# U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

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## Review of Research into the Nature of Engineering and Development Rework: Need for a Systems Engineering Framework for Enabling Rapid Prototyping and Rapid Fielding

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# BOTTOM LINE UP FRONT (BLUF)

- Rework has been a *persistent* problem for product development for decades yet it has *not been* a *focus* area for systems engineering research
- Much of the research on rework has been on *information exchange* and *organizational structure*
  – Analytical methods for understanding and analysis
  – Limited frameworks to reduce rework
  – Untapped advances in technology
- Future research is needed for the development of a systems engineering framework that addresses rework concerns, accelerates iteration and enables rapid prototyping

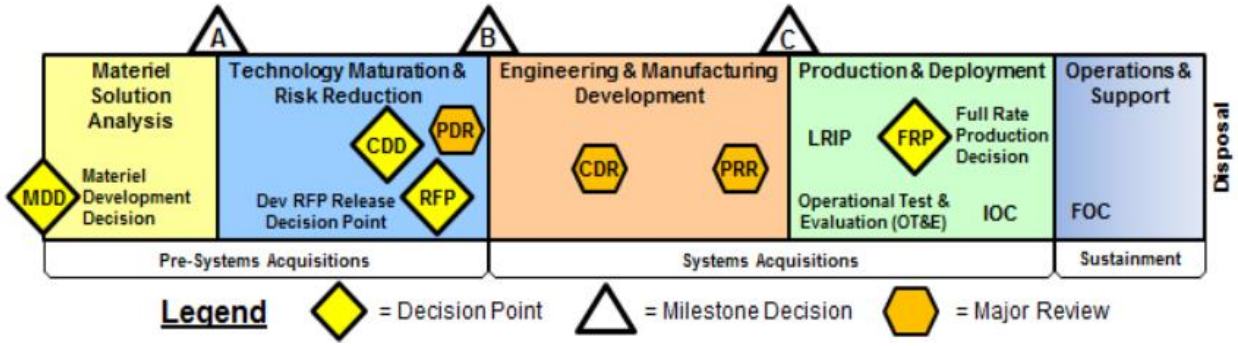
# PROBLEM

- Engineering design issues are a major concern for the DOD and most Industries
- Engineering design issues lead to *reworking* the design
- Rework can take up a significant amount of total design time
- The severity depends on where it is found during the product development life-cycle

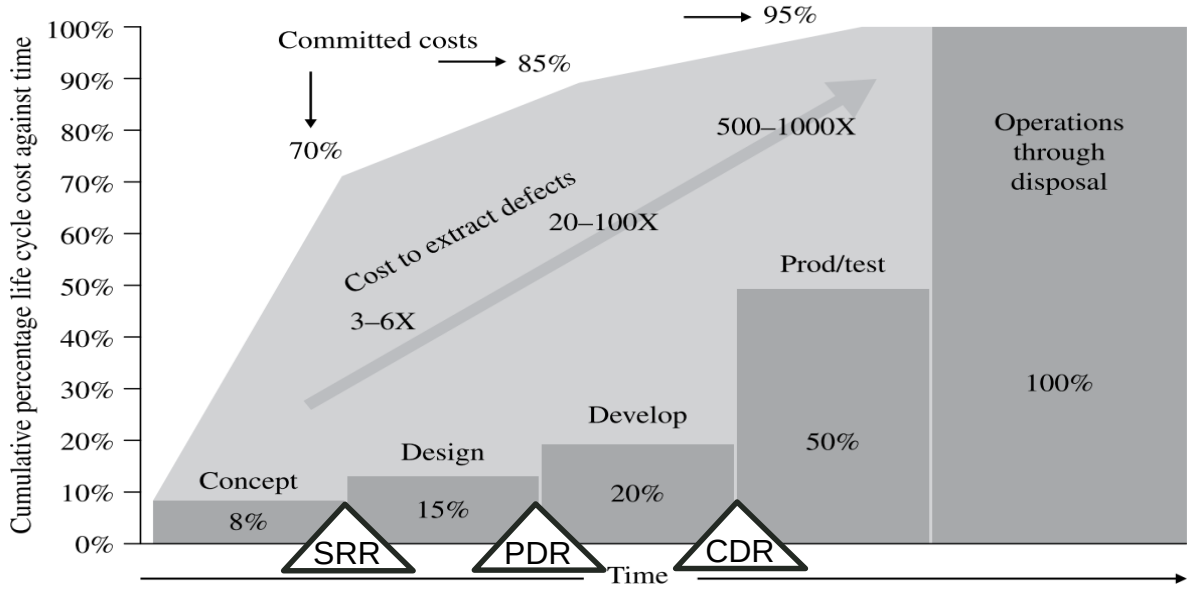
(Adopted from Orator, 2004)

