Cost Engineering in Axiomatic Design

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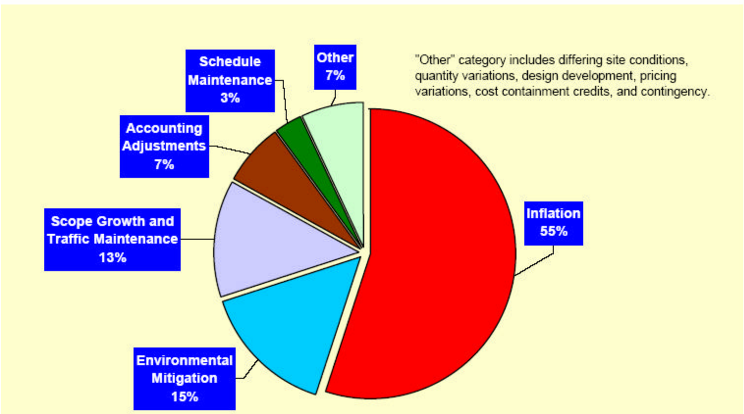
May 2nd, 2005

MIT

Cost: What’s the problem?

- “Cost nightmare”
  - The Big Dig
    - $2.6B (1982) to $14.6B (2004)



Causes of Growth in "Big Dig" Costs - From $2.6 Billion to $14.6 Billion

Boston’s Big Dig

Photo removed for copyright reasons.

  - Ingalls Shipbuilding Co.
    - Continuous design change, required by the Navy
    - $2.7B unsettled claim

