

Reducing Design Rework using Set-based Design in a Model Centric Environment

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By

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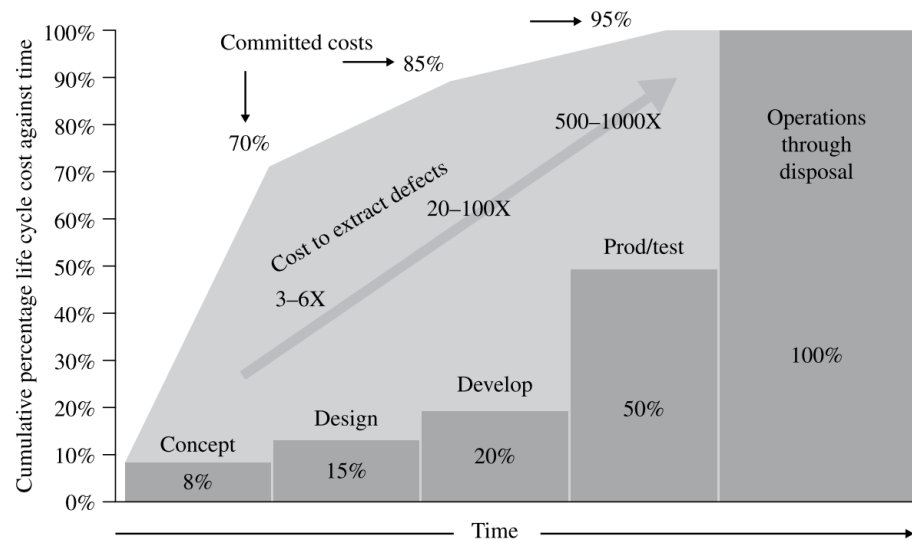
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Problem

- 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

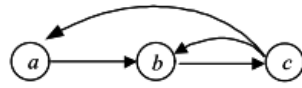


(Adopted from Orator, 2004)



(Adopted from Defense Systems Management College, 1993)

What is the Nature of Design Rework?



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)

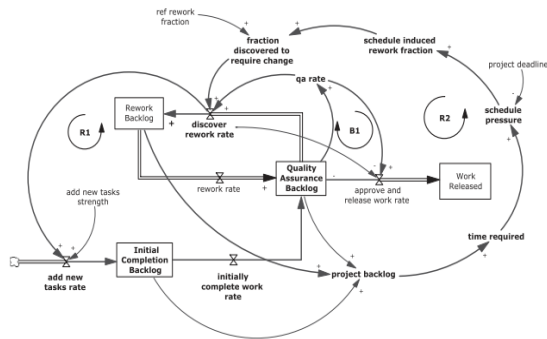


Figure 2: System Dynamics Model (adopted from Taylor and Ford, 2006)

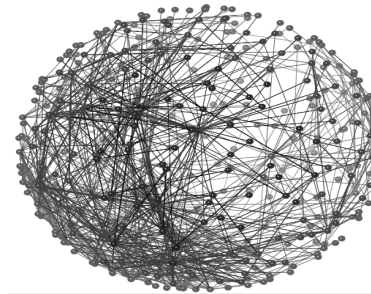


Figure 3: Network Model (adopted from Braha and Bar-Yam, 2007)

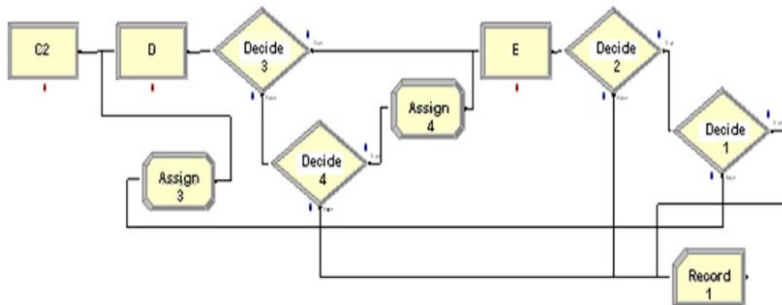


Figure 4: Arena Model (adopted from Yang et al., 2014)