What is the Nature of Engineering and Development Rework?

# SEVERITY OF REWORK



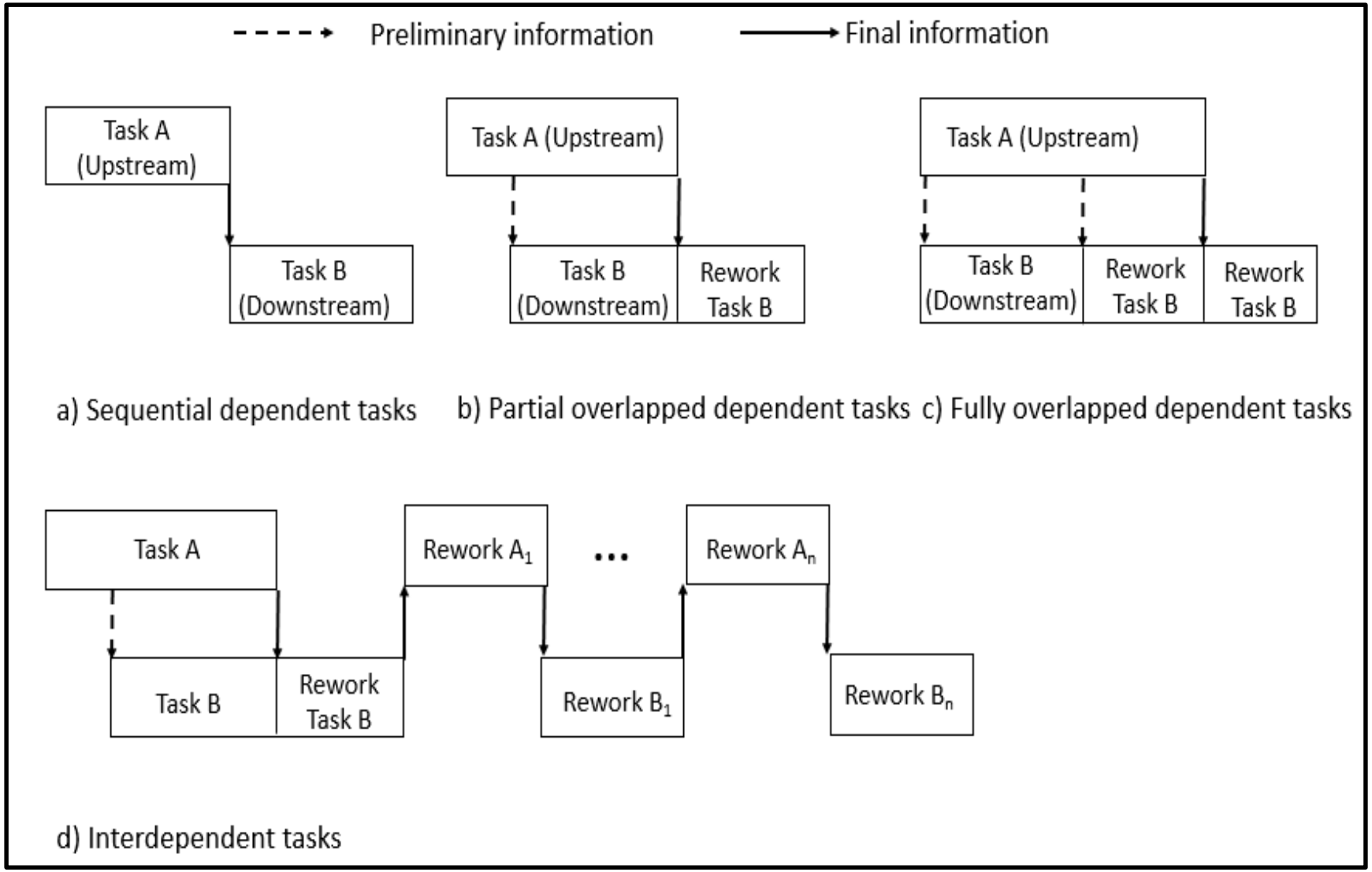

(Adopted from DoD 5000.02, 2015)



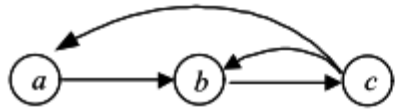

(Adopted from Defense Systems Management College,1993)

**Need to influence rework during Technology Maturation and Risk Reduction (TMRR)**

# INFORMATION EXCHANGE



# MODELING APPROACHES




| Task Name | | 1 | 2 | 3 |
