

Detection of Teamwork Behaviors as Meaningful Exploration of Tradespace during Project Design

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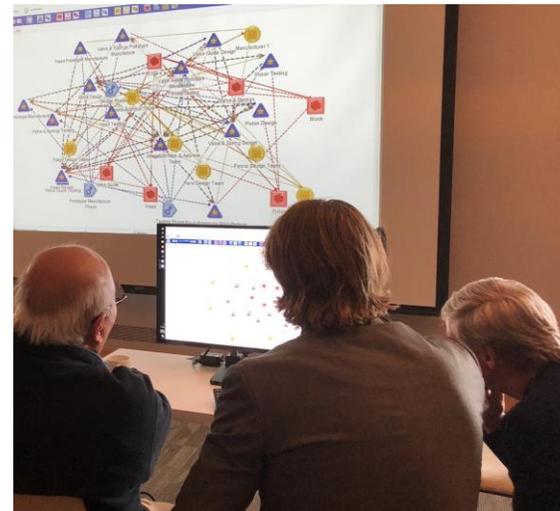


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Team of Teams working on Systems of Systems

Measuring Performance for Complex Problem Solving



About the Research

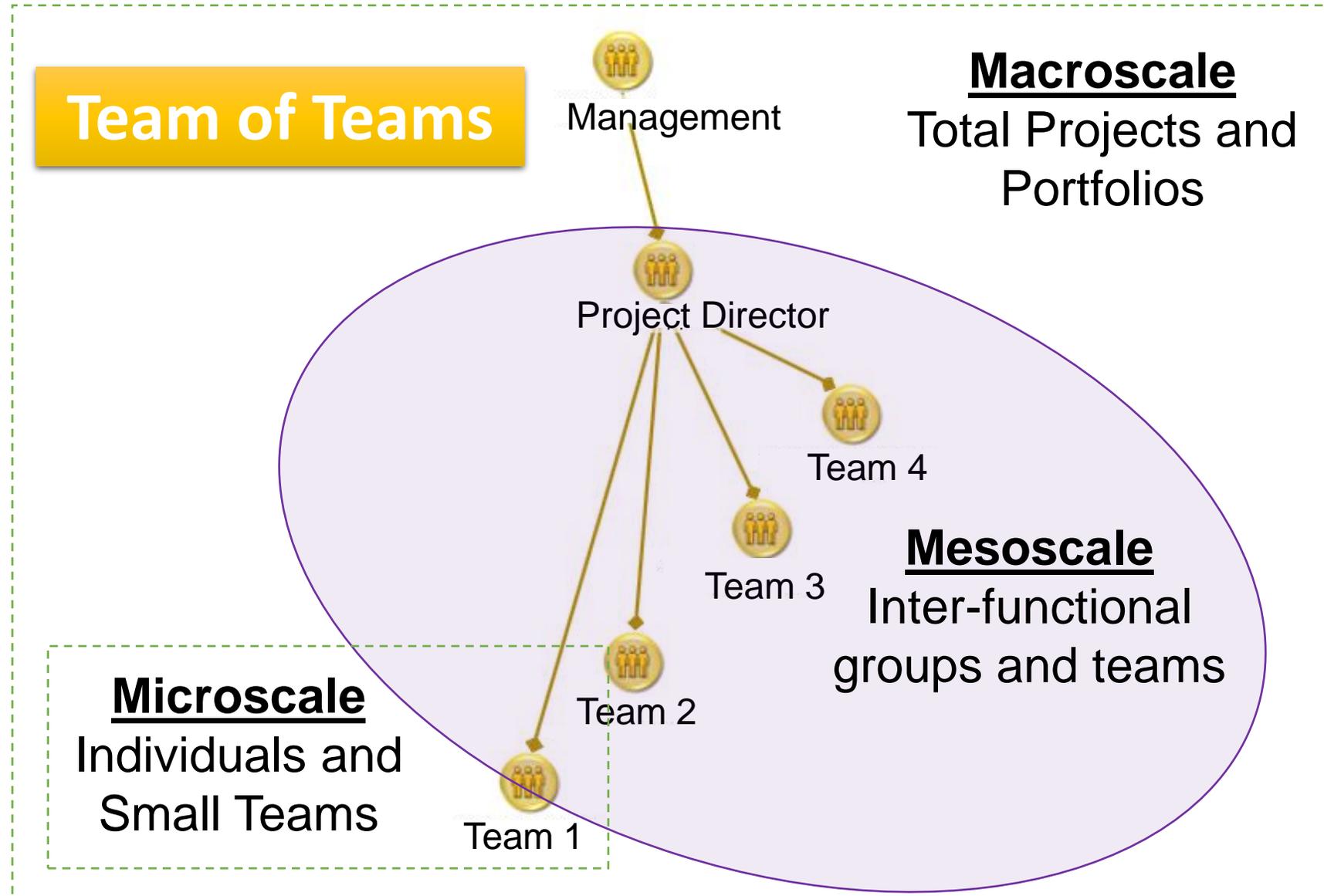


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Study of **Teamwork Behaviors** of *Team of Teams* by

- ❖ Quantifying team performance
- ❖ Visualizing patterns in making project trade-offs
- ❖ Detecting coherence in decision making

