



# Final Report

## MxD 19-04-04 Digital Twins for Process Manufacturing

28 April 2022

**Leon Grossman**  
DMC Engineering

Approved for public release: distribution unlimited.

# PROBLEM STATEMENT

*How would you visualize sensor data with the best User Interface/User Experience design to get a seamless experience in continuous manufacturing?*

## PAIN POINTS

- Need to vet digital solutions in manufacturing settings, but manufacturers are often limited by constraints of business environments to experiment with the full-array of sensors, commercial offerings, and architectures
- Need for process manufacturing-specific testbed at MxD for validation and side-by-side comparison with discrete
- Need education about end-to-end process for “How To” achieve digital twins benefits: how to collect, aggregate, analyze sensor data to build a digital twin
- Specific problem: **demonstration is needed to prove how digital twins can digitally enable operators in the field to make more educated decisions based on data and enhanced communication with leadership and other operators**

# KEY OBJECTIVES



## OBJECTIVES

- Development and implementation of a framework for gathering and analyzing all the data from a process manufacturing line necessary to improve visibility and control. This framework is a key first step in being able to implement proof-of-concepts for ‘mobile worker’, cybersecurity, predictive maintenance, and other digital twin use cases.
- Demonstration of a proof-of-concept ‘mobile worker’ solution.
- Primary end users:
  - **Plant managers** will have access to dashboard tools summarizing KPIs as well as active orders and processes
  - **Process operators** will have the capability to take the HMI with them into the field not only to supervise the process, but also interact with the active control system
  - **Maintenance Technicians** will consult a real-time digital twin before executing maintenance requests
- The testbed serves as an ideal dynamic lab for experimentation with many digital twin use cases in the future.



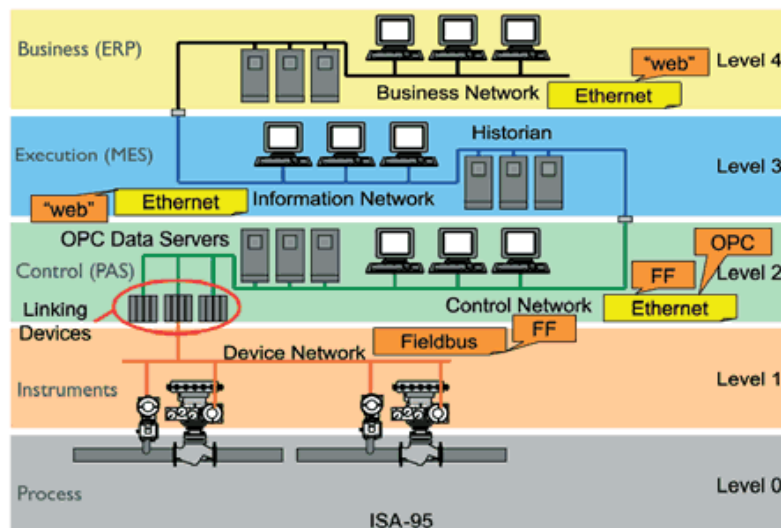
# PLANNED BENEFITS

- **Deployable:** Create a platform for generation of deployable outcomes for MxD members
- **Collaboration:** Create a platform that enables collaborative learning and sharing among MxD members specifically through deployment of MxD project outcomes
- **Cost Effectiveness:** Lower the cost of digital transformation by reducing disruption to production facilities and using a shared resource
- **Risk Management:** Minimize the overall risk for process industry and extend application of proven digital technologies beyond discrete manufacturing
- **Innovation:** Broaden innovation scope by engaging solution/service providers and end-users at the early stages of technology development and evaluation
- **Advancement in System Integration:** Accelerate screening, piloting, and adoption of digital tools/technologies (sensors, cybersecurity, data analytics, 3D printing, etc.)
- **Best Practices:** Jointly address operational and regulatory requirements of process industries, e.g. safety requirements, process optimization, and process disruption, and share best practices
- **Workforce Development:** Provide training for the workers of the “future” factory

# PLANNED BENEFITS

## ORIGINAL STATE

- Early discussion on the current technical baseline (for example Dow's existing testbeds) and pain points
- Discuss existing technology and current "day in the life" of current user groups
- Overview of existing Siemens Process Automation World skid



## FUTURE STATE

- The future state of the Digital Twin for Process Manufacturing showcase will be an **interactive, educational, knowledge sharing and training testbed**. It will provide a framework for **collecting, processing and analyzing data** from process manufacturing, enabling digital twins. It will be a foundation for future skids, test grounds for new solutions and new digital twins, and an area that demonstrates how today meets tomorrow for the **Process Industry**. The visitor to MxD facilities will **touch, see and feel** new technologies, and experience the art of what is possible for the Process Industries.
- The testbed will include key Industry 4.0 drivers and technologies, including Augmented Reality, IIoT, Big Data to recognize the needs of **Smart Enabled Mobile Operators, operators and cybersecurity specialists**. It will show digital transformation by **integrating** automation, software, and cutting-edge technologies.
- It will include solutions that are existing and currently available today, with data interacting **across the ISA 95 Model with vertical integrations**. These solutions can stand alone or work interactively. Siemens already offers a portfolio of solutions that comprises the core elements of the Digital Enterprise. With the scalable solutions, companies in the process industries can invest in Industry 4.0 and Digital Twin solutions for product, process and equipment, to become completely and comprehensively digitalized across the entire value chain.

# FUTURE STATE CONTINUED

- The final state of this project is a functional process system, showing the real world, with software representing its Digital Twin. This will be a hands on demo that will allow users from all areas across the lifecycle (EPC, Owners, Designers, Manufacturing and Plant Maintenance and Facilities) can see and learn about the art of the possible in the Process Industry
- The key benefits of a system like this are:
  - Visibility of physical and virtual models in an environment that is easily accessed
  - Impact is seen in flexibility, speed, accuracy. With the ability to model and predict outcomes and access to the right data at the right time, the user will see quality and time improvements in their tasks.
- “Day in the life” of a user
  - The user will have a role, as defined above. As an example , a mobile worker in the field technician role needs to do a block and bleed on the testbed, or pump maintenance. That user needs easy, accurate, fast access to information that applies to his/her role. The system will make the information available, allow the user to do his/her task and immerse the mobile worker in an AR/VR environment.
  - If the user has a different role, for example, s/he is doing a quality test, s/he still need the same easy, accurate, fast access to information, but job is to take a sample of product and test it, store that information and manage it for tracing. You will see how s/he interacts with the system and software.



# USE CASE SCENARIOS

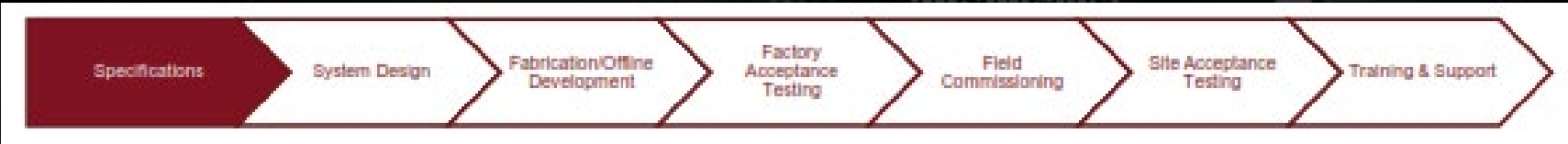
A composite image showing an airplane in flight above an industrial facility with a white truck in the foreground. The image is in grayscale and serves as a background for the title.

## PRIMARY USE CASE

As a **'mobile worker' operator**, I want to **receive all my tasks on a mobile device** and **access all data** (EH&S, process data, ERP information, documentation, procedures, alerts) needed to **perform my task directly in the field** so that **I can update data immediately to communicate status to my team and leadership.**

During operator rounds I want to **capture findings directly in the field** and **create workorders** for the maintenance department. I want to **view the process in the field directly** and **validate the process steps live** beside my other tasks. I want to use **augmented reality technology** in order to create a **seamless experience by seeing all needed information** (e.g. sensor data) when I am looking at the equipment.

