





# I Think outside the Box:

Expand Model-based Systems Engineering (MBSE)  
into Model-based Production Engineering (MBPE)  
to realize a Lego Manufacturing System

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# Have you ever heard of Model-based Production Engineering?



Go to [www.menti.com](https://www.menti.com)  
Enter the code  
1443 9492

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# Amira

## Head of Factory Planning

Source: LEGO Digital Designer

# Mind-Game: Current Status of Amiras team ... ... organized by Classical Collaboration Silos

157#



Product Design Team



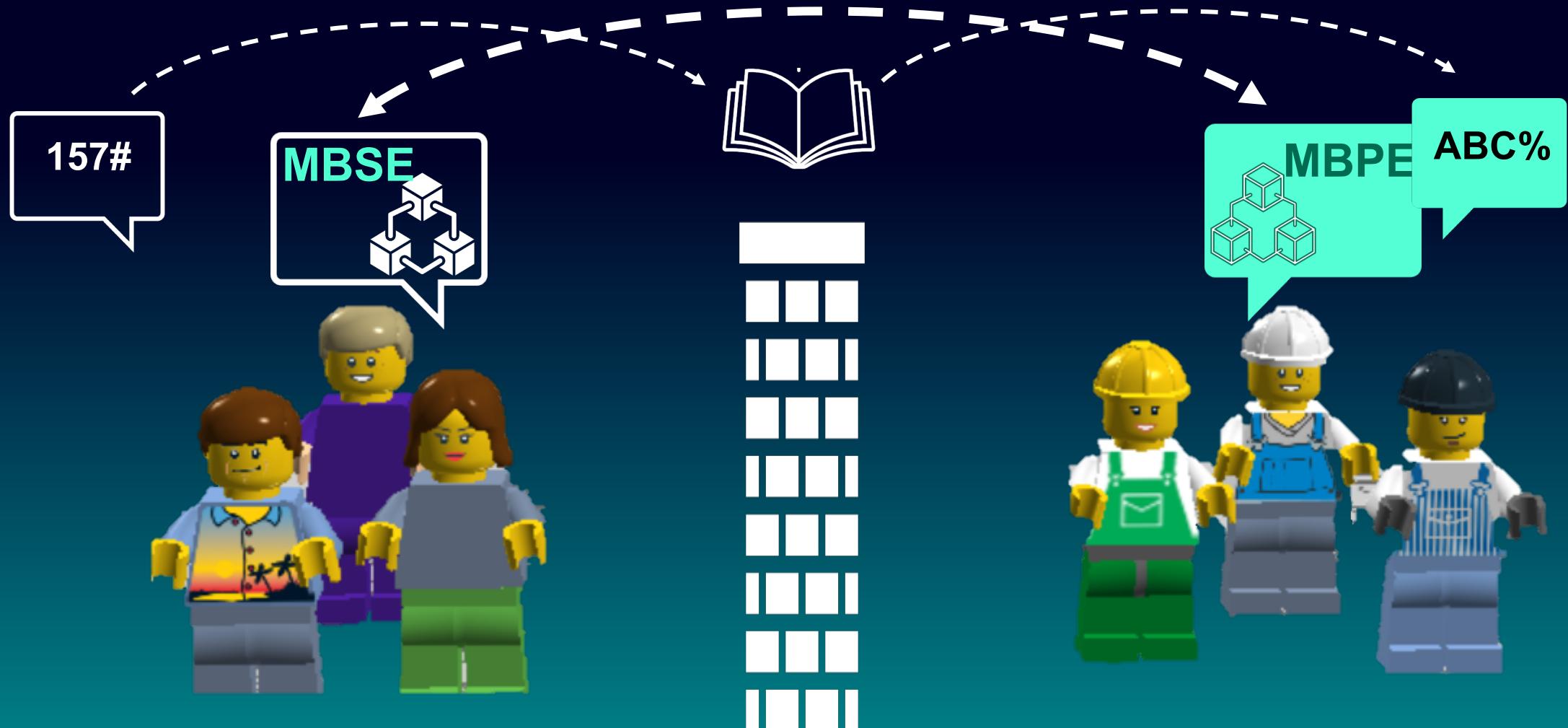
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Manufacturing Planning Team

