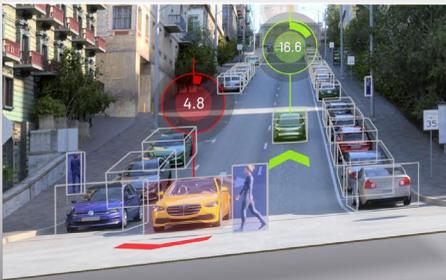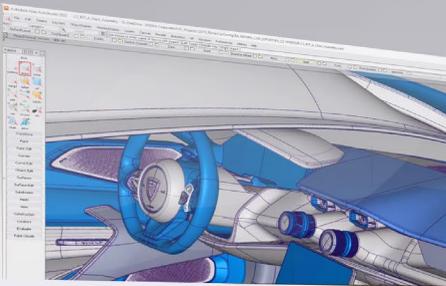# NVIDIA Omniverse™ for Automotive Design and Engineering

Images courtesy of NVIDIA, BMW Group, Rimac Automobili and Koenigsegg.

Advanced PRODUCT DEVELOPMENT Resource Center

DE247 Digital Engineering

NVIDIA.

DELL Technologies

Universal, Collaborative Design

The automotive industry is experiencing a digital revolution, spurred by the need to rapidly develop new types of electric and hybrid vehicle platforms. In addition, automakers need to integrate automated and autonomous technologies in these more efficient and sustainable mobility platforms. However, the traditional automotive design cycle can take years, and often involves laborious, manual processes that make it difficult to collaborate with partners and suppliers. To remain competitive and capture market share OEMs must embrace emerging technologies that allow them to rapidly design, iterate, and test new concepts.

Many automakers are rethinking the entire product development process, and digitalizing every phase of the automotive lifecycle. This transition has been complicated by the fact that automotive design and development involves many stakeholders, including the OEMs, suppliers, marketing teams, and more, all using different software tools and systems. To address this integration challenge, manufacturers need an open, virtual platform on which to collaborate. BMW Group, Mercedes-Benz and other automakers are leveraging the NVIDIA Omniverse™

Enterprise platform and Universal Scene Description (OpenUSD) to allow their teams to transform their 3D workflows and develop applications that enable collaborative and accelerated product design, simulatiion, testing and even manufacturing of new products.

