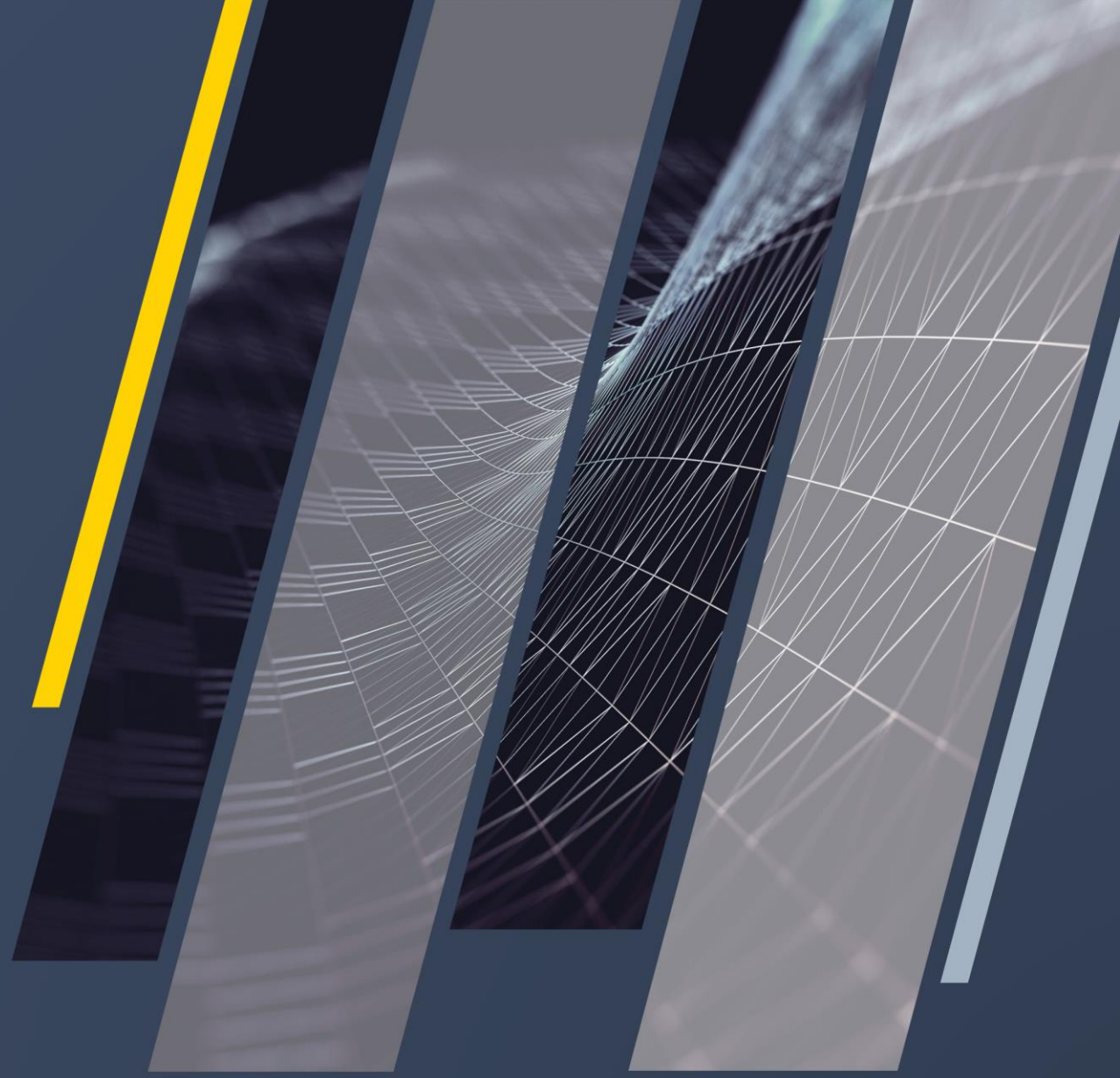


Simulation-Based Product Design in the Digital World

Prith Banerjee
Chief Technology Officer, ANSYS

October 4, 2019

Outline

ANSYS Introduction

ANSYS Long Term Technology Vision

Trends & Digitization View

ANSYS Simulation Offerings and Platform View

Support for High Growth Solutions – AV, EV, 5G, DT

ANSYS is the simulation leader

FOCUSED

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

TRUSTED

97 of the FORTUNE **100** industrials

More than **45,000** customers worldwide

ISO 9001 CERTIFIED

PROVEN

Member of the prestigious STANDARD &POOR'S 500

$1.3B revenue

$18B+ market capitalization

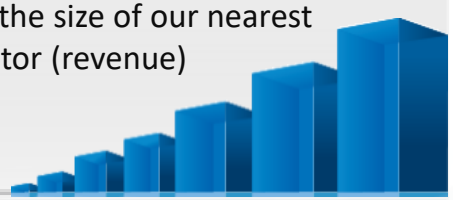
CAPABLE

4,000+ employees globally

75 offices in **40** countries

LARGEST

3x the size of our nearest competitor (revenue)



INDEPENDENT

Long-term financial stability

CAD agnostic

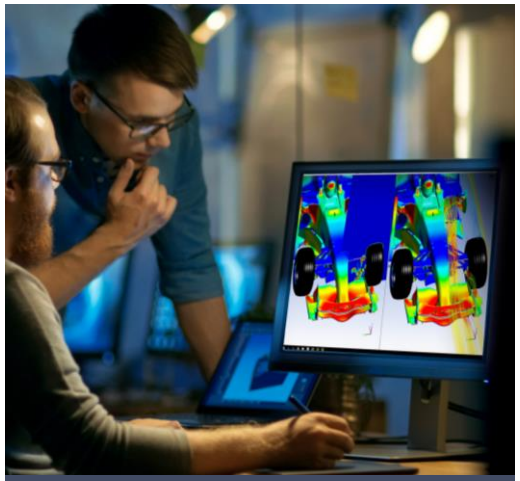
COMMITTED

Overall customer satisfaction globally is at **87.8%** in 2017

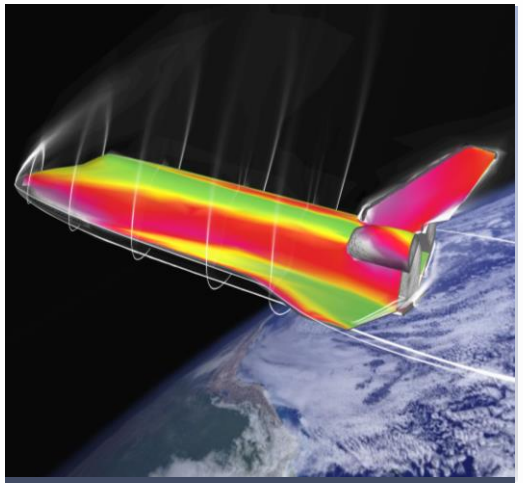
DRIVEN

Helping customers address new market challenges: **digital exploration, additive manufacturing** and **digital twins**