USS Peleliu

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Freiman Curve

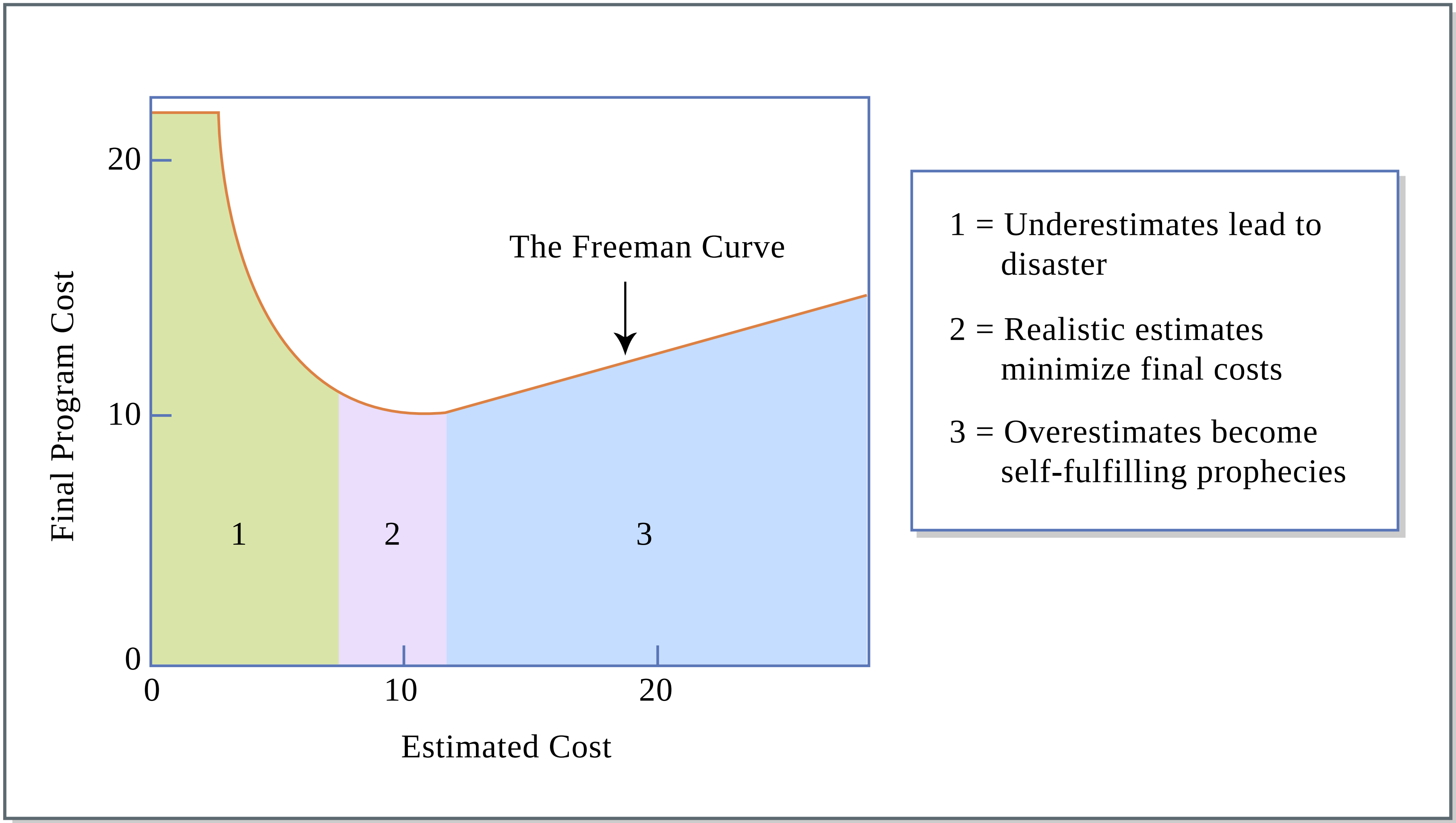


Figure by MIT OCW. Adapted from Freiman, F. R. “The Fast Cost Estimating Models.” *AACE Transactions* (1983).

- Fail to address:
  - Credible cost estimation
  - Cost drivers
  - Cost management
  - Schedule risk

WHY does a system cost how much?

- We need …
  - Systematic approach
  - Better utilization of cost data

TRACEABILITY

Goals & Approaches

- Goals
  - Enhance the credibility of life cycle cost estimation
  - Quickly predict the cost impact of engineering changes to the system
  - Identify key cost drivers to guide the cost reduction effort
- Approaches
  - Develop a general method for integrating cost information into the system architecture
    - Development, Production, Operation phase
  - Develop a method to predict the cost of system changes
    - Requirement changes, Solutions changes
  - Integrate the method into a usable tool for designers/ engineers

Value

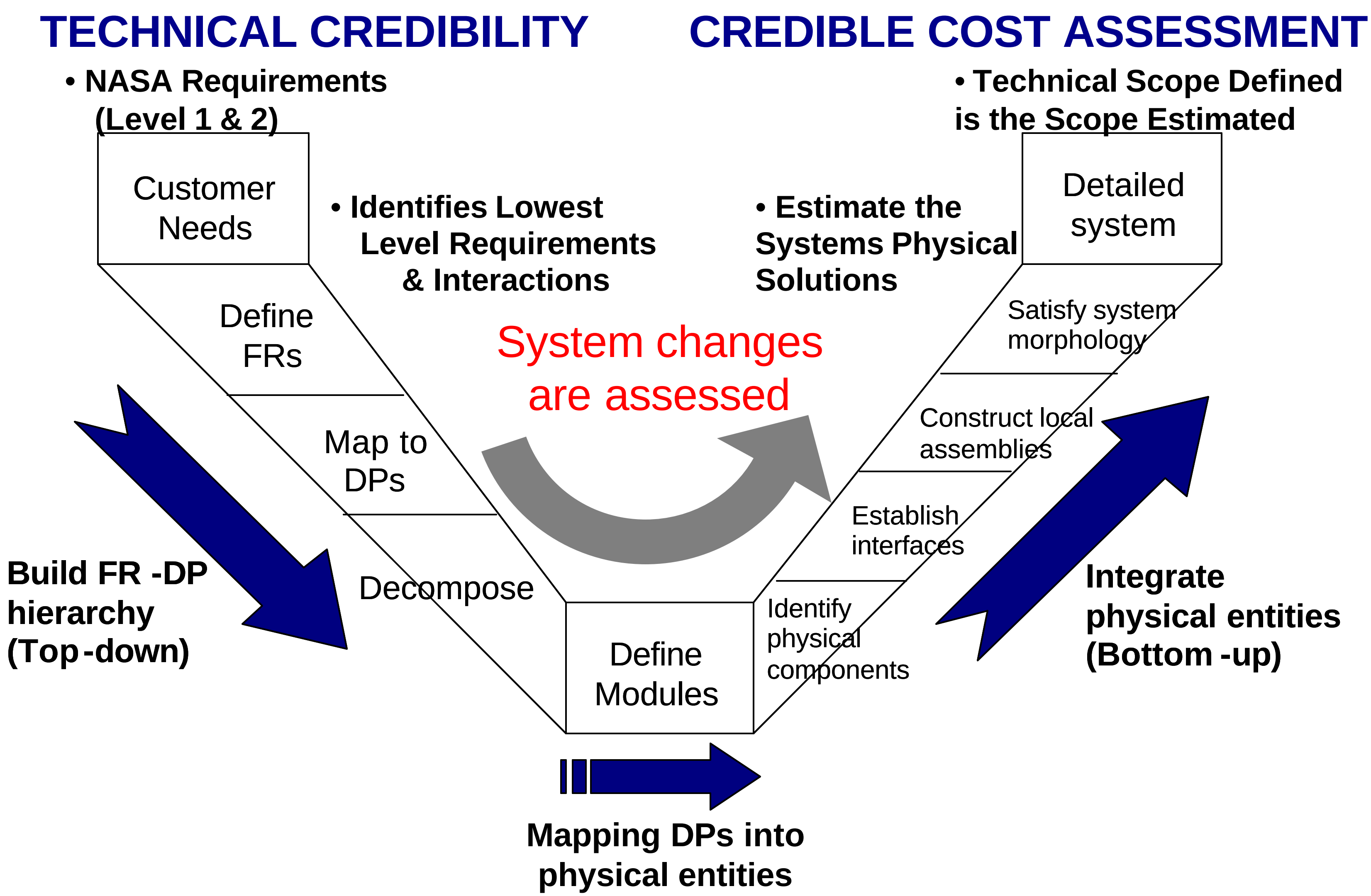
- Cost Credibility
  - Cost information is tied to system design information via Axiomatic Design (AD) framework
  - Scope of cost estimation becomes apparent
  - Unified framework for cost estimation at different stages of system design by constructing a hierarchical structure

