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CLM »»

Closed Loop Manufacturing

The value of integrated, smart manufacturing

Udo Buschbeck, Hans Johansson, Johan Nordling & Mikael Palm,
Siemens Digital Industries Software

The value of integrated, smart manufacturing

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Closed Loop Manufacturing overview

PLM: Digital Manufacturing Preparation

MOM: Digital Production Execution

Summary

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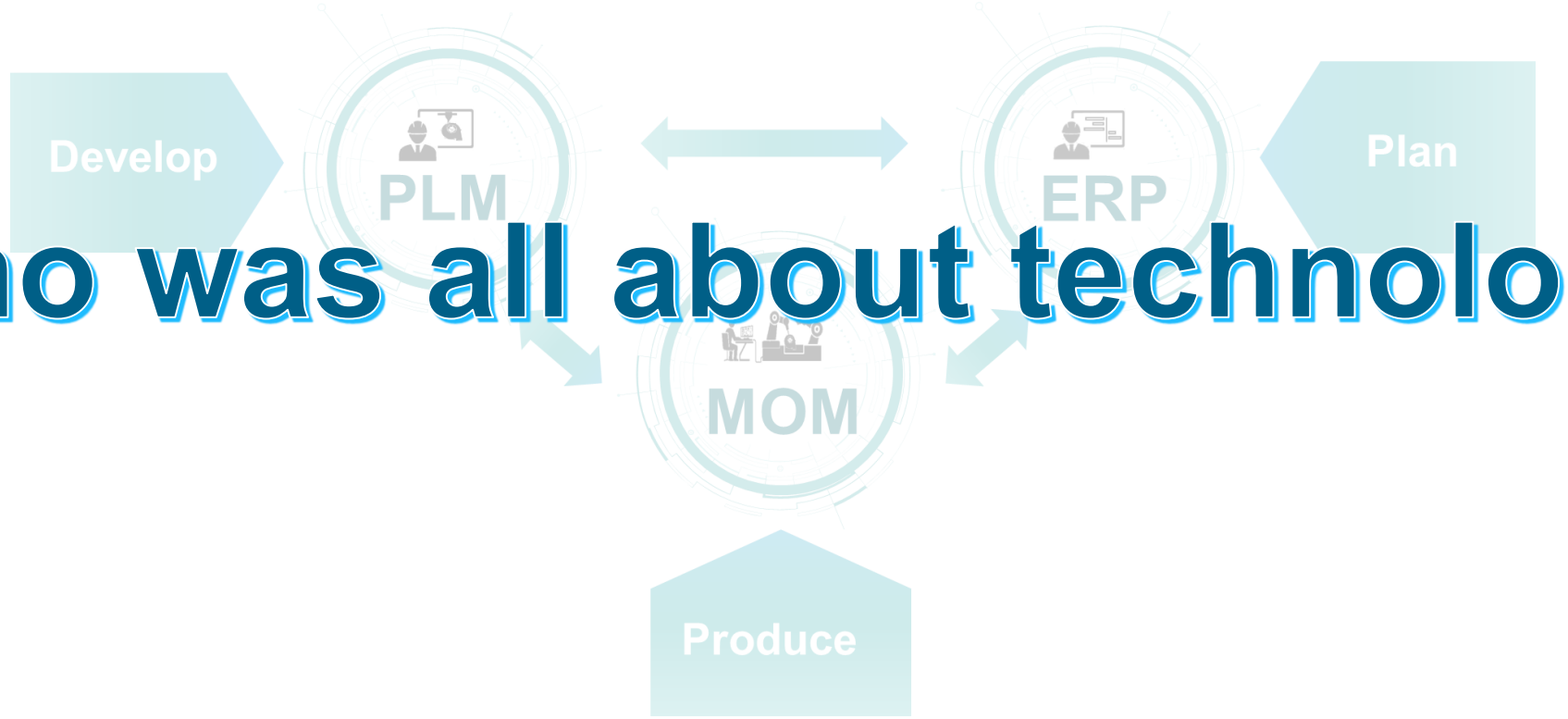

Demo was all about technology …

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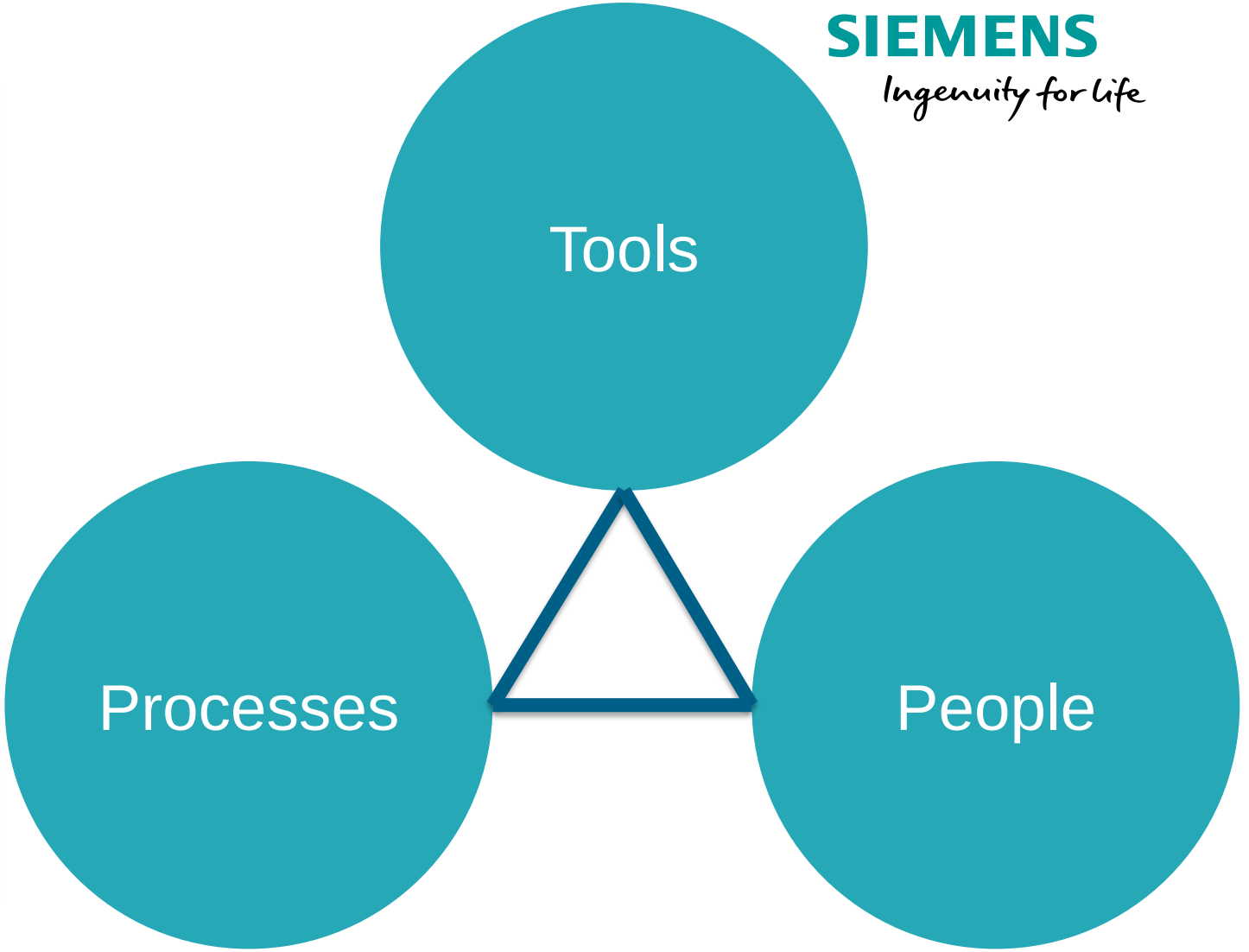

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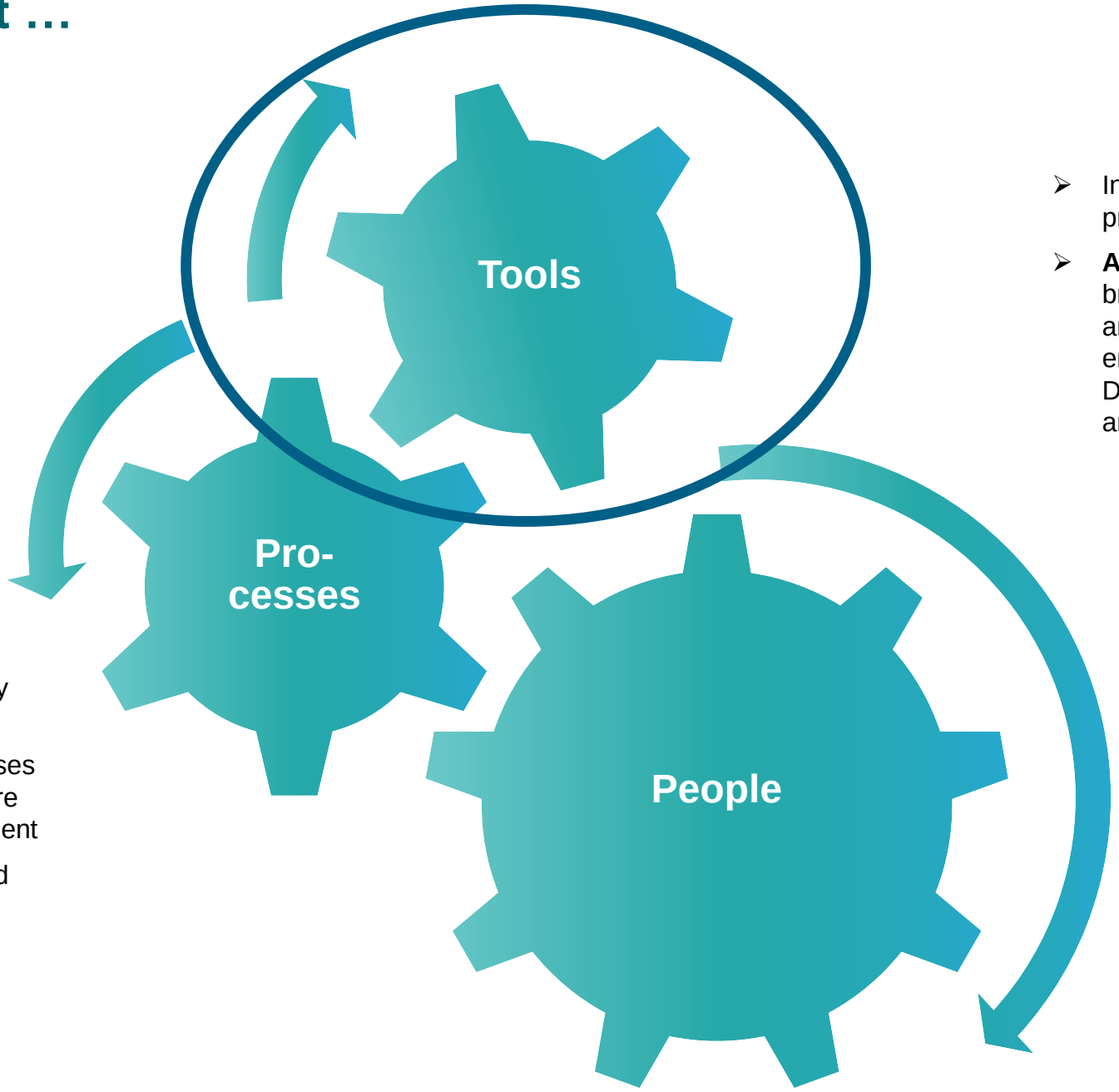
What's important …



- Integration tools are available and proven (>450 customers)
- **Active Integration Solutions** bridges the gap between PLM and ERP, MES, or other enterprise applications through Data Integration, Data Federation and Process Integration

- Processes are described pretty well, but often silo scoped
- Discussing end-to-end processes requires efficient change culture supported by senior management
- To-be process definition should focus on seamless cross organizational collaboration.

- People and organizations are asked to change how they work, so organizational change management should be part of the plan
- Right setup of project team is key (experienced, encouraged, commonly accepted)
- Everybody needs to understand what's new and changed, so don't forget teaching the benefits of new processes and how to operate them

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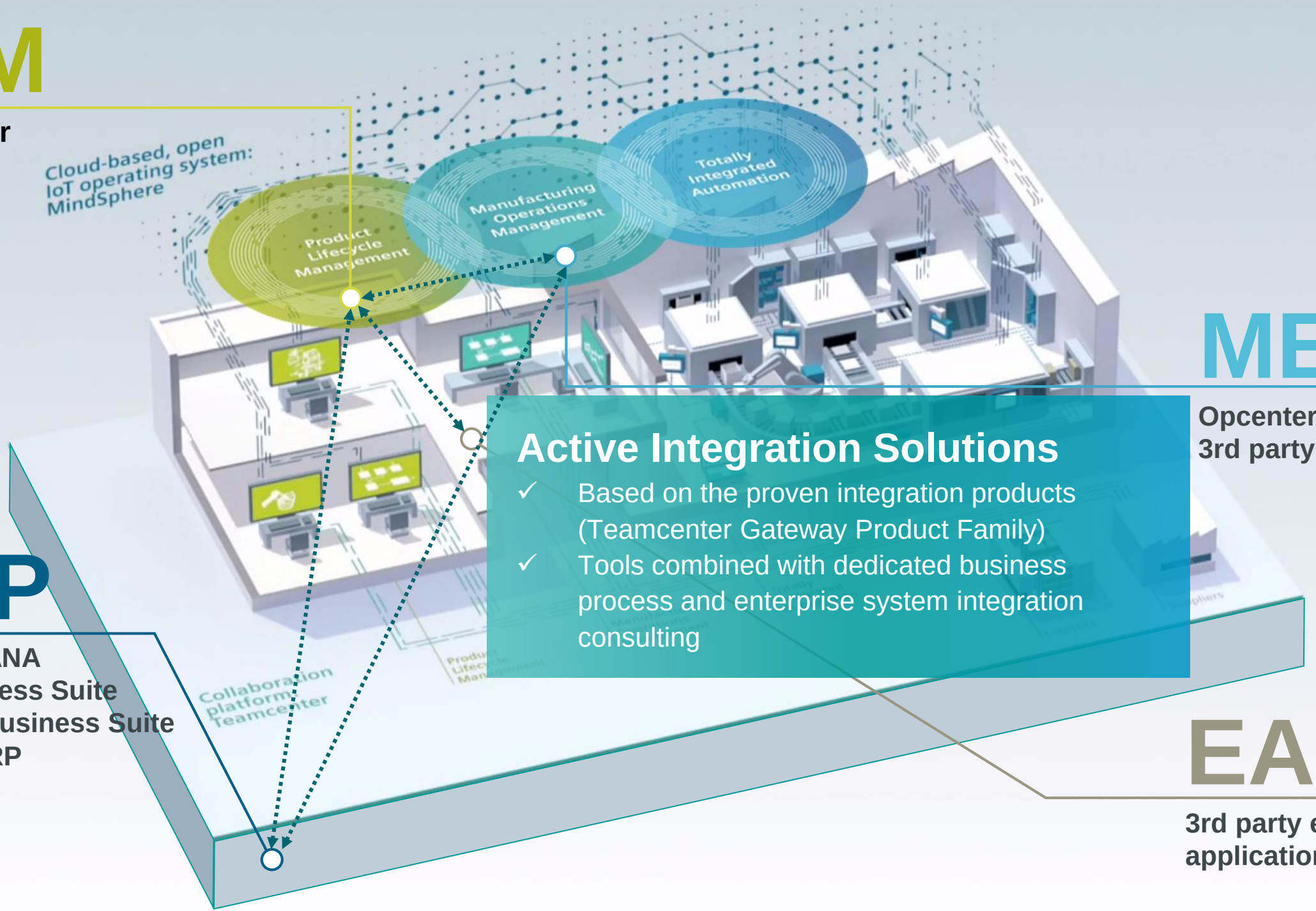
PLM

Teamcenter



MES

Opcenter Execution
3rd party MES

Active Integration Solutions

- ✓ Based on the proven integration products (Teamcenter Gateway Product Family)
- ✓ Tools combined with dedicated business process and enterprise system integration consulting

ERP

SAP S/4HANA
SAP Business Suite
Oracle E-Business Suite
2nd tier ERP

EA

3rd party enterprise applications

Key Elements of Active Integration

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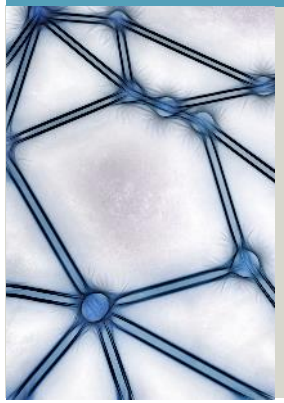
Connectability



- Tight integration between systems
- Configurable business process templates
- Aligns data models between domains
- Supports broad range of integration patterns

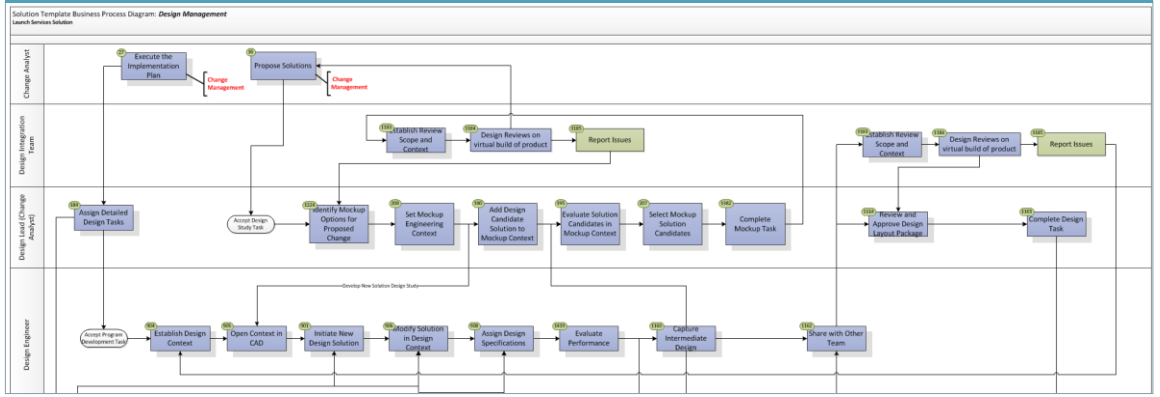
Manageability

- Robust and secure
- Easily extensible and modifiable
- Full admin & monitoring tool suite
- Track and log all data transfers

Usability

- Fully integrated into Active Workspace
- Reliable
- Transparent to users
- Upgradeable and maintainable
- High performance

Implementation Methodology + Services



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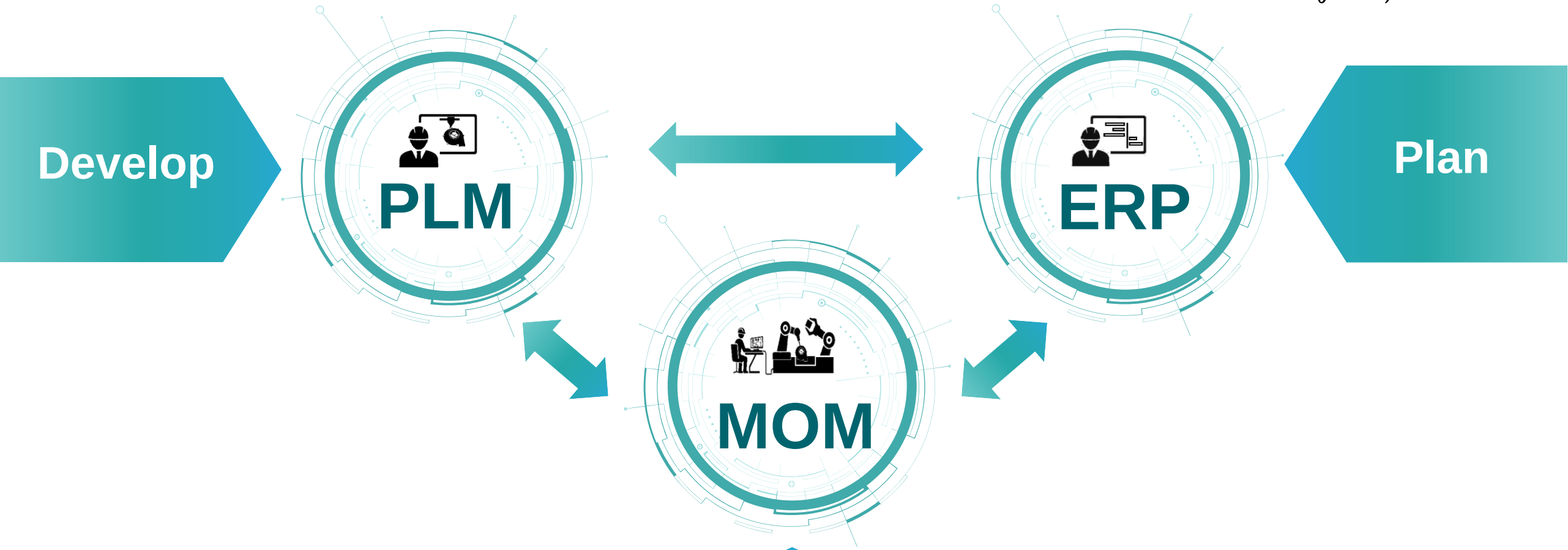
Closed Loop Manufacturing



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PLM:
Digital Manufacturing Preparation

Johan Nordling

The reality for many Manufacturers today

Silos of systems & processes with manual handoffs and redundancy

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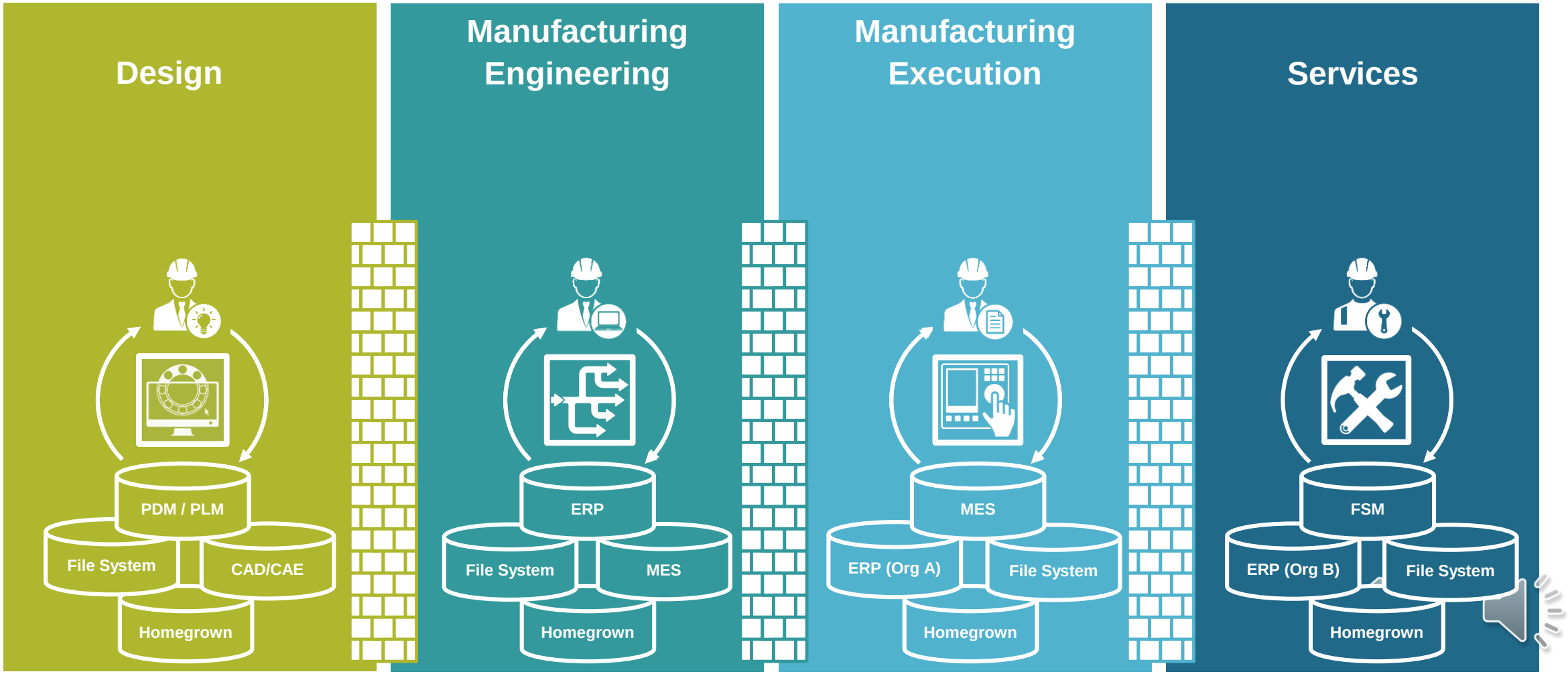

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How do you Realize Digitalization in Manufacturing?

