Digital Twins and Omniverse Workloads and System Design

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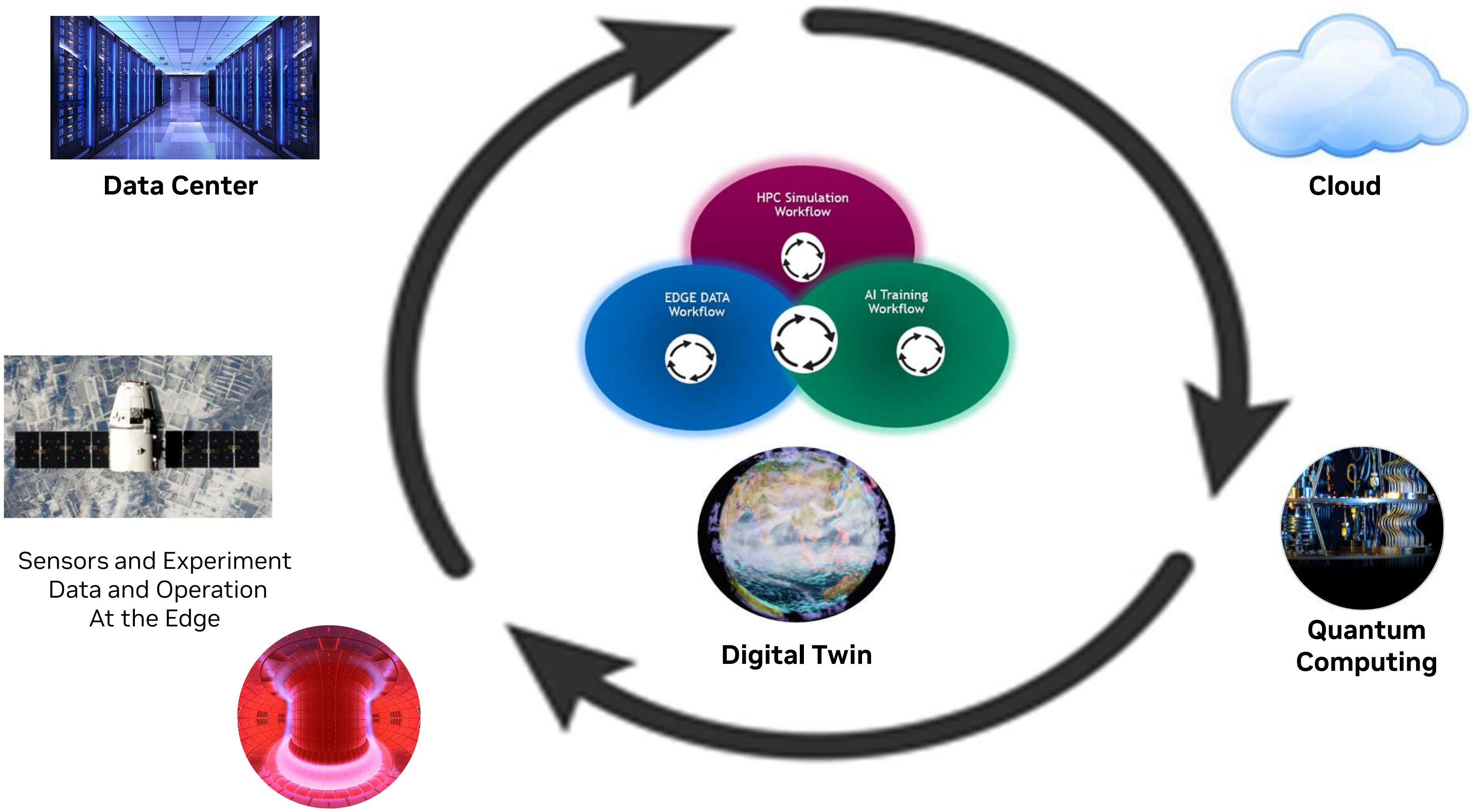
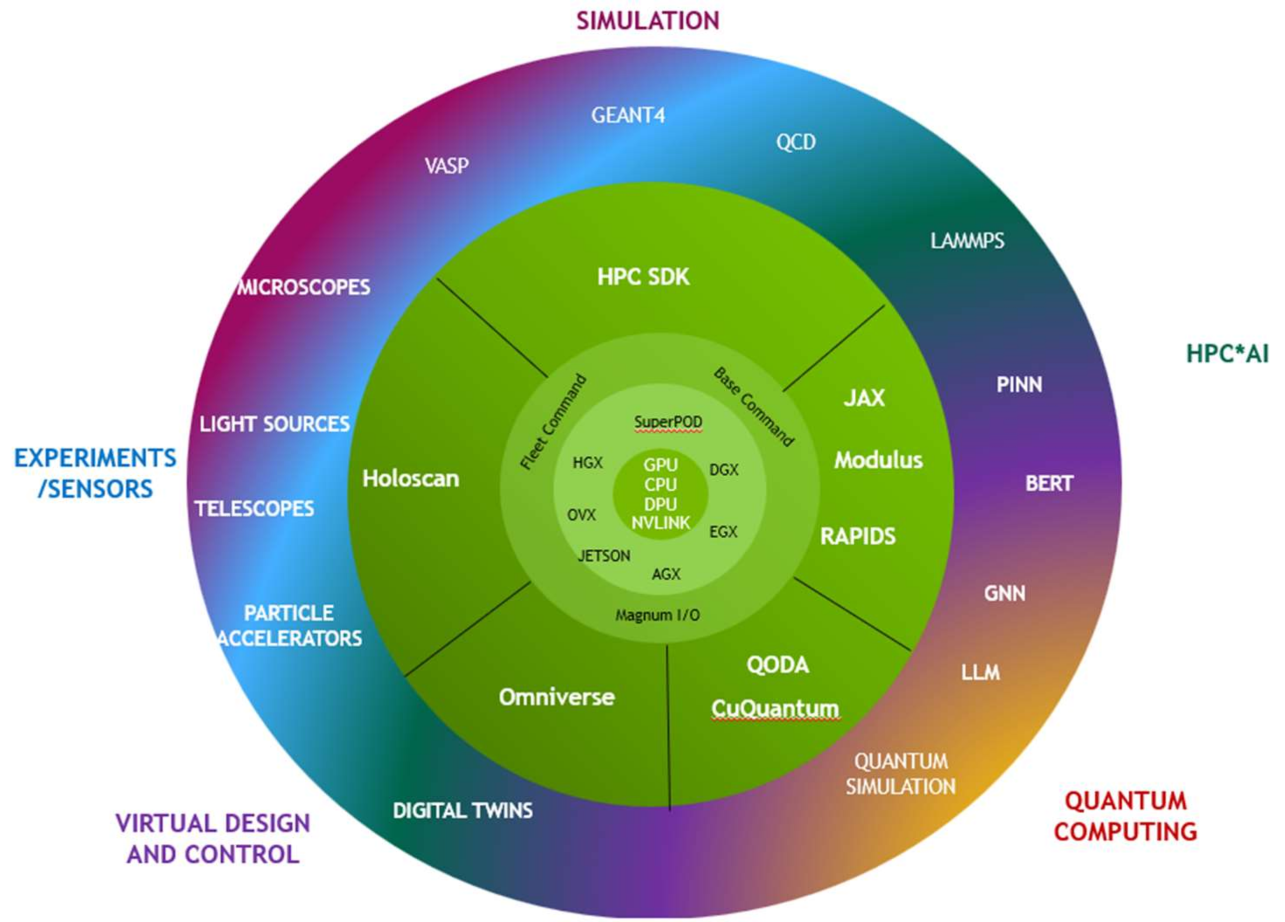
Composite Workflows Emerging