Completeness, Visibility

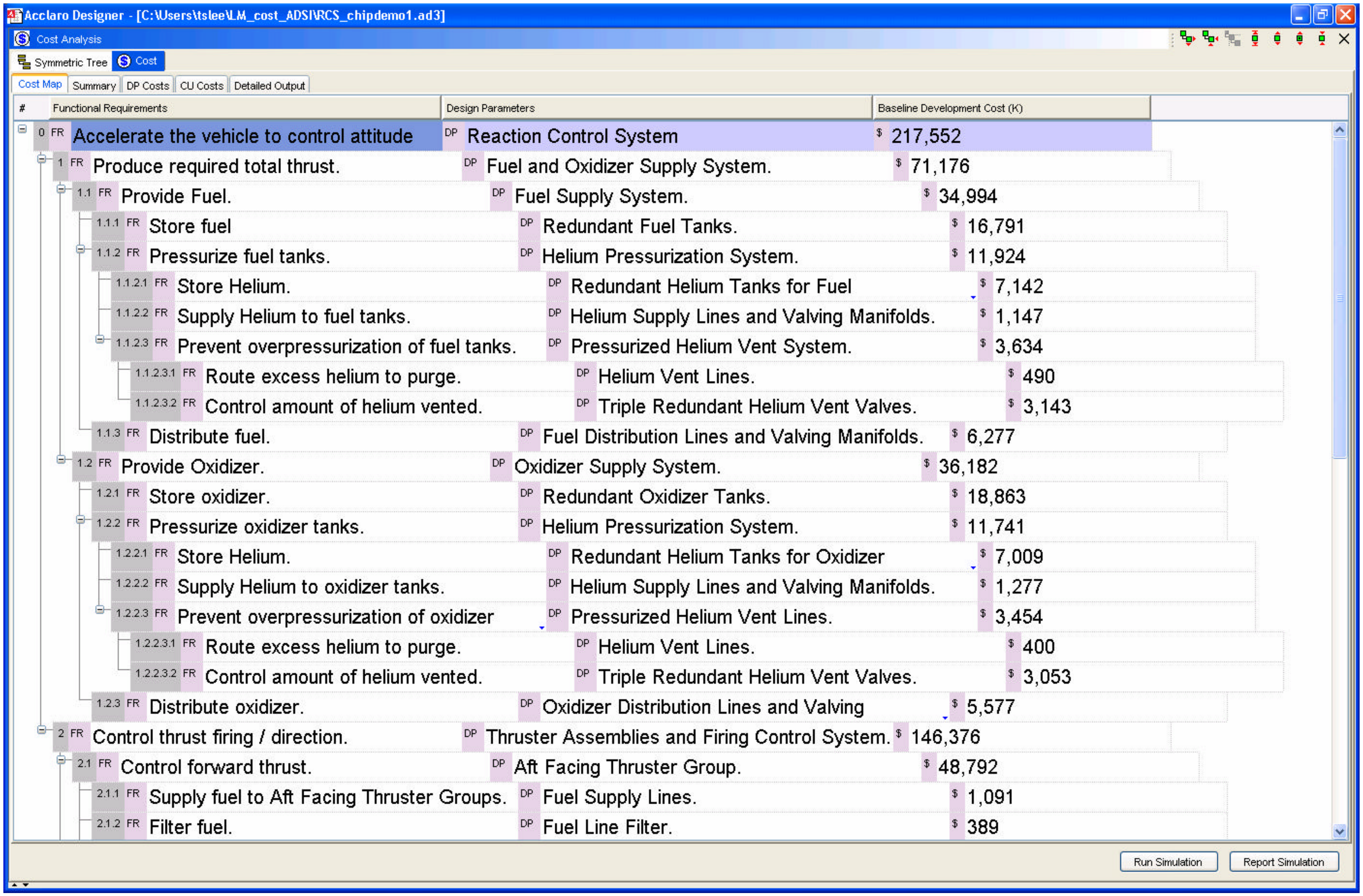
- Capability to Assess the Cost Impact of Changes
  - Ramification of changes in a requirement and/or design solution is captured by AD framework
  - The estimate of cost impact is quickly generated to support decision making process
  - Key cost drivers can be identified

