Ergonomia e Flessibilità

un'esplorazione delle tecnologie per l'automazione dell'Assemblaggio Industriale

Milano, 12-04-2024

OMRON

Atlas Copco

POLITECNICO MILANO 1863

OMRON

Agenda

10.00	Welcome Stefano Gandolfi, Regional Marketing Manager, Omron | Alessandro Aina, Product Manager, Atlas Copco Italia
10.10	Human Centricity e adattamento delle tecnologie nell'assemblaggio Maurizio Faccio, Docente di Sistemi Industriali e Logistica, Università di Padova
10.30	La robotica collaborativa per l'assemblaggio e la robotica mobile per l'intralogistica Daniele D'Adda, Area Sales Manager, Omron
10.50	Coffee Break
11.00	Digital Twin di processo per l'installazione ottimale di automazione collaborativa negli assemblaggi Andrea Zanchettin, Docente di Automazione e Robotica, Politecnico di Milano
11.20	Assemblaggio Industriale e ottimizzazione dei processi. Come i dati aiutano a spingere al massimo la produzione Alessandro Aina, Product Manager Atlas Copco
11.40	Open Discussion e Q&A
12.00	Omron iLab Tour & Demo Showcase
13.00	Light Lunch

OMRON

OMRON in Italy: Results of a 50 years-long journey

240

Employees

45 + 80

Field Application Engineers
+
Field Sales Engineers

170

million Euro annual sales (FY22)

OMRON

Complete portfolio for full Industrial Automation Solutions

OMRON

Empowering People Through Automation

THE FLEXIBLE MANUFACTURING

OMRON

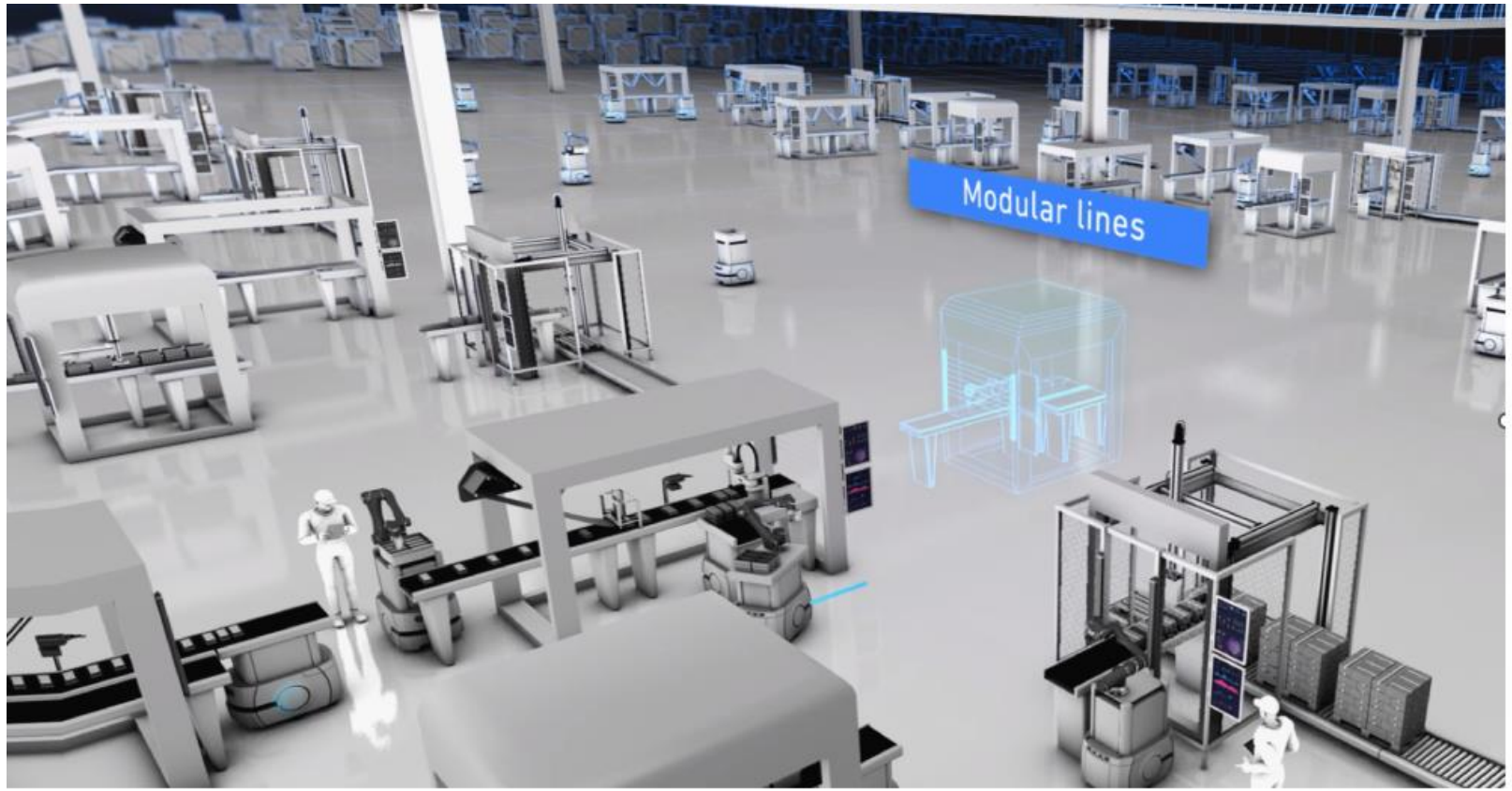
Empowering People Through Automation

THE FLEXIBLE MANUFACTURING

OMRON

Empowering People Through Automation

THE FLEXIBLE MANUFACTURING



Atlas Copco Group
Facts and figures

Atlas Copco
Group

This is Atlas Copco Group

Customers in more than **180** countries

49 000 employees in **70** countries

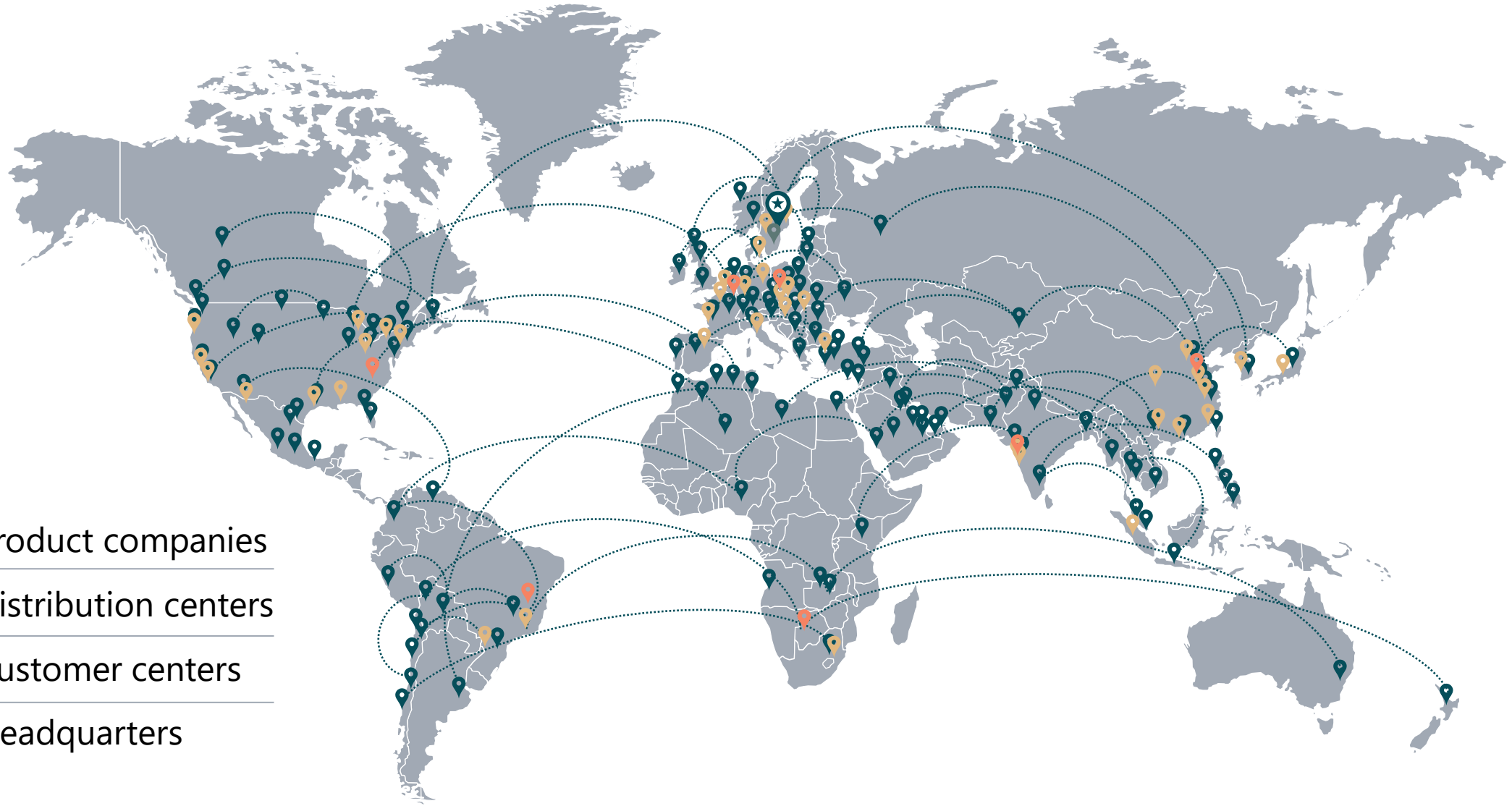
Established in **1873** Stockholm, Sweden

Turnover of **141** BSEK/ **13** BEUR*

*Based on the average exchange rate in 2022.

Atlas Copco Group

A very global presence



Atlas Copco Group

A decentralized Group

Board of Directors

President and CEO

Group management

Compressor Technique

- Compressor Technique Service
- Industrial Air
- Oil-free Air
- Professional Air
- Gas and Process
- Medical Gas Solutions
- Airtec

Vacuum Technique

- Vacuum Technique Service
- Semiconductor Service
- Semiconductor
- Semiconductor Chamber Solutions
- Scientific Vacuum
- Industrial Vacuum

Industrial Technique

- Industrial Technique Service
- MVI Tools and Assembly Systems
- General Industry Tools and Assembly Systems
- Chicago Pneumatic Tools
- Industrial Assembly Solutions
- Machine Vision Solutions

Power Technique

- Power Technique Service
- Specialty Rental
- Portable Air
- Power and Flow

Atlas Copco Group

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Atlas Copco

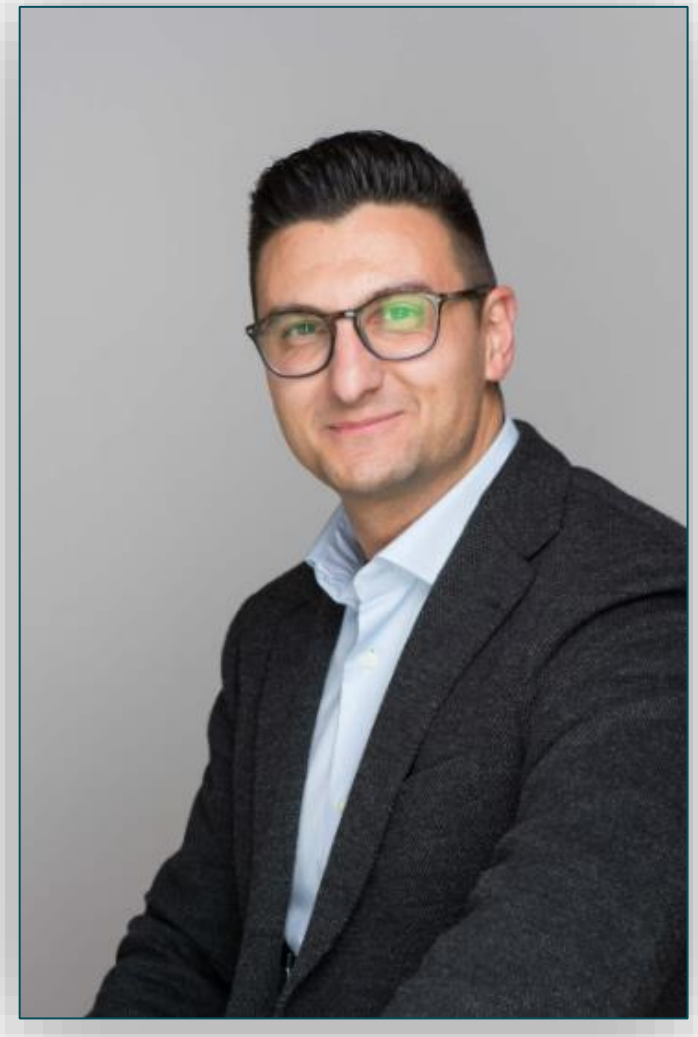
Alessandro AINA

Product Manager

div. Utensili Industriali

alessandro.aina@atlascopco.com

+39 335 13 26 207




POWER FOCUS 8

Atlas Copco Group

Technology that transforms the future

www.atlascopcogroup.com

Perchè siamo qui, oggi

Ergonomia e Flessibilità

Un'esplorazione delle tecnologie per l’automazione dell'Assemblaggio Industriale

Modena, 12 Aprile 2024

Ecosistema Tecnologico	Tecnologie abilitanti	Evoluzione Tecnologica
S.I. OMRON Atlas Copco		

Thank You

Ing. Daniele D'Adda

AREA SALES MANAGER
OMRON

Assemblaggio ed Intralogistica: Robotica collaborativa mobile e fissa

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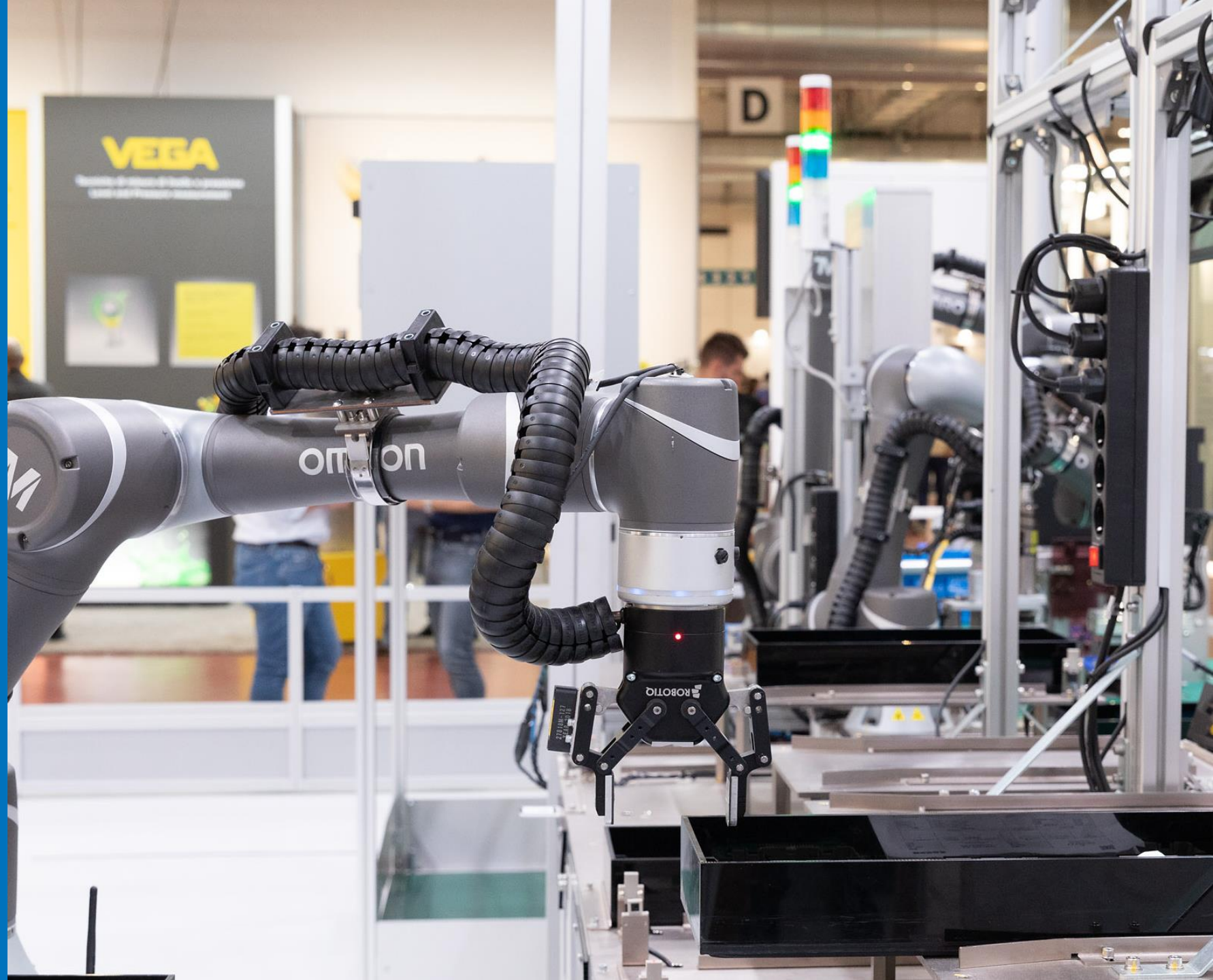
Agenda

ROBOTICS SOLUTIONS

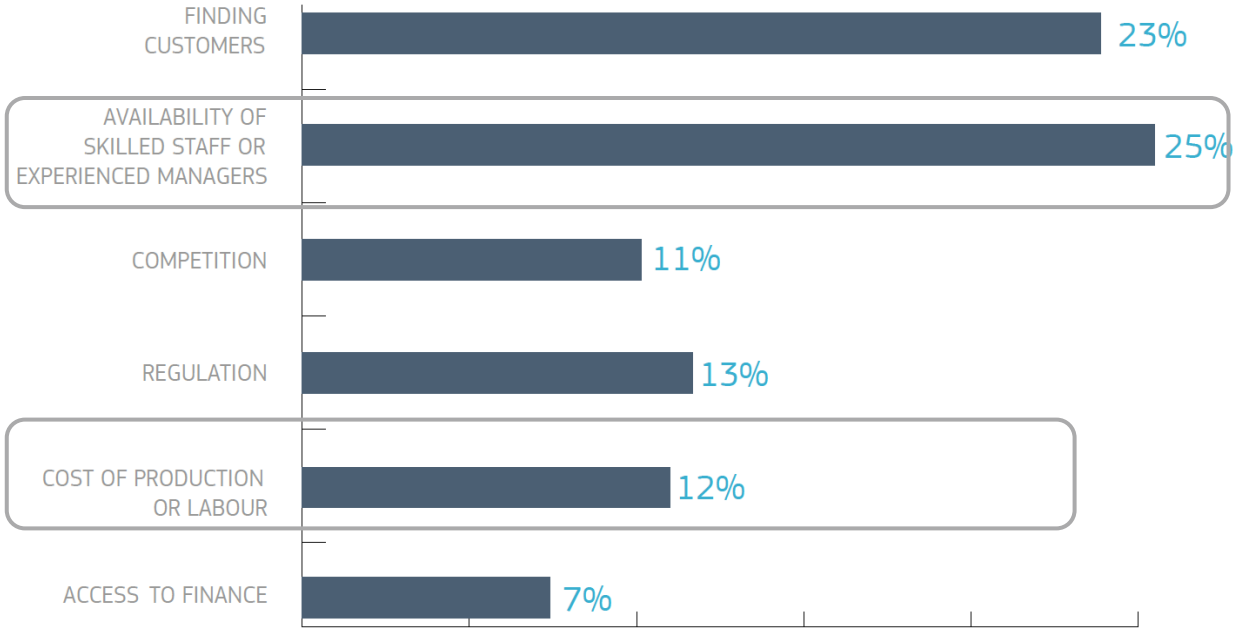
1. Robotics: status and trend
2. Technology: Industrial Robots vs Collaborative Robots
3. Collaborative applications
4. Mobile Robots

Robotics:
status and trend

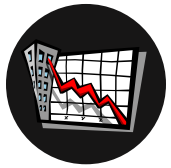


Why do we need robots?

REQUEST FOR LOCAL PRODUCTION

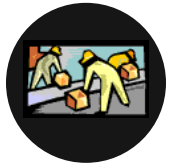


COST REDUCTION



Increase of productivity
Robots can execute production processes at a higher throughput
and/or at lower costs.

Increase of quality
The usage of robots leads to higher process liability, precision, accuracy and traceability.



Relief for employees
Robots take over monotone and repetitive processes of humans and allow the people, as the most important resource, to follow other tasks.

Population of Industrial Robots

Population of Industrial Robots per Area

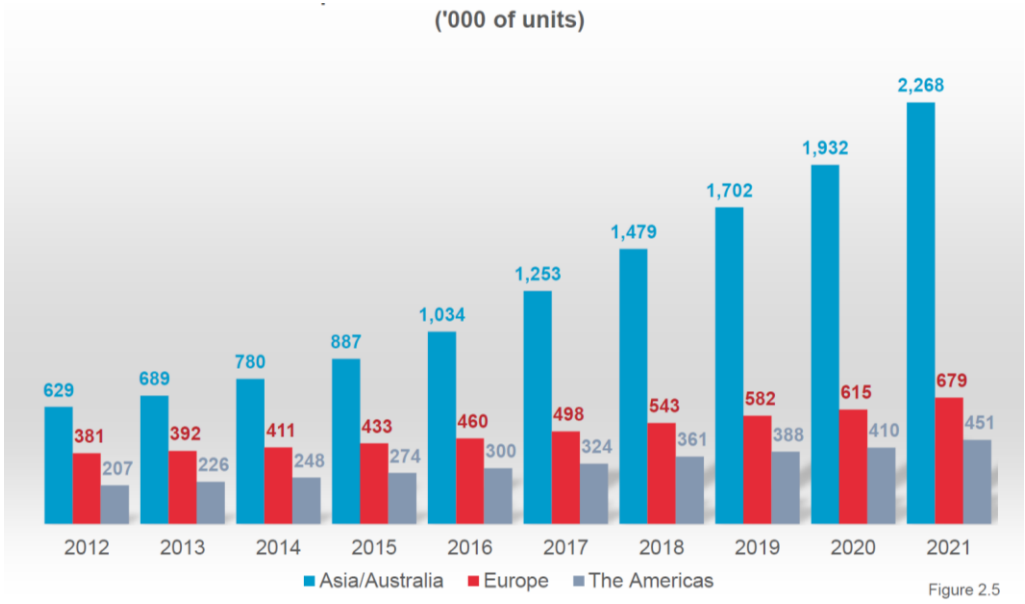
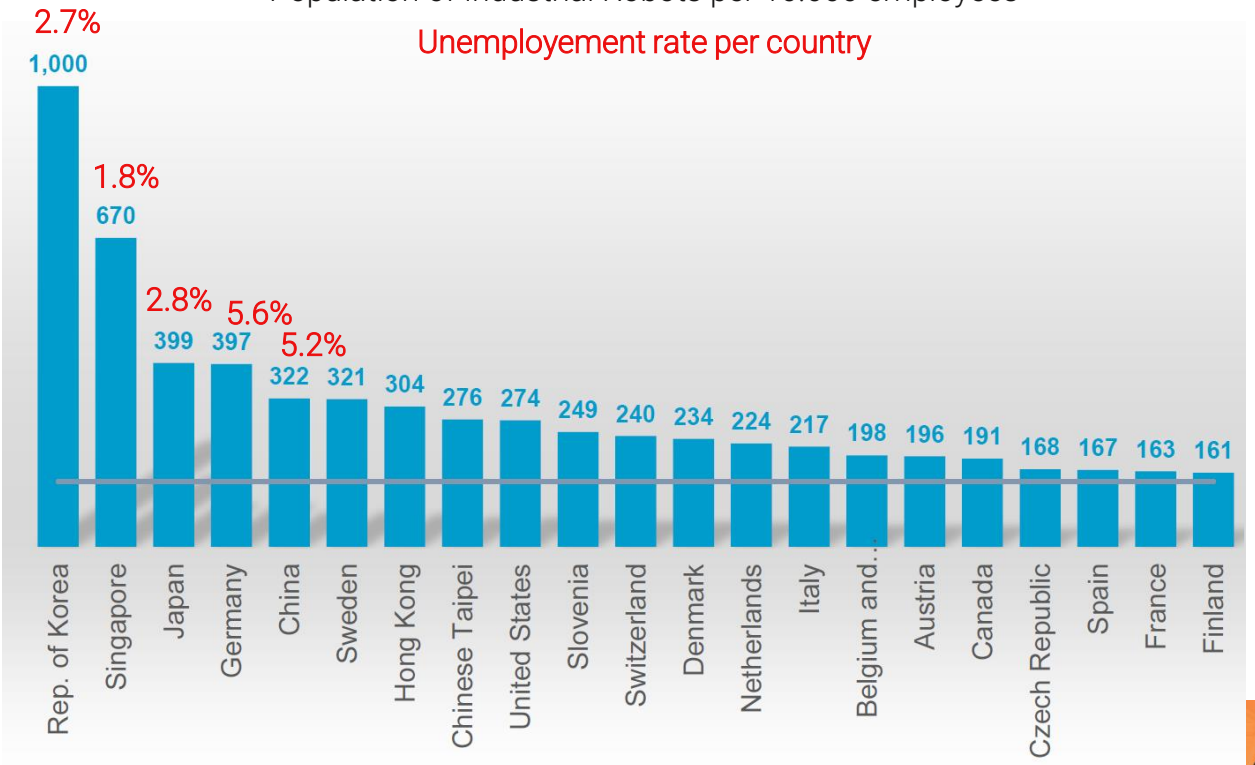
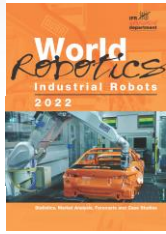


Figure 2.5

Population of Industrial Robots per 10.000 employees





Source: World Robotics 2022

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Industrial robots – Population of Industrial Robots per Application

