THE **AUTOMOTIVE** FIELD GUIDE

BUILDING AN OPEN AUTOMOTIVE PLATFORM AND DATA MODEL WITH UNREAL ENGINE

Presented by Epic Games

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The Automotive Field Guide v1.0r18

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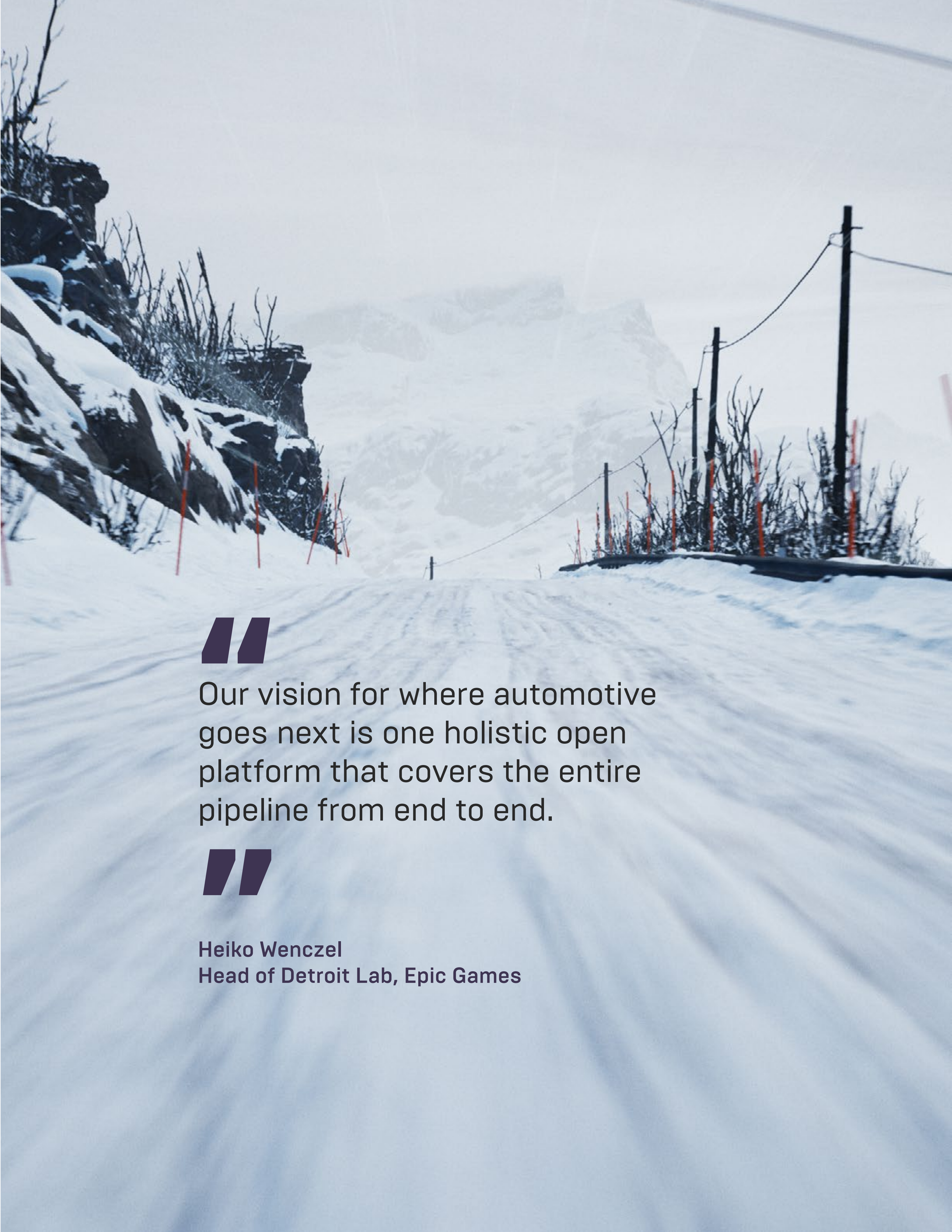

> Our vision for where automotive goes next is one holistic open platform that covers the entire pipeline from end to end.

Heiko Wenczel
Head of Detroit Lab, Epic Games

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A bird's-eye view of real-time for automotive

Interactive technology is already driving efficiency throughout today's automotive industry. Engineers are collaborating using real-time technology like VR to create and review new designs, R&D teams are conducting autonomous driving research in game engine-driven simulators, and customers are using real-time configurators to make purchasing decisions.

Courtesy of Ferrari S.p.A. | Mackevision

Introduction

Interactive technology is already driving efficiency throughout today's automotive industry. Engineers are collaborating using real-time technology like VR to create and review new designs, R&D teams are conducting autonomous driving research in game engine-driven simulators, and customers are using real-time configurators to make purchasing decisions.

In many cases, what's missing is a joined-up approach to connect these siloed use cases and supercharge the pipeline. That's our vision for where the automotive workflow goes next: one holistic open platform that covers the entire pipeline from end to end, from creating and visualizing the initial design, through reviewing, testing, and training in the engineering stages, and finally to creating beautiful marketing renders and photorealistic product configurators.

The data model of the future is to stay contained within a game engine, on a fully open platform where the features and tools that you need are already available without you having to switch between different software packages.

With an open-data ethos, a new world of possibilities will be established, providing an opportunity for automotive manufacturers to transform the way they work in the automotive industry.

In this guide, we'll explore those opportunities—and how to capitalize on them.

Courtesy of Ferrari S.p.A. | Mackevision

Who is this guide for?

While digitization—including the genesis of the automotive digital twin—has been increasingly important for success over the past decade, up until now the automotive industry has been in something of a Wild West of improvised implementation strategies and undefined cross-platform tools.

This guide explores how a game engine offers a solution to this inefficiency, providing the bedrock on which to build an entire automotive pipeline.

We'll look at how real-time workflows can drive efficiencies across each of the different automotive departments, then touch on key entry points for companies looking to develop a fully open-platform approach to automotive data.

The guide is for those seeking to understand where to start tactically—but also why executive decisions for the long term should be made with real-time technology in mind.

You might be a CTO, thinking about future-proofing your business with technology fit for a rapidly evolving digital era. You could be a head of IT, trying to find a more efficient way for teams to pass data along the pipeline. Or perhaps you're an engineer, interested in innovative solutions to today's automotive challenges.

Whatever your motivation, the following pages will provide plenty of food for thought. Let's get started.

"The guide is for those seeking to understand where to start tactically—but also why executive decisions for the long term should be made with real-time technology in mind."

History

The automotive world has changed dramatically since CAD pioneer Dr. Patrick Hanratty designed the first computer-aided drafting system in the 1960s. Mass production was possible thanks to the Industrial Revolution, but the act of designing vehicles was still stuck in the past, requiring a designer to draw each facet by hand. Life-sized visual prototypes mostly started and ended with a block of clay. Each method required countless hours of manual labor to achieve the end result. Making changes or variations in design meant a literal trip back to the drawing board and untold numbers of production delays.

It’s no wonder that by the 1970s, the auto industry was embracing CAD systems. The window between design and production shrank. Designers could suddenly make digital templates instead of starting every design from scratch. Minute drafting errors no longer meant fatal flaws. It became possible to simulate stress tests with a computer model instead of a physical prototype. By virtue of CAD being so much more efficient, designers could experiment with new ideas faster than ever before. By the 1980s, CAD had hit critical mass.

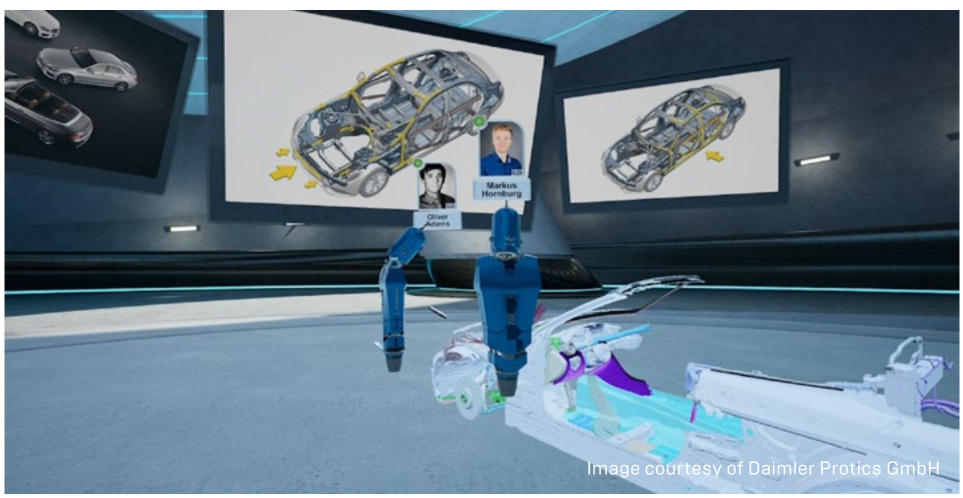


Image courtesy of Daimler Protics GmbH

Over the past 40 years, CAD systems have evolved from producing just 3D wireframes to generating 3D solid models complete with mathematically accurate physics and material properties, unlocking a new era of virtual analysis. This brings us up to date, where we now live in the era of the digital twin—a mathematically perfect representation of a physical object and all its variants in a digital space—and cloud-based collaborative virtual reality design sessions.

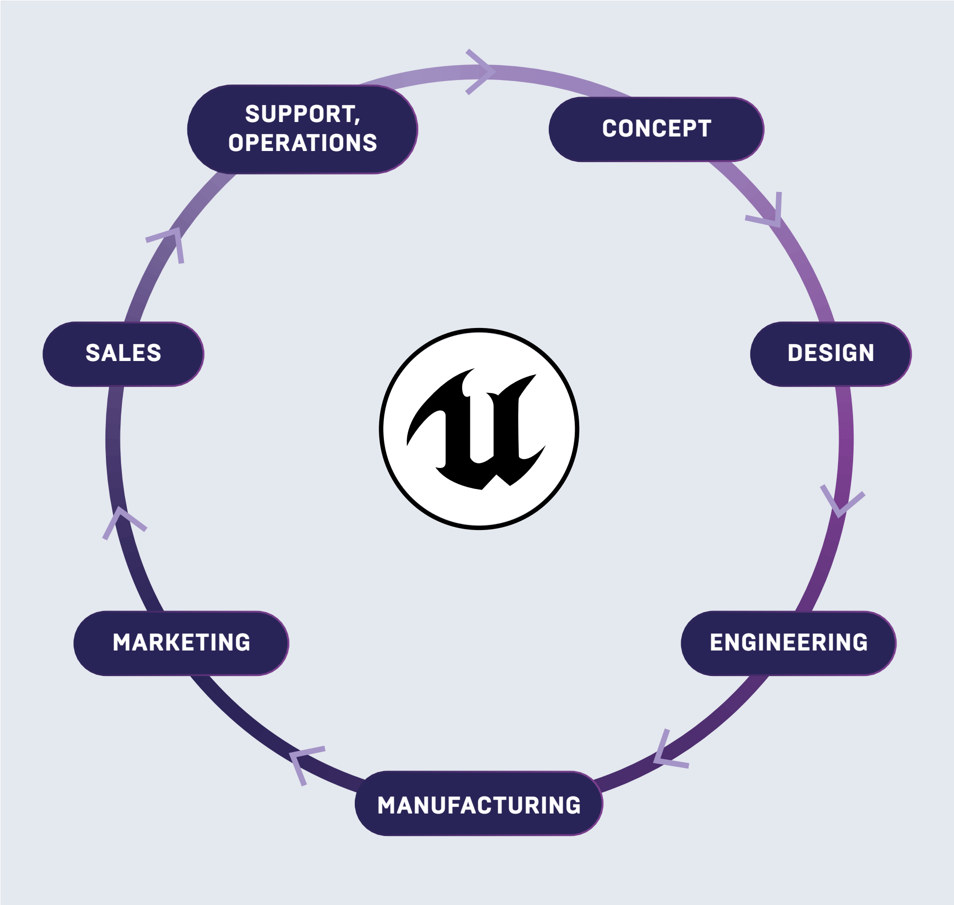
While CAD capabilities have increased exponentially, inefficiencies remain. Vehicles are manufactured from thousands of parts, and each one needs to be created digitally before it goes into production, and made again for the photorealistic touchscreen car configurator online or hanging on a dealership wall. And remade again for a TV commercial, and remade yet again at mobile-friendly resolutions. At this point, managing these multiple assets and their reams of metadata—and distributing them to partners throughout the automotive value chain—creates even more inefficiencies and introduces inaccuracies.

Courtesy of Lexus and Rotor Studios

What if there was a way to sidestep all this, and produce an asset *once* that could be used for every stage from design and validation through to photorealistic beauty shots for dealership literature? There is—it's called real-time visualization.

Production-proven in the world of blockbuster video games, Unreal Engine has interactive collaboration at its heart—it's built for high-performance, photorealistic visualization. And it's designed for the future. Create an asset once and use it everywhere; review designs in VR with a colleague across the globe; tweak the lighting on a real-time photorealistic 3D model on the fly. Transform your workflow and future-proof your design process. With Unreal Engine, it's all possible. This field guide will show you how.

Where the automotive industry is today



Today's automotive industry is undergoing a period of extraordinary change. In the not-so-distant future, most of the vehicles it produces are going to be fundamentally different from the ones on the road now. From fully electric vehicles to those that drive themselves, cars are being transformed.

Computers will be key to this evolution. Cars are no longer purely mechanical entities; increasingly, complex computer systems are playing a central role in how they operate. As vehicles become more and more autonomous, their "digital brains" will become as important as the frames from which they're constructed.

This shifting paradigm is one of the reasons automotive companies should be investing in digital infrastructure like real-time technology right now.

Beyond the software and programs that will play an increasingly central role in next-generation vehicles, real-time technology can transform traditional automotive processes, opening up new avenues for creative concepting and design, streamlined manufacturing workflows, and previously inconceivable marketing opportunities.

This evolution is already playing out across the automotive pipeline at forward-thinking companies. Here's a snapshot of how:

Concepting: Concept artists are using interactive tools to explore and iterate on ideas instantly.

Design: Designers are collaboratively tweaking and refining designs in real time.

Engineering: Engineers are testing engineering scenarios more cost-efficiently in real-time environments.

Manufacturing: Planners are streamlining production processes by reconfiguring digital twins of their manufacturing facilities.

Marketing: Marketing teams are creating product content personalized for each customer.

Sales: Salespeople are providing photorealistic vehicle configurations and customized after-sales materials.

Support and Operations: Operations managers are leveraging digital twins to provide better data analysis and systems monitoring.

In the next section, we'll highlight some of the key areas where real-time technology has been driving innovation.

> Unreal Engine is the highest-quality real-time software currently out there. It renders faster than any of the competitors, and it's open source, which is often overlooked.
>
> John Bulmer
> Visualization Manager,
> Geely Design UK

Spotlight: key real-time innovations

Real-time technology is driving innovation across the automotive pipeline in many different ways.

Some of these changes provide new opportunities for specific automotive departments. In the sales and marketing phase, for example, customers can walk away from a car dealership with a brochure showing the car they just personalized with a real-time configurator, rather than one filled with generic shots of the vehicle in various standard colors.

Other innovations relate to technology that is changing processes across multiple departments. VR can be used by designers to explore early car design concepts, by engineers to evaluate vehicle ergonomics, or by factory employees to train on new machinery, among many other applications.

In this section, we'll take a look at some of the key touch points across the automotive pipeline where real-time technology is providing new and exciting opportunities.

Research

Game engines are perfect for research because they're able to provide abstractions for a wealth of complex functionalities. If you only need to generate static 2D images or plots or don't need real-time rendering, you'll be best served by your existing tools and workflows designed specifically for those purposes. However, should you need an online rendering solution for 3D data visualization, or need to record a simulation in real time, game engines will provide the most powerful and flexible solutions. Their combination of powerful GPU-accelerated 3D rendering, real-time physics simulations, and native support for AR and VR make game engines a benefit in the field of automotive research.

Visualization of research data

Visualizing data points, and then creating an interactive demo based on these points, opens the floor for non-engineers to collaborate on complex studies and experiments. An engineer may be able to look at a mathematical model and know that if they adjust the angle on a front bumper by five degrees, the average air coefficient will be affected in a certain way, but no one else will be able to parse it.

When the data is in an interactive demo, anyone can interact and see how the changes they make will affect drag. In a game engine, you can easily adjust variables like wind direction and speed in real time.

These same principles can be used to test fluid dynamics like oil flow in an engine or water tightness around a windshield.

Geometry and building exploration

Game engines are also excellent tools for geometry exploration. For example, you can create a simulation with force feedback to test whether removing a seat from a fully assembled passenger cabin is relatively easy.

What if you could find out how hard it is—or if it's possible in the first place—to remove that seat, and which designs may need to change before a single physical model is ever produced? A game engine enables you to adjust variables like the height of the technician, various spacial tolerances, and the mechanical parts of the seat assembly, all in real time.

Materials testing

Because game engines can employ real-time ray tracing to generate photorealistic imagery on the fly, they're incredibly well-suited for materials testing. If you're experimenting with a carbon fiber dashboard design, for example, you can use an engine to test whether it reflects sunlight in any and all lighting conditions. If the dash is angled too far in one direction or the other, chances are that the dashboard will reflect off the windshield and produce a massive distraction. With a real-time engine, you can make adjustments and validate them immediately.

