Industry 4.0 Driving Innovation

George Thompson / Richard Weston – June 2019

Comau Global

- **Comau specializes in producing advanced industrial automation solutions**

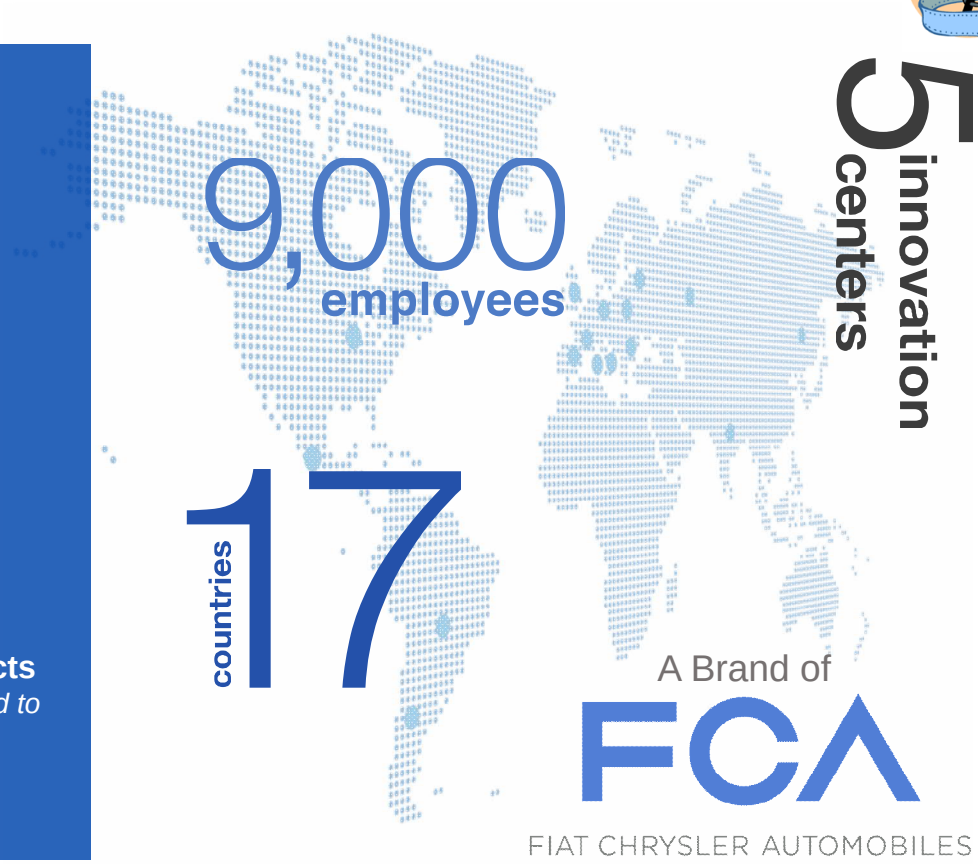
- **Integrate products, technologies and services**

To help companies of all sizes increase efficiency while lowering

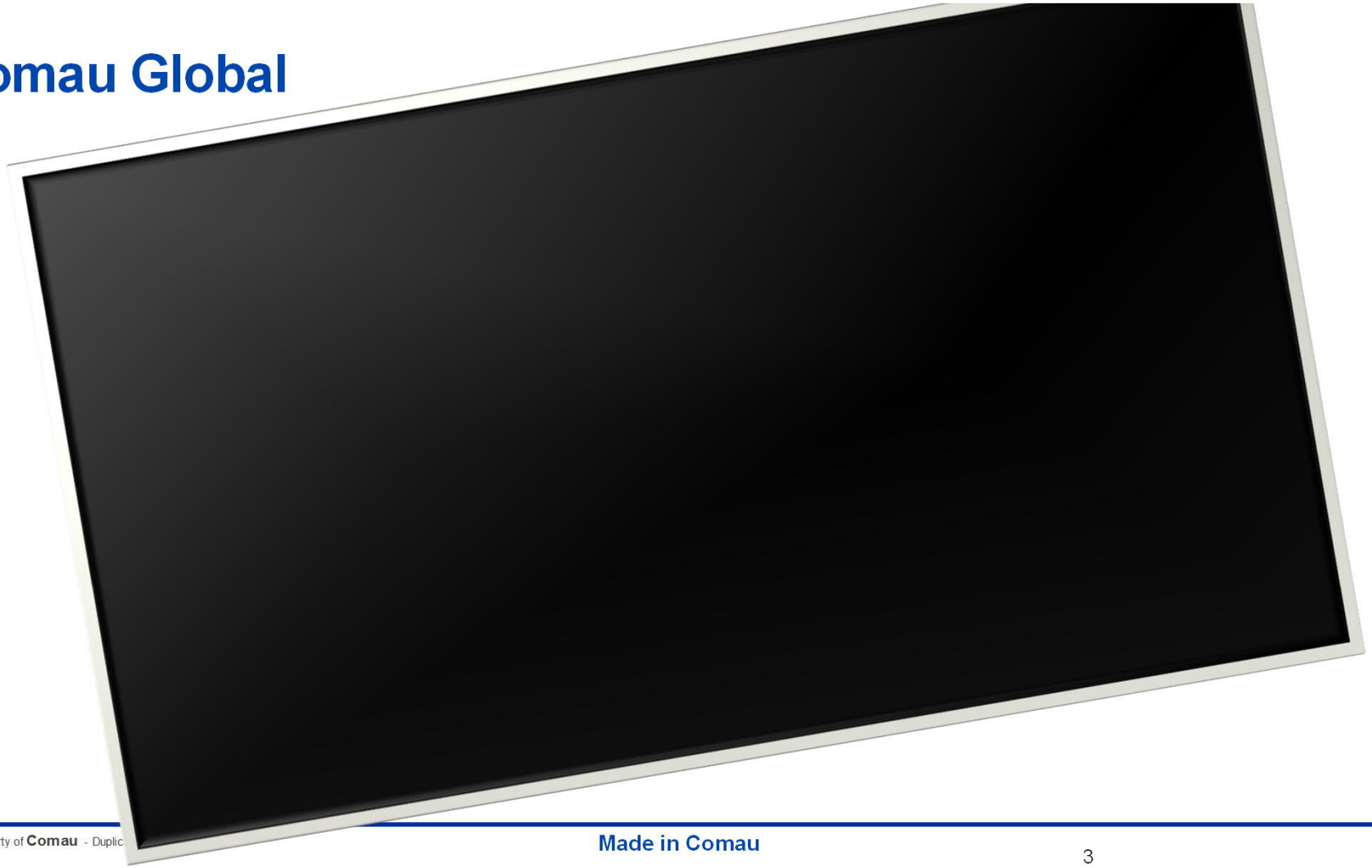
operating costs and optimizing returns.

- **Over 40 years of field-proven experience**
A strong presence within every major industrial country.

- **Modular, flexible and highly configurable products**
is based on open automation principles, and can be tailored to meet the needs of each individual customer.