Being Developed to Address the challenge of full-scale science models



NVIDIA PLATFORM TO DEVELOP A DIGITAL TWIN



DIGITAL TWIN OVERVIEW

Physical System

Physical Asset that we would like to model

Early Examples

- Data Center
- Factory Operation
- Fusion Reactor
- Climate
- Hazardous Weather
- Drug Development Lab
- Drive Sim

"Blueprint"

Describe what we want the Twin to do

High level outline of the model flow and how the digital assets will be combined

Identify the digital assets that will be needed

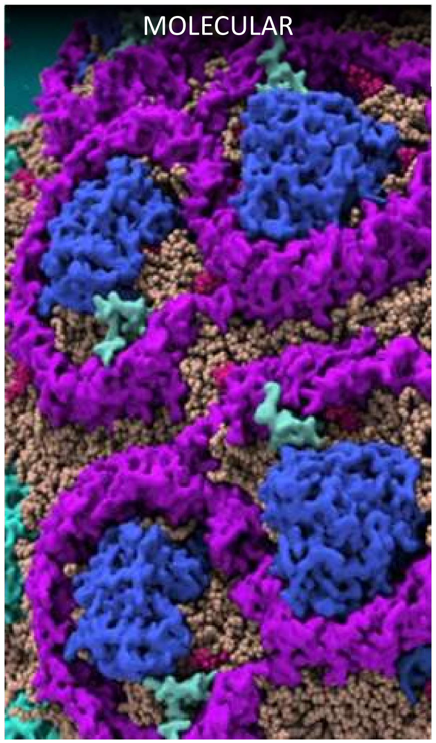
Digital Twin

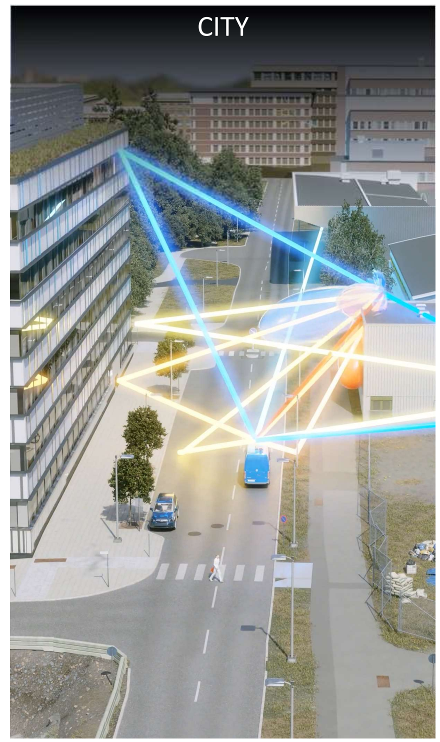
Generic Definition
An interactive model with real world scope and scale