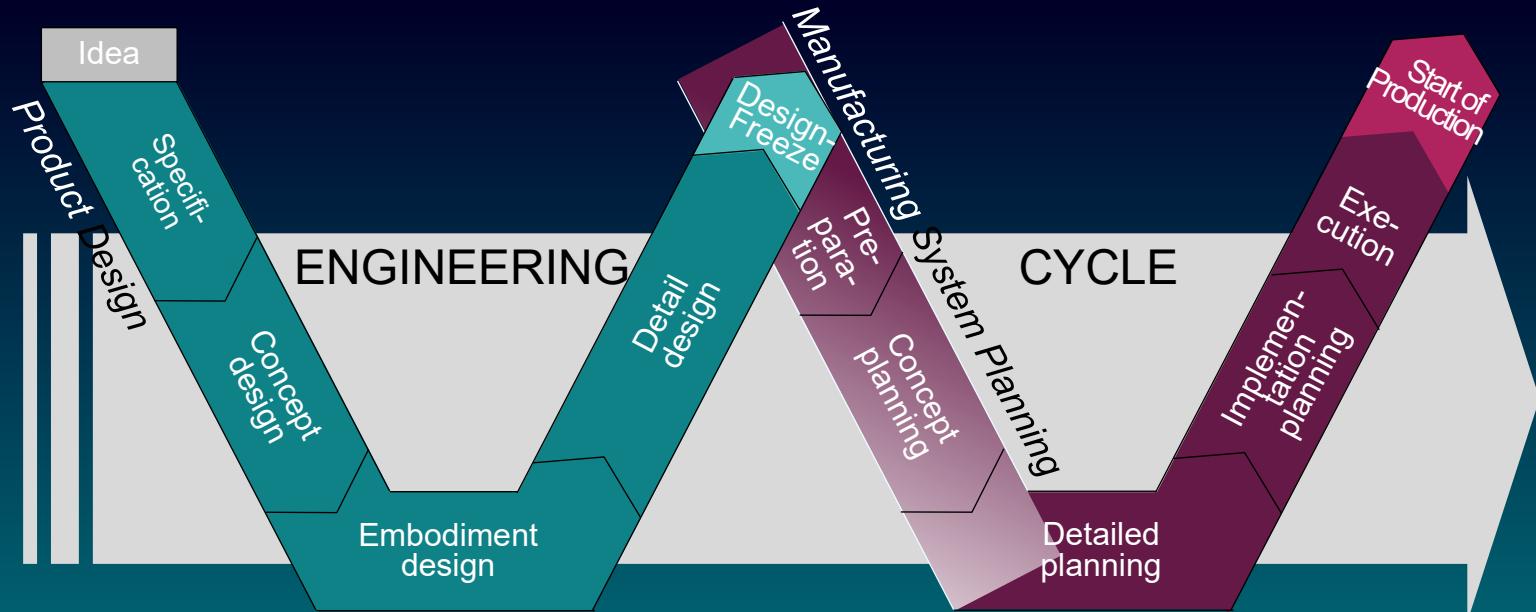
Source: LEGO Digital Designer

Let's imagine...  
... Amira would have integrated Engineering Teams

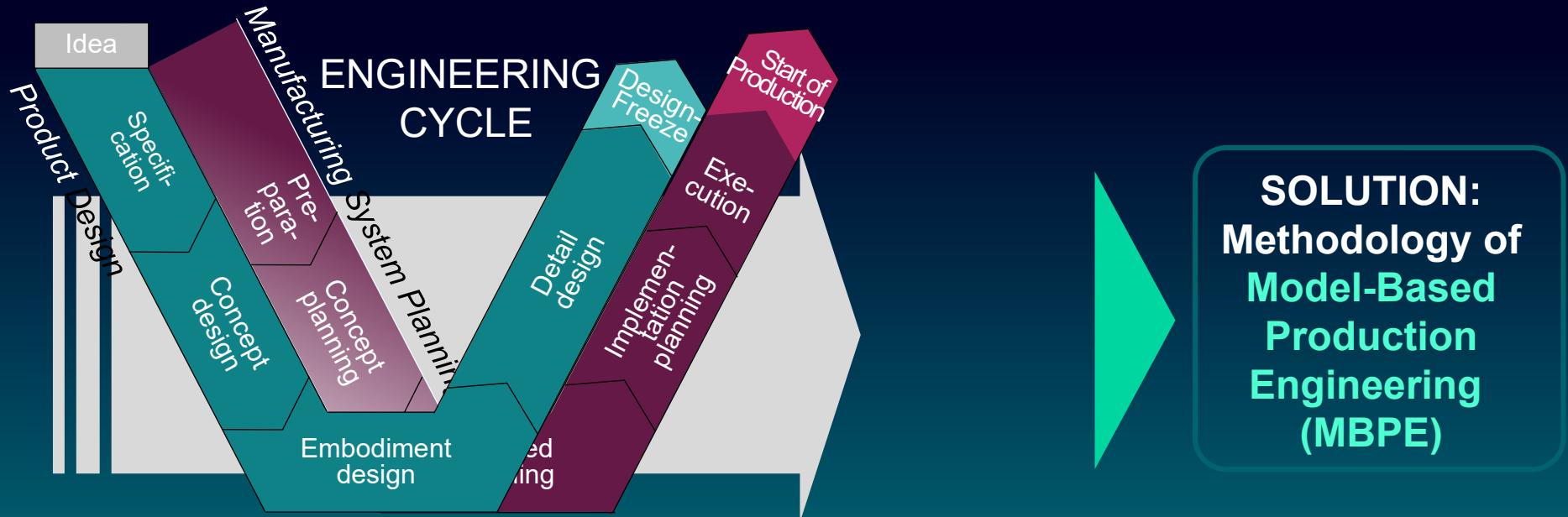


Source: LEGO Digital Designer

**Why should you think about Manufacturing Engineering in the early phase of engineering?**  
Because product design and manufacturing engineering do not collaborate efficiently!

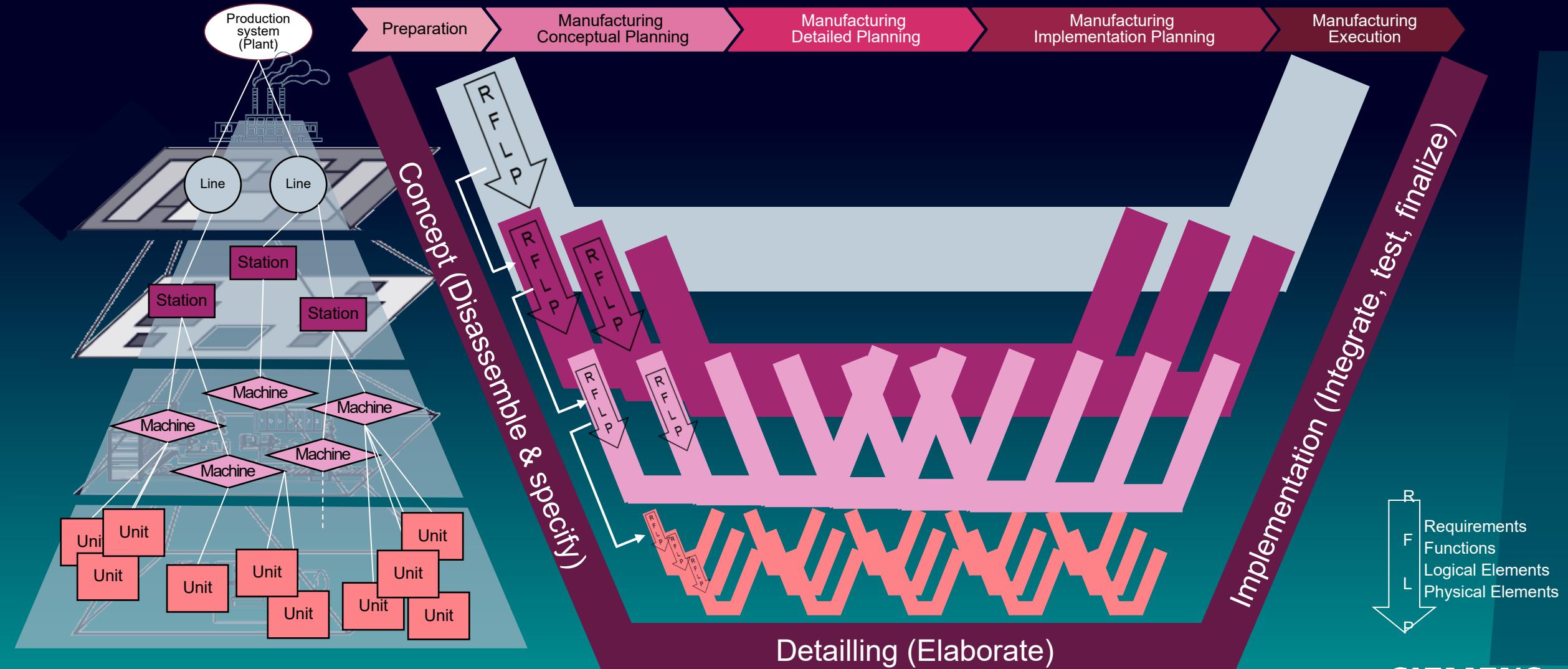


**Traceability through integrated system models during the overall design cycle is the key!**  
Model-based Production Engineering for better integration back into the engineering



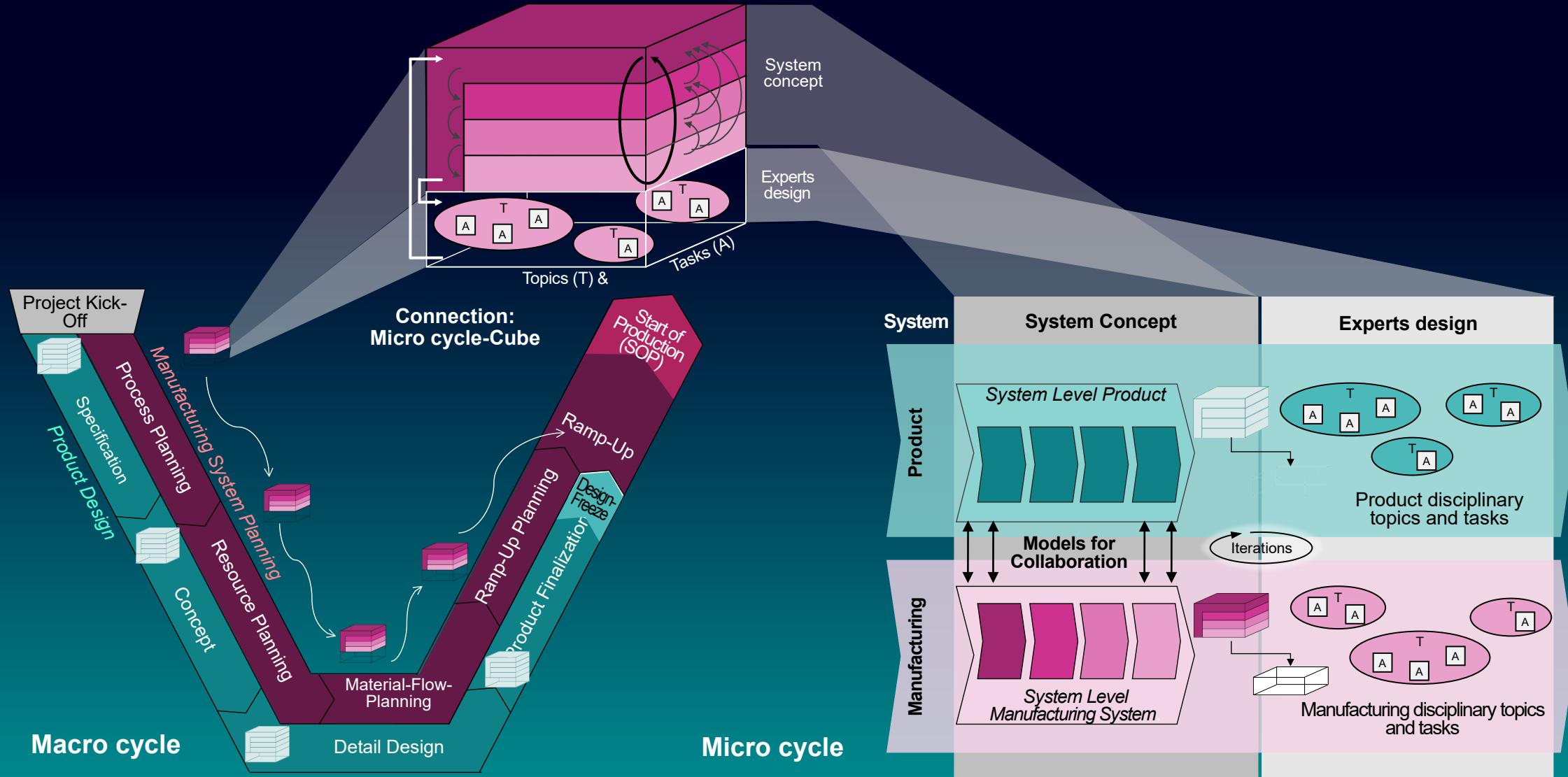
# MBPE means to hierarchically decompose Manufacturing Systems