Teamwork Behaviors





Modelling Approach to Measure Team Performance

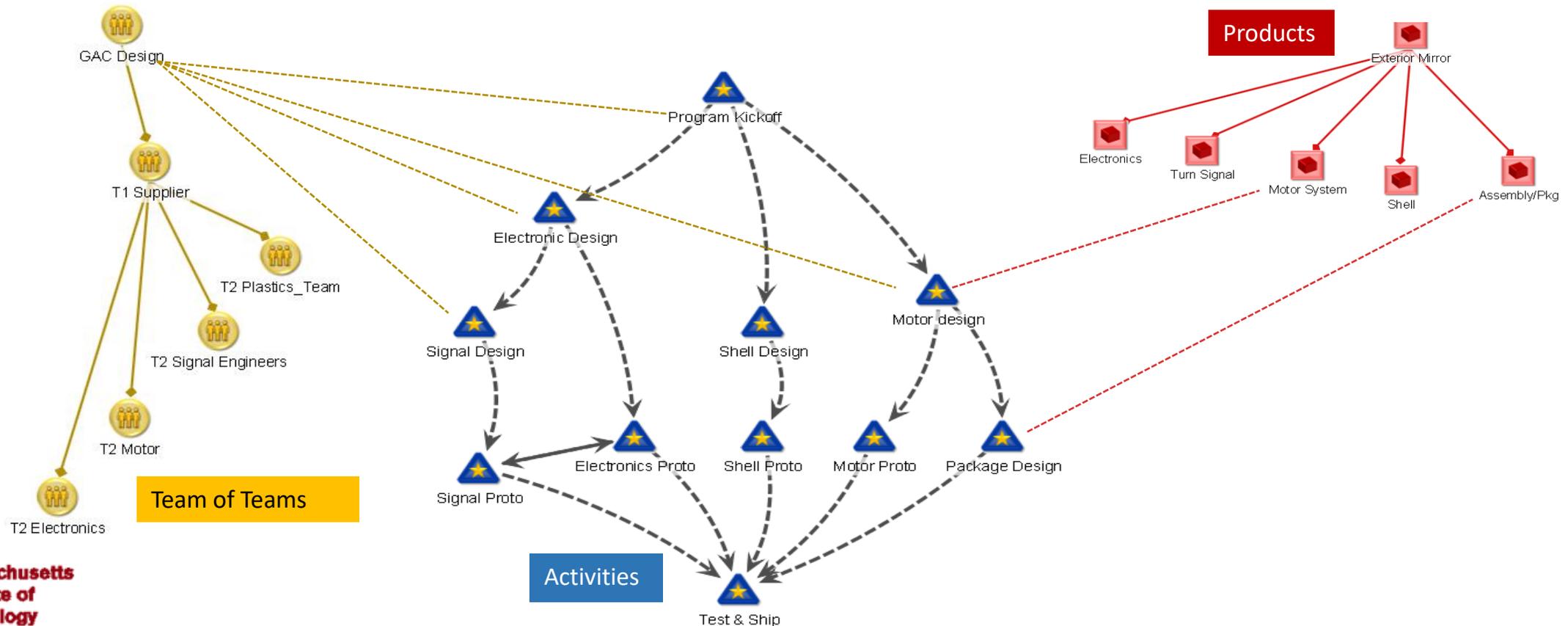
Project Design



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Model complex engineering project as a system

- ✓ Capture **dependencies** between resources, activities and products
- ✓ Simulate **project outcomes** to forecast cost and schedule



Development of Autonomous Vehicle

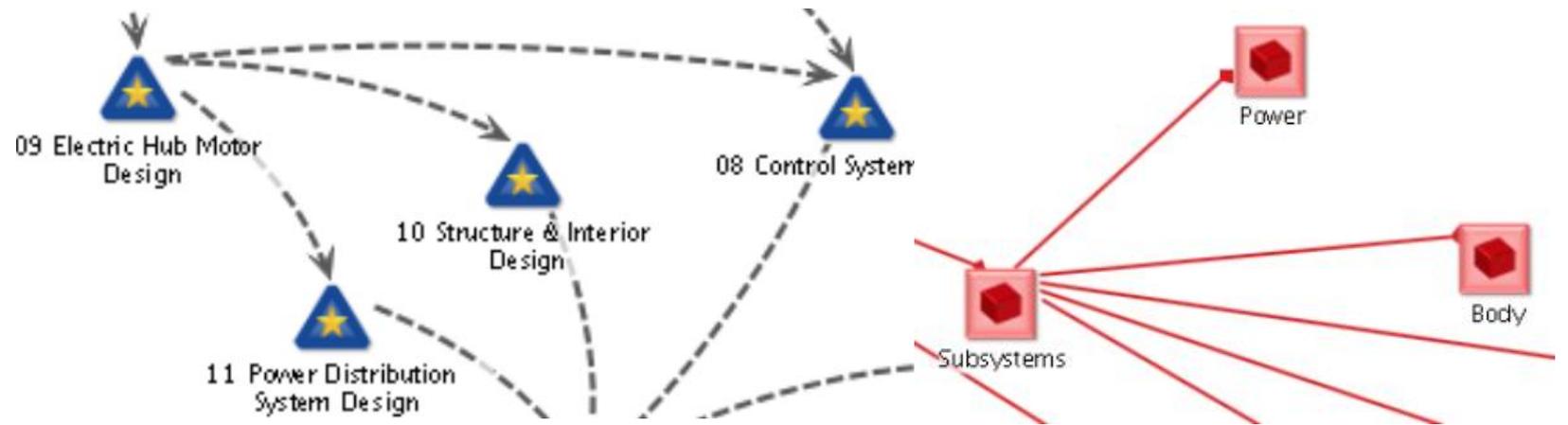
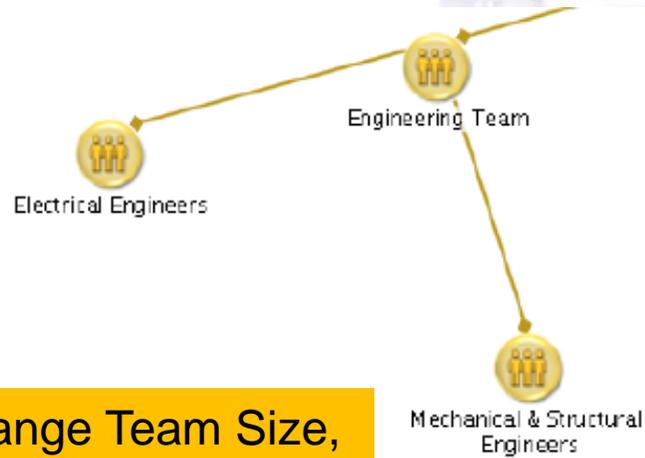