Traceability

System Design & Development



Software Tool to Aid the Process



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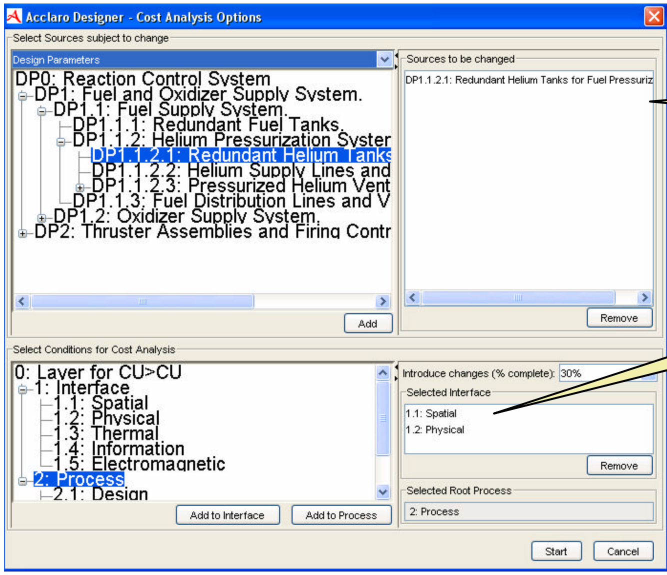
Software Tool Demonstration

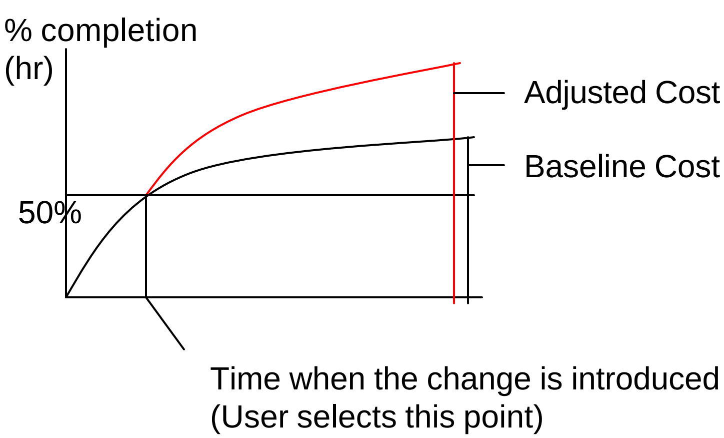
SDCM Development Module

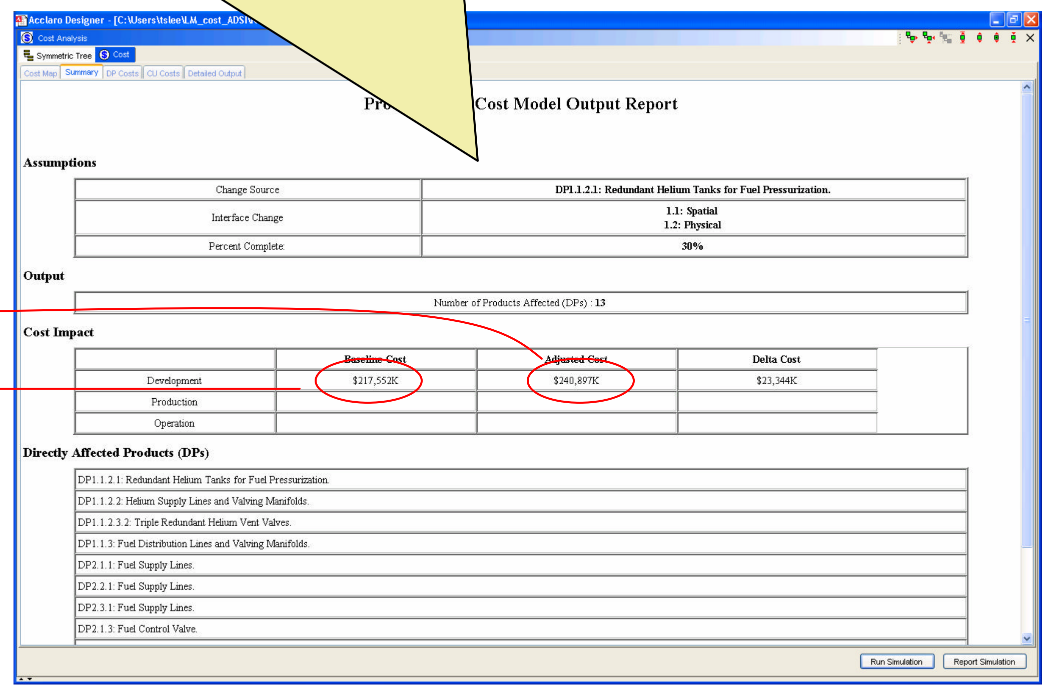


DP1.3.1 is Evaluated for Change

Nature of a 'change' is further specified

Simulation input (change, project phase), Result (cost impact), and Details are summarized