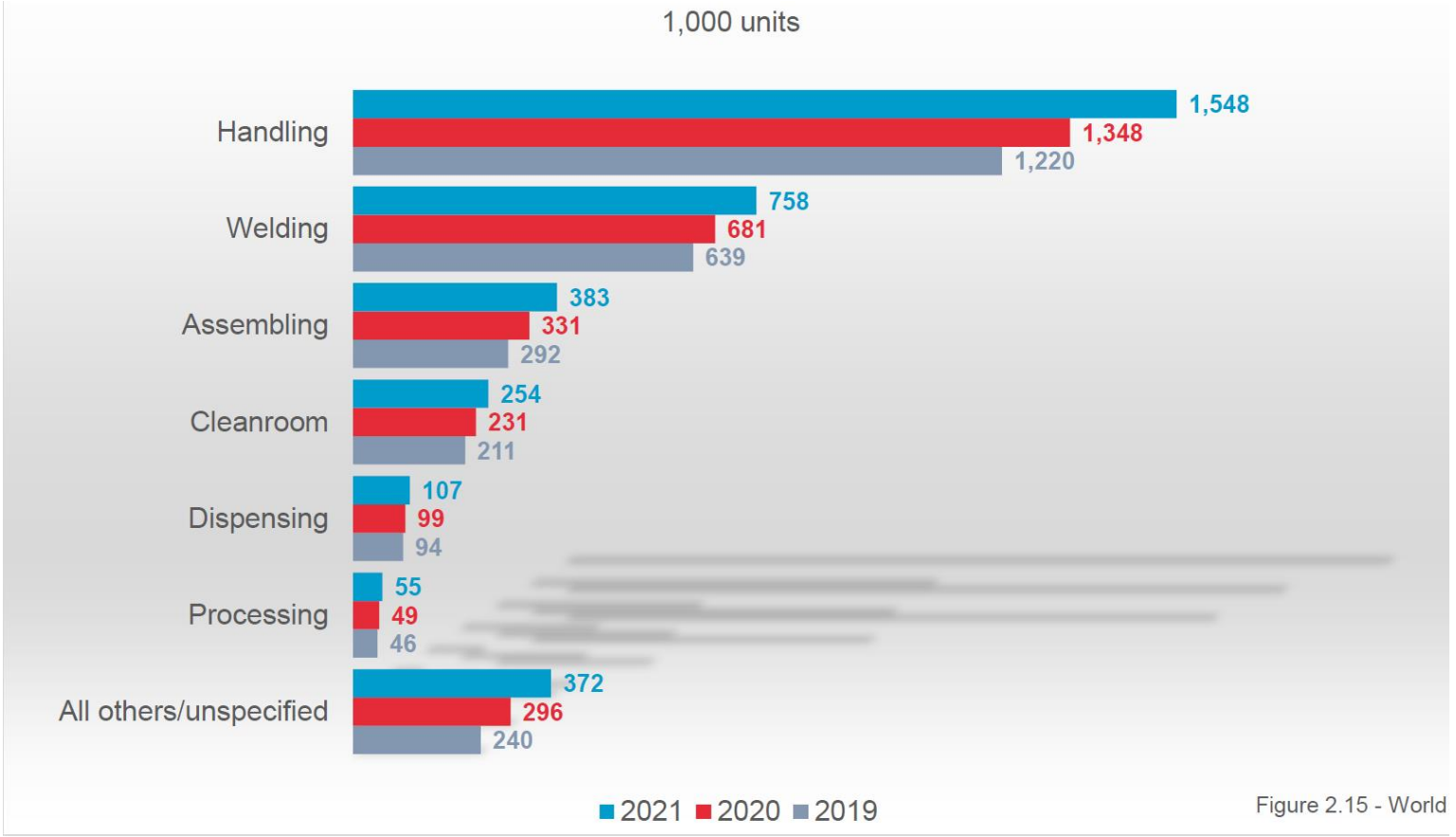
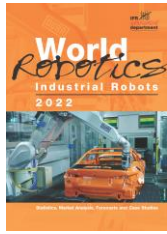


Figure 2.15 - World

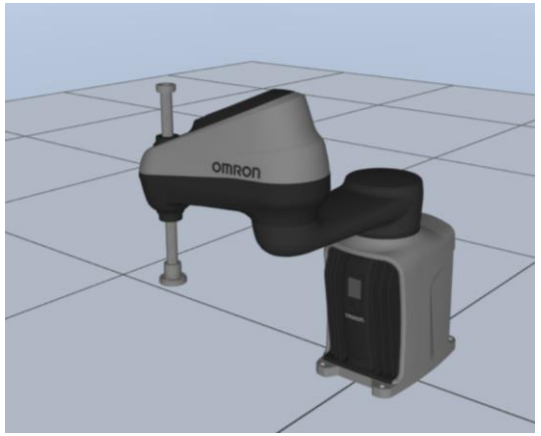


Source: World Robotics 2022

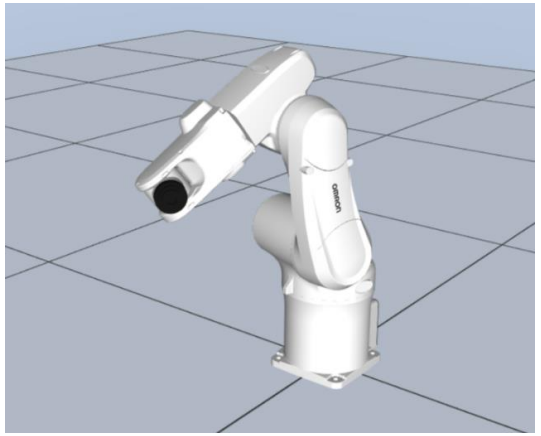
Robotics: Technologies and applications

Fixed Robotics: technologies

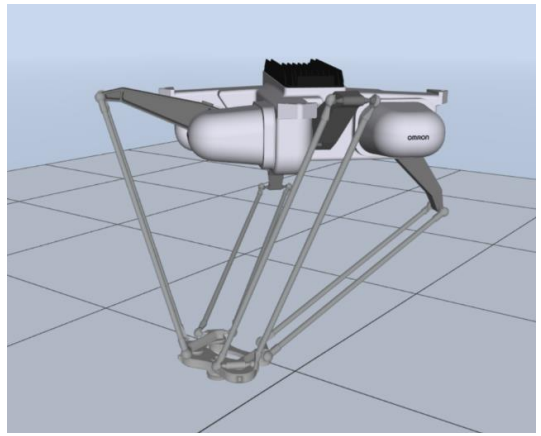
SCARA

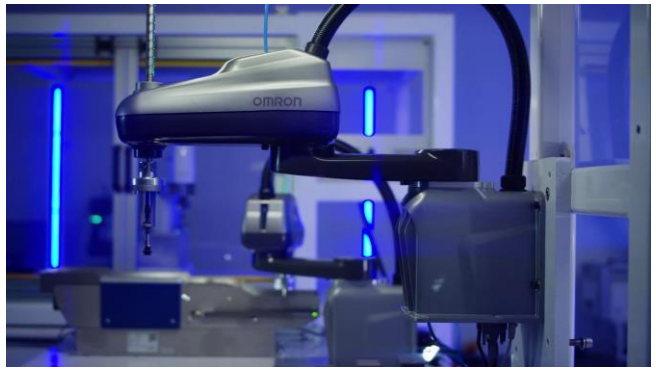


ANTROPOMORFO



DELTA





Fixed Robotics: FAQs

How difficult is the installation?

Safety? Are robots dangerous?

How difficult is it to program?

Do we need special educated people?

How to include the tool and
the other machines?

What are the costs? R(eturn)O(f)I(nvest)?

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Collaborative Robots (COBOT)

- Introduced into the market in 2008
- No need for safety fence or cage, cobots were created to work safely with people (depending on the application, users may need to use safety sensors).
- Easy to program: less time and skills needed to program an application.
- Flexible: can be moved from one location to another to work on different tasks (traditional industrial robots must be fixed to one place and are used for one specific task).
- Flexible: thanks to integration with vision systems, they are able to adapt to human inaccuracy

TRADITIONAL ROBOT

- Complex Configuration
- Robotic Experts are required
- Rigid Solutions
- Large Foot Print is required
- Protection Fences are required
- High additional cost associated

VS

COLLABORATIVE ROBOT

- Quick Configuration
- No Experts are required
- Flexible and easy to re-allocate
- Space saving / Small Footprint
- Human Machine Collaboration
- Short ROI

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Collaborative Robots: Payload and Reach

Model	Reach	Payload	Options
TM7	700 mm	7 kg	M = 20-60 VDC power supply M-SEMI = VDC + SEMI S2 certified X: No Camera
TM5	900 mm	5 kg	
TM12	1300 mm	12 kg	
TM14	1100 mm	14 kg	
TM16	900 mm	16 kg	
TM20	1300 mm	20 kg	
TM25	1900 mm	25 kg	




Main Features of Collaborative Robots - Safety

Safety

Cobot can share a workspace with workers, due to safety requirements

Risk Assessment

Main Features of Collaborative Robots – Deployment: easy to use

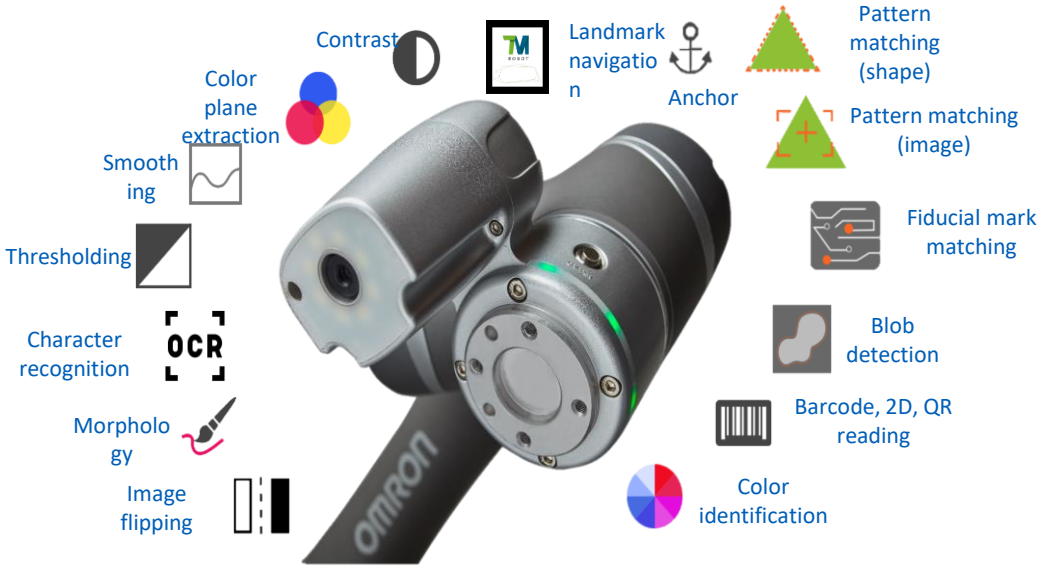
Deployment

- Programming can be done by an unexperienced personnel
- The deployment of a complex robotic cell is not needed

Main Features of Collaborative Robots - Change-Over: flexible solution!

Change-over

Suitable for repetitive tasks in high-mix very low volume applications



Cobots:
Application examples

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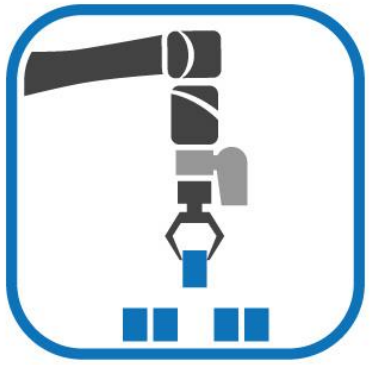
Examples of Applications



Pick & Place

Assembly

Machine Tending

Dispensing

Inspection

Palletizing

Screwing

Intra-Logistics

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Machine Tending

Application Description

The application load and unload valve actuator covers (in the red circle) from a CN. The robot pulls out one of the 5 drawers and picks up raw parts from the tray, localized with the vision system. It stores the finished goods in the free areas of the same tray. When all parts in a drawer are finished, the operator can extract them in the safe zone, which is opposite to the robot zone.

Omron Technology

Only a cobot and a laser scanner, for activating the collaborative mode when the operator get access to the robot zone (just for checking the application).

Benefit

Automatization of an operator boring task. The physical separation between operator zone and robot zone permits the cobot to work safety in high speed.

Palletizing

Developed entirely inside **Omron machine controller**

Available in OMRON Milan office!

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Screwing/Assembly

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Screwing/Assembly

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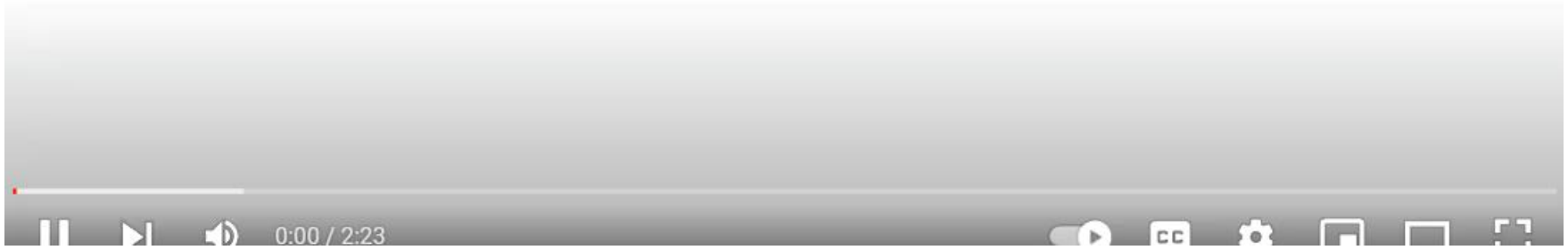
Screwing/Assembly



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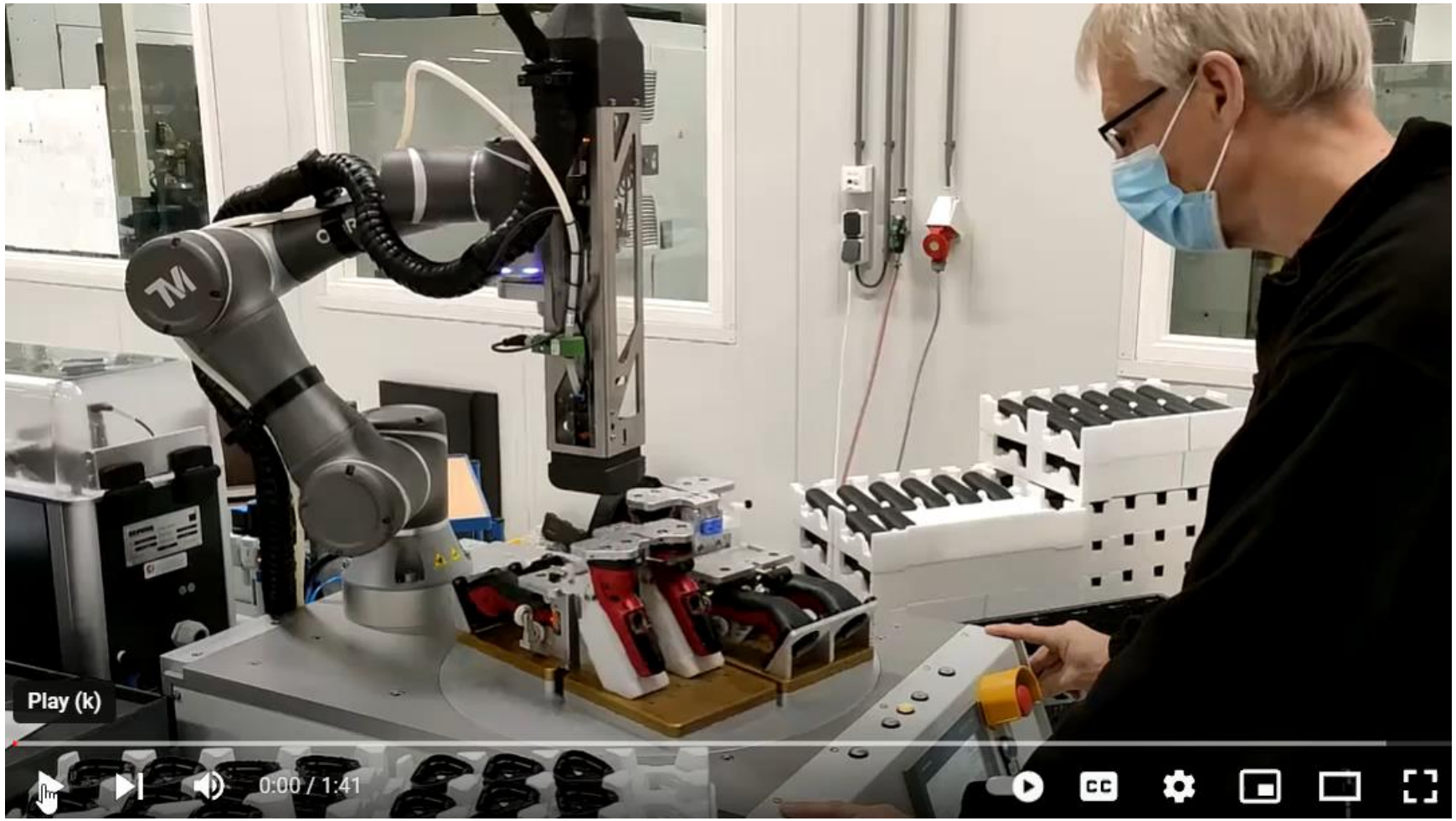
Screwing/Assembly



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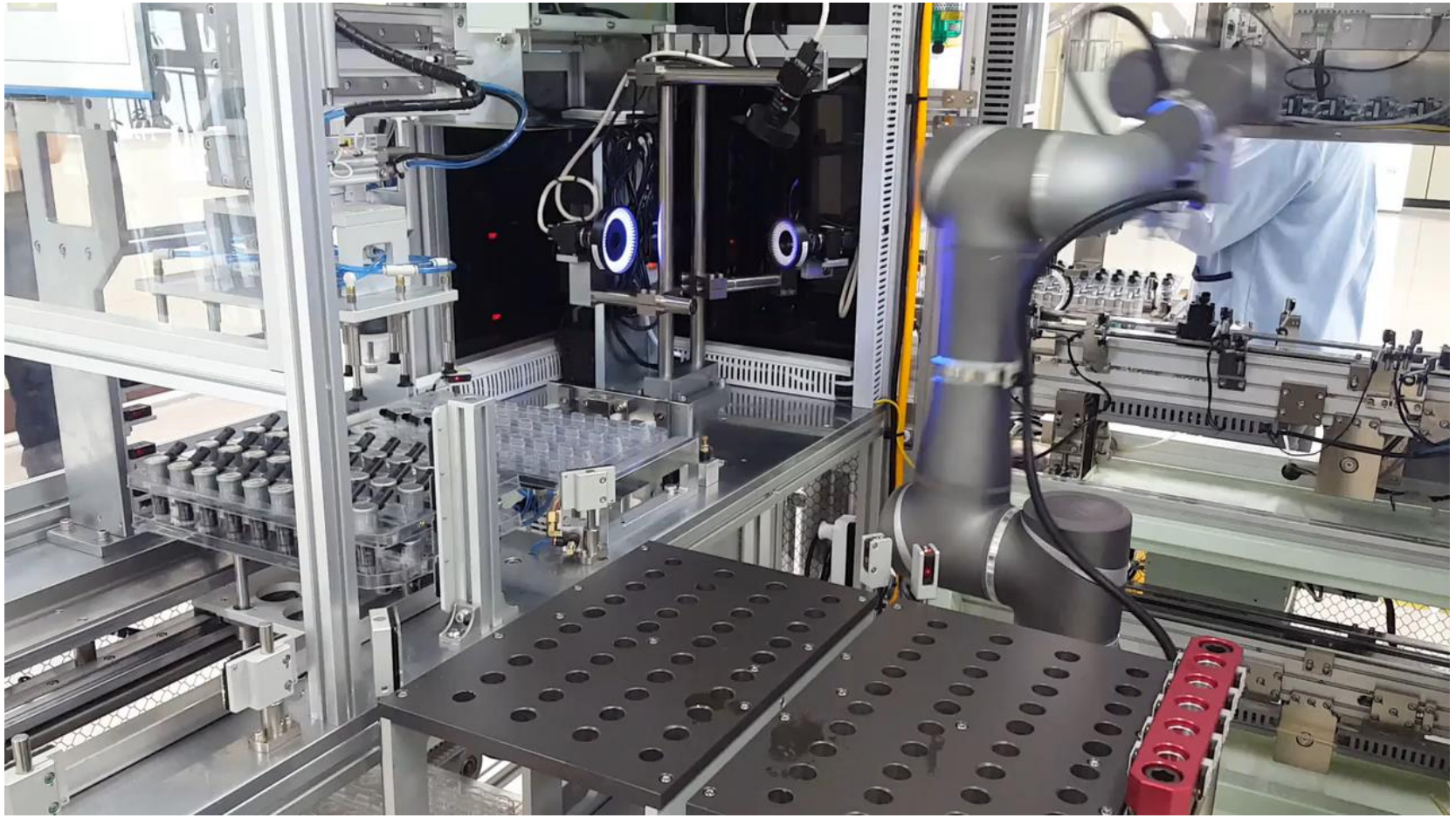
Inspection



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Helping People, improving productivity

Autonomous Mobile Robots (AMR)

Material Transportation & Intralogistics

SCALABILITY

Management of different products (different dimensions and weights)

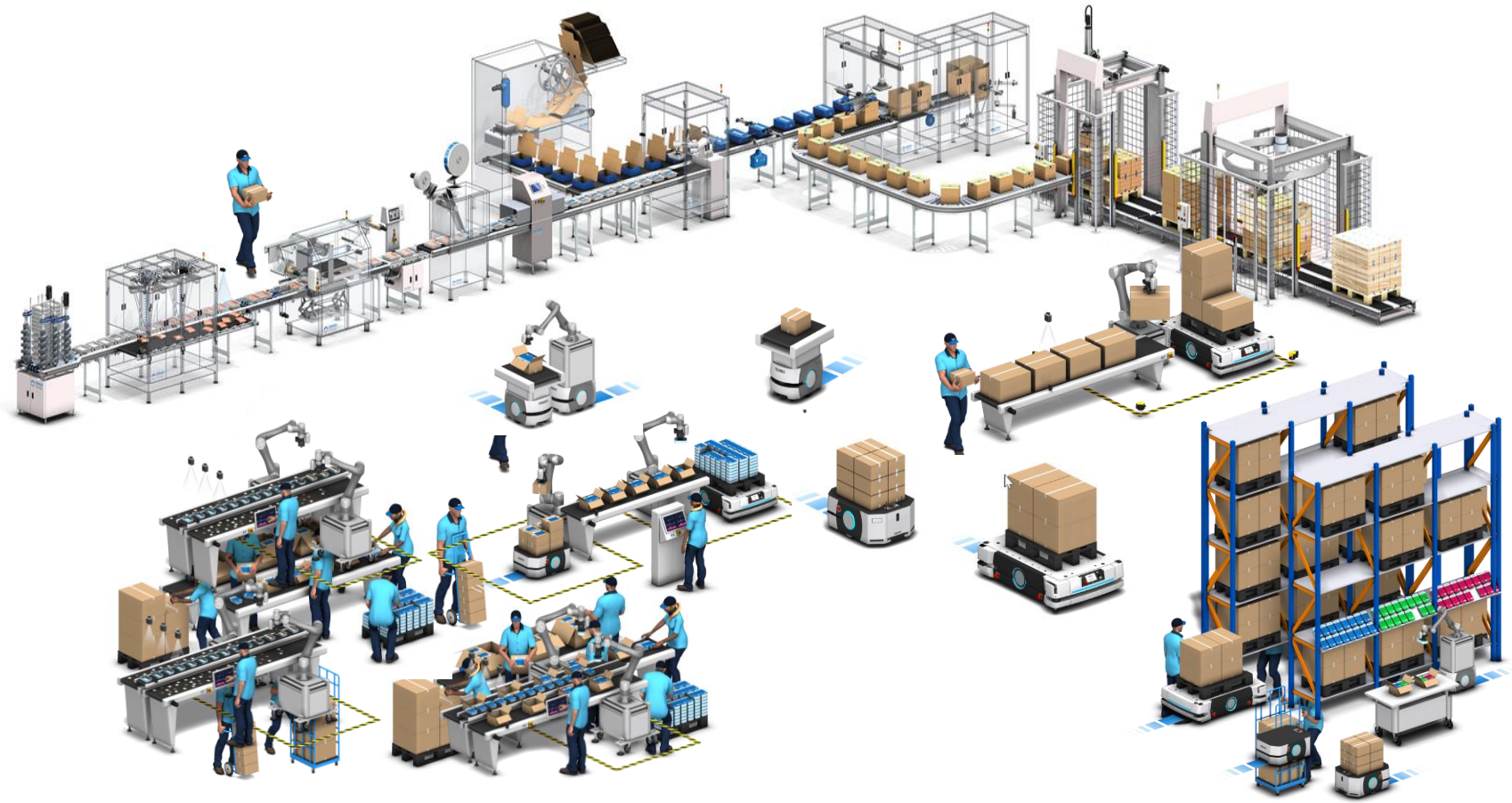
SAFETY

Transportation of materials in tight spaces, heavy payloads

EFFICIENCY

High consumption of materials

Material Transportation & Intralogistics



SCALABILITY

Management of different products (different dimensions and weights)

SAFETY

Transportation of materials in tight spaces, heavy payloads

EFFICIENCY

High consumption of materials

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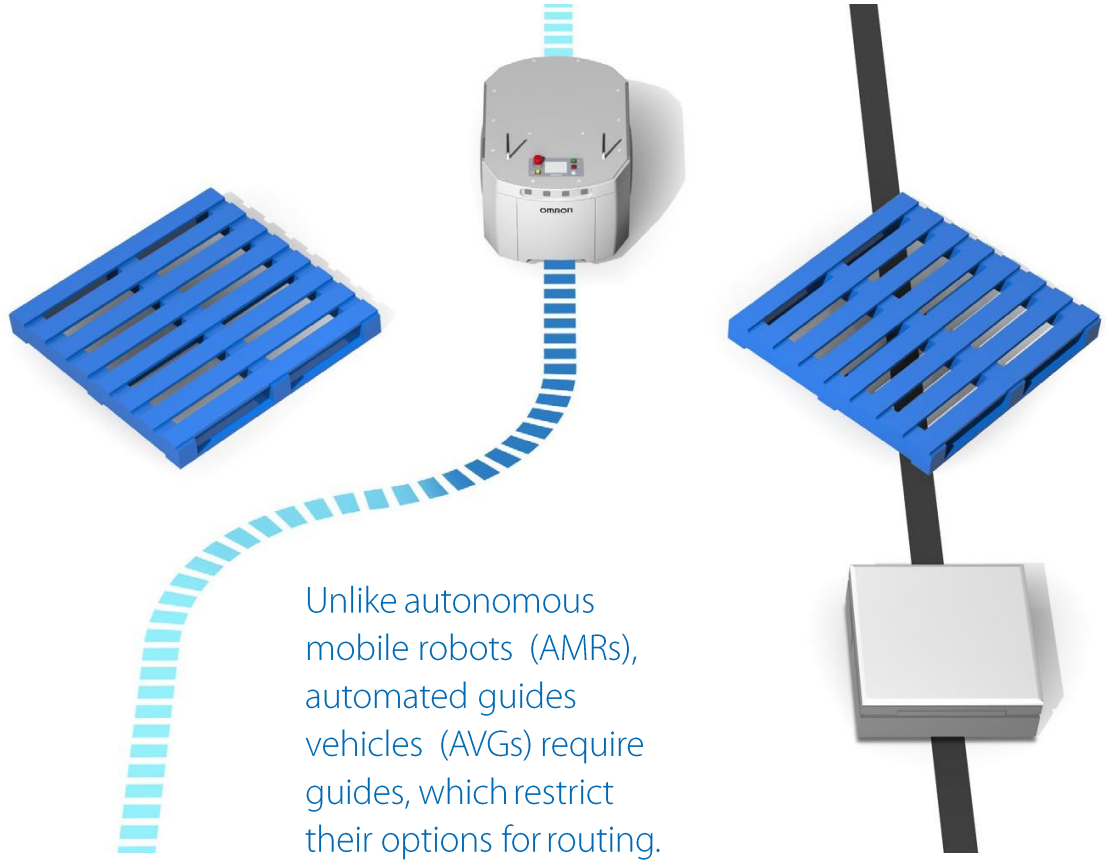
AMR vs AGV

The difference is flexibility

	OMRON AMR	AGV
Set Up	Ready to go after simple mapping	Requires navigation guides
Navigation	Navigates autonomously and **safely** without physical guides magnets or beacons	Needs guides, such as floor
Obstacles	**Safely** avoids obstacles without stopping	Stops at obstacles and remains still until obstacles are removed
Map Change	Easy	Factory modifications
Changing Destinations	Easy	Factory modifications
Scalability	Easy	Factory modifications



Unlike autonomous mobile robots (AMRs), automated guides vehicles (AVGs) require guides, which restrict their options for routing.