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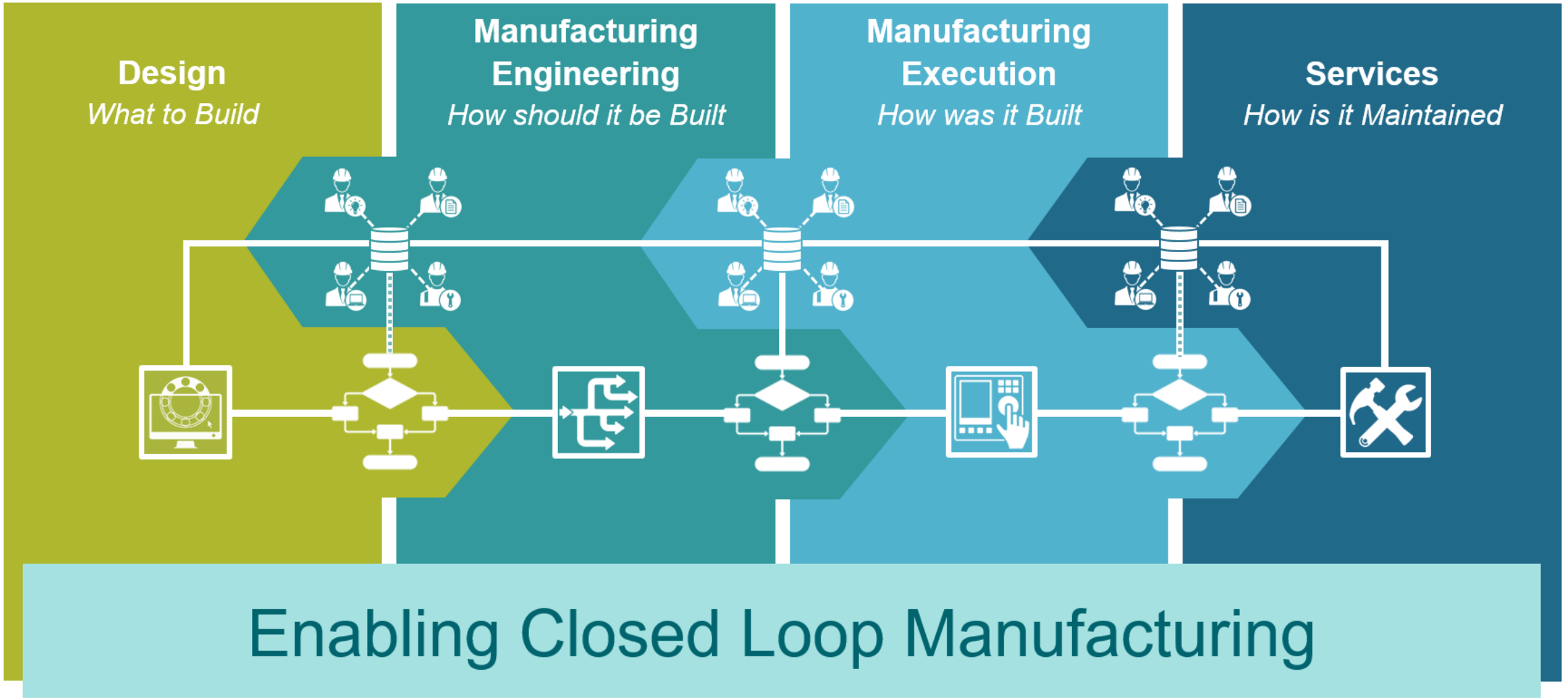

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Realizing the Production Digital Twin

Design and Execution Continuity via the Digital Thread

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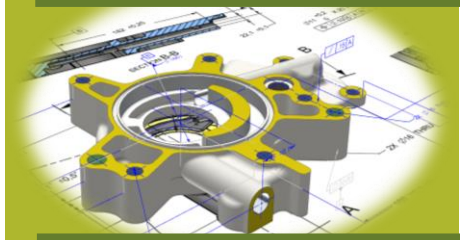
Design
What to Build

Engineering BOM

CAD BOM

Design for Mfg.



Design for Quality

Engineering Change

Manufacturing Engineering
How to Build It

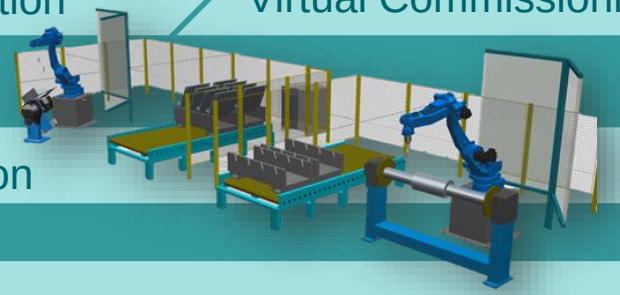
Manufacturing BOM

Manufacturing Preparation

Process Validation

Simulation

Virtual Commissioning



Plant / Line Design & Optimization

Model Based Quality

Manufacturing Data & Change Management

Execution
When/Where to Build it

As-Built

Routings

Work Instructions

Inspection Plans

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High Value Digital Thread Solutions

Manufacturing processes

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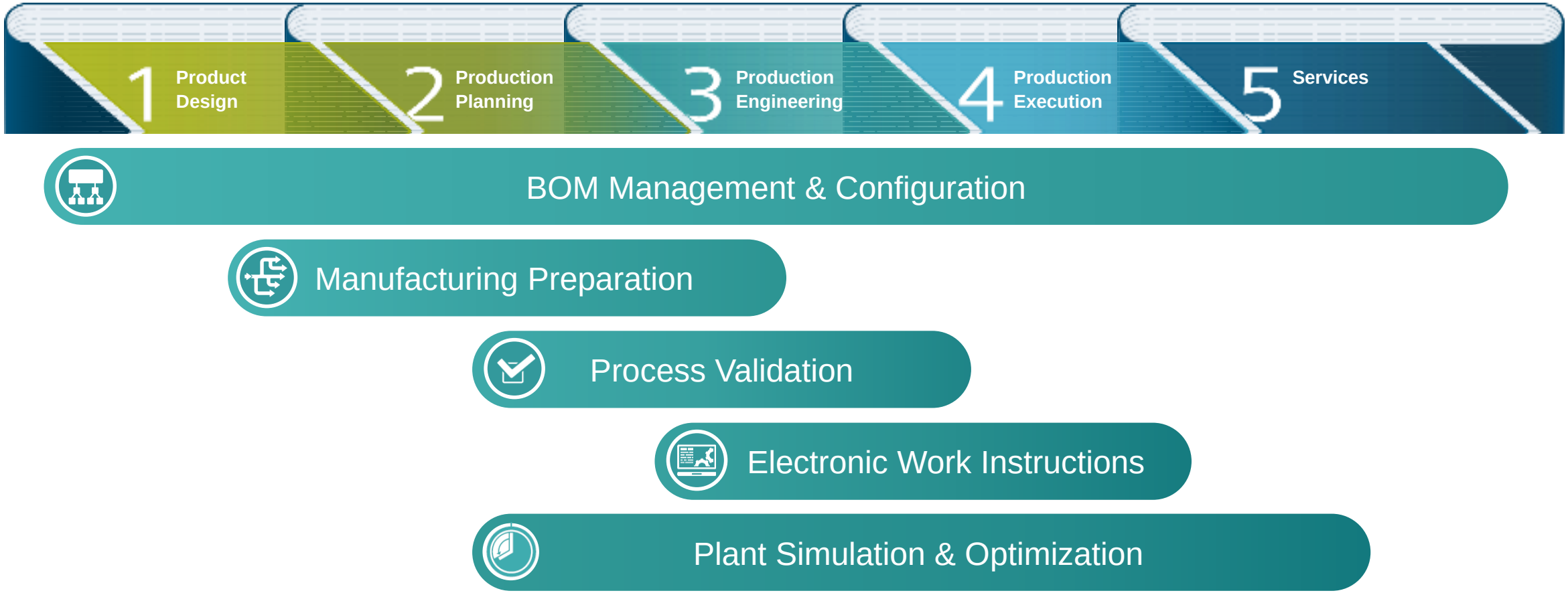

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Manufacturing processes

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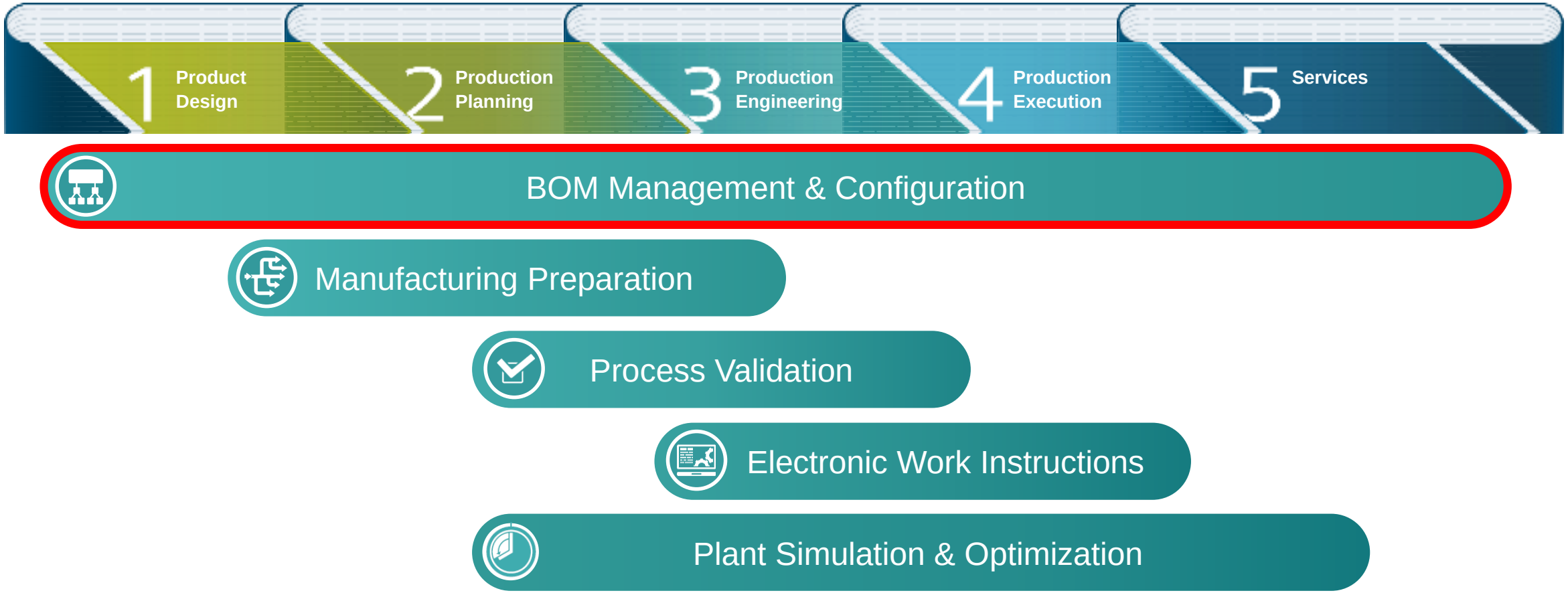

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Manage your Product Configuration & Complexity

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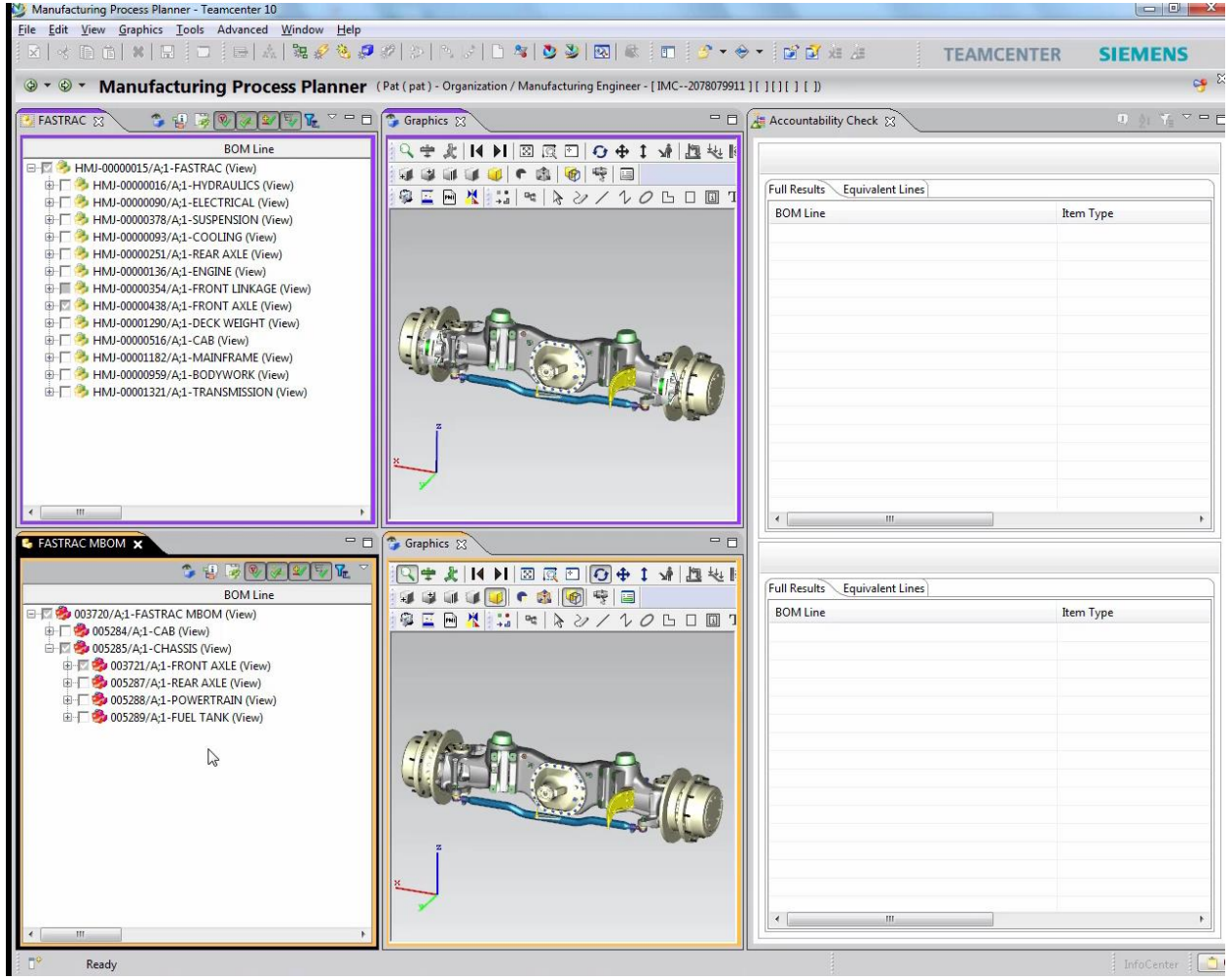
Challenges

- Increasing product complexity
- Manual entry across systems
- Disconnected from Engineering
- Speed of change

Key Benefits

- Design collaboration
- Improved accuracy & quality
- Timely reaction to critical changes



EBOM

MBOM

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Manage your Product Configuration & Complexity

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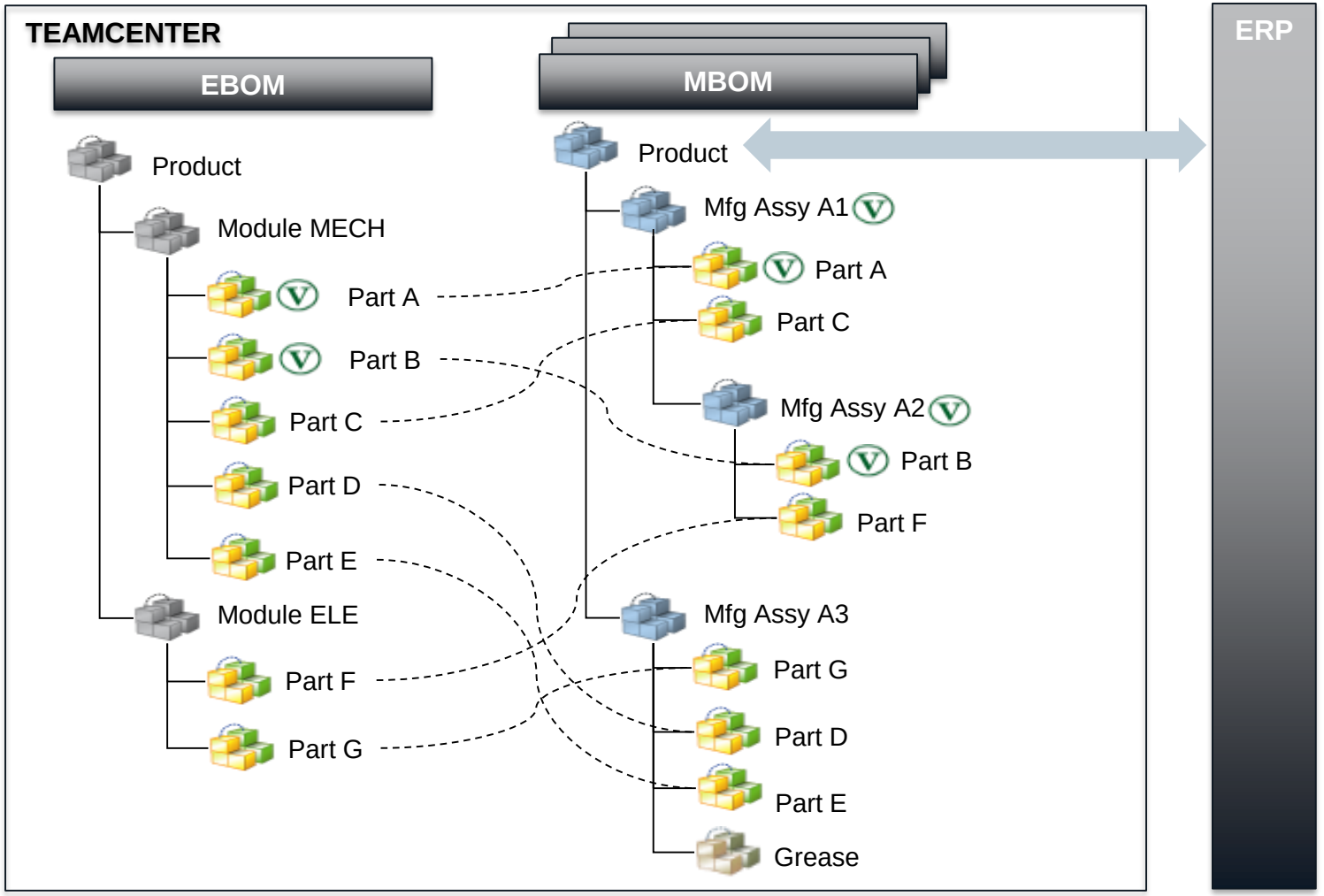