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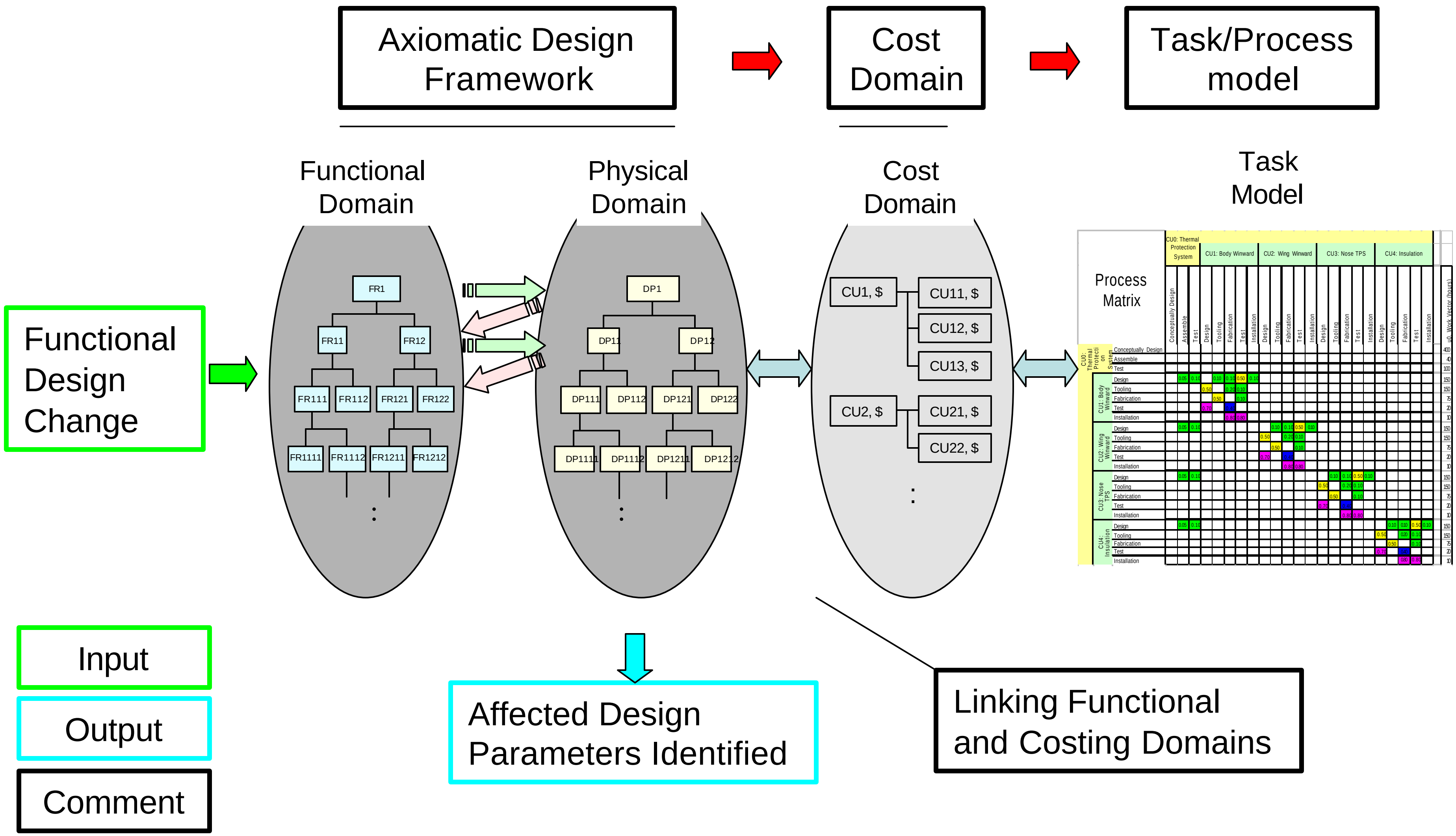
Development Module Model Structure