ANSYS Position in Market



ANSYS is the simulation market leader

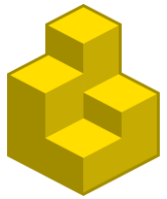


The simulation market is strong and growing

Our strategy capitalizes on this growing market

We have a proven record of execution

ANSYS offers the only true simulation platform with best-of-breed simulation across all major physics



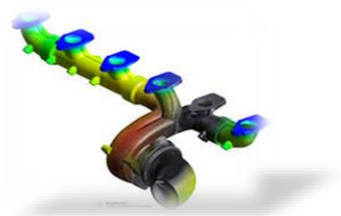
Platform

Fluids	Structures	Electromagnetics	Optics	Semiconductors	Software, Systems	Design & Additive
ANSYS Fluent	ANSYS Mechanical	ANSYS HFSS	ANSYS SPEOS	ANSYS PathFinder	ANSYS SCADE Architect	ANSYS Discovery AIM
ANSYS CFX	ANSYS Autodyn	ANSYS Maxwell	ANSYS VRX	ANSYS PowerArtist	ANSYS SCADE Display	ANSYS Discovery Live
ANSYS Chemkin-Pro	ANSYS LS-DYNA	ANSYS SI-Wave	ANSYS Theia-RT	ANSYS RedHawk	ANSYS SCADE LifeCycle	ANSYS SpaceClaim
ANSYS TurboGrid	ANSYS AQWA	ANSYS Icepak	ANSYS HIM	ANSYS RedHawk-SC	ANSYS SCADE Suite	ANSYS Exasim
ANSYS FENSAP-ICE	ANSYS ACT	ANSYS Q3D Extractor	ANSYS Genesis	ANSYS Totem	ANSYS SCADE Test	ANSYS Flex
ANSYS BladeModeler	ANSYS nCode	ANSYS DfR	ANSYS Aesthetica	ANSYS Variance FX	ANSYS medini Analyze	
ANSYS Polyflow				ANSYS Helic	ANSYS TwinBuilder	

Material Intelligence

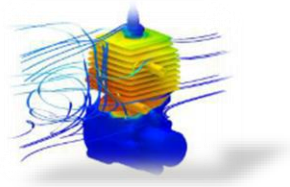
Customer journey from single physics to Digital Twin

Example: Cummins simulation adoption journey



Single Physics

Mid 1990's
Mechanical

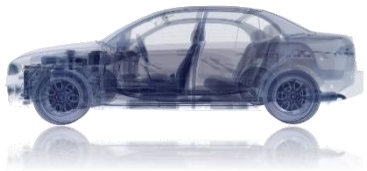


Multiple Physics

Mid 2000's
CFD
Late 2000's
Electrical

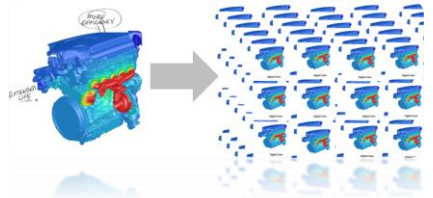
Multi-Physics

Mid 2010's
Multi-physics
Mechanical/CFD
Electrical/CFD
Exploring systems simulation



Complete Digital Prototypes

Today
HPC advances enable detailed subsystem analysis, including some full engine prototypes. Pushing simulation 'democratization'

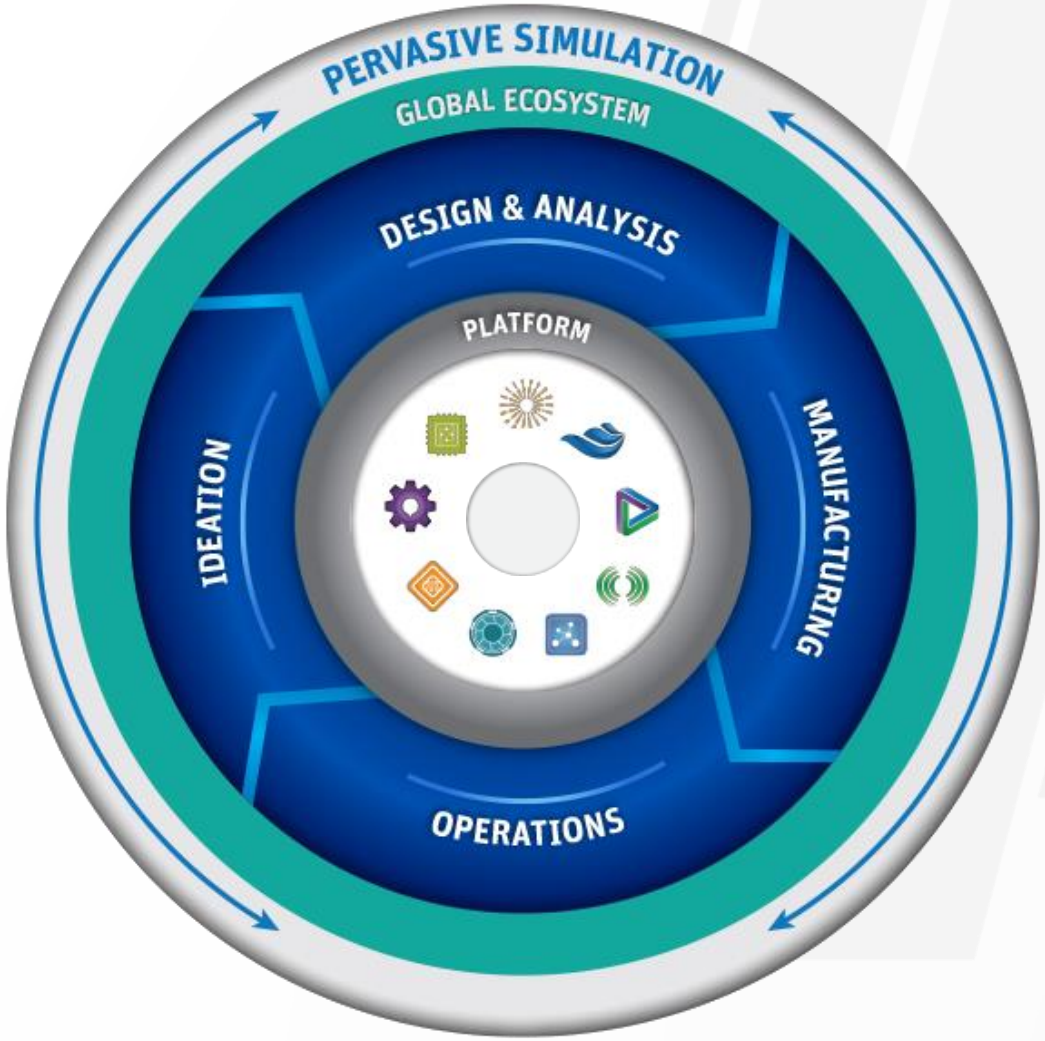


Digital Twin

Tomorrow
Exploring Digital Twin technology for engines in the field

Already using Multi-Discipline Optimization to drive ANSYS solver technology

Our Strategy Of Pervasive Simulation Is Aligned With Market Growth



Simulation Impacts Top-Line Growth And Bottom-Line Savings

Simulation impact

- Rapid innovation
- Lower cycle time
- Reduced risks
- Increased quality
- Manage complexity