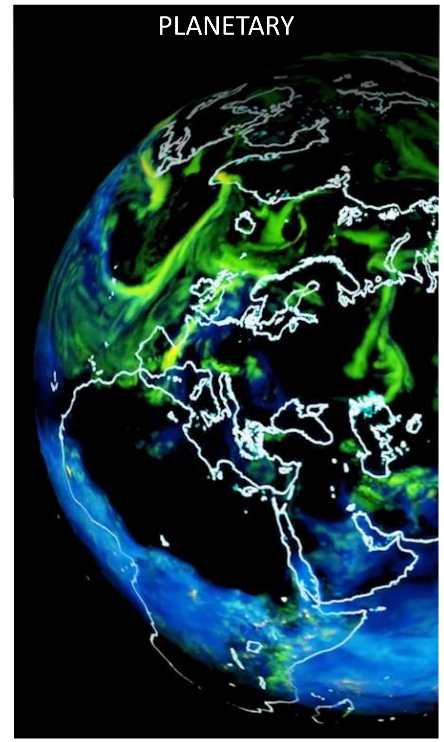
Scientific Twin
The model includes components with the accuracy and detail required for the model to support new science discovery and/or ingest live data to improve the operation of the physical system

Engineering Twin
The model includes components with the accuracy and detail required for the model to support optimizing the design and manufacturing process and monitor the physical system for the lifetime of a new or existing product.
Monitoring

DIGITAL TWINS WILL EXIST AT EVERY SCALE







BLUEPRINT

Define The GOAL

Describe what we want the Twin to do

- Optimize the PLM for a new Fusion Reactor
- Improve the control system for a new or existing Fusion reactor
- Model the Climate and impact of approaches to limit carbon in the atmosphere
- Provide hazardous weather response

Outline Model Flow

High level outline of the model flow and how the digital assets will be combined

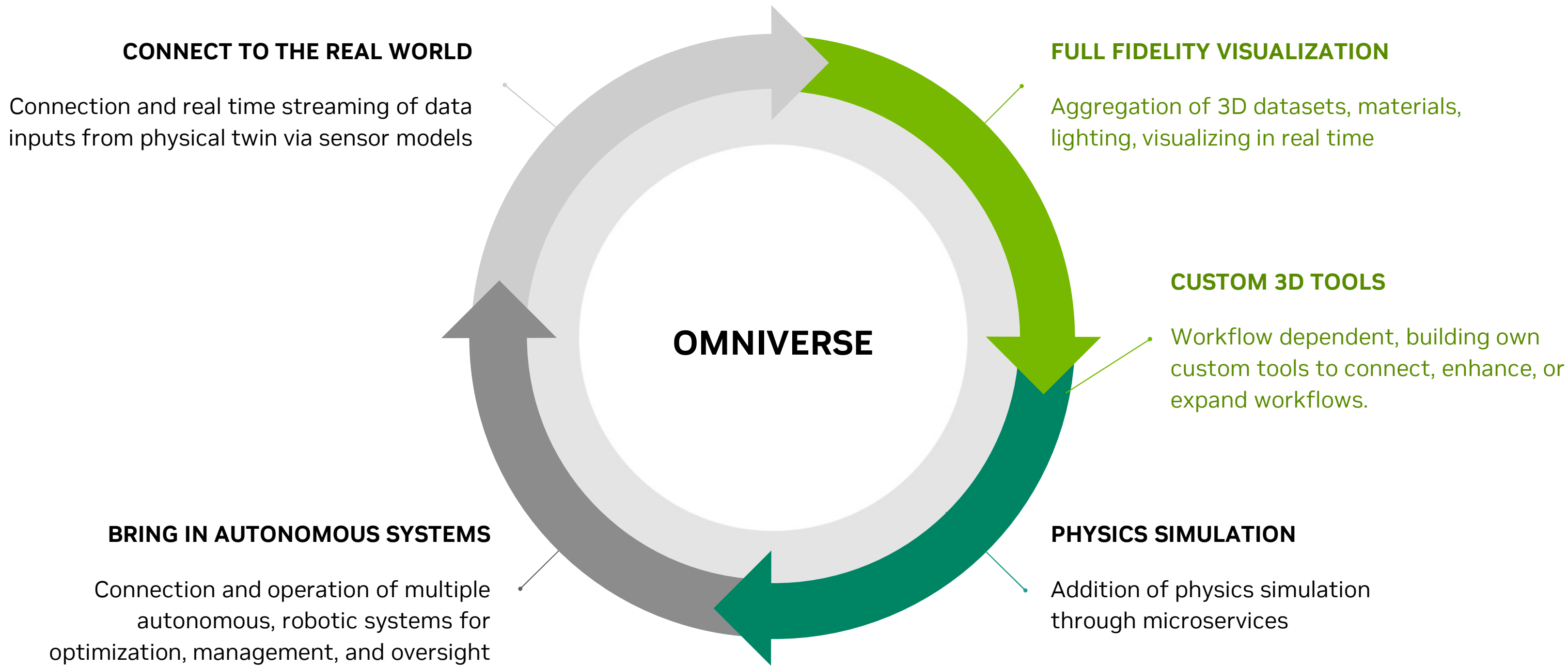
- As new parts are tested live or virtually the twin and PLM tools are synchronized
- The twin gathers data from the recent shot and provides updates to the prediction and recommender system that control the experiment
- A full scale model of the earth and atmosphere that can show trade offs with carbon input as a variable
- A model that connects sensors gathering data on the weather and the earth that can evaluate risk and mitigation and provide update to response teams in real time

Define the Digital Assets Required

- Fusion CAD tools (MOOSE), PLM tools, CAD Files …….
- Connector for EPIC Control system, Surrogate models of core and edge plasma, disruption predictor models, recommender system model, CAD files ……
- Legacy simulation with surrogates for key portions of the model…..
- Connectors for sensor inputs and response teams, surrogate models backed up by legacy simulation, risk/reward trade off model……..

