Toll Innovation Centre

Welcome to the Toll Innovation Centre! Here, we're dedicated to exploring and developing cutting-edge solutions in logistics and supply chain management. Our center is a hub of creativity and technology, where ideas are transformed into practical solutions to revolutionize the industry.

Digital Twins: An Overview

A digital twin is a virtual representation of a physical object or system across its lifecycle, using real-time data to enable understanding, learning, and reasoning.

Foundational Technology

Pioneering Implementation

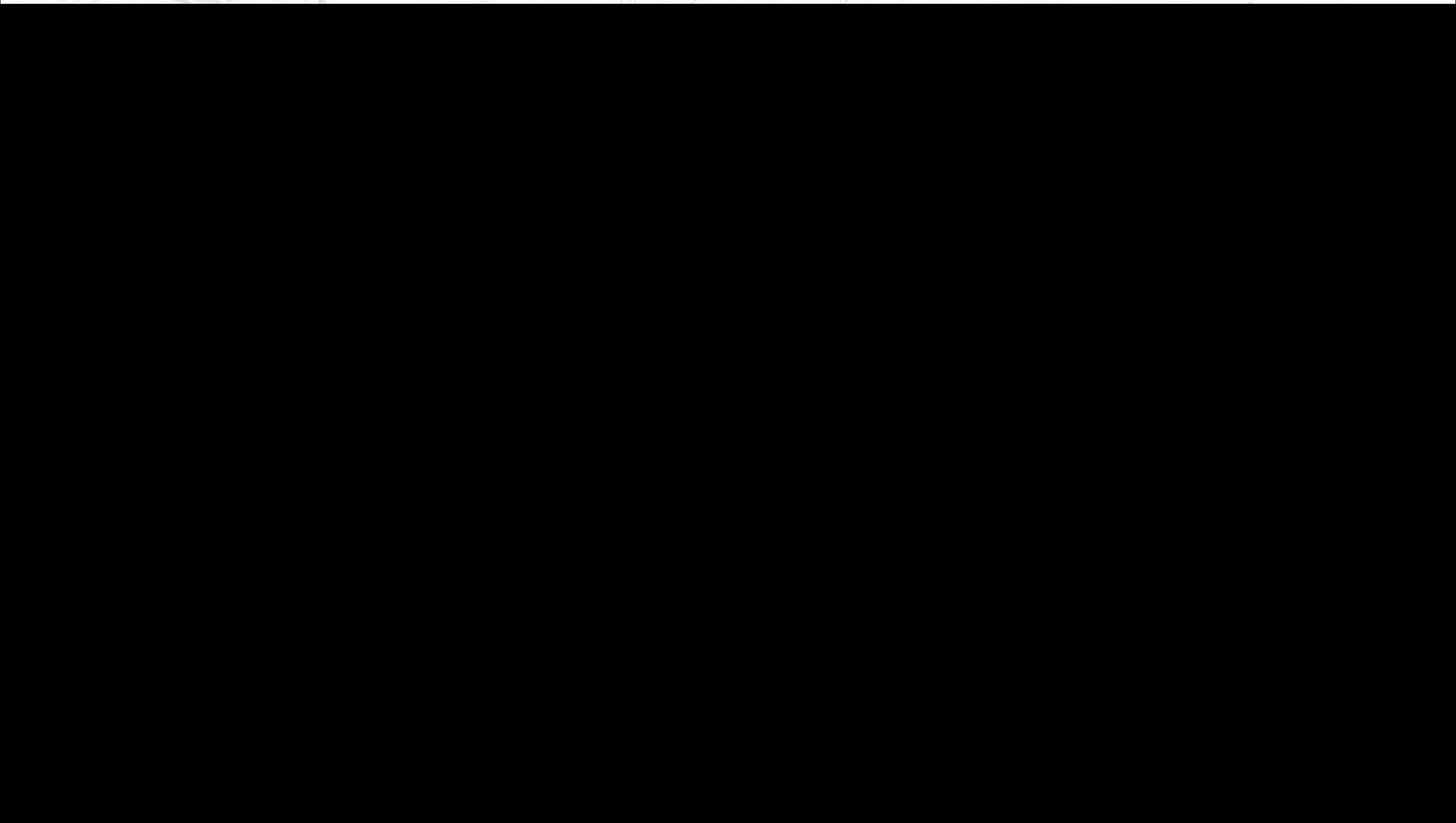
- The concept of a digital twin is far from novel. In fact, its roots can be traced back to practices employed by organizations like NASA, various inventors, and experts in theoretical physics, long before the term was officially coined.