In this paper, we will explain what NVIDIA Omniverse Enterpise is, how it can improve and optimize the design cycle, and provide real-world examples of how automotive companies are using the platform to improve automotive design workflows and collaboration.
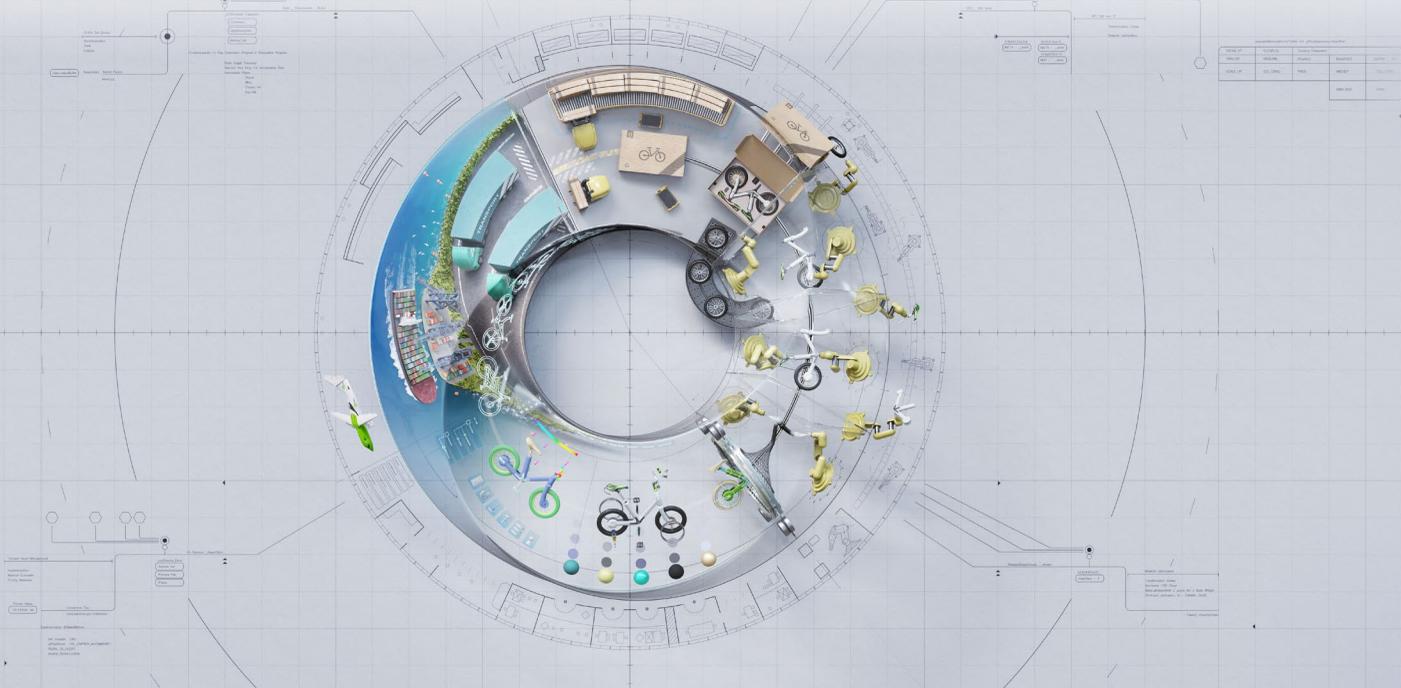
What is NVIDIA Omniverse?

Image courtesy of NVIDIA

NVIDIA **Omniverse Enterprise** is a scalable, end-to-end platform enabling enterprises to develop custom 3D pipelines and simulate large-scale, physically accurate virtual worlds.

Omniverse Enterprise is based on Universal Scene Description (USD), the Open-Source 3D scene description language developed by Pixar. The file contains mesh, light, shader, camera angle, and the data required to realistically depict 3D objects and scenes. The animation studio published USD as an open-source format in 2016, allowing the 3D modeling community to collectively enhance it. As such, it found support in Autodesk 3ds Max, Autodesk Maya, and other 3D content creation programs commonly used in the media and entertainment industry. It's also supported by the two major game engines, Unreal Engine and Unity.

Pixar developed USD to provide a 3D framework that would allow assets from different sources to coexist in the same scene to enable collaborative design. Because other industries, such as engineering and architecture, face these same collaboration challenges, NVIDIA identified USD as a solution when it began developing NVIDIA Omniverse.

Since USD is open source, CAD, PLM (Product Lifecycle Management), 3D visualization, computer aided engineering (CAE) and finite element analysis (FEA) solution vendors may develop plug-ins and add-ons to enable import/export features in their packages. USD's unique layering structure also opens the possibility to add other data, such as manufacturing requirements and part sourcing info, to 3D assets in NVIDIA Omniverse.

NVIDIA Omniverse Components

The NVIDIA Omniverse platform includes a number of components and modules that enable this cross-platform collaboration and visualization. Those components include:

NVIDIA Omniverse Nucleus™ This is the USD-based collaboration engine and database that manages asset interchange and version control in NVIDIA Omniverse. It provides collaboration and scalable core

microservices, and includes Omniverse Nucleus Workstation and Nucleus Server, as well as the ability to access the solution in the cloud.

With Nucleus, teams can have multiple users connected together live with multiple applications at the same time. Nucleus offers a set of fundamental services that allow a variety of client applications, renderers, and microservices all to share and modify representations of virtual worlds together. Nucleus also operates under a publish/subscribe model. Subject to access controls, NVIDIA Omniverse clients can publish modifications to digital assets and virtual worlds to the Nucleus database or subscribe to their changes.

