OPC DAY
FINLAND 2025
10.12.2025

MTP
in the Pharmaceutical Industry
… a paradigm change

Thomas Makait, QPRI / MTP4Pharma®

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MTP
in the Pharmaceutical Industry
… a paradigm change

Thomas Makait, QPRI / MTP4Pharma®

OPC DAY FINLAND 10. December 2025

@ AWS Finland Helsinki, Mikonkatu 7

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www.mtp4pharma.eu

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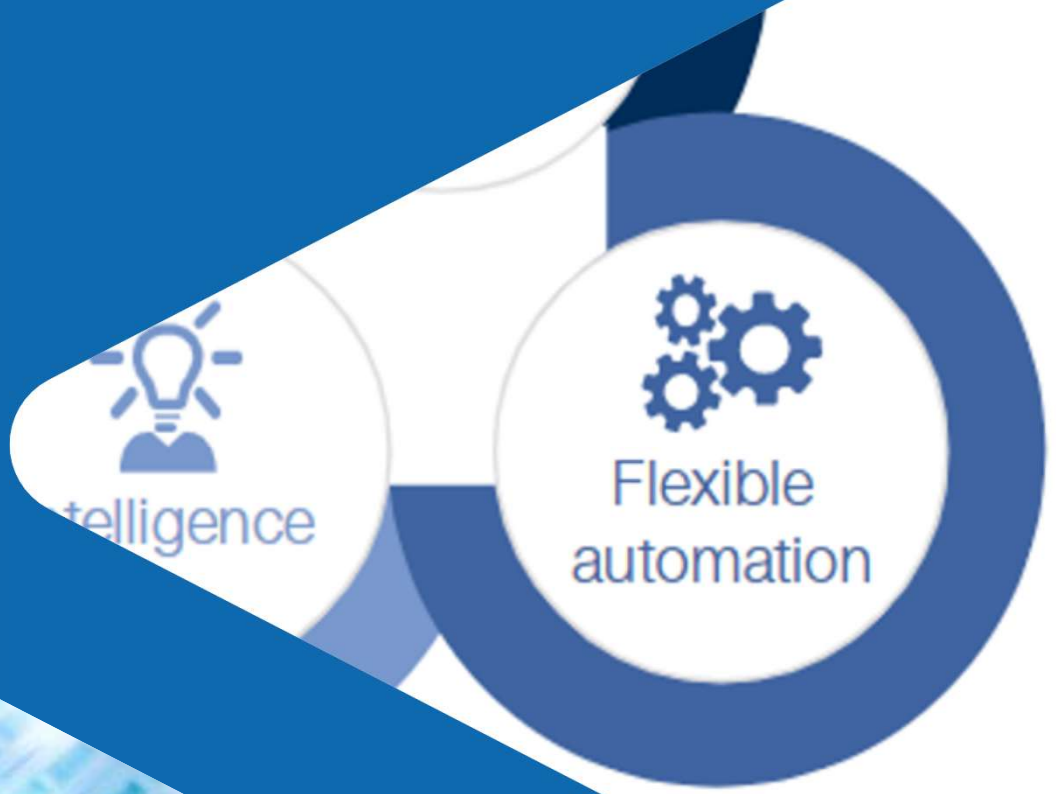
Smart Manufacturing - MTP in the Pharmaceutical Industry

- **Case study Merck Darmstadt:**
  First flexible modular plant in a commercial GMP environment based on the MTP standard - Advantages and challenges of flexible modular plants in the GMP
- **Efficient qualification and validation strategies**
  Optimize initial and recurring qualification and validation activities
- **Success factors**
  Key factors for the successful implementation, operation, and adaptation of flexible modular plants in the GMP environment
- **Next Steps**

Modular Automation for Time2Market & Costs



Essential for our current work
Connectivity as we all know it: Universal Serial Bus (USB)

Operating system

- Software applications
- Hardware configuration
- Equipment connection via driver

Smart Modules for Plug & Produce
Implement Smart Modular Production Platform

MTP+POL provide

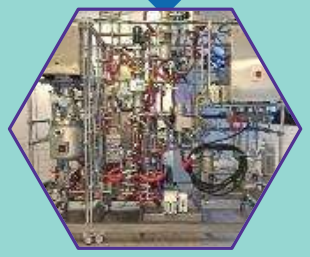
FAIR data

Process Orchestration Layer (POL)

- Simplified configuration
- Times Series & Meta Data Archiving and Trending
- Recipe driven by orchestrating Smart Module Services

MTP





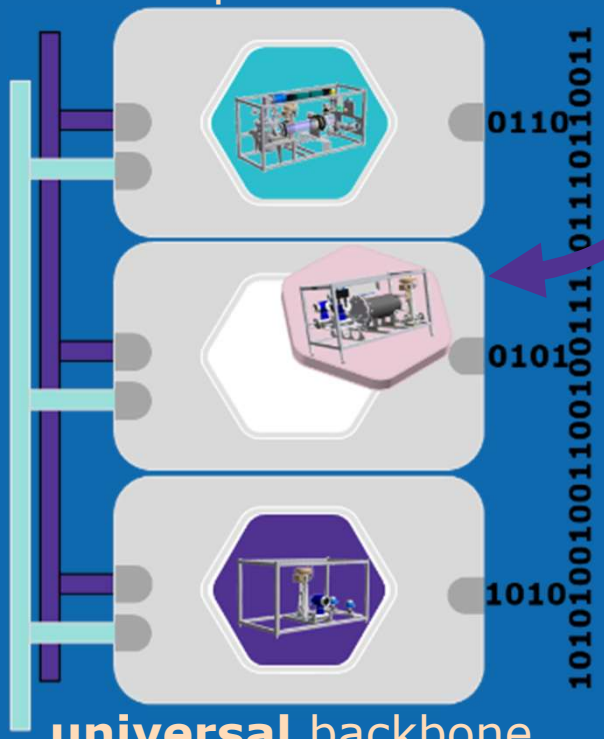

FAIR: Findability, **A**ccessibility, **I**nteroperability, **R**euse

MTP: **M**odule **T**ype **P**ackage, **soon international Standard IEC 63280 MTP 2.0**