## Handle Complexity and Collaboration aligned with Product Design



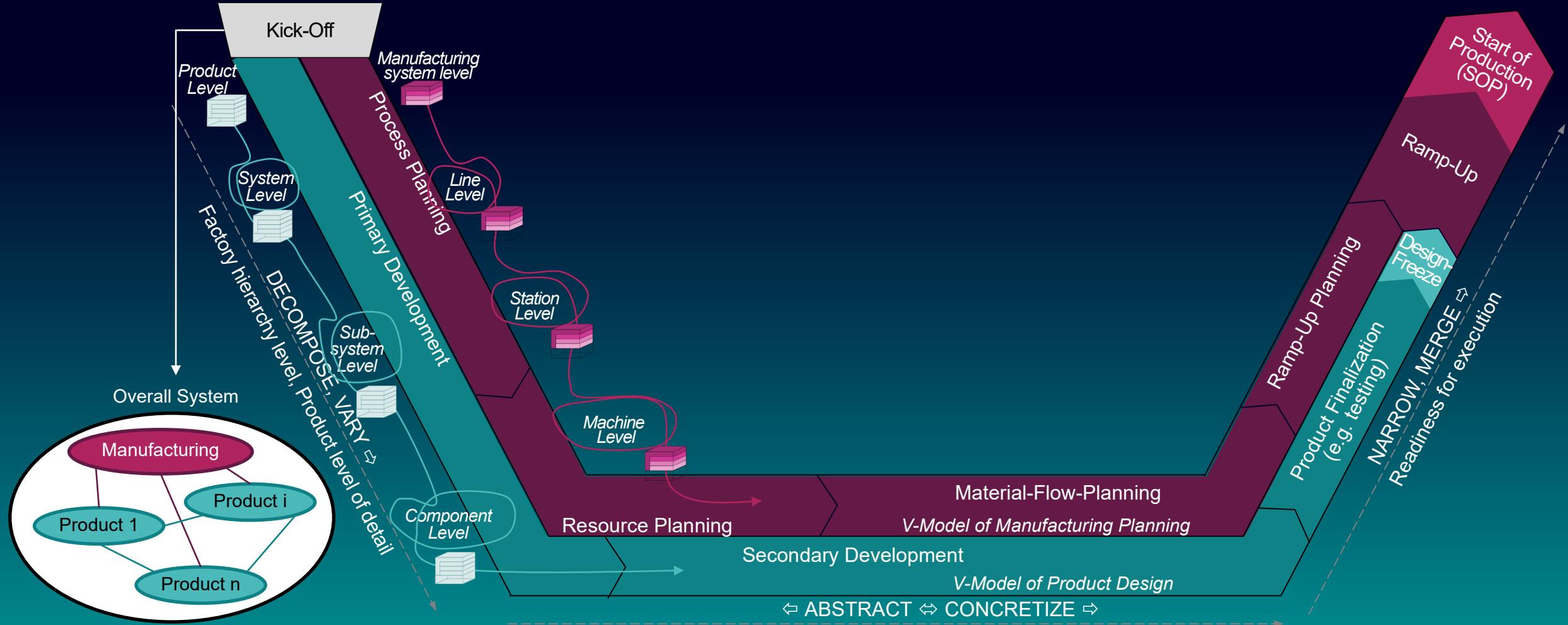
# The 3 parts of MBPE: Process vs. Methodology vs. Modeling

Integrated process model, systematic method for manufacturing concept design & modeling approach



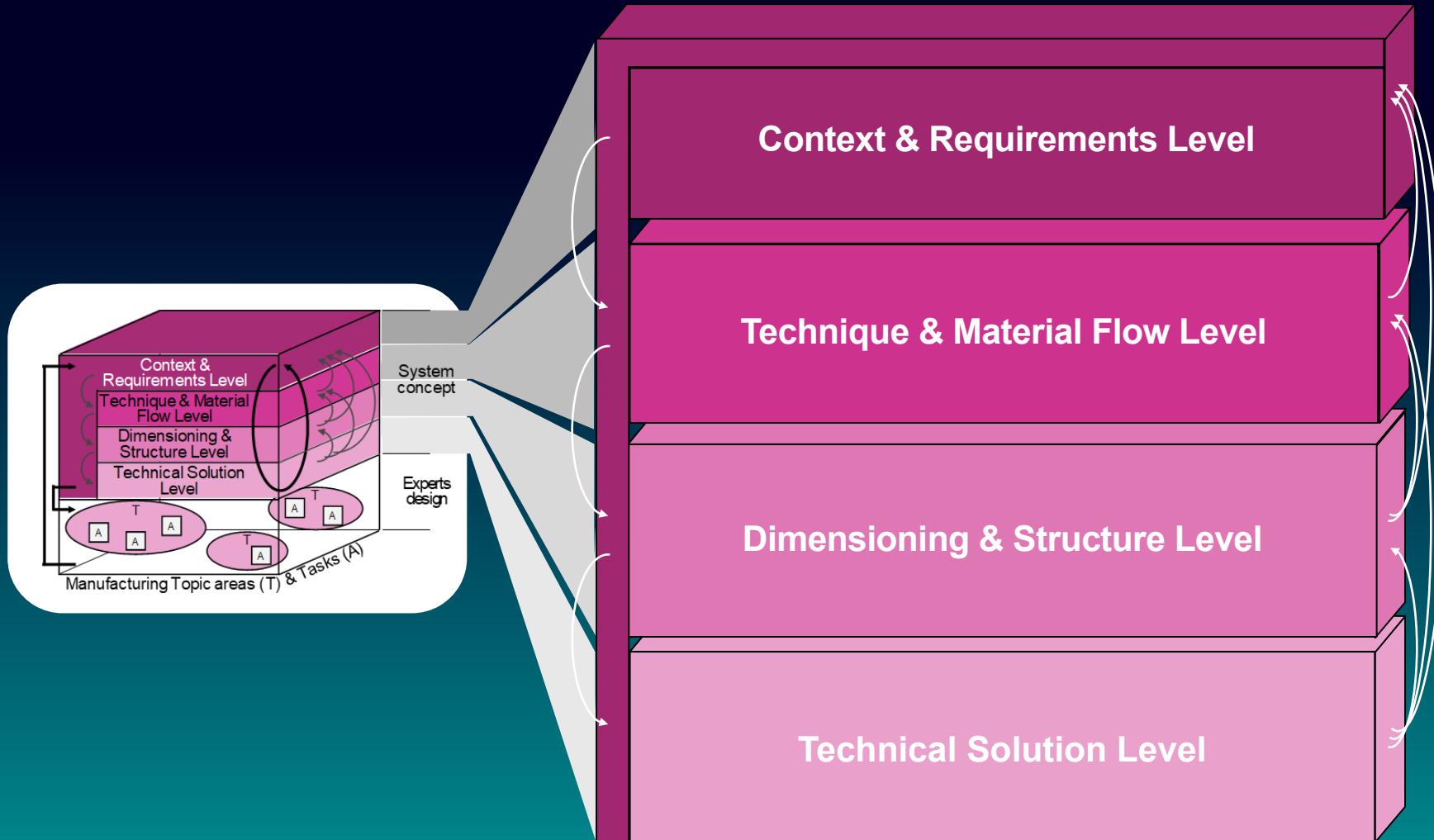
# Part 1: Integrated Process Model for Design and Manufacturing

