

Product Development Excellence through Modeling & Simulation

ANL – VERIFI

November 12, 2014

Keven Hofstetter

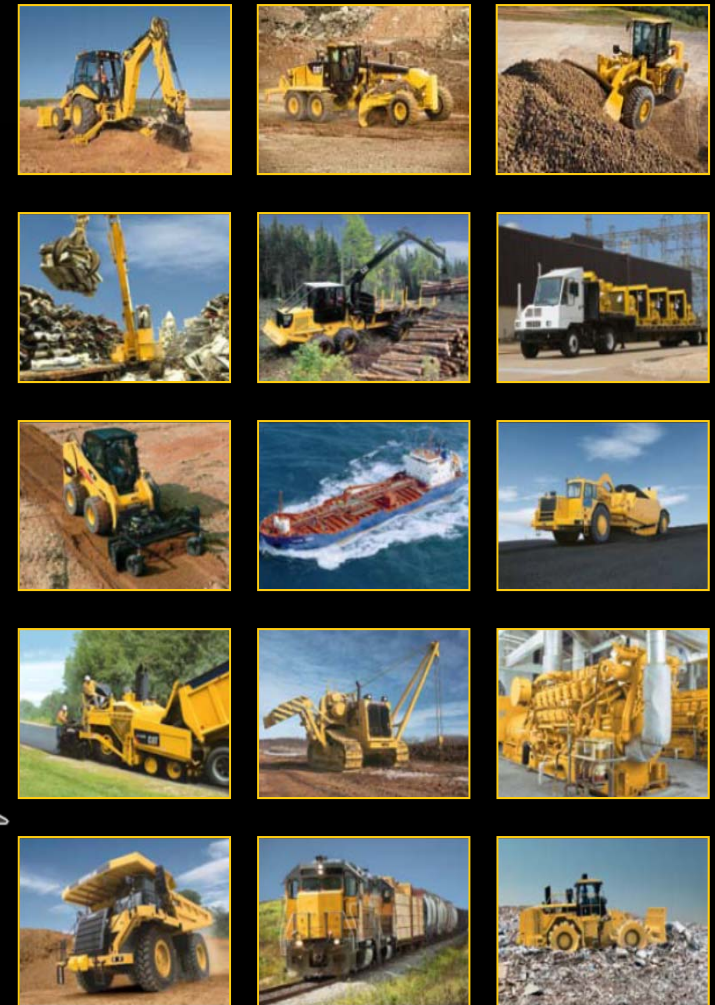
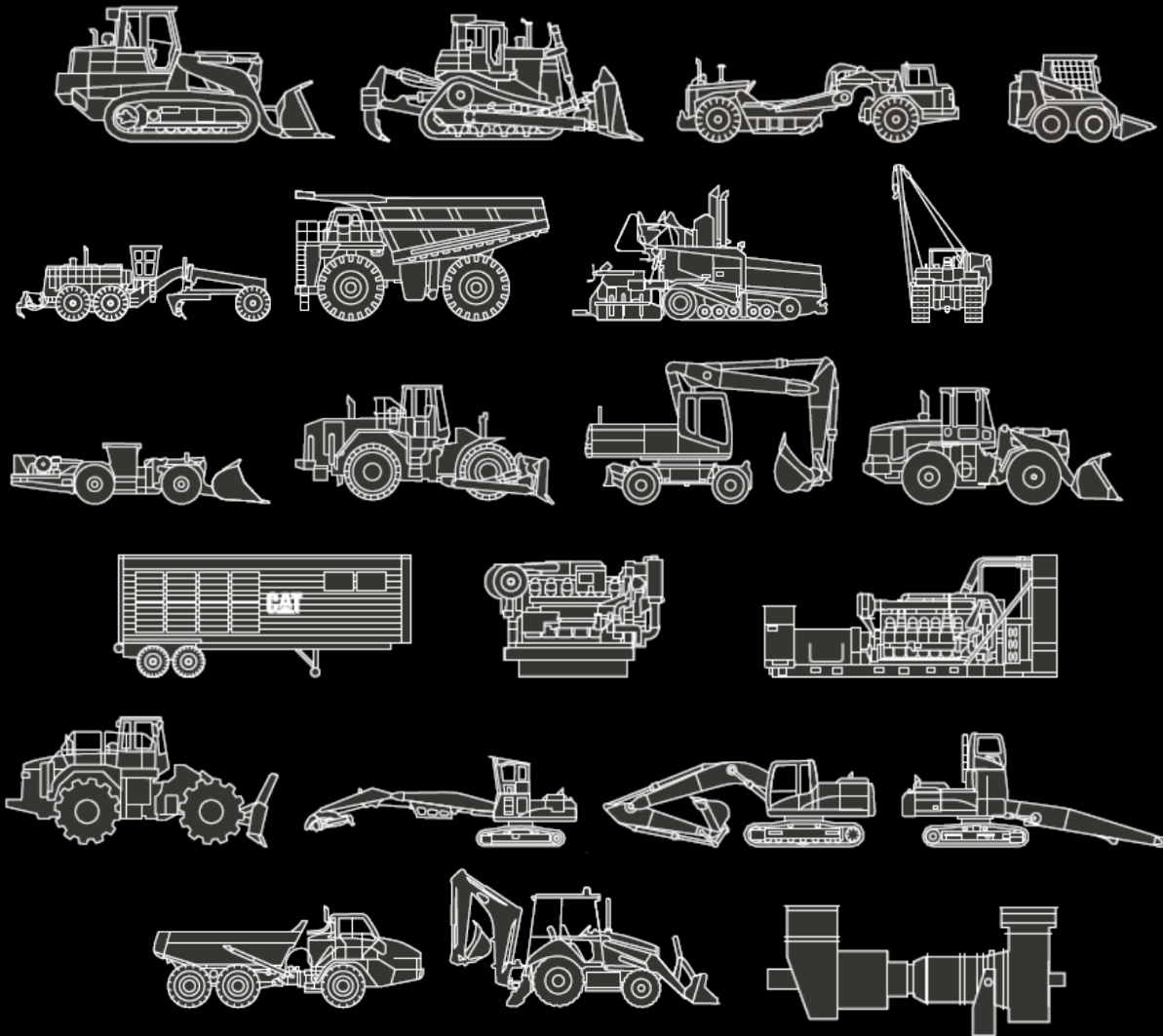
Agenda

- The Product Development Challenge
- Caterpillar “Virtual Product Development”
- A Future Vision

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A **diverse** range of Products and Industries



CATERPILLAR®

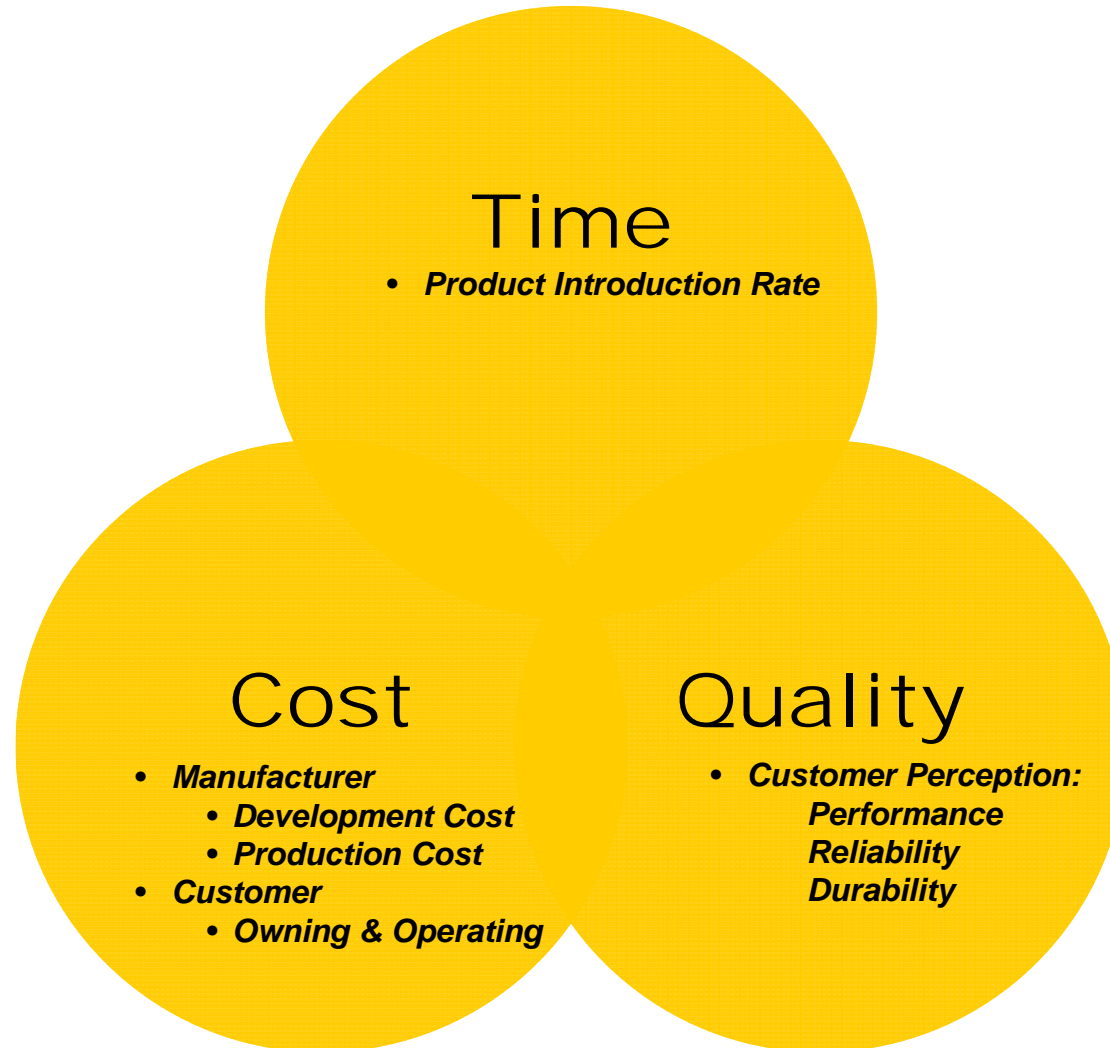
From our Chairman & CEO

"Our customers are *diverse*, but all have something in common – they all expect the best from Caterpillar. They expect the best quality, the best performance, the best productivity and more than anything, they expect the best value for the price they pay. We've got our work cut out for us to deliver on these expectations. That's why we have to set the bar high."