# Technical Approach

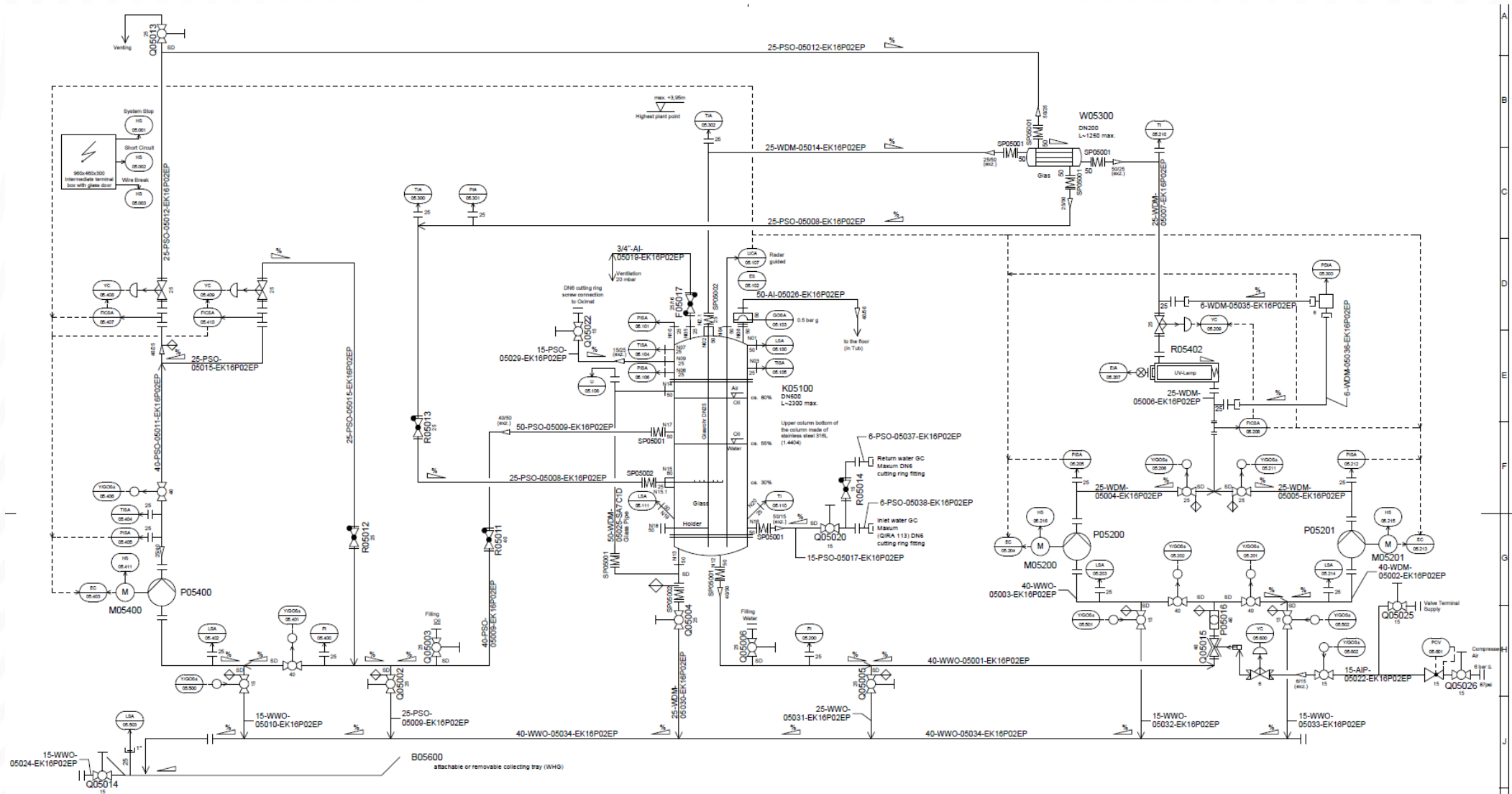


- **Specifications** – DMC/Siemens team will work with MxD staff to define the detailed scope of implementation for the demonstration skid and the software stack for initial deployment.
- **System Design** – The full hardware design will be finalized and approved by DMC, Siemens and MxD.
- **Fabrication/Offline Development** – The skid will be fabricated, and DMC/Siemens will begin offline development of the various components of the system.
- **Factory Acceptance Testing** – A checklist of requirements and test plan will be generated to confirm operation of the PCS neo control system. The system will be tested for full functionality against the documented procedures prior to delivery to MxD facility.
- **Field Commissioning** – The skid will be installed at the MxD facility and final integration of the full software/hardware stack will be completed.
- **Site Acceptance Testing** – The full system will be tested at MxD against a test plan mutually agreed upon by DMC, Siemens, and MxD.
- **Training & Support** – A training plan, consisting of up to 3 days will be agreed on between DMC and MxD. The goal is to provide knowledge on how to operate and support the showcase.