Control collaboration during the overall Product Engineering Cycle until SOP



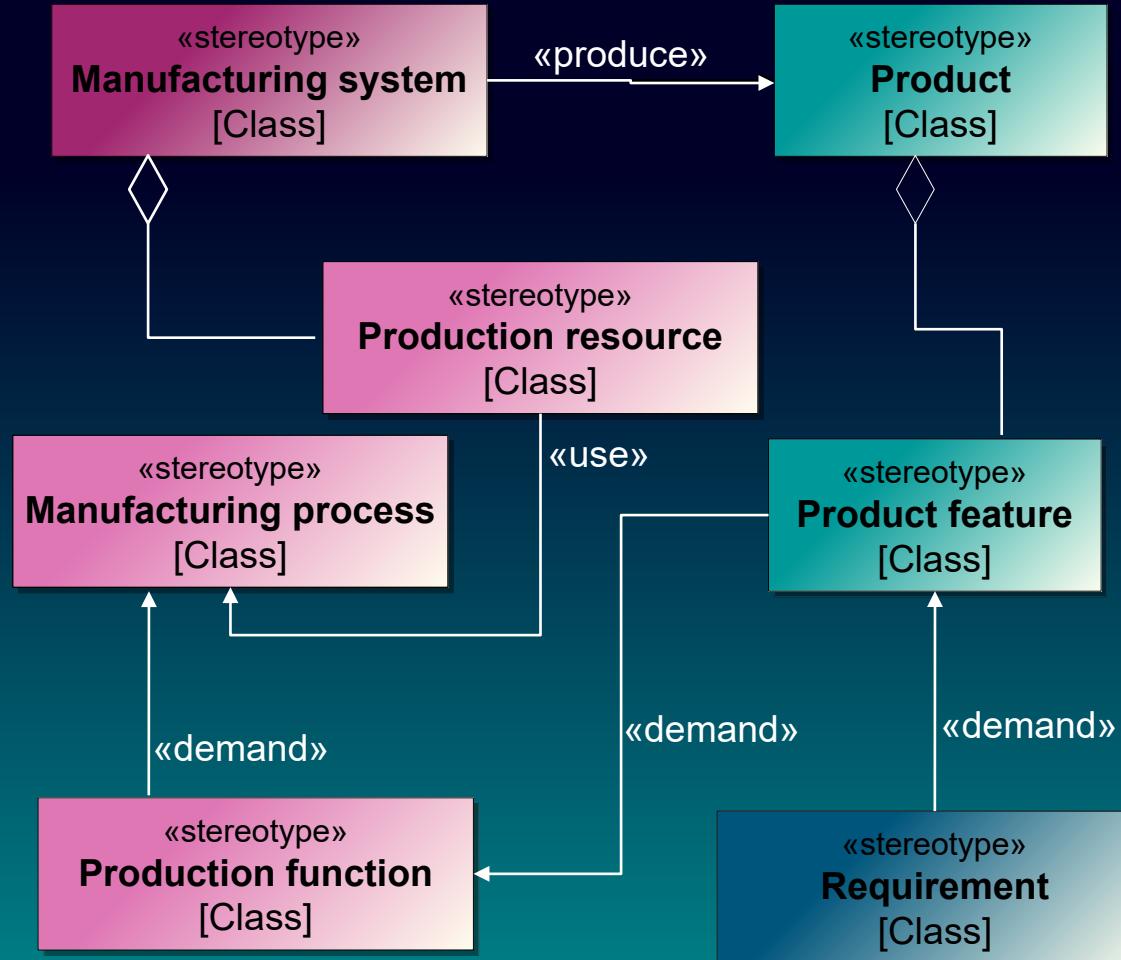
## Part 2: Systematic method for conceptual manufacturing system design

Is defined by its system design levels and a clear methodology



## Part 3: Modeling approach (originally designed for UML2)

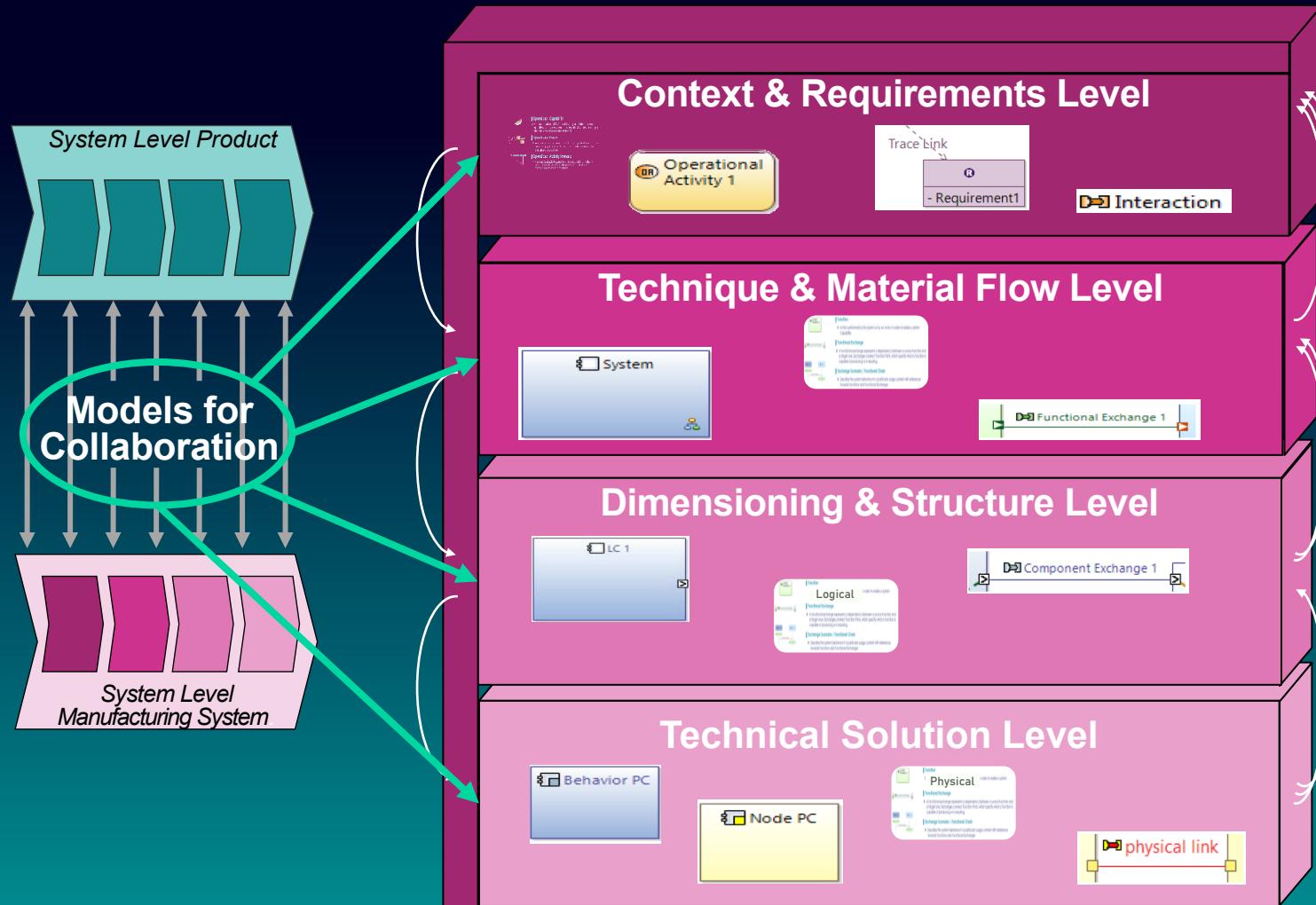
Common design language for design & planning using object-oriented modeling and UML-stereotypes



