Ansys Long Term Strategy for Simulation Based Product Innovation

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Chief Technology Officer, Ansys

Ansys

Changing the world through the power of simulation
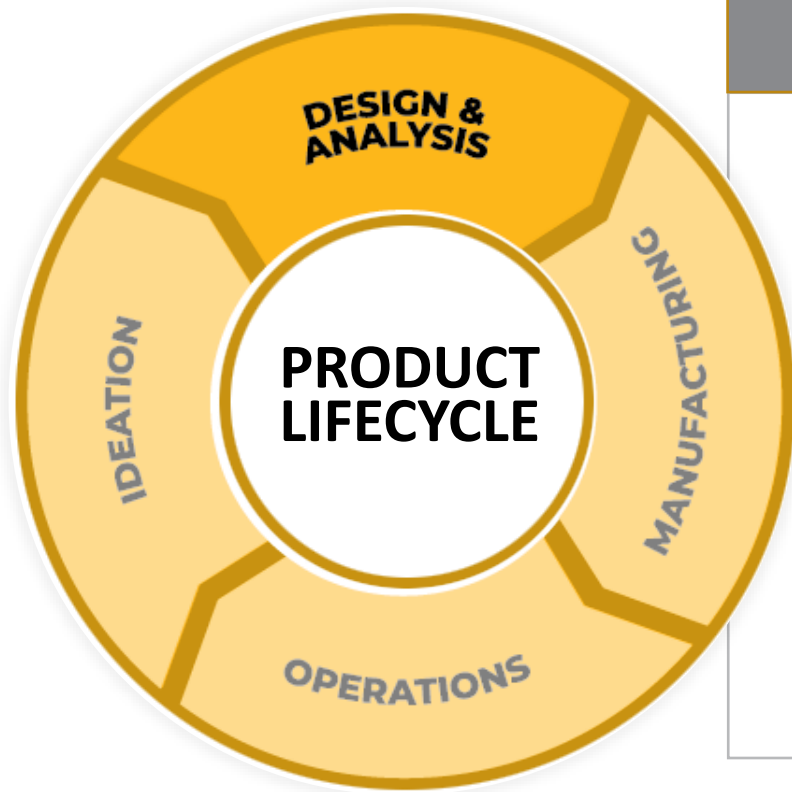

50 YEARS OF INNOVATION

Shatter Records

Unlock Possibilities

Make the Unmakeable

Save Lives

Ansys

Simulation based product innovation

PRODUCT LIFECYCLE

DESIGN & ANALYSIS · MANUFACTURING · OPERATIONS · IDEATION

Simulation impact

Rapid innovation

Lower cycle time
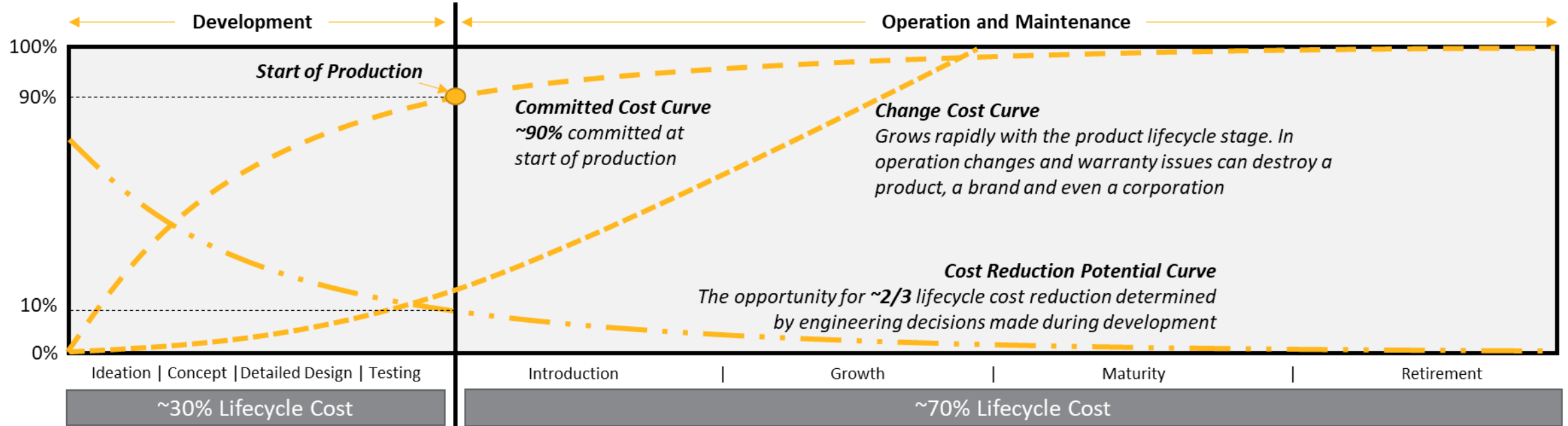
Reduced risks

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

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Simulation is critical to cost out across the product lifecycle

Development — ~30% Lifecycle Cost

Ideation | Concept | Detailed Design | Testing

Operation and Maintenance — ~70% Lifecycle Cost

Introduction | Growth | Maturity | Retirement

Start of Production

Committed Cost Curve
~90% committed at start of production

Change Cost Curve
Grows rapidly with the product lifecycle stage. In operation changes and warranty issues can destroy a product, a brand and even a corporation

Cost Reduction Potential Curve
The opportunity for ~2/3 lifecycle cost reduction determined by engineering decisions made during development

Quantified Impact of Simulation*

11% Reduction in physical prototypes

26% Greater Overall Equipment Effectiveness (OEE)
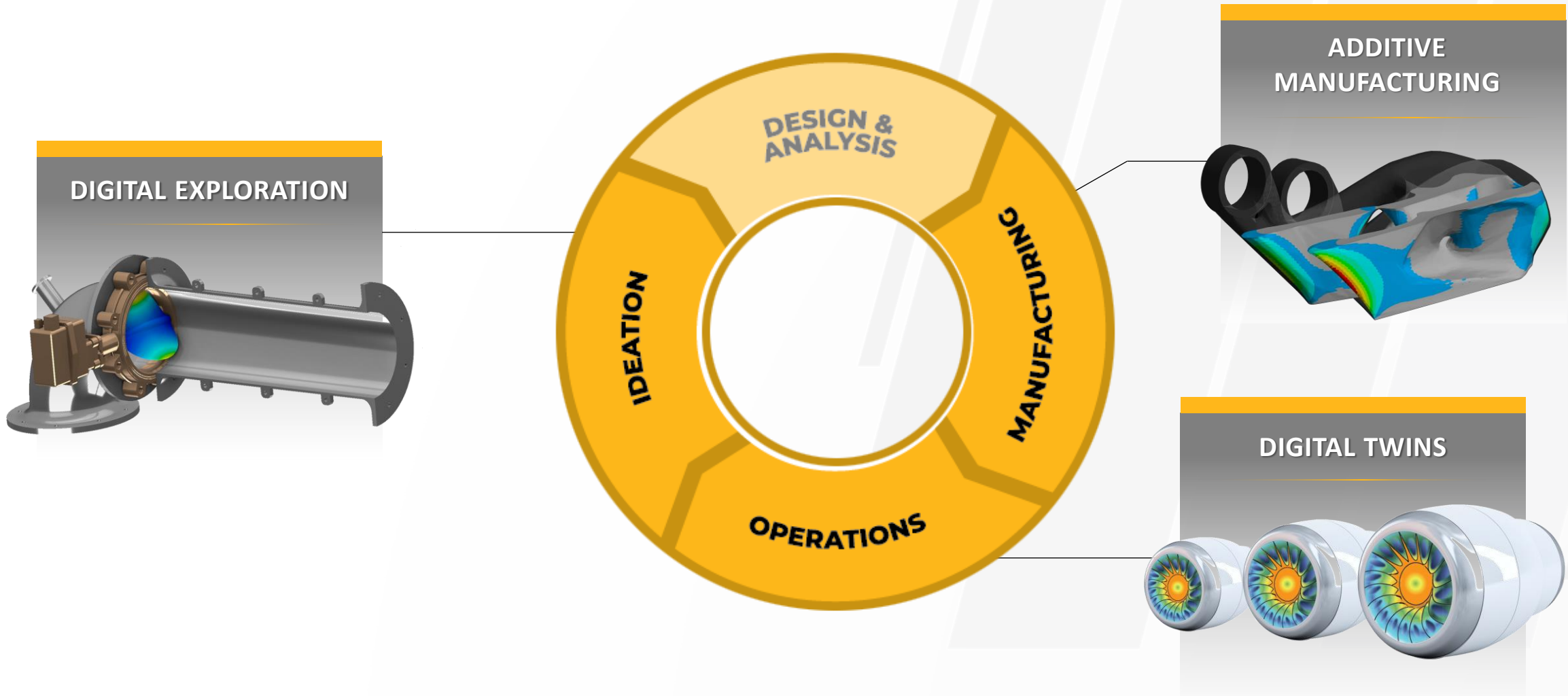
12% Improvement in meeting cost targets

