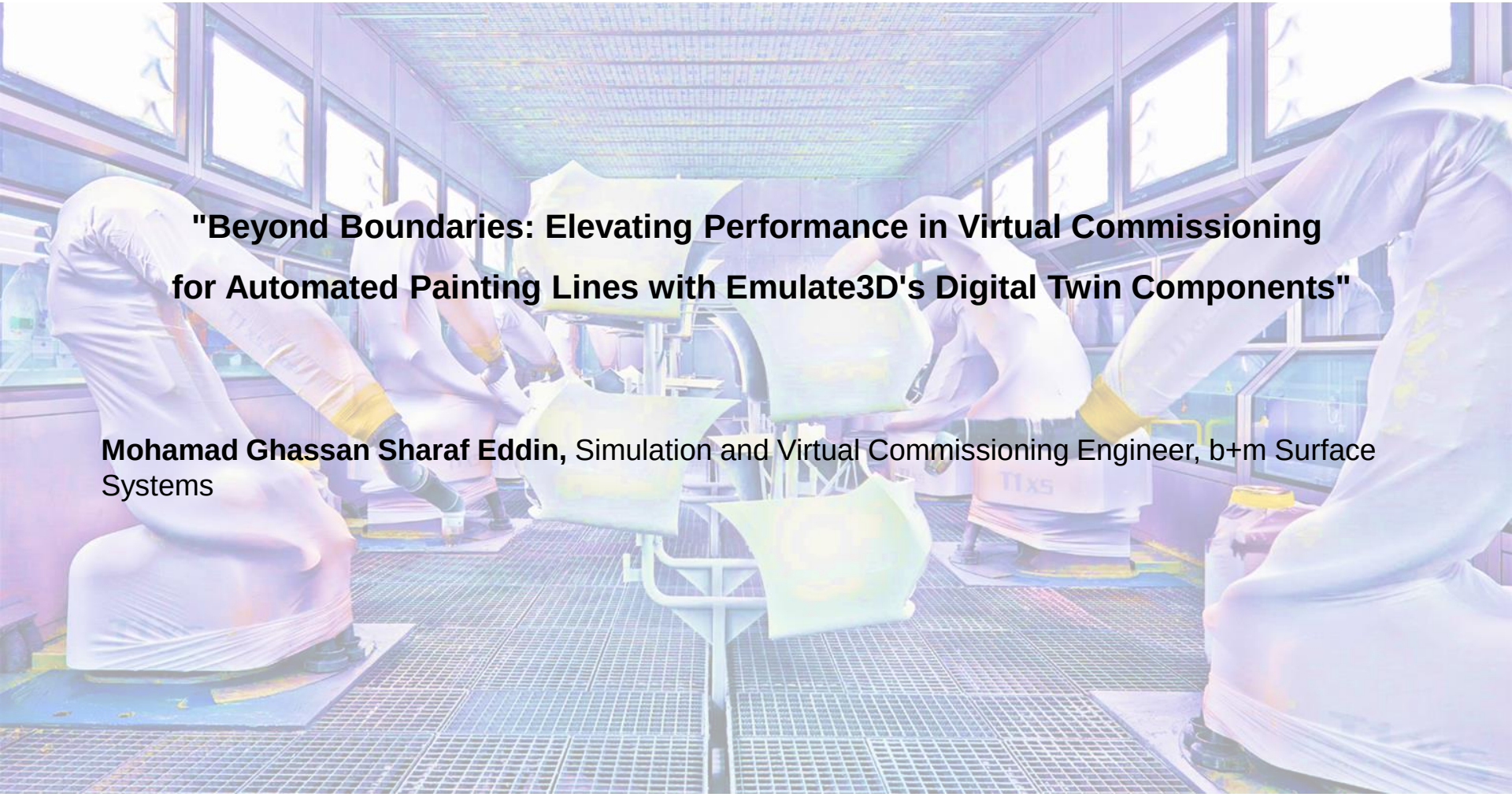
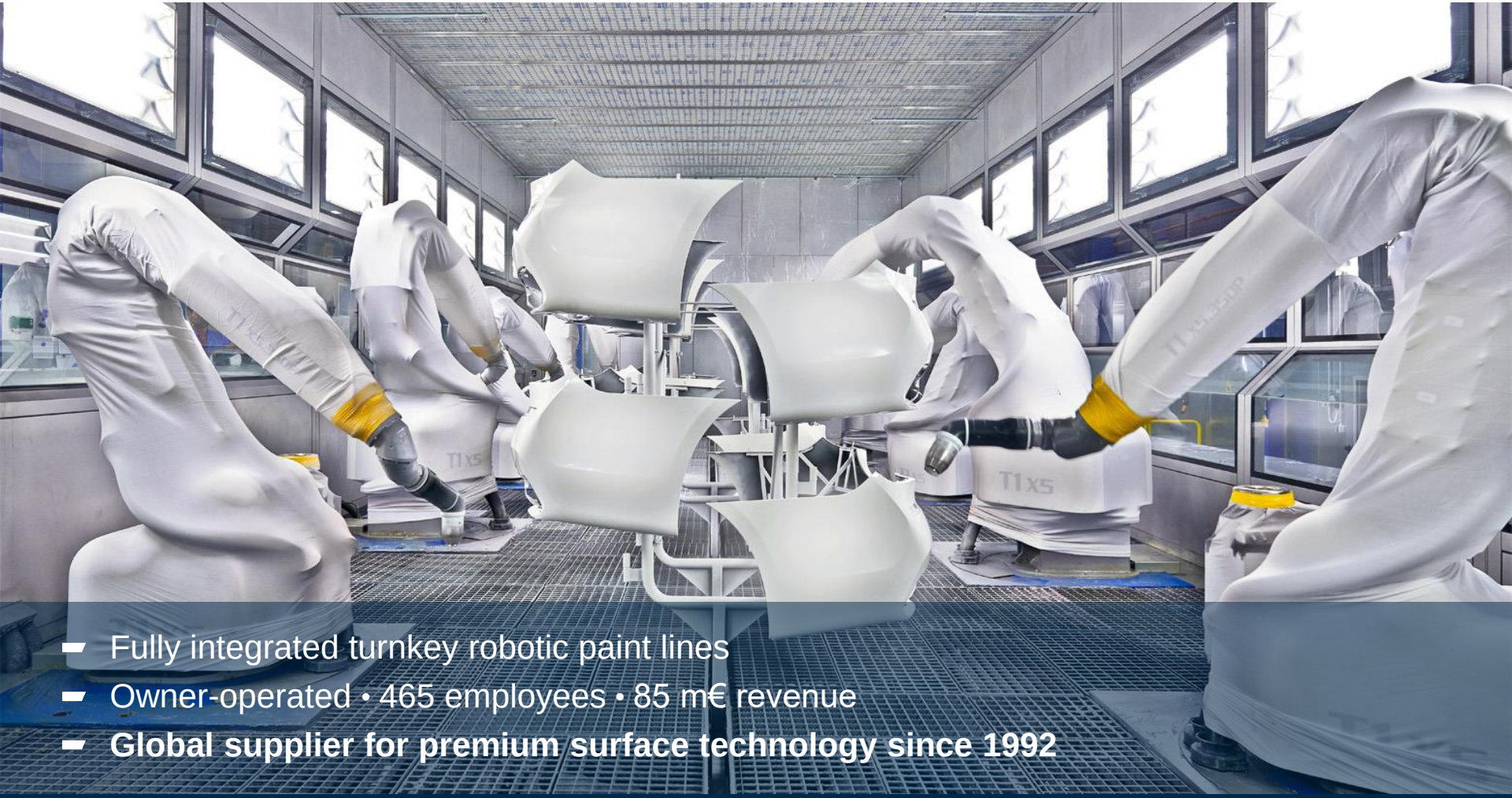


"Beyond Boundaries: Elevating Performance in Virtual Commissioning for Automated Painting Lines with Emulate3D's Digital Twin Components"

Mohamad Ghassan Sharaf Eddin, Simulation and Virtual Commissioning Engineer, b+m Surface Systems

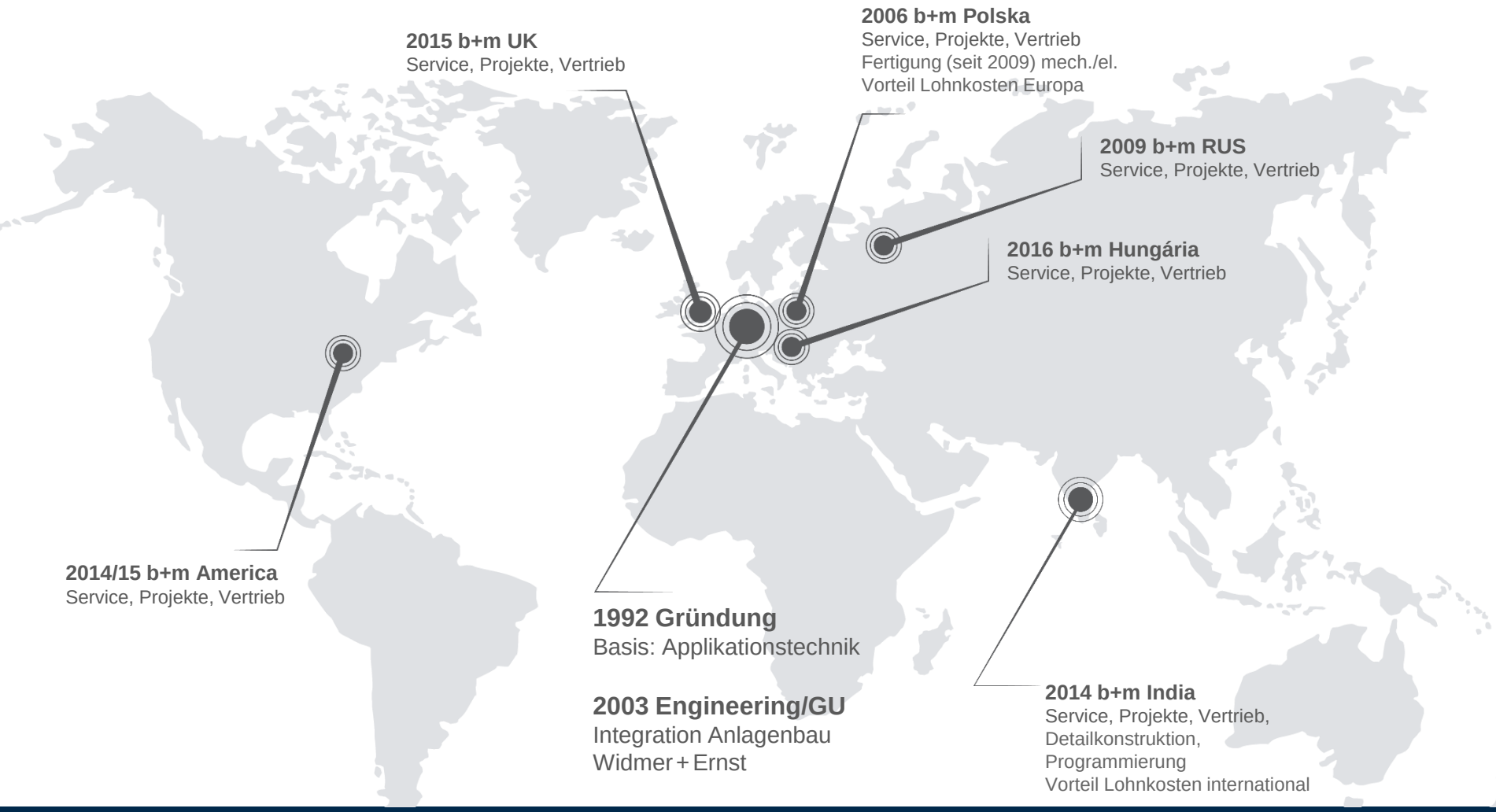
Agenda

1. Introduction to b+m
2. Automated Painting Facility Overview
3. Digital Twin
4. Simulation
    1. Application technology
    2. Process technology
    3. Conveyor technology
5. Diverse Use Cases



- Fully integrated turnkey robotic paint lines
- Owner-operated • 465 employees • 85 m€ revenue
- **Global supplier for premium surface technology since 1992**

International presence



2015 b+m UK
Service, Projekte, Vertrieb

2006 b+m Polska
Service, Projekte, Vertrieb
Fertigung (seit 2009) mech./el.
Vorteil Lohnkosten Europa