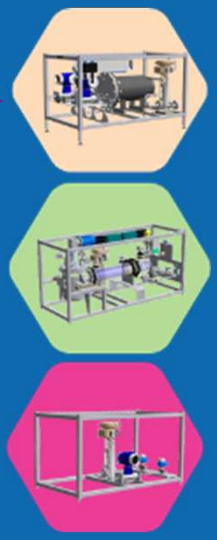
MERCK

Creating a Smart Platform Technology enabling Smart Manufacturing
The Best Match

Highly automated platform



Pool of **optimized smart Modules**



Low Conversion cost

Flexibility

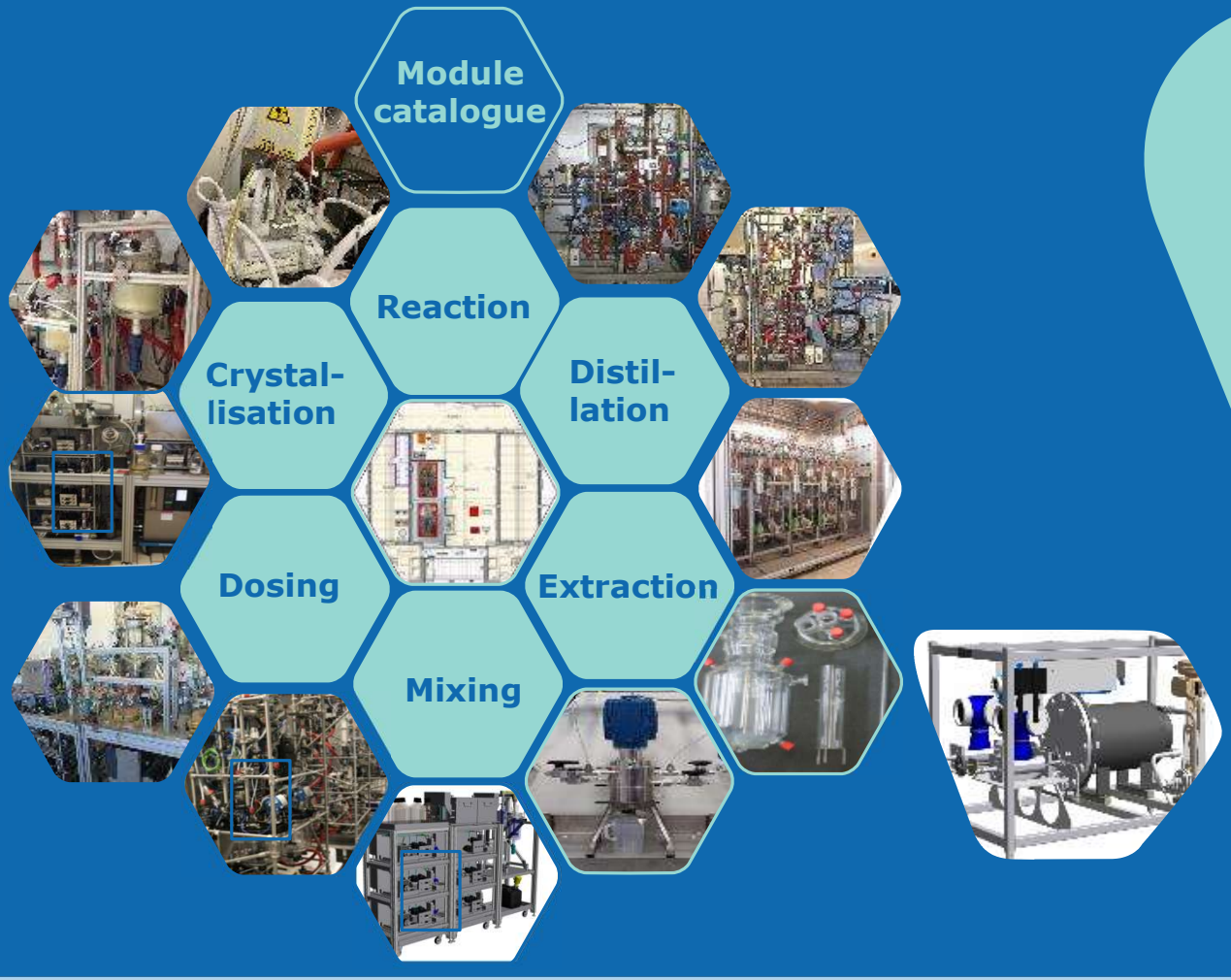
Breaking the paradox

between **flexibility** and **efficiency**.

pre-qualified Smart Modules are hooked into the Smart Manufacturing eco system

Continuous production technology

Optimize process efficiency (20 years of experience)

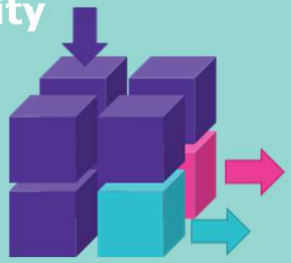


Over 100 modules built

Smart Modules optimized for specific unit operations

- High performance of unit operations provide overall process efficiency
- Safe by design (intramodular functional safety)