14% Reduction in development time
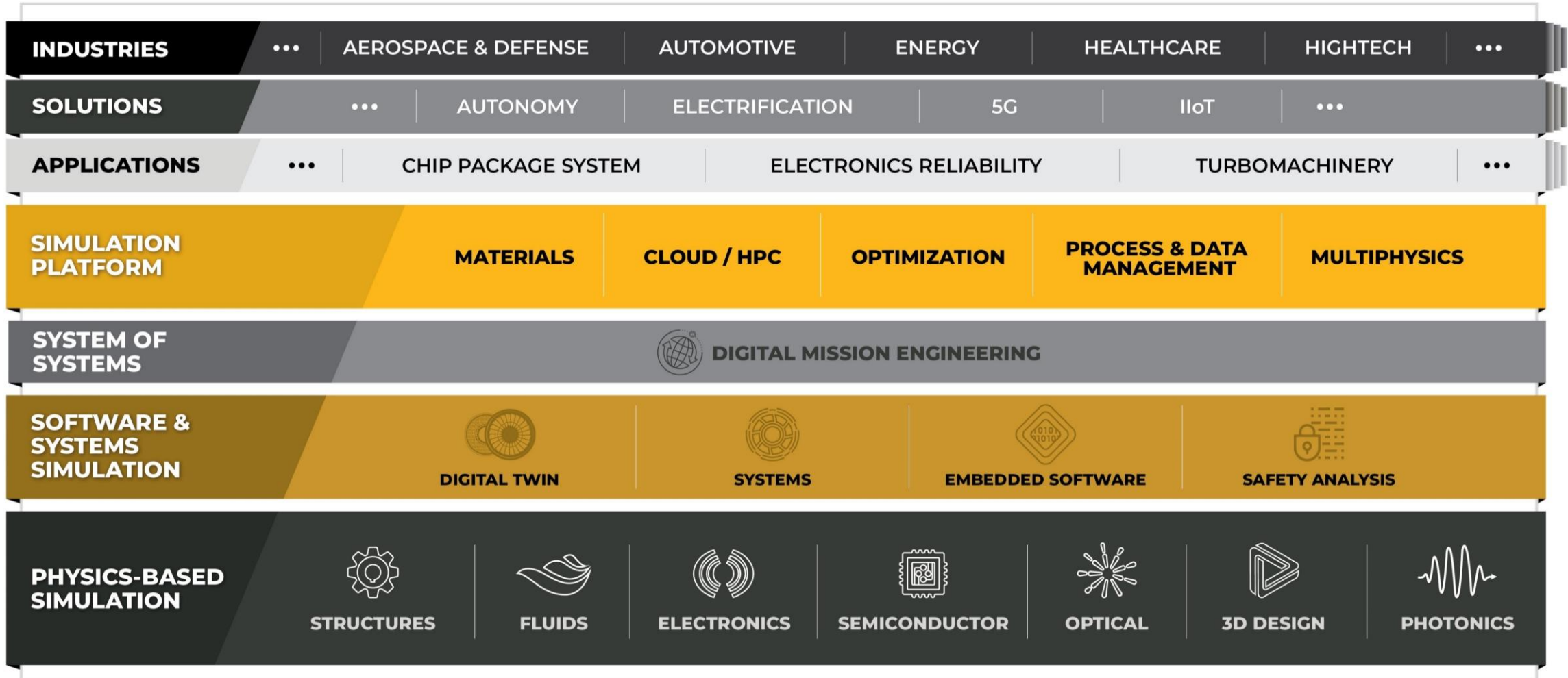
23% Greater Raw material utilization

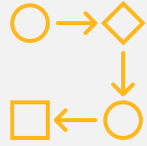**79%** Less likely to be concerned with recalls

*Aberdeen Group

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Pervasive simulation across the entire product lifecycle

DESIGN & ANALYSIS

IDEATION

MANUFACTURING

OPERATIONS

DIGITAL EXPLORATION

ADDITIVE MANUFACTURING

DIGITAL TWINS

Ansys product portfolio

| INDUSTRIES | ••• | AEROSPACE & DEFENSE | AUTOMOTIVE | ENERGY | HEALTHCARE | HIGHTECH | ••• |

| SOLUTIONS | ••• | AUTONOMY | ELECTRIFICATION | 5G | IIoT | ••• |

| APPLICATIONS | ••• | CHIP PACKAGE SYSTEM | ELECTRONICS RELIABILITY | TURBOMACHINERY | ••• |

SIMULATION PLATFORM — MATERIALS | CLOUD / HPC | OPTIMIZATION | PROCESS & DATA MANAGEMENT | MULTIPHYSICS

SYSTEM OF SYSTEMS — DIGITAL MISSION ENGINEERING

SOFTWARE & SYSTEMS SIMULATION — DIGITAL TWIN | SYSTEMS | EMBEDDED SOFTWARE | SAFETY ANALYSIS

PHYSICS-BASED SIMULATION — STRUCTURES | FLUIDS | ELECTRONICS | SEMICONDUCTOR | OPTICAL | 3D DESIGN | PHOTONICS

Ansys long-term technology strategy

NUMERICAL METHODS
- Solver methods: direct, iterative
- Finite element, finite volume, IGA
- Implicit, explicit, hybrid, Bayesian

AI/MACHINE LEARNING
- Analysis Productivity
- Augmented Simulation
- Data Driven, Physics Informed, ML Based

DIGITAL TWINS
- End to end solution architecture
- Data analytics/AI-ML/Hybrid
- Reduced Order Modeling

MESHING / GEOMETRY
- Non- & Conformal Meshing
- Morphing, Immerse-Boundary
- Parallel Meshing

HIGH PERFORMANCE COMPUTING
- Task based, Shared memory, message passing
- Fine grain (GPU)
- Exascale and quantum computing

ICME and Additive
- Materials Intelligence & Selection
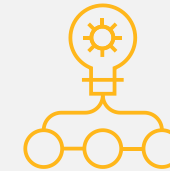- ICME & Multiscale Modeling
- Additive Science

VISUALIZATION AND UX/UI
- Augmented Reality/Virtual Reality
- Immersive User Experiences
- Safety Critical HMI
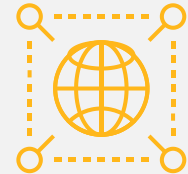
CLOUD
- Hybrid Cloud
- On-Prem, Private, Public
- HPC as a Service

SOLUTIONS
- Autonomy
- Electrification
- 5G

PLATFORMS/WORKFLOWS
- Multiphysics, Multi-domain, Multiscale
- Process Integration, & Optimization
- Simulation Process & Data Management

MODEL BASED SYSTEM ENGINERING
- Collaborative Architectural Modeling
- Virtual Verification and Validation
- Lifecycle Trade Analysis & Optimization

NEW VERTICAL HEALTHCARE
- Biopharma drug discovery
- Medical devices & equipment
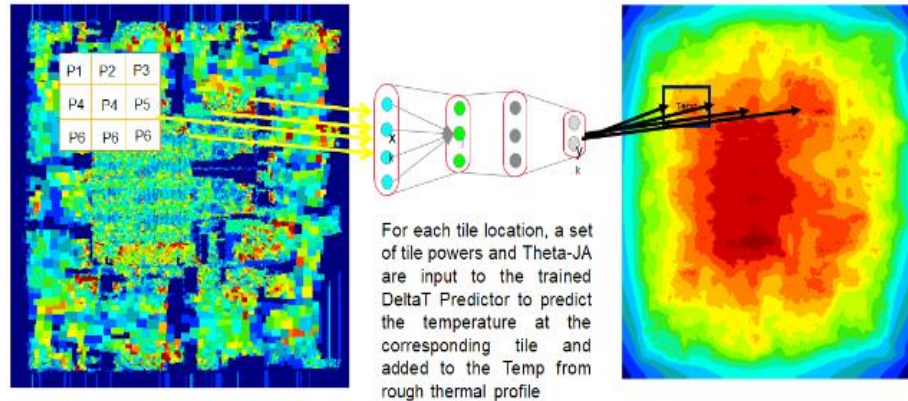- Clinical apps