2009 b+m RUS
Service, Projekte, Vertrieb

2016 b+m Hungária
Service, Projekte, Vertrieb

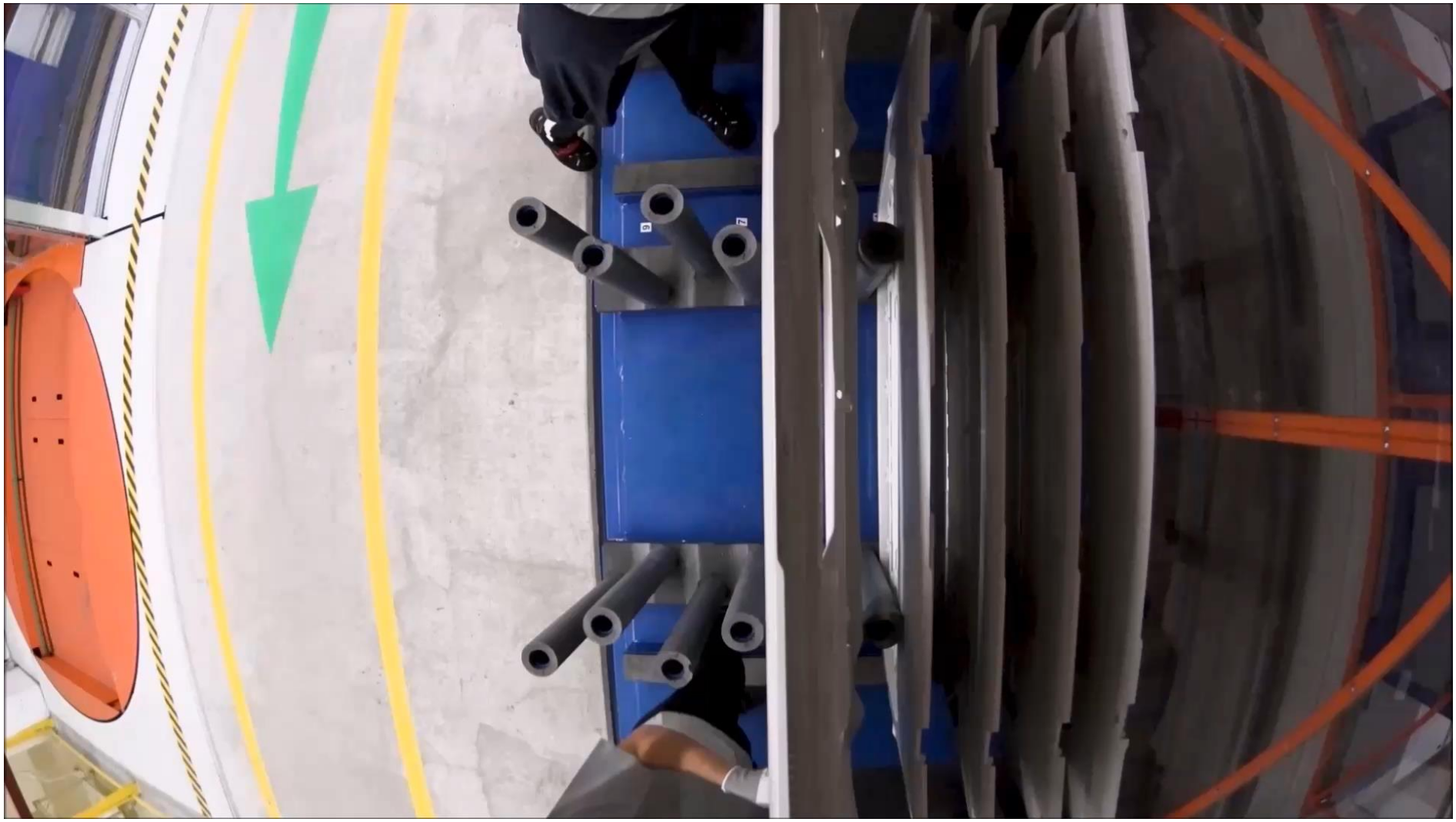
2014/15 b+m America
Service, Projekte, Vertrieb

1992 Gründung
Basis: Applikationstechnik

2003 Engineering/GU
Integration Anlagenbau
Widmer + Ernst

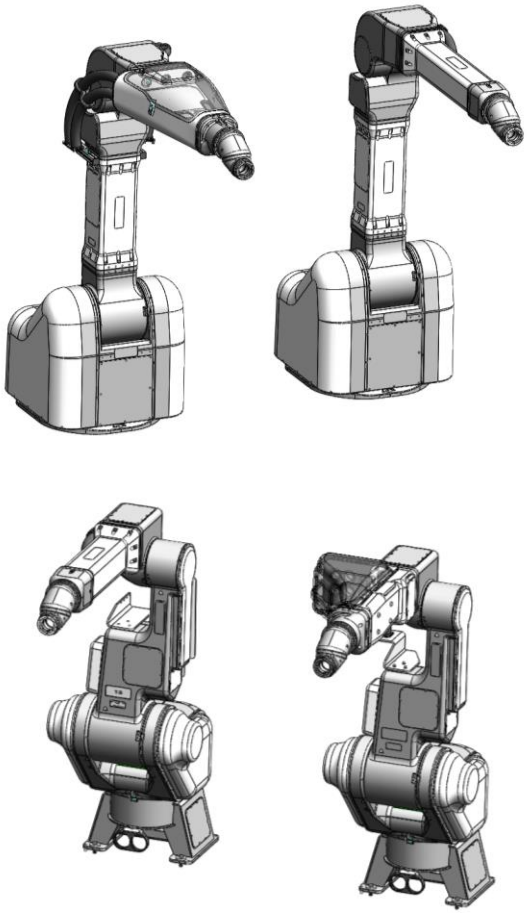
2014 b+m India
Service, Projekte, Vertrieb,
Detailkonstruktion,
Programmierung
Vorteil Lohnkosten international

Automated Painting Facility Overview



Automated Painting Facility Overview

- Main components of Automated Painting Lines
  - **Robotic**
  - APT :Application (Dosing)
  - PT : Process
  - CT : Conveyor
  - MES



What is Painting and Automated Painting Lines

- Main components of Automated Painting Lines
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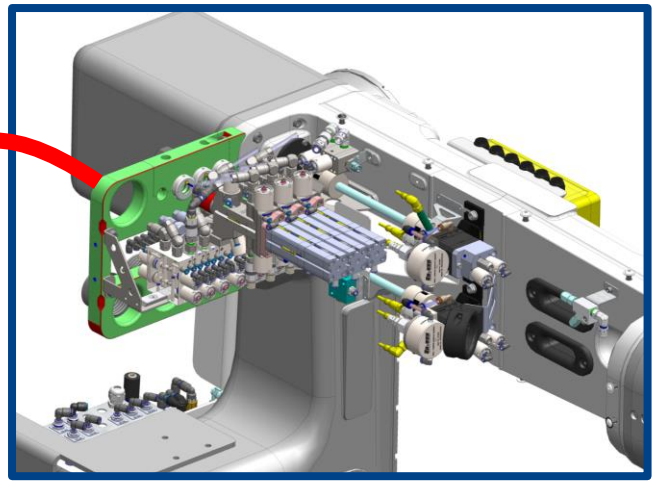
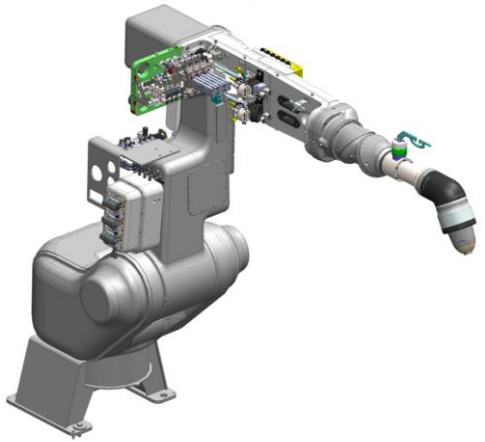
  - PT : Process
  - CT : Conveyor
  - MES





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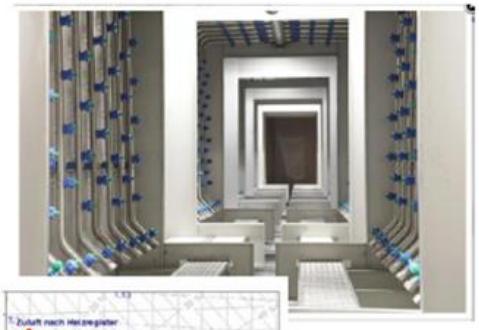

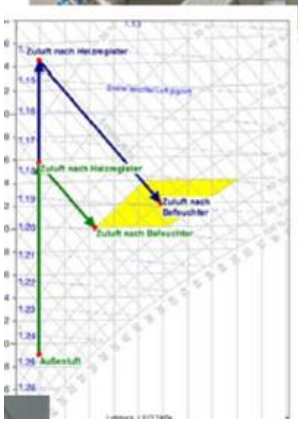

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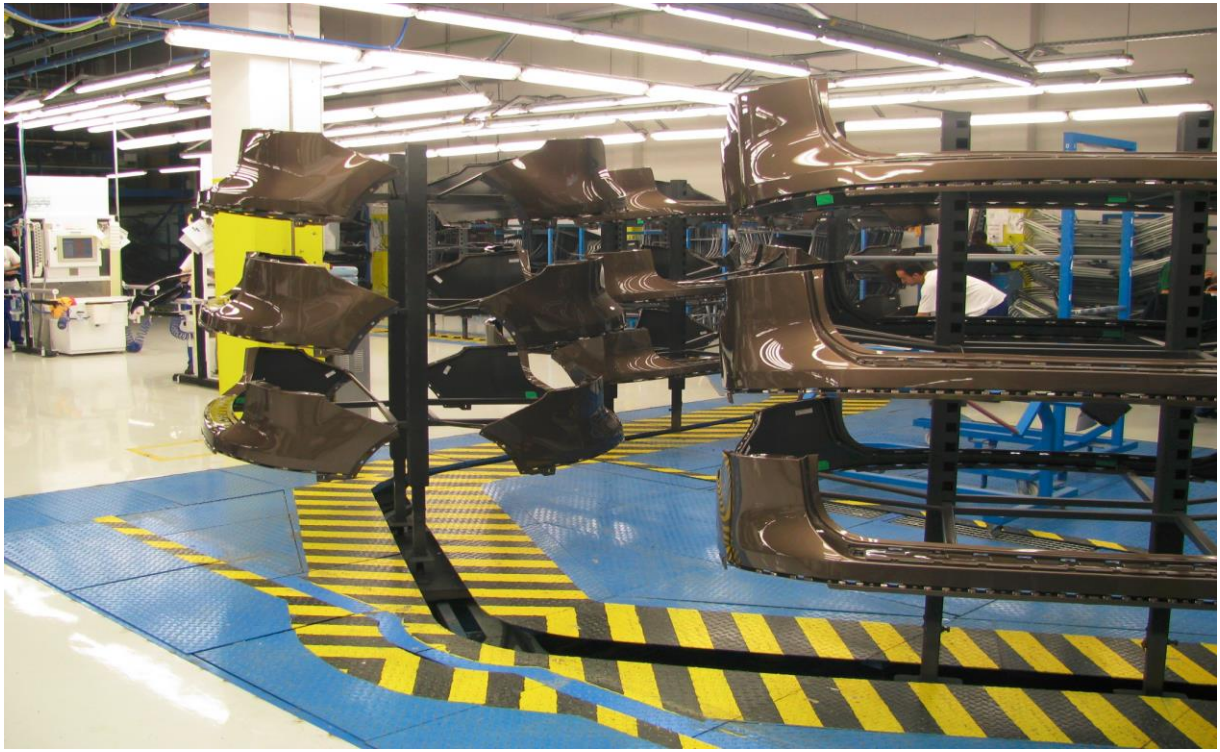
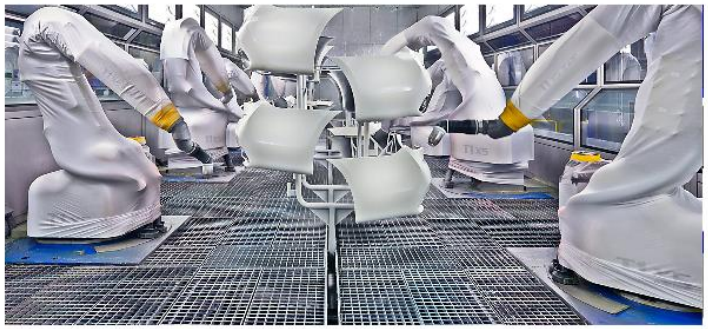
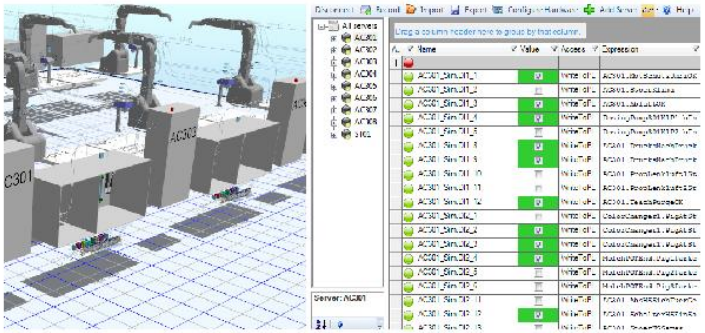
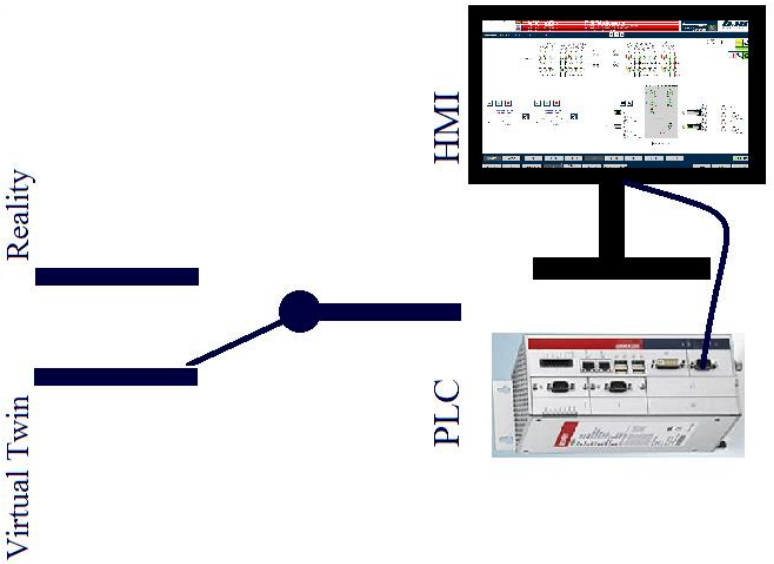


„Digital Twin“

- Digital Image of the Paint Shop
- Integration of Four Main Trades - APT, RO, FT, and VT
- Digital Pretesting before Actual Commissioning
- System Optimization without Risk for Real Systems

