ESD.33 -- Systems Engineering

Session #2
INCOSE Model of SE
RCI Model of SE

Dan Frey

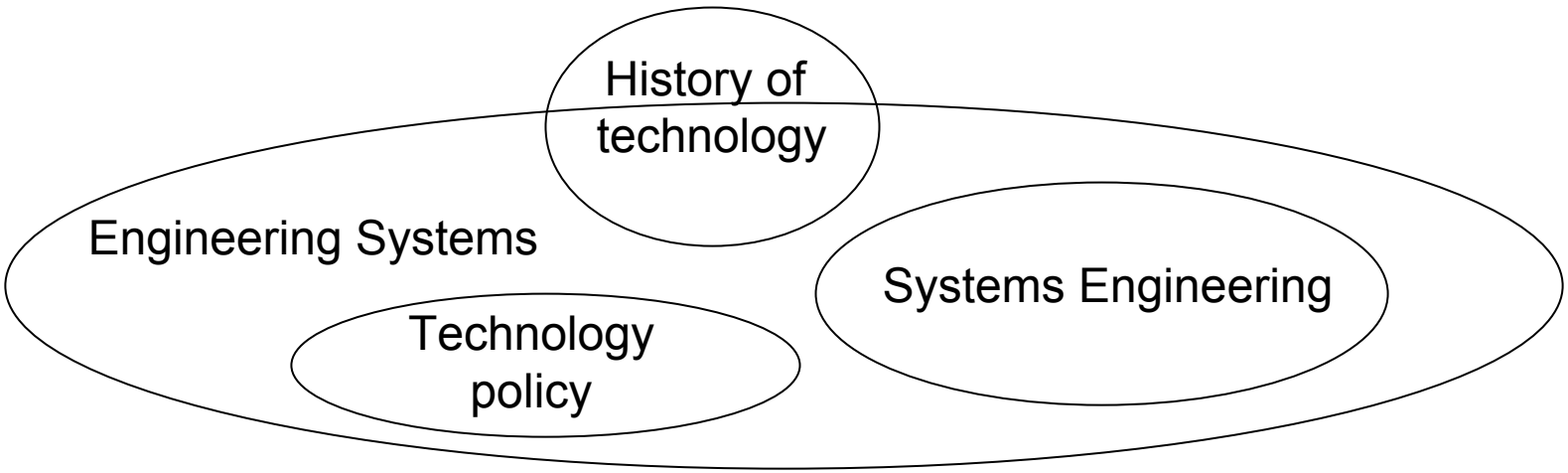
Don Clausing

Plan For the Session

- Follow-up from session #1
- INCOSE SE handbook
- RCI model of SE
- Review assignment #2

Engineering Systems & Systems Engineering

ESD mission: To establish Engineering Systems as a field of study focusing on complex engineered systems and products viewed in a broad human, social and industrial context. Use the new knowledge gained to improve engineering education and practice.



