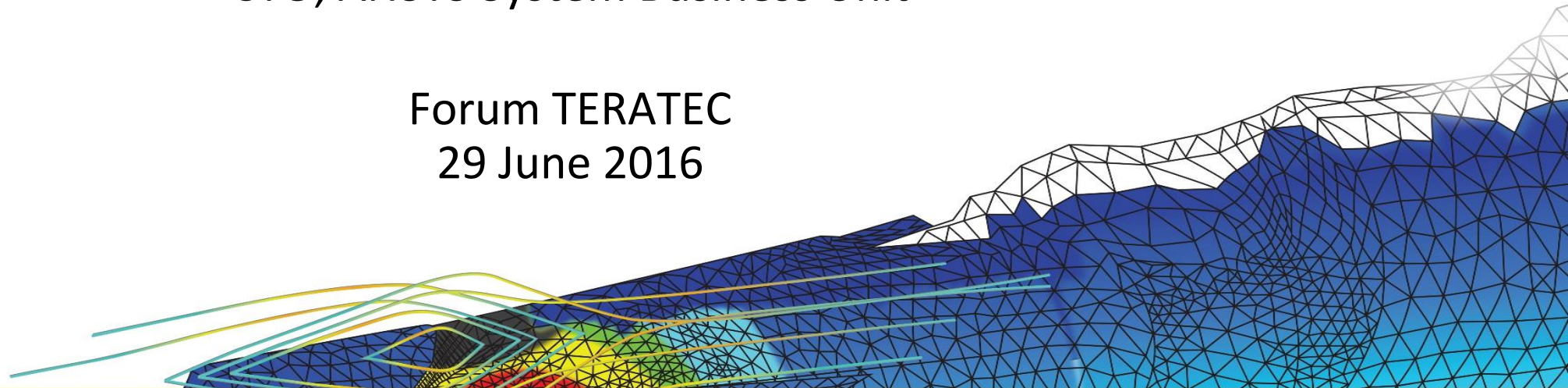




Predictive Analytics and the Digital Twin

Bernard Dion
CTO, ANSYS System Business Unit

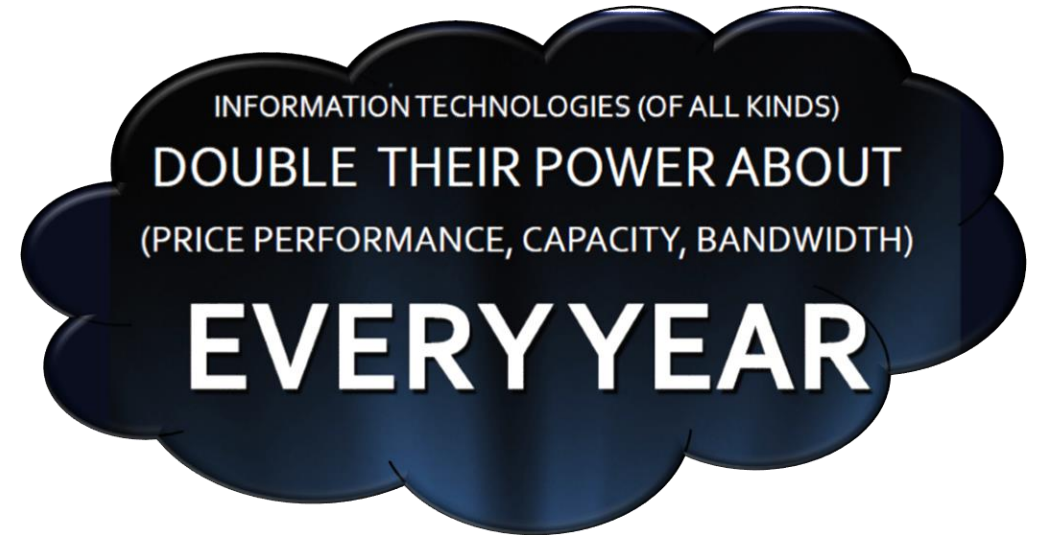
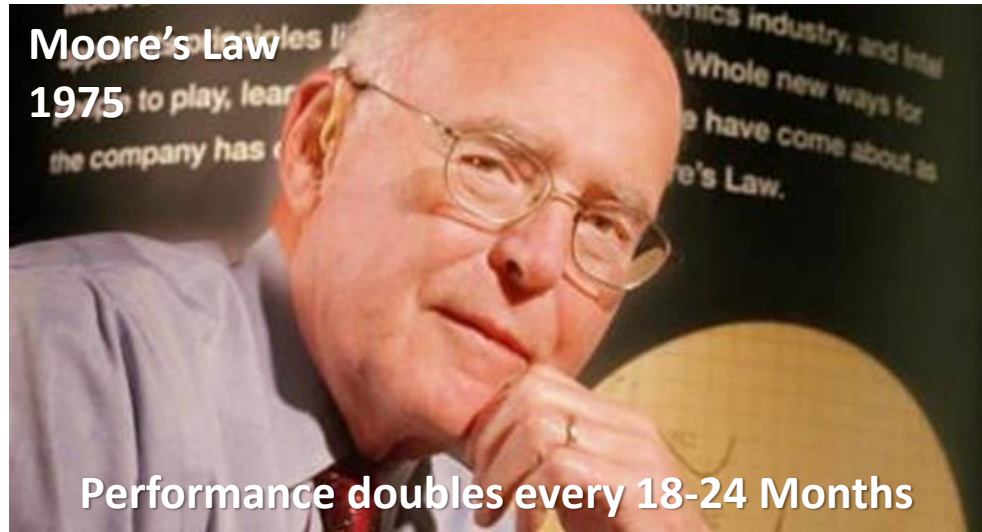
Forum TERATEC
29 June 2016



Agenda

- **Introduction**
- **Model-Based Systems Engineering (MBSE)**
- **Predictive Analytics and the Digital Twin**
- **Demonstration**
- **Q&A**

Unprecedented speed of technology evolution



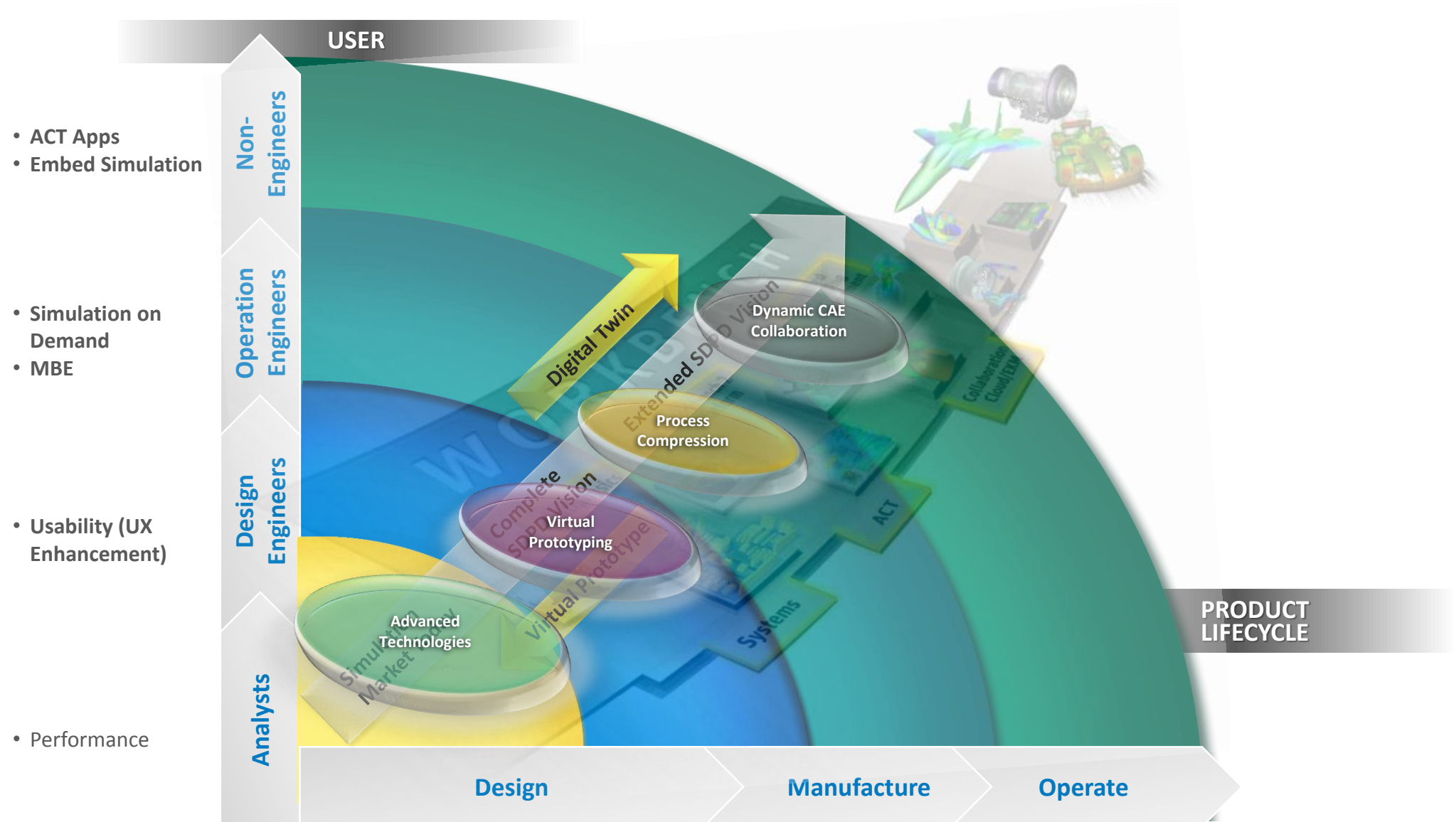
The Age of Exponential Thinking

The era of “Accelerating Returns” and
a new balance of “Price, Performance, Capacity and Bandwidth”

“...We better disrupt ourselves in our own way before somebody does an Uber to us.”

