Connected in 10min:
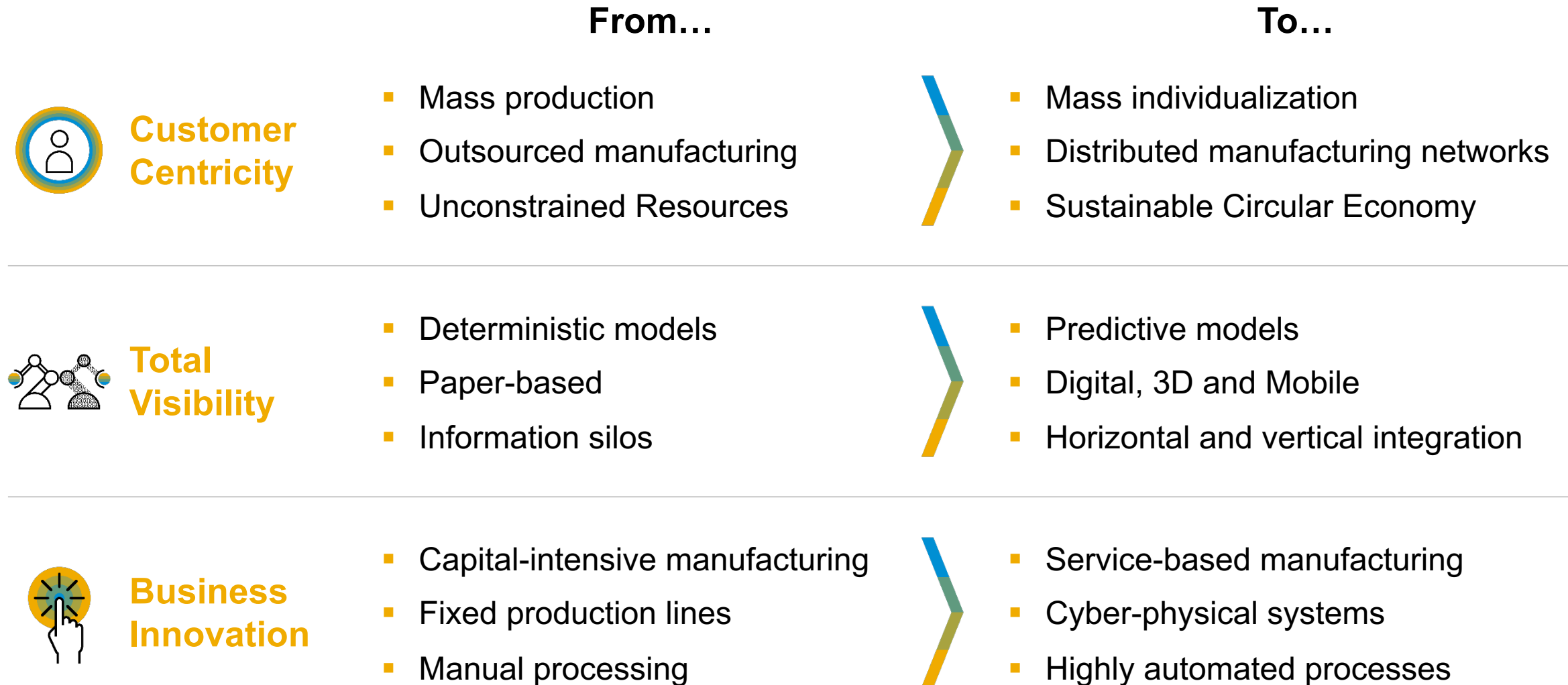# How SAP systems leverage OPC UA

Rüdiger Fritz
Director Product Management
SAP Plant Connectivity

PUBLIC

SAP **Run Simple**

Motivation: Global Trends in Manufacturing Industries

	From…	To…
Customer Centricity	▪ Mass production ▪ Outsourced manufacturing ▪ Unconstrained Resources	▪ Mass individualization ▪ Distributed manufacturing networks ▪ Sustainable Circular Economy
Total Visibility	▪ Deterministic models ▪ Paper-based ▪ Information silos	▪ Predictive models ▪ Digital, 3D and Mobile ▪ Horizontal and vertical integration
Business Innovation	▪ Capital-intensive manufacturing ▪ Fixed production lines ▪ Manual processing	▪ Service-based manufacturing ▪ Cyber-physical systems ▪ Highly automated processes

Motivation: Objective of Digital Transformation

MANUFACTURING PROCESSES
need to be

MACHINES
need to be

WORKFORCE AND LEADERSHIP
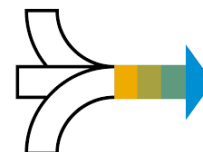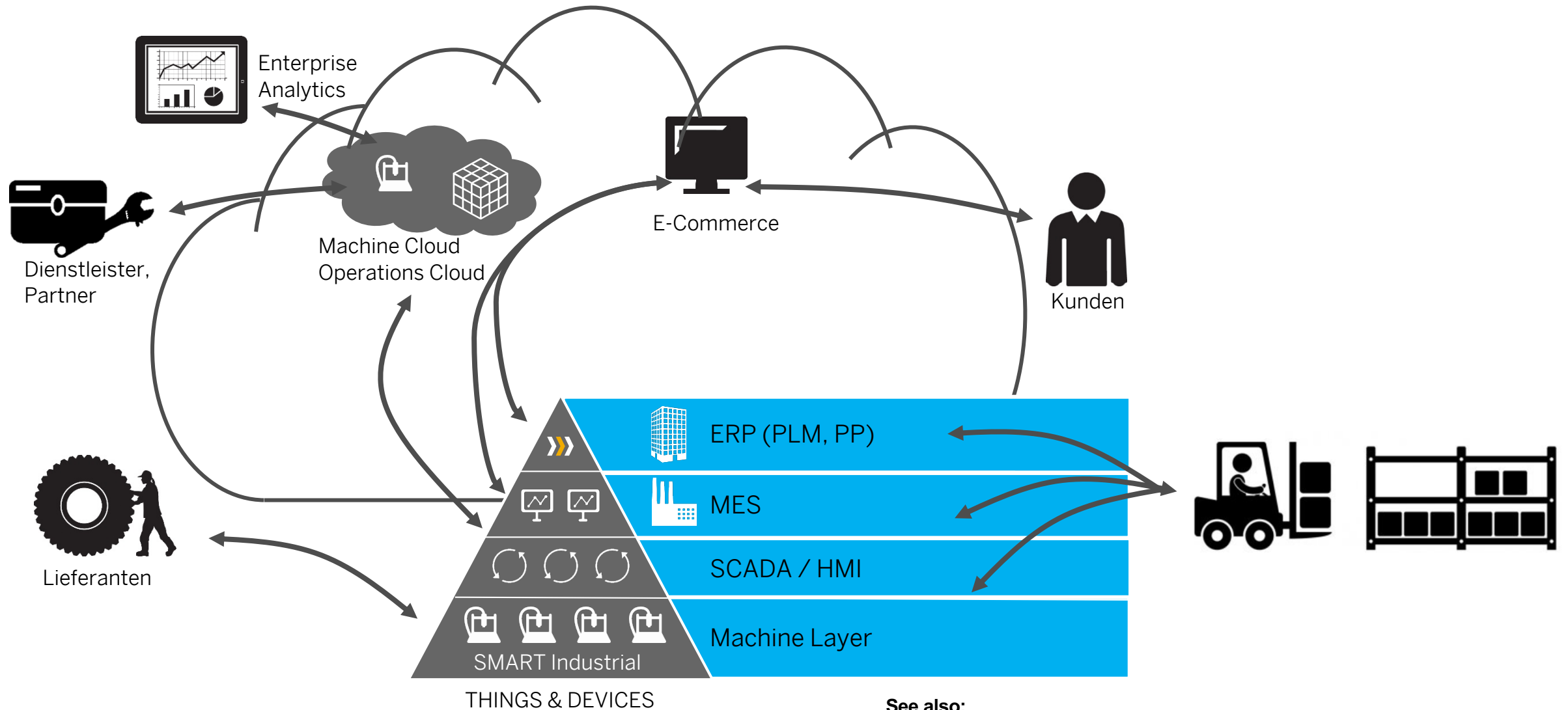needs to be

