





# Think outside the Box:

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

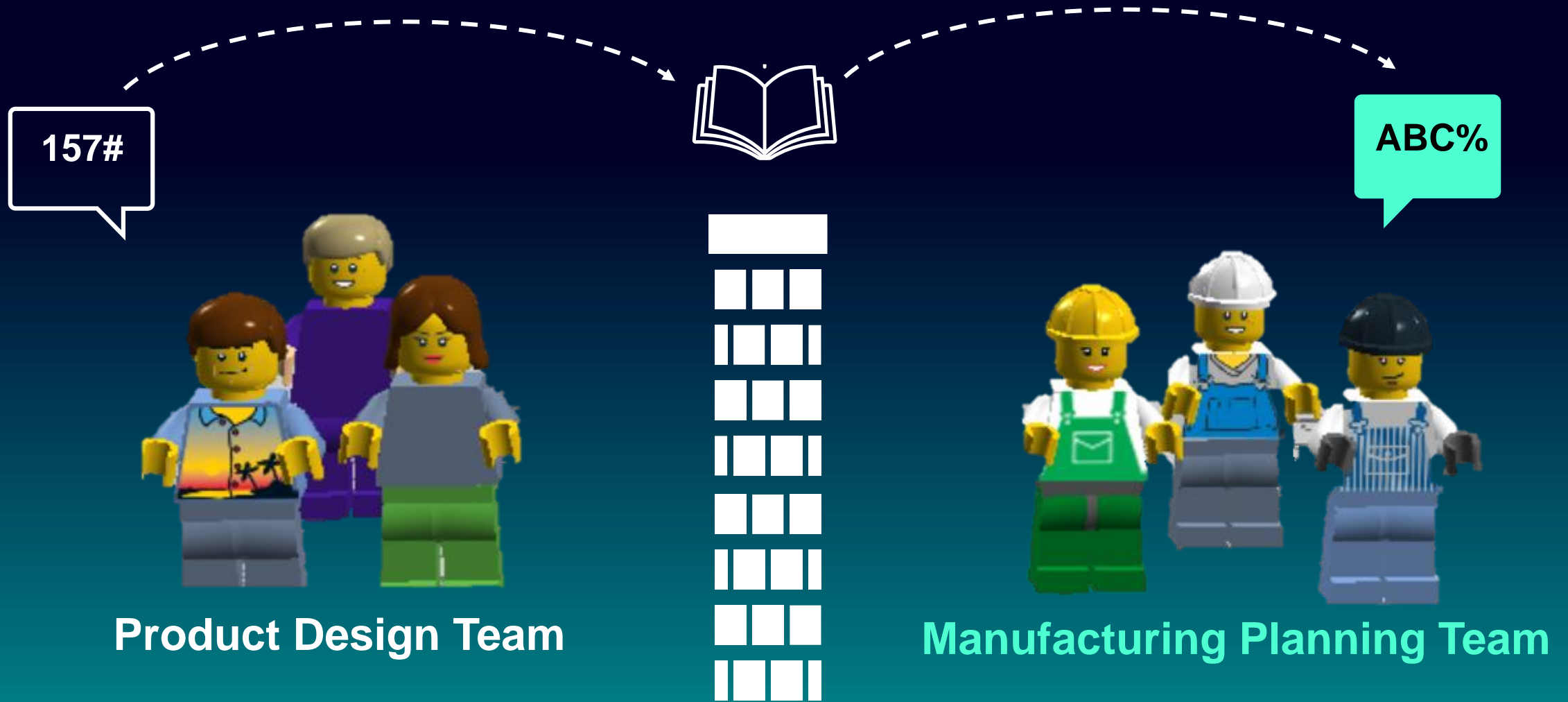


# Amira

## Head of Factory Planning

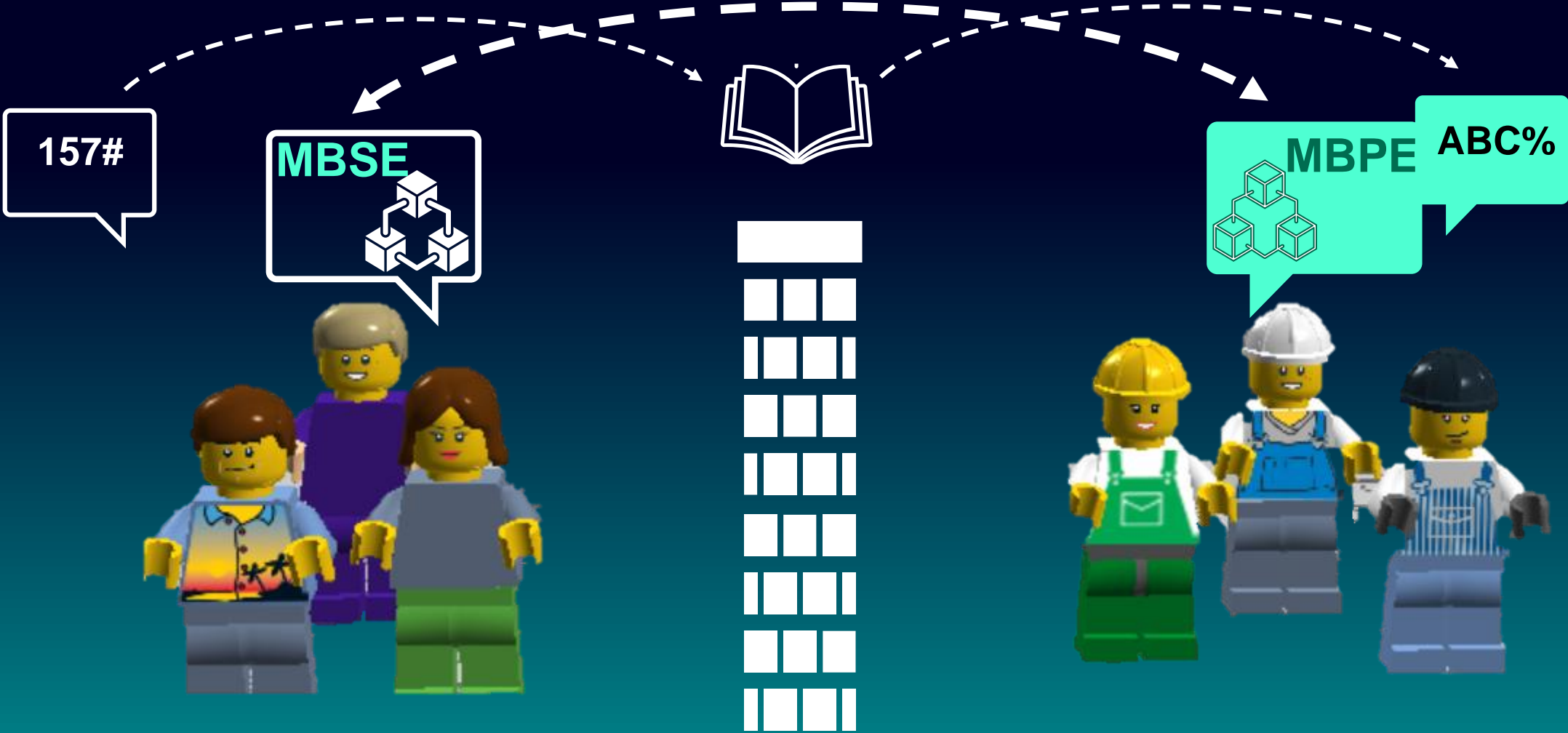
Source: LEGO Digital Designer

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