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Manufacturing processes

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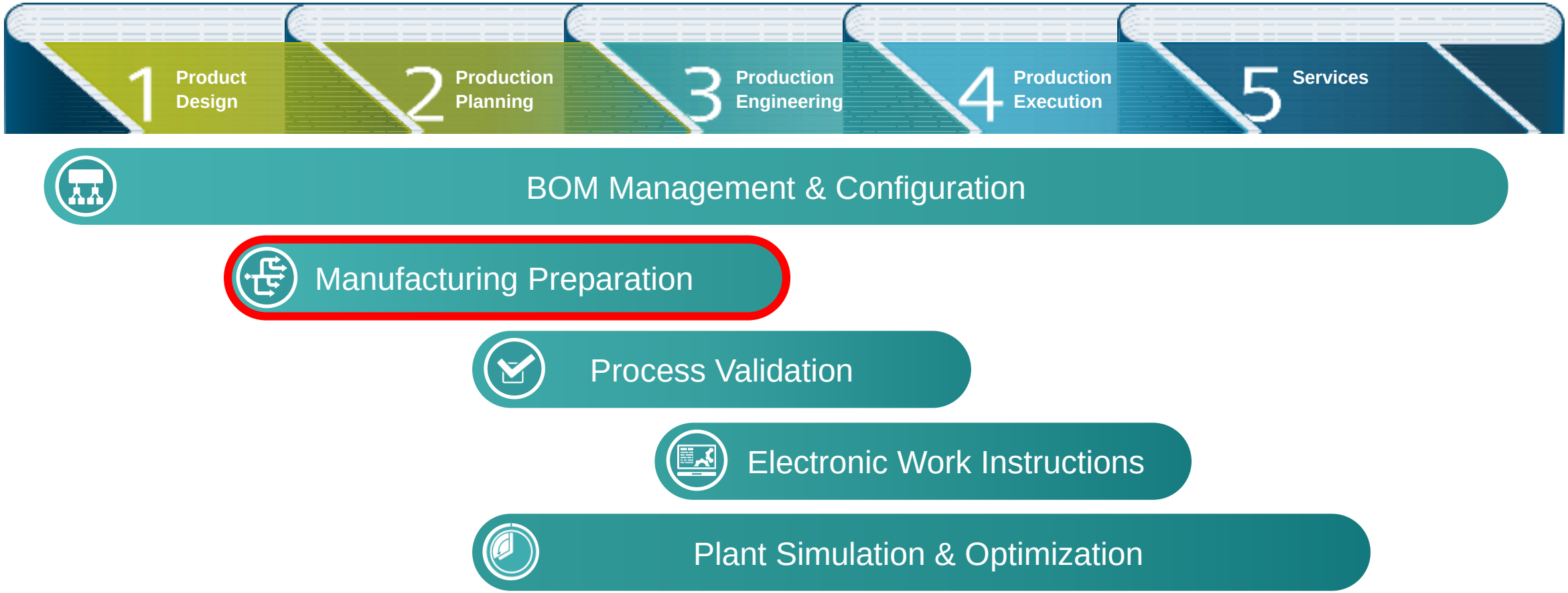

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Manufacturing Assembly Preparation

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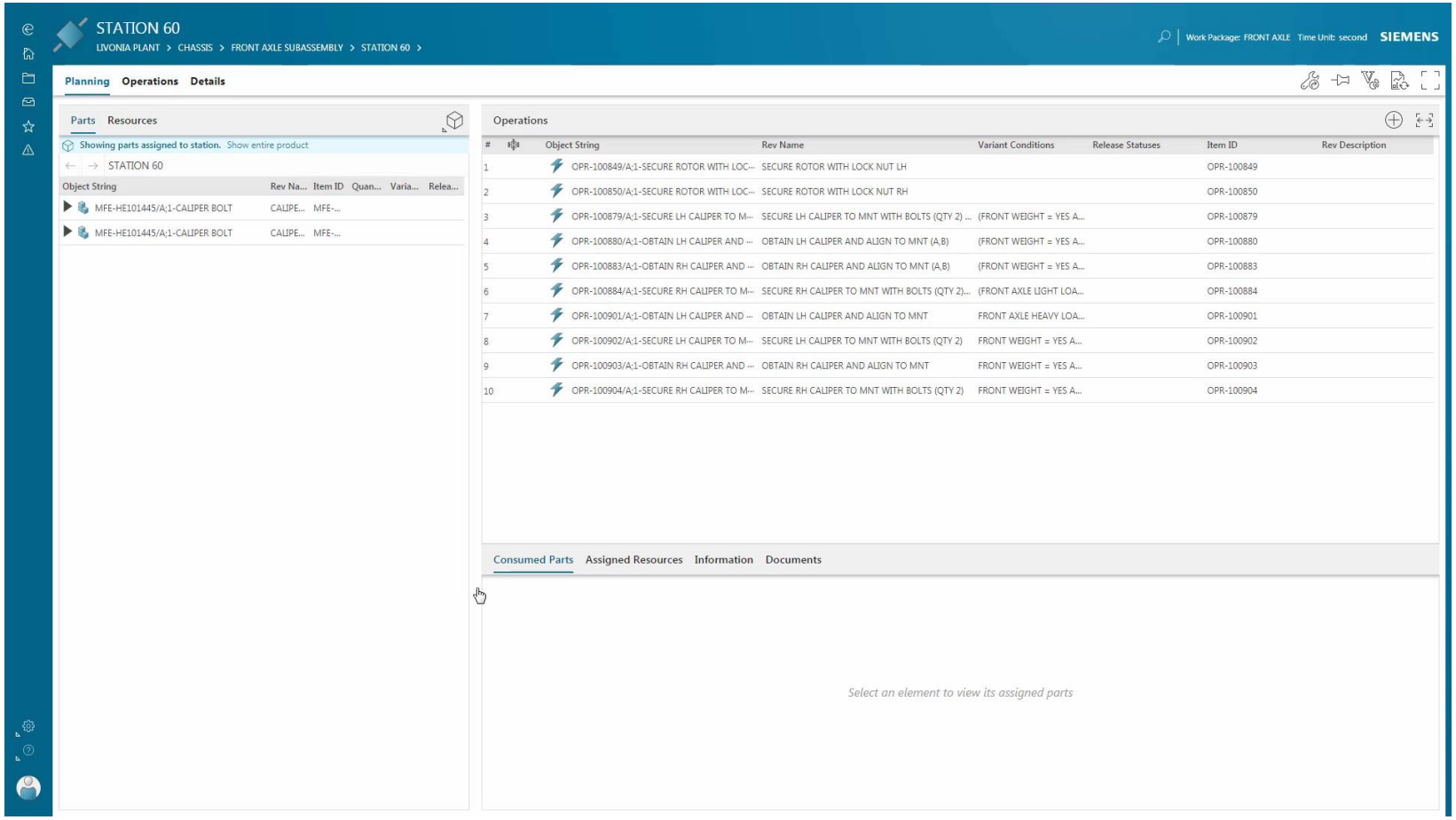
Challenges

- Disconnect from Engineering
- Reactive vs. planned changes
- Limited best practice / re-use

Key Benefits

- Faster NPI
- Early identification of potential resource gaps
- Improved quality with re-use of standard practices across sites



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Manufacturing processes

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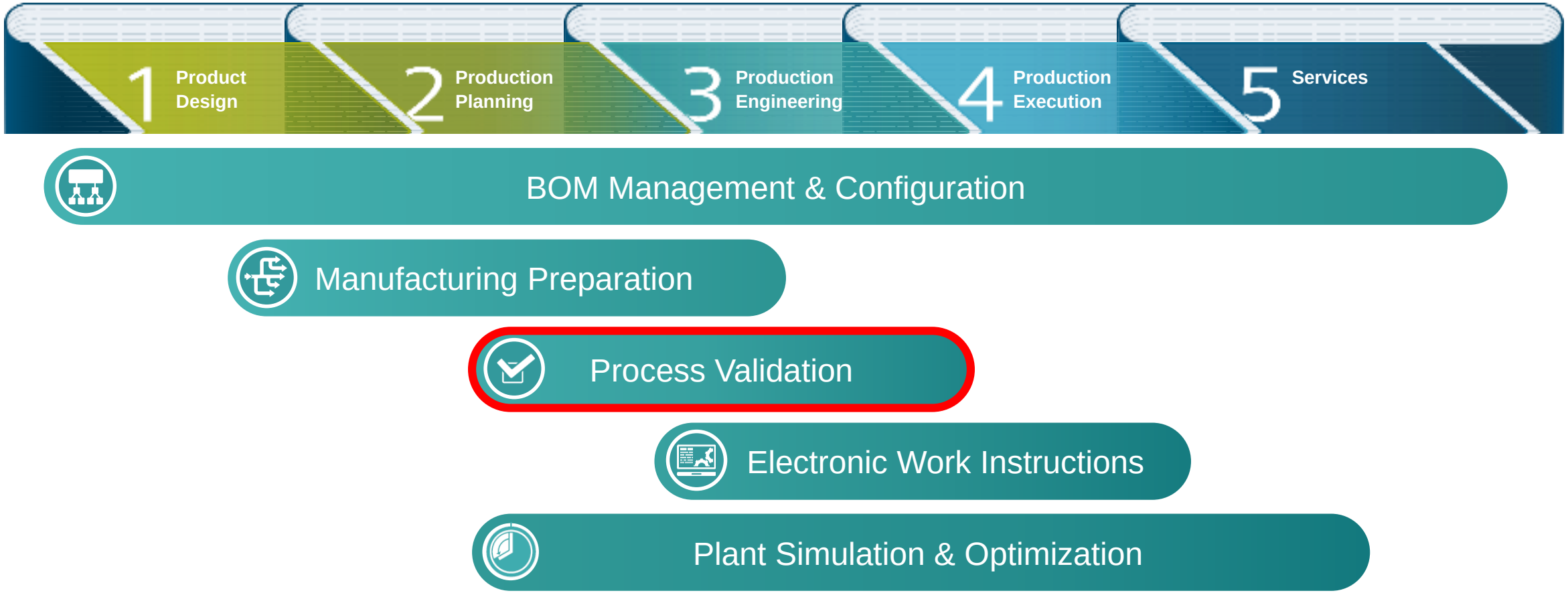

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Simulation & Validation
Digitally Validate Your Plan

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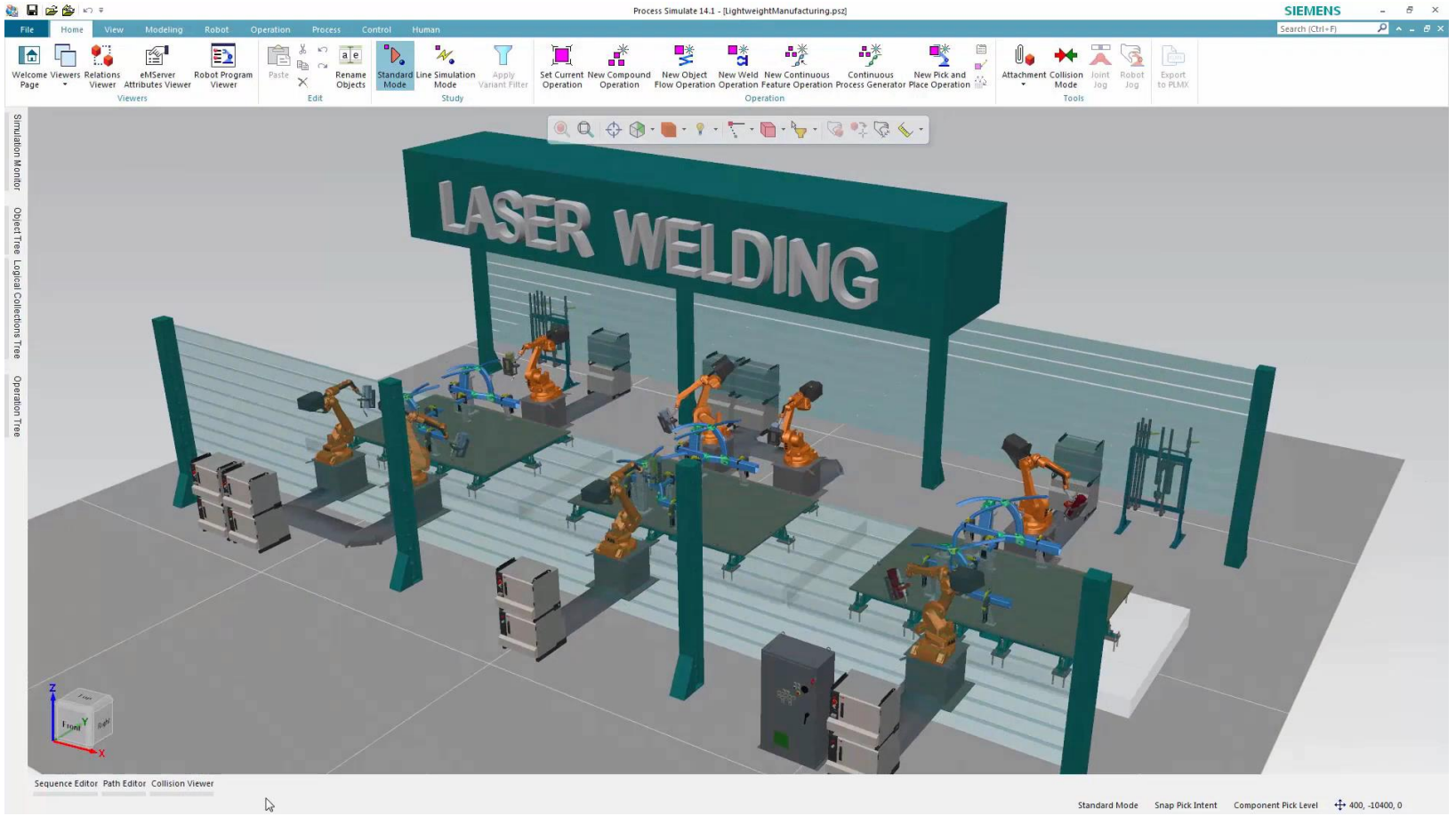
Challenges

- Time spent collecting data
- Latest changes not captured
- Late issue detection

Key Benefits

- Reduce shop floor errors and rework
- Right-first-time manufacturing plans
- Shorten system ramp-up time



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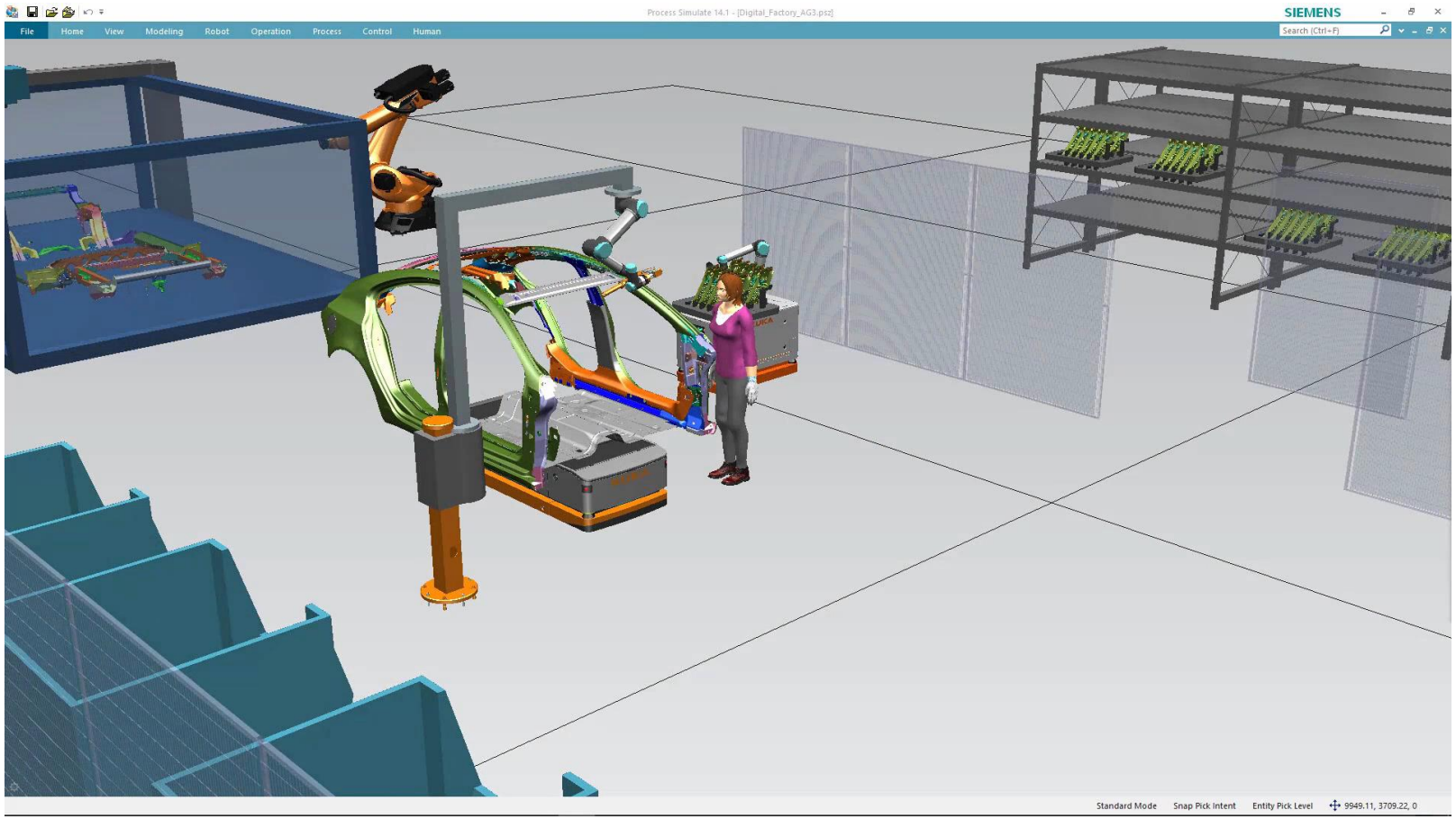

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Manufacturing processes

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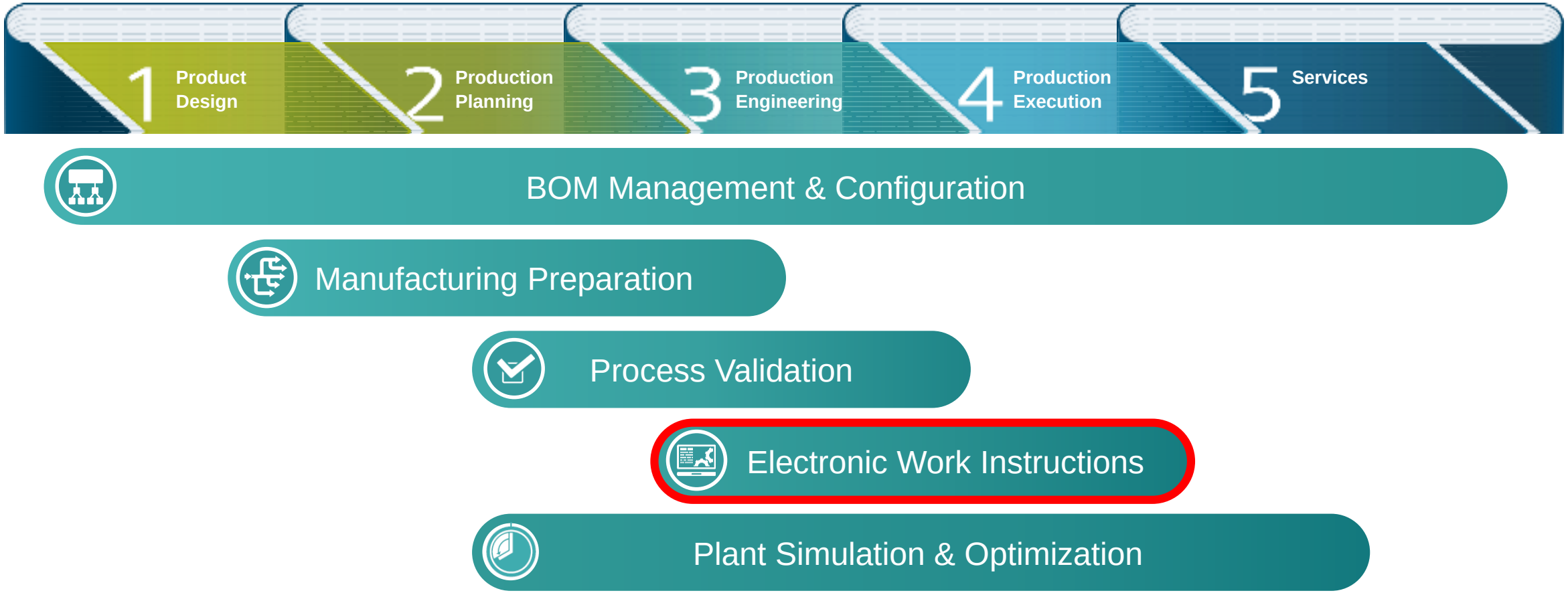

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Production Support

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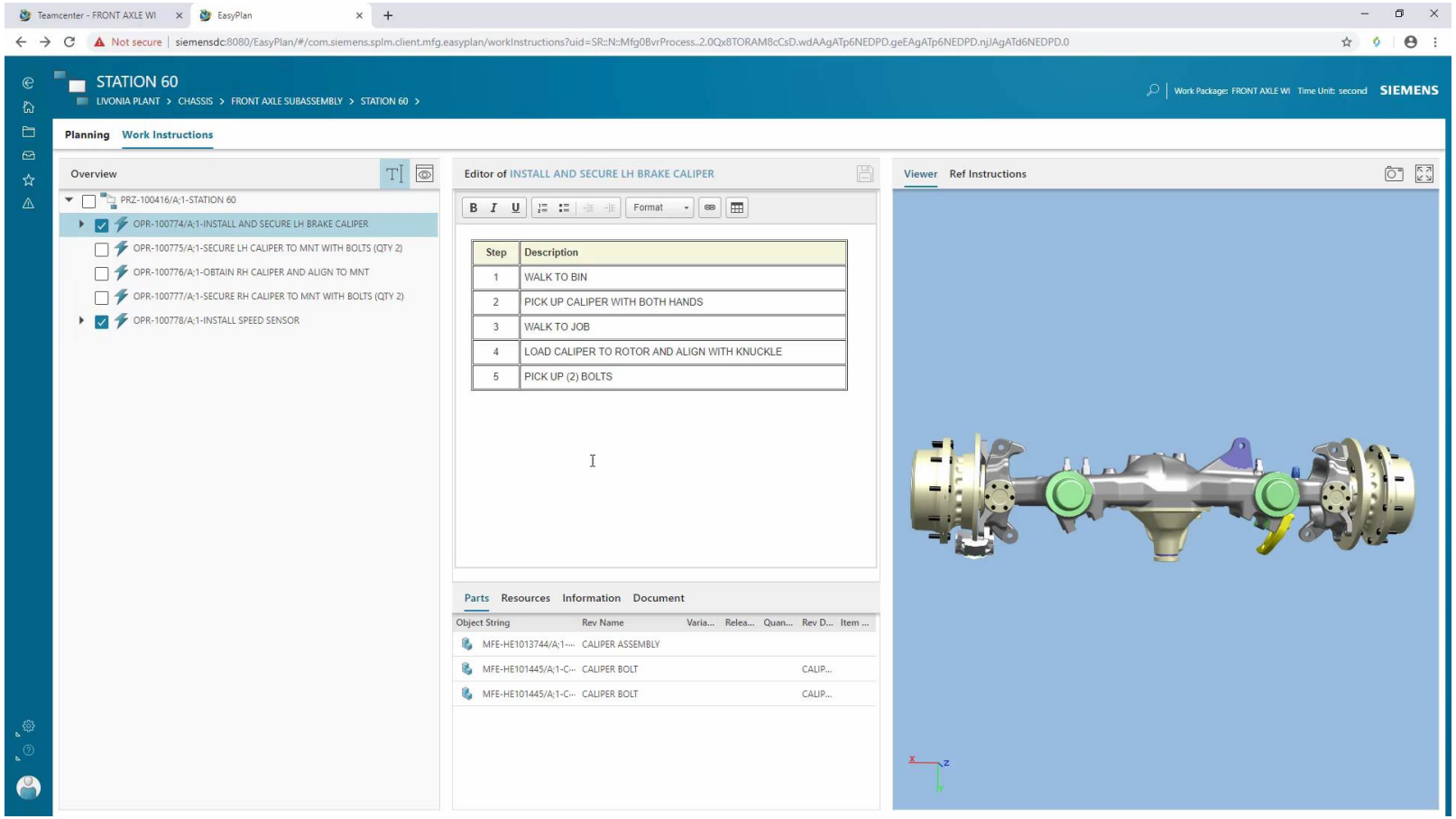
Challenges