SOFTWARE LANDSCAPE
needs to be

AND

flexible [flɛksɪb(ə)l] adjective
able to be easily modified to respond to altered circumstances.

dynamic [dʌɪˈnamɪk] adjective
(of a process or system) characterized by constant change, activity, or progress.
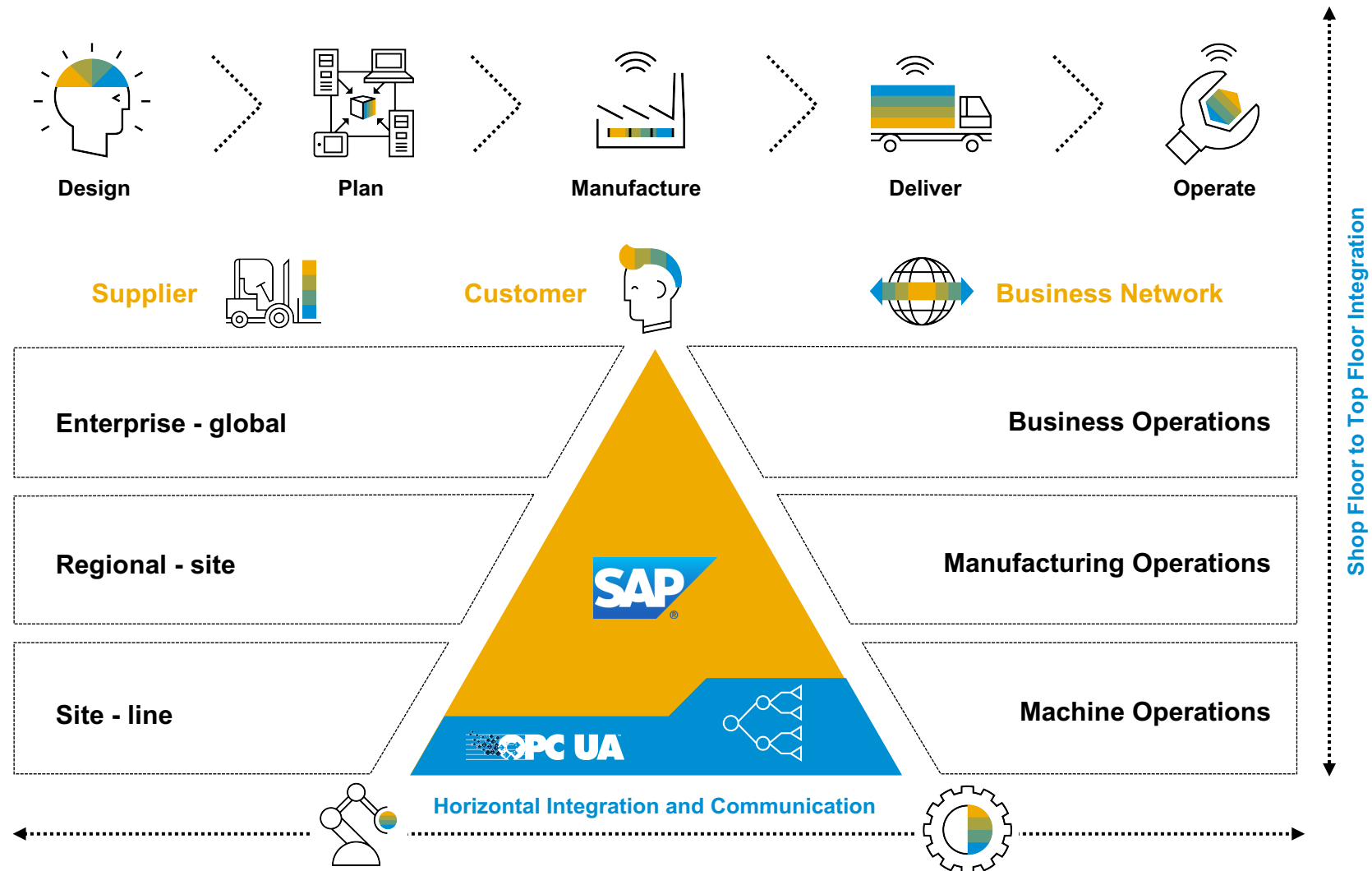
The "playground": Interoperability - also beyond Automation Pyramid

Enterprise Analytics

Machine Cloud Operations Cloud

E-Commerce

Dienstleister, Partner

Kunden

Lieferanten

ERP (PLM, PP)

MES

SCADA / HMI

Machine Layer

SMART Industrial

THINGS & DEVICES

See also:
http://www.it-production.com/index.php?seite=einzel_artikel_ansicht&id=63440

The Main Process Challenges for Manufacturing in the Digital Economy
Five Business Needs of "Connectedness"

Design > **Plan** > **Manufacture** > **Deliver** > **Operate**

Supplier   **Customer**   **Business Network**

Shop Floor to Top Floor Integration

Enterprise - global   **Business Operations**

Regional - site   **Manufacturing Operations**

Site - line   **Machine Operations**

SAP

OPC UA

Horizontal Integration and Communication

1. Intelligent Visibility Across the Business
2. Machine to Machine Automation
3. Complete E2E Supply Chain Integration
4. Predictive Service & Maintenance
5. Flawless Supplier Collaboration

Communication Patterns in context of automation

A Notification

B Query

Insights, Alarms etc.

PM · PP
MM · QM
ERP, S/4, Cloud

Dashboards, Applications

Transaction — DB Record (Time Series)

Destination
(e.g. MII, ME, HANA, SAP Cloud …)

Tag-Query

C Control Loops

(Guaranteed)
Notification Delivery,
Buffer mechanisms,
Filter/Rule Framework,
Customer specific code, …

Buffer* and Orchestration

Query-Interface
(Read/Write)

Classical Gateway Task: Protocol conversion, Source/Destination mapping

Device Tag (Data Point)

Data Source/Machine
(e.g. OPC UA-Server)

Services

Device Tag (Data Point)

First choice:

OPC UA

*Buffer option:
Project specific
configuration/implementation

Open Integrated Factory
Generation 2017

Industrie 4.0 | LIVE and REAL

OPC UA as the standard for each machine unit

Service oriented Architecture (SOA) also on level of machine units
→ Orchestration by means of OPC UA Client (and Server) SAP Plant Connectivity

…
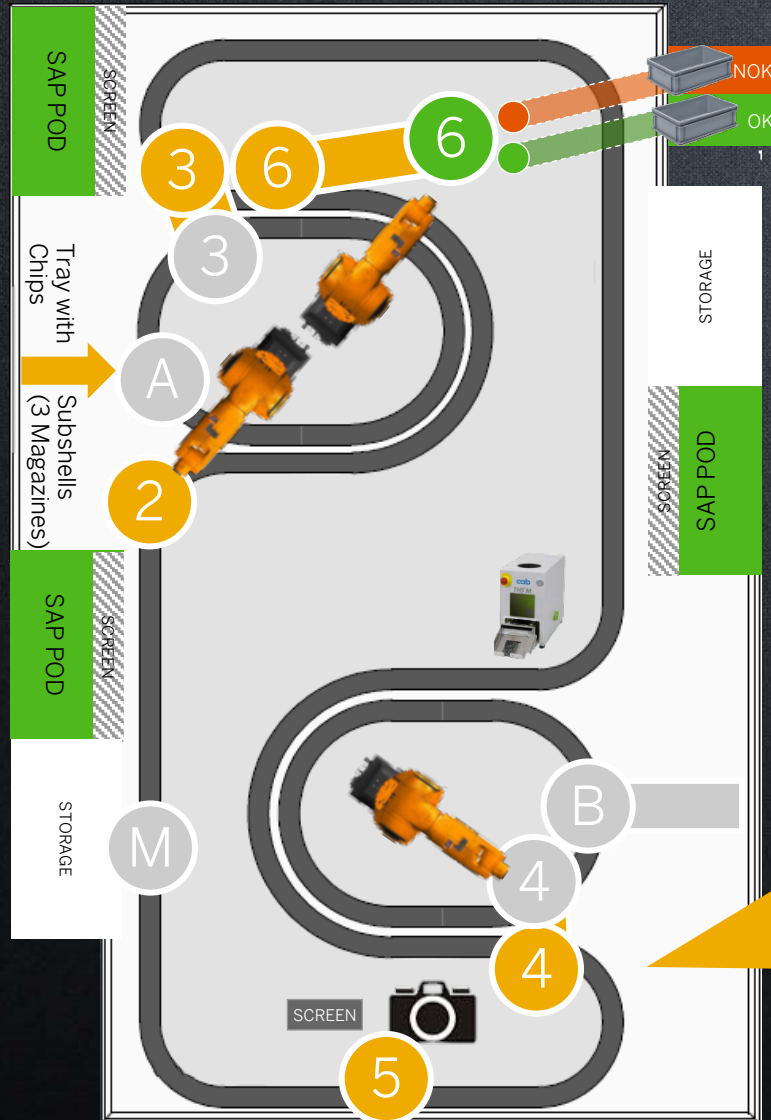
④ XTS M → PCo: "Mover with SFC 123 arrived at Pos Y4"