|---|---|---|---|---|
| a | 1 | | | 1 |
| b | 2 | 1 | | 1 |
| c | 3 | | 1 | |

Figure 1: Information flow diagram and DSM (adopted from Cho and Eppinger, 2001)

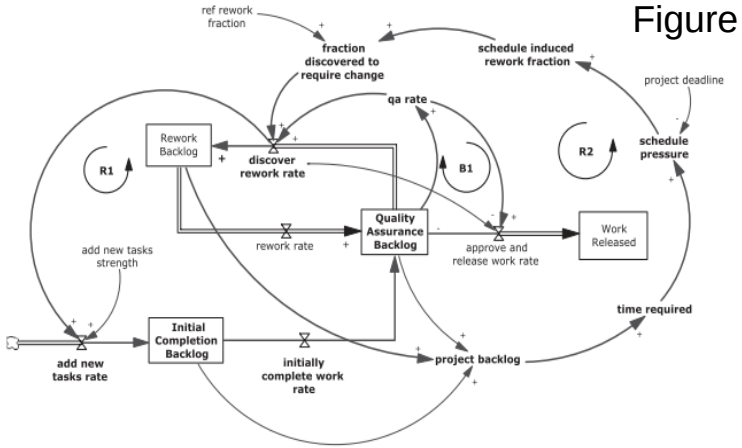



Figure 2: System Dynamics Model (adopted from Taylor and Ford, 2006)

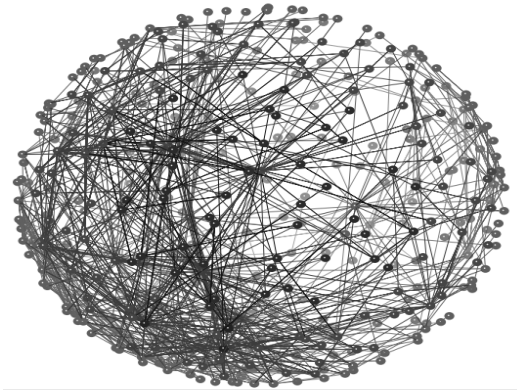


Figure 3: Network Model (adopted from Braha and Bar-Yam, 2007)

