SAP PEI enabled by ANSYS: Simulation-based Digital Twins

SBN Norge Webinar

Audun Grimstad / Ankit Aggarwal, SAP Norway Engineering Center of Excellence
November 2019

PUBLIC

THE BEST RUN SAP

Agenda

Introduction

SAP Landscape: D2O, IAM, PLM

SAP Predictive Engineering Insights: Physics-based DT, ANSYS partnership, the role of engineering simulations in product/process lifecycles

SAP PEI: Unique capabilities, features, application areas, real-time monitoring

Making a model – creating the Digital Twin, making a Reduced-order Model (ROM) for real-time monitoring

Closing

SAP Norway Engineering Center of Excellence

DSC, P&E, PEI SAP Norway CoE

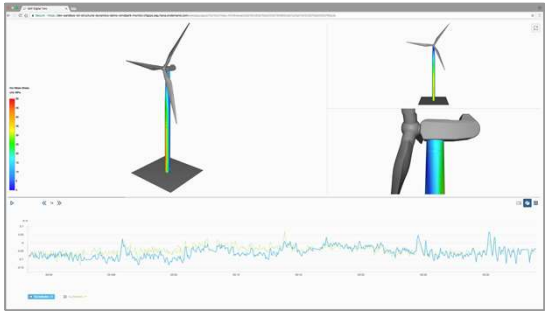
Based on the engineering and development team of Fedem (SAP acquisition 2016) in Trondheim, Norway.

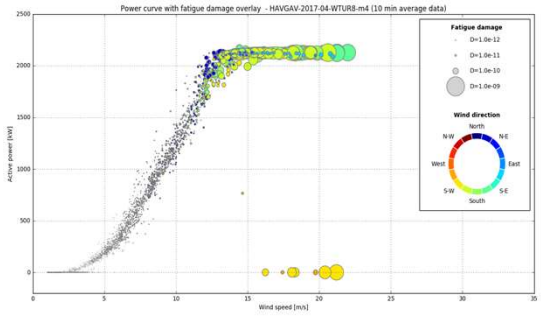
Tight relations with NTNU and UiO on R&D.

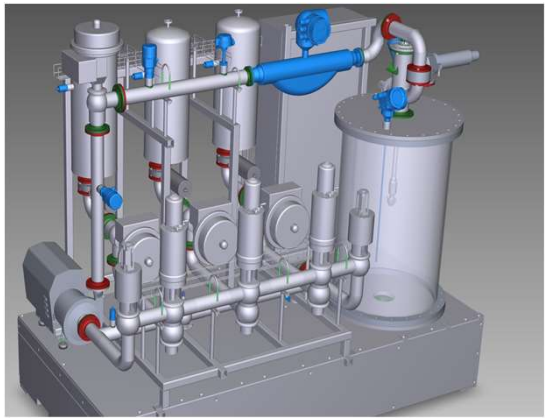
Development of physics-based Digital Twins, methodology, signal processing func., sensor applications, data visualisation, IoT data components, …

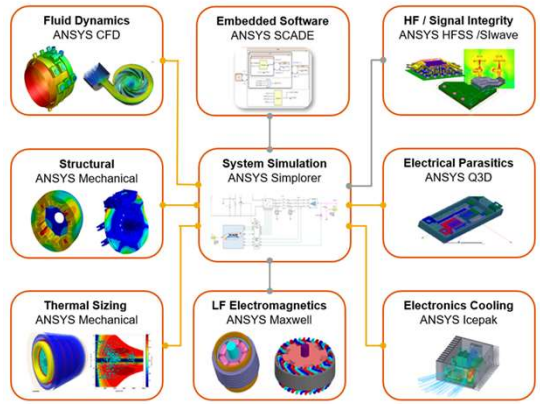
Project delivery unit: PMs, product support, services, onboarding/training, …

Model, implement and integrate ANSYS-based DTs in SAP Asset Management and PLM landscapes.









ANSYS®

About ANSYS

Company Profile

ANSYS Vision

Pervasive Simulation integration across the product lifecycle on a single platform.

FOCUSED

This is all we do.
Leading product technologies in all physics areas. Largest development team focused on simulation

TRUSTED

97 FORTUNE **100** of the industrials

ISO 9001-2015 CERTIFIED

PROVEN

Member of the prestigious STANDARD &POOR'S **500**

$18B market capitalization

GLOBAL

87 ANSYS offices

3,800 employees globally

>100 channel partners selling in more than 100 countries

LARGEST

3x the size of our nearest competitor (revenue)

INDEPENDENT

Long-term financial stability

CAD agnostic

COMMITTED

Overall customer satisfaction globally is at **89.1%** in 2018

DRIVEN

Helping customers address new market challenges: **digital exploration, 5G, additive manufacturing** and **digital twin**

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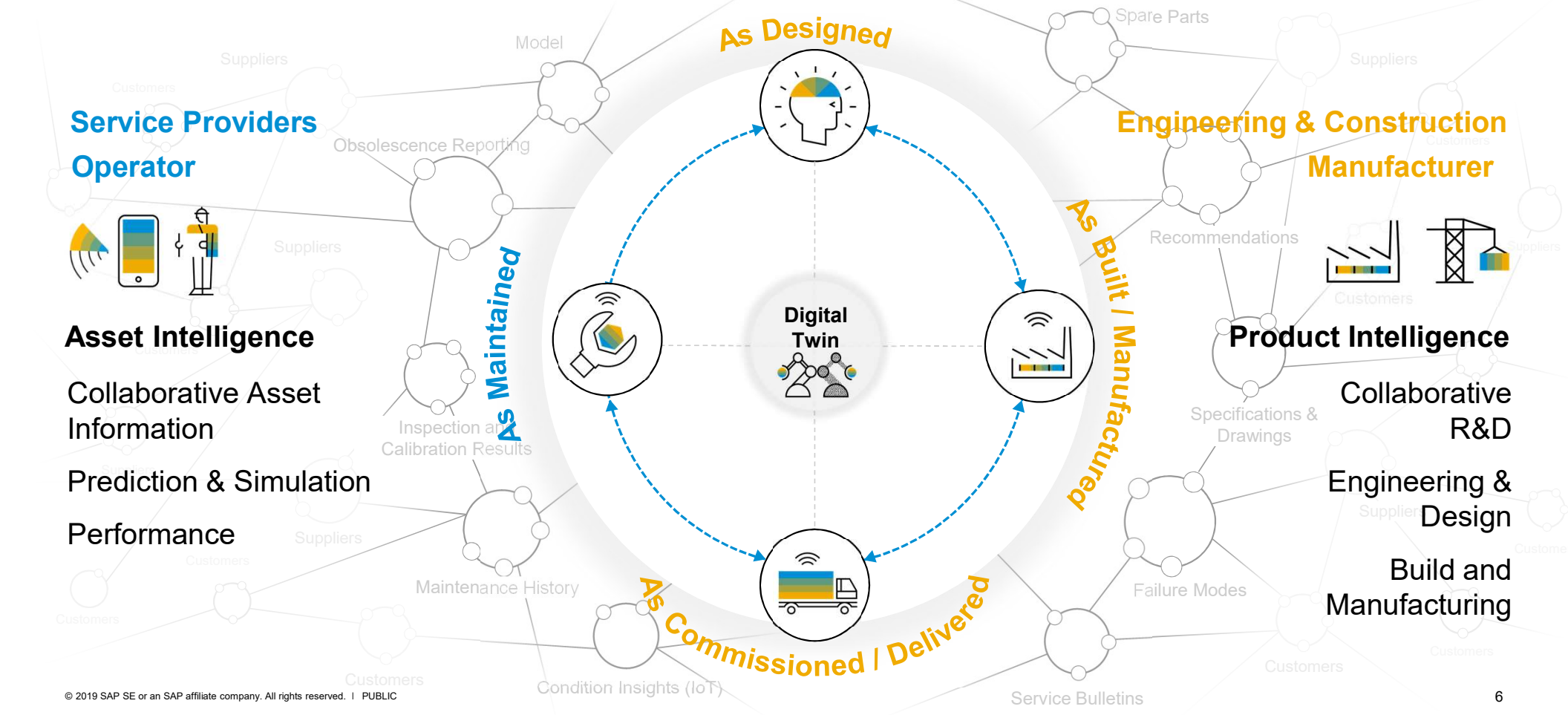
Closing

Digital Supply Chain

A Common Asset Foundation for the life-cycle of the Asset



Service Providers

Operator

Asset Intelligence

Collaborative Asset Information

Prediction & Simulation

Performance

Engineering & Construction

Manufacturer

Product Intelligence

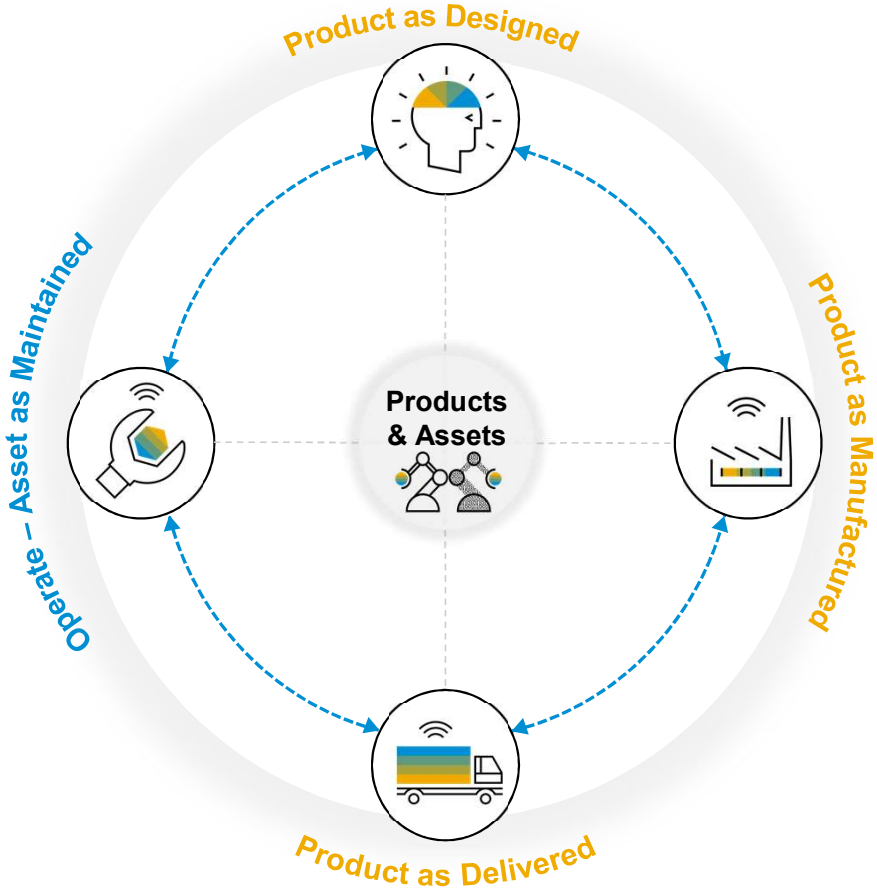
Collaborative R&D

Engineering & Design

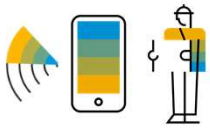
Build and Manufacturing

Product and Asset Lifecycle and the Digital Twin

The Asset Management view



Operator



Asset Intelligence

Asset Management, Predictive Maintenance and Service

Predictive Engineering Insights

As Operated – Strategic Partnership with ANSYS

Manufacturer

Product Intelligence

Collaborative R&D, Engineering and Manufacturing

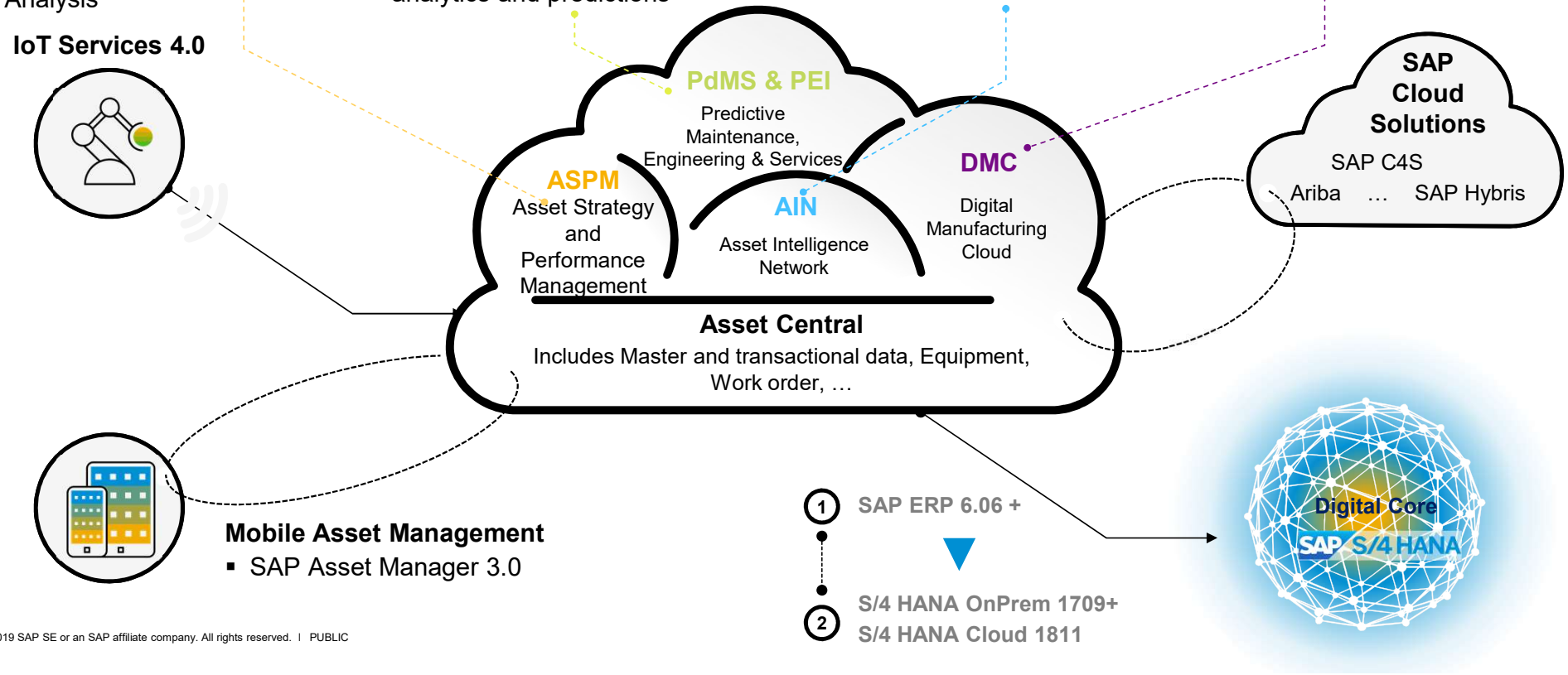
Asset Management Ecosystem

- Risk and Criticality
- Strategy Review
- Risk Centered Maintenance
- Failure Mode and Effects Analysis

- Condition Monitoring
- Dynamic Maintenance
- Derived Indicator Management
- Machine-learning enabled analytics and predictions