Product Flexibility



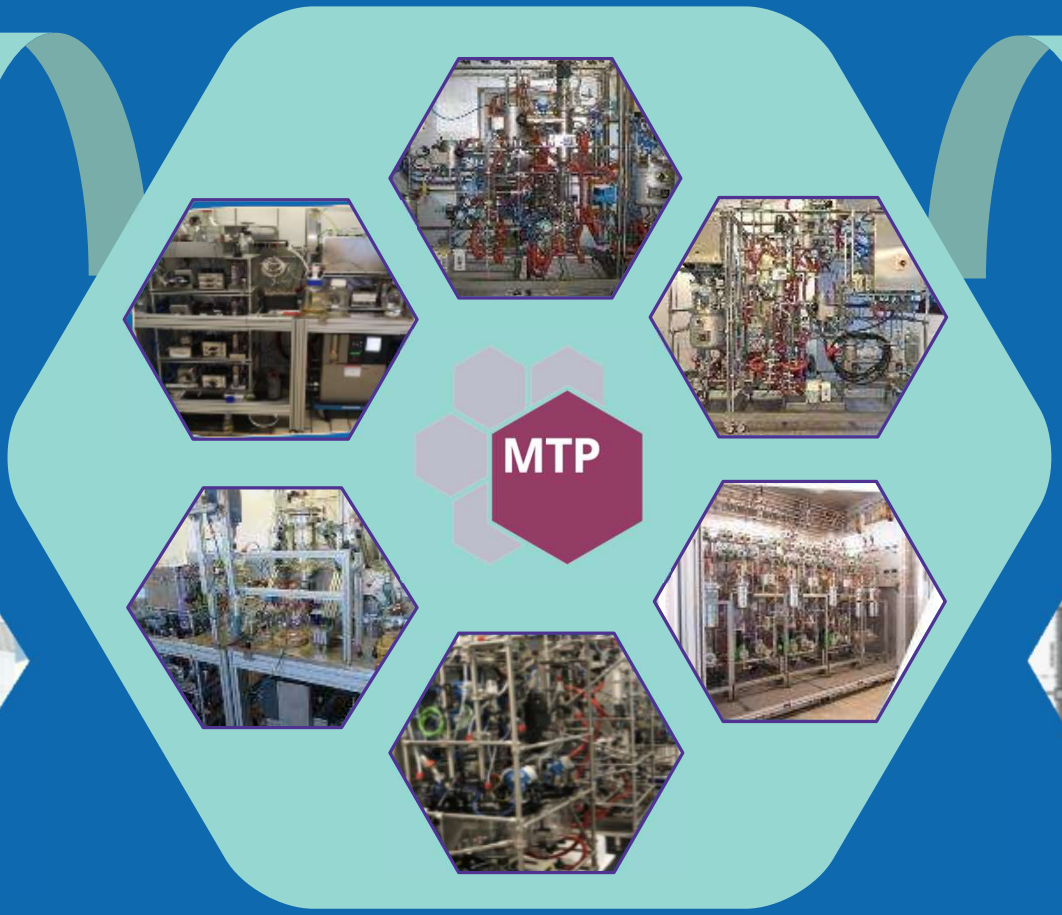
Upside potential "Process to Order"

Merging Smart Development and Smart Manufacturing Eco Systems

Develop and engineer

Smart Development eco system

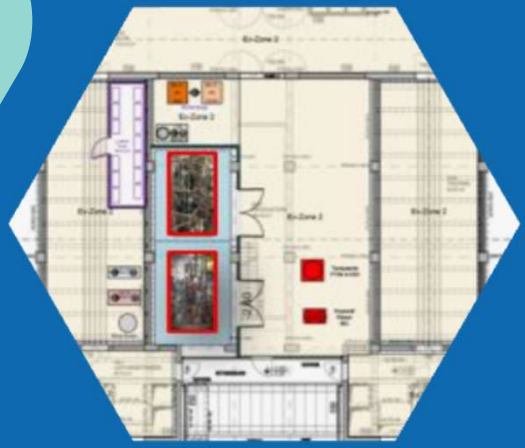
POL from Vendor A



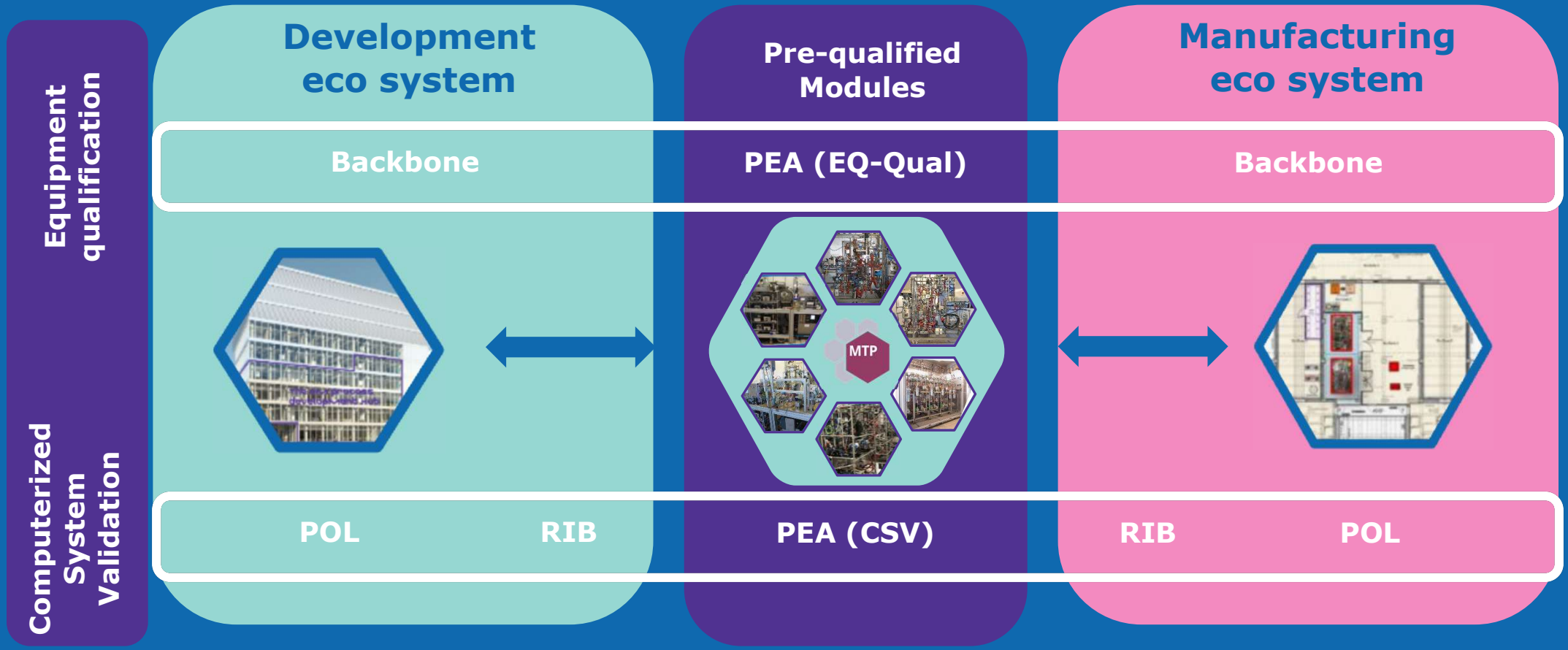
Plug and prodcue

Smart Manufacturing eco system

POL from Vendor B



Upside potential no scale up by leveraging modularized Continuous Manufacturing
Speed up tech transfer within <u>qualified</u> ecosystems



RIB: Runtime interface Bus • POL: Process Orchestration Layer • PEA: Process Equipment Assembly •
CSV: Computerized System Validation • EQ-Qual: Equipment Qualification • CM: Continuous Manufacturing