- Historically, these pioneers have used the principles of digital twinning – creating complex simulations and models to mirror physical objects or systems – to innovate and solve problems.

NASA and Space Exploration

- NASA, in its quest for space exploration, has been using digital twin-like concepts for decades.
- They created detailed simulations of spacecraft, equipment, and missions to anticipate challenges, plan for contingencies, and conduct remote troubleshooting.
- This early form of digital twinning helped in safely navigating the uncharted territories of space.

Visualizing Terabytes of Data



Inventors and Prototyping

- Inventors throughout history have conceptualized and tested their inventions using models and prototypes, which is a foundational idea behind digital twins.

- These prototypes served as physical or conceptual twins, helping inventors to visualize, test, and refine their creations.

Theoretical Physics and Conceptual Modeling

- Theoretical physicists have long used conceptual models to represent and explore complex physical phenomena.

- These models, akin to digital twins, allowed for the visualization and analysis of concepts that couldn't be observed or experimented on directly.

Modern Day Advancement

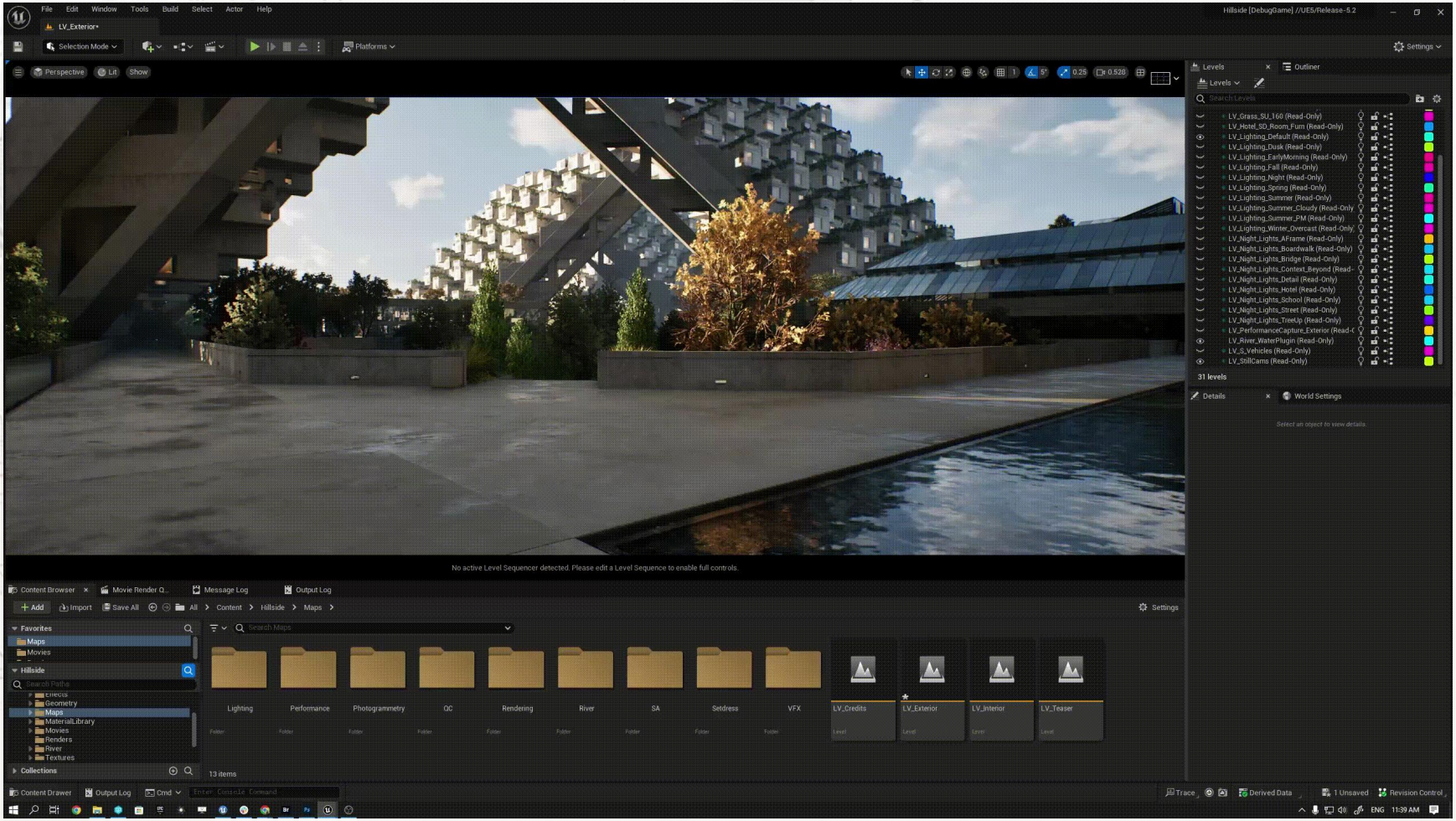
- Today, with the advent of advanced simulations and computational capabilities, what was once a theoretical has evolved into a sophisticated, highly accurate tool and modern digital twins enable not just visualization but also real-time monitoring, analysis, and prediction.