NVIDIA Omniverse™ Connectors The primary means of interacting with Omniverse is through Connectors, which facilitate data exchange from other applications. For Enterprise customers, there are currently connectors for PTC Creo, Kitware Paraview, Unreal Engine 4, Autodesk Maya, Autodesk 3ds Max, Autodesk Revit, Trimble SketchUp, and McNeel & Associates Rhino, with more in development. Uni-directional connectors, from, for example, Autodesk Alias, and Revit, PTC Creo, and McNeel Rhinoceros, allow for real-time updates from the source application to be reflected inside of Omniverse. Bi-directional connectors, like, for example, Unreal Engine, Autodesk Maya or Autodesk 3ds Max, allow real-time updates to be shared between both the source application and Omniverse.

NVIDIA Omniverse™ USD Composer (formerly NVIDIA Omniverse Create) This is an Omniverse foundation application for world-building that developers can extend upon to allow their users to assemble, light, simulate and render large scale scenes. It is built using the NVIDIA Omniverse Kit. NVIDIA Omniverse USD Composer and enables developers and users to take advantage of the advanced workflows of USD like Layers, Variants, Instancing and much more. Coupled with the MDL Material Description and an RTX based renderer running on an NVIDIA RTX™ graphics card, developers can develop applications that allow their users to generate visually compelling and

physically accurate worlds. NVIDIA Omniverse USD Composer is integrated with Pixar's Hydra, and therefore, can be used to display USD content in any Hydra renderer (e.g., Storm, Embree, PRMan etc.), which has been built against the appropriate version of USD.

When connected to an Omniverse Nucleus server, worlds can be authored live across multiple Omniverse applications, machines and users for advanced collaborative workflows.

NVIDIA Omniverse™ USD Presenter (formerly NVIDIA Omniverse™ View) This is a simple reference application for interactive viewing and annotating of 3D design projects with physically accurate photorealism. Presenter does not require any technical knowledge to navigate and interact with USD-based simulations and allows developers to provide easy-to-use review and annotation tools to their users. It is powered by the multi-GPU NVIDIA Omniverse RTX Renderer, which can output ultra-complex scenes in real time.

NVIDIA Omniverse Kit™ This developer toolkit can be used to build NVIDIA Omniverse Applications like NVIDIA Omniverse USD Composer and NVIDIA Omniverse USD Presenter. It can also be used to develop user-specific Omniverse Applications, microservices, or plugins. The SDK can be run headless as a microservice or with a user interface (UI). The UI can be fully written using the NVIDIA Omniverse UI engine and can be fully customized.

NVIDIA Omniverse Replicator™ Replicator is a highly extensible framework built on a scalable Omniverse platform that enables physically accurate 3D synthetic data generation to accelerate training and performance of AI perception networks. Replicator provides deep learning engineers and researchers with a set of tools and workflows that allows them to bootstrap model training, improve the performance of existing models or develop new models that were not possible due to the lack of datasets or annotations. Users can easily import simulation-ready assets to build contextually aware 3D scenes.

How Engineers can Benefit from NVIDIA Omniverse

Manufacturers in general — and automotive companies in particular — need real-time, interoperable engineering and design collaboration solutions in order to iterate faster and meet market demands. The high costs associated with manual process and traditional make-and-break physical testing indicates there is an increased need for virtualization and digital twins to simulate components, vehicles, and entire factories.

NVIDIA Omniverse Enterprise provides a scalable, end-to-end platform to enable enterprises to develop custom 3D pipelines and simulate large-scale, physically accurate virtual worlds that can enable this new level of innovation.