Discussion Point

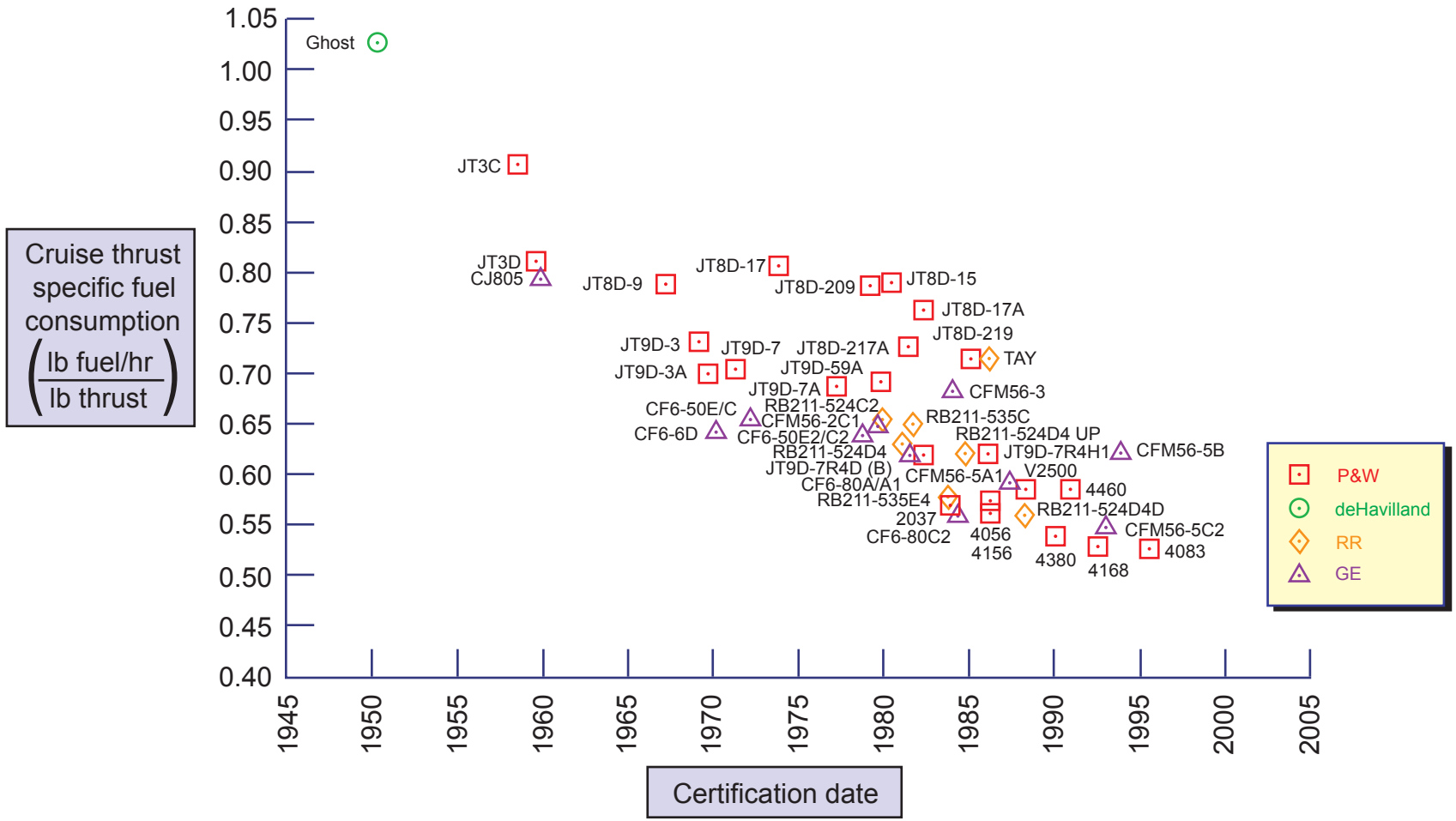
- Did the design of the CFM56 jet engine entail a systems engineering function?
- Did the design of Whittle's jet engine entail a systems engineering function?