BUILDING A DIGITAL TWIN

Multiple Steps, Different Entry Points



NVIDIA OMNIVERSE for Scientific Computing

COLLABORATION ENGINE FOR BUILDING A DIGITAL TWIN

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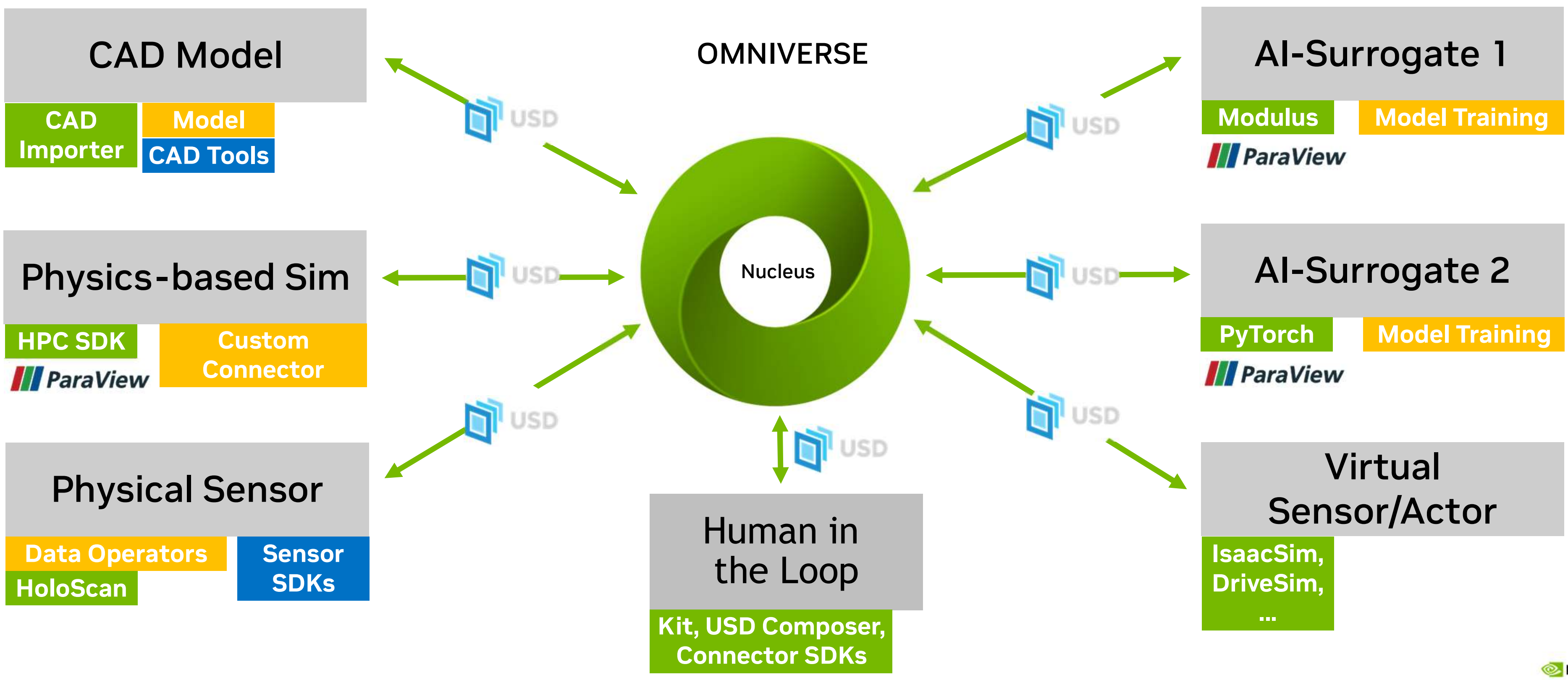


NVIDIA

WHAT IS USD?