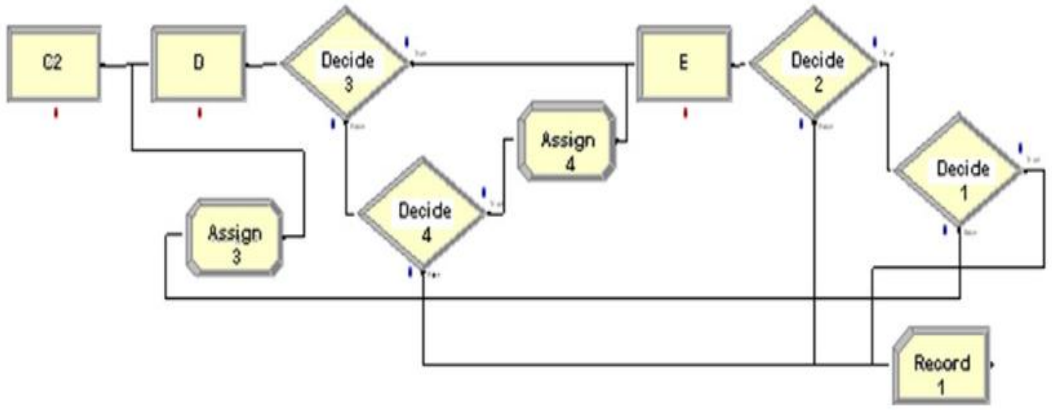



Figure 4: Arena Model (adopted from Yang et al., 2014)

