



# RESEARCH TOWARDS DESIGN OF CPS FOR SMART FACTORIES

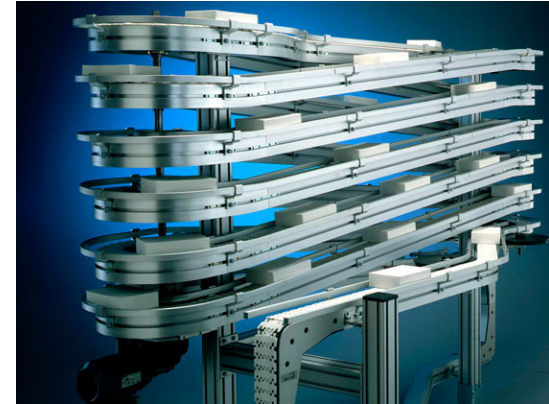
2018-09-25



a coesia company

# FlexLink

- 1100 employees
- Provider of high-end solutions to manufacturing industries such as: food, beverages, personal care, healthcare, automotive and electronics.
- Operating units in 30 countries

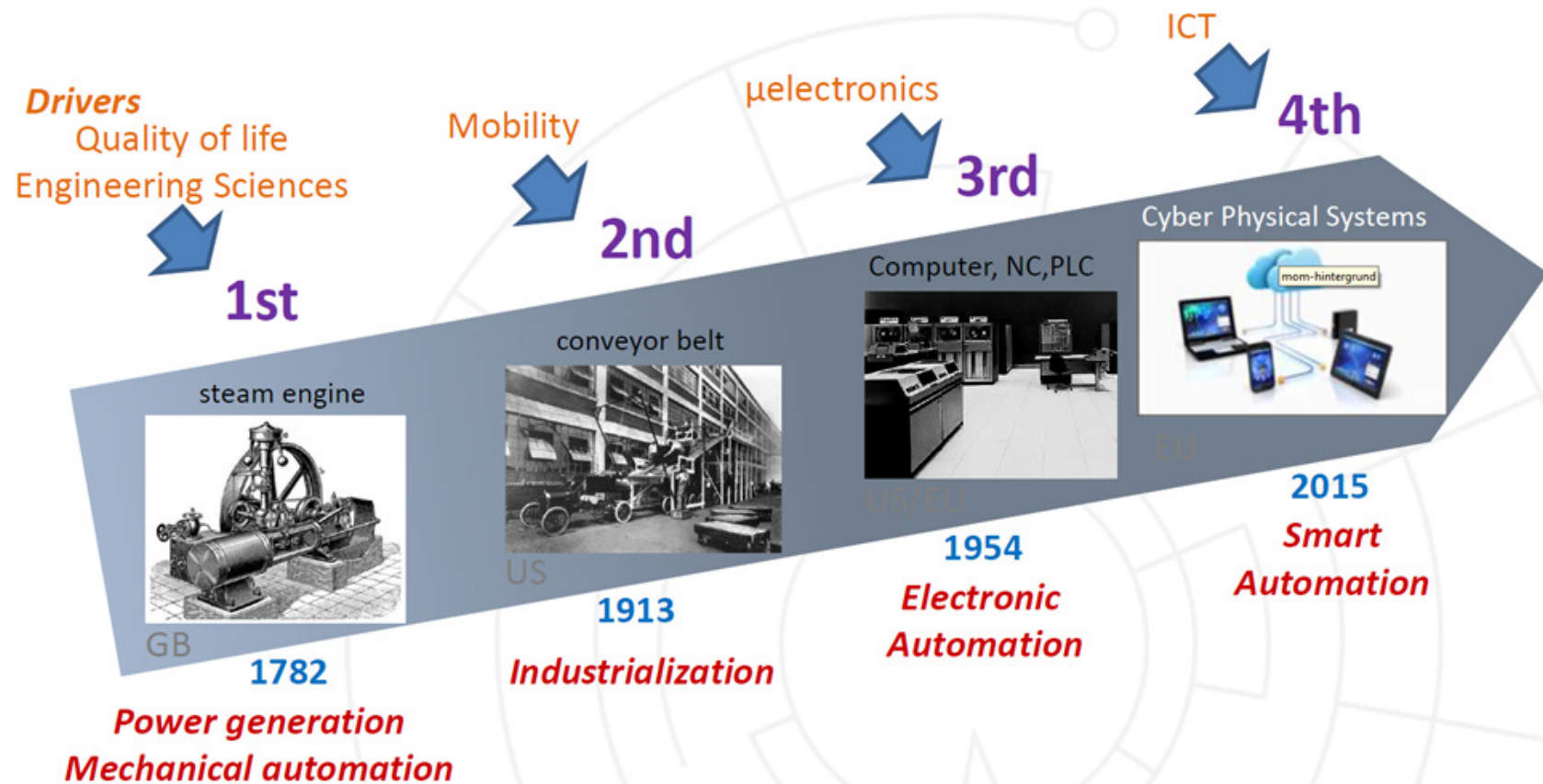