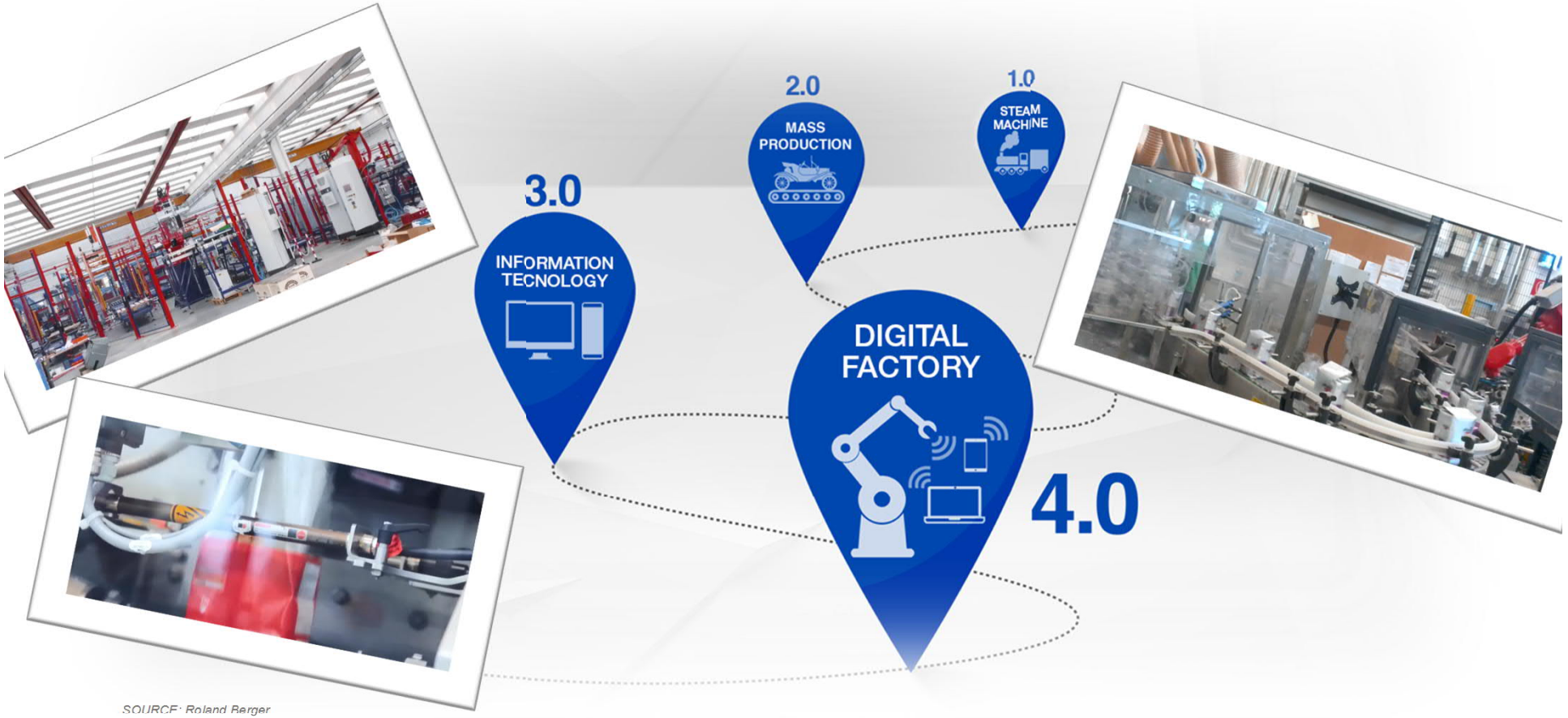
Comau Global



Comau In The World

Made in Comau

The Automation of Production Gains Ground



SOURCE: Roland Berger

Key Automation Trends

INVESTMENT OPTIMIZATION

- Maximize Overall Equipment Effectiveness
- Enhanced Virtual Commissioning
- Minimize Production Cost

AUTOMATION HIGH DENSITY

- Minimize Floor Space per Vehicle
- Maximize Machine Modules Reuse
- Minimize Plant Facility Construction Costs

MATERIAL MANAGEMENT

- Transportation Cost
- Minimize Path per Kitting
- Minimize man hours/kitting
- Minimize Implementation Time and Cost
- Minimize Non-Value Added Activities

INTEGRATED PRODUCT-PROCESS

- Product-Process standard template
- Non-Model Specific Architecture
- Minimize Startup Time
- Advanced Joining Technologies for Dissimilar Materials

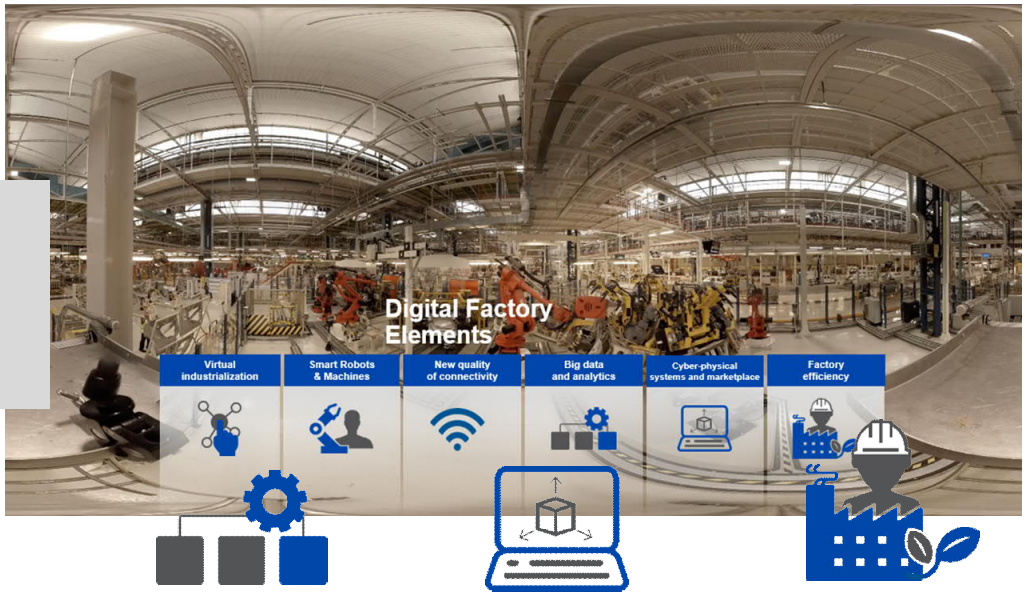
ZERO DEFECTS

- Minimize Scrap and Rework Costs
- Minimize Defect Rates

Digital Factory Elements

Characteristics of the new industrial landscape.