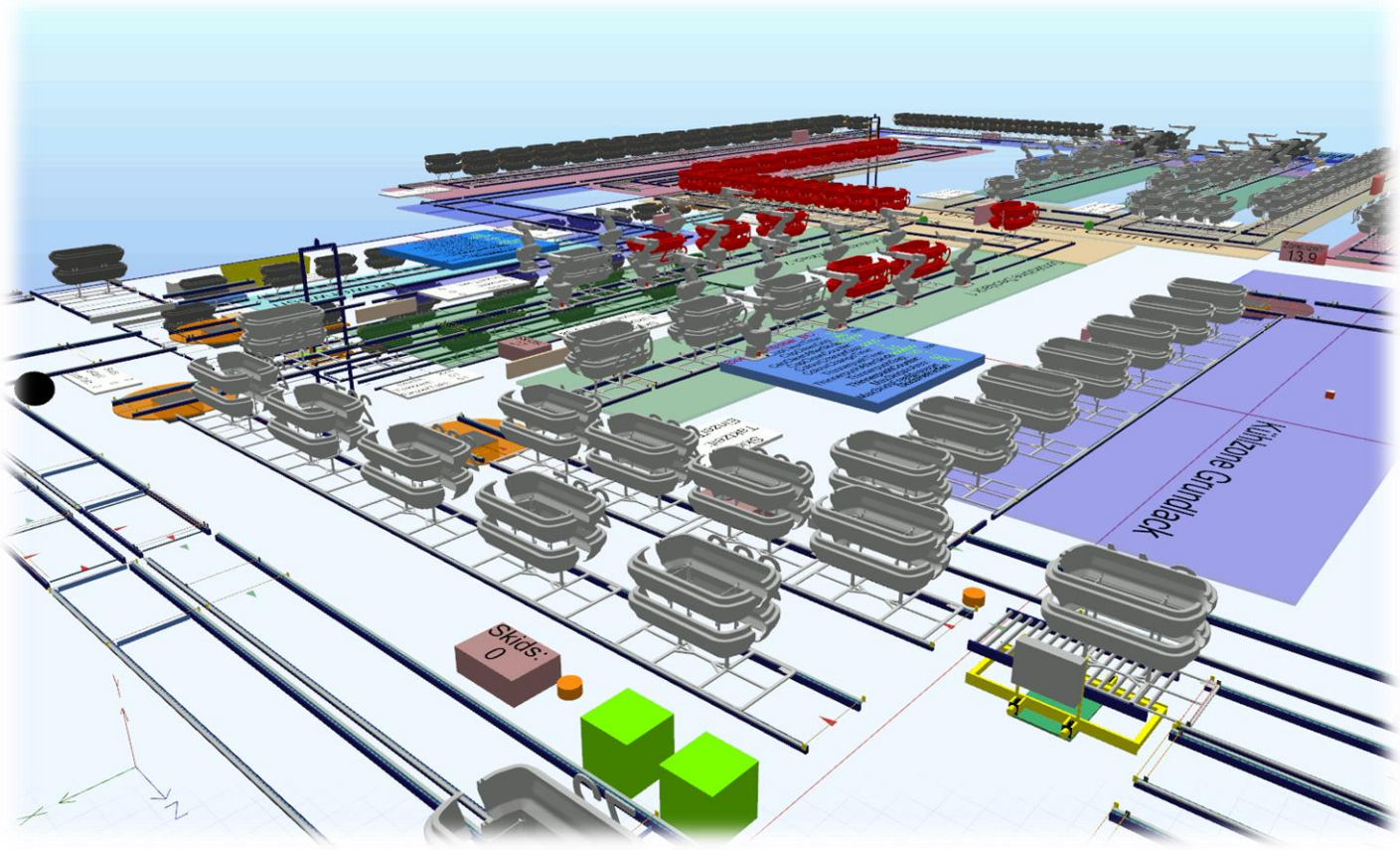






Simulation of the conveyor technology

- Cycle time analysis
- Feasibility analysis
- Design of the sensor layout
- MES system



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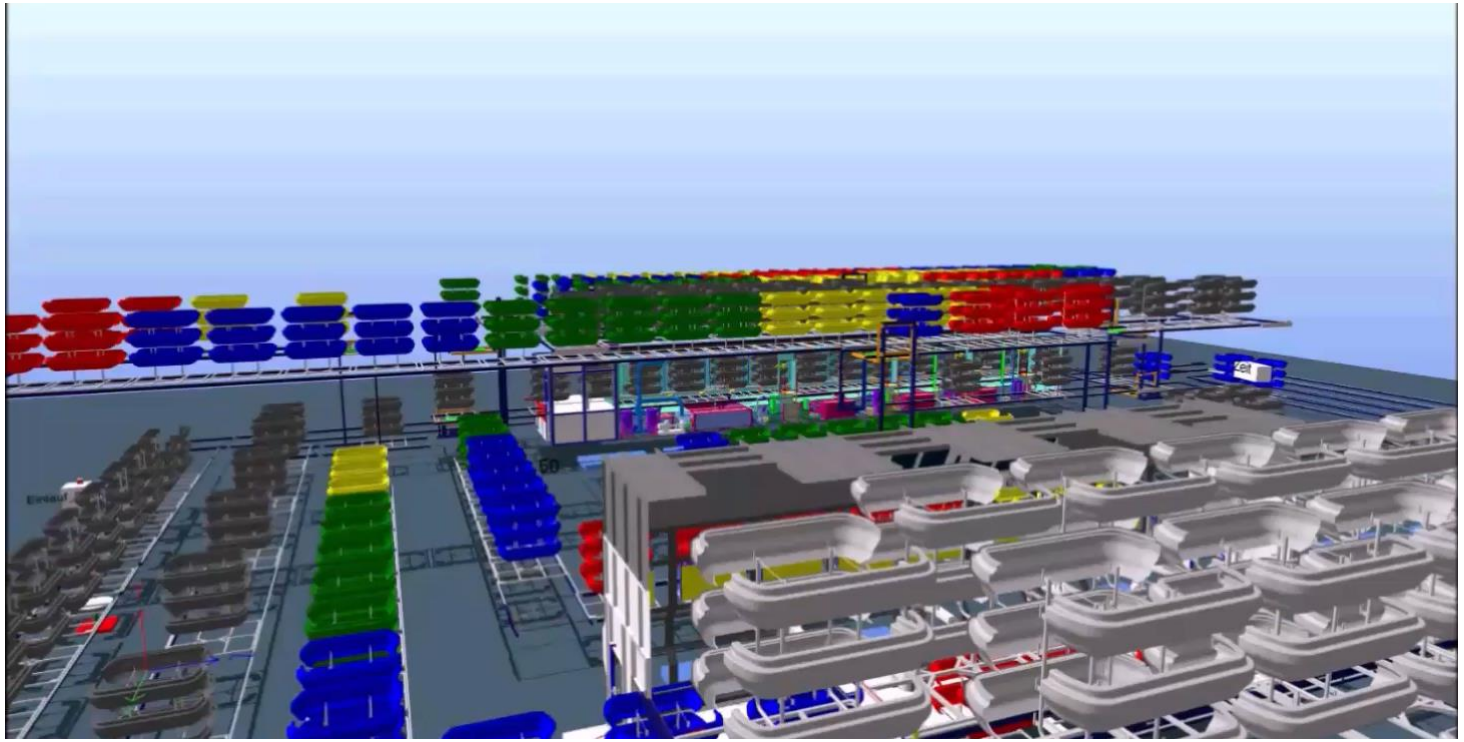


Project engineering in the virtual world

Planing → Projekt Engineering → Commissioning → After-Sales

„Digital Twin“

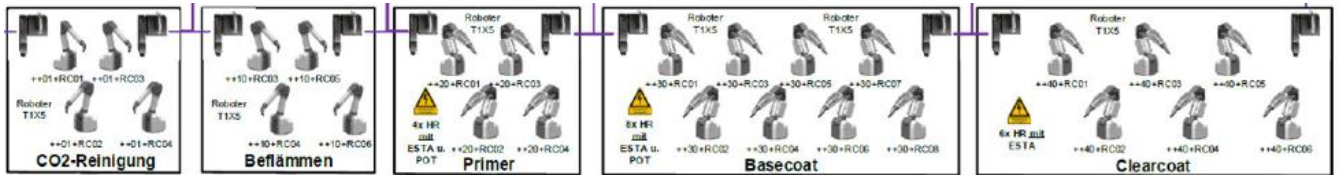
Simulation of Robot, APT and PT

- Where to start?
- No simulation for fluid
- CITM was not present.
- No catalog supports this.
- A very complex deployment of the control concept.
- A large number of PLCs.

10x AP

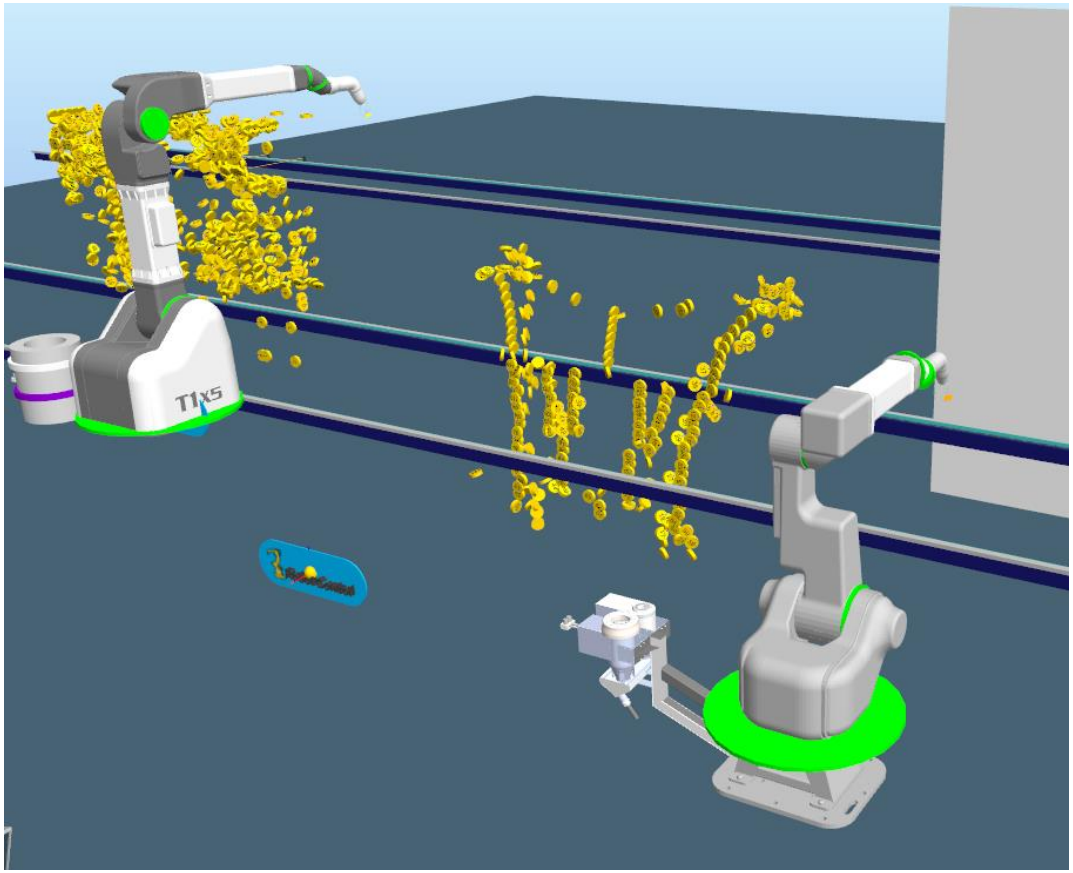
2x CT
2x PT

40x Robot



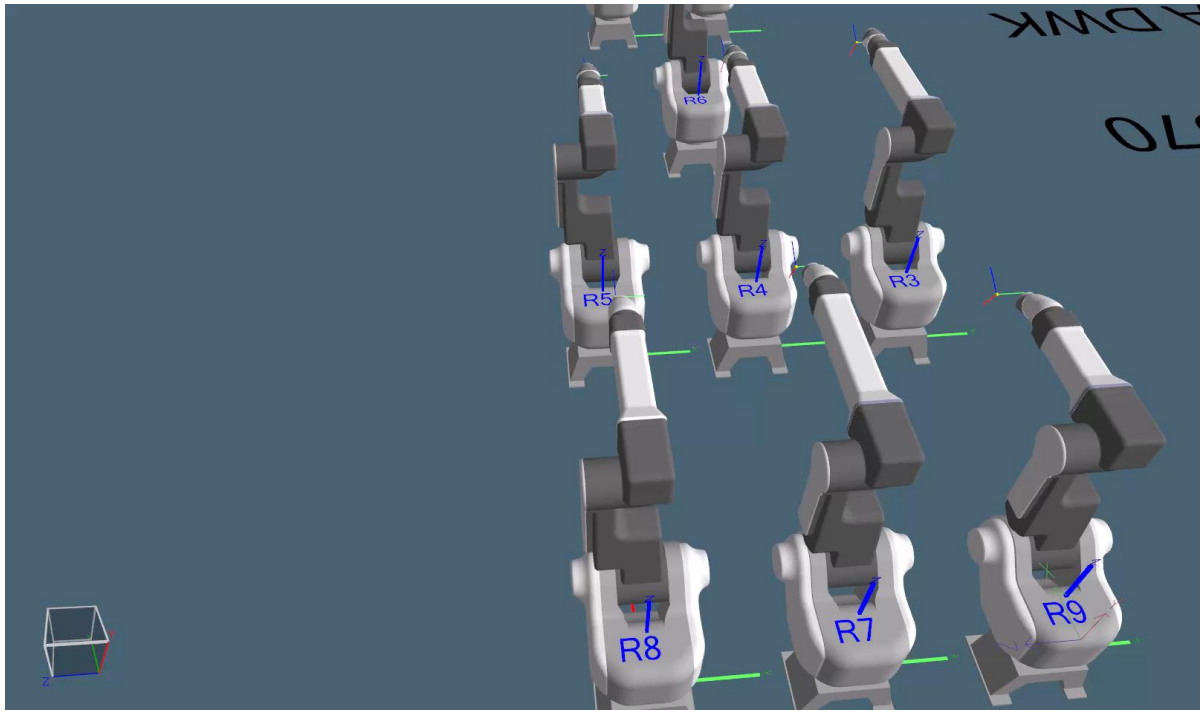
Simulation of Robot

- Use of D3d Robot Control
- Teach points as program
- First Edition as Simulation. Ok
- Problem of Emulation
- Problem of 40 Robots PLCs
- Performance issues.



