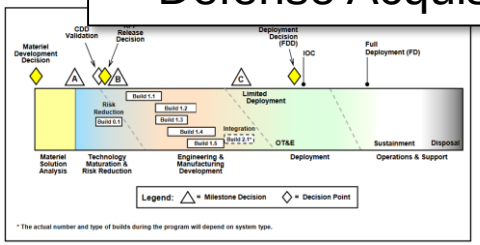


Spiral Development Model (Boehm 1986)

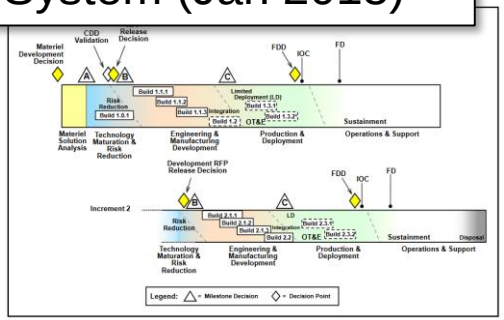


Incremental Commitment Model (Boehm 2007)

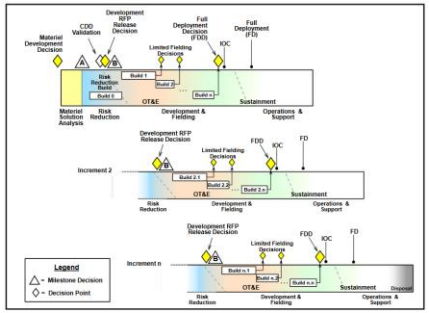
DoD Instruction 5000.02 – Operation of the Defense Acquisition System (Jan 2015)



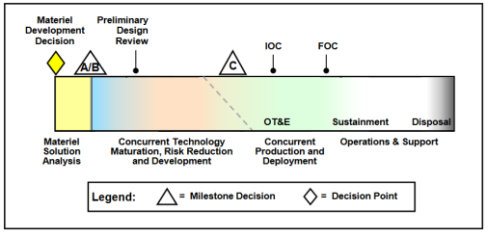
Software Intensive



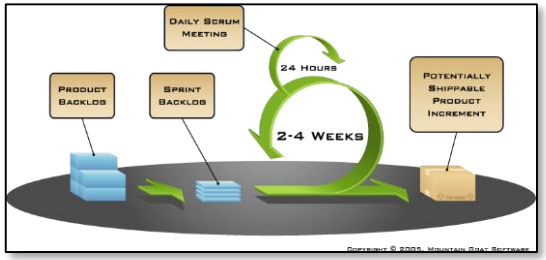
Hybrid – Software Dominant



Incrementally Deployed Software Intensive



Accelerated



Agile Development – 2001

Other Systems Engineering Perspectives

- **MIL-STD-499 Engineering Management**
  - Issued by Air Force in 1969 and 1974
    - Draft MIL-STD-499B never published in 1990's acquisition reform era
  - Not time-sequenced, like the V-model
  - Process seems to encourage trades in the "need-space" and the "solution-space"
  - Less focused on production
  - Less prescriptive – less useful in organizing activities