UNIVERSAL SCENE DESCRIPTION

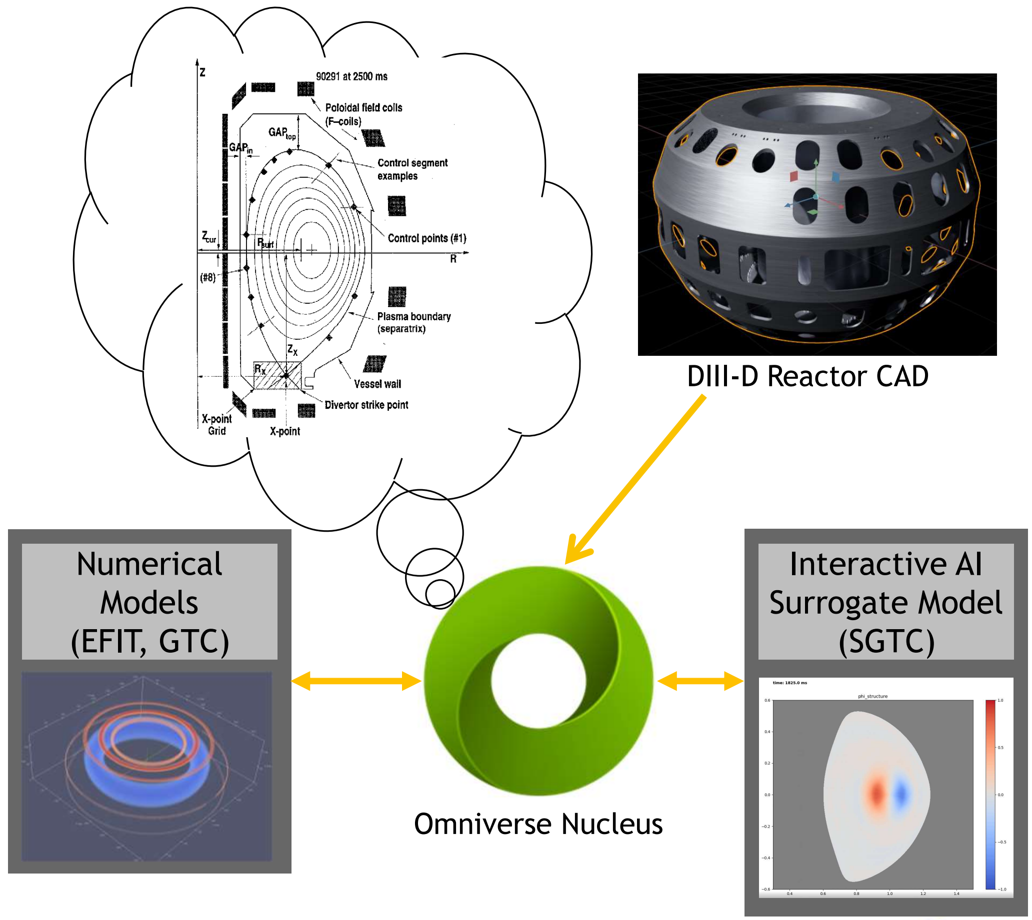
The “HTML” of 3D Virtual Worlds

- Developed by Pixar
- Foundation for NVIDIA Omniverse
- Open-sourced API and file framework for complex scene graphs
- Easily extensible, simplifies interchange of assets between industry software
- Introduces novel concept of layering
- Enables simultaneous collaboration for large teams in different department working on the same scene
- Originated in M&E, now becoming a standard across industries including AEC, Manufacturing, Product Design, Robotics
- Alliance for OpenUSD working on standardizing format and building community

RECIPE / INGREDIENTS FOR BUILDING A DIGITAL TWIN

INCORPORATING DIVERSE DATA SOURCES: GENERAL ATOMICS DIII-D, PPPL SGTC

- Collect relevant and complementary data sources into a unified model hosted in Omniverse Nucleus
- Link conventional numerical and physics-based simulations into Nucleus
- Add fast, interactive-rate AI surrogate simulations
  - *Actionable results in actionable time*
- DIII-D tokamak example cases:
  - DIII-D fusion experiment CAD geometry
  - EFIT 2-D equilibrium plasma field (offline simulation)
  - GTC 3-D plasma field (offline simulation)
  - SGTC 3-D AI surrogate plasma field (interactive, on-line simulation)
    - In-situ conversion of SGTC 3-D plasma field
    - Structured volume for interactive volume rendering
- **Twin:** Integrate DIII-D CAD, EFIT, GTC, SGTC, DIII-D sensors and control system data, …