- Uncontrolled documents
- Late reaction to changes
- Limited clarity with increasing product complexity

Key Benefits

- Reduce effort to create and maintain work instructions
- Increased speed & quality
- Configured to order



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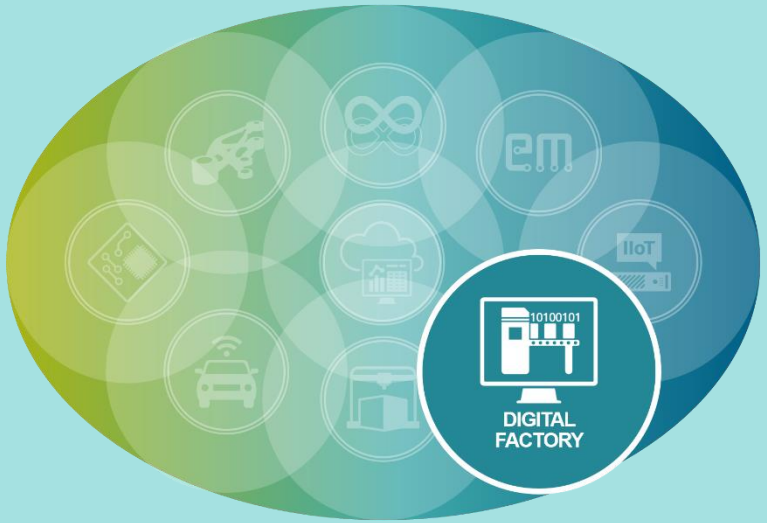

Digital Factory

Results

- Improved data and production quality
- Faster response to changes
- Extensive re-use of data across manufacturing sites
- Reduced ramp-up time for new product introduction

Challenges

- Implement design anywhere, build anywhere strategy
- Adopt a platform product strategy
- React quickly to changing conditions
- Accelerate new product introductions
- Maintain quality in assembly lines

High Value Digital Thread Solutions

Manufacturing processes

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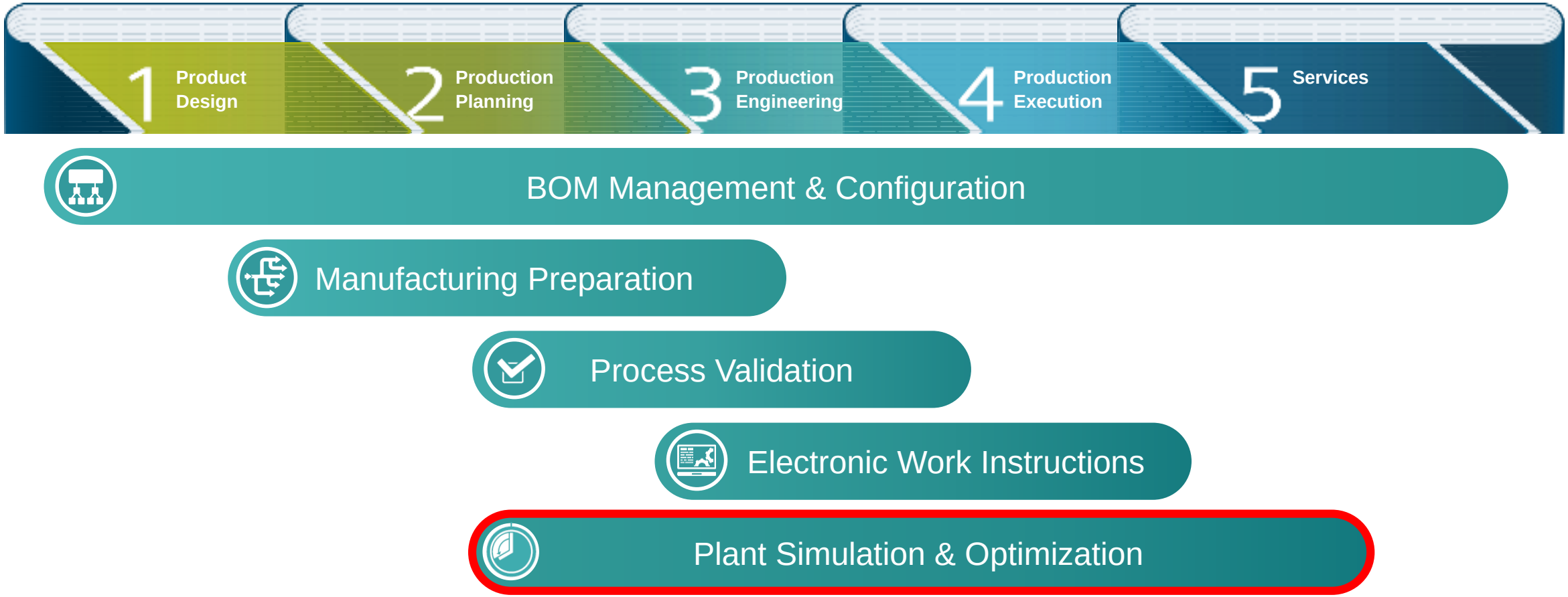

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Plant Simulation & Optimization

Design and validate your plant

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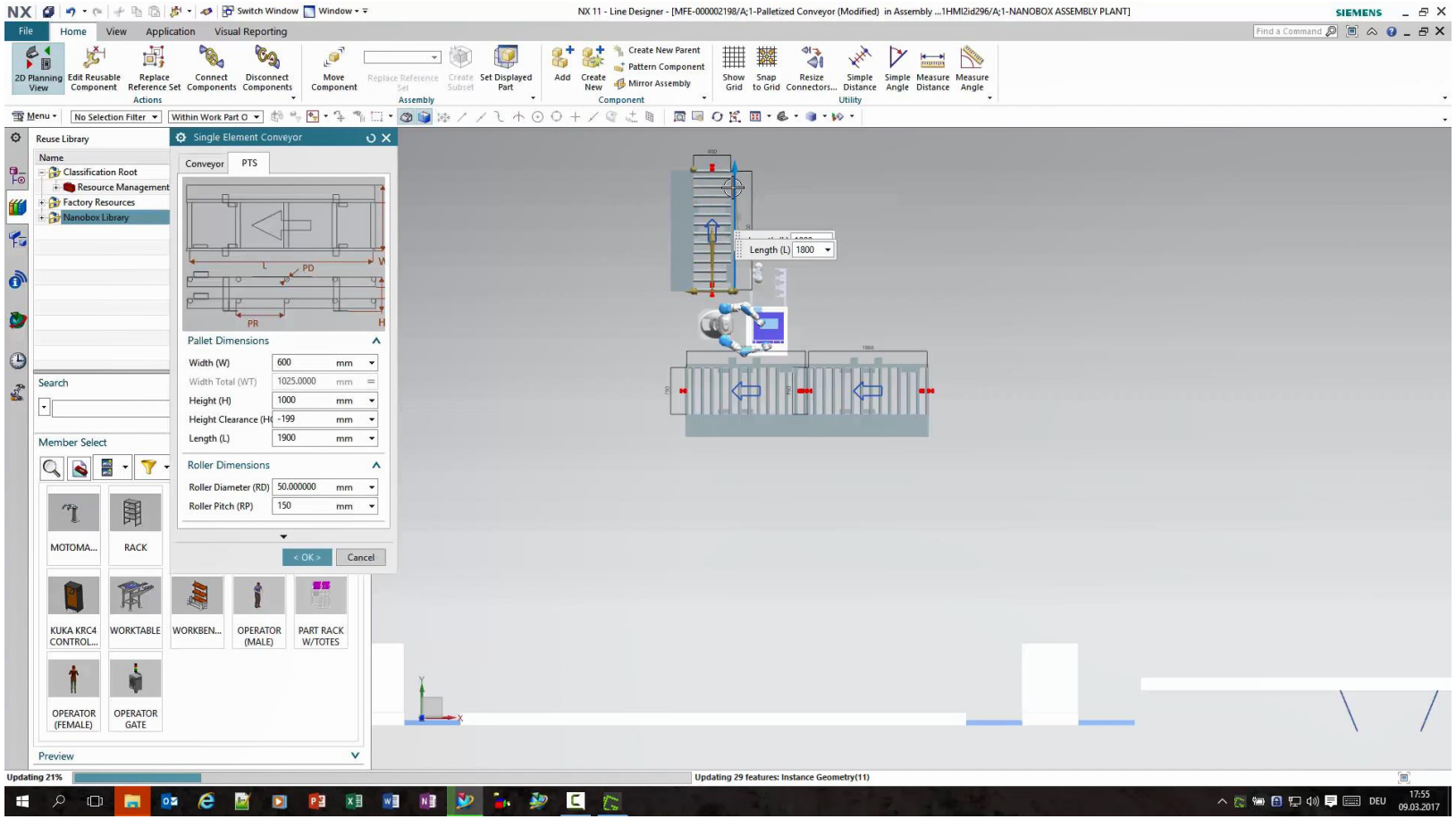
Challenges

- Layouts only in 2D
- Layout and Line design in different disciplines

Key Benefits

- Fast 3D layout tool with parametric re-use library
- Collaboration (process & data)
- Automated drawing generation



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Plant Simulation & Optimization

Design and validate your plant

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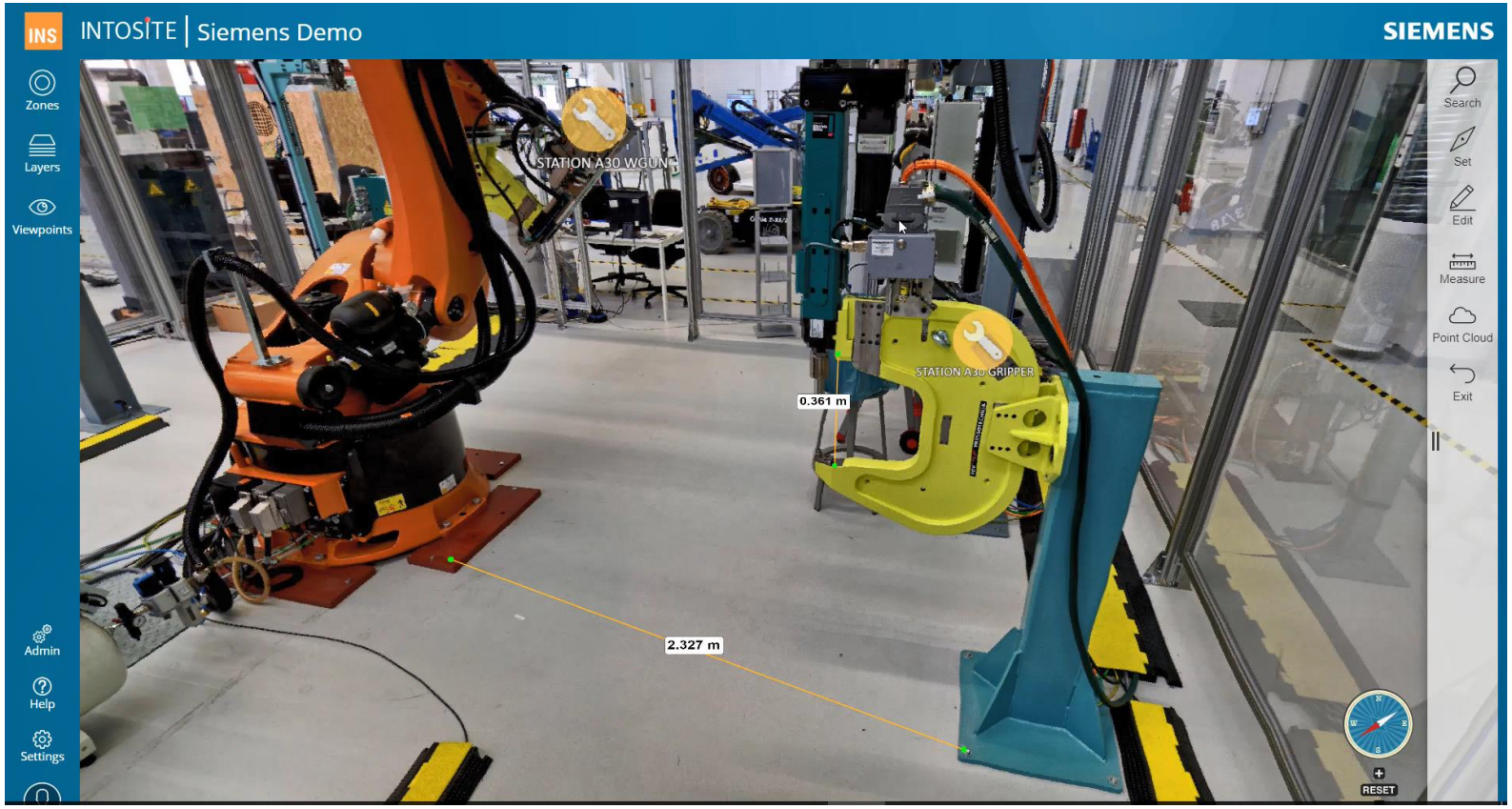
Challenges

- Brownfield factories without 3D layouts
- Keeping layouts updated with the pace of shop floor changes

Key Benefits

- Fast and accurate 3D scanning
- Incremental updates
- Invite suppliers to visit the plant (on the web)



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Plant Simulation & Optimization

Design and validate your plant

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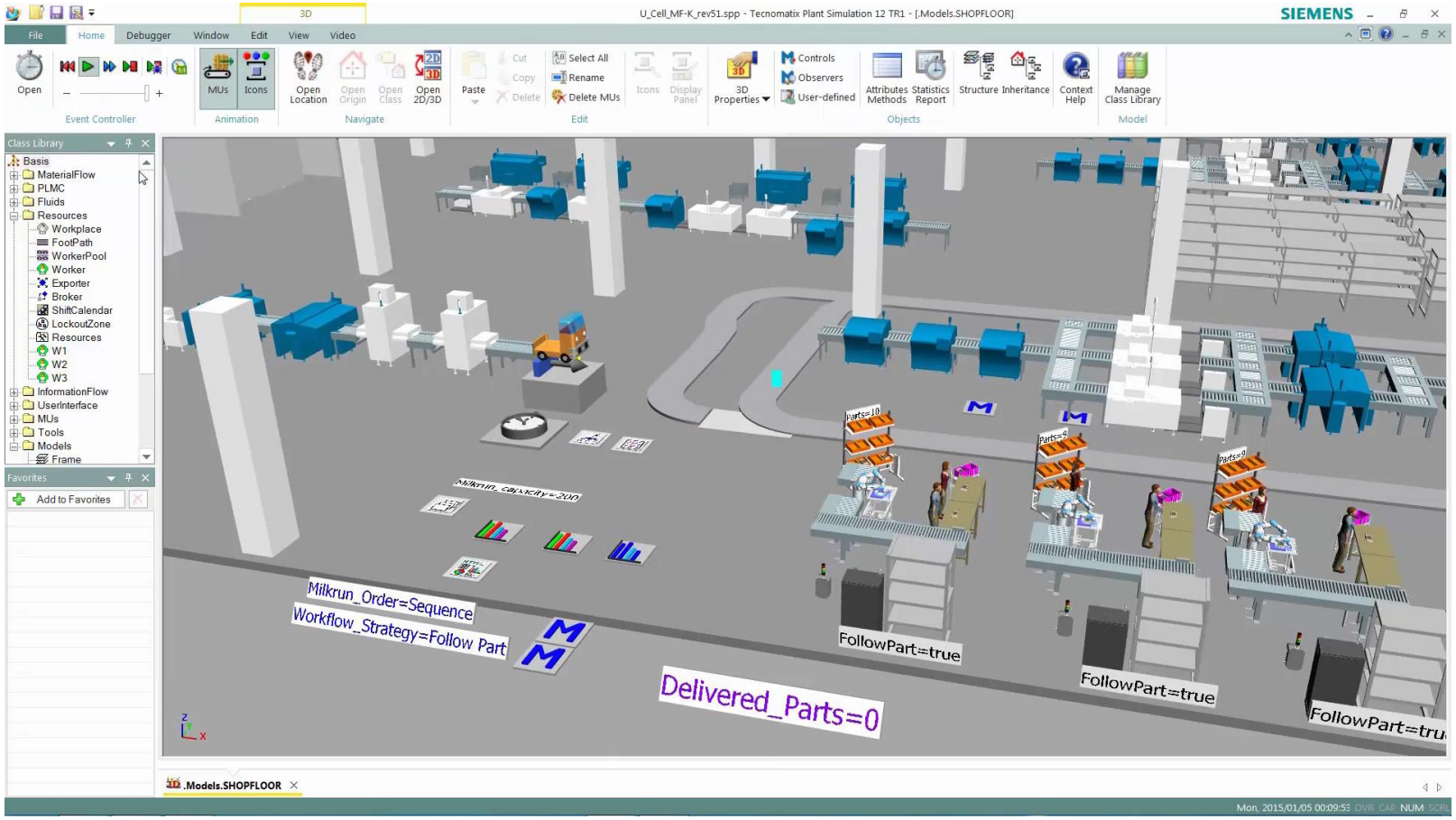
Challenges

- Need for quick answers
- Complex production
- Don’t want to disturb production

Key Benefits

- Validation of the productivity of the plant
- Detect and eliminate bottlenecks before they occur in reality
- ROI calculation



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Plant Simulation & Optimization

Design and validate your plant

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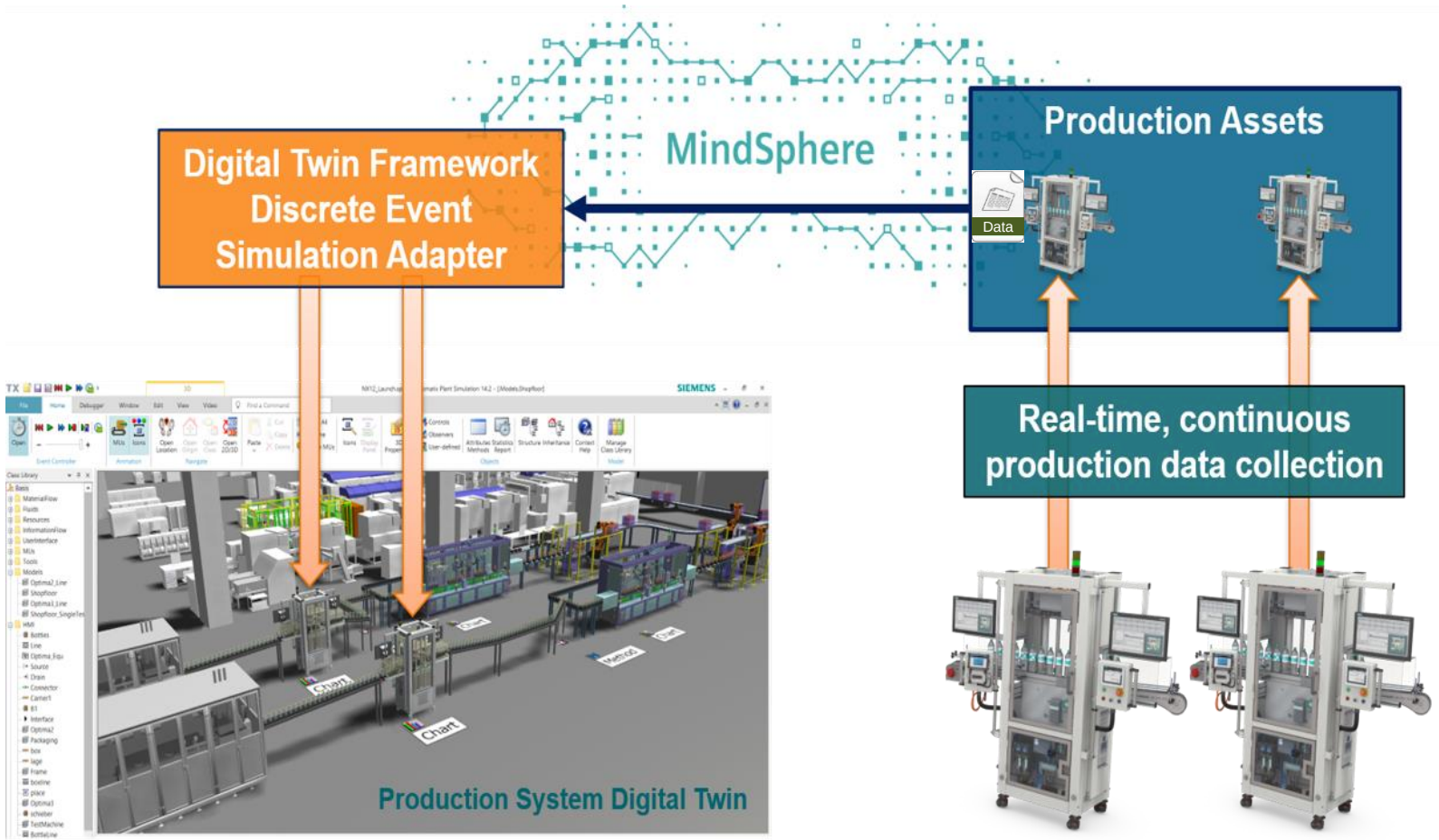
Challenges

- Achieve data-driven accuracy to more easily identify and solve production issues.