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Computerized Systems Validation – Basics and terminology

Please also remember:

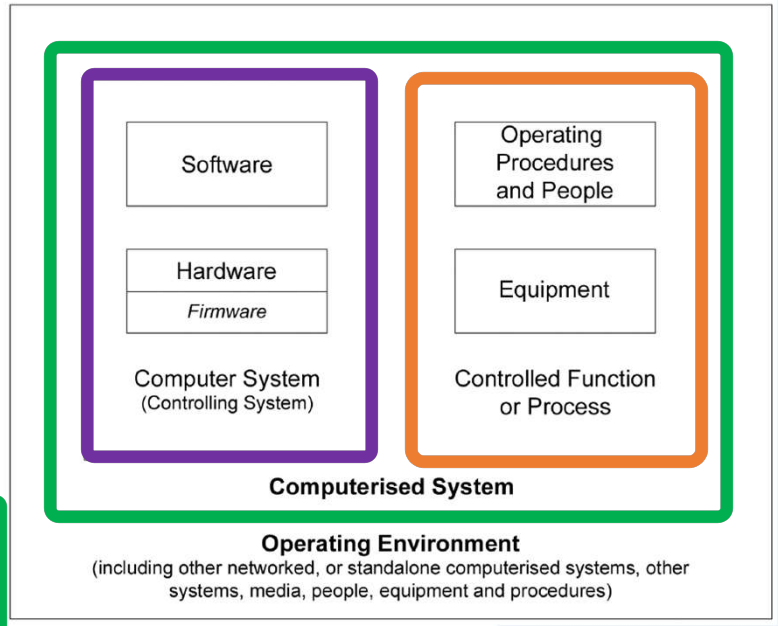
Computer System ≠ Computerized System

- To confirm fitness for intended use a framework of validation plan and report defines risk-based verification activities for the
- **Computer System (Controlling System)**
  - Computer System Hardware and Software
- **Controlled Function or Process**
  - Operating Procedures and People
  - Equipment (sensors, actuators (valves, motors, etc.), pipes, vessels, stirrers, etc.)
- **Computerized System (Automated Manufacturing Equipment)**
  - **Dynamic Interaction of Controlling System** with **Controlled Function or Process**

Considering GAMP® 5 2nd Edition's suggestion:

- For **Automated Manufacturing Equipment**, separate computer system validation should be avoided. Computer system specification and verification should be part of an **integrated engineering approach** to ensure **compliance and fitness for intended use of the complete Automated Manufacturing Equipment.**

Figure 2.2: Computerised System – PIC/S Guidance [22]



Source: ISPE GAMP® 5: A Risk-Based Approach to Compliant GxP Computerized Systems (Second Edition)

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A typical MTP-based modular plant consists of the following elements

In a **Modular Plant Operating Environment** the MTP standards defines a **Modular Plant (MP)** to consist of a **Process Orchestration Layer (POL)**, and **automated manufacturing equipment** as **Process Equipment Assemblies (PEAs)**, and its **Physical Integration**, and the **Functional Integration** of PEAs into the POL based on standardized interface definitions: **Module Type Packages[1] (MTPs)**, and the (Manufacturing) Process Orchestration

- based on pre-defined PEA-automation-services / procedures, parameters and report values

[1] MTPs = (XML-Files) = MTP Manifest

What's in an MTP file?

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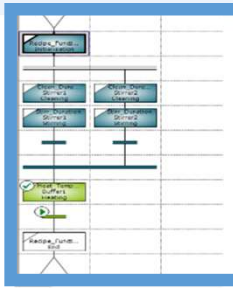
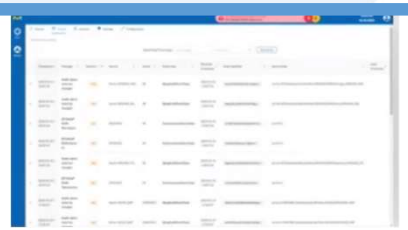
MTP file contains the MTP Manifest: the “passport” of a PEA module

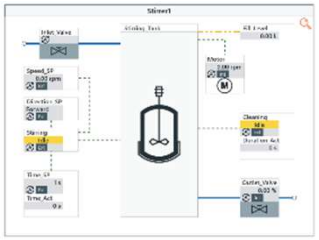
MTP file describes the module characteristics in a standardized and machine readable way.



PEA Services/Procedures, Control Parameters, Report Values (e.g. for Recipes and Reports)



PEA Alarms & Events



PEA Human Machine Interface (e.g. Description of P&IDs)

MTP

PEA Safety & Security Information (NAMUR/PNO standard in progress)

PEA Diagnosis & Maintenance information (NAMUR/PNO standard in progress)

Further aspects for standardization

Normalizing of data starts in Engineering, CSV & EQ-Qual: MTP-Standard based semantic data modelling of manufacturing processes & data in a machine readable XML-File!

Source: VDI/VDE/NAMUR 2658, soon IEC 63280

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MTP-Standards allows to standardize the functional integration

Based on the MTP standard an unheard level of standardization is possible for

- **Process engineering**
- **Equipment engineering**
- **Automation engineering**

and related

- **Computerized Systems Validation including Automated Manufacturing Equipment Qualification**

