GREATER BIRMINGHAM & SOLIHULL
INSTITUTE OF TECHNOLOGY

Our Cyber Physical Manufacturing Rig:

GBSIoT detailed guide to the Cyber Physical Manufacturing Rig
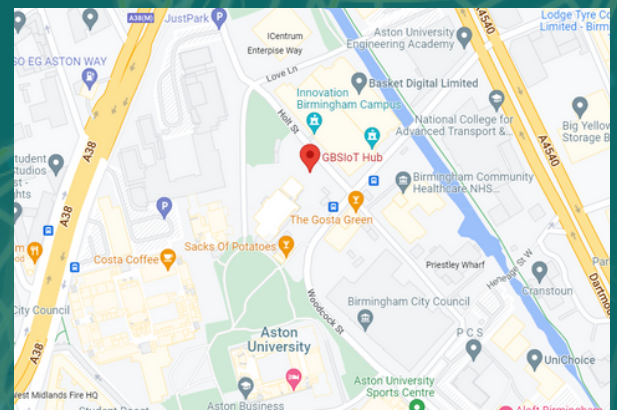
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What does the Cyber Physical Manufacturing Rig do?

The CP system enables the production of 7 different assemblies, the size of a mobile phone, each with a different colour of base and top covers as well as different inserts of PCB with different fuses or different granules in different compartments. The enriched mix of processes and different mix of assemblies makes the system ideal for a variety of industries such as:

- Automotive
- Food and Beverages
- Pharmaceutical
- Logistics
- Electronics Assembly
- Manufacturing, etc.

The assembly sits on a RFID tagged carrier and pallet that travels along the conveyor belt and stops at various stations. The RFID of each station reads whether it required to perform a task on the assembly or not, in doing the task it writes on to the RFID that the task has been completed. There is constant updating of the MES as the assembly goes from station to station.
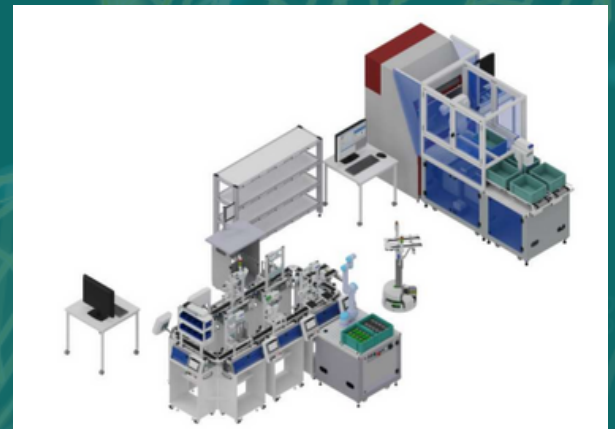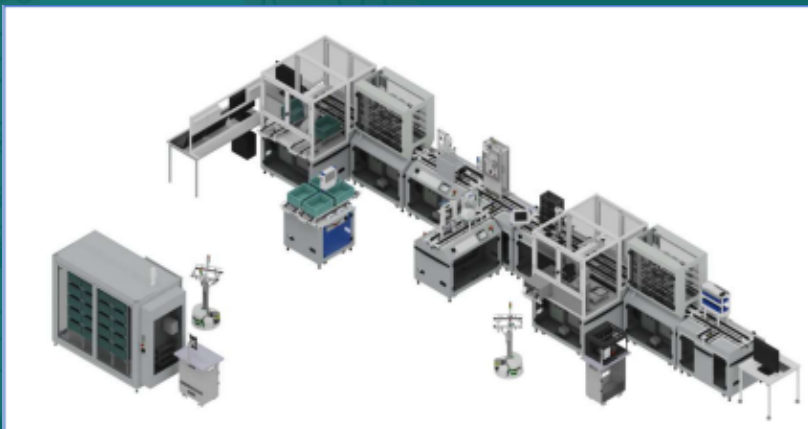
Further breakdown of the solution is as follows:

- **Cell 1: CP Factory System:**
- **Cell 2: CP Lab System:**
- **Cell 3: CP Lab System:**
- **Cell 4: Modular Production System (MPS) I4.0**

