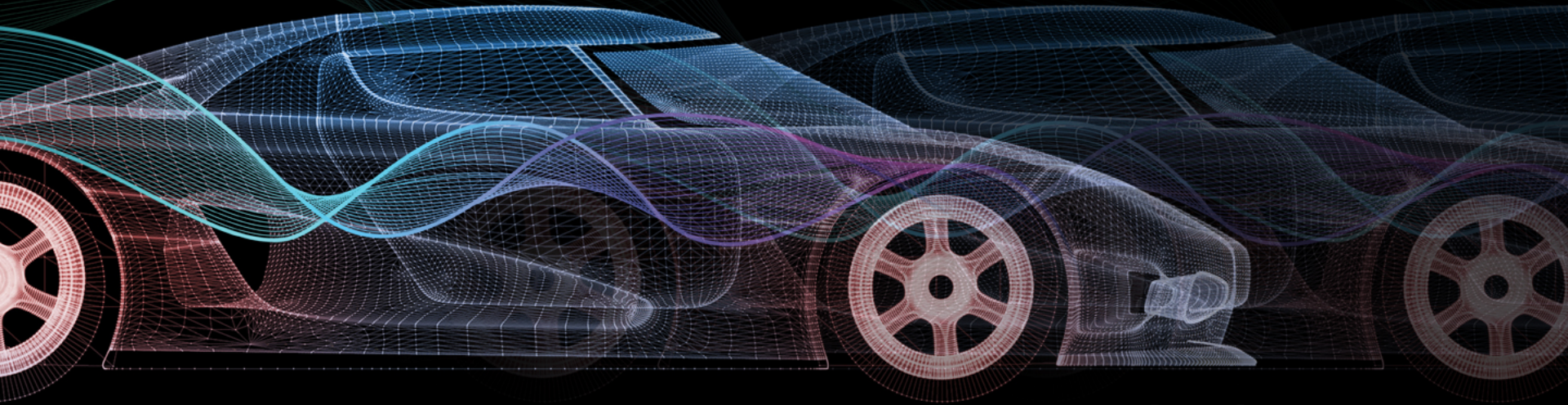


Set-Based Concurrent Engineering: Cultural Aspects and Benefits

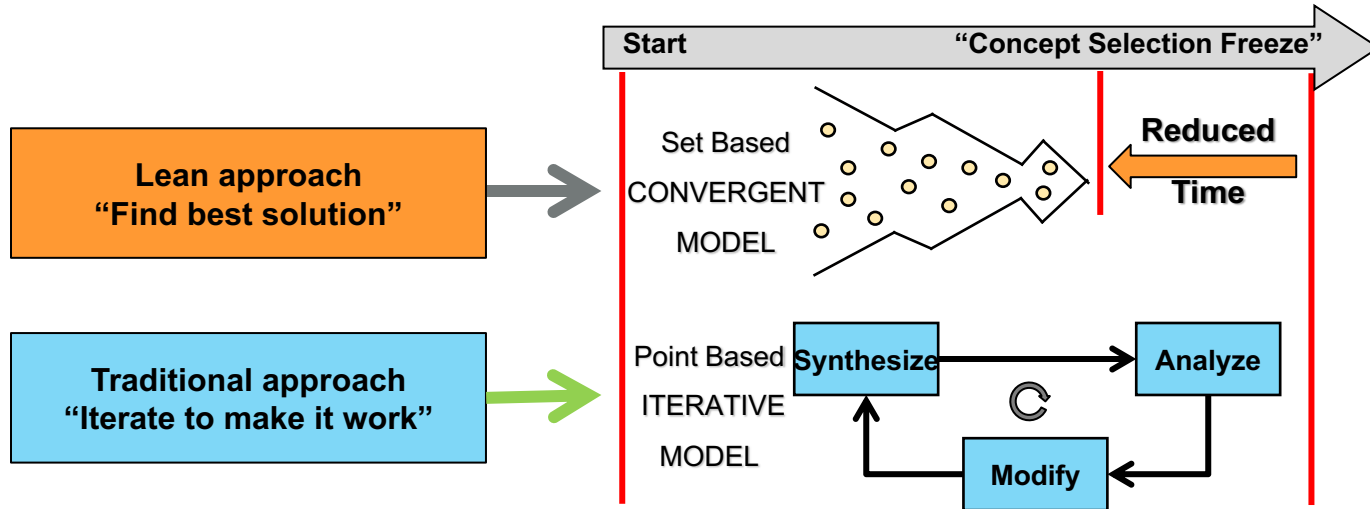
Presented By John Drogosz, Ph.D.