Revenue growth

- Offer more products
- Launch right products
- Faster time to market

Cost savings

- Improved R&D efficiency
- Fewer physical prototypes
- Lower warranty costs

Large, Highly Diversified Customer Base

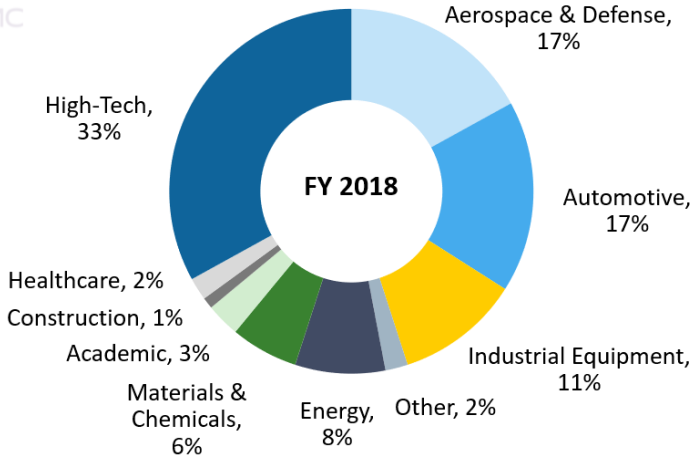
22 OF TOP 25 AUTO SUPPLIERS ARE ANSYS CUSTOMERS

23 OF TOP 25 A&D OEMs ARE ANSYS CUSTOMERS

10 OF TOP 10 INDUSTRIAL EQUIPMENT COMPANIES ARE ANSYS CUSTOMERS

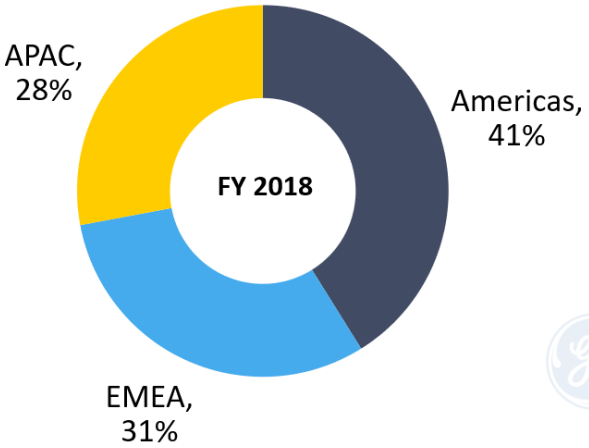
Customer Diversity

(% Total ACV by Industry)



Geographic Diversity

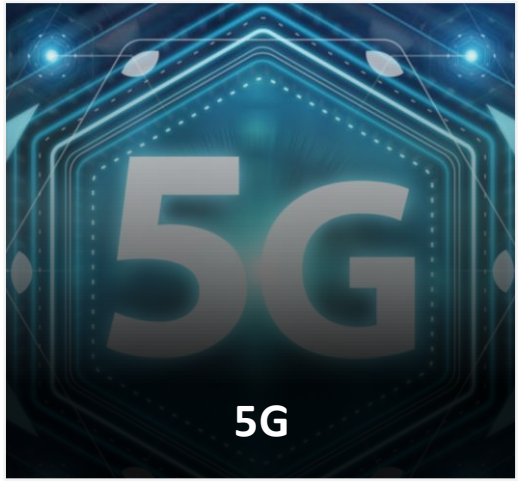
(Revenue by Geography – Non-GAAP)



7 OF TOP 10 OIL & GAS COMPANIES ARE ANSYS CUSTOMERS

10 OF TOP 10 LEADING CHIP DESIGNING COMPANIES ARE ANSYS CUSTOMERS

Emerging High-Growth Solutions: Cross-Industry Trends Will Accelerate Growth



Play to our strengths

Disruptive market opportunities

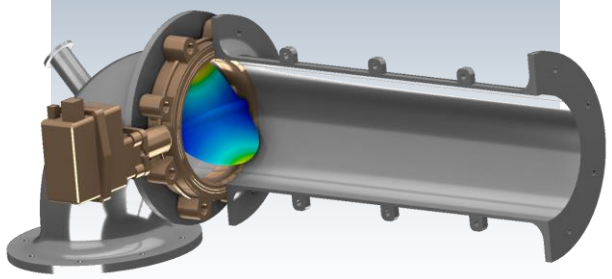
Large – and growing – customer investment

Unprecedented product complexity

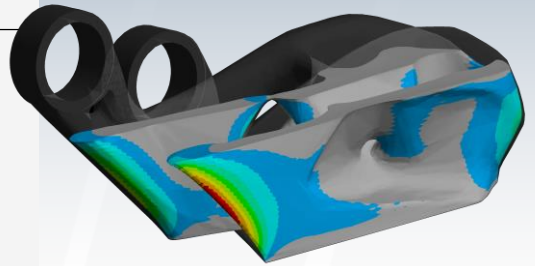
Requires extensive use of simulation

New Adjacencies: Drive Simulation Across The Entire Product Lifecycle

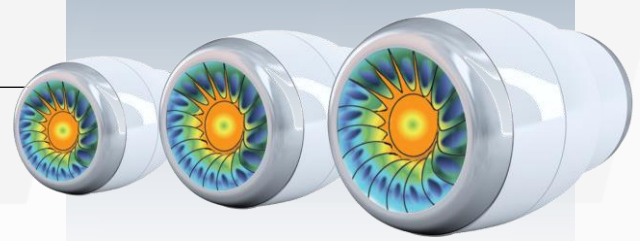
DIGITAL EXPLORATION



ADDITIVE MANUFACTURING



DIGITAL TWINS



ANSYS Long Term Technology Strategy Dimensions

Artificial Intelligence and Machine Learning
- Simulation used to train AI methods
- AI used to improve simulation
- ML based Models & data confluence

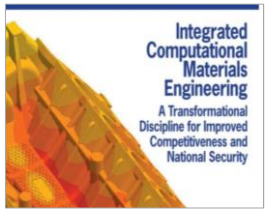
Platform for Multi-physics simulation
- Seamless simulation & visualization process
- Robust Multiphysics, Multi-disciplinary Optimization
- Azure/AWS microservices for simulation

Hyperscale Simulation, Collaboration on Cloud
- GPU, SMP, MPI, Task based
- Quantum computing?
- Hyperscale Real Time Simulation

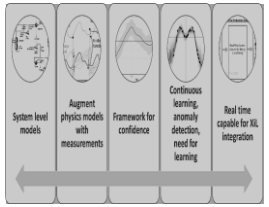
Predictive and Robust Design
- High accuracy, adaptive numerical methods
- Integrated Verification and Validation
- Uncertainty Quantification

Digital and Physical Worlds
- AR/VR for Simulation brings digital world to physical
- IOT and Connectedness brings physical world to digital
- Smart Energy, Smart Cities

Digital Transformation
- Digital Threads, Digital Continuity, Digital Twins
- Model Based Systems Engineering
- Simulation-led engineering outcome