Doug Oberhelman, Chairman & CEO

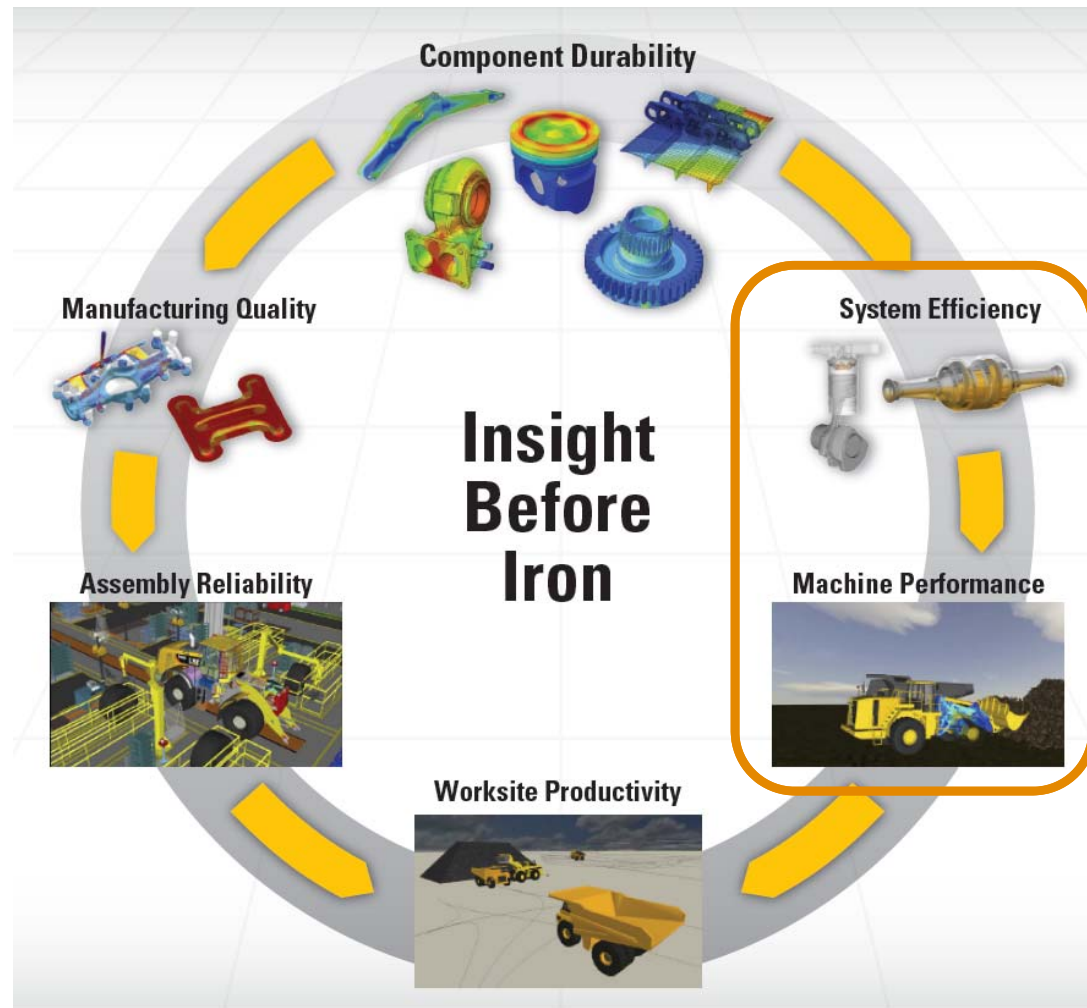
The Product Development Challenge



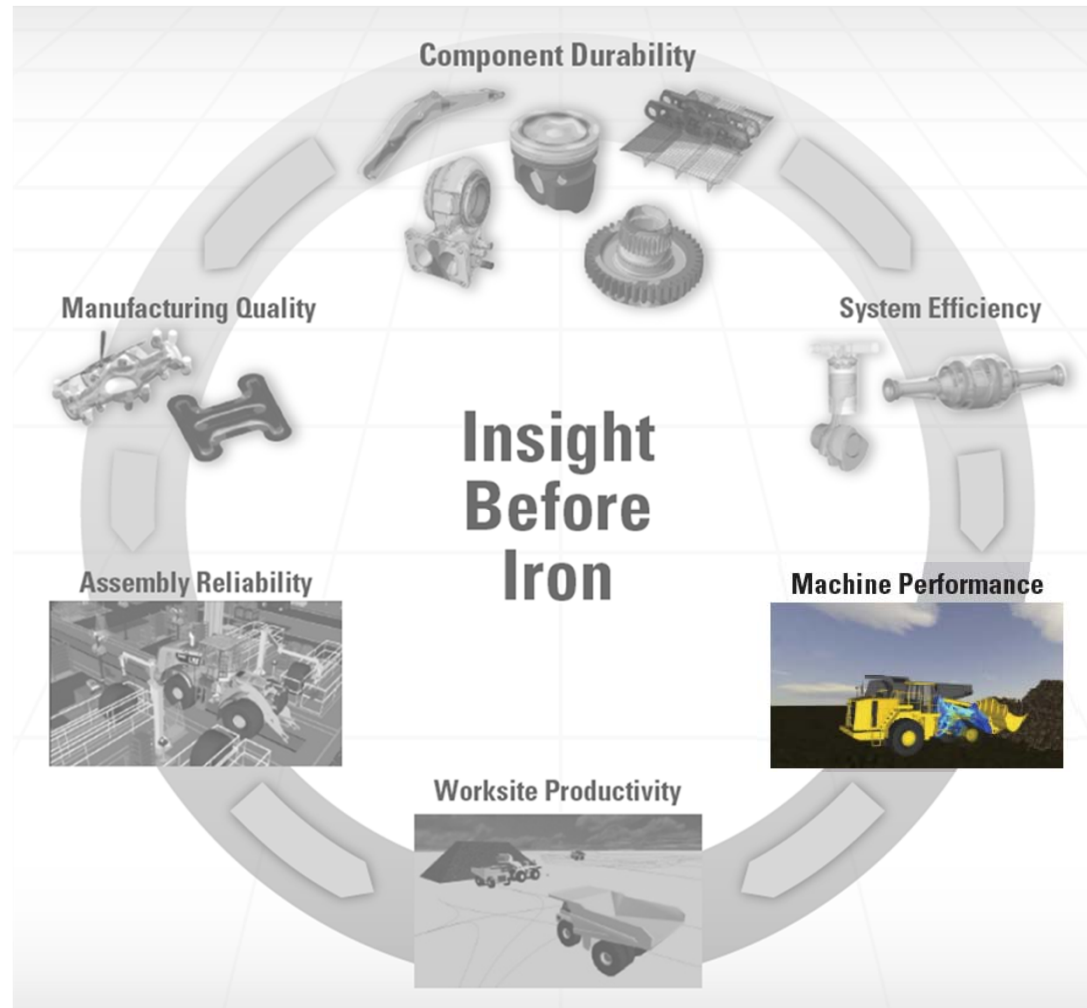
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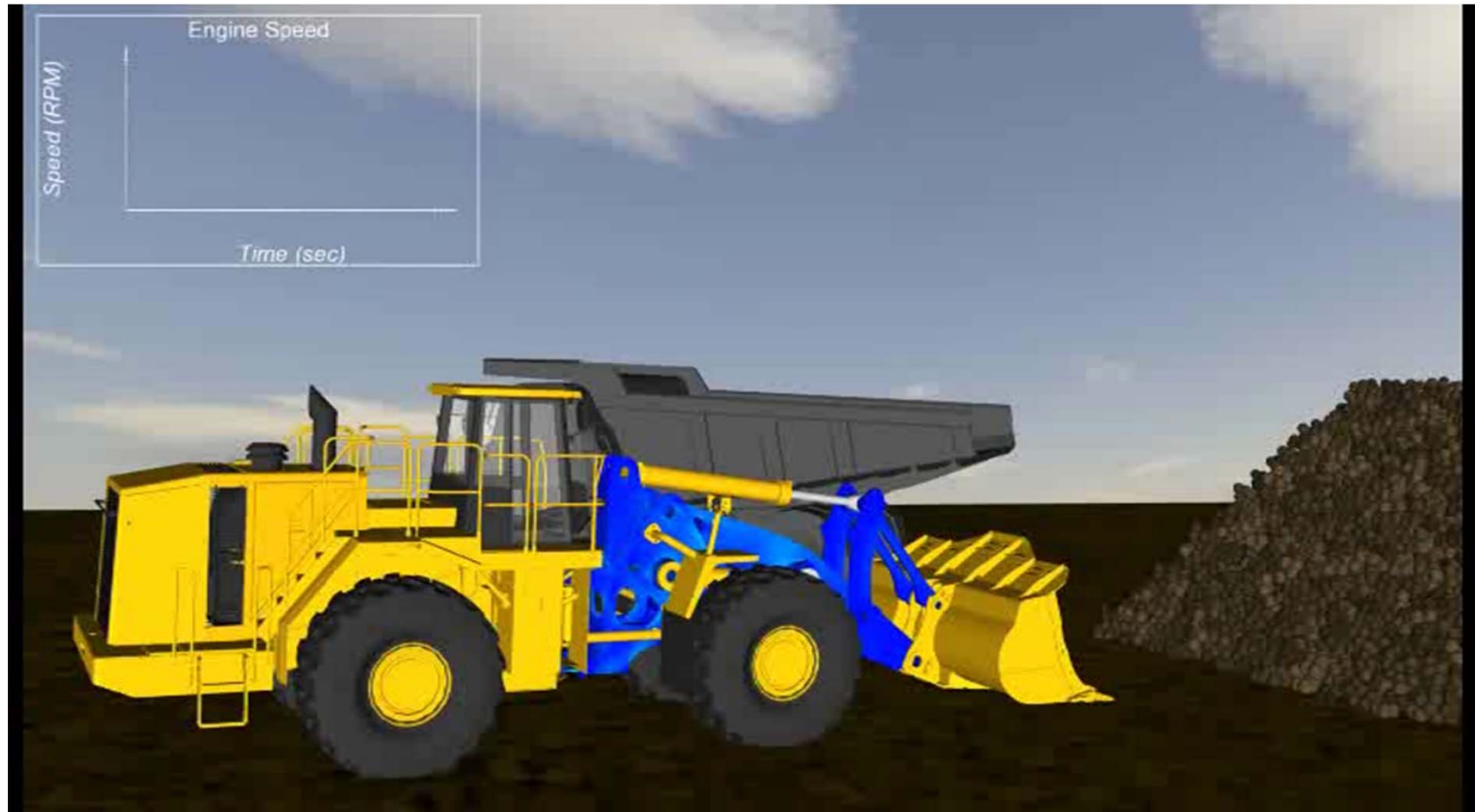
Simulation at Caterpillar...Virtual Product Development