Simulating complex interactions with product setups

At its core, research is all about testing to see if concepts work in the real world, and pushing the limits of these concepts. In a research environment, real-time engines provide methods for proving whether a concept is possible, or if there are ways to improve upon existing processes. Their high-quality physics and collision simulations, along with highly optimized network replication functionality, make it relatively simple to conduct experiments that are both accurate and accessible by multiple users simultaneously. You can feed live sensor data into a real-time engine and see how manipulation of key variables can augment your existing products.

Connecting sensors and test capabilities

Connecting sensors to a game engine enables you to test all the various scenarios and devices you want to research, and in a novel and relatively simple way. Game engines can serve as a consolidated environment where any source of data can be viewed, interacted with, and adjusted in real time. While purpose-built software already exists for doing these tasks, most solutions don't allow for real-time data manipulation, nor do they produce photorealistic imagery.

Image courtesy of Magicor/Granstudio

If you want to test claims that a new sensor has the best facial recognition capabilities, you can connect the sensor to a game engine to validate the claim. If it isn't actually better, you can examine the sensor and see if it's possible to build better facial recognition software and find out how far you can push its capabilities. Real-time engines excel at creating photorealistic imagery, so generating ground-truth training images for machine vision applications is an extremely common use for researchers.

Multi-user interaction with research data (AR/VR)

When sharing research data around the world, it's incredibly important to have a shared virtual environment that's closely synchronized from one user to another to ensure the validity of any collected data. The Pixel Streaming system in Unreal Engine, for example, enables multiple people in different locations to interact with, manipulate, and collect accurate data regardless of their individual local hardware configurations. Similarly, you can have one build in place and give various stakeholders access to the visual data in AR or VR, helping to eliminate information silos within your organization.

Manufacturing

Manufacturing can benefit from real-time engines in myriad ways. Game engines play a key part in Industry 4.0, serving as open-data platforms. When your organization's data is in a game engine, that data can be used in unlimited ways, including workflow visualization, tracking of production cycles, robotics programming with machine learning, and implementation of AR and VR training for complex tasks. The game engine becomes the hub for all your digital assets, be they models of vehicles or complete digital twins of the facilities in which your vehicles are manufactured. It becomes the source of truth across your entire organization, ensuring consistency and accuracy regardless of where the data is used.

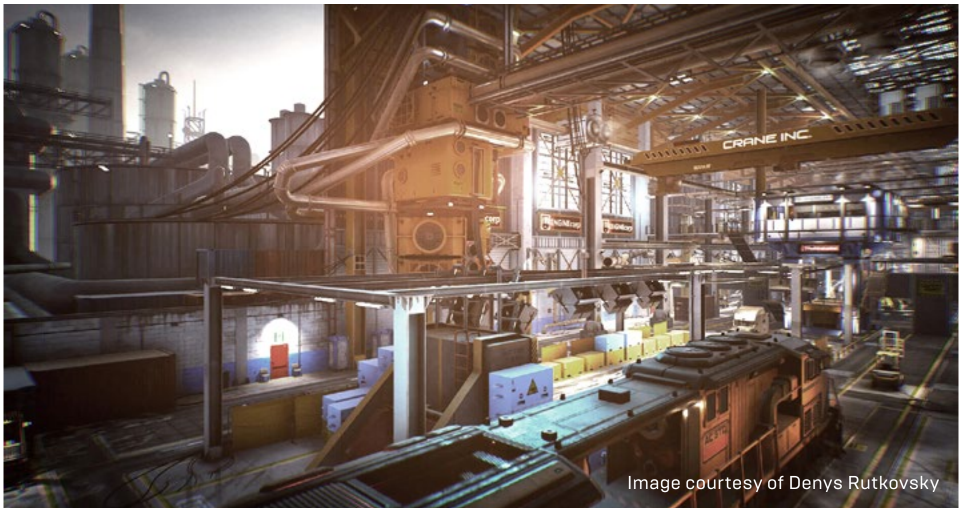


Image courtesy of Denys Rutkovsky

AR and VR in manufacturing

As manufacturing jobs become more sophisticated, you need more complex training environments. Furthermore, you need to decide whether the environment and task are more suited to augmented reality or virtual reality.

If the AR pieces of your production cycle remain relevant and provide training benefits, and the task is relatively low-risk for physical harm, AR makes the most sense for training. Should the task at hand be dangerous, a VR training simulator would be more practical.

AR tracking production cycles

Game engines make it easy to track production cycles in augmented reality. When you have sensors in place in your manufacturing environment, you can view production in real time and make tweaks to processes on the fly.

With a game engine, it suddenly becomes possible to monitor the path of a delivery cart throughout your facility and develop the ideal schedule for parts drop-off at any given station. With AR, visualizing the productivity "domino effect"—a rippling change that results from a small adjustment to technique or parts drop-off timing—is relatively simple, and can lead to unforeseen efficiencies throughout the production cycle.

These visualizations are easy to share, and because everyone at the review session is looking at the same model and the same data, even non-technical colleagues can easily provide input and suggestions.

It doesn't matter if one group of stakeholders is in Germany, another in Austria, and a third in Michigan—disparate teams in disparate locations can be in the same virtual space together, making decisions about production efficiencies.

> Using Blueprints, our technical artists were good to go, and with less effort compared to other engines.

Stephan Baier
Head of Immersive Experience, MHP

Robotics simulation

Implementing machine learning interfaces and AI into manufacturing is a cornerstone of Industry 4.0, as is an increased reliance on robotic labor for repetitive tasks. But for AI and robotics to be effective on your production line, they must first be trained for both conventional behavior and edge cases.

To make a robot efficient for its environment, you have two options for programming it: train the robot in a real-world scenario, or virtualize it by connecting all its sensors to a real-time virtual environment and running hundreds of thousands of test scenarios overnight.

Workflow visualization

Communicating complex processes without visualization makes it incredibly difficult to collaborate with others and discuss approaches to challenges. By replicating your manufacturing facility in a real-time engine, you can show stakeholders and business partners how your facility will operate down to a per-worker scale.

You can zoom in to any level of detail and see every screw you want to simulate, or zoom out to a high level and watch a box as it moves down its path through the facility. By implementing AI here, it's feasible to find the most efficient paths through a plant for any given just-in-time delivery model, and visually demonstrate that to key stakeholders. In Unreal Engine, you can use the Blueprint visual scripting system to automate and demonstrate different test scenarios as well, making it easier to convince others that these efficiencies are a better way to work.

Unreal Engine's Blueprint visual scripting system makes it easy for non-programmers to perform tasks and create objects without writing a single line of code. Scripting is done using a visual system of connecting nodes. Blueprint-specific markup, available as part of Unreal Engine's C++ implementation, also enables programmers to create baseline systems that can be extended by designers.

Game engines also make it easier for someone working in production to use a real-time tool to communicate and solve a problem. Production efficiencies can be developed by anyone in the field, and implemented sooner. Inefficiencies can be spotted much faster, and by anyone, not just a high-level engineer.

Connecting to production tools and sensors

Physical robots interact with the virtual world via sensors, and to train a robot you need a tool that can take physical sensors and interact with them in the simulation. Game engines have a certain amount of intelligence to handle simulations, but for more complex scenarios, offloading those calculations into a bespoke hardware-in-the-loop (HIL) simulation would likely be a better solution.

However, with a traditional simulation outputting a mathematical formula for a test scenario, it's difficult to grasp how the software came to its conclusion.

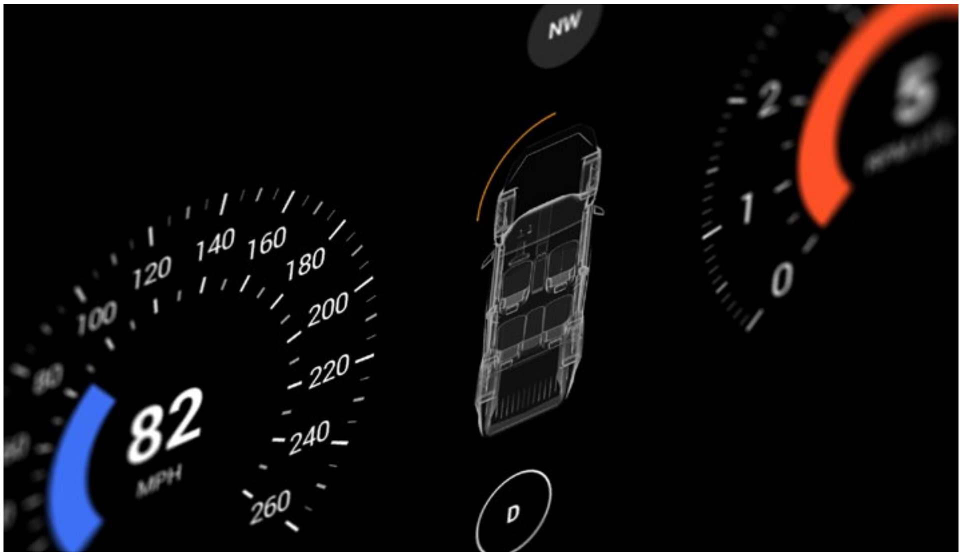
Connecting a game engine to HIL means you have a conduit between the data and the game engine visualization, enabling you to see high-quality visual representations of simulation results. Because the data is visualized in a game engine, it's possible to turn the visualization into a game that you can interact with in real time.

> The biggest benefit for us has been the ability to use Unreal Engine as a flexible platform that we can integrate into several different closed systems.

Jon Friström
UX Researcher & Cognitive Design Engineer, GEISTT AB

Digital twin as a communications platform

As you can see, when you start thinking about your data in terms of a unified, open platform, it becomes as valuable as it is malleable. By producing a digital twin of your manufacturing facility and your entire plant and its machines and production processes, you can freely explore ways of creating new efficiencies. Whether it's by changing the timing of part delivery or moving your process to a different part of the facility, with an open real-time platform you can see the ripple effects that one suggestion made during a collaborative review can have across multiple scenarios.



HMI app simulation

By creating a digital twin of your vehicle in a game engine, you can simulate all aspects of testing; you can even develop an app that runs on a human machine interface (HMI). You can create the HMI interface as a game, connect the real software it's running to a real-time engine, and simulate situations where it truly feels like you're interacting with the touchscreen. Interacting with the radio and screen in a simulation is a one-to-one experience of the real-world model. Similarly, it's possible to connect the simulation to a real car and test that the wiring works, the back-up camera activates when in reverse, and HMI controls for power windows function as expected.

Marketing

Automotive marketing in Unreal Engine began in 2016 with a cinematic trailer and product configurator for the McLaren 570S. In 2017, Epic Games teamed up with Chevrolet and visual effects production house The Mill to produce an interactive short film. But rather than users choosing between preset camera angles or making binary decisions about plot points, they were picking the 2017 Camaro ZL1 hero car's visual options, and adjusting the appearance from any angle using a massive touchscreen display. Whether they chose the stock Red Hot paint job, or opted for something a little more on the classic side—a skin of a 1967 Camaro SS, for example—or anything in between, it was all done in real time, and their choices were instantly reflected on-screen in photorealistic detail.

The Human Race, the world's first configurable live-action film, was built entirely in Unreal Engine. Lighting, tracking, and reflections are all convincing enough that you'd be forgiven for thinking these were production models carving out turns on cliffside coastal highways. *The Human Race* tells the story of a human race-car driver dueling an artificial intelligence (AI) driver, but the underlying narrative is about how real-time technology can propel automotive marketing into the future.

Image courtesy of The Mill | Sky F1 | Sky Creative Agency

Marketing innovations like these extend into the dealership. The BMW Group's Emotional Vehicle Experience (EVE) VR system, powered by Unreal Engine, runs in all BMW dealerships worldwide. Vehicles can be configured, animated, and swapped into different virtual environments, with the resulting images or videos emailed to the potential buyer.

A benchmark-level automated process could look like this: your customer spends an afternoon mulling over the myriad options for their dream car with a real-time configurator. They've spent more time looking at it from the exterior than they have sitting in the virtual driver's seat, and a vast majority of that time was spent looking at the car from a head-on view. The customer wants a coupé, not a convertible, and has decided that bright blue will look best in their

> When you start playing around in a real-time engine, you quickly see the benefits of it as a platform for directors and storytellers.
>
> Alex Hammond
> Head of 3D, The Mill

> We believe that in the future, all product-related content will be generated on demand in a personalized way.
>
> Stephan Baier
> Head of Immersive Experience, MHP

driveway. Or maybe the majority of their time was spent poring over different upholstery and interior options, figuring out if they could fit two kids and a dog in the backseat. The customer leaves the dealership, and as they're driving home, they get an automated email from the dealer's customer relationship management system thanking them for coming in. Except instead of generic, placeholder beauty shots of a hunter green convertible taken from the rear end, the customer sees the exact bright blue coupé they just configured, and from the angle they spent the most time considering. This could be the push needed to turn the customer's dream car into a reality.

The old days of picking a lone hero car for each market and going into production, only to find that the color or appearance options are wrong for that region—those days are over. With millions of dollars spent by the industry each year on producing assets for different regional markets and dealer groups, minimizing these inefficiencies has the potential to save significant amounts of money. Now you can take a 3D model and configure it on the fly for online and printed marketing materials, even for linear TV spots. The time a customer spends configuring their dream car doesn't have to be wasted: that experience can be portable, and follow them through their entire purchase journey. Every decision made along that journey is captured, and can be converted into tailored marketing materials to convert might-be buyers into lifelong customers.

When you use a real-time engine, it's possible to create marketing materials from approved design data much earlier in the production process. That goes for both online and offline content for making 4K broadcast-ready materials, interactive content for touchscreen video walls, or static content like print-ready still images.

These can all be created on demand and accessed by anyone in your supply chain and organization. Should the design change downstream, those changes automatically apply to the real-time model and the data file in the connected source application. With an open platform, everyone in the automotive value chain always has the most up-to-date data. In short, your entire organization has easy access to the source of truth, ensuring consistent, accurate content.

When a partner makes a request for marketing beauty shots, rather than waiting hours, days, or longer for a response, they can have them instantly. To create further efficiencies and reduce wait times, you can create easily accessible asset libraries full of approved still images, interactive activations, and broadcast materials.

Autonomous driving

Autonomous vehicles rely on physics-based sensors to detect the world around them. Their physical cameras, radar, LiDAR, and AI require thousands of hours and millions of miles of training in their collective effort to replace human drivers. Success is measured by the sensor array's ability to process the enormous amount of data, and interpret the vehicle's proximity to other vehicles, pedestrians, cyclists, and road debris. An autonomous suite also has to read the road in all weather and lighting conditions—lane markings, signal lights, traffic signs—and react as a human driver would.

Image courtesy of CARLA

That testing can be done in two ways, but regardless of whether you're doing physical or virtual testing—or both—you need a tool for processing the volume of data generated. When paired with the proper plugins, game engines can not only visualize the reams of physical sensor data, but can also be used to build complex scenes and test scenarios for visualization. If you opt for virtual testing exclusively, game engines provide greater levels of adaptability, given the sheer number of testing scenarios you can run and visualize overnight.

These traits also mean game engines are highly capable machine learning tools, making them ideal solutions for training AI to perform quality-control tasks in a factory's paint shop, or any other visual tasks.

There are a number of advantages to using game engines for autonomous driving simulation. Test runs can be replicated with 100% accuracy, enabling the engineer to figure out what went wrong more easily. You can quickly adjust test runs based on new findings to make sure specific errors don't reoccur. And you can run tests many times faster, reducing the time it takes to get software approvals for production.

Ultimately, these factors mean game engines are highly cost-effective for autonomous driving testing, enabling you to run simulations and validate the efficacy of your software faster, thus reducing both development time and time to market.

Connecting sensors to game engines

Once a sensor is connected to a game engine, what you can do with the output data is limited only by your ability. Jump into VR and assume the perspective of a pedestrian for a ground-level view of a test scenario, adjust sensor parameters in real time, render the changes overnight, and analyze the next day.

Building environments for sensors

There are a variety of ways to build environments for testing sensors. You can start from scratch if you're so inclined, but why do that when there are a number of templates and pre-made test environments already available for game engines?

Testing autonomous vehicles in the real world has inherent limitations, but a dynamic, photorealistic virtual testing environment does not. These testing environments give researchers and engineers granular control in monitoring how their AI responds and adapts to situations that might be impossible to test for in the physical world. You don't have to be in snowy Michigan anymore to test your computer vision system's acuity in a blizzard. Instead, you can load a point cloud of the American Center for Mobility's test track (via a third-party plugin) and control snow density and wind speed yourself—from anywhere.

Beyond AI training, game engines can be used to build virtual obstacle courses for robotic race cars as well—after all, game engines were designed for making entertainment. Imagine a Saturday night in the not-too-distant future where you load the family into your autonomous car for a trip to the race track, except instead of physical hazards on the asphalt, there are QR codes.

At this new type of race track, there are two video feeds running to the jumbotron: a conventional camera and another showing what the cars "see." Each QR code represents a different hazard picked by audience members before the race, giving fans a chance to have an investment in the action. Or, fans could even customize their own barriers at home and upload them to the stadium so everyone watching can see the piece that took out the first-place driver on the final lap.