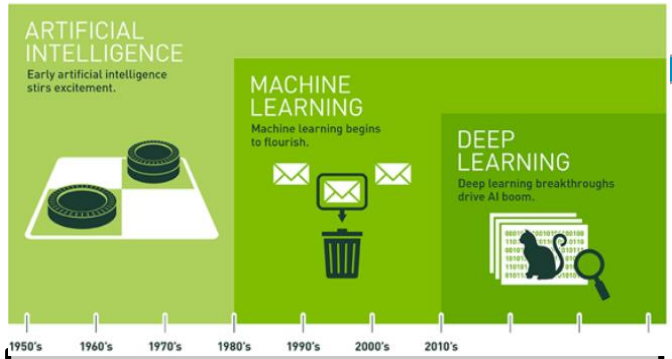


Computational Methods in New Areas
- Integrated Computational Materials Engineering
- Computational Chemistry, Drug Design, Healthcare,
- Photonic IC, 3D IC, Digital Manufacturing



How can Simulation be Disrupted?
- ML based Flow-Solver, Generative design
- Integrated synthesis and verification
- Automated Mixed mode (0D-4D), MF, MS simulation

Focus 1: Machine Learning and Simulation

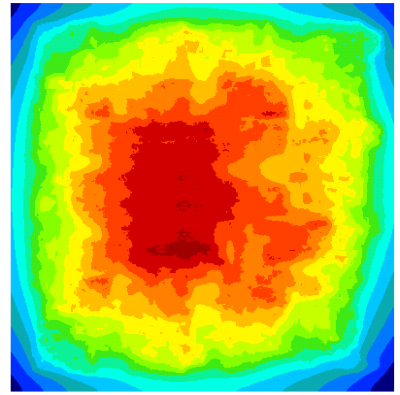


Machine Learning Methods

- Supervised Learning
- Unsupervised Learning
- Semi-supervised Learning
- Reinforcement Learning

AI/ML Use Cases

- Customer Productivity
- Augmented Simulation
- Engineering Design
- Business Intelligence / Guidance



Engg. Simulation Methods

- Geometry/Meshing
- 3D/4D Finite Element/Volume
- Physical/Math Models
- Reduced Order & System Models, Digital Twins
- Postprocessing/Visualization

AI/ML Use Case 1: Customer Productivity

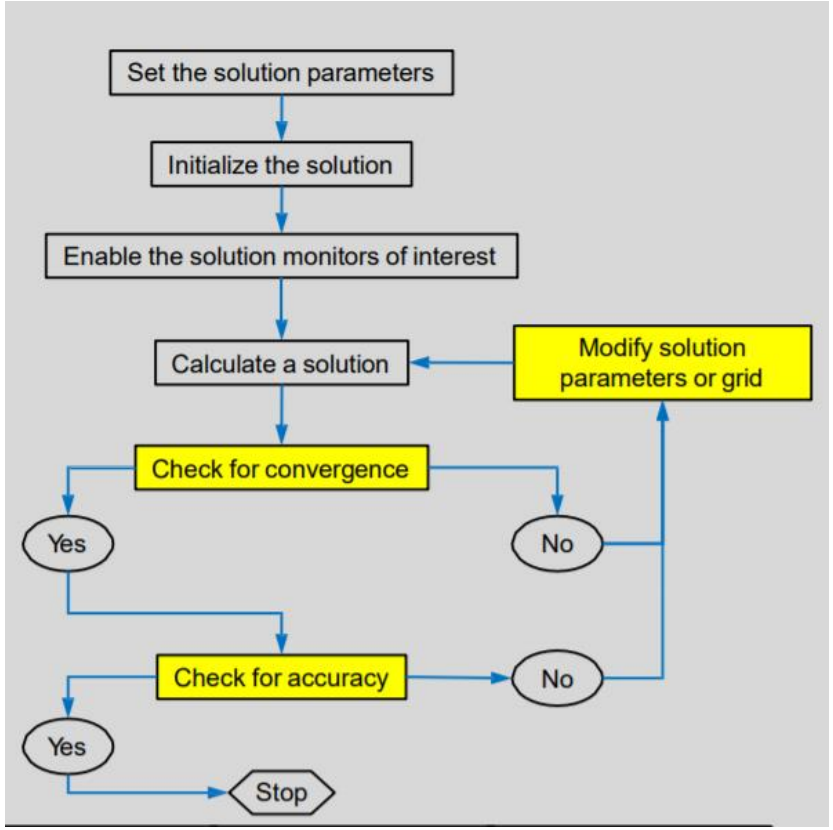
Customer Productivity

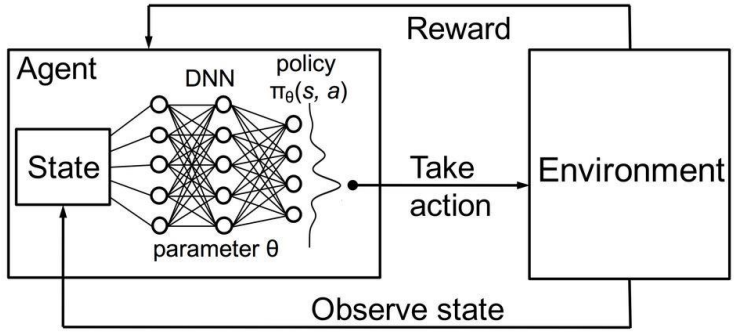
- Simulation strategies for workflow improvement
- Expert guidance on simulation results