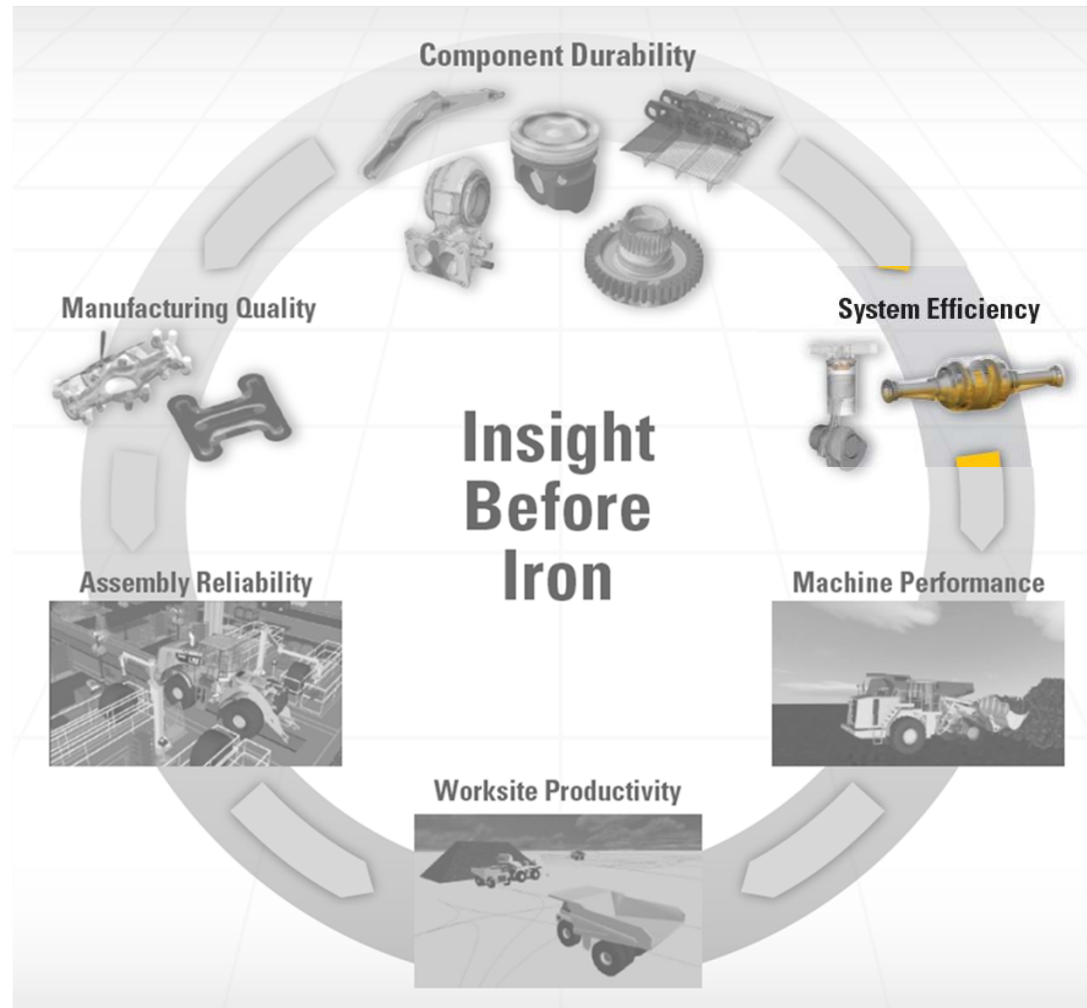
Simulation at Caterpillar...Virtual Product Development



VPD Applications – Machine Performance



Simulation at Caterpillar...Virtual Product Development



System Efficiency – Wheel Loader Axle Oil Simulation



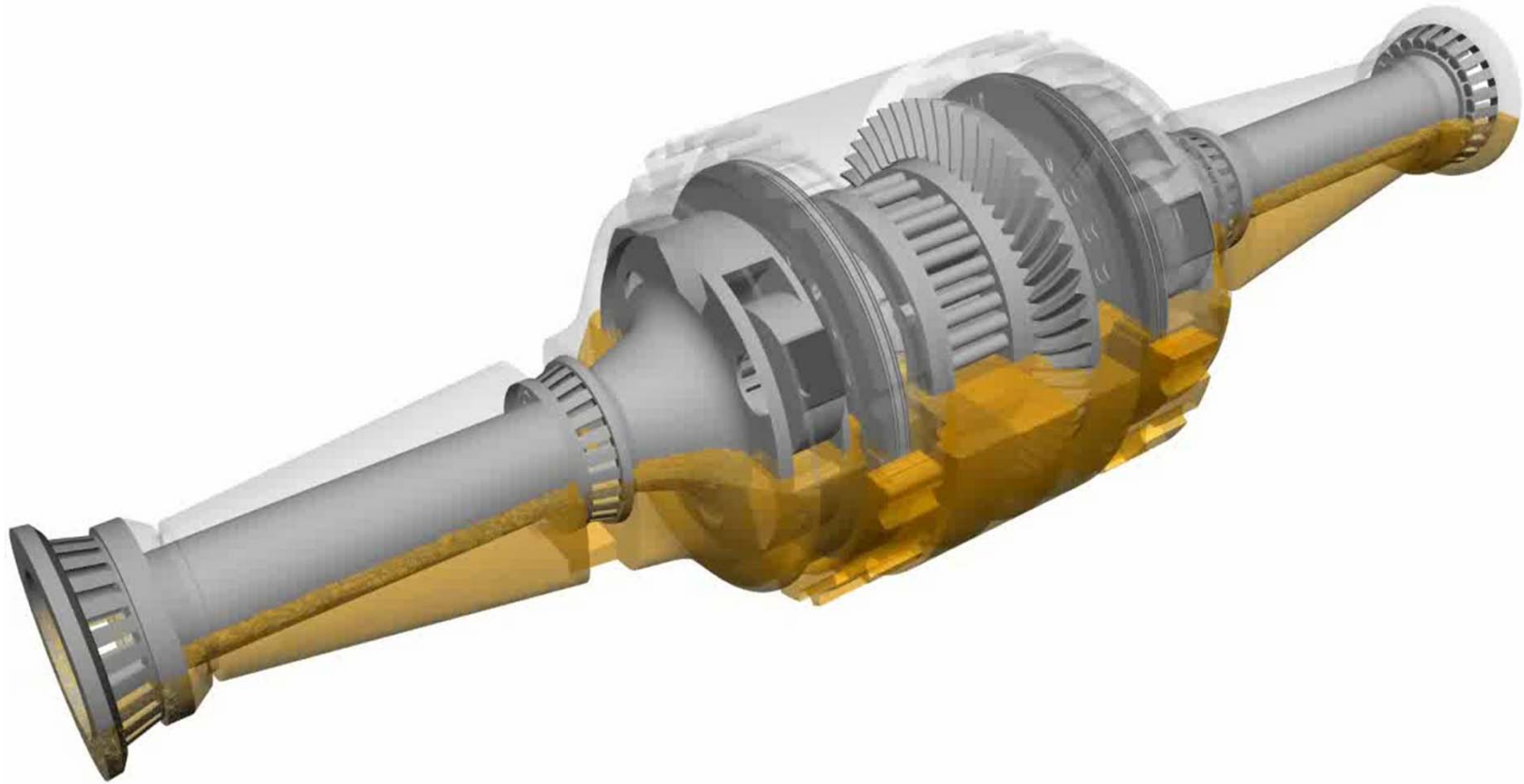
System Efficiency – Wheel Loader Axle Oil Simulation