Simulating and saving time in training and testing

The open nature of game engines means you don't have to reinvent the wheel to start simulating high-fidelity test scenarios in a real-time environment, either.

Instead, you can spend more time authoring these scenarios in the source applications best suited for the task.

Working within a game engine means that if a sensor isn't placed correctly and isn't gathering enough data, the error is noticed within hours or days—not months. You can change sensor geometry and test new fail-safe mechanisms in a fraction of the time it would take to test in the real world, leading to greater efficiencies in autonomous testing.

Regulation and possible future vision

Virtual crash tests are commonplace, but real-time technology brings a great deal of additional value to such tests. Now engineers can make a simulated crash look exactly like a real crash, and pause the test at any time to visually inspect how metal and plastic deform during an impact. Not only that, it's possible to peel away layers of the vehicle and see what's happening to each component in real time, from sheet metal to the wiring harness. A virtual crash can be viewed from any angle—you can even watch the entire accident unfold from inside the cabin. Virtual tests most likely won't ever replace physical crash tests, but the virtual environment means testing can happen earlier and knowledge can be applied and iterated upon before physical test vehicles are built.

Similarly, government regulations require autonomous vehicles to prove their mettle in the real world before they're cleared to operate on the street. Thousands of miles driven and countless tests performed in simulation don't mean a thing if the physical vehicle can't perform just as well, time and again. Game engines can't make the wheels of bureaucracy turn any faster, but their real-time visual nature can speed up AI training processes. Shrinking the gap between sensor prototype and a validated virtual model means you can start real-world testing in far less time.

Communicating the capabilities of autonomous features

Before vehicles get to Level 5 autonomy, they're going to get smarter in other ways first. Automatic reverse braking, lane detection systems, automatic stop—among others—are the features that provide bridges to full autonomy. The problem then becomes acclimating drivers to these features that change the traditional driving experience quite substantially. If they're accustomed to setting the cruise speed to 85 MPH and weaving around slower-moving traffic, then it's going to feel foreign to use radar-assisted cruise control to maintain a steady pace at a safe distance. By training drivers in a game, simulation, or VR during the purchase process, the shock can dissipate well before they get their new vehicle home, leaving them delighted rather than annoyed.

VR/AR

Without game engines, modern virtual reality (VR) is a static affair. Before game engines, you could look all the way around you but the experiences were limited to linear two-dimensional events like concerts filmed with 360-degree cameras. The advent of real-time technology changed all that and made interactive room-scale experiences possible. Suddenly, you were able to control your own view of the digital world, walk around an environment, and use your hands and natural motion to interact with it like you would the real world. VR presence—when your brain is convinced you're in a real space—quickly went from being an elusive target to an industry standard. But VR has so much more to offer than fun and games; its applications in enterprise are equally limitless.

Game engines excel at handling data and acting as open platforms. Using them to set up your data means it won't take a lot of extra labor to bring photorealistic interactive environments or augmented reality holograms into your work. Import existing CAD and design files into a real-time engine once and the associated data preparation software will remove the myriad parts not needed, producing high-quality assets that can be used across the entire automotive value chain.

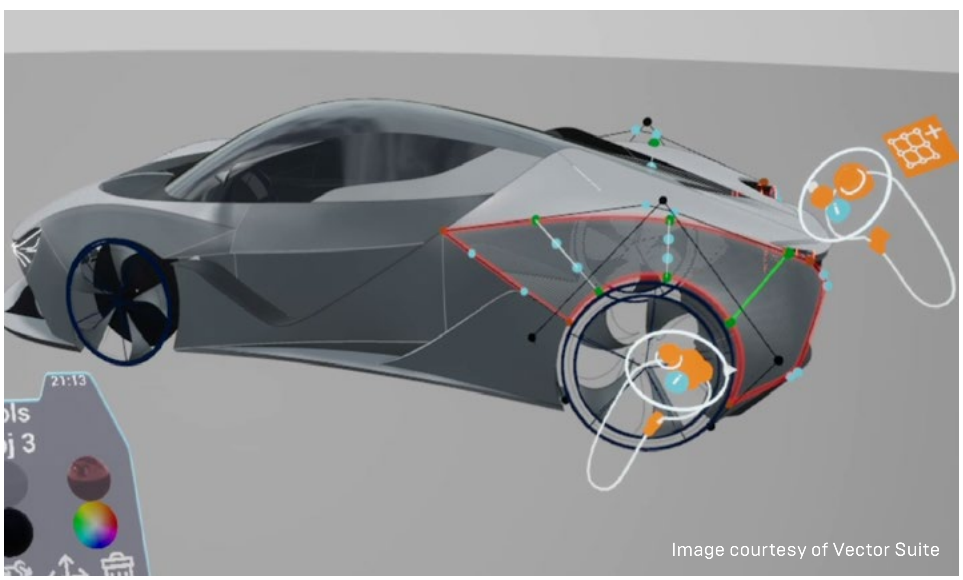


Image courtesy of Vector Suite

Game engines and the ecosystem of third-party tools around them enable other efficiencies too, like real-time collaborative design sessions. Even if a team is spread across the globe, one person could be sculpting a life-size model with VR wand controllers while another is drawing on a Wacom tablet and a third is reviewing designs as they're finished. Beyond design, VR is the perfect tool for retail and previsualization, too.


Copyrights: BMW AG

3D design software built to work in VR enables artists to be more expressive and artistic by its very nature. Vector Suite, for example, is easy to use and designed to be a collaborative, intuitive tool so an artist doesn't suddenly need to learn new skills to sketch in VR. By connecting this tool to an open platform such as a game engine, it becomes possible to draw a quick sketch in VR, have it approved, and move directly into concept and design.

The model doesn't have to be finished with pretty pixels and surfaces to be useful, either. Simply having the line drawing in a real-time environment means it can be exported to CAD without the artist needing any CAD training. So long as the main dimensions exist, the next person down the production chain can save time by not having to recreate the line drawing from scratch within their CAD toolset, and can spend that time on refinements instead.

Augmented reality is the next area ripe for real-time innovation. Rather than isolating someone from the real world, AR overlays critical information on top of what they're looking at. It quickly becomes much easier to train employees when they can see exactly where fasteners and wiring need to go, without them having to refer to a printed manual time and again throughout the day. This can have a profound impact in the area of safety training, where trainees can practice in simulated scenarios that would be unacceptably dangerous in the real world.

Enabling the workforce in such a way will only lead to even greater productivity as we move forward. These efficiencies at the heart of game engines empower employees to maximize their time, and focus on what they do best.

> We can change or tweak whatever we want in the source code. This is unheard of in previous automotive software.
>
> John Bulmer
> Visualization Manager,
> Geely Design UK

Challenges and opportunities

Real-time technology can help solve many problems across the automotive pipeline, and provide new opportunities to capitalize on. It can drive greater efficiencies in automotive processes, and gives us new ways to experience these processes via different types of display technology. It also opens up a world of new marketing possibilities.

Process

Building a product with thousands of moving parts is no small feat. As vehicles begin layering technological complexity on top of mechanical complexity, it's imperative that you devise a solution for comprehensively managing the production life cycle from ideation through post-launch marketing materials. Keeping vendor output and the various assets aligned—whether code, design files, or creative media—is paramount to maintaining your production schedule and budget throughout the automotive value chain. How, then, do you manage this, when vendors themselves are all working remotely?

By creating a single platform where all your data lives.

It makes a lot of sense to choose a game engine as your single platform, given how customizable they are. With Unreal Engine's open C++ codebase and access to features like Datasmith, Blueprint, and Visual Dataprep, defining a process for data input becomes less arduous.

Unreal Engine also offers access to pre-made asset libraries via the Marketplace and Quixel Megascans, reducing time spent on redundant tasks. Rather than having teams spend time creating every asset from scratch for a marketing photo shoot on a virtual set, you can create a common pool of pre-made photorealistic assets, and instead devote that time to fine-tuning the vehicle and lighting models.

To optimize your workflow and complex scene operations, the engine comes with Unreal Insights, a standalone profiling system that integrates with Unreal Engine to collect, analyze, and visualize data coming out of the game engine. Insights will tell you what's running well in your scene, what isn't, and what takes the most time to load, among other things. Adding your profile data is easy, and you can even record data remotely to minimize its impact on your project's execution.

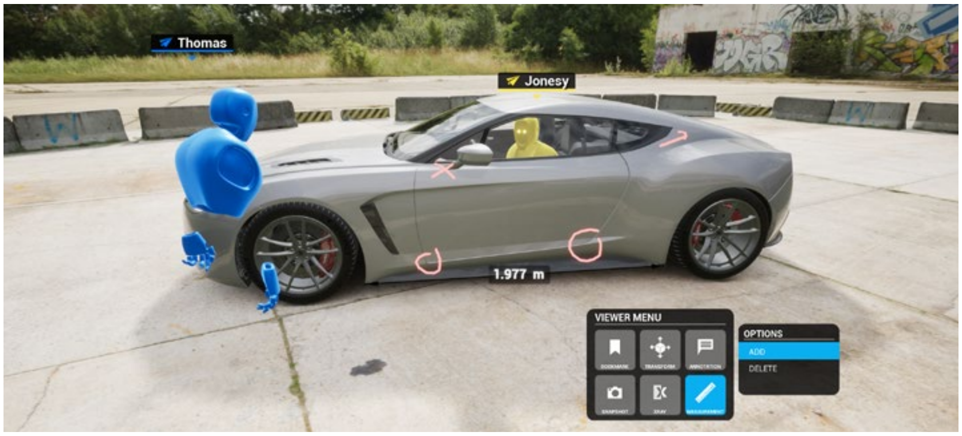
Workflow simulation and testing in manufacturing

If you're implementing telematics to set up your production workflows in a virtual environment to test how they work, game engines are an interesting option. Video games use defined parameters for collision detection and character behaviors, and these parameters directly translate to a production environment.

In a model of your facility, you can define where people will walk and work, enabling you to easily visualize and simulate what happens when you start tweaking aspects of the manufacturing process for efficiency. Connecting leading simulation tools and telematics suites to game engines makes it relatively simple to jump into a photorealistic simulation via augmented reality or virtual reality.

Real-time presentation of current status or production

Instead of trying to verbally describe the process efficiencies you've discovered, or explain them using a mathematical model that only a handful of people can understand, you can do it visually with a game engine. If someone asks a question about how you came to a conclusion, or makes a suggestion for changing a production process, you can demonstrate it right on the spot. Real-time technology enables more people in an organization to have input, even if they aren't technically proficient, which can lead to unforeseen benefits and a new diversity of ideas. The benefits of immediate interaction and collaboration with complex systems cannot be understated.



Ergonomics testing

In building a production process, it's important to keep ergonomics in mind. When designing a new seat, for example, it's possible to also design a test dummy to detect the pressure points where it sits. You can extrapolate further and study how the seat actually needs to be installed, and the motions needed to do so.

The real-time nature of game engines means you can track workflow and simulate the process needed for seat installation. Using a game engine, you could design the first part of the process, having the assembled seat delivered to the seat installation workstation while avoiding other delivery carts along the way. Then you can define the process for how the installer will have to twist and turn to fit the seat through the vehicle's door opening. Through simulation and process design, discovering and implementing production efficiencies becomes much easier.

Simulation and assessment of process changes

If you have a visual representation of a complex concept, gathering feedback becomes a much more streamlined process. Much of the time, verbal descriptions of abstract processes are incredibly difficult for non-technical team members to grasp. Making a claim that your process will result in greater efficiencies only goes so far. If you want to gain support from your team, using a game engine to visualize the data can lead to faster decision-making.

AI and machine learning

Using sensors and artificial intelligence in a manufacturing facility makes it possible to monitor production in real time. If one station on the line is more efficient than those adjacent to it, you can easily take the data from that station, feed it to AI, and let it run tests to find a more efficient way of working. In so many words, you're using AI to make your best-performing station even more efficient, and implementing that process across the entire sector to increase overall production efficiencies.

Assessment of running process in real time using digital twins

Game engines have the ability to fundamentally shift automotive digital twins to the next level and serve as the platform where everything comes together—predictive analytics for data analysis, 3D simulation tools, the Internet of Things, digital collaboration, and data system monitoring.

Everyone wants to have a digital twin for their products and processes, so it then becomes a question of how to make the reams of data relevant to the widest group of people. By representing the abstract concepts visually, you can take all the data and make it easier to understand, which can lead to better decisions, faster.

Collaborative AR meeting with process visualization

As more and more production environments grapple with workplaces that aren't physically connected, collaborative review sessions will be essential. Using collaborative augmented reality review sessions, you can leverage a game engine to easily connect people in disparate environments and ensure they're all commenting on the same thing at the same time. This not only increases cross-department understanding, but also saves a substantial amount of time—in addition to the money that would otherwise be spent on travel costs.

Image courtesy of WMG, University of Warwick

> "Reducing travel costs and removing barriers to fast problem-solving with 3D data is a big time and cost saver."

Jürgen Riegel
Principal Software Architect,
Daimler Protics

Interaction options

Different automotive processes require different types of display technology. Engineering teams might evaluate ergonomics using VR headsets, while salespeople might take customers through configuration options on a touchscreen. Unreal Engine can be set up and optimized to work with different display technologies depending on the use case.

Flat screen interactive application with/without touch

LED screens were, until recently, always flat, and any curved shape was created by placing flat screens at a slight angle to one another. Nowadays, LED screens can be designed to almost any form, shape, resolution, or pixel pitch. Flat LED screens can also be arranged in complex patterns to form three-dimensional displays. Because the image data for an LED screen comes via a cable rather than a projector, the seams between image portions can be precisely lined up, and thus overlap/blending between portions is not necessary.

AR/VR/XR templates in Unreal Engine

Collab Viewer

The Collab Viewer template joins multiple people together in a shared experience of the same 3D content. It's intended to make it easier and quicker for your team to review and communicate about designs in real time, so you can identify problems and iterate on the content more efficiently.

HoloLens Viewer

The HoloLens Viewer template is an adaptation of the Collab Viewer template that works on the Microsoft HoloLens 2. You can use it to see your 3D content overlaid on your actual surroundings in the HoloLens viewer. You can also interact with your models, moving them around and annotating them in real-world space.

nDisplay opportunities

The nDisplay plugin for Unreal Engine distributes the rendering of real-time content across a network of computers and generates images for as many displays as required. It features accurate frame/time synchronization, correct viewing frustum based on the topology of the screens in world space, and deterministic content that is identical across the visualization system.

With nDisplay, you have an out-of-the-box solution for putting content on video walls and installations. nDisplay supports genlocking, which enables you to synchronize multiple displays with rendered video frames at exactly the same time on the physical display device, be it an LED panel, dome, or Cave Automatic Virtual Environment (CAVE).

Virtual courtyard / LED stage virtual photo studio

The same technology Disney used for the series The Mandalorian is available to use for car commercials and marketing photo shoots. Real-time photorealistic imagery is fed to an array of LED screens serving as virtual backdrops while physical set dressings fill out the foreground. Because game engines are capable of producing ray-traced imagery and realistic lighting in real time, it becomes possible to light a scene with virtual softboxes to achieve the exact look you envisioned.

Vehicles are glossy surfaces, which makes using an LED volume an easy choice. Your vehicle model will reflect the LED walls naturally in camera, so there's no need to add artificial reflections in post. It then becomes possible to do multiple creative shoots for different markets in dramatically different environments, all from one location and in a fraction of the time. Other efficiencies include the elimination of travel costs for the vehicle and film crew, and a reduced chance of spy photos spoiling the surprise of your debut.

Unreal Engine-supported display standards

Unreal Engine supports multiple VR platforms and headsets. These include—but are not limited to—Varjo headsets, which we've seen used in the design stages, Oculus headsets, often used during the engineering phase, HTC Vive headsets, and of course, common platforms such as SteamVR for marketing.

When it comes to AR headsets, both the Microsoft HoloLens 1 and HoloLens 2 are supported, as well as technology like Magic Leap.

The integration of the OpenXR standard in Unreal Engine can futureproof your applications for new devices.

Finally, through the nDisplay plugin, Unreal Engine can render to multi-screen setups with projection warping and blending, such as powerwall LED displays and CAVEs.

Ancillary IP licensing and metaverse-like activations

One of the most exciting aspects of using real-time technology for automotive development is that it opens up endless possibilities for your product life cycle. Once you've created a vehicle's digital twin, it can traverse media and platforms relatively easily. You can tweak your models in the real-time engine, export them, and use them in the software of your choice to complete your experience, be that a VR test drive or a user-drivable version for the video game *Rocket League*.

You can put your vehicle practically anywhere for consumers to interact with—regardless of how far away you are from a rolling prototype.