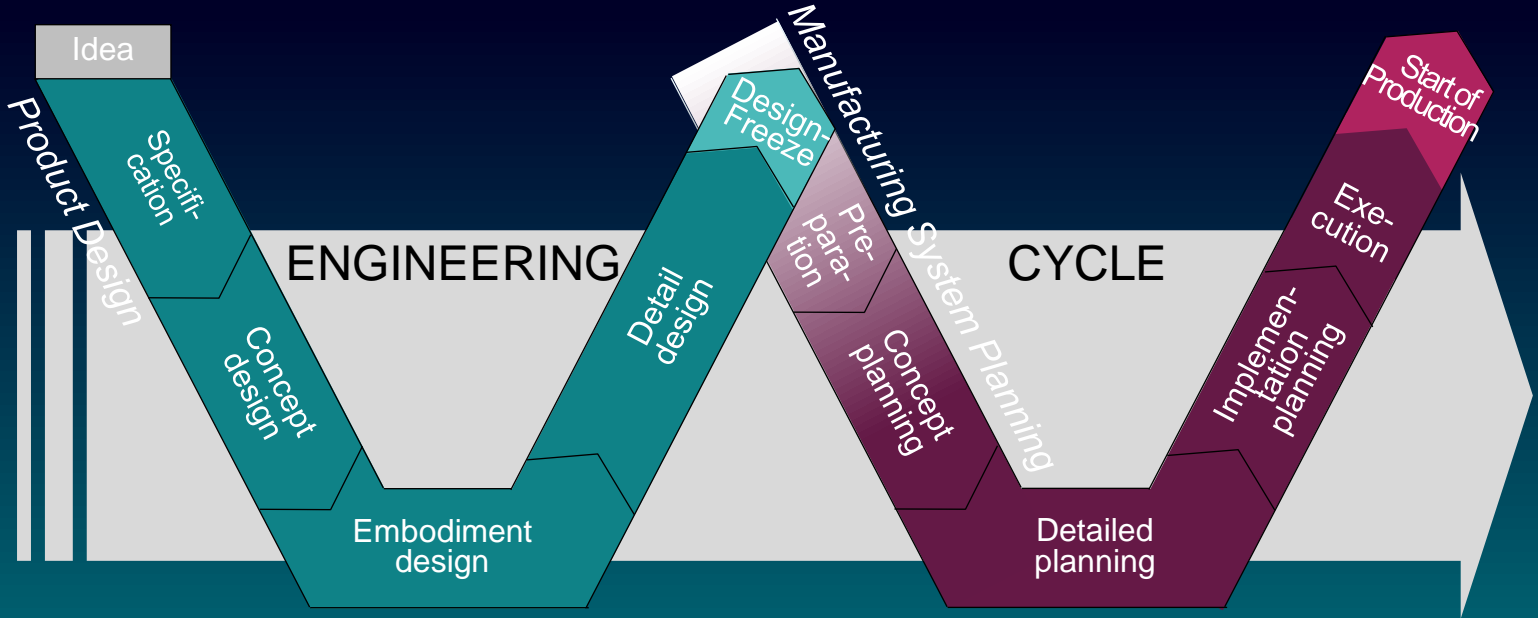
Source: LEGO Digital Designer

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



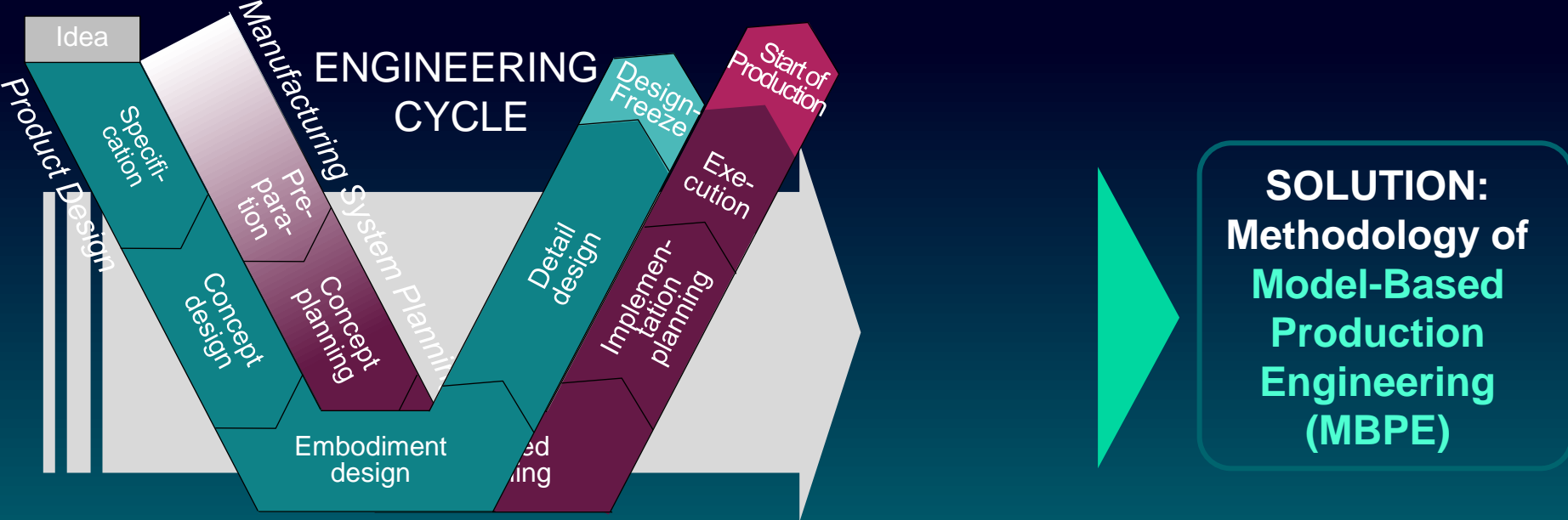
Source: LEGO Digital Designer

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



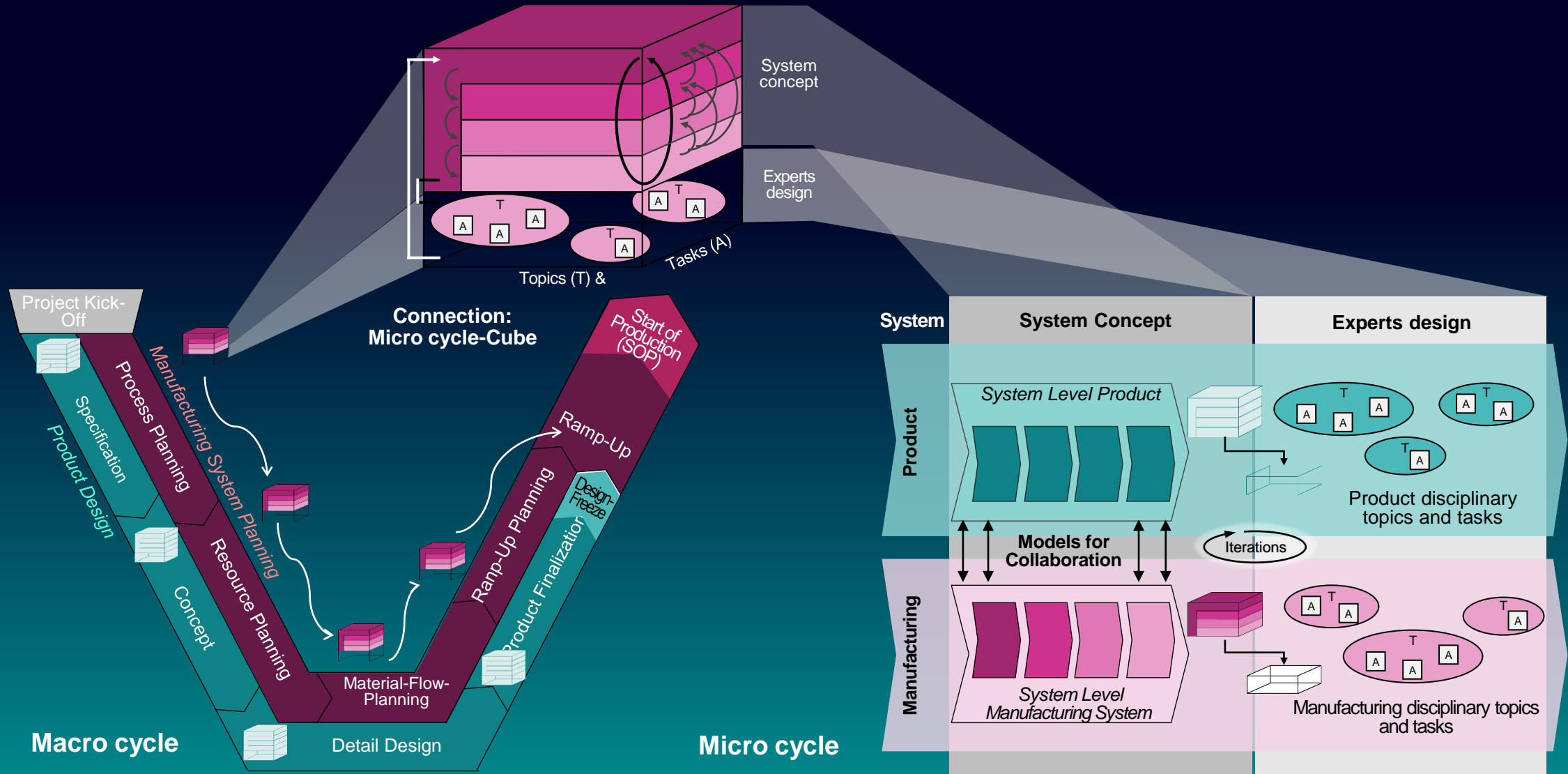