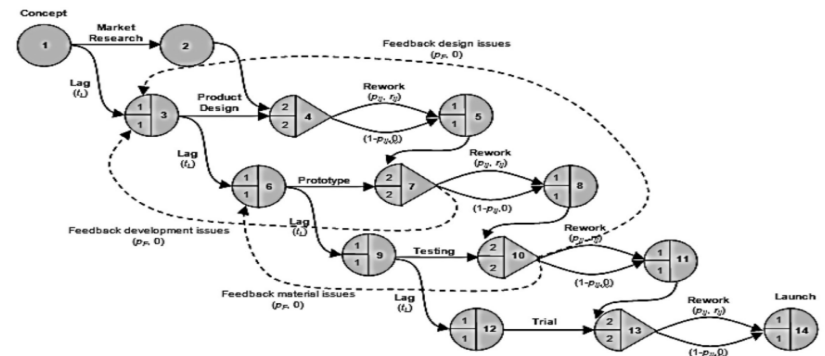
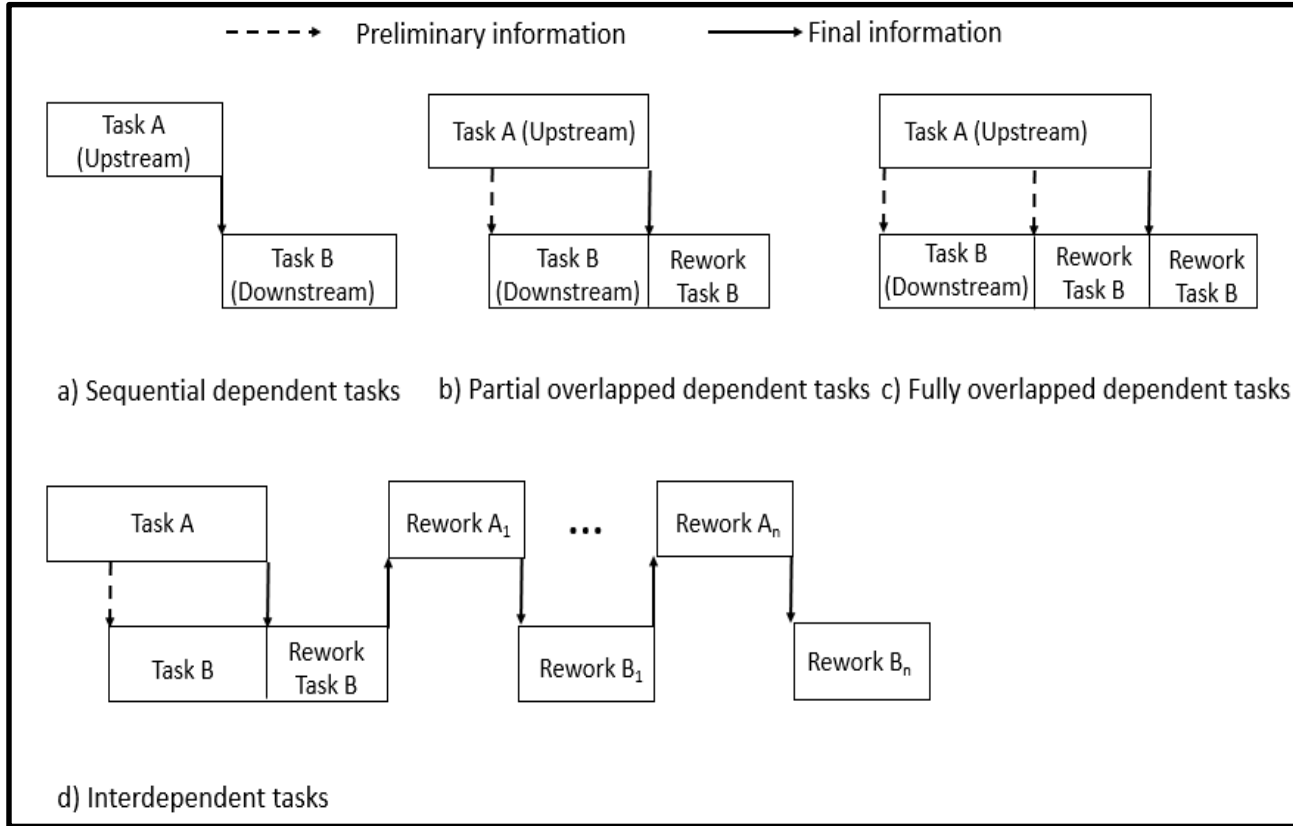