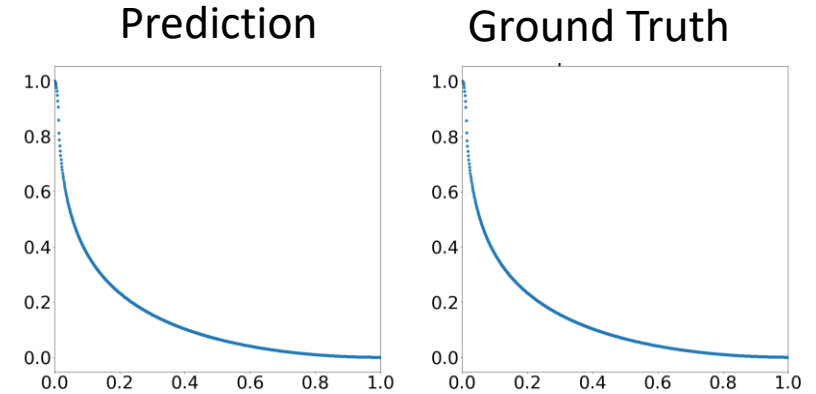**Ansys**

AI/ML initiative

Four Use Cases

- Customer productivity
  - ML for automatic setting of parameters in Ansys Discovery

- Augmented simulation
  - ML based flow solver

- Engineering design
  - Topology optimization

- Business intelligence
  - Resource estimates for solvers

- Partnerships with universities

# Augmented simulation: data-driven fast on-chip thermal solver

For each tile location, a set of tile powers and Theta-JA are input to the trained DeltaT Predictor to predict the temperature at the corresponding tile and added to the Temp from rough thermal profile

- Providing Inferencing by Striding Templates with One Tile for Predicting Temperature at all Tile Locations
- Goal: Train local temperature profile predictors for a "meta-algorithm" proposed by SCBU's Thermal artist
- The "meta-algorithm" calculates the global temperature distribution from local temperature profiles.

Static: Temperature decay curve from chip tile center (hot spot)

Prediction   Ground Truth

Transient: Temperature rise to steady state for chip tile center (hot spot)

Prediction   Ground Truth
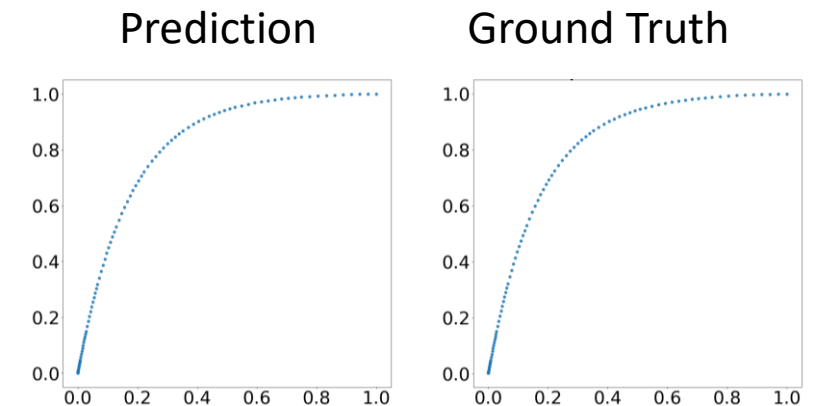
Augmented simulation: ML-based partial differential equation solver
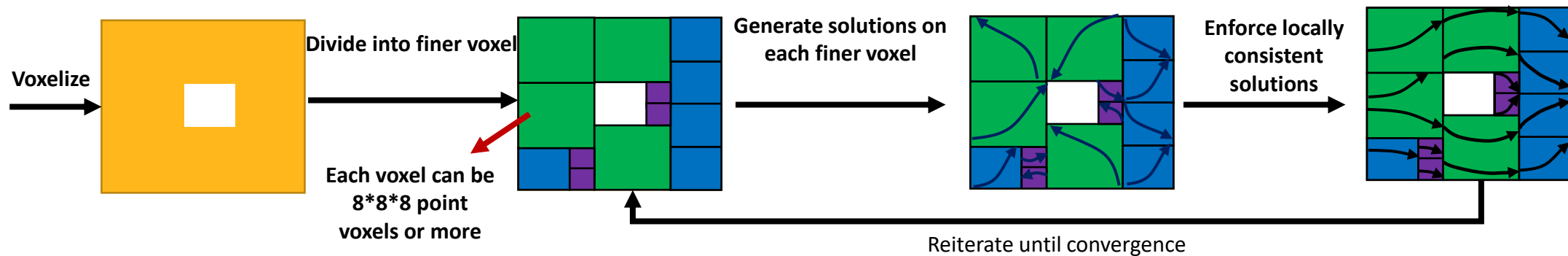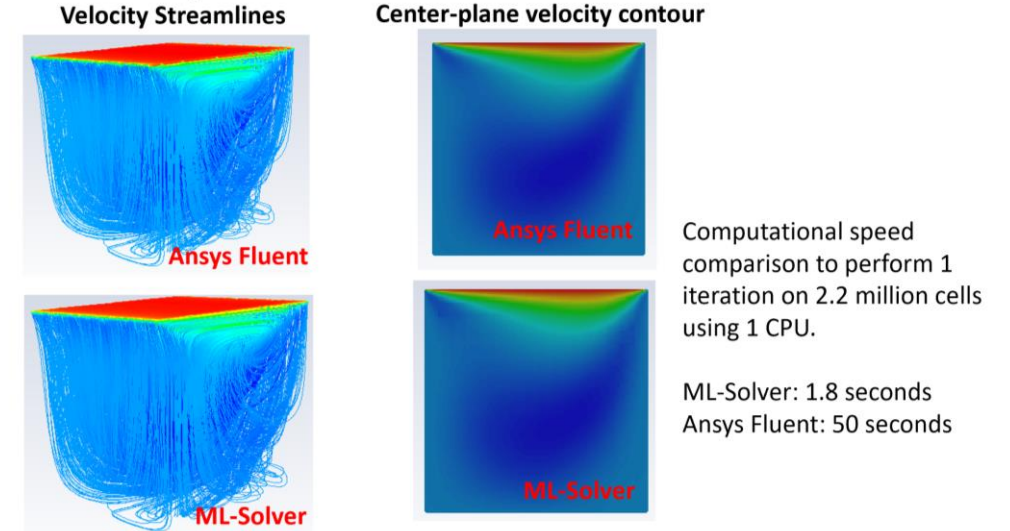
- **Motivation:**
  - Geometries and physics have lots of patterns.
  - Do we need to solve from scratch?
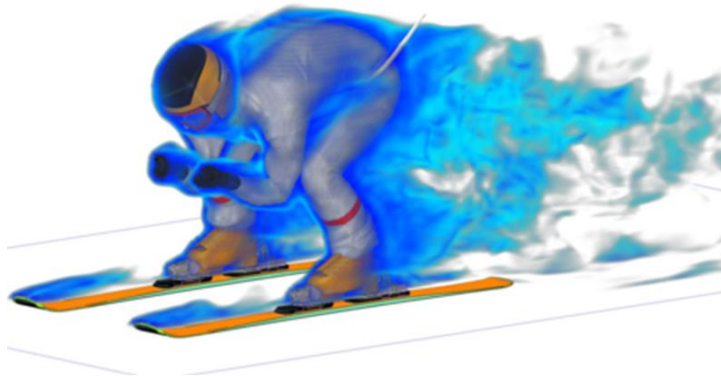   - No! Create solution instances on patches using a generative network
- **Key insights:**
  - Take a general domain and voxelize into patches
  - Decide boundary conditions for each patch
  - "Solve" for the latent vectors on each patch.
  - Requires learning a consistency condition between adjacent patches
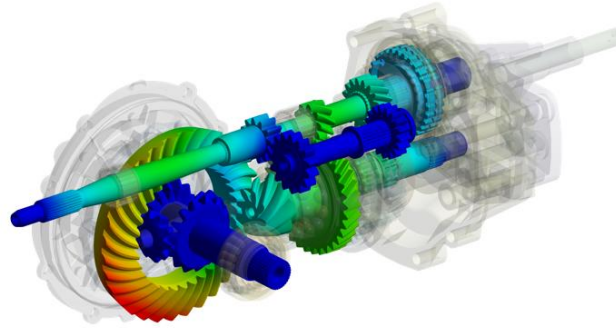 - More than 100X speedup in time to solution
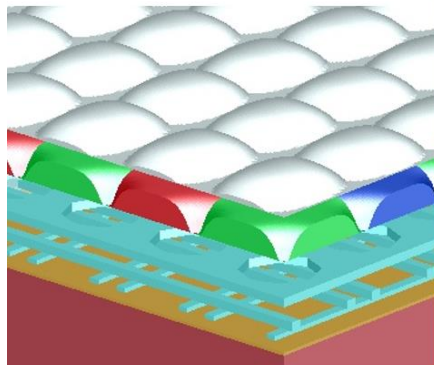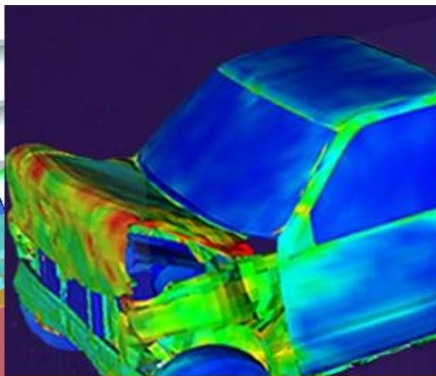
ML-Solver implementation verification

Velocity Streamlines   **Center-plane velocity contour**

Ansys Fluent

ML-Solver

Computational speed comparison to perform 1 iteration on 2.2 million cells using 1 CPU.