Designing the Future Summit 2018

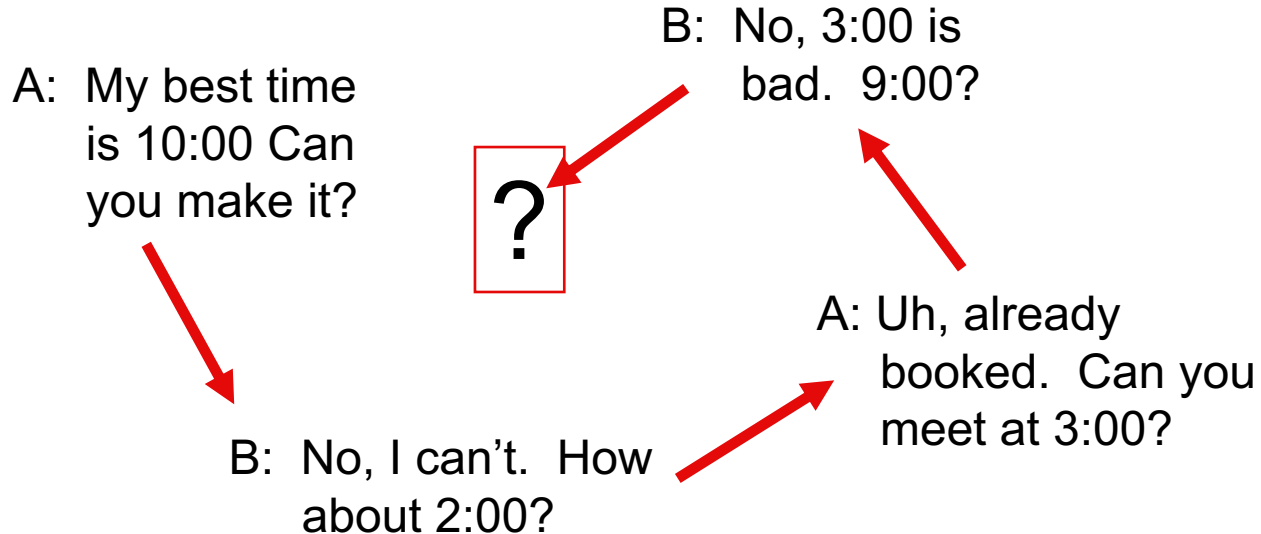
lppd  Lean Product &
Process Development

Set-Based Development



A Simple Example: Point-Based

Setting up a meeting using the point-based model



A Set-Based Approach

Now setting up the meeting by communicating about sets

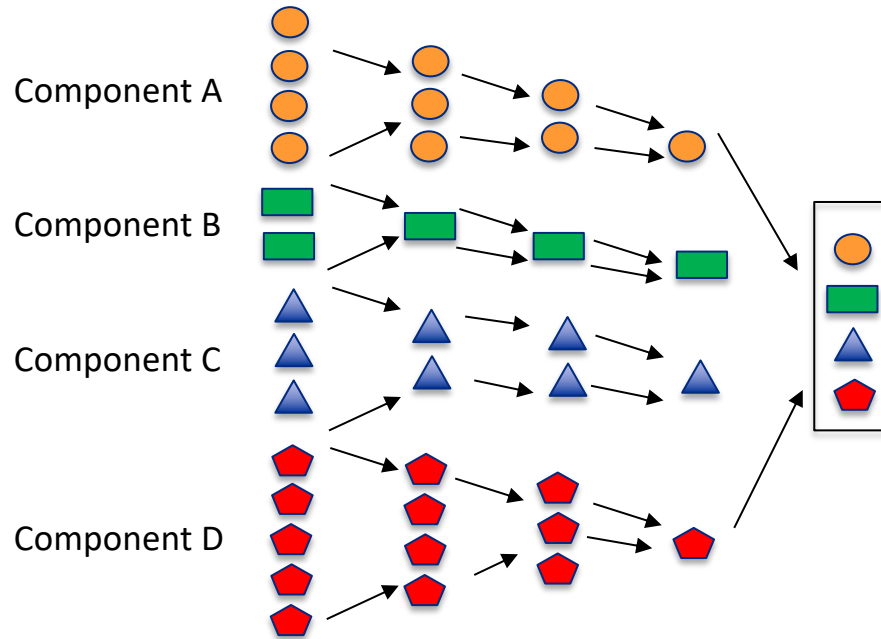
A: I can meet 10:00 -
1:00 or 3:00 - 5:00
Can you make any
of these times?