- Network
- Collaboration
- Equipment Portal

- 3D Virtual Simulation
- Real time engineering
- Dynamic 3D visualization



Digital platform for collaboration on equipment data

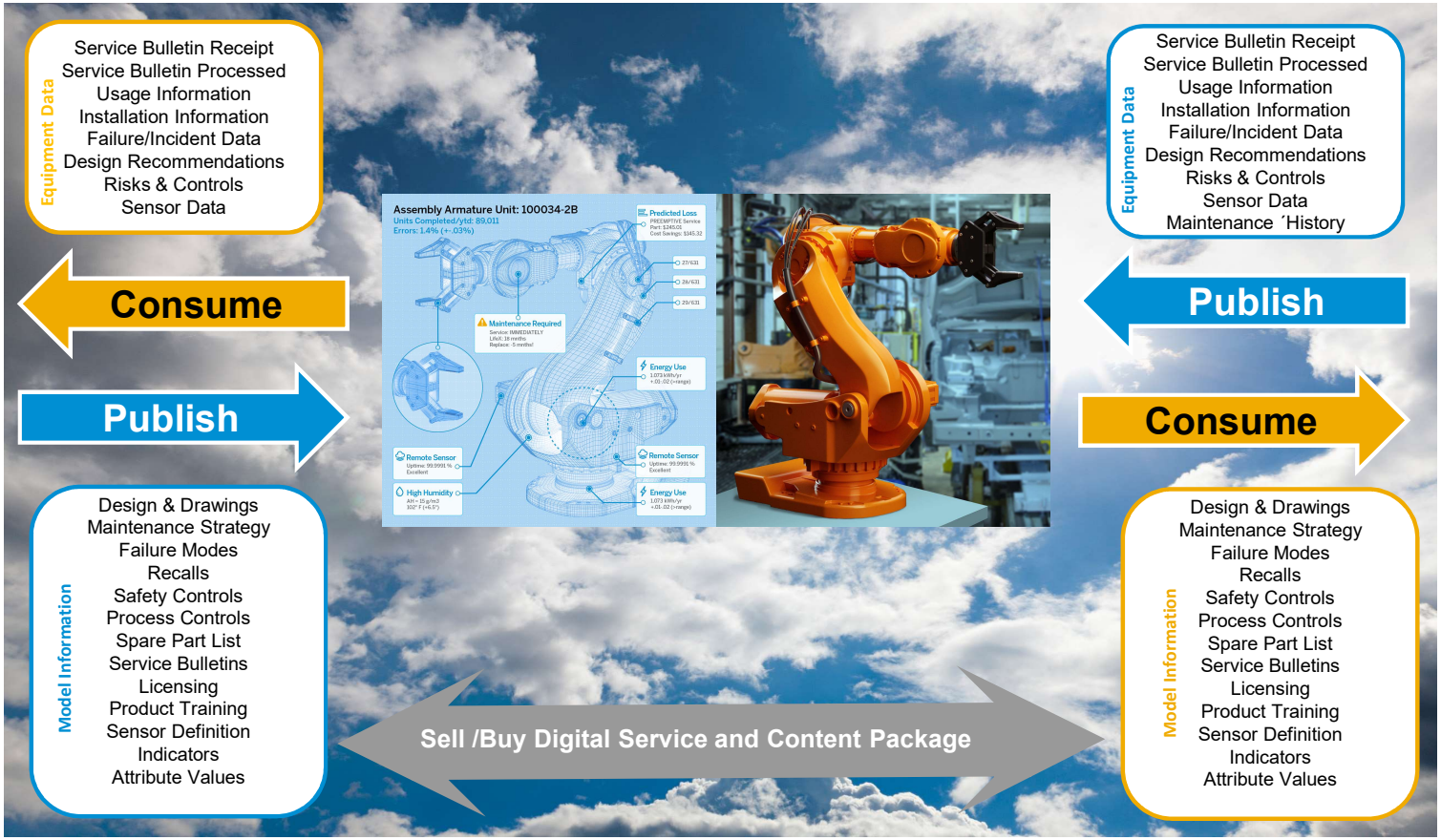
Secure data access, sharing and governance on a global scale

Manufacturers & Suppliers

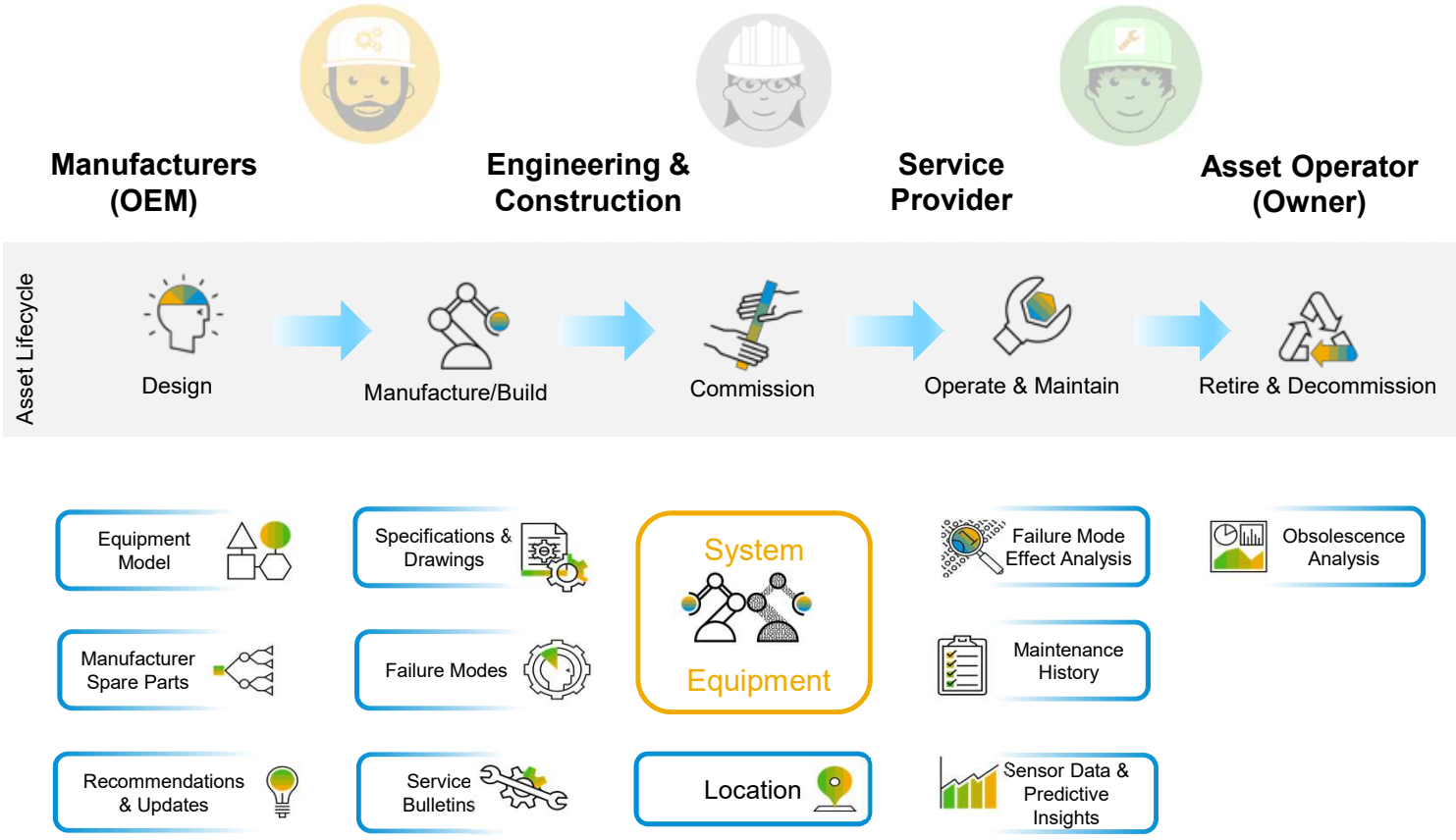
Engineering & Construction

Asset Operator

Service Provider

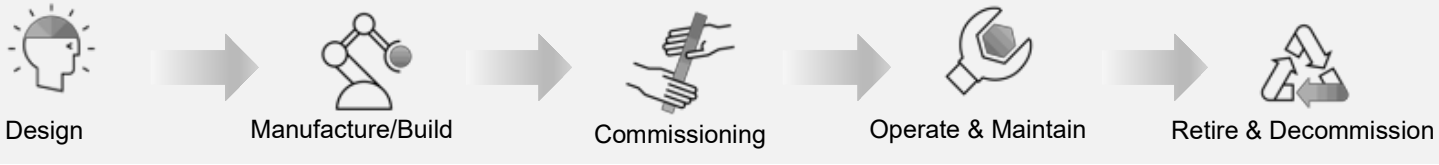


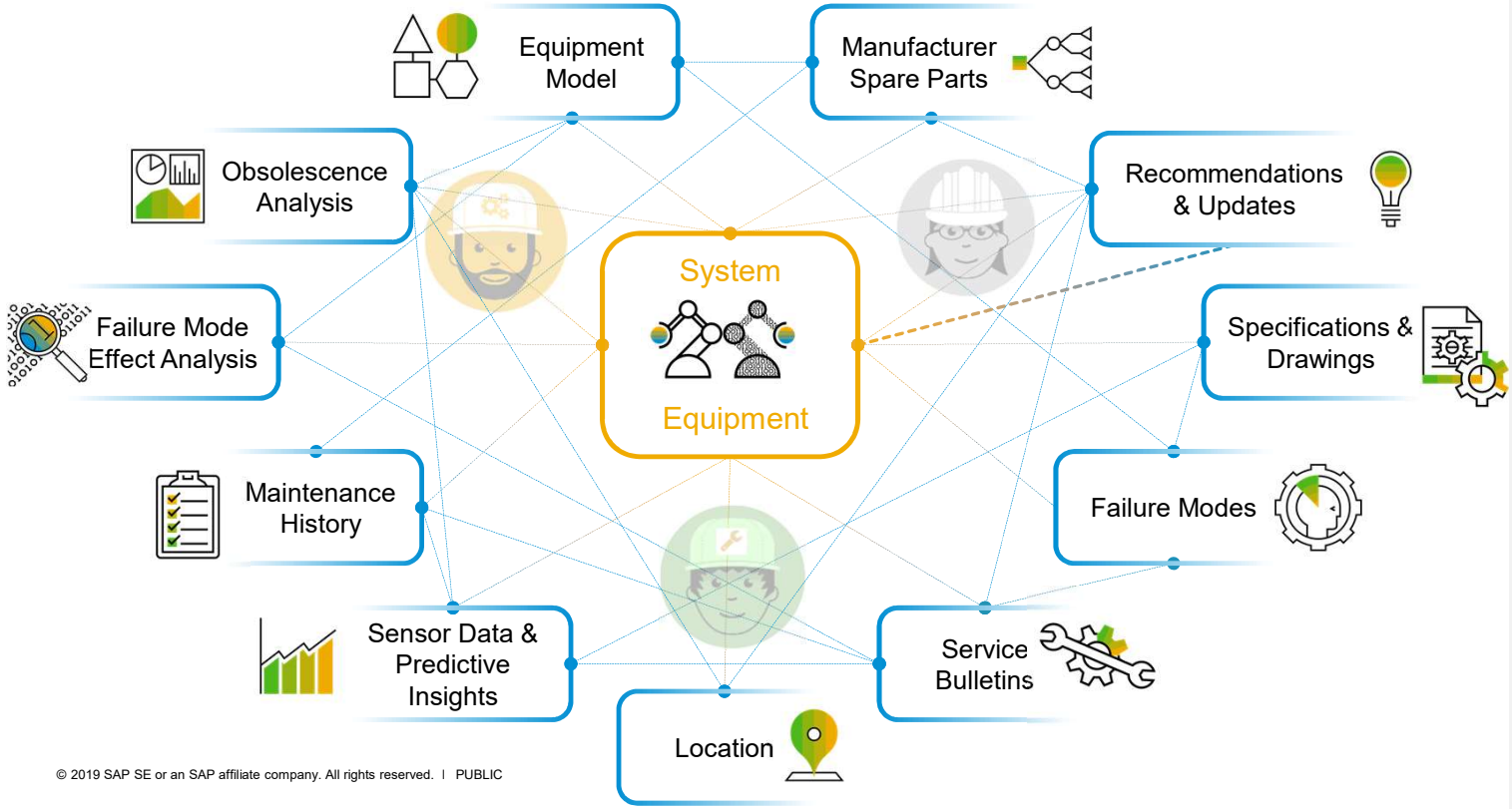
From ‘siloed’ asset information …



- No common asset taxonomy
- No business partner collaboration
- Siloed asset data
- Inefficiency asset data maintenance
- Poor asset data integrity

…to a collaborative asset information environment



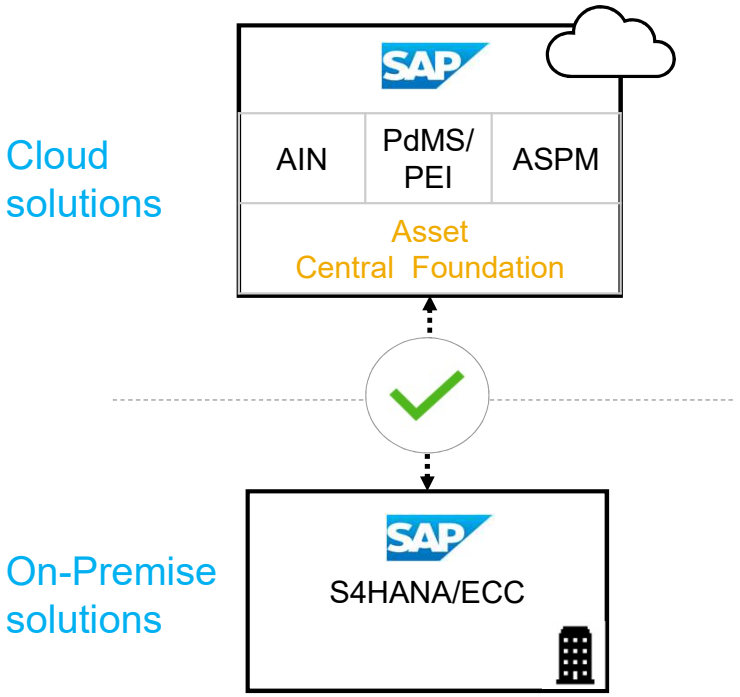


- Assess key players in your ecosystem and select your preferred alliances
- Find all the asset information in one place
- Share best practices for optimal equipment availability
- Provide opportunity to new business model to monetize content and services

Asset Central Foundation

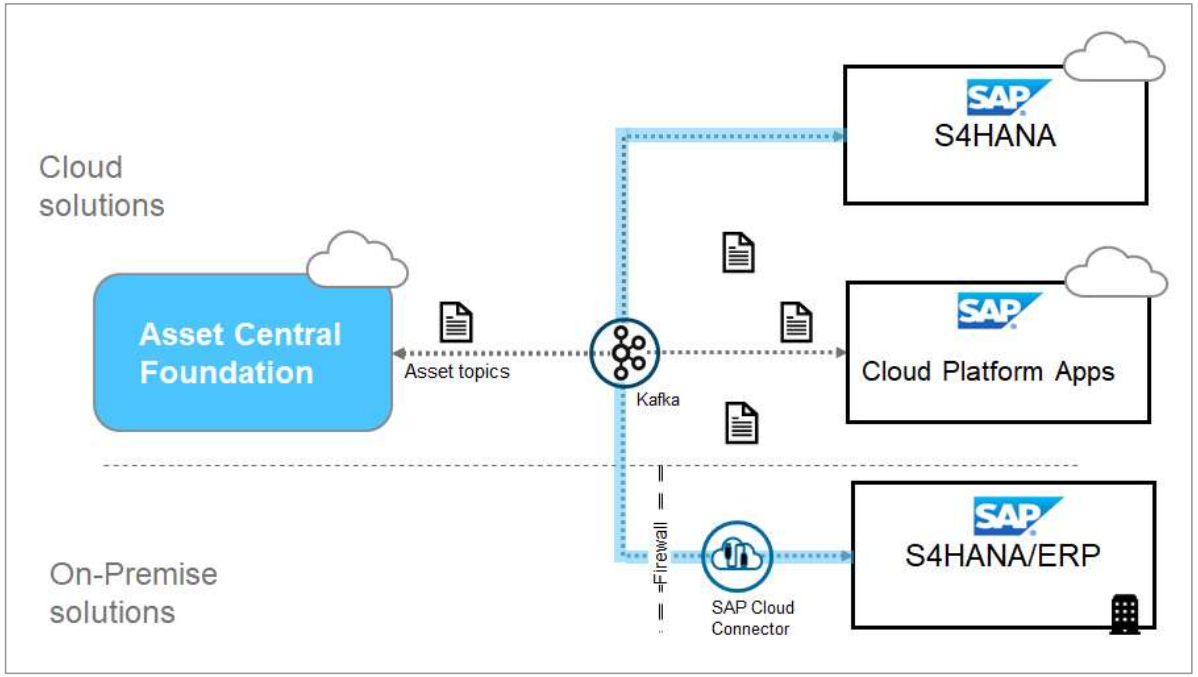
Asset Management integration data layer

- Integration data layer between Intelligent Asset Management suite (AIN, PdMS/PEI, ASPM & Asset Manager) and on-premise Asset Management solutions.
- Integration between Asset Central & On-premise Asset Management solutions covers both data and user experience improvements.
- Integration provides Bi-directional synchronization of asset information for technical objects:
  - Equipment
  - Functional Location
  - Documents
  - Notifications
  - Work orders



Supported Releases – **S/4 HANA On Premise 1709 & above**, **ERP Enhancement package 6 & above.**

Asset Central Foundation – Integration landscape



Asset information is kept current in near real time between asset suite of products in SAP cloud platform and Enterprise Asset Management (EAM)

Single integration for mobile and asset central

Supported Releases :

Cloud: 1906 Asset Central; S/4HANA 1905; **On Premise**: ECC 6.0(EhP7 & above) / S/4HANA(1709 & above)