Please see below what each cell entails:

Cell 1:
CP Factory System:

- Module Docking Robot Station and Bypass
- Module Box Buffer
- Automatic Storage / Retrieval System x 4
- Muscle Press
- Dosing
- Works Output
- Labelling
- Camera Inspection with Artificial Intelligence
- Robot Assembly
- Manual Station: pick by light
- 3D Printer
- Energy Monitoring Module
- Cyber Security Module
- AGV
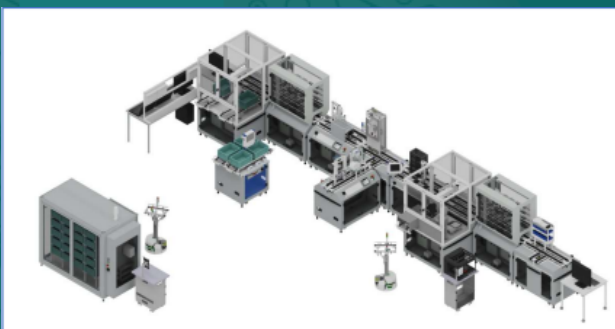
Cell 2:
CP Lab System 1

- Works' input
- Muscle Press
- Magazine for parts dispensing x 2
- Manual Station: pick by light
- Drilling
- Analogue Measurement
- Works Output
- AGV

Cell 3:
CP Lab System 2:

- Works input
- Cobot
- Muscle Press
- Magazine for parts dispensing x 2
- Manual Station: pick by light
- Drilling
- Analogue Measurement
- Works Output
- Manual Storage
- Docking Station with Robot and CNC Machine
- AGV

Cell 4:
Modular Production System (MPS) I4.0

- MPS Distribution Pro Station
- MPS Joining Station
- MPS Measuring Pro Station
- MPS Sorting-Inline Station

The MPS line up can be easily moved to another location as it is a self-contained system. It is also ideal for introduction into Industry 4.0.
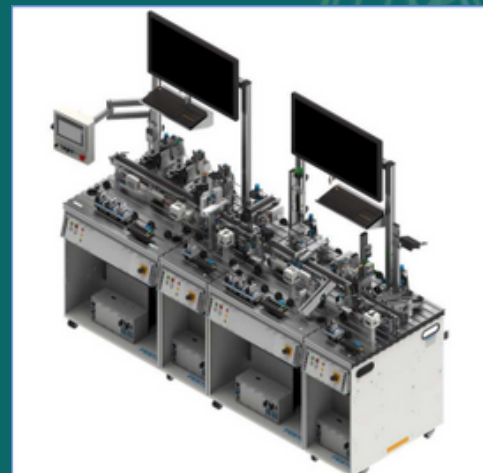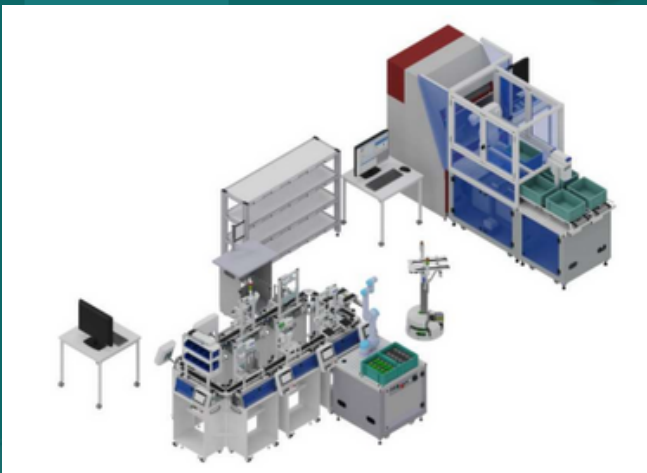
A brief synopsis of each separate component:

Non-conventional assembly techniques:
this is offered via the Manual Assembly (or
Pick-by-light) as well as Manual Storage
Stations.

Collaborative Robots: This is integrated
into cell 3 and performs component
insertion.