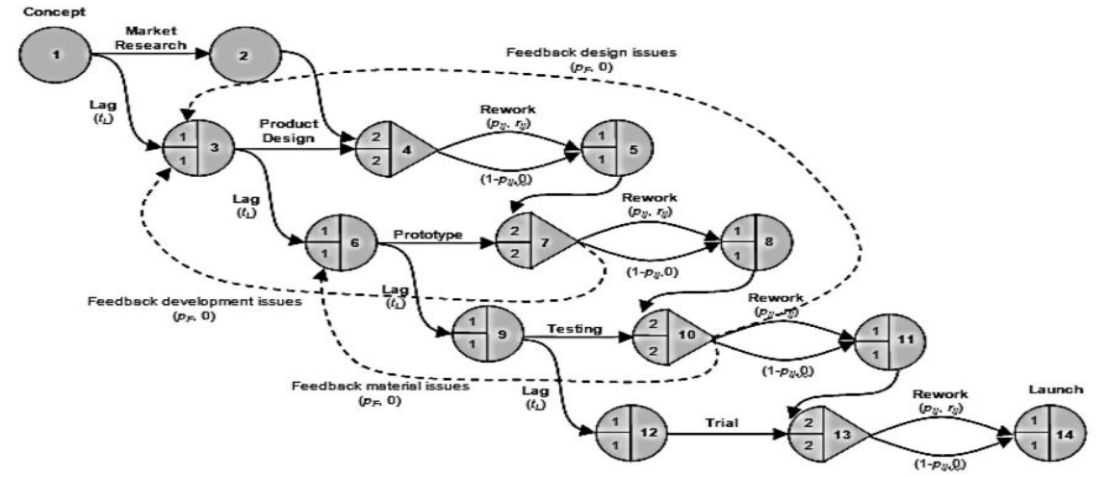


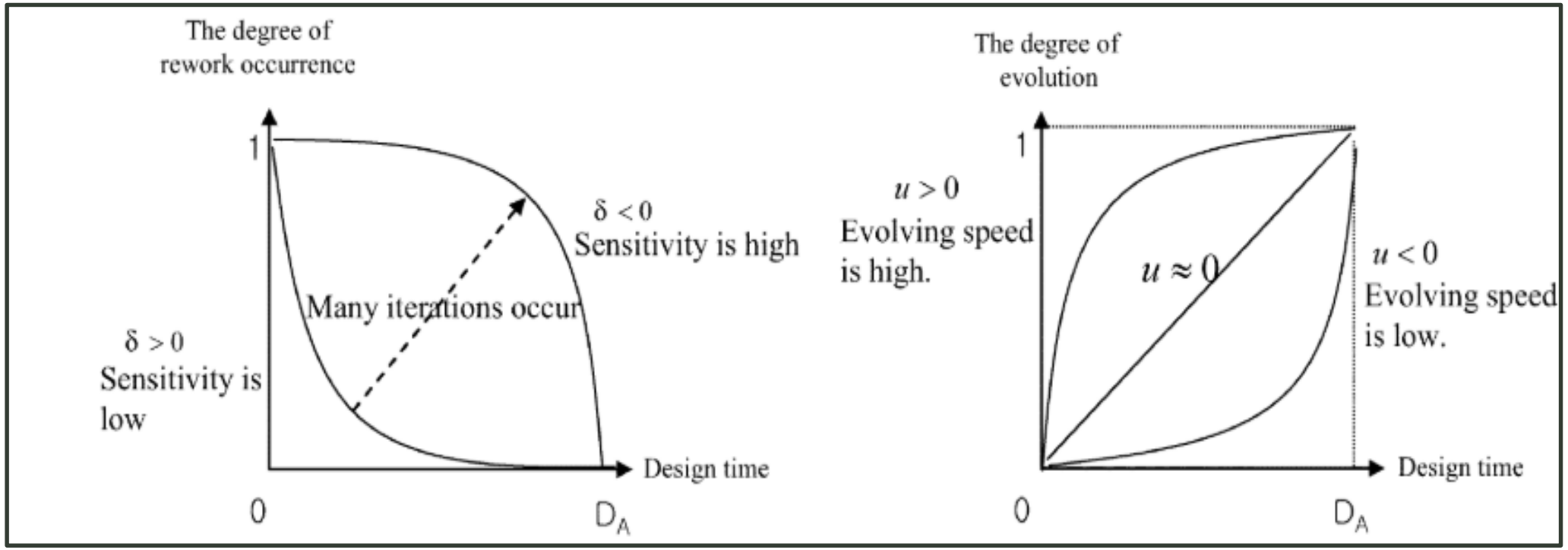

Figure 5: GERT (adopted from Nelson et al., 2016)

# MODELING CONSIDERATIONS

- Number of design reviews
- Timing of preliminary information release
- Timing and duration of crashing
- Team coordination and coordination time
- Task dependency (independent, dependent, interdependent)
- Number of activities directly related to one particular activity
- Degree of overlapping (none, partial, fully)
- Type of collaboration, routing, and synchronization
- Amount of overlapping of testing and design activities
- ***Uncertainty and ambiguity***
- ***Task sensitivity and knowledge evolution***