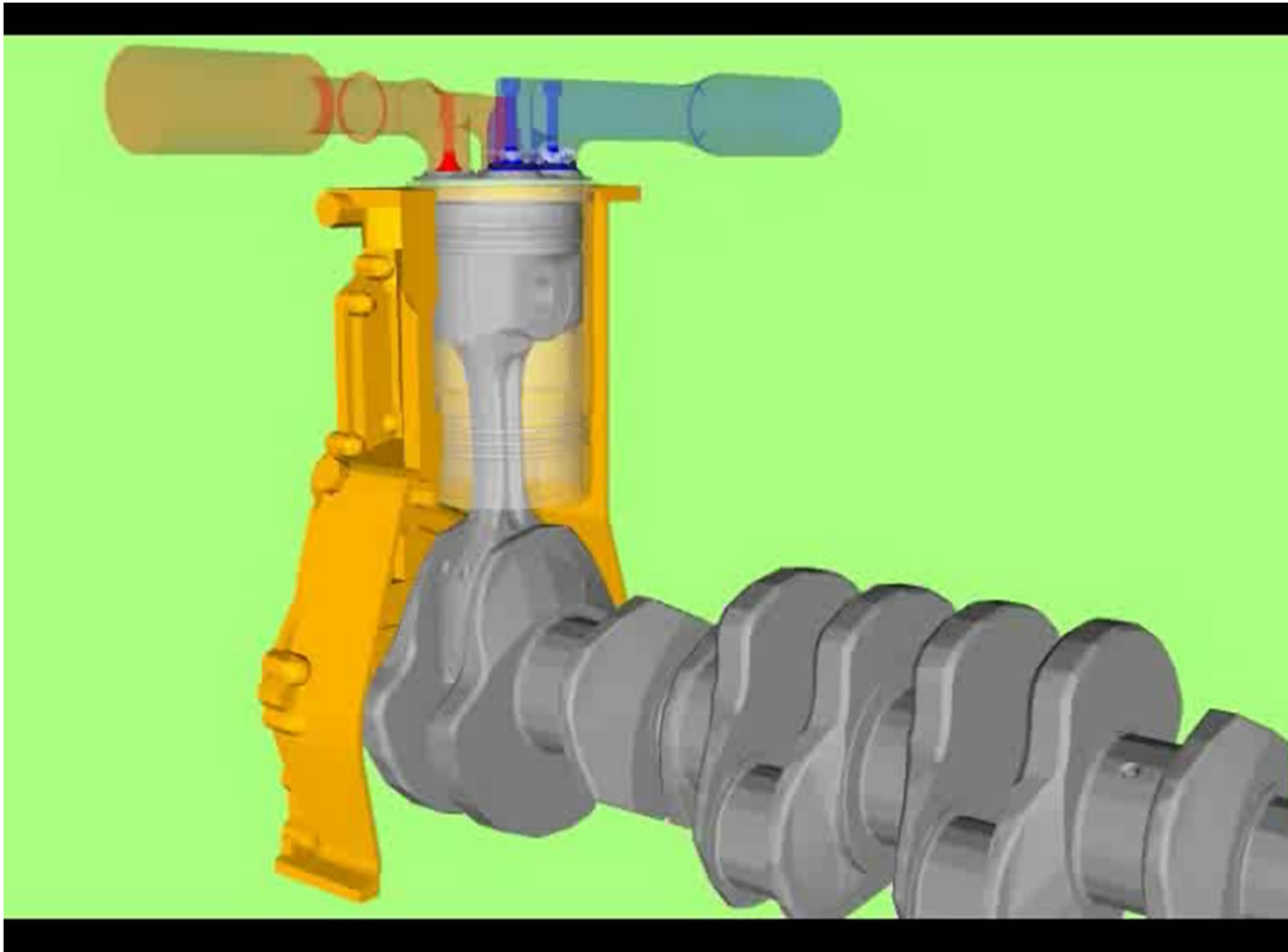
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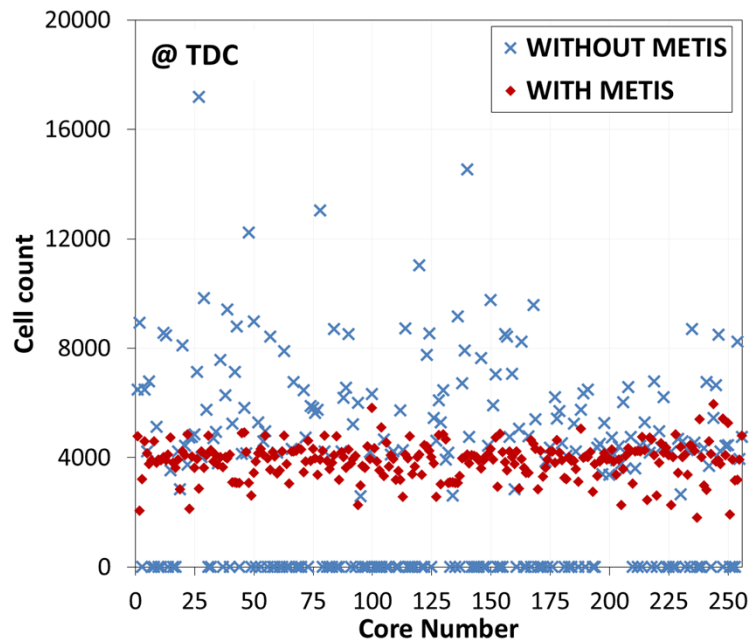
System Efficiency – Wheel Loader Axle Oil Simulation



System Efficiency – Engine



Caterpillar, Argonne, CSI Engine Simulation Partnership



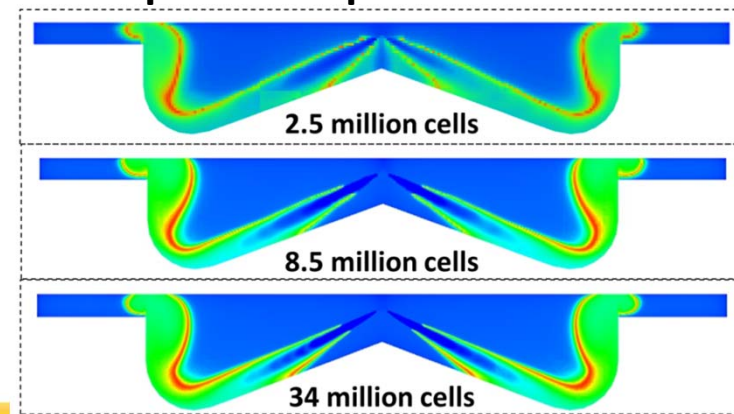
Scientific Achievements

- Use of High-spatial and temporal resolution
- Robust turbulence models
- Use of detailed chemistry based combustion models
- High-performance computing enabled due to the implementation of advanced load-balancing algorithms
- Solving “one-of-a-kind” problem

Project Impact

- Unprecedented insights into the combustion process
- Grid-convergent results
- Increased predictive capability
- Modify “best practices” in industry

Cut-plane temperature contours

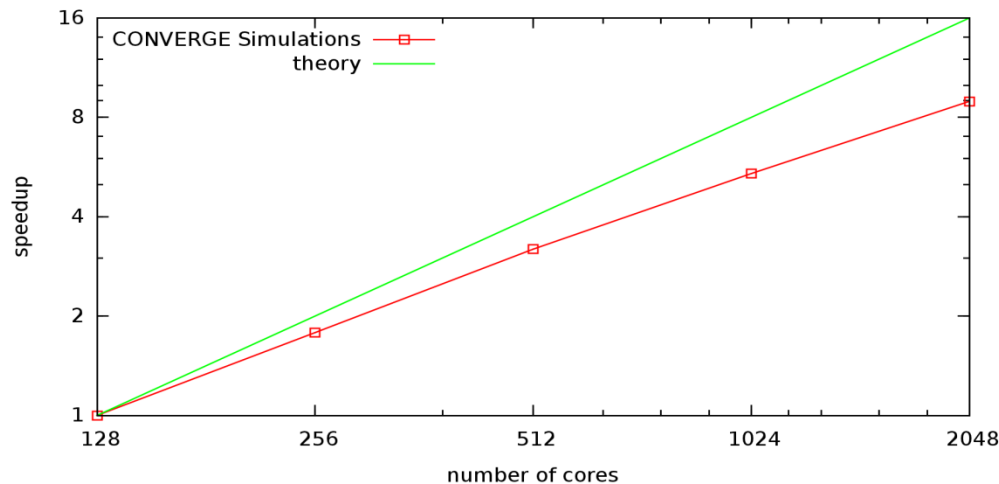


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High-fidelity simulations: 35 million cells, Minimum grid-size ~ 100 μm

Project Impact

Engine simulations have been run on a **scalable fashion** on **2048 processors** at the leadership computing facility