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Photo: www.mit.edu

120 Minutes Challenge
19 Design Groups
1 Common Baseline



Change Team Size,
Location, Abilities

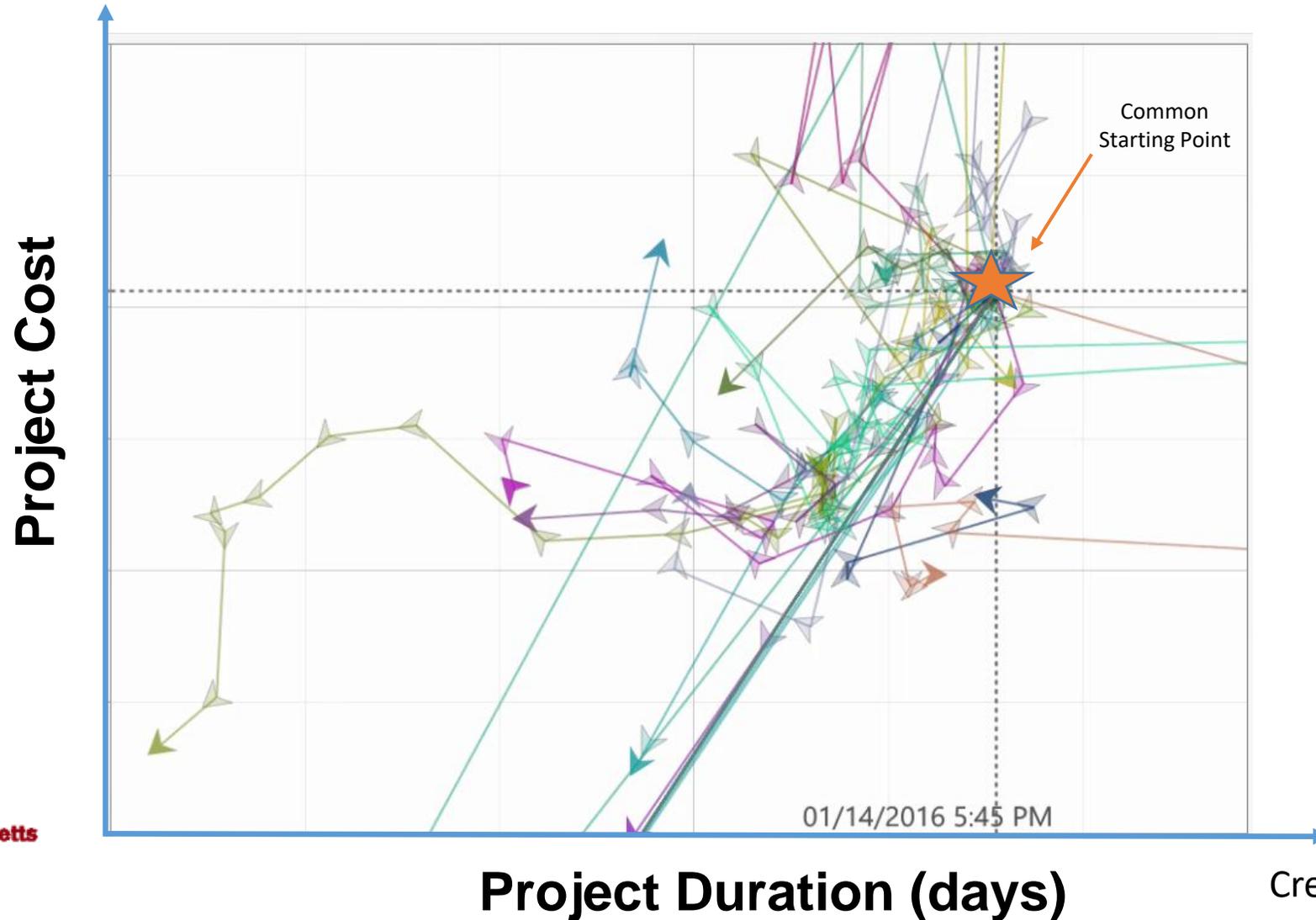
Add / Remove Activities, Change
Complexity and Dependencies