Solution

- Deploy an integrated, solution for real-time collaboration using collected IIoT data and the closed loop Digital Twin.
- This could also be done using recorded data from MES



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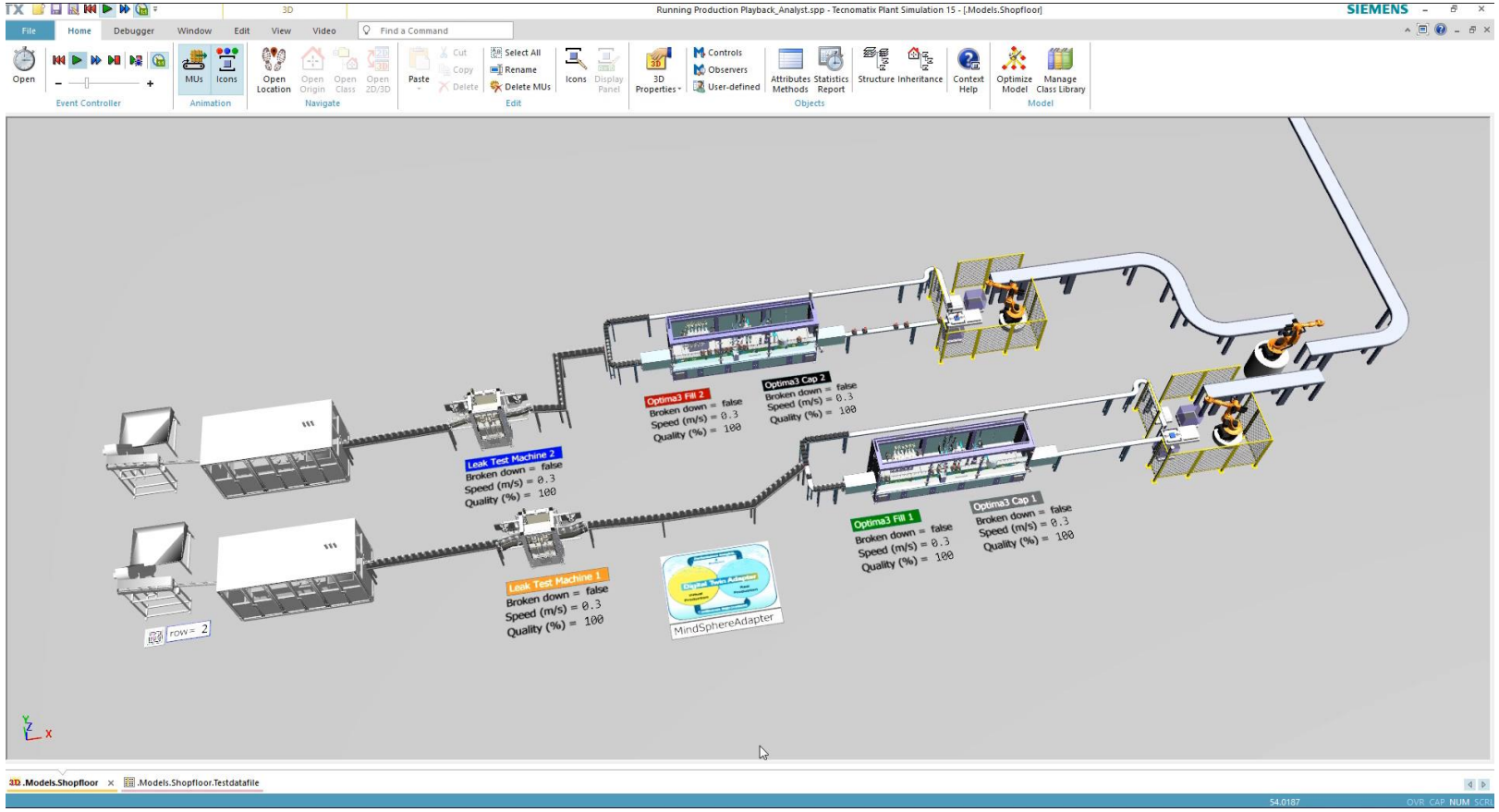

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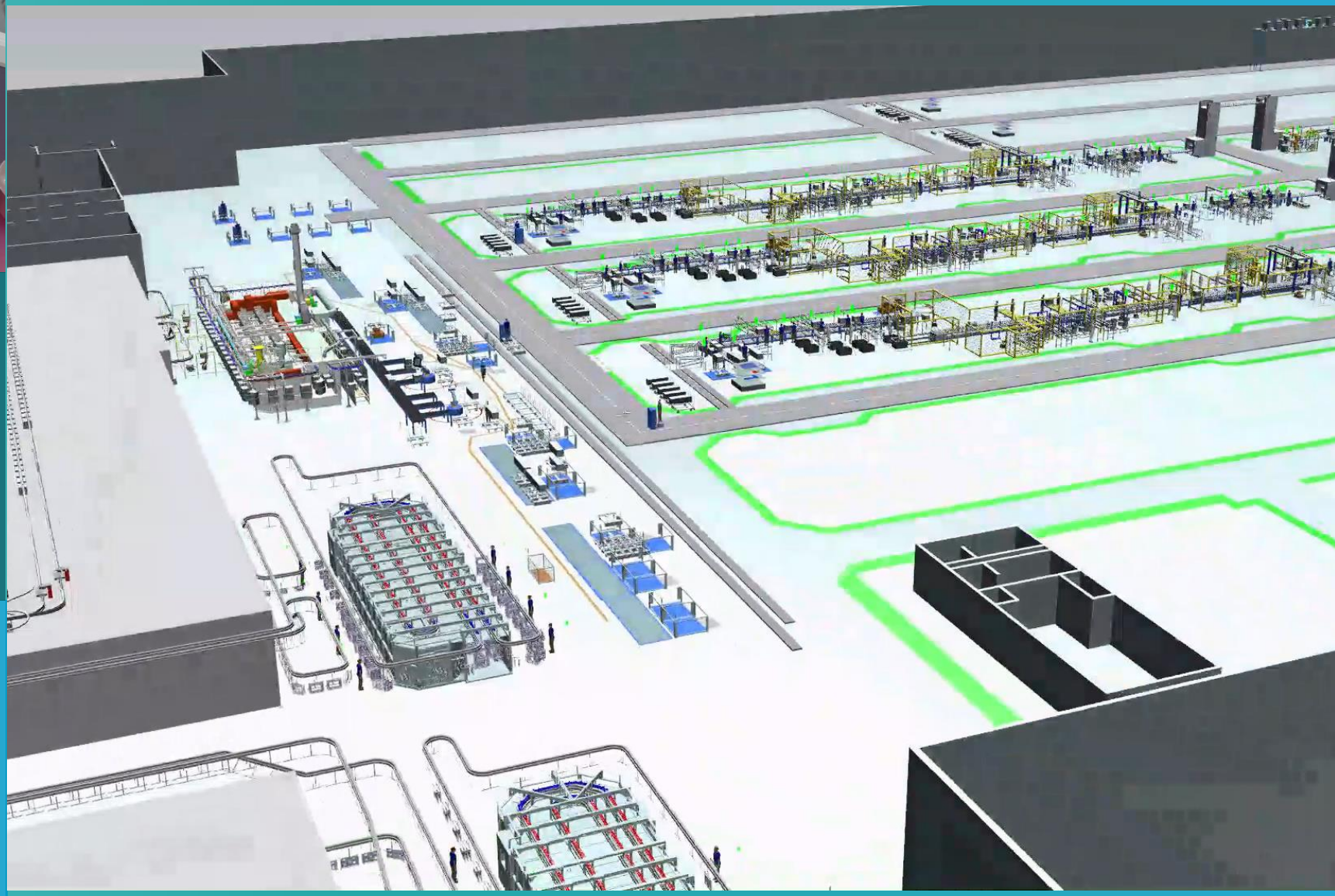
CHALLENGE

Maintain global operational excellence, eliminate production delays, and minimize inventory and investment costs.

SOLUTION

Electrolux leverages digital factories to plan and simulate production processes, virtually solving real manufacturing issues.



High Value Digital Thread Solutions

Manufacturing processes

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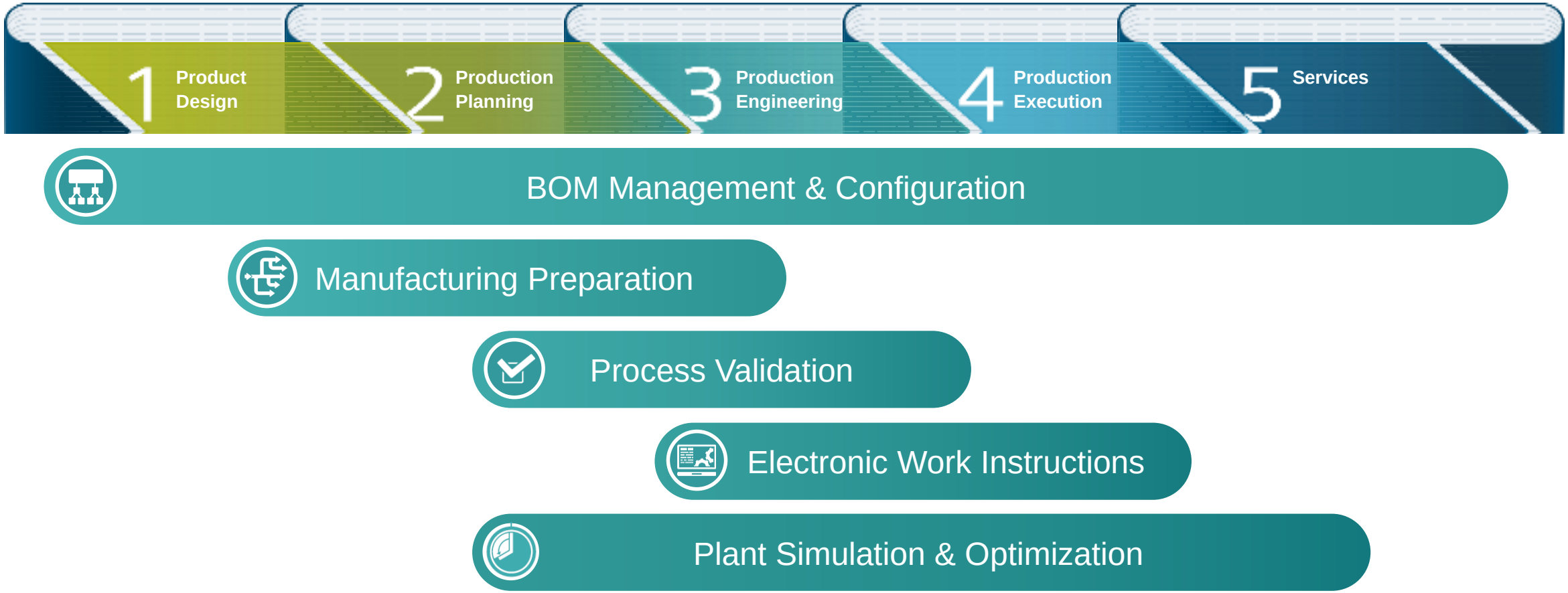

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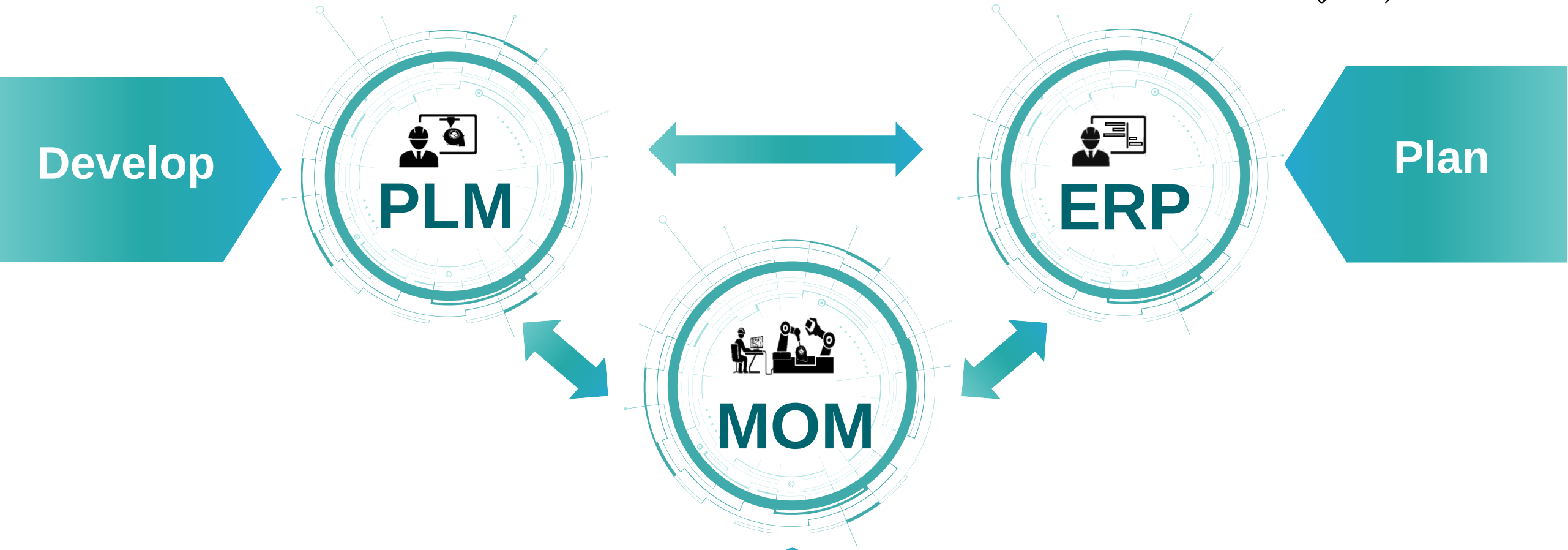
Closed Loop Manufacturing



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MOM: Digital Production Execution

Mikael Palm

Business requirements for a modern and integrated MOM

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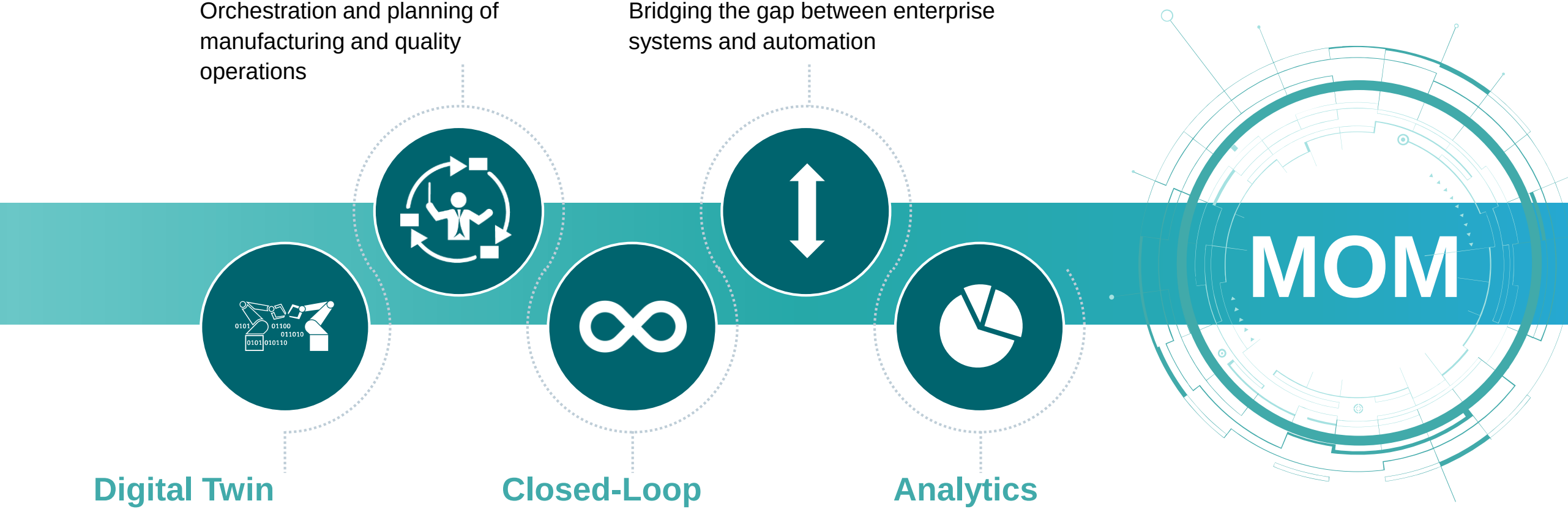
Orchestration

Orchestration and planning of manufacturing and quality operations

Vertical integration

Bridging the gap between enterprise systems and automation



Digital Twin

Implementation of the Digital Twin in the real production

Closed-Loop

Enabling continuous closed-loop improvement through as-planned and as-is data

Analytics

Transforming big data into IoT actionable information (smart data)

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Technological requirements for a modern and integrated MOM

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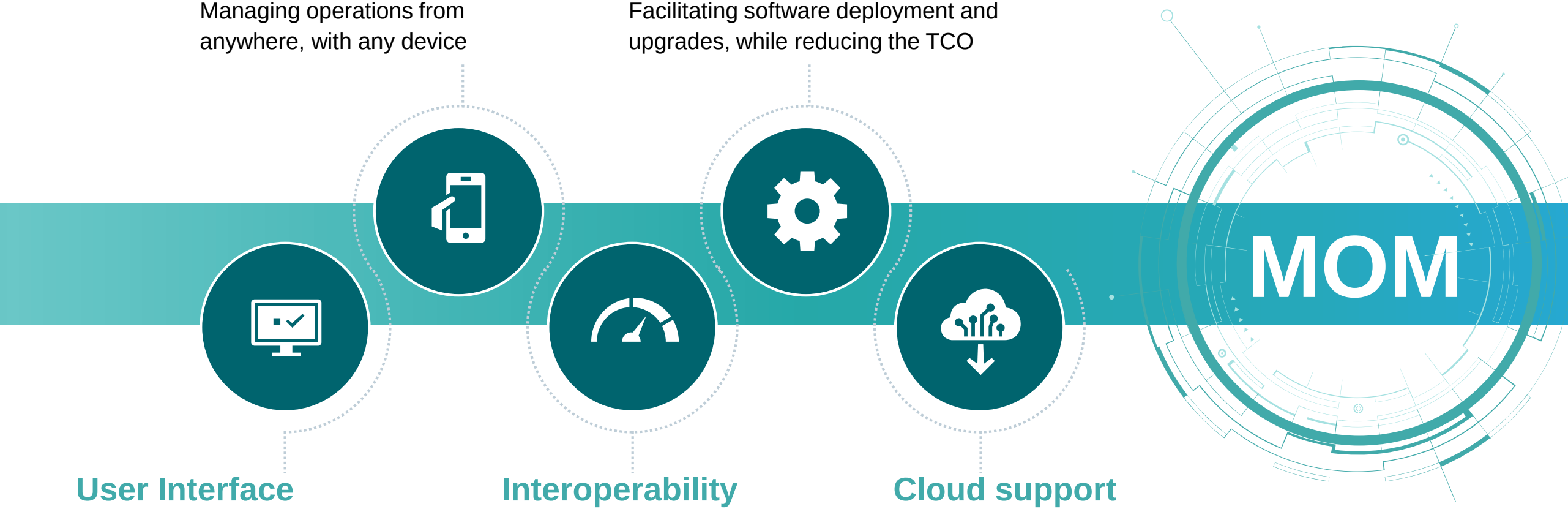
Mobility
Managing operations from anywhere, with any device

Extensibility
Facilitating software deployment and upgrades, while reducing the TCO



User Interface
Enhancing user experience with smart software interactions

Interoperability
Interfacing software solutions efficiently for faster data exchange

Cloud support
Enhancing global visibility and real-time information for the whole organization

Manage manufacturing complexity with MOM

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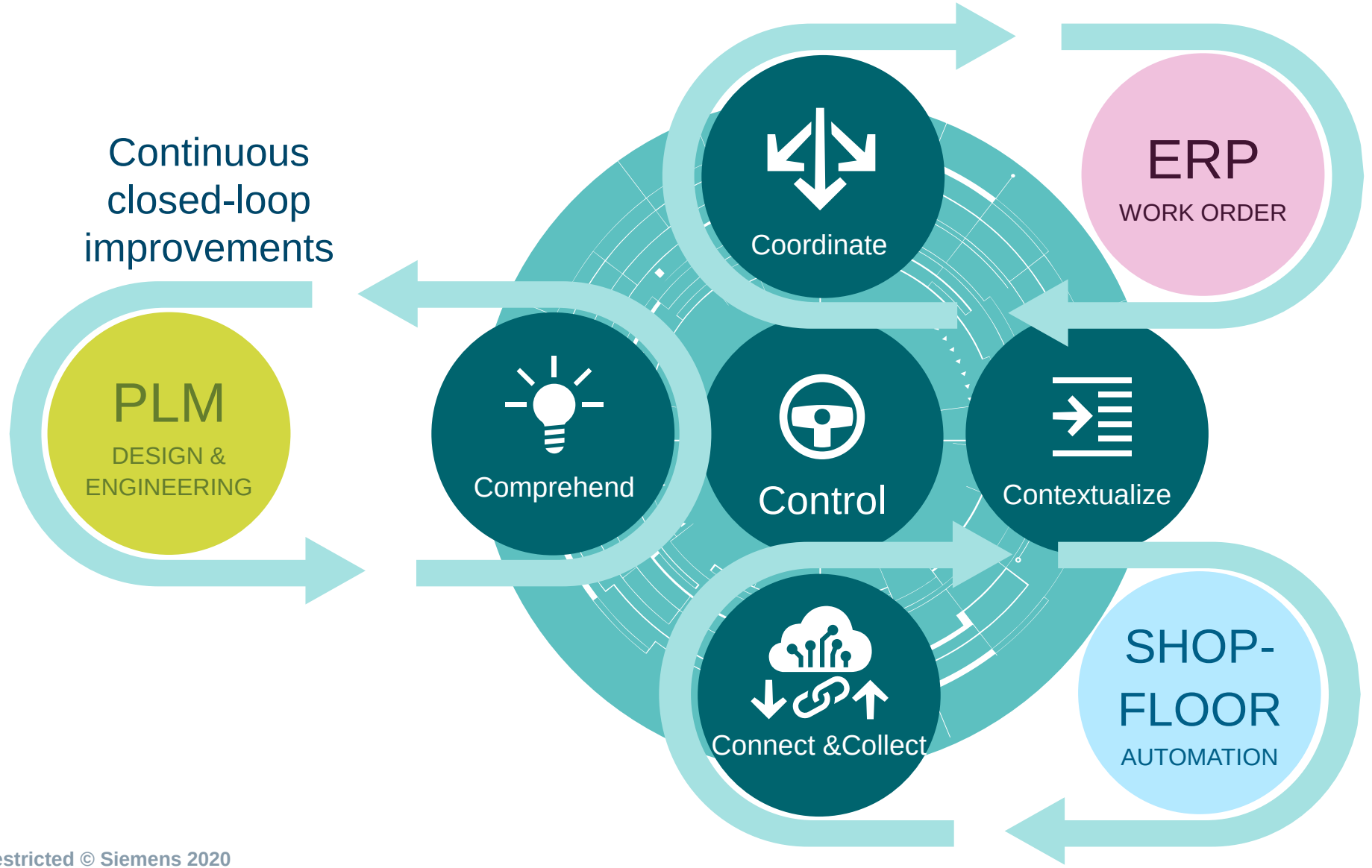