ML-Solver: 1.8 seconds
Ansys Fluent: 50 seconds

Voxelize → **Divide into finer voxel** → **Generate solutions on each finer voxel** → **Enforce locally consistent solutions**

Each voxel can be 8*8*8 point voxels or more

Reiterate until convergence

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High-performance computing

Fluent

Mechanical

Lumerical FDTD **LS-Dyna** **HFSS/SI-Wave**
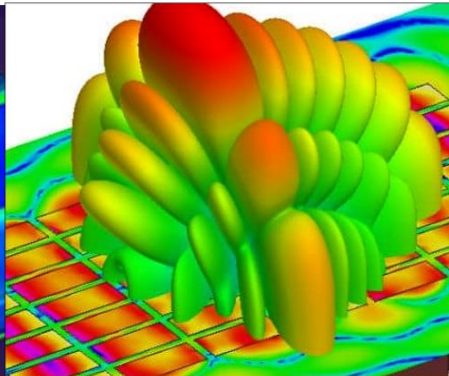
4 Layers of HPC

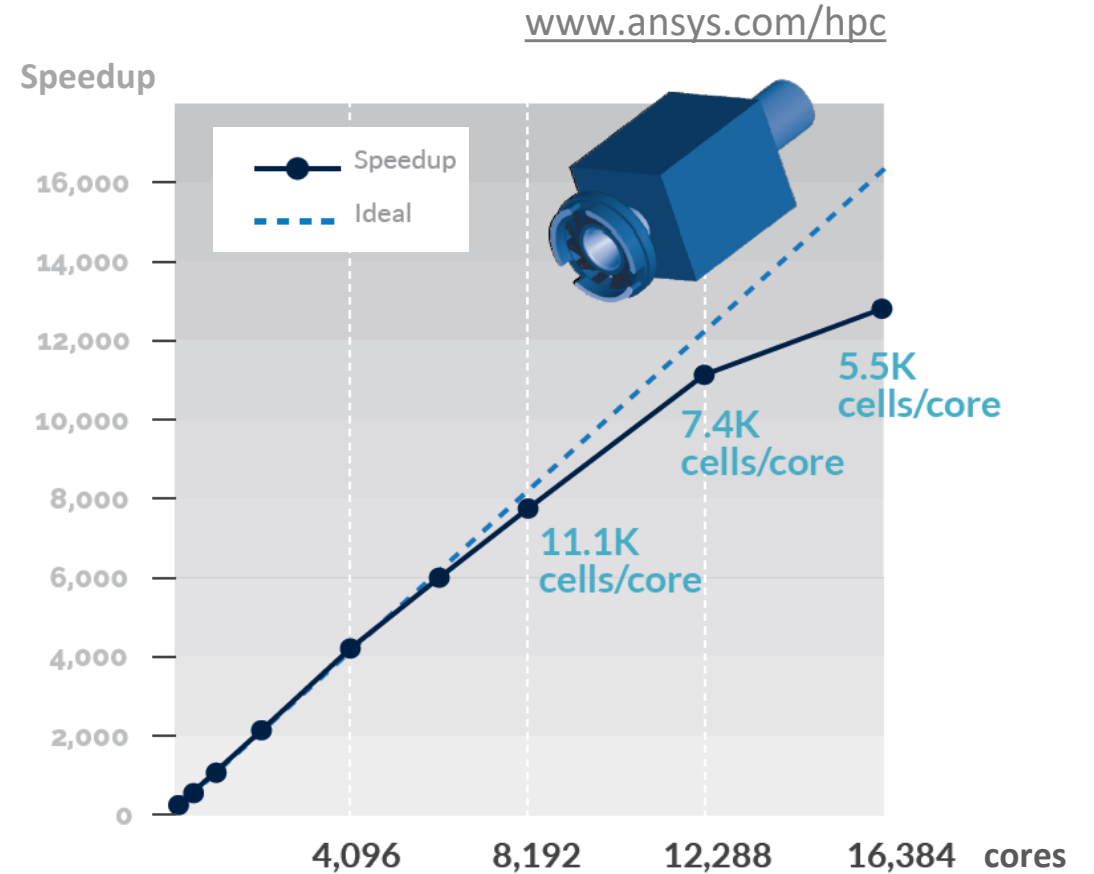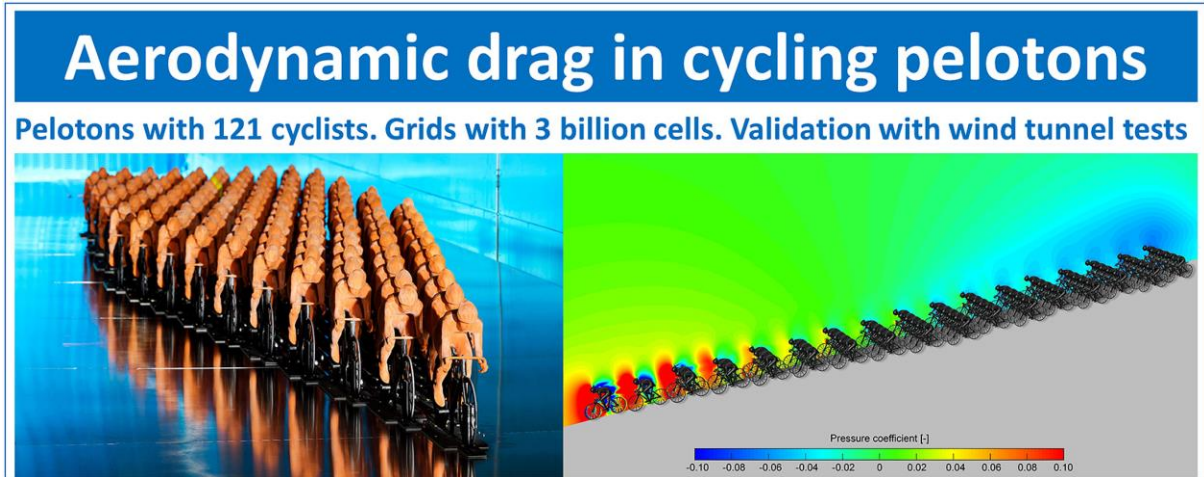|	
Parallel parametric analysis	HPC job scheduler
Domain decomposition	MPI – NUMA & Distrib. Mem. cluster
Parallel tasks/loops	Multicore / Multithread
SIMD vector processing GPU/TPU parallelism	Intra-core / GPU/TPU

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Ansys Fluent: sustained focus on HPC software development

Teams at Saudi Aramco using the Shaheen II at King Abdullah University of Science and Technology (KAUST) supercomputer have managed to scale ANSYS Fluent across 200,000 cores, marking top-end scaling for the commercial engineering code.