Value

- More rapid path to quality simulation results

Example: Automated Solution Control and Steering with Reinforcement Learning





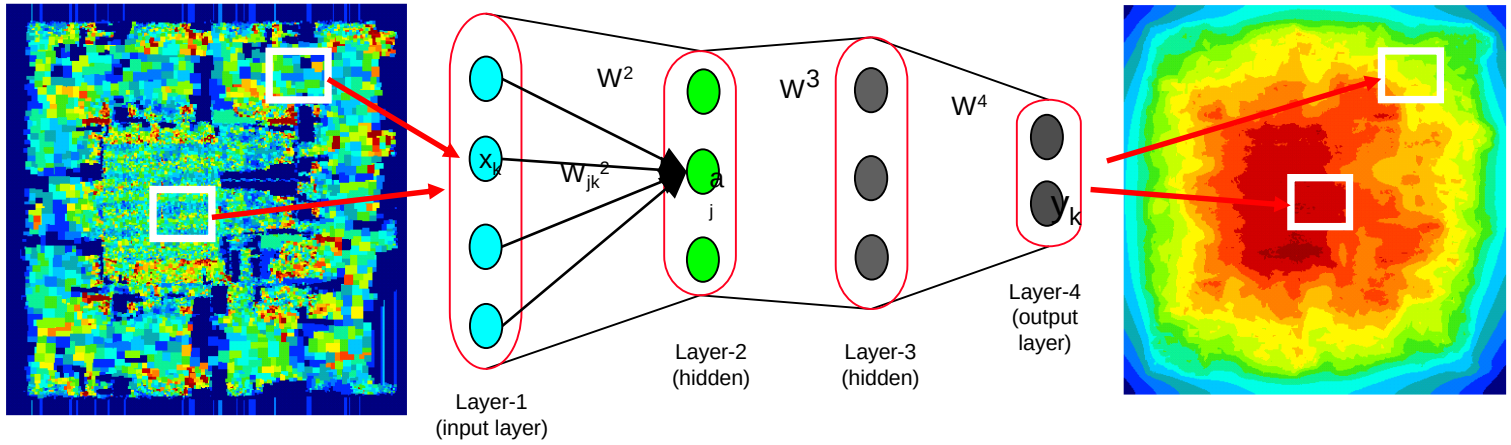
AI/ML Use Case 2: Augmented Simulation

Augmented Simulation

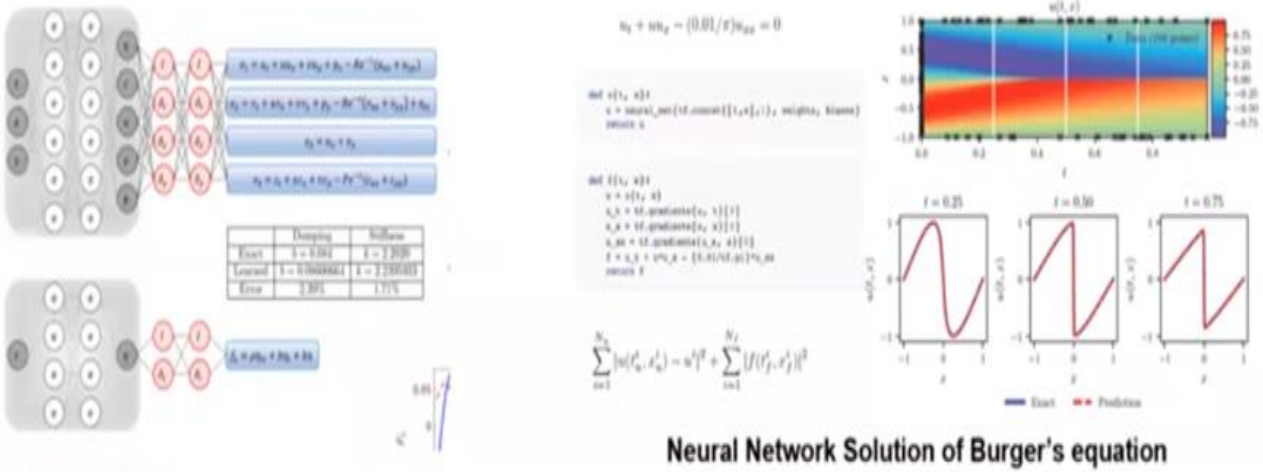
- Data-driven and Physics-informed modeling and solver