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MOM – What it does

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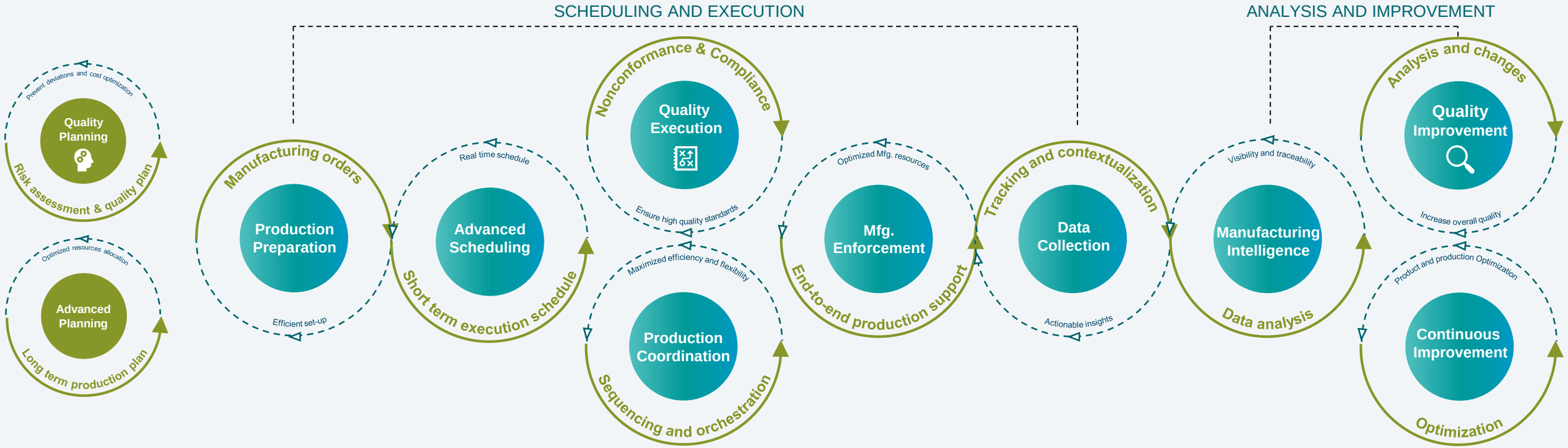

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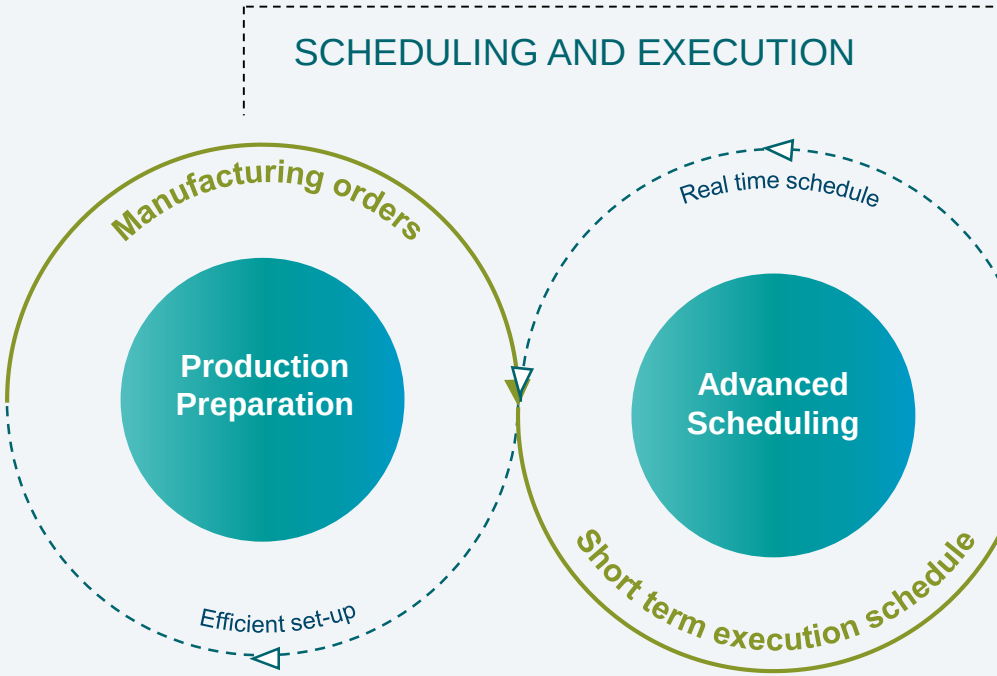
MOM – What it does

PLAN quality activities – Advanced Product Quality Planning (APQP)
ASSESS design and process risks through Failure Mode Effect Analysis (FMEA)
DEFINE communication practices with suppliers through Production Part Approval Process (PPAP)
CREATE inspection and control plans

COLLECT orders from ERP
ANALYZE material availability and plant capacity
PLAN what to make, when, where with long-term perspective
DEFINE materials and resourced required



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MOM – What it does

RECEIVE BoP and BoM i
customer orders from ER

TRANSFORM inputs fron
systems into executable r
orders

CHECK each manufactur
and resource at the shop
for production

SEQUENCE manufacturing orders to execute vs. plans

OPTIMIZE schedules with priorities, constraints, conflicts and what-if analysis

SYNCH global and local schedules

ENFORCE all manufacturing resou

Material – Ensuring the right mater
and used, per the latest revision of

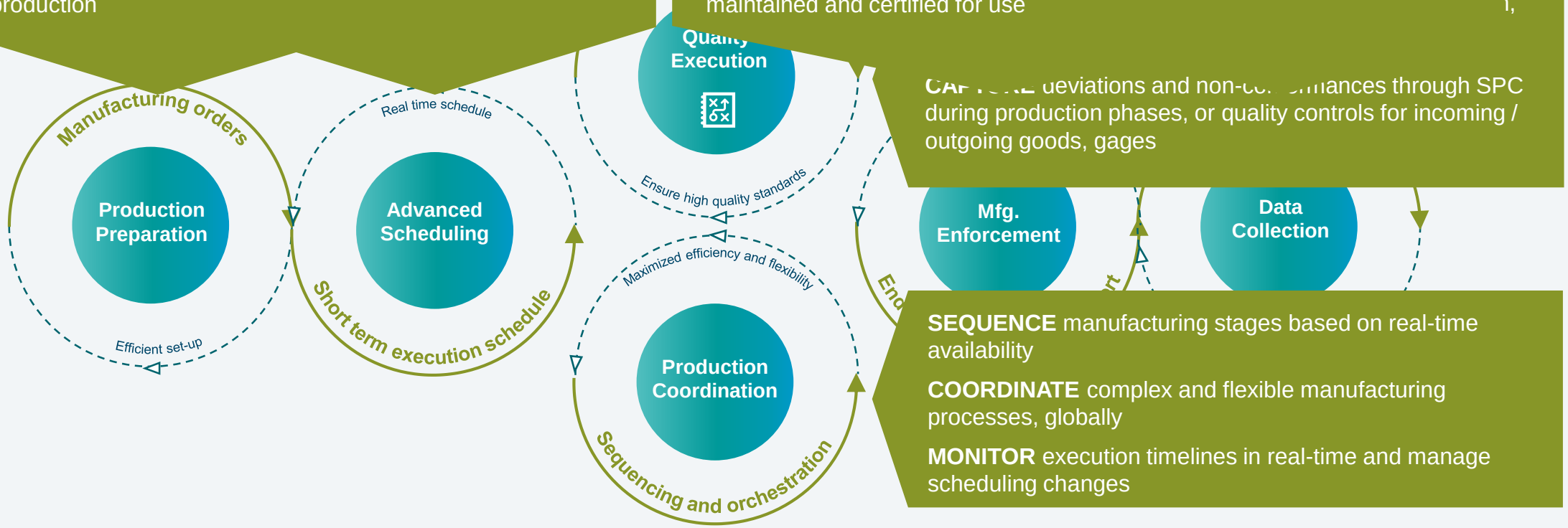
Operator – Ensuring the operator a
certifying that he is properly trained
tasks to be performed

Equipment – Ensuring the right eq
maintained and certified for use

COLLECT all raw production data and transactions from shop-floor

CONTEXTUALIZE raw data by adding detailed context information (equipment, material, person and production order)

TRACK resource-specific history records



CAP deviations and non-co mances through SPC during production phases, or quality controls for incoming / outgoing goods, gages

SEQUENCE manufacturing stages based on real-time availability

COORDINATE complex and flexible manufacturing processes, globally

MONITOR execution timelines in real-time and manage scheduling changes

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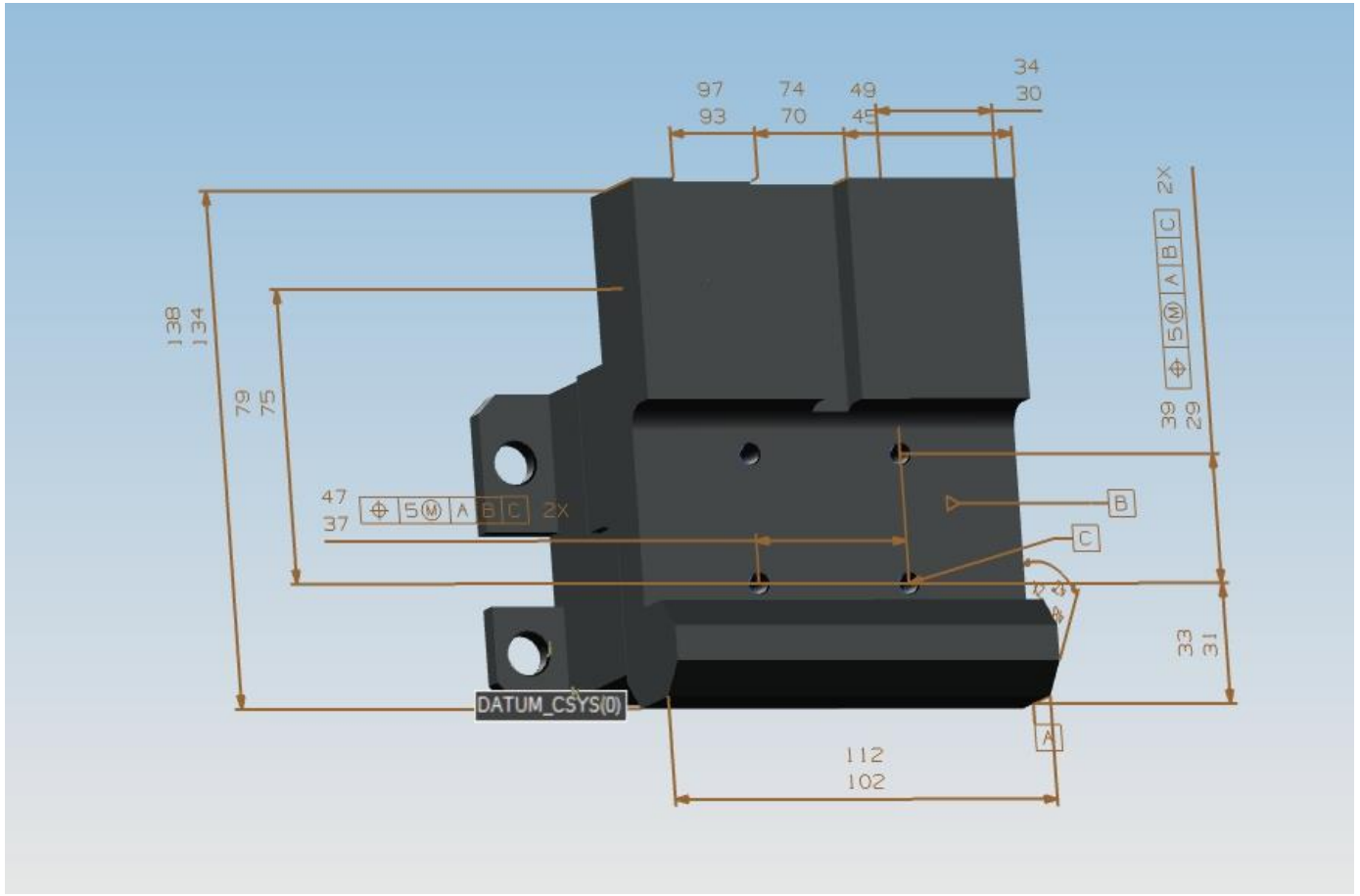
The Product to be produced

SIEMENS
Ingenuity for life



Metal Block Fabrication Process

SIEMENS
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Fabrication Process Semi Finished

- **OP10** Heating
- **OP20** Machining
- **OP30** Deburring & Inspection

Fabrication Process Finished

- **OP10** Mark - Create Serial Number
- **OP20** Clean
- **OP30** Final Inspection

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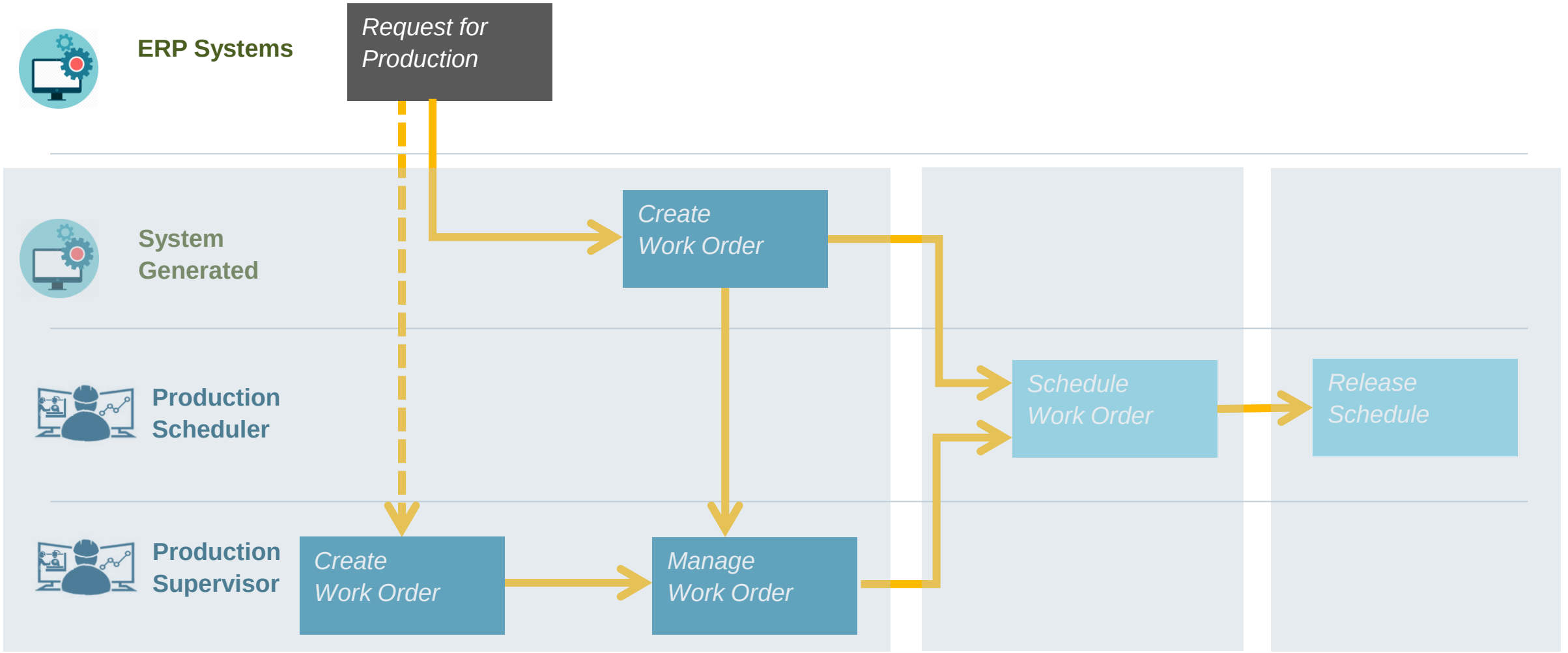
Detailed Scheduling with Opcenter

SIEMENS
Ingenuity for life



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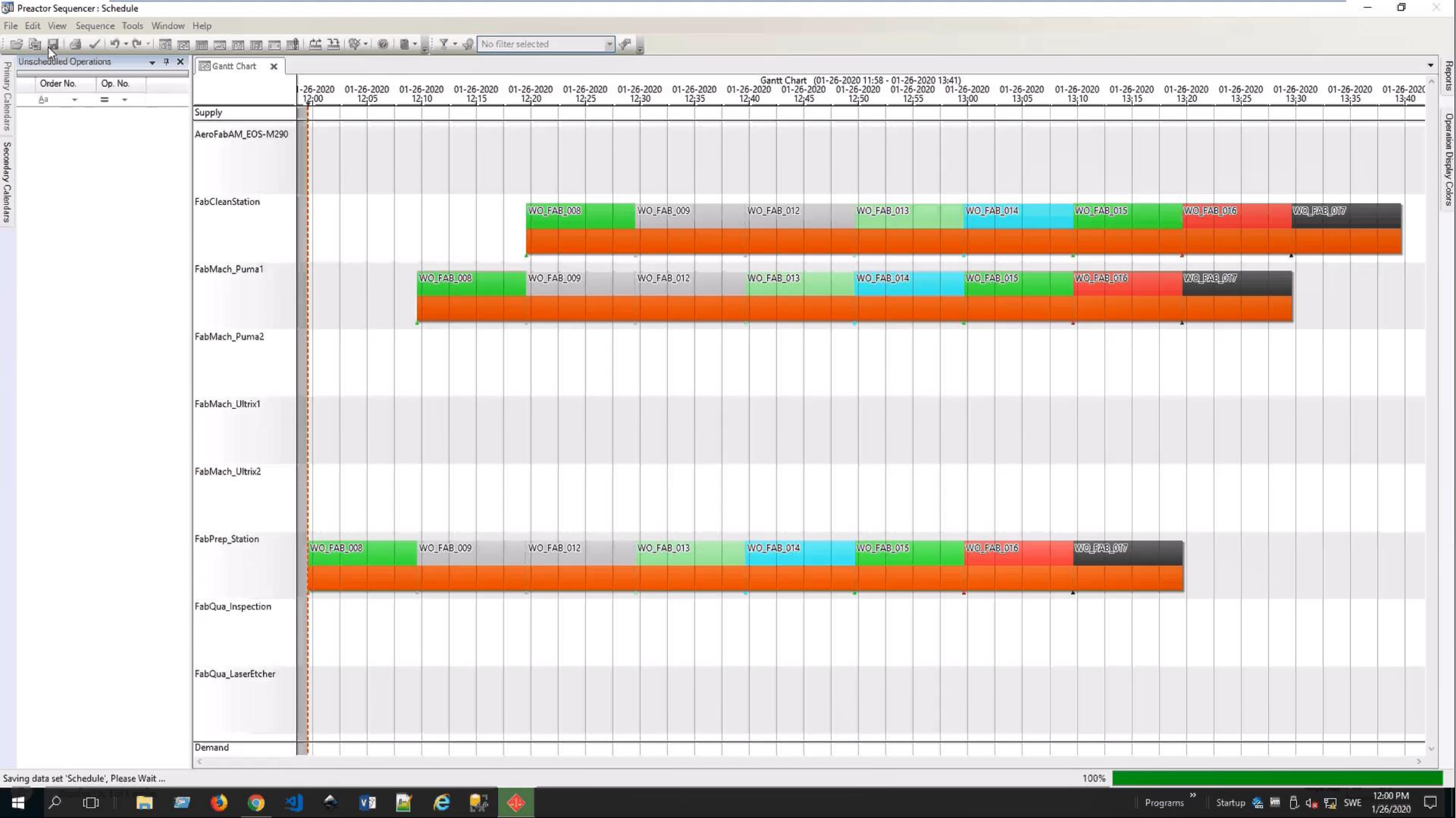
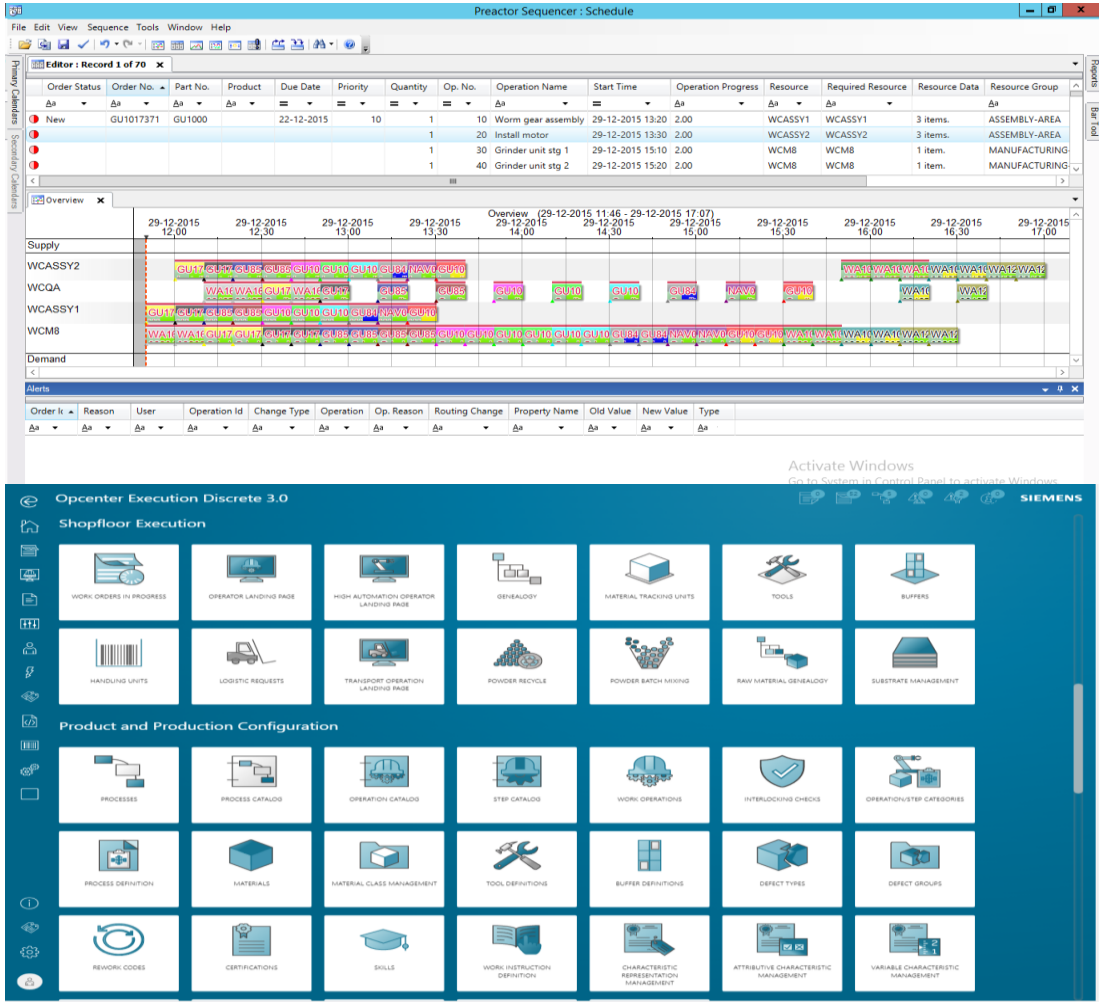