Add/ Remove
Products

Tradespace Exploration



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Defining Team Performance



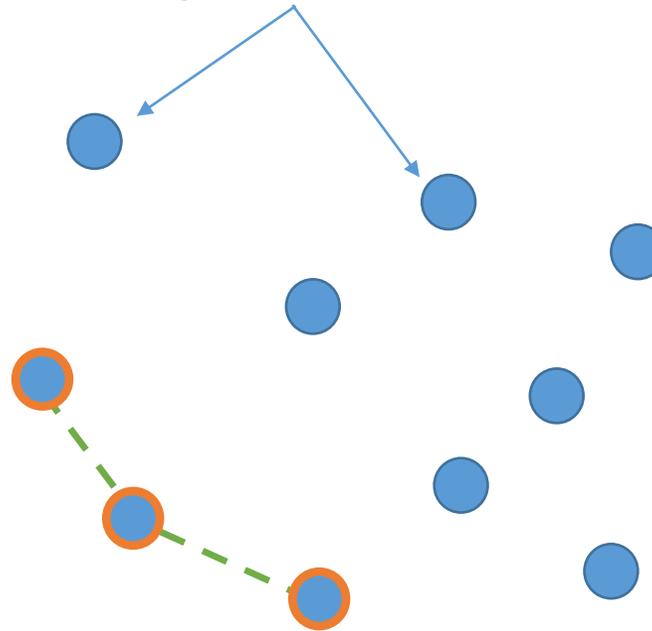
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Tradespace Exploration

Cost



Project Outcomes



Pareto Frontier:

Region of Non-Dominated Solutions

Non-Dominated Solutions:

Not out-performed by others in both cost and duration

Utopia Point



A **better performing** Design Group has:

- ✓ More non-dominated project outcomes
- ✓ More project outcomes on a Pareto Frontier

Duration (Days)



Methodology to Quantify Team Performance

Data Analysis

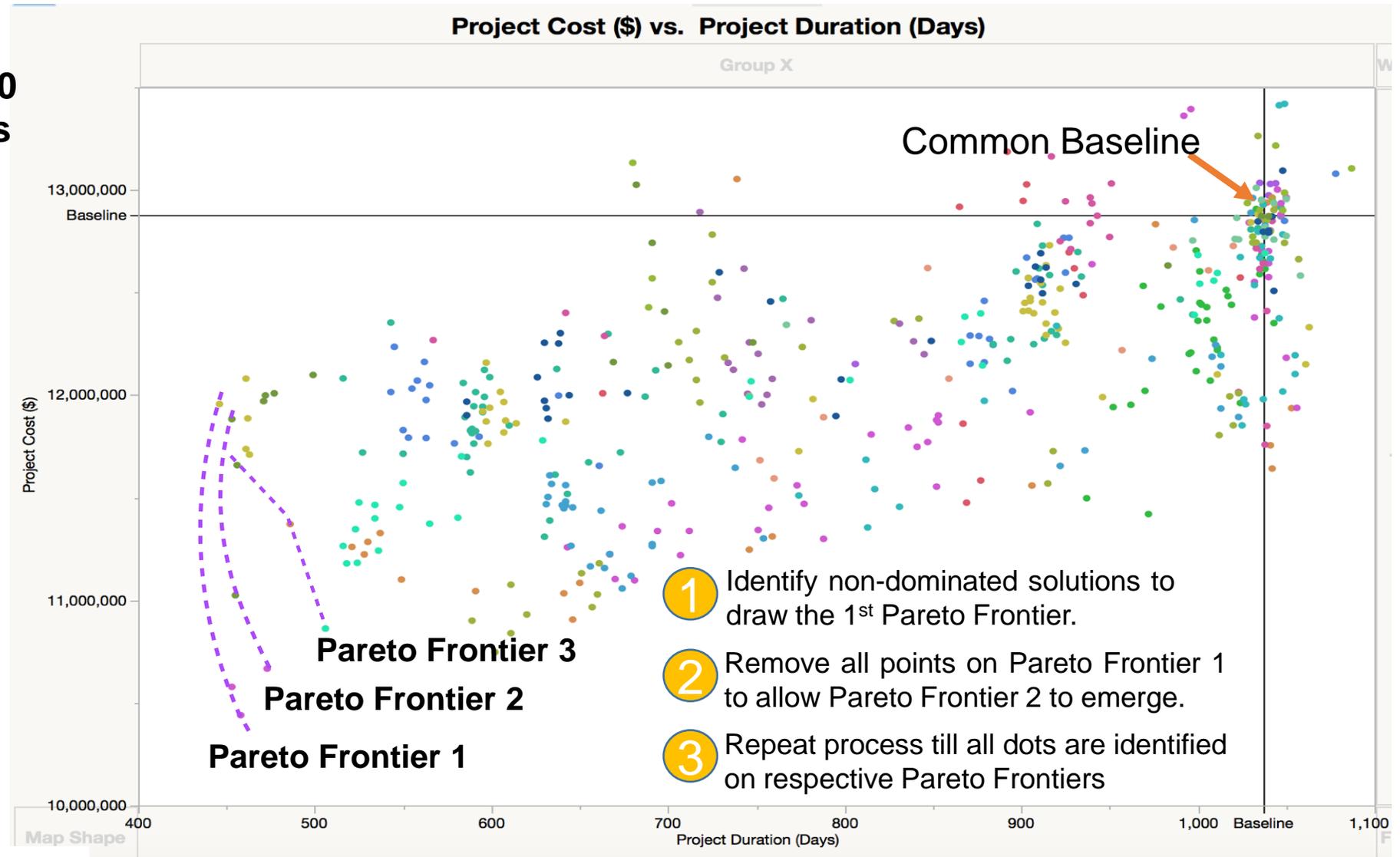


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Total of 529 project outcomes simulated in 120 mins by 19 Design Groups