# Traceability through integrated system models during the overall design cycle is the key!

Model-based Production Engineering for better integration back into the engineering



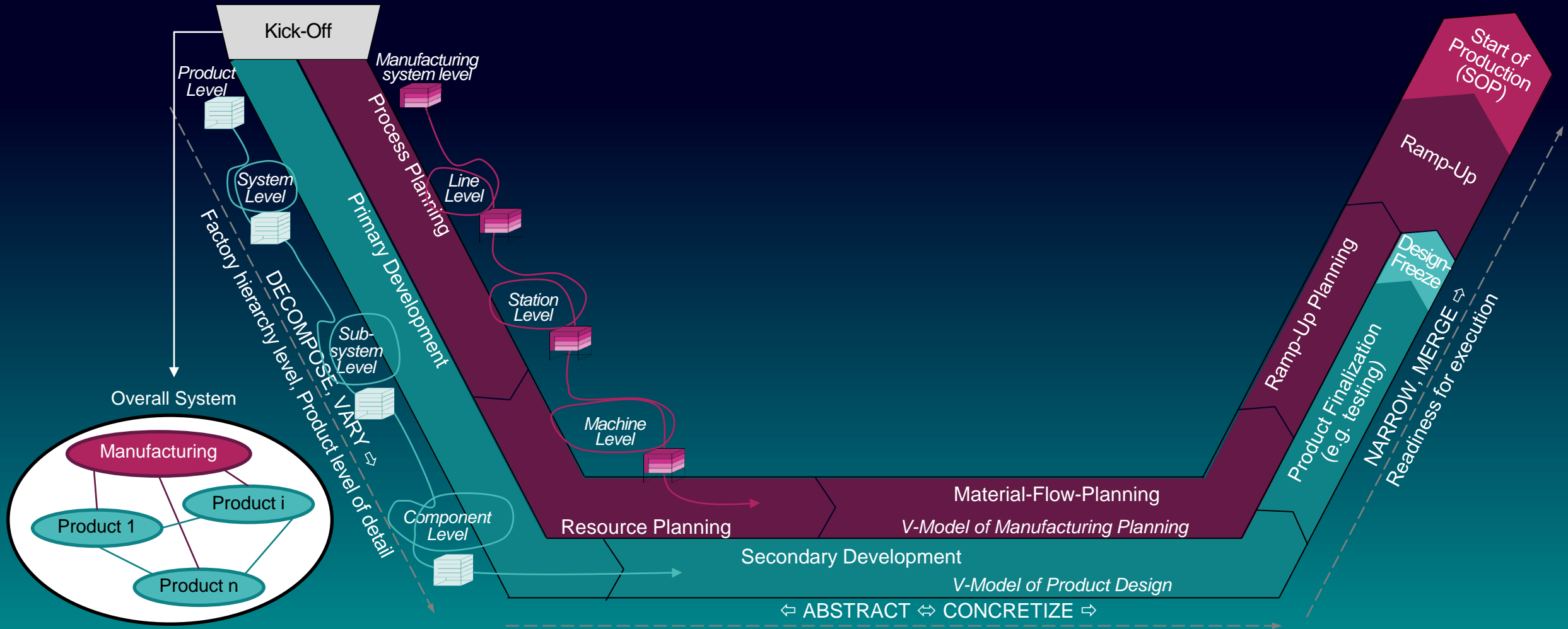
# The 3 parts of MBPE: Process vs. Methodology vs. Modeling