Value

- Providing fast simulation results with small design changes



Data-driven DNN-based Solver for enhancement of on-chip thermal solver

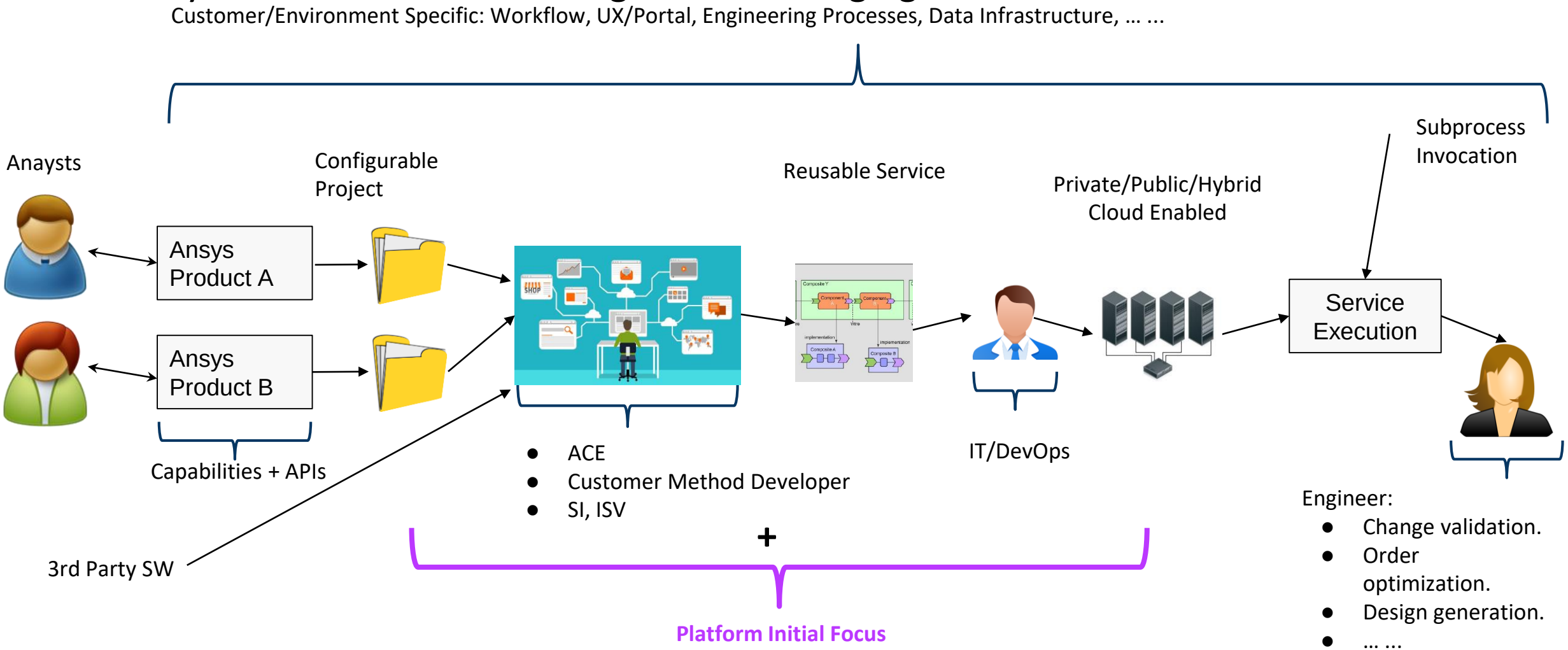


Neural Network Solution of Burger's equation

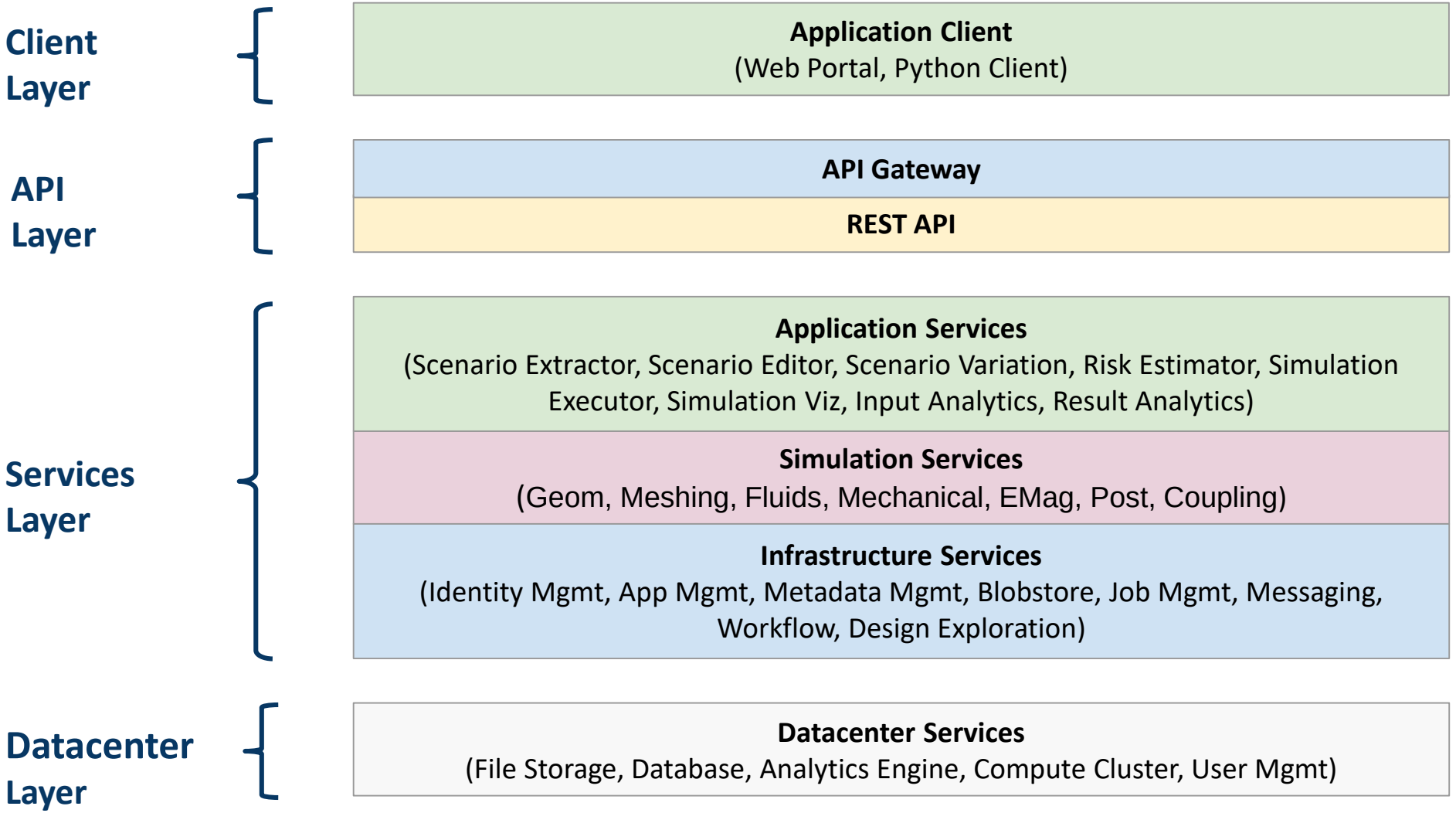
Physics-informed DNN-based Solver for IcePak application by Nvidia

Focus 2: Multi-Physics Platforms

We have best-in-class applications (solvers for different physics, Fluent, HFSS, Mechanical) but the way consumers are extracting value is changing...

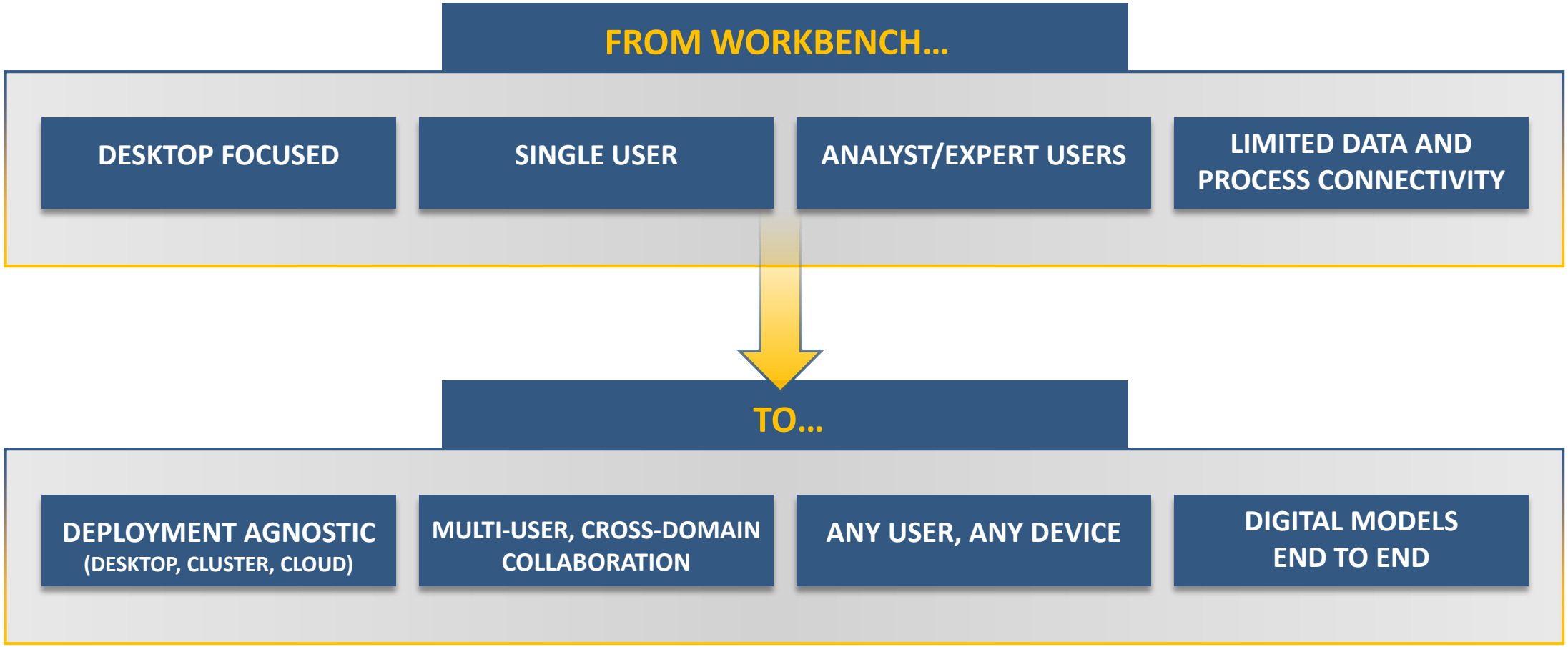


Multi-Physics Platform



3rd Party Services
(KPI Evaluators, Scenario Generators, Ground Truth Data, Sensor FMUs, AD Function, Vehicle Dynamics)

Need for a Platform evolution



ANSYS Minerva Platform capabilities

Simulation Process & Data Management

Traceability, collaboration and decision support

Multi-physics Process Integration & Optimization

Integration/automation of chained data flows and design space exploration for optimal performance parameters