Preactor Sequencer : Schedule
File Edit View Sequence Tools Window Help
No filter selected
Unscheduled Operations
Order No.
Op. No.
Gantt Chart
Gantt Chart (01-26-2020 11:58 - 01-26-2020 13:41)
01-26-2020 12:00
01-26-2020 12:05
01-26-2020 12:10
01-26-2020 12:15
01-26-2020 12:20
01-26-2020 12:25
01-26-2020 12:30
01-26-2020 12:35
01-26-2020 12:40
01-26-2020 12:45
01-26-2020 12:50
01-26-2020 12:55
01-26-2020 13:00
01-26-2020 13:05
01-26-2020 13:10
01-26-2020 13:15
01-26-2020 13:20
01-26-2020 13:25
01-26-2020 13:30
01-26-2020 13:35
01-26-2020 13:40
Supply
AeroFabAM_EOS-M290
FabCleanStation
FabMach_Puma1
FabMach_Puma2
FabMach_Ultrix1
FabMach_Ultrix2
FabPrep_Station
FabQua_Inspection
FabQua_LaserEtcher
Demand
WO_FAB_008
WO_FAB_009
WO_FAB_012
WO_FAB_013
WO_FAB_014
WO_FAB_015
WO_FAB_016
WO_FAB_017
Primary Calendars
Secondary Calendars
Reports
Operation Display Colors
Saving data set 'Schedule', Please Wait ...
100%
Programs
Startup
SWE
12:00 PM
1/26/2020

Value of connected solution

SIEMENS
Ingenuity for life

Key Benefits

- Vertical and Horizontal Integration
- Maximize usage of resources
- Minimize late orders



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Work Orders Management and Material Consumption

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Ingenuity for life

Production Scheduler

Schedule Work Order → *Release Schedule*

System Generated

Quality Inspector

Shop Floor Operator

Start Operation → *Instructions* → *Track Material Consumption* → *Complete Operation*

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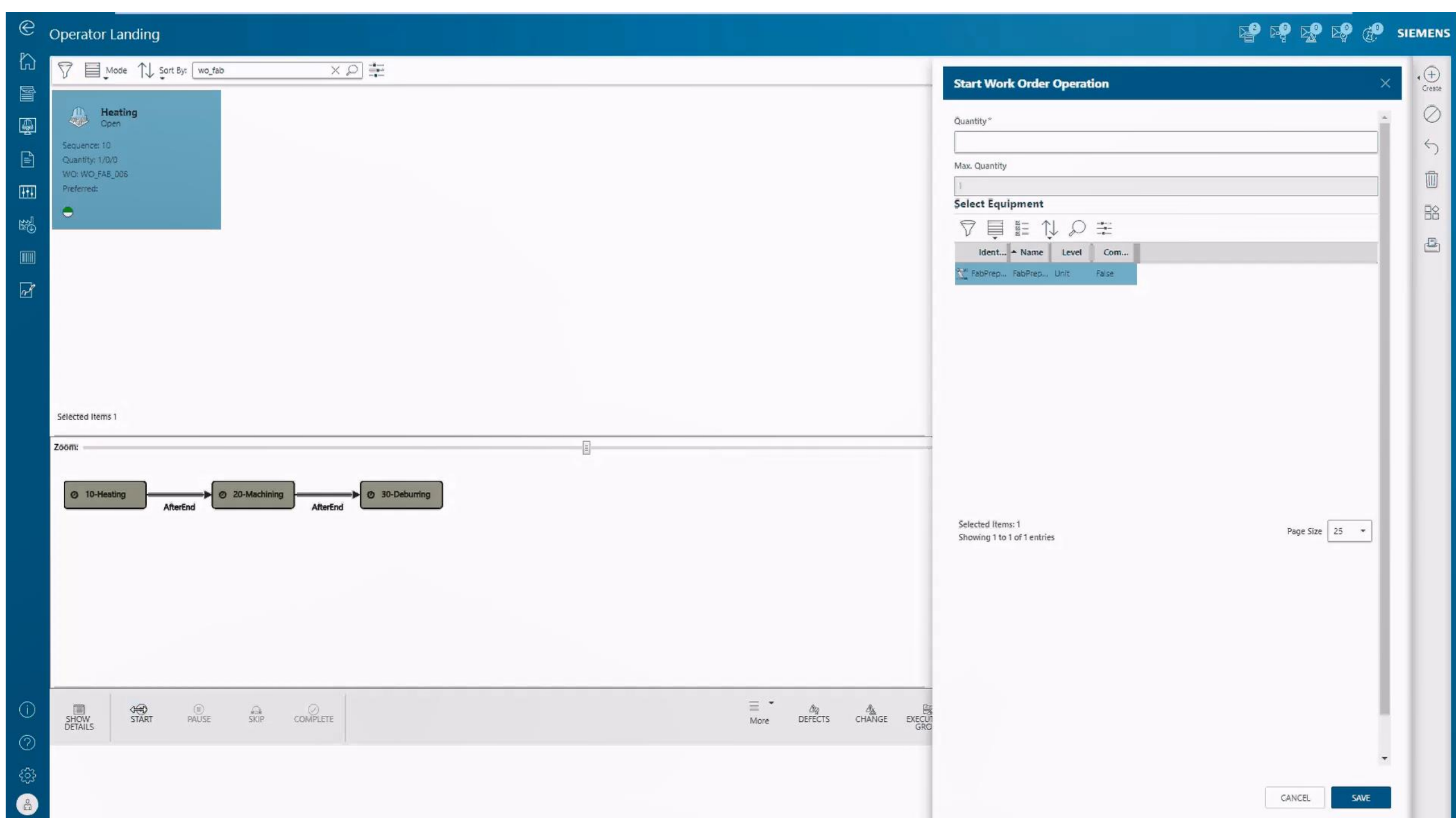
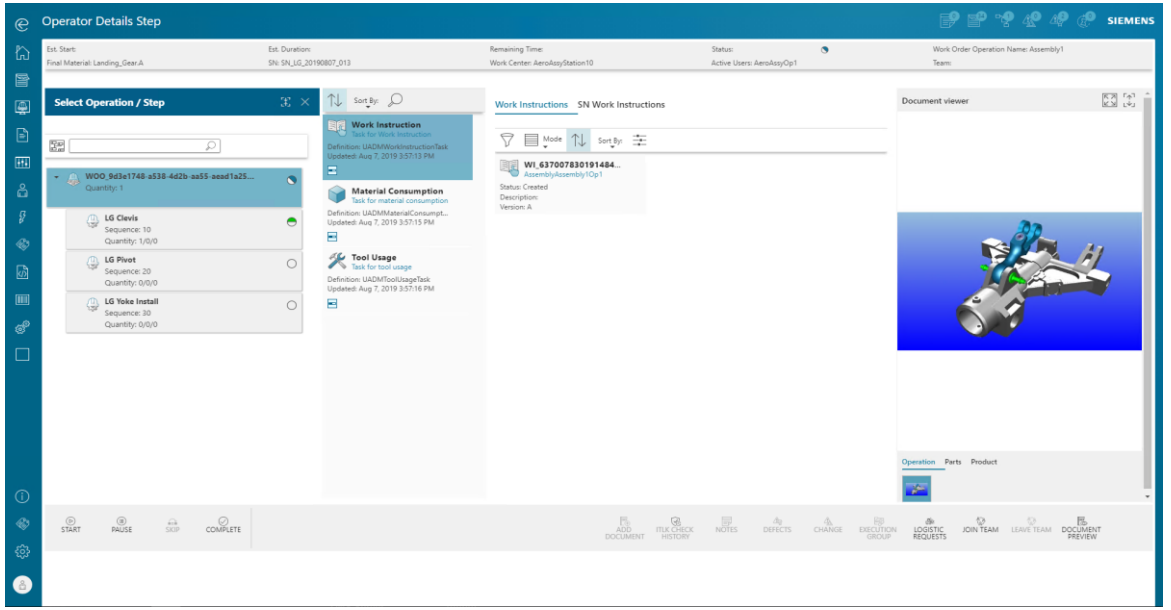

Operator Landing
SIEMENS
Mode
Sort By:
wo_fab
Heating
Open
Sequence: 10
Quantity: 1/0/0
WO: WO_FAB_006
Preferred:
Selected Items 1
Zoom:
10-Heating
AfterEnd
20-Machining
AfterEnd
30-Deburring
SHOW DETAILS
START
PAUSE
SKIP
COMPLETE
More
DEFECTS
CHANGE
Create
Start Work Order Operation
Quantity *
Max. Quantity
1
Select Equipment
Ident...
Name
Level
Com...
FabPrep...
FabPrep...
Unit
False
Selected Items: 1
Showing 1 to 1 of 1 entries
Page Size
25
CANCEL
SAVE

Value of connected solution

SIEMENS
Ingenuity for life

Key Benefits

- Keep operators up to date on current activities
- Minimize waste of time and material
- Improve on-time delivery



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Tools Consumption and Machinery Traceability

SIEMENS
Ingenuity for life

Production Scheduler

System Generated

Quality Inspector

Shop Floor Operator

Start Operation → *Instructions & Documents* → *Track Tool Usage* → *Track Machinery Usage* → *Complete Operation*

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Operator Task List

SIEMENS

Est. Start: 01/26/2020 12:09 PM | Est. Duration: 00:10:00 | Remaining Time: 09:33 | Status: | Work Order Operation: Machining

Final Material: Machined Block.A | SN: MB_MAB_20200109_048 | Work Center: FabMach_Puma2 | Active Users: SIEMENSDC\Administrator | Team:

Create

Work Instruction
Task for Work Instruction

Definition: UADMWorkInstructionTask
Updated: Jan 26, 2020 12:08:35 PM

Tool Usage
Task for tool usage

Definition: UADMToolUsageTask
Updated: Jan 26, 2020 12:08:35 PM

Part Program Transfer
Task for Part Program Transfer

Definition: UADMPartProgramTask
Updated: Jan 26, 2020 12:08:35 PM

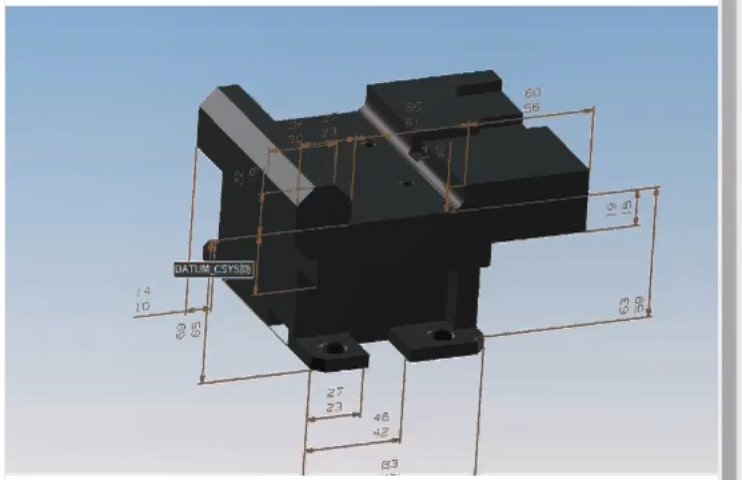
Machine:FabMach_Puma2

Tool: Cutter.A

Tool Id	Usage Time	Usage Duration
	1	

Times To Be Used: 10

Document viewer



Operation | Product

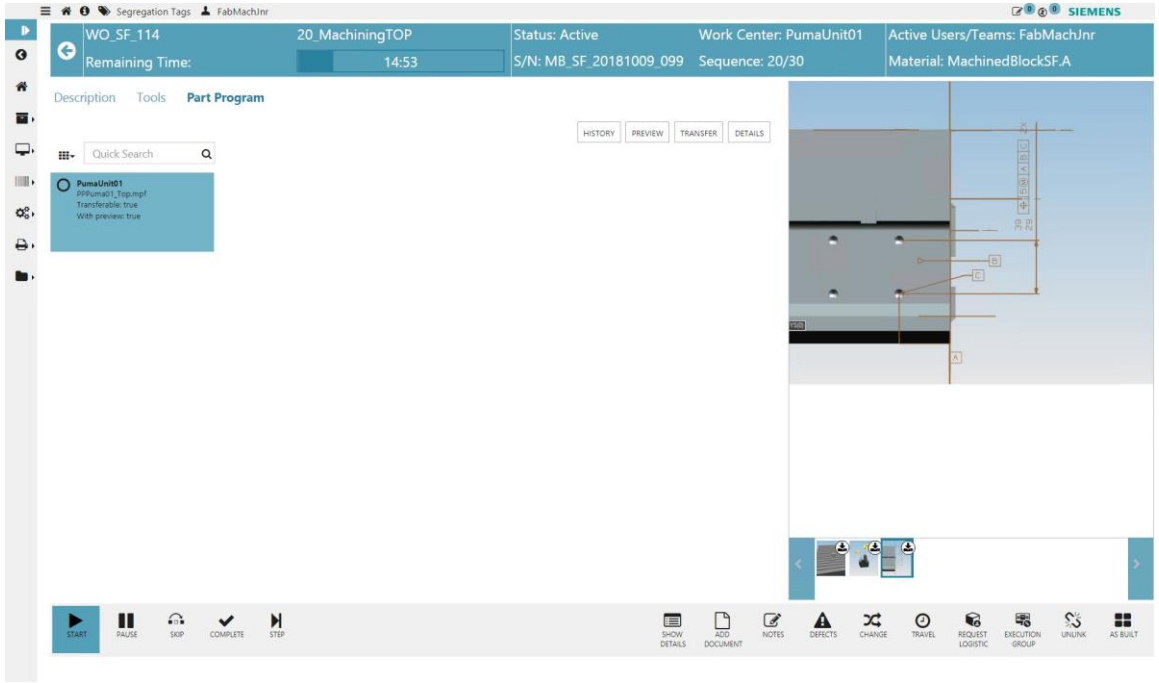
START | PAUSE | SKIP | COMPLETE | More | NOTES | DEFECTS | CHANGE | EXECUTION GROUP | LOGISTIC REQUESTS | JOIN TEAM | LEAVE TEAM | DOCUMENT PREVIEW | PRINT LABEL | CHANGE SN | FREEZE TARGET QUANTITY

Value of connected solution

SIEMENS
Ingenuity for life

Key Benefits

- Exploit resources according to actual availability
- Prevent error in execute the wrong part program
- Optimize declaration of resources consumption



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Data Collection and Quality Inspection

SIEMENS
Ingenuity for life

Production Scheduler

System Generated

Quality Inspector

Shop Floor Operator

Start Operation → *Instructions & Documents* → *Semi-Automatic Data Collection* → *Visual Quality Inspection* → *Complete Operation*

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Operator Task List

SIEMENS

Est. Start: 01/26/2020 12:19 PM | Est. Duration: 00:10:00 | Remaining Time: 09:51 | Status: | Work Order Operation: Deburring

Final Material: Machined Block.A | SN: MB_MAB_20200109_048 | Work Center: FabCleanStation | Active Users: SIEMENSDC\Administrator | Team:

Create

Work Instruction
Task for Work Instruction

Definition: UADMWorkInstructionTask
Updated: Jan 26, 2020 12:12:05 PM

Quality Inspection
Task for Quality Inspection

Definition: UADMQualityInspectionTask
Updated: Jan 26, 2020 12:12:05 PM

Work Instructions

FabaricationDeburringOp3

FabricationDeburringSection1 - Deburring Operation

FabricationDeburringStep2 - Data Collection From Field

Data Collection

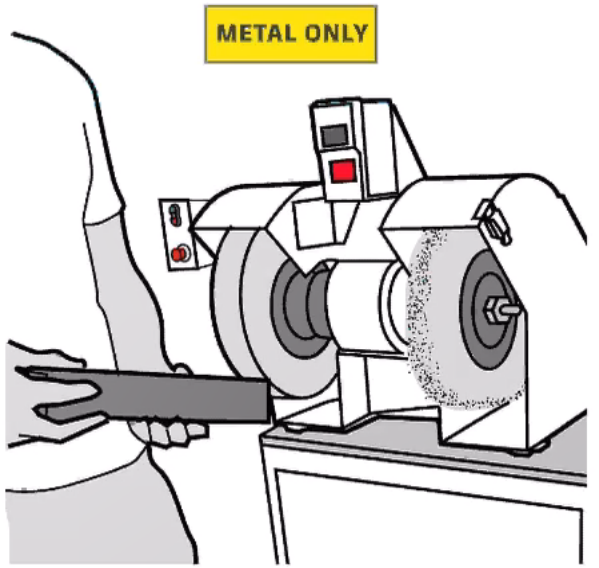
Length
Machined Block Length:
mm
Low Limit: 70 High Limit: 74 Target: 72

Width
Machined Block Width:
mm
Low Limit: 70 High Limit: 74 Target: 72

Height
Machined Block Height:
mm
Low Limit: 70 High Limit: 74 Target: 72

ACQUIRE CONFIRM

Document viewer



Operation Product

START PAUSE SKIP COMPLETE

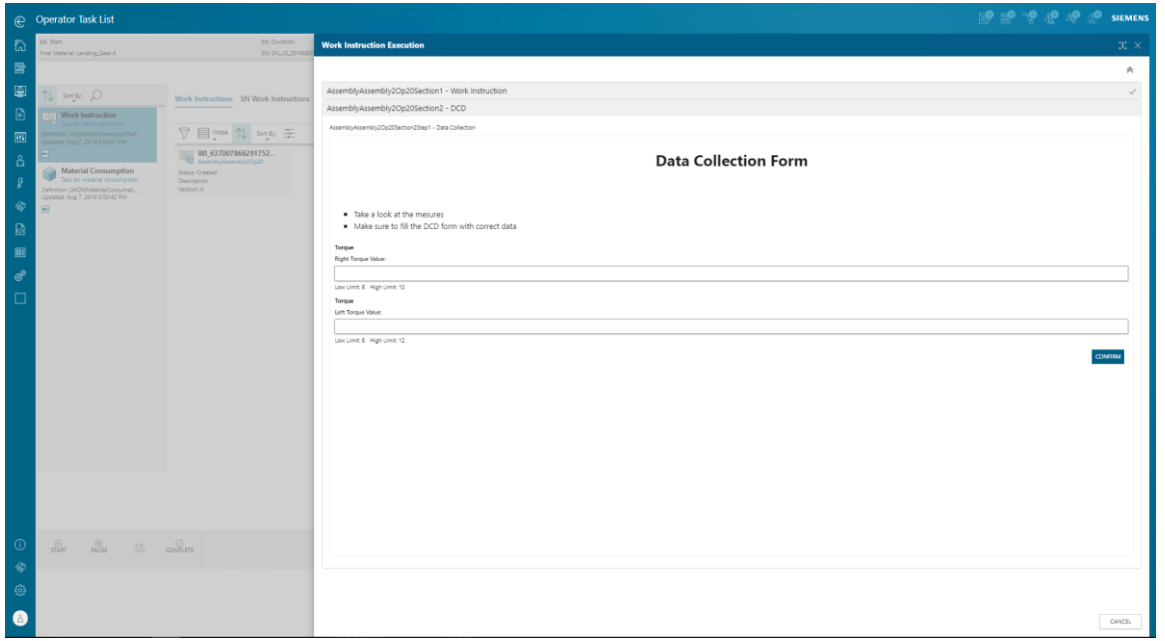
More NOTES DEFECTS CHANGE EXECUTION GROUP LOGISTIC REQUESTS JOIN TEAM LEAVE TEAM DOCUMENT PREVIEW PRINT LABEL CHANGE SN FREEZE TARGET QUANTITY

Value of connected solution

SIEMENS
Ingenuity for life

Key Benefits

- Ensure compliance with regulation
- Use real production data to support changes
- Maximize manufacturing transparency



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Production Transparency

SIEMENS
Ingenuity for life

System Generated

Generate Geneaology & As- Built

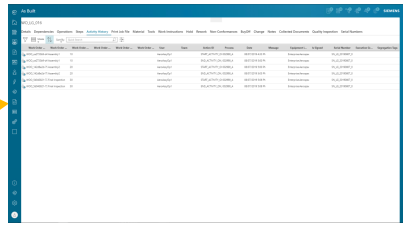
Manufacturing Engineer

Manufacturing Planner

Quality Inspector

Production Supervisor

Shop Floor Operator



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Work Order: WO_FAB_008

Serial Number / Batch ID: Find an entity

- WO_FAB_008
  - WO_FAB_008 - Machined Block - 1 - Complete
    - Machined Block - MB_MAB_20200109_048 - n/a
      - 10. Heating - Complete
        - Metal Block - 10 - MB_MTB_20200126_008 - NormalPart - n/a
        - FabPrep_Station
        - START_ACTIVITY_ON_ENTRY - 01/26/2020 12:05 PM - FabPrep_Station
        - END_ACTIVITY_ON_ENTRY - 01/26/2020 12:06 PM - FabPrep_Station
      - 20. Machining - Complete
        - Cutter - Cutter002 - 1
        - FabMach_Puma2
        - START_ACTIVITY_ON_ENTRY - 01/26/2020 12:08 PM - FabMach_Puma2
        - END_ACTIVITY_ON_ENTRY - 01/26/2020 12:09 PM - FabMach_Puma2
      - 30. Deburring - Complete
        - FabCleanStation
        - START_ACTIVITY_ON_ENTRY - 01/26/2020 12:12 PM - FabCleanStation
        - END_ACTIVITY_ON_ENTRY - 01/26/2020 12:13 PM - FabCleanStation
        - WI_637156339224406715-Machined Block Height-72
        - WI_637156339224406715-Machined Block Length-72
        - WI_637156339224406715-Machined Block Width-72
        - Scratch Presence - true
        - Visual Defects - Scratch
        - Hole Distance - 69

Identifier	Hole Distance
Inspected Variable Characteristic Value	69
Date	01/26/2020 12:12 PM
User	SIEMENSDC\Administrator

WO_FAB_008

Details Dependencies Operations Steps Activity History Print Job File Material Tools Work Instructions Hold Rework Non-Conformances BuyOff Change Notes Collected Documents Quality Inspection

Mode Sort By: Quick Search

Work Order ...	Work Order ...	Work Order ...	Work Order ...	Work Order ...	Work Order ...	User	Team	Action ID	Process	Date	Message	Equipment Id...	Is Signed	Serial Numb...	Execution Gr...	Baseline	Old Baseline
WOO_f7734f3c-...	Deburring	30				SIEMENSDC\Ad...		START_ACTIVITY...	FabricationProce...	01/26/2020 12:1...		FabCleanStation		MB_MAB_20200...			
WOO_8c0042dc-...	Heating	10				SIEMENSDC\Ad...		END_ACTIVITY_...	FabricationProce...	01/26/2020 12:0...		FabPrep_Station		MB_MAB_20200...			
WOO_df53cfd7-...	Machining	20				SIEMENSDC\Ad...		START_ACTIVITY...	FabricationProce...	01/26/2020 12:0...		FabMach_Puma2		MB_MAB_20200...			
WOO_f7734f3c-...	Deburring	30				SIEMENSDC\Ad...		END_ACTIVITY_...	FabricationProce...	01/26/2020 12:1...		FabCleanStation		MB_MAB_20200...			
WOO_8c0042dc-...	Heating	10				SIEMENSDC\Ad...		START_ACTIVITY...	FabricationProce...	01/26/2020 12:0...		FabPrep_Station		MB_MAB_20200...			
WOO_df53cfd7-...	Machining	20				SIEMENSDC\Ad...		END_ACTIVITY_...	FabricationProce...	01/26/2020 12:0...		FabMach_Puma2		MB_MAB_20200...			