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



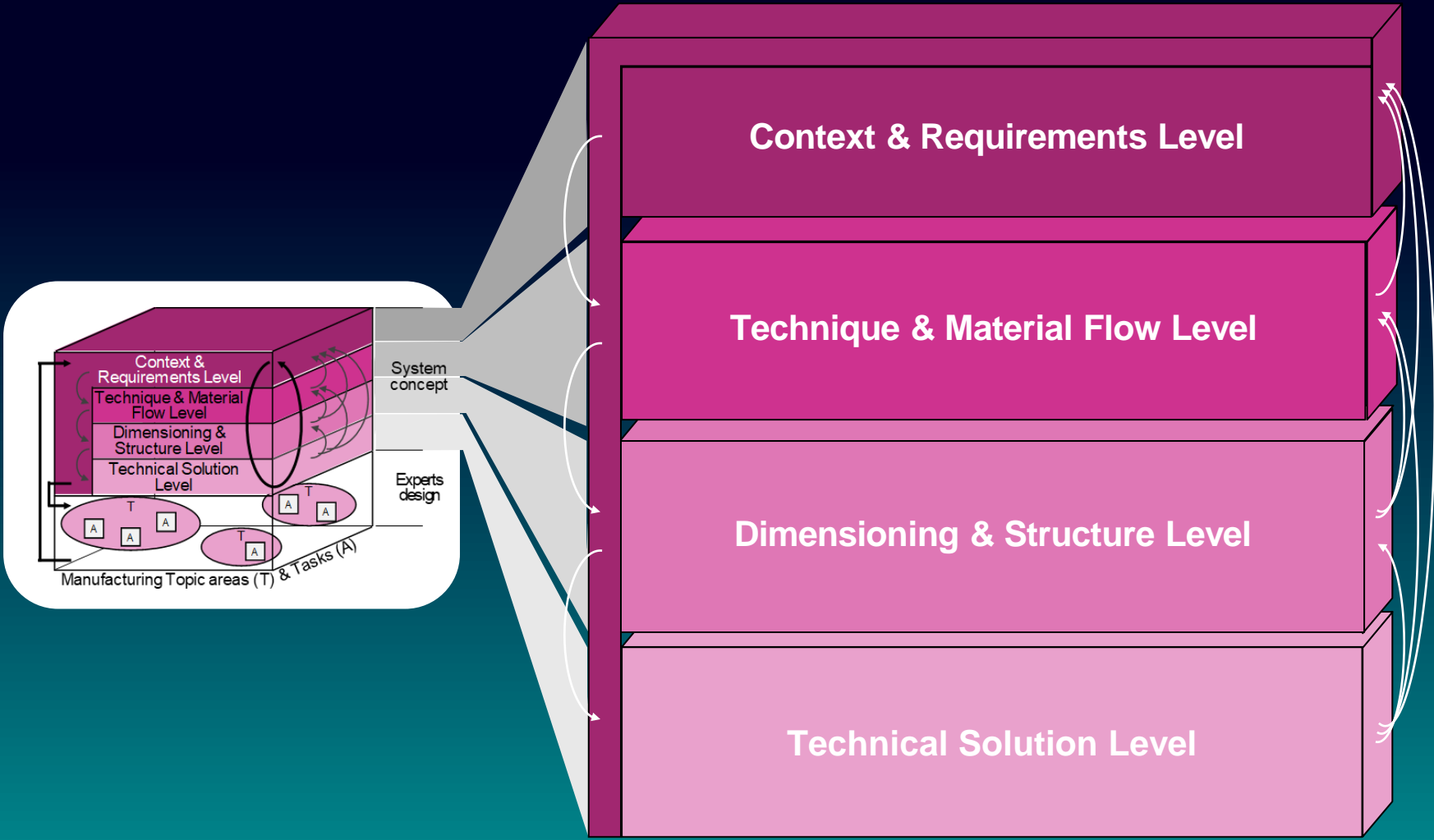
# Part 1: Integrated Process Model for Design and Manufacturing