## New business strategy for FlexLink



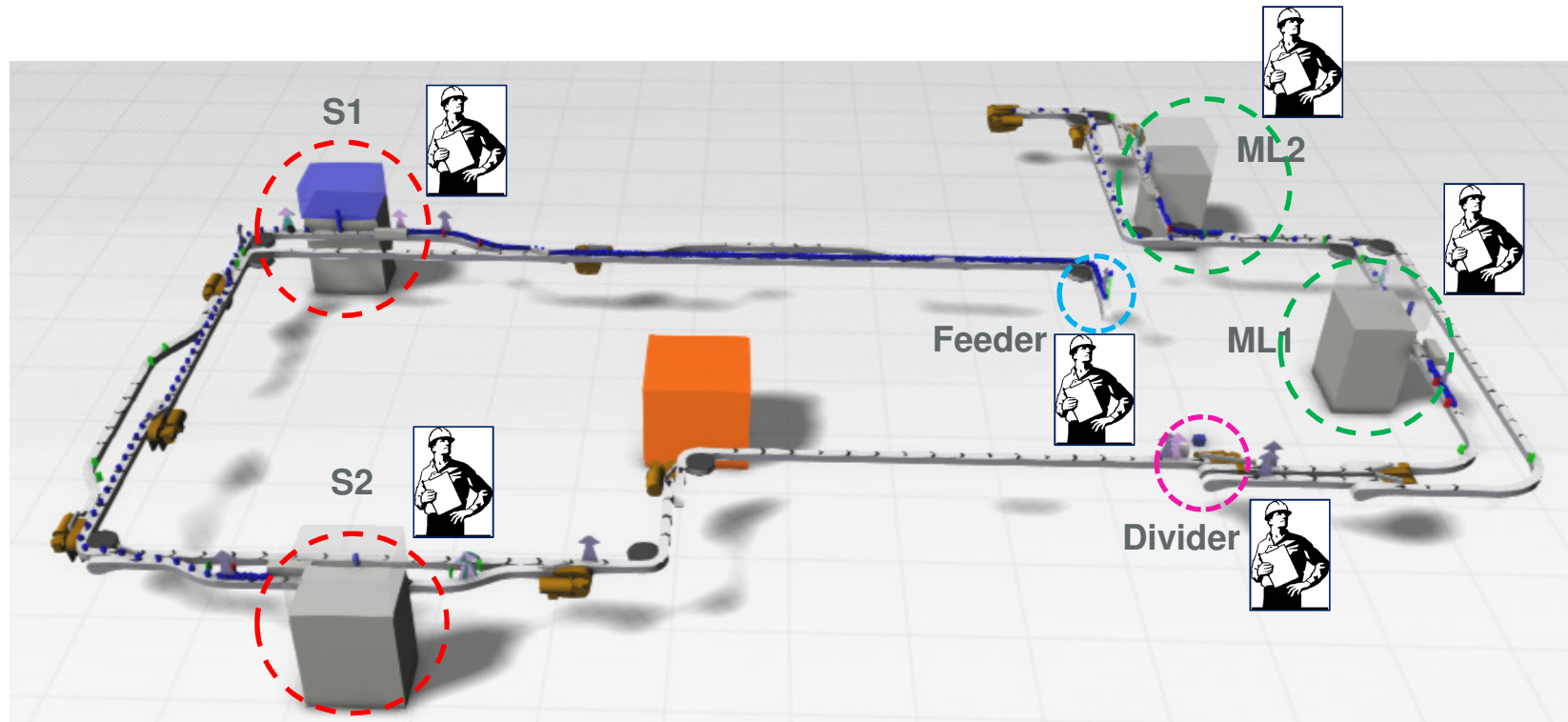
FlexLink has a new business strategy. Responding to the fast changes in industry as a whole, we aim to re-invent our entire company over the next five years (from 2016 to 2020). The commitment and engagement of each and everyone at FlexLink is crucial. It is a great challenge – with great rewards at the end of the rainbow.