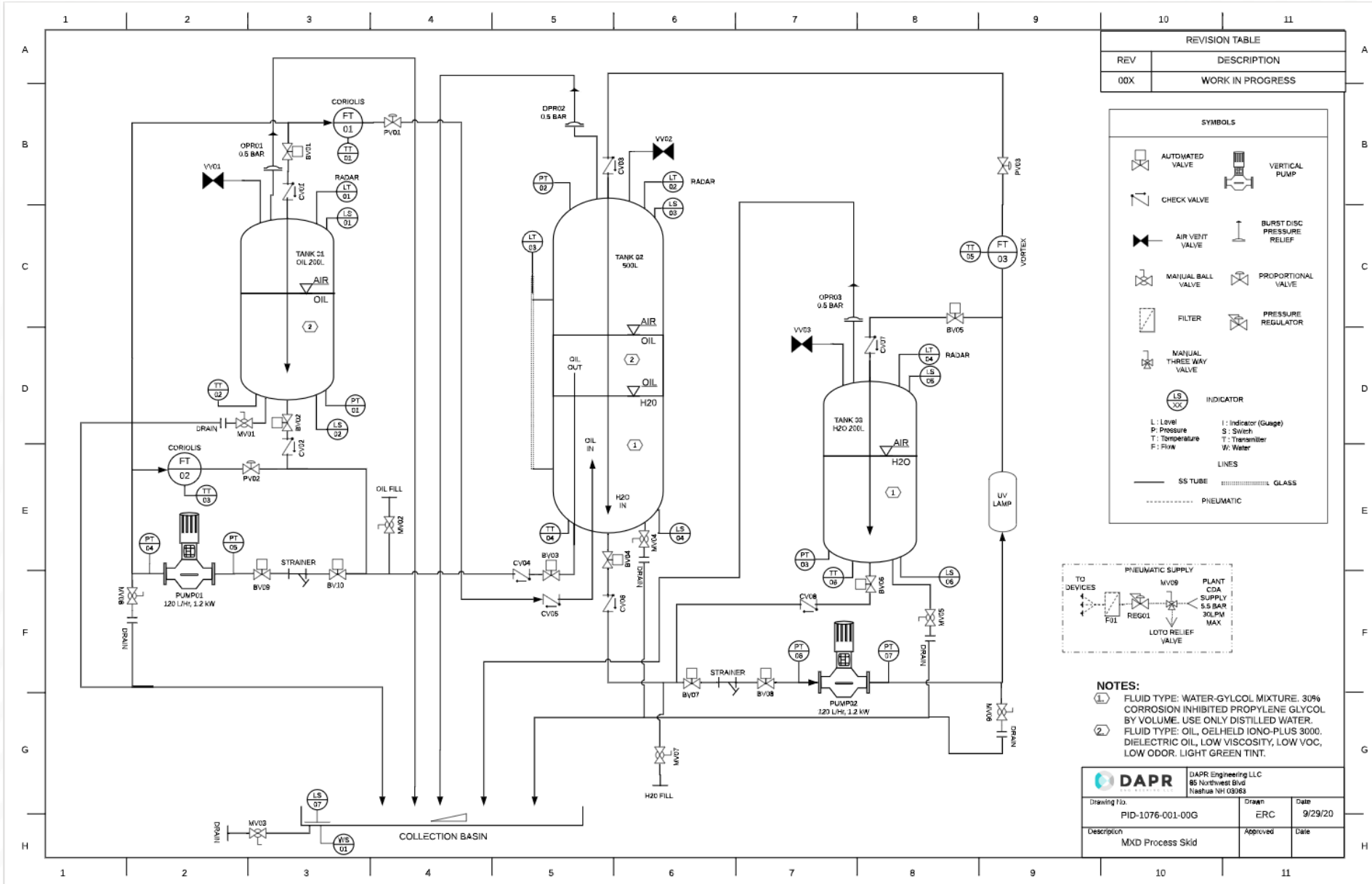




# PROCESS AUTOMATION WORLD SKID P&ID



# MxD SKID P&ID

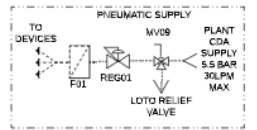


REVISION TABLE	
REV	DESCRIPTION
00X	WORK IN PROGRESS

**SYMBOLS**


L: Level  
 P: Pressure  
 T: Temperature  
 F: Flow  
 I: Indicator (Gauge)  
 S: Switch  
 T: Transmitter  
 W: Water

LINES  
 — SS TUBE  
 - - - - - PNEUMATIC



- NOTES:**
- ① FLUID TYPE: WATER-GLYCOL MIXTURE, 30% CORROSION INHIBITED PROPYLENE GLYCOL BY VOLUME. USE ONLY DISTILLED WATER.
  - ② FLUID TYPE: OIL, OELHELD IONO-PLUS 3000, DIELECTRIC OIL, LOW VISCOSITY, LOW VOC, LOW ODOR. LIGHT GREEN TINT.

		DAPR Engineering LLC 85 Northwest Blvd Nashua NH 03083	
Drawing No.	PID-1076-001-00G	Drawn	ERC
Description	MxD Process Skid	Approved	Date
			9/29/20



# MxD Process Demonstration Skid During Fabrication





# Project Status and Challenges

- Status
  - Hardware is fully operational
  - Development is complete and operational
- Challenges
  - Modern CAD design relies on models from component vendors. These have varying degrees of detail and are generally shells for “fitment”.
  - Digital twin functionality requires a higher level of detail than is normally generated for projects in several areas (design fidelity, physical placement, etc.)
  - Each of the software elements I’m about to show on the next slides would be an entire project in and of itself. Some of these would be multimillion dollar efforts making it difficult to realize this kind of tight integration in the real world.
  - Augmented Reality technology is still very immature and the industry is still evolving.

Figure 1 Technical Solution Functional View

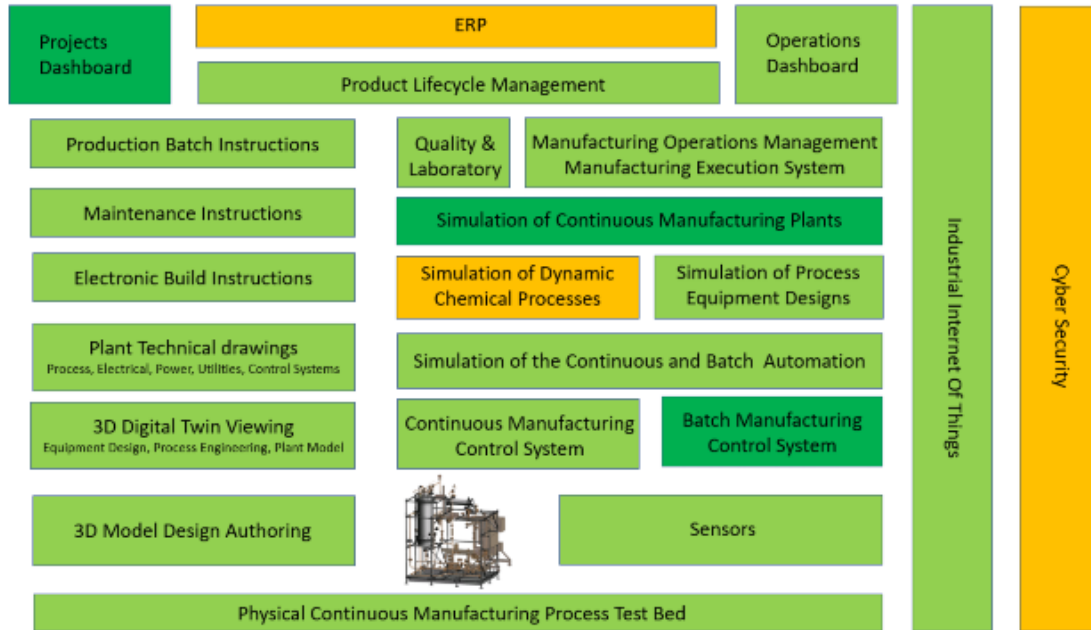
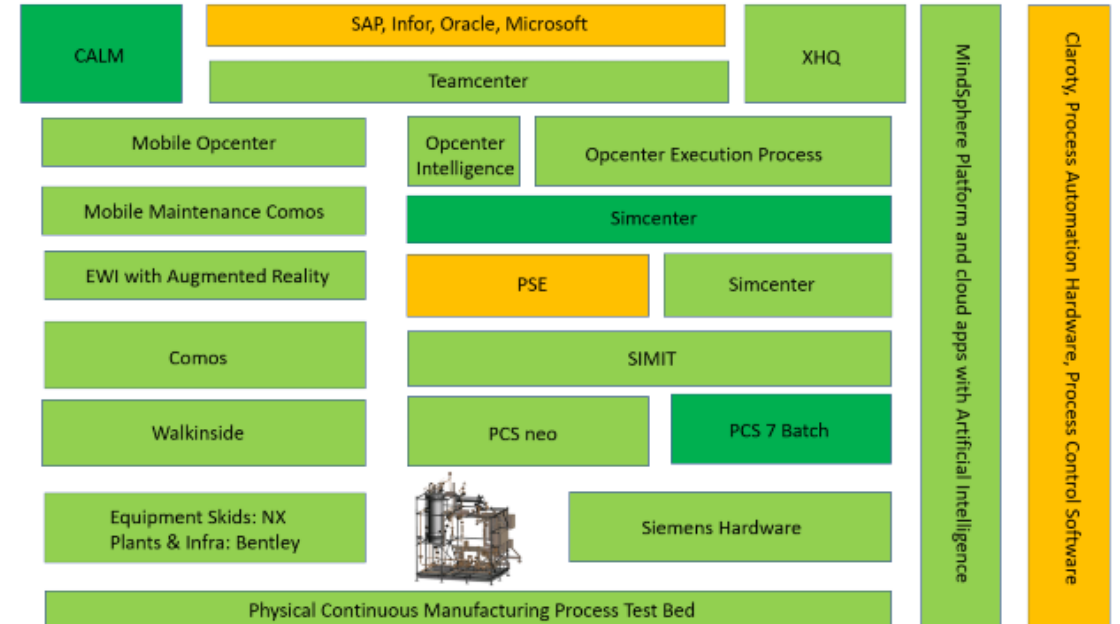
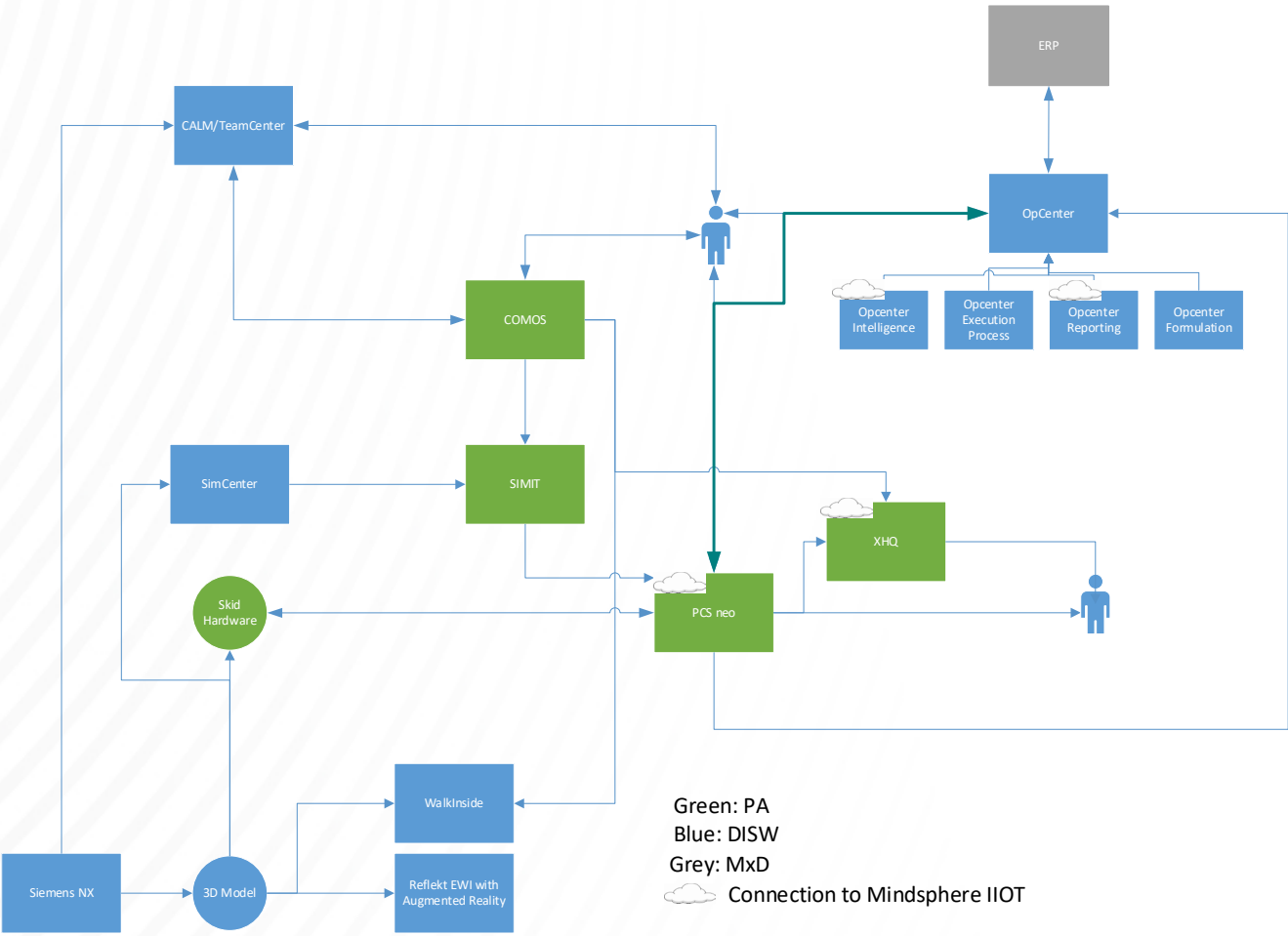
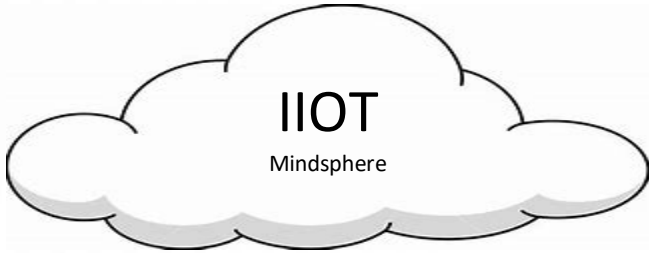