Limited frameworks to reduce rework

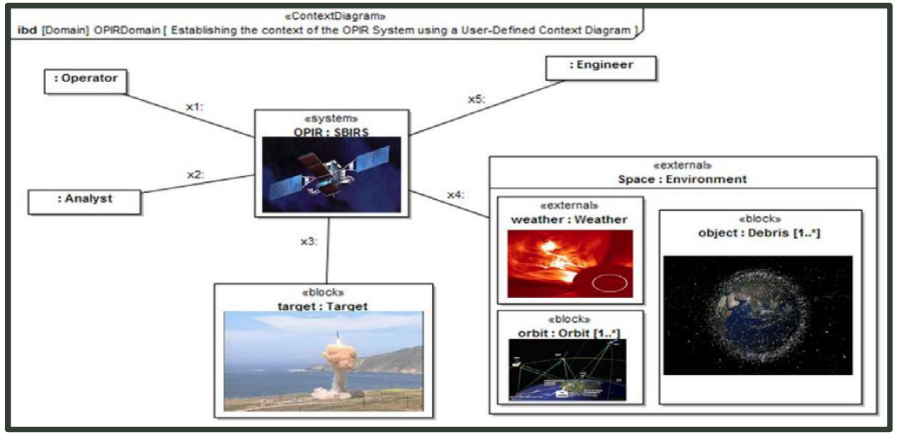
# INFORMATION SENSITIVITY AND KNOWLEDGE EVOLUTION

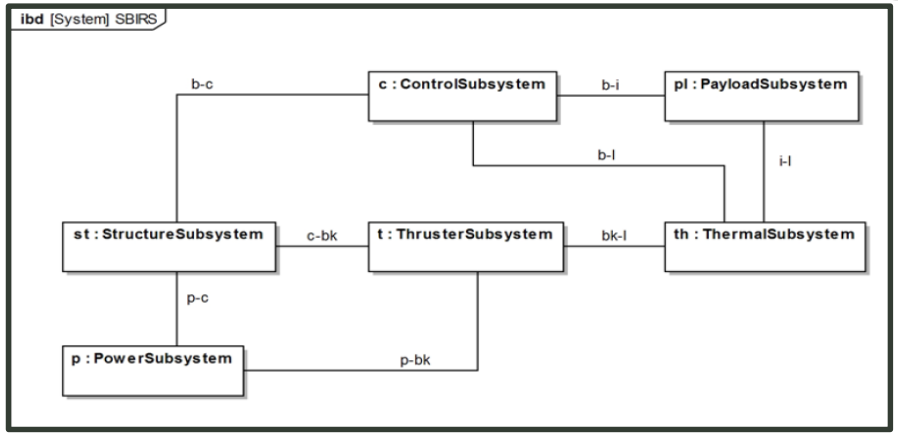


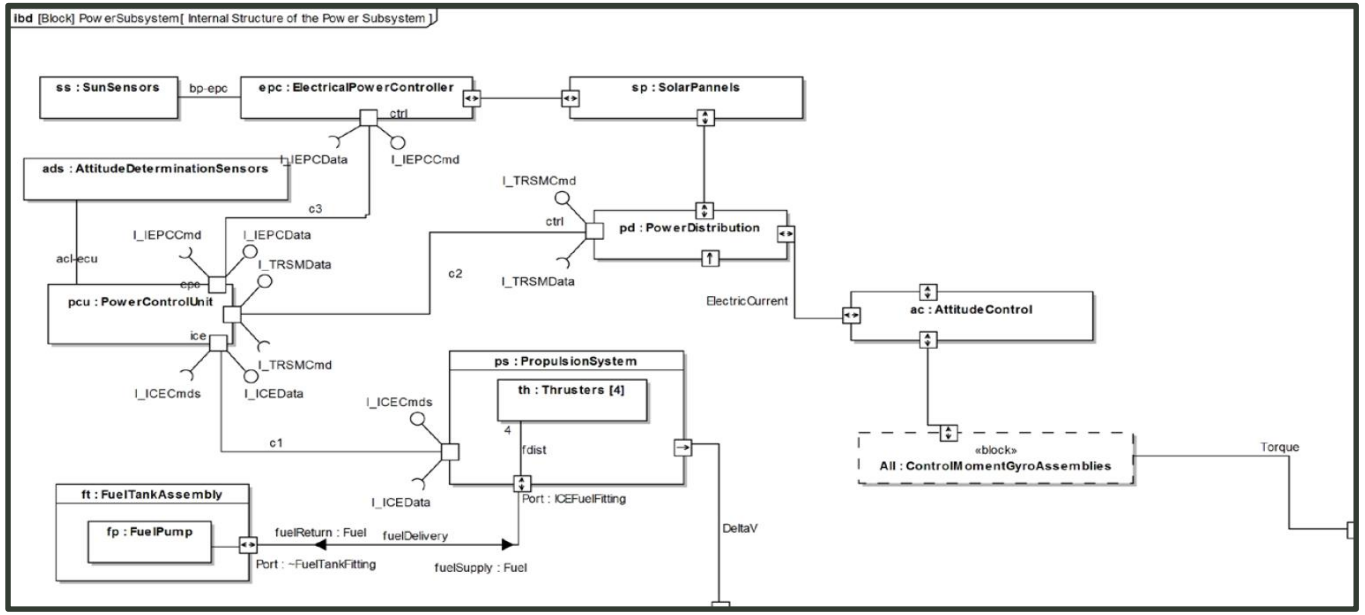

(Adopted from Jun, Ahn, & Suh, 2005)

Uncertainty and ambiguity significantly impacts rework

# COMPLEXITY




(Adopted from Jepperson, 2013)

Misalignment of activities and organizational structure

# FUTURE RESEARCH

Development of a systems engineering framework during the TMRR phase that addresses rework concerns, accelerates iteration and enables rapid prototyping

1) Mitigate the impact of information uncertainty and instability
2) Accelerate information evolution
3) Reuse knowledge for engineering reasoning

# QUESTIONS?

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