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Fleet Management

Manage Fleets of Up to 100 Robots

- Used when running more than one robot.
- Displays robot location and status
- Displays job queue
- Prioritizes important jobs
- Selects fastest routes based on human and robot traffic
- Identifies blocked paths and creates
- alternative routes
- Optimizes job assignments
- Optimizes battery charging

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Hybrid Fleet Management

OMRON's mobile solutions are extremely versatile and can be adapted to perform a wide variety of tasks and applications.

OEM Solution					Build Your Own			
Cart transporter	LD (ESD)	LD- 60/90	LD-250	HD-1500	Collaborative robot solution	Mobile manipulator with OMRON TM collaborative robot	Conveyor top	Courier with lock box

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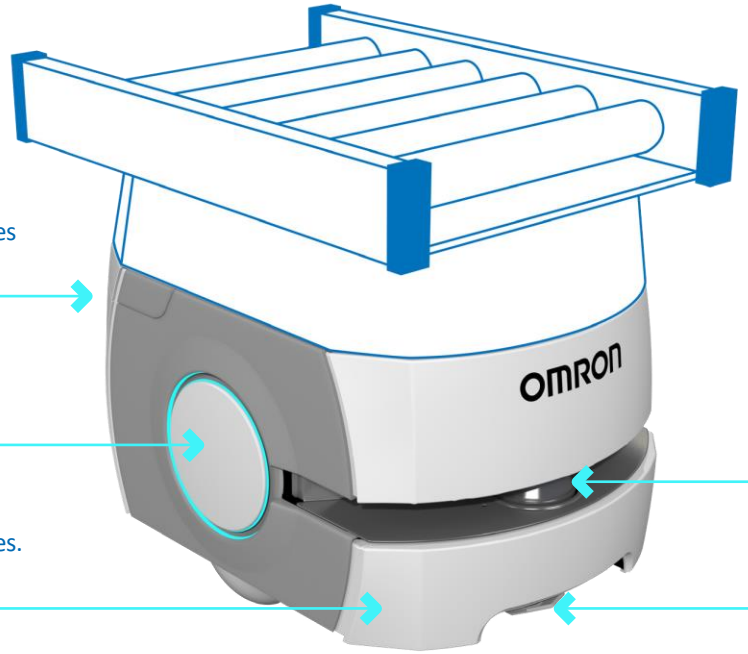
Anatomy of a mobile robot



REAR SONAR
Detect rear obstacles using sonar.

LIGHT DISCS
Status indicator is located on both sides.

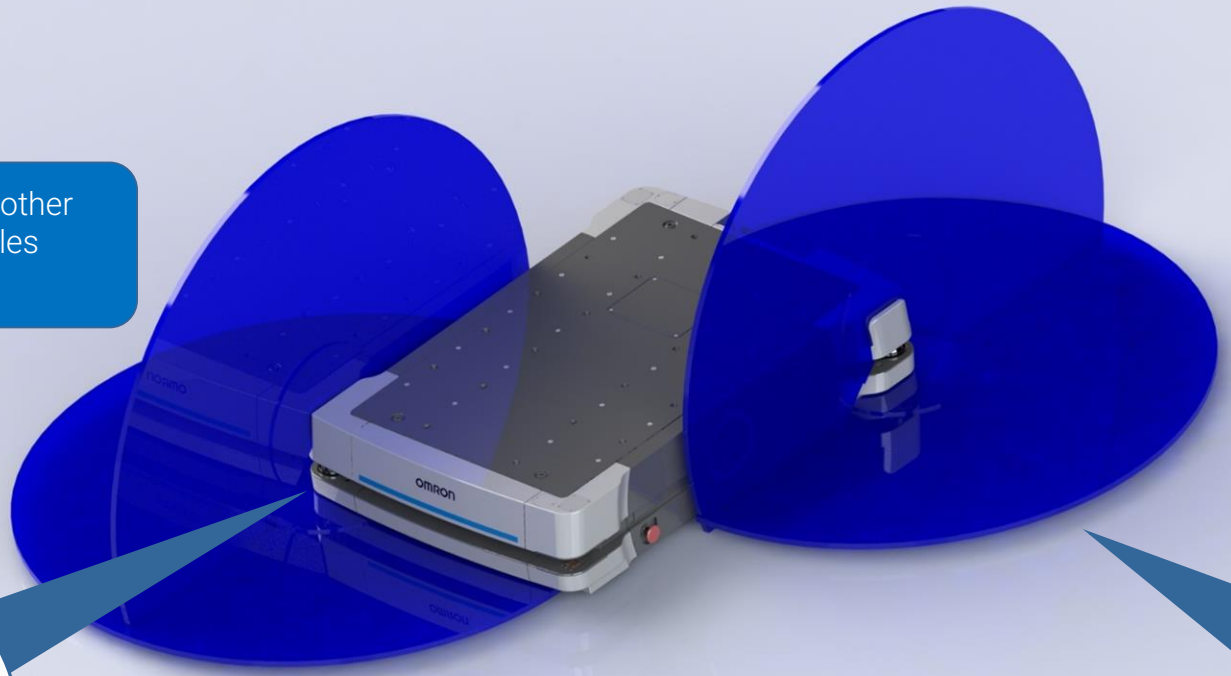
FRONT BUMPER
Stops when in contact with obstacle.

SAFETY SCANNING LASER
Safety-rated laser used for SLAM (simultaneous localization and mapping) and safety functionality.

LOW FRONT LASER
Obstacle sensor detects low-profile objects when moving forward.

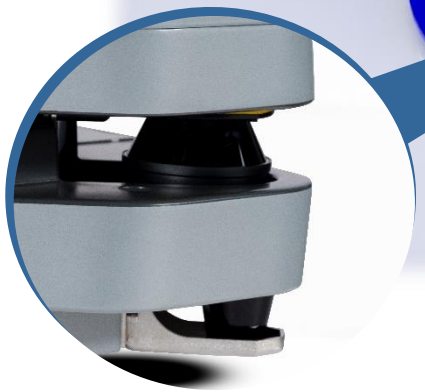
Full safety-compliant mobile robot

Onboard laser and other sensors for obstacles detection

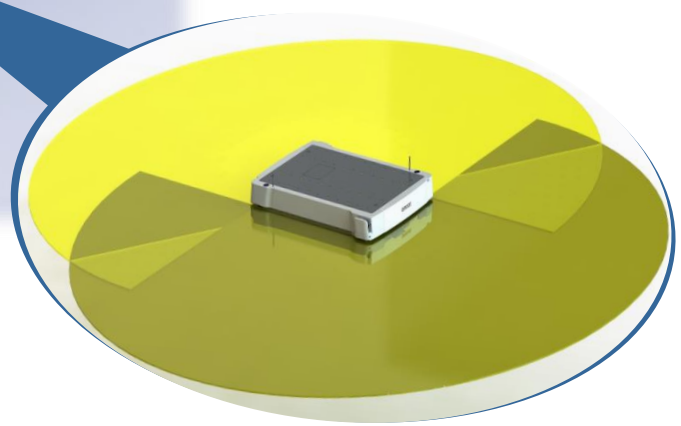


Sensors:

- Safety Rated Front Laser
- Safety Rated Rear Laser
- Front Low Laser
- Rear Low Laser
- Side Lasers (Patented)



Path based on speed of travel, trigger an E-stop to prevent vehicle collision.



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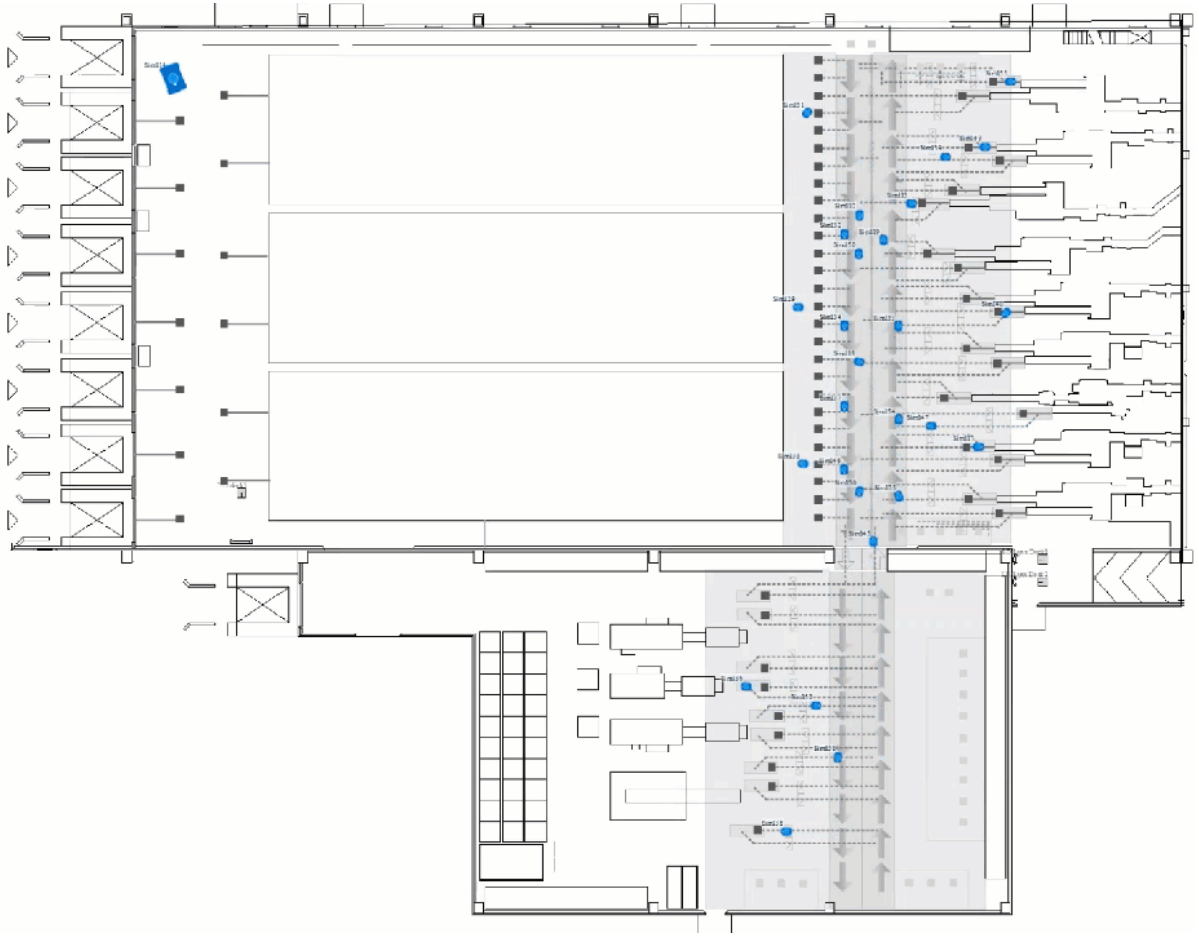
Fleet Simulator

Solve problems before they arise.
Optimize your fleet before deploying it.

- Helps assess impacts of map changes, scaling, route changes, and new software features
- Simulates custom environment based on real-world facilities
- Identifies traffic flow bottlenecks



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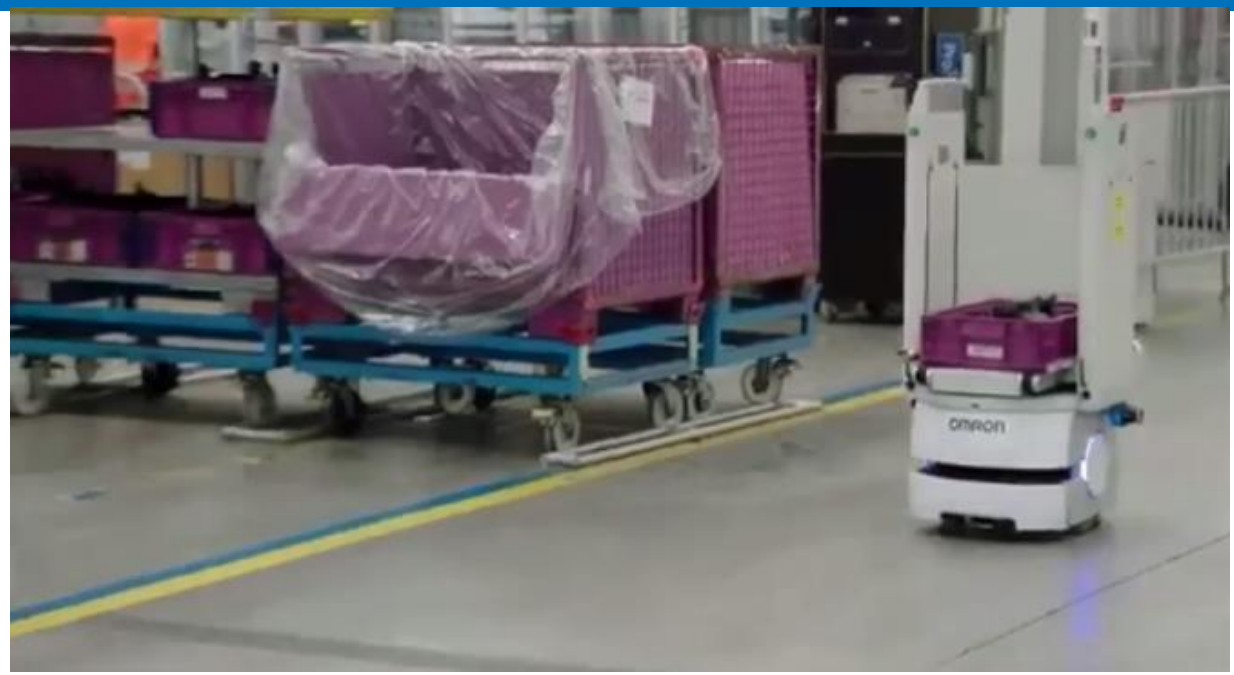
BMW

Challenge/Application details

- Location: Germany.
- LD transports 45kg work/parts in 3-5 shifts a day, in production lines and inter-logistics.
- Improve safety.
- Releasing skilled operators from simple transporting tasks.



OMRON Solution

- 100 x LDs (different several fleets with up to 20 robots).
- CTS as System Integrator deploying the complete application.
- Natural navigation of the LD robot.
- Fleet Management programming.
- https://www.youtube.com/watch?v=tNZJgmoUGs0

Customer Value

- Eliminated 72% of manual transport time.
- Improved safety by avoiding manual transport on the lanes of the tugger trains and forklifts.
- Optimized area utilization by reduction picking area.

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TePe

Challenge/Application details

- Location: Malmo, Sweden.
- Flexible manufacturing application of oral hygiene products for the dental industry, operating 24/7, producing toothbrushes and dental sticks.
- LD-90 robots move boxes to different locations.
- LD-90 brings boxes of secondary packaged products up and down elevators to conveyor at shipping dock.

OMRON Solution

- 3 x LD-90.
- Fleet Manager EM2100, 1 x SCARA, 1 x AnyFeeder, 3 x Parallel robots, Vision, Safety, ACE Software.
- Their decision to use OMRON's full automation solution was an easy choice because of the easy integration and full automation platform.
- They also valued the flexible manufacturing application and getting everything from one source.

Customer Value

- ROI in 14 months.
- TePe can easily reprogram machines to add more quality controls and process 300 toothbrush packs per minute increasing throughput 10x versus previous manual line.
- TePe can fulfill existing and new customer demands very quickly, which has been a key contributor for annual growth.
- The OMRON solution has improved flexibility, quality, safety, and efficiency for TePe.

Only complex and huge projects?

- Automotive customer in Ravenna, Italy
- Issues:
  - optimize intralogistics from production line to clean room
  - Minimize contamination of product
  - Make intralogistics a repetitive and controlled task

- Solution:
  - 2 mobile robots LD with lifter top
  - Simple cart and tables done by a local partner

- Next Steps
  - Automate the Palletizing process with a Cobot

Mobile Manipulator (MoMa)

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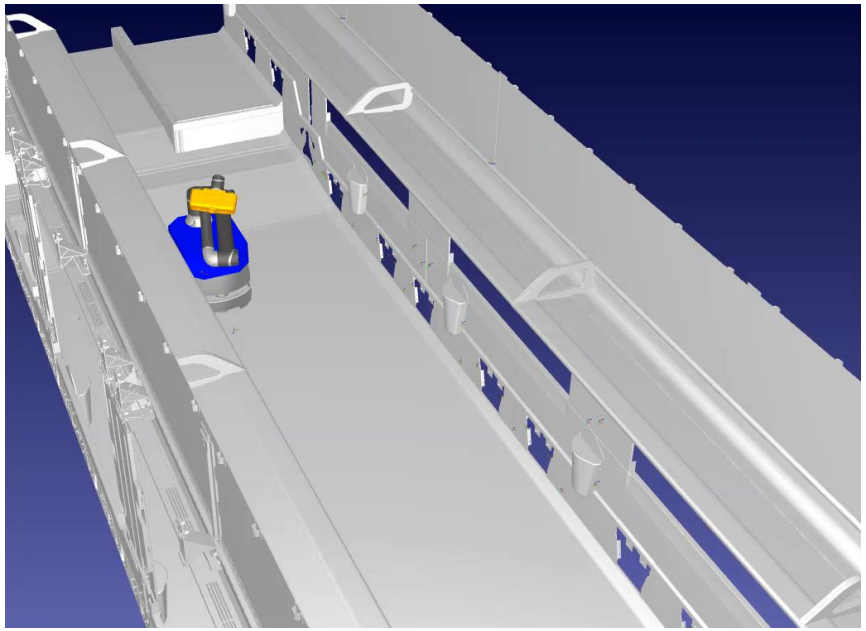
MoMa: Mobile Manipulator

Simulation



Concept

Application

To improve lives & contribute to a better society

Kazuma Tateisi, founder of Omron

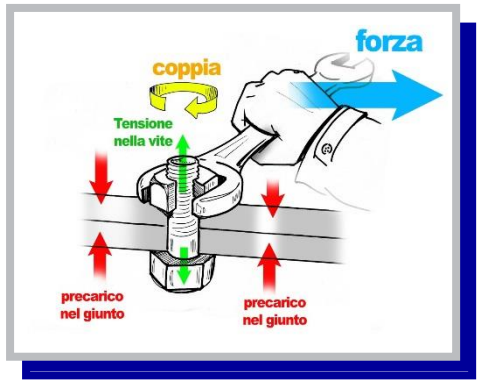
Avvitatura controllata

Alessandro AINA

GI Product Manager


SDS-SR
OK
6.510
1347

Cosa è la coppia



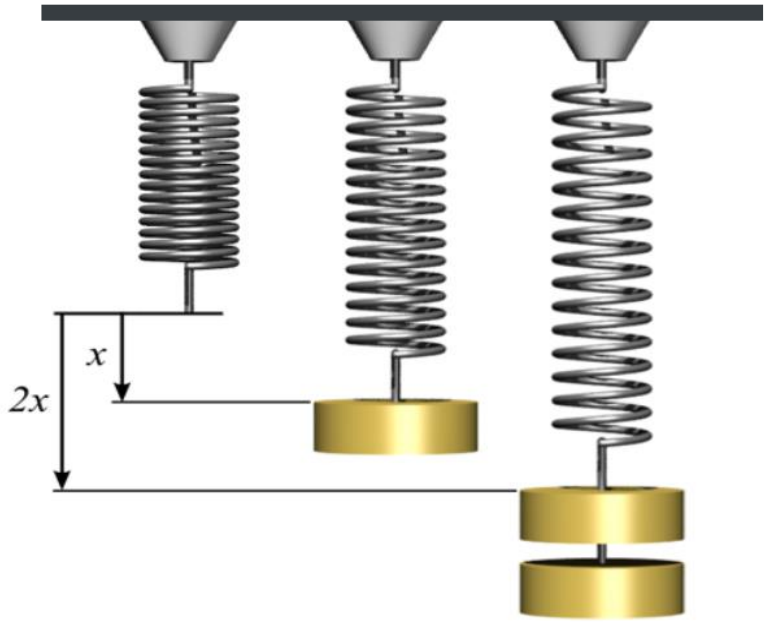
La coppia è la forza di **torsione** (rotazione) che viene applicata ad una vite per **ruotarla**.

Questa forza genera **tensione elastica** nella vite e, di conseguenza, precarico nel giunto.

Per generare coppia, la vite deve essere **allungata** così che lavori come una molla.

Senza allungamento elastico la vite non agisce come una molla.

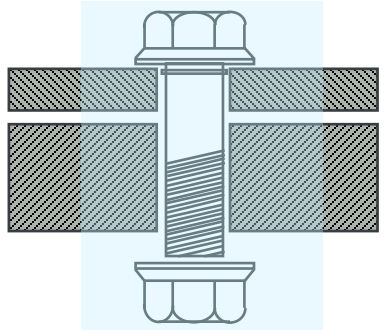
$$\vec{F} = -k\vec{x}$$



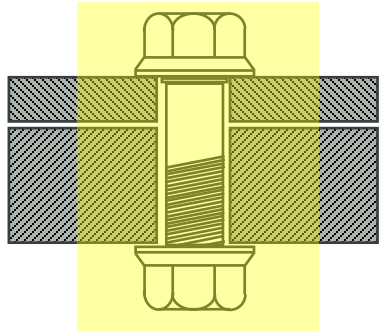
Torque

Four phases of a tightening

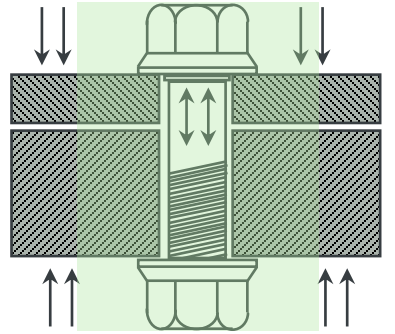
Phase I – Rundown
no contact between fastener head and the part



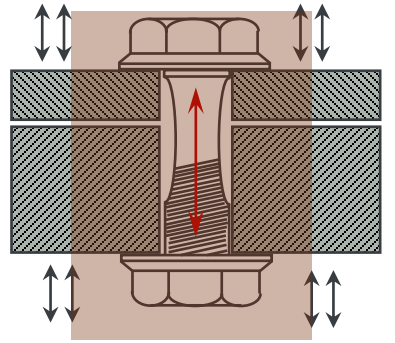
Phase II – Draw-Down contact, the joint is seated



Phase III – Elastic
elastic deformation, clamping force is built up

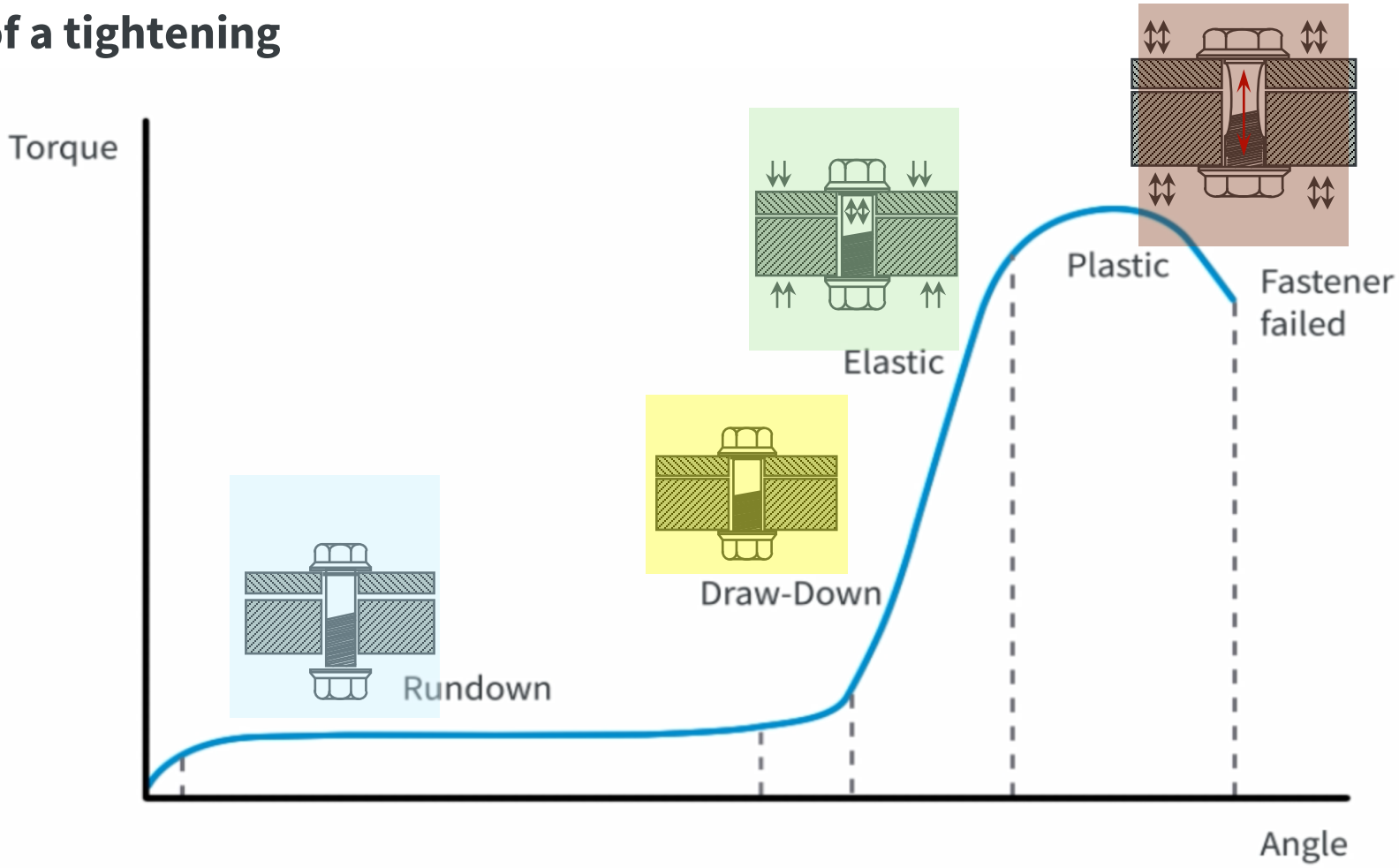


Phase IV – Plastic
plastic deformation, yield

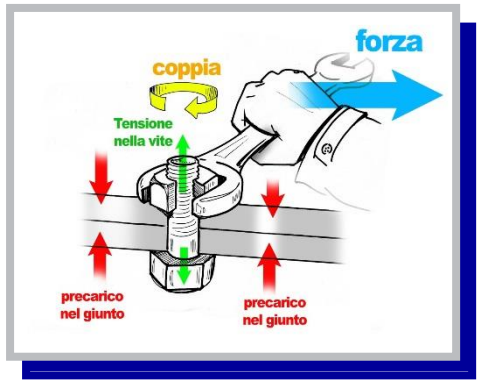


Torque

Four phases of a tightening



Cosa è la coppia



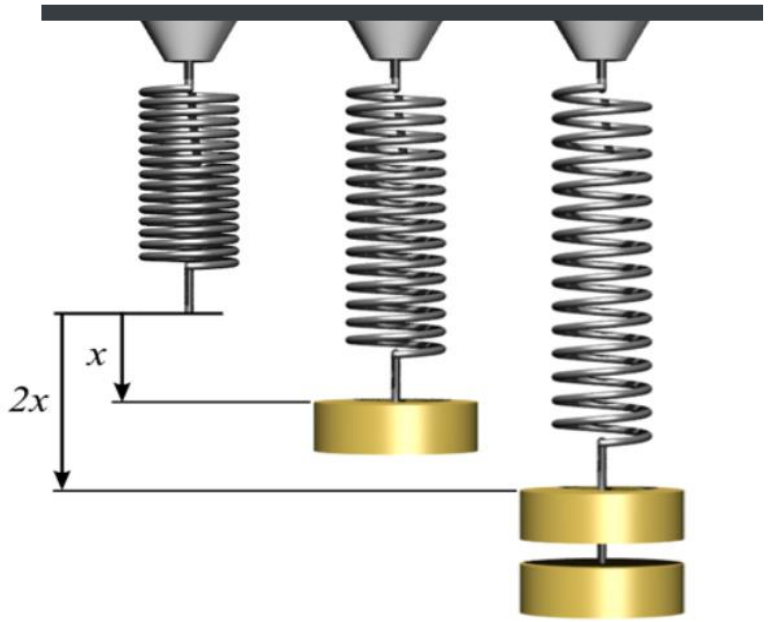
La coppia è la forza di **torsione** (rotazione) che viene applicata ad una vite per **ruotarla**.