ANSYS, Saudi Aramco and teams from KAUST sped up a complex simulation of a separation vessel from several weeks to an overnight run. This simulation is critical to all oil and gas

Aerodynamic drag in cycling pelotons

Pelotons with 121 cyclists. Grids with 3 billion cells. Validation with wind tunnel tests

Pressure coefficient [-]
-0.10 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.10

Speedup

Speedup
Ideal

16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0

5.5K cells/core
7.4K cells/core
11.1K cells/core

4,096   8,192   12,288   16,384   cores

Demonstrated scalability of Ansys Fluent above 80 percent efficiency with as low as 5,500 cells per compute core

Multi-GPU CFD, GPU-CPU comparison, 96M car case

dgx1 system, using 6 Tesla V100 GPUs, compared to in-house Intel cluster

- Running from 64 cores to 512 cores
- Intel(R) Xeon(R) Gold 6242, Cascade Lake, 32 cores per node

Fluent **scales linearly** in this case, and the rating reached is about 830 with 512 cores

- Projected performance is about 1670 at 1024 cores

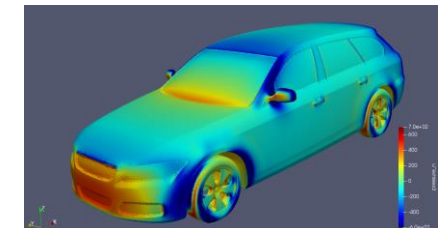**GPU Solver scales linearly** from 3 to 6 GPUs; rating is about 850 with 3 V100 GPUs, and 1700 with 6

- 6 V100 GPUs ≈ 1024 cores on 32 nodes, while 3 GPUs ≈ 512 cores on 16 nodes

Car_96M Flow + Turbulence
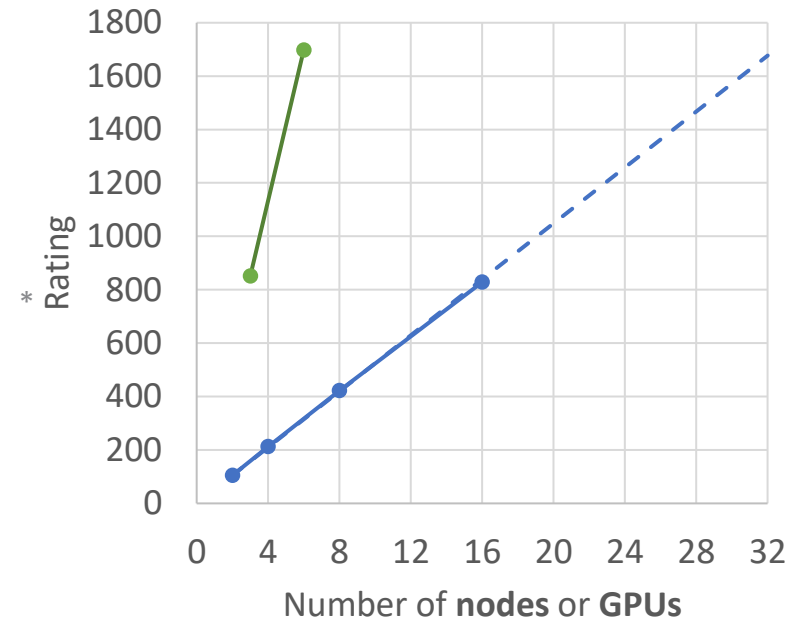
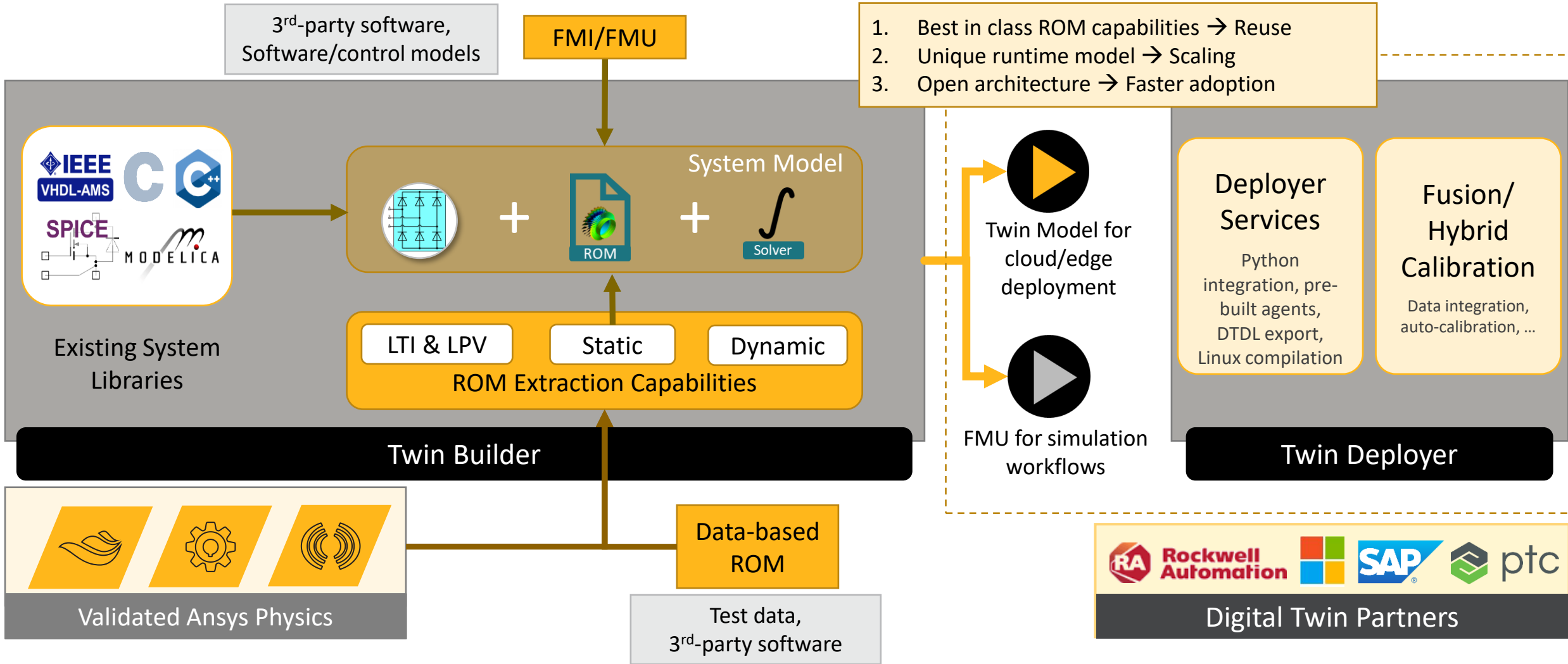- CPU Rating
- GPU Rating
- CPU Ideal

Y-axis: *Rating (0 to 1800)
X-axis: Number of **nodes** or **GPUs** (0 to 32)

*Rating: How many jobs can be finished in a day for a fixed number of iterations/steps for a fixed problem size

Digital Twins

3rd-party software, Software/control models

FMI/FMU

1. Best in class ROM capabilities → Reuse
2. Unique runtime model → Scaling
3. Open architecture → Faster adoption

Twin Builder

Existing System Libraries

System Model

+ ROM + ∫ Solver

ROM Extraction Capabilities
- LTI & LPV
- Static
- Dynamic

Validated Ansys Physics

Data-based ROM

Test data, 3rd-party software

Twin Model for cloud/edge deployment

FMU for simulation workflows

Twin Deployer

Deployer Services

Python integration, pre-built agents, DTDL export, Linux compilation

Fusion/Hybrid Calibration

Data integration, auto-calibration, ...

Digital Twin Partners

Rockwell Automation   SAP   ptc

Ansys

Hybrid Digital Twins

- Hybrid analytics combines data and physics to create the best possible twin
- Leverages the entire Ansys portfolio to combine system (top-down) with 3D (bottom-up)
- Hybrid analytics add-on developed for deployed digital twins
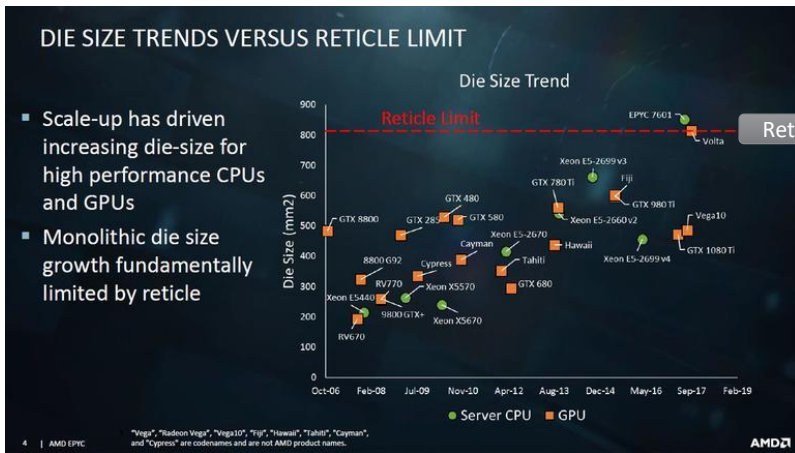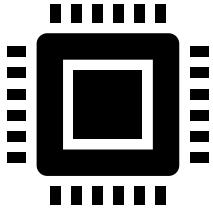- Fusion capability to augment with data when available