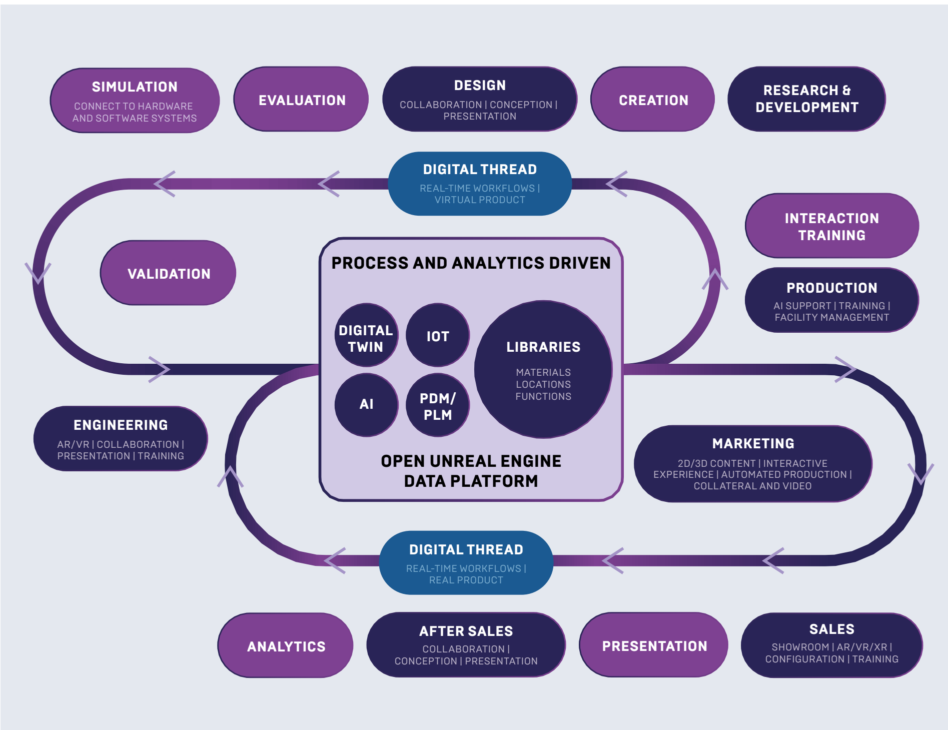
Marketers and designers can work on a project in parallel, leading to both time and cost efficiencies. If you use an engine that runs online and you introduce a new steering wheel option, you can generate all the imagery you want just once, and all the videos, VR experiences, and interactive experiences—like car configurators—will update behind the scenes. This asset reusability facilitates iteration across multiple teams that isn't possible with typical offline workflows.

Your vehicle can go from a VR exhibit to 2D imagery to an interactive location-based entertainment experience. A designer will still have to design, but the engine handles a lot of the heavy lifting and data porting from medium to medium. This process of moving the 3D model from one medium to the next is far more efficient than with previous options.

Nowadays, consumers want to do more than read a sales brochure—they want to share a moment with their friends. That could be driving Tesla's Cybertruck together in VR, or visiting an interactive exhibit in Salty Springs in *Fortnite*. Giving consumers the ability to share creates a much richer experience for the buyer, and myriad possibilities for reaching a wider audience. These types of experiences, when developed early in the product's life cycle, will enable you to build relationships with consumers from debut to purchase and beyond.

The connected platform: processes and departments

The diagram below illustrates the flow of data throughout an automotive pipeline with game engine technology at its heart. The light purple modules show the processes you can use real-time technology for, and the dark purple modules show the different departments it can be used in.



IOT
The Internet of Things (IoT) refers to the connection of devices (other than conventional computers and smart-phones) via the internet.

It implies a continuous connection between a large number of devices that perform automated data processing without human participation.

PDM
Product data management (PDM) is the use of software to manage product data and process-related information in a single, central system. This information includes computer-aided design (CAD) data, models, parts information, manufacturing instructions, requirements, notes, and documents.

CHAPTER 2

Bringing your data into the engine

Taking a vehicle from initial concept to the showroom floor creates huge amounts of data in many different formats.

If you want to build a single platform that connects siloed automotive departments together, you need a way to bring in and work with all these different data types.

In this chapter, we'll look at how automotive manufacturers can quickly and easily export diverse content and file types from across the automotive pipeline for easy import into Unreal Engine.

> With Datasmith, I can literally do the same thing I did in four weeks in one day and that is magic.
>
> Carlos Cristerna
> Visualization Director, Neoscape

What is Datasmith?

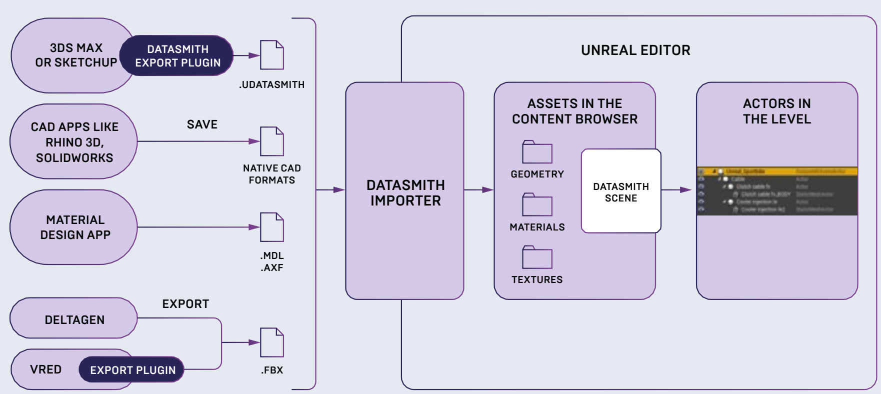
Digital platforms live and die by their data input and output capabilities. With Unreal Engine, the key entry point is Datasmith, a collection of tools and plugins that bring entire scenes and assets constructed in other industry-standard design toolsets into a real-time editor, no matter how large, dense, or heavy they may be.

You can save hours—if not days—when you import your fully assembled scene data into Unreal Engine's open platform with Datasmith.

From there, every aspect of the product life cycle can be managed: data linking, data conversion, data updates, and life cycle connection. Even if you need to reimport the complete Datasmith scene after a round of stakeholder feedback and source scene adjustments, Unreal Engine has tools and workflows for avoiding arduous and expensive rework.

Supported design applications and file types

Datasmith is compatible with many industry-standard digital creation tools and over 20 file formats. Take a look at our documentation on Datasmith-supported software and file types. You can find step-by-step support documents in our Datasmith software interop guides.



The three key Datasmith workflows

Unreal Engine offers a variety of tools to address the data preparation requirements for visualization and interactive experiences in the automotive industry. Datasmith enables a direct-from-CAD workflow, enabling import and conversion of 3D models stored in the industry's standard file formats.

The Unreal Editor can perform tasks like tessellation of NURBS data, manipulation of triangle mesh geometry, decimation, UV generation, and many other operations that are used in traditional pipelines. With the Visual Dataprep system, Python scripting, and Blueprint visual scripting, Unreal Engine offers automation capabilities to minimize manual work.

The Unreal Engine toolset can be integrated into your existing data preparation processes in a number of ways.

Unreal Engine as the end point

One approach is to fully prepare data in legacy applications, then import it into Unreal Engine for consumption. In this instance, users continue to use the tools and processes they are familiar with, although the legacy software may not offer the same array of operators to prepare and adapt the model for final use and rendering in a game engine. For example, the data may not be fully optimized for the target hardware platform.

Unreal Engine as the final preparation step

With this approach, data conversion, tessellation, and several processing steps are performed in other third-party applications, but the last key data preparations steps happen in Unreal Engine with the help of Visual Dataprep, Python, and other in-engine tools.

This setup makes sense when matching specific platform requirements and optimizations that cannot be achieved in other software, or performing some preparation tasks related to the final look development and rendering.

Unreal Engine as the central data preparation tool

The final case is to have Unreal Engine as the central data platform, orchestrating the whole data preparation process. This does not preclude Unreal Engine from round-tripping data to other third-party applications for some specific operations. Unreal Engine can also be used from end to end, from CAD to final pixels. This paradigm reduces the number of tools involved in the process and minimizes friction induced by interfaces and interexchanges.

Key data enhancement tools in Unreal Engine

We don't want to make you change the way you work in your source application just so you can start using Unreal Engine for real-time editing. Unreal Engine accepts many export formats from top 3D design and CAD tools, and also offers application-specific export plugins for Revit, 3ds Max, SketchUp Pro, and ARCHICAD. The key ingredients for successfully importing automotive data are Datasmith data conversion, flexibility in the data pipeline, and editor tools for optimizing and editing assets.

Datasmith is not just a geometry conversion tool—it also supports the import of extra information and provides a flexible pipeline with reimport and automation features.

Metadata: The metadata you assign to an asset in your CAD or 3D design software can be imported into Unreal Engine along with the geometry. This makes it easy to distinguish assets and display BIM data like structural properties or gap info. Users can run Python scripts to automate metadata assignment as well. The metadata can be used in a variety of ways. For example, when cost metadata is associated with options, your configurator can display a real-time cost calculator to the customer as they customize their vehicle.

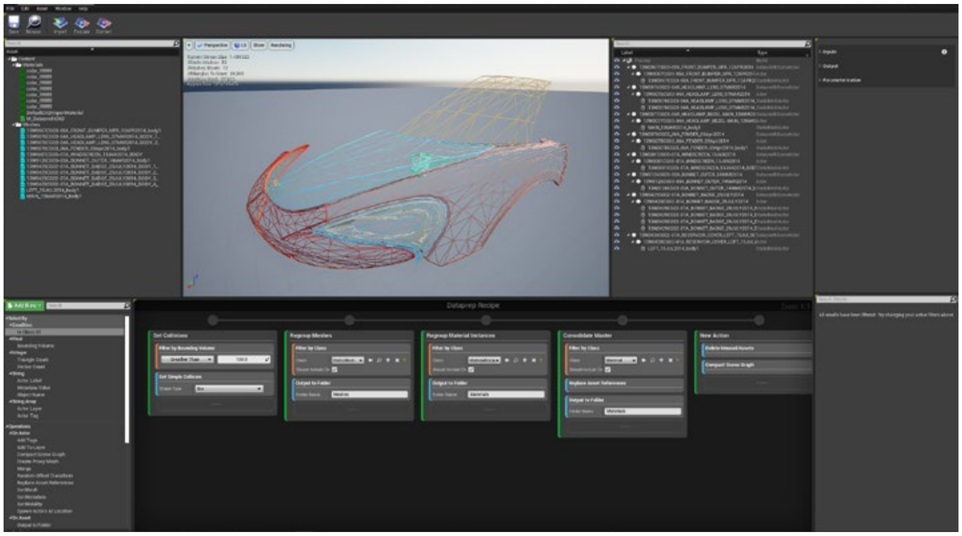
Unreal Engine is compatible with metadata from a wide range of software, including:

- 3ds Max
- Revit
- Solidworks
- SketchUp Pro
- Cinema 4D
- IFC2x3

Animation: If your source scene has objects with animated 3D transforms, Datasmith can import those into your Unreal Engine project. The engine does so by creating new Level Sequences that contain tracks for each animated object in the scene. Then, it saves this Level Sequence into the Animations folder next to your Datasmith scene asset. You can use this Level Sequence to play back the animation in the Unreal Editor or in Unreal Engine at runtime.

Visual Dataprep: This high-level tool in Unreal Engine enables a non-programmer to define an automation pipeline. Rather than have designers perform the repetitive task of manually getting CAD data ready for a real-time editor, with Visual Dataprep they can create linear recipes for importing data, assigning materials, applying tessellation, and renaming objects with a simple visual UI.

Re-import: With Unreal Engine's nondestructive reimport feature, you can easily make tweaks to your data in the source application and have the changes reflected within the Editor—automatically. Unreal Engine will watch a set of user-defined folders for changes to source content files. If the file used to import an asset gets updated, the engine will reimport the changed file into its dependent asset(s) without any additional user input.



Editor tools

Unreal Engine comes preloaded with tools for fine-tuning your data after import, ensuring you don't need to return to the source application for minor tweaks.

UV mapping: Some CAD programs don't offer the ability to create high-quality UV maps. Once you've imported CAD data into Unreal Engine, you can easily unwrap mesh geometry and set up parameters to control the results of the unwrapping. UVs can also be edited via Blueprints or Python scripts. By default, the engine will automatically unwrap some UVs to ensure you can utilize advanced scene performance efficiencies like baked lighting.

Levels of detail (LODs): LODs are an effective way to optimize your meshes and scenes for performance and frame rate goals. The LOD management system in Unreal Engine chooses the most appropriate mesh to show at runtime. LOD creation can be automated with Blueprints or Python scripts; LODs are reusable from one mesh to another.

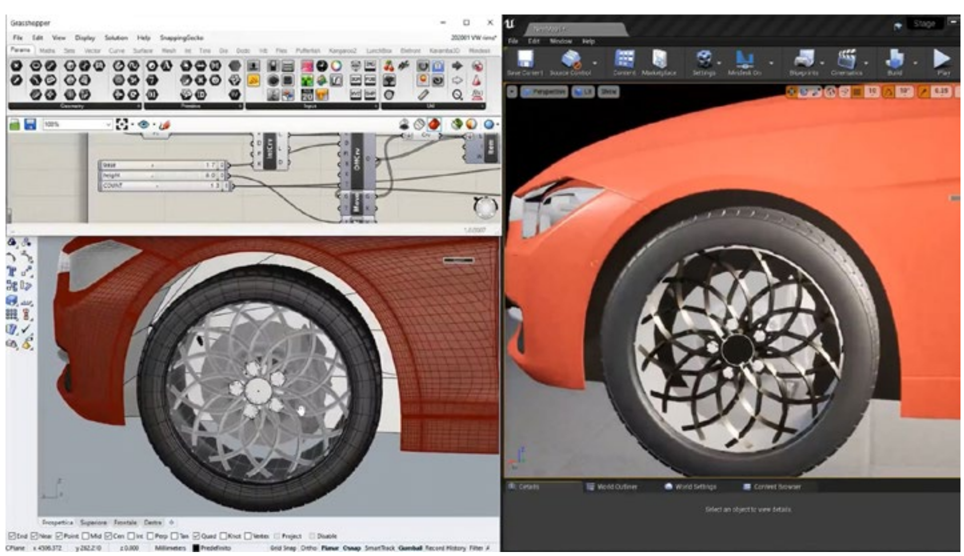
Mesh editing and defeaturing: You can easily fill holes and remove protrusions from your meshes with simple drop-down menus. Any meshes that are imported with Datasmith or FBX can be defeatured in a few clicks. Defeaturing can also be applied with Blueprints and Python scripts.

Sculpting: Geometry Brushes are available for rapid prototyping of levels and objects. These brushes are ideal for creating simple geometry for filling a gap or space. You can also use the Subtractive brush to remove solid spaces.

How to automate data setup

Unreal Engine can automate a majority of the tedious but necessary tasks when importing from CAD applications, leaving artists more time to focus on artistry.

Direct Link plugins: When you import data using Unreal Engine's Direct Link plugins, you can make changes in your source application and they will automatically reimport to the scene you're working on in the engine without affecting the objects and assets you haven't tweaked. For example, if you've changed the materials and geometry in your source application for some objects but not all, you can place the scene in a folder and import it, and Unreal Engine will only alter the assets and objects that you've changed.



Visual Dataprep setup and tools

Datasmith does its best to maintain geometry, materials, and scene hierarchy during import. CAD tools don't always prepare raw data in a way that makes sense for a real-time rendering engine like Unreal Engine, which is where creating automation "recipes" with Visual Dataprep comes in.

With Visual Dataprep, you can create Actions by simply dragging and dropping blocks of Filters and Operators into the Blueprint-like Dataprep Graph. From there, you can connect multiple nodes in sequential order to make your own custom import workflow recipe.

You can expose the parameters of those Filters and Operator blocks at any time, making it easy to identify what each recipe does, and making it efficient to reuse these workflows for other scenes and projects. The goal is to automate a vast majority of the tedious dataprep work and leave the fine-tuning to a designer.

Visual Dataprep also enables you to automate LODs, set up lightmap UVs, substitute materials, and delete or merge objects based on class, name, size, and metadata tags—all while previewing the processing results from your current scene within the Visual Dataprep viewport. Dataprep automation can be handled with Blueprints or Python scripts.

Blueprinting key processes: Blueprint is Unreal Engine's visual scripting language that enables designers to use the full range of concepts and tools typically only available to programmers. In addition to using Blueprint to automate material assignment, object selection, and merging, you can create reusable macros and functions, and modify the Unreal Editor UI itself to suit your work style. It is also possible to create custom Dataprep Filters and Operations in Blueprint.

Swim lane

In the diagram on the next page, you'll see a traditional swim lane covering the dozens of data sources typical in the automotive production workflow, with the red line representing a drop-dead cut-off.

When you use Unreal Engine, the window for making additional changes expands dramatically, enabling you to make changes up until the month before production starts. With a typical offline process, you need around six months' notice to make the same changes.