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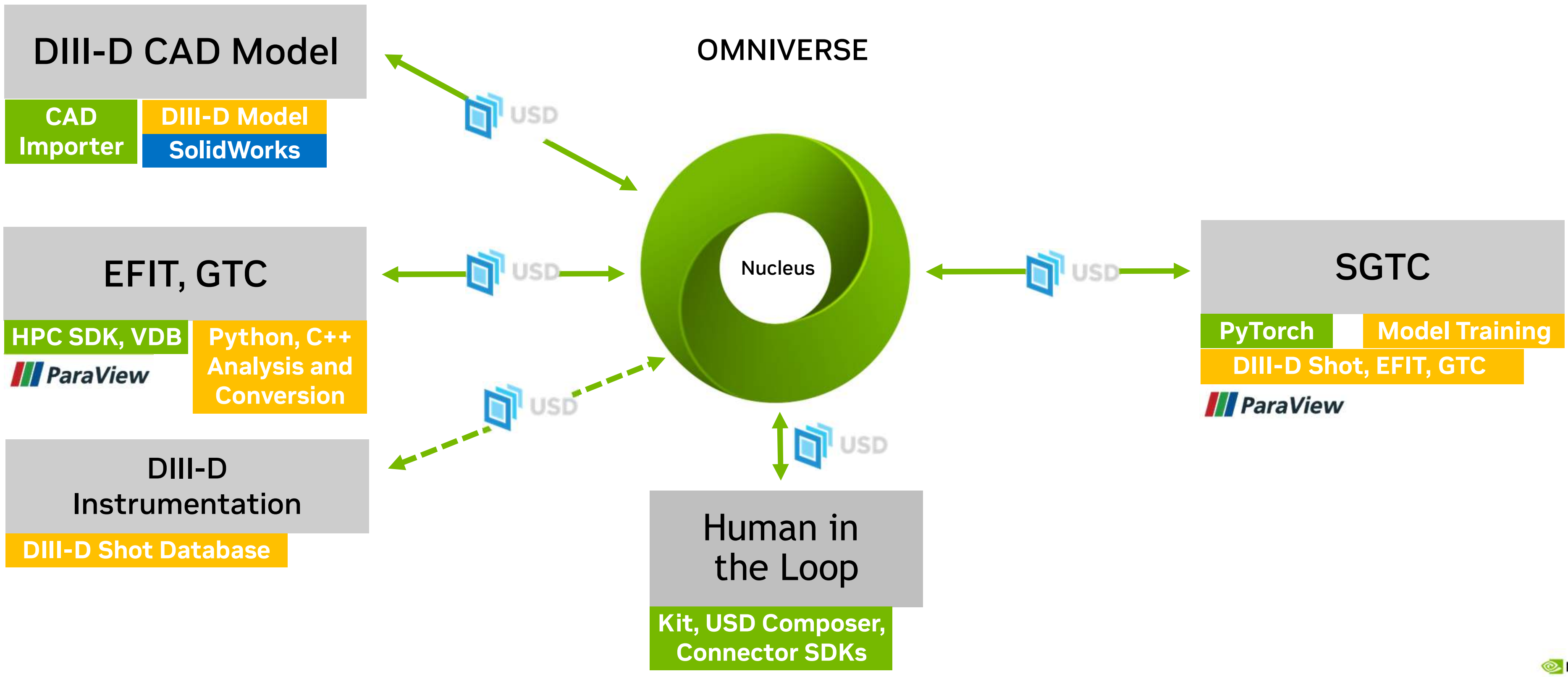
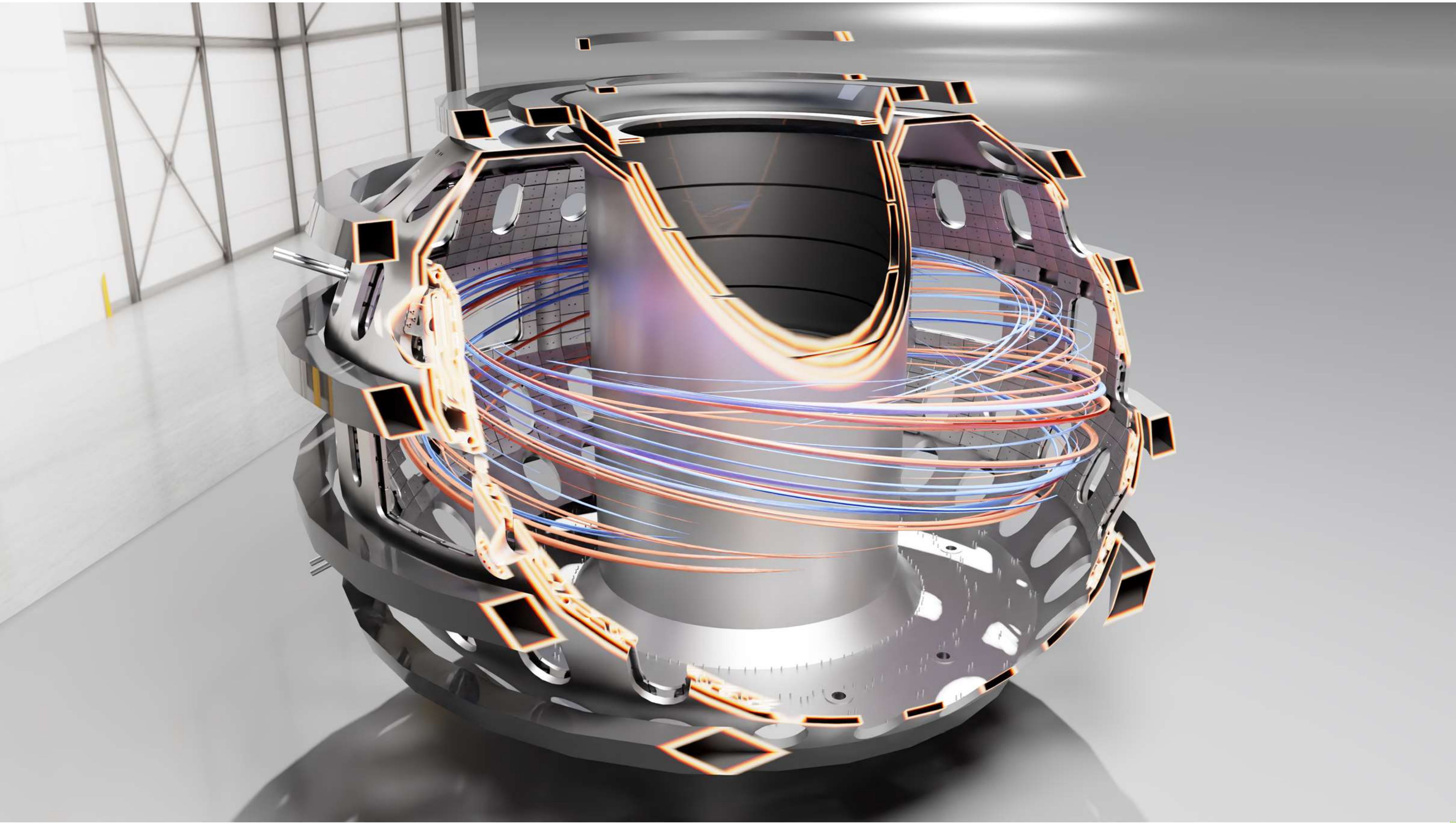
GA/Princeton DIII-D SGTC Digital Twin