## Control collaboration during the overall Product Engineering Cycle until SOP



# Part 2: Systematic method for conceptual manufacturing system design

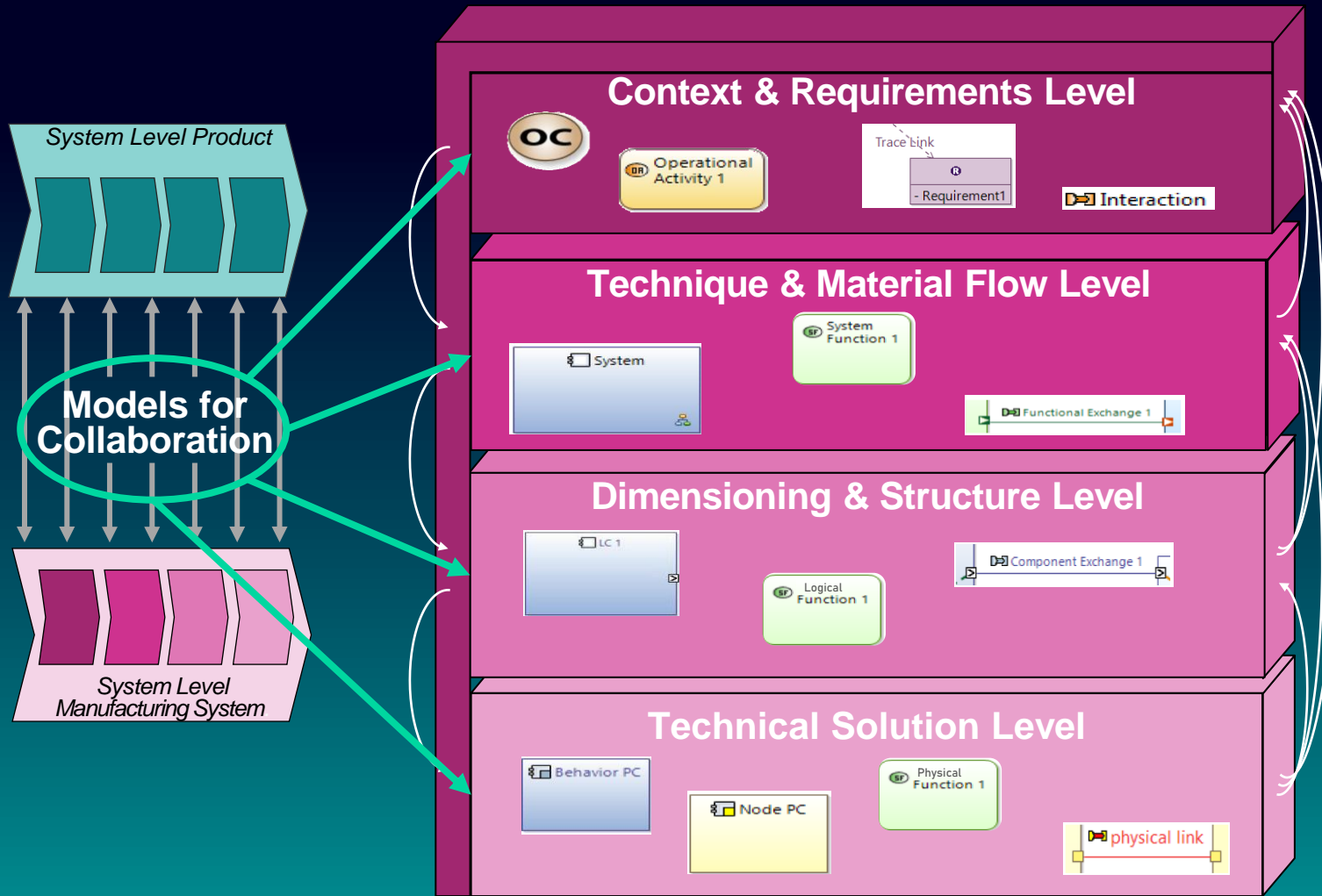
Is defined by its system design levels and a clear methodology



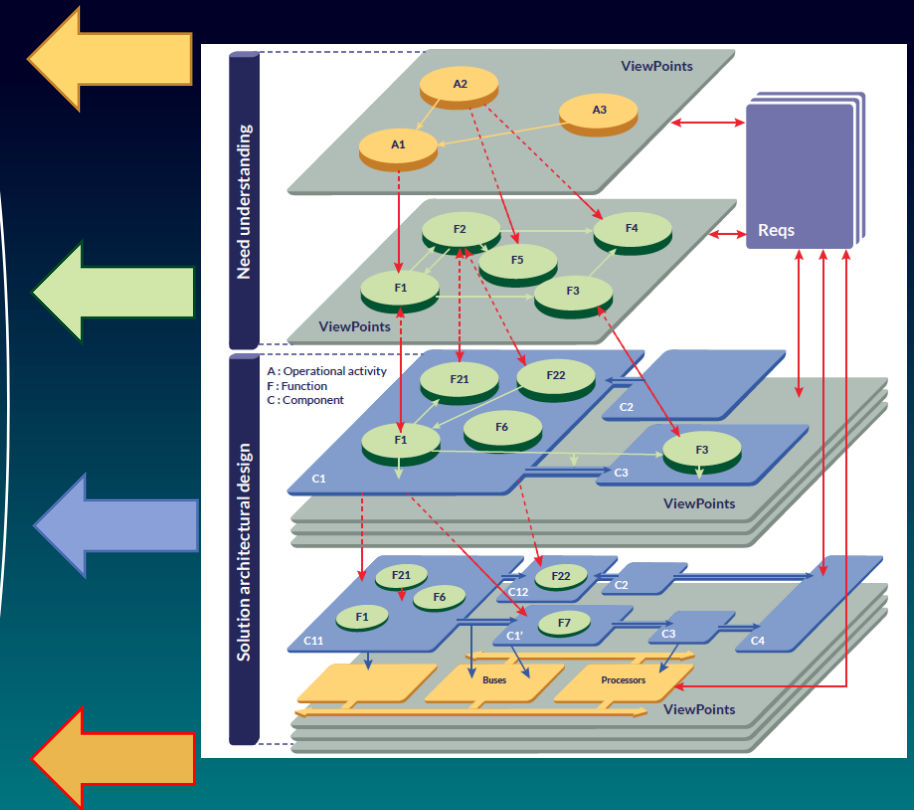
# Part 3: Modeling approach (originally designed for UML2)