B: Let's meet
12:00 - 1:00

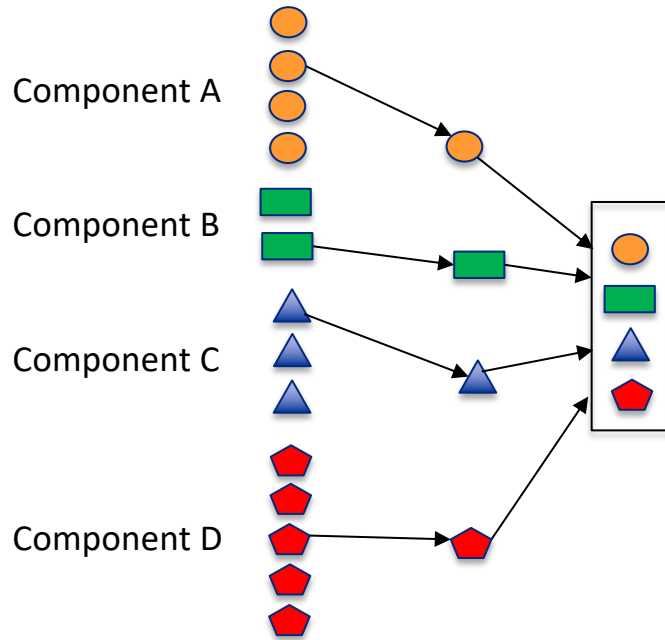


Traditional Concept Exploration



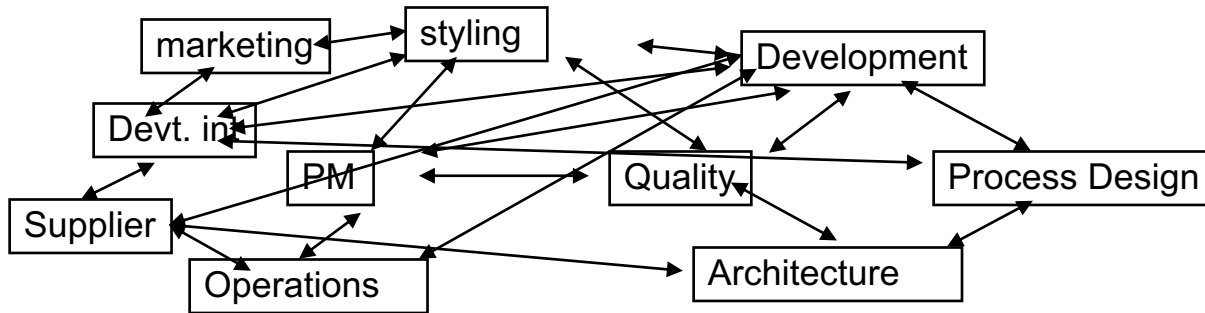
- The 'best' solution for each system is chosen
- The 'best' solution may not lead to the 'best' overall solution as compatibility between sub-systems are not understood
- A lot of iterations later to 'fix' the interface issues & trade-offs that typically arise

“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

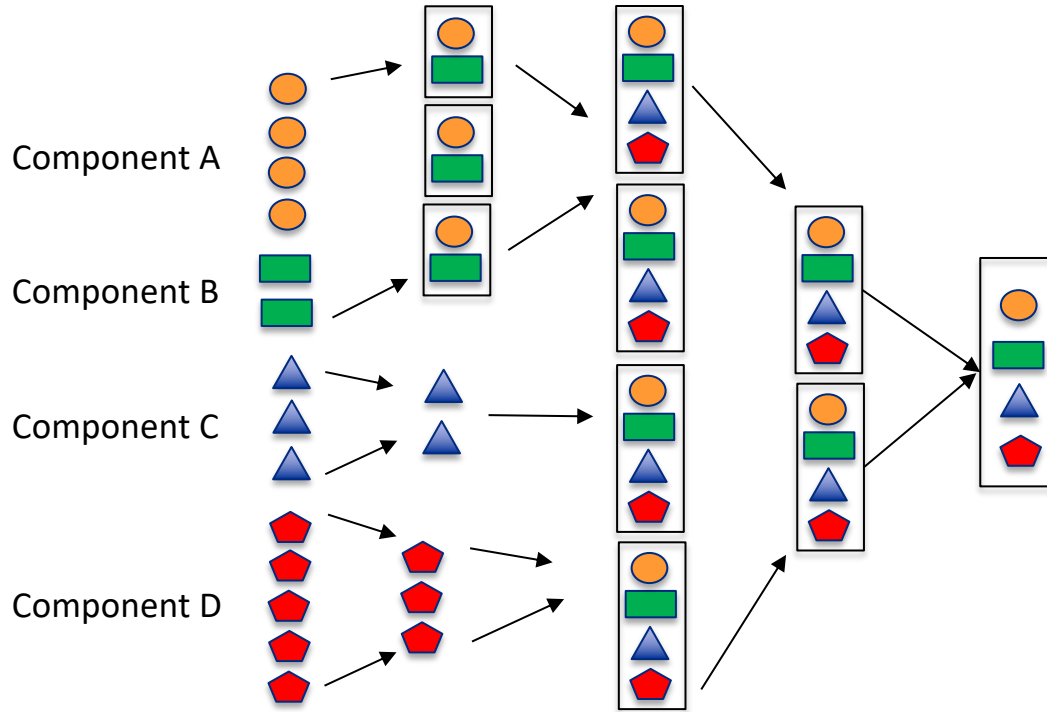
Generating multiple potential solutions to a design or engineering challenge and working through a convergence process to achieve the best possible solution.