④ PCo → XTS B: "Move SFC 123B to Pos B4"

XTS B → PCo: "Mover with SFC 123B arrived at Pos B4"

PCo: (Get Lock for Rob B)

PCo → Rob B: "Do Job #3 – Handle SFC123"

Rob B → PCo: "Job #3 – Handle SDF123 done"

PCo → XTS B: "Release Mover" (move on)

PCo → XTS M: "Move SFC 123 to Pos 5"

XTS M → PCo: "Mover with SFC 123 arrived at Pos 5"

⑤ PCo → Cam: "Take Photo [Par: expected colour blue]"

Cam → PCo: "Camera result: [not blue, URL to .jpg …]

Log non-conformance

…

Technical Basis → Key Innovation
Service Oriented Architecture (SOA) approach for machine unit orchestration

(1) Each machine unit is independent

- » the units are <u>not</u> linked to each other by a single program inside a single PLC
- » Each unit comes with its own controller

(2) Units are talking to each other on the basis of OPC UA

- » From business perspective (production order details like routing and recipe/set-points) the units are orchestrated by SAP Plant Connectivity (Vertical Integration)
- » From technical perspective, some machine units – here Camera and Robot - exchange information directly (Horizontal Integration)

(3) Units can be OPC UA Client and OPC UA Server at the same time

- » A server can offer tags, events and methods
- » A client can consume/react on tag changes and events and can call methods

(4) Units publish their capabilities

- » → a Service Oriented Architecture with regards to hardware is possible
- » Companion specifications will allow easy modelling

SAP MES

SAP PCo

Buffer Business Context

OPC UA Server | OPC UA Client

OPC UA

OPC UA Client | OPC UA Server
OPC UA Client | OPC UA Server
OPC UA Client | OPC UA Server

3* XTS Transport System

OPC UA Server

Camera

OPC UA Client | OPC UA Server
OPC UA Client | OPC UA Server
OPC UA Client | OPC UA Server

OPC UA Server
Camera

3* Robot Pick & Place

OPC UA Server

Laser Printer

- » OPC UA Client/Server Communication ONLY via OPC UA method calls
- » SAP initiates actions for equipment
- » Equipment confirms "job done"

SAP Plant Connectivity – more than just a simple Gateway for Connectivity → OPC Client and OPC Server for methods → enables orchestration

SAP Cloud/ SAP Digital Manufacturing Cloud

SAP Business Suite, S/4 HANA

ABAP NetWeaver, DB

REST-WS + MQTT

Other PCo	SAP MII	SAP ME	SAP EWM	SAP Data Streaming
OPC UA Server or Webserver	Proprietary (TCP/IP) or SOAP -WS	SOAP-WS, ODATA-WS	Socket	Proprietary (TCP/IP based), REST

RFC, SOAP-WS, ABAP Push Channels (WebSocket) ODBC, ODATA, REST

SAP Plant Connectivity (PCo)

+ **OPC UA Server for configurable Methods**
+ **Webserver for configurable Methods**
+ **WebSocket-Server for Query Access**

Supported protocols:
- ❖ OPC UA, MQTT, OPC DA, OPC HDA, OPC A&E, Citect, IP21, Osisoft PI (2), Proficy Historian, File-Monitor (2), ODBC, OLE DB, Socket, Modbus
- ❖ SDK for **proprietary, project specific agents**
  (e.g. ifm Linerecorder, UDP, RFC1006, Euromap 6x, Atlas Copco Open Protocol, SICK Telegrams and multiple other project specific implementations)

Devices, Logic Controllers, Historians

DCS PLC

MES

Plant DB

Plant Data Collection

Plant Historian

Wireless Integration

LIMS

SCADA / HMI

Environmental Building Management

Sensors

Open Integrated Factory – Generation 201x
Technical Basis: buffer automation related (Master) Data close to machine

(1) Read ME data in advance:
  » Next Production Order(s) incl.
  » Routing steps
  » Set-Points

(2) PCo buffers this data

(3) Machine requests data

(4) PCo responds from buffer

(5) PCo manages posting to ME asynchronous

| PM | ERP, S/4, Cloud | PP |
| MM | | QM |

Destination
(e.g. MII, ME, HANA, HCP ...)

C synchronous Service Calls

SAP PCo
Buffer* and Orchestration

Data Source/Machine
(e.g. OPC UA-Server)

Response from buffer in case of OIF:
< 10 Milliseconds
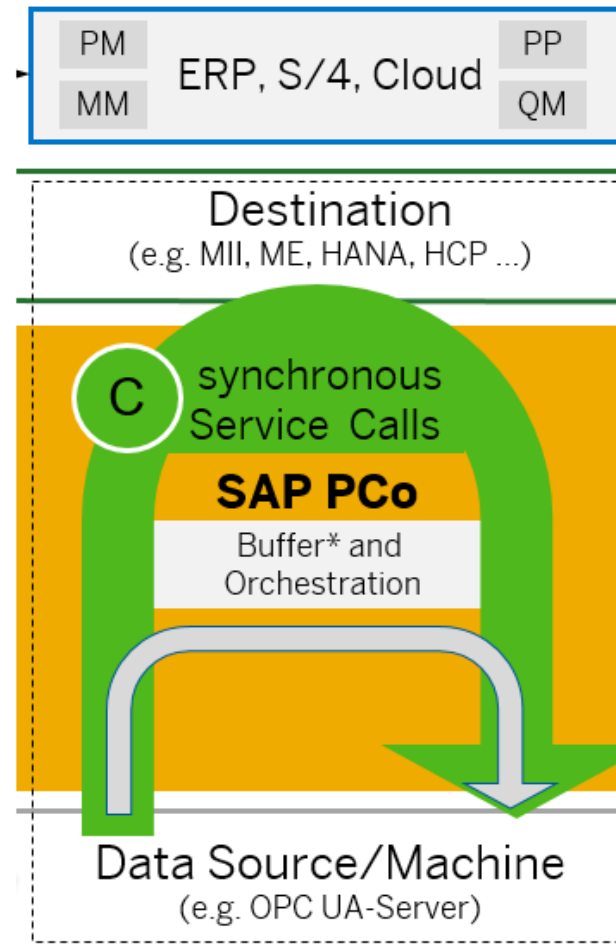
* Buffer option:
Please note:
PCo 15.1FP2 does not contain a generic library which covers various scenarios to buffer data.
We provide how-to guides and example code but project/implementation specific coding will be necessary if the described idea of the Open Integrated Factory shall be adopted to your situation.
For more details see
http://help.sap.com/pco -->
"Enhanced Method Processing"