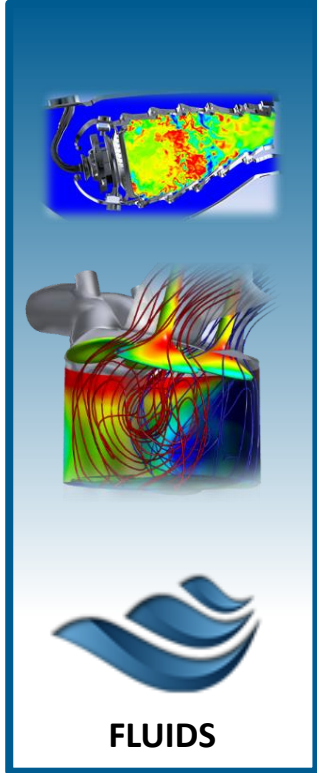
Doug Oberhelman, CEO CATERPILLAR @ CIW, Oct15, 2015

Evolution of simulation



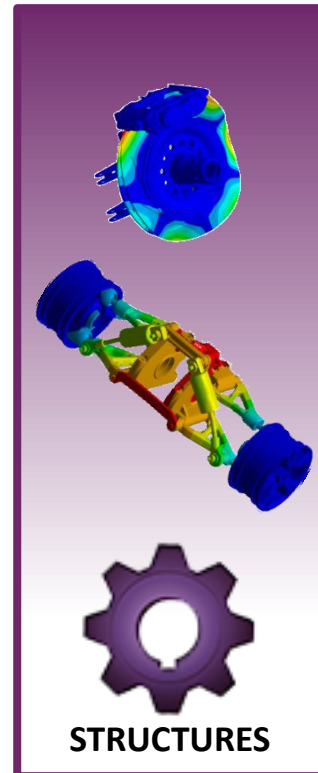
ANSYS enables systems

From comprehensive component-level design & simulation ...



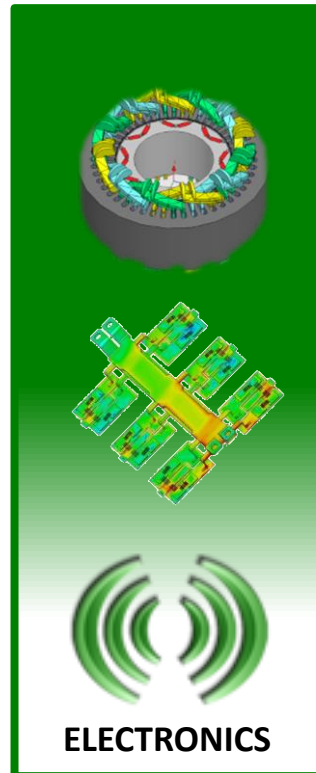
FLUIDS

This panel features a blue background. At the top, there is a 3D model of a turbine engine with a color-coded simulation showing temperature or pressure distribution. Below it is a 3D model of a propeller with streamlines representing fluid flow. At the bottom is a blue icon of three wavy lines representing fluid flow.



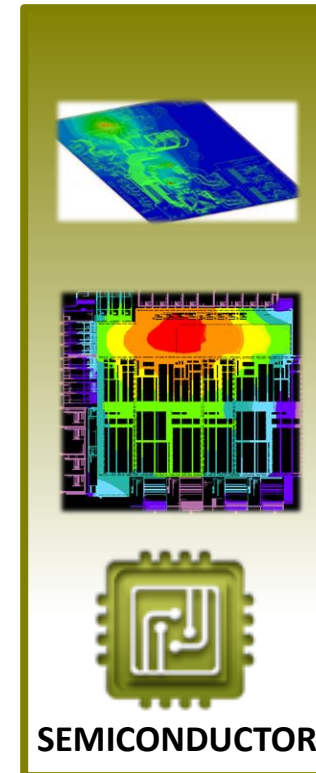
STRUCTURES

This panel features a purple background. At the top, there is a 3D model of a mechanical part with a color-coded stress simulation. Below it is a 3D model of a vehicle chassis with a color-coded stress simulation. At the bottom is a purple icon of a gear.



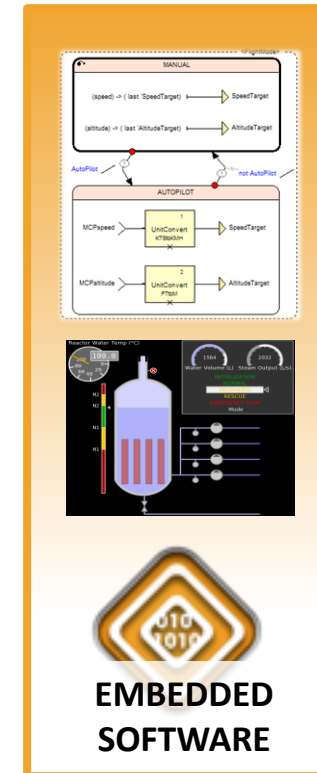
ELECTRONICS

This panel features a green background. At the top, there is a 3D model of a circular electronic component with a color-coded simulation. Below it is a 3D model of a printed circuit board (PCB) with a color-coded simulation. At the bottom is a green icon of two concentric arcs representing electromagnetic waves.



SEMICONDUCTOR

This panel features an olive green background. At the top, there is a 3D model of a semiconductor chip with a color-coded simulation. Below it is a 3D model of a semiconductor package with a color-coded simulation. At the bottom is a green icon of a microchip.

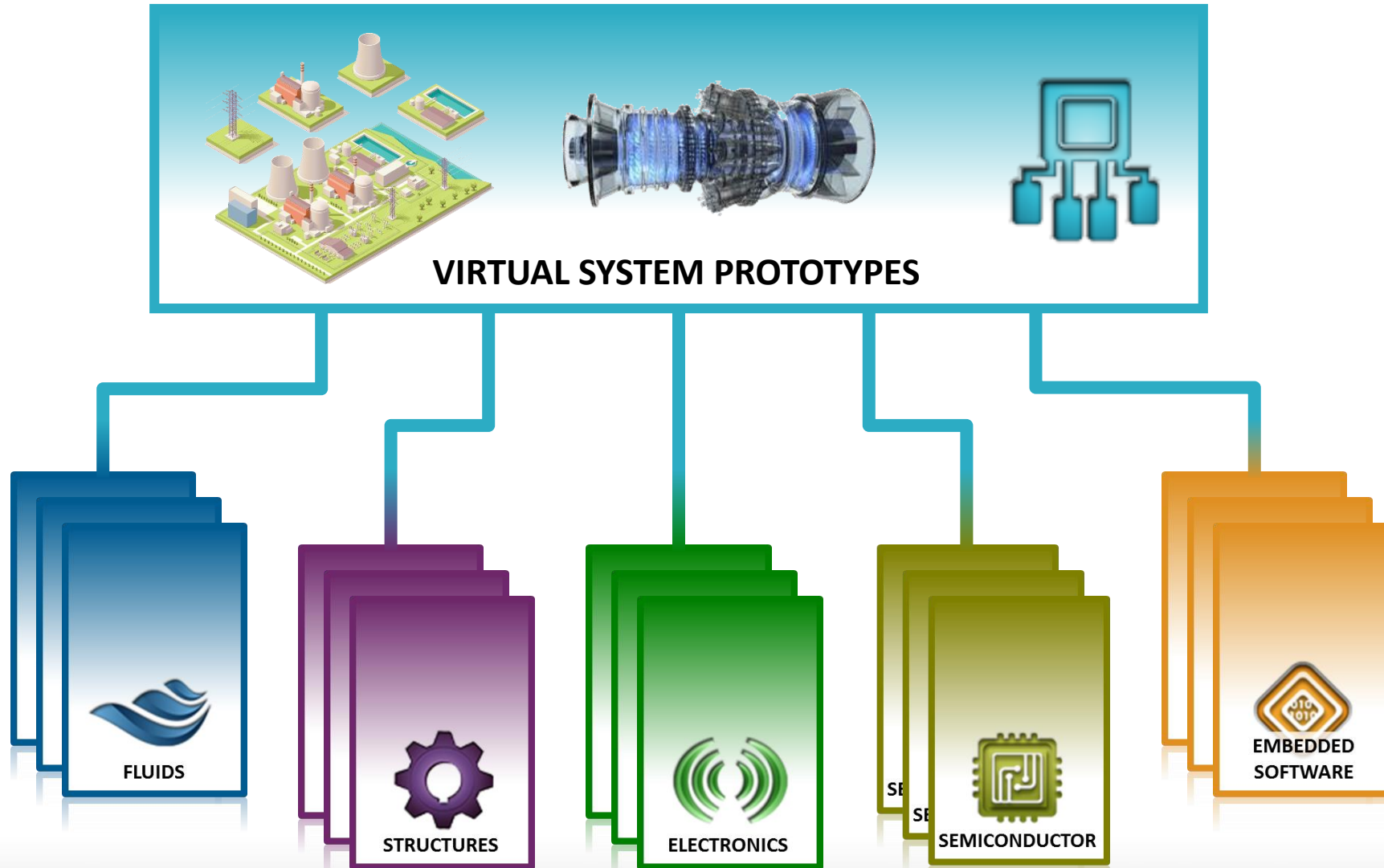


EMBEDDED SOFTWARE

This panel features an orange background. At the top, there is a screenshot of a control system interface showing a manual mode and an autopilot mode. Below it is a screenshot of a control system interface showing a tank level control system. At the bottom is an orange icon of a diamond shape with the letters 'OTO' inside.