- They bridge the gap between the physical and digital worlds more effectively, allowing for the manifestation of ideas and theories into tangible, testable realities.

Real World Use Cases

- Logistics Process Simulation
- Fast-Track Industrial Factory Planning
- Deploying Next-Gen 3D Car Configurators
- Remote Monitoring and Control Systems
- Online Ecommerce Marketing
- NASA Lunar Terrain Visualization
- Transforming Industries with Digital Twins
- Siemens enable industrial metaverse
- PepsiCo Simulates and Optimizes Distribution Centers

Recreating Habitat 67



Changi Airport DT

Telco DT Lifecycle

Pesoco Simulate and Optimize

The D.R.A.G.O.N

- D - Diagnostic: Highlighting the capability of digital twins to diagnose issues in their physical counterparts.
- R - Replication: Emphasizing the replication of physical objects or systems in a digital environment, a core aspect of digital twin technology.
- A - Analytics: Focusing on the analytical capabilities that digital twins provide, enabling deep insights into the performance and potential of the physical entity they represent.
- G - Geometric Representation: Acknowledging the importance of precise geometric representation in digital twins, especially in fields like manufacturing and architecture.
- O - Operational Efficiency: Reflecting the role of digital twins in enhancing the efficiency of operations and processes.
- N - Network Integration: Pointing to the integration of digital twins within broader networks of IoT devices, systems, and data sources.

Digital twin and Bruce Lee

- The concept of a digital twin can be intriguingly related to Bruce Lee and his approach to martial arts.
- A digital twin is a virtual replica of a physical entity, process, or system, used to analyze, simulate, and predict real-world behaviors.
- In the context of Bruce Lee, imagine creating a digital twin of him.

Precision and Adaptability

- Bruce Lee was known for his precision and adaptability in martial arts, always analyzing and refining his techniques.

- A digital twin of Bruce Lee would encapsulate this ability, simulating and analyzing his movements to optimize performance, much like how he continually evolved his martial arts style.

Jeet Kune Do Philosophy

- Bruce Lee's martial arts philosophy, Jeet Kune Do, emphasized flexibility, efficiency, and practicality. Similarly, a digital twin is flexible and efficient, adapting to various conditions and providing practical insights.

- By simulating different combat scenarios, the digital twin could demonstrate how Lee might adapt his techniques, reflecting his philosophy of "using no way as way, having no limitation as limitation".

Predictive Analysis

- A digital twin of Bruce Lee could be used for predictive analysis in martial arts training and combat strategy.

- By inputting different combat styles or opponent data, it could predict outcomes, suggesting strategies Bruce Lee might have used.

Legacy Preservation

- The digital twin technology could preserve Bruce Lee's legacy, enabling martial artists to learn from and interact with a virtual version of Lee.

- It's like having a virtual master teaching and demonstrating his unique techniques, ensuring his knowledge and skills are passed down digitally.

Performance Enhancement

- Just as digital twins are used in industries to enhance performance and prevent failures.

- A Bruce Lee digital twin could analyze his body mechanics to enhance performance and prevent injuries, offering insights into optimal training regimens and techniques.