By embracing USD-based workflows and building upon NVIDIA Omniverse foundation applications such as USD Composer and USD Presenter, designers and engineers can visualize every facet of a car's interior and exterior in the full context of the broader vehicle. Global teams can iterate quickly with real-time, physically based, photorealistic rendering, and universal file formats. Omniverse gives designers the flexibility to lay out every element of the vehicle, including physical components, electronics, and even the driver interface, to ensure better-informed decision making. Each element can be seen within the context of the entire vehicle design in the same 3D space at full fidelity. With this approach, automakers can identify design issues or flaws much earlier in the process and then make real-time improvements, reducing the number of physical prototypes and review cycles.

With NVIDIA Omniverse, manufacturers can create and simulate virtual products and even entire factories to optimize designs quickly, before a single prototype is created. Metaverse applications are poised for huge growth, according to several market analyses. More importantly, the opportunity for manufacturers is enormous — model-based digital twins such as those enabled by Omniverse can generate cost savings of as much as 70% to 80%.

Design Cycle Evolution
From an engineering and manufacturing perspective, there are three functional areas where Omniverse can provide benefits in a manufacturing use case — custom application development, full-fidelity visualization, and synthetic data generation. By combining these functional areas in different configurations, manufacturers are able to go beyond just visualization, and actually incorporate physics simulation and develop full-scale digital twins of their products and environments.

Custom Application and 3D Pipeline Development
Using NVIDIA Omniverse, companies can build simplified interfaces to match their unique design processes in a low code environment, using foundation applications and extensions to accelerate app building. Manufacturers have traditionally been forced to use software the way that vendor designed it. With NVIDIA Omniverse, every company has foundational tools to build their own applications. For example, NVIDIA Omniverse developers have created custom, simplified interfaces so that executive leadership can interact with 3D models, and custom user interfaces for a variety of workflows such as collision detection and analysis.

Full-Fidelity Visualization and Data Aggregation

As more processes are digitalized and manufacturers rely more heavily on 3D modeling, companies need to visualize everything from discrete products through to entire factories. NVIDIA Omniverse delivers the ability to connect existing tools and enable multiple users in different locations to work together for rendering, product reviews, and other design cycle activities. NVIDIA Omniverse Connectors enable this level of visualization and collaboration. Where a Connector does not yet exist, Omniverse provides software, source code and documentation that enables partners and customers to develop their own Connectors. At the factory scale, Connectors exist that can allow full factory simulation studies, including logistics and material flow optimization elements.

Synthetic Data Generation
Artificial intelligence (AI) and autonomous systems require large amounts of data for testing and training. Synthetic data generation within Omniverse allows companies to complete this work in days rather than weeks or months. NVIDIA first introduced this concept around self-driving vehicles with DRIVE Sim, built on Omniverse. Instead of driving vehicles millions of miles, NVIDIA Omniverse allows for the creation of virtual environments and testing scenarios.

With NVIDIA Omniverse, users can develop virtual worlds and full-scale digital twins that can be used to help train AI platforms or augment human decision making.

These three functional areas cut across key parts of the automotive development cycle. In the design and engineering phase, Omniverse provides a way for multiple stakeholders to quickly collaborate and test new concepts, conduct virtual testing and simulation, and rapidly explore different design options. In manufacturing, NVIDIA Omniverse allows companies to virtually create entire assembly lines or even factories and simulate and test those facilities before ground is broken or an existing facility is retrofitted. And because NVIDIA Omniverse creates photorealistic models, sales and marketing teams can more quickly access images and other critical information about new products.

With Omniverse, the BMW team can aggregate data into massive, high-performance models, connect their domain-specific software tools and enable multi-user live collaboration across locations.

NVIDIA Omniverse in Action

Image courtesy of BMW Group.

Virtual Automotive Factory

The costlier the physical prototype, the greater the digital twin's appeal. For running what-if scenarios and simulating failure modes, doing it in pixels is less expensive than conducting destructive physical tests, which is why many automakers such as BMW Group, Mercedes-Benz, and General Motors are embracing NVIDIA Omniverse for building digital twins.