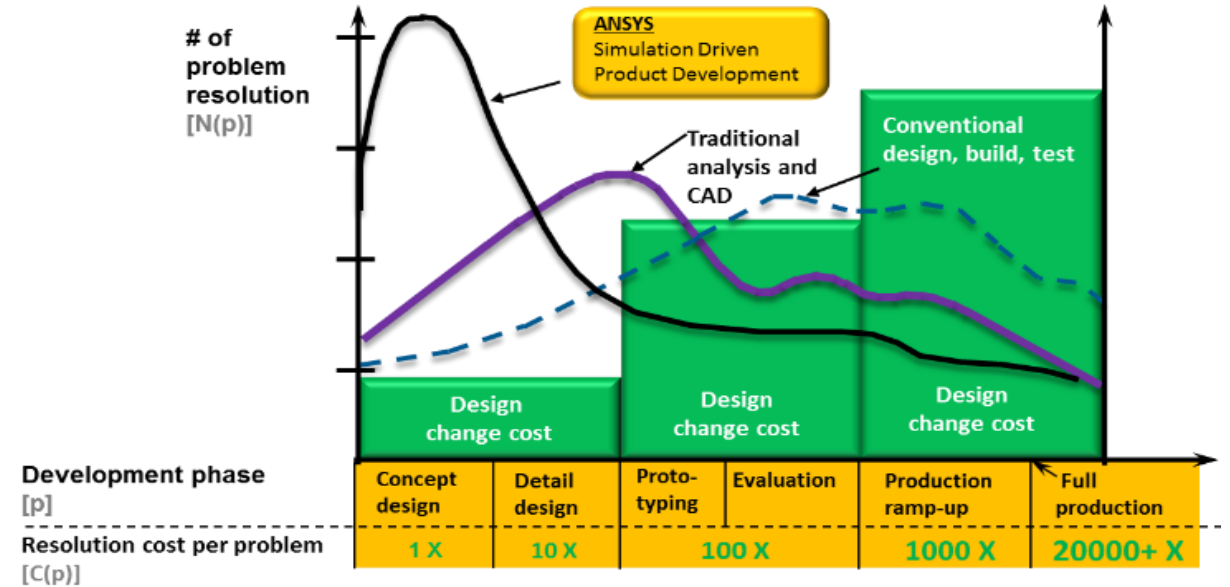
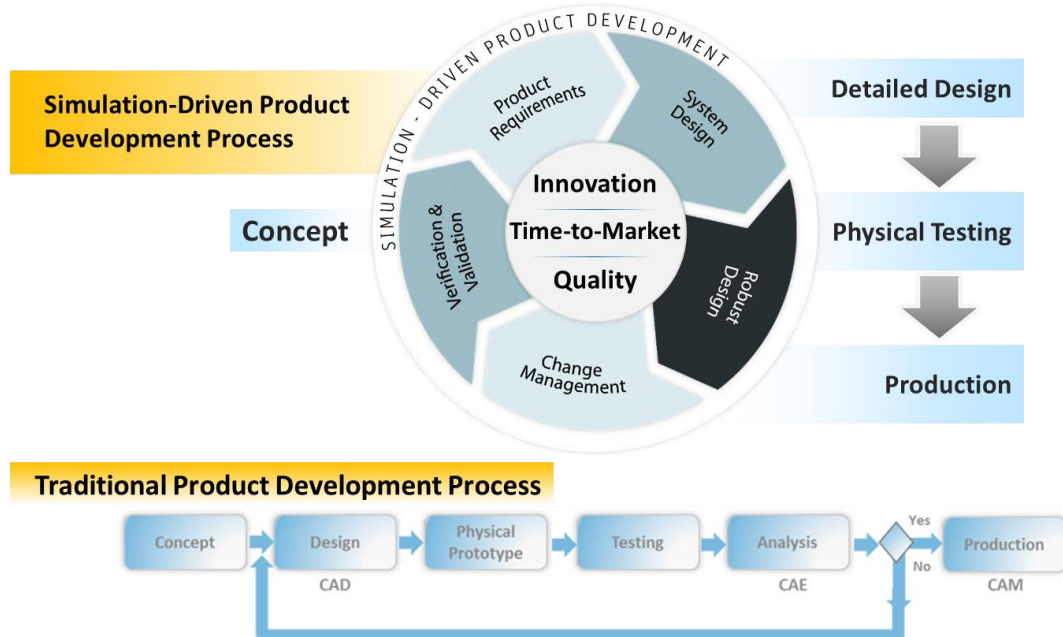
ANSYS enables systems

... to complete systems simulation



Simulation Driven Product Development

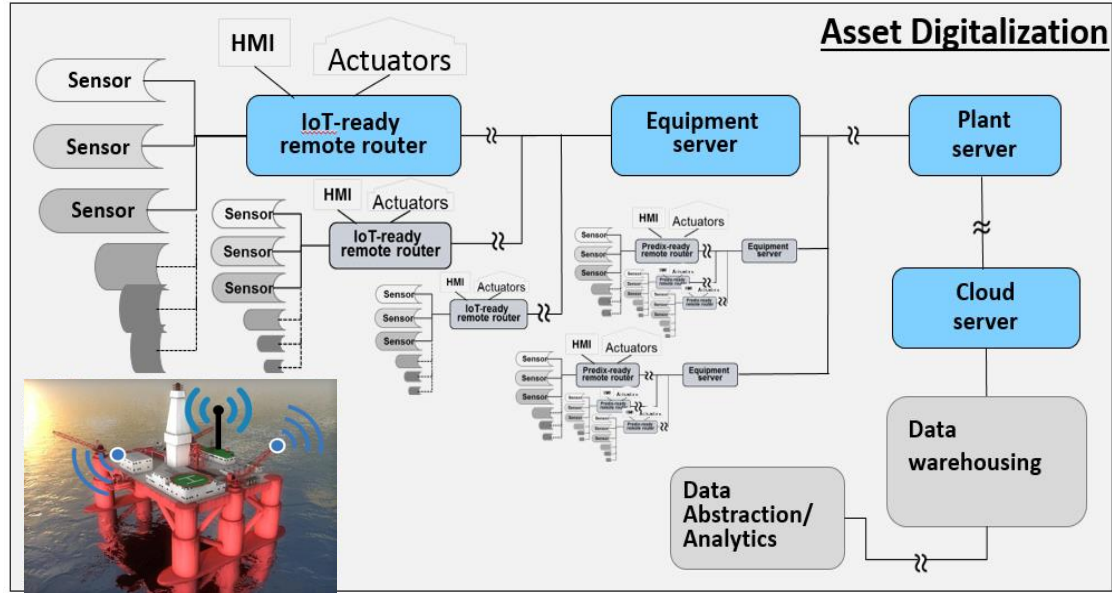
From build & test to virtual development



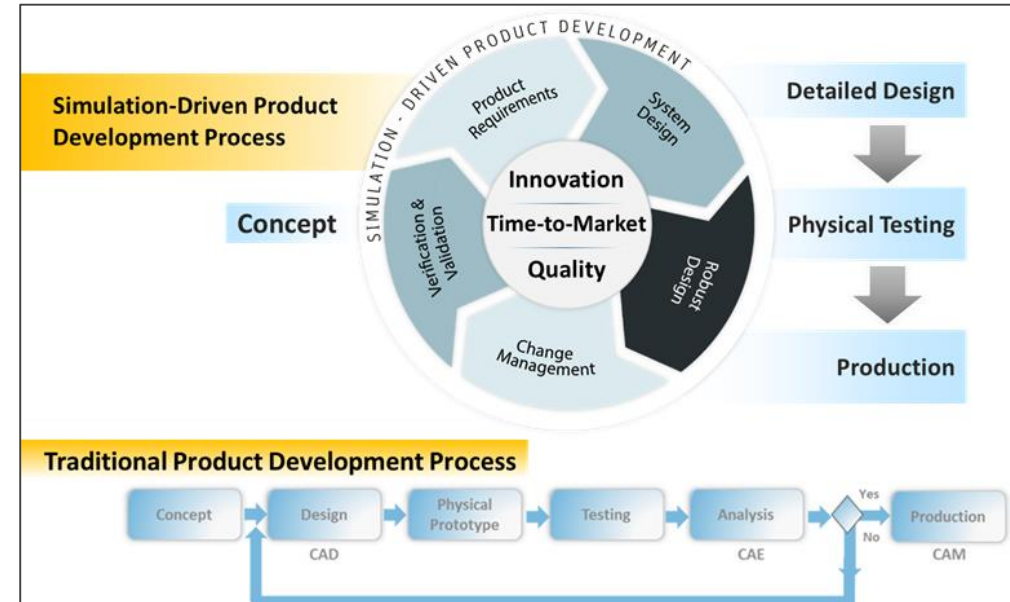
Platform based SDPD adoption enables enterprise level scalability for NPI acceleration