Questa forza genera **tensione elastica** nella vite e, di conseguenza, precarico nel giunto.

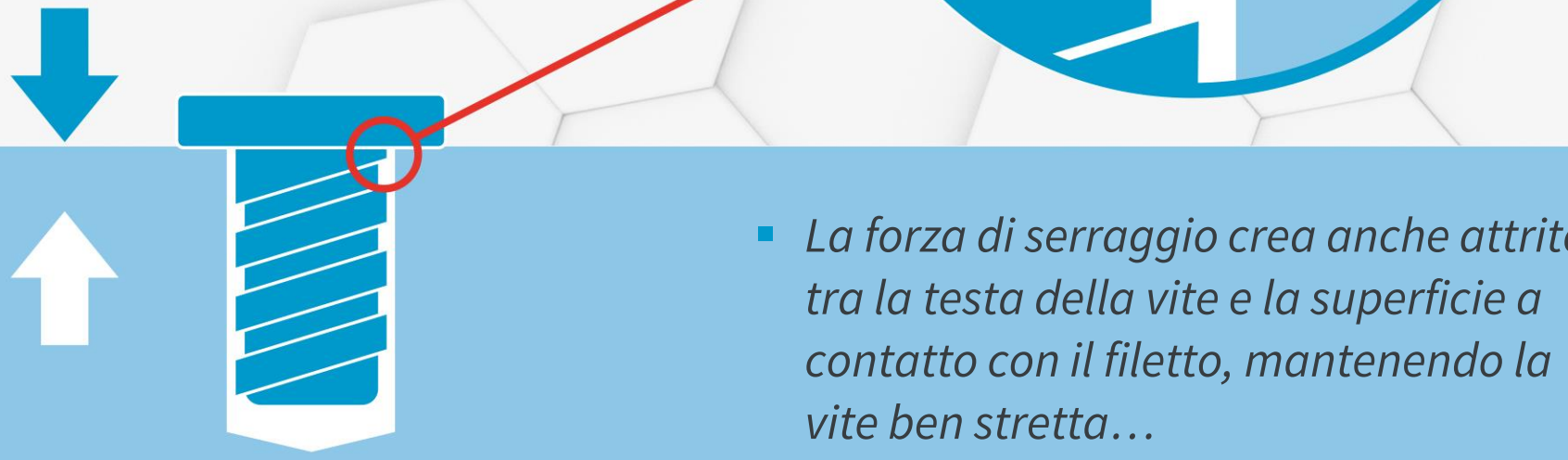
Per generare coppia, la vite deve essere **allungata** così che lavori come una molla.

Senza allungamento elastico la vite non agisce come una molla.

$$\vec{F} = \ominus k\vec{x}$$

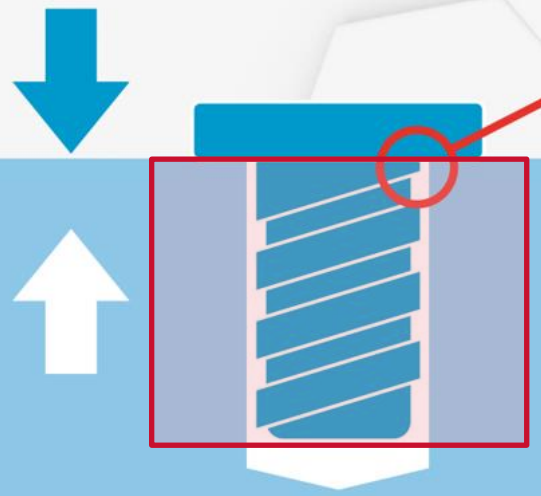


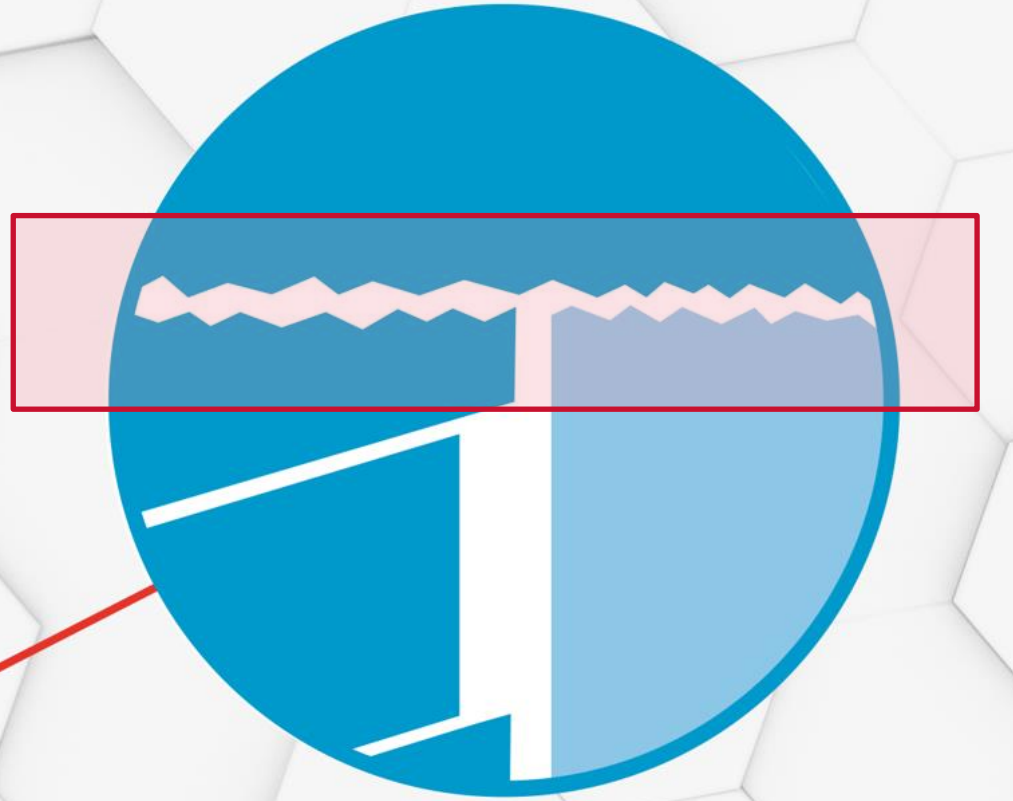
La forza di serraggio



- *La forza di serraggio crea anche attrito tra la testa della vite e la superficie a contatto con il filetto, mantenendo la vite ben stretta…*

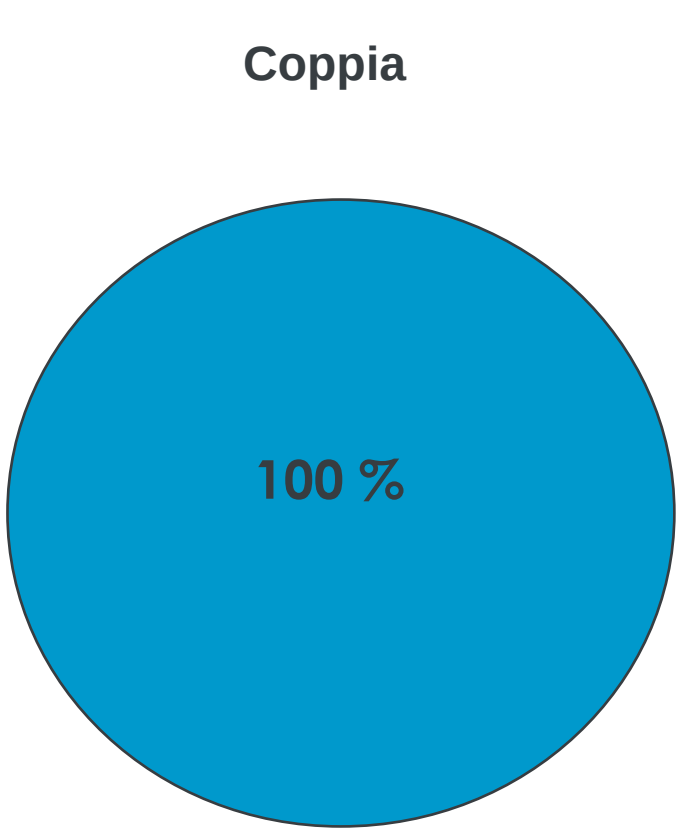
La forza di serraggio

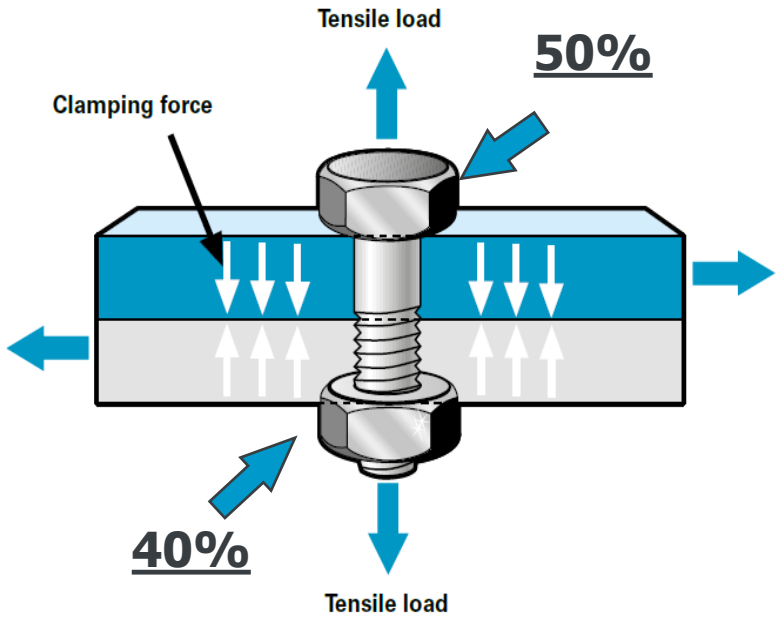


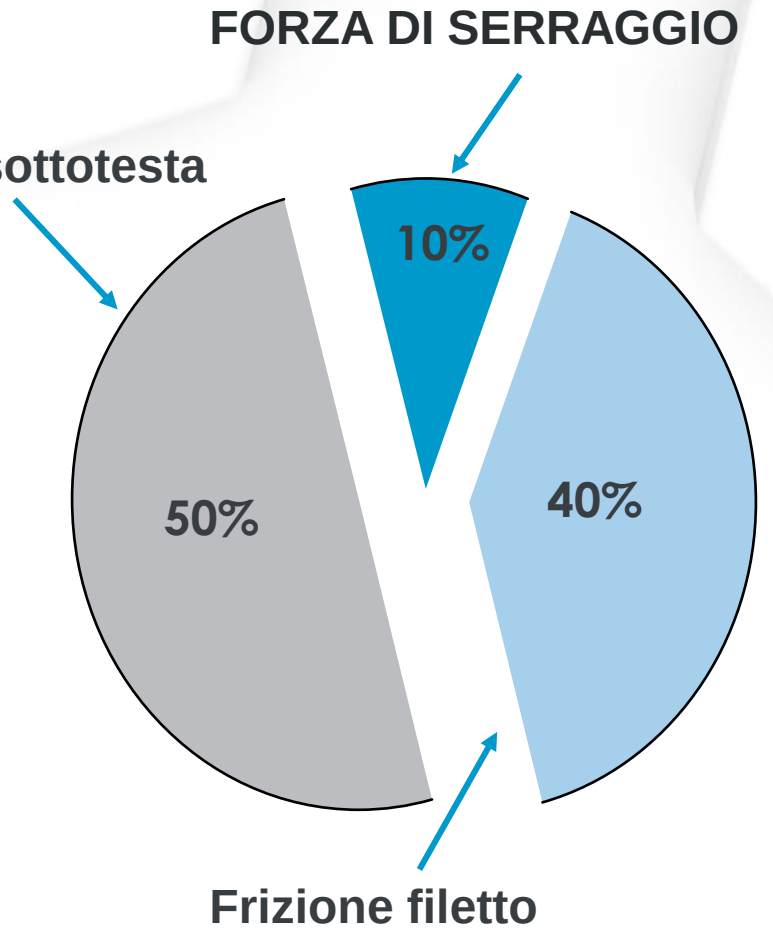


- *La forza di serraggio crea anche attrito tra la testa della vite e la superficie a contatto con il filetto, mantenendo la vite ben stretta…*

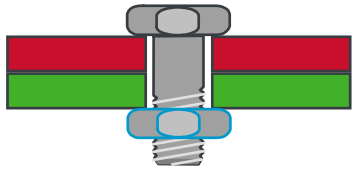
Coppia vs forza di serraggio

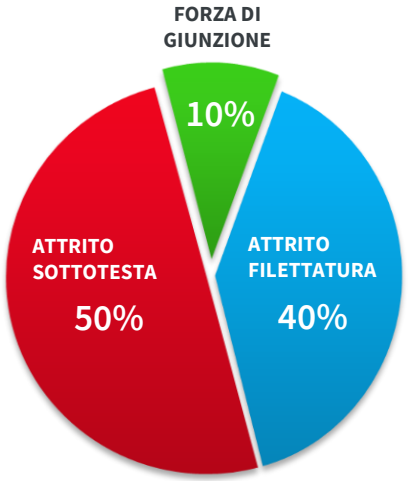






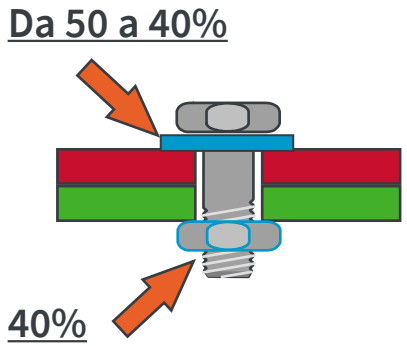
Influenza dell’Attrito

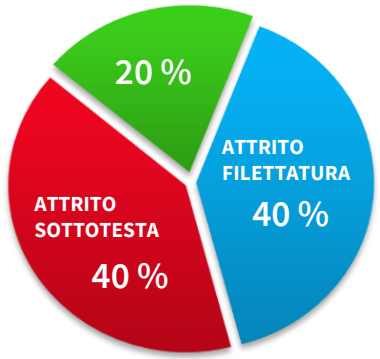




- Gli attriti determinano quanta coppia vada in forza di giunzione (normalmente il 10%)

Giunzione modificata (ad es. aggiunta rondella teflon)