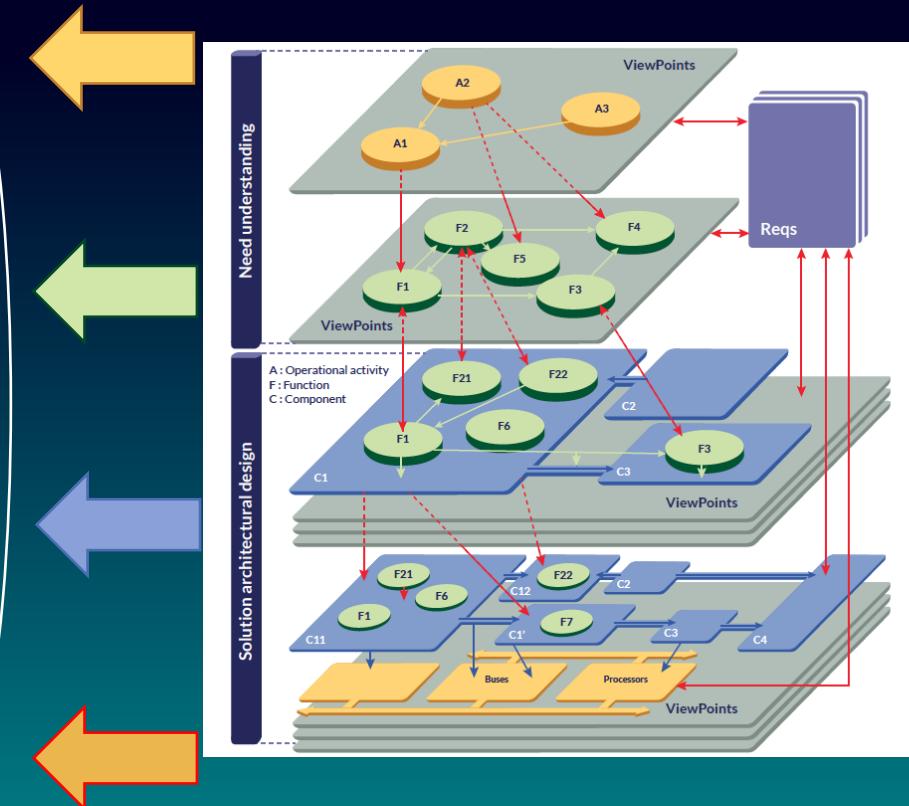
## Part 3: Modeling approach (originally designed for UML2)

Common design language for design & planning adapted for using ARCADIA modeling artefacts