Creation of the digital twin

Connected Industrial Assets



Digital Prototype

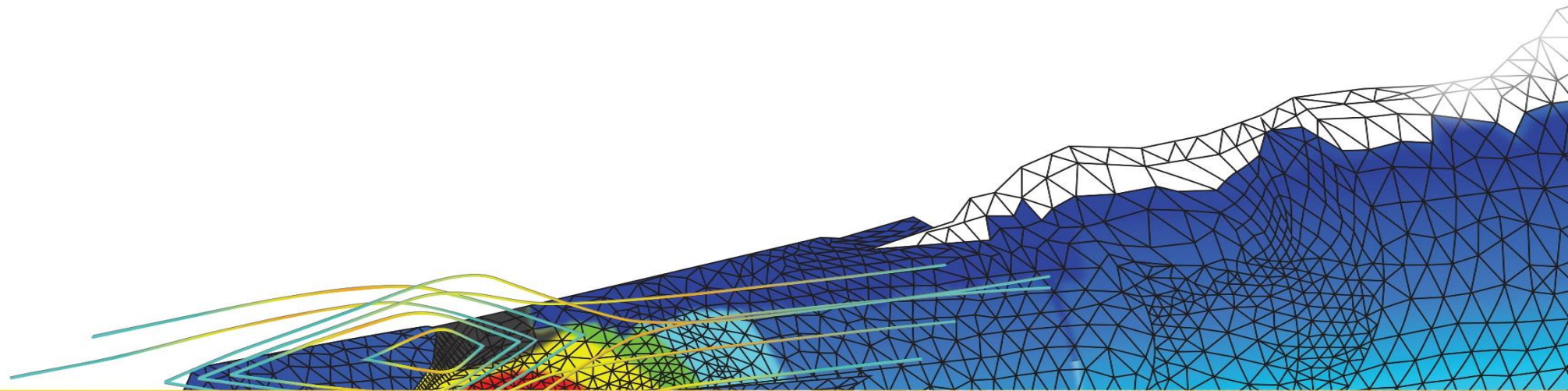


Digital Twin

**Predictive Maintenance
Zero Unplanned Downtime
Asset Performance Management**



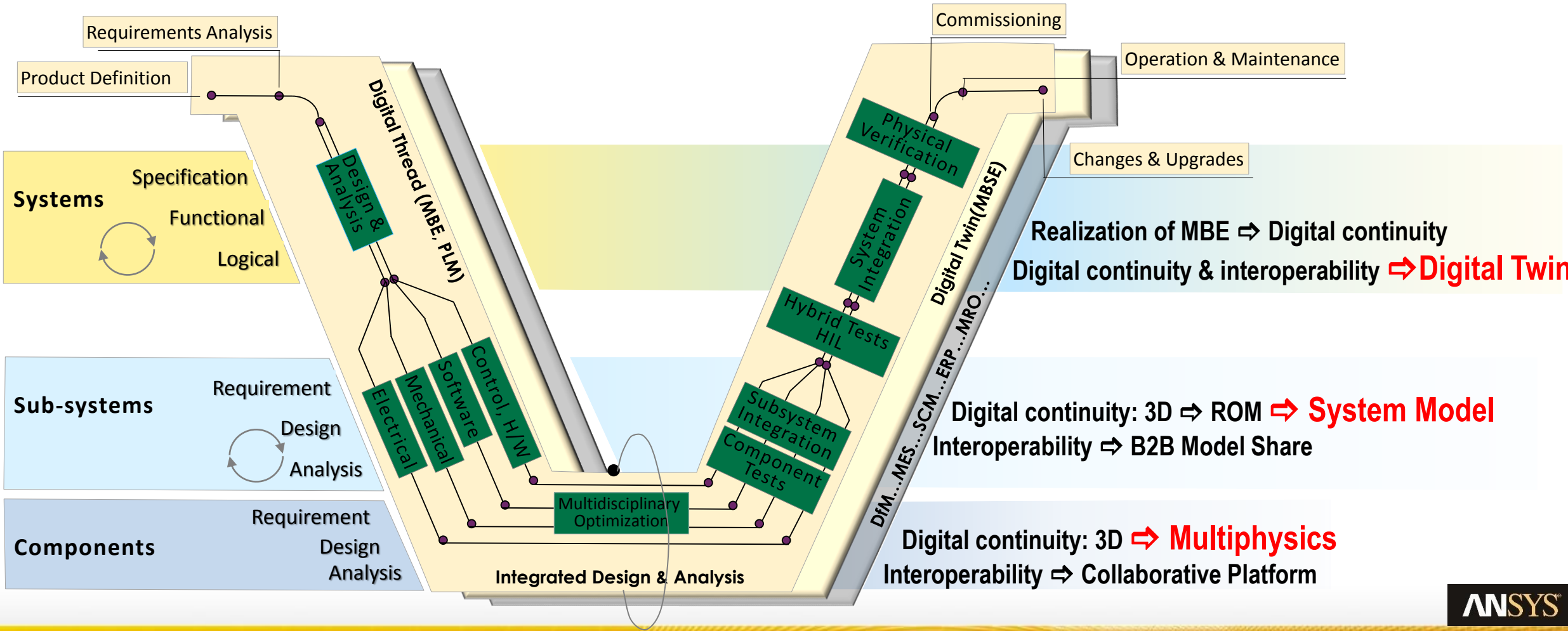
Model-Based Systems Engineering (MBSE)



Model-Based System Engineering (MBSE): Product Lifecycle

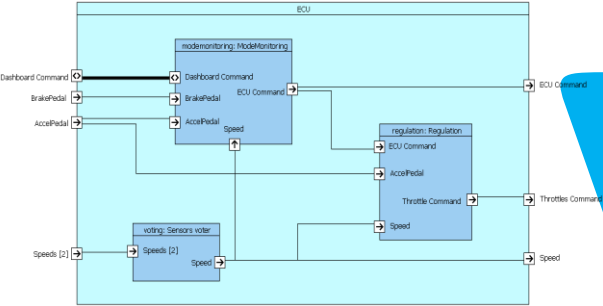
Evolution of Model Based Engineering

Single Source of Truth Between Design Models, Manufacturing and Operations

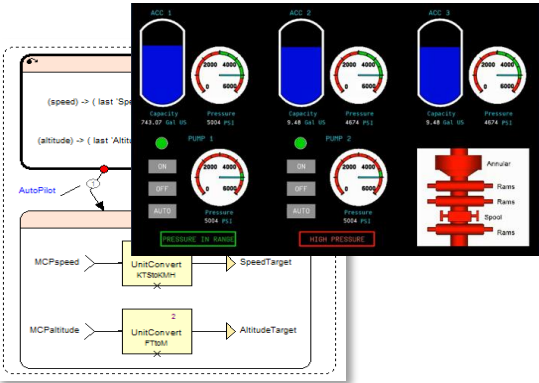
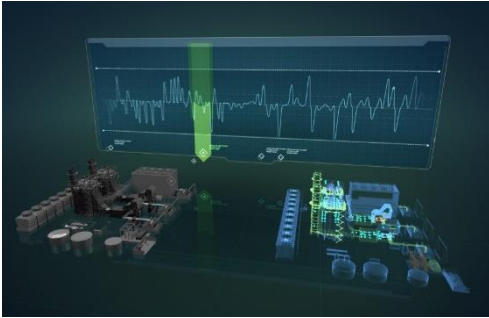


Model Based System Development

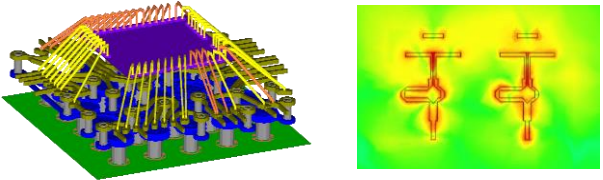
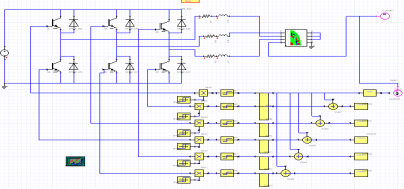
Model-Based System Engineering