* Buffer option:
Project specific
configuration/implementation

Example of CPS:
Flexible Manufacturing requires Dynamic Decision Making

Source: http://blog.audi.de/2016/11/23/modulare-montage-statt-fliessband
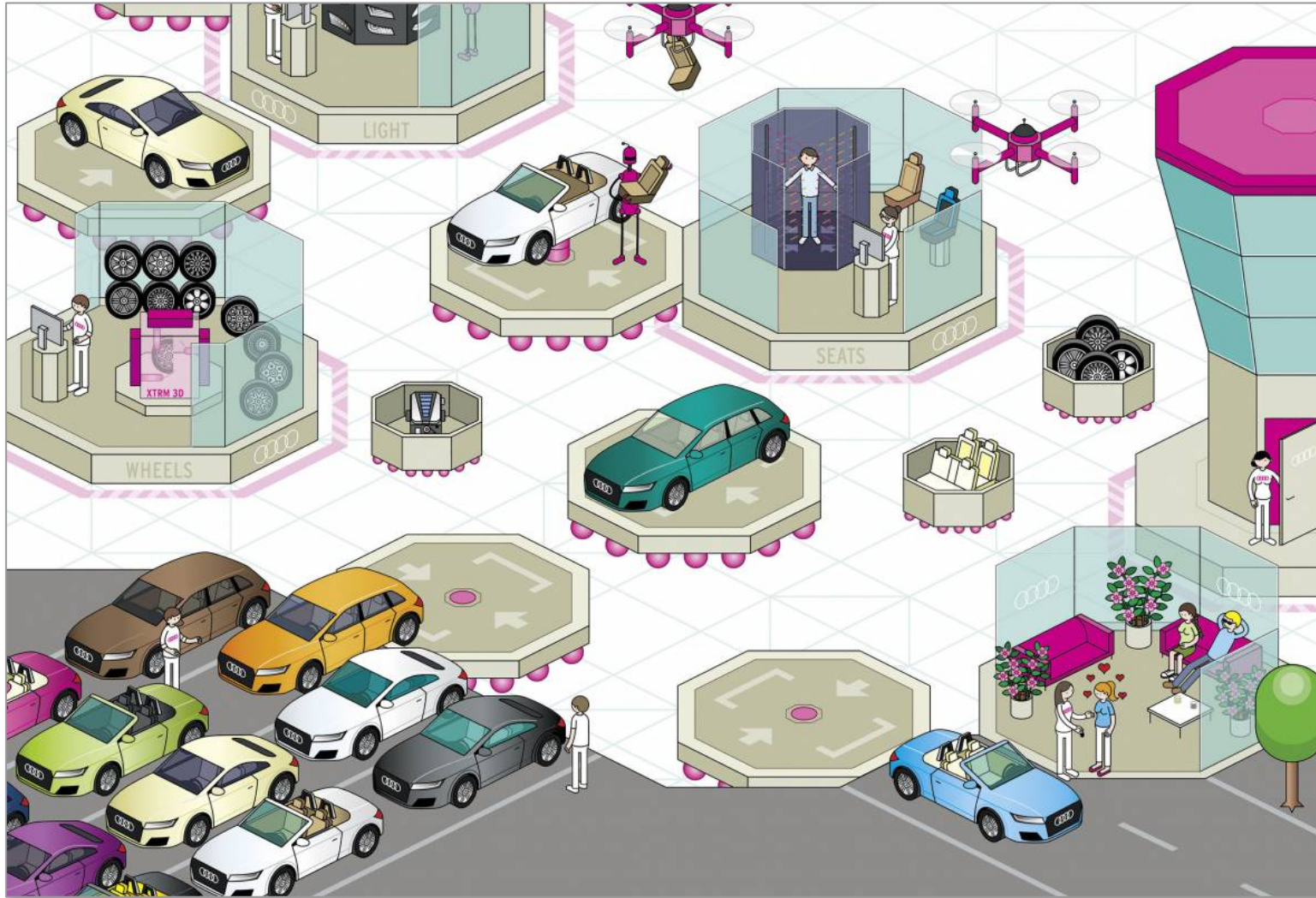
Modular Assembly

» Assembly Line replaced by Cellular Manufacturing

» New organizational structures require ad-hoc decisions

» Increasing Interoperability

Impressions – on stage at Hannover 2018

Flexible and Dynamic Manufacturing Processes

Fictitious Example from a Car Assembly:

Operation 100 =
Install Hood at Resource (Work Station) A

Next:
Operation 130 =
Mount Tyres at either Resource C or D
          OR
Operation 135 =
Install Seats at Resource B

→ **Decision which of both Operations at which Resource depends on ad Hoc Situation**

Next: 130 if 135 before OR 135 if 130 before

Next:
Operation 140 =
Install Air Condition at either Resource C or D
          OR
Operation 145 =
Install basic Ventilation at Resource F

→ **Decision which Operation depends on Material Variant**
→ **Decision which Resource depends on ad Hoc Situation**
…

Arbitrary sequence

Either / Or

Legend

Operation

Potential resources

M Mandatory
O Optional
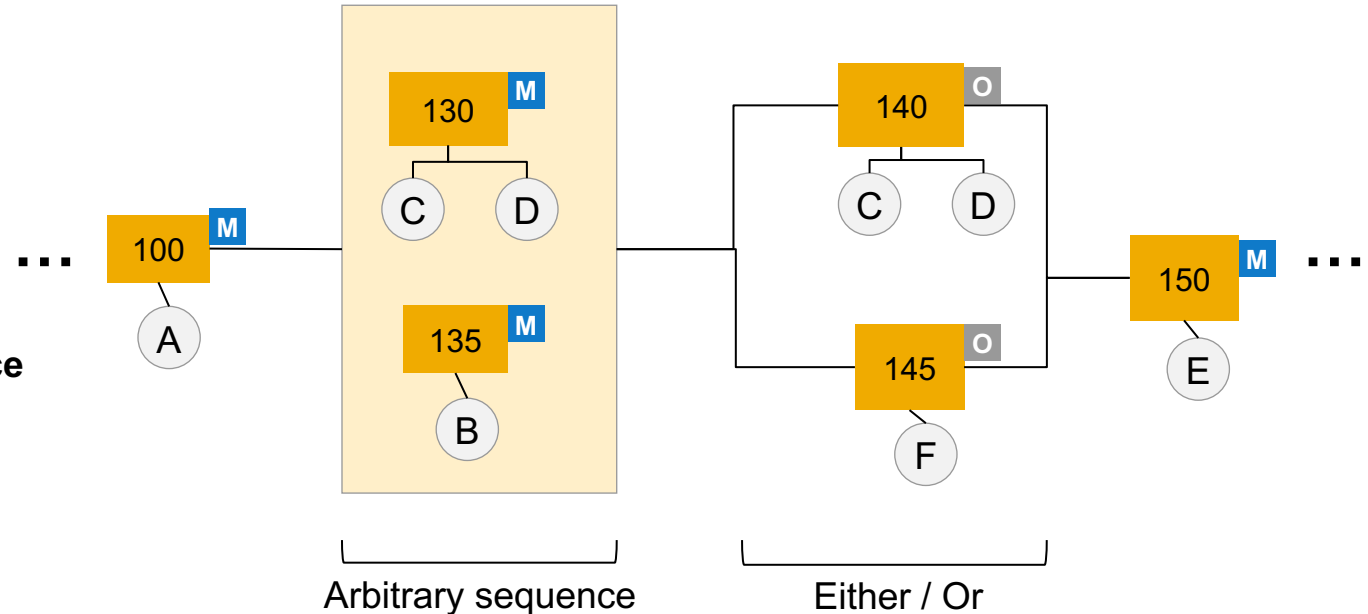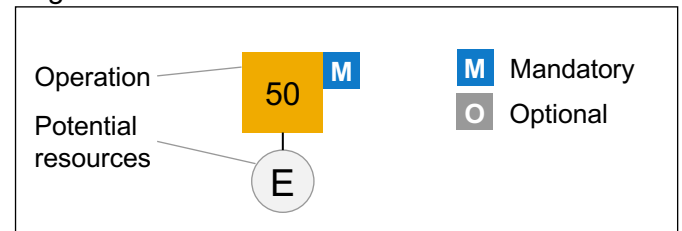
Solution Approach 2018

Building Block A:

Transfer Routing and Resources with all their options result in a Graph/Tree

Arbitrary sequence

Either / Or

Operation — 50 M

Potential resources — E

M Mandatory
O Optional
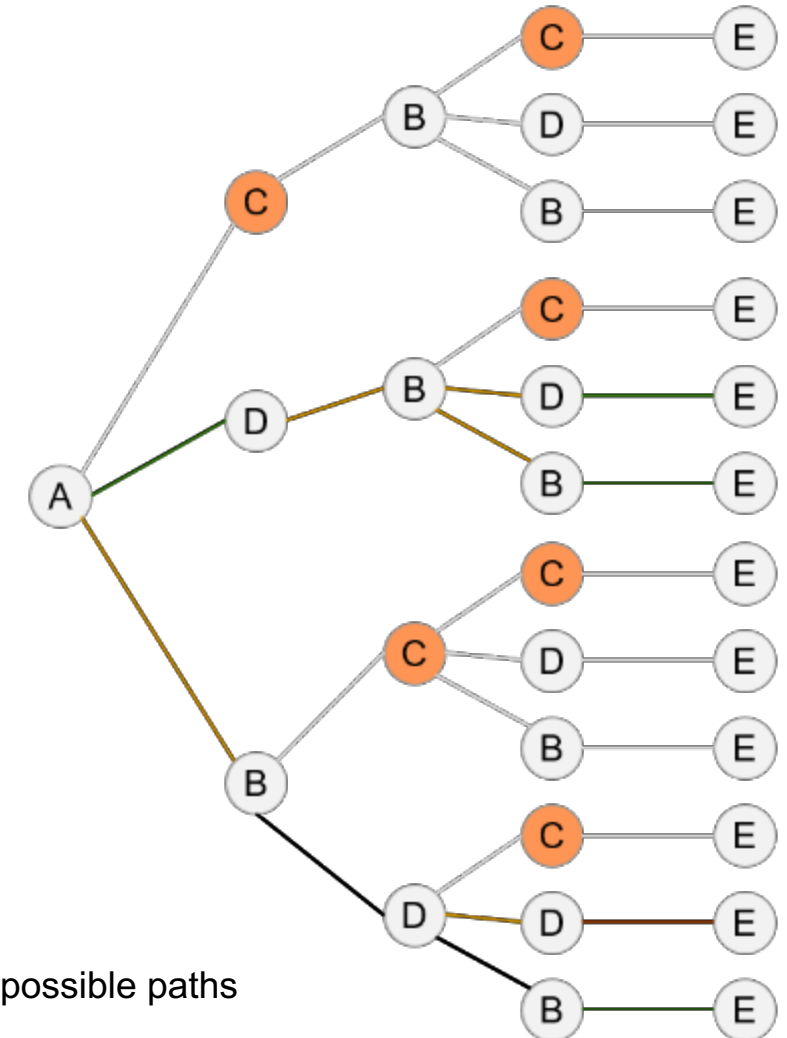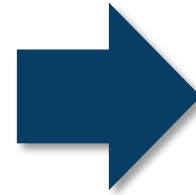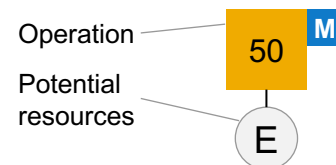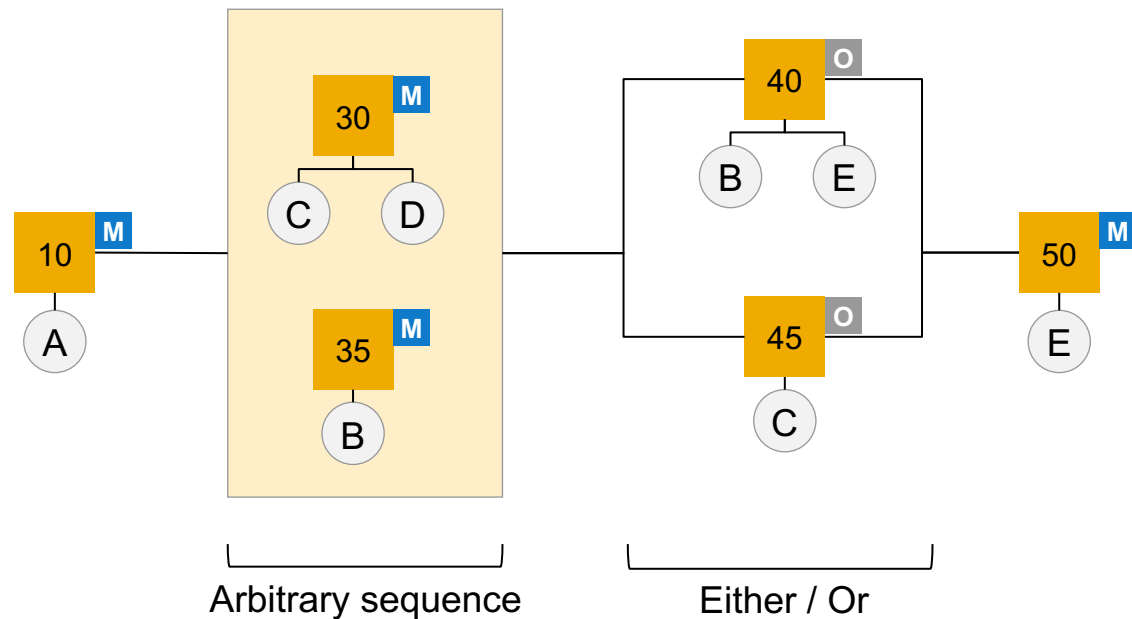
All possible paths

Dynamic Scheduling – ad hoc consideration of events and incidents on the shopfloor – OPC UA as basis for common interoperability architecture

Arbitrary sequence

Either / Or
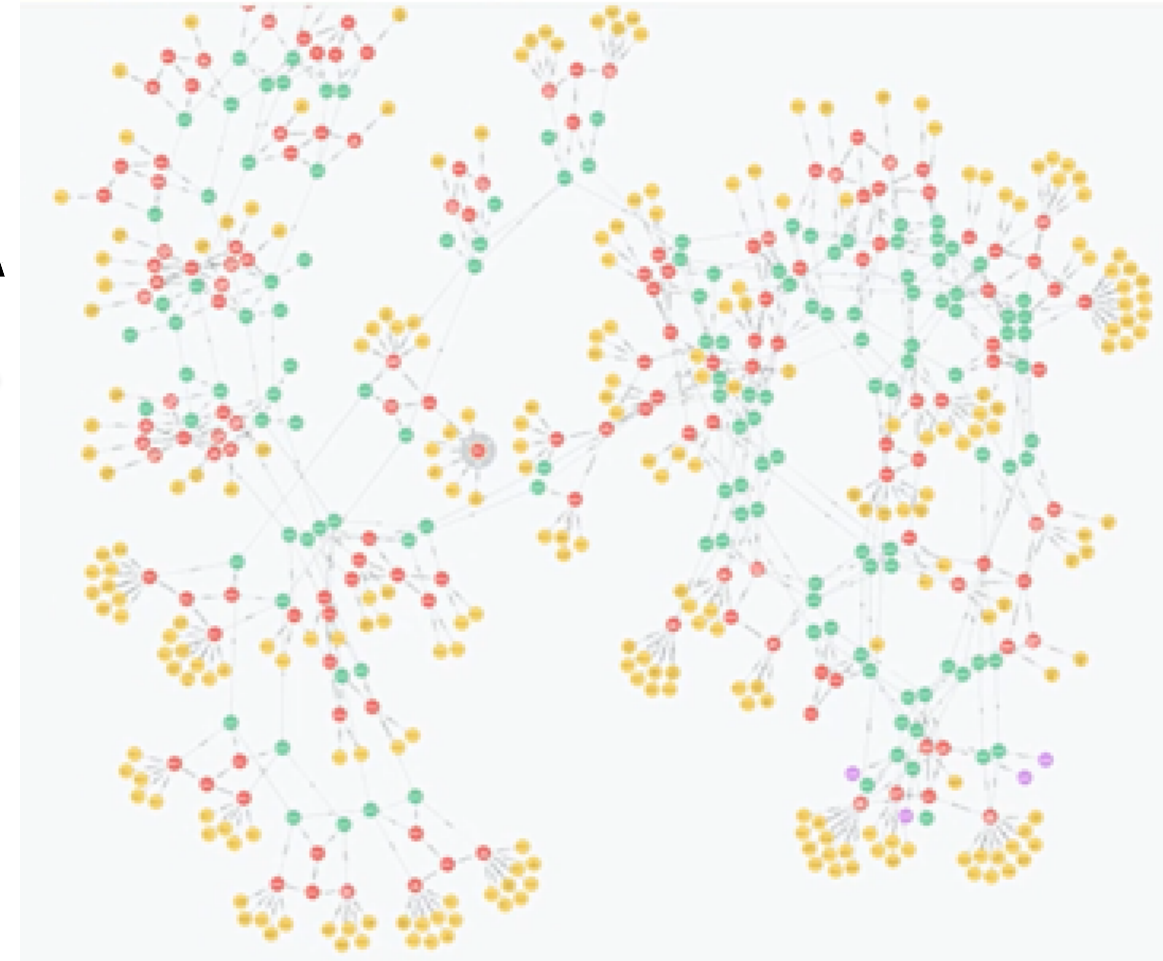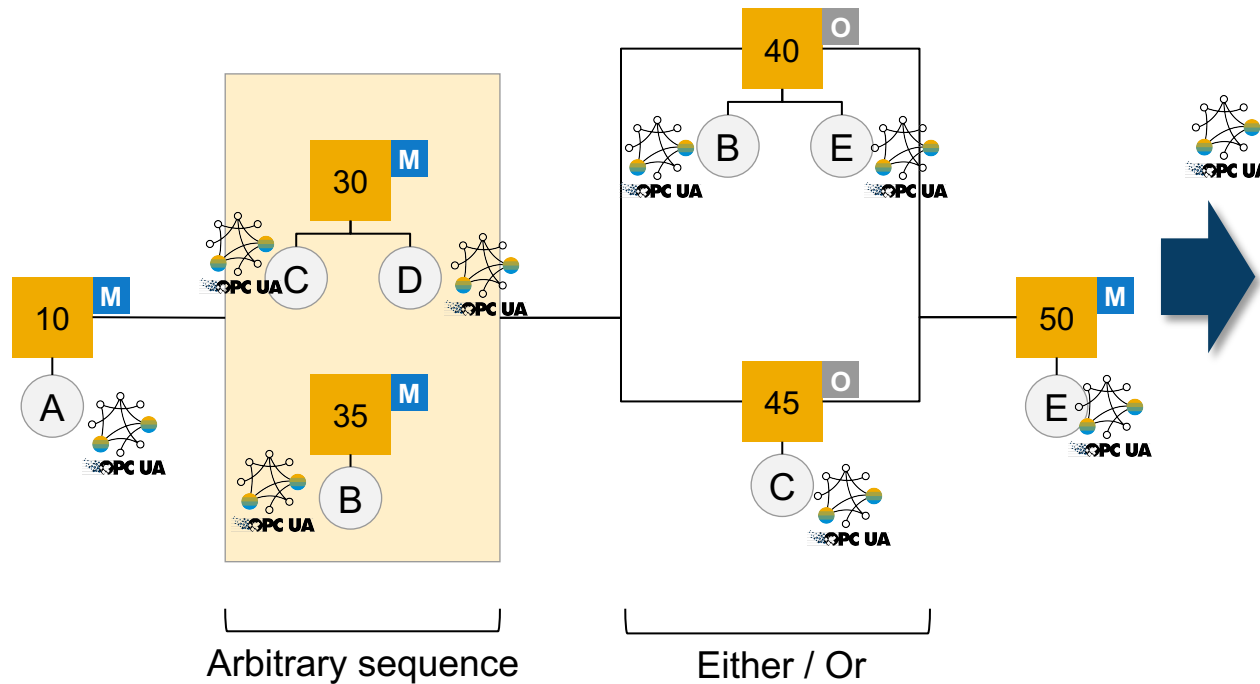
Solution Approach