# Industrial revolutions

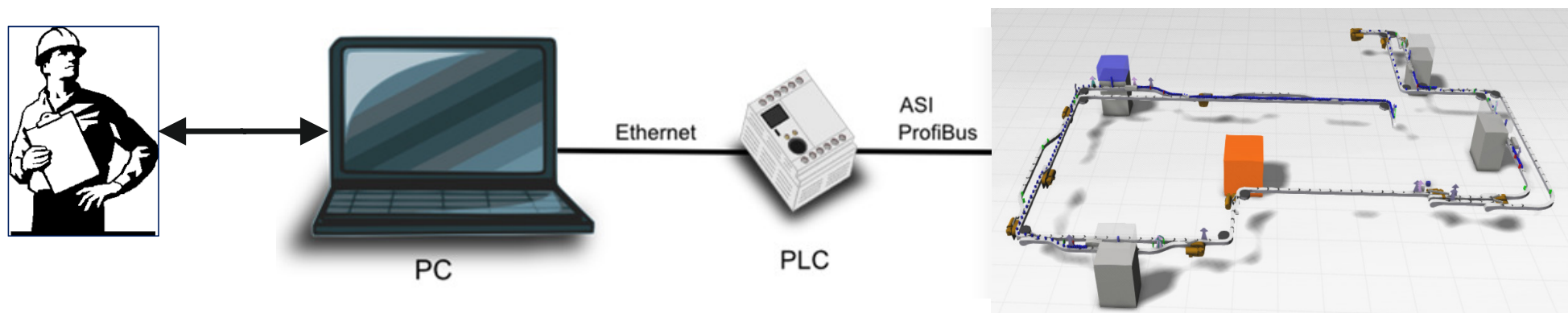




# Fast dynamic production line



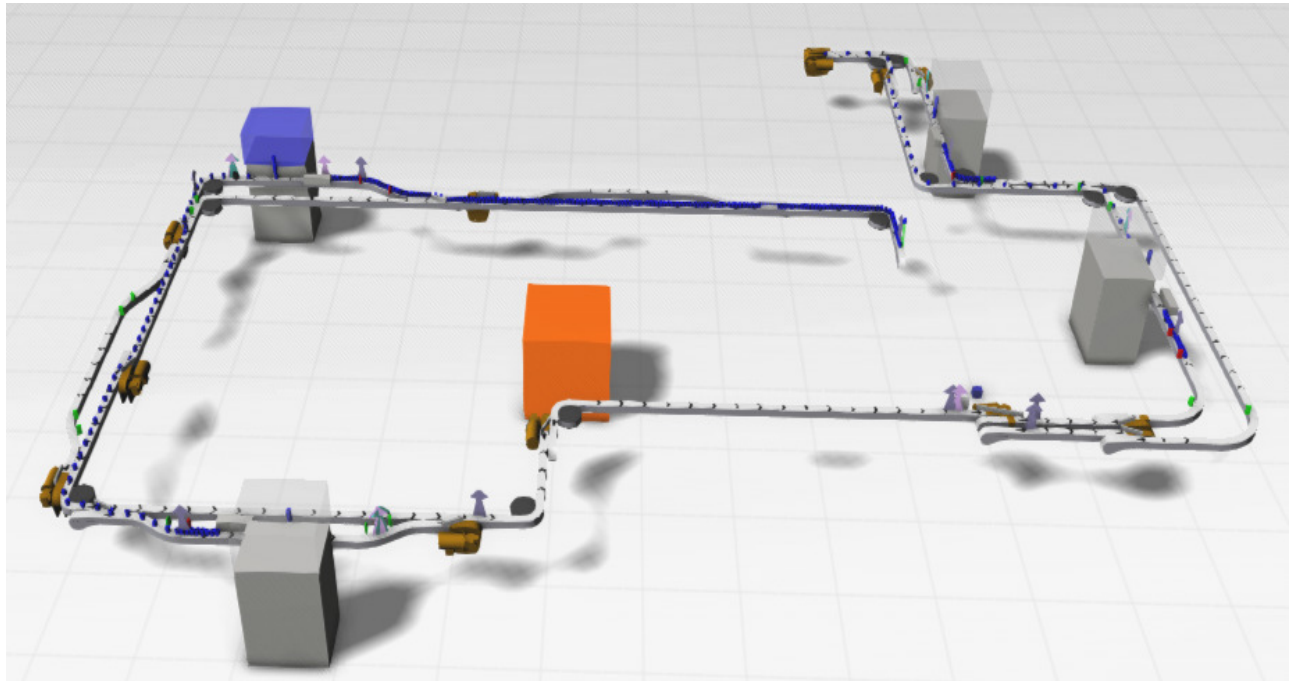
## Conventional control of production lines



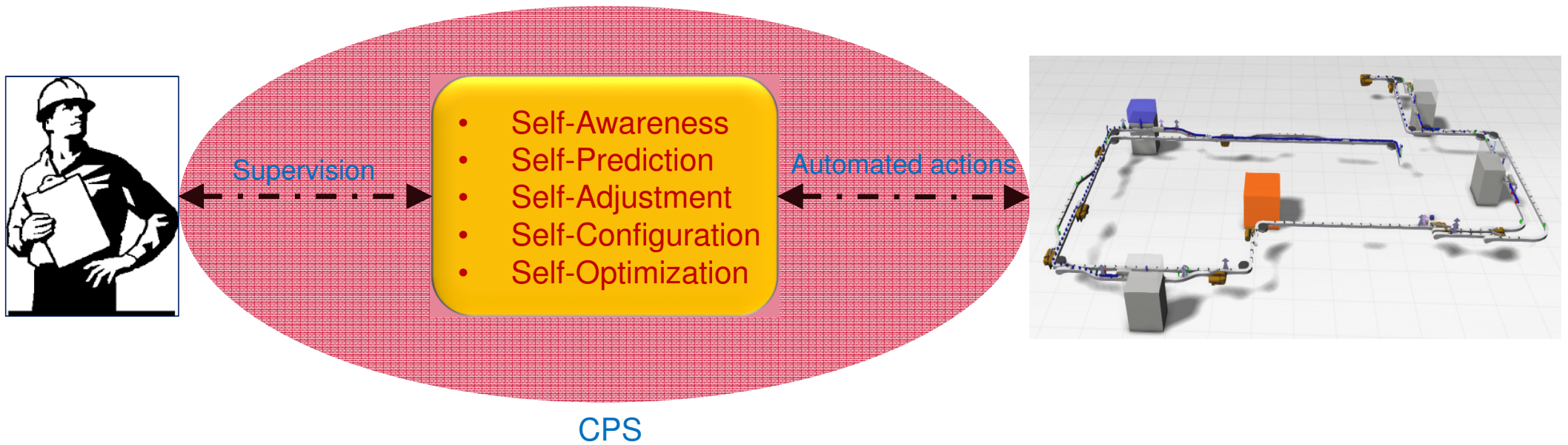
- **Awareness:** observe state of production
- **Prediction:** use knowledge, experience
- **Adjustment:** set low level control parameters
- **Configuration:** set high level control parameters
- **Optimization:** maximize production rate

## Issues regarding conventional control

- Fixed control set points
- High level of noise
- High energy consumption
- Low resource utilization
- High losses
- Low OEE