Virtual Prototyping of Complete System

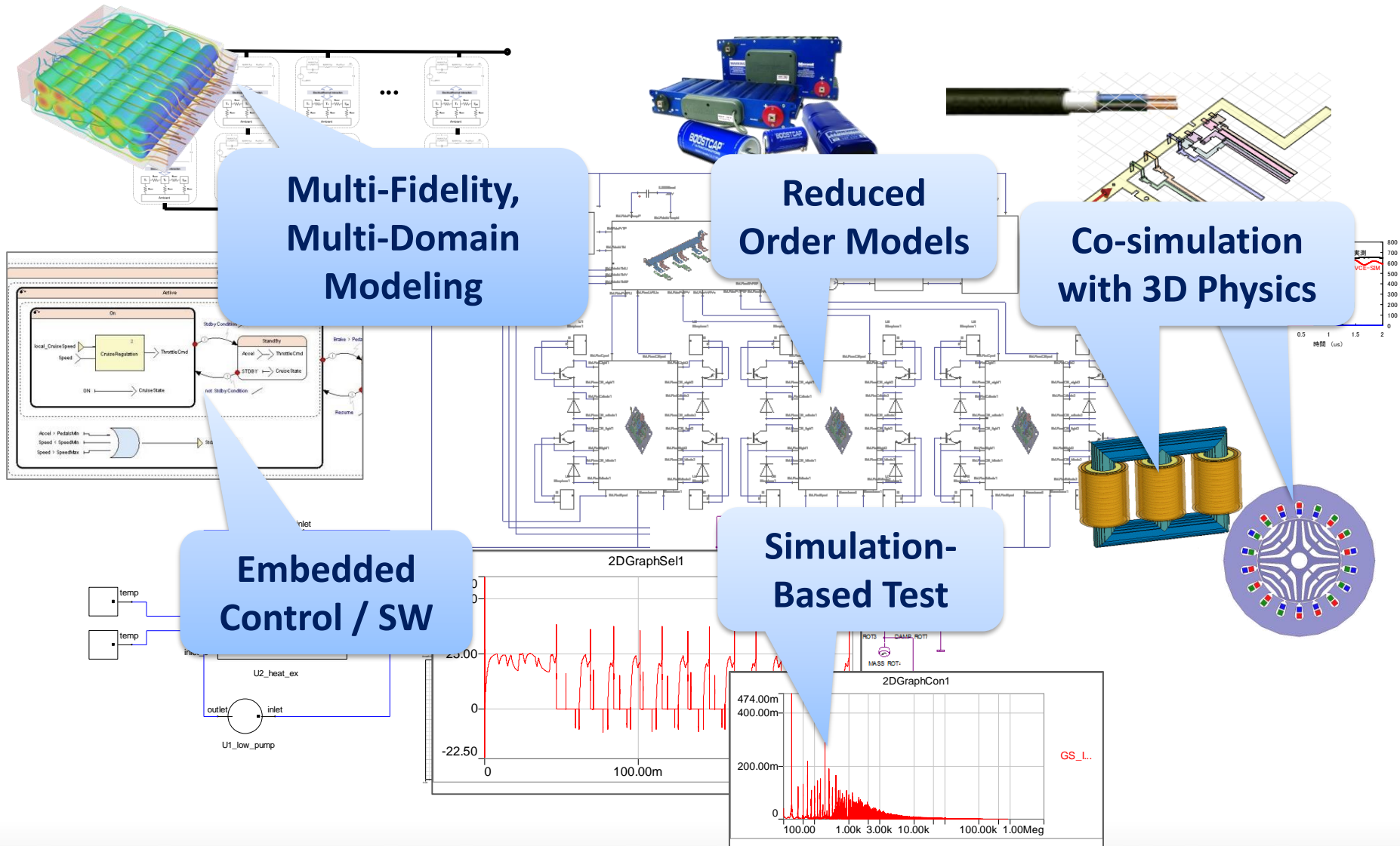


Model-Based Embedded Software Development



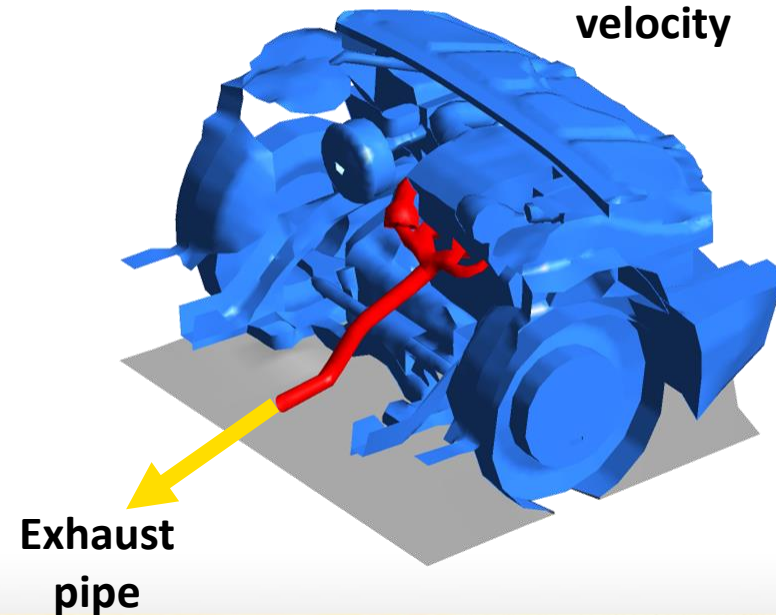
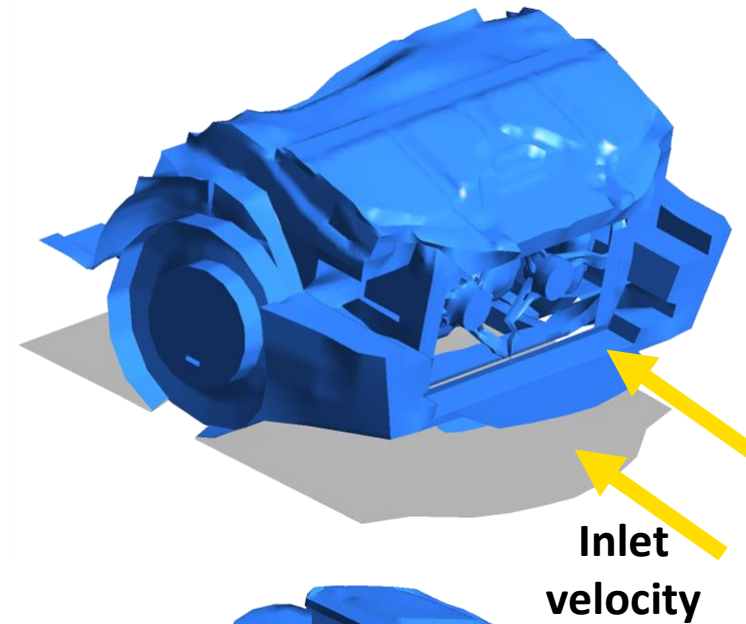
Virtual Prototypes of Physical Components

System Modeling & Simulation



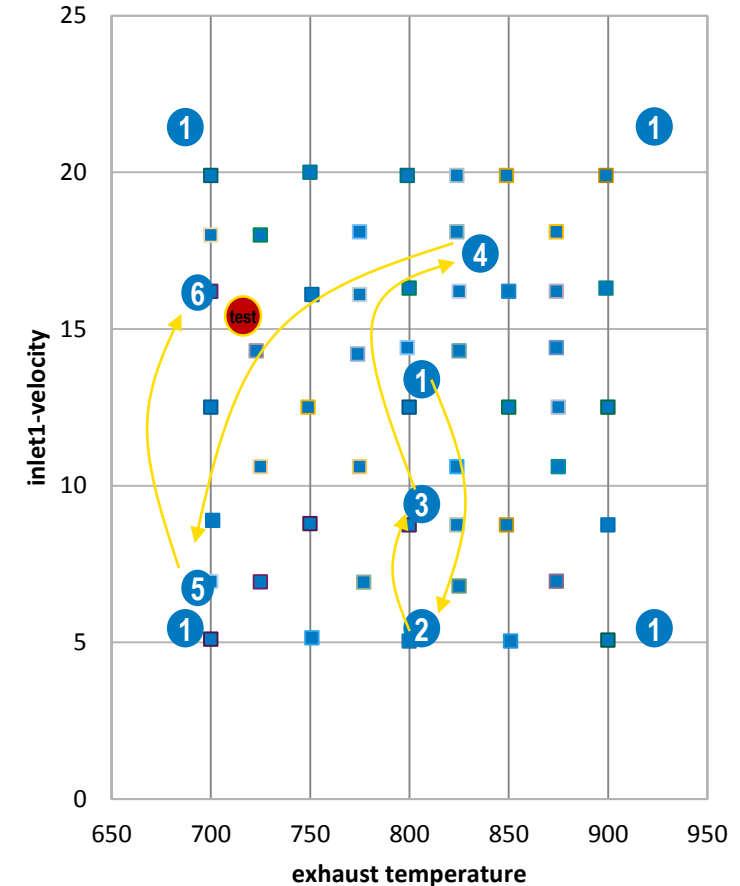
ROM creation example: Generic underhood test case

- 3D thermo-aerodynamic
- 2 parameters :
 - Inlet velocity from 5 m/s to 20 m/s
 - Exhaust Temperature from 700K to 900K

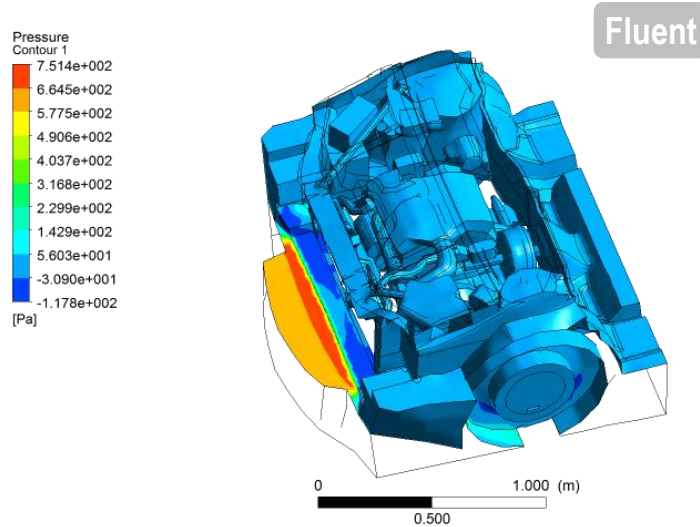


Reduced Order Model generation process (learning process)

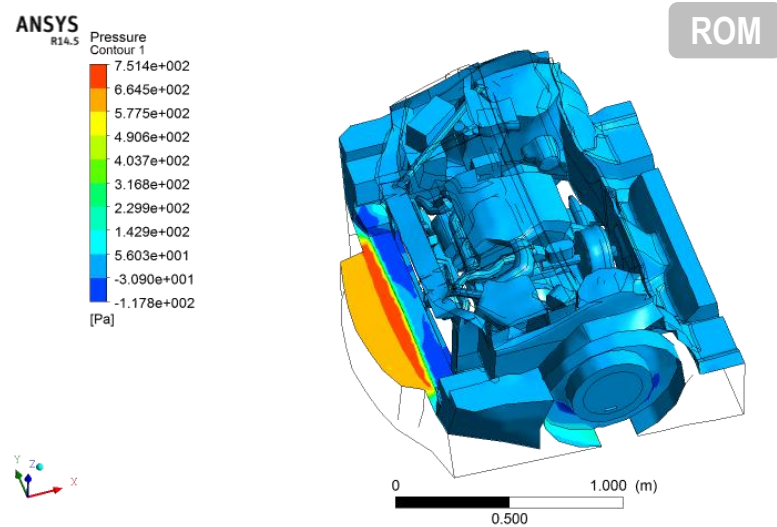
- **50 calculations were done**
 - 10 were used to create the model
 - 40 others used for verification
- **ROM Model creation is 9 seconds**
- **Average error on velocity : 0,06 m/s**
- **Average error on temperature : 0,49 K**
 - Quantitative differences in between
Fluent calculation and ROM model are presented
on the worst verification point