Apply **Optimization Algorithm** to Simulation Engine whenever a change has occurred

→

the Algorithm itself can be very scenario specific and depends on the target function

→

In case of Autonomous Guided Vehicles, any AGV in move (= any Production Order that is not in work right now) can be re-routed
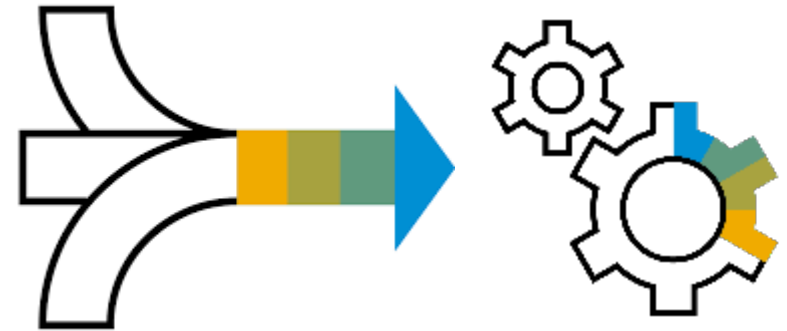
Solution Approach for Showcase and current Customer Project as of 2018

Algorithm runs inside Serva TS Fleetmanager

(here a Genetic Algorithm is applied)
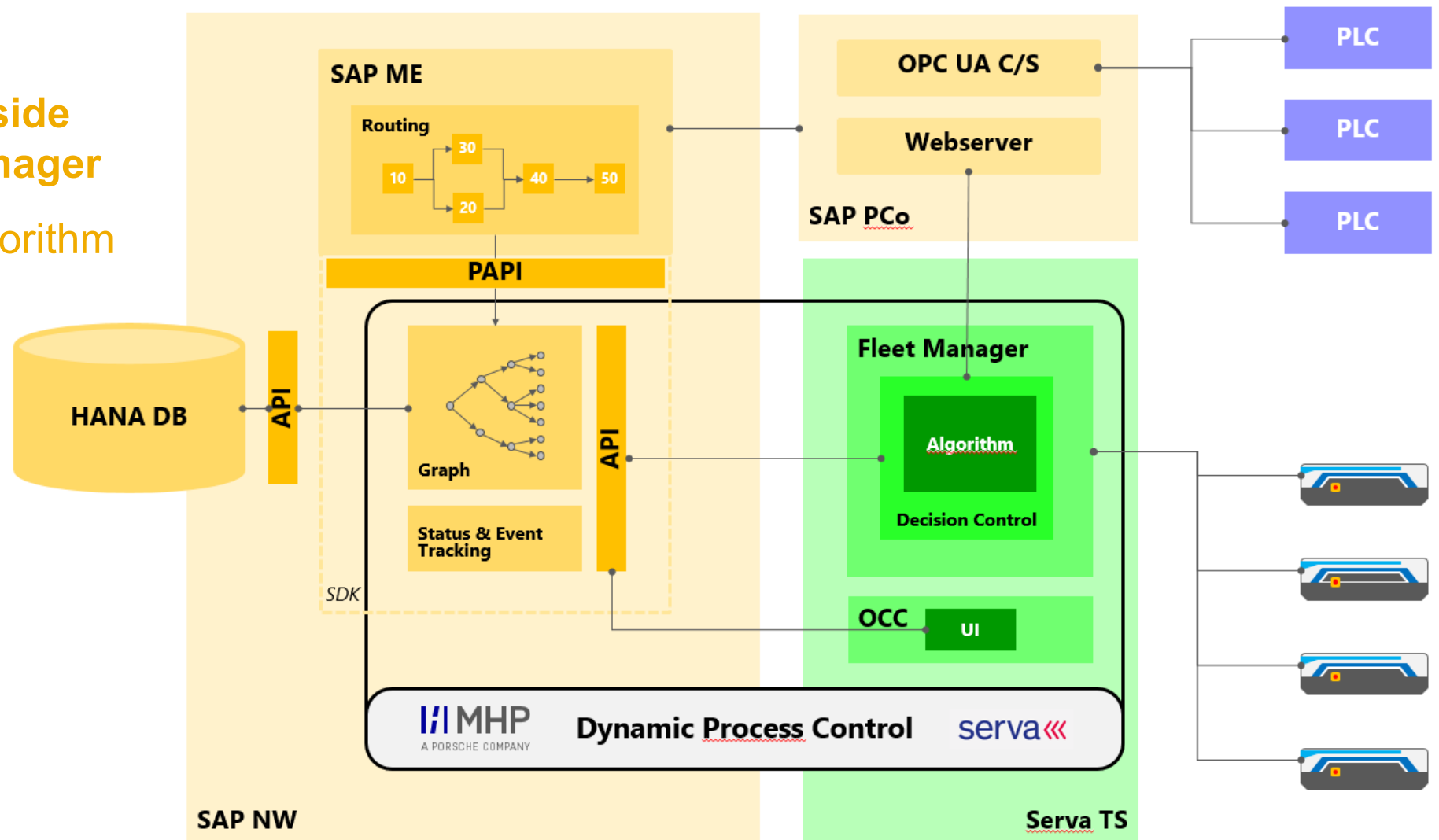
Other use cases and possible usage in SAP context – here first UMATI Companion Spec. approaches