Scott Thomson

Hamilton Sundstrand, Section Lead - Electric Systems

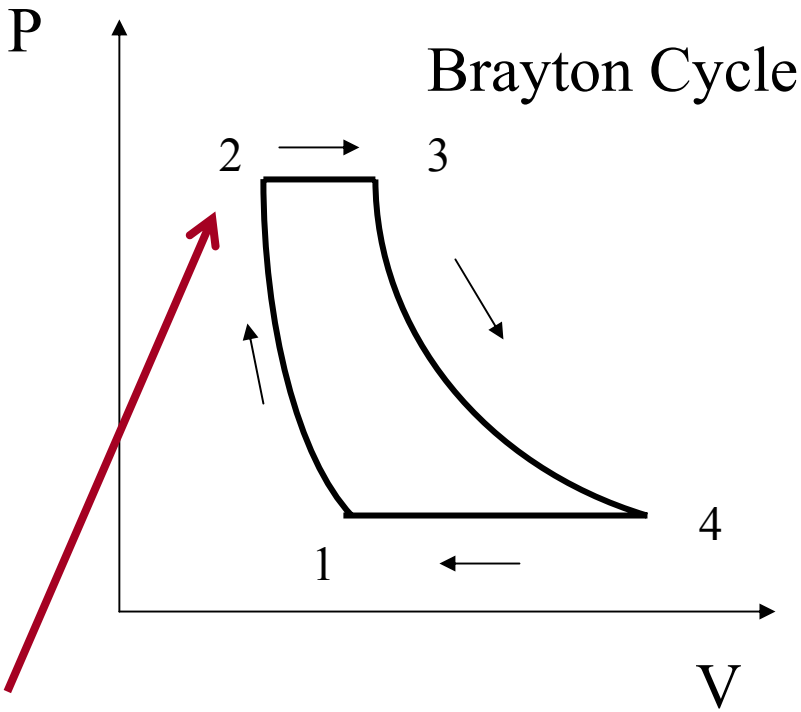
- I wanted to comment on the CFM56 vs Whittle engine.
- The CFM56 engine is …an example of the system engineering aspects of organizations and their architecture/structure and how they relate to the partitioning of the engine itself. The engine being built by CFMI, which is a consortium of GE, SNECMA and Hispano-Suiza. No single player builds the entire engine … Whittle had his fairly small shop with a collection of machinists and his lab - all probably within his domain and span of control.
- One of the other greatly complicating factors of the CFM56 vs. Whittle engine are all of the secondary power extractions that are powered from today's engines, which have an enormous impact on the engine's performance
- SyE makes this possible today; whereas Whittle was focused on a revolutionary powerplant for propulsion.

Evolution of Gas Turbine Engine Performance



Adapted from Koff, B. L. "Spanning the World Through Jet Propulsion." AIAA Littlewood Lecture. 1991.

Performance Drives Complexity

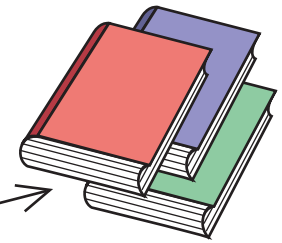


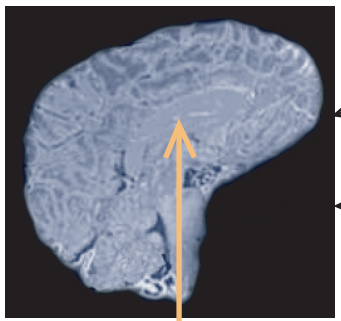
Consequently, complex secondary flows required

Need higher and higher turbine inlet temperatures for efficiency

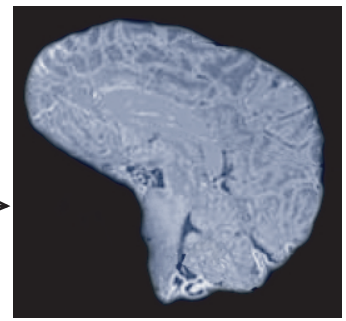
$$\eta = 1 - \frac{T_1}{T_2} = 1 - \left(\frac{p_1}{p_2}\right)^{\gamma/(\gamma-1)}$$