Materials Data Connectivity

Smart materials decisions via reference databases, materials research and test calibration

PLM/ERP Interoperability

Standards-based connectivity to engineering applications and lifecycle systems

Simulation and Data

Connect physics with data. Reimagine and amplify simulation using AI

Cloud / Hybrid Deployment

Composable on-prem and cloud deployment for more complex and broader usage

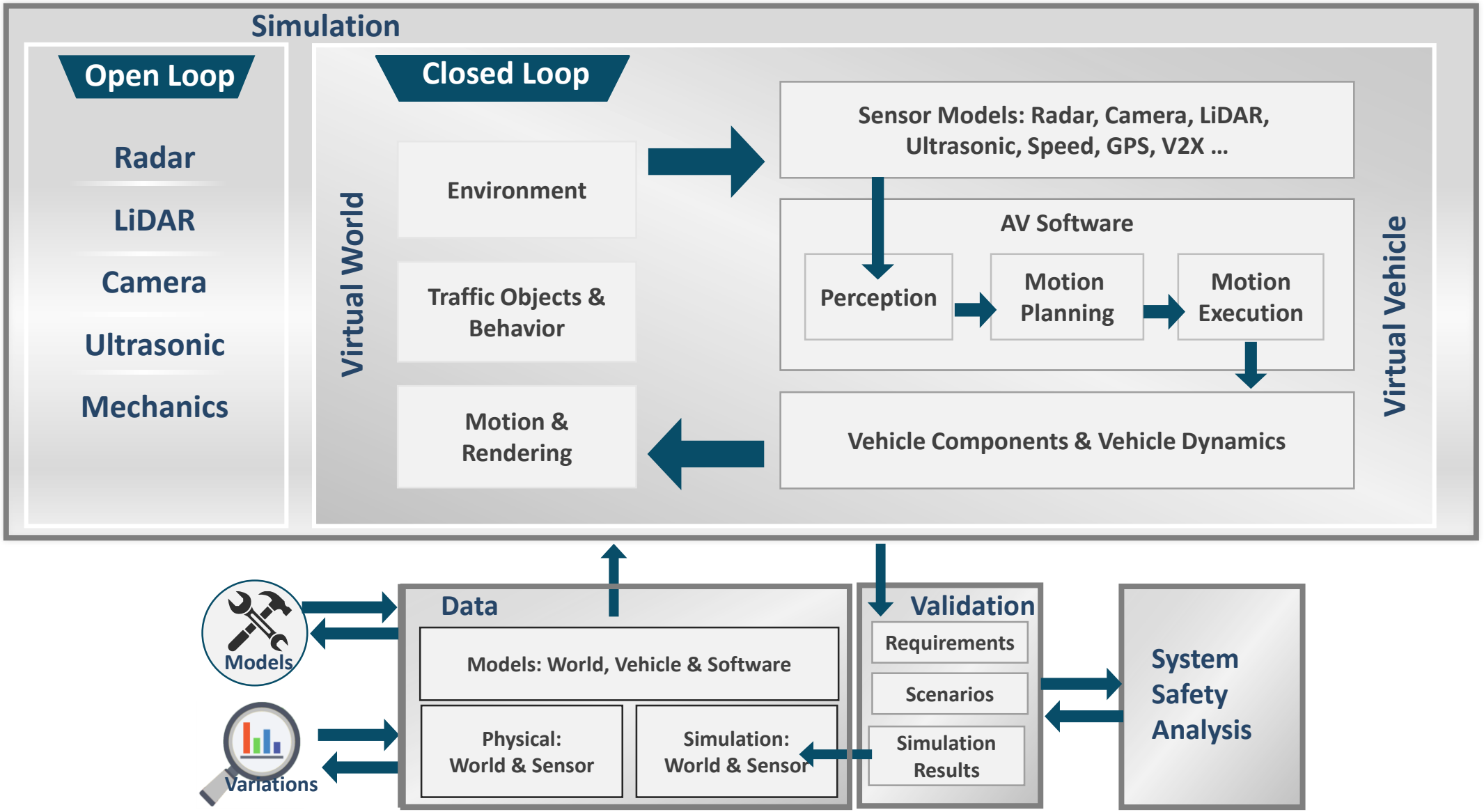
ANSYS Cloud – HPC as easy as it should be

1-click burst-to-the cloud	*Web-based 3D visualization*	*Highly optimized for ANSYS solvers*	*Single vendor solution for SW+HW*

Support for High Growth Solutions and Adjacencies

- Autonomous Vehicles
- Electrification and EV
- 5G
- Digital Twin
- Digital Exploration

ANSYS AV Open Simulation Environment



ANSYS Electrification Open Simulation Environment

For Product Design and Validation

Simulation

Component

- Battery
- Power Electronics
- Embedded Software
- Mechanics
- Busbar & Cables
- Electric Machine

System

Battery

Inverter

Busbar

Motor

Mechanics

Functional Safety

Embedded Software

Hardware in the Loop (HIL)

Multicore CPU
Mechanical & vehicle dynamics

PCI-Express

FPGA Firmware
Electrical motor & inverters

Signal Conditioning

Digital signal

Analog signal

Actual Controller

Data

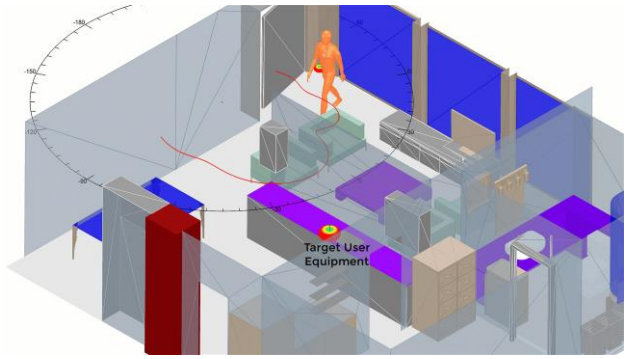
- Models: Components & Software Vendor or Supplier
- Physical Test & Measurement
- Simulation

Validation

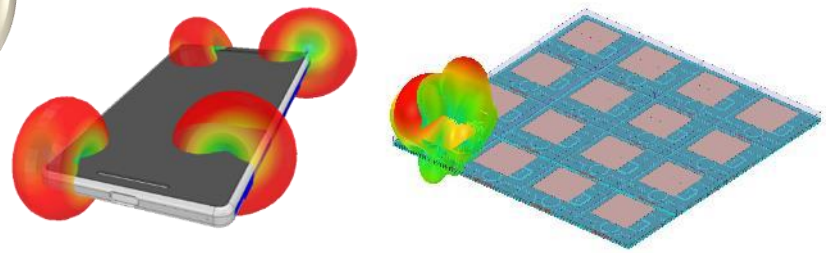
- Simulation Results
- Requirements

https://www.linkedin.com/pulse/impact-equipment-reliability-human-safety-dustin-m-etchison-cmrp/
https://tec.ieee.org/newsletter/september-2013/hardware-in-the-loop-hil-for-electric-drive-applications