### MBPE Micro Cycle Cube

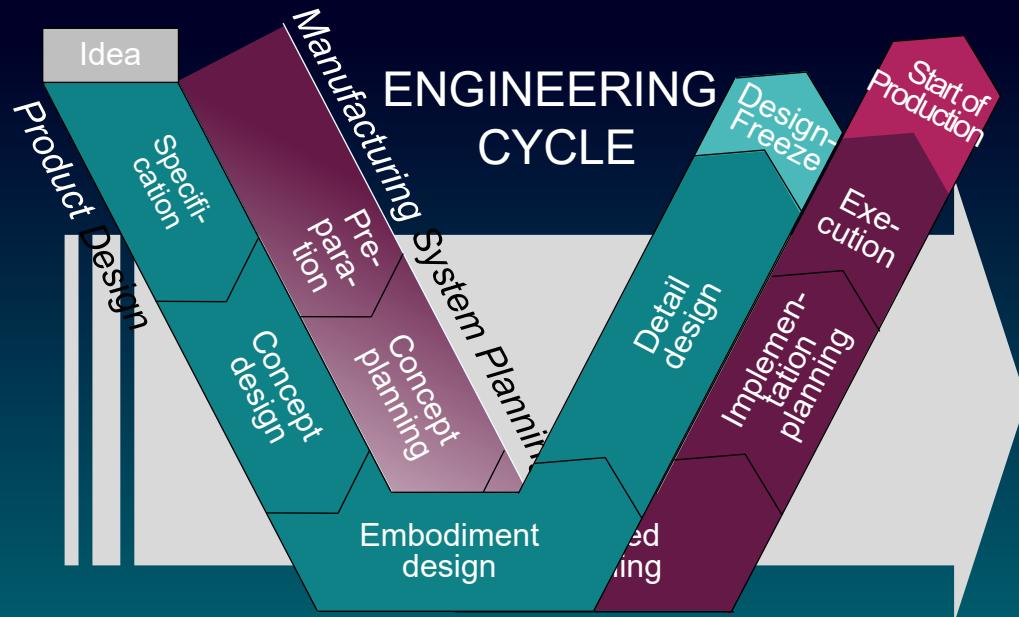


### ARCADIA-Method Framework



# What's behind Model-based Production Engineering?

## MBPE in a nutshell





# Amira

## Head of Factory Planning

Source: LEGO Digital Designer

# UseCase – Develop a Lego toy car product family and automated manufacturing line

## Variability of min. 3 & corresponding manufacturing line using a minimum of Lego Mindstorms Bricks

Product Design



Source: LEGO Digital Designer

Manufacturing Planning



Source: <https://robotics.benedettelli.com/lego-car-factory/>

# MBPE connects Engineering & Manufacturing Teams

## ONE Team approach



Source: LEGO Digital Designer

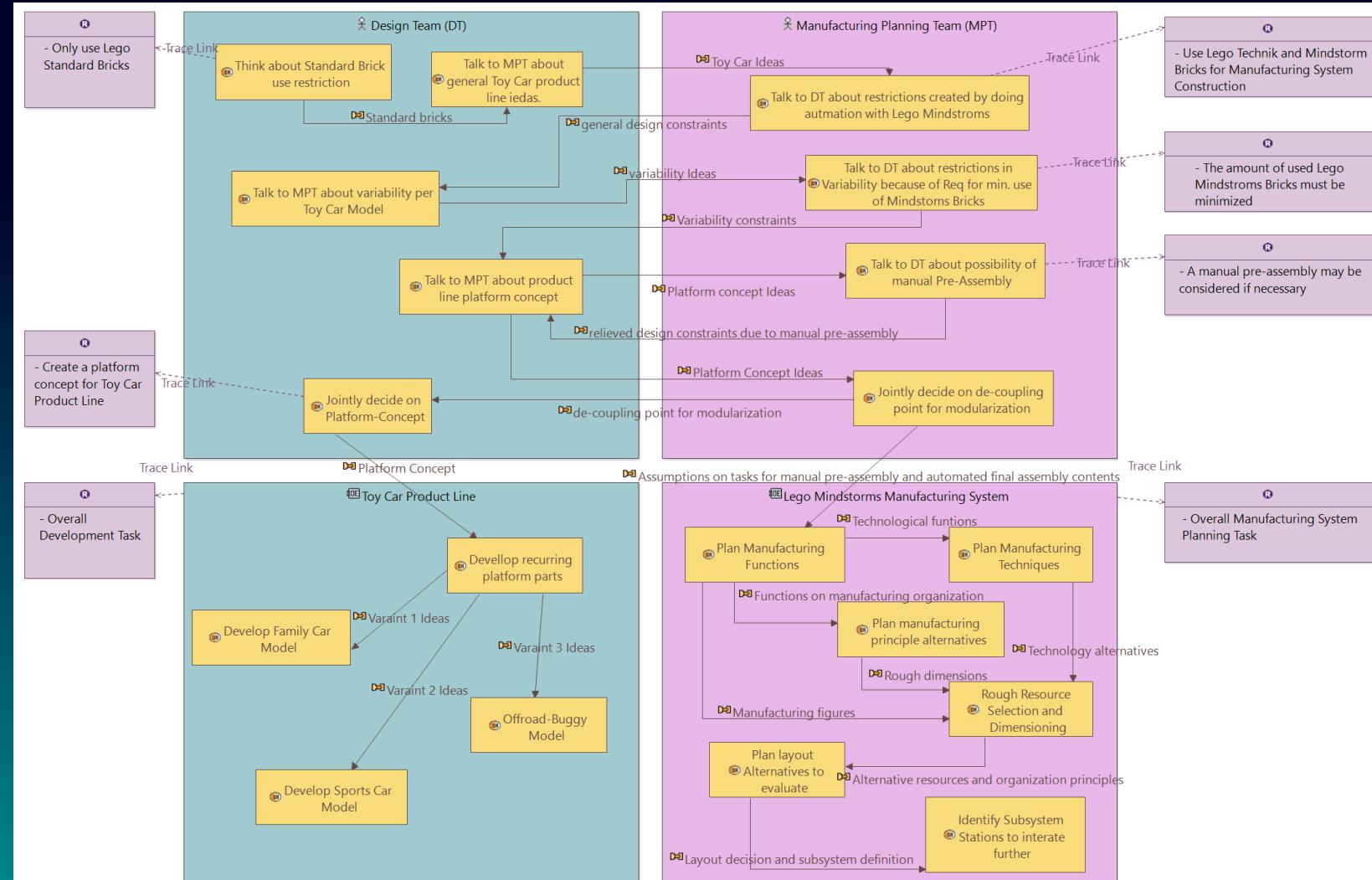
# Operational Analysis

## Manufacturing Purpose on Context and Requirements Level

The LEGO  
toy car family  
shall ...



Source: LEGO Digital Designer



The LEGO  
manufacturing  
line shall ...