Static Pressure Comparison



Fluent

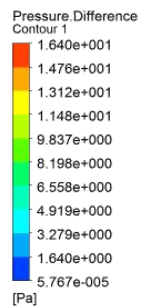


ROM

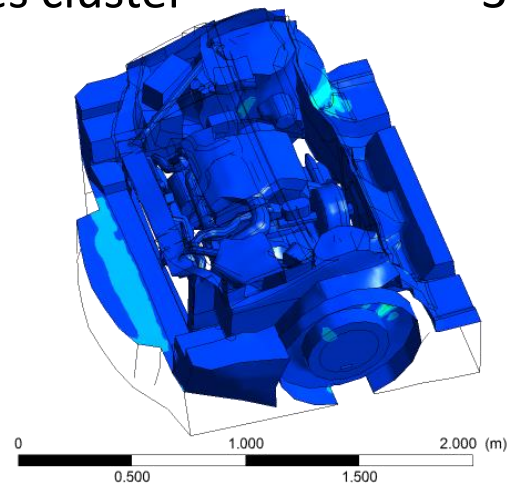
ANSYS R14.5

2 hours on 16 cores cluster

3 seconds on laptop



Absolute Difference



$T_{\text{exhaust}} = 723\text{K}$
 $V_{\text{car}} = 14,3 \text{ m/s}$



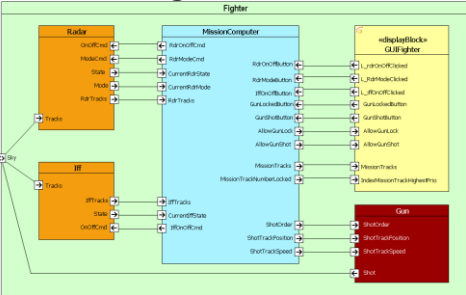
ANSYS R14.5



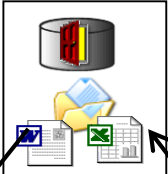
System Design and Safety Analysis



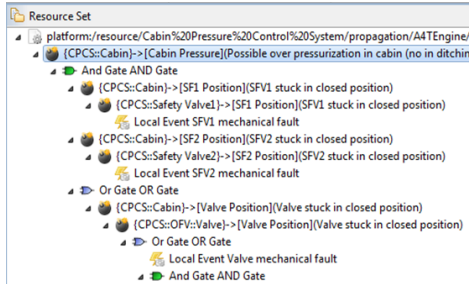
System Design



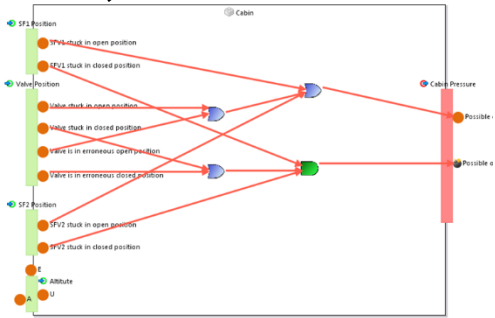
System Requirements



Safety Analysis



Safety Analysis



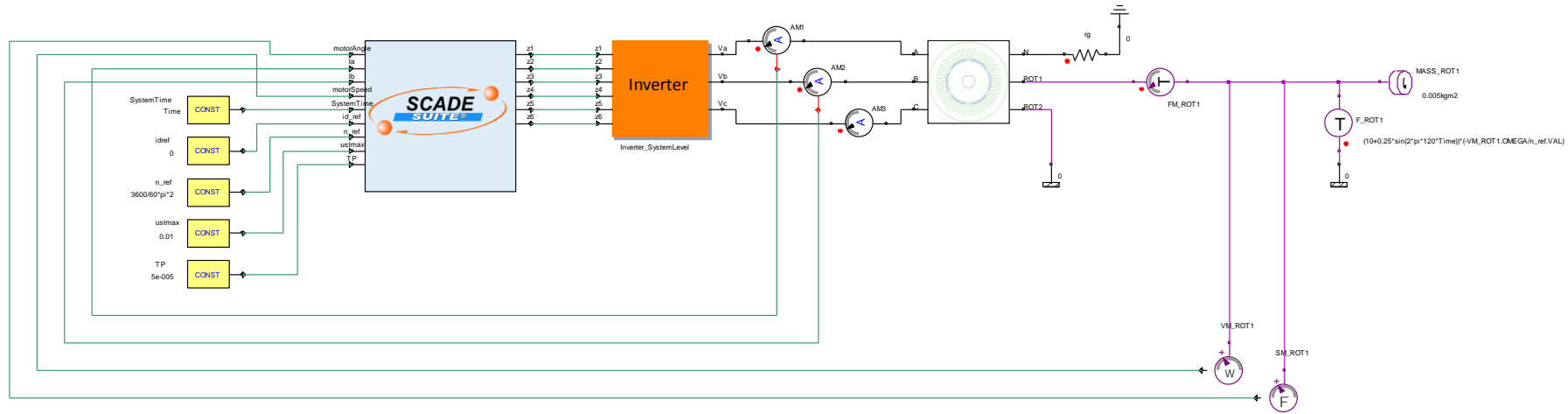
Translation and Merge

FTA
FMEA
etc.

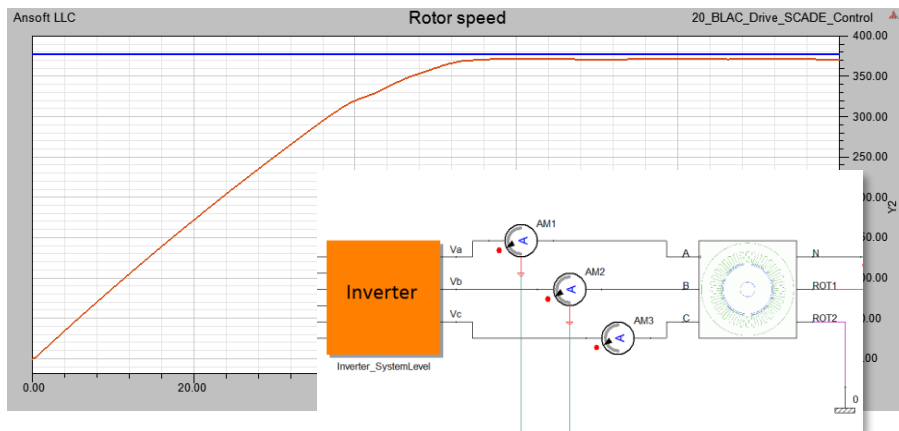


System Simulation and Safety Analysis (FMEA)

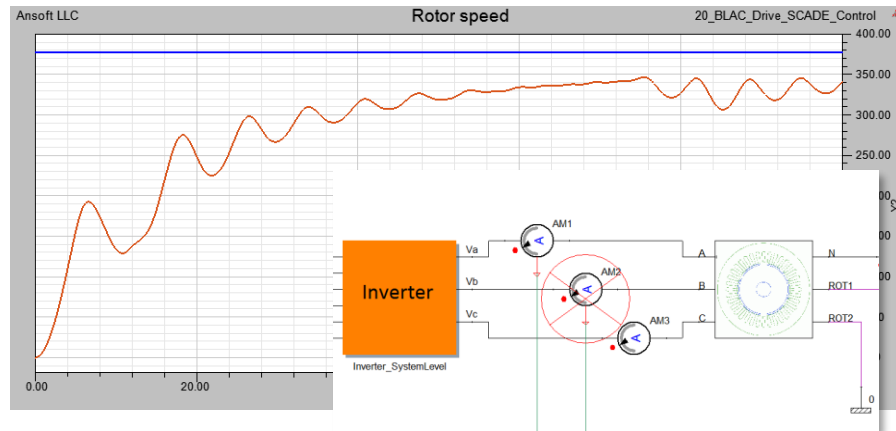
Injecting and analyzing faults



Normal Behavior



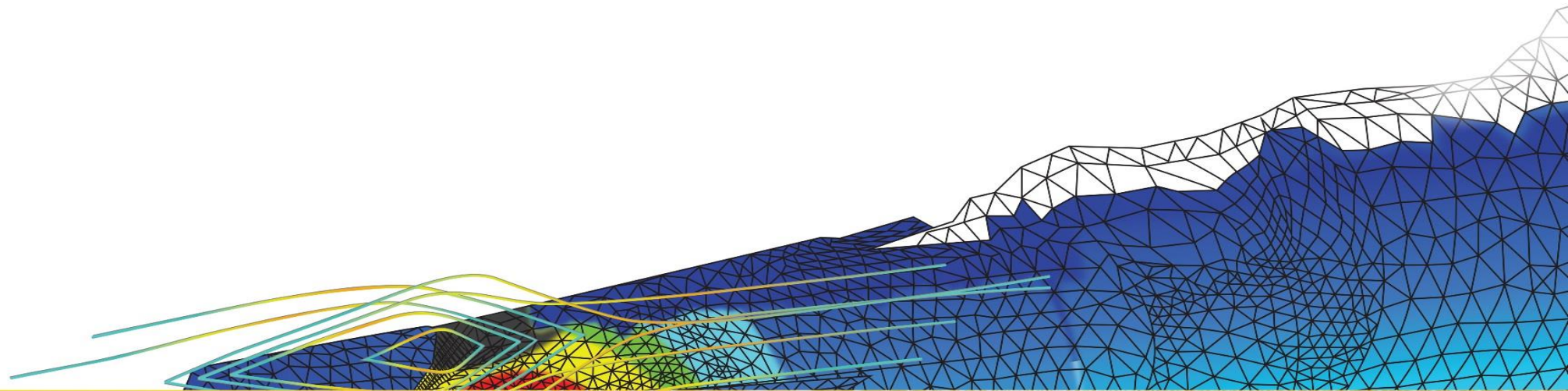
Sensor Failure



Simulation has been used so far to
Engineer better products and improve
Bottom line.



Predictive Analytics and the Digital Twin



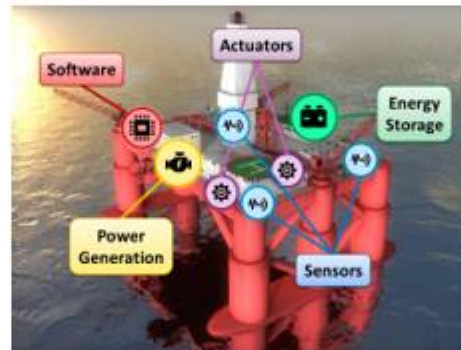
Industrial IoT (IIoT) is a Logical Evolution of Product