BMW Group can set up new factories faster and more efficiently with Omniverse and AI. They have already **begun a global rollout** of NVIDIA Omniverse-hosted virtual factories – the company planned and validated a new plant in Debrecen completely virtually before construction began. Thousands of planners, product engineers, facility managers and lean experts within the global production network are able to collaborate in a single virtual environment to design, plan, engineer, simulate and optimize extremely complex manufacturing systems before a factory is actually built or a new product is integrated.

"NVIDIA Omniverse and NVIDIA AI give us the chance to simulate all 31 factories in our production network. All elements of the complete factory model—including the associates, the robots, the buildings and the assembly parts—can be simulated to support a wide range of AI-enabled use cases such as virtual factory

planning, autonomous robots, predictive maintenance and big data analytics," says Milan Nedeljkovic, member of the board of management of BMW AG, responsible for production.

"These new innovations will reduce the planning times, improve flexibility and precision, and at the end produce 30 percent more efficient planning processes," Nedeljkovic adds. "Omniverse is a game-changer that is setting the standard for collaboration platforms for our industry."

This could set precedent for other carmakers and manufacturers, to plan and test out production activities in digital replicas. BMW Group said it is "taking a digital-first approach to validate and optimize complex manufacturing systems across its production network using NVIDIA Omniverse Enterprise." BMW Group also plans to launch the current Omniverse Enterprise platform across its production network worldwide.

Mercedes-Benz Takes Factory Planning Into the Omniverse

Image courtesy of Mercedes-Benz

Mercedes-Benz Adopts NVIDIA Omniverse for Vehicle Assembly and Production Planning

Retooling a production plant for a new vehicle is a resource-intensive and often a disruptive undertaking for auto manufacturers. Vehicle production involves the coordination of thousands of parts and workers, along with robotic assembly systems and a complex logistics infrastructure.

To prepare for the launch of its new electric vehicle platform, which will be manufactured in 2024 at its site in Rastatt, Germany, Mercedes-Benz is building a digital twin of the factory using NVIDIA Omniverse. By designing and planning manufacturing facilities in Omniverse, the automaker will be able to rapidly simulate new facility configurations virtually and, in the process, reduce waste and continuously enhance operational quality.

Mercedes-Benz is establishing a digital-first planning process that will enable them to design and test the complete production lines without disrupting ongoing production at the current site. The automaker will then roll out the process to other parts of the production network to create a more agile manufacturing ecosystem.

According to an NVIDIA blog: "With Omniverse, Mercedes-Benz planners can access the digital twin of the factory, reviewing and optimizing the plant as needed. Every change can be quickly evaluated and validated in the virtual world, then implemented in the real world to ensure maximum efficiency and ergonomics for factory workers."

Reinventing 3D Configurators

Image courtesy of Mercedes-Benz and NVIDIA.

Electric vehicle innovator Rimac Automobili has built a new 3D configurator for the company's Nevera Hypercar. The solution, powered by NVIDIA Omniverse, provides realistic renderings of the vehicle in a variety of configurations — all made possible by the simulation capabilities of the NVIDIA platform and technology. By using the **NVIDIA Omniverse™Cloud** offering, customers can access the solution from any device. (You can access the configurator **here**.) RIMAC also plans to leverage NVIDIA Omniverse for design and marketing activities.

The new 3D configurator allows RIMAC to preview the vehicle for customers without having to pre-render each feature or layer, which will save time and money. NVIDIA Omniverse can work with full design fidelity CAD and 3D datasets from a variety of software sources, and designers are able to work on NVIDIA-powered RTX™ workstations or access the platform via the cloud.

NVIDIA Omniverse enables RIMAC to use the same USD file to create different types of multimedia and distribute elements to multiple teams without worrying about what software or formats were being used.

According to Andrew Morris, product manager for Omniverse Manufacturing at NVIDIA, "The RIMAC configurator built in Omniverse exposes the full 3D engineering model, and you can change the materials and assets directly on that model, and then view it from any angle. If you want to introduce new options, you don't have to create all new logic."