- 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

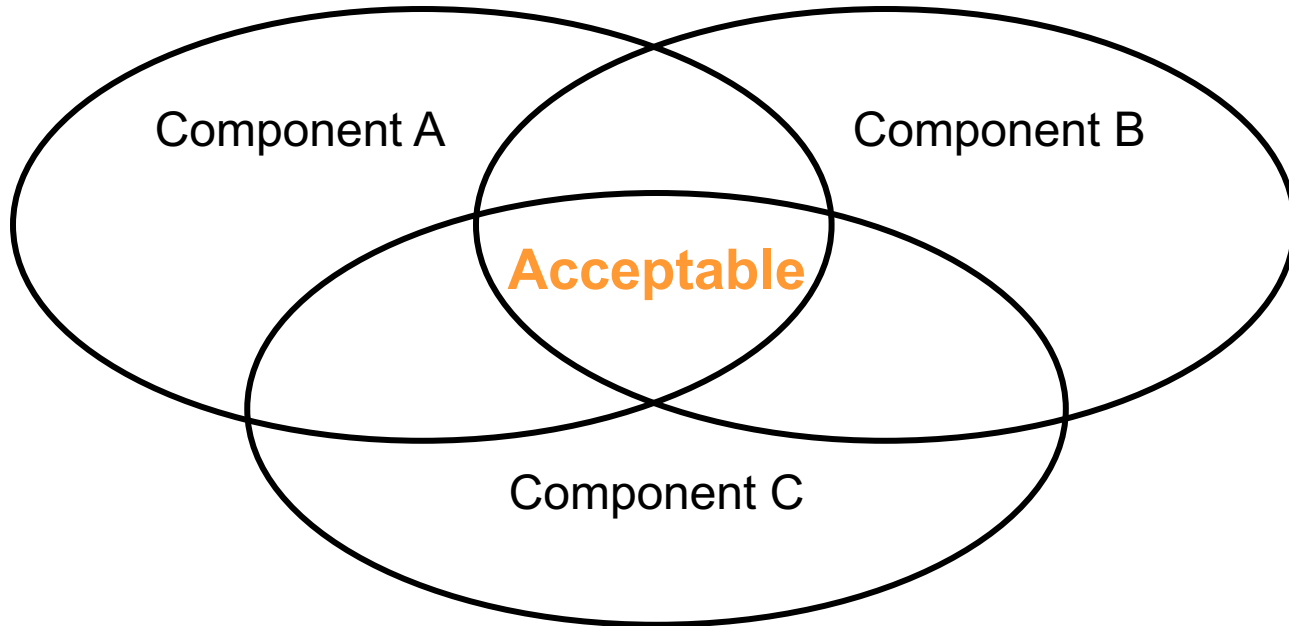
***“I don’t play my 11 best players.
I play my best 11 players”***

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...

Play 1		Cost
		-5
Play 2		
		-9
Play 3		
		-3
Play 4		
		-5
Play 5		
		-5

Final Hand: 