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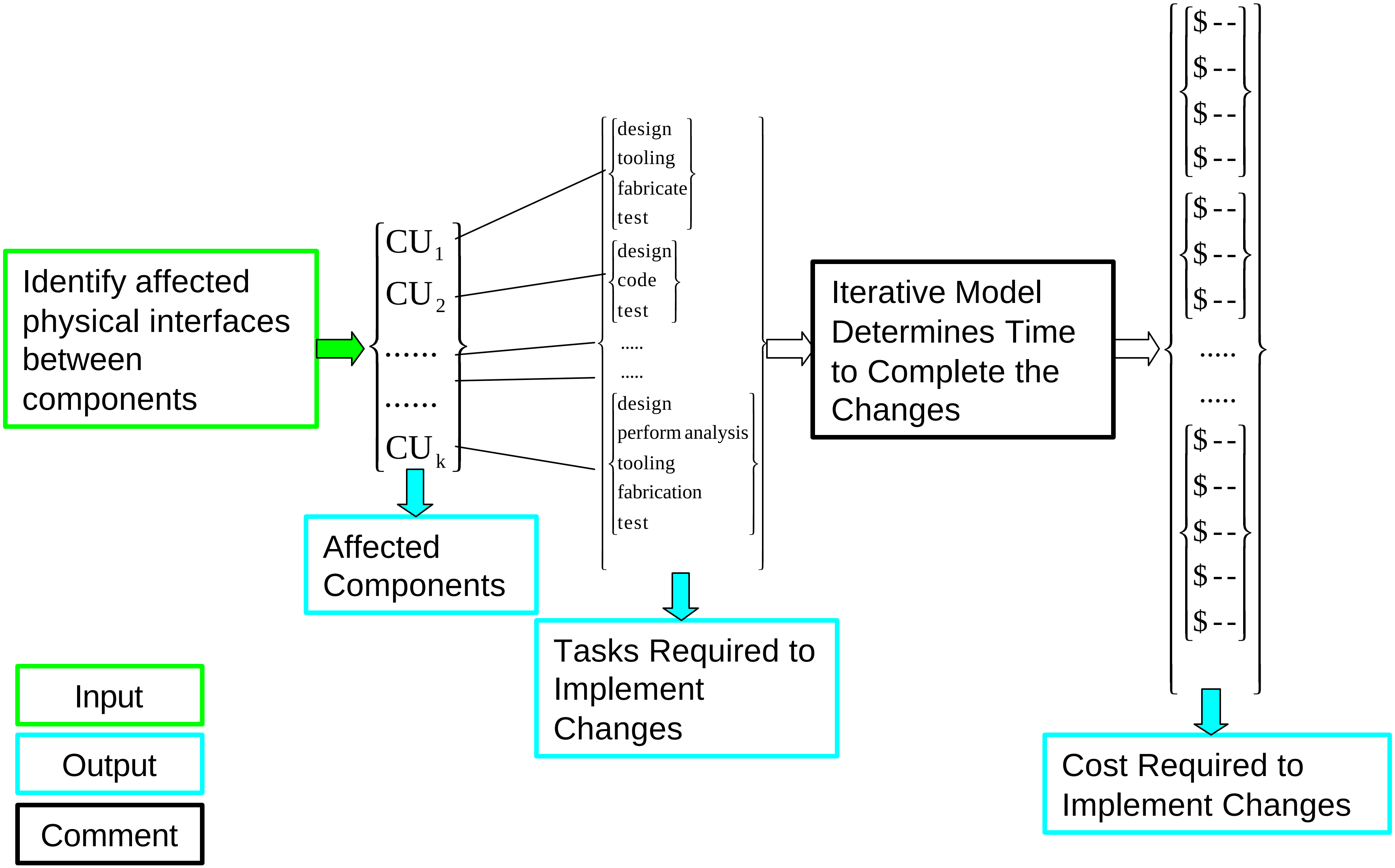
Development Module Model Structure