Cognitive Parameters





rate of learning = about 5,000 chunks / yr



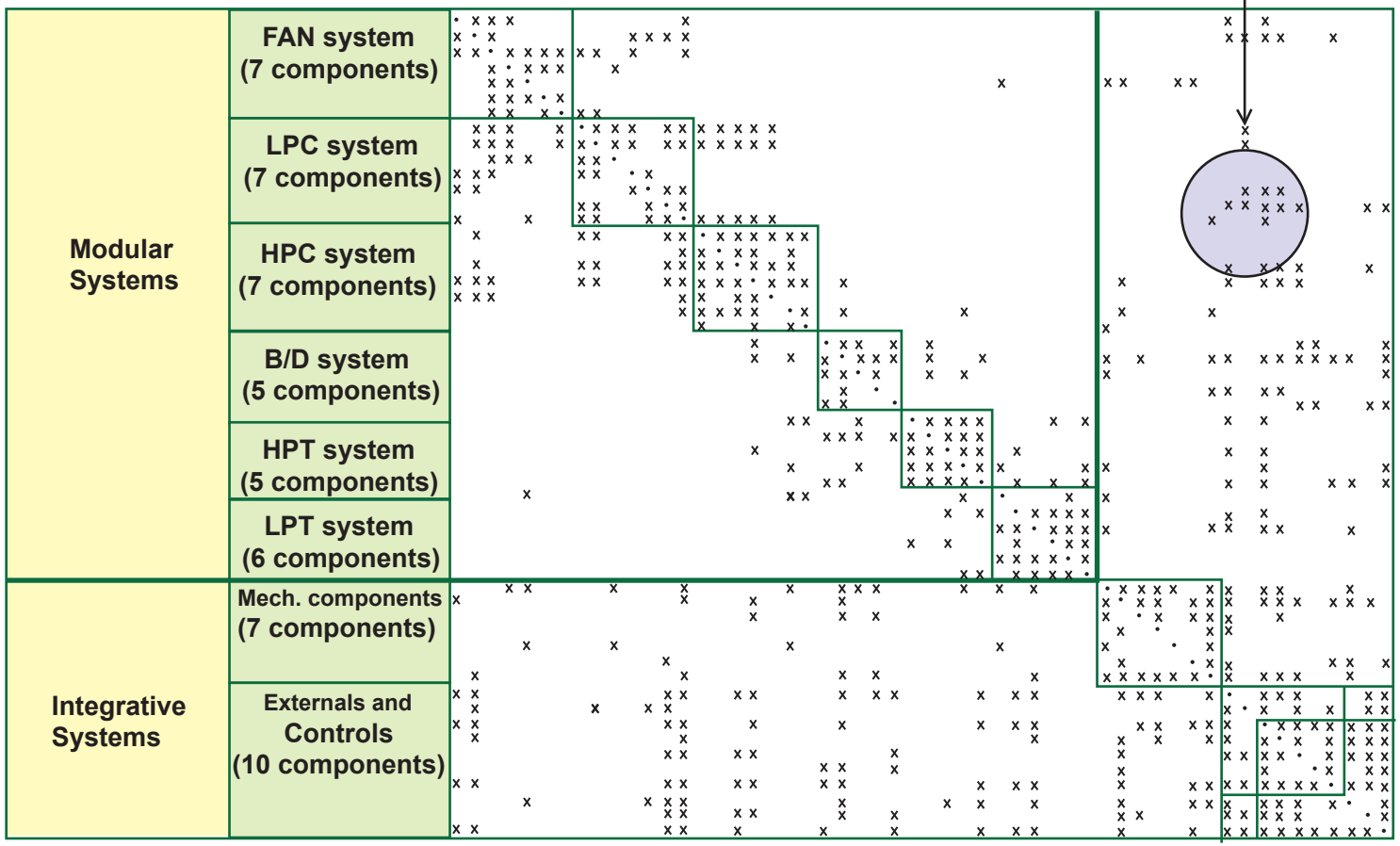
$$\frac{\text{connections within a brain}}{\text{connections between two brains}} \approx 10^6$$

working memory = 7 ± 2 chunks

expert knowledge $\approx 50,000$ chunks

Adapted from Simon, Herbert, 1969, *Sciences of the Artificial*, MIT Press.

Secondary flow systems and controls cause a risk of rework



Design Interface Matrix

Adapted from Sosa, Manuel E., S. D. Eppinger, and C. M. Rowles, 2000, "Designing Modular and Integrative Systems", *Proceedings of the DETC*, ASME.