"That creates huge efficiencies, because creating those 2D layers can be time consuming and error prone," he adds. "The other key piece is being able to take advantage of NVIDIA Omniverse RTX™ enabled graphics and physics and having that streamed to you as well for a fully interactive, intuitive, and realistic experience."

Omniverse Hardware Recommendations

Successful deployment of NVIDIA Omniverse within an engineering environment requires users to have correctly configured, professional workstations that allow designers, engineers, and other stakeholders to utilize Omniverse within their workflows while also operating their traditional design, simulation, and rendering tools.

Dell Technologies and NVIDIA collaboratively certify and develop Omniverse recommendations to run on NVIDIA RTX™ powered Dell Precision fixed and mobile workstations. Dell / NVIDIA-Certified Systems™ enable enterprises to confidently deploy hardware solutions that securely and optimally run their modern accelerated workloads. (Learn more about Dell and Omniverse here.)

The Reference Architectures provided below provide a starting point and are validated solutions with NVIDIA-Certified Program guidance. Bear in mind
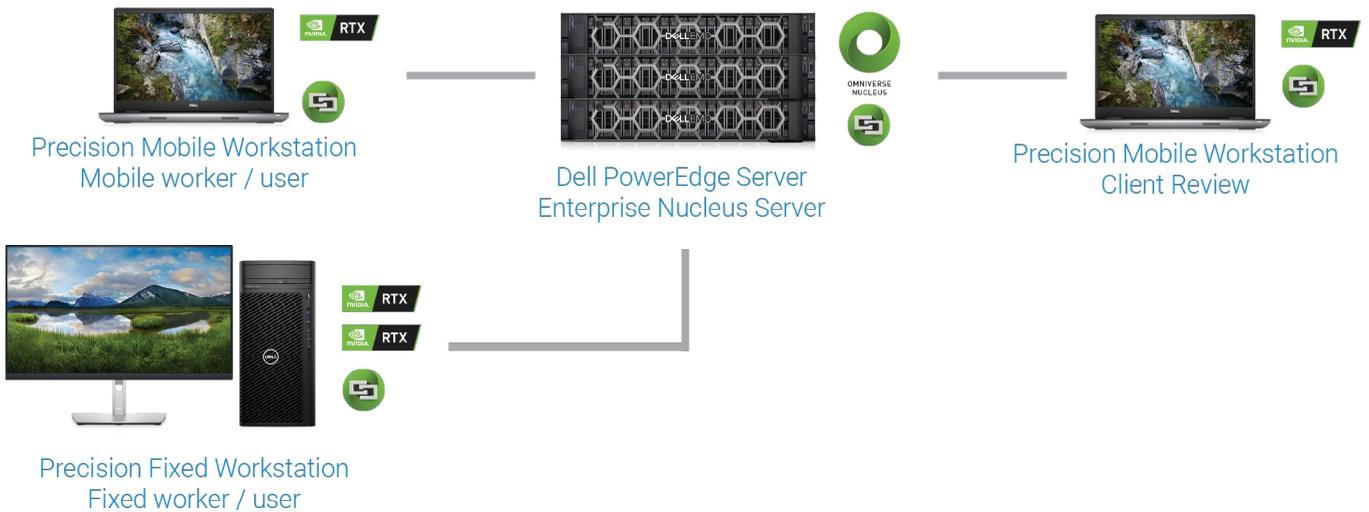
that storage, networking, and other options can vary considerably depending on the IT infrastructure available for each deployment. It is important to ensure that both workloads and workflows are understood and validated in order to determine the best profile and sizing for each environment.

The reference architecture presented here outlines a workflow with creators / designers, reviewers, and the end client as users across the various mobile and desktop workstations. A proof of concept, or POC, will be an important step in ensuring performance is acceptable to any given set of users.