- **Fully Integrated Digital Factory incorporating digital monitoring with all equipment installed by Comau.**
- **Digital readouts can be Lineside, Maintenance Offices or anywhere that requires the outputs**



Virtual industrialization	Smart Robots & Machines	New quality of connectivity	Big data and analytics	Cyber-physical systems and marketplace	Factory efficiency
Virtual plants and products to prepare physical production via simulation, verification and physical mapping	Multipurpose «intelligent» robots able to adapt, communicate, and interact with each other and with humans based on remote control	Connection of digital and real worlds with constant exchange of information between machines, work pieces, systems and human beings	New methods to handle huge amounts of data and tap into the potential of cloud computing	IT systems built around machines, storage systems and supplies linked up as CPS	Preventive and predictive maintenance; energy efficiency; decentralization and remotization; process reengineering

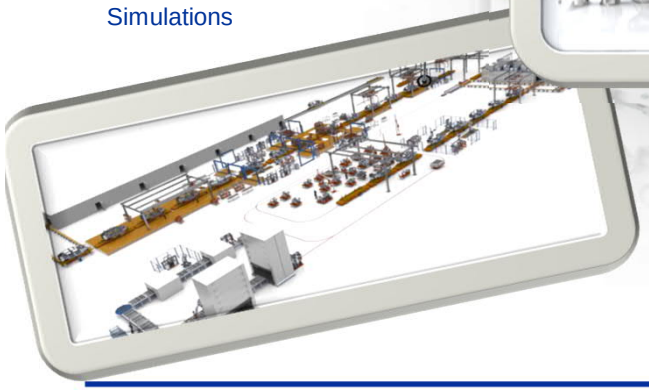
V.R. & V.C

- **V.R. Suite**
- **Virtual Commissioning Suite**
- **Oculus Rift 360 Virtual & Augmented Reality.**
- **Process Simulations**
- **Process Training**

Virtual Commisioning

Virtual Reality

Process Simulations



- **Core experience in Engineering & Automation**
- **Transferable technologies from other Industries**
- **Cherry-Pick ideas from *'Best Practice'* solutions**
- **'Fresh-Eyes approach to the deliverables**

Welding Machine

A differentiating dimension in joining performance

What

- Integrated welding machine incorporating patented Hollow Wrist robot and Compact Gun
- Configurable to incorporate other process technologies, e.g. roller hemming, laser applications
- Exceptional technical performance and reliability

Why

- Improved system efficiency and performance
- Consistent innovation for all industrial applications (one family of compatible products)
- User-friendly

Saving

- Capital investment savings (it is the only integrated solution on the market)
- Reduction in inventory
- Reduced space and energy consumption

DIWO: Digital Workplaces

EASY TO USE SOLUTIONS

Why

- Current practice is based on corrective maintenance, which leads to unpredictable downtime
- Process and product information are not fully correlated
- Process capability and bottleneck analysis are difficult to perform, due to the huge amount of unstructured data

What

- Remote collection of operational and quality data from equipment's, analysis and correlation of data with service operations to predict future malfunctions and process drift.
- Cognitive systems able to improve efficiency and throughput, using the available information

Value proposition

- Improved efficiency of existing and new systems
- Direct saving on impacted maintenance cost
- Reduction of breakdowns of equipment's operations resulting in optimization of Overall Equipment Effectiveness

Monitoring Activities

EASY TO USE SOLUTIONS

Why

- Avoid any unnecessary activities, even when planned according to current scheduling
- Plan in advance and in detail for any intervention, ensuring availability of spare parts, facilities, tools and trained resources

What

- Prevent breakdowns while equipment's are in operations
- Prevent extended maintenance downtime due to unforeseen activities

Value proposition

- Direct saving on impacted maintenance cost
- Reduction of breakdowns of equipment's operations resulting in optimization of Overall Equipment Effectiveness

Wearable and Mobile Technologies

EASY TO USE SOLUTIONS

Why

- Today factory floor fixed HMI have a low flexibility and mobility

What

- Applications to support assembly and maintenance operators with consumer smartwatch/smartphone/tablet devices and intuitive gesture-voice-based input to perform their daily activities

Value proposition

- Continuous advancements in human machine interface (HMI) technology are driving huge gains in productivity and usability
- Smartwatch gives operators more flexibility when executing and certified assembly task
- Tablet gives maintenance team fast assistance when repairs machines

SMU Sensorized Memory Unit (Monitoring)

EASY TO USE SOLUTIONS

Why

- In many cases the equipment are not able to provide specific information to evaluate their condition avoid failures
- Recognize machine component misalignment, defective bearing, bent need signal analysis (es. vibration, torque,..) properly done
- Control loops on industrial robots are closed through position sensors which are positioned on the motors and there is no feed back from the physical mechanical components

What

- Integrated sensor solutions that combine hardware with data analytics and transmission in an easy to setup and use application for predictive maintenance
- Solid state inertial platform to collect acceleration data from the last joint of the robot

Value proposition

- Easy sensorization of existing equipment
- Reduce sensors setup time and cost
- Reduce bandwidth usage for data transmission
- Robot performance closed loop optimization

New Generation Robot Software

EASY TO USE SOLUTIONS

Why

- Nowadays robots are programmed by using classical automation industry paradigm, making the experience effective only for high experience users
- Actual robot controllers are developed as rigid embedded system closed to interoperability, making system integration tricky

What

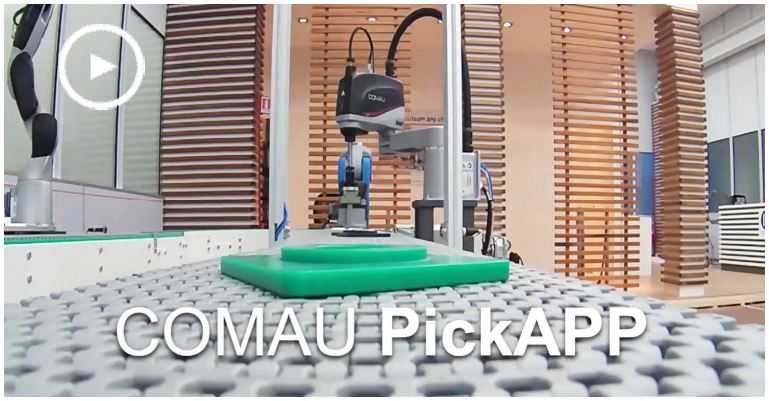
- BYOD (bring your own device) approach to leverage everyday life experience in making robot usage an easy and effective experience for every kind of user.
- Standard, open, high performance protocols-frameworks-APIs (ROS, OPC UA, DDS, TSN,) to enable connectivity, interoperability and external devices easy integration
- Software architecture develop according to modularity and virtualization concepts

Value proposition

- Reduce programming time and programming learning curve, especially for unexperienced users
- Easy and flexible system expansion/integration by use of standard, off-the-shelf devices
- Controller core functions (trajectory planning, motion, dynamic models) can be accessed as a service (SAAS).