Figure 2 Technical Solution Product View



# SIEMENS SOFTWARE OVERVIEW



Software Stack

Reference info

Subra...	Person	Compatibility	Status	Primary Dev	Secondary Dev	Computer	Viru...	UI Type	Internet Access	Date
Process Network		Undetermined	Not Started	Undetermined	Undetermined	Undefined		Unknown	Undefined	
DISW Network		Undetermined	Not Started	Undetermined	Undetermined	Undefined		Unknown	Undefined	

Physical Computers

Subra...	Person	Compatibility	Status	Primary Dev	Secondary Dev	Computer	Viru...	UI Type	Internet Access	Date
Domain Server		Undetermined	Not Started	Undetermined	Undetermined	Domain Server		Unknown	Undefined	
Single Server		Undetermined	In Development	Undetermined	Undetermined	PA Single Server		Unknown	Undefined	
Process Historian		Undetermined	In Development	Undetermined	Undetermined	Historian		Unknown	Undefined	
Terminal Server		Undetermined	In Development	Undetermined	Undetermined	Terminal Server		Unknown	Undefined	
ES/Operator Station 1		Undetermined	In Development	Undetermined	Undetermined	Operator Station 1		Unknown	Undefined	
ES/Operator Station 2		Undetermined	In Development	Undetermined	Undetermined	Operator Station 2		Unknown	Undefined	
Client Server (VM Stack)		Undetermined	In Definition	Undetermined	Undetermined	Client Server		Unknown	Undefined	
Simulation Server		Undetermined	In Definition	Undetermined	Undetermined	Simulation Server		Unknown	Undefined	
GPU Server		Undetermined	Undetermined	Undetermined	Undetermined	GPU Server		Unknown	Undefined	
Win10 Tablet		Undetermined	Blocked	PA	Undetermined	Win 10 Tablet		Unknown	Undefined	
iPad		Undetermined	In Definition	Undetermined	Undetermined	iPad		Unknown	Undefined	

Siemens Process Automation

Subra...	Person	Compatibility	Status	Primary Dev	Secondary Dev	Computer	Viru...	UI Type	Internet Access	Date
Windows Domain Server		Undetermined	In Development	DMC	None	Domain Server		PC Application	Undefined	
PCS neo		Undetermined	In Development	DMC	PA	PA Single Server		Web	Undefined	
Process Historian		Undetermined	Not Started	DMC	PA	Unknown		Unknown	Undefined	
COMOS		Undetermined	In Development	DMC	PA	Domain Server		PC Application	Undefined	
3HQ/Plantsoft		Undetermined	Not Started	PA	DMC	DMC Cloud/DTT		Web	Undefined	
SMIT		Undetermined	Not Started	DMC	PA	PA Single Server		PC Application	Undefined	
Walkinside		Undetermined	Not Started	DMC	DMC	GPU Server		PC Application	Undefined	
SPXX		Undetermined	Not Started	PA	DMC	Win 10 Tablet		Industrial Tablet	Undefined	
Mindsphere OPA		Compatibility Pending	Not Started	PA	DMC	Cloud		Web	Undefined	
Mindsphere PEA		Compatibility Pending	Not Started	PA	None	Cloud		Web	Undefined	
Mindsphere BDA		Compatibility Pending	Not Started	PA	DMC	Cloud		Web	Undefined	
Mindsphere Valiemon		Compatibility Pending	Not Started	PA	DMC	Cloud		Web	Undefined	
Mindsphere MyEiPart		Compatibility Pending	Not Started	PA	DMC	Cloud		Web	Undefined	
Mindsphere SCRIVE IQ		Compatible	Not Started	PA	DMC	Cloud		Web	Undefined	