Asset intensive Integrations

Standard Integration

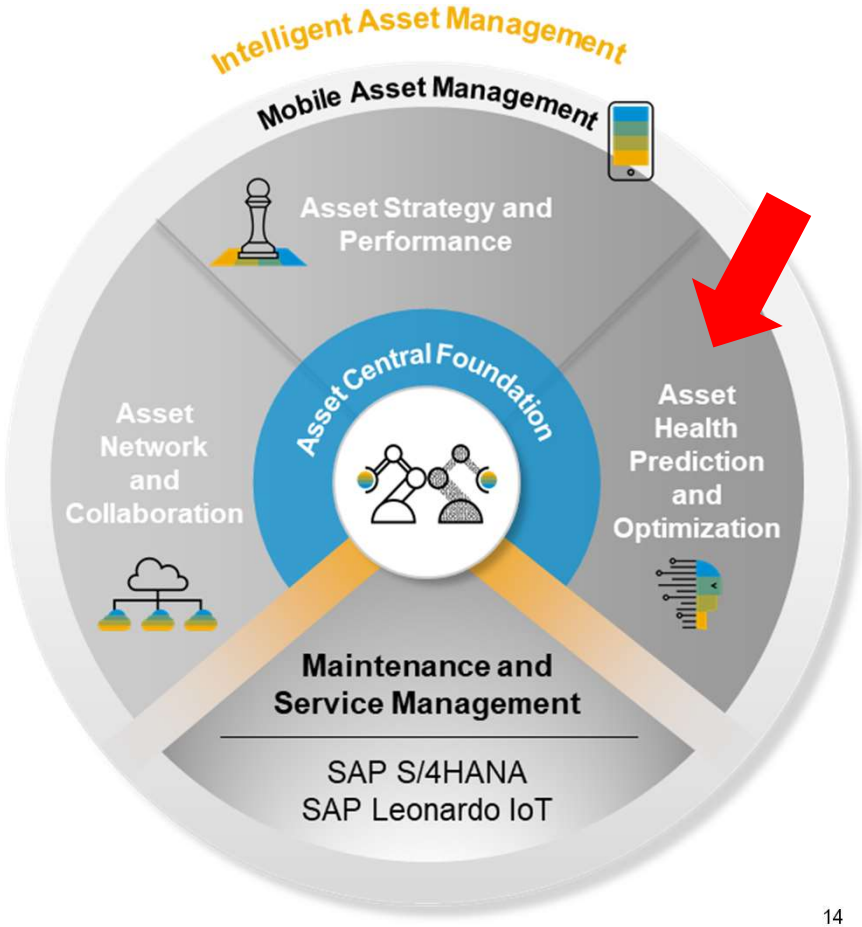
The runtime simulation models from PEI are integrated in SAP‘s Intelligent Asset Management portfolio for asset health prediction & optimization.

Asset Network and Collaboration
SAP Asset Intelligence Network

Asset Strategy and Performance
SAP Asset Strategy and Performance Management

Asset Health Prediction and Optimization
SAP Predictive Maintenance and Service
SAP Predictive Engineering Insights enabled by ANSYS

Mobile Asset Management
SAP Asset Manager



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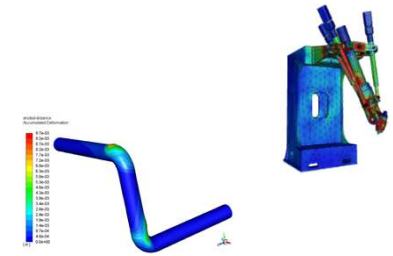
Closing

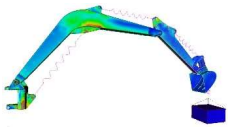
SAP Predictive Engineering Insights drives value for OEM's, Service Providers and Operators in different ways

	OEMs	Dealerships / Service	Operators
Primary operation 	▪ Design, manufacture and sale of original equipment ▪ Service and warranty management ▪ Design digitally connected products	▪ Dealership: Sale/lease and servicing of products ▪ Service: Servicing of industrial assets	▪ Operating equipment for business purposes (e.g. energy generation)
Value proposition 	✓ Reducing warranty costs/ prevent frauds ✓ Customer satisfaction ✓ Inputs for engineering ✓ Offering self-service functionality to their customers ✓ New business models (e.g. service contracts based on availability to boost revenues	✓ Reducing service costs ✓ Higher % calls resolved ✓ Higher first visit fix rate ✓ Higher service contract renewal rates ✓ Customer satisfaction	✓ Higher equipment effectiveness/ yield ✓ Reducing maintenance costs ✓ Faster reaction to alarms ✓ Lower mean time to repair ✓ CAPEX optimization through virtual sensors

[1] Tech-enabled disruption of products and services

Engineering models (e.g. FEM, CFD) are historically used in the R&D context of a new product design, but not in sales, service and operations.

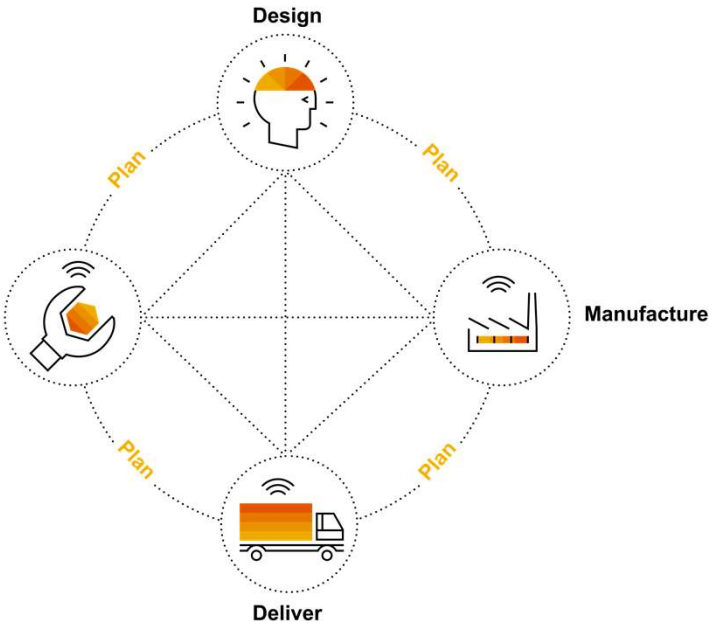




Reduced-Order Models
In-house tools
Systems
Optical
Finite Element Analysis
Simulation Engineer
Computational Fluid Dynamics
Electromagnetics
Mathematical Models

Key Challenge

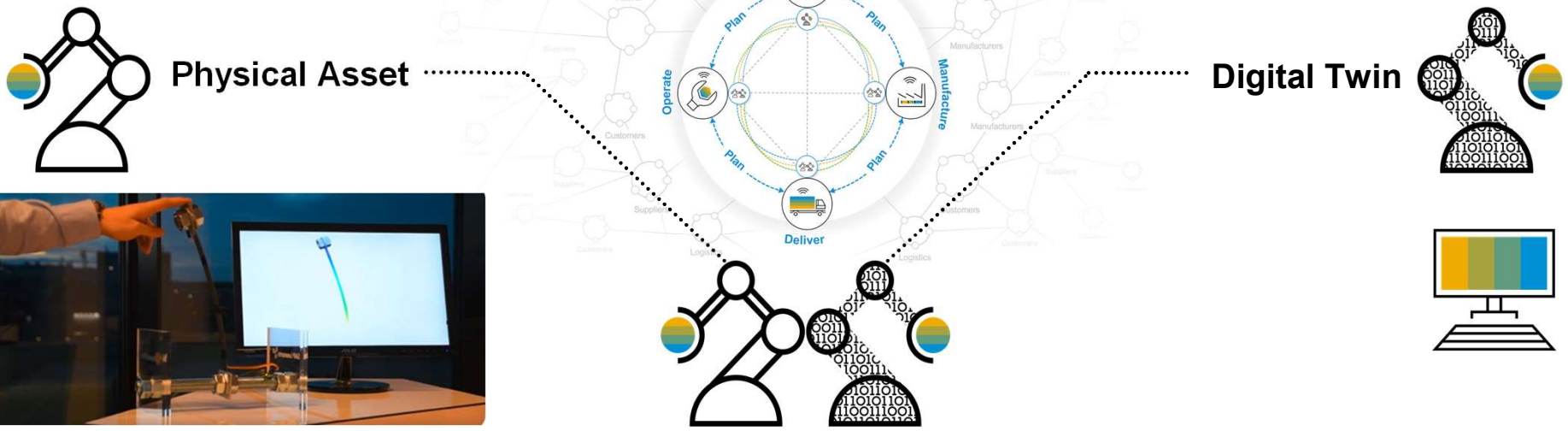
Simulation insights not available across Design-to-Operate



The Physical Asset and the Digital Twin

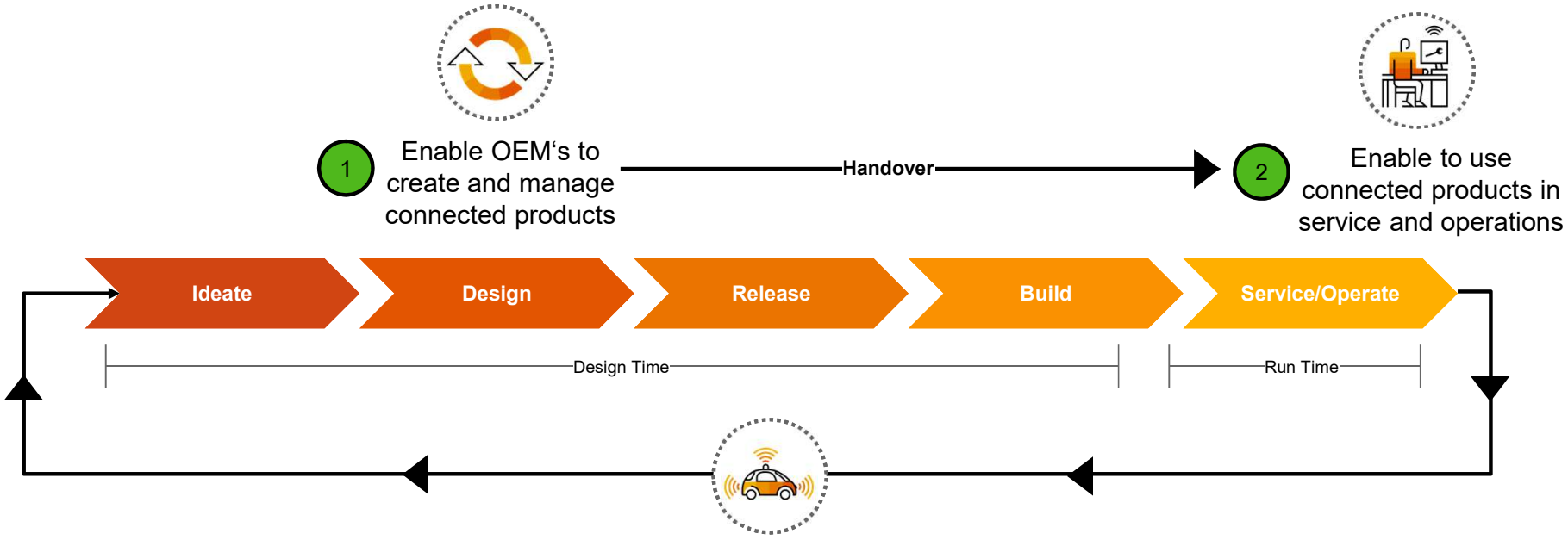
Connect Digitally to Perfect Reality for Your Asset Management

Full digital representation of connected assets along their lifecycle delivering an embedded, collaborative and real-time set of next generation processes and systems



Engineering models and the business process life-cycle perspective

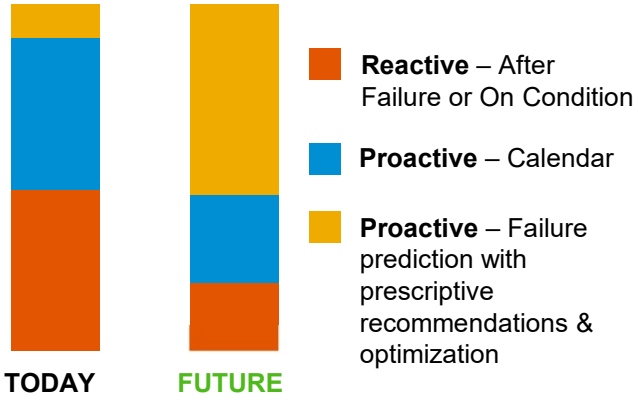
From a process perspective, we want to enable OEM's to create **digital products** in the design phase, manage the **handover to services & operations** and establish a **data backbone** for all product specific usage and IoT data.



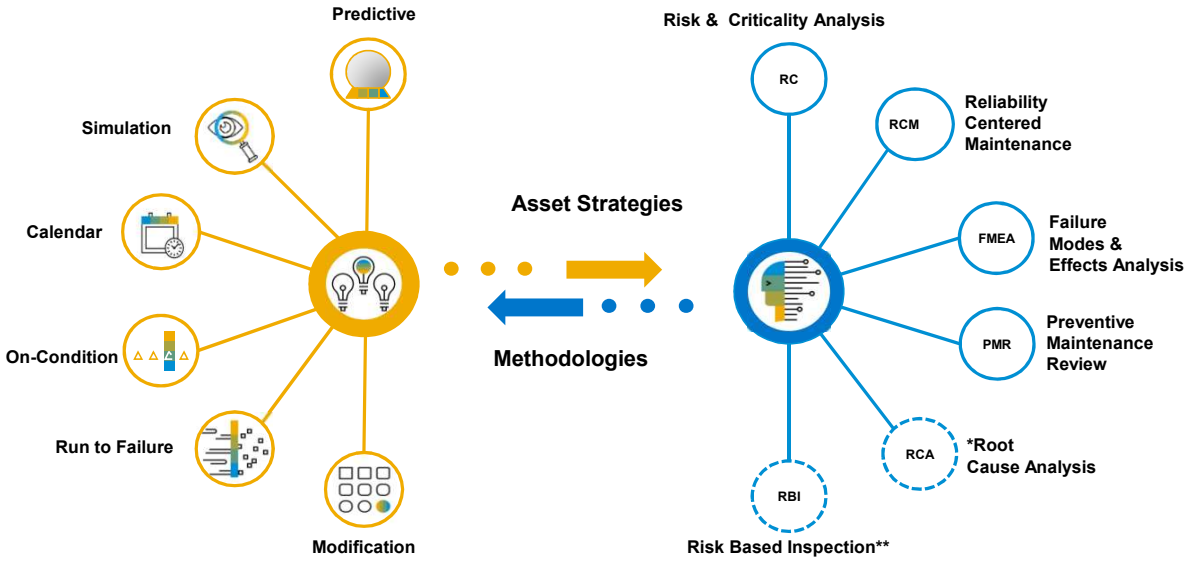
Evolve from reactive and preventive to reliability-centered & prescriptive maintenance

Calendar based maintenance results in **over-maintaining** assets at higher costs / less availability