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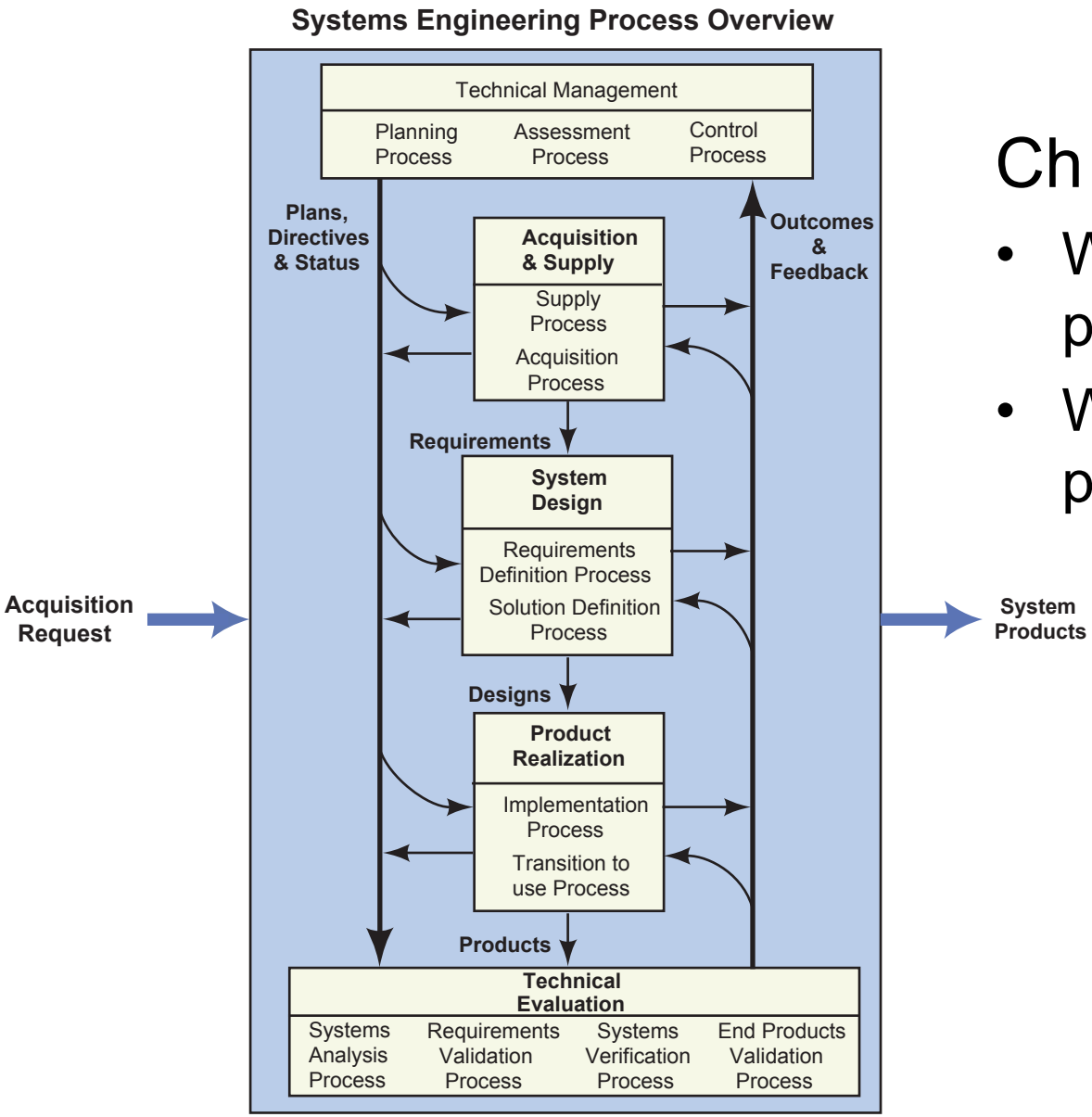
Questions to Probe Chapter 2

According to INCOSE:

- When did SE emerge as a separate branch of engineering?
- What are some of the key functions of SE?
- Who should carry out the SE function?
- What fraction of the program budget should be spent on SE?
- Do SE methods apply to “smaller” systems?

INCOSE

International Council on Systems Engineering



Ch 4 Questions

- Who participates in each process?
- What emerges from each process?