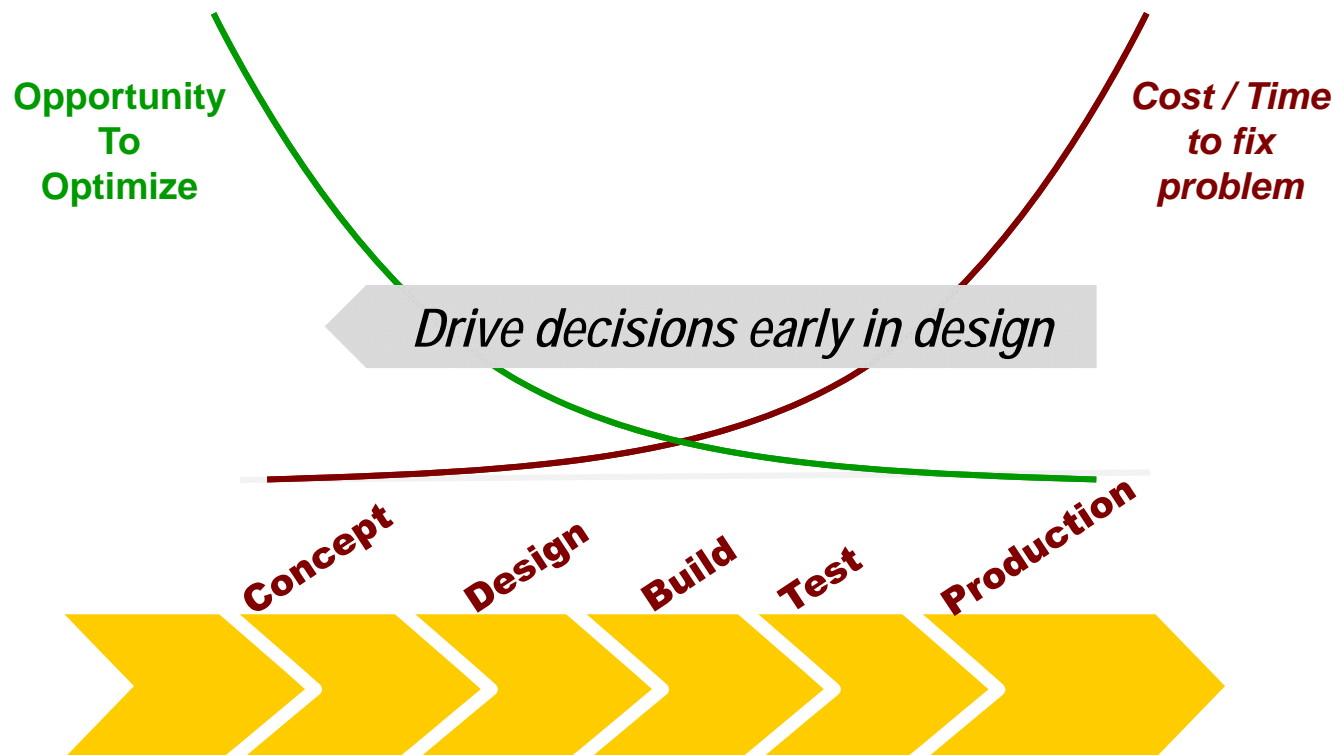
Scientific Achievement

This was possible due to the implementation of **METIS load-balancing algorithm** in CONVERGE software in a collaborative project between **Argonne, Convergent Science Inc., and Caterpillar Inc.**

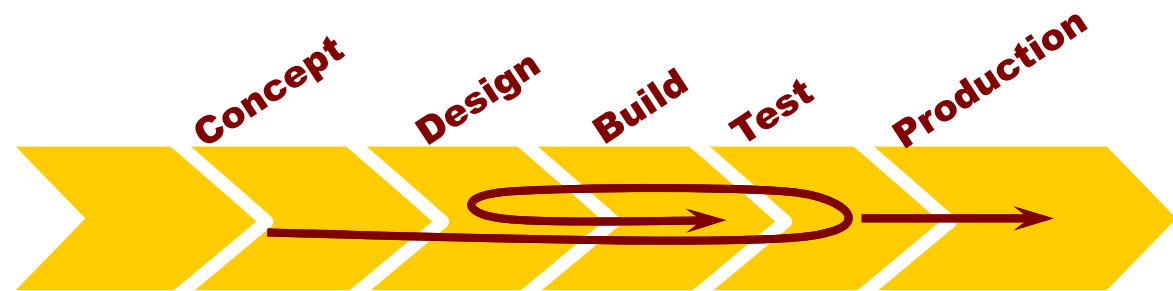
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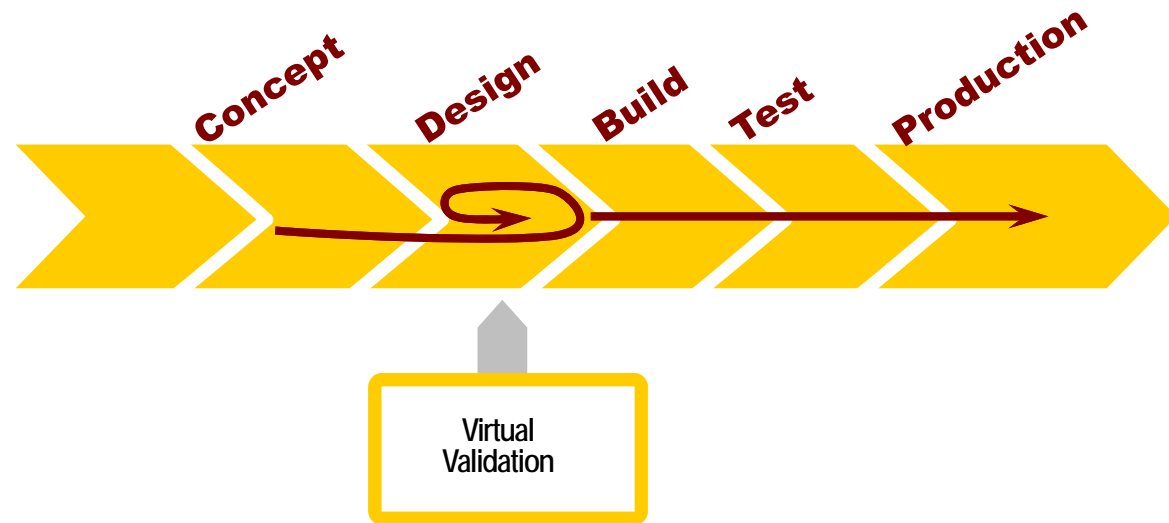
Simulation in Product Development



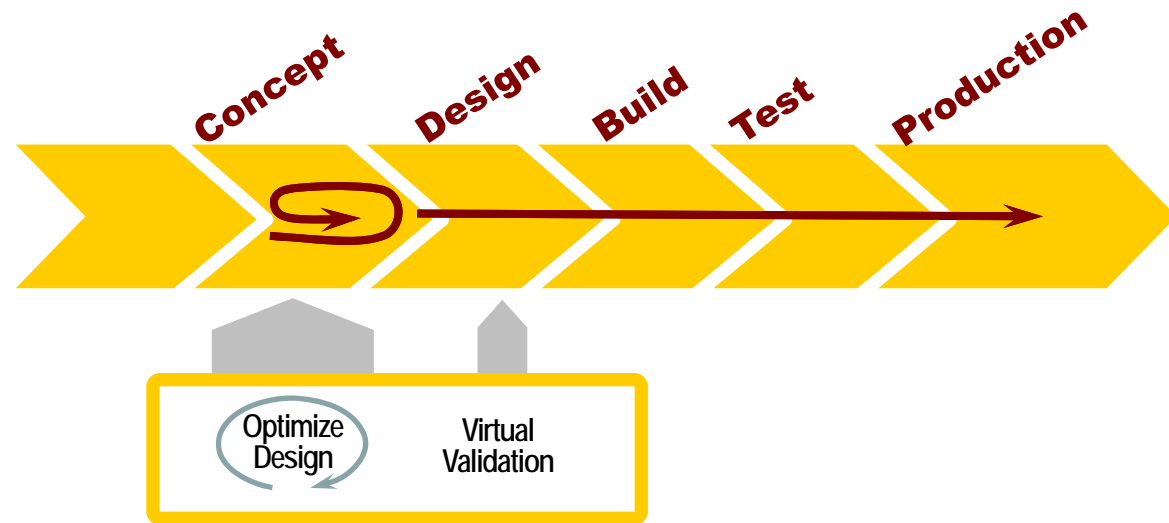
Simulation in Product Development



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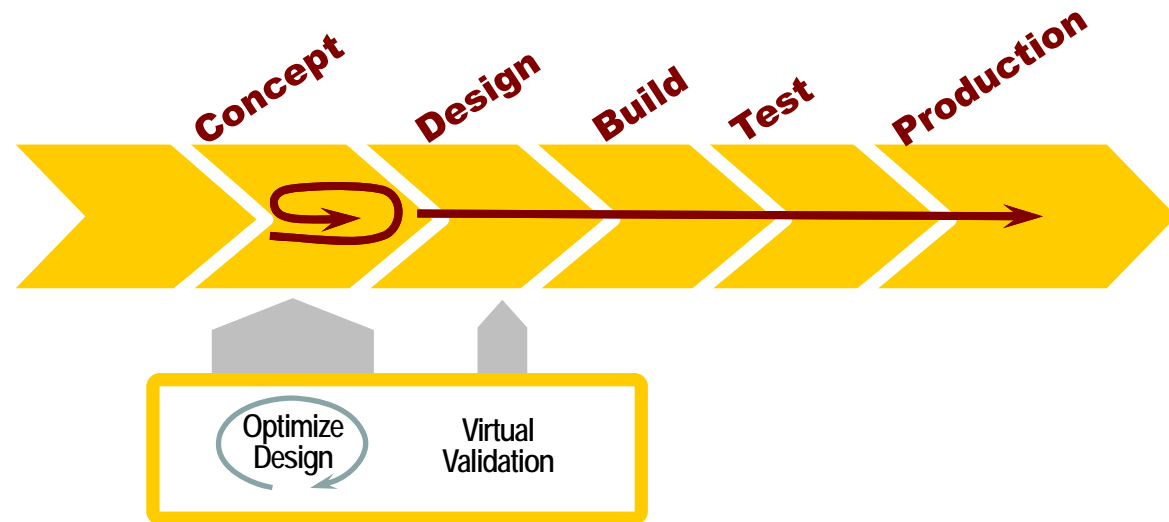