Reactive based maintenance is too late for efficient planning and optimization



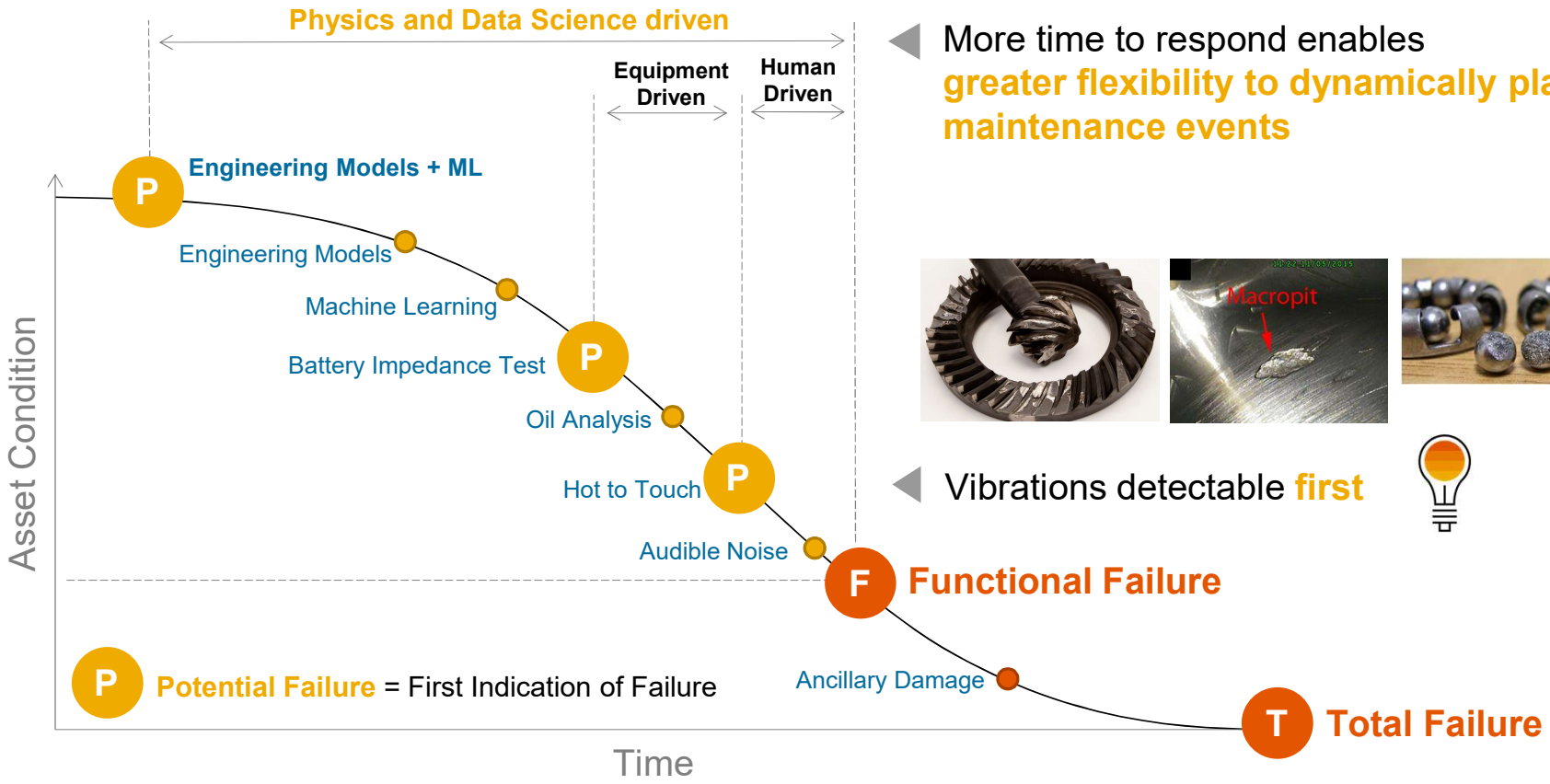
Intelligent Asset Management supports **data driven proactive** strategies with execution and optimization based on reliability & other goals. This achieves the delicate balancing of **profitability, asset health** and **availability**



*Future Functionality
**Partner Application

There is a whole range of Predictive Maintenance approaches

…and some of them are more powerful than others



More time to respond enables **greater flexibility to dynamically plan maintenance events**

Vibrations detectable **first**

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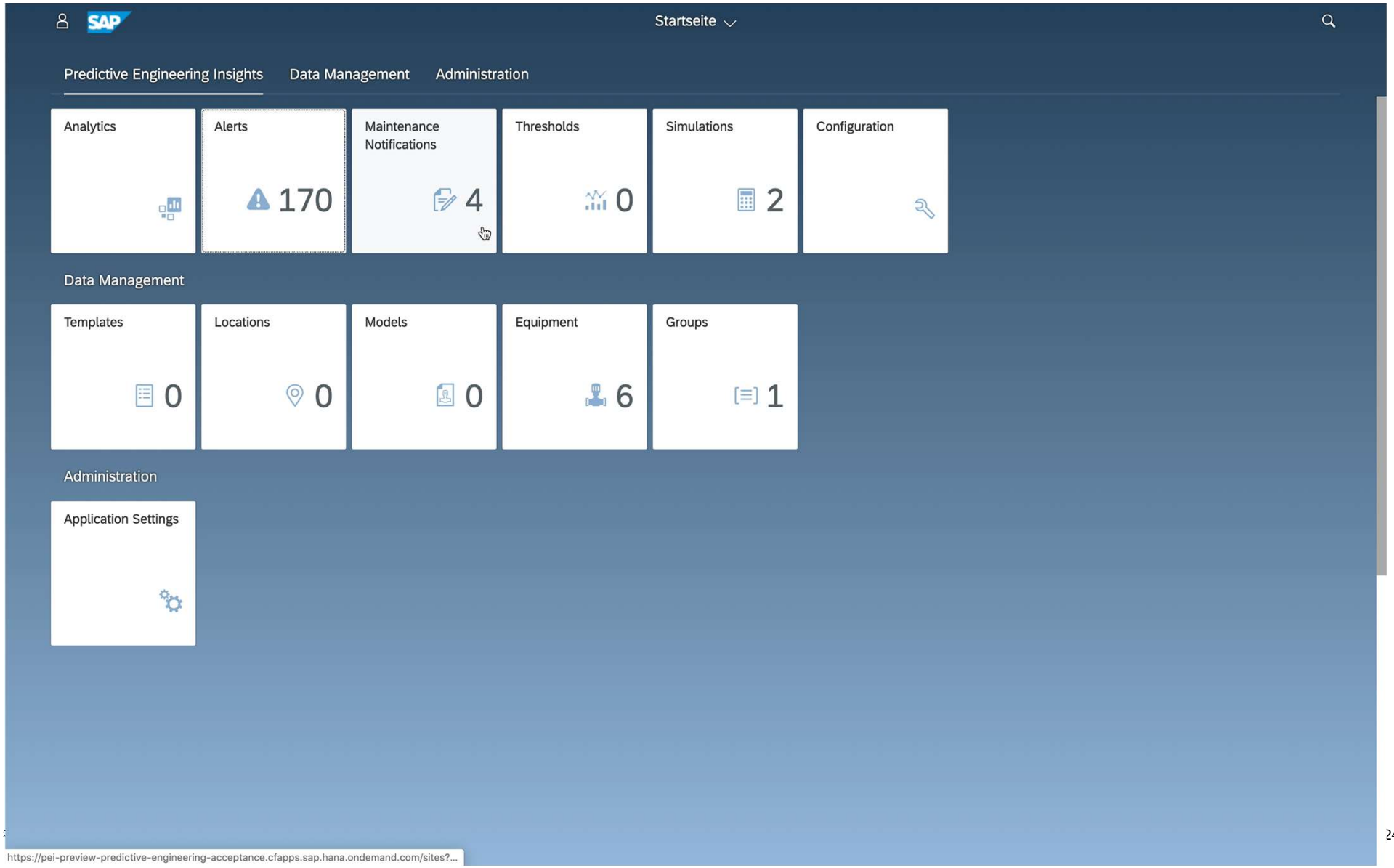
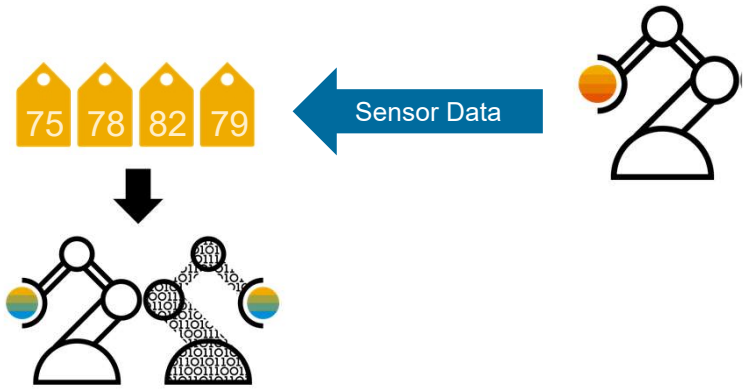

Startseite
Predictive Engineering Insights
Data Management
Administration
Analytics
Alerts
170
Maintenance Notifications
4
Thresholds
0
Simulations
2
Configuration
Data Management
Templates
0
Locations
0
Models
0
Equipment
6
Groups
1
Administration
Application Settings
https://pei-preview-predictive-engineering-acceptance.cfapps.sap.hana.ondemand.com/sites?...

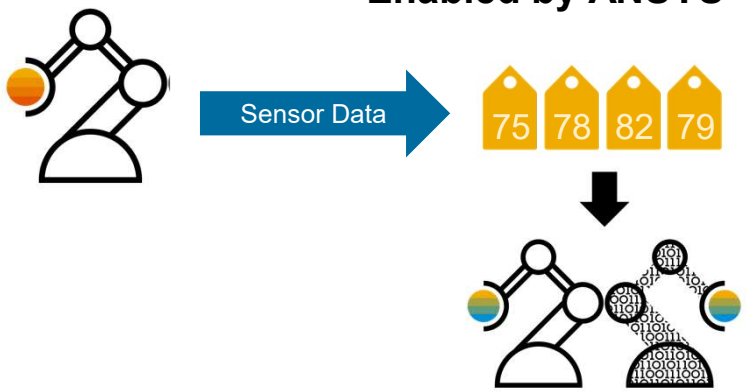
SAP Intelligent Asset Management

Asset Health Prediction and Optimization

SAP Predictive Maintenance and Service



SAP Predictive Engineering Insights Enabled by ANSYS



A Data Science Driven Approach to Predictive Maintenance

A Physics Driven Approach to Predictive Maintenance *(Behaviour focus)*

Bypassing the limitations of current condition monitoring software

Problem Statement

The lack of engineering-based data analytics can increase the cost of false predictions and will thus reduce the confidence in prediction algorithms

False positives

Alerts based on data science can lead to false positives (due to wrongly trained models) increasing the cost of wrong predictions

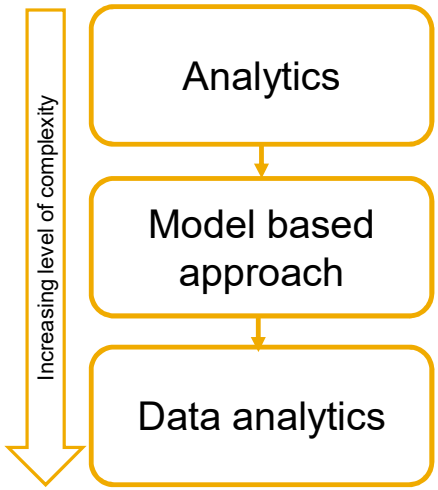
Historical data required

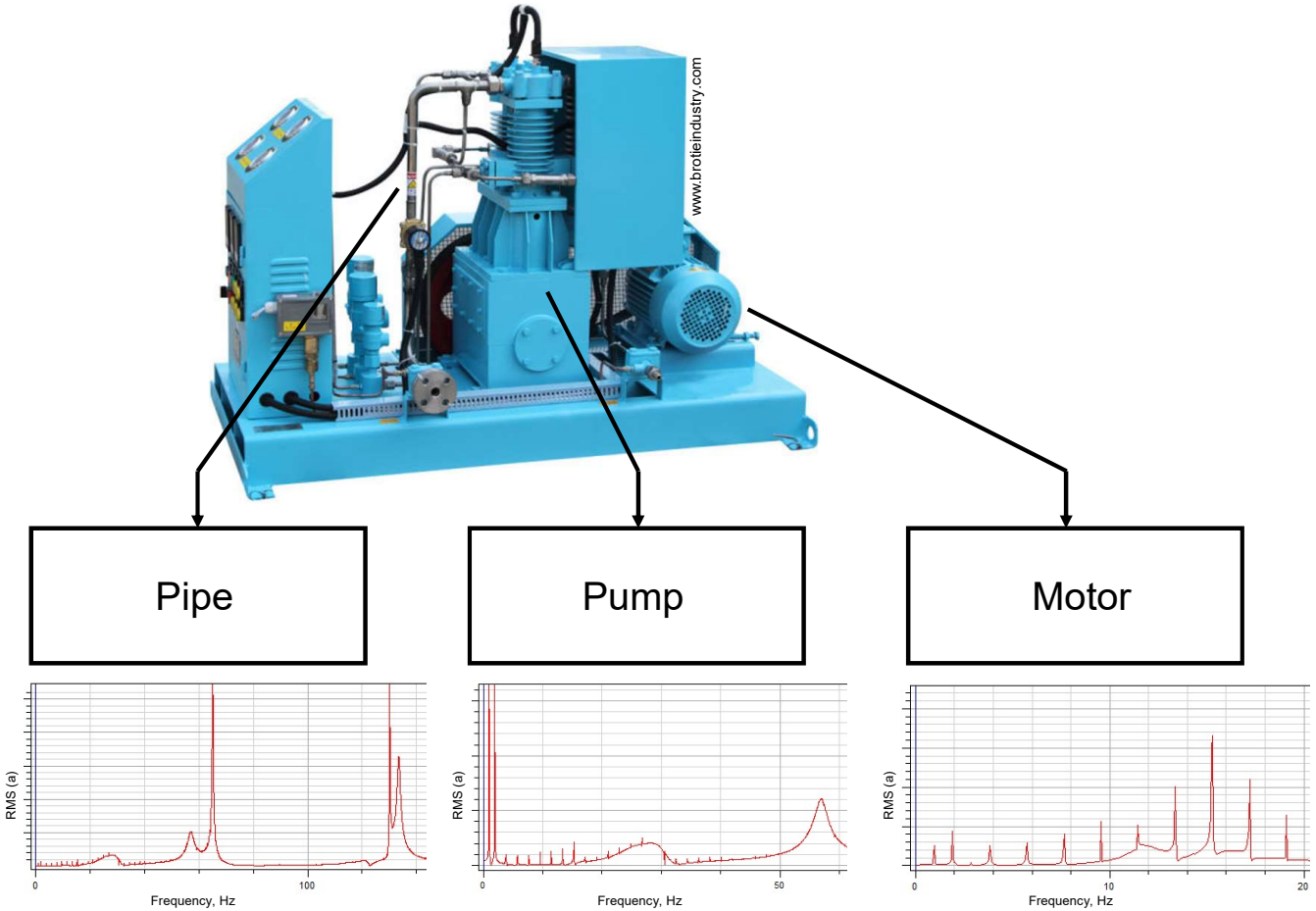
Data science based prediction methods require historical machine data and failure insights. One-off events can not be predicted.

Algorithm selection

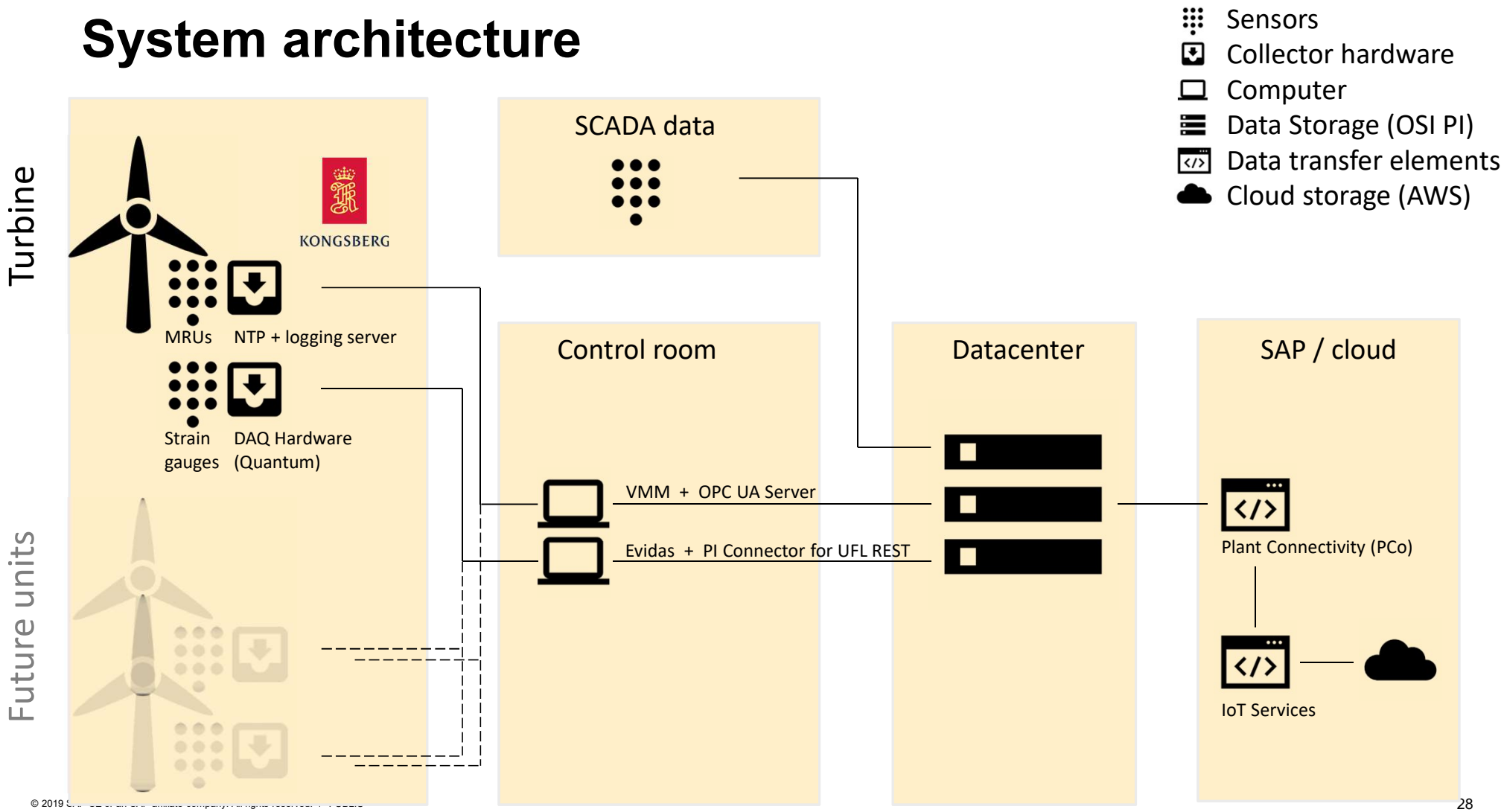
Choosing machine learning algorithms for complex predictive maintenance problems is an iterative and time consuming process