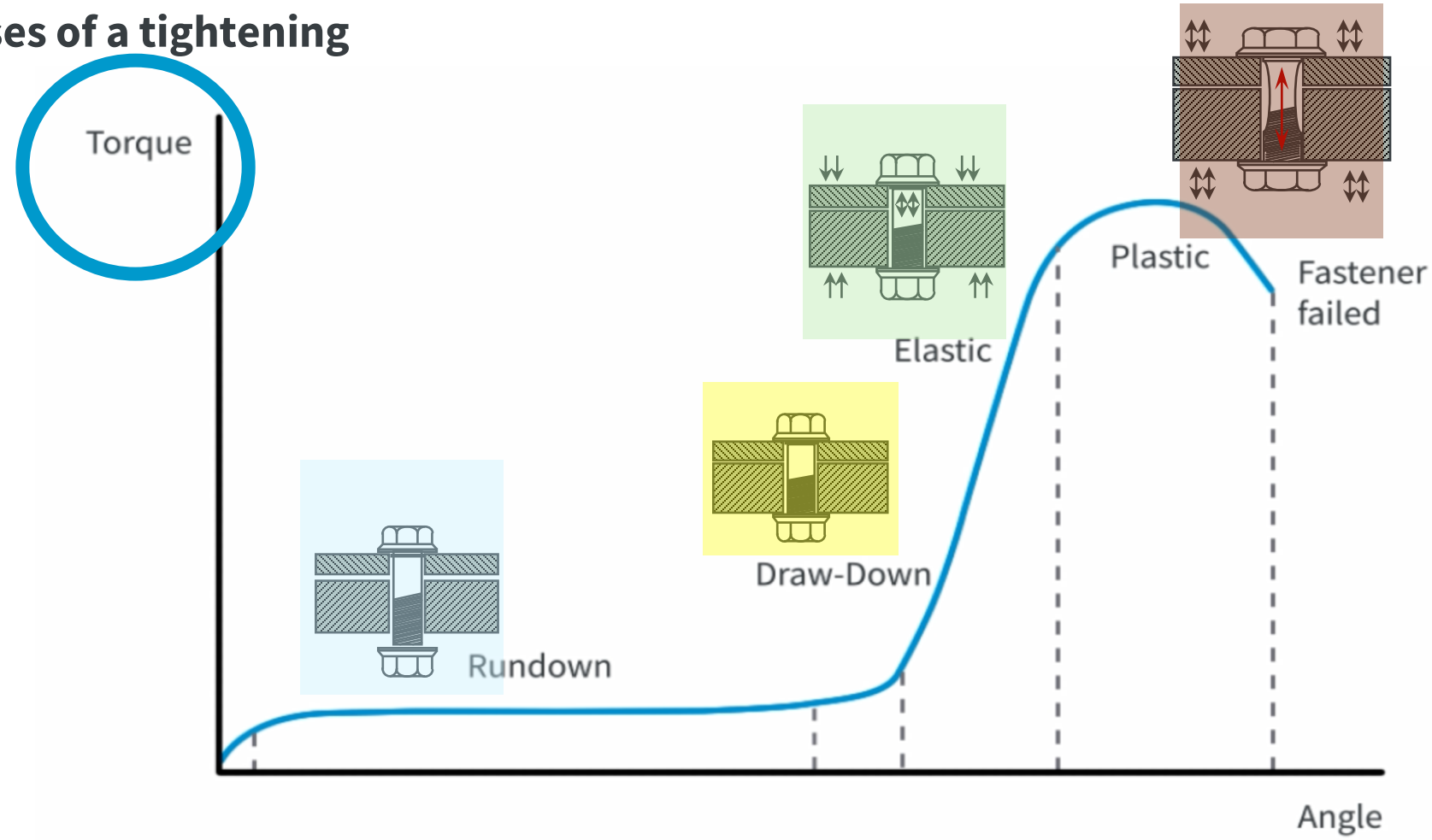




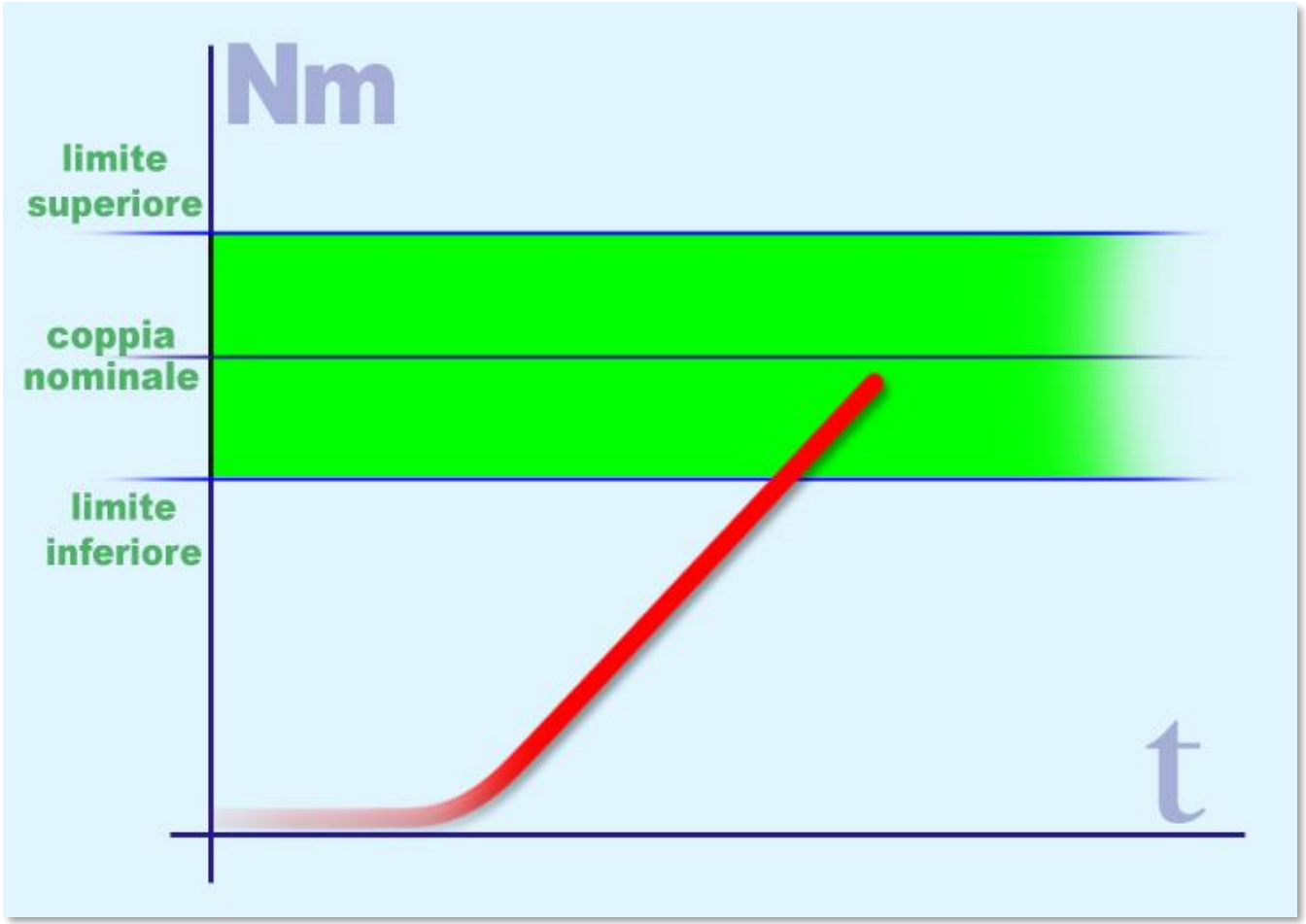
FORZA GIUNZIONE RADDOPPIATA!
RISCHIO DANNO COMPONENTI O CEDIMENTO VITE

Torque

Four phases of a tightening

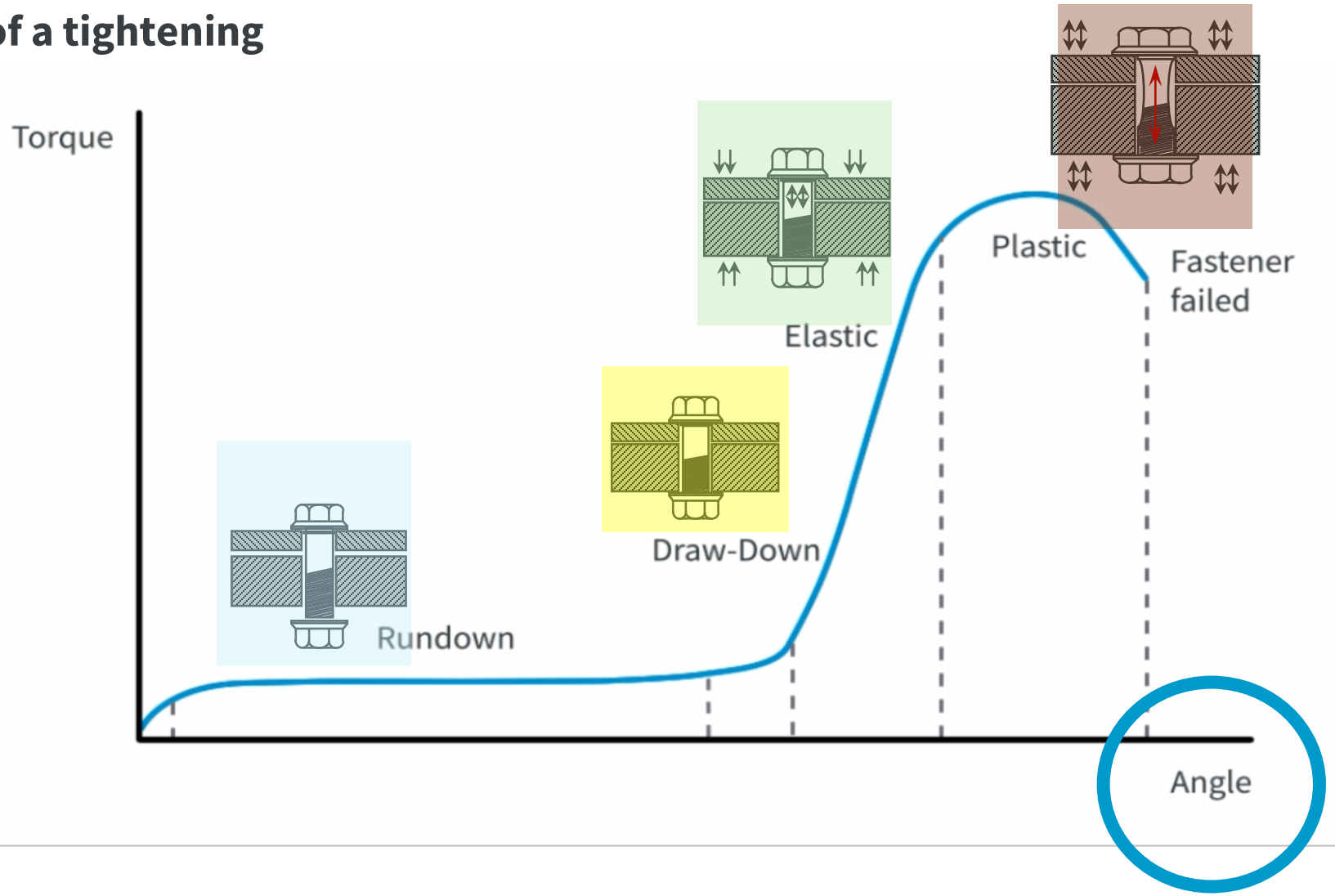


Serraggio con controllo di coppia

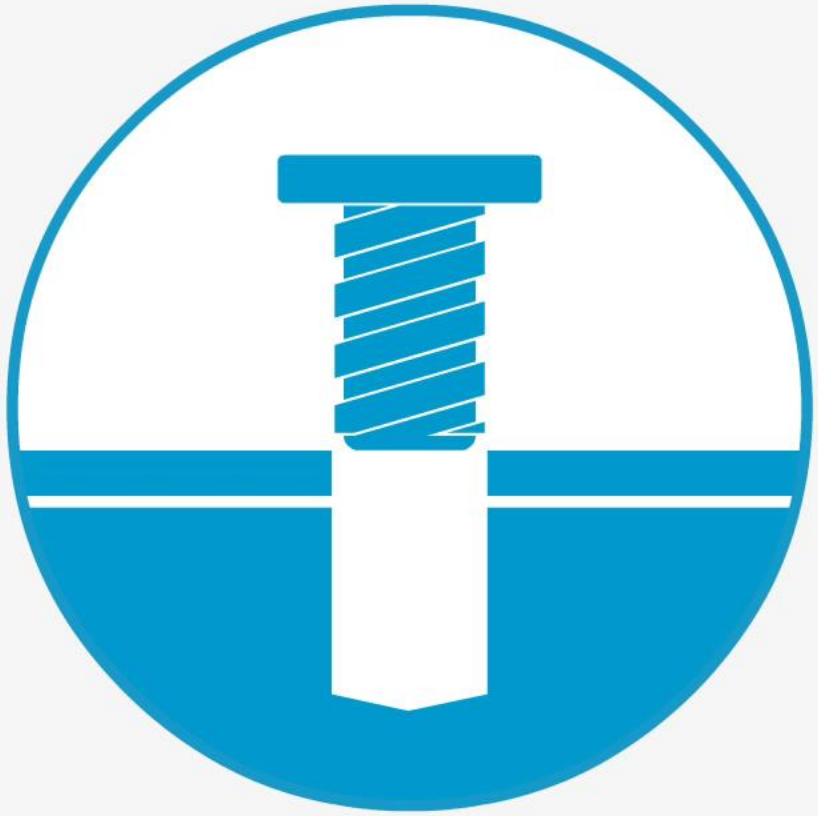


Angle

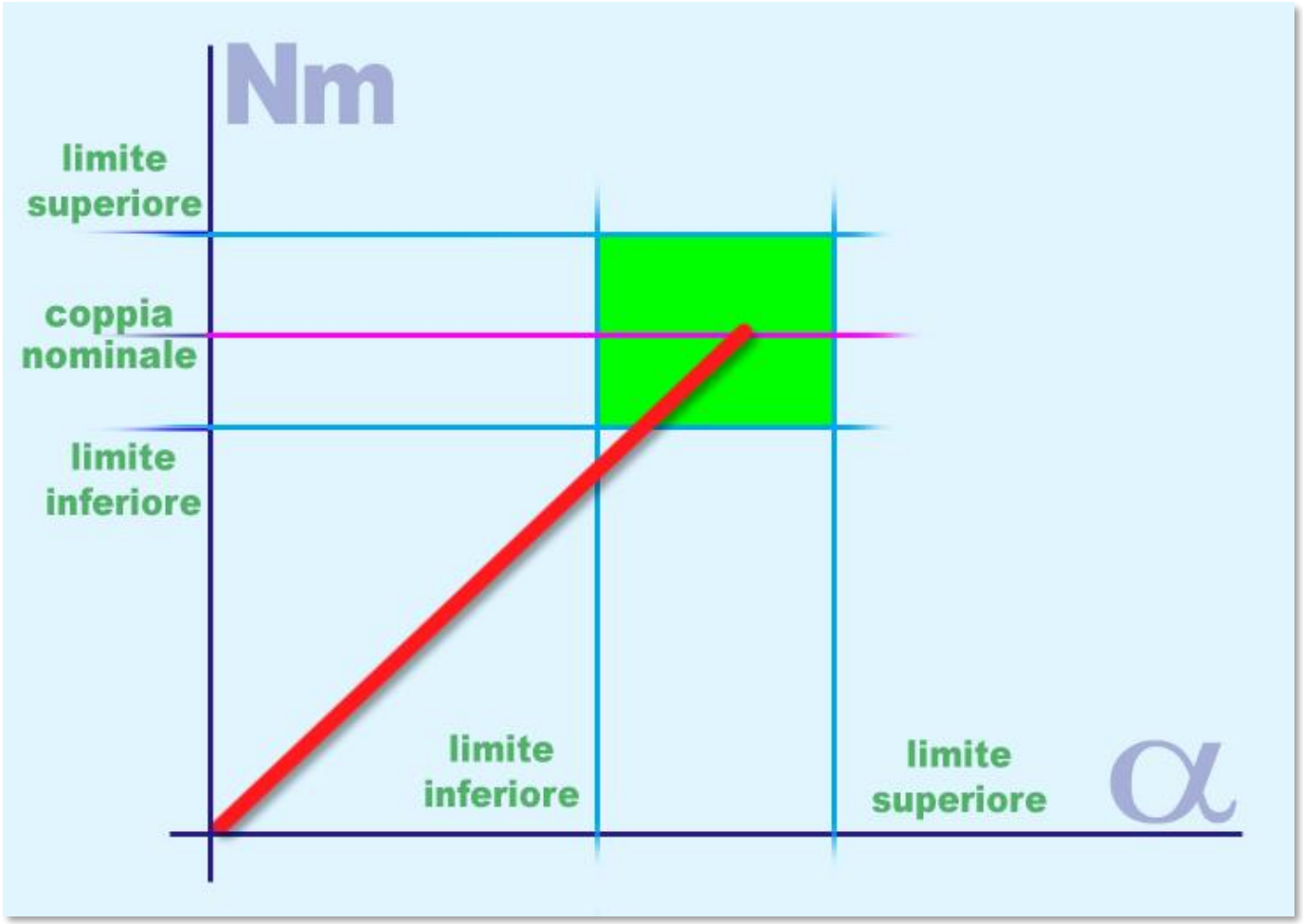
Four phases of a tightening



Angolo



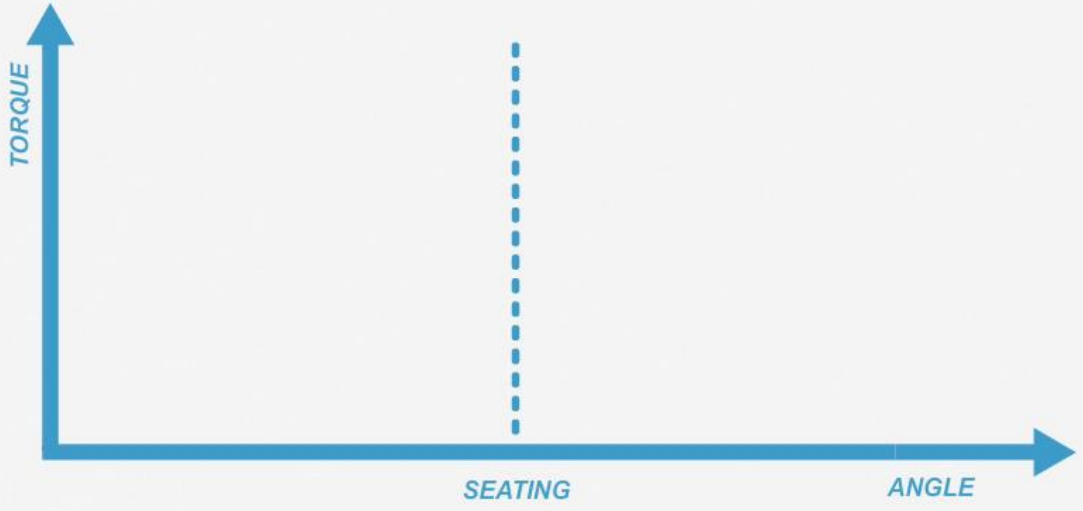
Serraggio con Controllo di Coppia e Monitoraggio Angolo



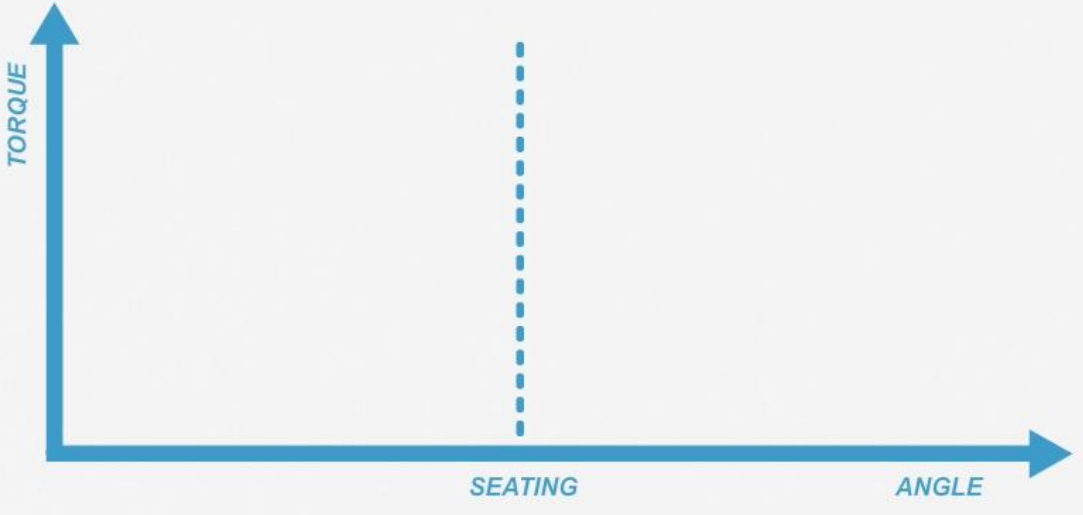
Il serraggio è OK solo se coppia e angolo sono contemporaneamente nei limiti

Questo metodo di serraggio previene diversi errori

HARD JOINT

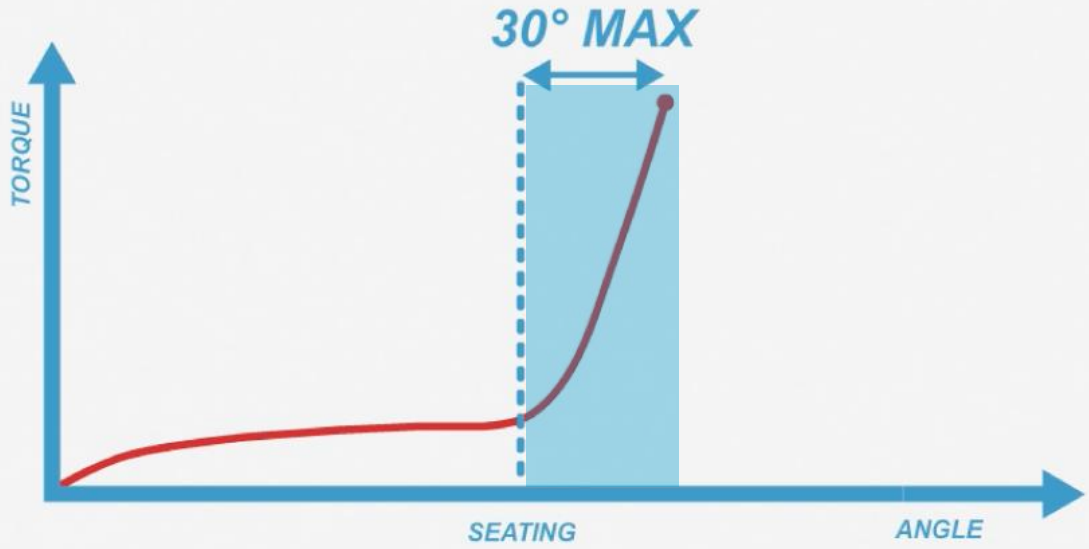


SOFT JOINT

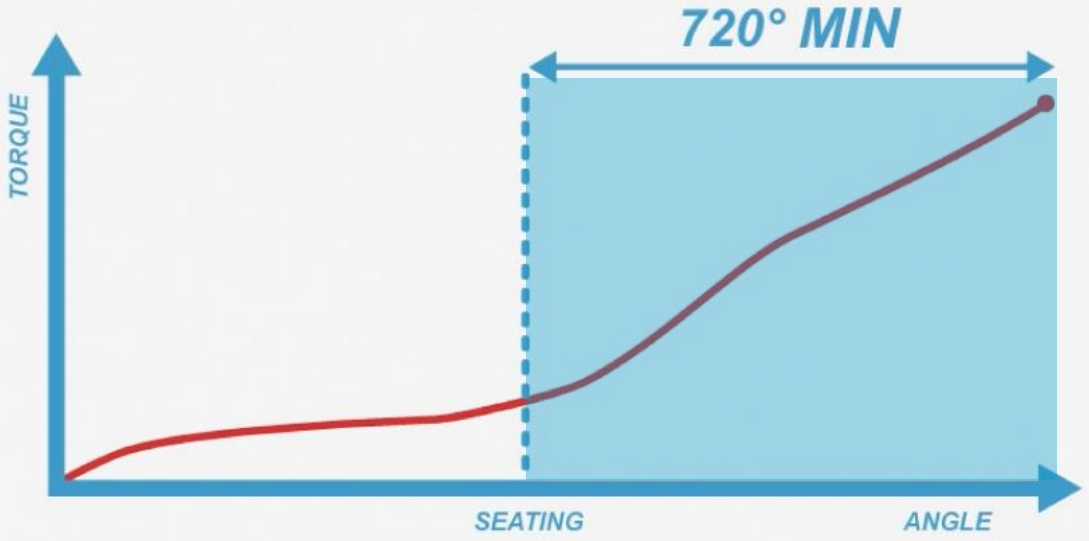


Atlas Copco

HARD JOINT



SOFT JOINT



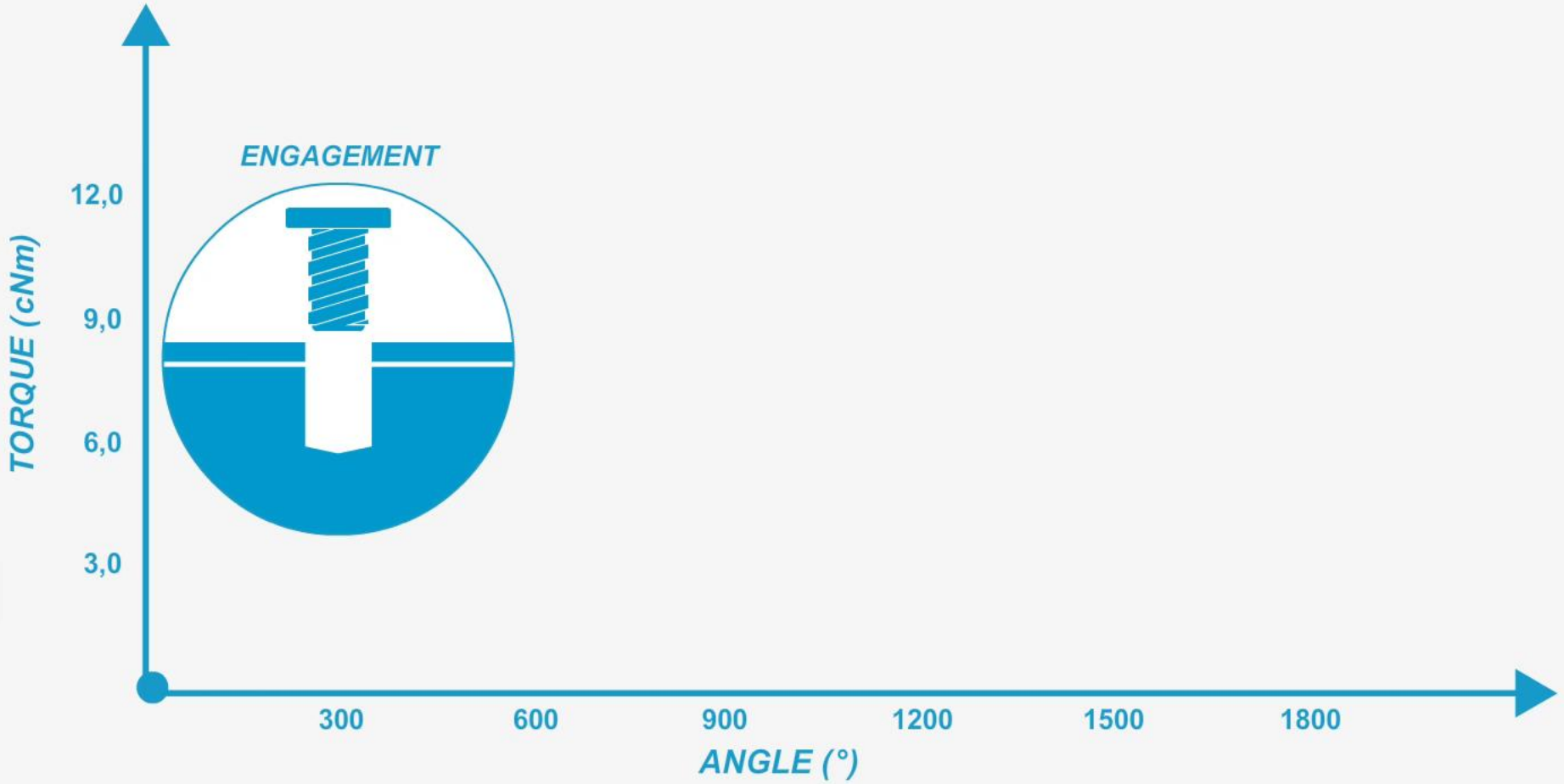
Atlas Copco


Dashboard
Reports
Statistics
Analysis
Notifications
Tool center
Command center
Administration
0
1000
3000
4000
5000


Dashboard
Reports
Statistics
Analysis
Notifications
Tool center
Command center
Administration
0
1000
3000
4000
5000

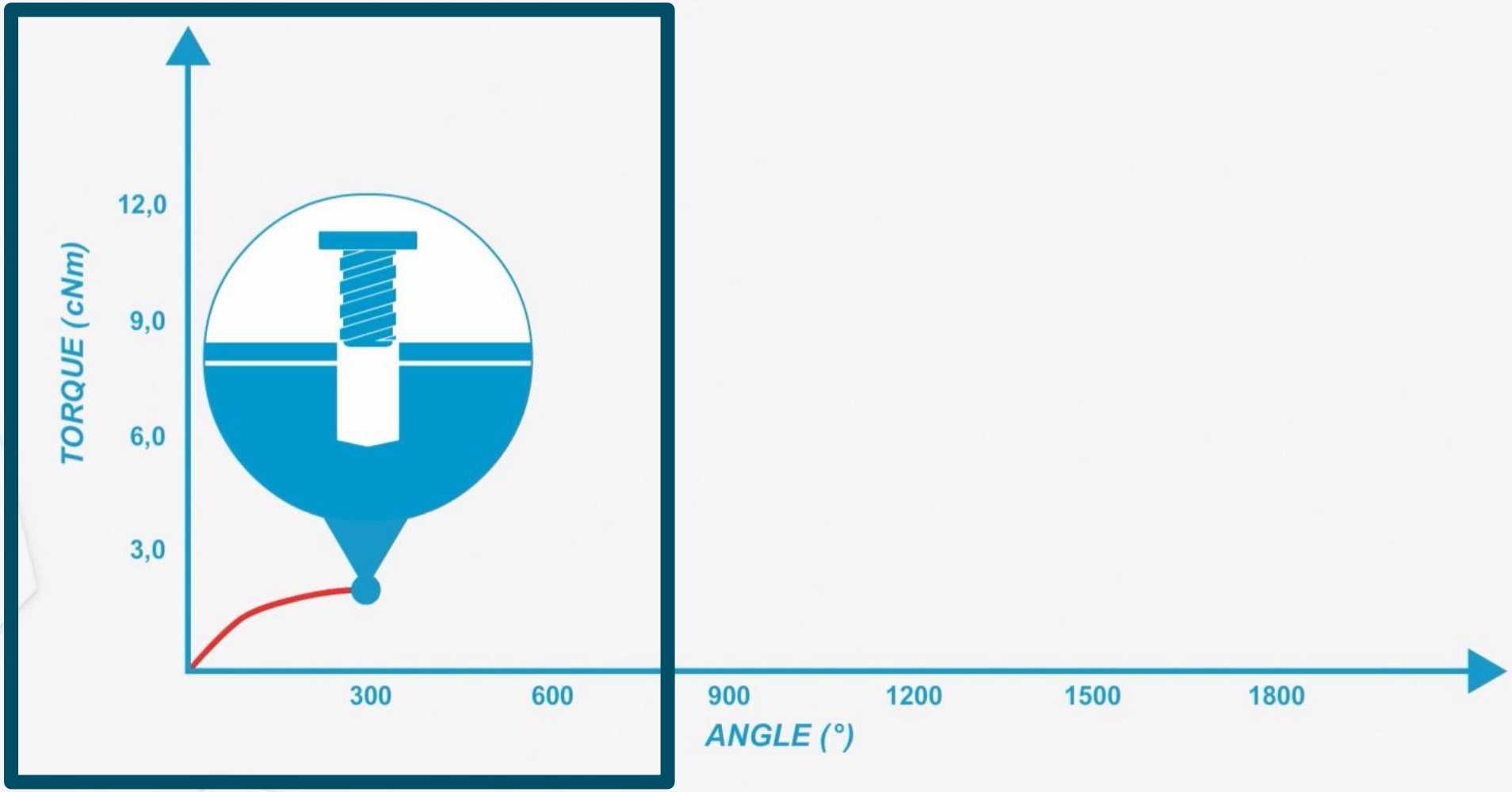
Processo di avvitatura

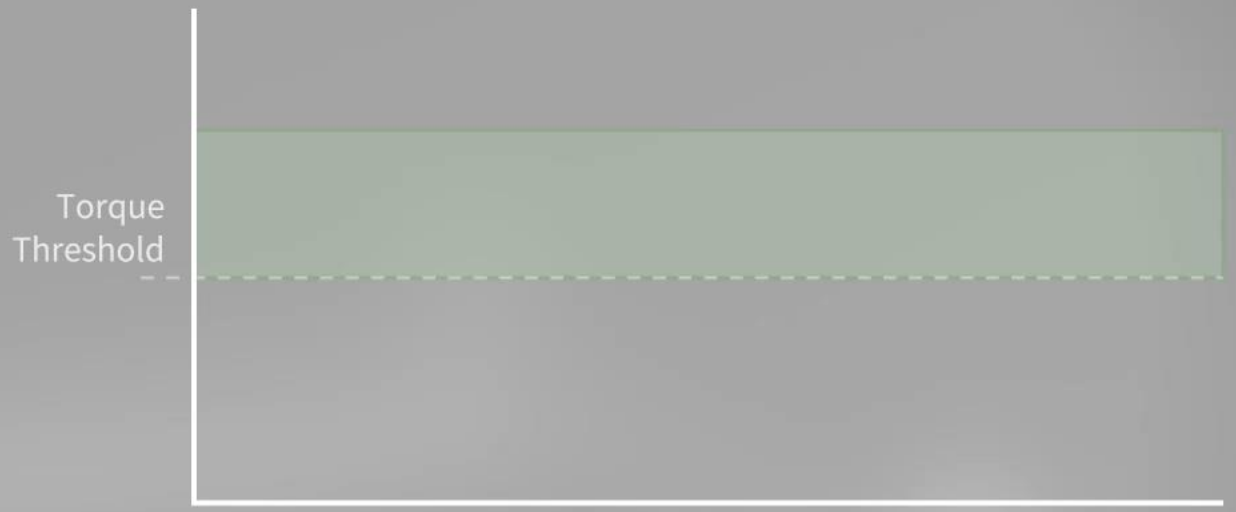
- *Engagement*
- *Rundown*
- *Tightening*