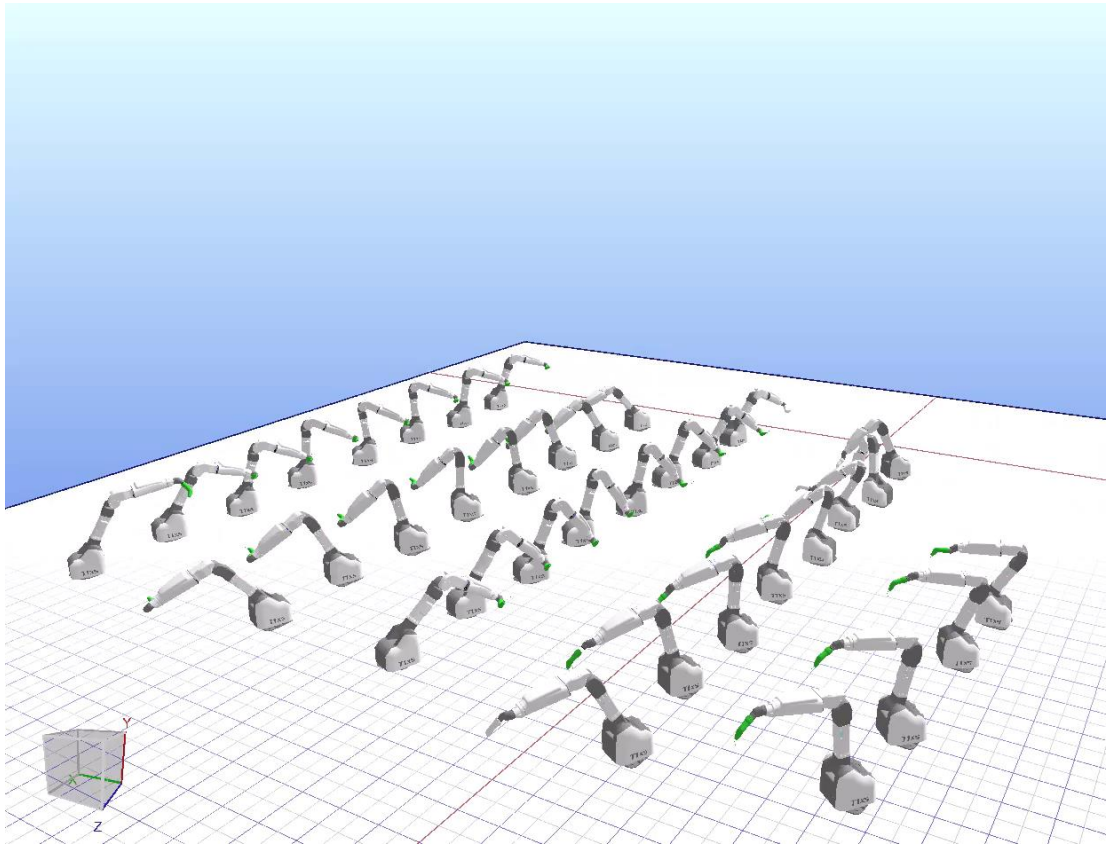
Simulation of Robot

- Implementation of CITM.
- No more Use of D3d Robot Control
- No more teach points
- Design of full Digital Twin for both Simulation and Emulation.
- 12,000 lines of code.
- Full functionality of robots and signals.



Simulation of Robot

- Performance testing.
- Code improvements.
- 40 robots working together.

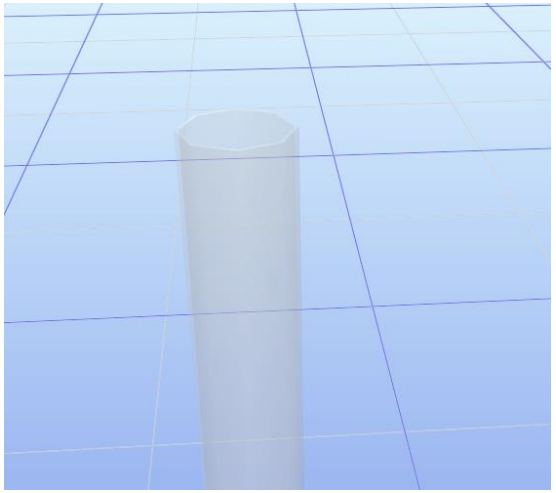


Simulation of APT

- How to create a full simulation of the fluid in the pipes:
- Pipe length
- Pipe Diameter
- Speed / Flow rate
- Viscosity
- Pressure
- Losses

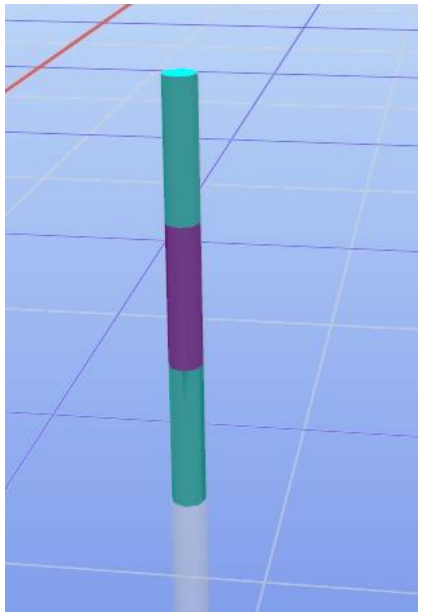
Simulation of APT

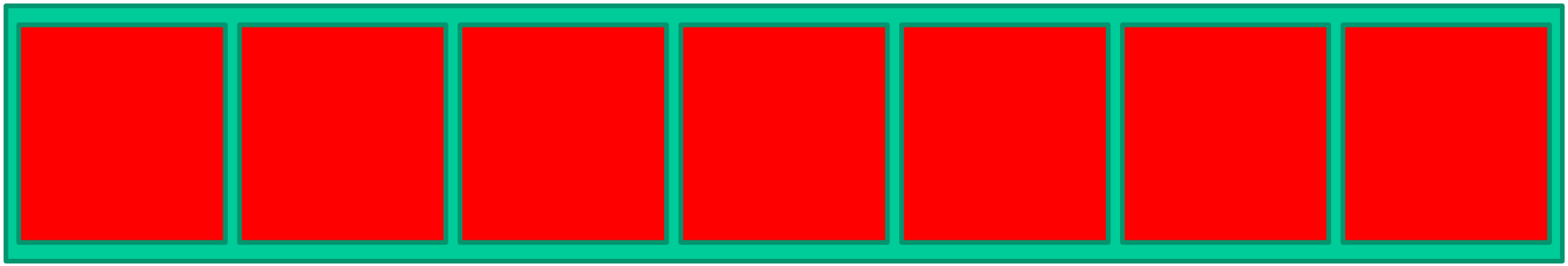
- How to create a full simulation of the fluid in the pipes:
- Create a cylindrical pipe.
- Generate small cylinder slices and simulate their movement.
- Performance issues associated with long pipes and changes in the flow direction.



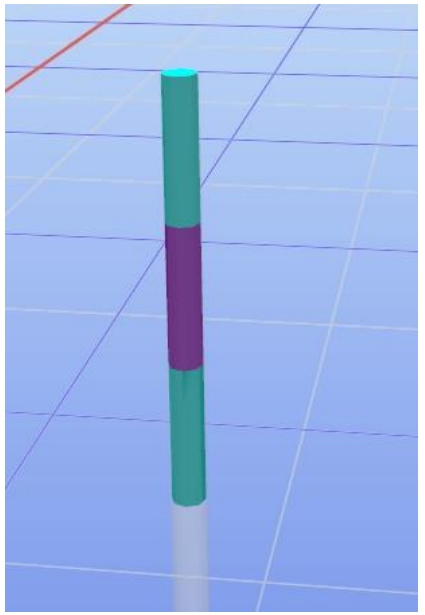
Simulation of APT

- How to create a full simulation of the fluid in the pipes:
- Generate all slices from the beginning.
- Adjust the color and transparency of the slices.
- Issues related to a large number of slices and pipes.
- Manage numerous parameters such as pressure, flow rate, and others.

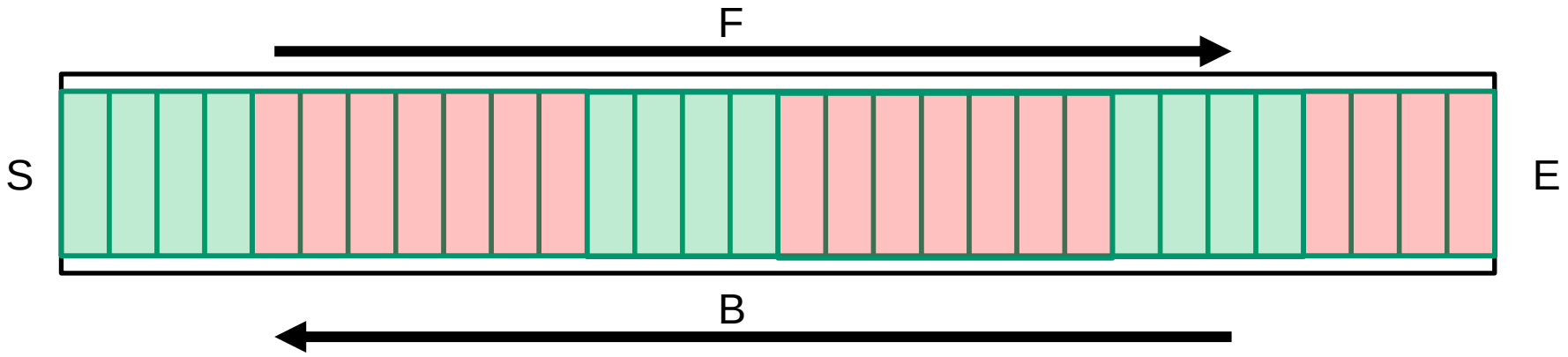




Simulation of APT

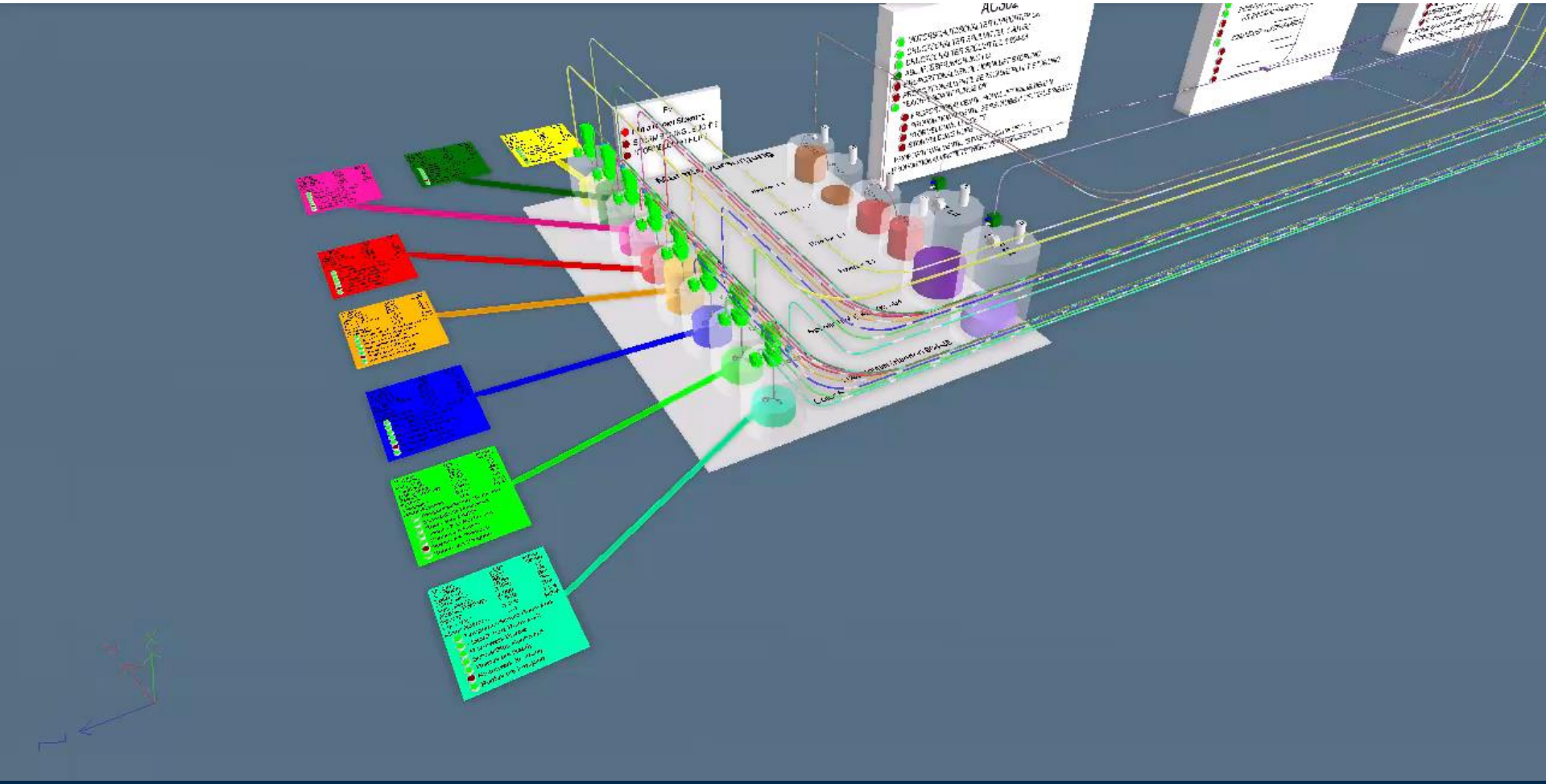


- How to create a full simulation of the fluid in the pipes:
- Generate all slices from the beginning.
- Adjust the color and transparency of the slices.
- Issues related to a large number of slices and pipes.
- Manage numerous parameters such as pressure, flow rate, and others.
- **Enable the ability to change the direction of the flow without losing any parts of the different colors.**



Simulation of APT

- First Generation.