Score + Bonus - Cost
 = 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

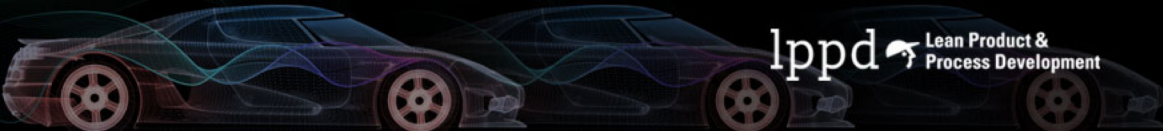
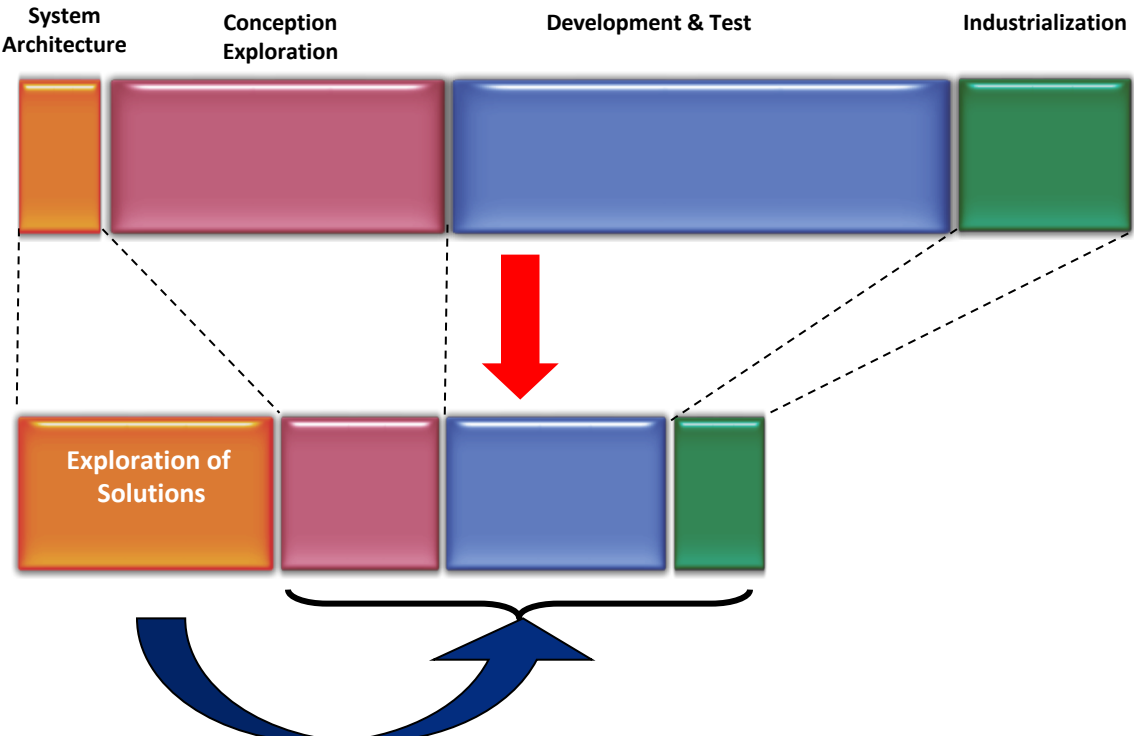
Compare scores – within teams and between teams. What do you see?