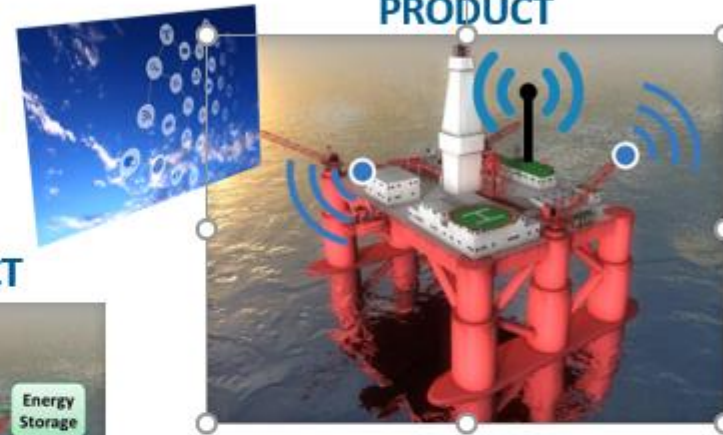
PHYSICAL PRODUCT



SMART PRODUCT

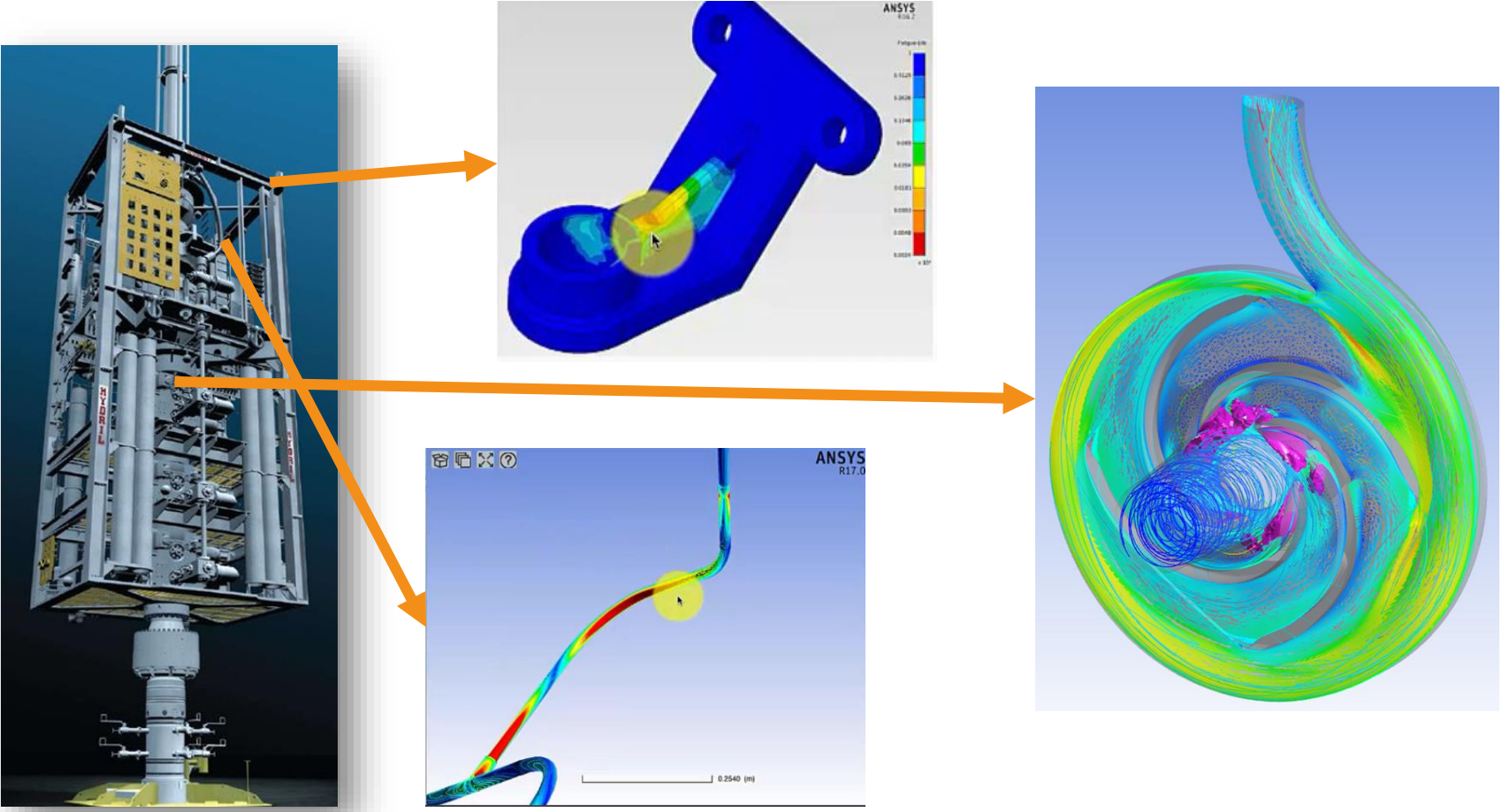


IoT = SMART & CONNECTED PRODUCT



System Simulation coupled with **IoT**
can now be used to **Better Operate**
Products and improve **Top Line**.

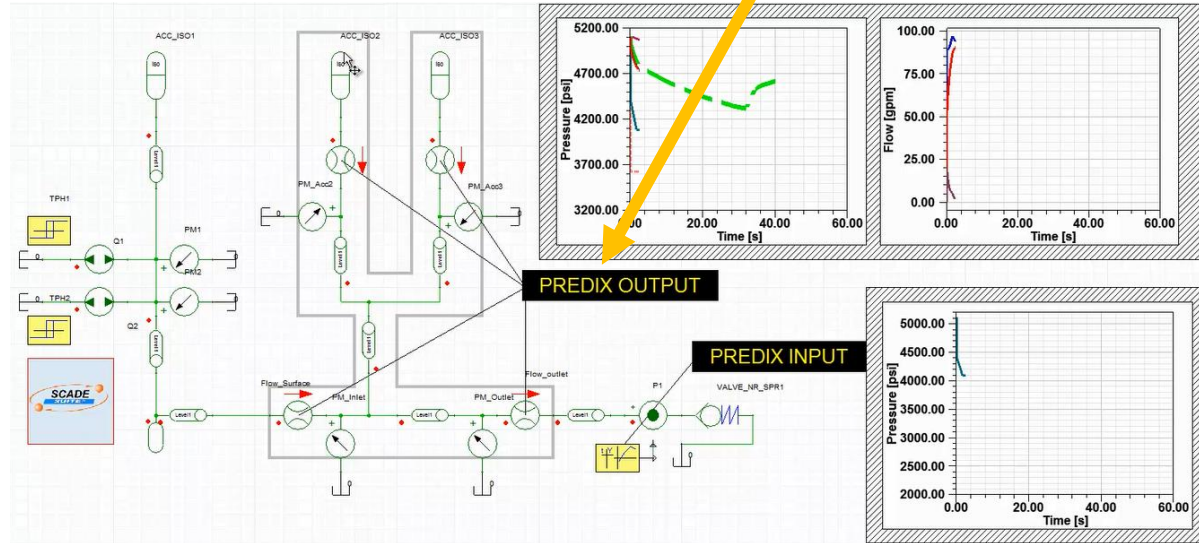
Engineering Simulation: Example Oil Field Blow Out Preventer



Physical Simulation
of all the **Mechanical & Fluids Components** of the BOP System

Engineering Simulation: scaling to System Level

Virtual Sensors

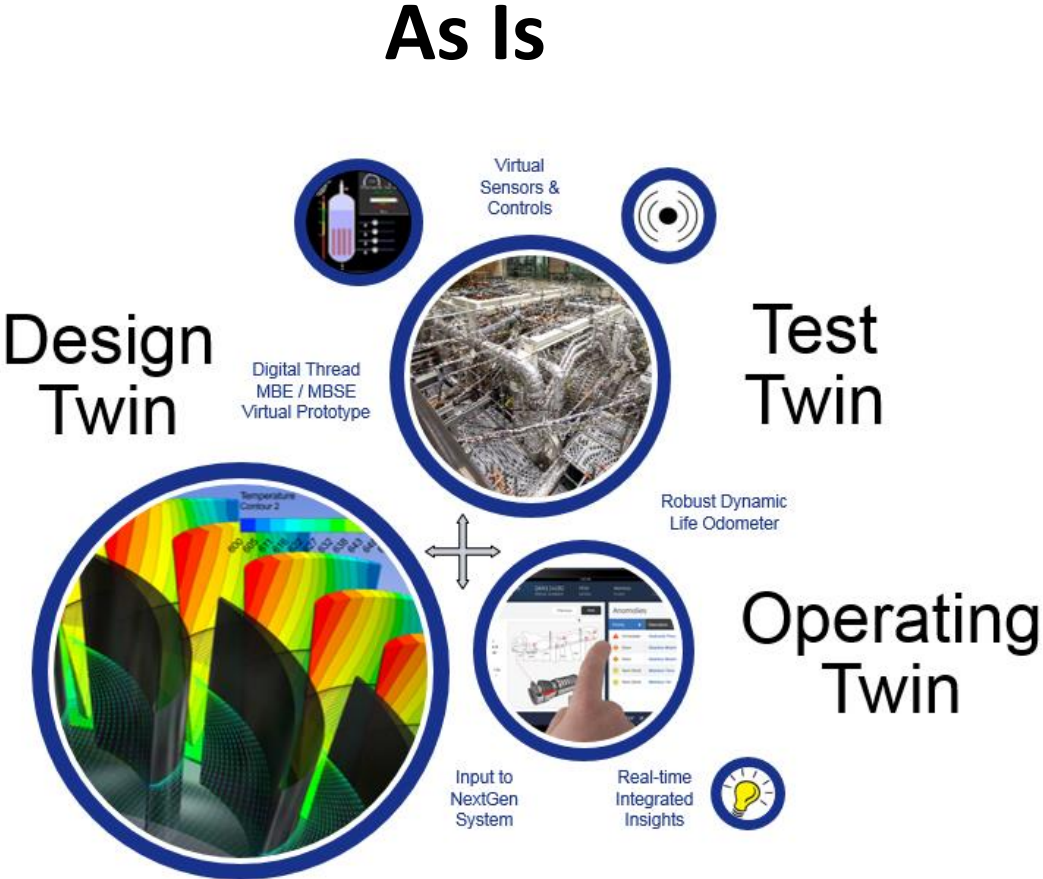


Complete System Simulation,
including Physics, Electronics
and Embedded Software Controls