Simulation of APT

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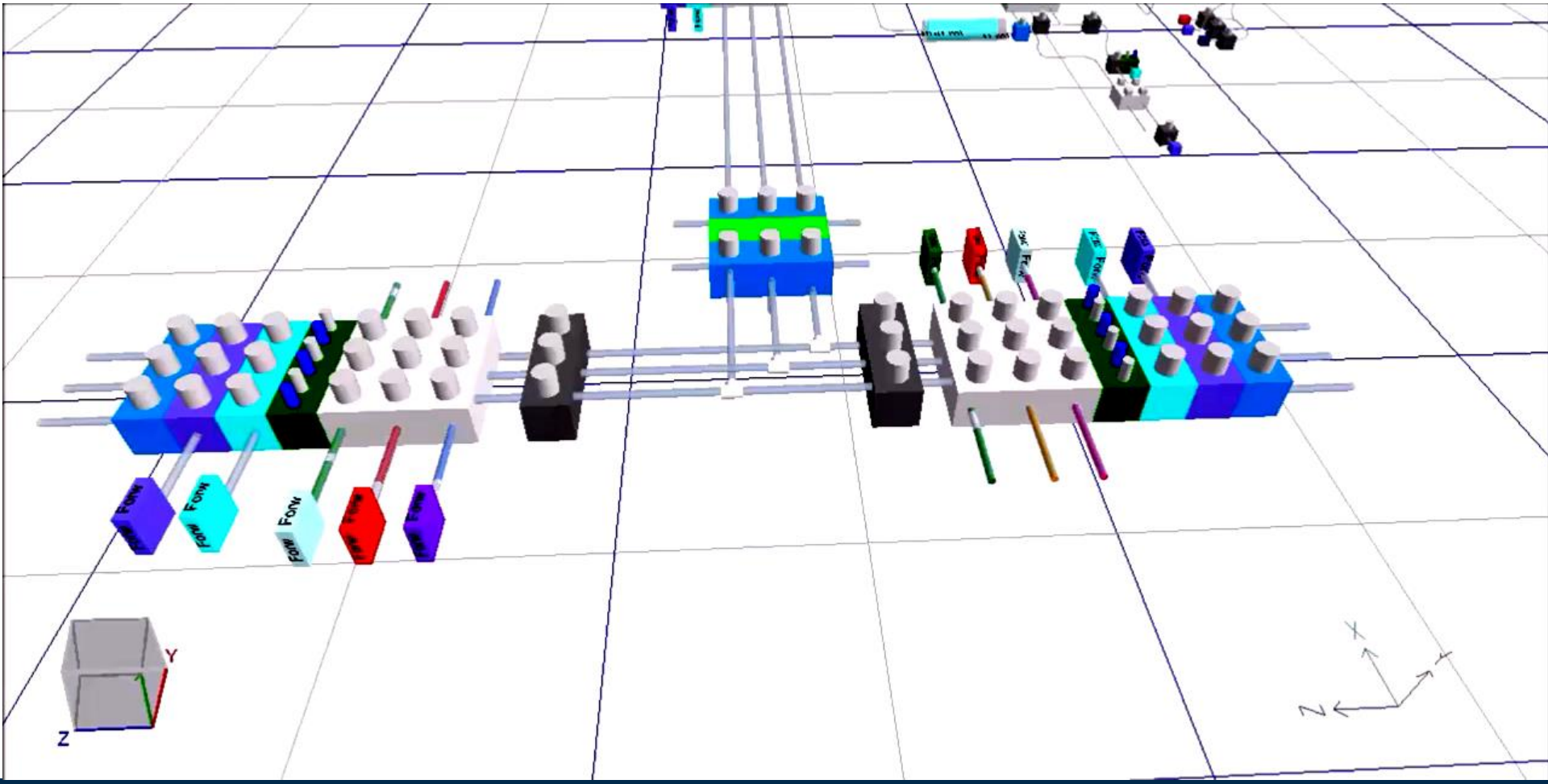
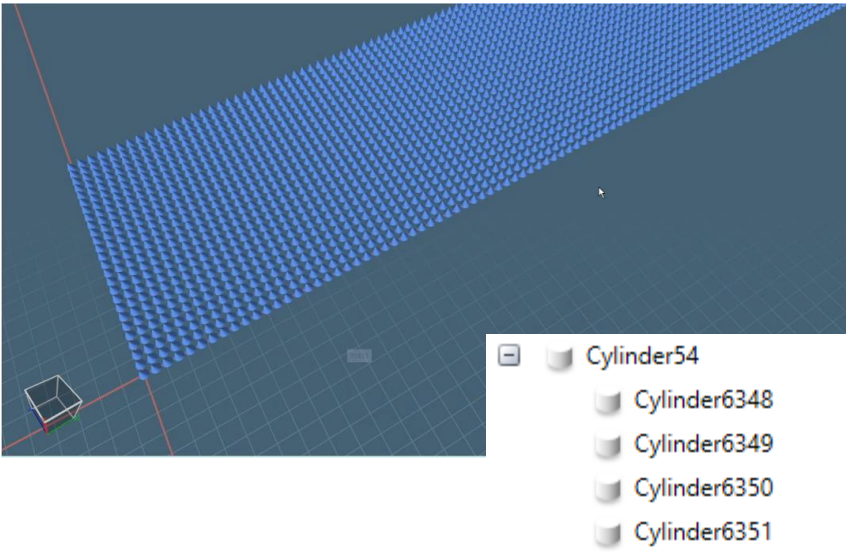


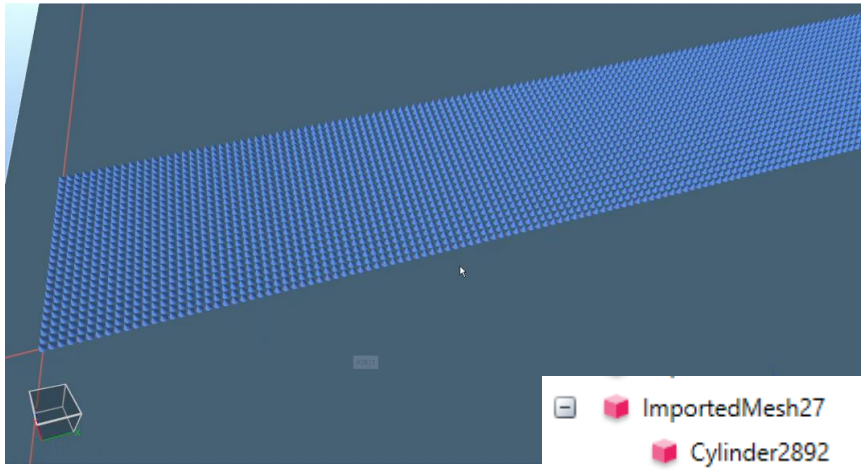
Simulation of APT

- First Generation Problem :
- Performance, rendering, Accuracy.

Solution: Implement the concept of merging.

- Work extensively on mesh optimization.
- Make further improvements in the code.
- Incorporate AI for enhanced performance and accuracy.





Simulation of APT

Implement the concept of merging.

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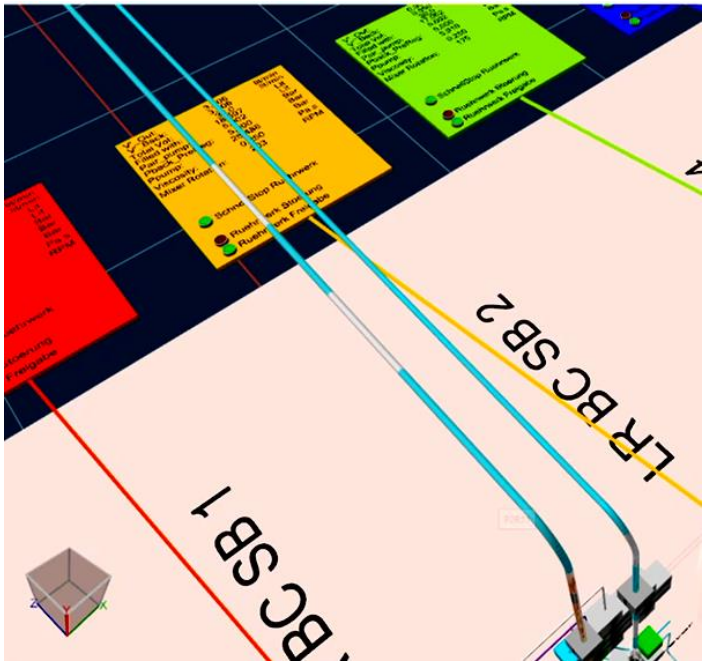
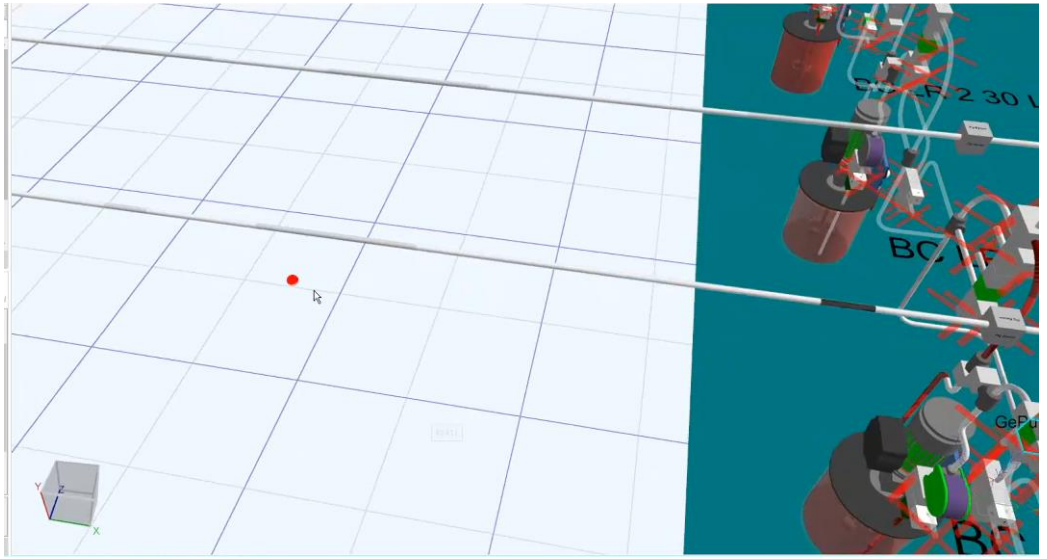
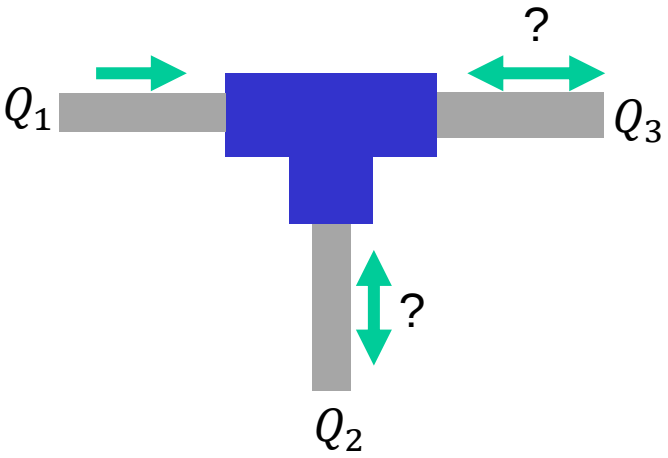
Make further improvements in the code.

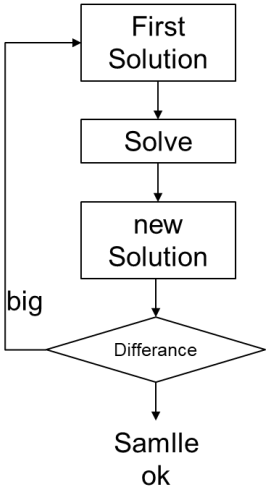


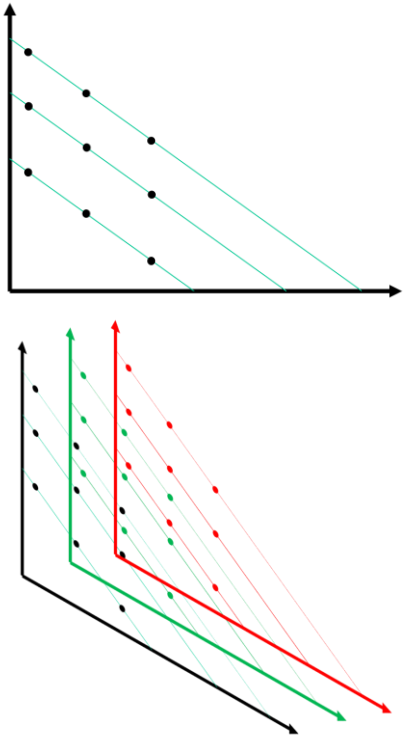


Simulation of APT

- **Some Fluid simulation has no direct mathimatical solution.**
- Using trial and error methode.
- Using Lookup Tables