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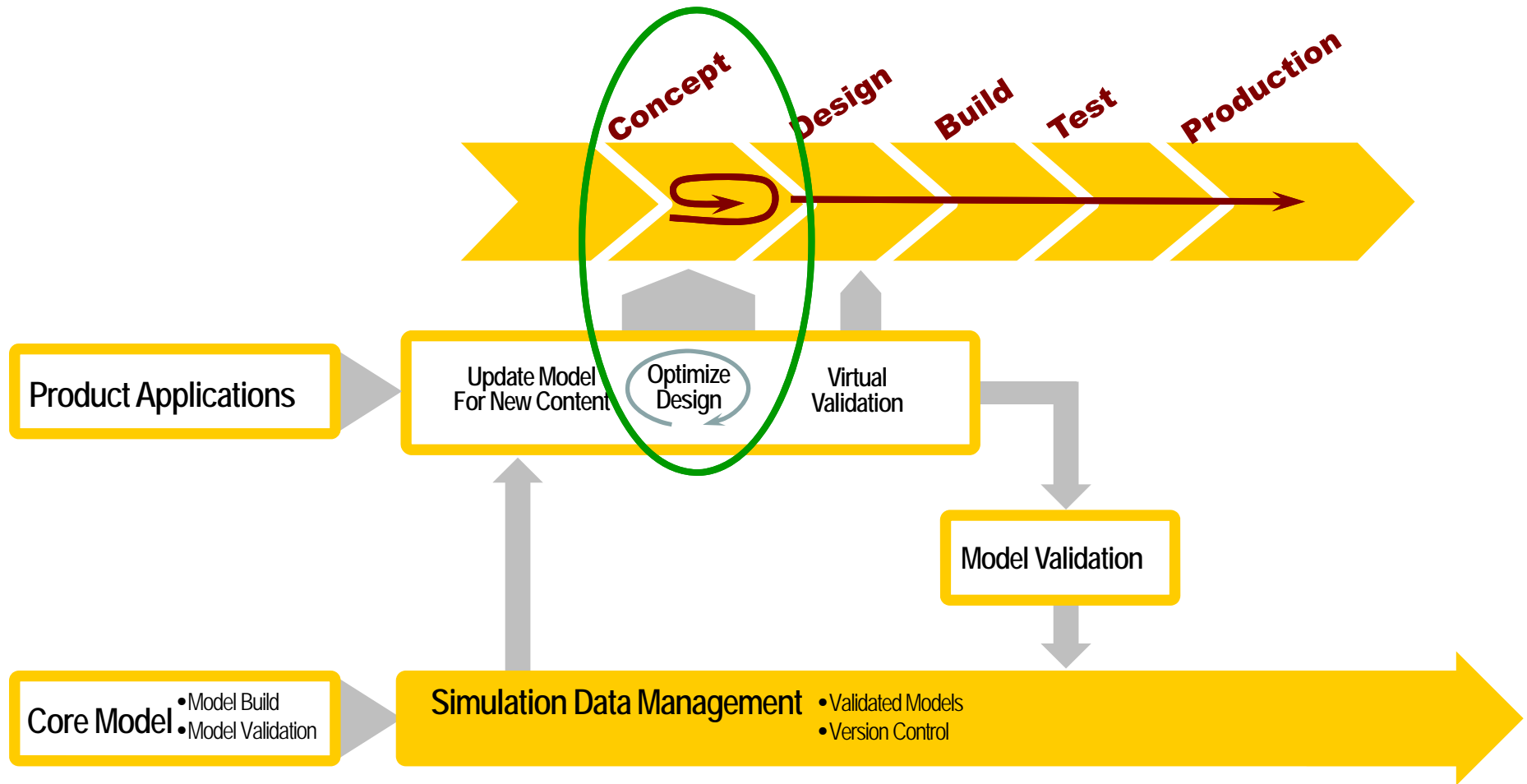