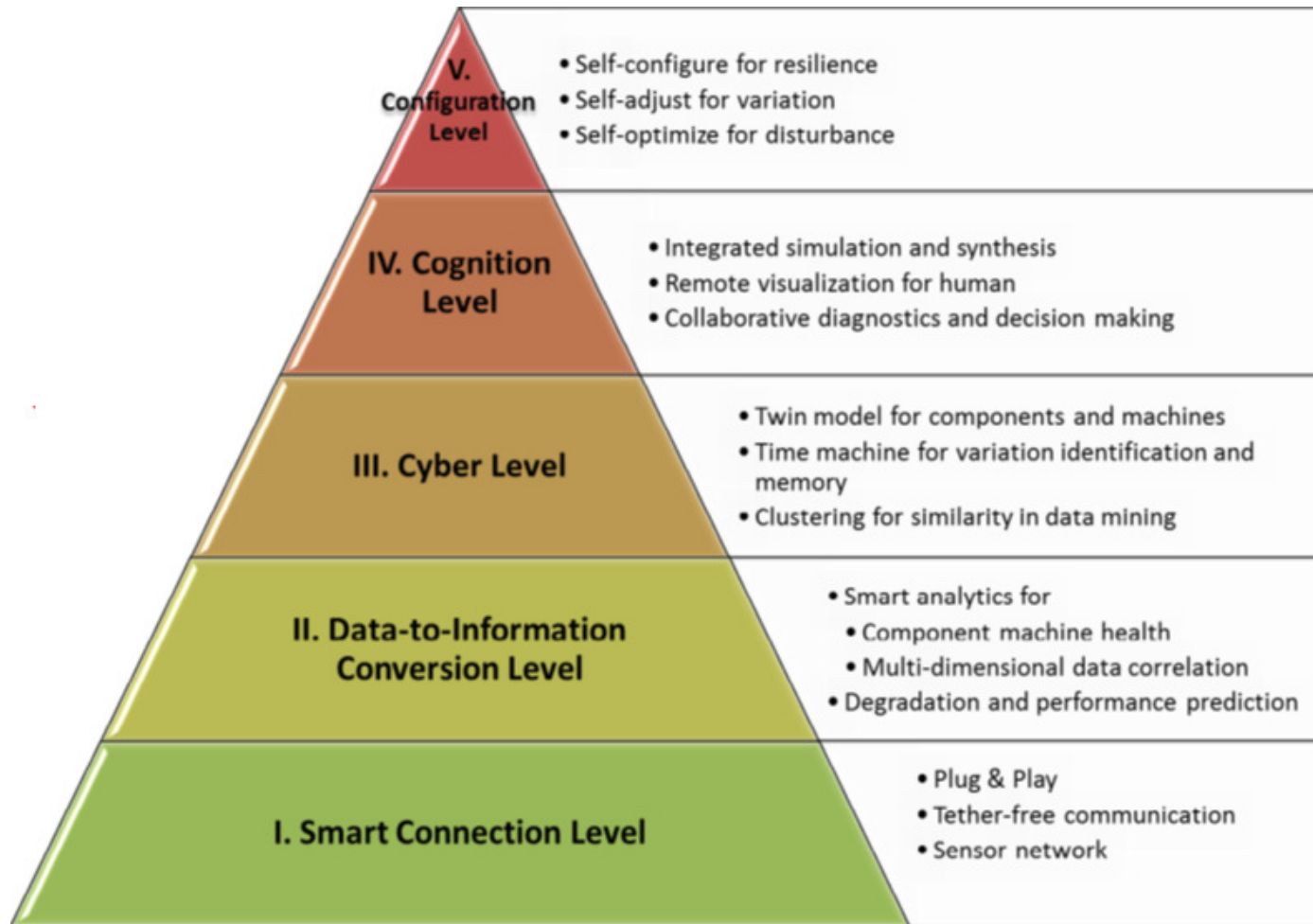


# Cyber physical system attributes for smart factories

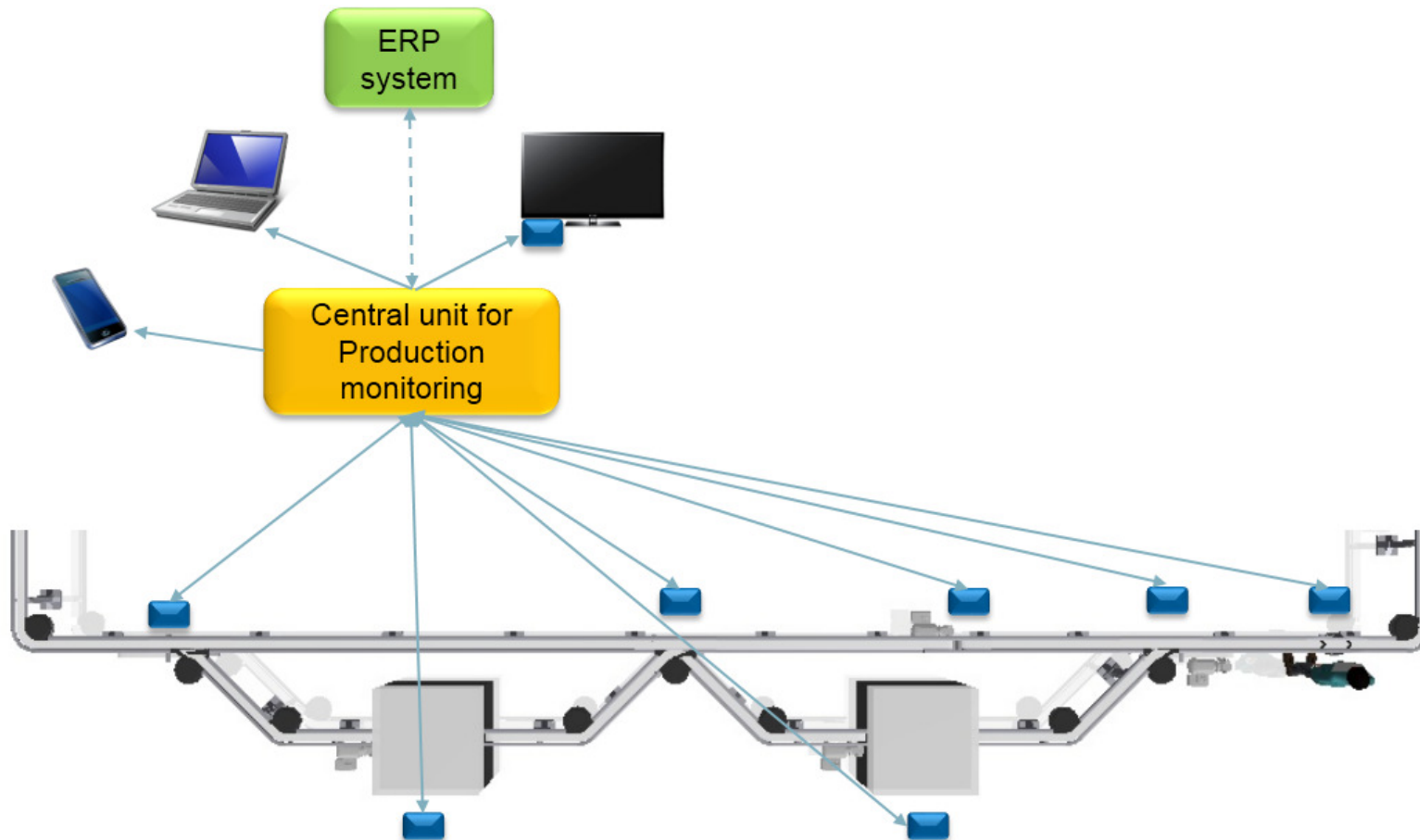