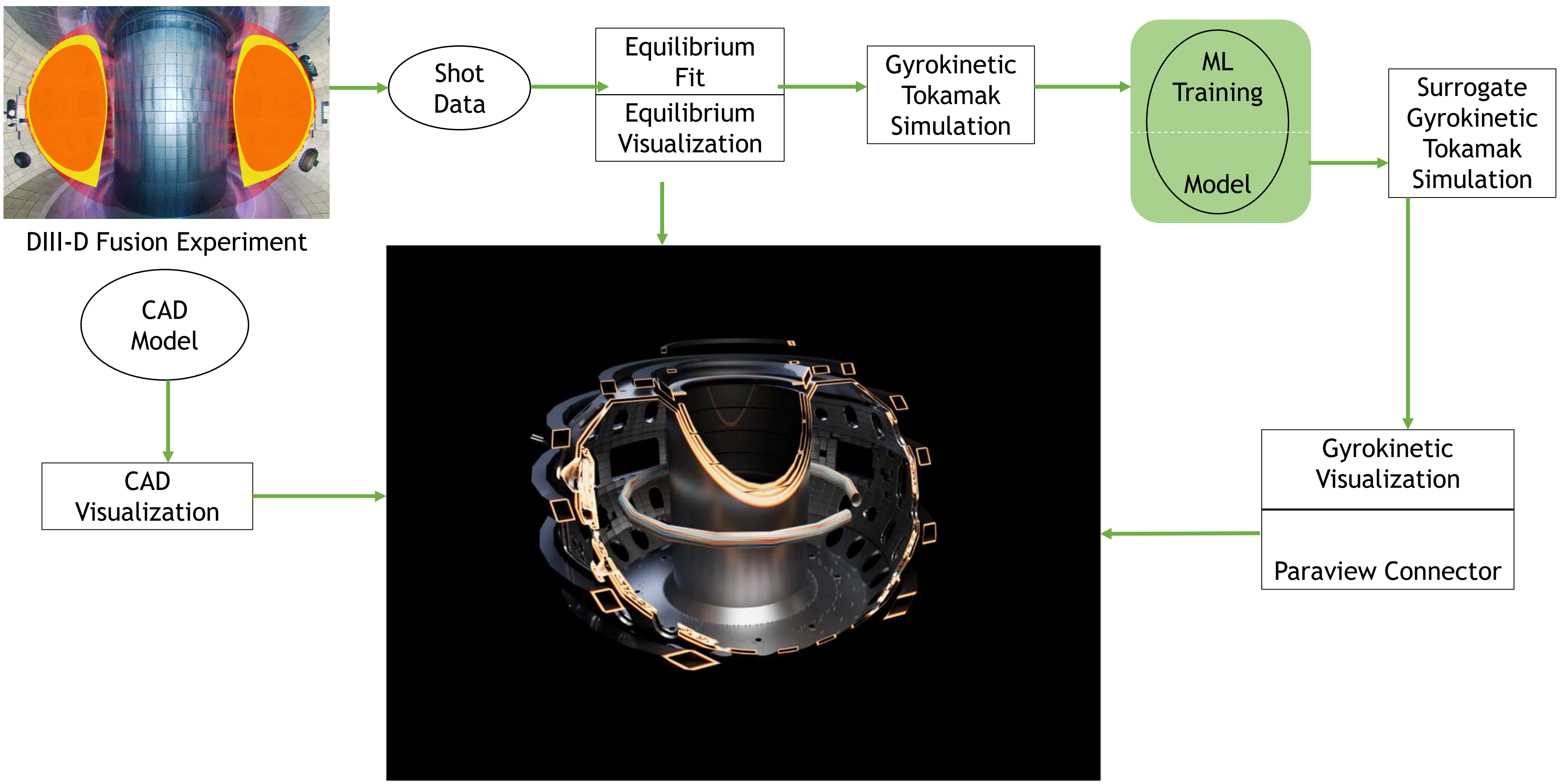
In-Progress Functional Prototype





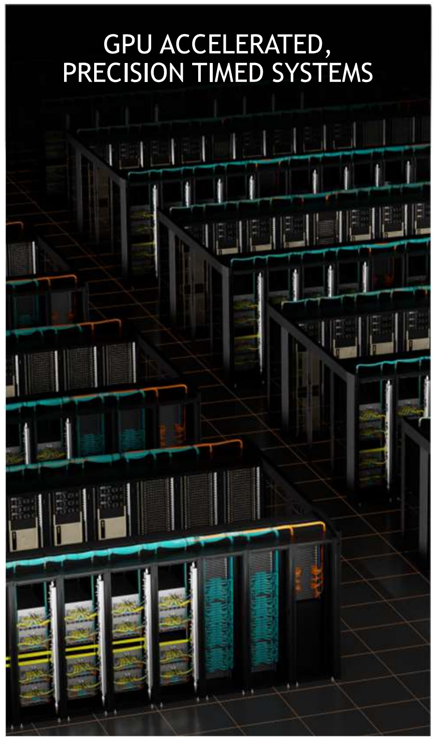
Fusion Digital Twin Workflow

File-Based Prototype



DIGITAL TWINS BRING NEW TECHNOLOGICAL DEMANDS

Simulation, AI and visualization are not optimal on the same compute resources.