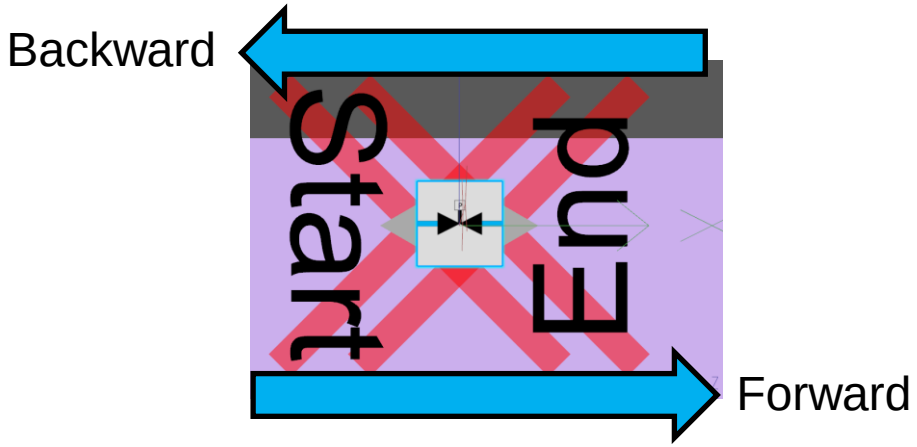
Simulation of APT

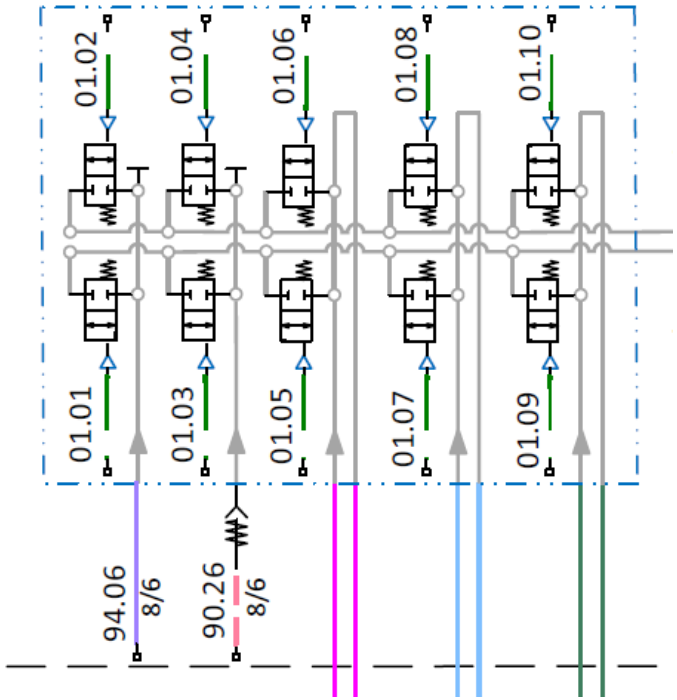
- **Some Fluid simulation has no direct mathimatical solution.**
- Using AI

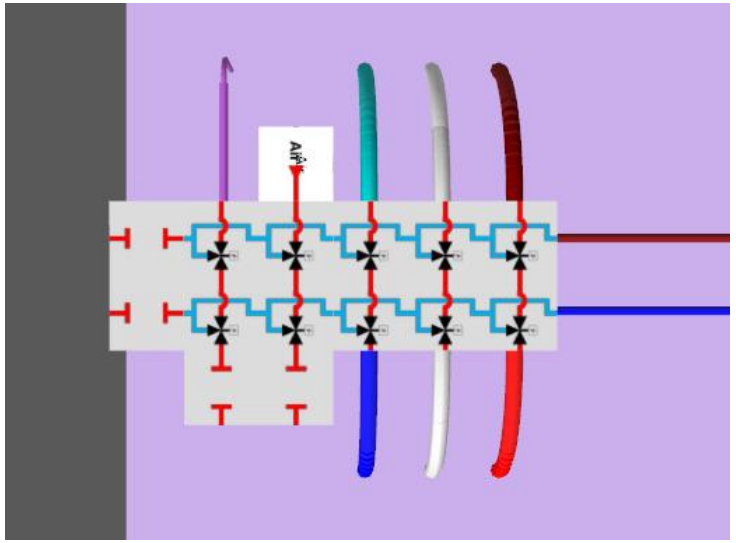
Radius[m]	P_air [bar]	Viscosity [Pa.s]	P_back [bar]	V1[lit/min]	V2[lit/min]	V3[lit/min]	V4[lit/min]	V5[lit/min]	V6[lit/min]	V7[lit/min]	V8[lit/min]	Length 0[m]	Length 1[m]	Lengt h2[m]	Length 3[m]	Lengt h4[m]	Lengt h5[m]	Lengt h6[m]	Length 7[m]	Lengt h8[m]	V[lit/min]	P_Valve_1 [bar]	P_Valve_2 [bar]	P_Valve_3 [bar]	P_Valve_4 [bar]	P_Valve_5 [bar]	P_Valve_6 [bar]	P_Valve_7 [bar]	P_Valve_8 [bar]
0,0075	4	0,12	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	3,384	7,286	7,013	6,741	6,468	6,196	5,923	5,651	5,379
0,0075	4	0,12	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	3,037	7,899	7,655	7,411	7,166	6,922	6,677	6,433	6,188
0,0075	4	0,12	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	2,69	8,513	8,297	8,08	7,864	7,647	7,431	7,214	6,998
0,0075	4	0,2	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	2,119	7,45	7,165	6,881	6,597	6,313	6,028	5,744	5,46
0,0075	4	0,2	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	1,902	8,047	7,792	7,537	7,281	7,026	6,771	6,516	6,261
0,0075	4	0,2	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	1,684	8,644	8,418	8,192	7,966	7,74	7,514	7,288	7,062
0,0075	4	0,5	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	0,882	7,61	7,314	7,018	6,723	6,427	6,131	5,835	5,539
0,0075	4	0,5	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	0,792	8,191	7,925	7,66	7,394	7,129	6,863	6,598	6,332
0,0075	4	0,5	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	0,701	8,771	8,536	8,301	8,066	7,831	7,596	7,36	7,125
0,0075	6	0,12	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	5,62	9,771	9,318	8,866	8,414	7,961	7,509	7,057	6,604
0,0075	6	0,12	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	5,284	10,397	9,972	9,546	9,121	8,696	8,271	7,845	7,42
0,0075	6	0,12	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	4,949	11,025	10,626	10,228	9,83	9,431	9,033	8,635	8,236
0,0075	6	0,2	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	3,593	10,18	9,698	9,216	8,734	8,252	7,77	7,288	6,807
0,0075	6	0,2	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	3,384	10,794	10,34	9,886	9,432	8,978	8,524	8,07	7,616
0,0075	6	0,2	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	3,176	11,408	10,982	10,556	10,13	9,704	9,278	8,852	8,426
0,0075	6	0,5	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	1,533	10,626	10,111	9,597	9,083	8,569	8,055	7,54	7,026
0,0075	6	0,5	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	1,444	11,214	10,729	10,245	9,761	9,276	8,792	8,307	7,823
0,0075	6	0,5	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	15	1,355	11,802	11,347	10,893	10,438	9,984	9,529	9,074	8,62
0,0075	4	0,12	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	3,292	7,448	7,183	6,918	6,653	6,388	6,123	5,858	5,593
0,0075	4	0,12	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	2,955	8,045	7,808	7,57	7,332	7,094	6,856	6,619	6,381
0,0075	4	0,12	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	2,617	8,643	8,432	8,221	8,011	7,8	7,59	7,379	7,168
0,0075	4	0,2	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	2,059	7,615	7,338	7,062	6,786	6,51	6,233	5,957	5,681
0,0075	4	0,2	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	1,848	8,195	7,947	7,699	7,451	7,203	6,955	6,707	6,46
0,0075	4	0,2	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	1,637	8,775	8,555	8,336	8,116	7,897	7,677	7,458	7,238
0,0075	4	0,5	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	0,856	7,777	7,49	7,203	6,915	6,628	6,341	6,054	5,767
0,0075	4	0,5	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	0,769	8,34	8,083	7,825	7,567	7,31	7,052	6,794	6,536
0,0075	4	0,5	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	0,681	8,904	8,676	8,447	8,219	7,991	7,763	7,534	7,306
0,0075	6	0,12	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	5,472	10,047	9,606	9,166	8,725	8,285	7,844	7,404	6,964
0,0075	6	0,12	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	5,144	10,656	10,242	9,828	9,414	9	8,586	8,172	7,758
0,0075	6	0,12	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	4,823	11,273	10,884	10,496	10,108	9,72	9,332	8,944	8,555
0,0075	6	0,2	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	3,495	10,468	9,999	9,53	9,061	8,593	8,124	7,655	7,186
0,0075	6	0,2	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	3,292	11,065	10,623	10,182	9,74	9,299	8,857	8,415	7,974
0,0075	6	0,2	5	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	3,09	11,662	11,248	10,833	10,419	10,005	9,59	9,176	8,761
0,0075	6	0,5	3	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	1,489	10,919	10,42	9,921	9,421	8,922	8,423	7,923	7,424
0,0075	6	0,5	4	0	0	0	0	0	0	0	0	15	5	5	5	5	5	5	5	20	1,403	11,49	11,02	10,55	10,079	9,609	9,139	8,668	8,198