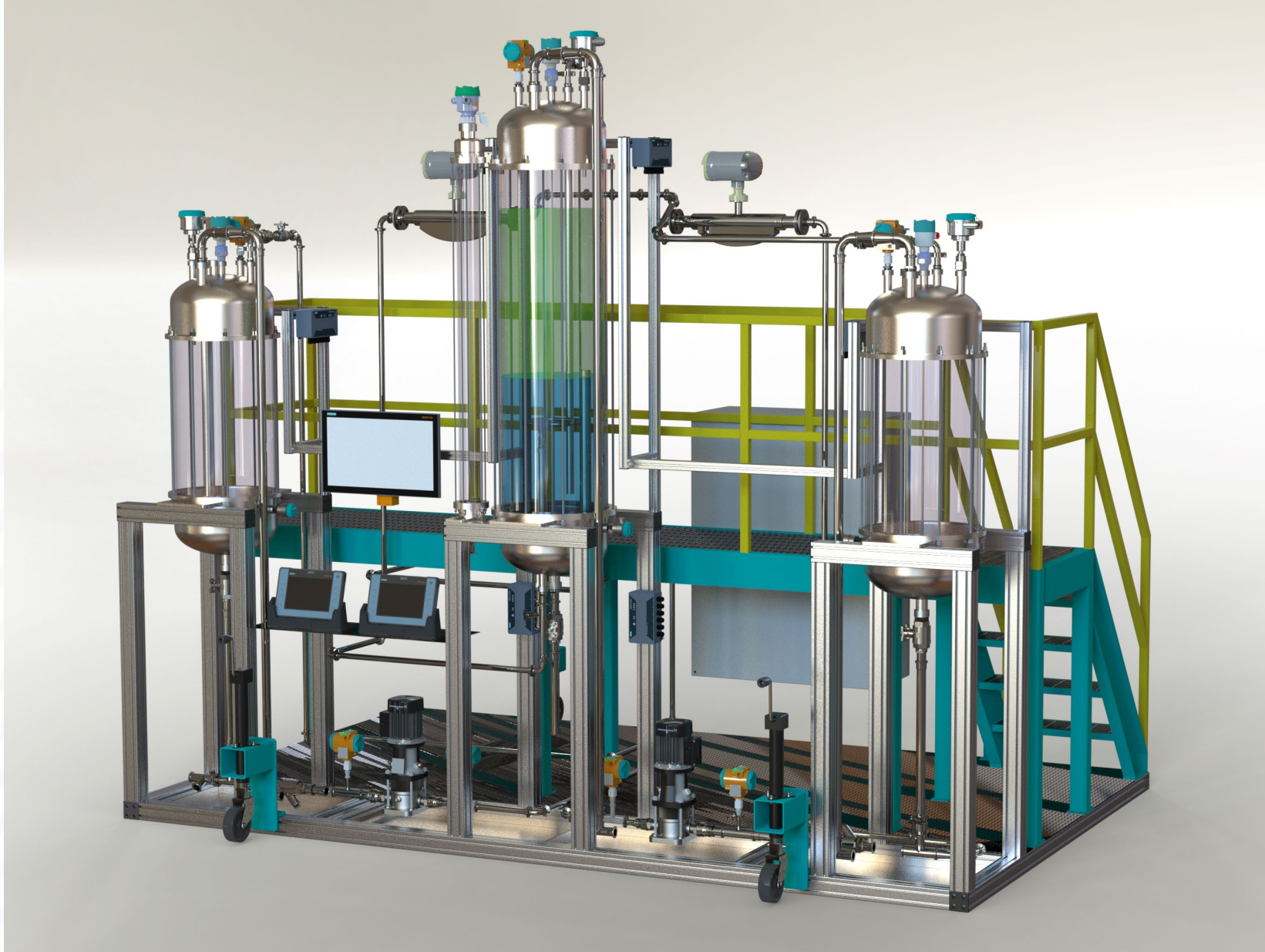
Siemens DISW

Subra...	Person	Compatibility	Status	Primary Dev	Secondary Dev	Computer	Viru...	UI Type	Internet Access	Date
NXC		Compatible	Not Started	DAPE	None	GPU Server		PC Application	Undefined	
Simcenter		Undetermined	Not Started	DISW	None	GPU Server		PC Application	Undefined	
Mindsphere APS		Compatibility Pending	Not Started	Undetermined	Undetermined	Cloud		Web	Undefined	
Mandix		Undetermined	Not Started	DISW	DMC	Cloud		Web	Undefined	
Reflect One Author		Undetermined	Not Started	CAD-IT	DMC	GPU Server		External Device	Undefined	
Reflect Sync		Undetermined	Not Started	CAD-IT	DMC	GPU Server		External Device	Undefined	
Teamcenter/CALM		Undetermined	Not Started	DISW	DMC	Client Server		Web	Undefined	
Opcenter/Execution		Undetermined	Not Started	DMC	DISW	Client Server		Web	Undefined	
Opcenter/Formulation		Undetermined	Not Started	DISW	None	Client Server		Web	Undefined	
Teamcenter/Visualization Server		Undetermined	Not Started	DISW	DMC	GPU Server		Unknown	Undefined	
Teamcenter client RAC/AVC		Undetermined	Not Started	DISW	DMC	GPU Server		Unknown	Undefined	