Note: Vibration monitoring is part of PEI and not the data driven solution

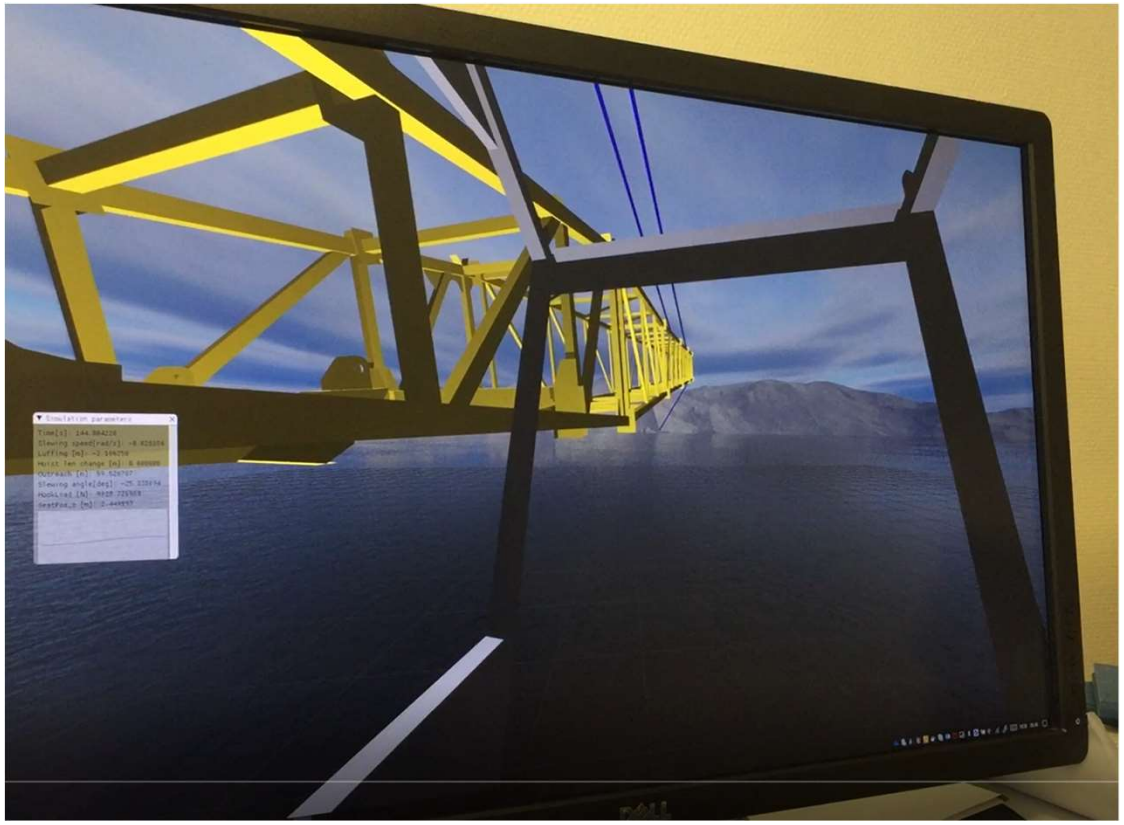


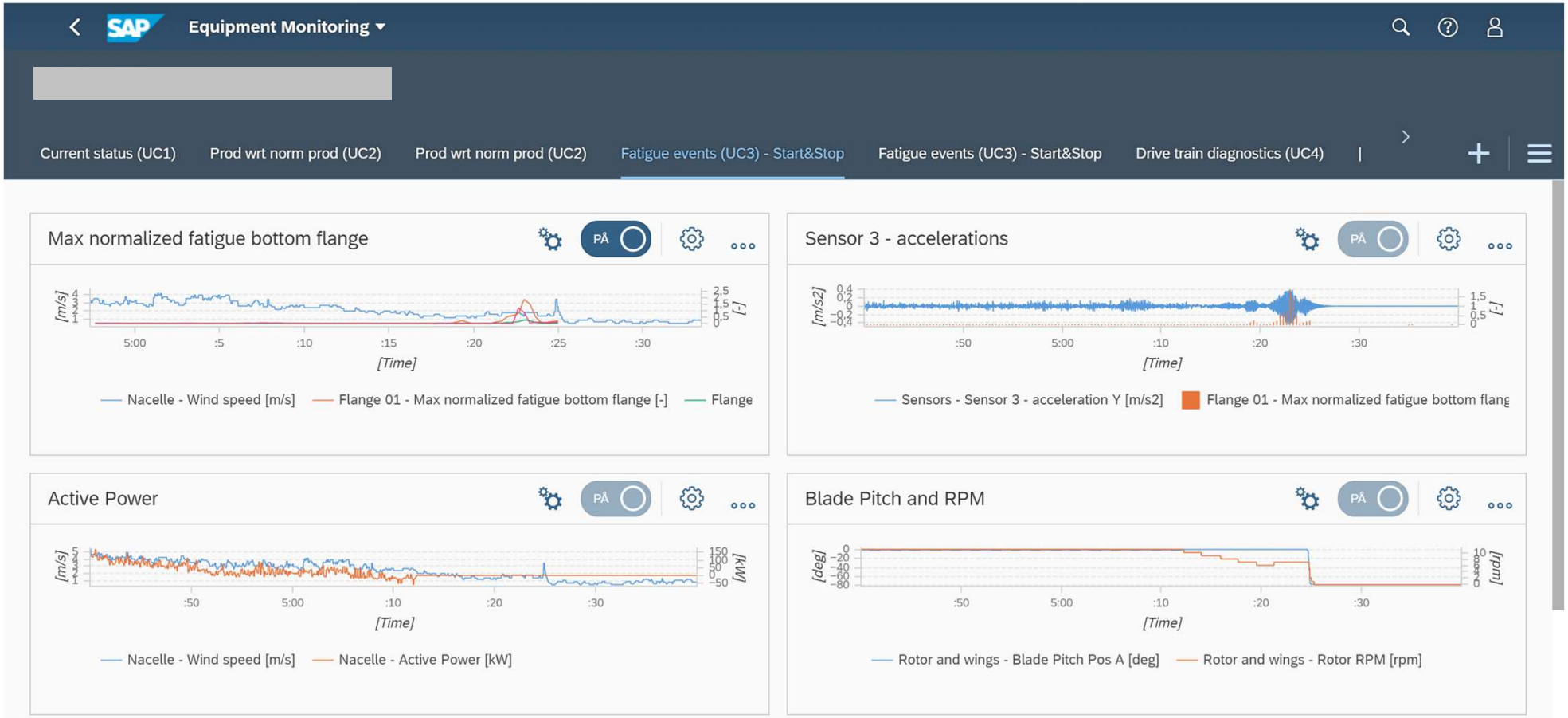


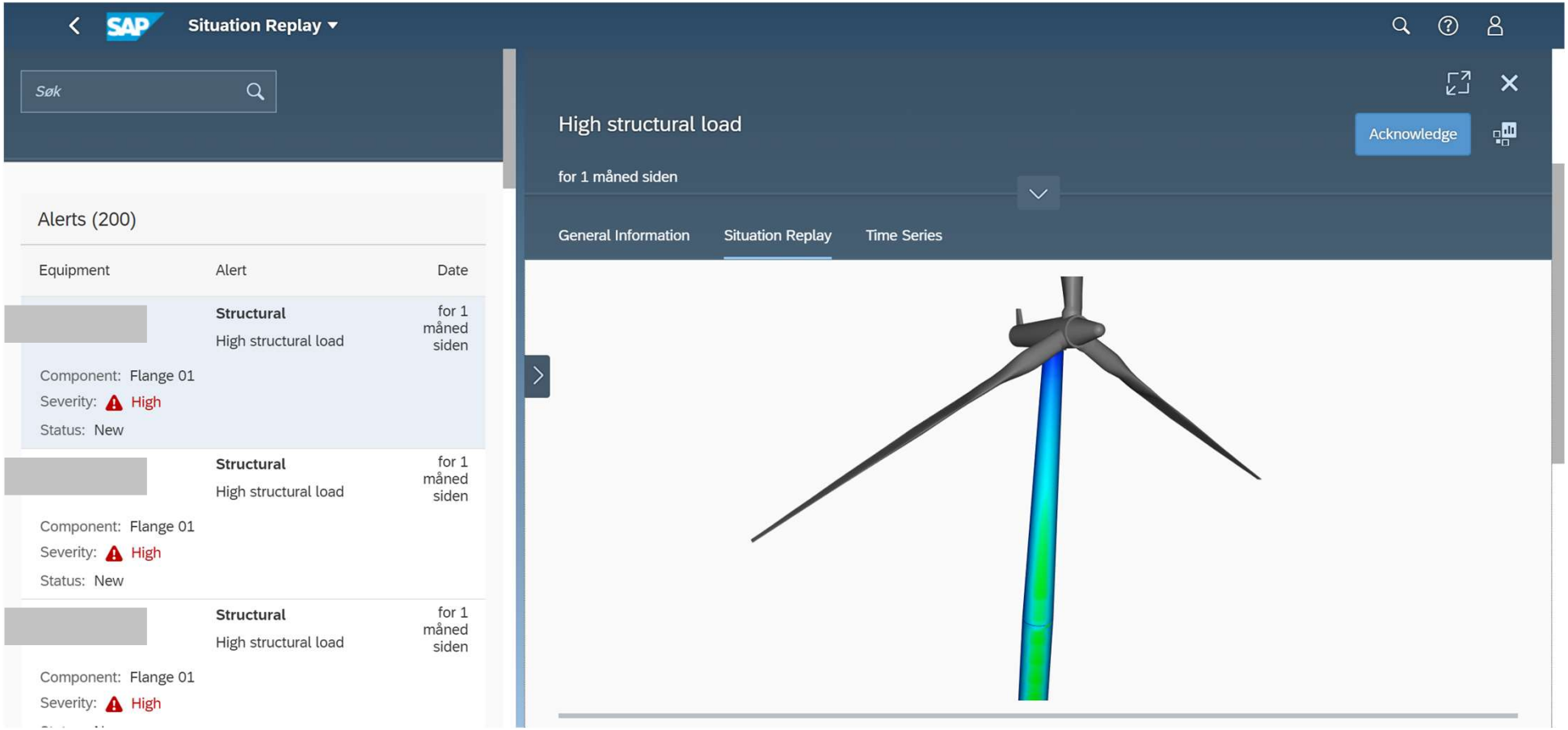
System architecture



Teaser: Life-cycle value of an engineering model







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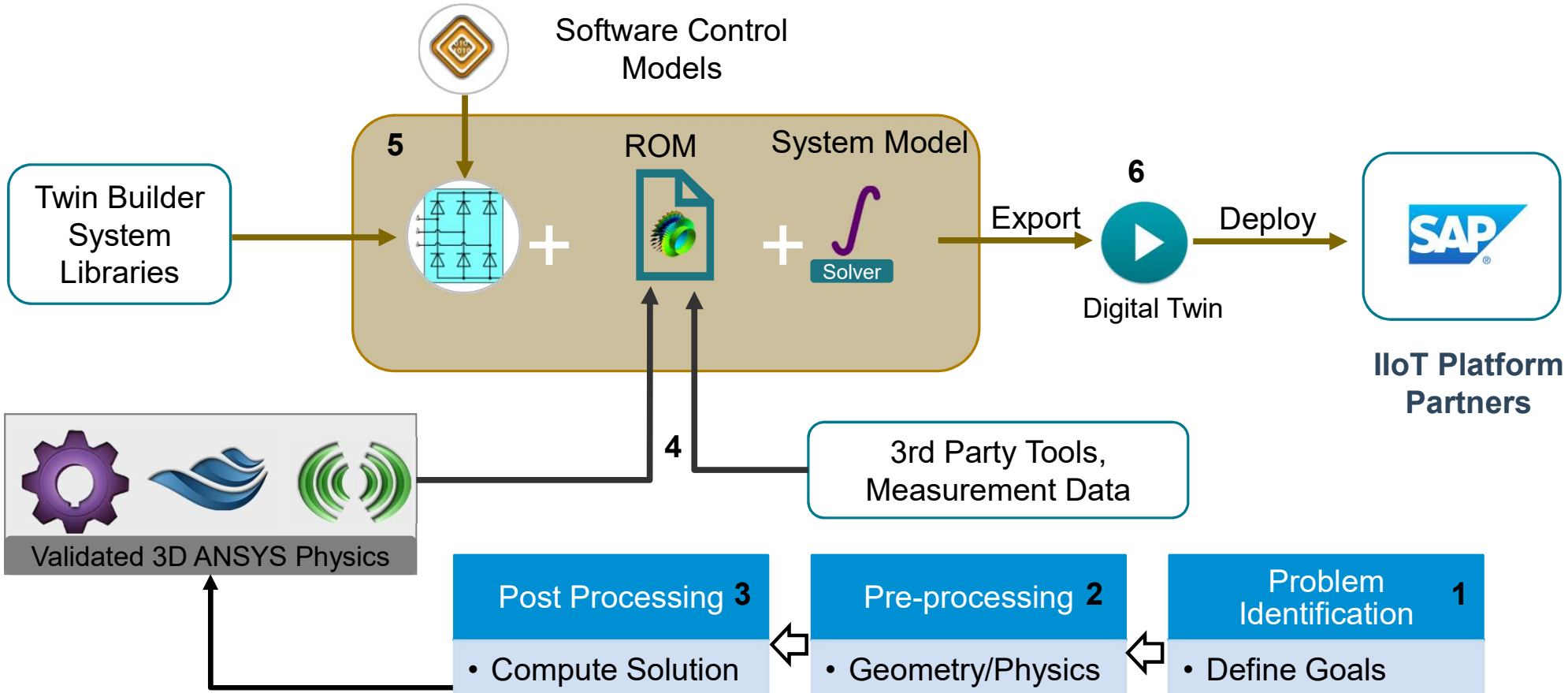
Simulation Based Digital Twin Workflow



Reduced Order Models (ROMs)

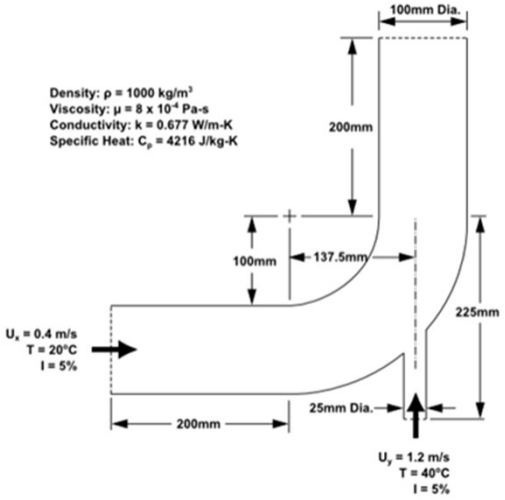
- Simplification of the high-fidelity and complex models making it much faster and cheaper to solve
- Optimize product designs
- Provides the ability to monitor the industrial assets in real-time
- Static and dynamic ROMs
- 3rd party data