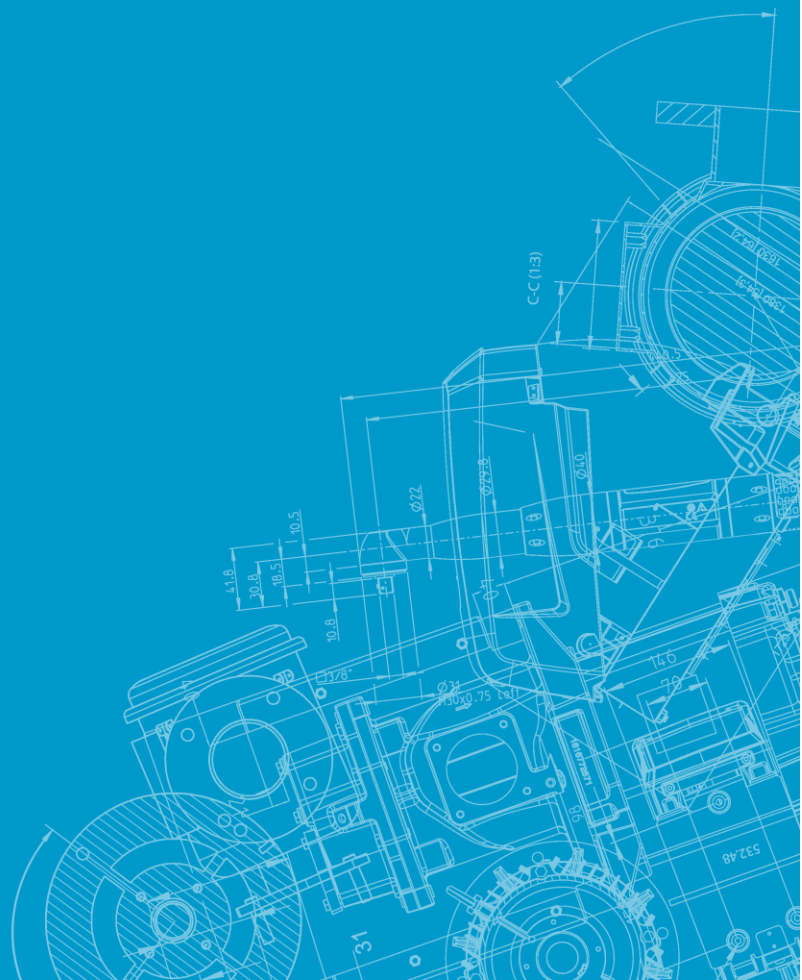
Processo di avvitatura

- *Engagement*
- *Rundown*
- *Tightening*




Torque
Threshold

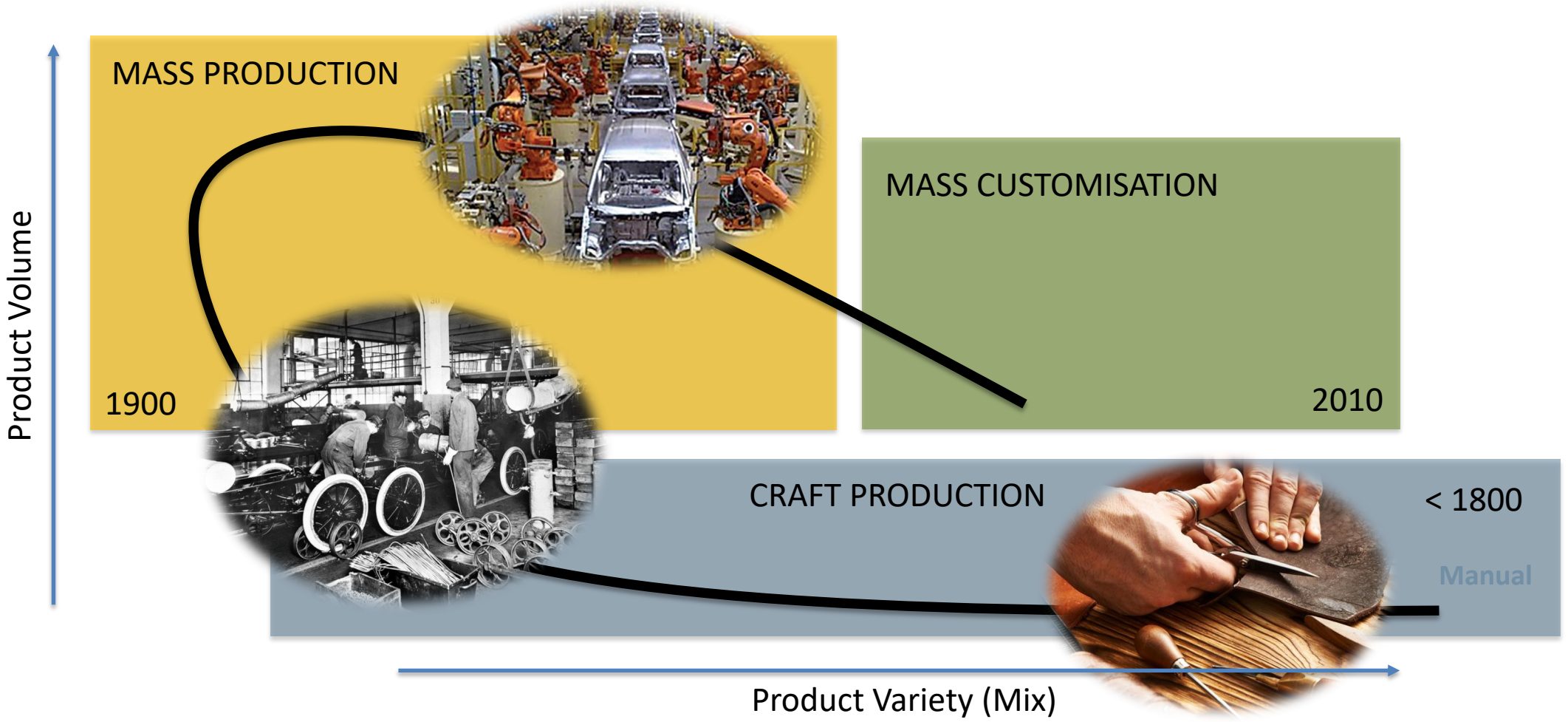
Atlas Copco



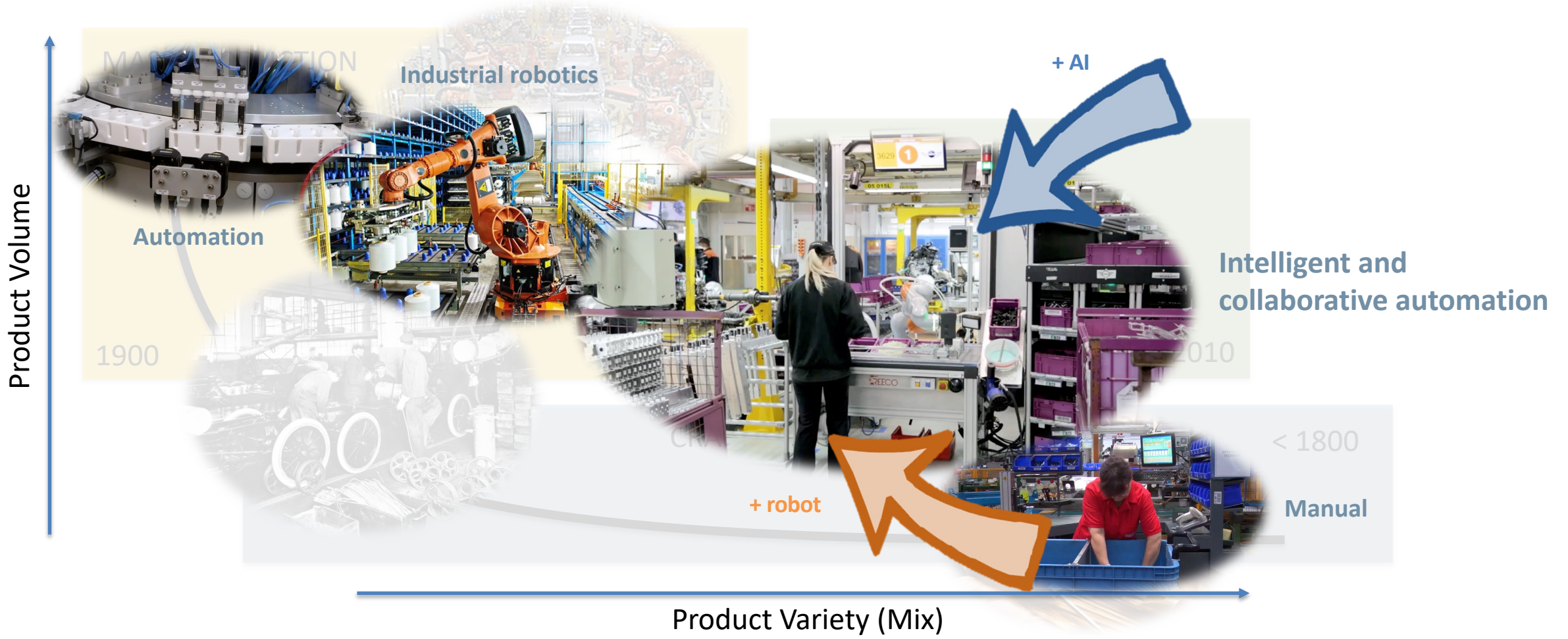
Digital Twin di processo per l'installazione ottimale di automazione collaborativa negli assemblaggi

Prof. Andrea Zanchettin – andreamaria.zanchettin@polimi.it

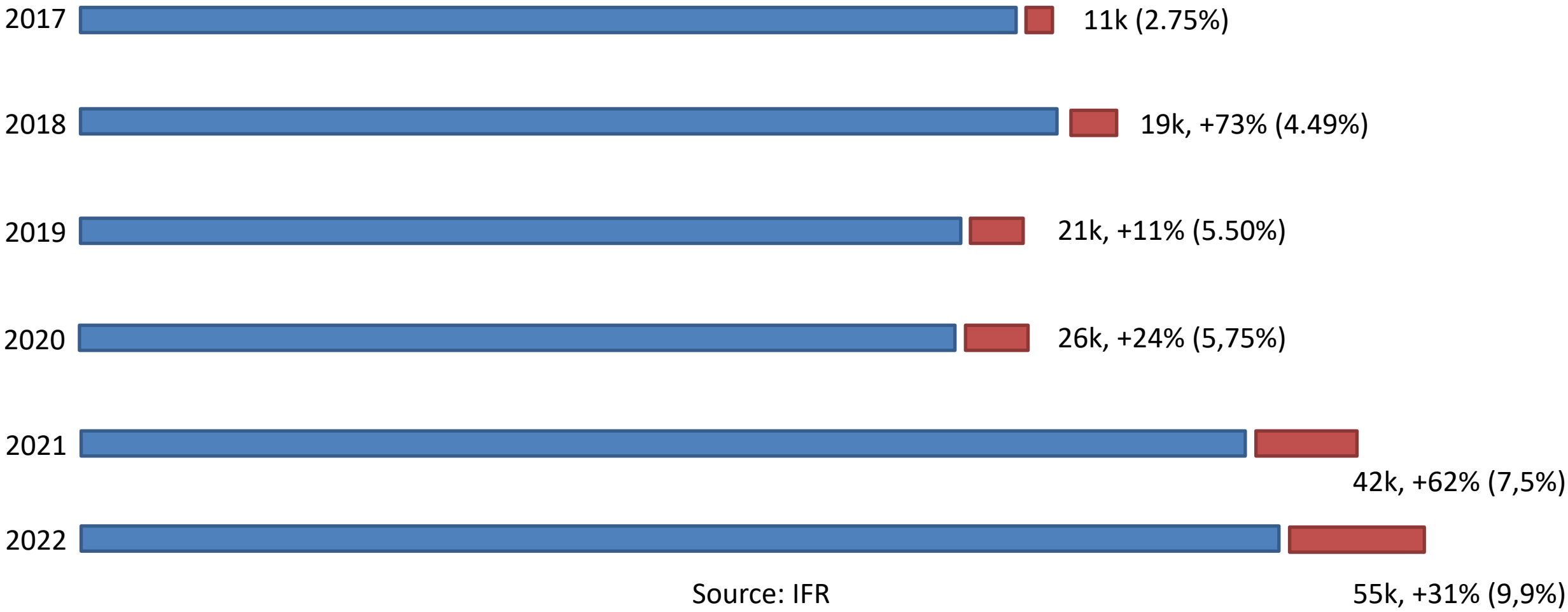
An evolving paradigm



An evolving paradigm

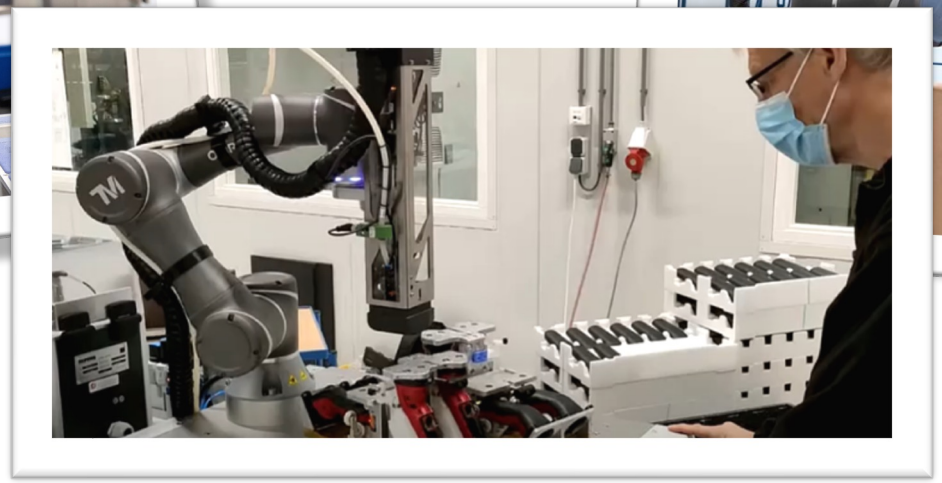


An evolving paradigm



An evolving paradigm

Machine tending

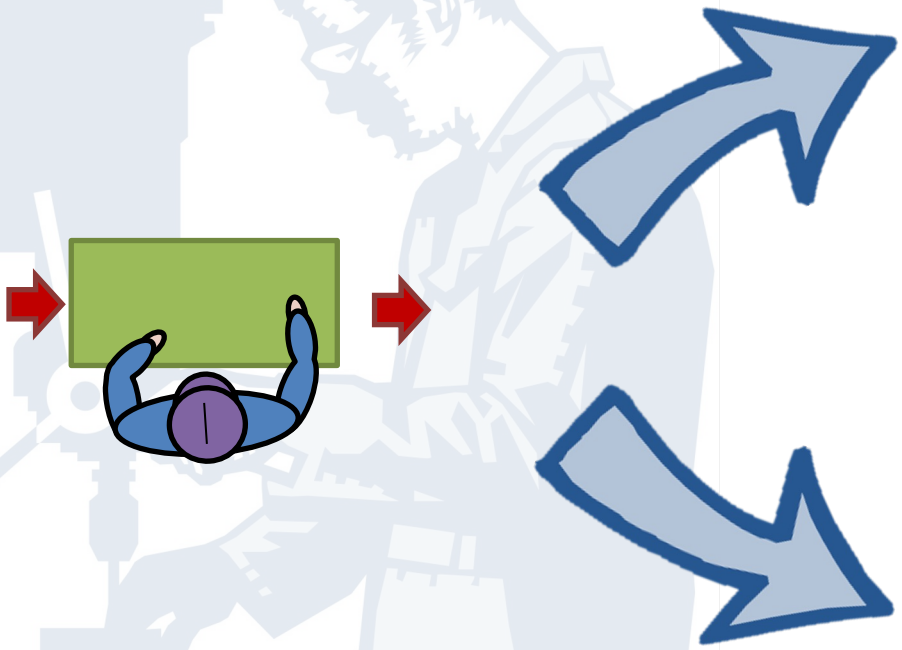


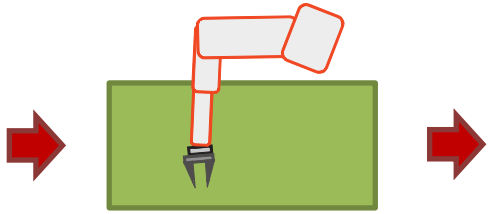
Assembly

Palletizing

https://www.youtube.com/watch?v=HPfLMlv4HEo

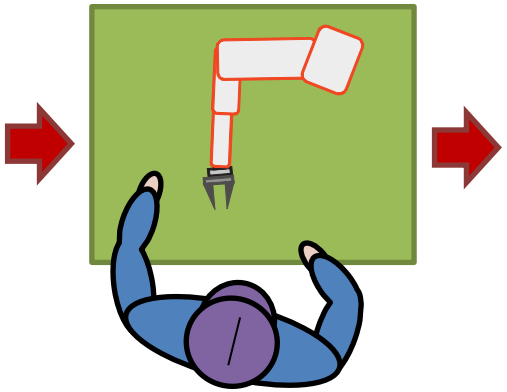
An evolving paradigm





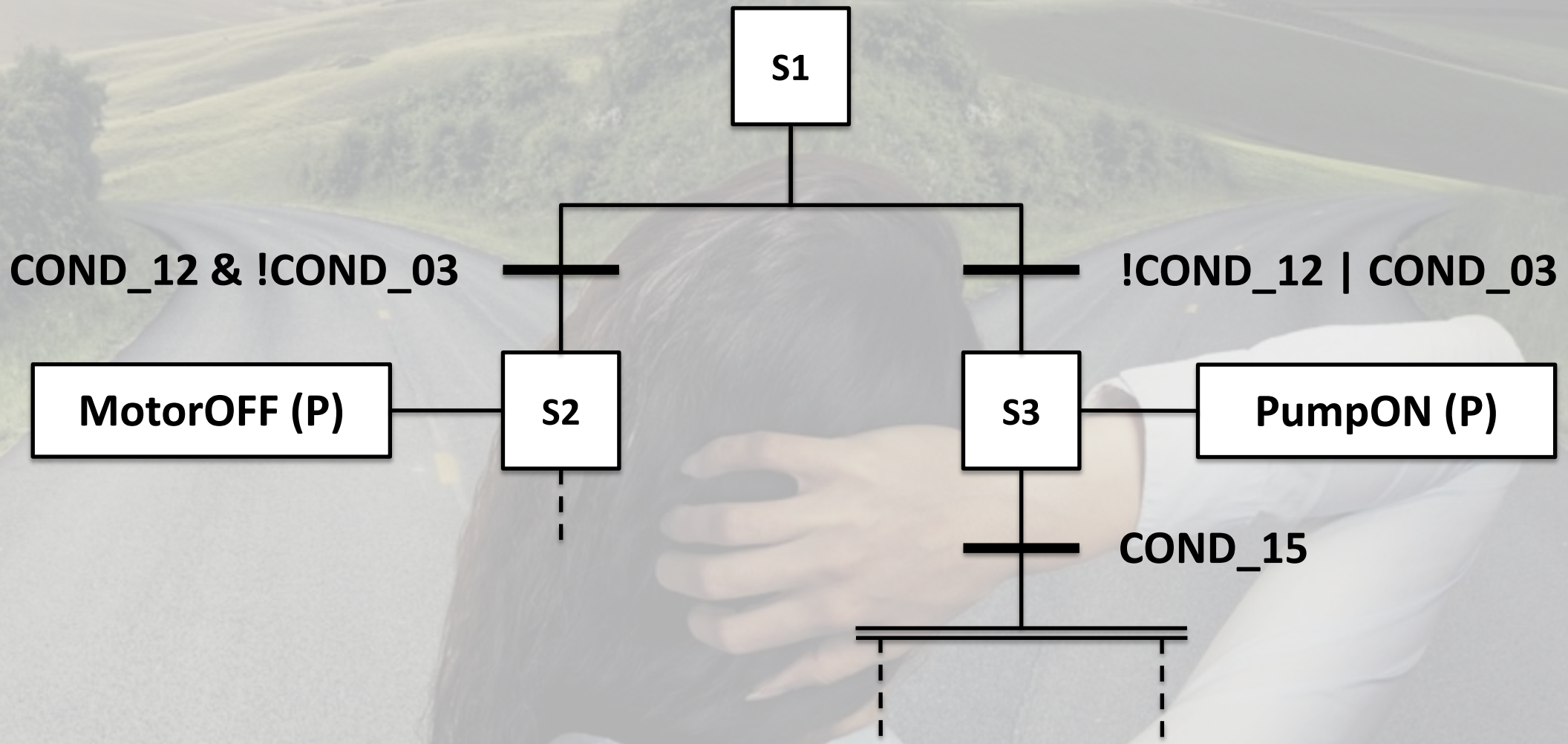
Warning:
Not all tasks can be fully automatized

Low potentiality

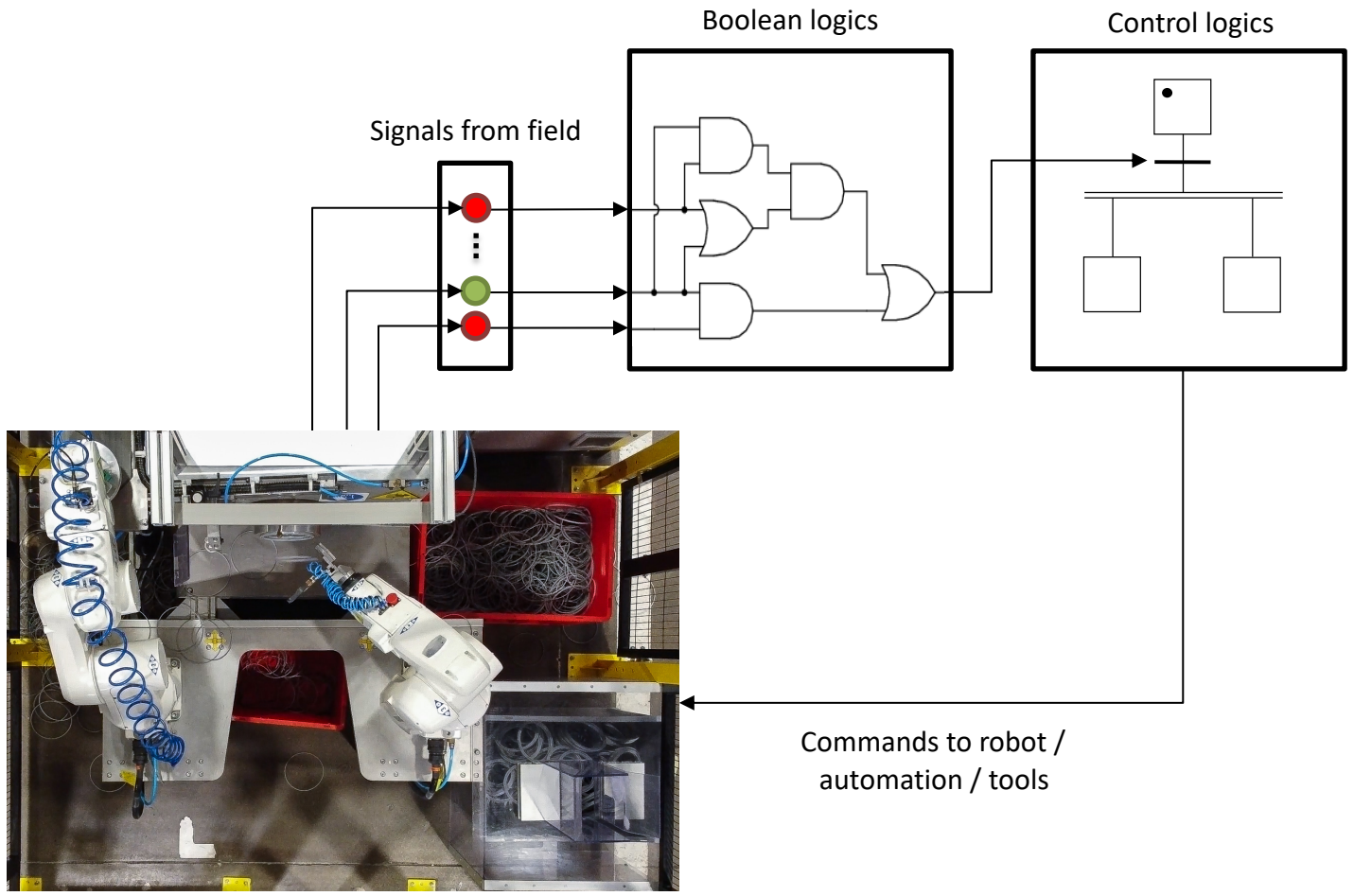


Challenge:
Need for synchronisation

High potentiality


S1
COND_12 & !COND_03
!COND_12 | COND_03
MotorOFF (P)
S2
S3
PumpON (P)
COND_15

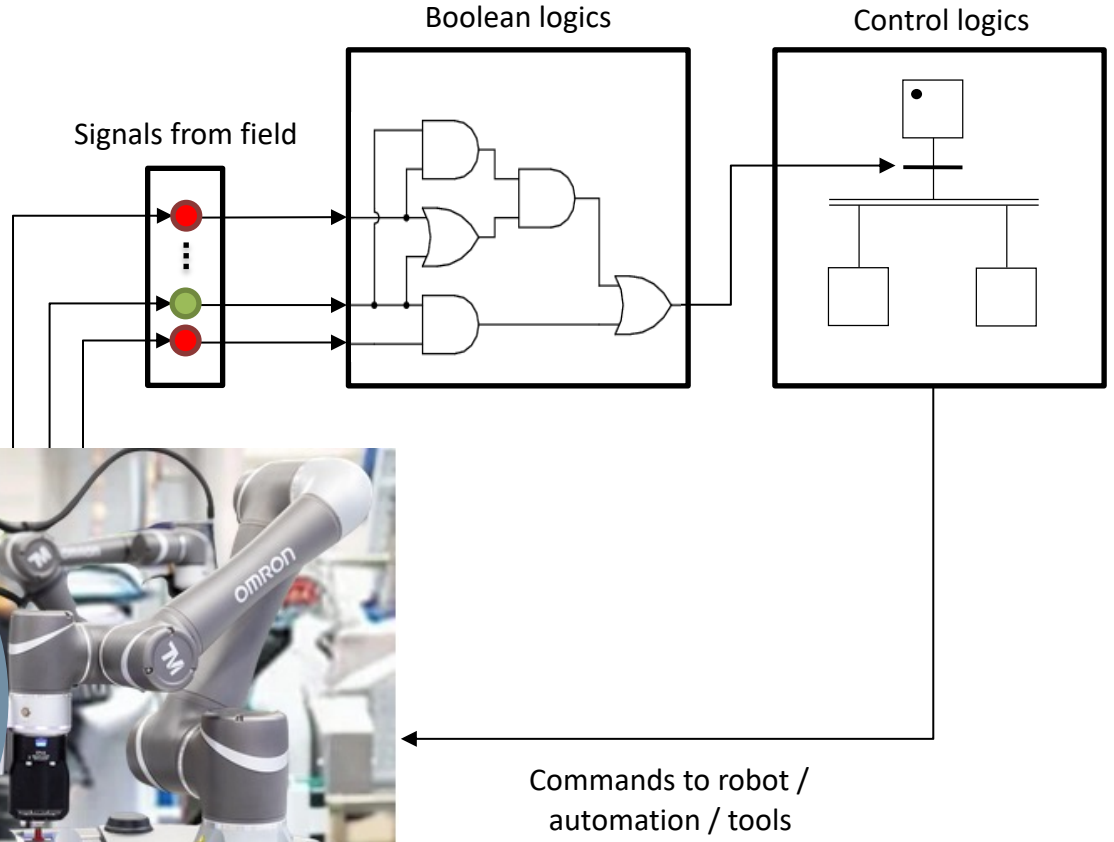
From Industrial Automation to Intelligent Automation



Industrial Automation
PLC-centered

From Industrial Automation to Intelligent Automation

In the production process, but outside the decision/control loop

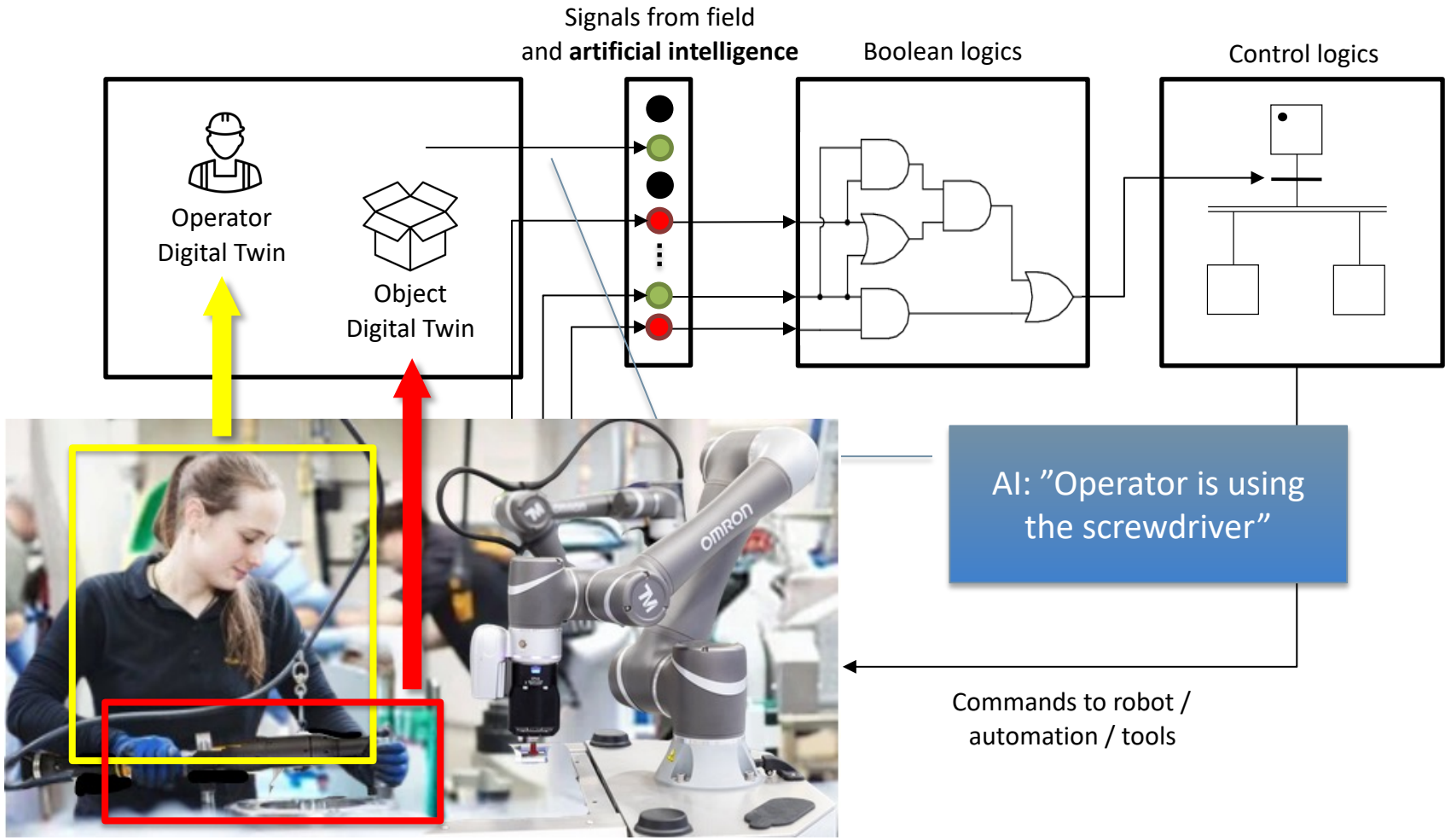


Industrial Automation
PLC-centered

From Industrial Automation to Intelligent Automation

Zanchettin et al., *A Formal Control Architecture for Collaborative Robotics Applications*, ICHMS 2020.