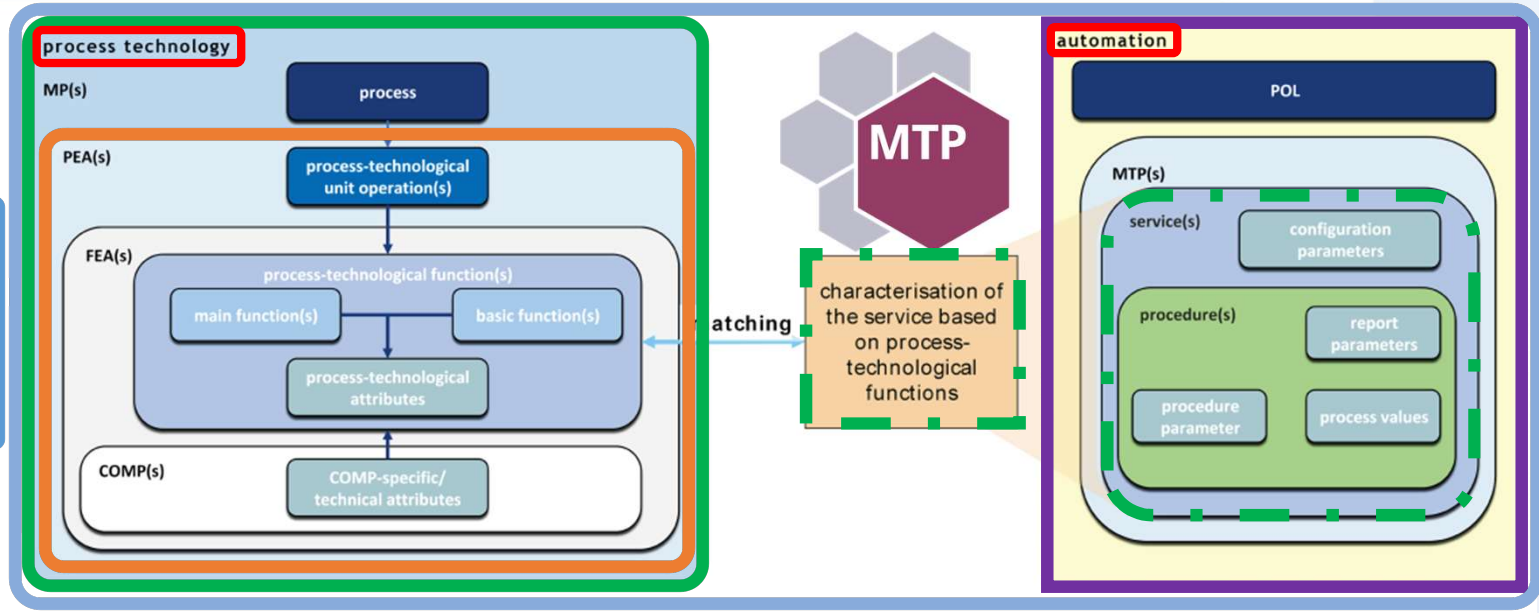

Figure 1. Relationship between process-technological functions and automation engineering services

Source: **VDI 2776** Process engineering plants - Modular plants
VDI/VDE/NAMUR 2658 Automation engineering of modular systems in the process industry
soon **IEC 63280** Automation engineering of modular systems in the process industry

Normalizing of data starts in engineering, CSV & EQ-Qual: MTP-Standard based semantic data modelling of manufacturing processes & data based on Automation Services!

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MTP-Standards allows to standardize the physical integration

Industry wide standardized

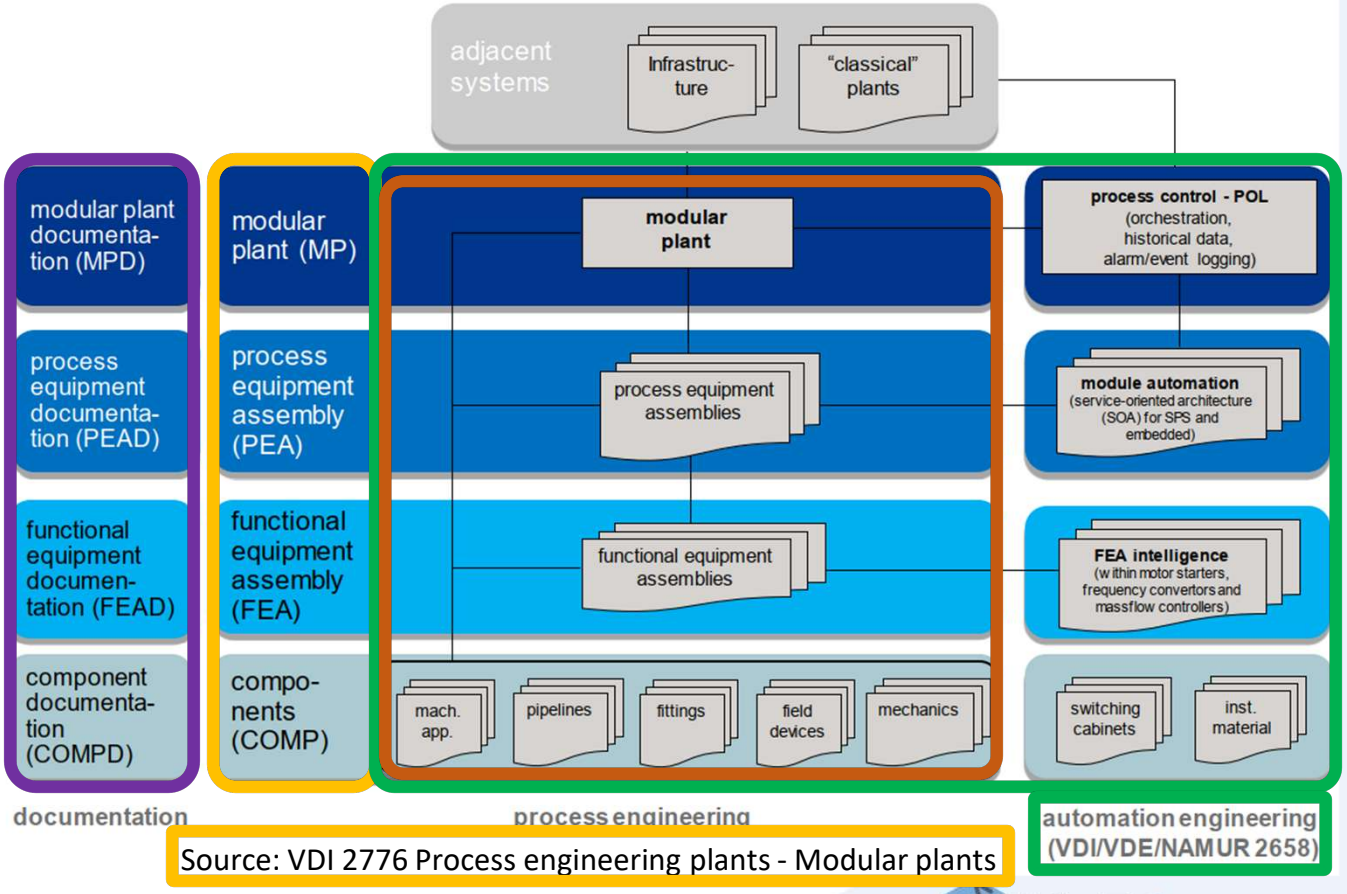
- Modular plant structure
- Documentation structure

allows to standardize

for GxP environments

- Computerized Systems Validation approach and documentation

including Automated Manufacturing Equipment qualification approach and documentation