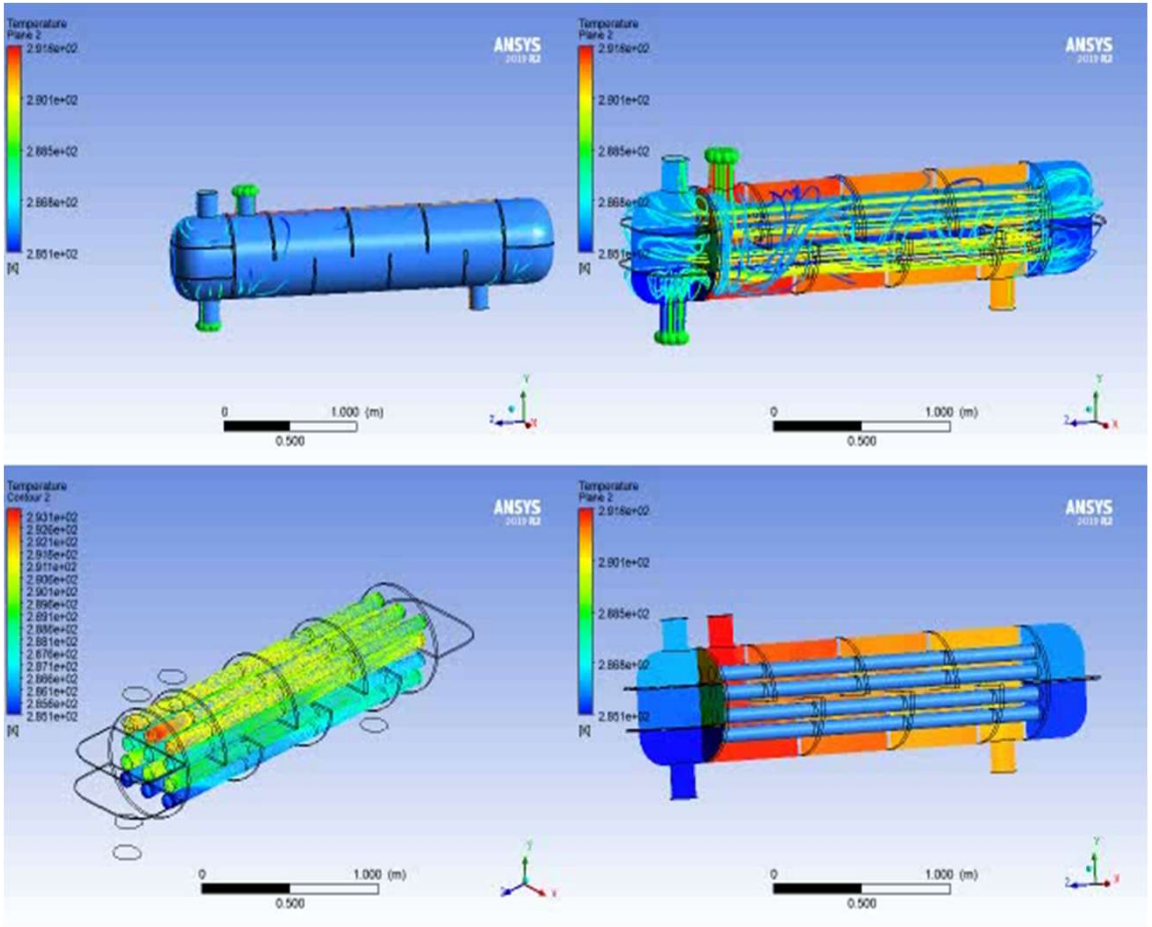
Step 1

- Problem specification
- Goal definition
- Parameters to be monitored
- Level of fidelity

Example:

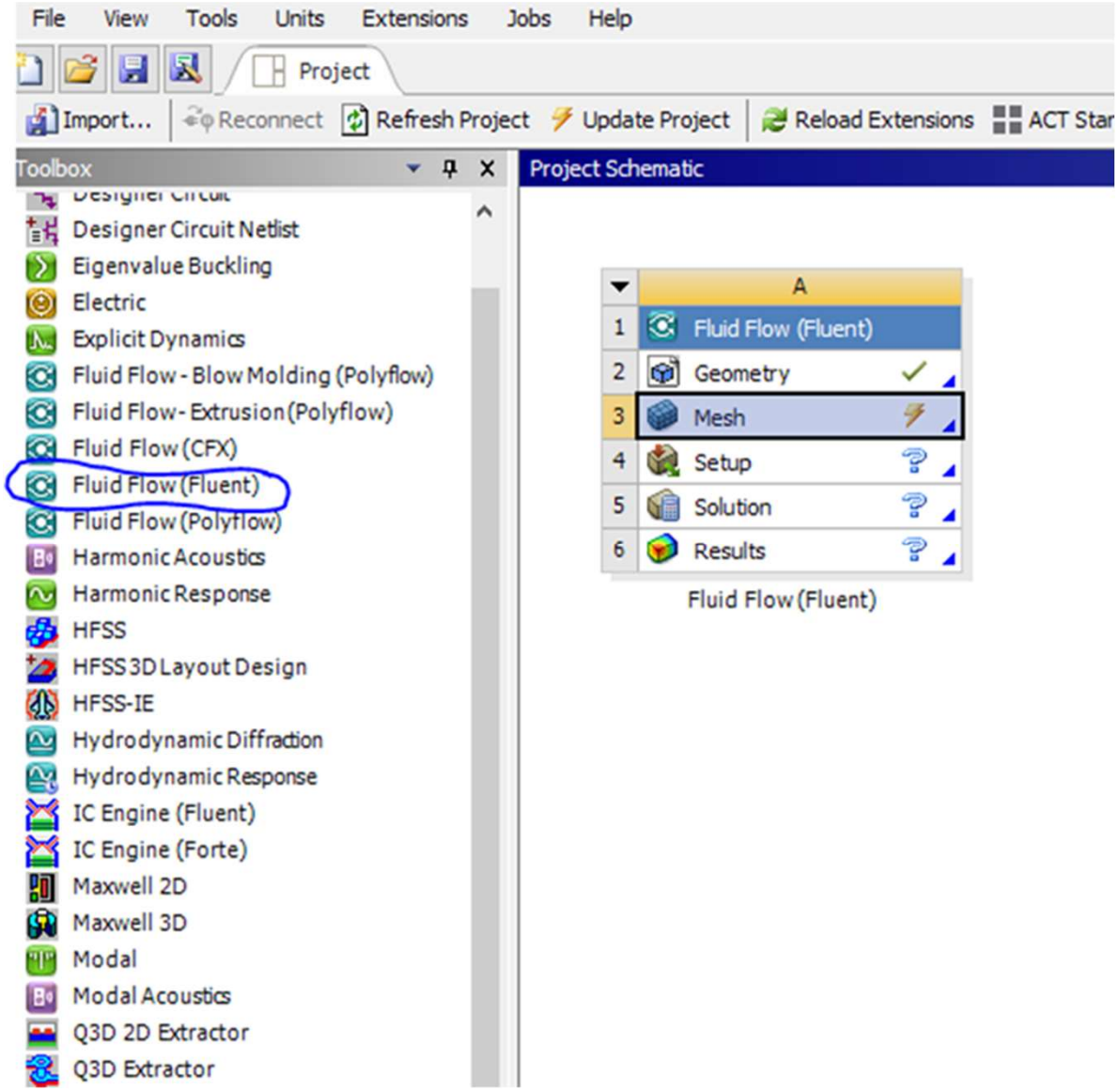
Mixing of hot and cold fluid from two inlets and ***monitor temperature and velocity at the outlet***



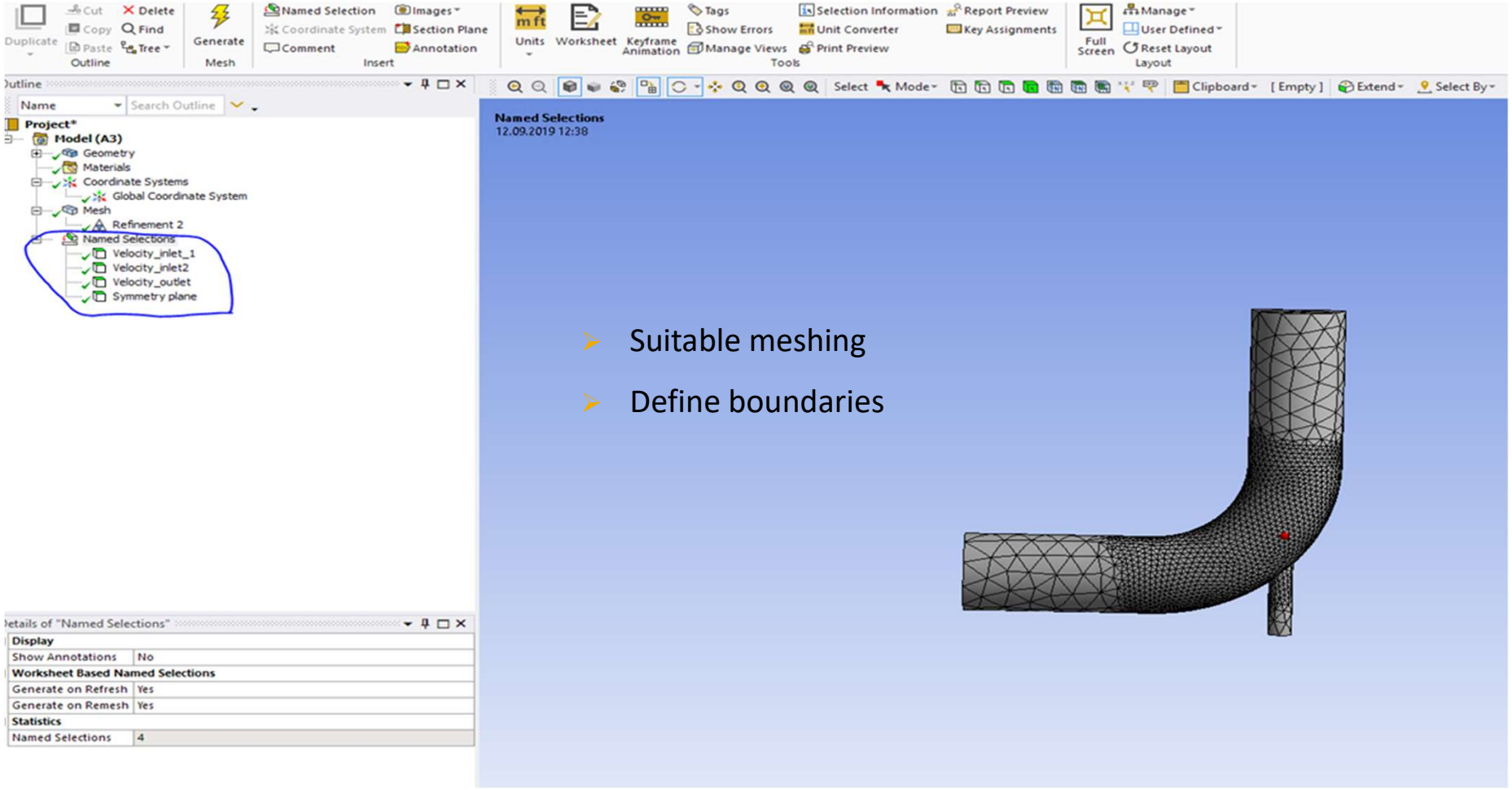


Step 2a

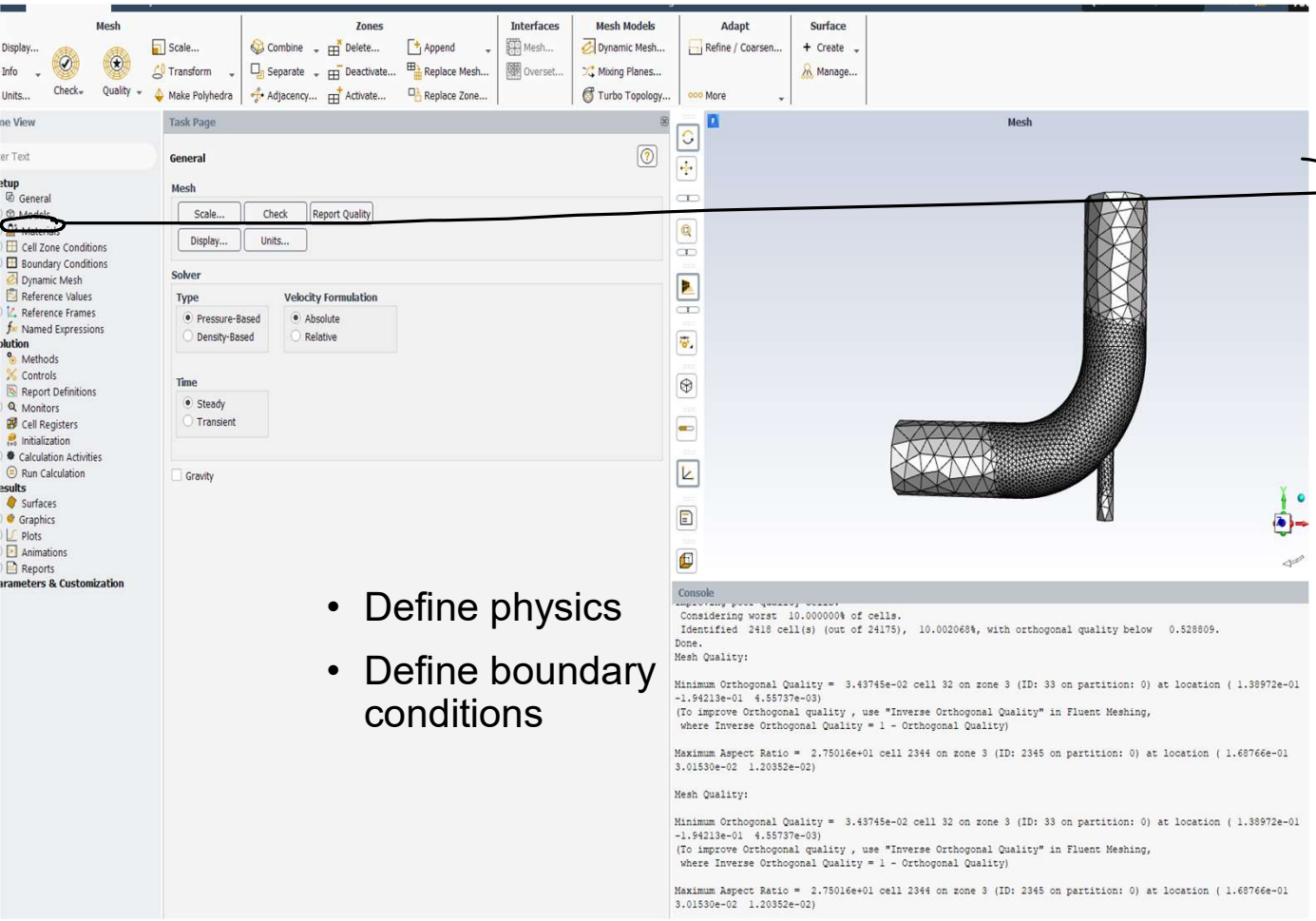
- Suitable ANSYS workbench tool
- CAD geometry