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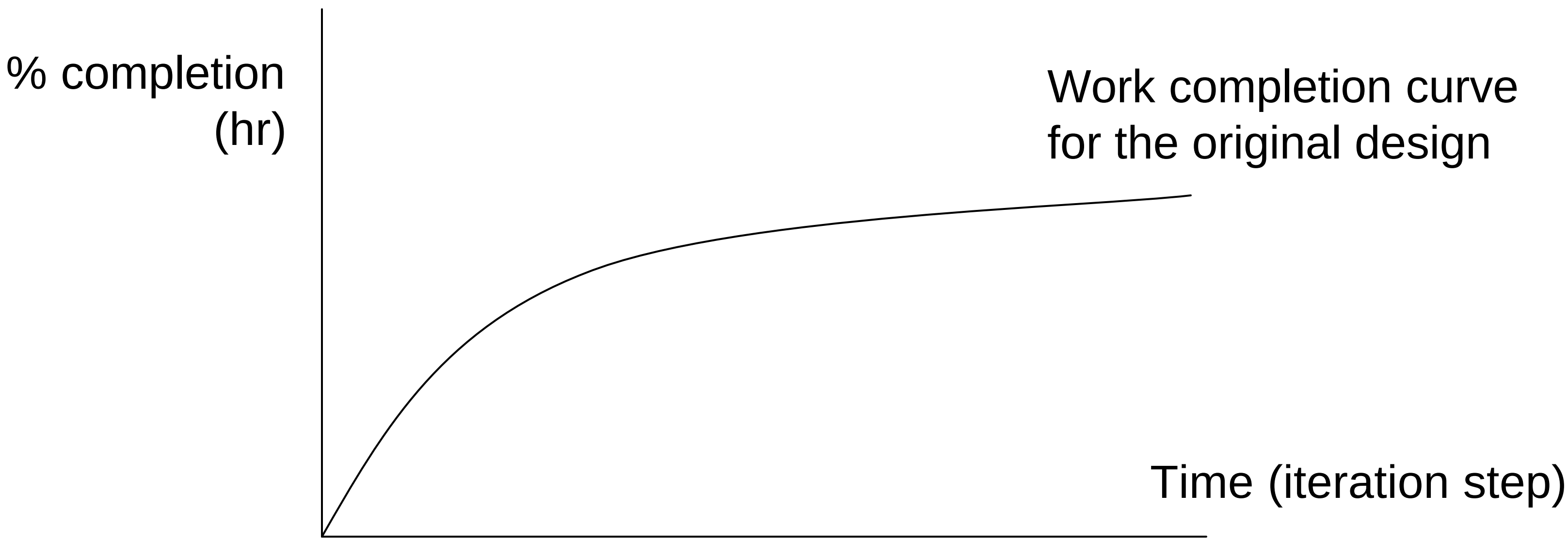
Iteration model