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

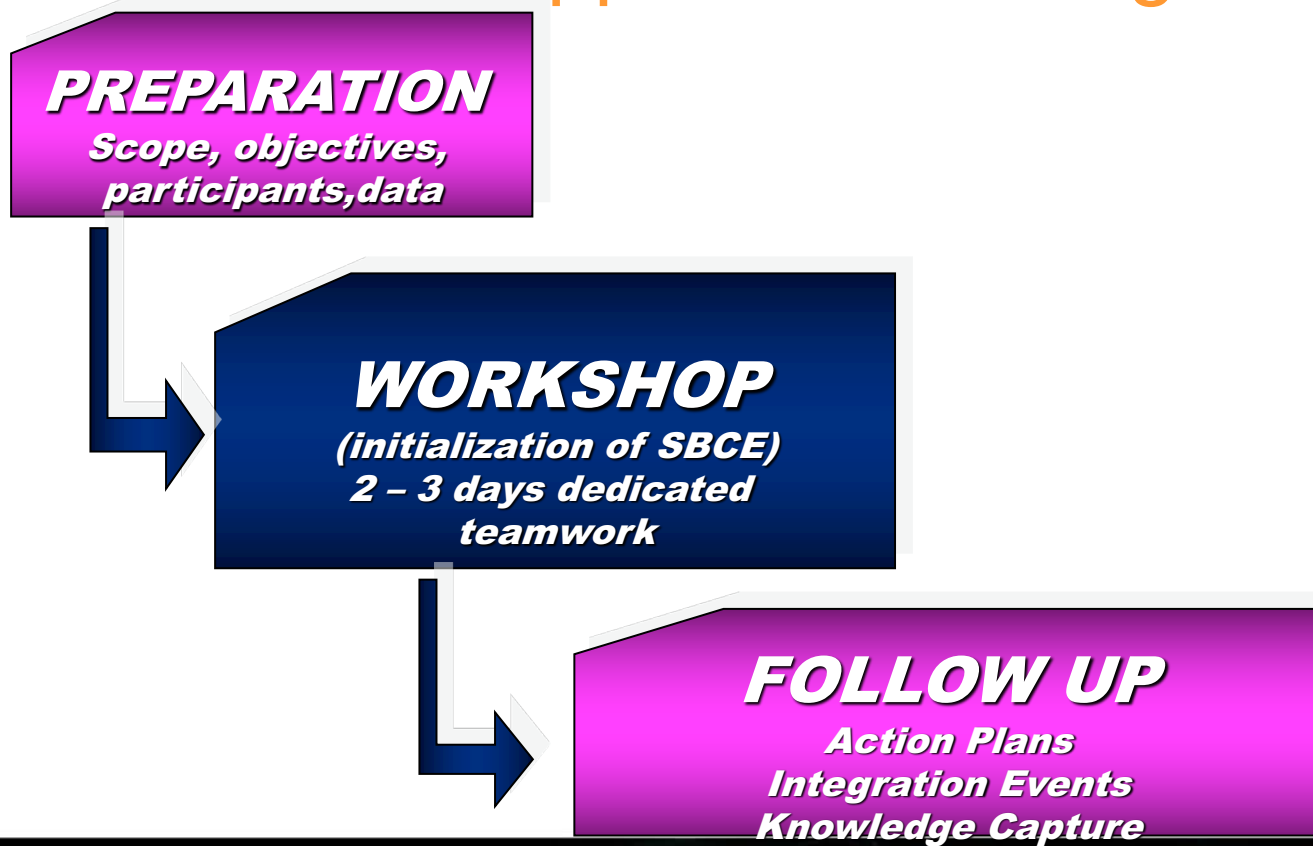
What cultural behaviors did you observe in the first versus the second rounds?



Front-load to thoroughly explore alternatives



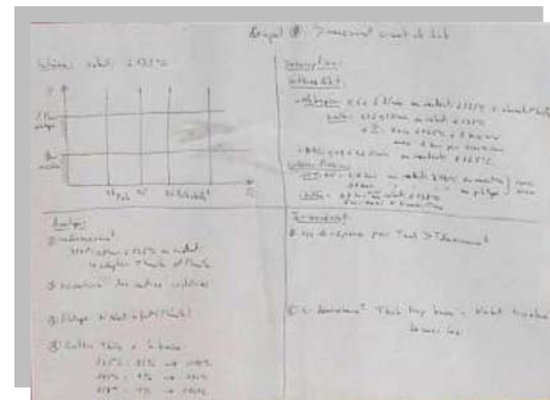
SBCE Approach: Getting Started



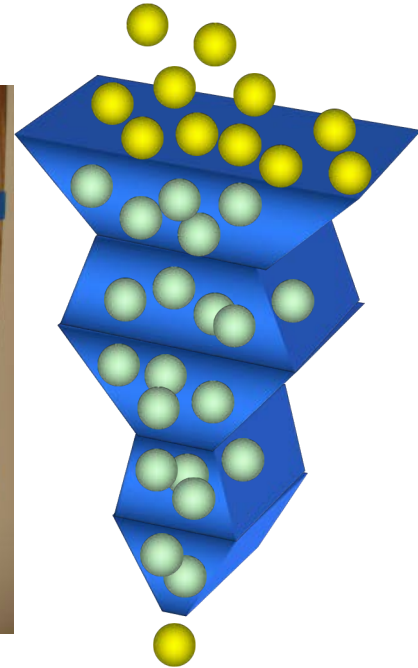
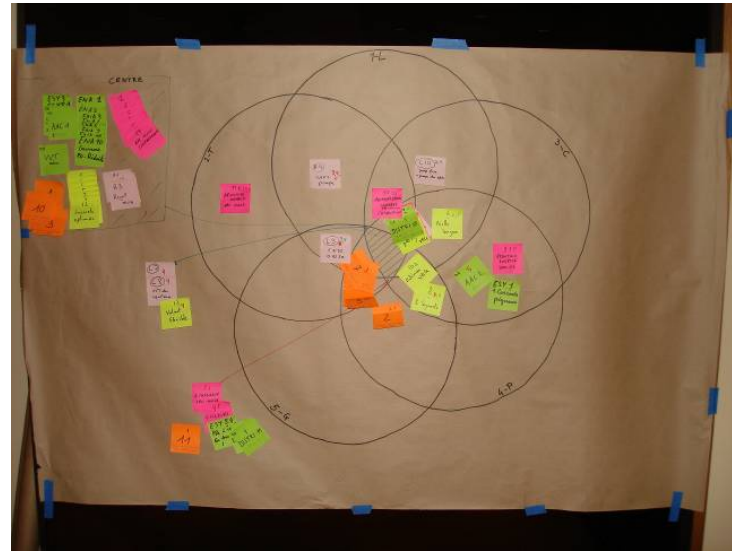
Working in Sub-Groups