# Siemens NX Model





- Full featured CAD system
- Highly integrated into Siemens stack

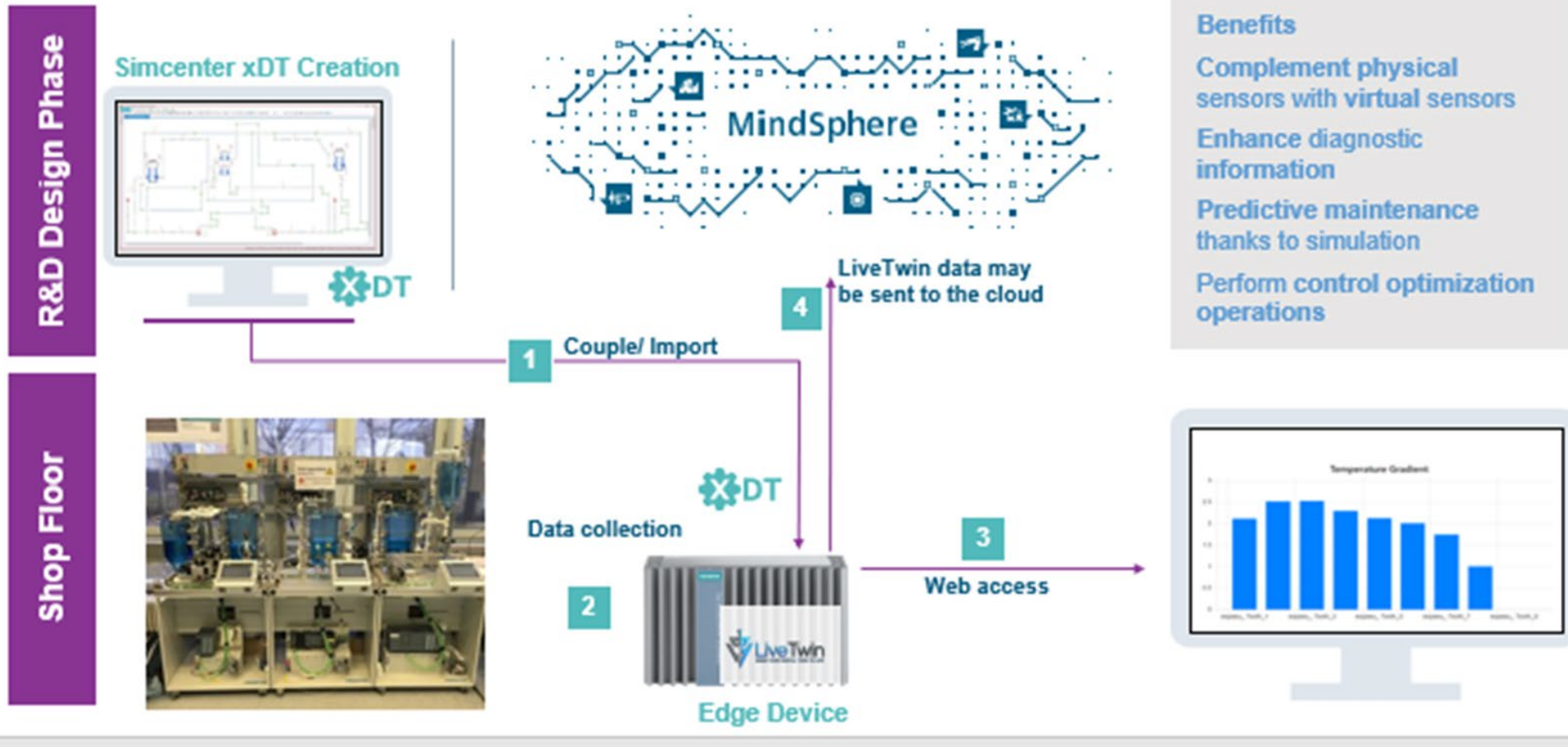


# Installation at MxD





# Simcenter Flomaster Virtual Sensing



# Opcenter Manufacturing Operations Management

19

Vertical/Horizontal  
Integration

Workorder  
Orchestration

Integrated Quality

Production Reporting

Genealogy

Manufacturing  
Intelligence

The screenshot displays the Siemens SIMATIC PCS neo interface. The browser address bar shows the URL: `siemensdcj/it-uj/runtime/ProcessDemo.OperatorProcess/#/screen/home.Siemens_SimaticT_UAPL_PICore_OperatorTask_OperatorTaskList`. The page title is "Task Execution" with a sub-header "Production Context: Not Defined". The main content area shows a task execution screen for "SecA - Input Level" with the sub-header "LvlInput - Input Oil Tank Level". A central image shows an industrial facility with yellow liquid in tanks. Below the image, the text "Confirm Oil Tank Level To Transfer" is displayed. At the bottom, there is an input field for "Level:" with the value "35" and a unit "Liter". Below the input field, it shows "Low Limit: 10 Target: -- High Limit: 70" and a "Confirm" button. The Siemens logo is in the top right corner. The Windows taskbar at the bottom shows the time as 10:21 AM on 4/6/2022.