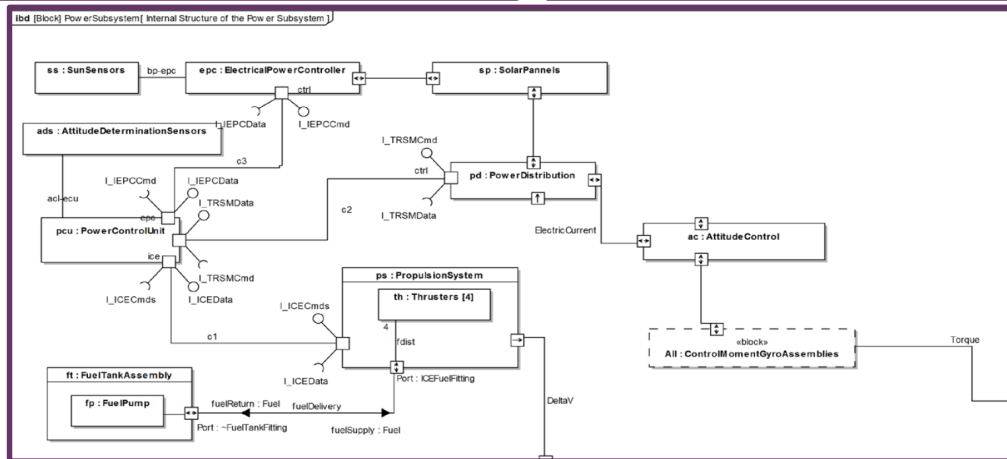
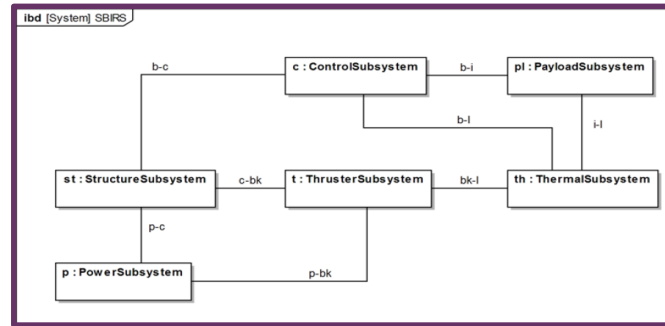
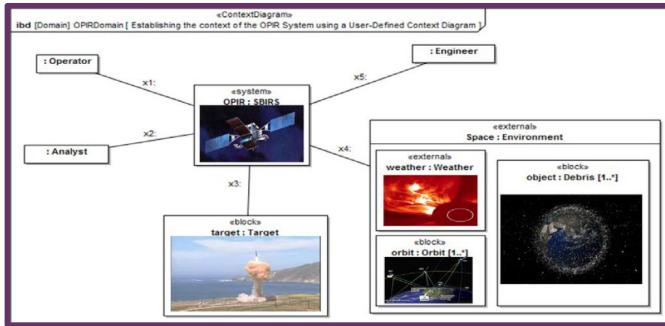
Figure 5: GERT (adopted from Nelson et al., 2016)