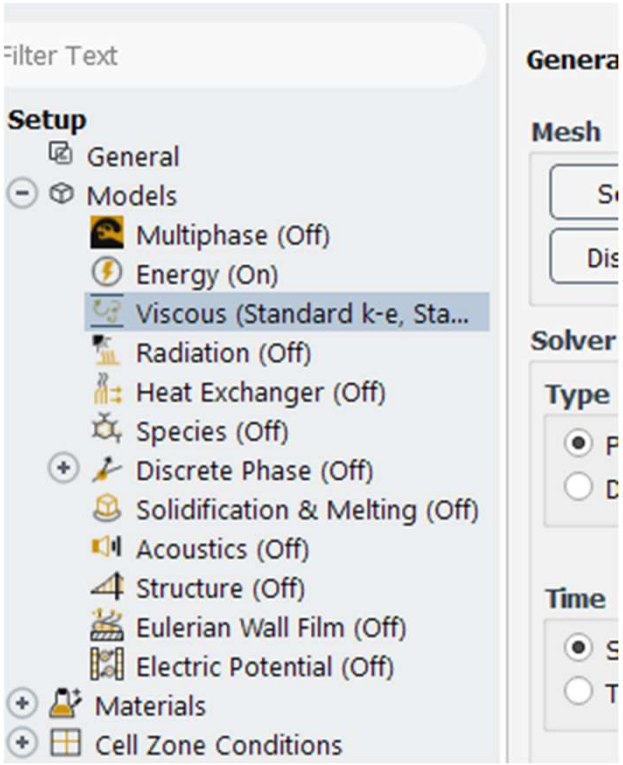
Step 2b



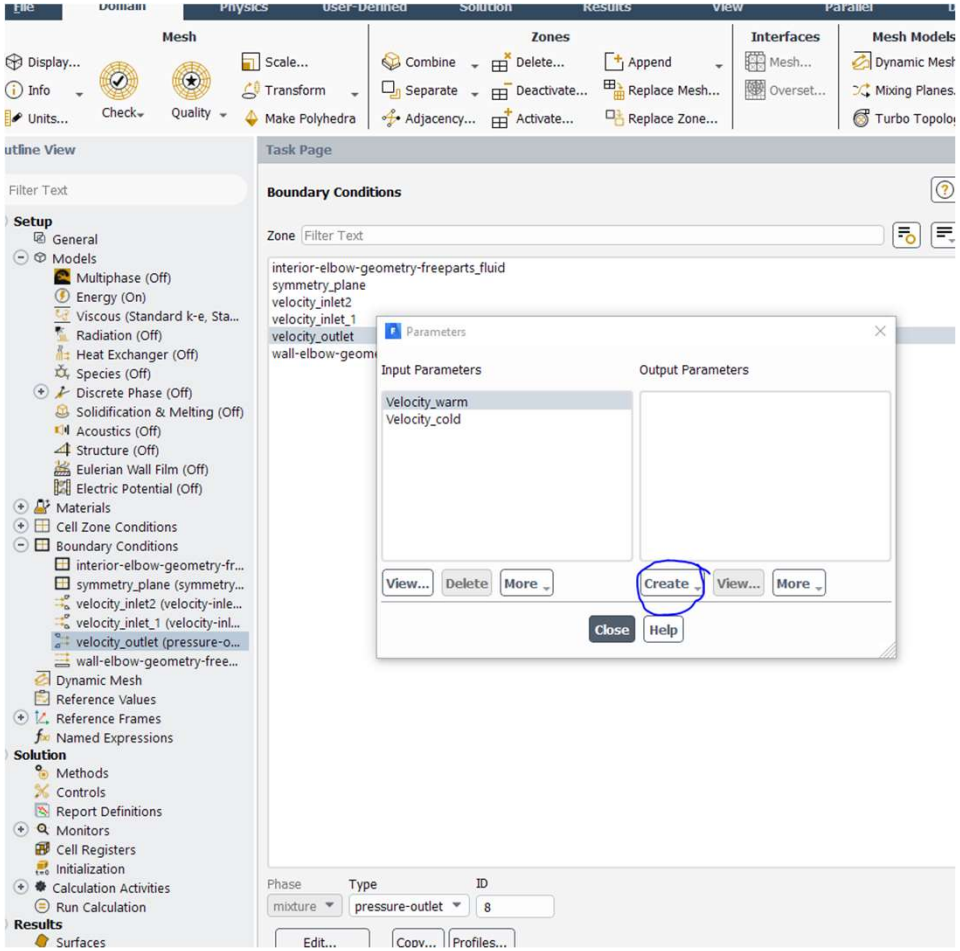
Step 2c

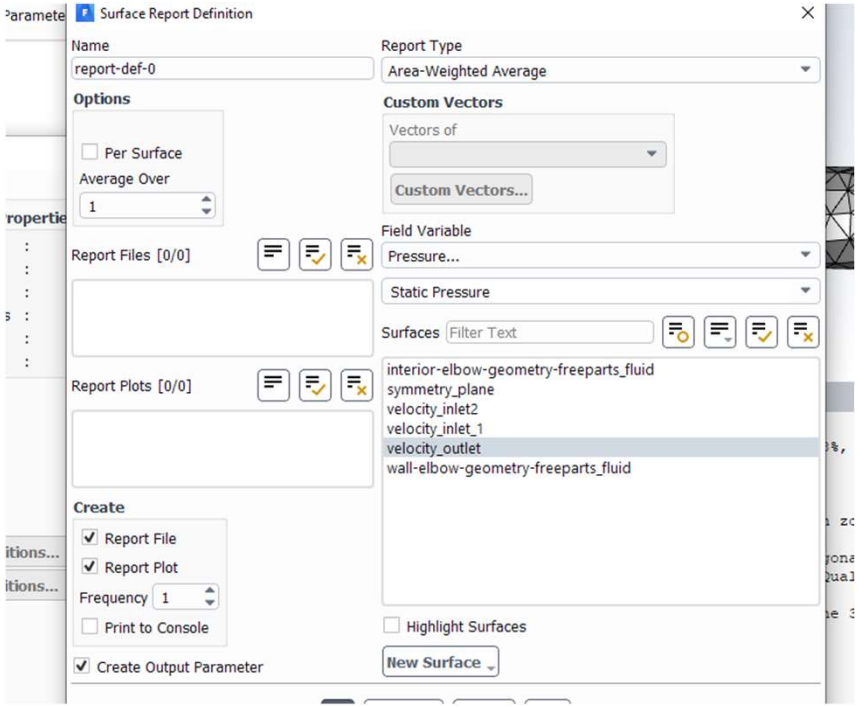


- Define physics
- Define boundary conditions

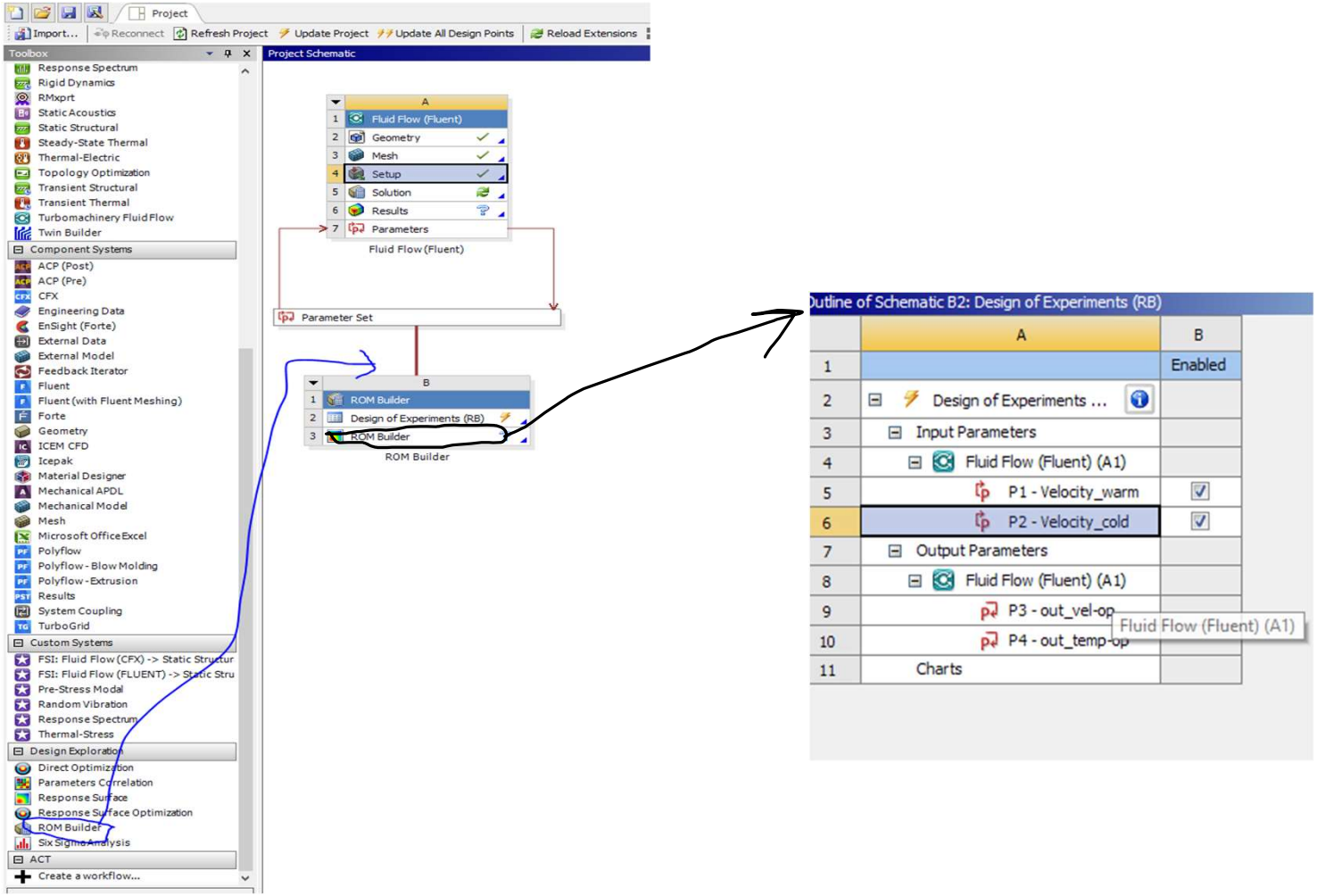


Step 2c:





Step 2d



Step 3

Outline of Schematic B2: Design of Experiments (RB)

	A	B
1		Enabled
2	Design of Experiments ...	
3	Input Parameters	
4	Fluid Flow (Fluent) (A1)	
5	P1 - Velocity_warm	☑
6	P2 - Velocity_cold	☑
7	Output Parameters	
8	Fluid Flow (Fluent) (A1)	
9	P3 - out_vel-op	
10	P4 - out_temp-op	
11	Charts	

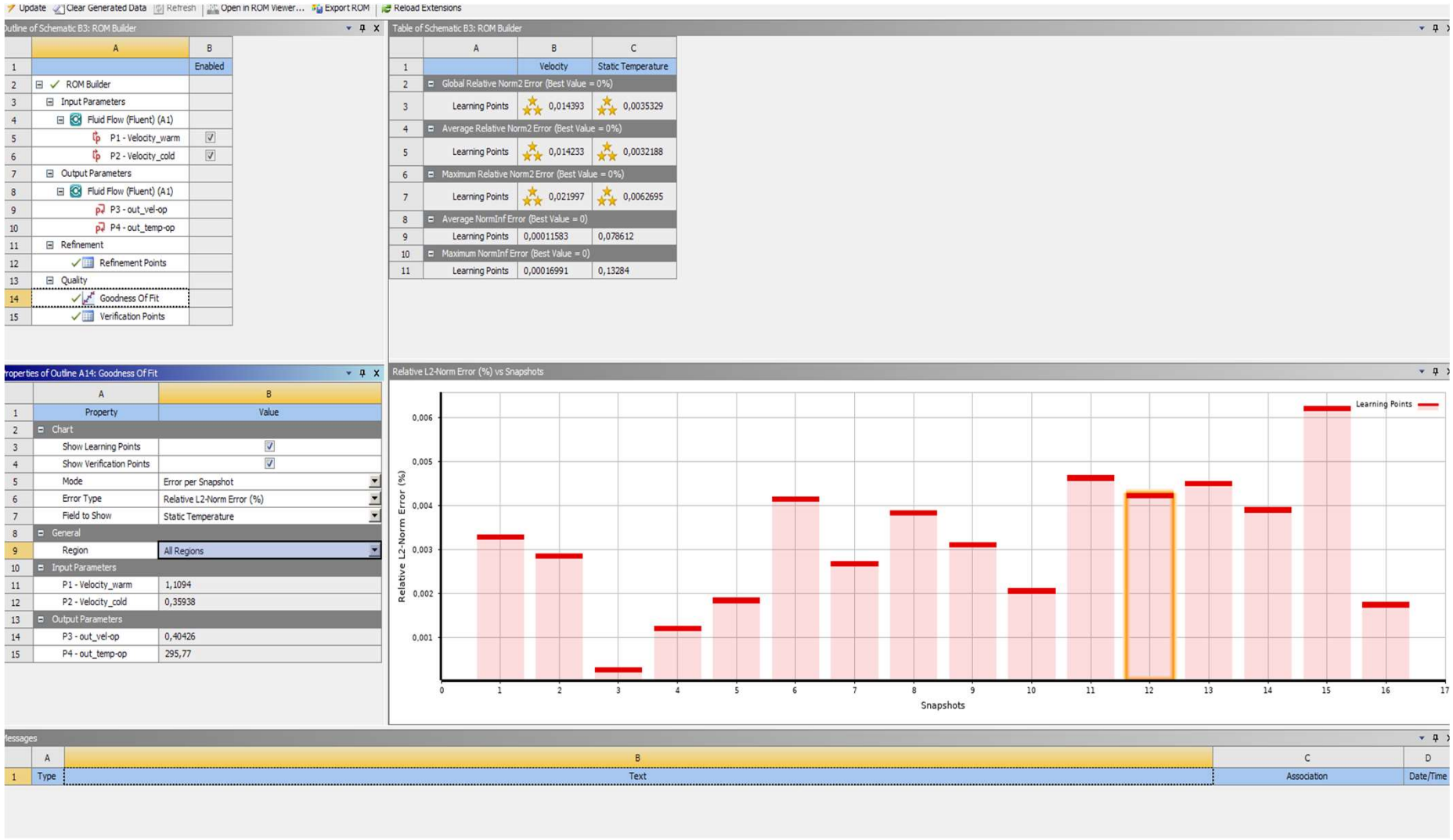
Properties of Outline A5: P1 - Velocity_warm

	A	B
1	Property	Value
2	General	
3	Units	m s^-1
4	Type	Design Variable
5	Classification	Continuous
6	Values	
7	Lower Bound	0,5
8	Upper Bound	2

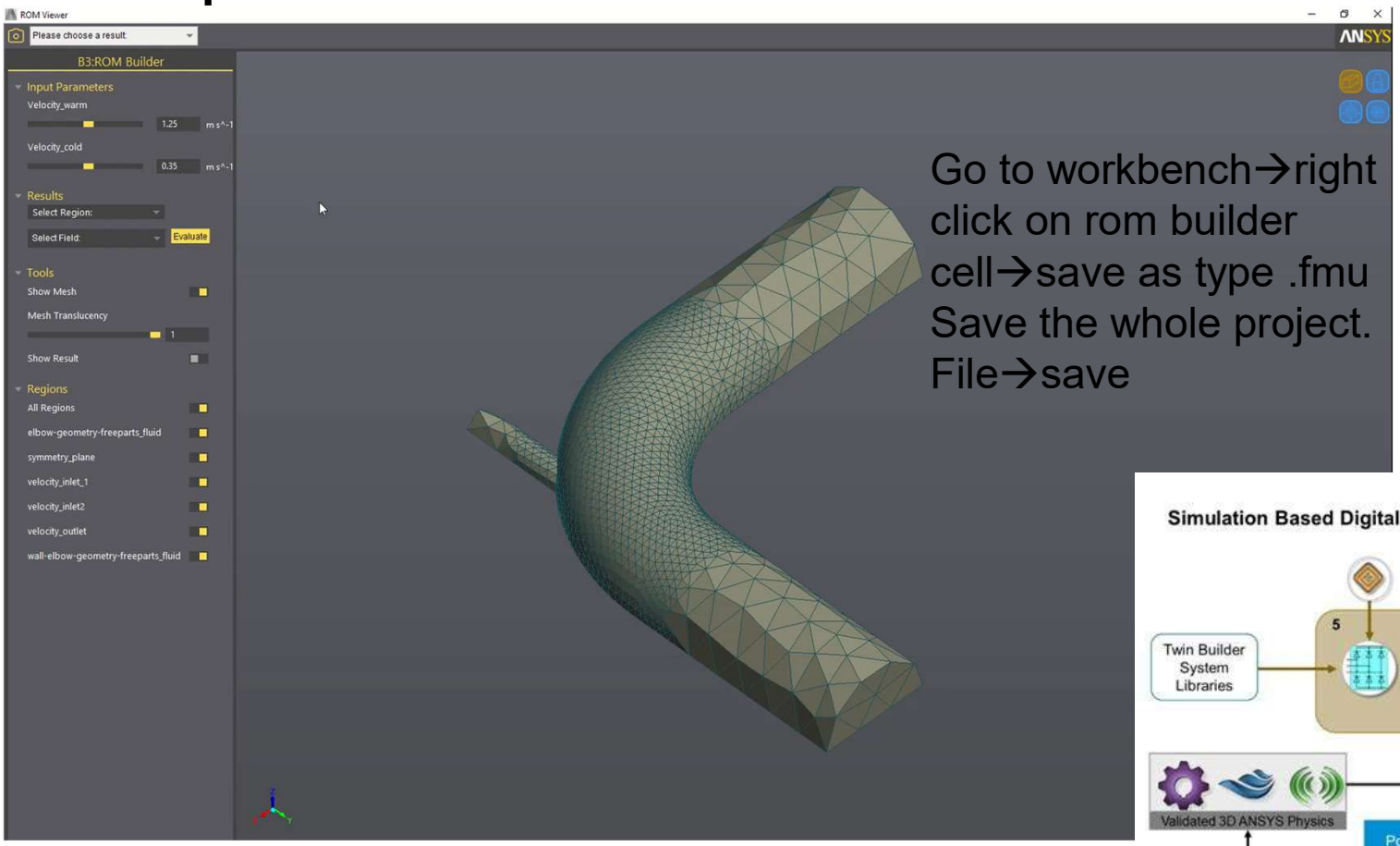
Table of Outline A6: Design Points of Design of Experiments