PickAPP

Intuitive interface for robot programming

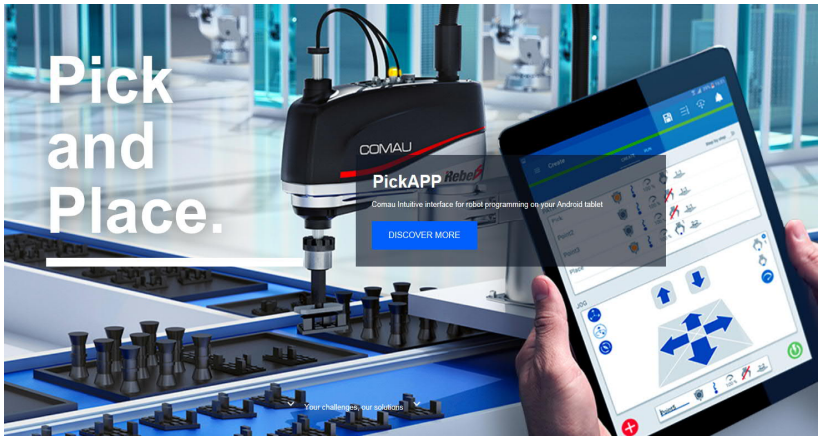


Android application to perform “pick & place” operations in a completely new way, based on an “**ease of use**” philosophy.

1. Download the APP on www.comau.com
2. Install and run the application on a consumer **Android tablet**
3. Control a robot with a **wireless** device though a plant wi-fi or dedicated access point
4. Use the same tablet to control **multiple** robots one at the time (or vice versa) as alternative to the physical Teach Pendant
5. Move the robot in programming mode (movement joint by joint or Cartesian)
6. Movement options: cycle commands (e.g. START, HOLD, robot speed), IO read and write.
7. Create a pick and place program without writing any line of code.

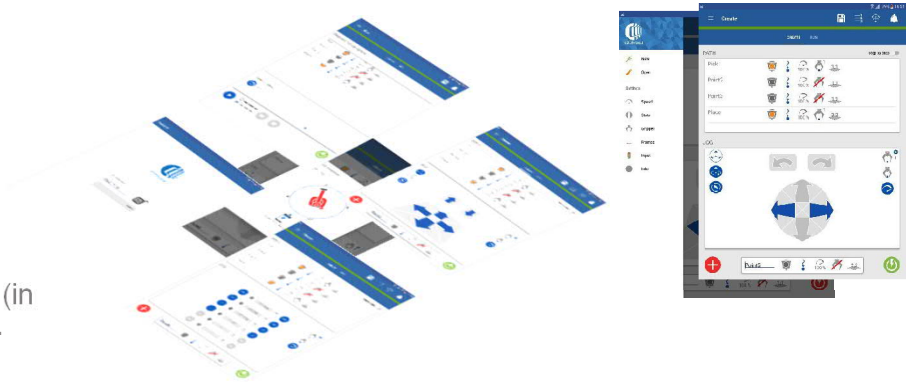
The App is available in **Italian and English**
Configure a **vision camera** system (in future releases).
Configure a **conveyor** tracking system (in future releases).

PickAPP



- Racer3-5 can be moved and programmed through the application with safety gate closed.

- Rebel-s can be programmed with open safety gate (in programming mode) and robot be moved manually.

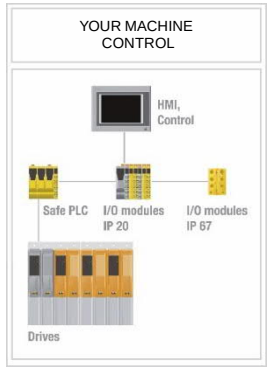


COMAU– B&R MAPP

Comau supplies the Robot arm and robot cables, which are ready to be driven directly by your machine

Available robots

- Rebel-S6-0.45
- Rebel-S6-0.60
- Rebel-S6-0.75
- Racer 3 - 0.60
- Racer 5 - 0.63
- Racer 5 - 0.8
- Racer 7- 1.4
- Racer 7 - 1.4 Plus
- NS 12 - 1.85
- NS 16 - 1.65
- NJ 40 - 2.5
- NJ 60 - 2.2
- NJ 110 - 3.0
- NJ 130 - 2.0
- NJ 165 - 3.0
- NJ 220 - 2.7
- NJ 290 - 3.0
- NJ 370 - 3.0
- NJ 650 - 2.7
- PAL 260 - 3.1
- NJ 420 - 3.0
- PAL180 - 3.1



open ROBOTICS

Benefits:

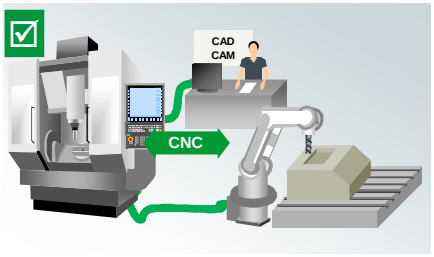
- Easy integration
- Easy installation and commissioning
- Maintenance-Efforts
- Training Needs for Programmers and Operators
- Needed Production Space

COMAU– SIEMENS Sinumerik

Comau suppies the Robot arm and robot cables, which are ready to be driven directly by your machine

Next availabilities

- Racer 7 - 1.4 Plus
- NS 12 - 1.85
- NS 16 - 1.65
- NJ 40 - 2.5
- NJ 60 - 2.2
- NJ 130 - 2.05
- NJ 130 - 2.6
- NJ 220 - 2.7
- NJ 370 - 2.7
- NJ 500 - 2.7
- NJ 650 - 2.7



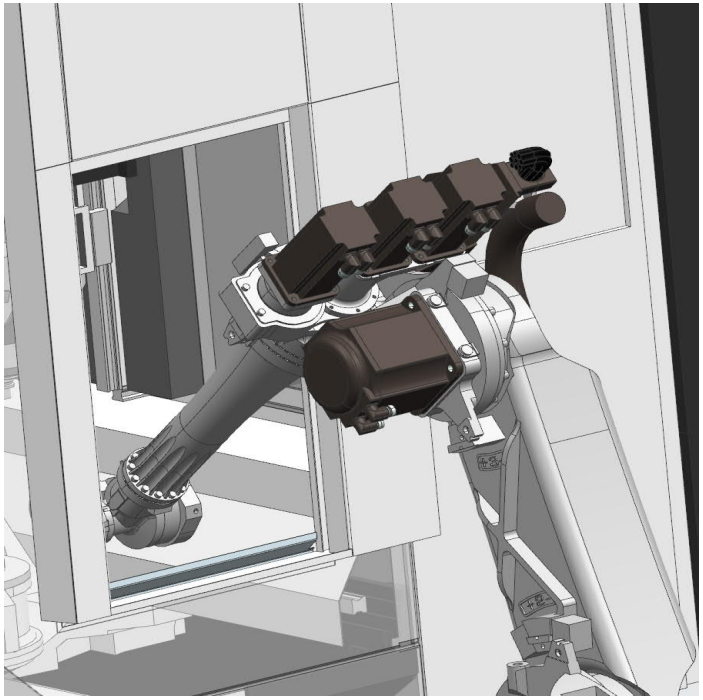
SINUMERIK Integrate
Run MyRobot /Direct Control

Features:

- Continuous path control with SINUMERIK (Single Controller)
- Connection at mechanical level
- All CNC programming methods are employed
- Digital twin with NX-CAM and VNCK
- Remote monitoring diagnosis of the entire process
- Cost-effective monitoring of fault states and integration of in-house service and maintenance processes
- Simple optimization of work processes on machine tools
- Easy synchronize processes between machine tools and robots