Each dot is a project outcome simulated by the Design Groups

Each Design Group is denoted by a different color



Defining Ranking Logic



Pareto Frontier	No of Project Outcomes per Design Groups				
	A	B	C	D	E
1	2	1			
2			1		
3				2	2
4				3	2

Design Group	Rank
A	1
B	2
C	3
D	4
E	5

Rule 1:

Design Groups with project outcomes in the earlier Pareto Frontiers are ranked higher

Rule 2:

Within a Pareto Frontier, Design Groups with more project outcomes are ranked higher

Rule 3:

For ties, keep comparing at subsequent Pareto Frontiers (with Rule 1 & 2) till tie breaker occurs.

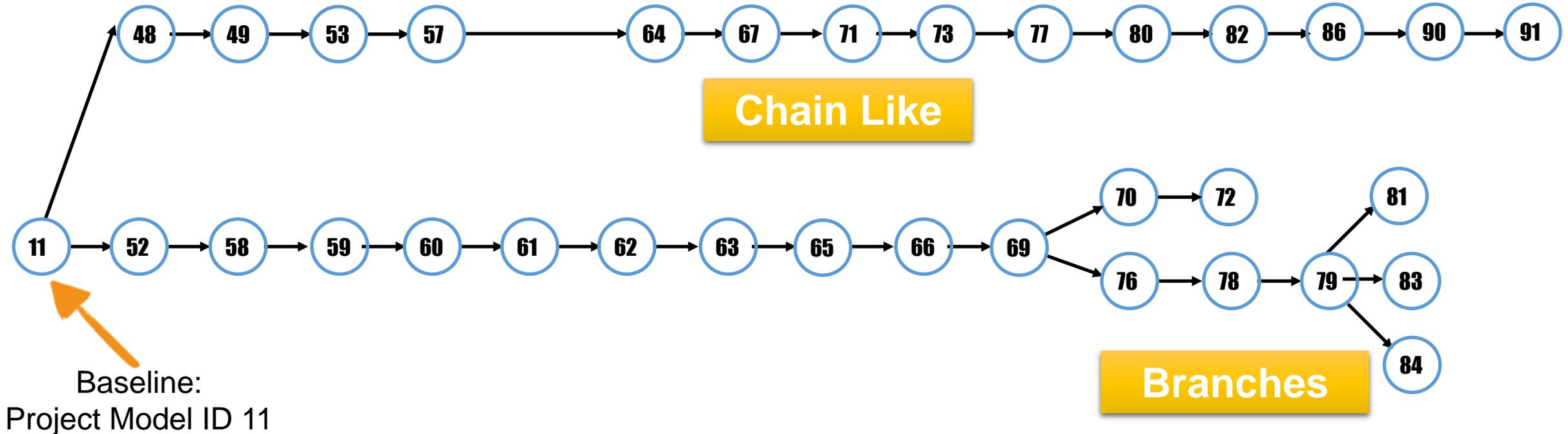


Visualizing Tradespace Explorations with **Project Design Tree Diagrams**

Tree Diagrams



A circle represents an **iteration** simulated to obtain a project outcome

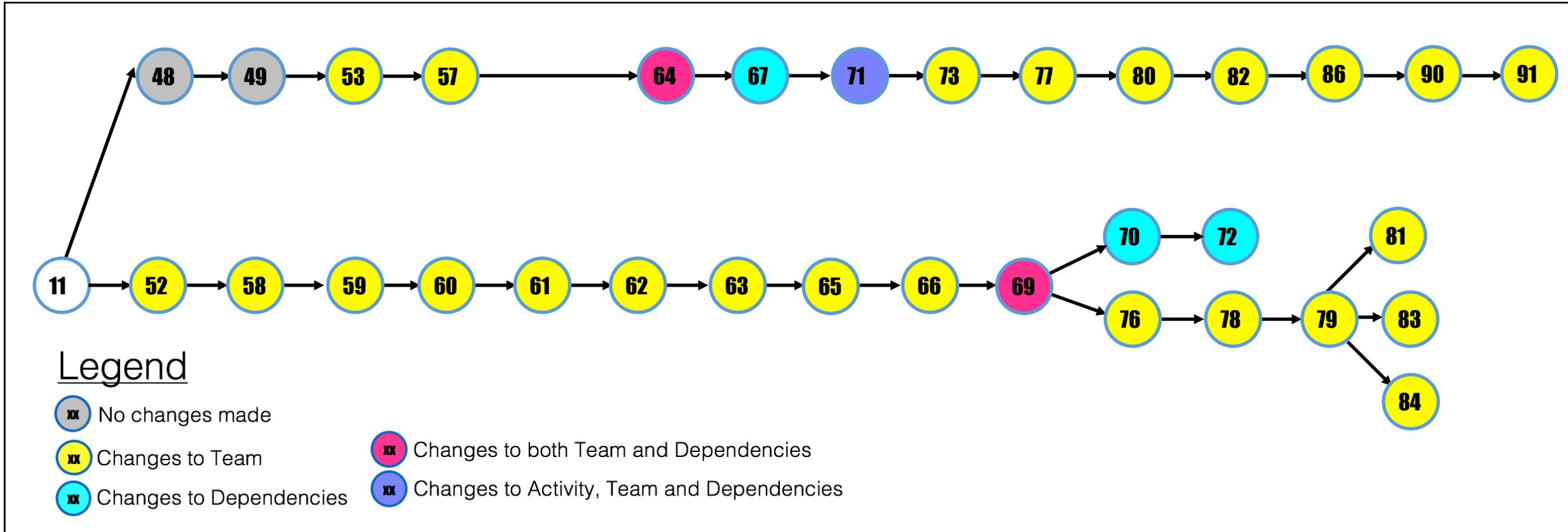


Project models build on from previous models forming **Iteration Streams** during tradespace exploration