Document each concept on 1 page



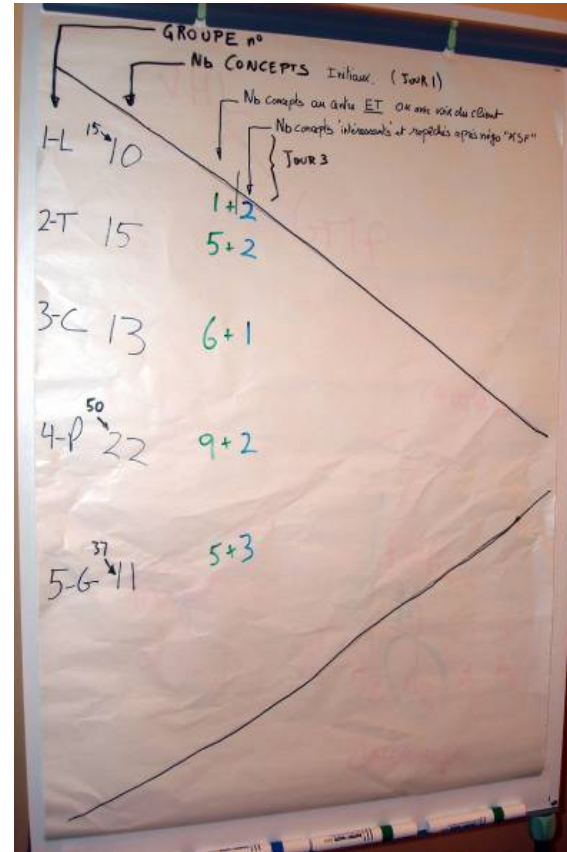
Evaluation and Compatibility



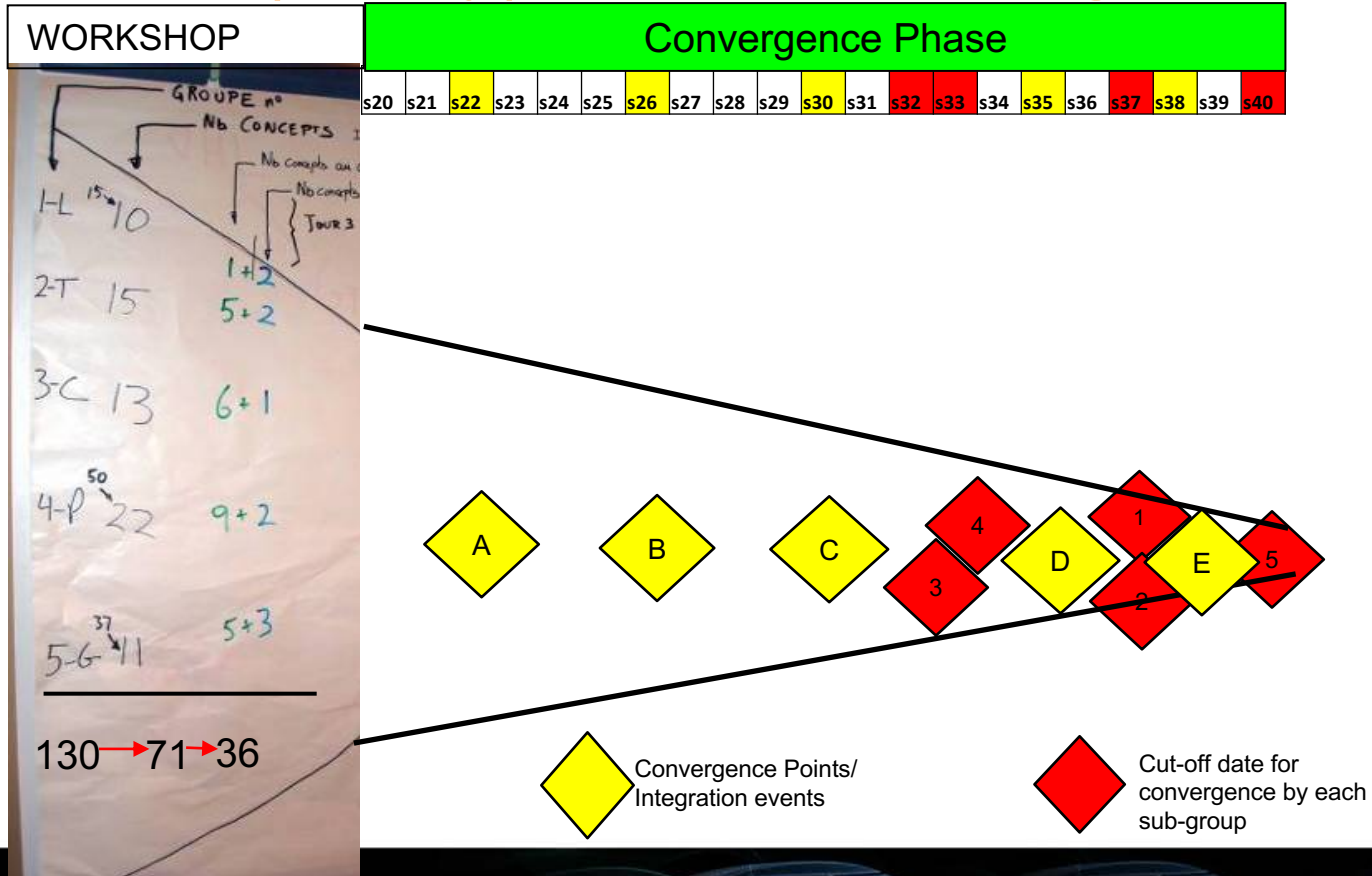
- Present Concepts
- Evaluate Compatibility
- Eliminate weaker alternatives