- **Fast overview if production is running**
- **Job overview, job order**
- **Errors, alerts and interruptions**
- **Machine status, state of operation**
- **Information about upcoming manual intervention**
- **Unified identification of machine tools from various suppliers**
- **Data analytics (program run time, errors, interruptions, energy and other consumables)**
- **OEE analysis**
- **Tool management**
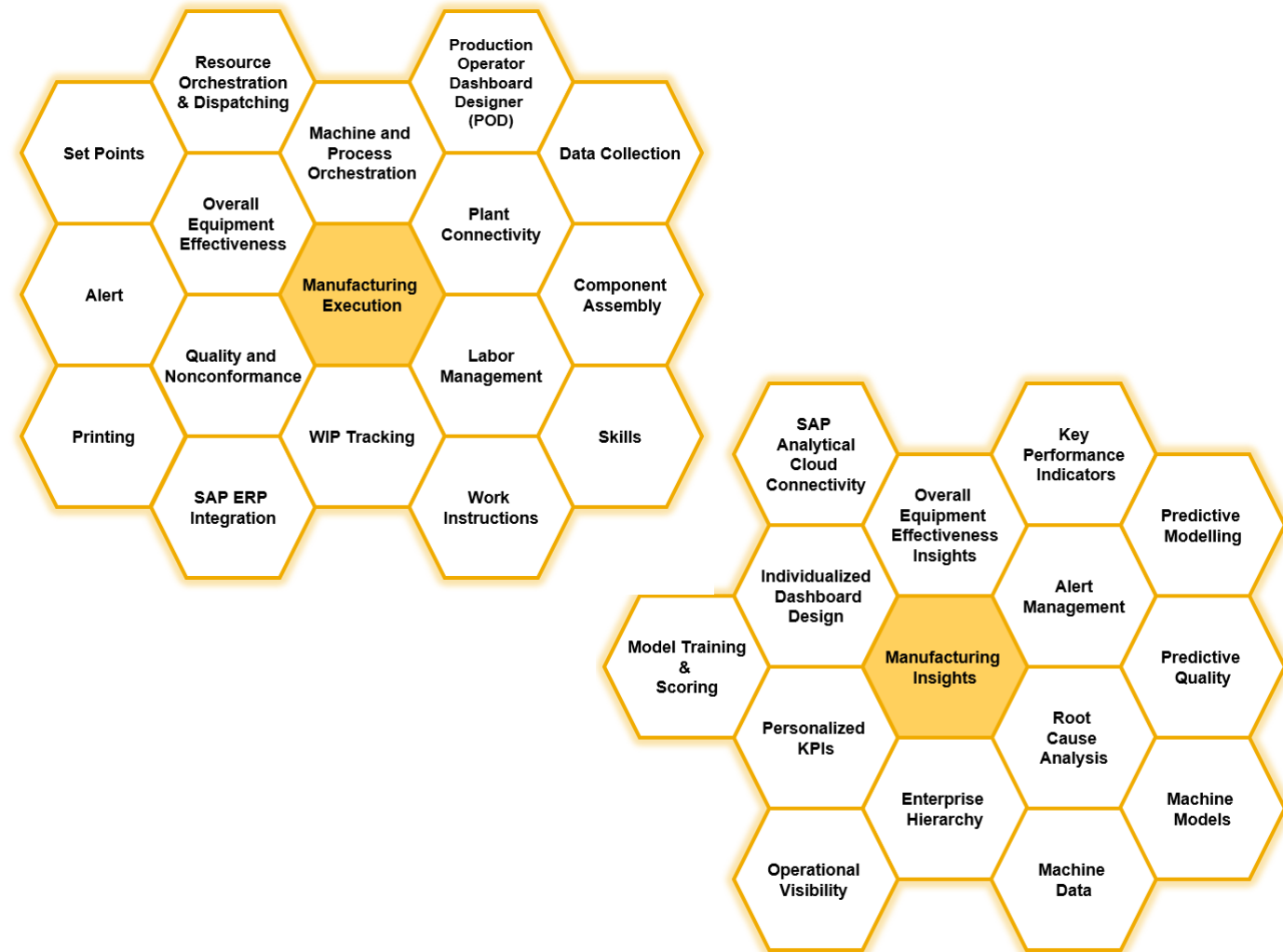
Key Performance Indicators
(UI examples from SAP Digital Manufacturing Cloud for Insights)
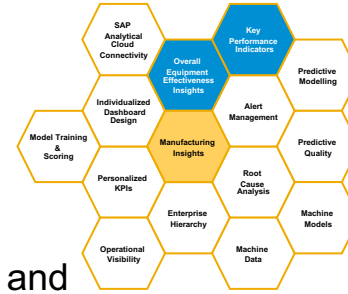
Manufacturing Insights can provide insight on real time sensor data, transactional/operational data from the ERP/MES Systems and calculated KPI's which can help manufacturers to know what happened in manufacturing at the very first time

| Predefined and customized KPI	Global Manufacturing Insights	OEE Insights

▪ Monitor performance using standardized key performance indicators e.g.:
  – First past yield
  – Plan vs Actual
  – Overall Equipment Effectiveness (OEE)
▪ Customize key performance indicators (KPI)
	▪ Real time insights on mobile devices
	▪ Governance for entire enterprise
	▪ Generate and measure global performance across regions, countries and plants
	▪ Subscribe to alerts for ease of monitoring
	▪ Monitor business and operational data in real time in one context
		▪ Overall equipment effectiveness (OEE) analytics
		▪ Shift wise analysis of different losses
		▪ Root cause analysis for OEE losses (availability / quality / performance)
		▪ OEE time element chart provides losses overview
		▪ Compare OEE across plants, lines, work centers
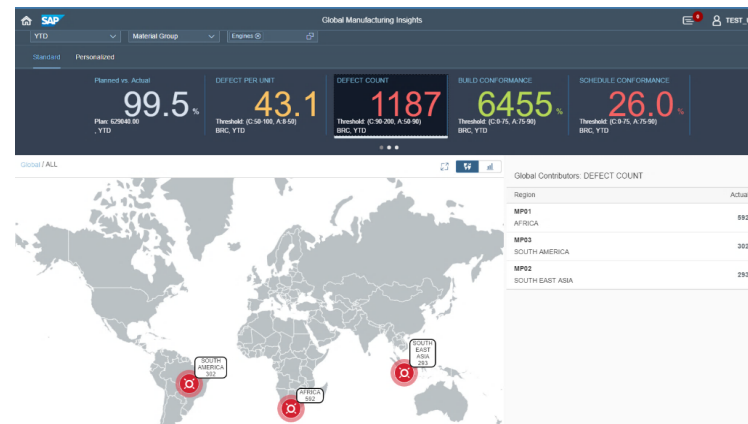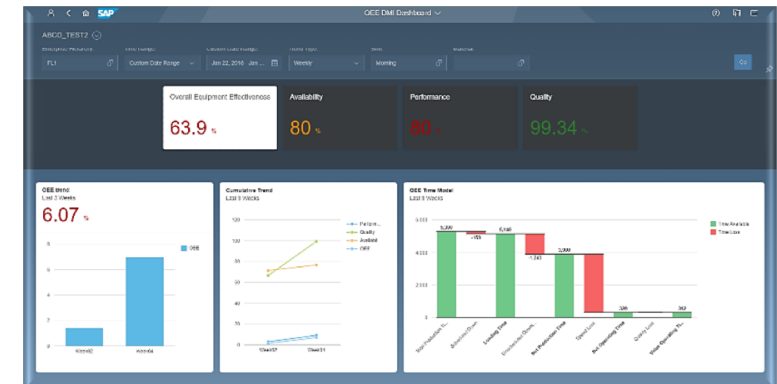
Operational Visibility – Live Transactional Data
(UI examples from SAP Digital Manufacturing Cloud for Insights)
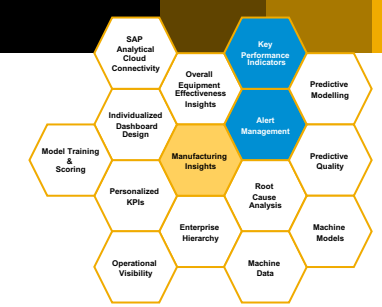
Realtime visibility of Business Data