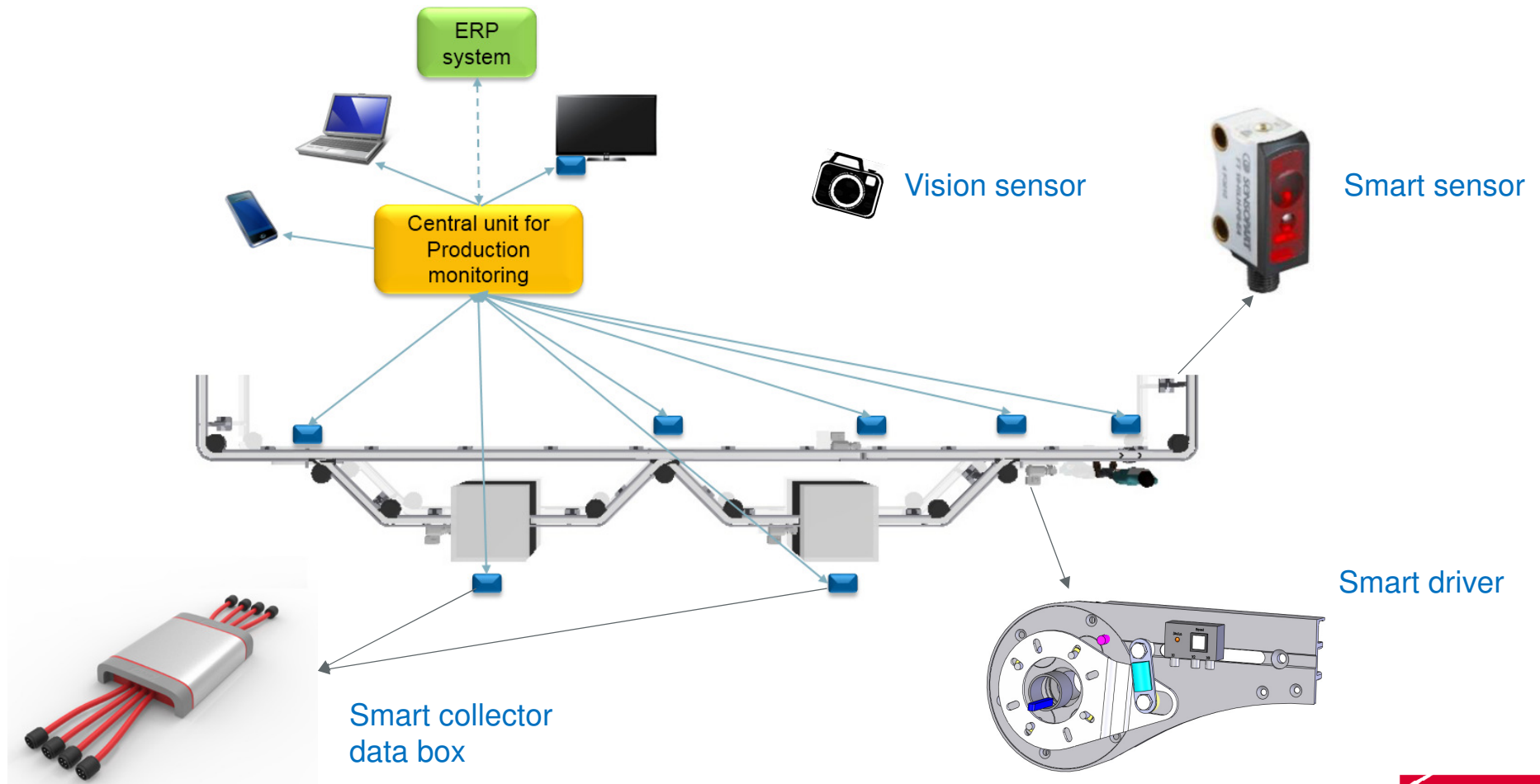
# 5C architecture for CPS: Jay Lee, Behrad Bagheri, Hung-An Kao