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

## MBPE Micro Cycle Cube



## ARCADIA-Method Framework





# Amira

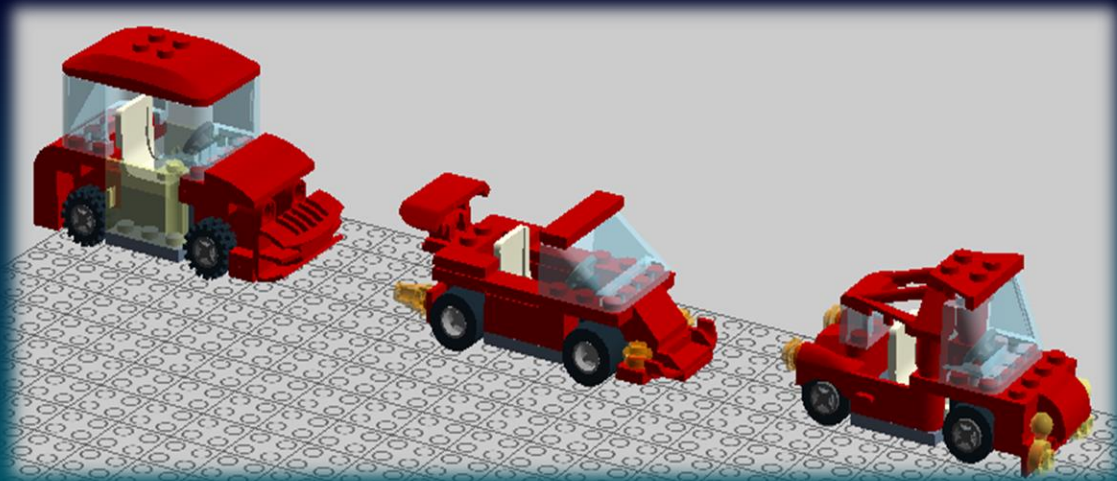
## Head of Factory Planning

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

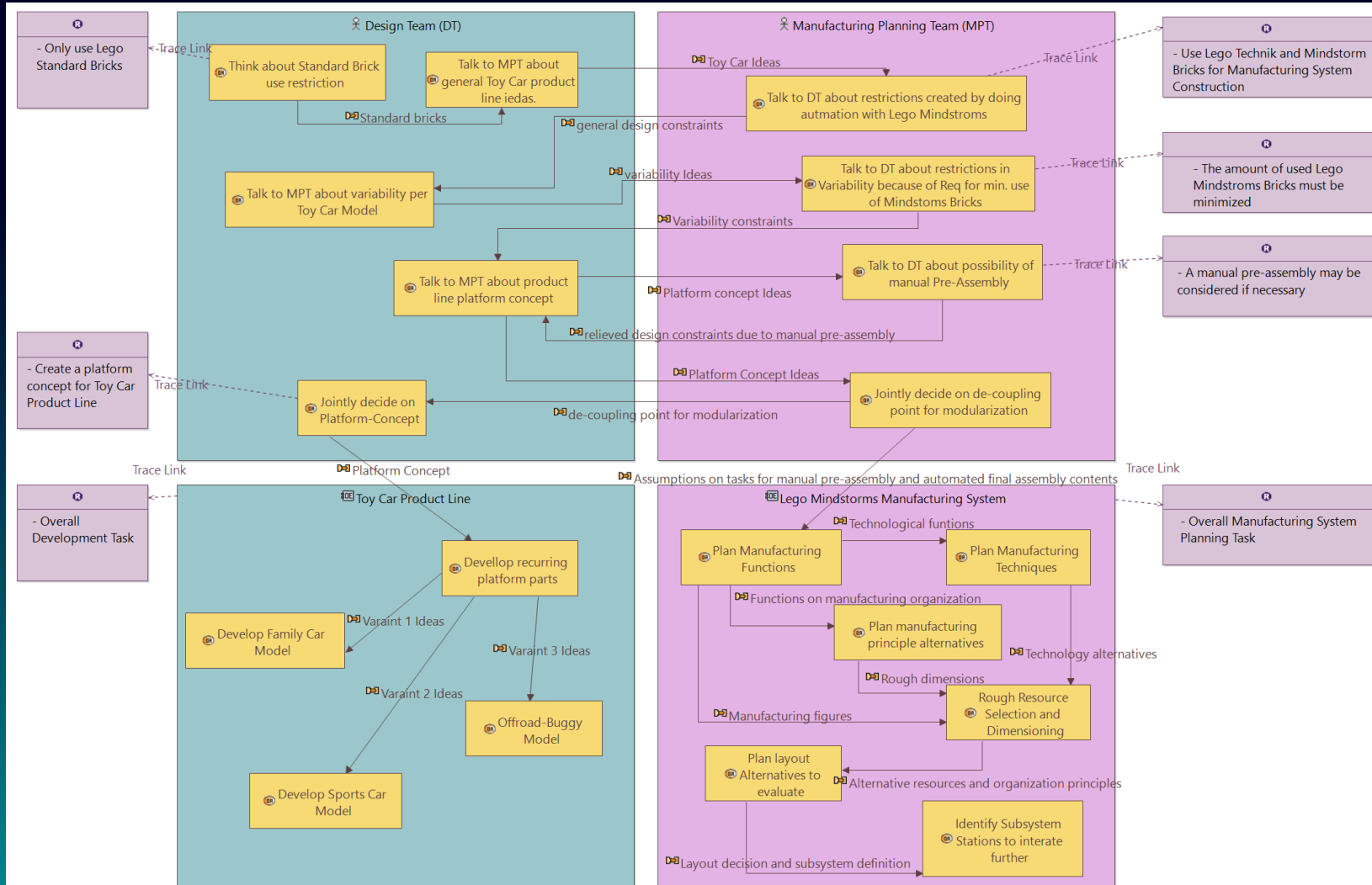
# Operational Analysis

## Manufacturing Purpose on Context and Requirements Level

The LEGO toy car family shall ...



Source: LEGO Digital Designer



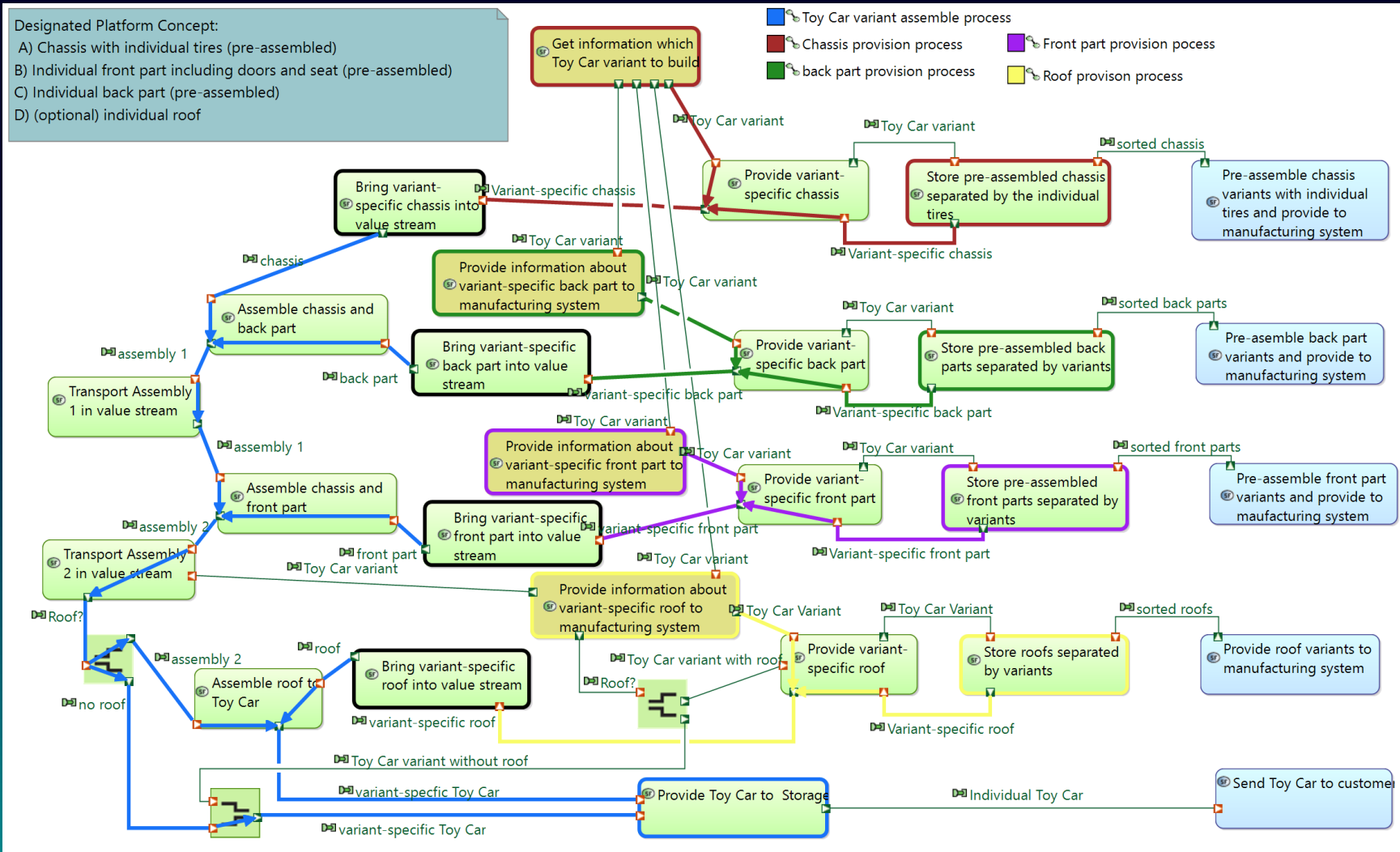
The LEGO manufacturing line shall ...