Source: VDI 2776 Process engineering plants - Modular plants

VDI/VDE/NAMUR 2658 will soon be an international Standard IEC 63280 MTP2.0

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Recommended steps to leverage key benefits of MTP Standard based Modular Plants in GxP-environments

- **Standardize and streamline Good Engineering Practices (GEP) based on Quality By Design (QbD) Principles:** Establish seamless data driven Process-, Equipment- and Automation-Engineering **& choose Standard-Modules (if available).**
  => Standardize Computerized Systems Validation incl. Equipment Qualification!
- **Increase operational flexibility and decrease time to market by design** by taking the following **key Operations & Engineering decisions** early to
  - design **Blue Field / Modular Manufacturing Platforms**, and to
  - specify an **Operations Philosophy**, enabling a
  - **Smart Automation Architecture**, which is implemented using
  - **Smart Modules procured pre-qualified**[2)]!
- **to reduce On-Site Computerized Systems Validation incl. Equipment Qualification**
  - initially
  - re-occurring

[1)] Source: NAMUR; ProcessNet, VDMA, ZVEI)

[2)] Term dependent on regulated company QMS.

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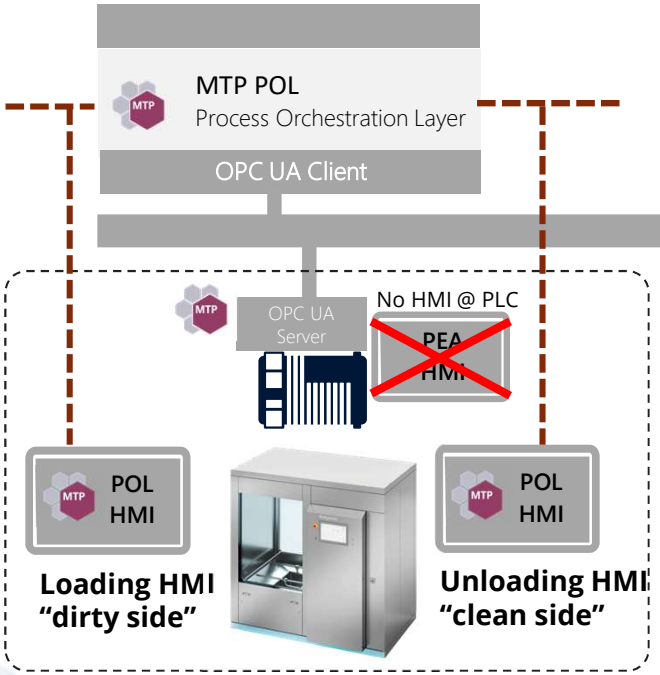
Smart modular architecture & smart CSV Strategy: Vendor independent One System Approach based on MTP-Standard

Modular Plant Operations Philosophy: Only the POL shall be used for user management, operation, audit trail, data historian / trending, alarm ACK & history, report generation / reporting, calibration, maintenance, and …



POL: shall satisfy ERES, DI & Audit Trail requirements for **all PEAs** connected **once**!

PEA: No ERES, DI & Audit Trail requirements on PEA level, except admin. access mgt. for remote access, back up restore, etc.

Operation / Function	PEA	POL
Access Management		
- User	-	X
- Calibration	-	X
- Maintenance	-	X
Manual operation (e.g. open close valve):		
- Logic code / Service / Procedure implementation	X -	- X
- Operate		
PEA Automation Services (MTP):		
- Management Logic	X	-
- Operate (START, HOLD, STOP, ...)	-	X
Recipes (based on PEA Automation Services):		
- Configuration / Management	-	X
- Execution	-	X
Alarm Management:		
- Alarm Generation / State	X	
- Alarm ACK	-	X
- Alarm History	-	X
Audit Trail:		
- Audit Trail generation	-	X
- Audit Trail history	-	X
Out of process Operations:		
- Maintenance	-	X
- Calibration	-	X
Reporting		
- Report generation (template)	-	X
- Report creation per run (execution)	-	X
...		
- ...	...	...
- ...	...	...

Data Integrity (DI), Electronic Records/ Electronic Signatures (ERES)

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Example of a smart modular architecture allowing to minimize Computerized Systems Validation effort on Automated Manufacturing Equipment / PEA level

Reducing onsite CSV/EQ-QAL[2)] by up to **- 60 %**

Smart Operations Philosophy:
Operation, Maintenance, Calibration of Modules **via Process Orchestration Layer (POL) only!**

Equipment / PEA Level
Process
Equipment
Assembly

Benefits of this approach:
Following an integrated engineering approach to implement a Smart Operations Philosophy for Process Equipment Assemblies (PEAs),

allows regulated companies to cut PEA Requirements Specifications by up to 50 %!

How? By moving most requirements for Data Integrity (DI), Electronic Records/Signatures (ERES) & Audit Trail to the POL only!

Data Integrity Compliance Risks are minimized!

Moving functions required for PEA Operation to POL level only
- Human Machine Interface (HMI)
- User Management
- Audit Trail
- Alarm Management
- Reporting
- ...

allows PEA vendors to focus verification effort to pre-qualify PEAs during FAT/SAT under QA oversight of the regulated company to
- Verification of Equipment
- explicit MTP-file verification:
  - Functional Verification (OV) executing Services -> CPPs
  - Alarm generation/state of CPPs
  - Param. / Report Values -> CPPs
- PEA Documentation
- ...

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Critical Process Parameters (CPPs)

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ISPE® working groups supporting Modular Plants in GxP-Environments

Global
GAMP® SIG MTP in Pharma

The key objective is an efficient approach for Computerized Systems Validation (CSV) including Equipment Qualification of Modular Plants in GxP environments.

MERCK
BAYER
Lonza

… more

Global
Plug & Produce - MTP4ISPE

ISPE working group MTP4ISPE as part of the overall “Plug & Produce” initiative has the objective to further leverage the MTP standard within life-science as it will be a piece of the puzzle for the Pharma 4.0 offering Flexibility, Business efficiency, Reliability, through standardized services defined for each module.