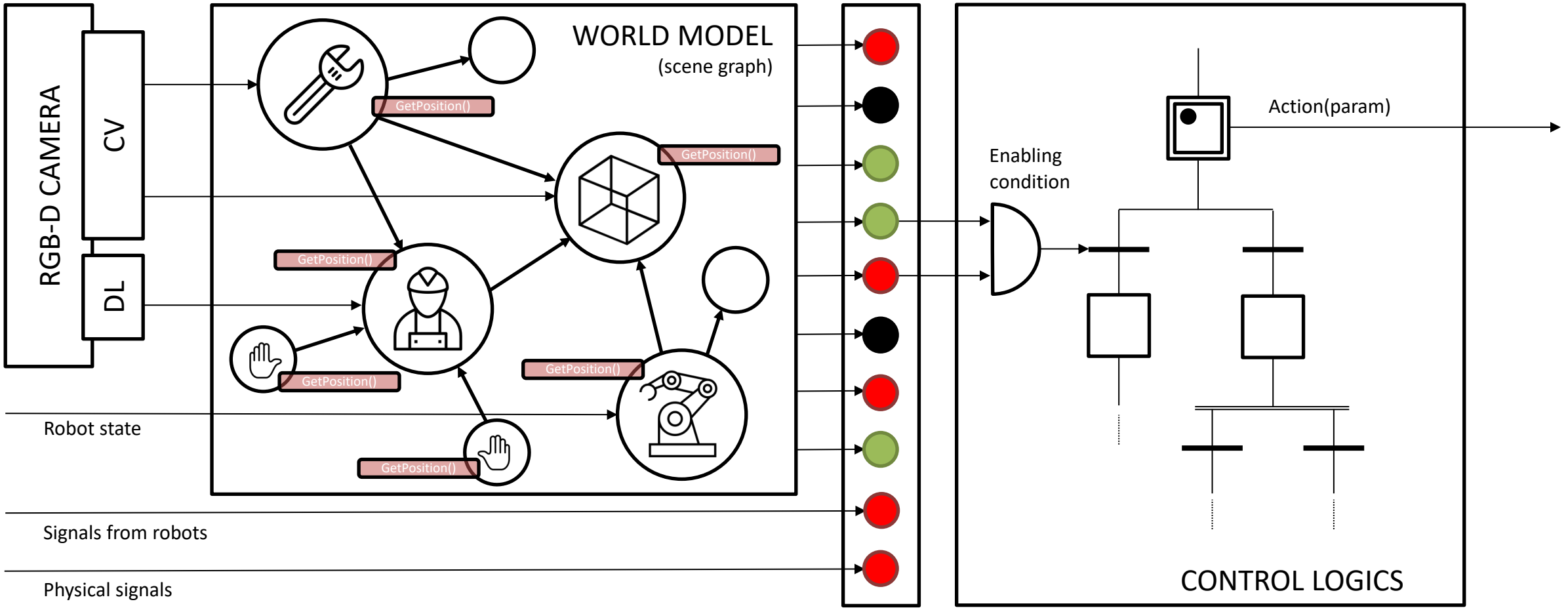
Intelligent Automation
AI-powered



Industrial Automation
PLC-centered

How it works

Zanchettin et al., *A Formal Control Architecture for Collaborative Robotics Applications*, ICHMS 2020.



How it works

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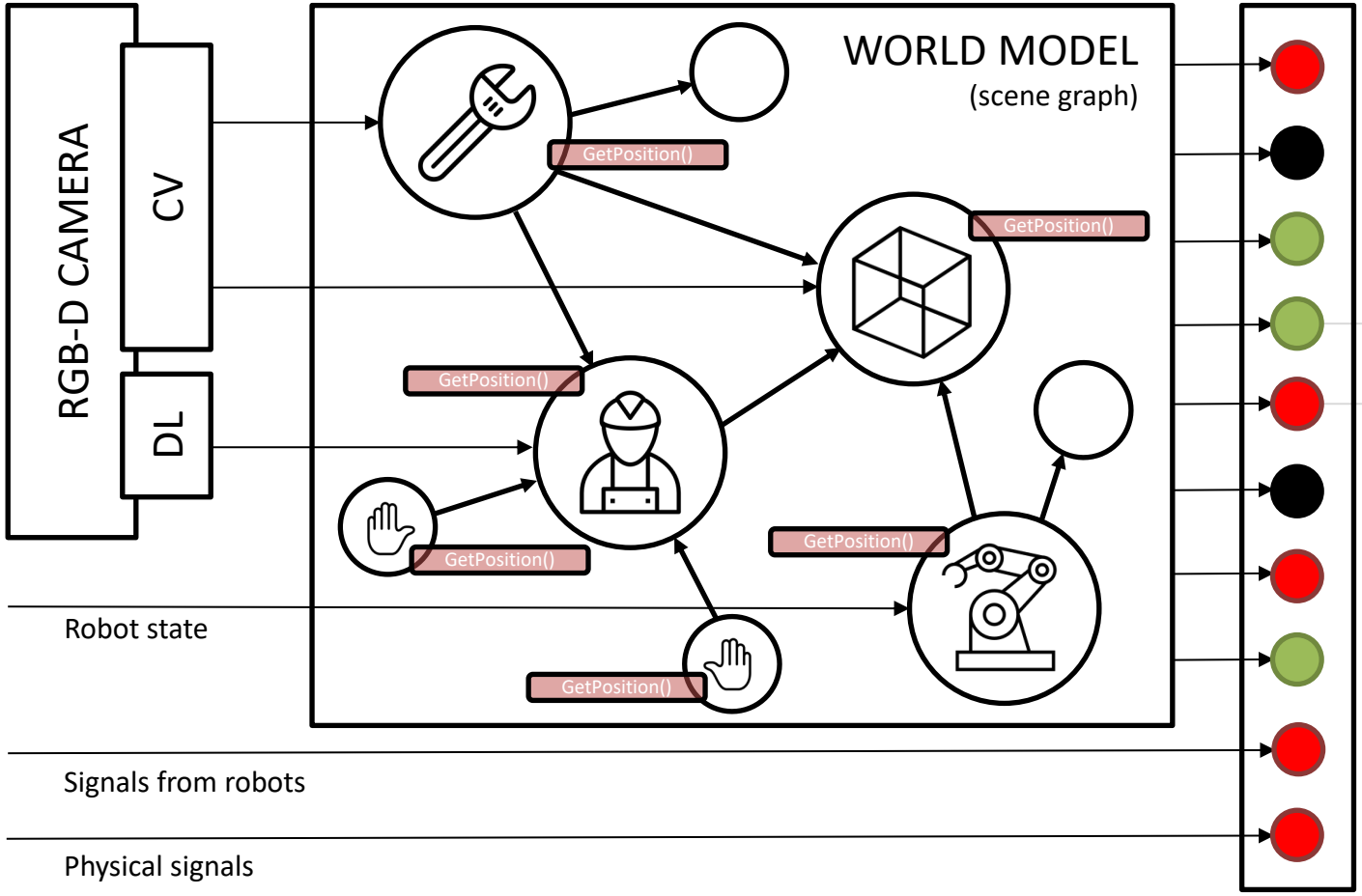


The world model is a dynamical system expressing how the scene graph is changing over time

$$G_{k+1} = f\left(G_k, y_k\right)$$

Its outputs consists in Boolean values

$$b_k^i = g^i\left(G_k\right) \in \{0, 1\}$$

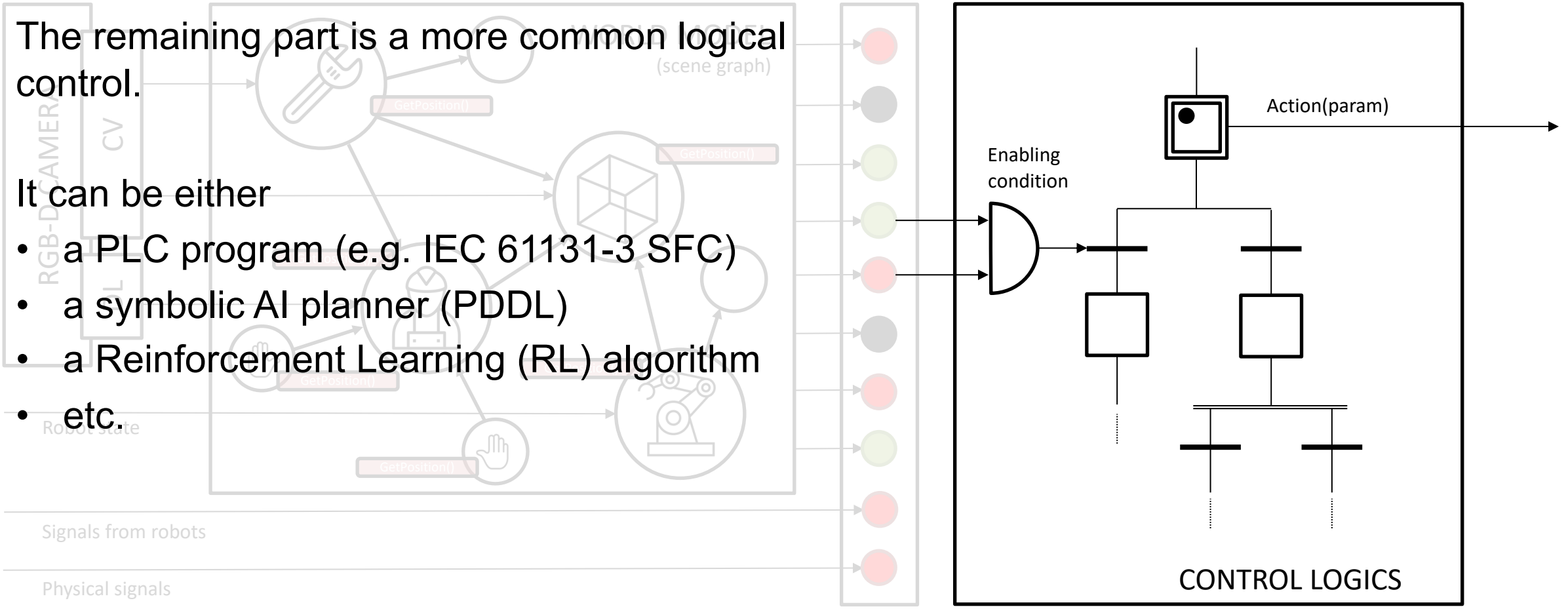
indicating whether or not given conditions hold true.

How it works

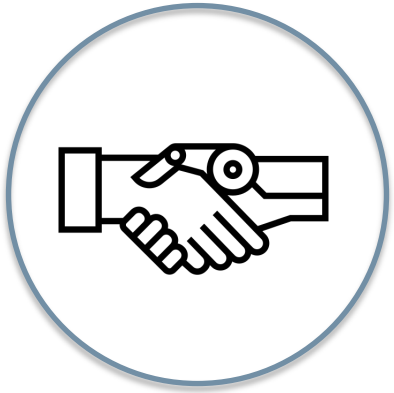
The remaining part is a more common logical control.

It can be either

- a PLC program (e.g. IEC 61131-3 SFC)
- a symbolic AI planner (PDDL)
- a Reinforcement Learning (RL) algorithm
- etc.



Applications and Examples

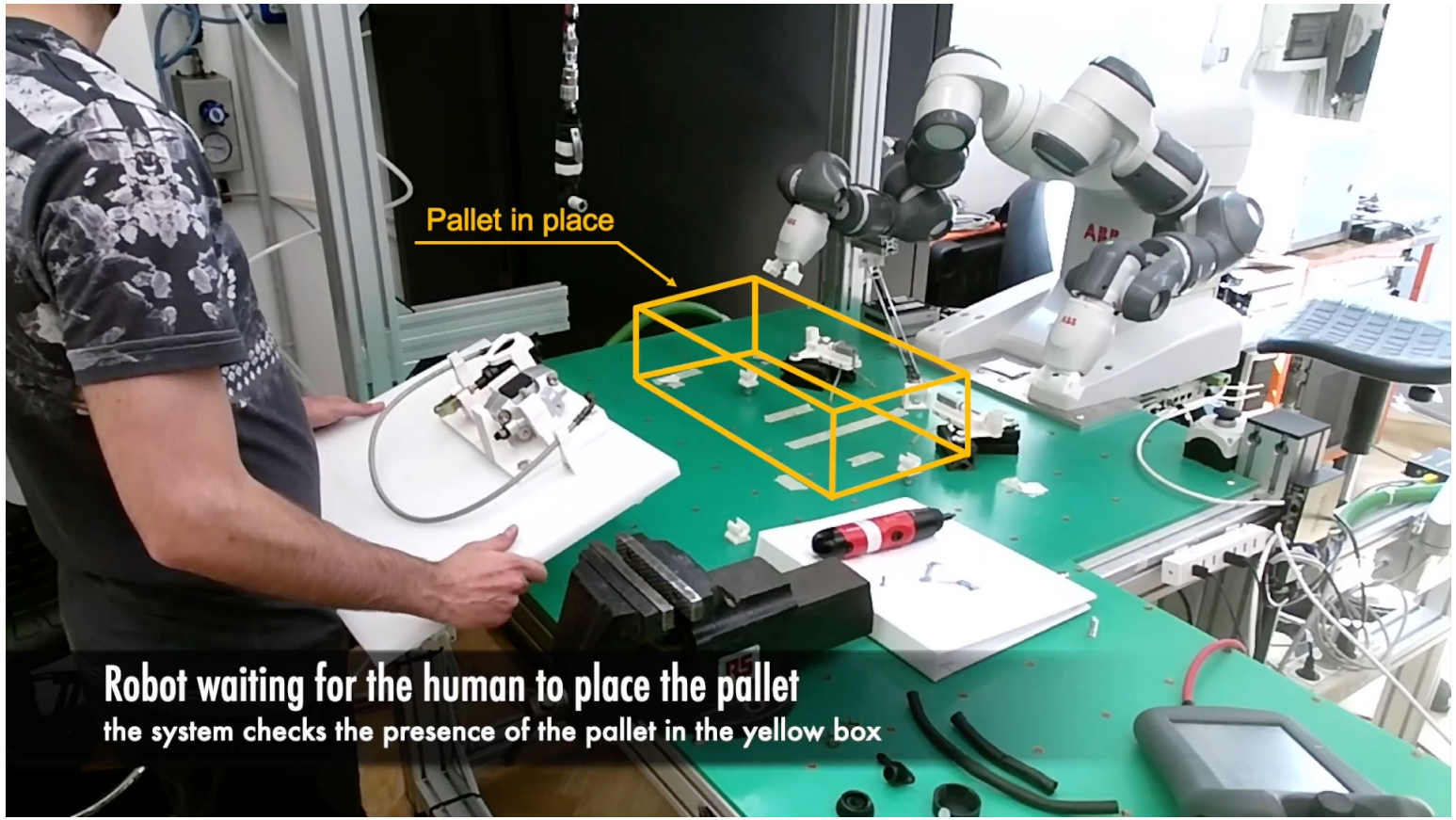


Collaborative Assembly

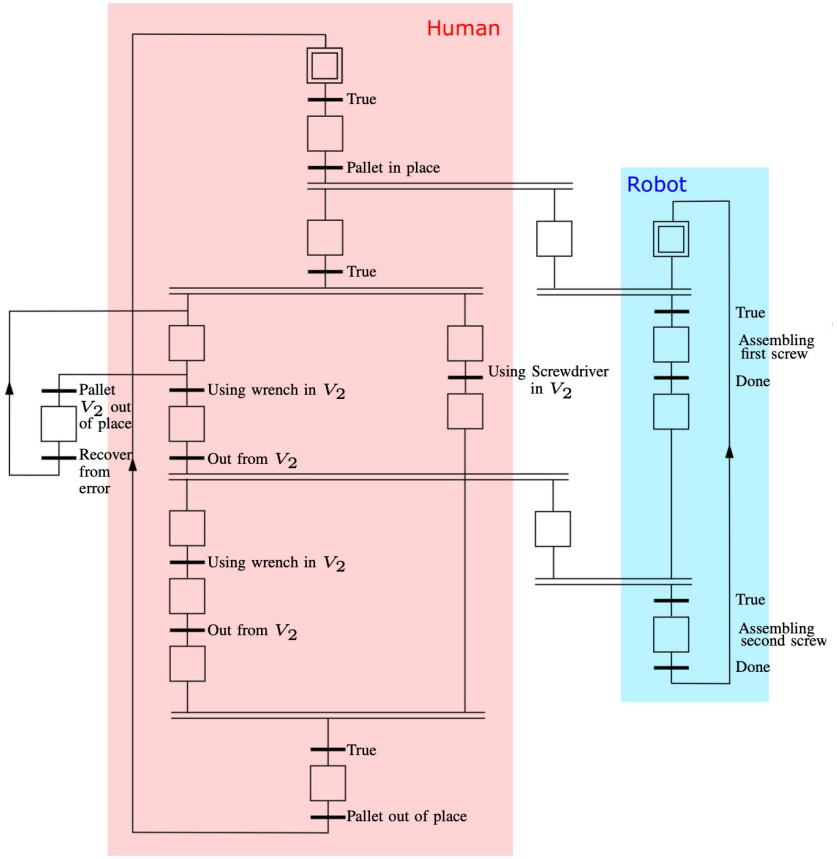
Monitoring and Quality Control

Collaborative assembly with RL

Applications and Examples



https://www.youtube.com/watch?v=g_sZjZCVx0w



Applications and Examples

Collaborative Assembly

Monitoring and Quality Control

Collaborative assembly with RL

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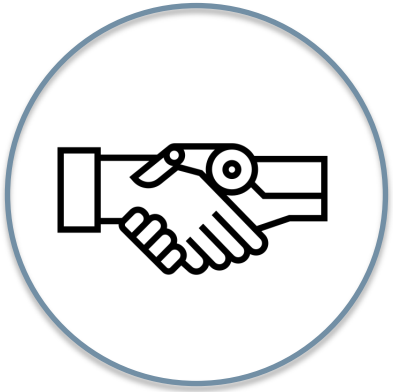
Applications and Examples

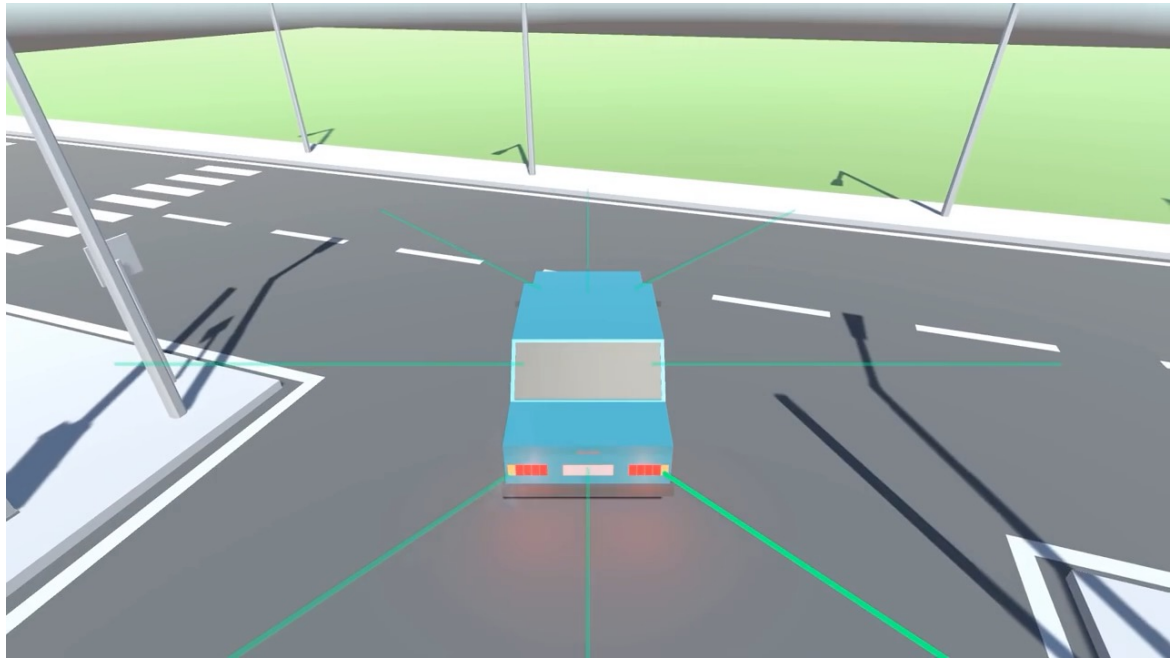
Collaborative Assembly

Monitoring and Quality Control



Collaborative assembly with RL

What is a Digital Twin?