Systems Engineering Process

According to INCOSE, the basic Systems Engineering process tasks are:

1) Define the System Objectives
2) Establish the Functionality
3) Establish the Performance Requirements
4) Evolve Design and Operation Concepts
5) Select a Baseline
6) Verify that the Baseline Meets Requirements
7) Validate that the Baseline Satisfies the User
8) Iterate the Process through Lower Levels

INCOSE

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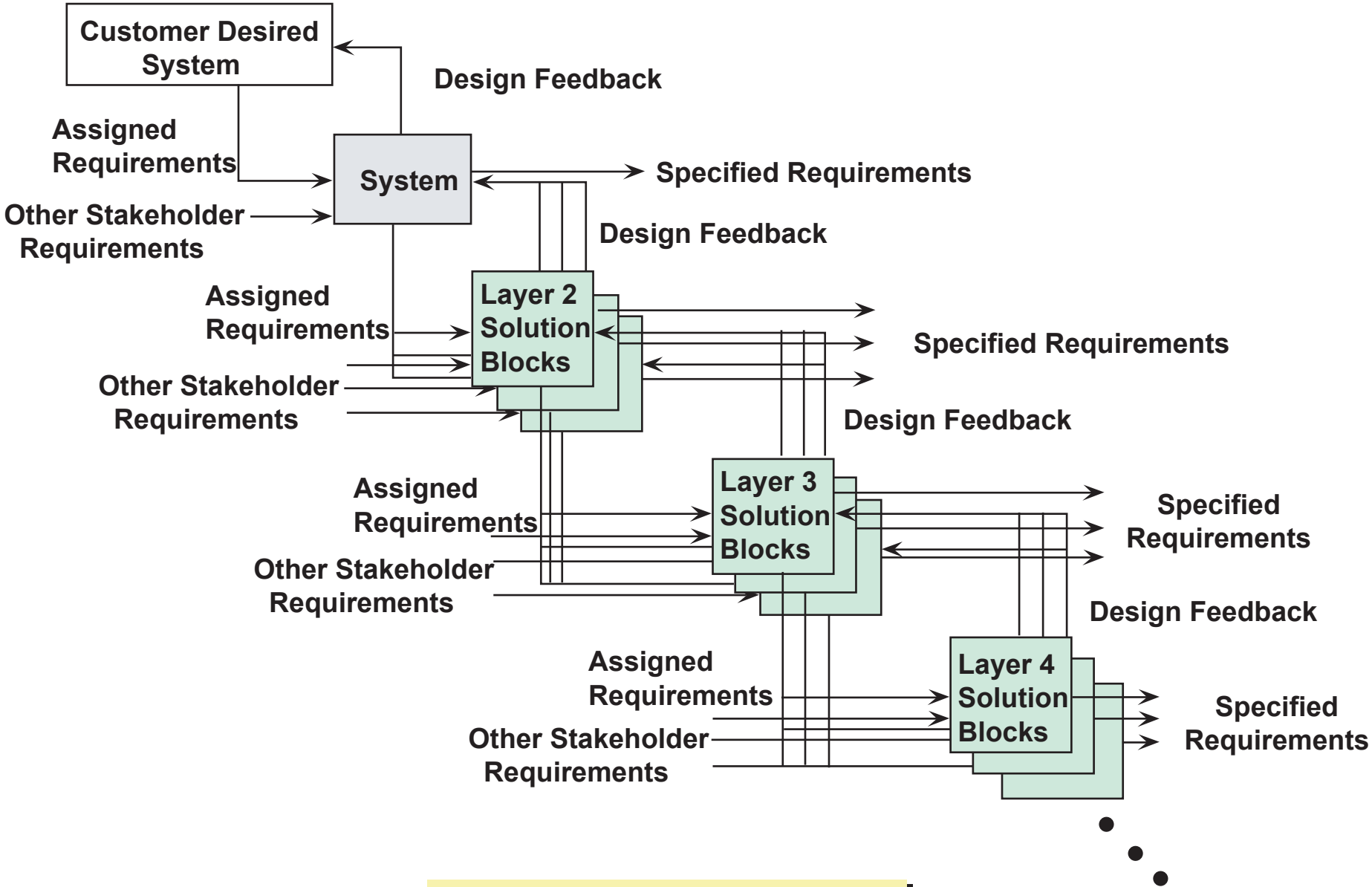
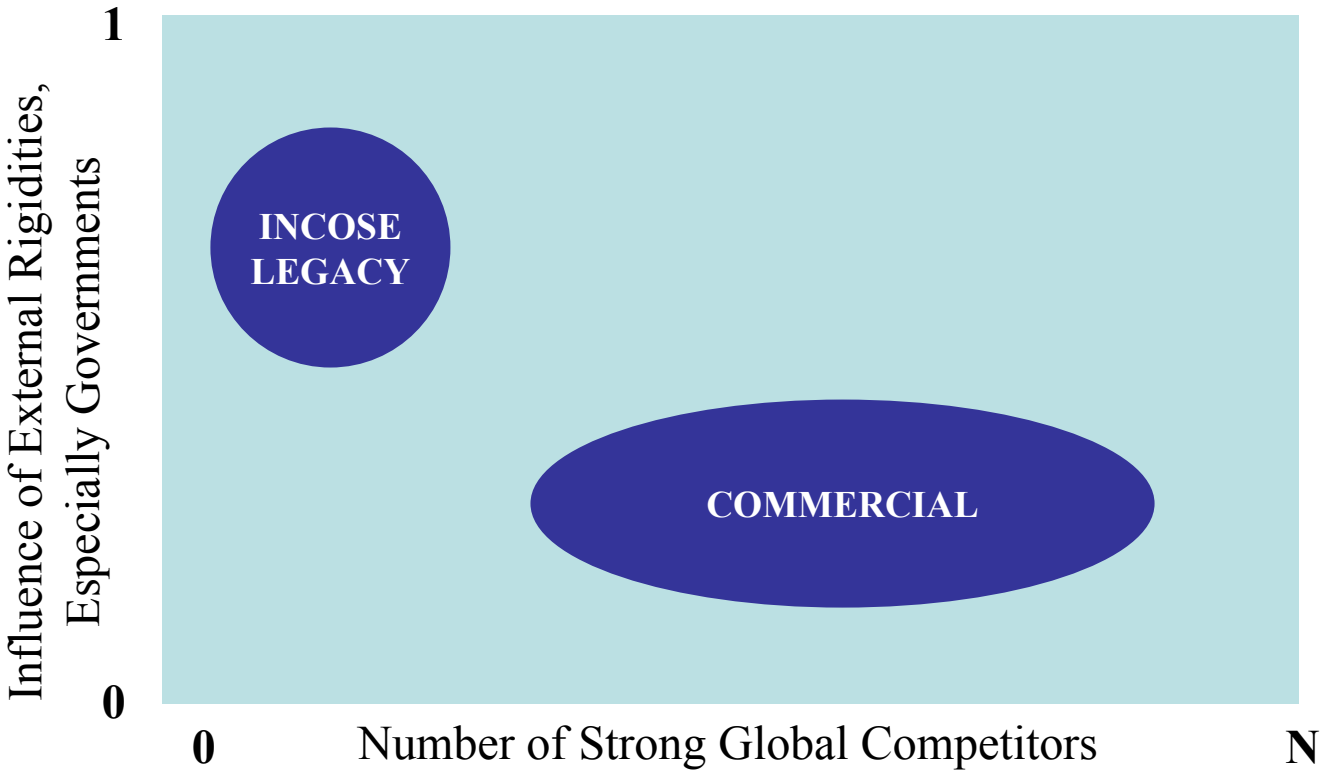