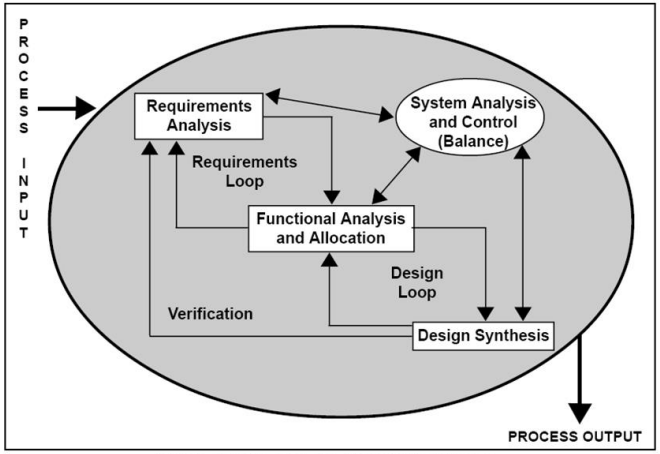
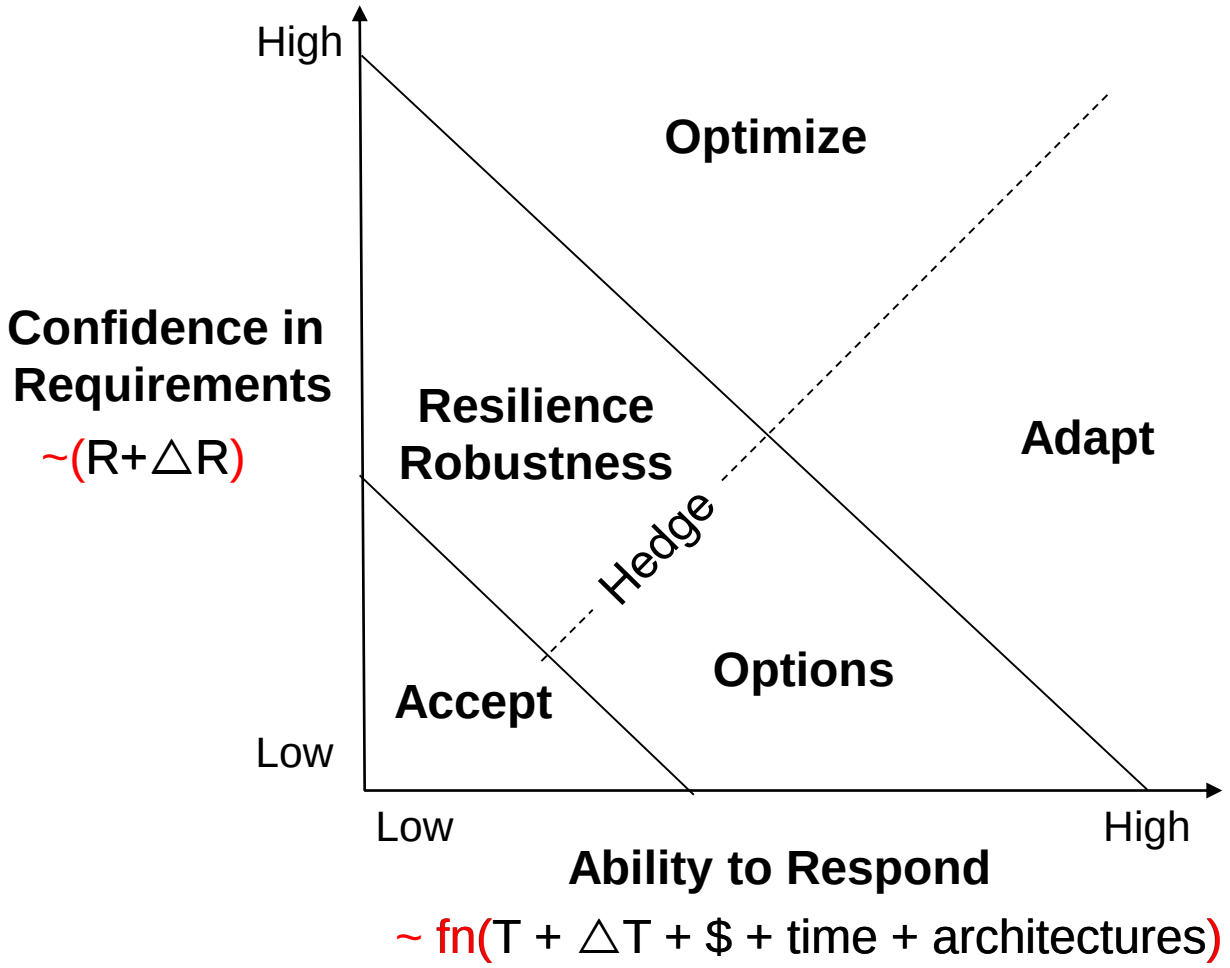


Figure 1-3. The Systems Engineering Process

Methods for Selecting Acquisition Approaches



Notes:

- Framework helps overcome tendency to develop optimal solutions to static requirements
- Each axis belongs to a separate community
- Uncertainty around Requirements and Technology can be informed by intelligence community

Credit: Derived from Michael Pennock, Stevens Institute

Interesting Research Questions

- **Gauging confidence in requirements, ability to respond**
- **Analysis of trades across the mission space and the solution space**
- **Gauging risk, rework**
- **Hedging methods**
- **Actual increases in velocity of capability delivered**
- **Methods to increase ability to respond**
  - e.g., MBSE, advanced manufacturing
- **Dynamic and continuous learning and certification**
- **Multiple systems interrelationships**
  - Portfolio management, mission engineering
- **Others?**

For Additional Information

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Systems Engineering: Critical to Defense Acquisition










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