	A	B	C	D	E	F
1	Name	P1 - Velocity_warm (m s^-1)	P2 - Velocity_cold (m s^-1)	P3 - out_vel-op (m s^-1)	P4 - out_temp-op (K)	Fluid Flow (Fluent) ROM Snapshot
2	1	1,2031	0,28438	0,33377	295,99	✓
3	2	1,9531	0,30313	0,38451	296,35	✓
4	3	0,54688	0,41563	0,4362	295,25	✓
5	4	0,82813	0,49063	0,52256	295,38	✓
6	5	1,5781	0,32188	0,38726	296,13	✓
7	6	1,2969	0,20938	0,26307	296,31	✓
8	7	1,4844	0,39688	0,45744	295,92	✓
9	8	1,3906	0,47188	0,5279	295,75	✓
10	9	1,6719	0,24688	0,31632	296,37	✓
11	10	1,8594	0,37813	0,45497	296,15	✓

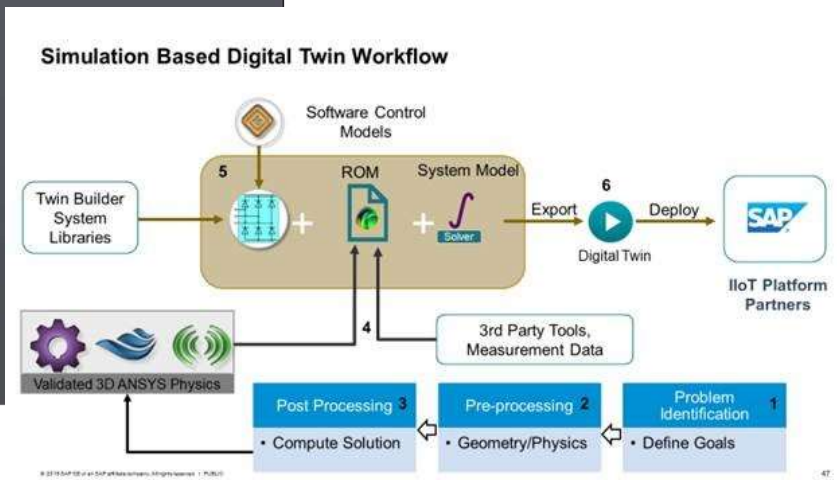
Step 3


Update
Clear Generated Data
Refresh
Open in ROM Viewer...
Export ROM
Reload Extensions
Outline of Schematic B3: ROM Builder
ROM Builder
Input Parameters
Fluid Flow (Fluent) (A1)
P1 - Velocity_warm
P2 - Velocity_cold
Output Parameters
Fluid Flow (Fluent) (A1)
P3 - out_vel-op
P4 - out_temp-op
Refinement
Refinement Points
Quality
Goodness Of Fit
Verification Points
Table of Schematic B3: ROM Builder
Velocity
Static Temperature
Global Relative Norm2 Error (Best Value = 0%)
Learning Points 0,014393 0,0035329
Average Relative Norm2 Error (Best Value = 0%)
Learning Points 0,014233 0,0032188
Maximum Relative Norm2 Error (Best Value = 0%)
Learning Points 0,021997 0,0062695
Average NormInf Error (Best Value = 0)
Learning Points 0,00011583 0,078612
Maximum NormInf Error (Best Value = 0)
Learning Points 0,00016991 0,13284
Properties of Outline A14: Goodness Of Fit
Property
Value
Chart
Show Learning Points
Show Verification Points
Mode Error per Snapshot
Error Type Relative L2-Norm Error (%)
Field to Show Static Temperature
General
Region All Regions
Input Parameters
P1 - Velocity_warm 1,1094
P2 - Velocity_cold 0,35938
Output Parameters
P3 - out_vel-op 0,40426
P4 - out_temp-op 295,77
Relative L2-Norm Error (%) vs Snapshots
Learning Points
Relative L2-Norm Error (%)
Snapshots
Messages
Type
Text
Association
Date/Time

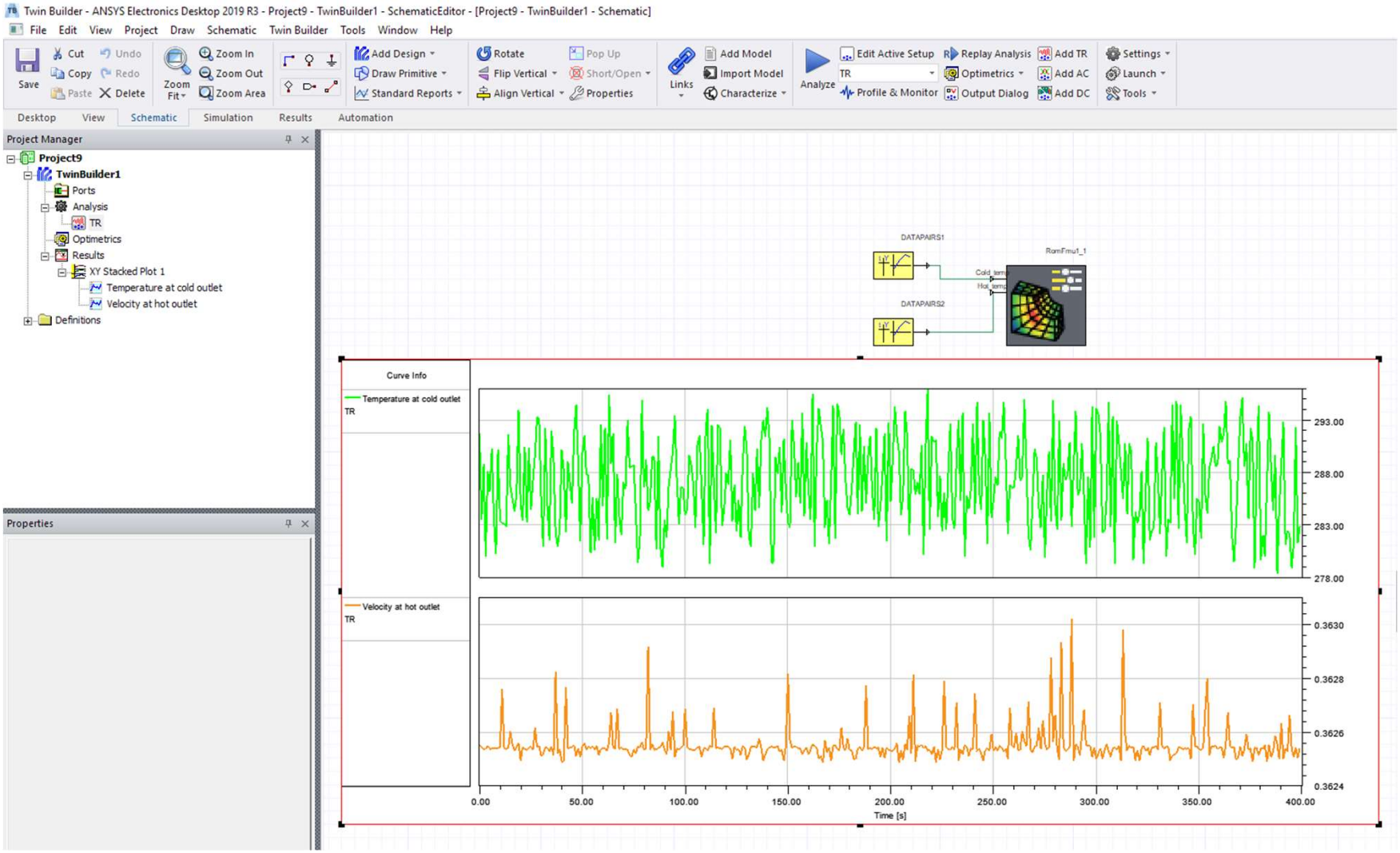
Steps 4 and 5



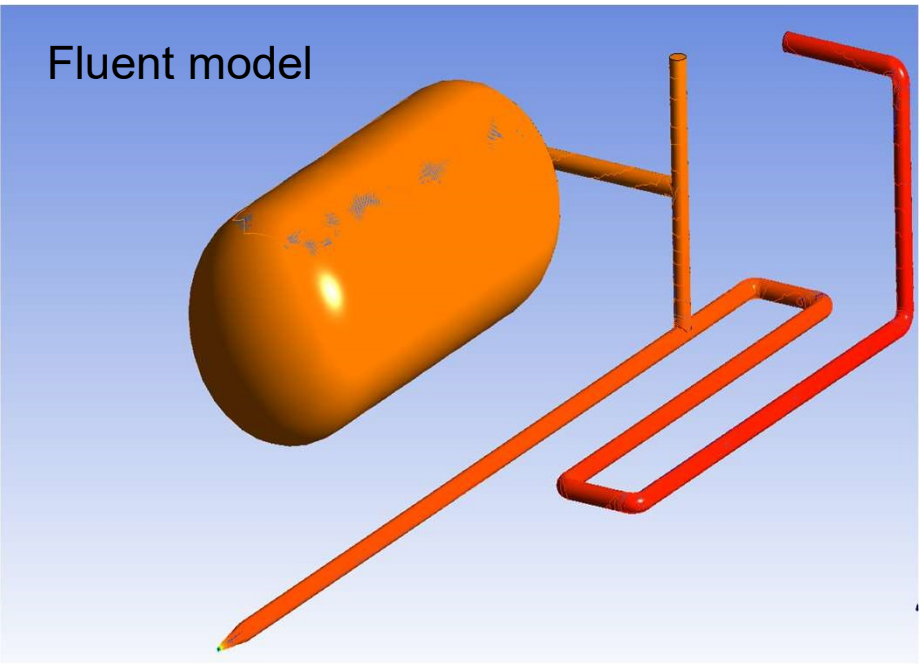
Go to workbench→right click on rom builder cell→save as type .fmu
Save the whole project.
File→save

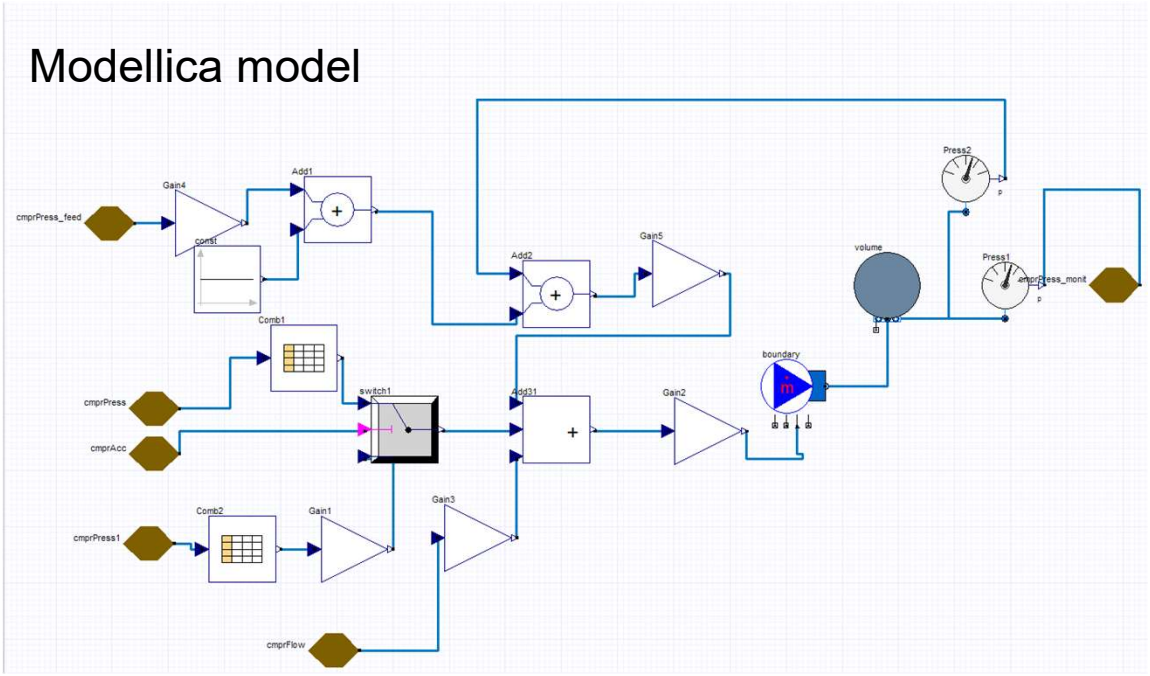


Steps 5 and 6


Twin Builder - ANSYS Electronics Desktop 2019 R3 - Project9 - TwinBuilder1 - SchematicEditor - [Project9 - TwinBuilder1 - Schematic]
File Edit View Project Draw Schematic Twin Builder Tools Window Help
Save
Cut
Copy
Paste
Undo
Redo
Delete
Zoom Fit
Zoom In
Zoom Out
Zoom Area
Add Design
Draw Primitive
Standard Reports
Rotate
Flip Vertical
Align Vertical
Pop Up
Short/Open
Properties
Links
Add Model
Import Model
Characterize
Analyze
Edit Active Setup
TR
Profile & Monitor
Replay Analysis
Optimetrics
Output Dialog
Add TR
Add AC
Add DC
Settings
Launch
Tools
Desktop
View
Schematic
Simulation
Results
Automation
Project Manager
Project9
TwinBuilder1
Ports
Analysis
TR
Optimetrics
Results
XY Stacked Plot 1
Temperature at cold outlet
Velocity at hot outlet
Definitions
Properties
DATAPAIRS1
DATAPAIRS2
RomFmu1_1
Curve Info
Temperature at cold outlet
TR
Velocity at hot outlet
TR
293.00
288.00
283.00
278.00
0.3630
0.3628
0.3626
0.3624
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
Time [s]

Different possibilities





- Level of fidelity?
- Parameters to be monitored?

Agenda

Introduction

SAP Landscape: D2O, IAM, PLM

SAP Predictive Engineering Insights: Physics-based DT, ANSYS partnership, the role of engineering simulations in product/process lifecycles

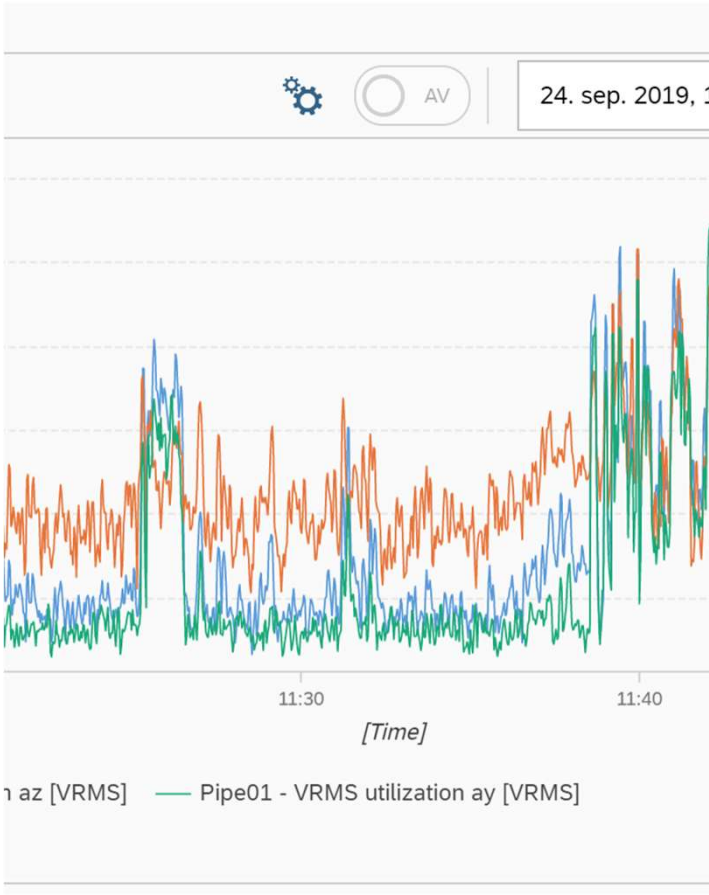
SAP PEI: Unique capabilities, features, application areas, real-time monitoring

Making a model – creating the Digital Twin, making a Reduced-order Model (ROM) for real-time monitoring

Closing

SAP PEI: Take-home messages

- SAP Intelligent Asset Management solutions and Digital Twins will both enable improved processes and improve the insight on Asset Health directly
- Solutions are mature – implemented and tested in operation, and are offered with the assistance of the CoE here in Norway
- Get in touch with us for one-on-one sessions or more info



Thank you.

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