Key Components

- Real-time data collection
- Integration with IoT devices
- Advanced analytics and simulation
- Continuous updating and learning
- Integration with other digital systems

Applications in Various Industries

- Manufacturing: Optimizing production lines
- Healthcare: Patient monitoring and treatment simulation
- Urban Planning: City infrastructure management
- Energy: Monitoring and optimizing energy systems
- Automotive: Vehicle design and testing

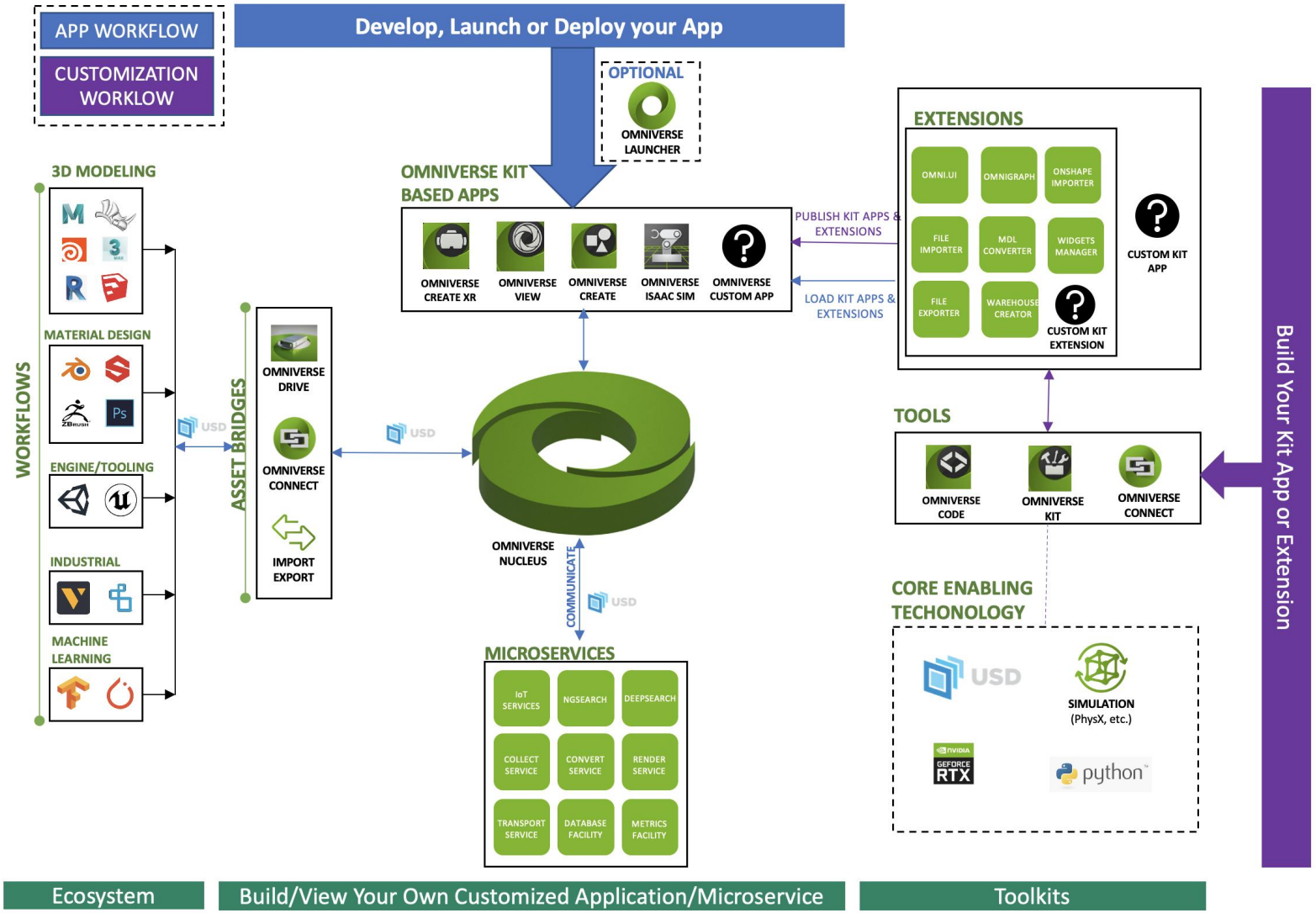
Digital Twins Reinventing Sports

- Digital twins offer innovative ways to perform tasks that have traditionally taken more time, creating opportunities to accelerate the pace of innovation.

- A key point of the digital twins project was the partnerships to create injury reconstruction datasets. As an example, Biocore, coordinated additional computer vision algorithms.