Range of Analogue Processes: Analogue
processes are covered via the Analogue
Measurement and Muscle Press Stations.

Additive Manufacturing: This enables a
3D printed part to be inserted into one of
the product configurations.

Manufacturing Process: The CNC enables a manufactured part to be inserted into one of the product configurations.

Vision and Quality Inspection: This is offered via the Camera Inspection Station.
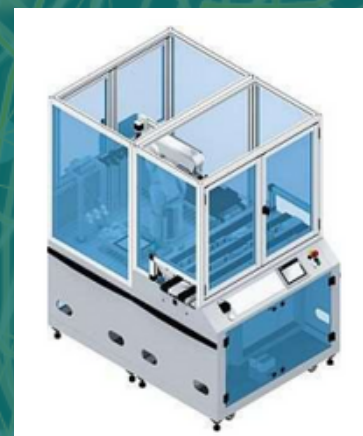
Artificial Intelligence: This is offered via the Camera Inspection Station.


Automated Warehousing and Storage. Automated Storage and Retrieval System (AS/RS) is part of the proposed system.

Robotics: This is covered via the Robot, Visual Inspection and Assembly Station.

Logistics: Fully integrated Robotino AGV are fully integrated within the system and can be programmed via the specified open programming environments. Their normal operation is via the Fleet Manager of the Manufacturing Execution System (MES).
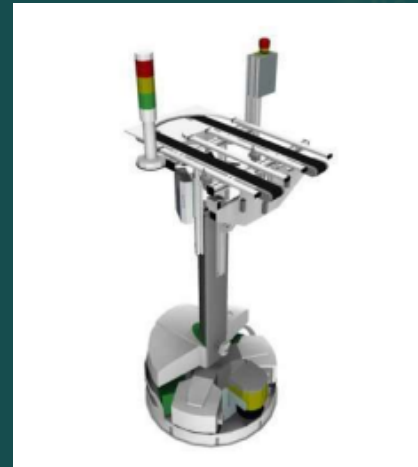

Energy usage analysis. A dedicated system is included within the offer for energy consumption and analysis. The system is equipped with an energy measurement device for electrical energy and sensors for recording the pressure consumption. The measurement devices are connected to a CECC controller. It concentrates the energy data and sends it to the energy database via OPC UA for filing and evaluation.

Cyber Security: A dedicated system is included within the offer for cyber security for single- and double-seat or team scenarios providing a wide range of learning topics in the field of cybersecurity.

**Digital Shadow and Simulation:** This is covered via CIROS software.
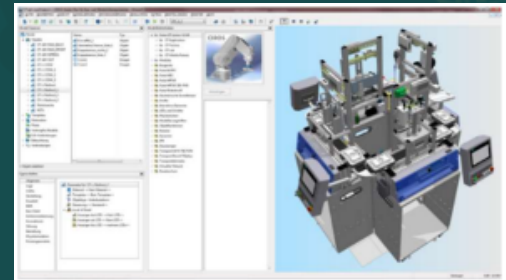
Digital Twin and Simulation using industry recognised software: This is covered through Siemens MindSphere software. Some CP processes have already been integrated into the software. CAD models of the stations could be made available to the IoT for integrating into MindSphere.


Manufacturing Execution System (MES)
MES4 is a didactic structured Manufacturing Execution System (MES), which is designed for Industry 4.0 learning platforms. Special importance is placed on the topics of production control and management. The MES4 can directly communicate with the PLC via open communication interfaces. The individual controllers communicate with the MES4 via TCP/IP.
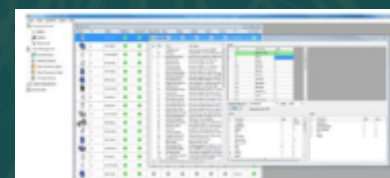
Augmented Reality: Data visualization is available via Augmented Reality (AR). The App can be downloaded from Festo.