Source: LEGO Digital Designer

# System Analysis

## Manufacturing Techniques and Material Flows Level

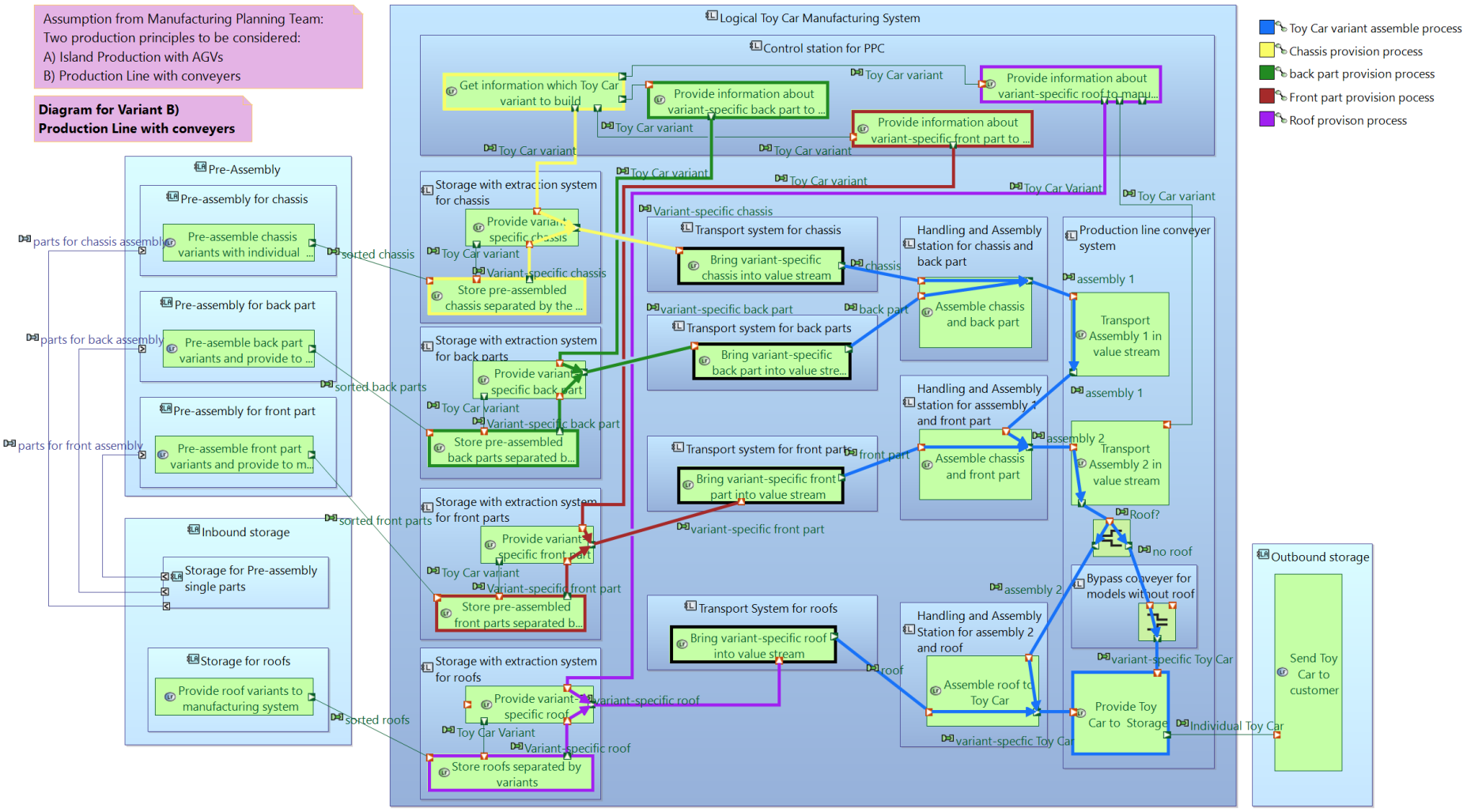


Source: LEGO Digital Designer



# Logical Architecture

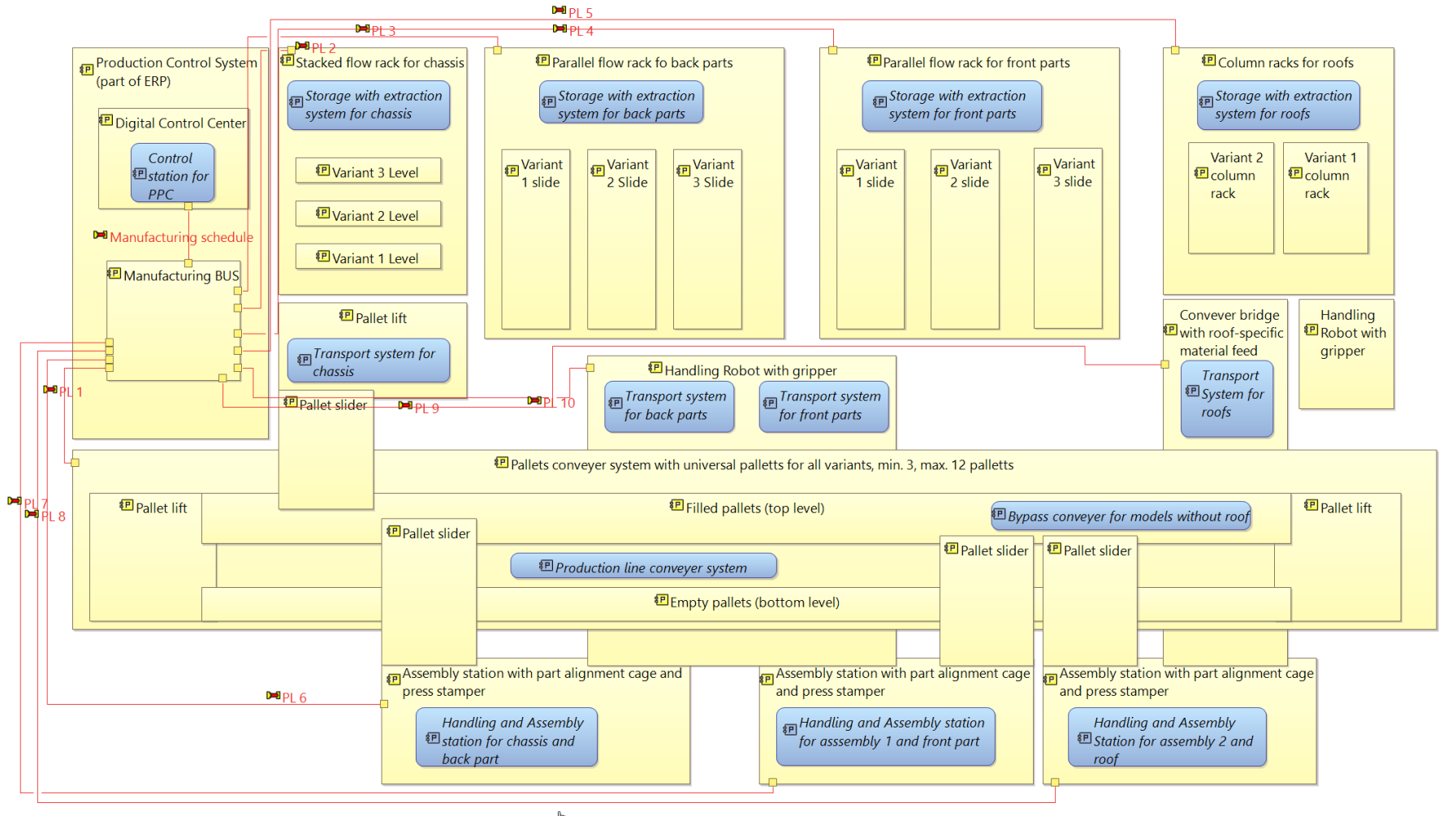
## Manufacturing Dimensioning and Structure Level



Source: LEGO Digital Designer