- Realtime visibility of operational execution of any of the plant
- Realtime visibility of key production information e.g. yield, scrap, 2nd pass yield, production rate, plan vs. actual for a given duration
- Contextualize the sensor data with business data

Realtime visibility of shop floor data

- Real time visibility of machine parameters to get operational visibility
- Possibility to check current value, or a trend
- Possibility to overlap tag value & Business KPIs on top of an image providing more contextual real-time insight

Resource Orchestration & Dispatching
## (UI example from SAP Digital Manufacturing Cloud for Execution)

- Orchestrate labor and resources on the shop floor to achieve maximum availability

- React quickly to unexpected events utilizing built-in intelligence

- Dispatch and sequence operations to reflect the "real world" on the shop floor

- Monitor the entire manufacturing process to optimize resources and execution

- Reflect the reality on the shop floor by visualizing high priority orders, **machine breakdowns**, missing labor and **production progress**
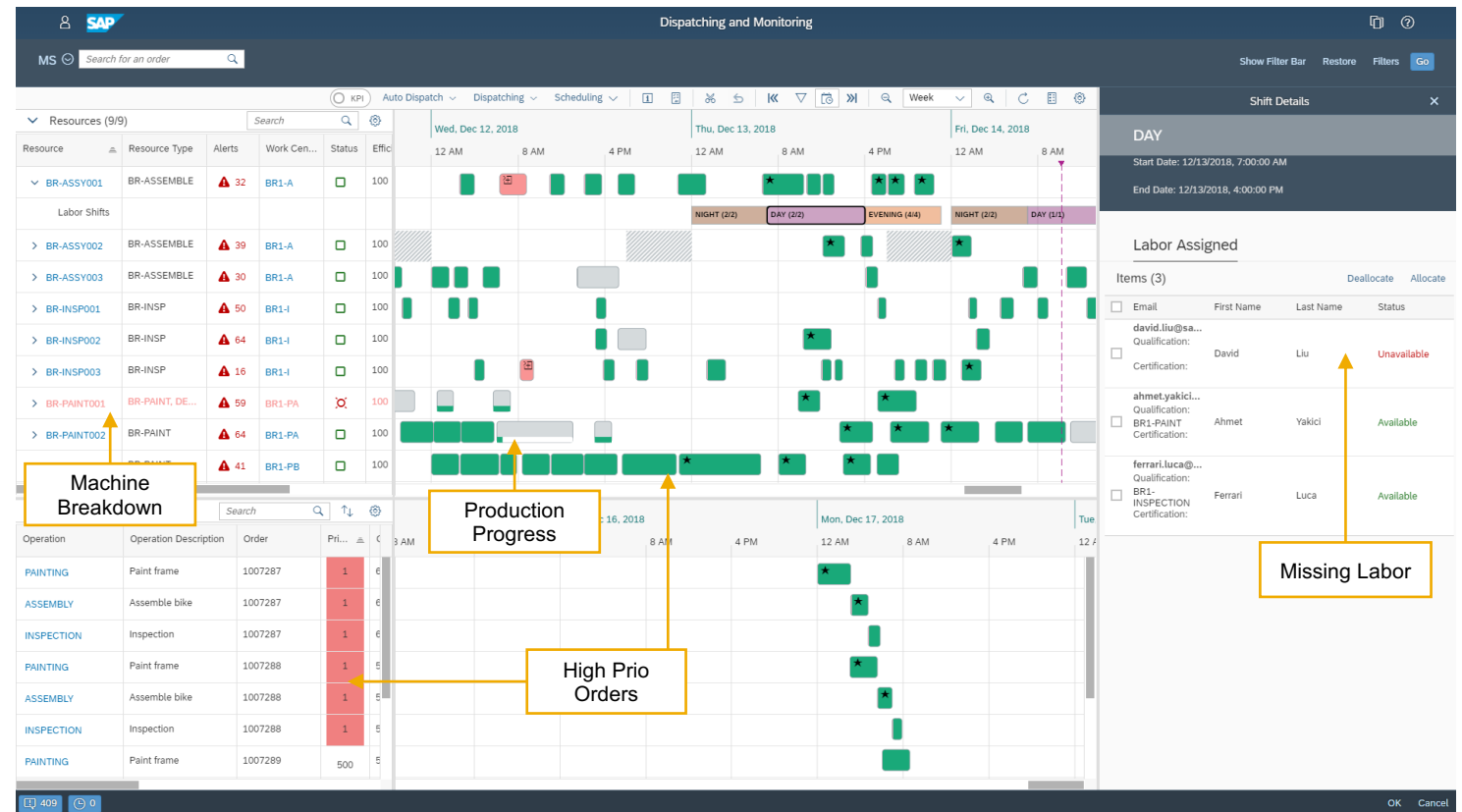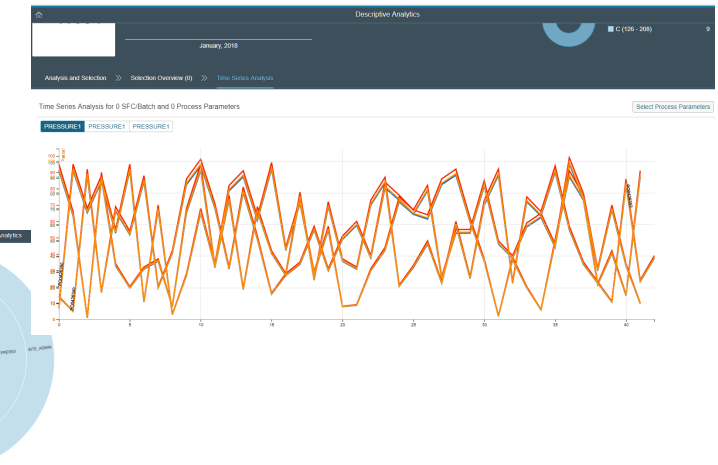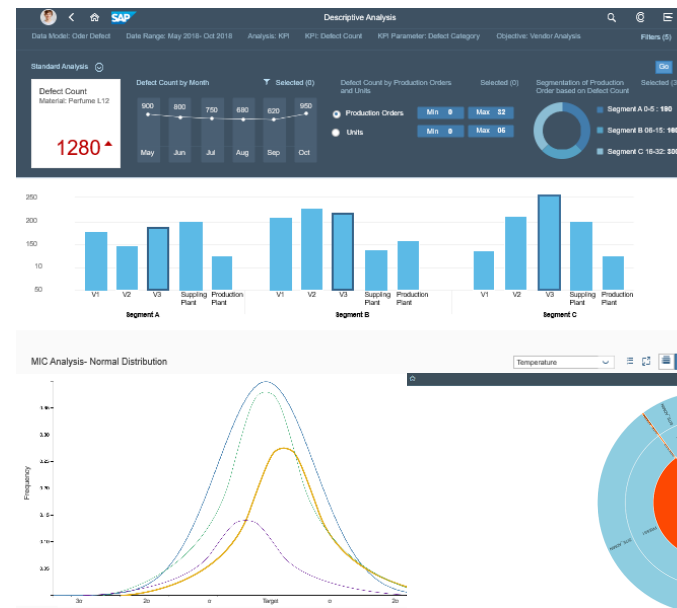
Predictive Quality
(UI examples from SAP Digital Manufacturing Cloud for Insights)
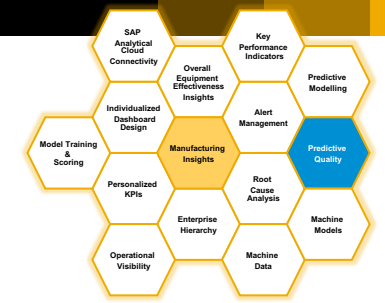
Key Capabilities

- Expose **manufacturing big data (IT/OT data)** in the pre-defined manufacturing semantics

- Intuitive workbench to Analyze & Correlate multi-tier data related to 3Ms of manufacturing
  - 3Ms = Machine, Material, and Method

- Simplify predictive model building and model life cycle management to keep pace with the operations

- Near real-time evaluation/scoring of predictive models and trigger corrective actions to the right people

Predictive → **Quality Improvements** ← **Deep Dive**

Thank you.

Contact information:

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Industrie 4.0 and Digital Manufacturing

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SAP Run Simple