AstraZeneca

… more

Outcome:
A common Good Practice Guide (GPG)
Technical Implementation & Computerized System Validation for Modular Plants according to MTP (Module Type Package)

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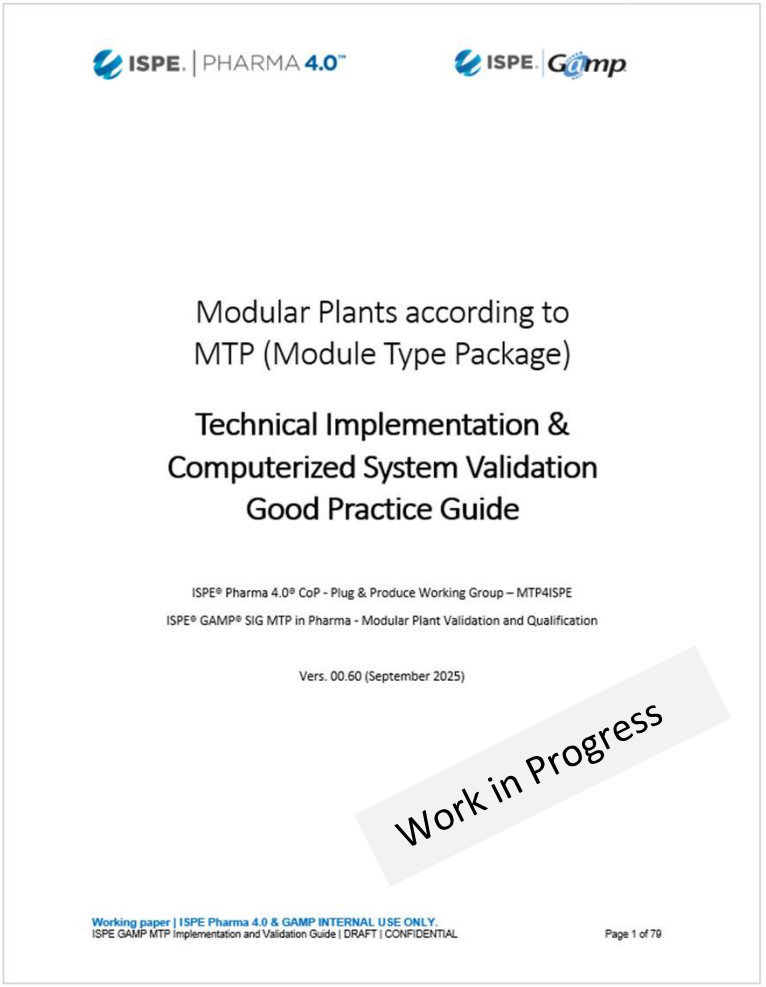
Modular Plant Good Practice Guide (GPG)

Objective of the guide

- Provide a clear, practical guidance of how to implement and validate modular plants applying the MTP standard
- Cover both greenfield and brownfield scenarios

Target audience:

- Engineering, process, equipment and automation teams in pharmaceutical companies.
- Equipment manufacturers & production line suppliers
- Hardware and software technology providers
- Quality Assurance and Computerized System Validation & Equipment Qualification professionals



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AAS as the Environment for Semantic PEA Datasheet (SPEAD)

SOURCES

PDF

MTP

STANDARDISED ENVIRONMENT

AAS

Asset Administration Shell

MANUFACTURING-X

Catena-X
Automotive Network

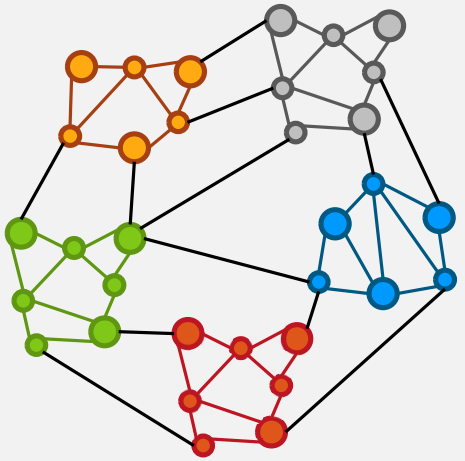
SEMICONDUCTOR-X

FACTORY-X

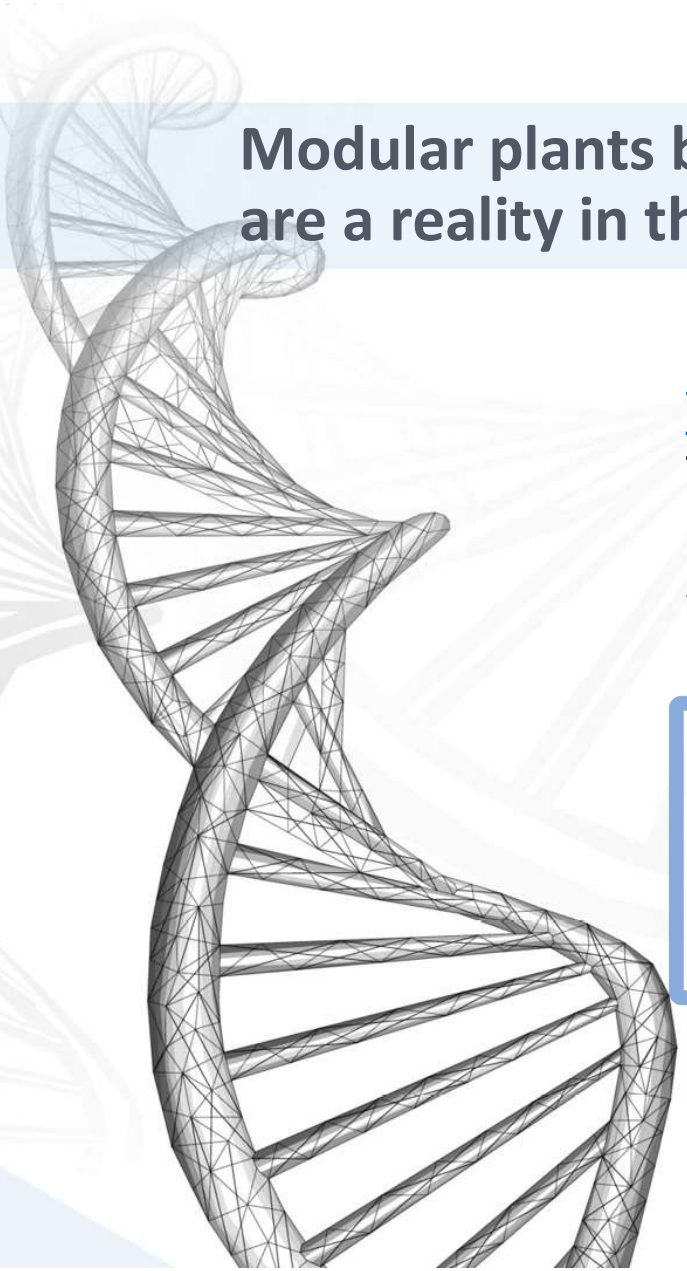
CHEMIE-X

AEROSPACE-X

OUTPUT



Modular plants based on the MTP standard are a reality in the pharmaceutical industry!