Information Exchange



Rework caused by information uncertainty/ambiguity

Complexity

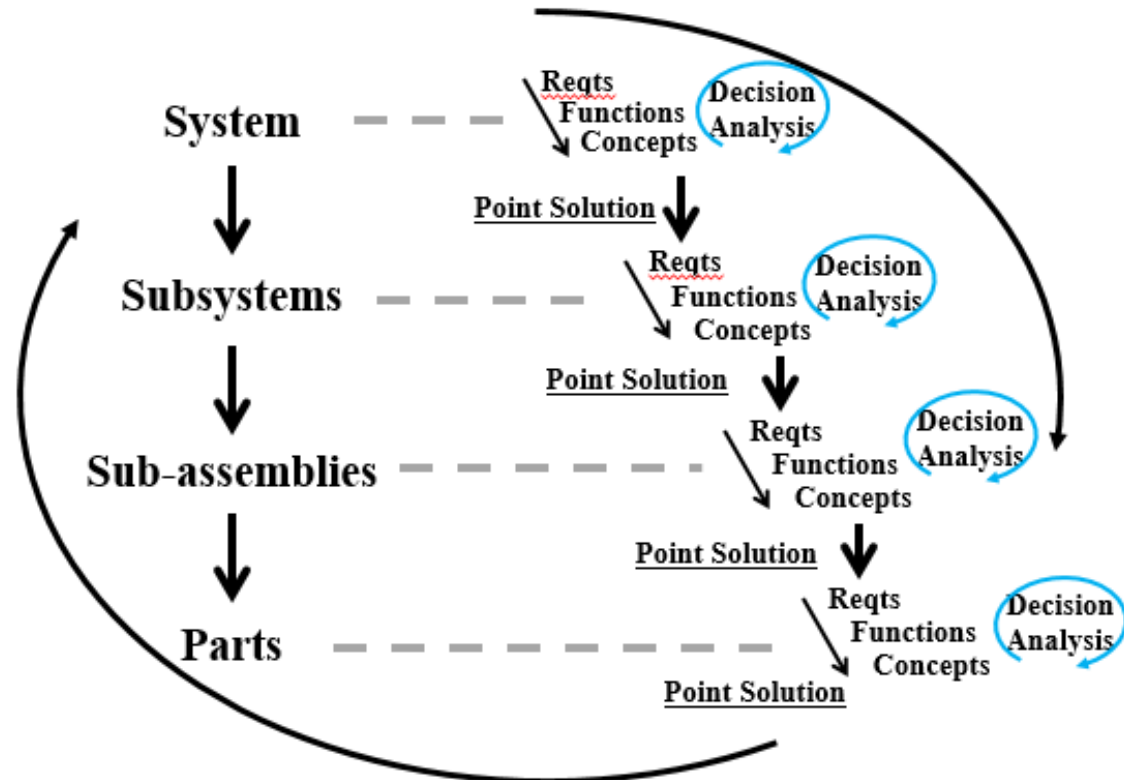


(adopted from Jepperson, 2013)

Rework caused by misalignment of activities and organizational structure

Point Based Design (PBD)

- Susceptible to the same causes of rework as sequential and concurrent design
- Converging too early to a point design
- Overly constraining the design