System Design Hierarchy

Discussion Point

Under what conditions should “commercial” enterprises be plotted in the upper left quadrant?



Asking Better Questions

Questions	Better Questions
• What is the best way to store and access our inventories?	• ?
• How can we accurately predict our field reliability?	• ?
• Another example?	

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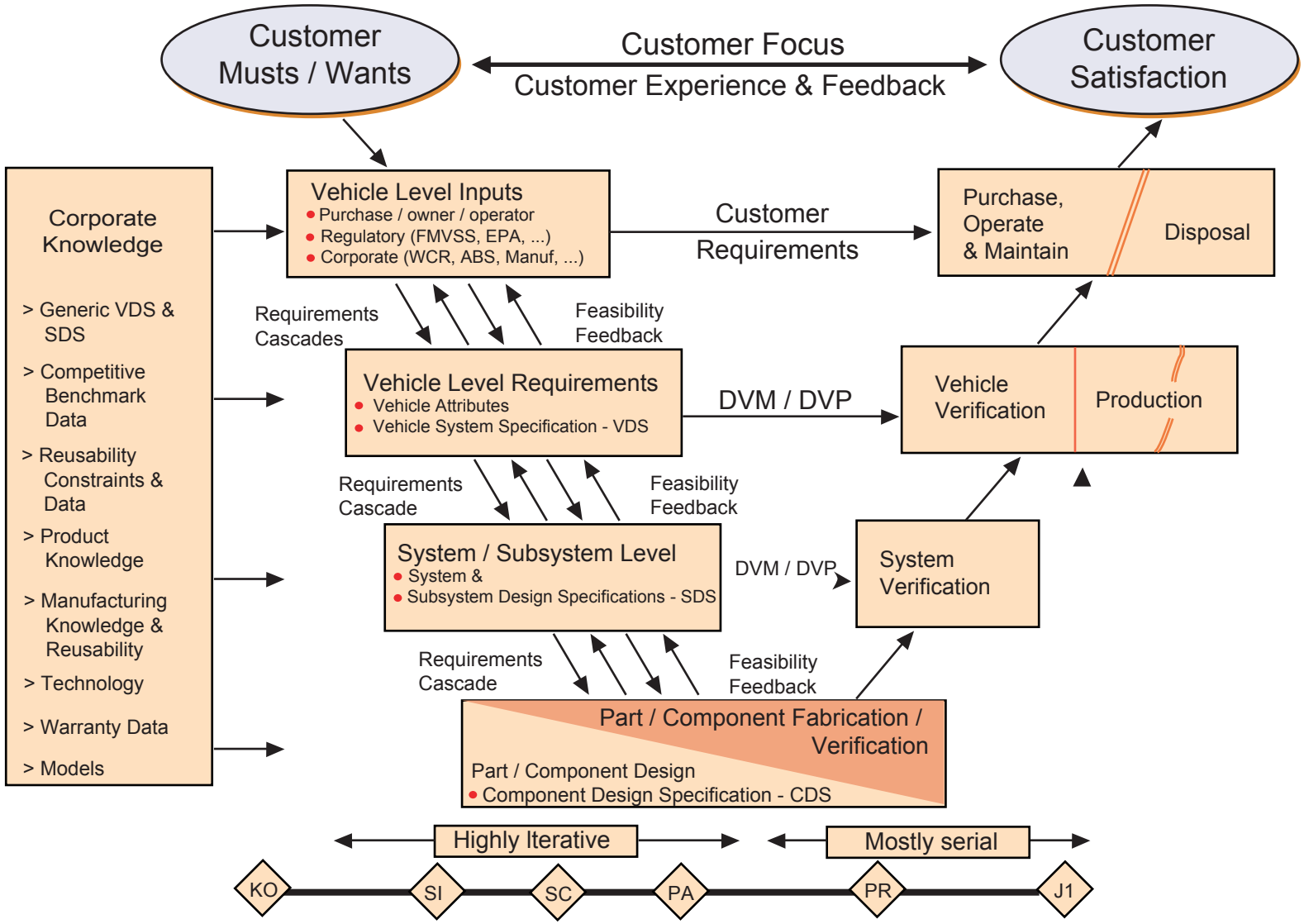
Assignment #2
Frameworks

- Due: Thursday 6/17 at 8:30AM
- Self select teams of 2-4 (preferably at the same company or in the same industry)

1. Select a company and write about the tools/processes related to RCI at the company
2. Do a value stream map of any value creating process of your choice
3. Develop an example of a set-based approach

System Engineering Implemented in FPDS



Adapted from Ford Motor Company.

Next Steps

- Do the reading assignments for session #3
  - Womak_Lean Thinking Introduction.pdf
  - Stanke_Murman_Lifecycle Value in Aerospace.pdf
  - Ward_The Second Toyota Paradox.pdf
- If you want, begin Assignment #2
- Come to session #3
  - 8:30AM Tuesday 15 June