Basel / CH on 14 Oct 2025:

Tech Tuesday @Lonza - ISPE D/A/CH

There, LONZA presented the impact of MTP-based Modular Automation onto on their global CAPEX projects!

Call to action:

Check whether the next CAPEX project should be implemented as a modular plant based on the MTP standard!

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MTP
in the Pharmaceutical Industry
… changing the Matrix

In The Matrix, the red and blue pills symbolise two different choices:

- The red pill represents the realisation of the truth and awakening from the illusion. It allows one to see the true nature of reality, even if it is uncomfortable or frightening.
- The blue pill means remaining in ignorance and staying in the illusion. It represents continuing a peaceful but illusory life without facing the hard truths.

These symbols come from the film 'The Matrix', in which Neo has the choice between these two pills to either realise the truth or remain in the illusion.

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Back Up Slides

Thomas Makait - MTP4Pharma® - Plug & Produce for Smart Manufacturing

- Owner / Managing Director QPRI / MTP4Pharma®
  Plug & Produce for Smart Manufacturing - Intrinsic Quality & Compliance
- Degree in Electrical Engineering / Automation
- Over 26 years experience in the pharmaceutical industry
  Leading roles in engineering, technical compliance and quality assurance
- Over 5 years conception, implementation and validation of Modular Plants
- Supporting industry organisation regarding MTP-based standardization:
  VDI, NAMUR, PROFIBUS e.V. (PNO), ISPE®, GAMP® D-A-CH, BioPhorum
- Leading the Global ISPE® GAMP® Special Interest Group
  „MTP in Pharma - Modular Plant Validation and Qualification”

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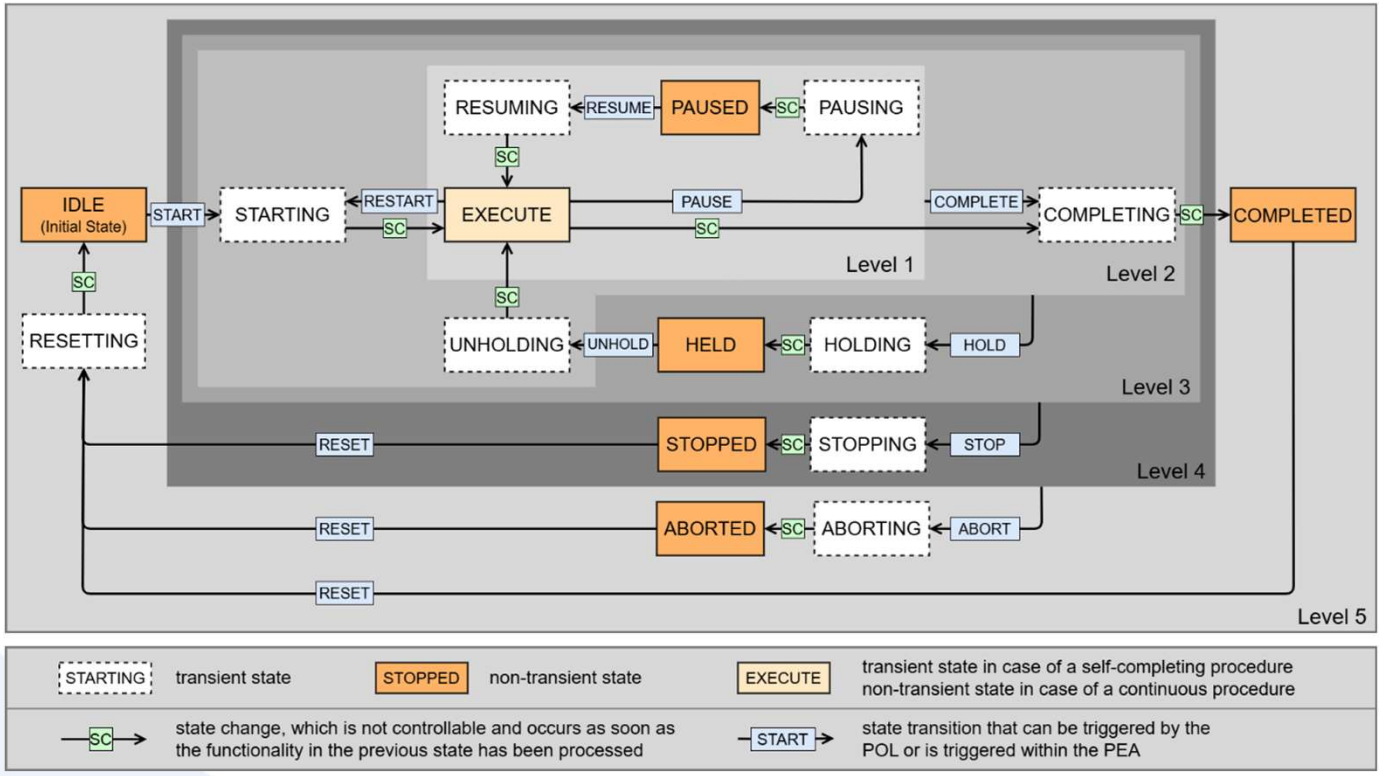
PEA Automation Service: Structure of the State Machine



- **Level 1** contains the states Execute, Pausing, Paused, and Resuming.
- **Level 2** contains the states Starting, Completing, and Unholding as well as level 1.
- **Level 3** consists of the states Holding and Held as well as level 2.
- **Level 4** contains the states Stopping and Stopped as well as level 3.
- **Level 5** contains the states Idle, Completed, Resetting, Aborting, and Aborted as well as level 4.

Source: Module Type Package Specification MTP 2.0
Part 4: Automation Services and Process Values

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