Simulation of APT

- Generation II
- Concept of Lego component

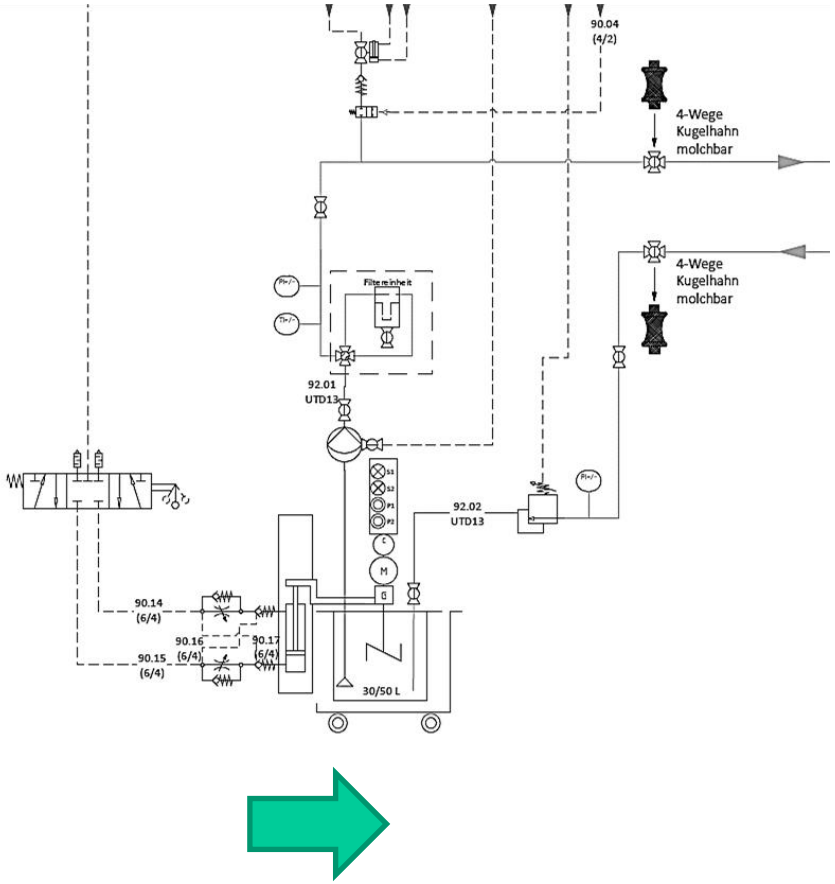


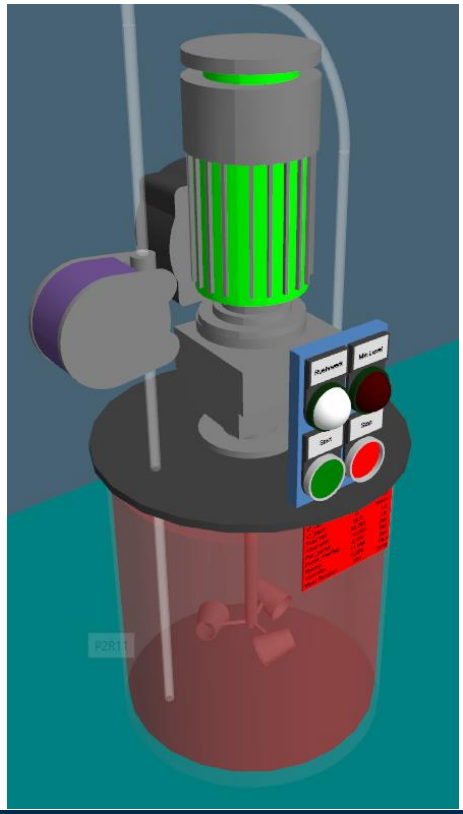




Simulation of APT

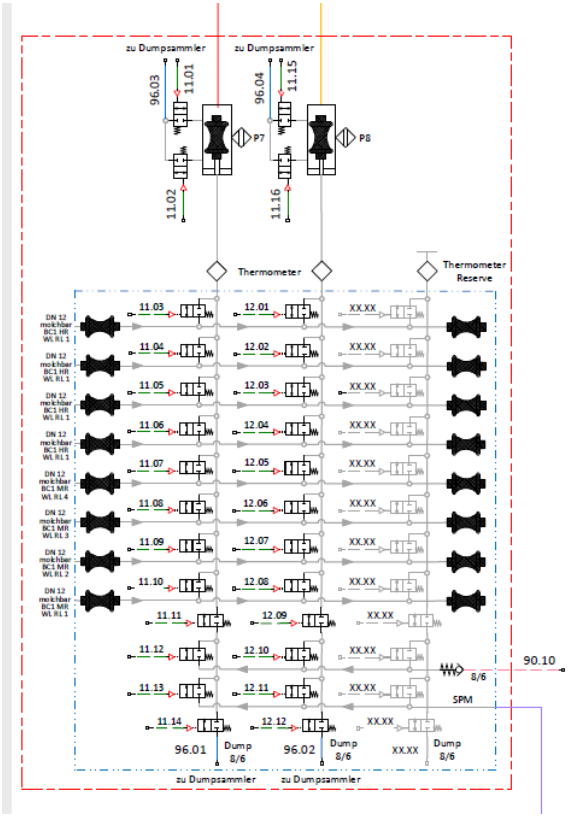
- Generation II
- Use of CITM

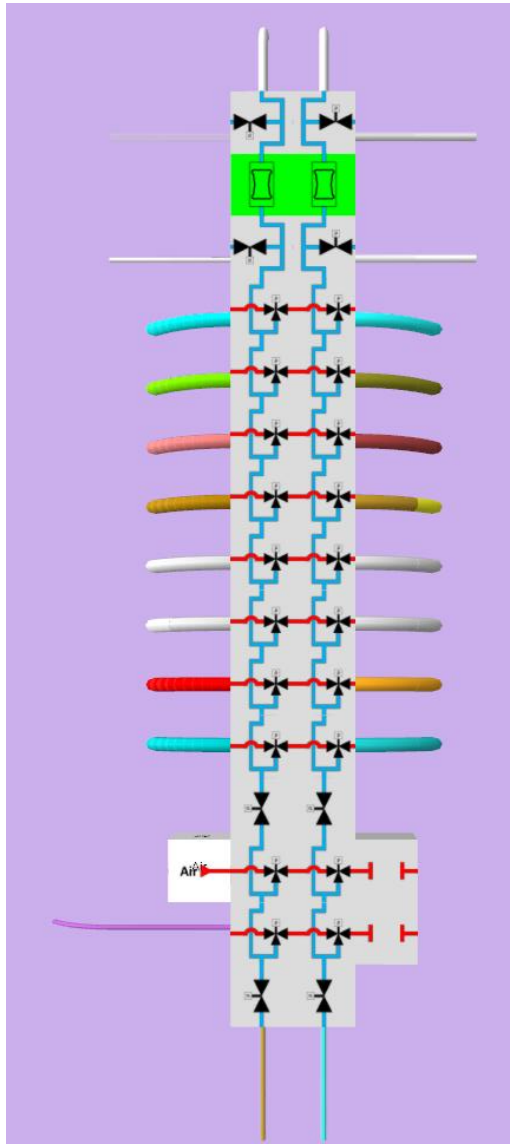




Simulation of APT

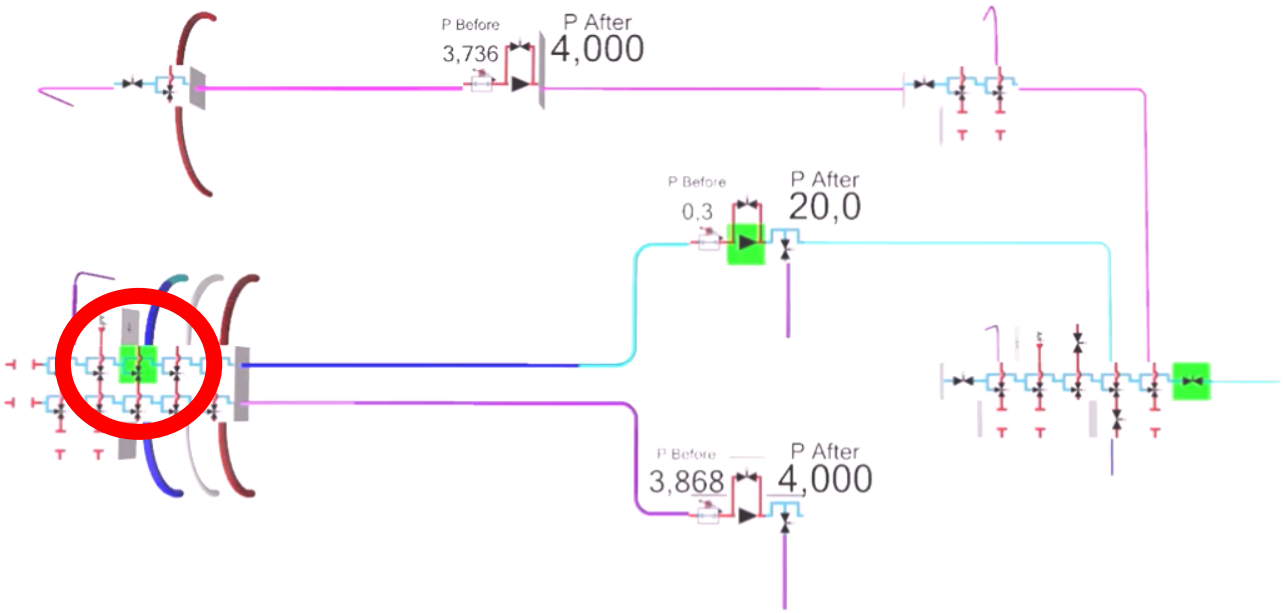
- Generation II
- Concept of Lego component



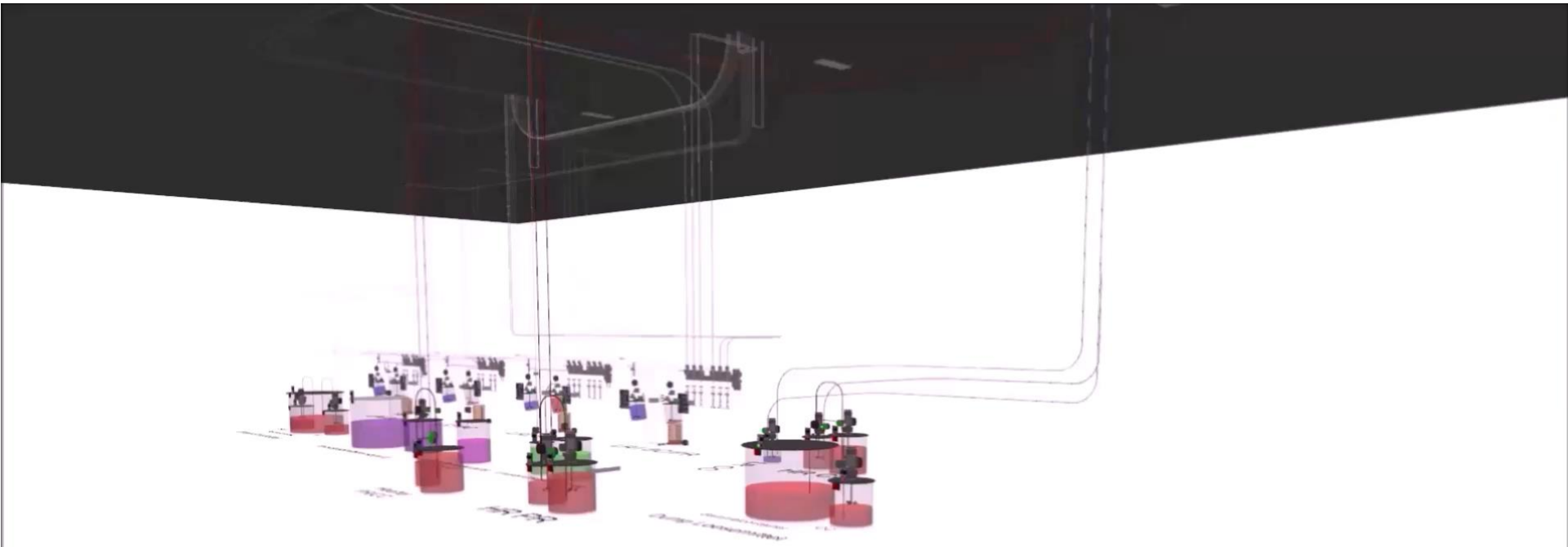


Simulation of APT

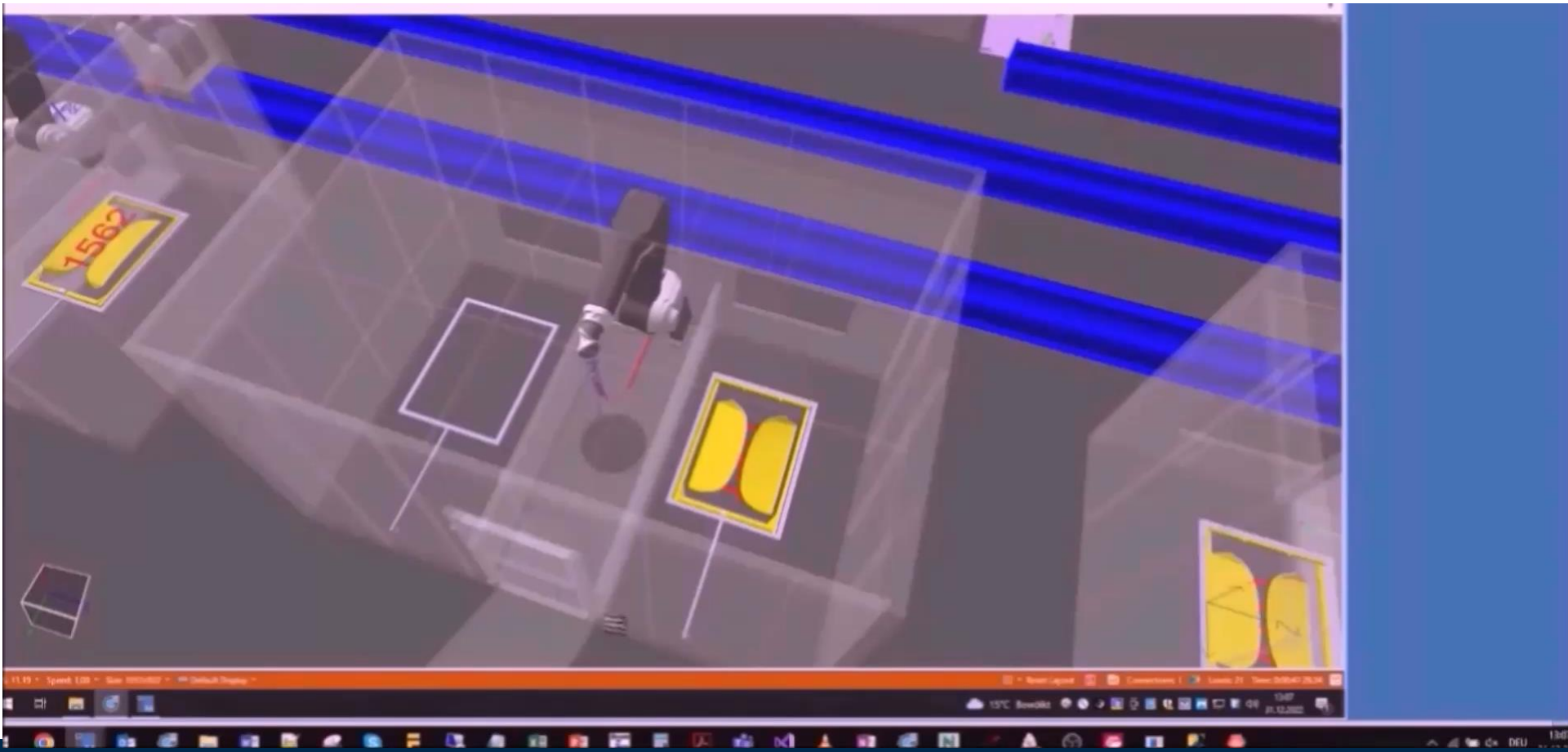
Simulation of APT



Simulation of APT

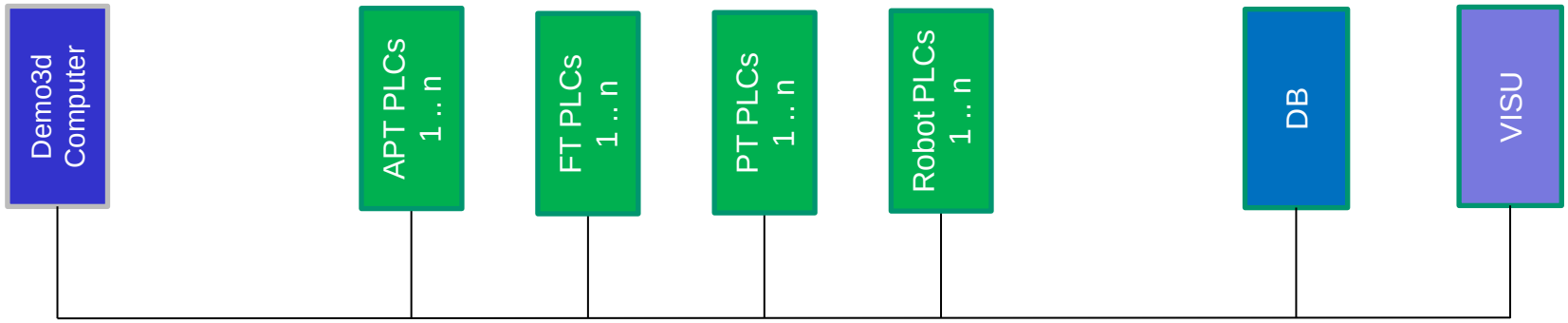


Simulation of APT



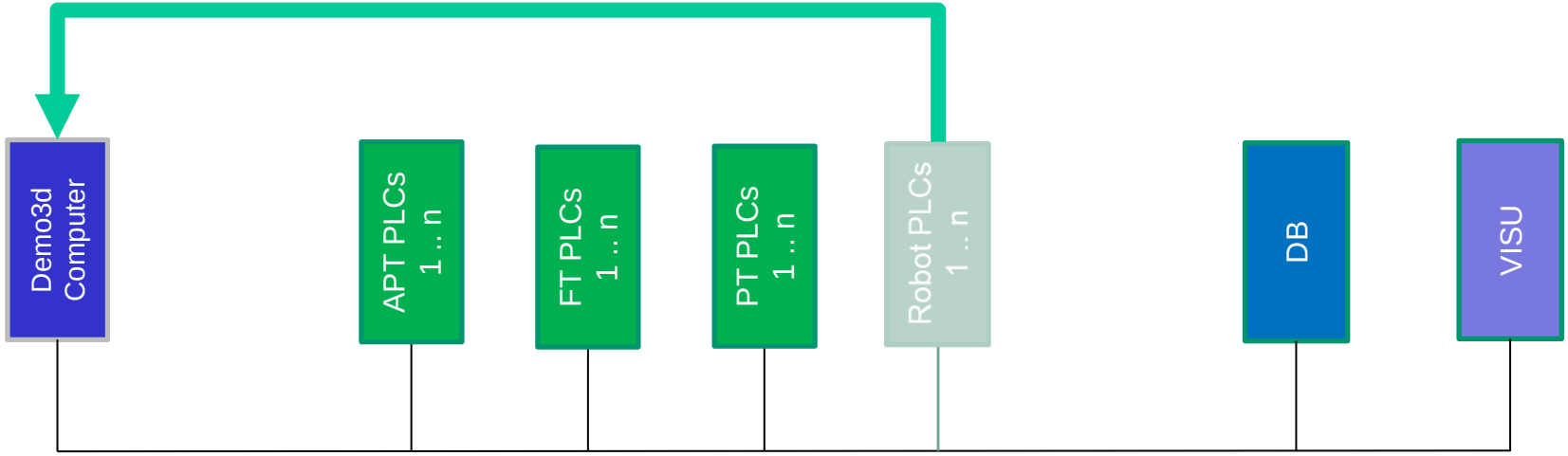
Simulation of Robot, APT and PT

- Main Concept
- Dealing with a large number of PLCs.
- Performance ??.
- Main Requirement: No changes are acceptable in PLC code.
- Var type in PLC problems : (byte-word-…)
- Life bit problems