ANSYS 5G Open Simulation Environment

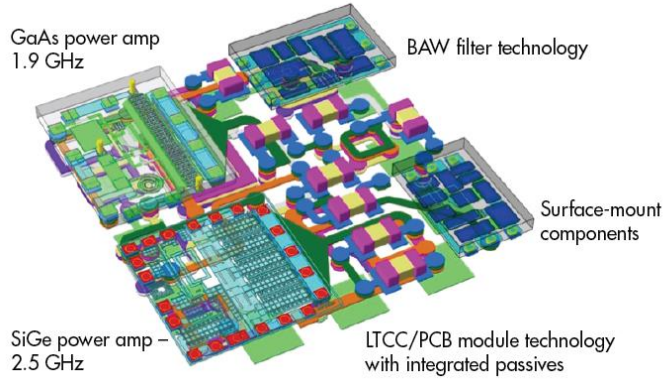


- Phased Array Beamforming
- Propagation and Channel Modeling



- Low Power Design
- SoC and IP Analysis
- Package & Board Reliability

- RFIC and RF Front-End Analysis



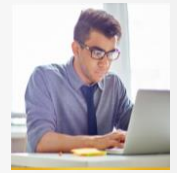
Model Courtesy : National Instruments

ANSYS Digital Twin Key Capabilities

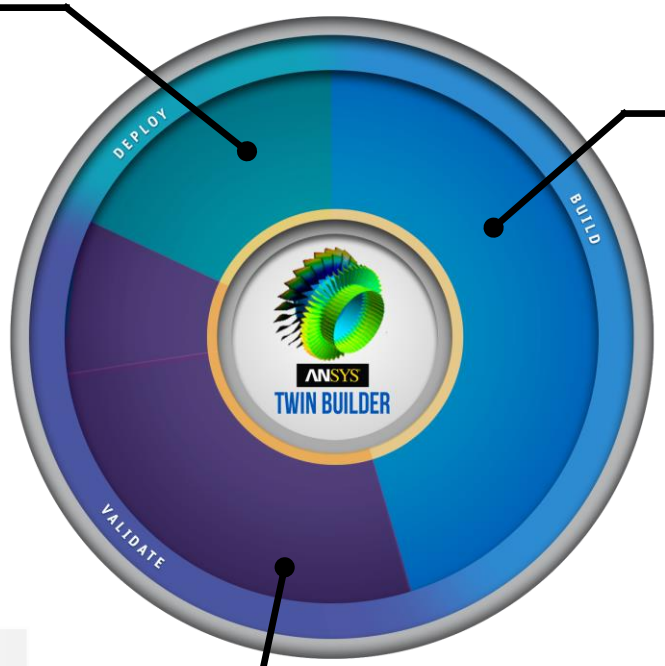
System Preventive Maintenance

CONNECT the TWINS to IIoT Platforms and DEPLOY TWIN Run times in OPERATION

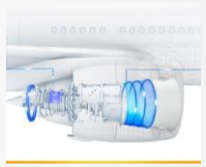
System Simulation



BUILD an accurate Physics-Based DIGITAL TWIN in record time



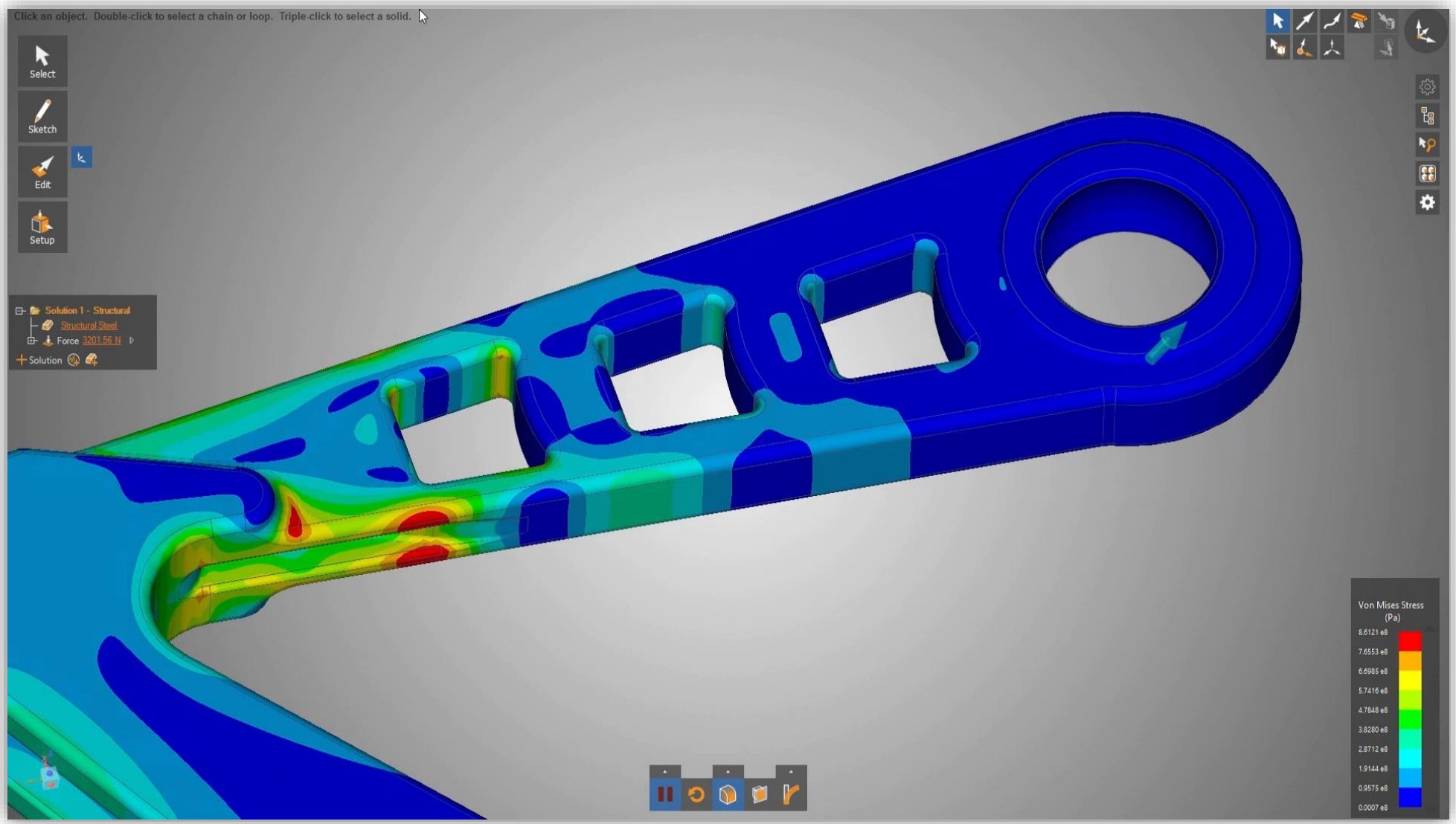
System Validation & Optimization



VALIDATE and OPTIMIZE the TWINS

ThingWorx
A PTC Business
PREDIX
SAP Leonardo
Other IoT Platform

ANSYS Discovery: Simulation for all engineers



Summary

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