*Most Designs are
Derivatives of
Previous Designs*

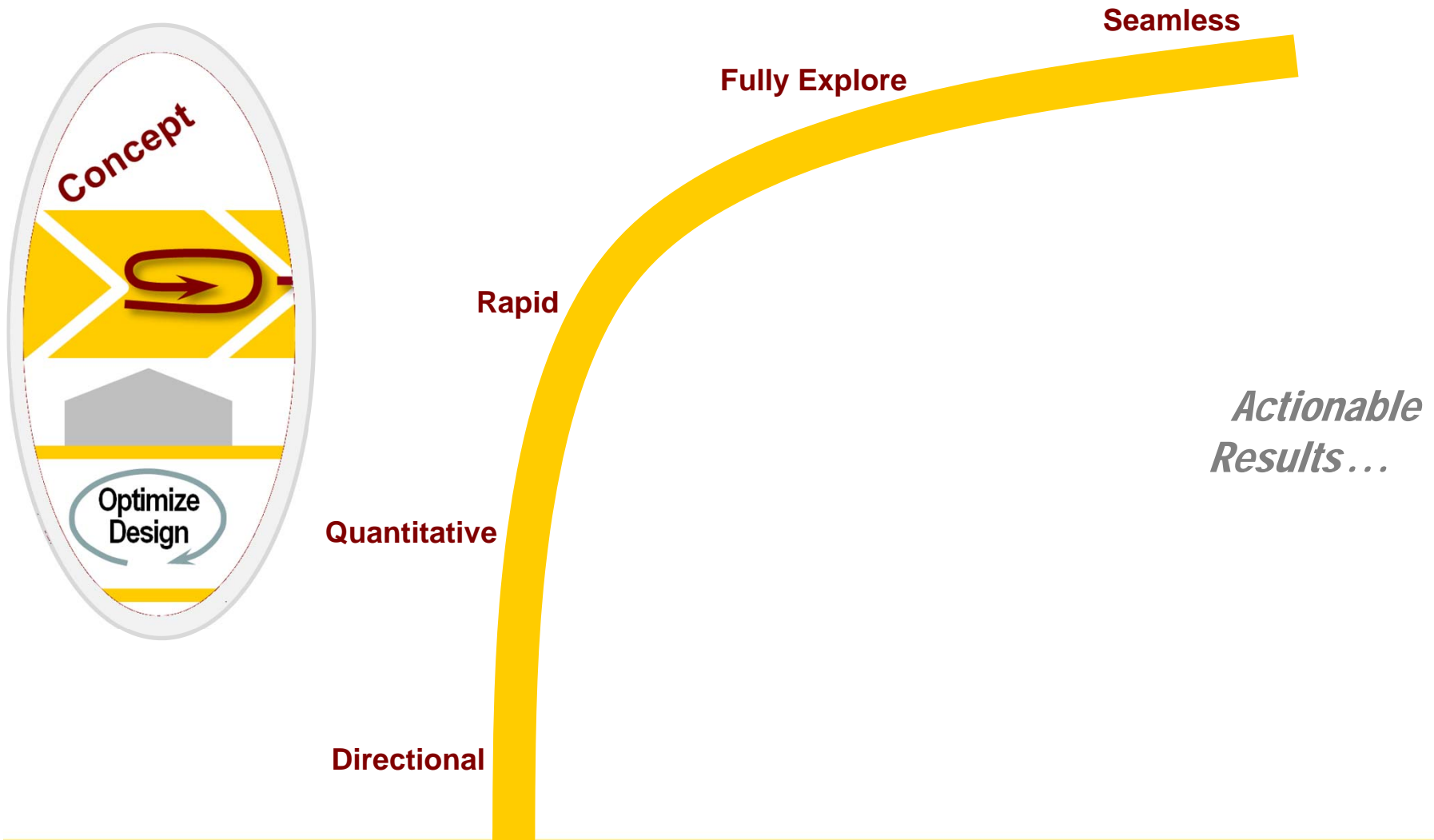
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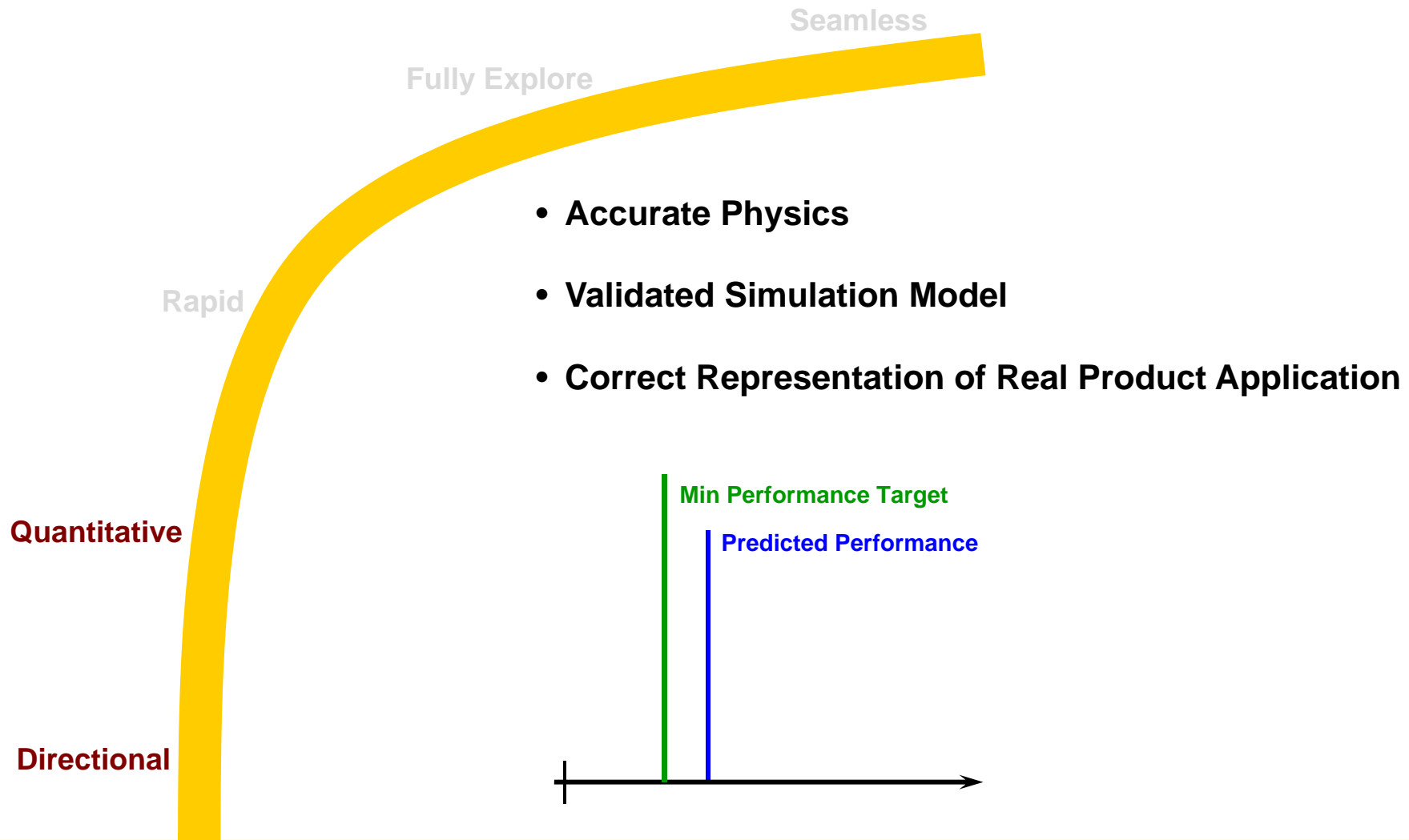
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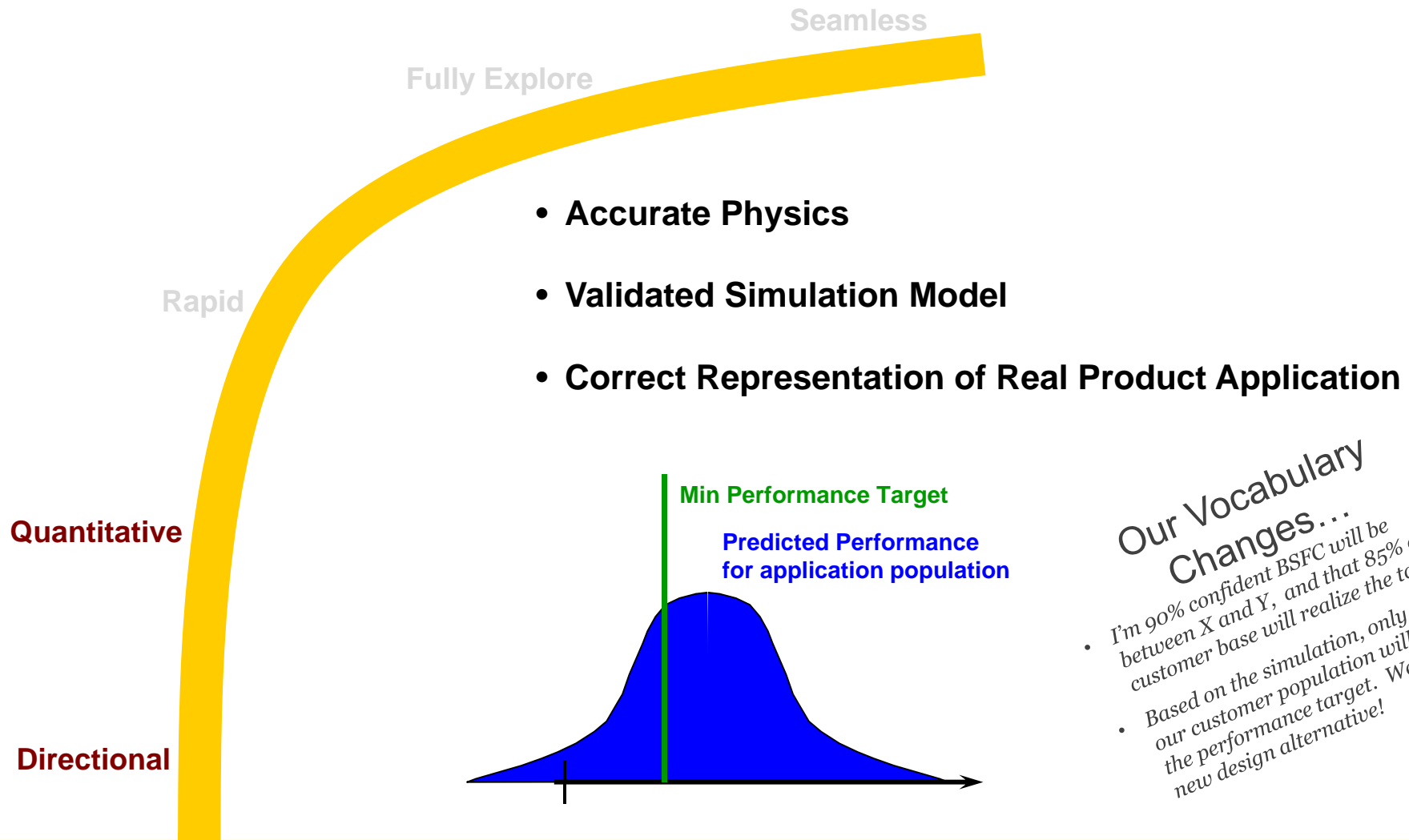
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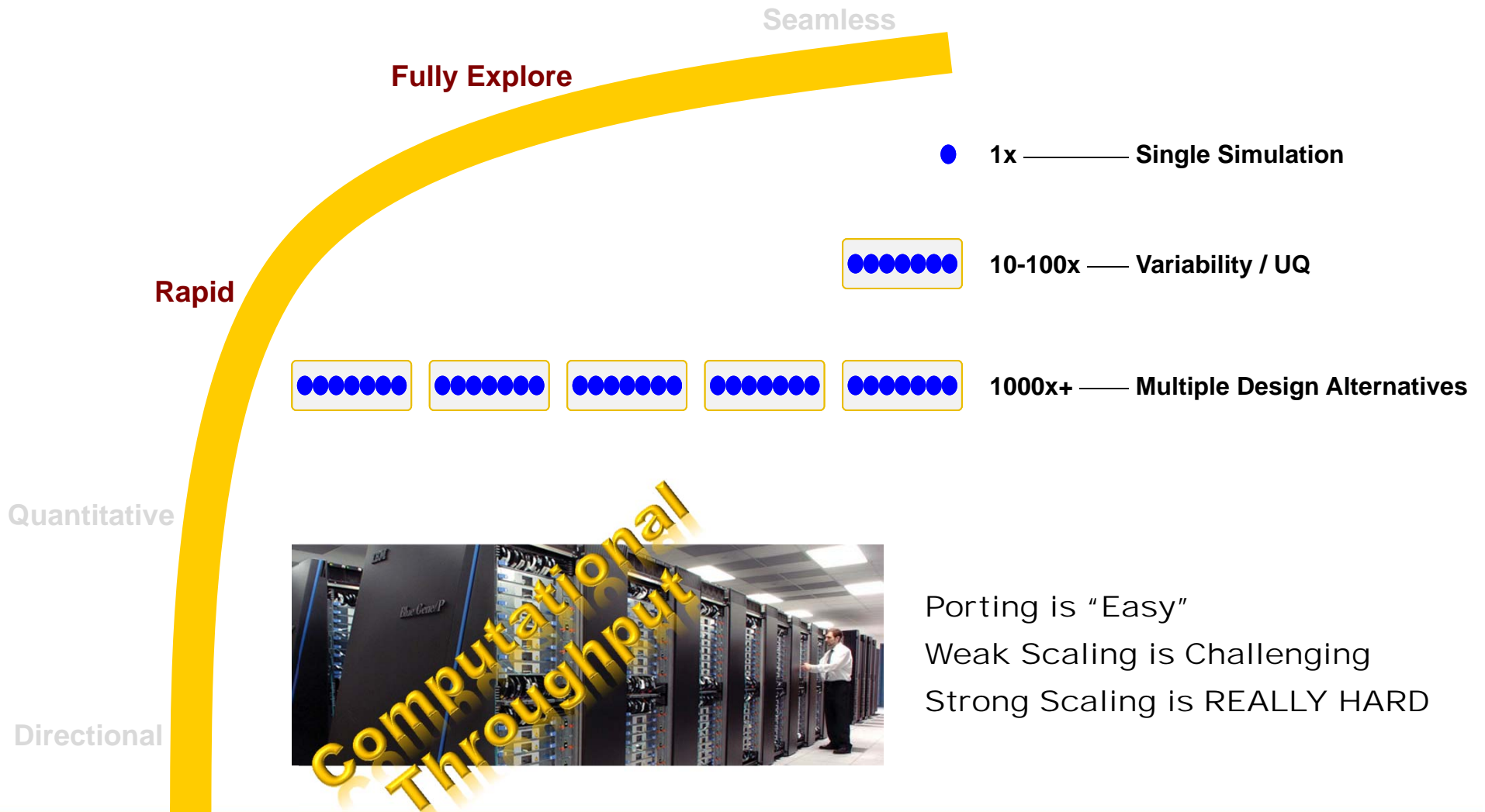
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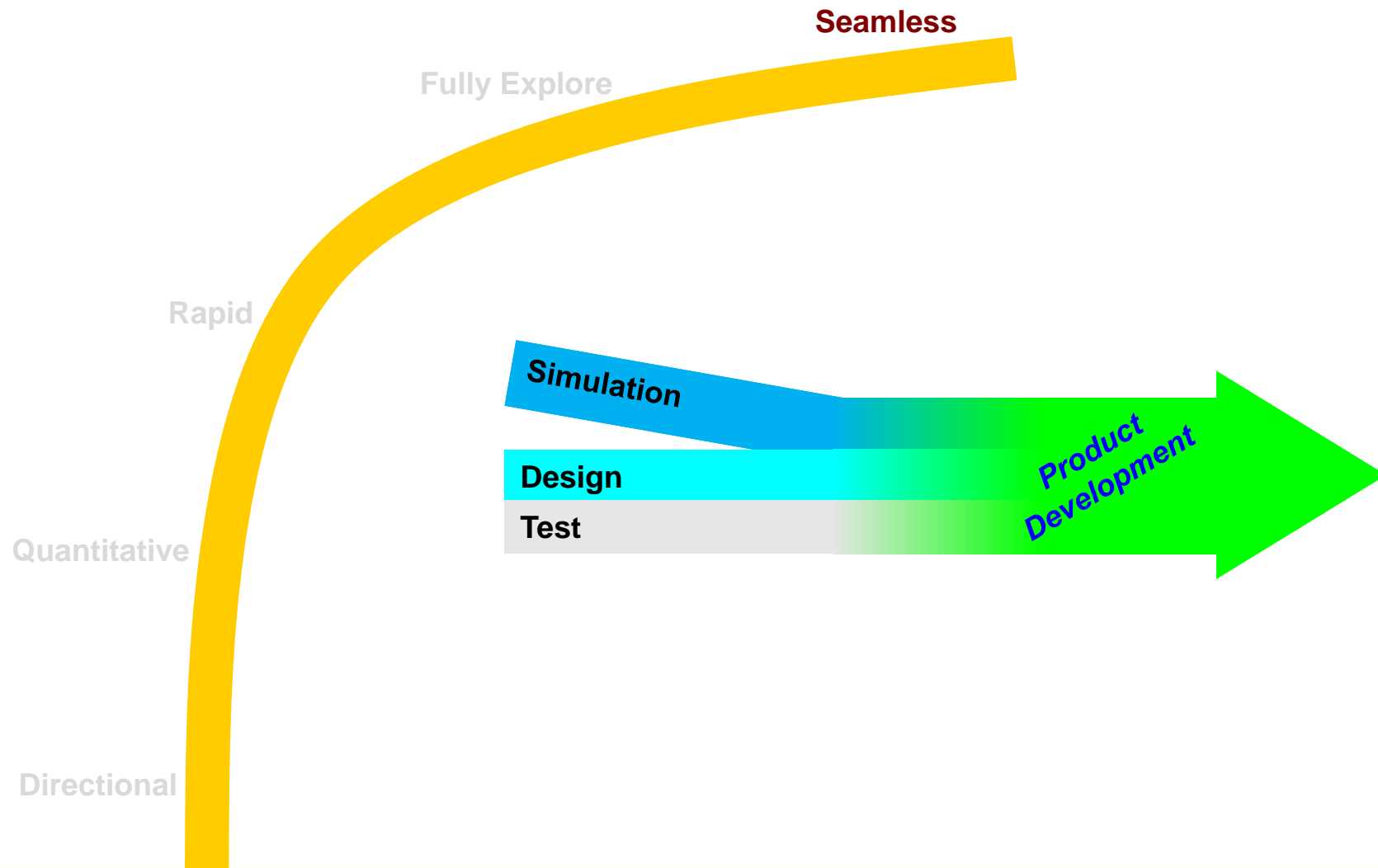
Our Vocabulary Changes...