Accuracy

Both: ~98%

Sim: ~90%

Data: ~80%

Combined Flow Rate

Data — Nominal — MAP — ML Model
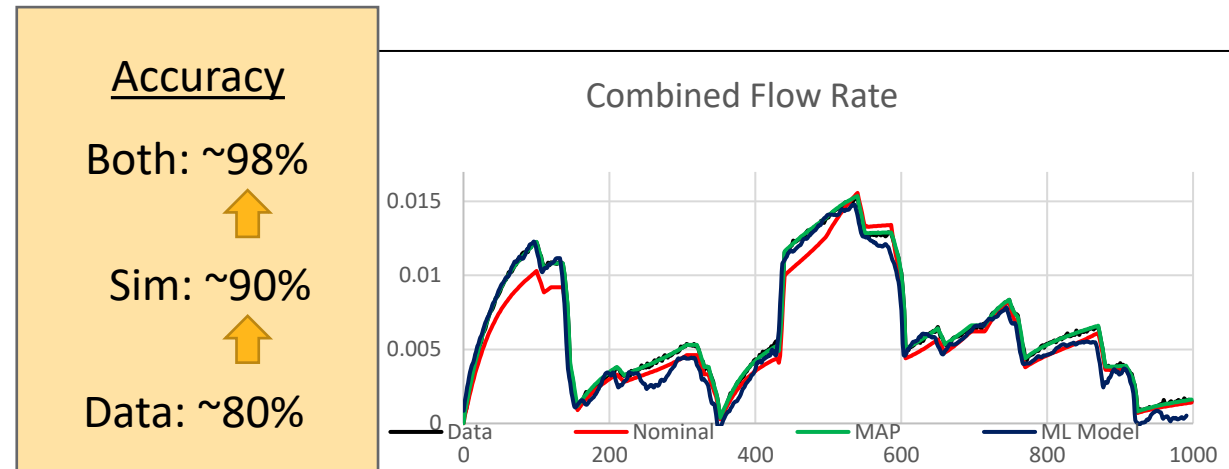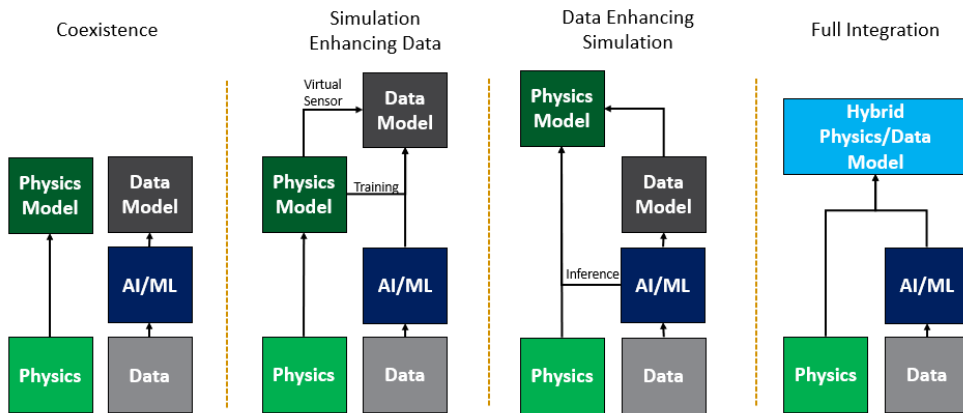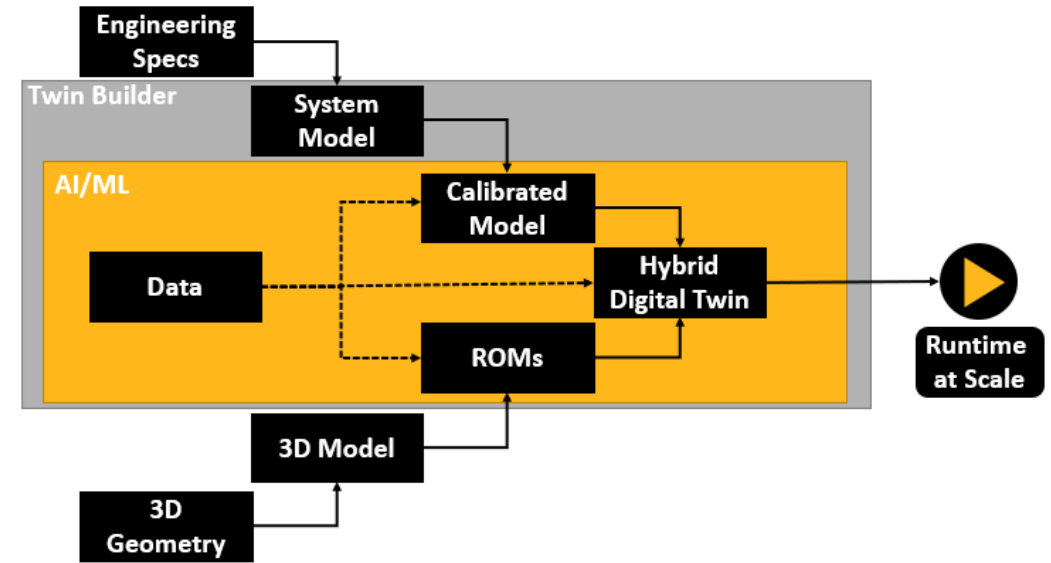
*manuscript submitted to IEEE special magazine on Digital Twins

Semiconductor Challenges – HPC, 5G, AI, Autonomy
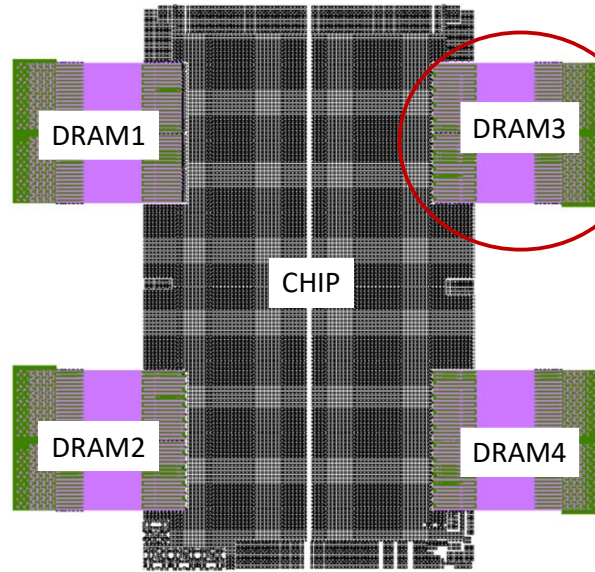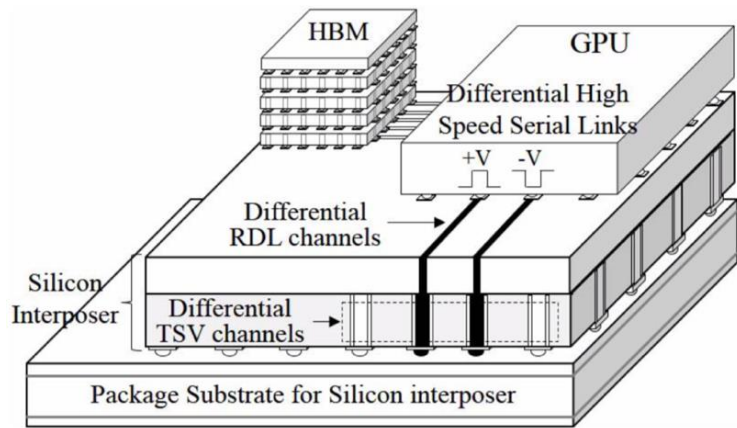
250W+
System

112Gbps+
Data Rate

54B+
Transistors

DIE SIZE TRENDS VERSUS RETICLE LIMIT

- Scale-up has driven increasing die-size for high performance CPUs and GPUs
- Monolithic die size growth fundamentally limited by reticle