Color Code Tree Diagrams



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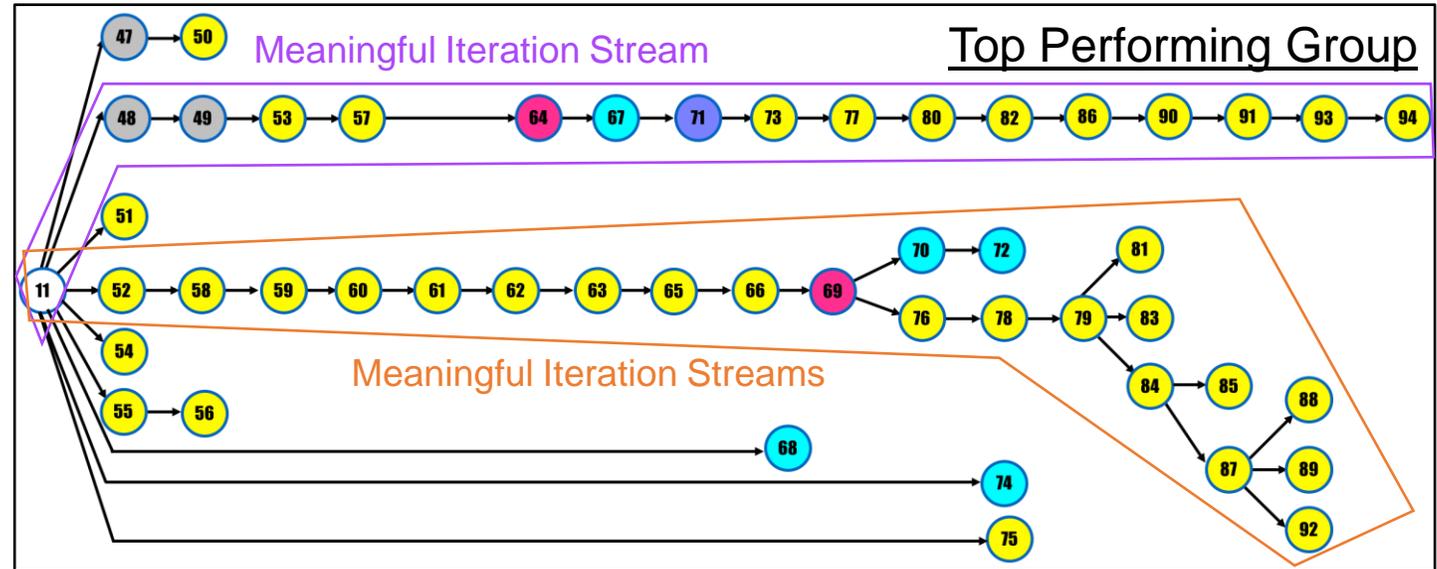
Color codes reveal *type of changes* in each iterations

Meaningful Explorations

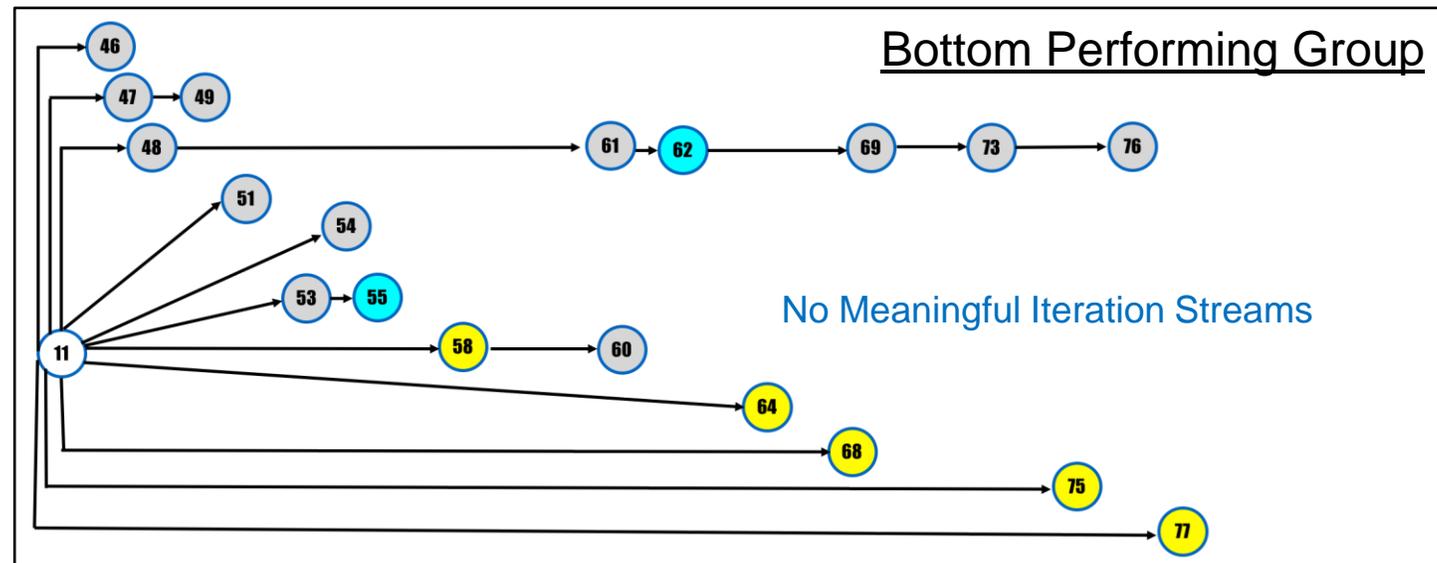


Insights from Tree Diagrams:

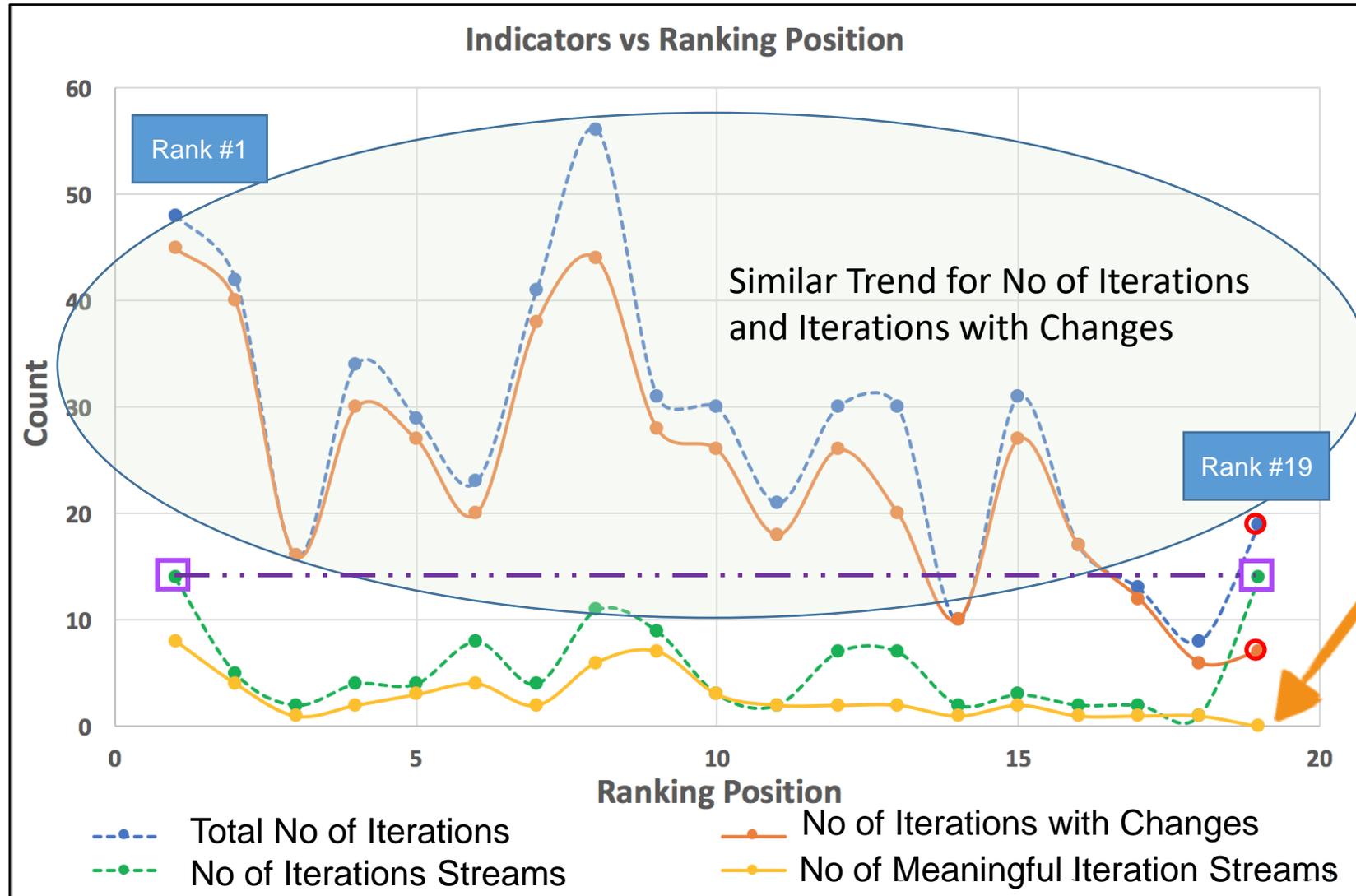
- ✓ Top Performing Group has many iterations with changes (colored circles) than Bottom Performing Group.
- ✓ Top Performing Group has many branches but Bottom Performing has none.