SINUMERIK Run Myrobot/Direct Control

Full integration of the robot into the CNC-controlled machining process



- According to IFR, the number of handling and machining robots on machine tools will continue to rise sharply (**15% CAGR***)
- By integrating the robot in the SINUMERIK control, the **full range of CNC functionalities** are available to the robot, which makes for **precise path control.**
- **Performing qualified tasks** synchronously with the machining time using a robot enables **parallelization of machining steps**.
- Moreover, dispensing with an additional robot controller produces benefits for spare-part inventory and significantly reduces the **space needed for the electrical equipment.**

* Source: IFR (International Federation of Robotics) class 114/193

COMAU– KEBA KeMotion

Comau suppies the Robot arm and robot cables, which are ready to be driven directly by your machine

Next availabilities

- Racer3 – 0.63
- Racer5-0.63
- Racer5-0.80
- Racer 7-1.4 (PLUS)
- PAL 180-3.1
- PAL 260-3.1
- Rebel-S6-0.45
- Rebel-S6-0.60
- Rebel-S6-0.75

Benefits:

- Easy integration
- Easy installation and commissioning
- Maintenance-Efforts
- Training Needs for Programmers and Operators
- Needed Production Space

e.DO: A New Concept

EASY TO USE SOLUTIONS

e.Do

Why

- Popularize Robotics in schools
- Test for innovation
  - Open Source platform development
  - Modular approach for arm and controls development

What

- Modular Architecture Components for Robot and Automated Mobile Devices
- Educational Package
- Application Storage Server and Community Management Tools

Value proposition

- Modular Architecture Components for Robot and Automated Mobile Devices
- Educational Package
- Application Storage Server and Community Management Tools

AGILE

Autonomous Guided Intelligent Lean Equipment

ADDED VALUE MANUFACTURING SOLUTIONS

Why

- Autonomous vehicles are one of the key tools meeting the Factory of the Future's needs, such as growing demand of flexibility, riconfigurability and minimal use of resources in production systems

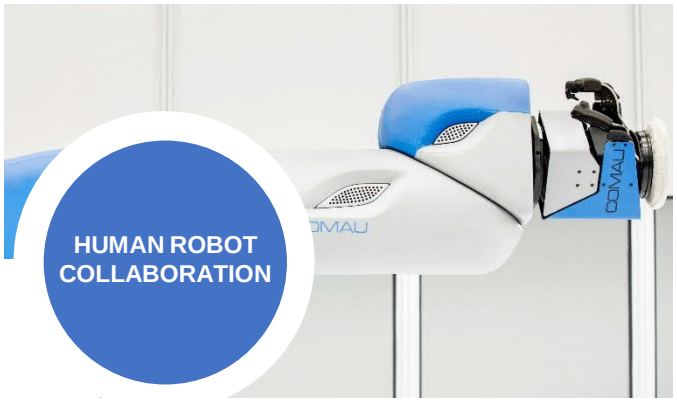
What

- An autonomous mobile platform providing modular and wide ranging solutions for logistic applications in manufacturing systems through all process stages
- Step 1 will be a 1.5 ton vehicle (AGILE 1500)

Value proposition

- High performance vehicle (best in class payload / size + speed) with best TCO ratio
- Modular, Scalable, fully Customizable - All navigation systems implementable
- Customer investment protection

AURA
Advanced Use Robotic Arm



Why

- To reach the goal of building an adaptable factory, it is necessary:
- to avoid fences or other obstacles to a free floor
- to allow men and robots to work side by side, complementing each other peculiar skills
- to allow men an easy interaction with robots, correcting their behaviour when necessary and easily teaching them new tasks

What

- High speed collaborative robot (170kg payload & 2.8m Reach)
- 6 safety layers for a modular approach
  Laser scanner, Foam with Proximity sensor and Piezo-resistive sensor, Force sensor on wrist (manual guidance), Vision system

Value proposition

- Optimization of working process
- Reduction production time
- Reduction of manual processes / working steps

Exoskeleton

Why

- In modern industries, wearable robotics will become an integral part of a factory, by helping and assisting workers in performing their everyday job's activities.
- Workers weakened by aging or injuries need support to continue to work.
- Prevention and avoidance of possible injuries have positive effects in the productivity.

What

- Wearable active and passive devices to improve the quality of specific manual tasks and relieve workers' fatigue.
- Wearable active and passive devices to work out ergonomic aspects.

Value proposition

- Improvement of workers' job quality.
- Reduction of the risk of musculoskeletal diseases.
- Reduction of workers' fatigue during task execution.