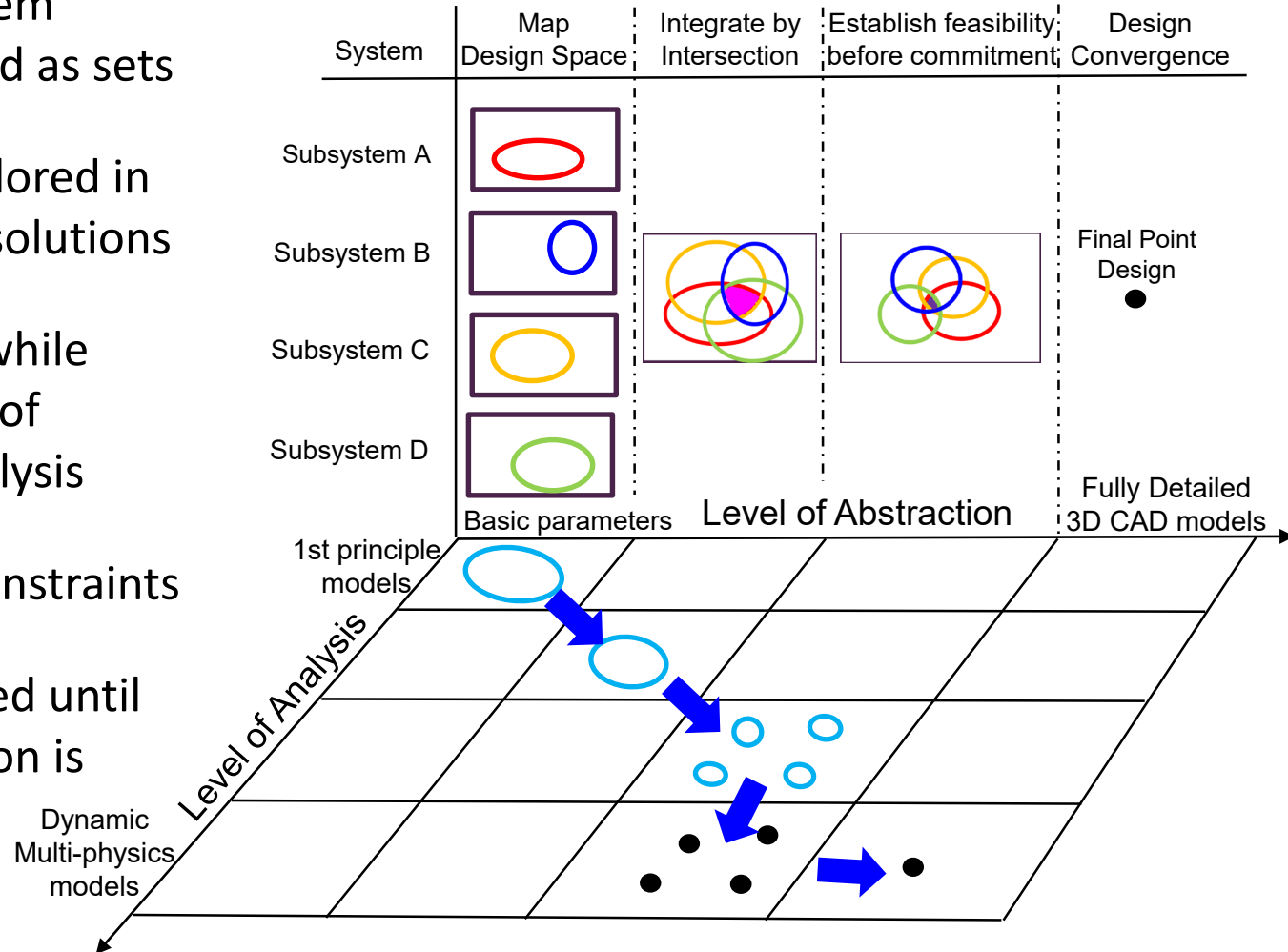


Rework occurs because decisions are made with uncertain information

Propose reducing Rework using Set-Based Design



- System and subsystem solutions are defined as sets
- Subsystems are explored in parallel to systems solutions
- Sets are narrowed while improving the level of abstraction and analysis
- Imposes minimal constraints
- Decisions are delayed until adequate information is available



What is the current state of SBD Procedural Models?

- What are the strengths and limitations to these approaches and models?
- How is knowledge developed, captured, and reused to cause convergence of sets
- What Digital Engineering (DE) tools were recommended/used to enable SBD?