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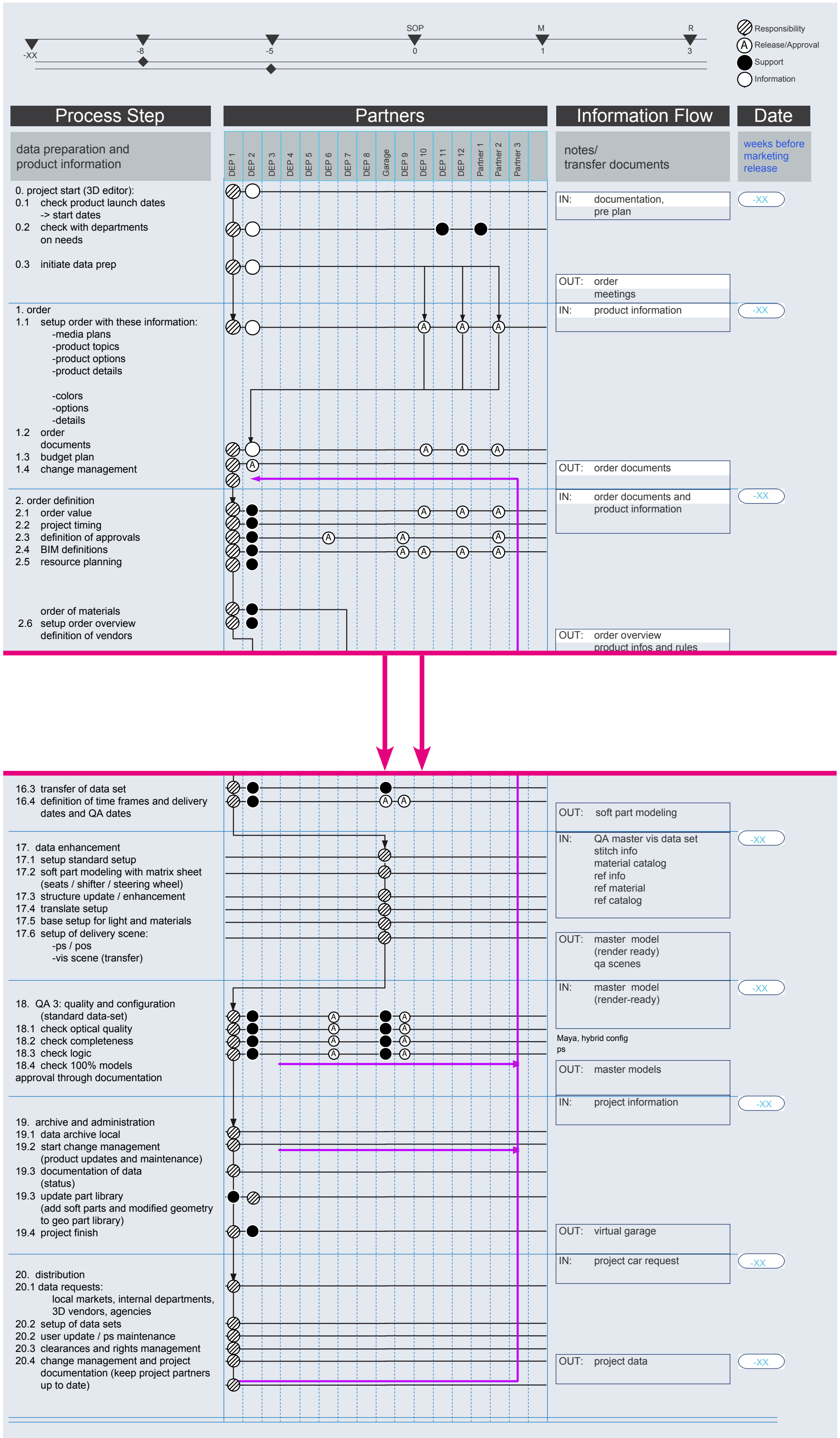

SOP
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Responsibility
Release/Approval
Support
Information
Process Step
Partners
Information Flow
Date
data preparation and product information
DEP 1
DEP 2
DEP 3
DEP 4
DEP 5
DEP 6
DEP 7
DEP 8
Garage
DEP 9
DEP 10
DEP 11
DEP 12
Partner 1
Partner 2
Partner 3
notes/ transfer documents
weeks before marketing release
0. project start (3D editor):
0.1 check product launch dates -> start dates
0.2 check with departments on needs
0.3 initiate data prep
IN: documentation, pre plan
OUT: order meetings
1. order
1.1 setup order with these information:
-media plans
-product topics
-product options
-product details
-colors
-options
-details
1.2 order documents
1.3 budget plan
1.4 change management
IN: product information
OUT: order documents
2. order definition
2.1 order value
2.2 project timing
2.3 definition of approvals
2.4 BIM definitions
2.5 resource planning
order of materials
2.6 setup order overview
definition of vendors
IN: order documents and product information
OUT: order overview product infos and rules
16.3 transfer of data set
16.4 definition of time frames and delivery dates and QA dates
OUT: soft part modeling
17. data enhancement
17.1 setup standard setup
17.2 soft part modeling with matrix sheet (seats / shifter / steering wheel)
17.3 structure update / enhancement
17.4 translate setup
17.5 base setup for light and materials
17.6 setup of delivery scene:
-ps / pos
-vis scene (transfer)
IN: QA master vis data set stitch info material catalog ref info ref material ref catalog
OUT: master model (render ready) qa scenes
18. QA 3: quality and configuration (standard data-set)
18.1 check optical quality
18.2 check completeness
18.3 check logic
18.4 check 100% models
approval through documentation
IN: master model (render-ready)
Maya, hybrid config ps
OUT: master models
19. archive and administration
19.1 data archive local
19.2 start change management (product updates and maintenance)
19.3 documentation of data (status)
19.3 update part library (add soft parts and modified geometry to geo part library)
19.4 project finish
IN: project information
OUT: virtual garage
20. distribution
20.1 data requests: local markets, internal departments, 3D vendors, agencies
20.2 setup of data sets
20.2 user update / ps maintenance
20.3 clearances and rights management
20.4 change management and project documentation (keep project partners up to date)
IN: project car request
OUT: project data
-XX

CHAPTER 3

Real-time workflows in detail

By now, you should have a good sense of the many verticals in the automotive pipeline that are ripe for transformation by real-time technology. Let’s take a deep dive into different automotive departments to find out how teams can leverage Unreal Engine for specific workflows and processes.

Real-time technology across the product life cycle

By now, you should have a good sense of the many verticals in the automotive pipeline that are ripe for transformation by real-time technology. Let's take a deep dive into different automotive departments to find out how teams can leverage Unreal Engine for specific workflows and processes.

Concepting

Real-time rendering's impact on concepting

Game engines make the process of visually representing the idea in your head much faster. Because you can get up and running quicker in real time, you can spend more time iterating and creating better concepts than you would with offline processes or drawing by hand within the same timeframe. Collaborative design sessions enable cross-platform 3D design in virtual reality, with multiple users around the world commenting and participating in real time much as if they would when playing an online video game.

Abstract versus real: game engines support both

Depending on how your lighting model and shaders are defined, you can go from complete abstractions to finely detailed pencil sketches relatively easily. It's up to you, depending on what you're trying to achieve.

One need only look to the video games created with Unreal Engine for examples of what's possible. The open nature of game engines, and the sheer number of game projects that have gone to market, mean there's a robust worldwide network of available support and premade assets so you can execute your own vision faster.

Images courtesy of Daimler Protics GmbH, Vector Suite, and Pagani

Premade assets still leave plenty of room for vision and originality. The games *Rocket League* and *Assetto Corsa Competizione* couldn't look more different despite both involving cars. Even though they're both shooters, *Fortnite* looks nothing like Microsoft's gritty *Gears 5*, which is itself miles apart from the cel-shaded chaos that *Dragon Ball Fighter Z* needs to remain faithful to its source material.

Libraries

Libraries are a way for automotive manufacturers to create an asset once and then reuse it across their entire organization, be that a Blueprint script, object, AI behavior, texture, or anything else within a game engine. Libraries serve as a centralized source of truth for the digital assets in your organization, and can eliminate the need to start from scratch for every new process or design item.

Setting up a library of Quixel Megascans in Unreal Engine means you don't have to create skyboxes and backdrops from the ground up, nor would an artist have to author every texture needed to dress objects in a scene. The time saved enables your team to focus on what it's creating versus dealing with the distraction of problem-solving. You can simply pick up assets, drop them into a library, and focus on what you really want to do.

> We no longer need to wait to understand the impact of a design decision or change, it's just a smoother process all round.

John Bulmer
Visualization Manager,
Geely Design UK

Data as a platform across the automotive value chain

What we've witnessed in the automotive space is that the tools used to create data and communicate the data visually are all vastly different from the tools used for engineering. Because there's no connection point for all the data sources, you have to recreate everything from scratch time and again with different tools. This means you lose most, if not all, of the metadata and smart features authored in purpose-built applications.

If you use a game engine as the platform where all this data comes together, you can ensure those features and metadata are readily available across your organization, unlocking many efficiencies along the way. And because everyone in the automotive value chain can easily understand the concept you're trying to convey from the outset, you can gain a lot of trust from the people who are working downstream.

Design

Using game engines for creative design

If you use game engines for illustrating a concept, the design process can go much faster because the rough ideas have already been sketched out. From there, designers can easily begin working from an approved concept without having to recreate it from scratch.

With Datasmith and Visual Dataprep, each designer can author in the application they're most comfortable with and then import the data to Unreal Engine so design reviews can take place all in the same platform. In a studio where each designer is using the same game engine, it becomes possible to have an apples-to-apples comparison of one-off iterations and apply unified feedback across the board.

What's more, software is now being developed that provides a live link between applications to reduce the friction of data push and pull. Third-party plugins such as the Mindesk Rhinoceros Live Link create a live connection between Unreal Engine and 3D CAD software, ensuring that all changes made in Unreal Engine will be reflected in their source applications—automatically—for further efficiencies.

As an example, vehicle door handles aren't typically created by one designer. There may be as many as 20 creatives working on their versions, each in their own preferred design tool. By importing the door handle data into Unreal Engine, you can ensure that each designer's version is the same size, has the same rendering applied to it, and behaves how you need it to behave for simulation. By agreeing on a common workflow and common toolset, you gain efficiencies and save time.

Simultaneous creation of design and visualization data

Not all design tools are set up for making stunning final-pixel visualizations, or offer access to the helpful asset libraries during design. Thanks to third-party live link plugins and Datasmith, you don't have to pick a new tool over the one you're intimately familiar with just to create downstream production efficiencies.

Because data is feeding back and forth between the 3D rendering tool and CAD—with a game engine connecting the two—an artist can easily generate a rough concept for designers to work into a prototype, all without ever touching CAD themselves. These designs will have perfect Class-A surfaces, ready to hand off to engineering, and the different departments can use them to communicate intent.

Virtual courtyard

What if you could eliminate the challenges of waiting for the weather and lighting to be just right, shipping pre-production models to faraway places, and sidestepping prying eyes? These challenges can become a thing of the past if you use the right tools. The virtual production principles used in Disney's *The Mandalorian* can be applied to the automotive world just as easily—except instead of dressing a set to look like a forest encampment that's mid-battle with an Imperial walker, you can use panoramic LED screens to recreate the typical outdoor courtyard evaluation area.

Evaluating a physical design in all light conditions from every angle can happen in a matter of keystrokes. For marketing shoots, these walls create photorealistic real-time reflections, enabling VFX to be captured in camera and offering far greater flexibility in shot composition. With Quixel's Megascan library, it's easy to change scenes so your press release photos look different from the marketing campaign—it simply becomes a matter of picking from a different set of premade assets.

The stage setups can also be used for car configurators and training clinics. Because everything is happening indoors, it becomes less of an issue to make evaluations based on a non-drivable concept model—and you won't have to camouflage the car to keep it disguised, either. By using a virtual courtyard, you can have everything you want whenever you want it.

AR/VR design, review, and development environment

In a perfect world, everyone who has a stake in a vehicle will be able to review and provide feedback at the same design review session.

The reality is that cars aren't made entirely in one location, or even one country. As digital design tools have taken hold in the past 20 years, there's been less reliance on clay models, but the process of designing a vehicle and gathering feedback requires the same amount of collaboration. Instead of sending the design team across the globe to evaluate a rolling prototype or clay model, you can save on budget by collaborating on a design review in virtual reality (VR).

With a game engine, it becomes possible to connect stakeholders in VR much as you would on a Zoom call. But instead of sharing screens and PowerPoint decks, creatives are sharing, interacting with, and commenting on real-time 3D models. Pixel Streaming means that everyone sees the exact same model at the same quality level from anywhere in the world, regardless of their local hardware's capabilities.

Cabin review

A few millimeters can change everything. Using VR to review cabin design gives designers the context and perception of dimensions they need for making accurate decisions. It's easy to get disconnected from how large a component actually is when you're viewing it on a 2D screen. Suppliers change, and while one was able to create a dashboard within your original tolerances, another may not. It's possible to avoid lots of rework if you know this as early as possible, and have every stakeholder present to inspect a life-size model when big changes need to be made.

Unified viewer for all verticals starting in design

One of the biggest bottlenecks in the automotive industry is communication between departments. Delays in communicating a concept will directly impact production time. When many processes operate in series, a slowdown in one area affects everything downstream.

When you use a game engine as a platform for your visual data, you can get away from the traditional linear path—and it becomes possible to perform tasks in parallel and share assets as they're created. This unified process gives downstream departments a way to see and understand data during the design stage, as opposed to just before it gets to them. Because the downstream portions of production have an earlier starting point, they'll gain the advantage of having a better idea of how the data works before they commence their phases.

HMI integration and testing

Every day, we get closer to merging the digital and physical worlds. Once vehicles reach Level 5 autonomy, HMIs will offer a whole new world of opportunity for in-car experiences. We predict that screens will increase in size and number and will eventually become an important part of interior design at every level, and may even replace traditional surfaces altogether.

Virtual representations of textures and materials—either displayed or projected—could replace the physical materials of a leather-wrapped dashboard. This would make the car as customizable as one found in a video game, and would offer customers endless personalization options well beyond initial purchase. Interacting with and testing these bleeding-edge features as early as possible enables more iteration, faster.

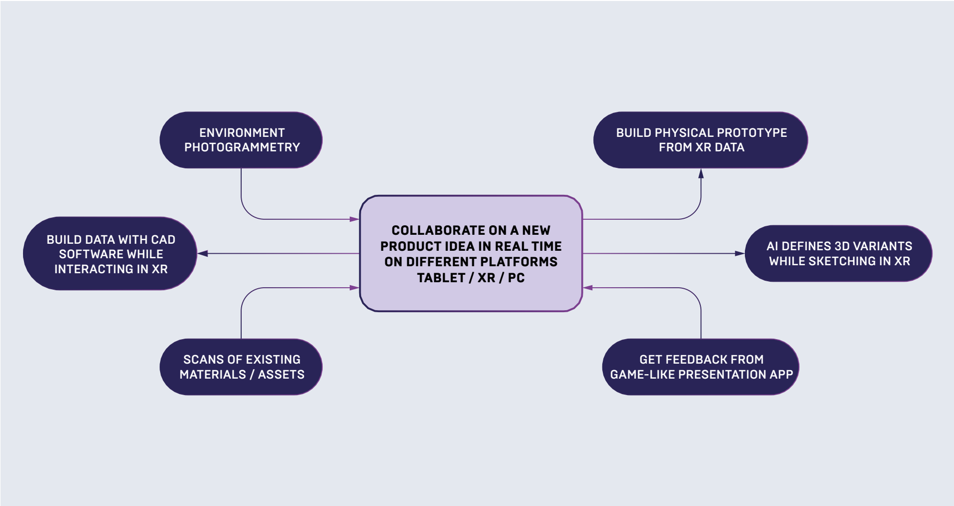
With a digital twin, your design files for advanced HMI applications are stored in a central place and can be applied to working virtual prototypes to test user experience. The virtual product you create will translate to the virtual display, and communicating complex ideas should become easier when your stakeholders can directly interact.

For the present, using game engines in the HMI space allows for a more personalized in-car experience. Instead of seeing a generic representation of your personal vehicle on your in-dash HMI, you could see the exact vehicle you're driving: the same exterior color, the same wheel option, the same trim level.

Changes to design methods overall

By and large, automotive manufacturing hasn't changed much in the past century—most vehicles start out as line sketches on paper. These designs are fleshed out into full concept drawings before a clay model of the design is produced. It's a legacy workflow that traces back 120 years.

Industry 4.0 has changed certain aspects, but the impact of immersive real-time technology has yet to be fully realized. A new breed of automakers has disrupted the field and has altered consumer expectations about how fast changes should be applied. Not only that, but these automakers are smaller and more nimble, and are able to incorporate change at a much faster pace.



This diagram illustrates the different elements of a collaborative design environment, including inputs and outputs. To have a truly immersive collaborative design experience, you have to access and share resources simultaneously in real time.

Rideshare companies have changed the automotive landscape as well. Now, instead of producing vehicles for individual customers or commercial fleets, an automaker may dedicate part of its production capacity to building Level 5 autonomous shuttles. How will that change how factories are designed, and production in general?

We believe that game engines can be the next big disrupters to the automotive world.

Fast integration of new tools and connection to simulation tools

Adopting a game engine as an open-data platform for connecting all your disparate authoring tools can be greatly beneficial to an automotive manufacturer. The data platform created with a game engine becomes the source of truth for your organization, one that's open, cross-platform, and easily accessible.

