Set-Based Concurrent Engineering: Cultural Aspects and Benefits

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Set-Based Development

Lean approach  “Find best solution”

Traditional approach  “Iterate to make it work”

Start  “Concept Selection Freeze”

Reduced Time

Set Based CONVERGENT MODEL

Point Based ITERATIVE MODEL

Synthesize

Analyze

Modify
A Simple Example: Point-Based

Setting up a meeting using the point-based model

A: My best time is 10:00 Can you make it?

B: No, I can’t. How about 2:00?

A: Uh, already booked. Can you meet at 3:00?

B: No, 3:00 is bad. 9:00?
A Set-Based Approach

Now setting up the meeting by communicating about sets

A: I can meet 10:00 - 1:00 or 3:00 - 5:00
Can you make any of these times?

B: Let’s meet 12:00 - 1:00
Traditional Concept Exploration

- The ‘best’ solution for each system is chosen
- The ‘best’ solution may not lead to the ‘best’ overall solution as compatibility between sub-systems are not understood
- A lot of iterations later to ‘fix’ the interface issues & trade-offs that typically arise
“Accelerated” Concept Exploration Approach

- Pressure to move quickly into developing the solution
- Don’t fully explore the design space
- Rush to a “winner” with minimal knowledge
- Rework the design in the development phase
Challenges with the Point-Based Approach

- Causes us to pass a solution around, each member making changes
- Each change causes further changes and we never get a clear picture of the possibilities.
Set-Based Philosophy

Generating multiple potential solutions to a design or engineering challenge and working through a convergence process to achieve the best possible solution.

- Dr. Al Ward

Pursue innovative ideas while managing uncertainty in design.
Set-Based Concurrent Engineering (SBCE)

- Develop enough knowledge to understand which alternatives to eliminate
- Keep building knowledge around the remaining alternatives over time and keep eliminating weaker alternatives
- Use integration events to ensure compatibility
- Final selection is ultimately made with significant amount of accumulated knowledge
- High confidence in selected solution to go into detailed design
“I don’t play my 11 best players. I play my best 11 players”

Bear Bryant
Former Alabama Football Coach
Set-Based Perspective

System Integrator & teams look for intersections between feasible sets of alternatives to arrive at best system-level solution.
SBCE EXERCISE

Cultural Aspects and Benefits
Set-Based Simulation Exercise
Card Game: Round #1

Teams of 5 players
Objective: Try to have the “optimal hand” with 5 cards
Set-Based Simulation Exercise
Card Game: Round #1

Scoring:
- Face cards = 10 points
- Other cards = face value (e.g. ace=1,2,3,4..9)

Bonus:
- All the same color (black or red) = +10 points
- All the same suit (spade, heart, etc) = +25 points
- 4 of one kind (e.g. aces, jacks, etc) = +50 points
- 5 all in sequence in same suit (4,5,6..) = +50 points
Set-Based Simulation Exercise
Card Game: Round #1

Game play:
- 5 total plays
- Each player initially selects 1 card from the deck
- Up to 4 additional plays where, team assesses score and may:
  - Stop and keep the existing hand as-is
  - Keep some cards, reject others and re-draw from deck

Costs:
- -1 for each initial draw (play 1)
- -3 for each additional draw (plays 2,3)
- -5 for each additional draw (plays 4,5)
Example of play...

Final Hand: = 46 + 50 – 27 = 69 points
Round #1: Now let’s play…

Assign a scorekeeper in your team to capture score throughout the exercise

Play the game twice to compare results

Provide final scores and number of iterations to the facilitator
Set-Based Simulation Exercise
Card Game: Round #2

Scoring:
• Face cards = 10 points
• Other cards = face value (e.g. ace=1,2,3,4..9)

Bonus:
• All the same color (black or red) = +10 points
• All the same suit (spade, heart, etc) = +25 points
• 4 of one kind (e.g. aces, jacks, etc) = +50 points
• 5 all in sequence in same suit (4,5,6..) = +50 points
Set-Based Simulation Exercise
Card Game: Round #2

Game play:

• Each player initially draws 5 cards from the deck
• Team members compare “sets” of cards to create the highest possible scoring hand

• Costs:
  • -3 for each player for 5 draws
  • Total Team cost = - 15 points
Round #2: Let’s play again…

Assign a scorekeeper in your team to capture score throughout the exercise

Play the game twice to compare results

Provide final scores to the facilitator
Debrief: Group Discussion
Discussion points

Compare scores – within teams and between teams. What do you see?

What are the benefits you saw between the first and second rounds?

What cultural behaviors did you observe in the first versus the second rounds?
Front-load to thoroughly explore alternatives
SBCE Approach: Getting Started

**PREPARATION**
Scope, objectives, participants, data

**WORKSHOP**
(initialization of SBCE)
2 – 3 days dedicated teamwork

**FOLLOW UP**
Action Plans
Integration Events
Knowledge Capture
Working in Sub-Groups

Document each concept on 1 page
Evaluation and Compatibility

• Present Concepts
• Evaluate Compatibility
• Eliminate weaker alternatives
Convergence Phase & Set Expansion
Kentou (Study) Phase convergence

WORKSHOP

Convergence Phase

- Convergence Points/Integration events
- Cut-off date for convergence by each sub-group
Hedging: Innovation vs “Failure”

Simultaneous pursuit of multiple alternatives provides robustness against engineering failure.

• Problem is broken down as far as possible, and multiple approaches pursued to each sub-problem
• Pursue both radically innovative and conservative approaches (Backup) in parallel
• Decision dates set to show success based on knowledge generated for innovative/radical alternatives
Set-Based Concurrent Engineering

Integration Events
- Determine the cadence for the integration events
- Determine the decisions to be made at each event
- Identify knowledge needed to make the decisions
- System Integrator manages to the plan

Concept Exploration

Development
Kentou (Study) Phase: Follow up

Key Points:

- Document all solutions that have been explored during the Kentou phase in a designated repository as they may be applicable to future projects.

Key success factors:

- All disciplines respect decisions made by the team.
- Avoid going back to second-guess or re-explore solutions already eliminated.
- Decisions are made when specified on the convergence plan based on the knowledge generated.
1.6 VCT - Torque / Power / Backpressure comparison

System I:
RFO 1418 / D48 / MFO 8102 / D48

System II:
RFO 1418 / D50 / MFO 8102 / D50

System III:
D50 / MFO 8102 / D50 / NFO 1429

Capturing and Re-using knowledge
Conclusions: Front-loading & SBCE

- Encourages innovation & risk-taking upfront
- Encourages growth and sharing of knowledge
- Encourages multi-discipline collaboration
- Helps better manage technical & project risks
- Reduces the probability of late (and costly) “discoveries”
- Drives a structured cadence of decision-making
- Optimizes system solutions that best meet our customers’ needs

SBCE helps to drive the cultural aspects of Lean PPD into an organization (e.g. customer first, rapid learning and continuous improvement)
Q and A

Thank You