	Task A	Task B
Task A		0.5
Task B	0.3	

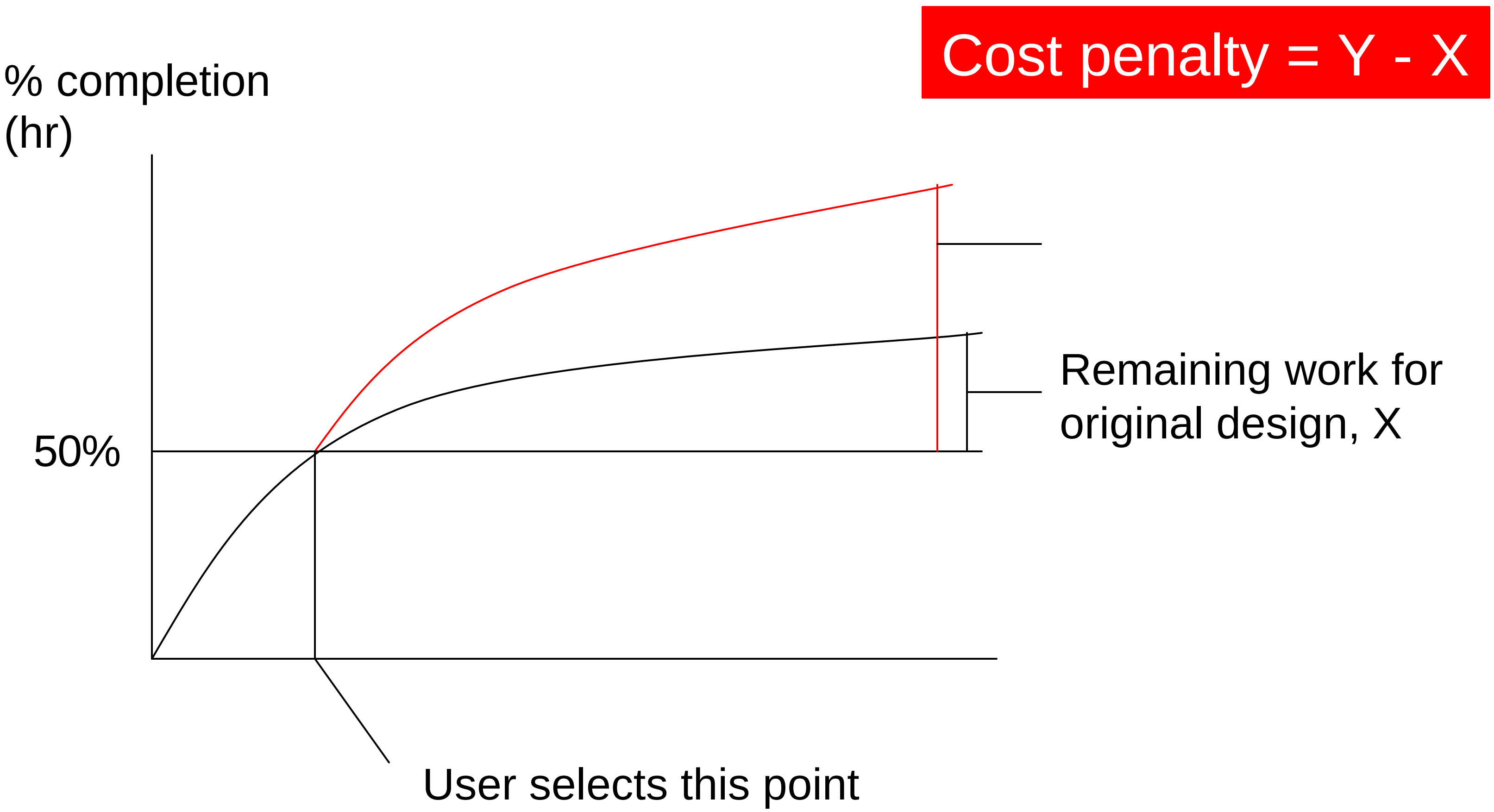
Work Transformation Matrix

$$u_n = WT \cdot u_{n-1}$$

$$\begin{aligned} U &= u_0 + u_1 + \cdots u_N \\ &= u_0 + WT \cdot u_0 + WT \cdot (WT \cdot u_0) \cdots \\ &= (1 + WT + WT^2 + \cdots + WT^N) \cdot u_0 \end{aligned}$$

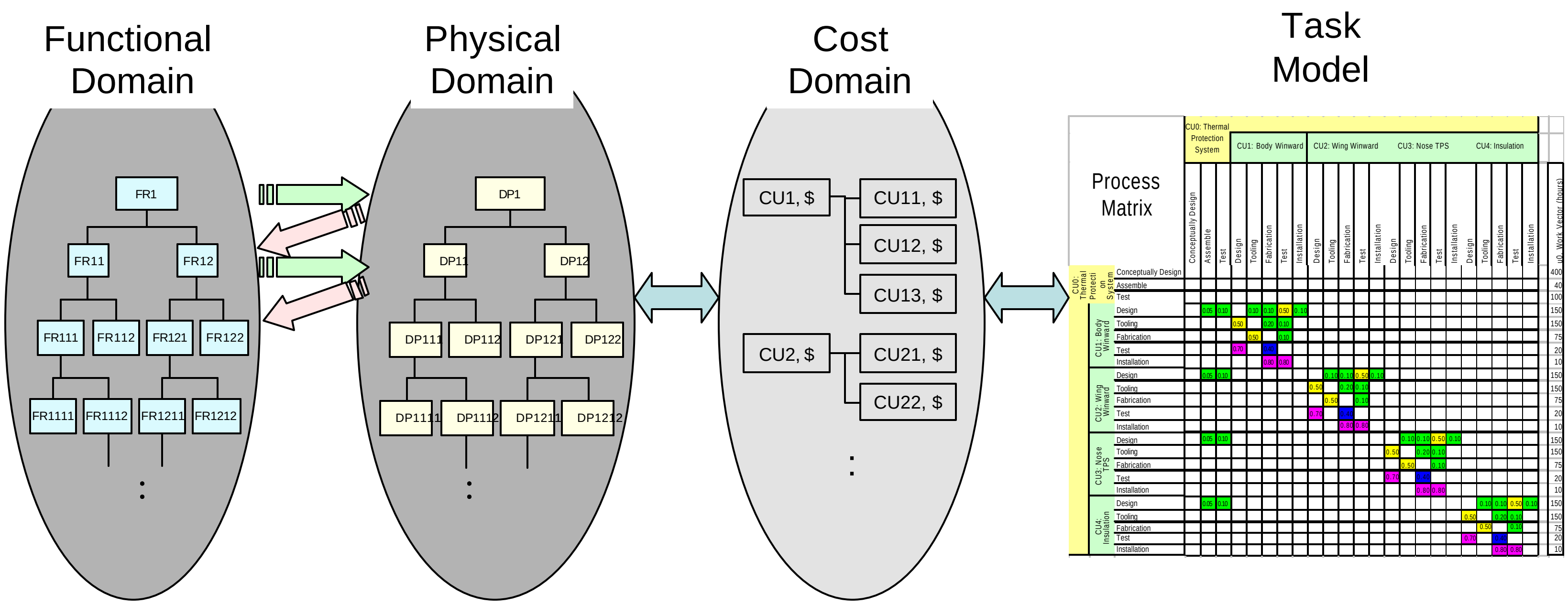


Cost Impact of Change



Summary

Complete Traceability from Design to Cost Information



Steps

1. Identify affected DP's from FR change
2. Identify CU' corresponding to DP's
3. Identify CU'' from CU'
4. Estimate % rework input
5. Estimate total change-workload