Game engines are updated with new features, often requested by their users, at a regular cadence. Unreal Engine 4.25, for example, added support for Siemens PLM XML via the Datasmith data importer for large-scale CAD projects. That's in addition to the new Mixed Reality UX Tools plugin, which provides mixed reality designers with a set of UX tools to speed up XR development, and improvements to the material system such as the addition of a proper anisotropy input, a new physically based translucency shading model, and updates to the clear coat model.

Improvements to Datasmith include added support for technical metadata for Rhino objects and better control over triangular meshes used to render parametric surfaces.

These features rolled out to all users at the same time, and for free.

Engineering

Digital mockup exploration

When you use a real-time engine as a data platform, you can translate your data into an interactive 3D model accessible across multiple departments. Engineering data can travel back and forth between concept and design within the same platform, unlocking efficiencies in time and budget because data doesn't need to be constantly replicated.

When you have earlier access to data, the window for experimentation expands, enabling you to test scenarios you might otherwise not have time for. Or, the extra time could be used to test new engineering scenarios to see how changes to frame geometry can affect crush zones and component protection.

Building an environment for testing trunk size is another example. It's relatively simple to use design data to create an interactive digital version where you can test if a trunk can fit golf clubs, suitcases, groceries, dog food, or patio bricks.

Fast data communication and access

Not everyone has an engineer's ability to look at a dataset and easily discern what the math means. Not everyone has access to, or familiarity with, Rhino or CATIA, which is why it becomes important to have a platform that can connect to multiple data sources and represent them in photorealistic visual detail. However, loading a full simulated model to do a quick design check isn't feasible due to the time needed to load all that data.

Real-time engines can easily create reduced versions of those CAD files and visualize them, enabling more people to access the models in far less time. The data isn't as malleable as it is in the source file, but you can work with it in a collaborative AR/VR experience to check for visual references and version status.

Simulation of assembly and parts

With a real-time engine, you can simulate not only vehicle assembly but also the robots that are assembling your vehicle. From there, it becomes possible to swap alternate parts and accessories to see which configuration works best for which task, or which is faster at assembling a given part.

Manufacturing

Firms know that digital assets are important—it's just that they're so entrenched in the mindset of producing physical goods that the digital transformation is very hard. Legacy processes rule the day because they've been battle-tested for decades, countless times over. That's in stark contrast to agile, digital-native firms using processes that may be only a few years old.

Problem areas

The process of making highly complex physical goods is rife with opportunity for failure, and automakers have been perfecting their processes for getting vehicles out the door for over a century. Unfortunately, these processes haven't been set up in a way that makes the business digitally savvy. Unlike a CG car in a video game, physical car designs are not created to be used in a game engine.

This leads to multiple problem areas, including:

- Data weight
- Holes in meshes
- Missing data
- Presence of manufacturing elements that are superfluous in a game engine
- Data in different formats

- Inability to scale across multiple platforms
- Lack of staff expertise and education

Moving forward, automakers and suppliers need to change the way they think of digital assets. Instead of being viewed as a necessary evil for getting the physical good, OEMs need to consider digital data as a key part of distributing their goods across the entire automotive value chain.

AR and VR in manufacturing

A line technician being trained to route a wiring harness through a firewall, for example, could use a HoloLens headset to visualize the scenario in 3D before performing the real task. She could practice the steps she'd need to take to ensure the necessary grounds are fastened, the wires aren't pinched, and all connectors are plugged in. Such AR devices remain expensive, but as economies of scale play out, we believe they'll become commonplace in manufacturing environments.

The game engine can be configured to measure each aspect of each training session, feeding data back for analysis. It's easy to turn the training into a game to make technicians faster as well. Your fastest, highest-scoring technician's technique can be digitized and used to train an AI algorithm, which in turn can test countless edge-case scenarios overnight and develop a different method that could shave off one minute of production time per harness.

Training a forklift driver in a simulator or VR makes the most sense, given how dangerous mistakes can be. You can easily create training simulators in a real-time engine, then feed the scale-accurate digital version of your manufacturing facility to screens mounted around a physical forklift. With the forklift on the treadmill synced to photorealistic images coming from the game engine, you have a highly accurate representation of what it feels like to drive through a manufacturing facility, but in an incredibly safe way—one without the potential for injuries or damage to the facility.

AR tracking production cycles

Imagine a conference room where a number of stakeholders are gathered around the table, each wearing a HoloLens headset, viewing a digital twin of your manufacturing facility. They're looking specifically at a welding station, and asking what the output of the station is at this exact moment. Because your facility was designed with AR and computer vision in mind, you can watch physical interactions on the floor represented digitally in the office in real time. Everyone can see the same model and the same data at once, and they're all able to interact with it.

This AR data can be used to simulate different engagements at the welding station, and to analyze what the most efficient workers do, with a view to replicating this behavior across the production line. Modeling instructions based on that employee's behavior is also a possibility, as is seeing how production output would change if that employee's behavior was applied to every welding station in your plant.

It also becomes possible to simulate emergency response procedures based on AR-captured data. You can recreate what happened during an emergency through interaction with Internet-of-Things connectivity and sensors running in a game engine, then test the effectiveness of different response scenarios.

Digital twin production analytics

By digitizing your entire production facility in a real-time engine, you can experiment with changes to your manufacturing process and visualize the results. Whether it's by changing the timing of part delivery or moving your process to a different section of the facility, with an open real-time platform you can see how one suggestion in a collaborative review can have ripple effects across multiple scenarios.

By placing sensors throughout a factory and using a virtual or augmented reality version of the building, it becomes possible to watch production flow and interact in real time. For example, if a stamper malfunctions, then requesting life support, alerting key personnel, and pausing the line could be done within seconds without affecting production beyond the stamper.

Machine learning for robotics programming

Bringing physical sensors into a virtual environment for autonomous vehicle testing is just the beginning. The principles remain the same, however. Industry will increasingly use artificial intelligence for automation, and that AI needs to be trained—whether it winds up in a robot or a piece of software.

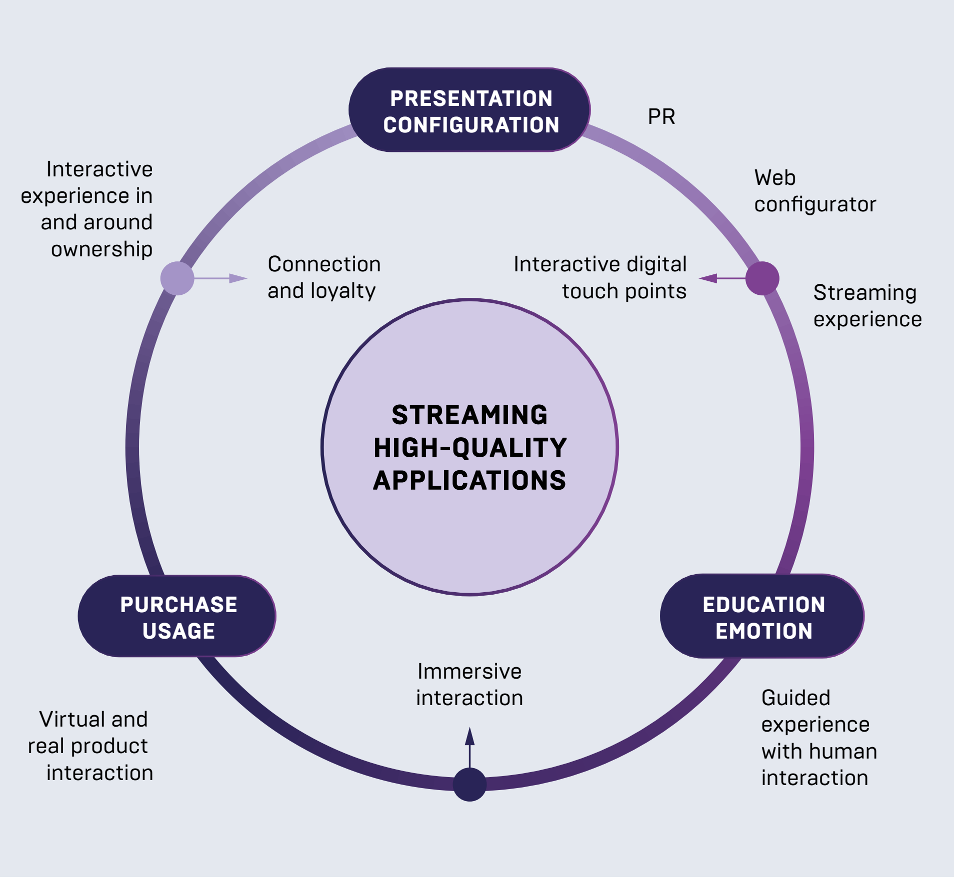
Game engines have a lot to offer in robotics programming for manufacturing as well. To make a robot efficient in the environment it's in, you need to program it. Once it's programmed, you can connect sensors to it and connect those sensors to a game engine to visualize its movement and performance data. The robot can then use that data to train itself on various use cases or events unique to your production environment.

Those use cases can be anything— computer vision applications for quality control, for example, or even a movement pattern that takes its surroundings into account and treats humans as obstacles that must be avoided. These tests can use millimeter-accurate models of your manufacturing facility to test hundreds of thousands of edge-case scenarios overnight, and create an AI algorithm for that particular task.

Sales and marketing

Real-time content production for all channels

Once a vehicle exits the concept phase, you can start creating digital assets for PR and marketing materials, mobile applications, configurators, POS experiences, and more—all based on existing and approved design data. The data and images are all easily shareable with clients and third-party vendors. The ability to create marketing materials this early translates to greater efficiencies downstream. Should any of the design change over the course of production, the changes are reflected in the universal data model, ensuring every department remains in lockstep, and that marketing materials are reliably accurate.



This diagram illustrates the user journey of a customer purchasing a vehicle. It shows how a streaming application can sit at the heart of that journey, connecting all the customer touch points by serving up the same content on a consolidated platform.

> Real-time ray tracing is a quantum leap for the whole realm 3D graphics.
>
> Manuel Moser
> Head of Real-Time Development, Mackevision

When it comes time to debut your vehicle to the press, with real-time technology you can create print-quality photorealistic collateral images up to the minute the news release publishes. Game engines make the process of creating PR materials smoother and more cost-efficient. Different assets can be created for different territories—or different colors and configurations for different campaigns—without the need to have several production models in various configurations on hand. This flexibility extends to creating highly customizable, 4K broadcast video assets as well. If you include video walls at your activation, you can use the same assets from the app to create one-off video content.

At your activation, you can show off the rolling concept and use the same assets for apps that demonstrate new features and explain how they work. For example, you could show how adaptive headlamps work in a simple tablet game or experience that puts attendees behind the wheel of your new model. Setting up a simple game with a branded racing wheel and cabin diorama becomes an easy way to demonstrate autonomous features like assisted cruise control and lane-keeping technology, using the same code that will power the features in production.

Showrooms

Currently, BMW, Toyota, Audi, and many other companies use Unreal Engine-powered point-of-sale and virtual showroom technology. Connecting a configurator to your point of sale (POS) system means that the car your customer configures is the exact one that's built and delivered, increasing customer satisfaction.

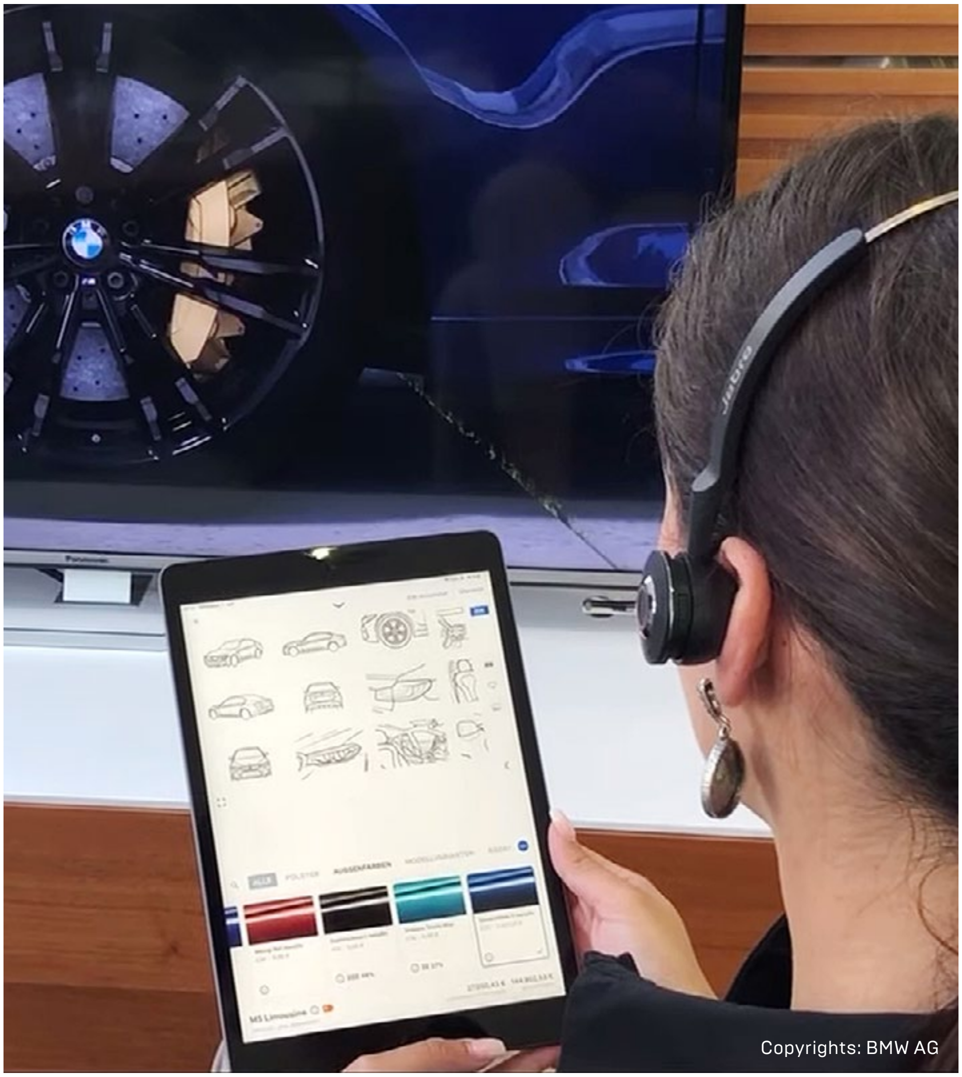
Immersive technology remains expensive and some dealerships may be slower to adopt than others. To address this, these VR and video wall experiences can be hosted offsite via Pixel Streaming, eliminating the need for a workstation or other high-end PC to run the app. This also opens up doors to flexibility. In the future, it might be more cost-efficient to have a VR headset connected via Pixel Streaming than it would a video wall. A customer could still get an immersive experience, but delivered in a more budget-friendly way.

A similar experience could be hosted on the web as well, helping to fuel e-commerce and remote vehicle sales. While it's unlikely your customers have a touchscreen video wall at home, virtually all will have a computer. Customers can get up close and personal with different upholstery, stitching, and trim options, experiencing 360-degree views of the cabin from a browser window. And if a customer configures their dream car at home and then wants to take a closer look on a video wall or in VR at the dealership, they won't have to start from scratch each time, because there's parity and uniformity across these disparate experiences.

Configurators

Game engines are a perfect match for car configurators. Unreal Engine's best-in-class real-time rendering and ray tracing makes it a good choice when you need photorealism on the fly. Getting started is simple: either create your own configurator with Blueprint, or download a template from the Unreal Marketplace. It's of the utmost importance to ensure parity between the digital configurator and the real vehicle.

Case in point: wheel options. Not only do different wheel options affect a vehicle's aesthetics, they affect ride height and, depending on the application, tire options as well. Rather than have a wall of wheels mounted in your dealership, you can replace that with an interactive video wall that shows life-size versions of the car as your customer configures it, and shows how each wheel option affects the car's appearance.



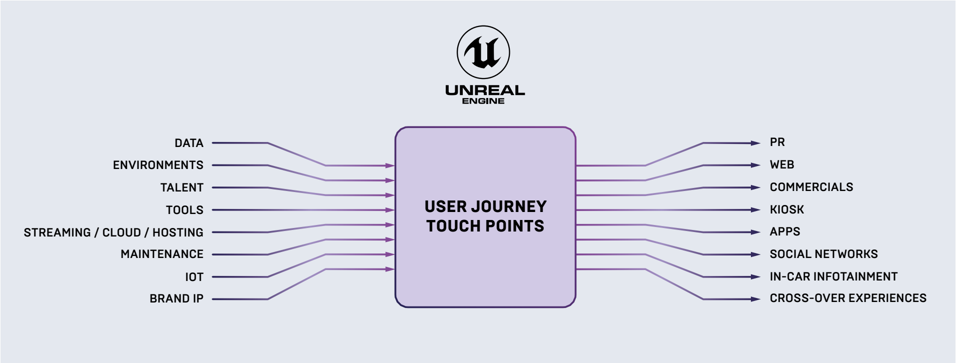
Copyrights: BMW AG

Knowing which wheel option shows more of the brake caliper—and how the now-exposed brake caliper's color coordinates with the body color and other trim options—is key to earning customer confidence when they place an order. The same can be said for accurately conveying changes in ride height by going from a 17-inch alloy wheel to a 20-inch chrome option. Making that fully complete real-time model available in a dealership setting can lead to increased sales and provide insights about your customers. You can easily see which options are the most popular, eliminate the ones that aren't, and learn how you can better predict your customers' needs.