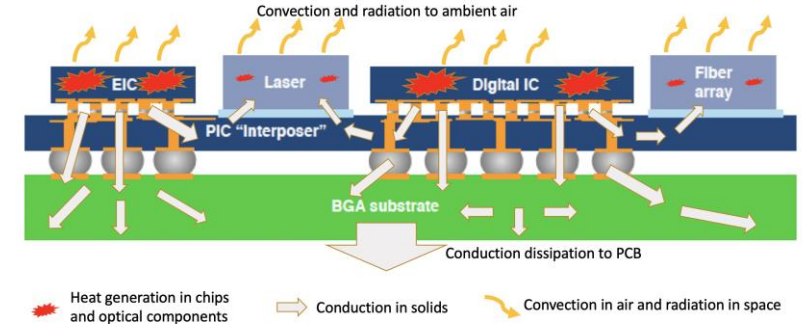|		
Power		> 250 W
High speed		> 112 Gbps PAM4
Miniaturization		3D IC
Thermal reliability		-40°C to +125°C
EMI/EMC		CISPR/IEC/ISO/SAE
Reliability and life		10 Years

Reticle limit defines the maximum X, Y space   Continued innovation drives expansion into X, Y, and Z axes

Ansys

Electronics and Semiconductor Unifying Themes

HBM — GPU

Differential High Speed Serial Links

+V   -V

Differential RDL channels

Silicon Interposer

Differential TSV channels

Package Substrate for Silicon interposer

Power Integrity   **Thermal Integrity**   **Signal Integrity**

Power   **Thermal**   **Mechanical**   **Electromagnetics**

20+ 3D-IC tapeouts with RedHawk-SC in 2020

3D-IC (stacked die)
Multiphysics
nightmare

DRAM1   DRAM3

CHIP

DRAM2   DRAM4

Lumerical and Ansys Multiphysics for Silicon Photonics

Convection and radiation to ambient air

EIC   Laser   Digital IC   Fiber array

PIC "Interposer"

BGA substrate

Conduction dissipation to PCB

Heat generation in chips and optical components   Conduction in solids   Convection in air and radiation in space

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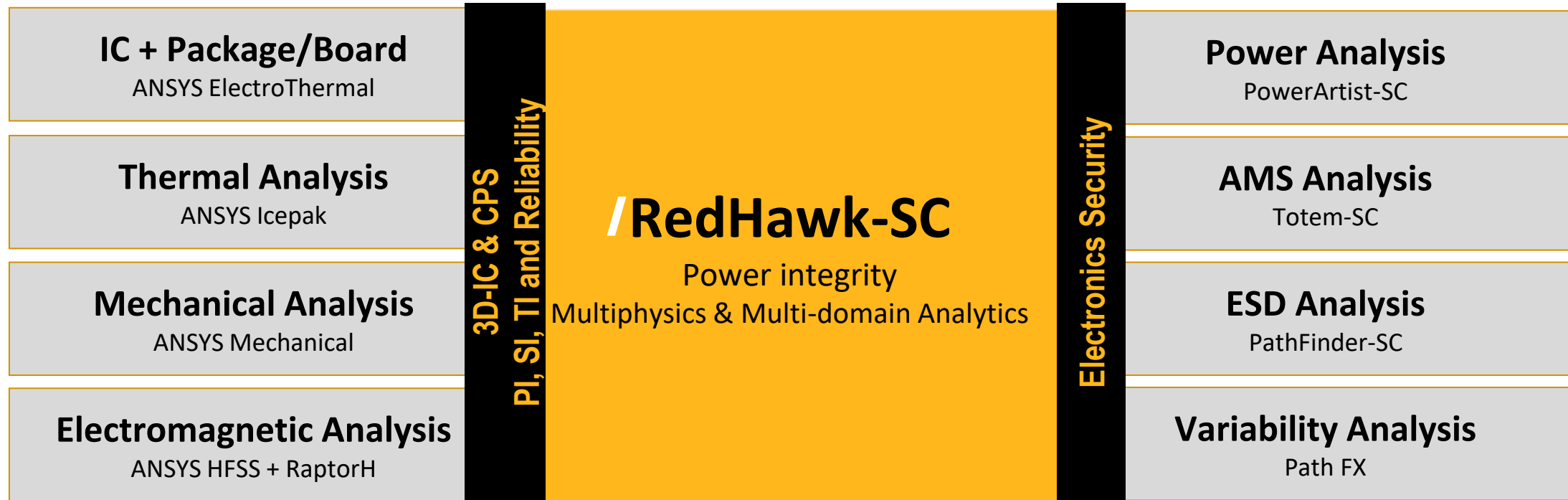

~180ps

~40ps

Time [ps]

Multiphysics Solutions for SI/PI/TI/Reliability
(**Electromagnetics, Optics, Thermal**) x (Die, 3D-IC, Package, Board)

Power Integrity & Reliability Analytics
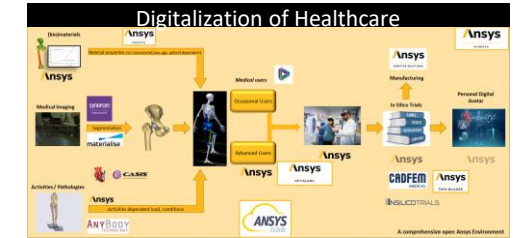## *RedHawk-SC* – *Solution for On-chip Multiphysics*

IC + Package/Board ANSYS ElectroThermal		**Power Analysis** PowerArtist-SC
Thermal Analysis ANSYS Icepak	**/RedHawk-SC** Power integrity Multiphysics & Multi-domain Analytics	**AMS Analysis** Totem-SC
Mechanical Analysis ANSYS Mechanical		**ESD Analysis** PathFinder-SC
Electromagnetic Analysis ANSYS HFSS + RaptorH		**Variability Analysis** Path FX

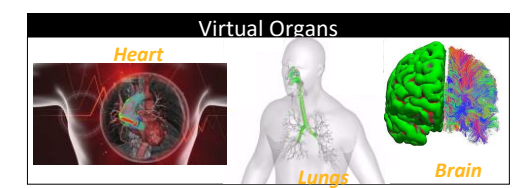**3D-IC & CPS PI, SI, TI and Reliability**

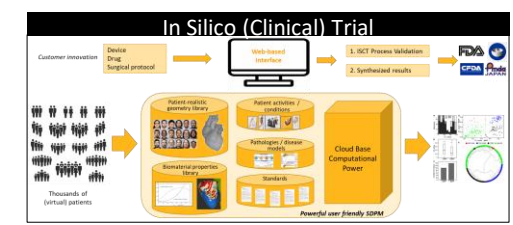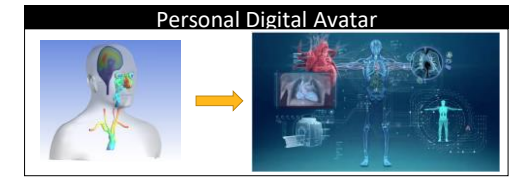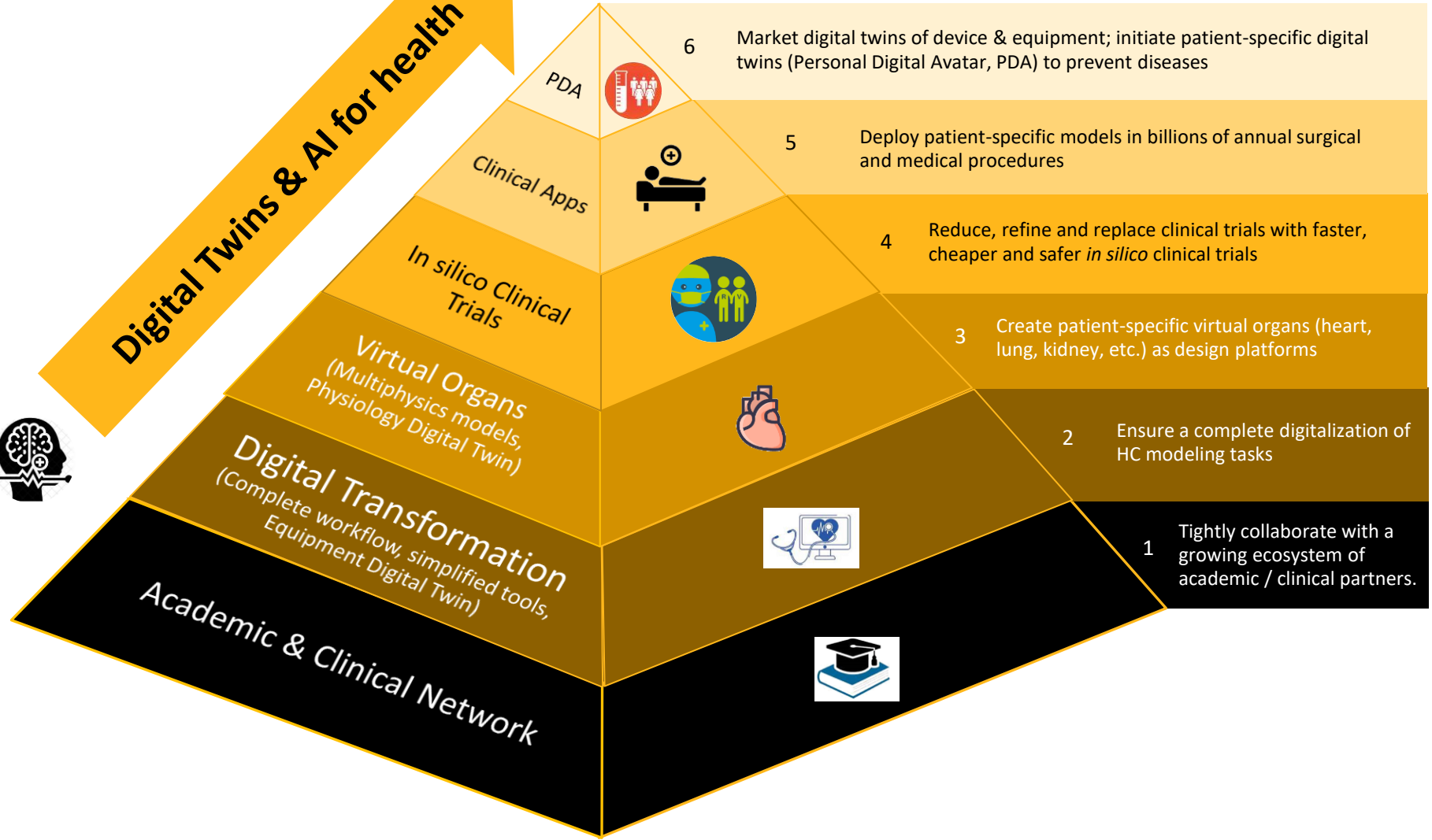**Electronics Security**