Convergence Phase & Set Expansion



Kentou (Study) Phase convergence



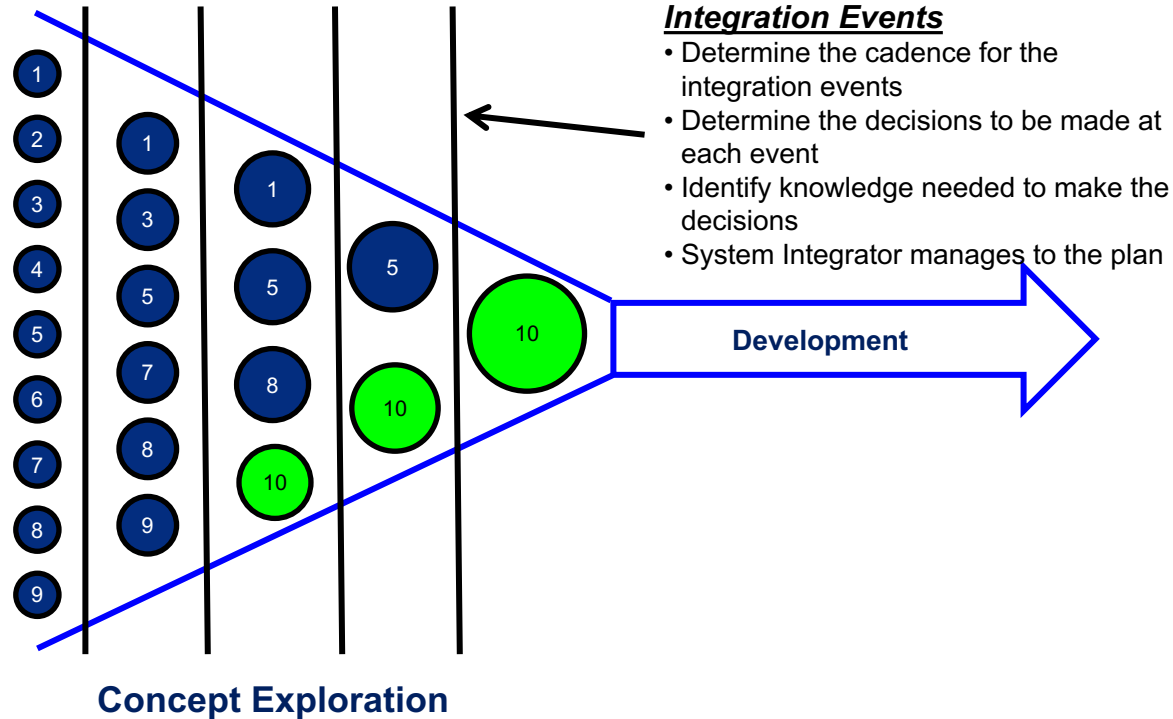
Hedging: Innovation vs “Failure”

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



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



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