Game engines are built for this type of configuration and interaction; when connected to a POS system, the potential to drive both sales and customer satisfaction is baked in.

Trade shows

As the world grapples with COVID-19, the appeal of large-scale in-person events has declined. Automakers still need to show off their new models and then sell them, though. Why not host them virtually? When your design data exists on an open platform, creating new experiences with it becomes much easier. With Unreal Engine's Datasmith specifically, you can import a 3D model of the exhibition space, and turn it into an interactive experience.



This diagram illustrates how different stages of the automotive product life cycle feed the outputs on a customer user journey. On the left side, you have the various design inputs. On the right side, you have the parts of the user journey they feed into.

Your attendees will be able to interact with your exhibit on whatever platform is most convenient for them, be it mobile, VR, browser, or game console. It could be a virtual test drive, interactive exploded views of the vehicle, or images of the car in otherwise impossible environments. With Unreal Engine's virtual production techniques, you can blend the physical and virtual. The only limit is your creativity.

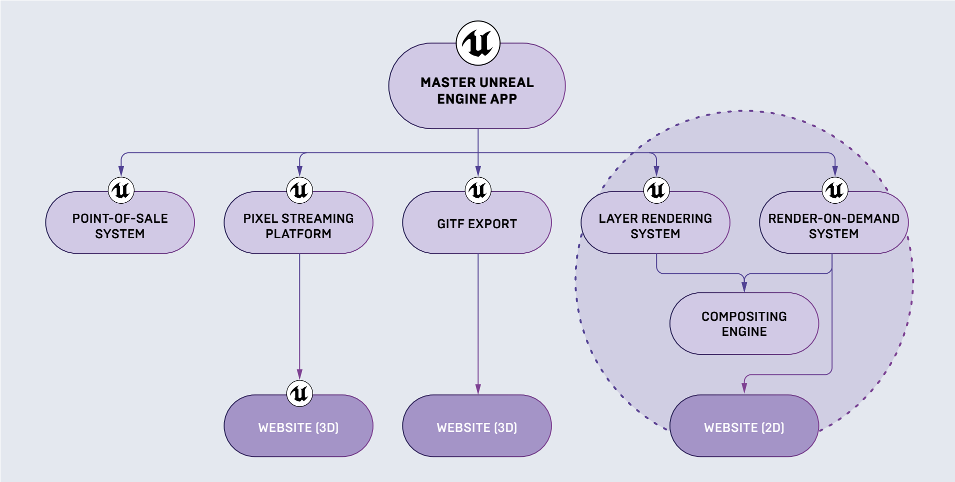
Operations

Virtual garage, digital twins, and the 150% model

A digital twin is the complete digital replica of a vehicle and all its variants. From this model, you have all the data necessary to create any variation of the vehicle, with any combination of parts and options. If your pickup truck has three different bed options, the model is one variant, with the data from the other bed options readily available.

Today's automotive data model is built on the concept of centralized design data that third-party tools access to analyze and display results. With multiple tools each producing their own data, your flexibility to bring together data from different sources is limited by the inability of tools to share it.

Further compounding this restriction, the process of collaborating, experiencing, visualizing, and interacting with the data is limited by each tool's capabilities. Ultimately, that means your ability to work effectively is determined by a mix of vendors who attempt to predict your needs. But what if you could control and manage how data works for your process and problems? This is the level of control you can have with a holistic, open platform based on game engine technology.



This diagram shows how Unreal Engine can be the master application in the automotive pipeline, from serving up content in a dealership kiosk (left), all the way back to creating the content in the system (right).

Armed with a set of new AI-driven tools, a handful of key automotive partners will be the pioneers of Industry 4.0: data-led manufacturing where information from every stage of the product life cycle can be leveraged to build higher-quality, more cost-efficient products at a faster pace.

Game engine technology will drive the automotive digital twin to the next level, bringing together the key technologies of IoT, 3D simulation tools, and predictive analytics to provide analysis of data and monitoring of systems that solve problems even before they occur.

Autonomous driving research

Autonomous testing

When connected to simulation software, game engines become powerful tools for visualizing the capabilities of your autonomous suite. Game engines can be used in a variety of autonomous testing situations.

Testing scenarios for AI

Game engines are good choices for creating test scenarios for AI because they are infinitely customizable tools that can create photorealistic images in real time. Using synthetic data, it's possible to achieve the millions and billions of miles needed to validate autonomous driving systems. The simulations can run on cloud-based hardware, and a few days later you can have a rudimentary AI model, achieving in hours what would take years of real-world perception training and testing.

Edge case training and simulation

Unreal Engine has been used by clients for testing edge cases, as well as AI training. Unreal Engine's open nature and C++ environment ensure you can customize your experience to your company's individual needs and demands.

Uber Technology Group
Uber Technology Group has been using game-engine technology as a means of visualizing and validating test scenarios for its fleet of self-driving vehicles. Engineers create one-off scenarios to further refine the capabilities of UTG's autonomous suite and test its mettle in a safe, interactive environment. This enables the team to run thousands of tests per day in simulation, changing a variety of parameters like the speed of an oncoming car, weather, or traffic patterns, and introducing scenarios such as a car suddenly entering the autonomous vehicle's lane. Only after the new behaviors have been battle-tested in simulation are they deployed to a test track, and then on real-world roads.

General Motors Cruise and The Matrix
General Motors' autonomous division Cruise used Unreal Engine to create its own end-to-end simulation tool dubbed The Matrix. The company regularly performs 30,000 tests per day, generating 300 terabytes of data from each drive. The Matrix enables Cruise to test for one-off scenarios that are hard to replicate in the real world, like an object falling off a curb and into the vehicle's path.

Cruise also employs a technology called Replay, which compares real-world sensor test data to data from onboard software and users.

The Matrix provides a means of making fine adjustments to parameters like space between vehicles, light conditions, real-world traffic signal patterns, and more.

Available plugins and open-source data visualization tools

Microsoft AirSim Plugin

AirSim is Microsoft's open source, dynamic, photorealistic environment for testing AI. The Unreal Engine AirSim plugin gives you far more control over exploring how their algorithms respond and adapt to conditions that would be hard to replicate. This ensures that in a training-driven scenario, the AI brain is learning based on correct and accurate data and sensor information, which is vital for the success of autonomous technology. Applications include AI experimentation, deep learning, and reinforcement learning.

Siemens Simcenter Prescan C++ simulation interface

Siemens Simcenter Prescan C++ simulation interface connects to Unreal Engine for out-of-the-box rendering and visualization. With it, you get Unreal Engine's photorealistic imagery in an advanced driver-assistance system (ADAS) simulation without impacting the tests you're running.

CARLA

Powered by Unreal Engine and maintained by Toyota and Intel, CARLA is a free, open-source simulator that's been designed to support development, training, and validation for autonomous driving systems. The simulator enables you to visualize all your test scenarios and their results in real time. The open-source nature democratizes autonomous testing, and ensures that even the smallest startup has access to world-class testing tools and environments.


Image courtesy of CARLA

Passenger entertainment options

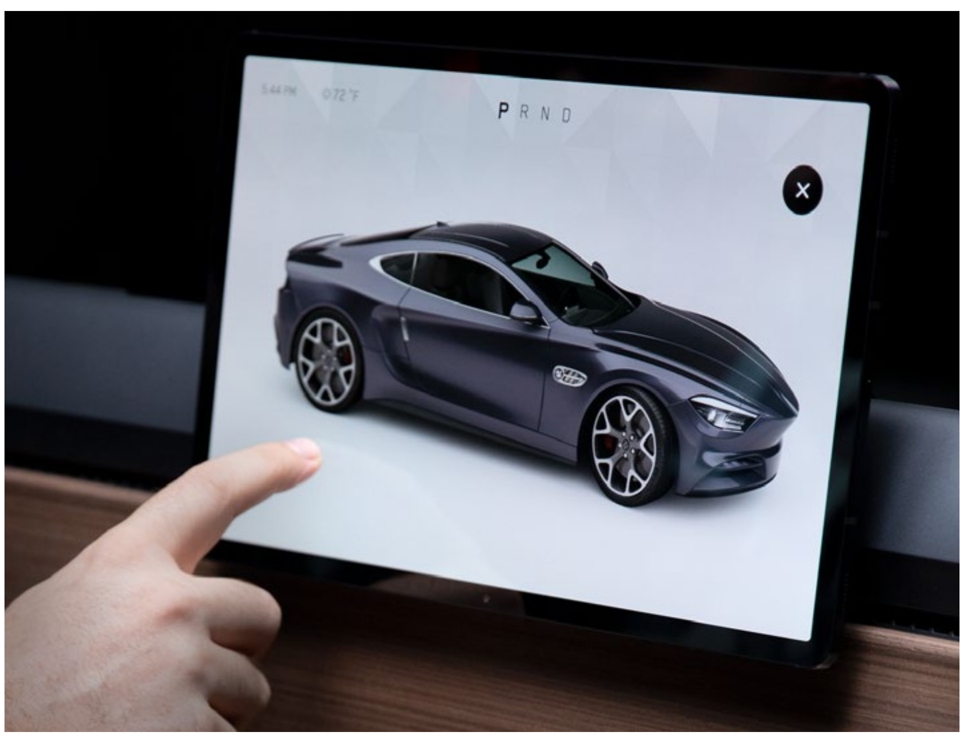
Within the next 20 years, fully autonomous vehicles will be commonplace on the road. At that point, the entire in-vehicle experience changes, and screens are everywhere. The onboard AI can use those screens to relay information such as where the vehicle is along its route, road conditions, outside air temperature, and more. The AI could also be paired with computer vision to recognize who is in the vehicle, and load the user's preferences automatically.

Because Unreal Engine is an open platform, the options for engaging with passengers in this configuration are limited only by creativity.

Human-machine interfaces

Once vehicles reach Level 5 autonomy, entertainment experiences can take over the car because you no longer have to pay attention to driving. The dashboard of the future is where your in-vehicle entertainment experience will live. With origins in the world of entertainment, game engines can play particularly well here.

Fortnite's scalability to run on multiple hardware platforms and provide cross-platform connections to different online environments proves that cutting-edge game engine technology can easily run on embedded systems with even modest hardware specs. It can handle millions of users, each with their own account, security, and networking on a global scale.



The work lies in ensuring quick start-up times and lowering the amount of resources you need to produce the results expected from Unreal Engine projects. Using Unreal Engine for HMI applications enables you to quickly catch up to new automotive startups that have had to invest heavily in their own proprietary technology.

How Android and Unreal Engine can define the platform

Android is a secure, reliable mobile operating system that has been optimized to work on moderate hardware. With Android as the base layer of your HMI OS, you can be sure that the vehicle's main drive OS and essential features will remain stable.

HMI is a key element of the automotive data platform that manufacturers must consider. By integrating HMI experiences with the rest of your automotive data, you can save time and create efficiencies with easily shareable data across multiple departments. Unreal Engine's capabilities as a data platform enables you to begin work on visual design systems during the concept phase that remain consistent across the entire workflow.

We're optimizing Unreal Engine to run on minimized systems, providing scaling solutions for large-load CAD files and real-time 3D models with accurate ray tracing. Using the Blueprint visual scripting system, it's possible to automate LOD creation so your creatives can use the time on actual artistry instead of needless work.

Options that could be driven by Unreal Engine

When every surface in a vehicle can be a screen, the options for customizing a vehicle are limitless. One potential future application would be things like user-selectable surfaces and textures; pick carbon fiber for the dashboard, woodgrain for door panels, or just go for solid red. It could all be changed as easily as the color of ambient lighting is today.

Every screen turns into an opportunity for entertainment and education. Play a video game, watch a movie, or access educational material. You could also call up an AR experience that overlays facts and information about landmarks as you pass them.

Beyond entertainment, the screens can be used to play interactive tutorial videos showing you how to use advanced features or perform maintenance.

Everything that displays on a vehicle—whether it's speedometer and tach readouts in your digital instrument cluster today, or panoramic rolling concert experiences tomorrow—can be stored, made, and accessed from Unreal Engine.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Silver Terrace
BRISBAN

HMI-specific features in Unreal Engine

There are a number of HMI workflows in Unreal Engine that you can leverage right now.

HMI startup processes in Unreal Engine have been optimized to boot extremely quickly. Content that is not needed at startup can be loaded after the initial boot, reducing boot time even further.

Best-in-class visuals for production HMI include car paint materials and reflections that bring the highest-quality real-time graphics to the vehicle. Designers also have the opportunity to work with various automotive materials and shaders that extend themselves to mobile HMI.

A comprehensive set of visual effects features that have been hardened by game development give automotive designers a robust set of tools to express creativity in their HMI designs. The possibilities to enhance automotive displays—such as energy visualizations, ADAS visualizations, and RPM gauges—are suddenly wide open.

OpenGL ES3.2 and Vulklan support on automotive hardware facilitates state-of-the-art rendering that brings the best visuals to the screen efficiently, while Unreal Motion Graphics UI Designer (UMG) provides an extensible and powerful built-in UI framework that enables designers to use Blueprints backed by C++ to easily create the HMI widgets they need.

The engine's suite of profiling tools, such as Unreal Insights, ensures designers can keep applications running smoothly, guaranteeing high-performance, fluid user interactions.

Downloadable content packs can be dynamically loaded from Over-the-Air (OTA) updates quickly, enabling you to rapidly change functionality and content in your HMI experience. And fast style-switching gives users the ability to make the car their own by changing every aspect of the user interface with the press of a button.

CHAPTER 4

Real-time technology in action

While automotive companies are increasingly bringing visualization technology in house, many rely on external agencies to provide this expertise. Mackevision and Burrows are two of the specialists that firms like Ford and Mercedes-Benz turn to when they need to integrate real-time solutions. These studios provide insights into why automotive companies should see real-time technology as a ripe opportunity to streamline processes, improve ROI, and provide better customer experiences.

Burrows

Robin Lowry is Head of Product Visualization at Burrows, a real-time visualization and CGI studio that has worked with global automotive companies including Ford, Volvo, and Mazda.

Ford Mustang MACH-E - courtesy of Burrows

“

What types of projects do you work on for automotive clients?

We produce some of the world's first glimpses of products using CGI, from simple images to major shots in a TV commercial to online and in-dealership configurators, for some of the most prestigious automotive manufacturers in the world.

At the beginning, we ingest the manufacturing CAD data, so we have a fully configurable model to use to produce any content the client needs. Most of our content is used to launch new vehicles or what is known as pre-launch, and then we produce content for all markets.

Specifically for automotive clients, we create a range of still imagery and animations of the car itself in multiple paints, finishes, and variants, and also accessories and the finer details such as trims, wheels, and optional extras.

Burrows also produces immersive experiences and product configurators, again visualizing the car in full detail.

How does using a game engine get you closer to your ideal way of working?

The holy grail would be to have a single software pipeline that does everything. Using a game engine for real-time feedback is similar to the pre-digital workflows of 20 years ago, when art directors, clients, and producers had a vehicle on set and could film it, drive it, take pictures of it, and see the result “in camera”.

With CGI in a non-real-time era, we sometimes had to wait days before we could see what we can now see instantly using Unreal Engine. Now, the vehicle inside the engine can be in any configuration, in a location where we can take virtual images or make a virtual movie and add post effects, all in the same software.

There's no need to take up valuable time and resources jumping in and out of different software packages—once the data is in Unreal Engine, we can just stay in the engine and do everything there. The most important thing for me is seeing the results instantly, so decisions on things like look and style are made there and then, and can be dealt with straight away. The old way of running things back through a multi-software pipeline can get fantastic results, but also takes a lot longer to get to the finish line.

How useful is it to have the ability to extend Unreal Engine's functionality?

We've found it very useful to create and modify our own features when required. Most of the features we've developed are driven by client needs; for example, increasing the resolution of scene captures to produce 8K HDR stills before this feature became available as part of UE 4.25, or extending the functionality of Pixel Streaming to enhance security. Because of Unreal Engine's flexibility, we're able to treat it as a sandbox for ideas to achieve higher-quality results.

Ford Mustang MACH-E - courtesy of Burrows

Ford Mustang MACH-E - courtesy of Burrows

Why do you think the automotive industry should be excited about real-time technology?

The automotive industry has long been hesitant to change, traditionally requiring customers to rely on dealerships and salespeople, offline marketing, and physical viewings to learn about and purchase a car.

Online purchase pathways have increased significantly for automotive consumers, and they are becoming more accustomed to technology and how to use it. With this shift, real-time technology can play a big role in a customer's buying decision, as well as how they consume information. Given the flexibility and speed of real-time technology, automotive brands have a lot to look forward to.

Can you sum up the benefits of using Unreal Engine for visualization?

Unreal Engine has enabled us to speed up our workflow considerably within a real-time environment. We're able to use Unreal Engine to get live feedback, which would typically take hours or days. It's also enabled us to be more flexible, providing the ability to adapt and make changes on the fly. Ultimately, it has given us a broader landscape to work in. Knowing which workflow is suitable before we begin enables us to explore potential options before even starting a new project.

Can you tell us about an automotive project you've worked on that was particularly interesting?