Industry 4.0 examples

FCA Cassino Plant

FCA

FIAT CHRYSLER AUTOMOBILES

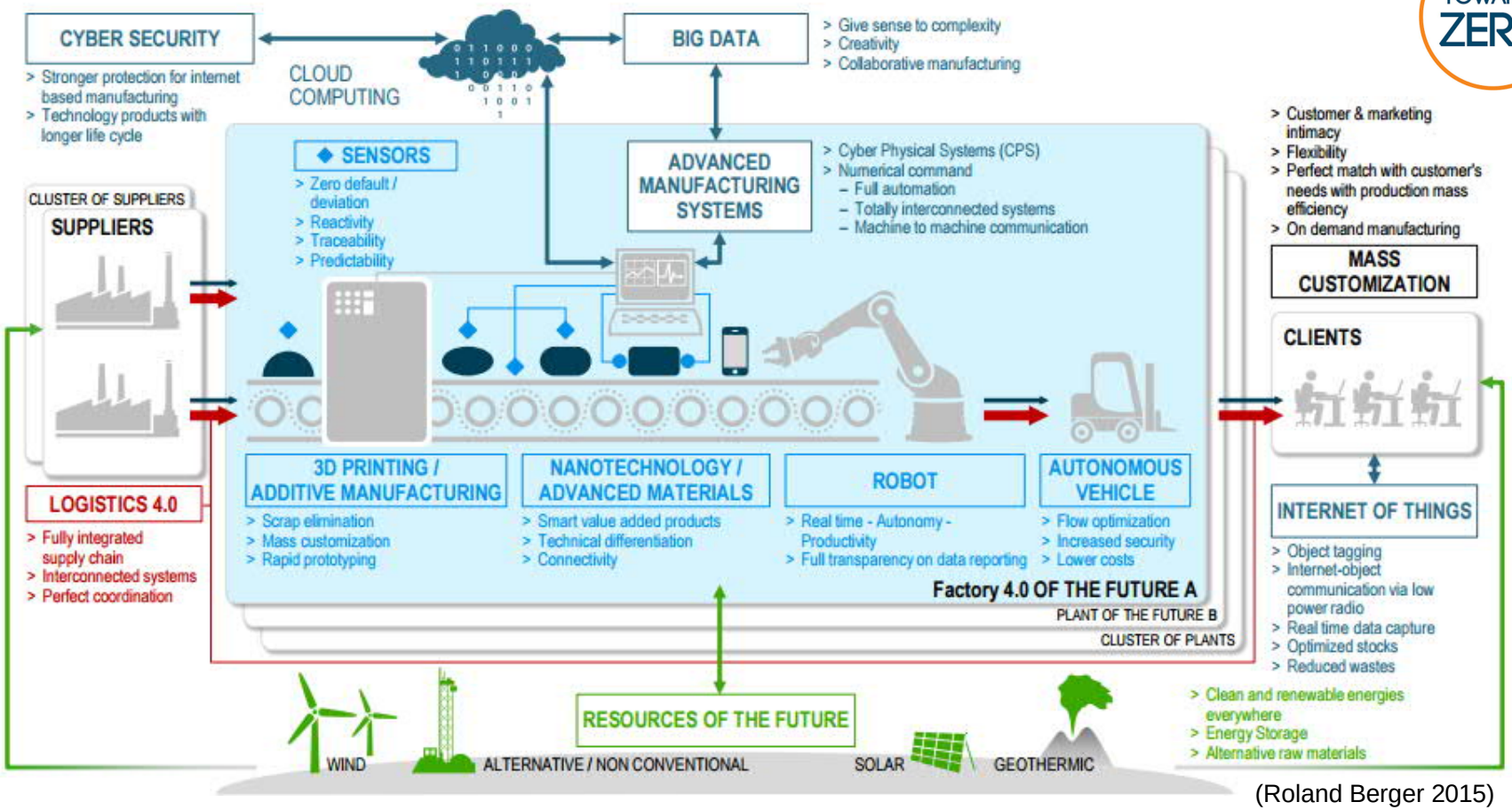
Open Arm Human Robot Collaboration

HUMANufacturing

The Zero Manufacturing Paradigm

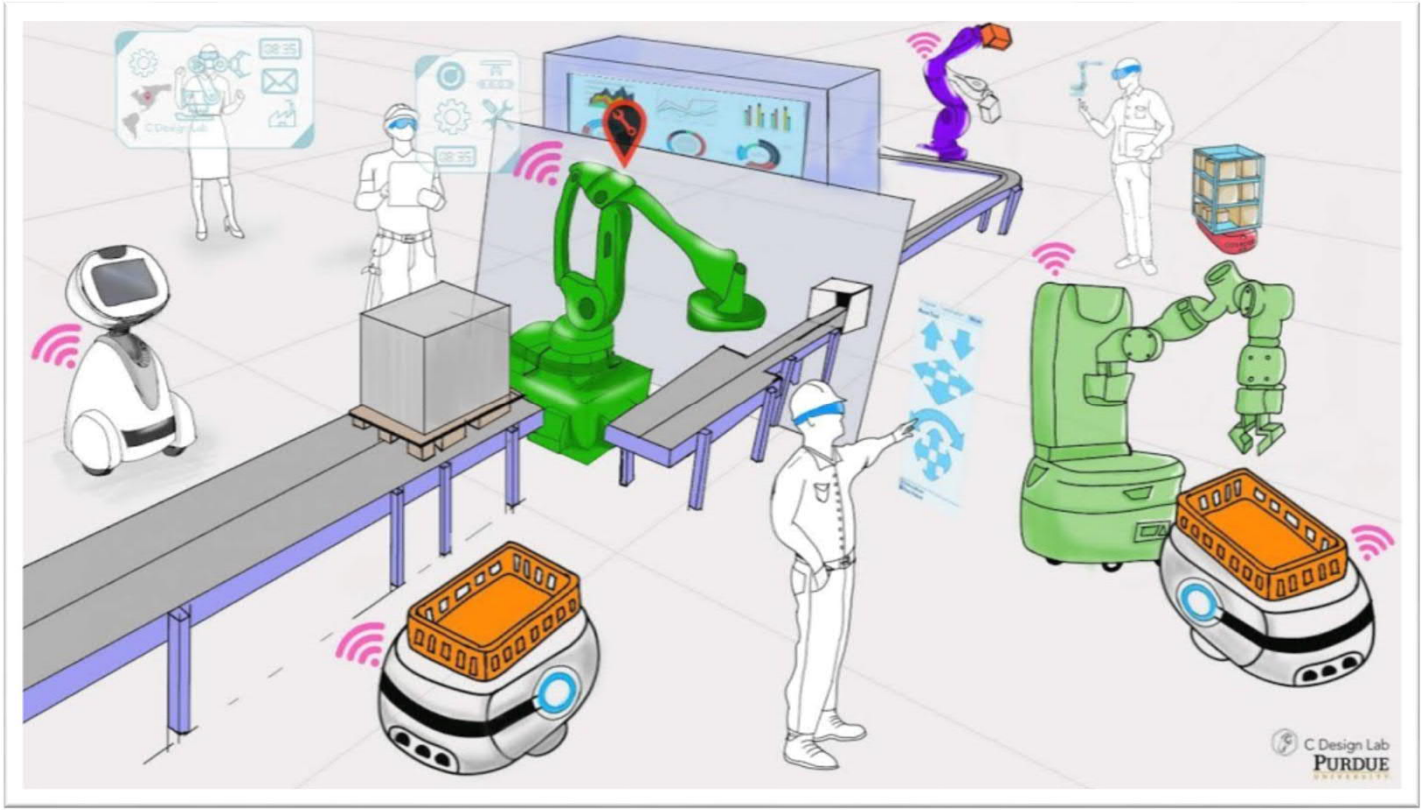
- Zero Defects
- Zero Inventory
- Zero Downtime
- Zero Waste
- Zero Injuries
- Zero Set-up time
- Zero code applications
- Zero learning curve
- …

Factory 4.0 ecosystem



(Roland Berger 2015)

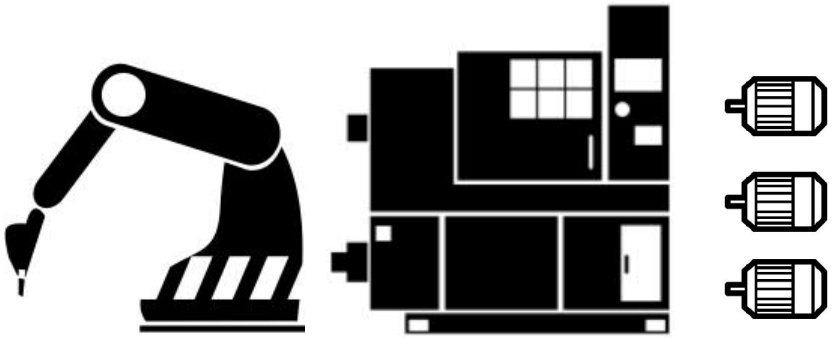
Introduction to Factory of the Future



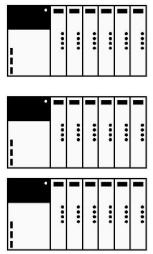
5G Connected Factory (Only one Network)