Selected Items: 0
Showing 1 to 6 of 6 entries

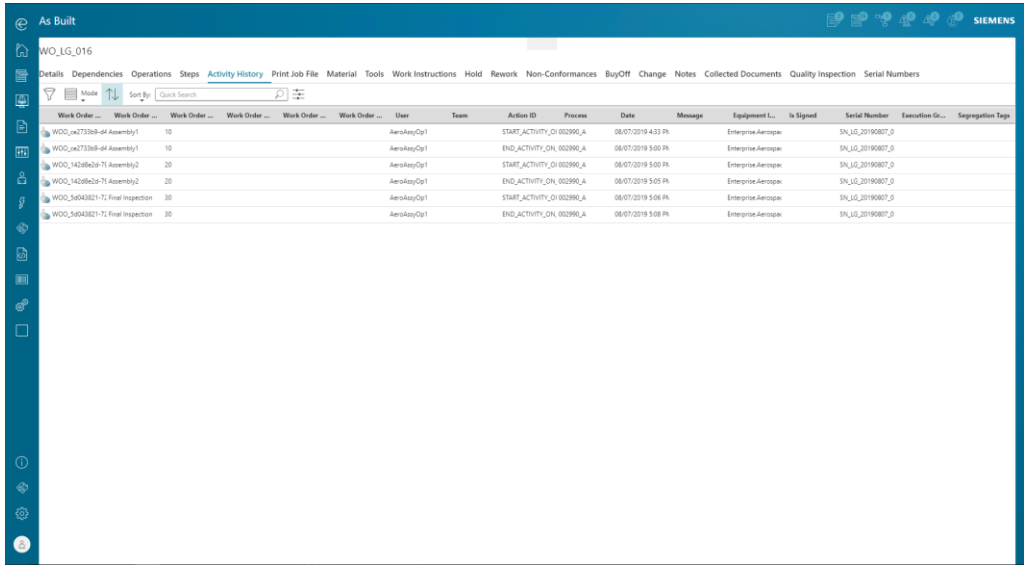
Page Size 25

Value of connected solution

SIEMENS
Ingenuity for life

Key Benefits

- Complete Product and process build history
- Work Order and Rework Order visibility
- All data from products, user and execution is recorded and is available to feedback to ERP and PLM systems



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MOM – What it does

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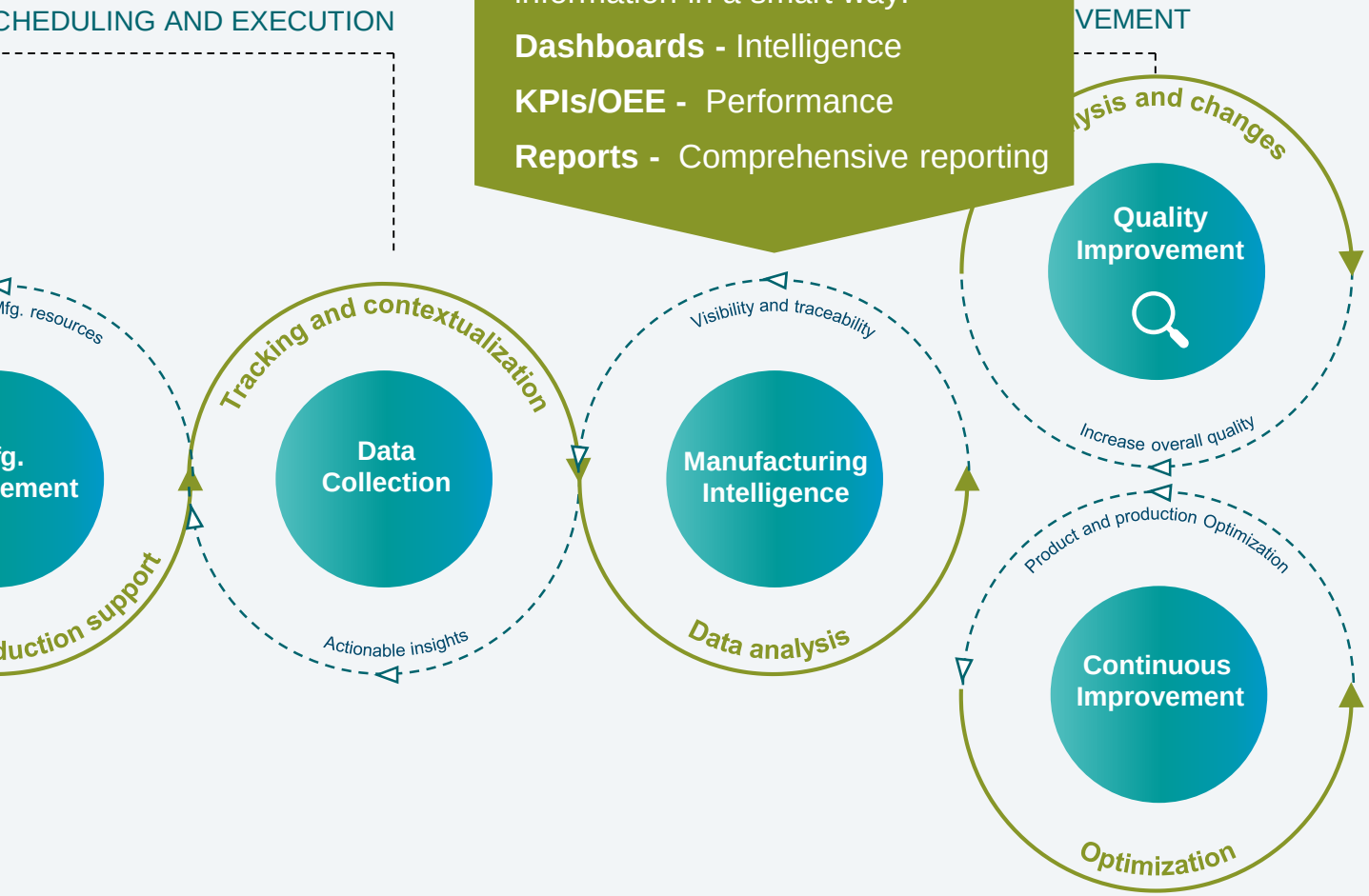
VISUALIZE production data and information in a smart way:

Dashboards - Intelligence

KPIs/OEE - Performance

Reports - Comprehensive reporting



COLLECT & RAISE complaints based on deviations, customer inputs or supplier assessment

ANALYZE root causes of non-conformances / complaints and define lessons learned

DEFINE changes to design and/or processes to improve product quality

IDENTIFY product / production issues during manufacturing execution (or afterwards)

DETAIL issue characteristics by creating and attaching issue-specific documentation

TRIGGER product design/production engineering adjustments leveraging on shop-floor and production feedbacks

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Manufacturing Intelligence

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Date Filter
3/12/2018 12/31/2020

Process Filter
All

Equipment Filter
All

Total Used Equipment
4

To Be Justified
43

This report shows Time Category duration and the Status duration for the selected machines.

The context area details the interval circumstances.

Status

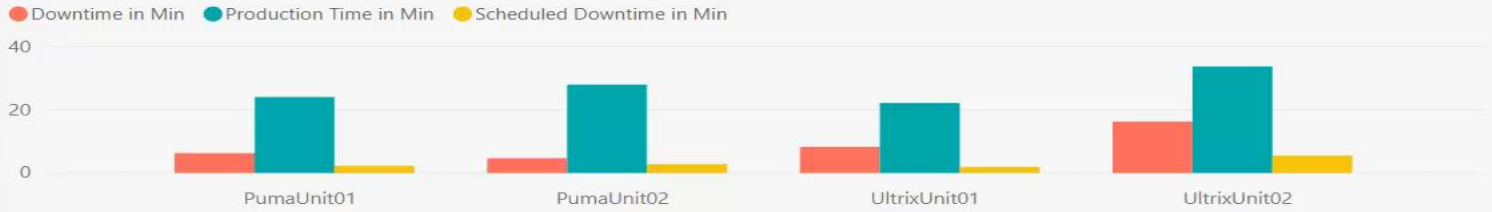
Total Duration (min.)
2,318.57

Total Availability
4.66%

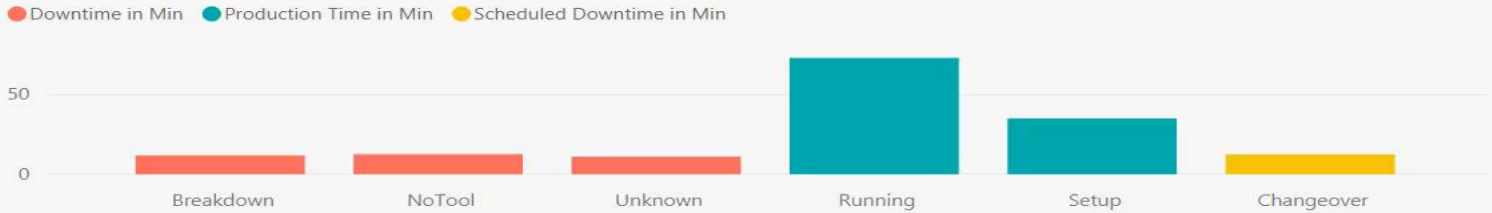
Planned Duration (min.)
143.48

Planned Availability
75.25%

Time Category Duration (min.)



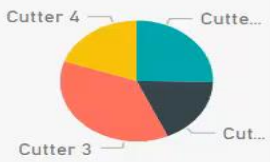
Status Duration (min.)



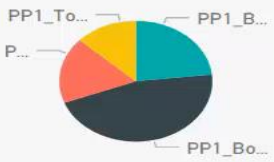
Context

Materials
MachinedBlockSF.A
35.52
Downtime in Min

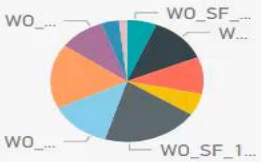
Tools



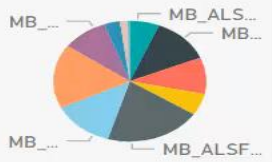
Part Programs



Work Orders



Batch ID



FILTERS

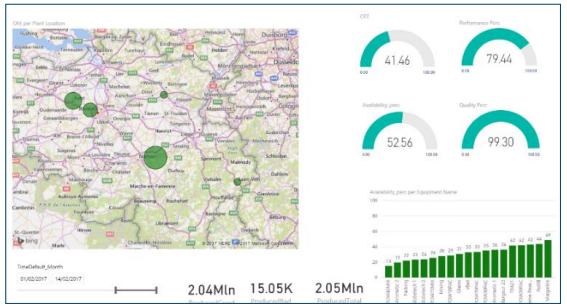
Main KPIs | Defects | Products | Work Orders | Delay | Non-conformance Duration | Non-conformance Duration Trend | Equipment Usage | Equipment Status | Process Values Trends | OEE

Value of connected solution

SIEMENS
Ingenuity for life

Key Benefits

- KPIs and Advanced analytics answering old and new questions
- Common Analysis for WIP and Machine Performance
- High level indicators to suggest where to lead analysis



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MOM – What it does

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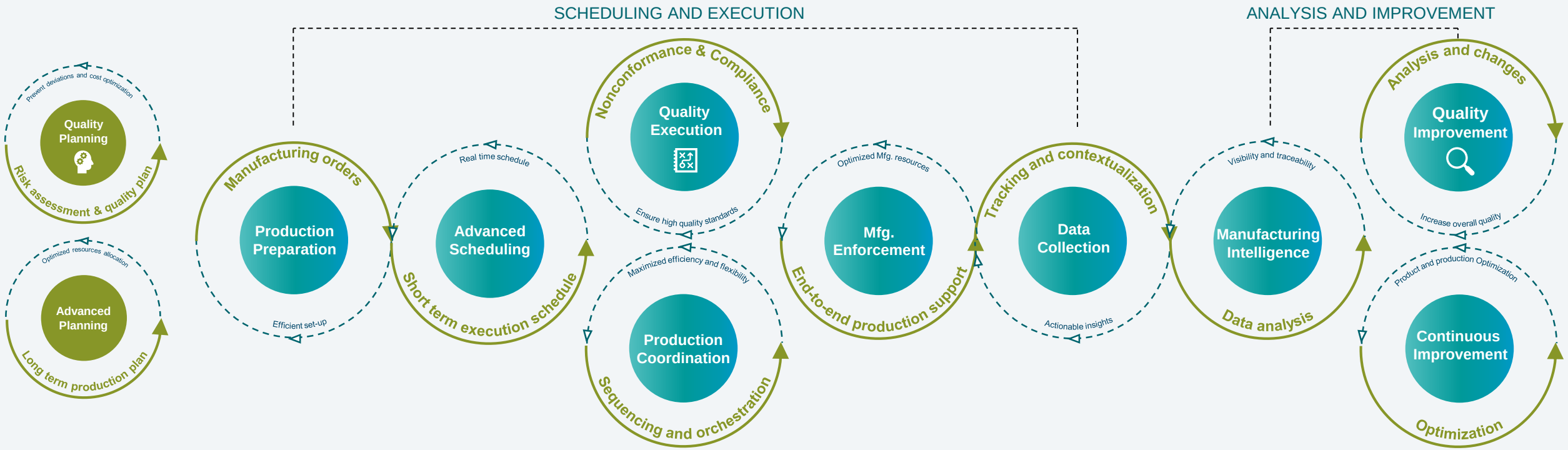

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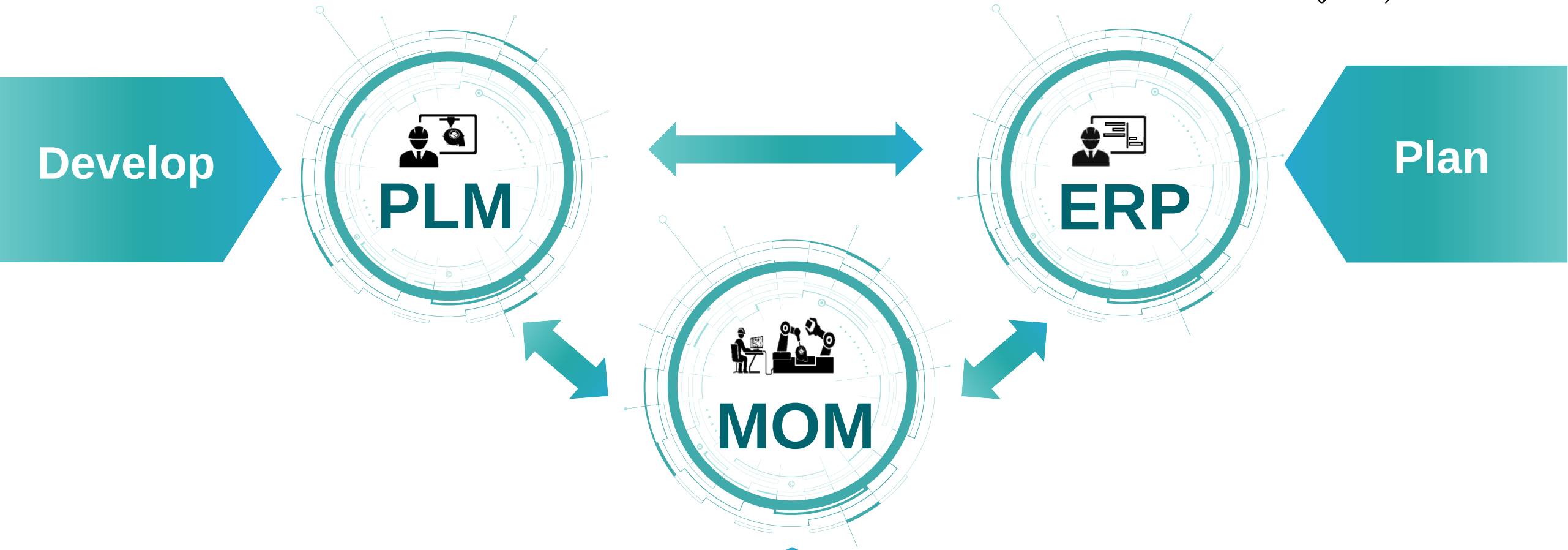
Summary

Closed Loop Manufacturing



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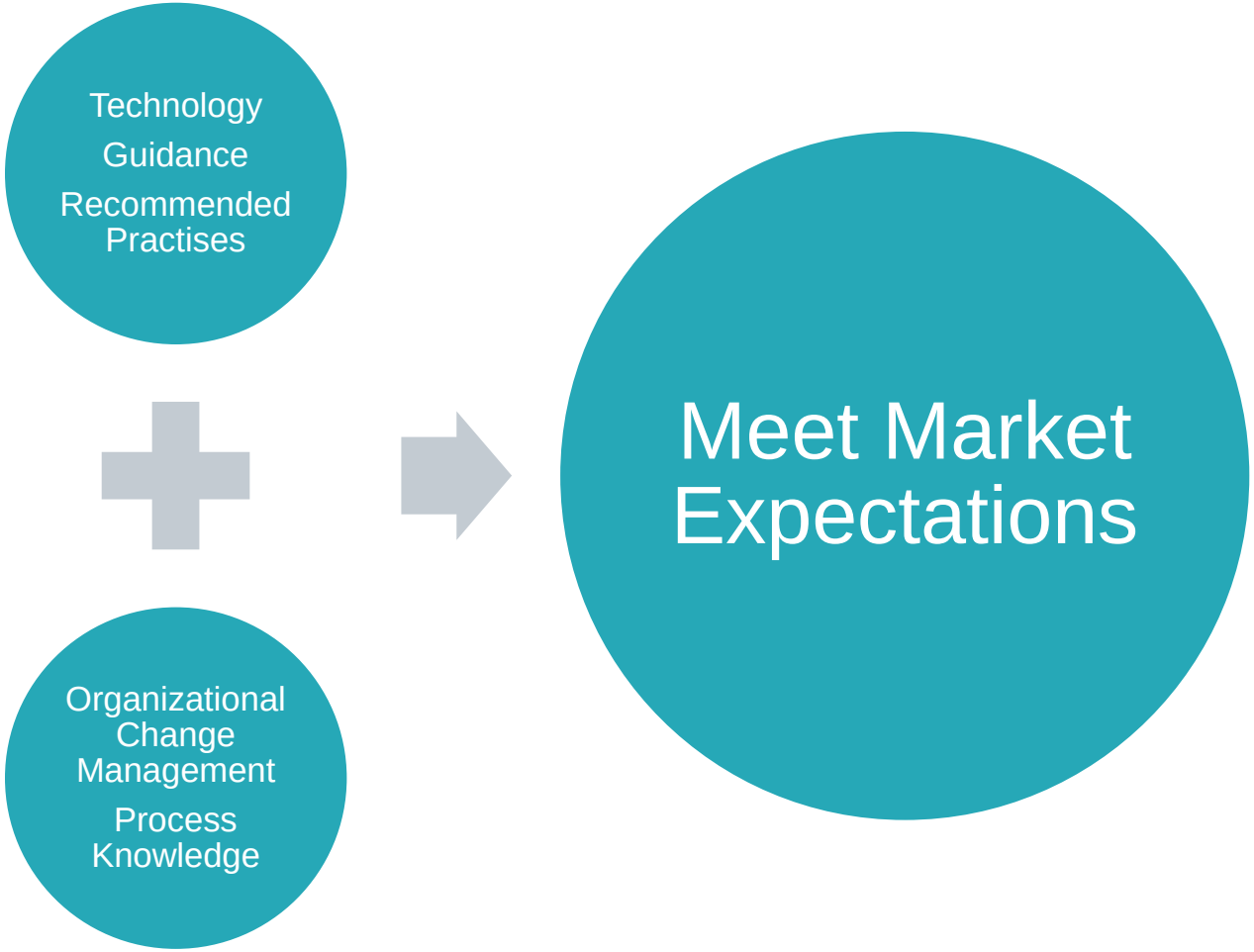
Collaboration is the key



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Take away …

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- ✓ Process integration is a key enabler for end-to-end process optimization because these processes touch PLM, ERP & MES at the same time.
- ✓ Integrated and optimized processes offer big potential for improvements, supported by technology.
- ✓ Consider the possibilities of current technology to support streamlined processes, rather than tweaking tools to link old fashioned processes.

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CLM
Closed Loop Manufacturing
Thank you.