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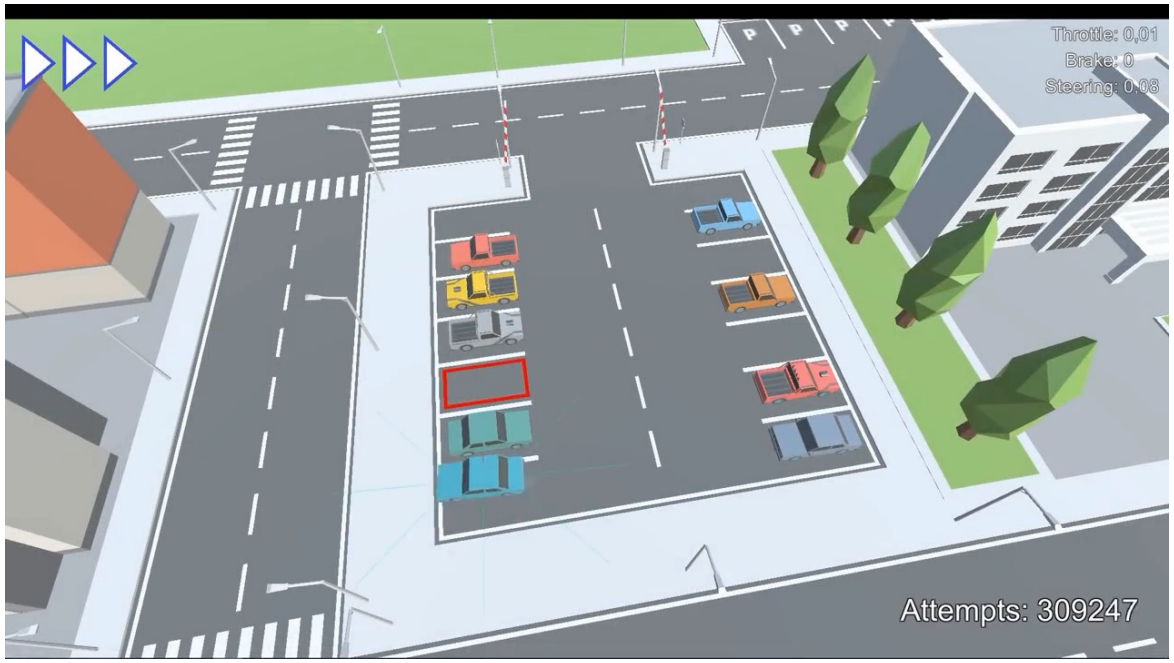
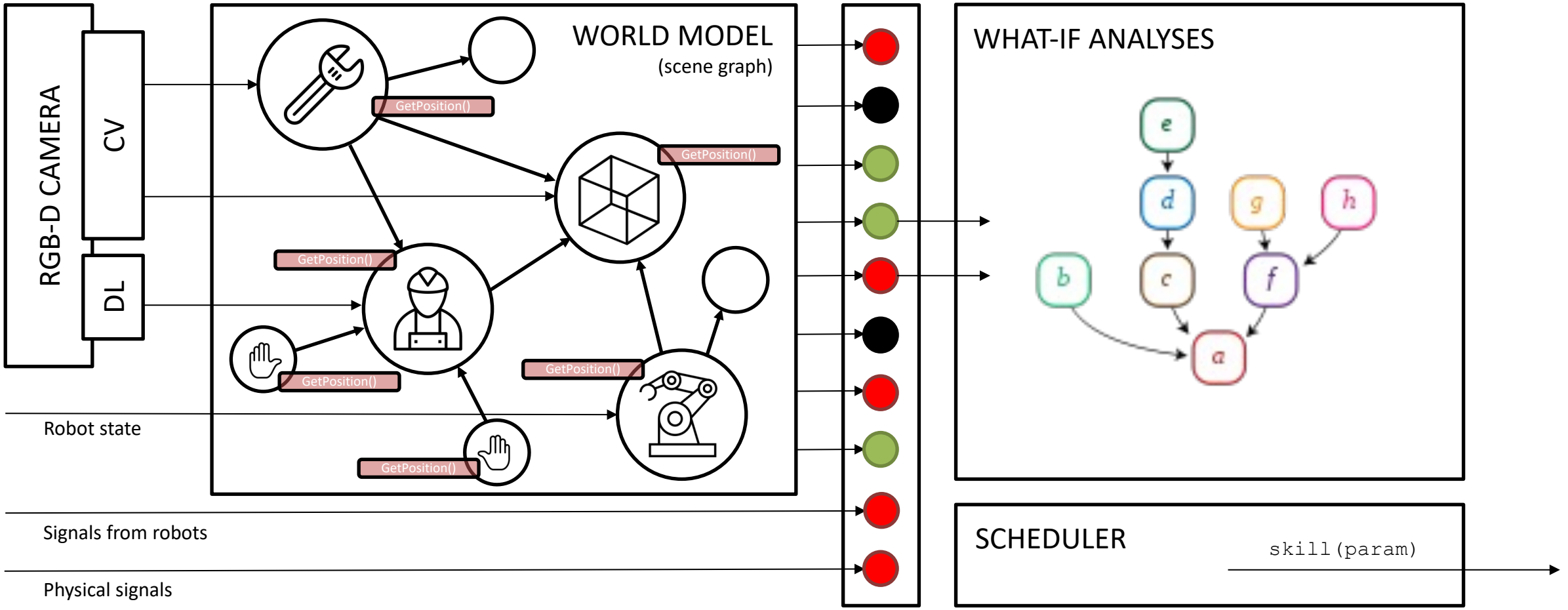
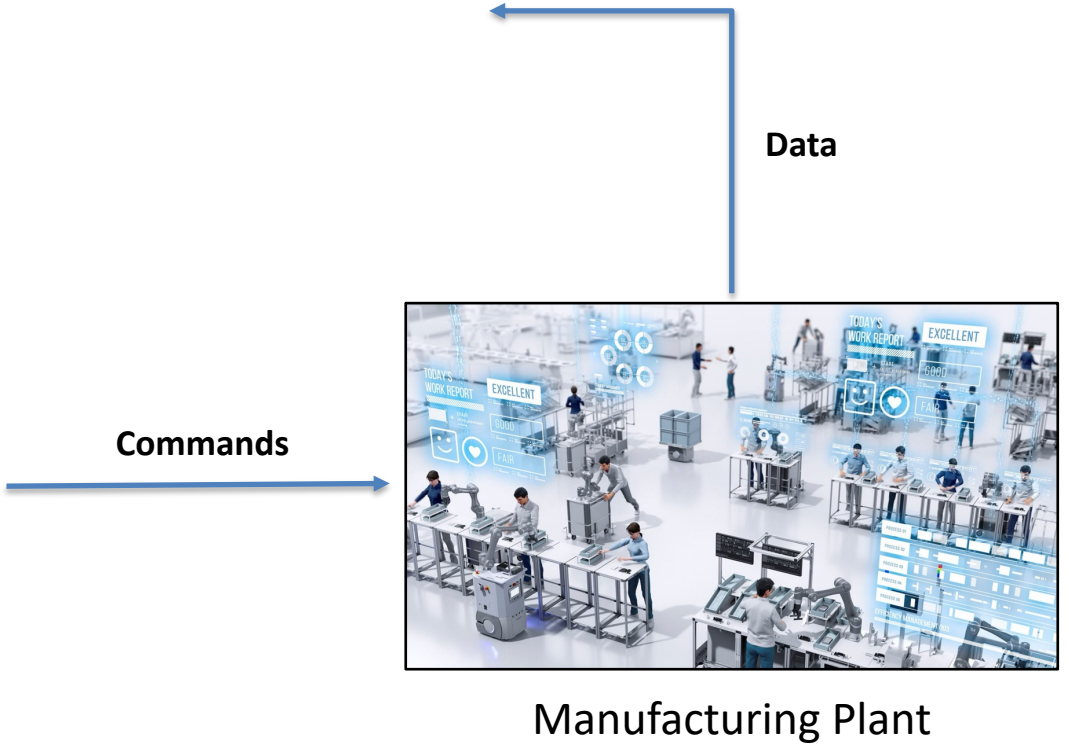


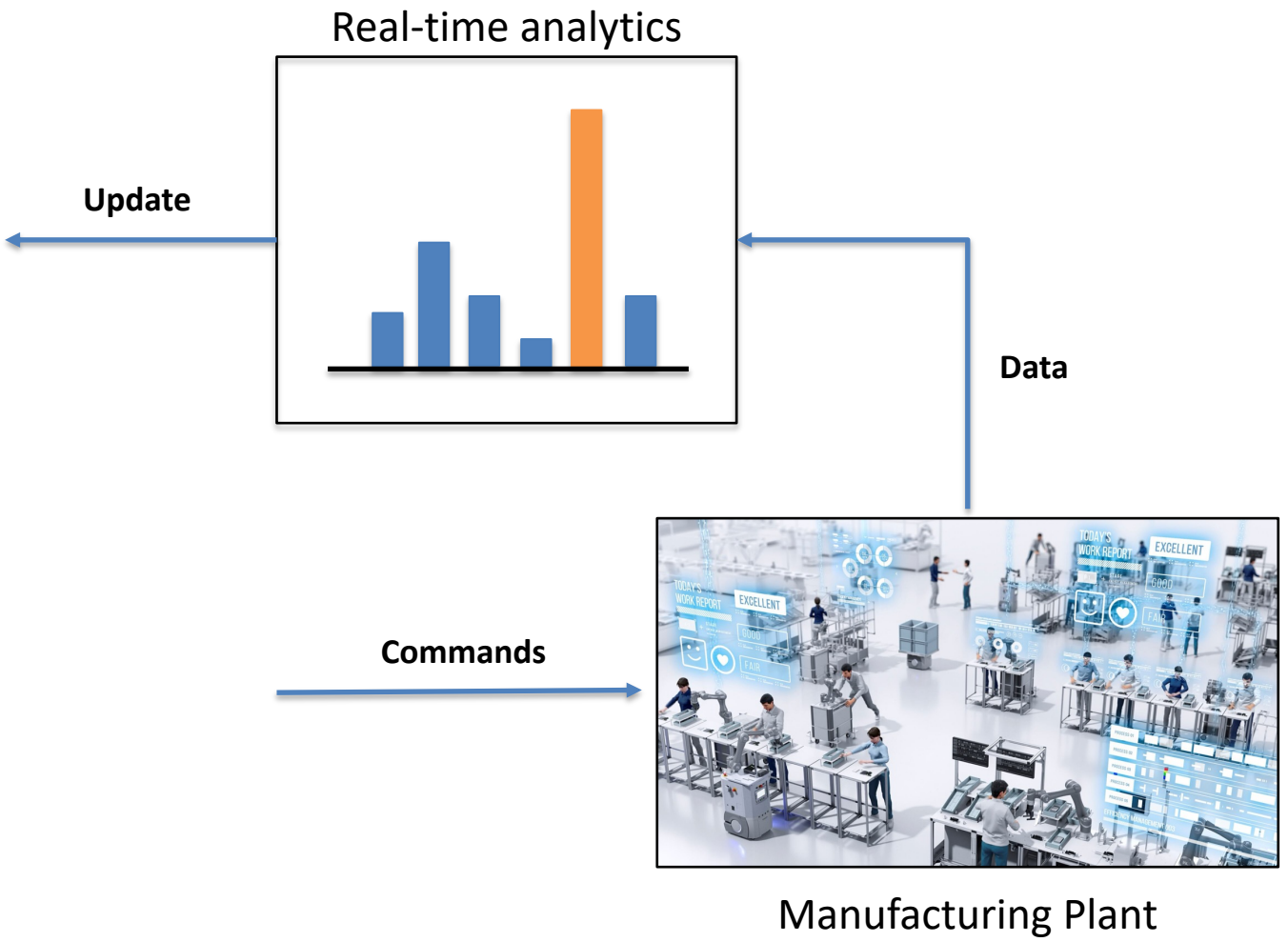
What-if analyses for optimal executions



The Role of Digital Twins

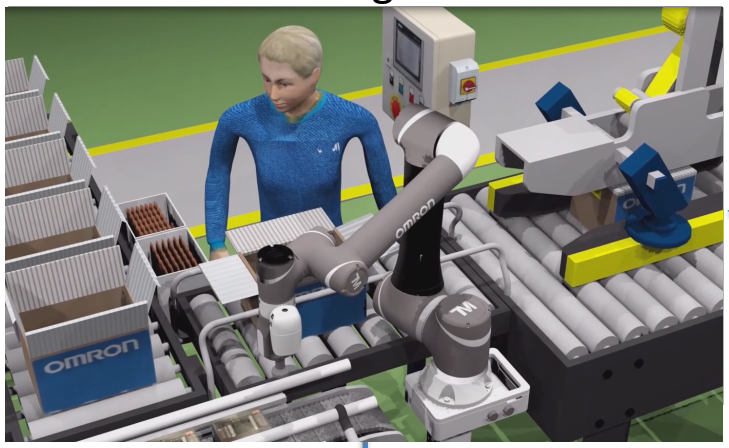


The Role of Digital Twins



The Role of Digital Twins

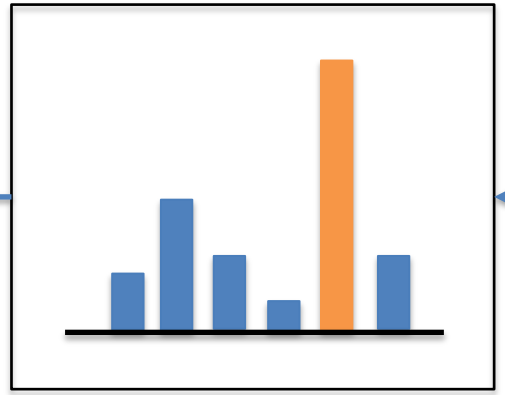
Process Digital Twin



Thousands of simulations

Update

Real-time analytics



Data

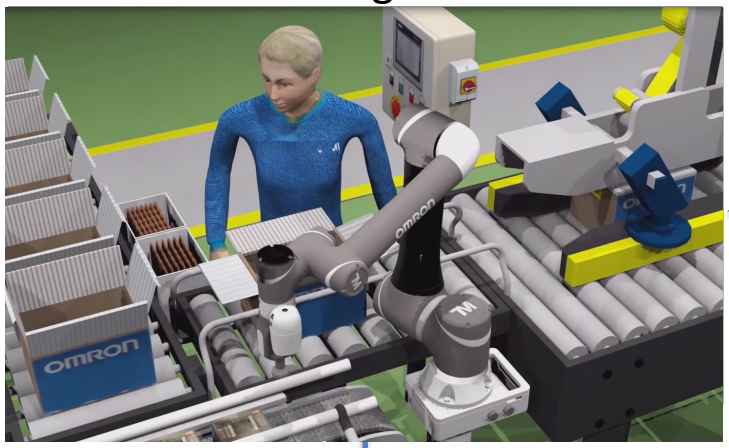
Results

Commands

Manufacturing Plant

The Role of Digital Twins

Process Digital Twin

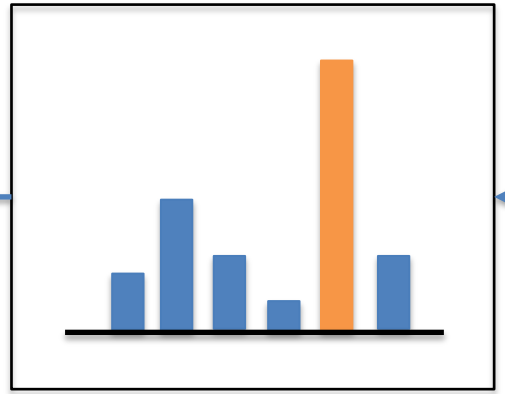


Thousands of simulations

Minimize Expected Squared Production Error

$$\min \mathbb{E}\left\{\int_0^T \boldsymbol{e}(t)^T \boldsymbol{e}(t)\, dt\right\}$$

Real-time analytics



Update

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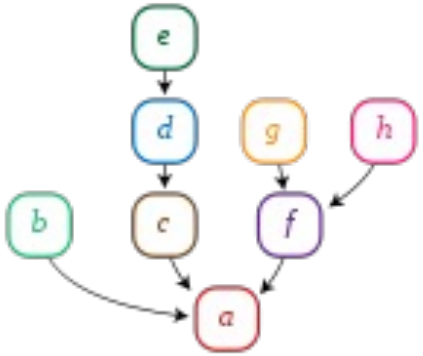
Results



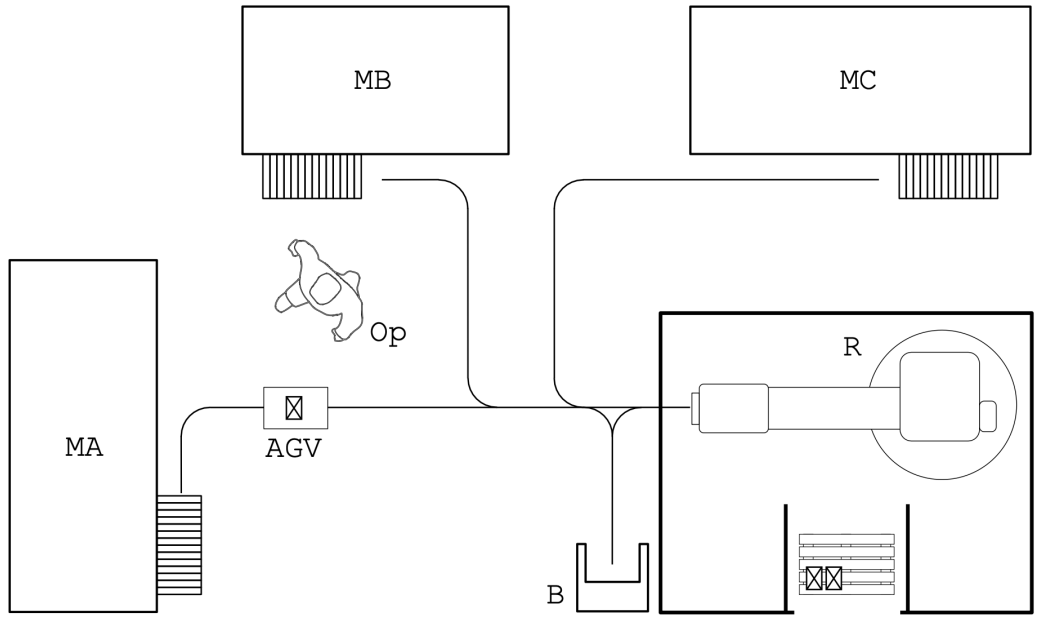
What-if analyses

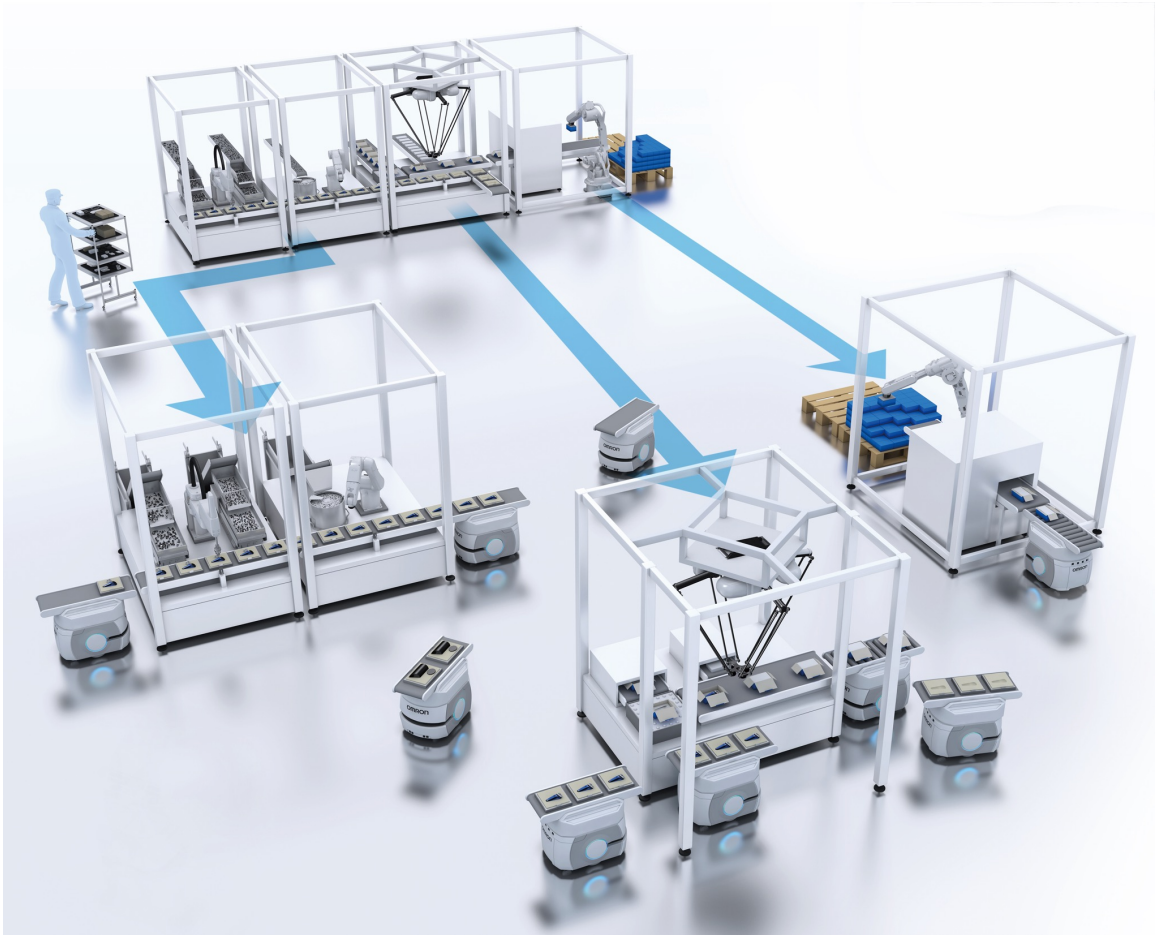
Commands

Manufacturing Plant

A Case Study

Product	Quantity	Arrival time (min)	Deadline (min)
A	12	0	35
B	8	8	30
C	4	10	35
C	7	30	60
B	13	30	60
A	3	35	60





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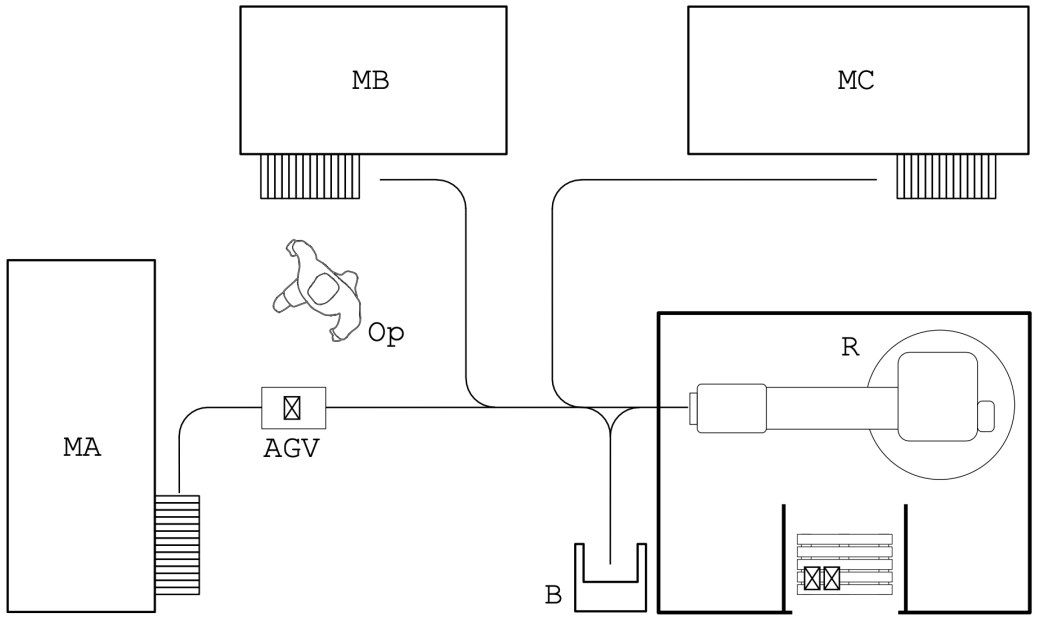
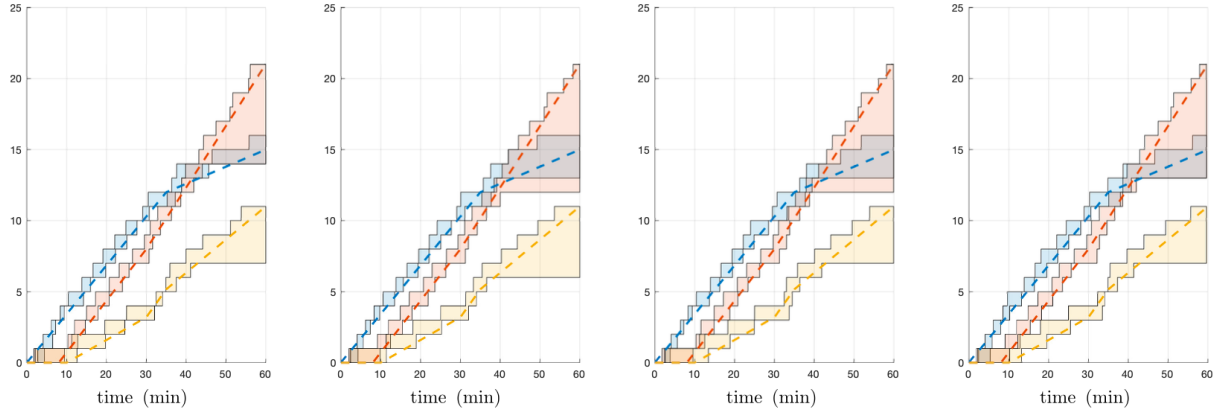
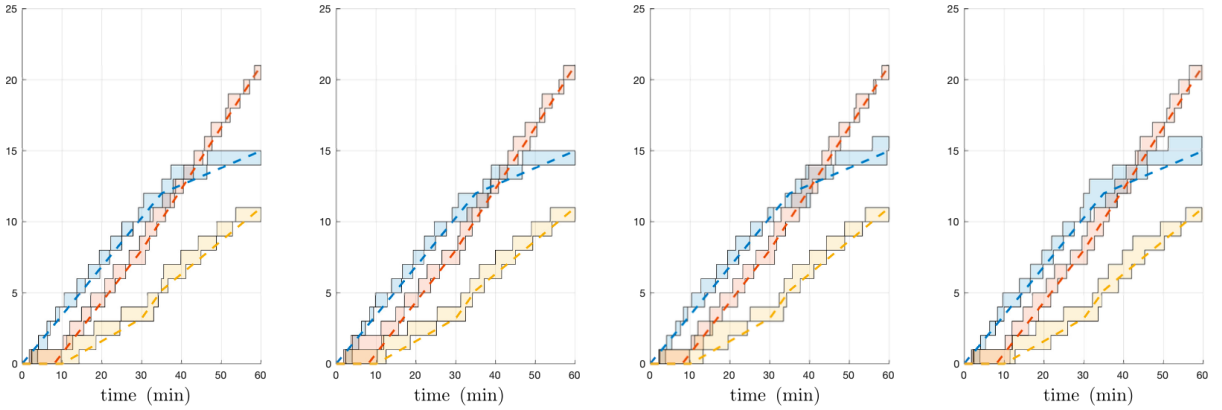
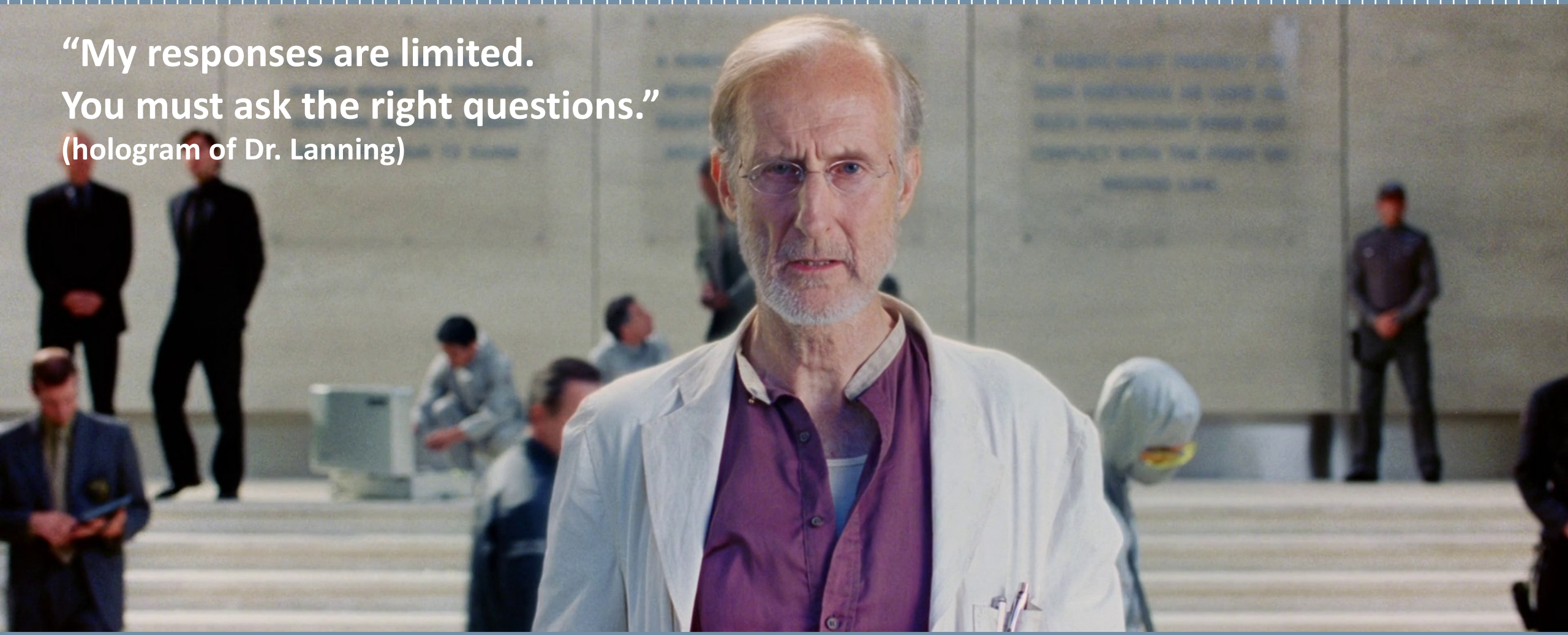


without RL



with RL




“My responses are limited.
You must ask the right questions.”
(hologram of Dr. Lanning)


POLITECNICO
MILANO 1863