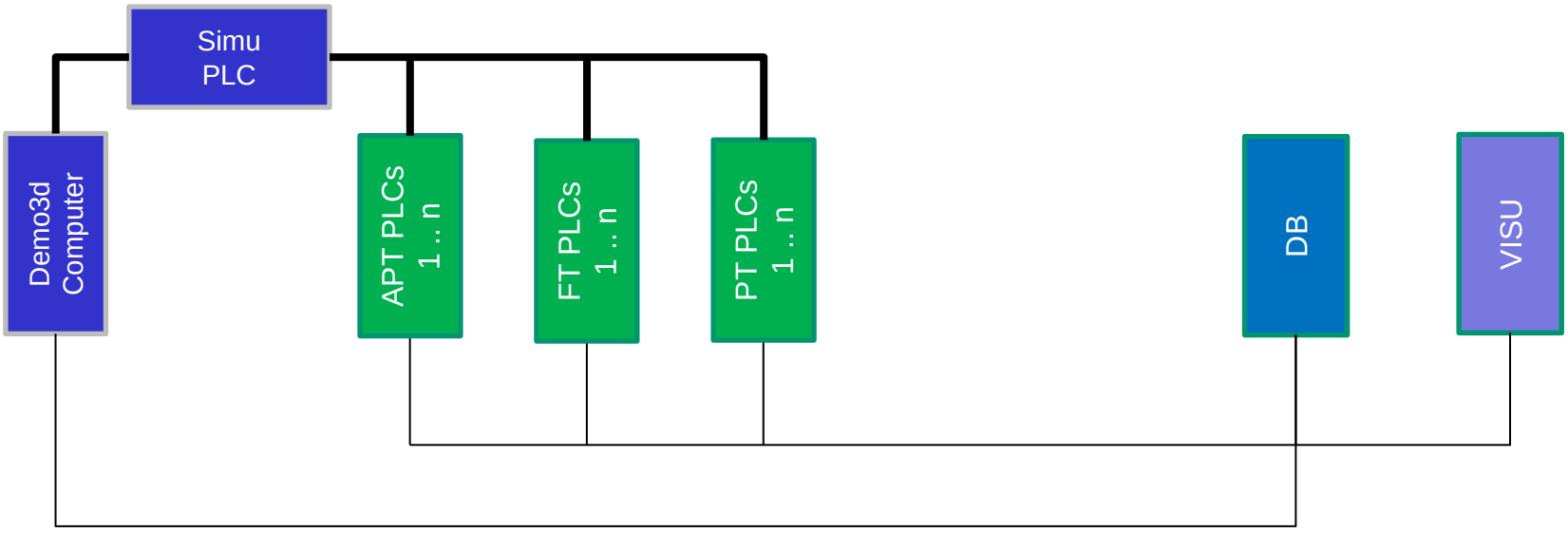
Simulation of Robot, APT and PT

- Robots are completely integrated. All of the robot signals originate from E3D.
- Alle of the Robots sigales come out from E3d.
- What is the maximum number of PLCs that can connect to E3D?
- Delays based on the reading/writing time from the E3D side.
- Limiting E3D access to certain levels in PLCs.



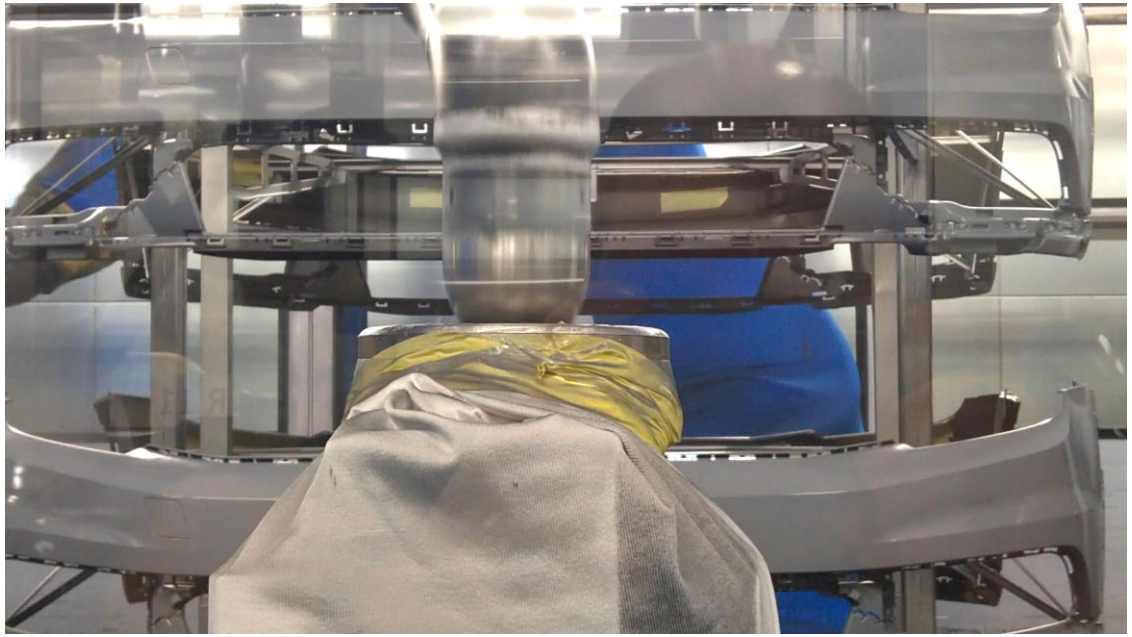
Simulation of Robot, APT and PT

- All PLCs connect to the Simu PLC.
- The Simu PLC is responsible for filtering the signals.
- The Simu PLC is responsible for decoding certain variable types.
- Some coding is required on the Simu PLC side.
- Performance was elevated by x times.



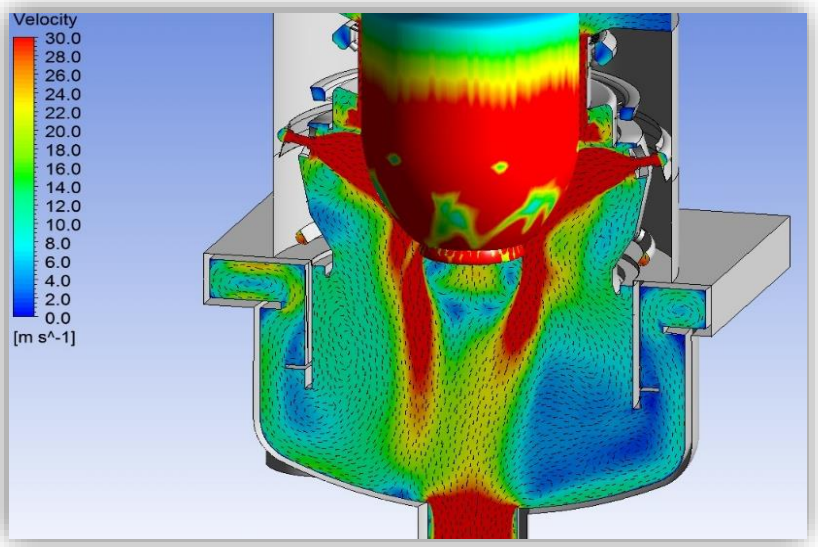
Another Use Cases

- Optimize the timing of the bell cleaner



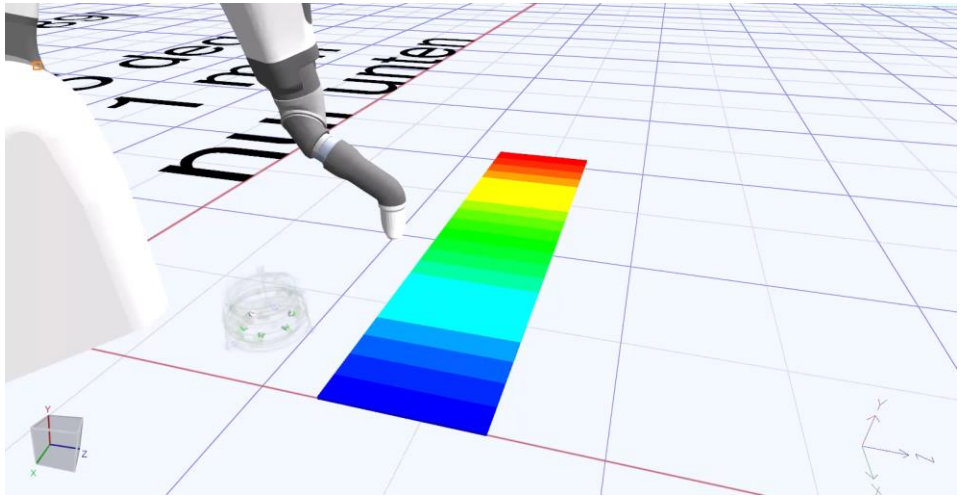
Another Use Cases

- Computational Fluid Dynamics
- Support for new developments
- Pressure loss calculation
- Speed and temperature profiles

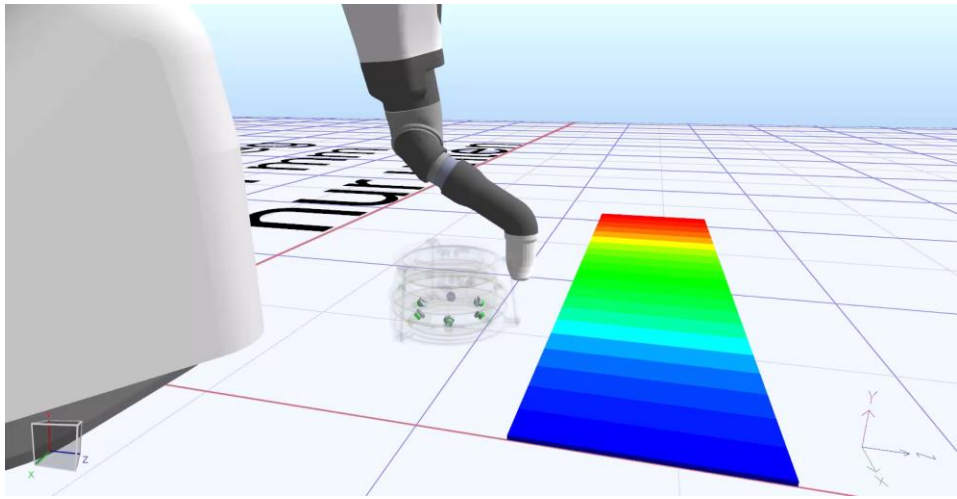


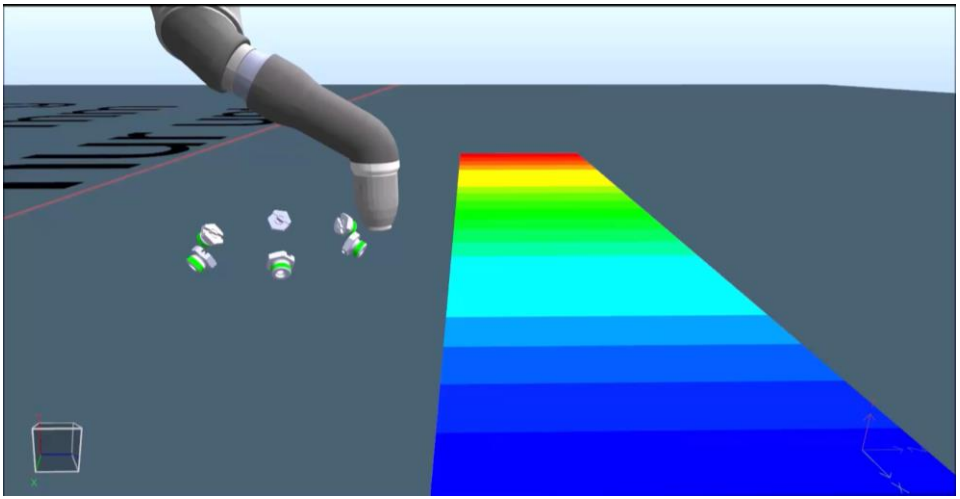
Another Use Cases

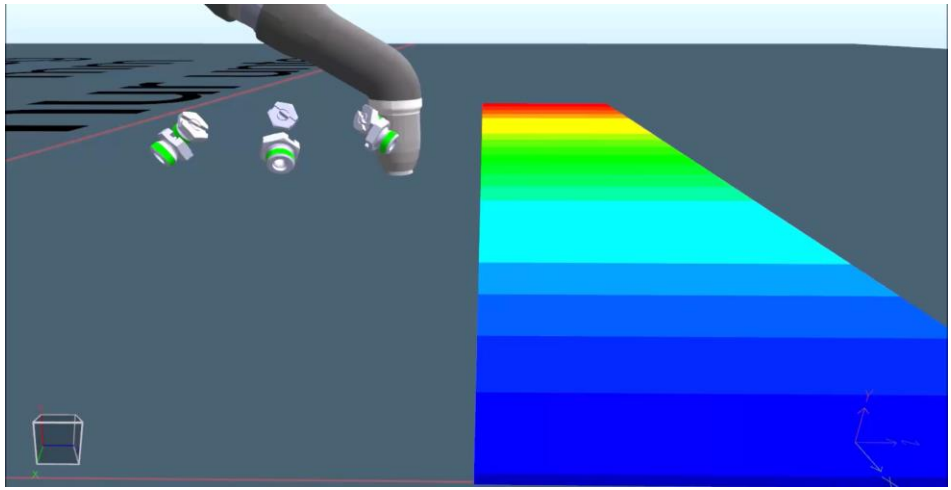
old



new







Thank you for your attention!

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