Digital twins will stress new data center architectures to accomplish their promise.

WHAT IS THE BEST SYSTEM DESIGN FOR DIGITAL TWINS?

Interactivity of multiple types requires smart data center scale design

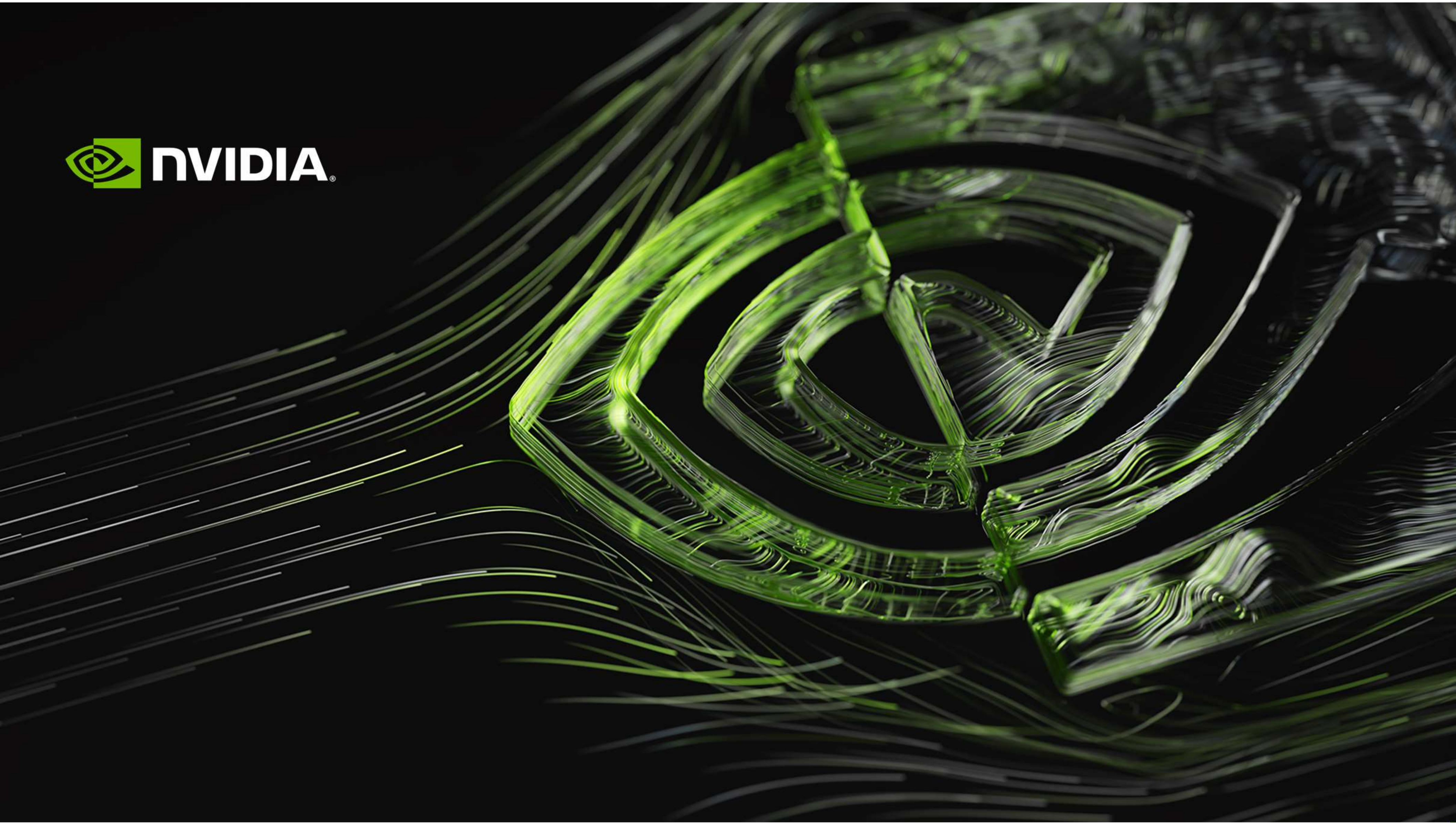
- Realtime **visualization** interactivity requires significant rendering and data movement capabilities
- Realtime what if scenarios requires fast **AI surrogates** to quickly update models
- Models of experiments need to be updated through **quick retraining** to have relevance to the next trail
- **Simulations** are needed to provide high fidelity data for both visualization and AI models
- **Data providence** is important for long-lived tracking of parts in engineering twins
- **Compute location and requirements** for edge based workflows presents tradeoffs

In addition, to these each twin has its own time requirements driven by things like experimental frequency and accuracy needs.

OPEN MODSIM QUESTIONS

Just some possible things to figure out

- What are the workflow requirements for compute and data motion for high productive twins?
- How to best balance a system for the AI inference, training, visualization and simulation needs of twins?
  - Its unlikely one compute device is enough what is the balance?
- What parts of a workflow need tight connectivity?
- Are there systems that can be good enough for most classes of twins?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