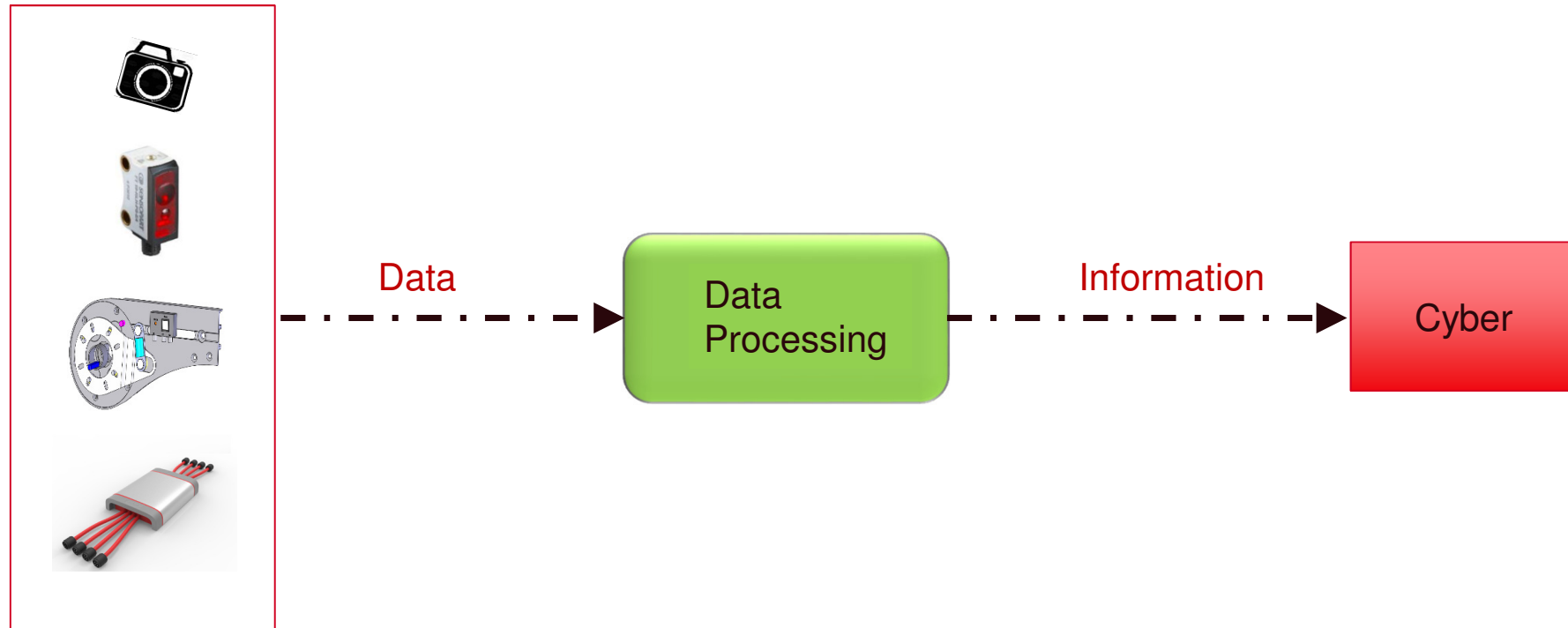
## Connection: Data collection



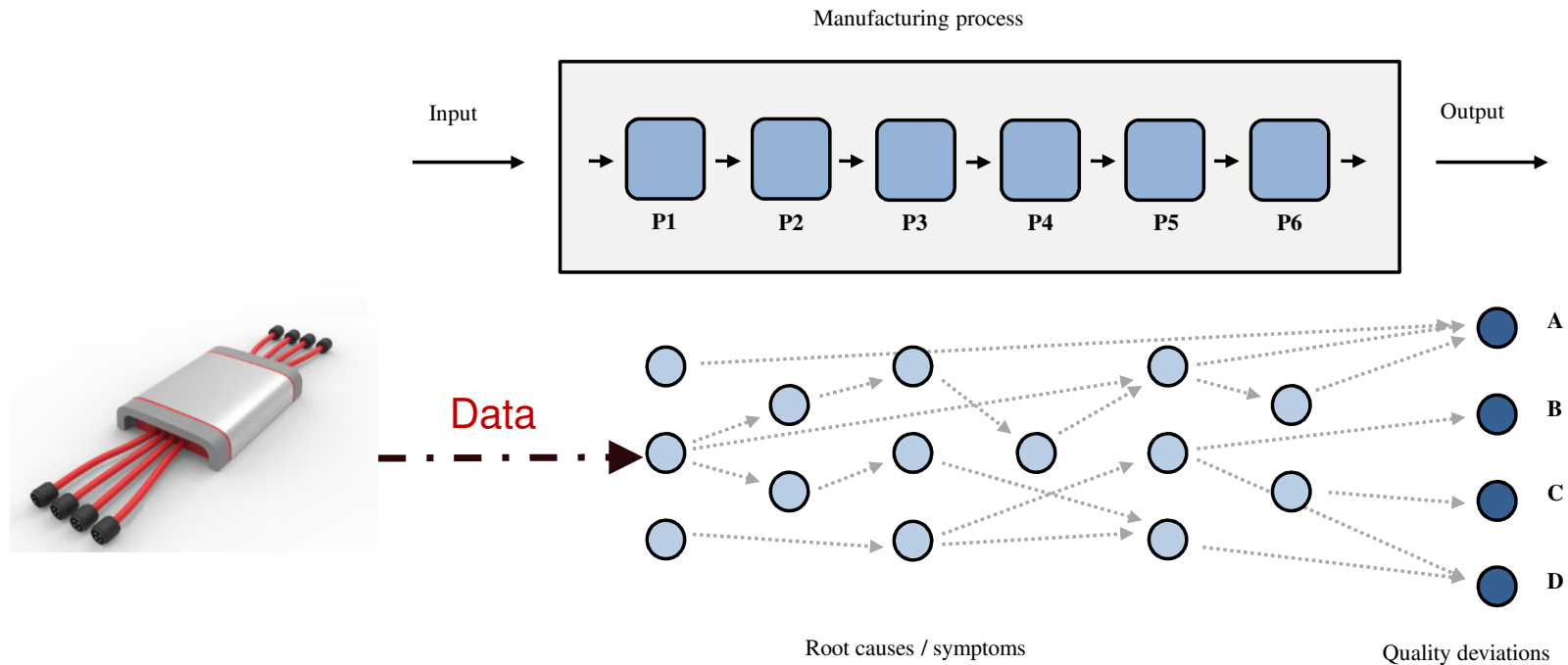
# Smart sensors and drivers



## Conversion: Data to information

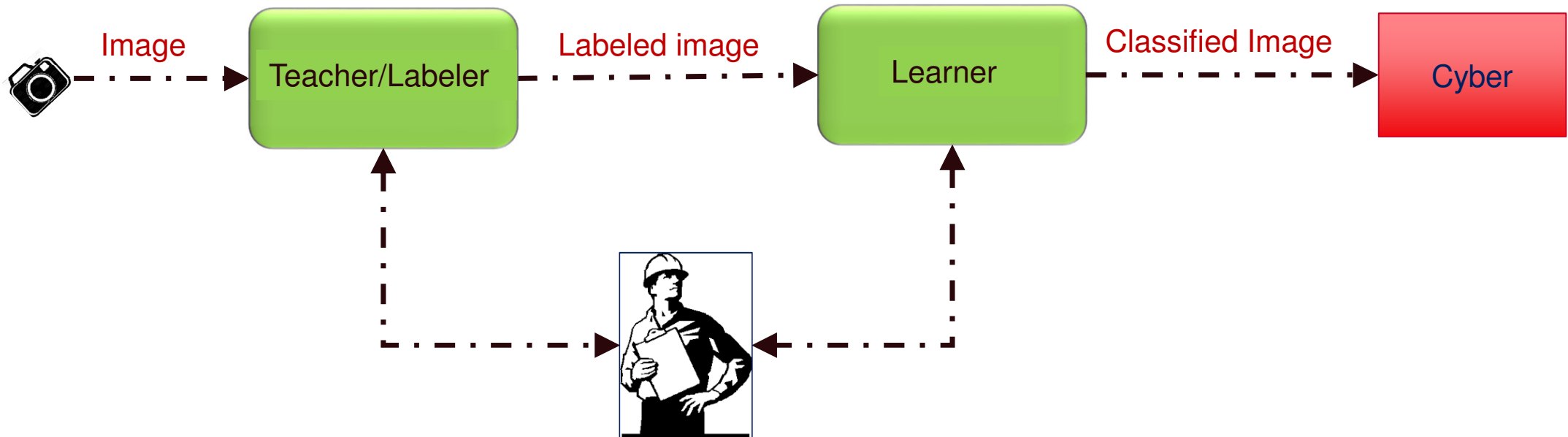


# Root cause analysis of quality deviations in manufacturing using machine learning





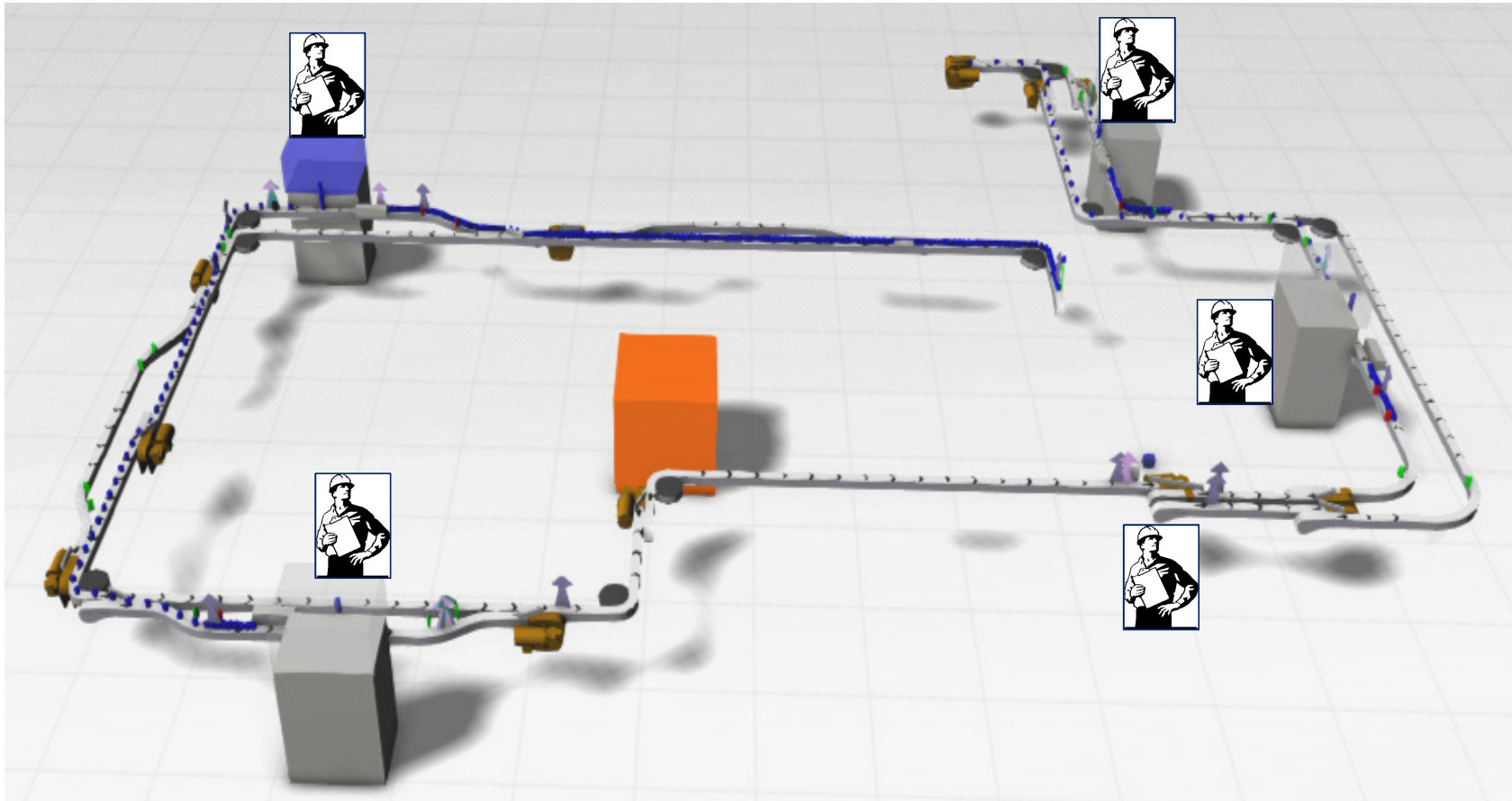
# Image to information conversion under controlled conditions



# Robust image classifier



## Cyber level: Agent-based control of production line



# Agent



- is persistent and goal-oriented.
- gathers information and reacts to its environment.
- runs without continuous direct supervision.
- performs complex analysis for an end-user.
- learns the environment and gets experience.
- has a character: cooperative, competitive, selfish.