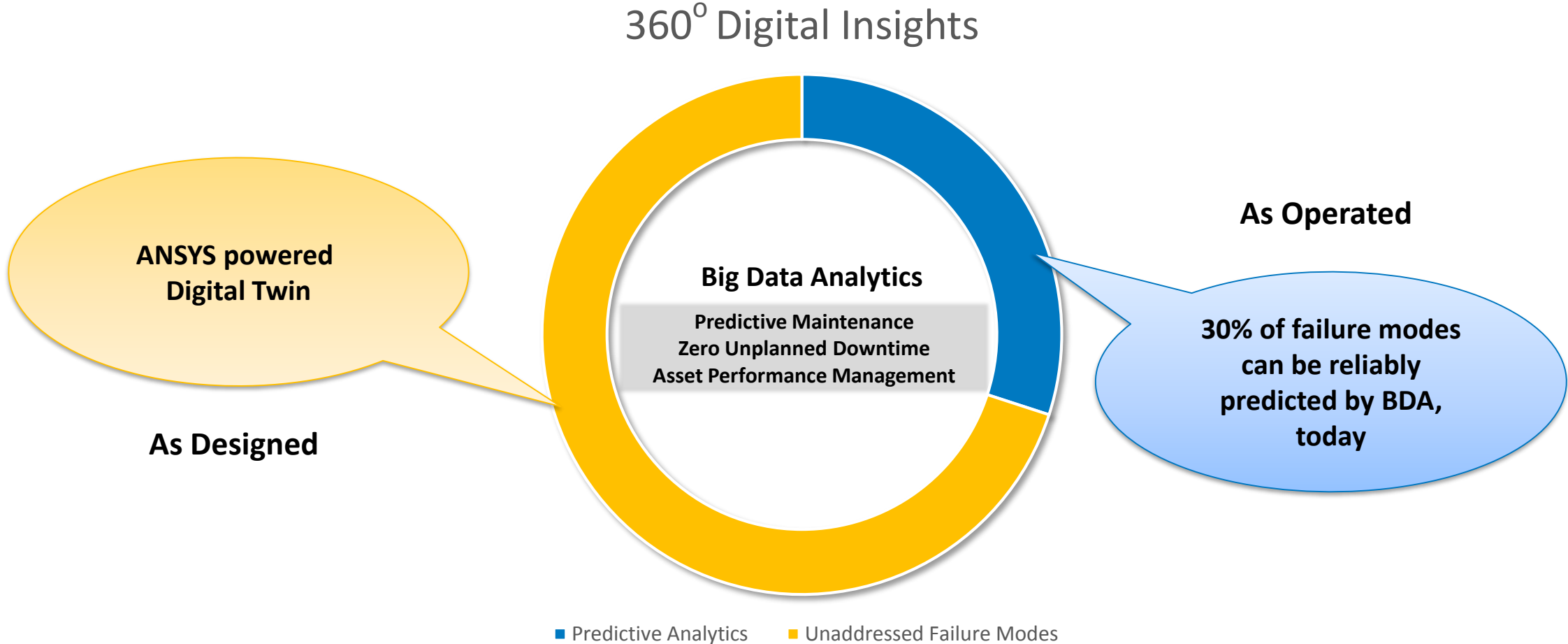
=

Digital Twin of the BOP

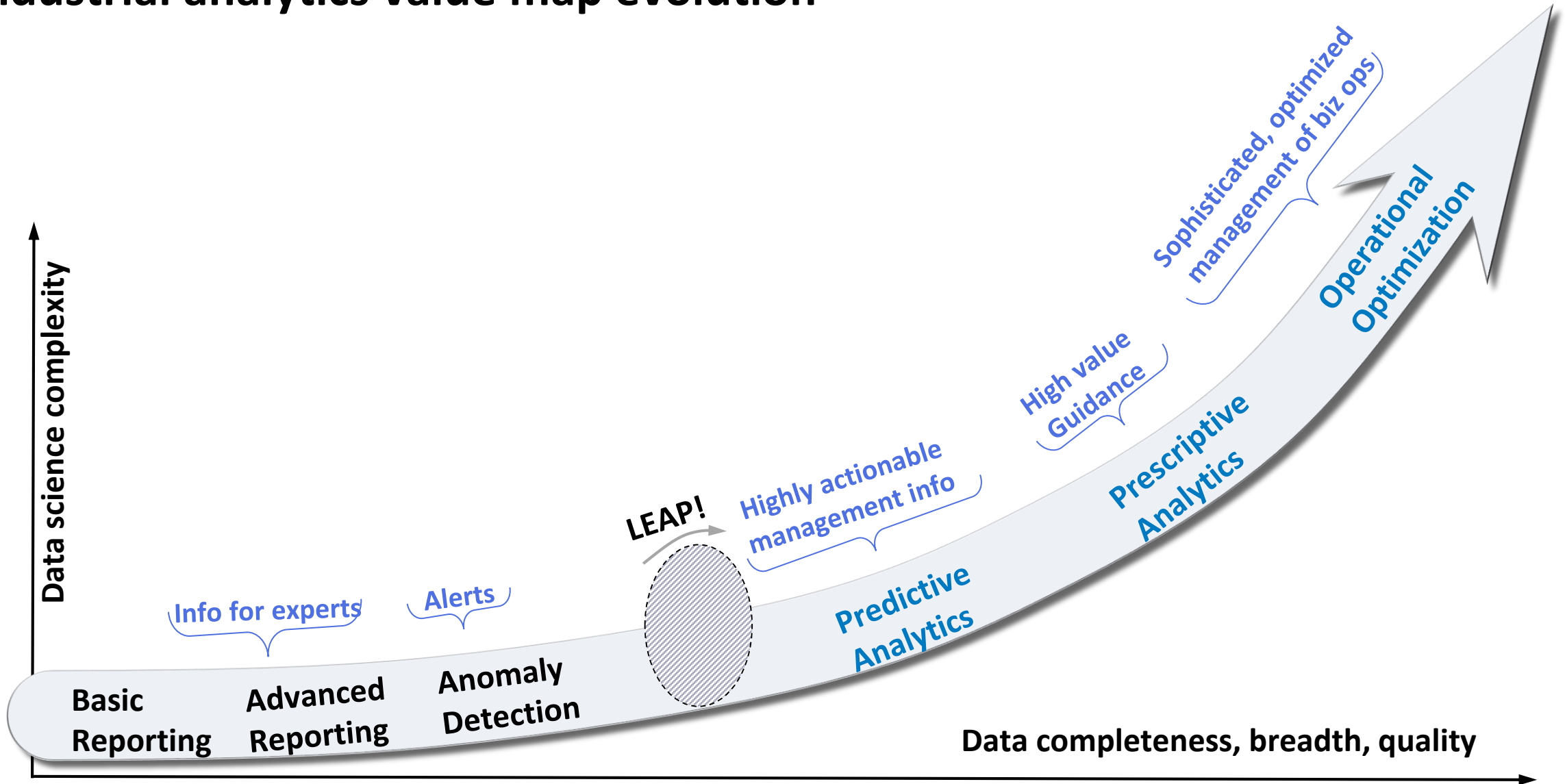
Transformational journey to digital twin



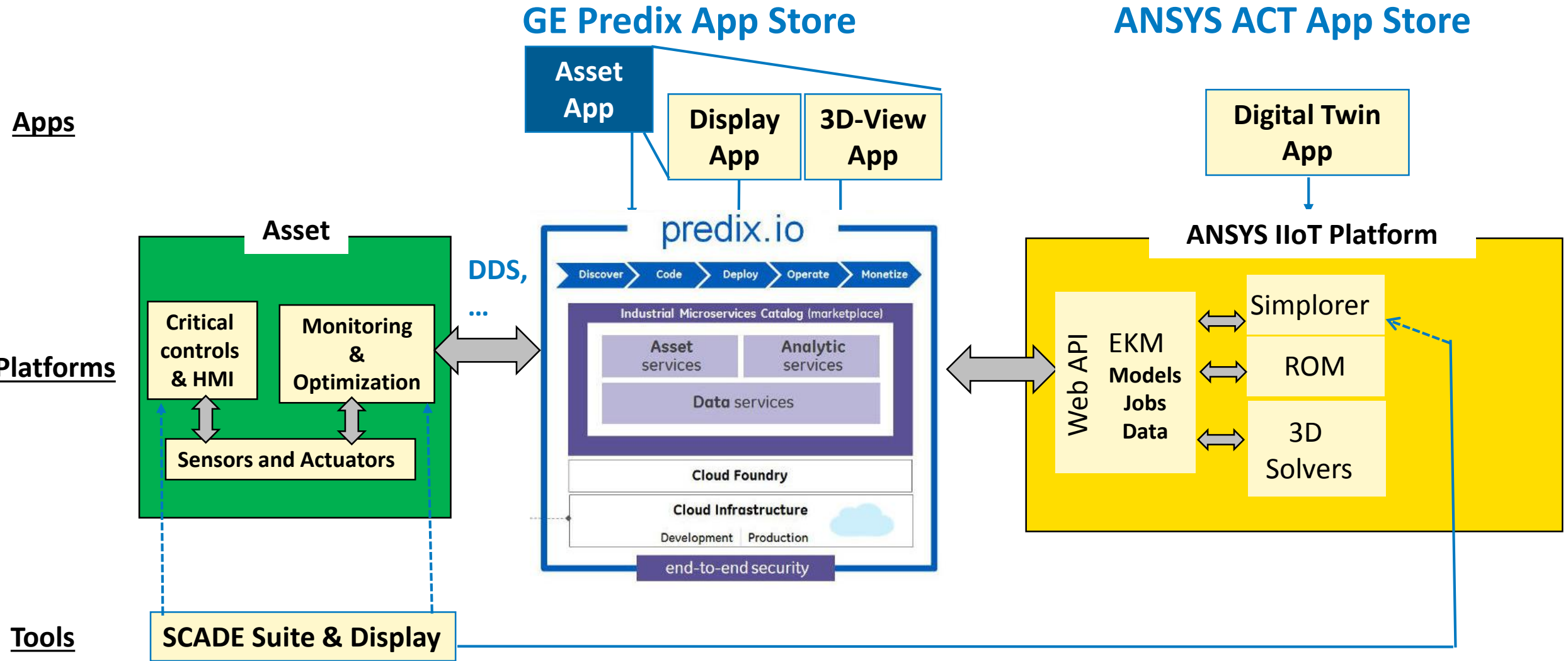
Digital twin opportunity



Industrial analytics value map evolution



GE Predix* and ANSYS Industrial IoT Global Architecture



* Similar architecture has been set up with PTC ThingWorx

A Connected Smart Asset

Digital Twin Summary

As Designed

As Operated

MODEL-BASED ENTERPRISE & SYSTEMS ENGINEERING

INTEGRATED IOT ASSETS & ECOSYSTEMS

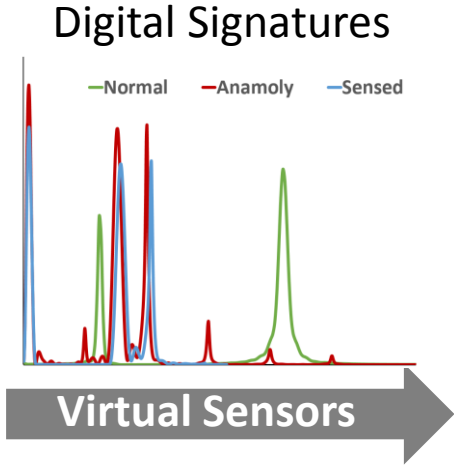
FLUIDS

STRUCTURES

ELECTRONICS

SEMICONDUCTOR

EMBEDDED SOFTWARE



FLOWSERVE

Customer: Nameplate, Location: Power Lab A, City: USA, Asset ID: 49657

Parameter	Value	Status
Flow	27.18 gpm	OK
Discharge Pressure	17.79 psi	OK
SC Pressure	14.44	OK
Actual Pressure	3.29 psi	OK
Control Valve	8.67	OK
Efficiency	48%	Warning

FAILURE PREDICTIONS

Category	Time	Count
Electrical Failure	5 Days	3
Hydraulic Failure	3 Days	3
Mechanical Failure	2 Days	3

Design Decisions

- Cost
- Weight
- Efficiency
- Robustness

Operational Decisions

- Life
- Performance
- Diagnostics
- Optimize





Q&A