TOWARDS ZERO

Replace Wired Equipment 1-2 ms

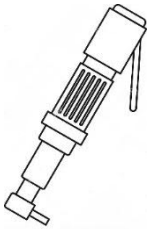


Replace Wired PLC10-30 ms

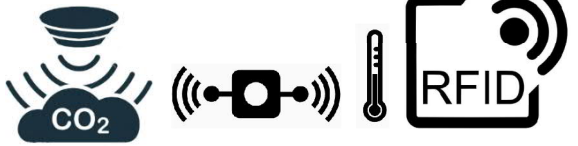


Replace Wifi AGV 10-30 ms

Replace Wifi or BT Tools 10-100 ms



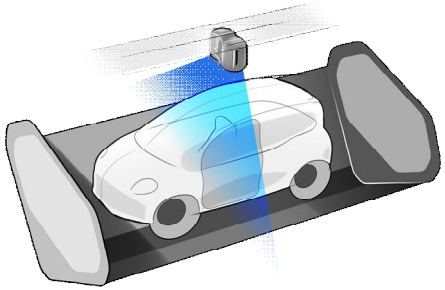
Replace WiFi or BT IoT 10-1000 ms



Made in Comau

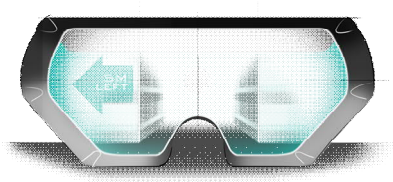
5G Factory Control (Only one Network)

Replace Wired Equipment 1-2 ms



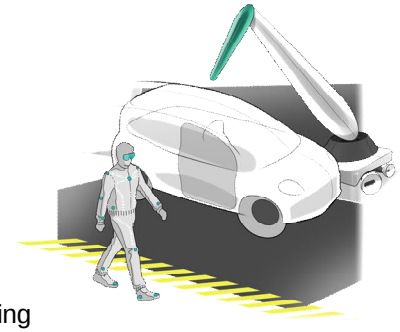
Video Analytics

Replace WiFi10-30 ms



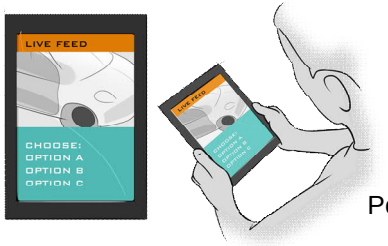
Augmented Reality

Replace Wifi 10-100 ms



Natural Language Processing

Replace WiFi or BT IoT 10-1000 ms



Portable devices

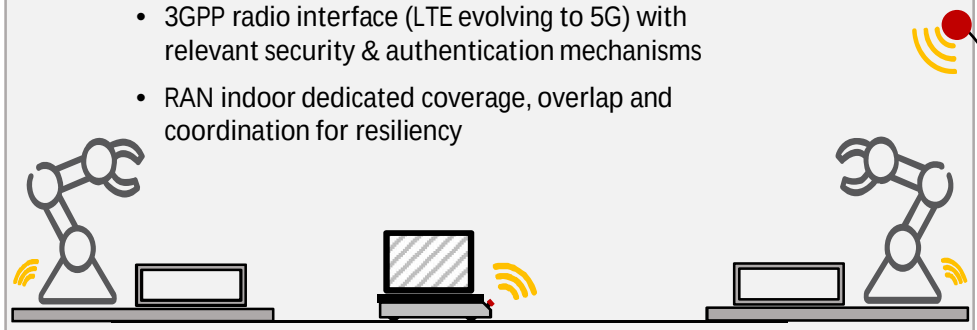
Edge/Fog Robotics

Test Area – Indoor Coverage

The AGV shuttles materials between the two robotic arm replacing the conveyor
Robotic arms and AGV are controlled via mobile network by the control applications in cloud.

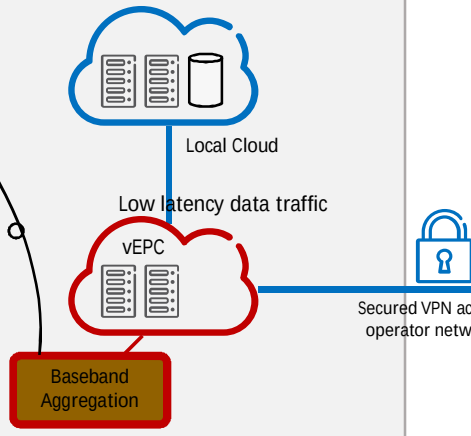
Local segregated RAN & EPC solution in Factory controlled area:

- TIM licensed spectrum & dedicated PLNM ID
- 3GPP radio interface (LTE evolving to 5G) with relevant security & authentication mechanisms
- RAN indoor dedicated coverage, overlap and coordination for resiliency



Local IT Area

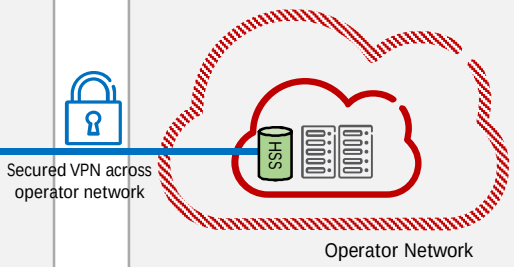
Baseband unit and v-EPC for radio infrastructure, line-PLC and local cloud server, where applications will run.



Operator's Domain

Centralized Core Network & Security

- Centralized TIM Core Network for low & sporadic control traffic (i.e. authentication, SIM management)
- External traffic for nRT and maintenance traffic over TI VPN