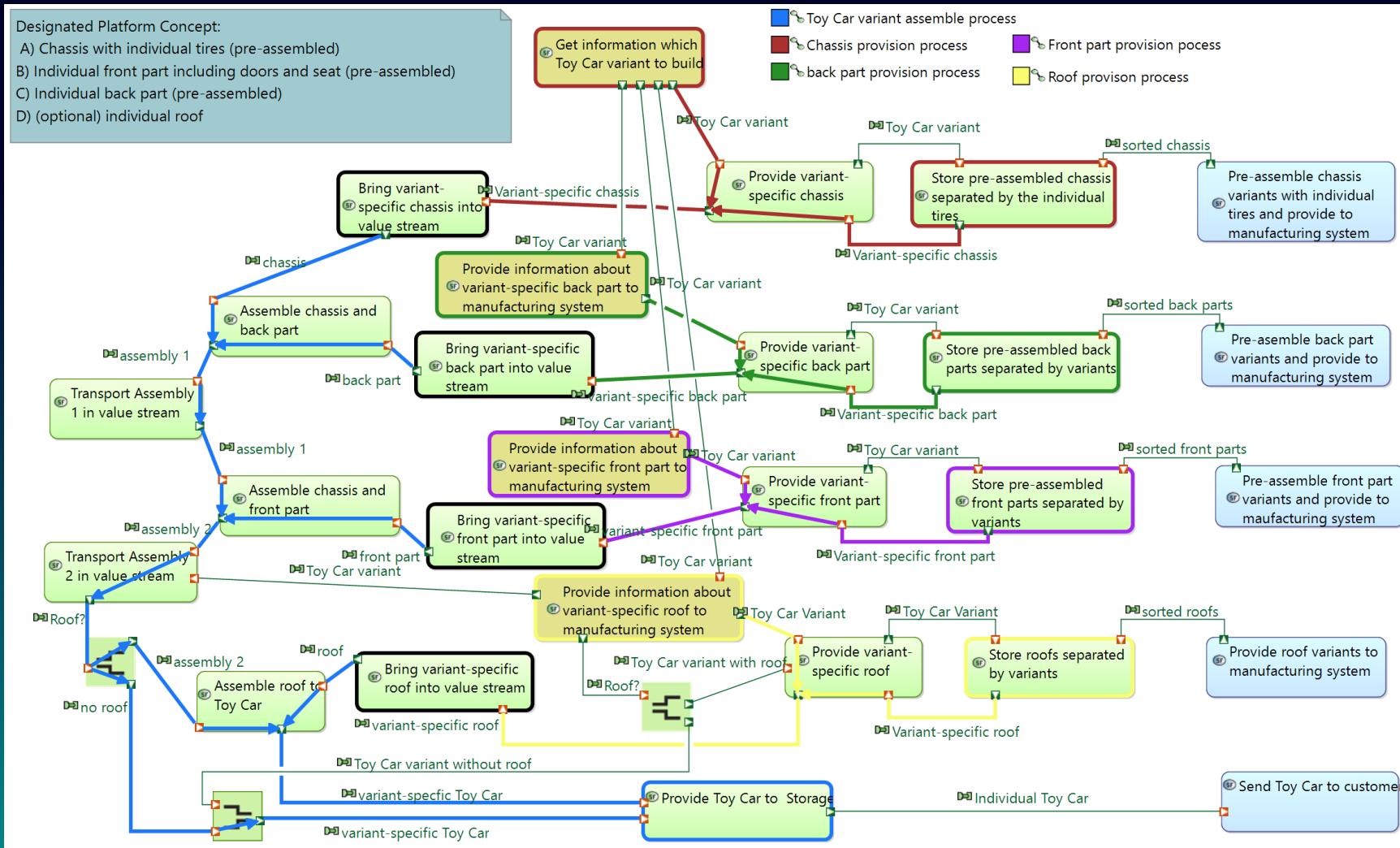


Source: LEGO Digital Designer

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# System Analysis

## Manufacturing Techniques and Material Flows Level

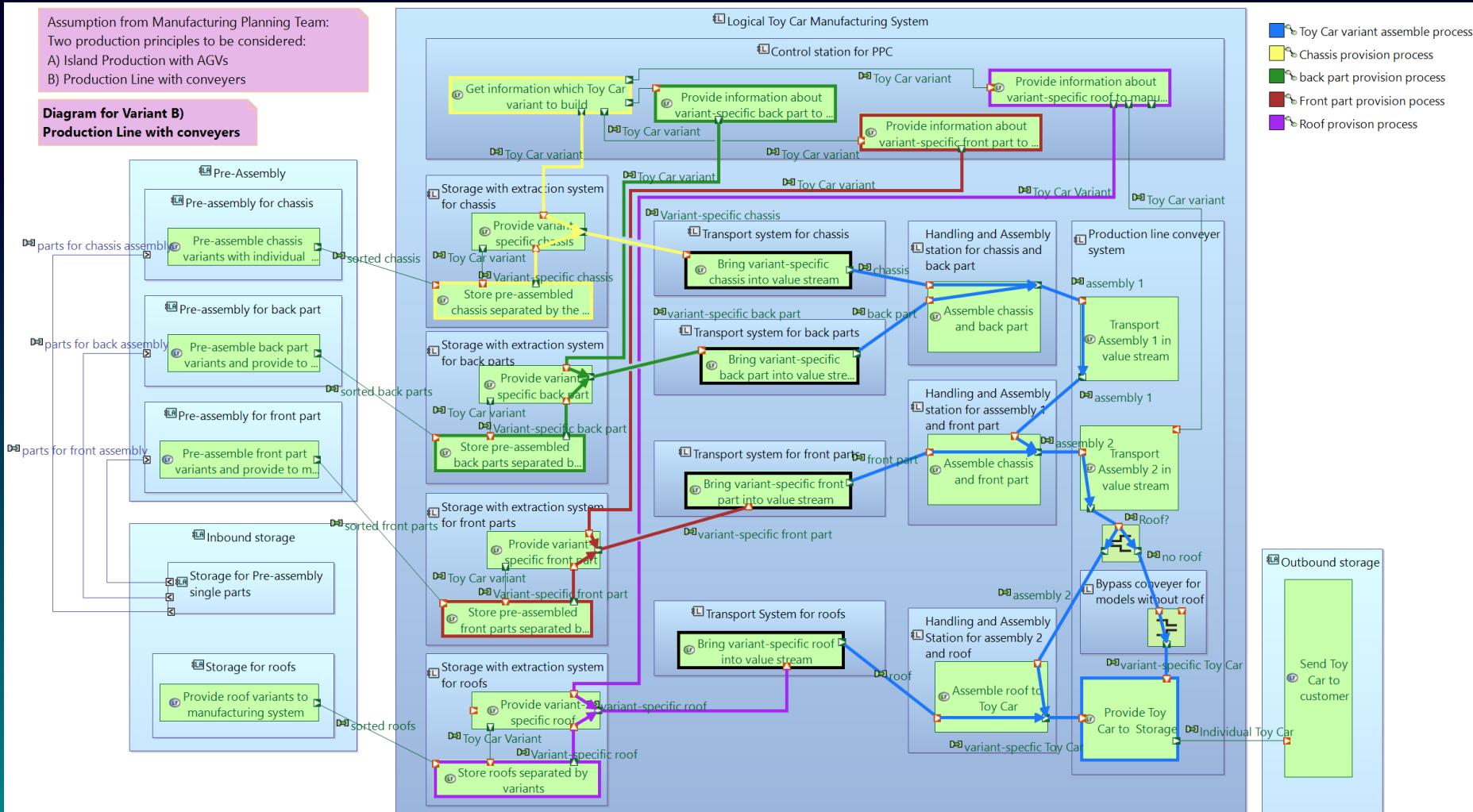


Source: LEGO Digital Designer

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# Logical Architecture

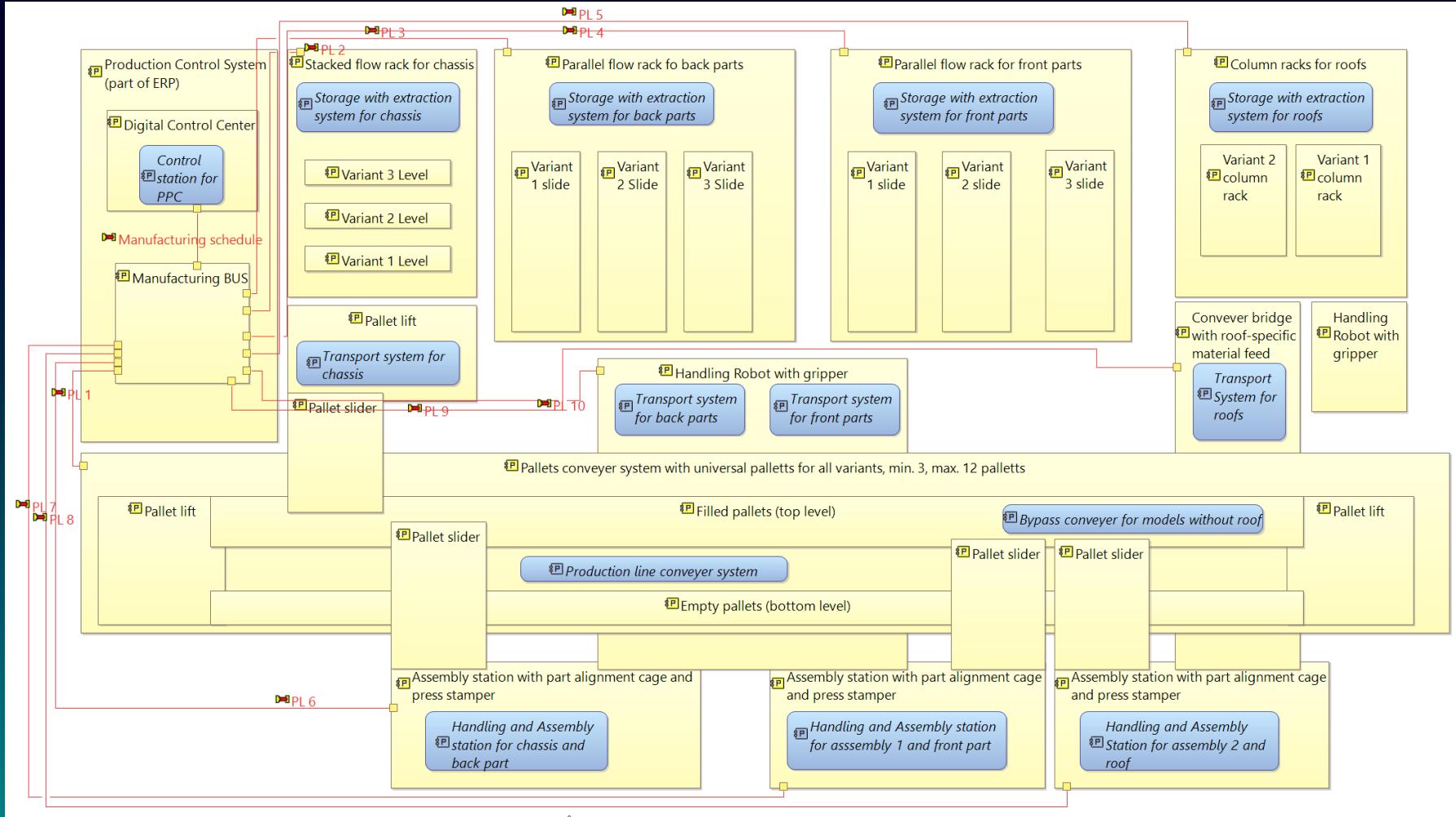
## Manufacturing Dimensioning and Structure Level