Correlation between IT/OT/ET

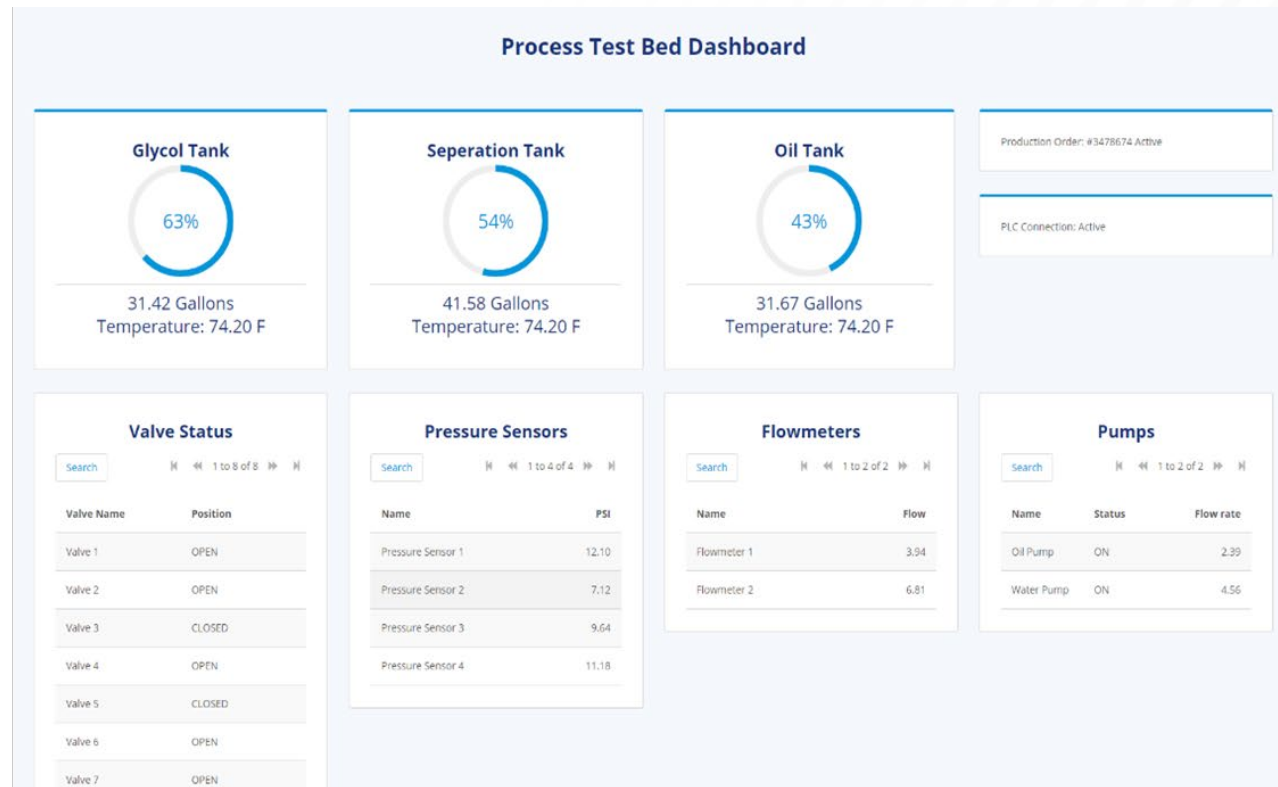
Value to disparate data

Easy Adoption

Insight

Connectivity to systems

Support many roles needing mobile capabilities



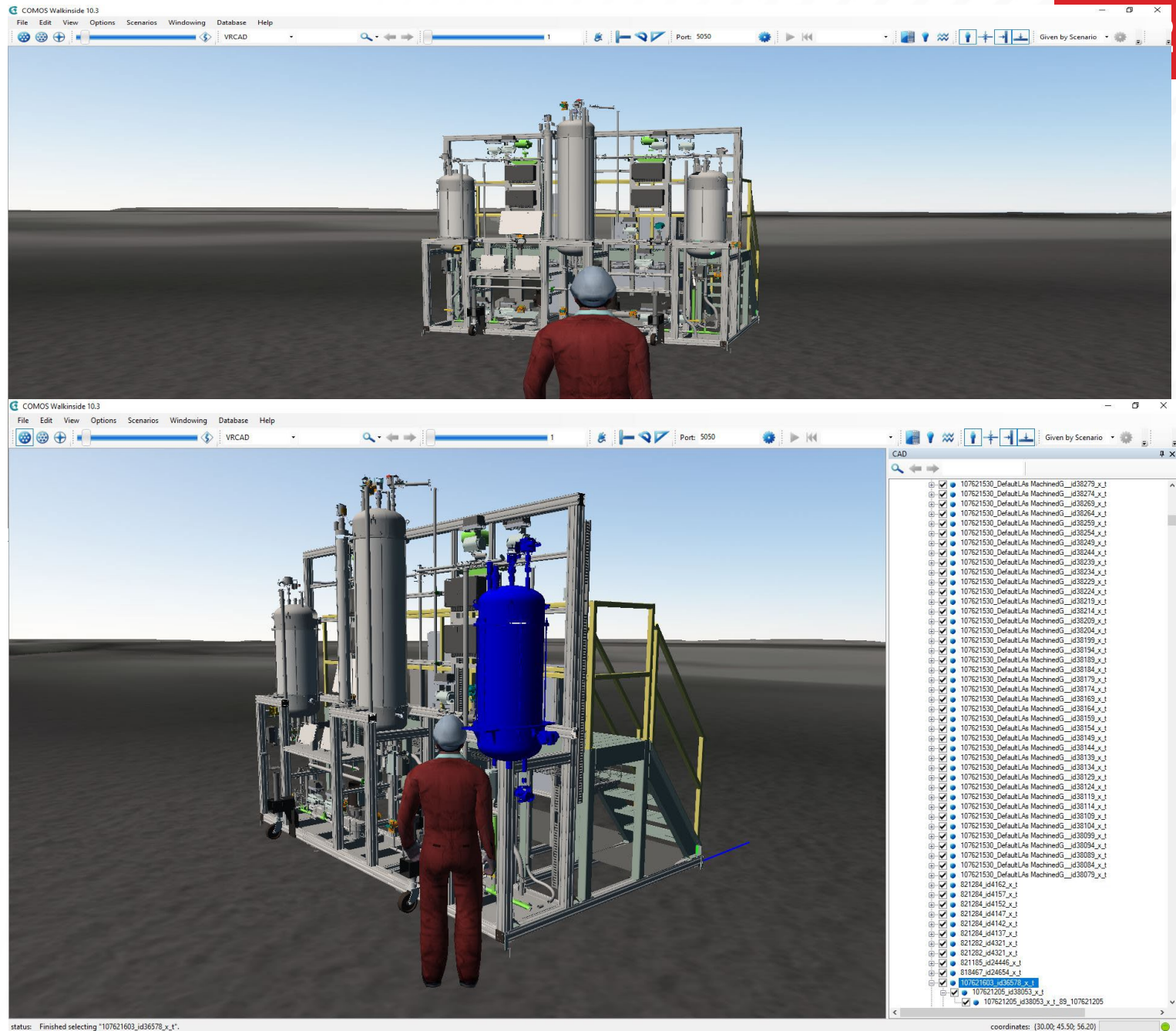


The screenshot displays the COMOS Plant Engineering Software interface. On the left is a tree view showing the project structure: Grant P&ID linked to M&D Development, IDB\_P02, and various equipment and piping objects. The main window is divided into several sections:

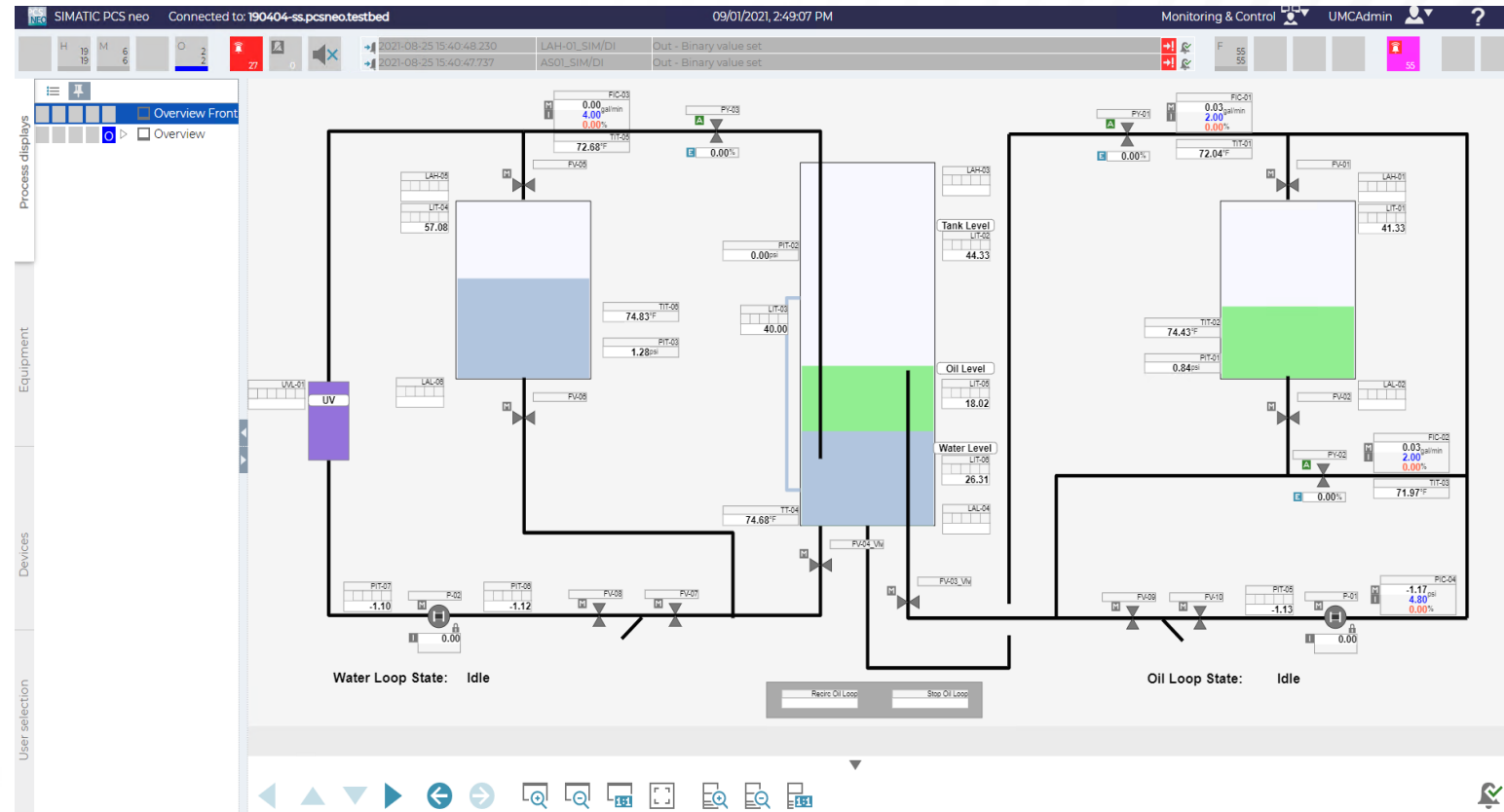
- General information 1:** Type: Vertical Pump, 1.5 inch, 1 HP Multi-stage; Manufacturer: Grundfos; Supplier: Grundfos; Date of commissioning: [blank]; Lifecycle status: [blank].
- General information 2:** Main constr. material: [blank]; Design pressure: [blank] psi (a); Design temp.: 194 °F; Volume flow: 45 gal (US); Design head: 86.7 ft; Seal type: HQQV.
- Comments:** A section for entering comments, binding norms, and general remarks.
- P&ID Document:** A detailed process flow diagram showing three tanks (TANK 01: Oil Reservoir, TANK 02: Separation Tank, TANK 03: Water Reservoir), two pumps (PUMPO1 and PUMPO2), a collection basin (00-01-B-001), and various piping, valves, and instruments.