/SeaScape Big Data Platform

Actionable Analytics - Machine Learning/AI - Elastic Compute - Visualization and Debug

/Ansys

Healthcare

Digital Twins & AI for health

Pyramid (bottom to top):

Academic & Clinical Network

Digital Transformation (Complete workflow, simplified tools, Equipment Digital Twin)

Virtual Organs (Multiphysics models, Physiology Digital Twin)

In silico Clinical Trials

Clinical Apps

PDA

6. Market digital twins of device & equipment; initiate patient-specific digital twins (Personal Digital Avatar, PDA) to prevent diseases

5. Deploy patient-specific models in billions of annual surgical and medical procedures

4. Reduce, refine and replace clinical trials with faster, cheaper and safer *in silico* clinical trials

3. Create patient-specific virtual organs (heart, lung, kidney, etc.) as design platforms

2. Ensure a complete digitalization of HC modeling tasks

1. Tightly collaborate with a growing ecosystem of academic / clinical partners.

Right side panels:

Personal Digital Avatar

Clinical Applications

Optimeyes

In Silico (Clinical) Trial

Virtual Organs

Heart

Lungs

Brain

Digitalization of Healthcare

Ansys

Building clinically validated patient specific models of virtual organs as a platform to treat chronic diseases

- **High-fidelity** simulation of patient specific organs.

- **General framework** to test medical devices in diseased organs in-silico.

- **All physics included** in a single compact package.

- High scalability to thousands of cores.

- **Flexible interface** connecting with Twin Builder for a more realistic simulation of the full system.

- **Strong interaction with industry and academia** provides realistic expectations and goals.
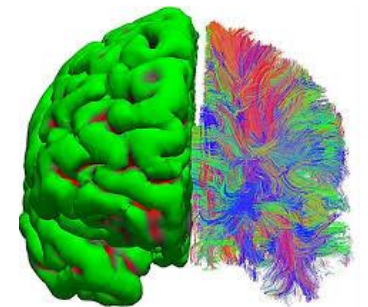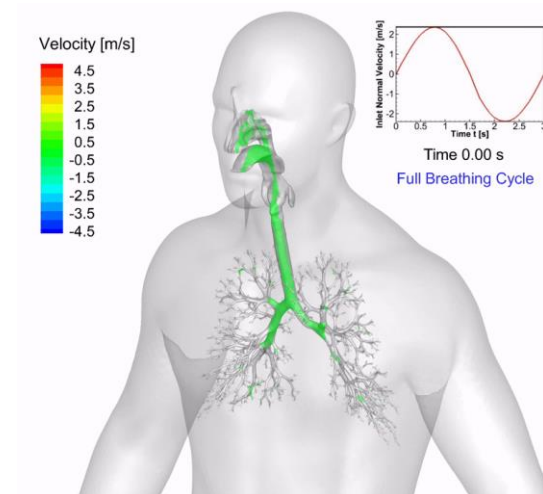
Degenerative diseases, concussion, aneurysms

In silico clinical trials (ISCT) test the treatment before manufacturing the first prototype
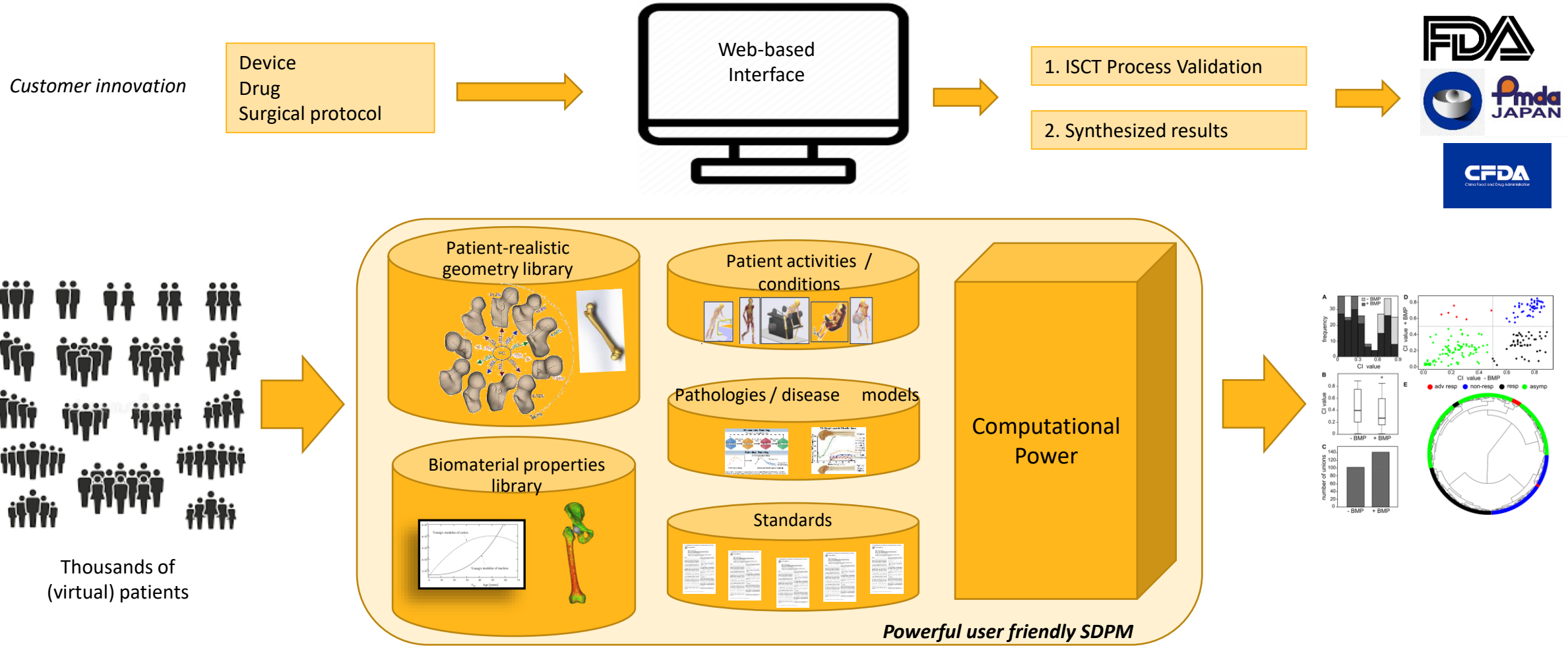
Summary

- Simulation is at the center of virtual prototyping
  - Moving from hardware prototyping and testing to software prototyping and validation and verification
- Simulation allows our customers to grow top-line revenue and bottom-line savings
  - Rapid innovation, lower cycle time, lower risks, increase quality manage complexity
- Ansys provides the broadest and deepest simulation platform in the industry with the leading physics solvers
- AI/ML and HPC (enabled by GPUs) are two ways of rapidly accelerating simulation for product innovation