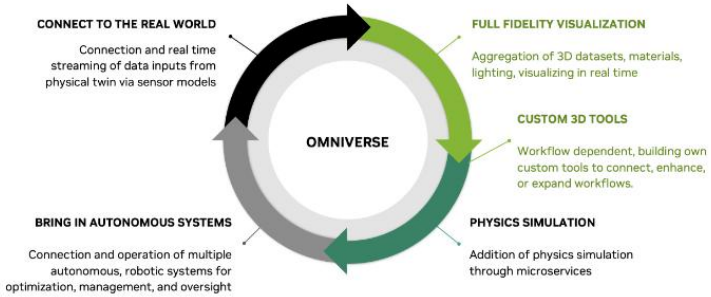
NVIDIA Omniverse Foundational Technology

Development Workflows



Building Digital Twin Warehouse

Regardless of your industry, use case, or organizational capabilities, the creation of large-scale digital twins can be broken down into four critical components:



Full Fidelity Visualization & Custom 3D Tools:

- Data Pipelines and workflows are established
- 3D models and datasets are ingested, aggregated, and normalized into USD while retaining a link to the source data
- 3D models, data, and workflows are customized and optimized
- Materials, lighting, textures, and rendering are added to 3D models to enable full-design-fidelity visualization
- 3D models act as a single source of truth and are continuously shared with, collaborated on, and refined by contributors and key stakeholders in real time

Physics Simulation:

- Sensors are simulated
- Physics simulations are applied to 3D models and environments
- Results from domain specific solvers are visualized and brought to life
- Using AI, physics can be predicted in real time with high accuracy and fidelity.

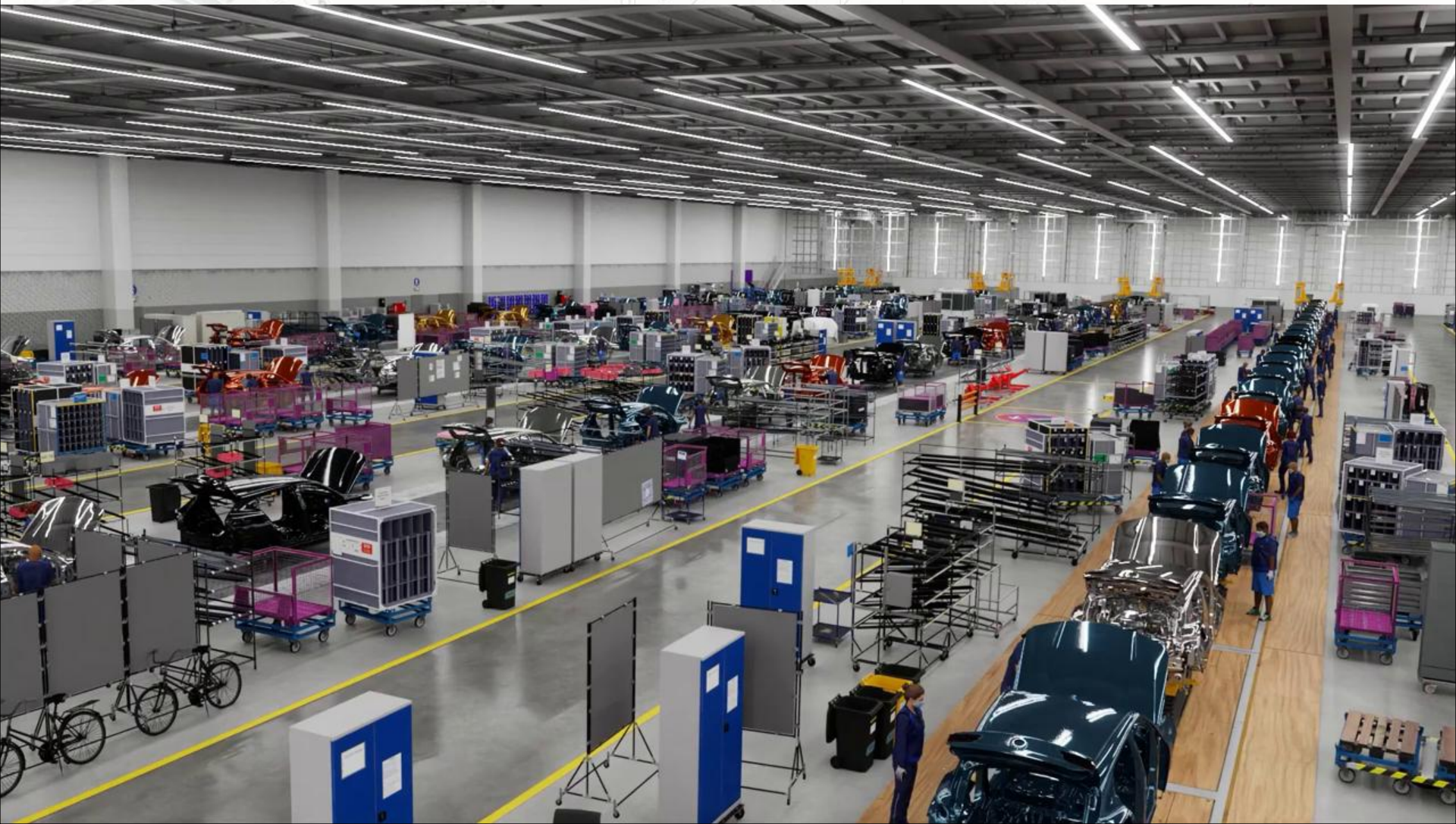
Connect & Train Autonomous Systems:

- Robotics models are brought in.
- Synthetic data pipelines are created
- The digital twin and generated synthetic data are leveraged to train, test, and optimize autonomous systems, including robots and perception systems, for scenarios that are impractical or impossible in the real world.

Connect to the Real World:

- Digital twins are connected to real-world systems and live data streams via IoT sensors and PLC
- Physical systems and digital twins are monitored and optimized in real-time

Designing Factory of the Future



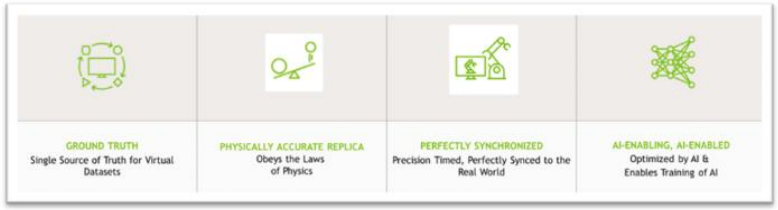
Digital Twin Warehouse

Future Trends

- Increased adoption in various sectors
- Integration with AI and machine learning
- Enhanced predictive capabilities
- Greater focus on sustainability and resilience
- Collaboration with augmented and virtual reality technologies

Attributes of a Live Digital Twin

Accurate and trustworthy virtual testing, experimentation, and optimization are possible only if a digital twin simulation include specific attributes. Those digital twin attributes include being the single source of truth for all virtual datasets, obeying the laws of physics, being perfectly synchronized to the real world, optimized by AI, and enabling the training of AI.



Using Omniverse Platform to build your warehouse digital twin, you can satisfy the required attributes as follows:

Ground Truth:

Built on open standards, Omniverse enables enterprises and developers to aggregate and connect 3D design and CAD (Computer Aided Design) applications to build and iterate upon a single source of truth for virtual datasets. Teams can also connect and extend to IoT, data systems, and industrial automation tools.

Physically Accurate Replica:

Omniverse digital twins are physically accurate with true-to-reality physics, materials, lighting, rendering, and behavior – powered by the Omniverse RTX Renderer. The Omniverse RTX Renderer is a physically based real-time ray-tracing renderer built on NVIDIA's RTX technology, Pixar's Universal Scene Description (USD), and NVIDIA's Material Definition Language (MDL). It provides two render modes supporting fully dynamic lighting (without any light baking) with thousands of lights, millions of objects, and the flexible MDL material representation.

Physics in Omniverse is enabled by the NVIDIA PhysX SDK, you can add rigid-body dynamics to building blocks and topple them over; create ragdolls or simulate walking robots using articulations; build complex mechanisms using joints; or pour a jar of gummy bears into your scene using deformable-body simulation. Read more about the Physics Core here. For more advanced physics and simulation workflows which incorporate artificial intelligence, visit the Modulus extension.

Perfectly Synchronized:

Omniverse digital twins are true real-time, living simulations that operate at precise timing, where the virtual representation is constantly synchronized to the physical world. This enables enterprises to not only diagnose a single moment in time but accurately simulate and predict infinite "what-if" scenarios.

AI-Enabling, AI-Enabled:

Coupled with NVIDIA Isaac, Metropolis, cuOpt, Modulus, and more, enterprises can achieve an autonomous feedback loop between the real world and digital twin environments, constantly retraining and optimizing perception AIs like robots or conveyor belts, or, constantly run predictive "what-if" simulations to re-optimize the digital twin itself.

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Supercomputing for the Next Era of Digital Twins

Enhanced Logistics

Thank you