# COMOS Walkinside

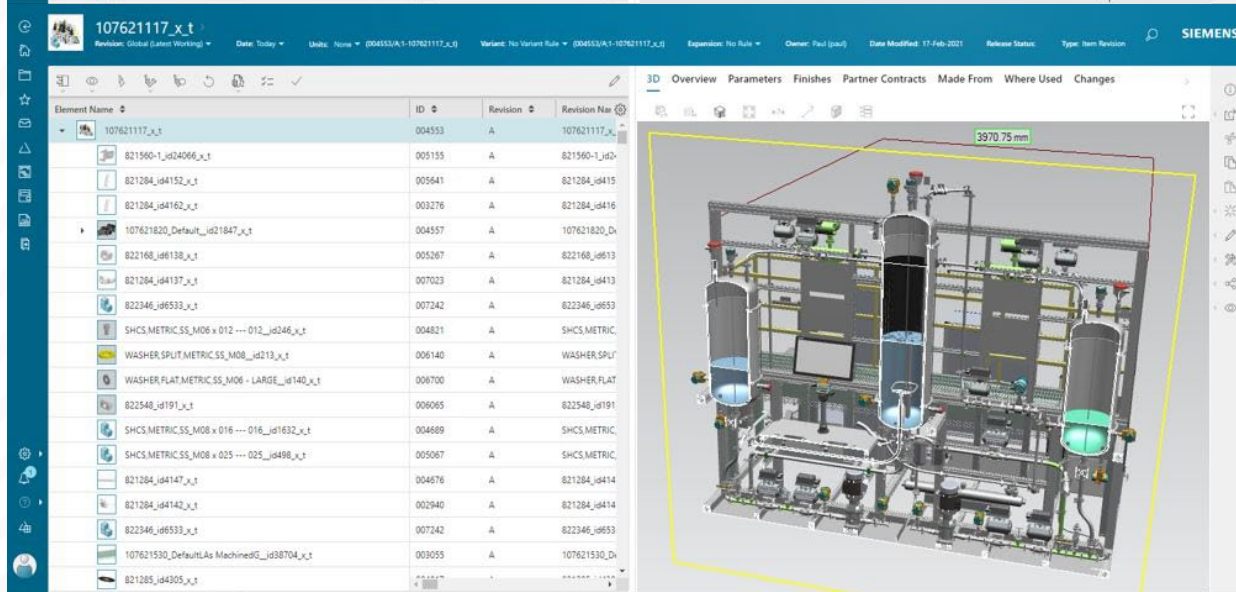
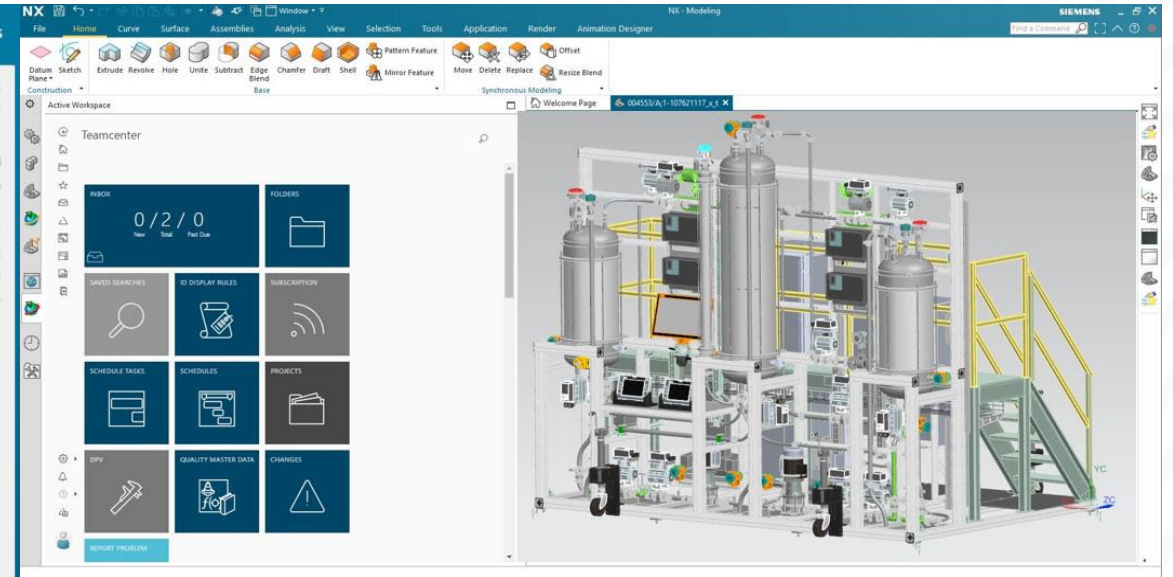
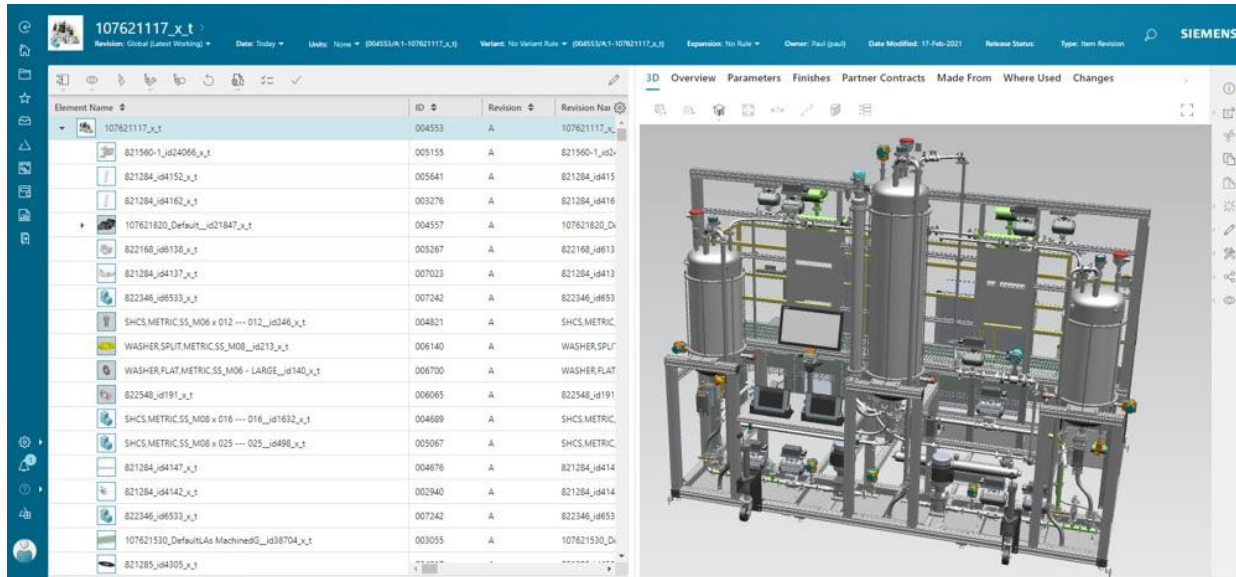
- 3D virtual skid immersion for maintenance, training, and interactivity.
- Interacts with SIMIT to allow safe training and interaction on an emulated skid.
- Works with PCS Neo to provide live skid status and information in the digital twin.
- Utilized in dashboarding apps to provide quick 3D skid reference to objects from other applications.



- Next generation process control system
- Web based client architecture allows for zero install clients with simplified licensing and maintenance.
- HTML 5 UI system allows for seamless transition between desktop and mobile clients.







- Tree of parts on the left allows visualization of part location in 3D model
- Tracks detailed information such as vendor, revision, and specifications for parts
- Can be integrated with COMOS P&ID and plant CAD





- Skid training complete
- Siemens Process Automation mobile worker training complete
- Siemens DISW training next week





# Conclusions & Next Steps

- Conclusions
  - Rapid industry advancement is beginning to allow tighter integration of entire processes with these “next generation technologies”
  - Integrating this level of software stack is extremely challenging, even in a well controlled environment like this
  - Digital twin functionality requires a dramatic increase in design and data fidelity over that normally generated for systems
- Promotion
  - This testbed provides an excellent playground of technologies for potential consumers of the technology to experience the benefits firsthand
- Next Steps
  - Use this skid as the framework to trial and implement better ways of performing these integrations and transitioning them to industry