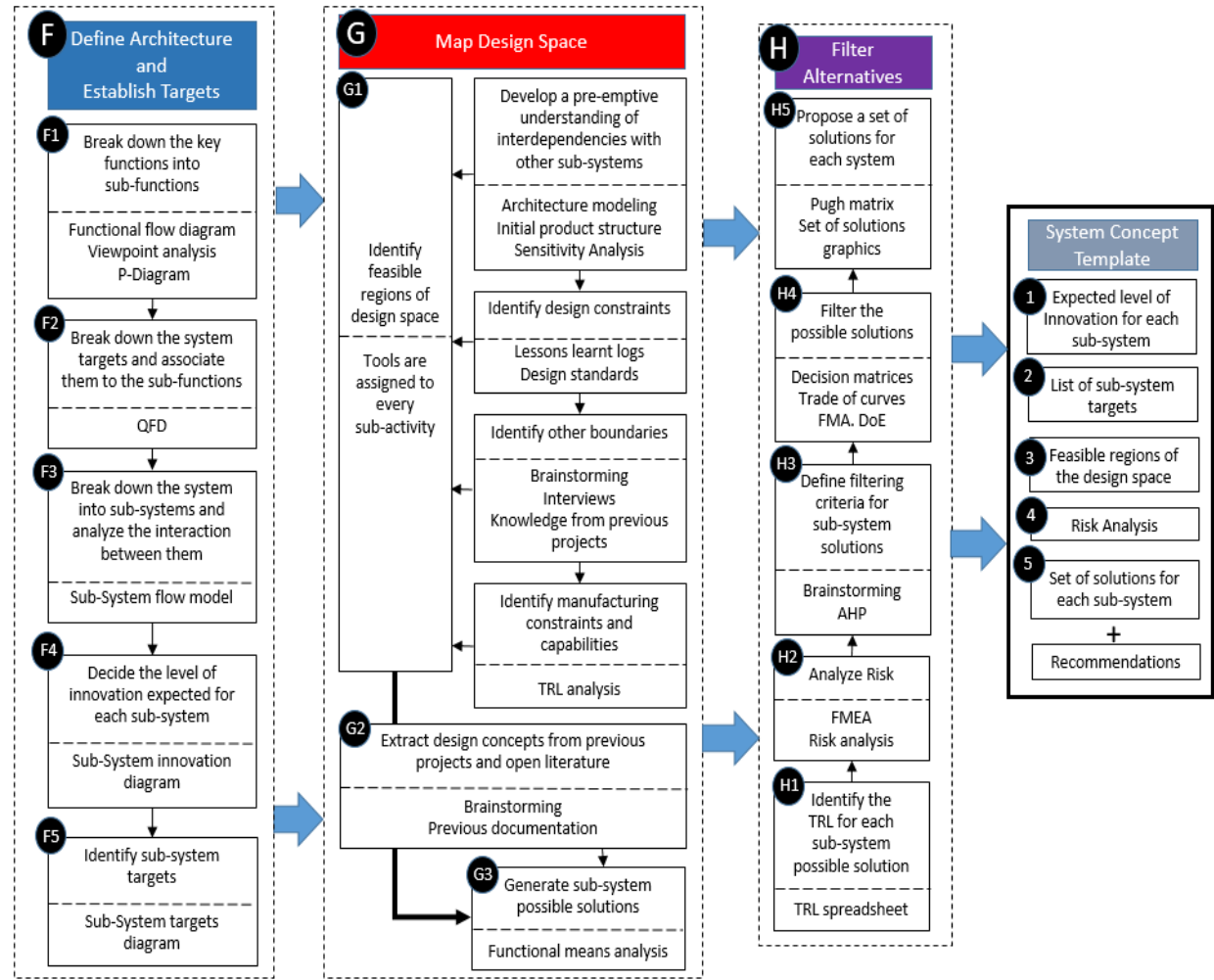


Figure 1: Partial Rolls-Royce Lean Product Development Model (modified from Al-Ashaab et al., 2013)

Future Work

- Opportunity to solidify guidance on how to implement SBD
 - How to narrow sets while improving level of abstraction and level of analysis
 - How to define and reason about sets
 - How to capture and reuse knowledge
 - Illustrated industrial application
- Opportunity to improve the connection of SBD to SE technical processes
- Opportunity to implement SBD in a DE Environment
 - What tools are best suited for knowledge development, capturing and reuse
 - How can model centric engineering and rapid-prototyping be utilized to accelerate learning
 - Application of integrated multi-fidelity models to include multi-physics models

Questions



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