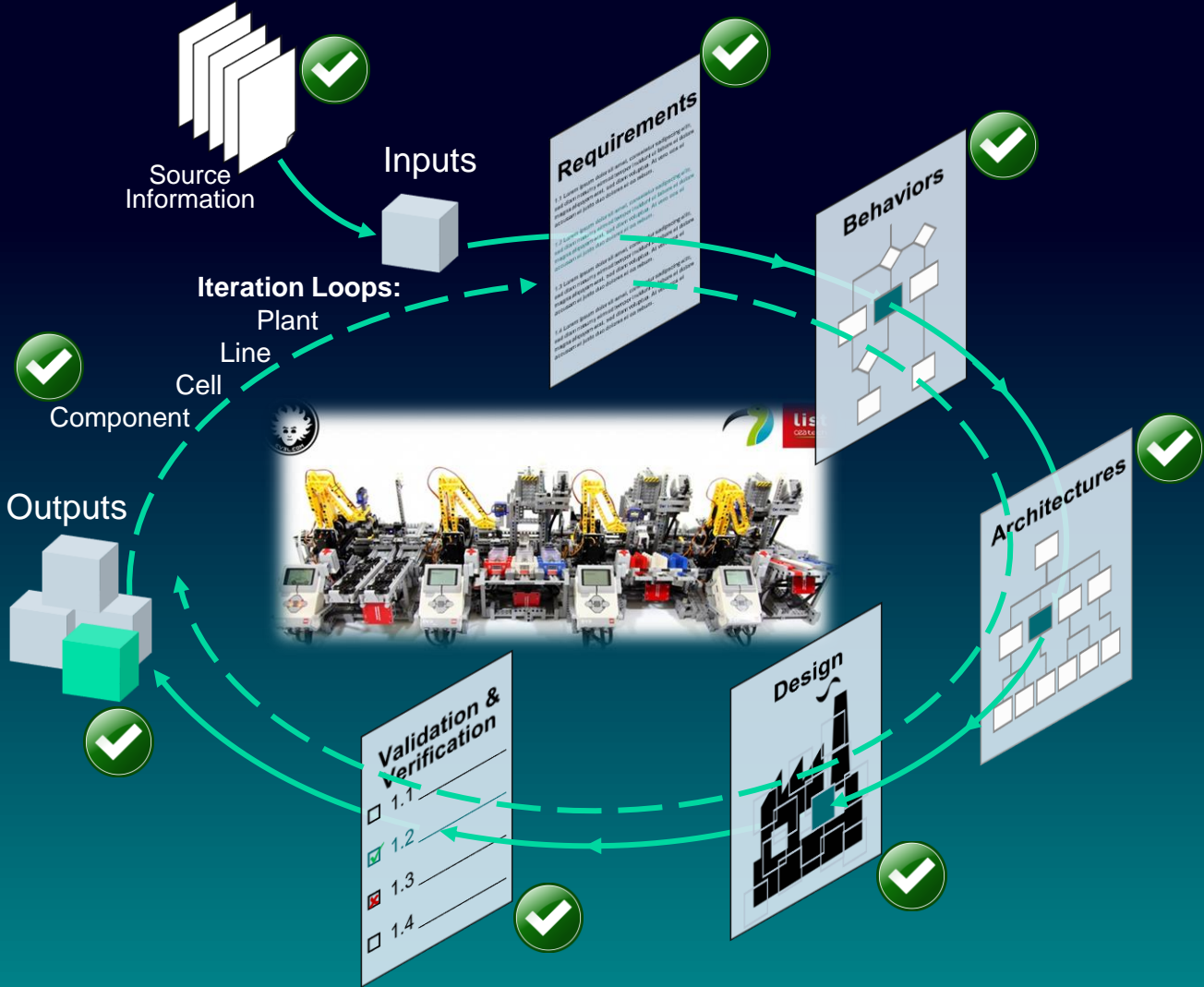
# Physical Architecture

## 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





# Want to learn more about MBPE?

## Q&A

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 früherer Produktinformationen – Ein Beitrag zur Integration von Produktionssystemplanung und Produktentwicklung unter Einsatz des MBSE*