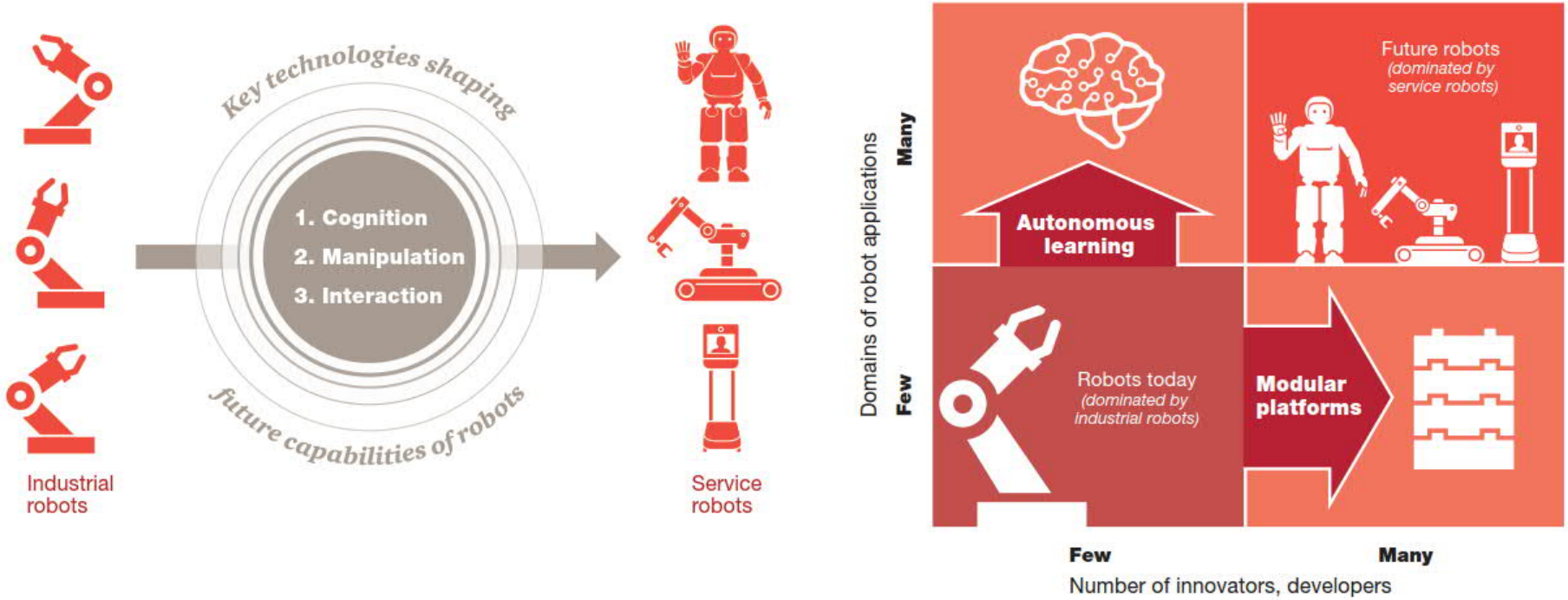


AI and Human-Machine Collaboration

- Material Delivery A.I. Linked
- ‘Right Part – Right Time’

- Zero Defects
- Zero Training
- Maximised Process Output

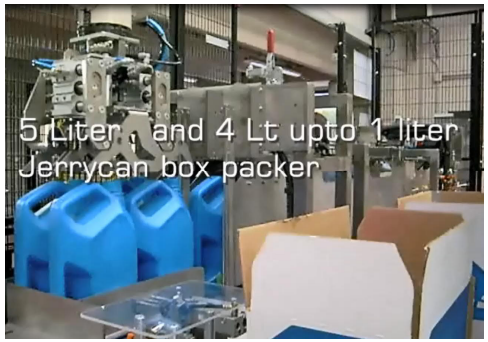
Big Data and Machine Learning



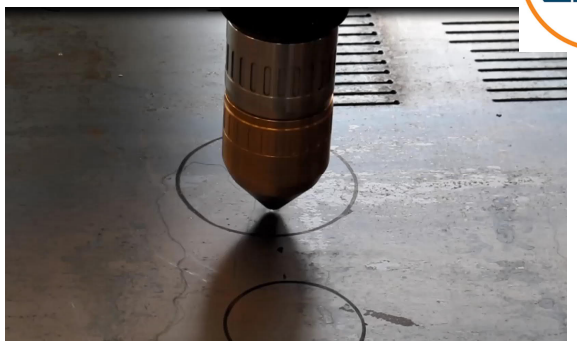
[PWC Technology Forecast: Future of Robots]

Applications

Bottle Handling

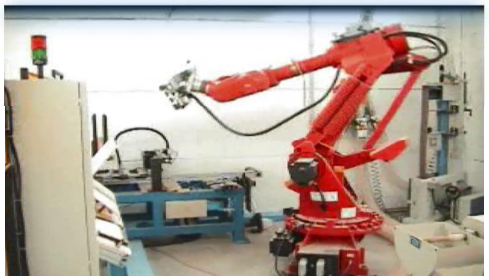


Jerrycan Box Packing



Laser Cutting

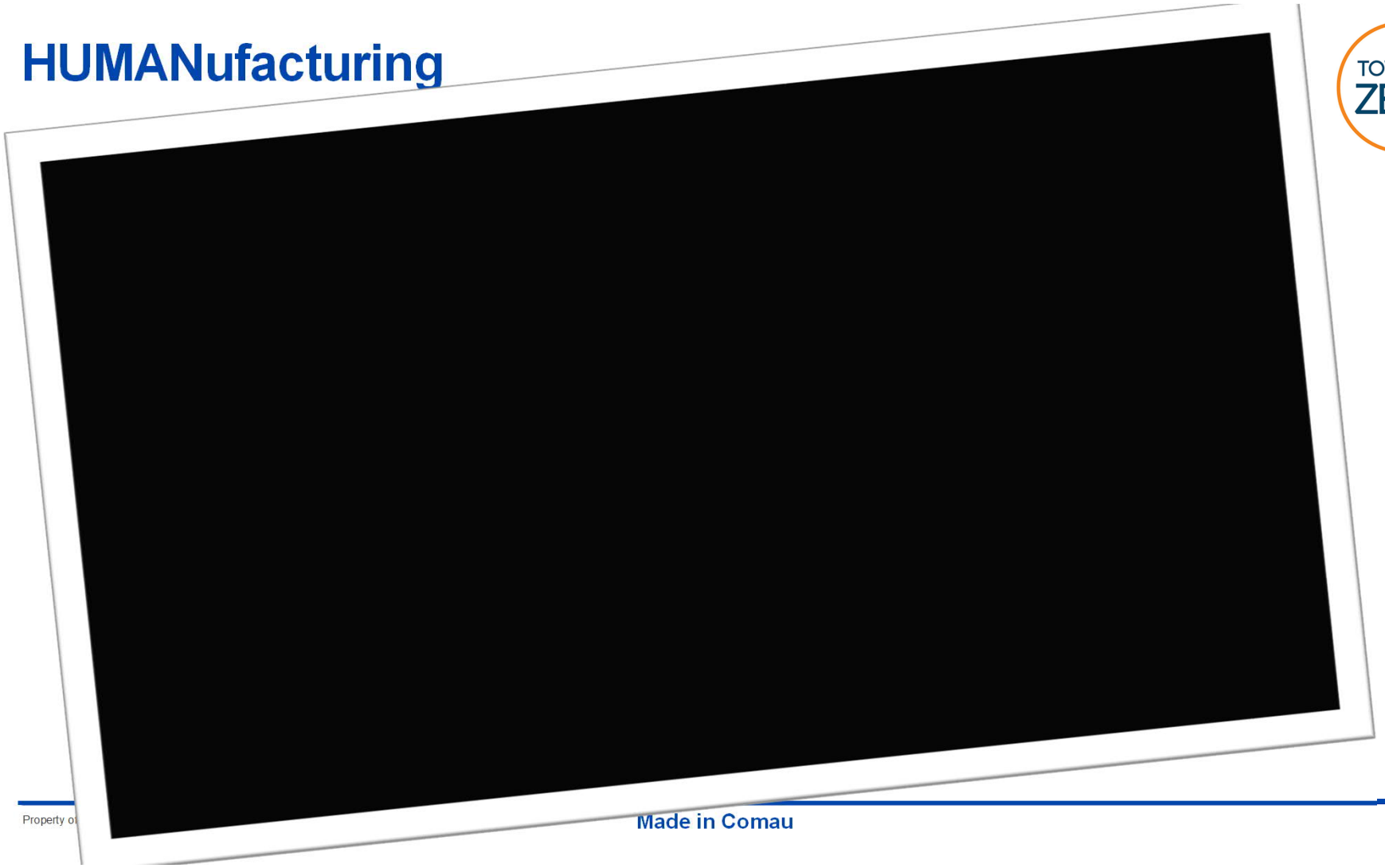
Metrology Measurement Cell



Wooden Seat Manufacture

Box Packing

HUMANufacturing



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