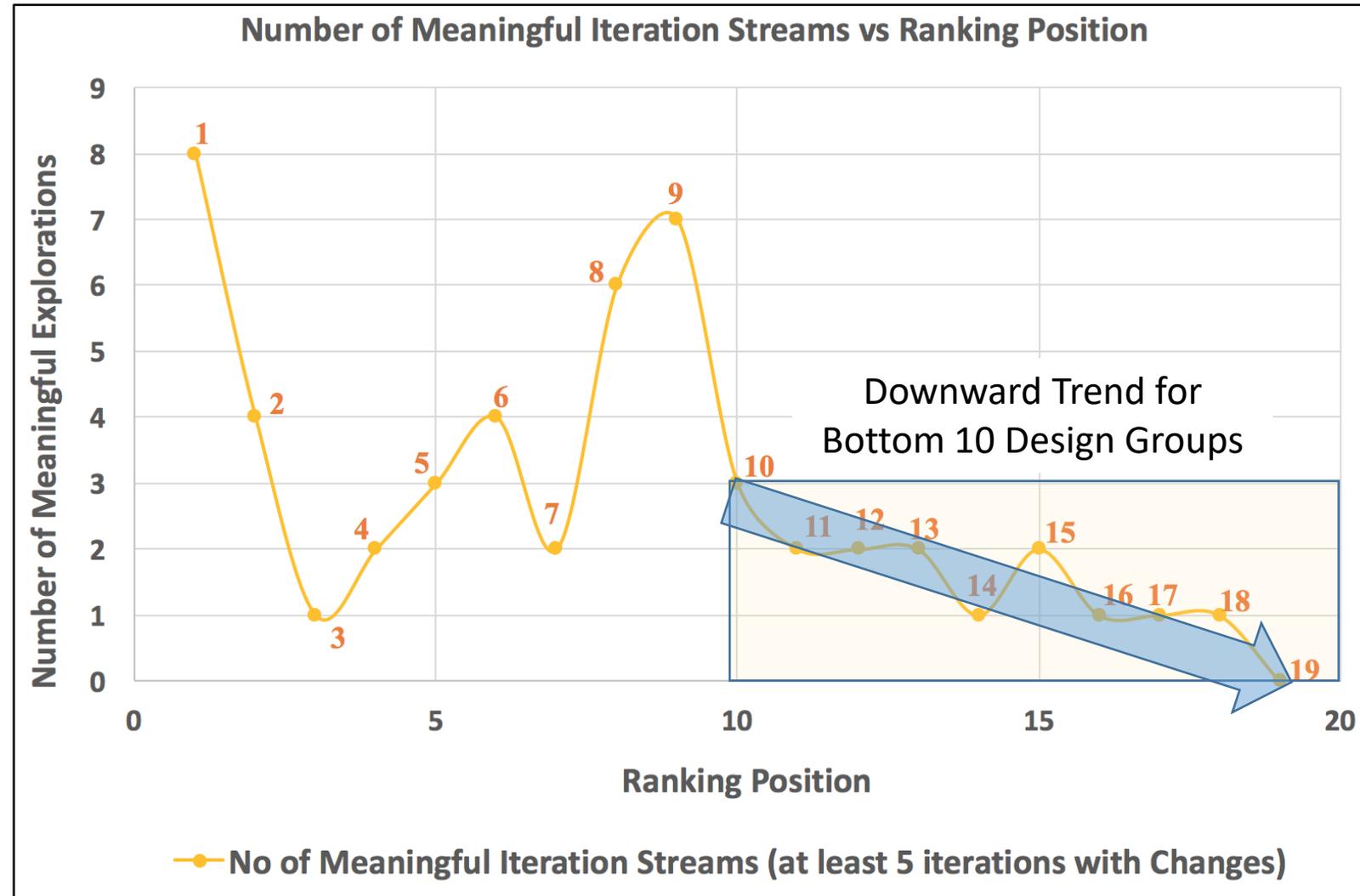
Meaningful Iteration Stream is an Iteration Stream with more than *five (5)* iterations with changes



Investigating Indicators for Team Performance

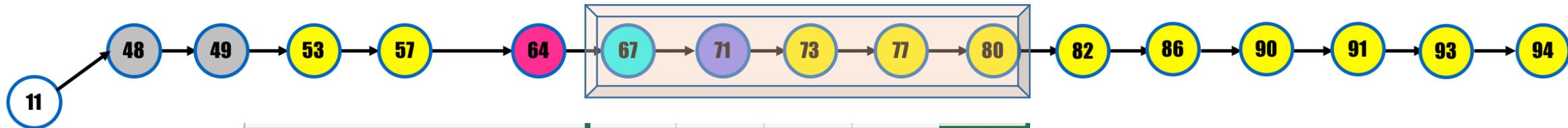


Investigating Indicators for Team Performance



Chunking the Tree Diagram

Meaningful Iteration Stream 1



Project Model ID	67	71	73	77	80
Team Size	6	12	18	6	12
Net Change	6				
Team Size			2	4	
Net Change			2		
Dpendency Changes	2	0			
Net Change	0				
Dpendency Changes	2	0			
Net Change	0				
Activity Change	Changed Comm Time				
Activity Change	Changed Work Time				

By observing segmented chunks to see the “blocks of changes” may further reveal if the Design Group are **coherent** in their **decision making** by measuring how focused they are

Conclusions from Experiment



- Meaningful Iteration Streams is a better indicator of Team Performance
- Measuring how focused a Design Group is during decision making process can be defined as an Indicator of Coherence
- A Design Group with coherence may signal a better chance of meaningful changes made during tradespace exploration

Conduct Similar Experiment in Real-World Industry

- ❖ Further refinement of the framework in evaluating team performance
- ❖ Provide real-time feedback on team interactions & performance in organizations

Measurement of Team Learning Effects

- ❖ Repeat Design Challenge with same participants 2-3 months later
- ❖ Measure any learning effects arising from Project Design Challenge



Teamwork Behaviors at Mesoscale: Meaningful Explorations of Tradespace During Project Design

by

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