Source: LEGO Digital Designer

# Physical Architecture

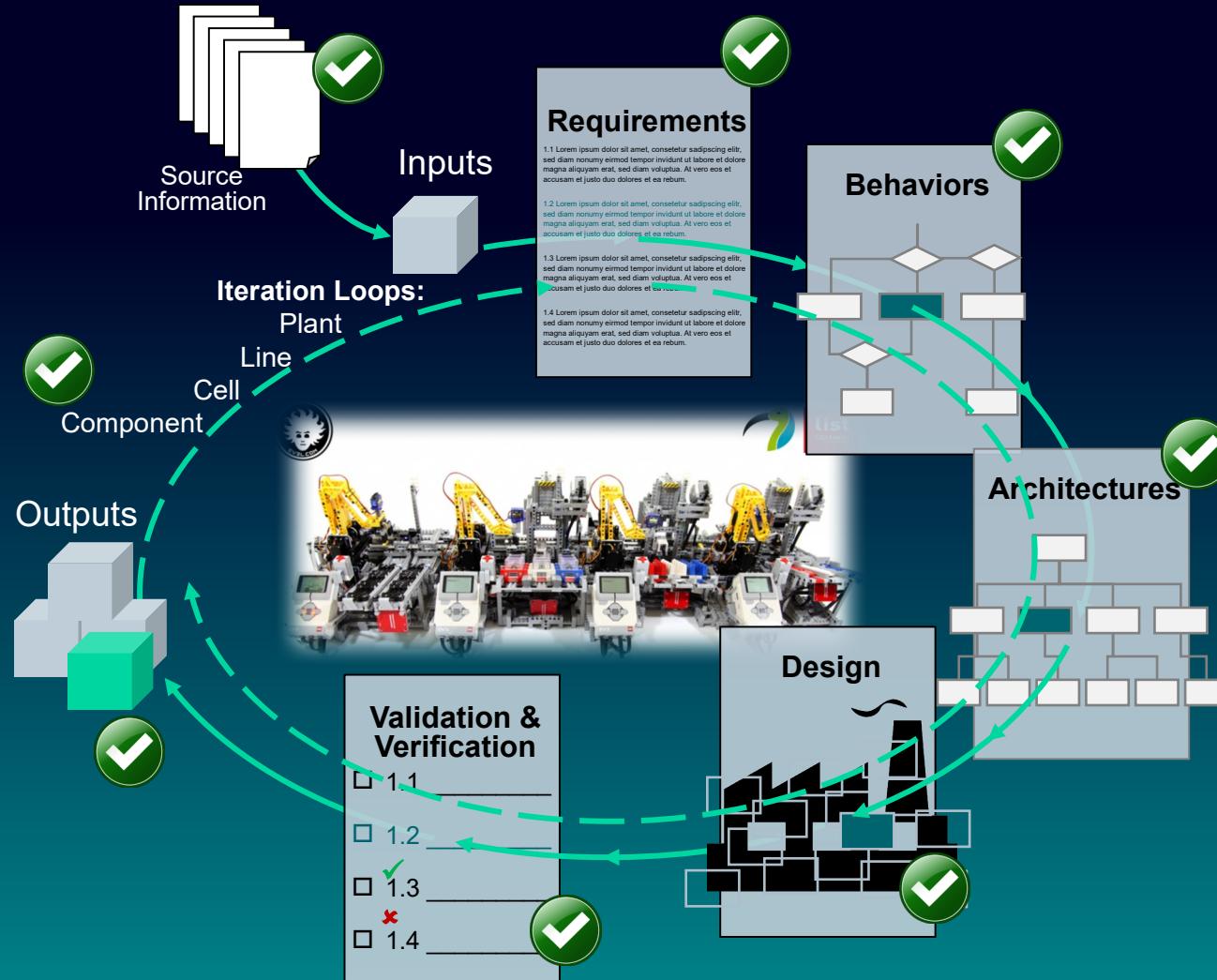
## Manufacturing Resources and Layout on Technical Solution Level



Source: <https://robotics.benedettelli.com/lego-car-factory/>

# MBPE results in the Availability of consistent Information

## For Design, Manufacturing Engineering, Simulation and Virtual Commissioning



# Q&A

Want to learn more about MBPE?

Read paper:  
*CIRP Annals 2019 – Conceptual manufacturing system design based on early product information*



Have a look into PhD-Thesis:  
*Methode zur Produktionssystemkonzipierung auf Basis früher Produktinformationen – Ein Beitrag zur Integration von Produktionssystemplanung und Produktentwicklung unter Einsatz des MBSE*

A thumbnail image of a PhD thesis cover. The title is 'Methode zur Produktionssystemkonzipierung auf Basis früher Produktinformationen – Ein Beitrag zur Integration von Produktionssystemplanung und Produktentwicklung unter Einsatz des MBSE'. The author is Chantal Fiona Desirée Sinnwell. The supervisor is Prof. Dr.-Ing. Jan C. Aurich. The publisher is FBK (Lehrstuhl für Fertigungstechnik und Betriebsorganisation). The thesis is part of 'Produktionstechnische Berichte aus dem FBK Band 02/2020'. The logo of Technische Universität Kaiserslautern is at the bottom.

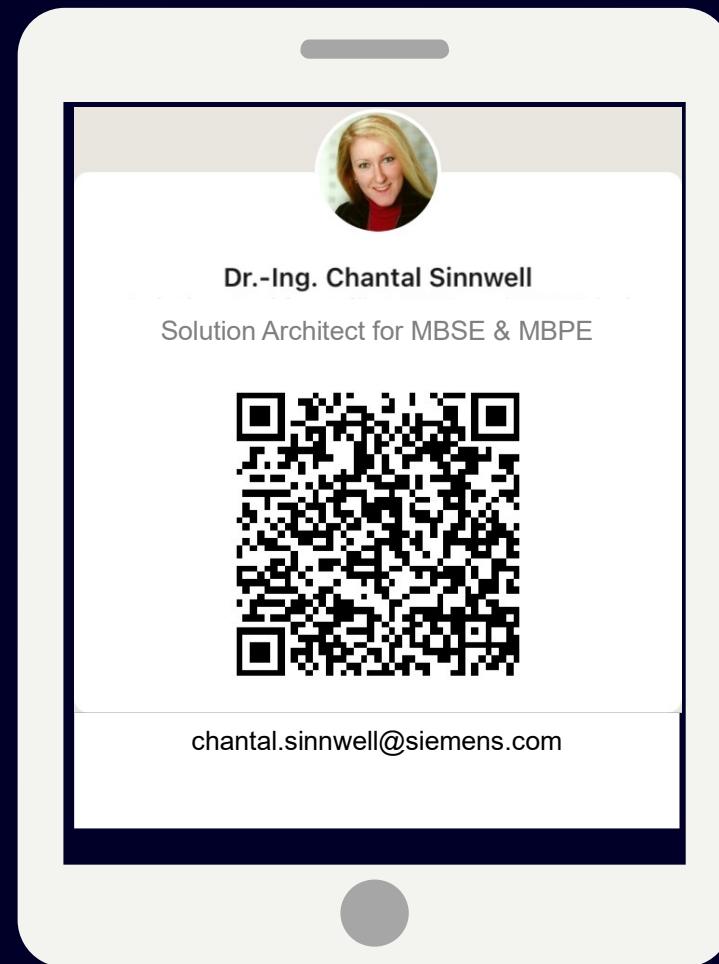
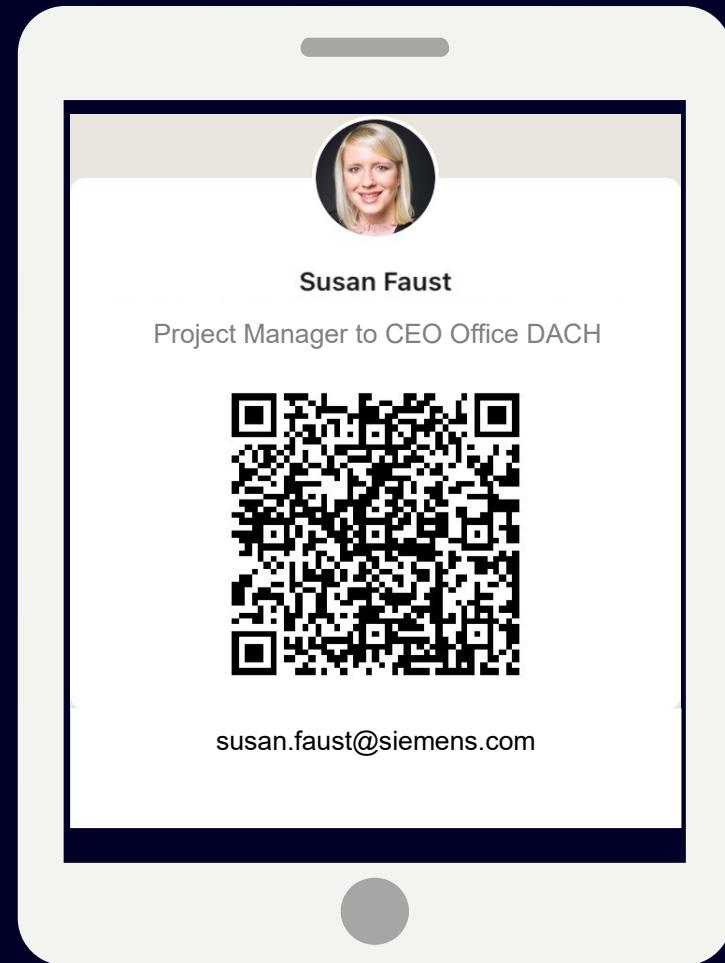
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# Amira Head of Factory Planning

- ✓ NO more silos based on integrated MBSE & MBPE approach
- ✓ Aligned language between teams based on ARCADIA
- ✓ Faster processes thanks to interdisciplinary digital twin

Source: LEGO Digital Designer



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