# Agent design



Operation knowledge

Production rules

Operator experience

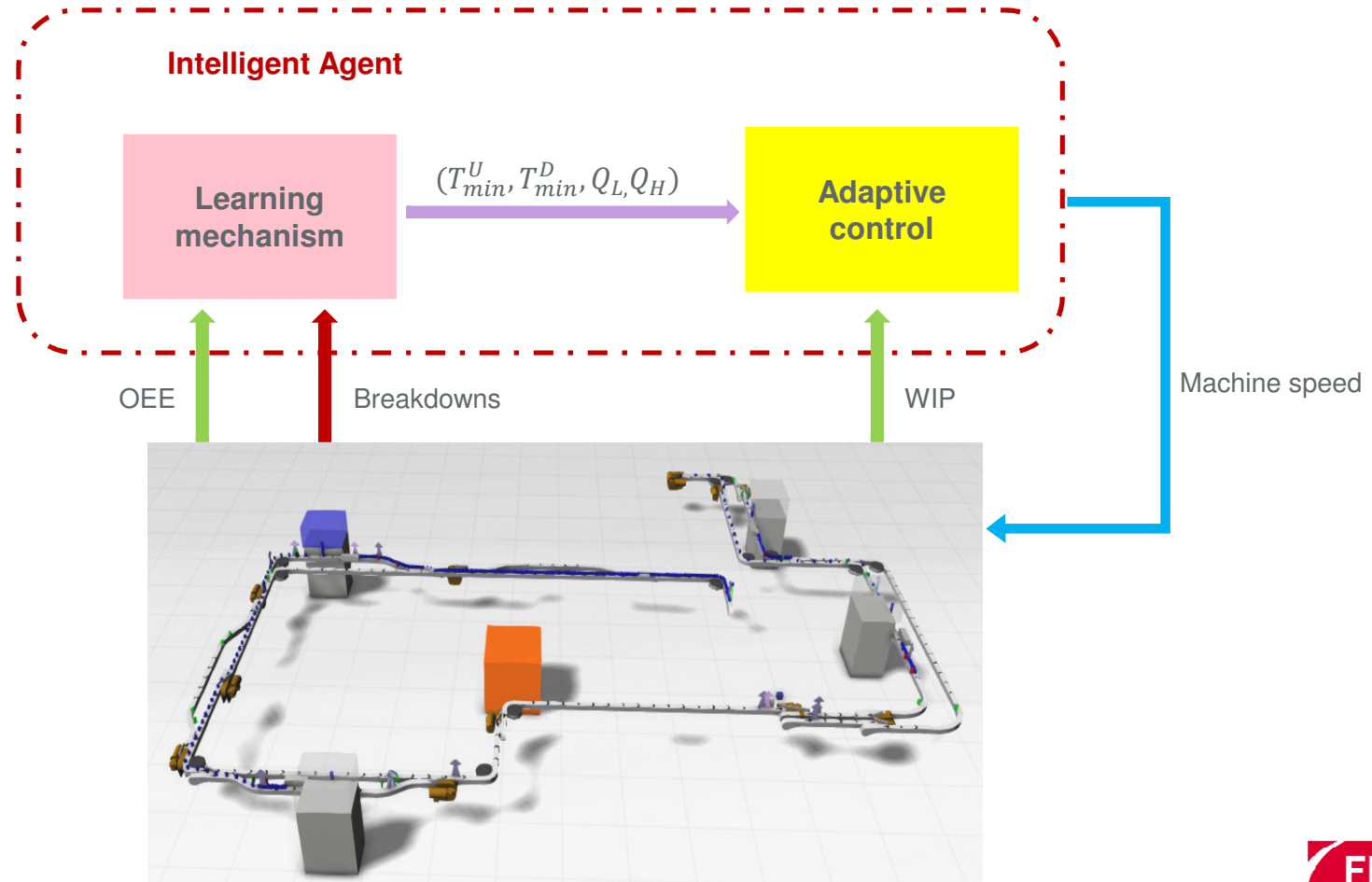
Production goals

Formal Translation





# Agent design diagram



# Cognition: Human agent interface (HAI)



# HAI: Interface to setup production goals

## Adaptive line balancing service

Instance: maziar

Status: idle

Number of segments: 4

Machine capacity (1/min): [222.22221, 187.5, 187.5, 160.0, 160.0]

Actual WIP: [13, 26, 13, 15]

Max transportation time (s/m): 5.0, 5.0, 5.0, 5.0, 5.0

Min transportation time (s/m): 1.0, 1.0, 1.0, 1.0, 1.0

Segments length (m): 5.80, 3.79, 2.69, 2.74

Conveyors length (m): 5.80, 1.35, 2.44, 2.69, 2.74

Number of conveyors in segments: [1, 2, 1, 1]

New machine process time (s): 0.392, 0.395, 0.396, 0.407, 0.375

Product transportation time (s): [[0.055], [0.160, 0.168], [0.125], [0.130, 0.130]]

Algo cycle time (s): 0.392, 0.395, 0.396, 0.407, 0.375

Algo machine relative speed: 0.523, 0.603, 0.593, 0.691, 0.824

Algo conveyor result (m/s): [0.917], [0.313, 0.297], [0.400], [0.383, 0.383]

Measured cycle time (ms): 0.537, 0.521, 0.514, 0.498, 0.5

Filtered cycle time (ms): 0.536, 0.554, 0.539, 0.497, 0.501

Algo messages:

Start

Stop

Reset

## Settings

Segment	0	1	2	3	4
<b>Target WIP</b>		12	25	12	12
<b>Max WIP</b>		50	50	50	50
<b>Min machine speed</b>	20	7	7	7	7
<b>Max machine speed</b>	100	100	100	100	100
<b>Min cycle time, s</b>	0.32	0.32	0.32	0.375	0.375
<b>Max cycle time, s</b>	4.57	4.57	4.57	5.36	5.36
<b>Target queue</b>		0	0	0	0
<b>Calc interval, ms</b>	500				
<b>Conveyor speed</b>	<input type="checkbox"/> Calculation active				
<b>Kalman filter (Q, R)</b>	0.1	0.1			
<b>External algorithm</b>	flab.alb.algo.maziar				
	<input type="button" value="Edit"/>				

# HAI: Interface for monitoring of production states



# Configuration: Self-adaptive and self-configure





# Questions?