- I'm 90% confident BSFC will be between X and Y, and that 85% of our customer base will realize the target
- Based on the simulation, only 60% of our customer population will realize the performance target. We need a new design alternative!

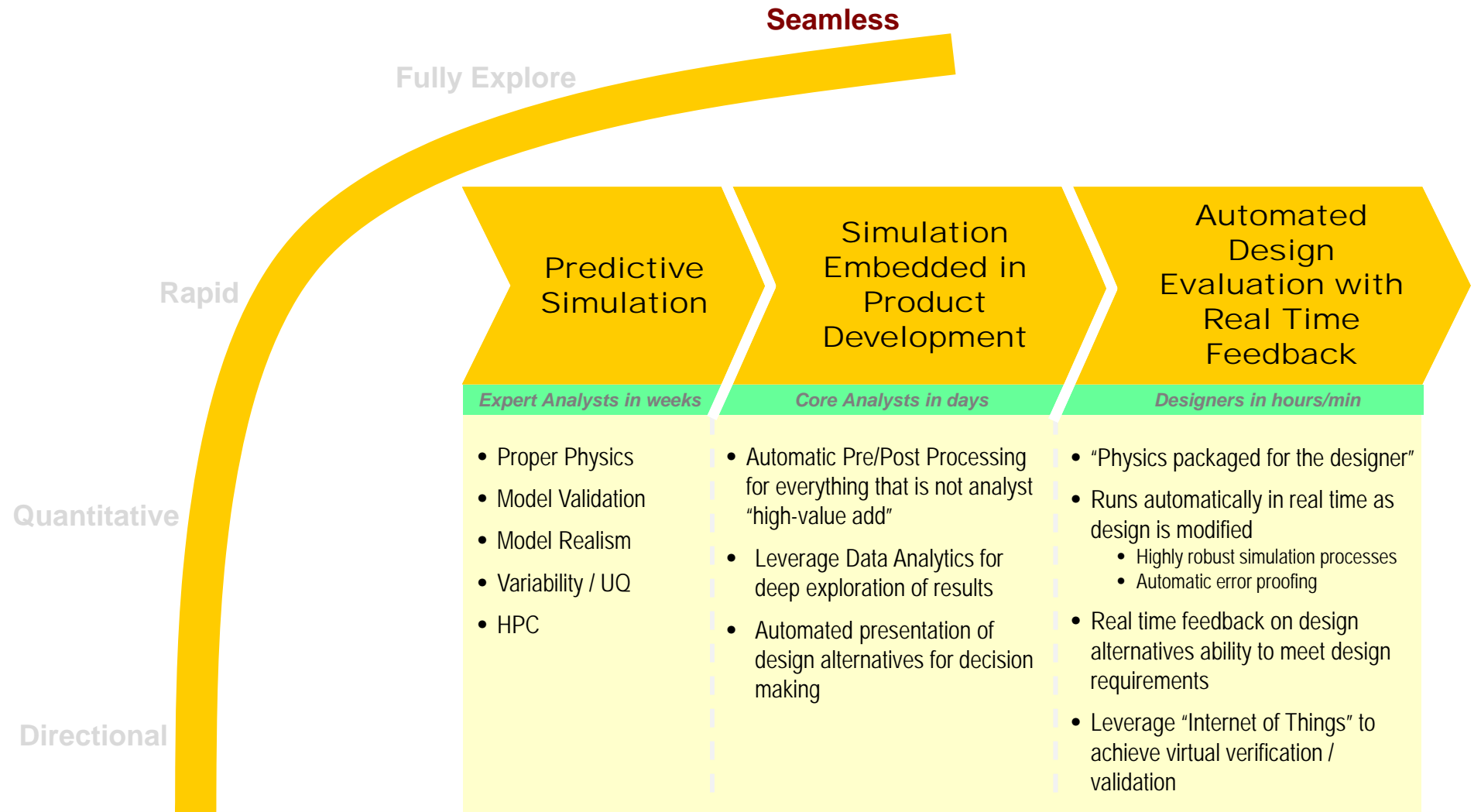
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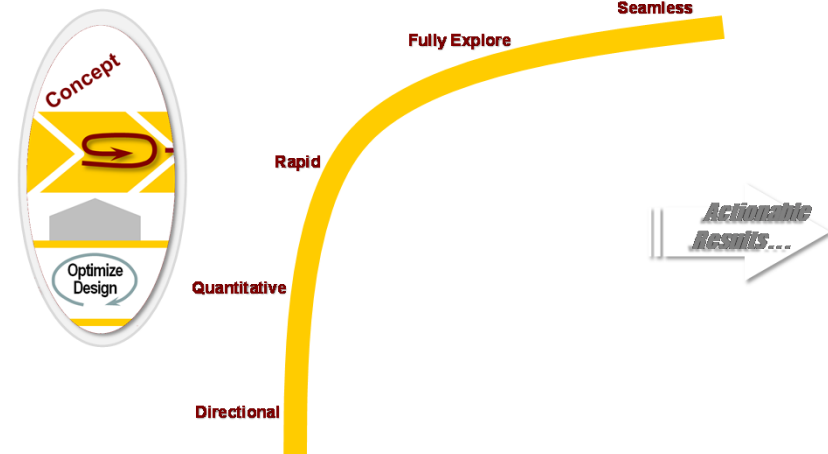
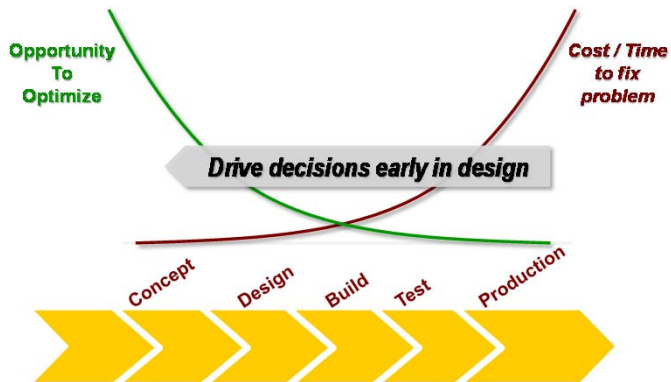
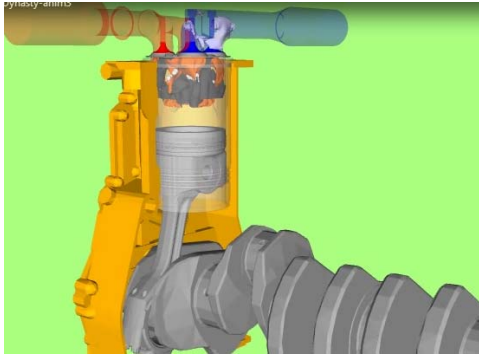
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Questions



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