RFID: RFID read- and write-system exchanges data with the workpiece that communicates through an IO-link-interface with the main Controller. Each CP Conveyor is equipped with a PLC and all necessary interfaces in order to be complemented by an application module and to communicate with the MES. Conveyors that are placed in line communicate through an optical 2-bit communication system.
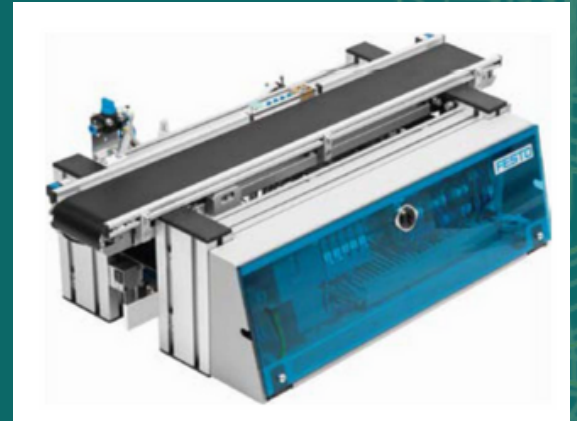

Stepper Control Drive: Workpiece Output Station demonstrates Ethernet based communication to stepper controlled drive allowing for position and speed configuration.

PLC communication: Drill Station offers communication between different brands of PLC's: Siemens <--> Festo Codesys communication via TCP/IP

Smart Maintenance: The MMS software and equipment are used in conjunction with a CP Lab or CP Factory system with MES4 to cover various types of maintenance: planned, timeout, message via mobile device, sensor triggered through to provision of spare parts.
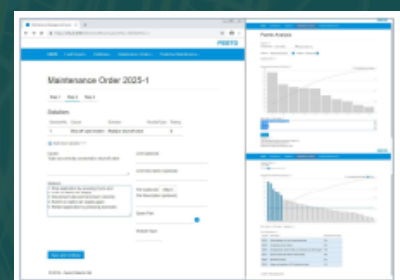
In addition, the following technologies are covered:

Big data / cloud interface:
Covered within MindSphere software.

QR Code:
This is available on every station.

OPCUA / nod-red:
All Stations can be integrated with OPCUA and a remote dashboard, powered by node-red is provided. This allows complete control of all stations via OPCUA, in addition to the TCP/IP communication protocols utilized by the MES.

IO-link:
All stations include IO-link RFID sensors. Additional IO-Link devices can be added, as 3 x IO-Link Master is available on each station as spare.

Remote visualisation:
- Drill Station offers remote visualisation and monitoring, using embedded CECC Webserver
- Workpiece Output station offers remote operation monitoring
- All stations offer remote monitoring via Siemens SmartClient, and OPCUA

It can be seen that the CP Industry 4.0 system, covers as a minimum, the following areas:

- Artificial Intelligence and Augmented Reality for Manufacturing
- Data Driven Economy & Big Data
- Clean & Sustainable Manufacturing
- Non-conventional assembly techniques
- Instrumentation & Control
- Sensors & Data Logging
- Robotics & Automation inclusive of
- Collaborative Robotics
- Automated Guided Vehicles
- Modular development of Industry 4.0/robotics alongside traditional manufacturing methods
- Cyber Security
- Logistics
- Additive Manufacture

The CP System covers the following learning outputs and topics:

- Mechanical and Electrical set up
- Pneumatics Actuators
- Set up of Sensors and Limit Switches
- PLC Programming
- Vacuum Technology
- Optimization of set-up times
- Material flow control
- Enhanced I/O communication
- Commissioning of complex and Automated Systems
- Measurement and Control of Electrical, Mechanical and Process Variables
- Process Operation and System Management
- Setting and Optimization of Controllers
- Open and Closed-loop Control Programming
- Inspection, Maintenance, and Servicing, Fault Finding and Error Control
- Predictive Maintenance, System Planning, Worker Guidance
- Digital Product Memory, IO-Link
- UID product identification (RFID / QR/ Binary ID) IP communication
- Embedded Control, Remote Service Concepts
- Web store ordering to production, Modern-decentralized control technology
- System simulation
- Energy efficiency & Management
- Augmented reality (AR), Cyber-physical systems
- Cyber security
- Digital twin
- Plant optimization