Local Topology

Precision Fixed Workstation
Fixed worker / user

Precision Mobile Workstation
Mobile worker/ user

Precision Mobile Workstation
Mobile worker/ user

Precision Fixed Workstation
Fixed worker/ user

Local Topology With Separated Enterprise Nucleus Server

Precision Mobile Workstation
Mobile worker / user

Dell PowerEdge Server
Enterprise Nucleus Server

Precision Mobile Workstation
Client Review

Precision Fixed Workstation
Fixed worker / user

Precision Mobile Workstations

Model	GOOD	BETTER	BEST
	Precision 5680	**Precision 7680**	**Precision 7780**
Graphics	RTX 4000 Ada 12GB	RTX 5000 Ada 16GB	RTX 5000 Ada 16GB
Processor	Intel® Core™ i7-13700H	Intel Core™ i7-13700H	Intel® Core™ i9-13950HX
RAM	16 GB	32GB	64 GB
Storage	256 GB NVMe SSD	512 GB NVMe SSD	1 TB NVMe SSD
OS	Win 10/11, Ubuntu Linux	Win 10/11, Ubuntu Linux	Win 10/11, Ubuntu Linux

Model	GOOD	BETTER	BEST
	Precision 3660 Tower	**Precision 5860 Tower**	**Precision 7960 Tower**
Graphics	RTX A5500 24GB / RTX 5000 Ada 32GB*	RTX A6000 48GB / RTX 6000 Ada 48GB x2	RTX A6000 48GB / RTX 6000 Ada 48GB x3/4
Processor	Intel® Core™i9-13900	Intel® Xeon® w5-2455X	Intel® Xeon® w5-3435X
RAM	128 GB	256 GB	1 TB
Storage	1 TB Boot + 2 TB NVMe SSD	1 TB Boot + 2-4 TB NVMe SSD	2 TB Boot + 2-4 TB NVMe SSD
NIC OS	Win 10/11, Ubuntu Linux	Win 10/11, Ubuntu Linux	Win 10/11, Ubuntu Linux
	*coming soon		

Conclusion

Modern 3D design workflows incorporate a wide range of incompatible tools and collaboration with design and engineering teams across time zones. Designs have become increasingly complex as the role of sensors, software, electronics, and other components are more deeply integrated with physical and mechanical components of vehicles and other products. The demand for more iterations, faster time-to-solution, early and rapid simulation, and more innovative designs is increasing.

NVIDIA Omniverse Enterprise allows manufacturers to create a virtual environment in which multiple stakeholders – from engineers and executives, to customers and marketing professionals – can quickly collaborate, simulate, test, and alter new design concepts without the need to convert data or create multiple versions of the same file. Automakers and other manufacturers can leverage Omniverse to create interactive models of products and even entire factories to improve designs more rapidly prior to prototyping or production.

To learn more about NVIDIA Omniverse Enterprise, visit the links below.

Review for NVIDIA GTC 2023 Sessions

GTC Spring 2023 Keynote

Toward an Industrial Metaverse

How General Motors Explores Future Automated Workflows Using a Single 'Live' USD Dataset with Omniverse

Building a Digital Twin of the German Rail Network for the Next-Generation Railway System

Driving the future of Smart Factories with Cloud-enabled Digital Twins

Creating Digital Twins and Simulations of Industrial Robotic Work Cells for Smart Factories

Leveraging the Omniverse & Metropolis Microservices Platforms to Optimize Warehouse Operations

3D Synthetic Data: Simplifying and Accelerating the Training of Vision AI Models for Industrial Workflows

Connect with the Experts: How to Build a Digital Twin in Omniverse

Dell Technologies and Omniverse:

NVIDIA Omniverse is optimized to run on the Dell Precision 7920 Tower and Dell Precision 7920 Rack. You can learn more here.

Try out Omniverse via a Hands-on Lab:

Bring Your Own Data to Omniverse Enterprise | NVIDIA

Check out a Manufacturing Project Workflow:

Predator Cycling Project Workflow - Part 1: Working with Data Transport

Predator Cycling Project Workflow - Part 2: Creating Assets with Data Visualization