The Ford Mustang Mach-E Interactive Experience is a great example of what we can achieve using Unreal Engine. It shows a hint of what we're capable of and offers a truly immersive touchscreen experience.

There's a lot more to come from us. We're excited to continue our journey into real-time experiences across a range of industries, with more opportunities to fully unleash our capabilities within the interactive and immersive space coming up.

> "We're able to use Unreal Engine to get live feedback, which would typically take hours or days."

Mackevision

Mackevision (part of Accenture Interactive) is an award-winning studio that develops, implements, and runs data-driven content-creation solutions. Manuel Moser is Head of Real-Time Development.

Image courtesy of BMW AG with Mackevision

What sort of automotive projects do you work on at Mackevision?

The real-time department at Mackevision started out developing the proof of concept for a real-time/VR car configurator application. Since then, we've developed several globally deployed car configurator solutions for different automotive manufacturers. As a service provider of those solutions, we're involved from initial consulting and solutioning to final delivery and ongoing maintenance and support.

We are mainly involved in the later stages of the automotive pipeline, shortly before the start of communication with customers. But we've also created some applications for visualizing design studies of prototype cars as well.

What are the benefits for Mackevision of working on an open platform such as a game engine?

The benefits include access to source code to inspect functionality/implementation details, the community support and broader knowledge base, and the third-party integrations of different kinds, including hardware such as VR headsets.

How useful is it to have the ability to extend Unreal Engine's functionality?

Adding functionality to the existing source code is key for developing more complex solutions. The ability to reuse modules really adds business value, whether these are Unreal Engine plugins or even modifications to the engine code itself. Automation tasks at the asset level have become easier with the Python API for the Unreal Editor, and it's easy to integrate third-party libraries or data pipeline tools.

Courtesy of Ferrari S.p.A. | Mackevision

Image courtesy of BMW AG with Mackevision

Why did you choose Unreal Engine as your real-time platform?

A huge benefit of using Unreal Engine is its artist-friendliness compared to other engines. The Unreal Editor has extensive functionality, and offers the possibility to extend and expose custom build (C++) features via the Blueprint system and integrate proprietary functionality into the editor UI.

What's important for Mackevision about using tools that are production-proven?

As a company working with automakers, the production-readiness of tools is of huge importance because the clients' expectations and requirements are very high. The ability to provide globally deployed systems that factor in the client's requirements for reliability, security, and data protection comes into play.

Why do you think the automotive industry should be excited about real-time technology?

Real-time technology provides high-fidelity visualization of products such as cars, with the added benefit of interactivity and the opportunity to "experience" a car—in VR, for example. The impression of a spacious interior is conveyed to the customer so much better in VR than in a set of plain 2D images.

And it's not only exciting for product visualization—short-cycle design reviews and the ability to create real-time simulations are also benefits.

Real-time ray tracing is a quantum leap for the whole realm of 3D graphics. There are still some technological challenges that need to be solved—such as the ability to work in 4K resolution with all ray-tracing effects—but the development of new hardware and technology will surely make this available in the near future.

CHAPTER 5

Case studies

Forward-thinking automotive companies are already harnessing the power of real-time technology across the automotive production pipeline. In this section, we'll take a look at how real-time workflows are transforming processes and driving efficiencies among some of the biggest vehicle manufacturers in the world.

BMW


Copyrights: BMW AG

The BMW Group has embraced real-time technology to an extent that few other major automotive makers have, leveraging Unreal Engine across departments from design to production planning to sales.

With Unreal Engine's powerful real-time workflows at their fingertips, designers and engineers at the BMW Group can now assess vehicle designs together in minute detail in a virtual environment. This collaboration can take place from sites around the world, with the participants interacting and working together as they would in a multiplayer game.

Real-time technology has similarly transformed manufacturing at the company. Using Unreal Engine, production processes can be tested out in a virtual assembly hall before being set up in the real world, to ensure they are safe and efficient.

For BMW's customers, real-time technology completely changes the car purchasing experience. Now, they can personally configure photorealistic vehicles in an Unreal Engine-powered configurator and assess them from any angle in a range of different virtual environments. They can even sit in the driver's seat of the virtual vehicle to try it out before they buy.

The VR and AR capability that real-time technology like Unreal Engine provides is effecting sweeping change across the BMW Group. In the dealership, it's about the customer seeing their future car. In the design engineering phase, it's about seeing the car that will be on the street three to five years later.

When it comes to production planning, VR is a powerful tool for harvesting the knowledge of employees who work on the factory floor day in and day out. Show them what their future workspace will look like, and they'll spot problems that might otherwise be missed. For example, they might point out that placing a box in a slightly different spot will make screws easier to reach, shaving seconds off their work process each time.

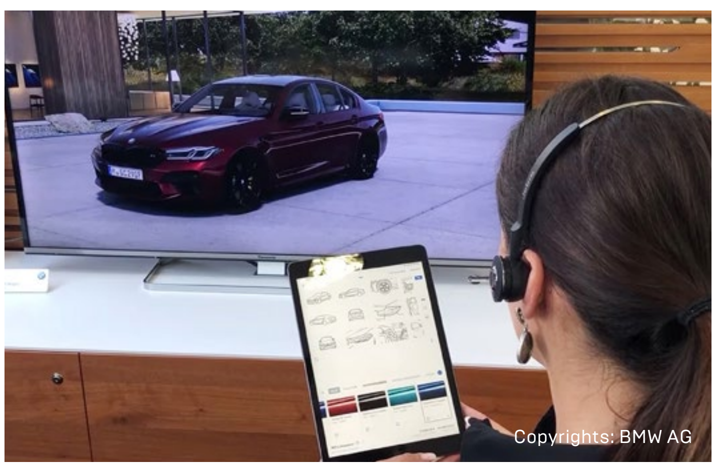
The BMW Group also uses AR for assembly training. In the past, training car assembly workers meant an experienced person had to stand next to the trainee and take them through the process. Now, trainees can learn solo in AR, where they wear a mixed reality headset and each step of the manual is displayed to them as they go through the process. This not only frees up the experienced worker, but also ensures that all new workers are getting the same training.

Similarly, salespeople on the dealership floor now have more tools at their fingertips when it comes to selling a car. Using the BMW Group's Unreal Engine-powered Emotional Virtual Experience (EVE) VR system, vehicles can be configured, animated, and swapped into different virtual environments—and then an image or video is emailed to the potential buyer so they can show their friends and family.

Cars are no longer purely mechanical entities; they are increasingly a hybrid of software and hardware. In the future, computers will play an even great role. And it won't be possible to design and test these elements purely in a hardware mock-up—technologies like game engines will be required.

Viewed through this lens, the BMW Group's wholesale adoption of real-time technology like Unreal Engine is clearly a strategic initiative. It places them in an enviable position to conceive, design, and manufacture the vehicles we'll be driving tomorrow.

Find out exactly how the different departments at BMW leverage Unreal Engine to enhance creativity, save time, and improve ROI in this article.


Copyrights: BMW AG

MHP | Pagani

Image courtesy of Pagani

Customizing a Pagani hypercar is a unique journey that enables the client to express their own taste down to the smallest detail. Understanding exactly how the seat leather will look or how the light plays on a certain finish is key to the experience.

The journey to customization is where MHP comes in. MHP is a Porsche-owned international management and IT consultancy that focuses predominantly on the automotive industry.

The consultancy's best-in-class Unreal Engine-powered configurator enables Pagani clients to play with different options and custom features—including a wide color palette, different finishes, and a range of materials—then visualize their favorite layouts in real time at an unprecedented level of detail.

Leveraging the NVIDIA RTX platform on Google Cloud, the interactive live 3D experiences created in this digital showroom can be streamed to mobile and connected devices via Pixel Streaming.

Once the client has customized their vehicle, Pagani can create a video showing the car racing in different environments, along with a digital brochure showcasing their exact vehicle with the different options they've chosen.

This highly personalized experience is the perfect match for a brand that prides itself on delivering unique products to clients.

Stephan Baier is Head of Immersive Experience at MHP. User experience was at the forefront of his mind when it came to developing the digital showroom for Pagani. "A dealership configurator should be as easy to use as your personal Instagram account," he says.

MHP used Unreal Engine to build a configurator that has usability at its heart. "This is the core benefit of our solution—it's really easy to use, even the installation process," says Baier. "It's basically the same as if you download a game from the Epic Games launcher."

Of equal importance to Baier was empowering his whole team to help develop the configurator, whether they were programmers or artists. "Initially, our thoughts concerning Unreal were that it is really user-friendly for technical artists," says Baier. "At that time, we didn't have many developers on our team. Using Blueprint, our technical artists were good to go, and with less effort compared to other solutions."

The Blueprint visual scripting system enables non-programmers like artists and designers to harness the power of programming without writing a single line of code.

Beyond its dealership configurator, MHP is picking up the baton from The Mill by creating a configurable automotive film for Pagani.

The MHP team is shooting the film at the Imola race track, and will integrate live footage of the real environment with a digital Pagani hypercar. The project is funded by an Epic MegaGrant, and Pagani will use the film for the launch of a new project from its atelier. To push the visuals as far as they can go, the rendering will accurately reproduce the real lighting from the filmed environment using real-time ray tracing.

At a glance, the film might look like a regular TV ad, but there is one big difference. Like its photorealistic configurator, the cars in the film are instantly customizable. "You can show each car as the film runs," explains Baier. "This is not possible with a conventional TV ad, because you'd have to invest a lot of effort in creating tens of thousands of different variations of the car on the racetrack."

MHP believes that soon, all marketing content will be created this way. "We don't see product-related content being pre-produced anymore," says Baier. "We believe that in the future, all product-related content will be generated on demand in a personalized way."

It's not hard to see brands buying into this vision, taking into account the cost savings of not having to pre-produce content, and the compelling proposition of having viewers tailor-make their own ads. "This is only possible with real-time technology like Unreal Engine," says Baier.

Read the full story to find out more about how MHP created Pagani's real-time dealership configurator and customizable TV ads.

The Mill

Image Courtesy of The Mill | Sky F1 | Sky Creative Agency

Since pioneering innovation in automotive advertising in 2017 with BLACKBIRD—a fully adjustable car rig that can quickly transform its chassis to match almost any car for a live-action shoot—The Mill has been battle-testing its real-time workflows on commercial advertisements.

The creative content studio developed the high-octane launch promo idents for the new F1 2020 season, harnessing the power of real-time rendering to deliver on a tight schedule ahead of Sky TV's coverage of F1.

The initial brief for the project was for a montage of driving shots of a single F1 car. Once the team had committed to creating the ads via a fully CG route, this concept quickly evolved into the narrative of racing drivers Charles Leclerc and Lewis Hamilton going head-to-head down the straight of the Abu Dhabi Grand Prix.

Unreal Engine is one of the core components of The Mill's real-time technology stack. Creative Director Russell Tickner played a key role in helping develop the story for the ads, principally using Sequencer to create the edit, lay out the car and camera animation, and handle versioning and revisions. "The real benefit of real-time tech is how nimbly you can work without the usual file creation and exchange between applications," says Tickner.

Alex Hammond is Head of 3D at The Mill. For him, real-time workflows provide many advantages compared to traditional methods of creating ads. "Unlike traditional, single, linear-narrative commercials, we develop 3D assets that take advantage of a real-time approach for the purpose of generating multiple versions of content that can be re-used with changes to details within the designed environment or character," he explains.

Using real-time technology completely changes the way you "tell the story" for automotive television advertising. The exploratory nature of real-time enables The Mill to quickly try animation and editorial choices that were not previously so fast to conceive.

The team can take previs to a whole new level, showing high-quality visuals and a much better representation of the final film or content it is creating. Because of the real-time feedback, they can instantly change camera angles or lighting conditions. These will then automatically populate the edit, allowing for faster iterations and ultimately more outcomes to the film.

> "Simply put, real-time workflows will revolutionize the automotive industry."

"Unreal Engine is like a Pandora's box of tools that are all designed to emulate real-world and camera effects," says Hammond. "When you start playing around in a real-time engine, you quickly see the benefits of it as a platform for directors and storytellers."

When it comes to the impact real-time technology is going to have in the future, Hammond is emphatic. "Simply put, real-time workflows will revolutionize the automotive industry," he says. "At the Mill, we have already used technologies to help car manufacturers visualize their products for rapid prototyping and high-end commercial films."

The ability to quickly reskin cars, alter paintwork, and adjust details has all been made possible by advances in real-time technology. Having the capacity to show off these quick alterations in automotive conferences and car showrooms is incredibly appealing, as it becomes a powerful tool for selling vehicles customized exactly to the consumer's specifications. "Unreal Engine really shines—quite literally—when it comes to rendering cars," says Hammond. "Seeing super-slick vehicles rendered through a VR headset is really quite impressive.

"The automotive sector for real-time is very exciting... and who knows, perhaps you won't need to visit a Formula One track in order to get up close to the race action in the near future."

Read the full story to find out more about The Mill's configurable advertising workflows.

Daimler Protics

Image courtesy of Daimler Protics GmbH

Real-time technology provides many opportunities to drive efficiency in the engineering phase of the automotive pipeline. At forward-thinking vehicle manufacturers today, teams are already reviewing, iterating, and collaborating on vehicle designs in VR from anywhere in the world.

> There are massive time-saving and ROI benefits from taking this approach to visualization.

[Daimler AG](#) is one such manufacturer. The German car giant's 3D and digital data arm, Daimler Protics, has developed a multi-user, online environment for engineers, all built on Unreal Engine. It's used across the company to provide virtual reality walkthroughs and real-time 3D visualization, slashing development time and costs as well as helping to deliver higher-quality products.

Jürgen Riegel, Project Lead and Principal Software Architect, describes this Engineering Hub as a multiplayer online game for engineers. "We needed a solution that would enable an engineer to load CAD data directly into a game session," he says. "We used a tool developed by NetAllied to inject a CAD render into the Unreal Engine render pipeline. That lets us have a fully Unreal network game *and* load 3D data directly from the PDM system at runtime—no data prep necessary."

Daimler had been using UberEngine, a technical 3D CAD renderer created by NetAllied Systems, to give engineers a quick look at large CAD datasets and make inspections of vehicle designs. The plugin developed by NetAllied integrates UberEngine into Unreal Engine, enabling Daimler to open up the engineering visualization process by leveraging the core functionality of a game engine.

Previously, Daimler's engineering team merely had a fast way to see CAD data, whereas now it has that and all the real-time, interactive functionality of a game engine on top. That means engineers no longer have to rely solely on 2D screens to communicate and visualize designs—they also have the option to put on a VR headset and interact with the design at full scale in a fully immersive environment.

This innovation has enabled engineers to catch errors that might otherwise have been hard to spot—and has even improved output. "It's much easier to judge sizes and assess problems if you see them with your own eyes," says Riegel. "Also, the ability to do an ad-hoc collaborative session with your data increases productivity."

Daimler's design and engineering teams are located all over the world. Having a means for multi-user collaboration in a shared immersive environment, one that's accessible from anywhere, has been a huge win. It's no longer necessary to wait for feedback on designs via email or phone calls. Reviewing work, sharing ideas, and fixing issues can now happen on the spot, collaboratively in real time.

This boosts creativity and efficiency—and also has a significant effect on the bottom line. "There are massive time-saving and ROI benefits from taking this approach to visualization," says Riegel. "We have such a diverse design process around the world. Reducing travel costs and removing barriers to fast problem-solving with 3D data is a big time and cost saver."

Daimler has leveraged real-time technology to remove the silos and guesswork that can hinder productivity, driving it towards a more agile and collaborative engineering process.

Find out more about this story.

Geely

For the past two years, Geely Design UK has been using Unreal Engine to showcase the latest designs from the studio in the highest fidelity. Today, roughly 60% of the CGI content the visualization team produces is rendered out of Unreal Engine.

With designs undergoing continuous iteration, it's vital that the design and visualization teams keep track of updates and changes. "The design is constantly changing and evolving, so having version control is essential," says John Bulmer, Visualization Manager at Geely Design UK. "Custom tools in Unreal allow us to control new data, specs, and variants."

To ensure everyone is on the same page during this back-and-forth process, it's essential to clearly communicate design intent. To that end, executable files are created in Unreal Engine and sent to the whole design team, giving everyone access to the latest design and specifications. "With this, everyone has a point of reference for the latest design," says Bulmer.

Because the designs are rendered using high-fidelity real-time ray tracing powered by NVIDIA RTX technology, they are much less likely to be misunderstood or misinterpreted. "With the quality of RTX, there's no confusion around the materials. We're able to render materials as design intended," says Bulmer. "People gain confidence in our visualization and this means fewer feedback loops, which in turn saves time."

The team can also now create instantly customizable virtual sets to showcase designs. These let them change the time of day or location at the click of a button and understand how these changes impact the materials on the vehicle, both in an interior and exterior setting. "It's extremely useful and sounds simple, but it's not been done to this level before," says Bulmer. "We don't have to wait a few seconds for the screen to update or to sort out the anti-aliasing—this is at a high frame rate on a single GPU, and it's smooth."

While the instantaneous nature of real-time tools naturally enables faster iteration and greater creativity, Unreal Engine extends this broadening of horizons to those looking to do more with the technology itself. "We can change or tweak whatever we want in the source code," says Bulmer. "This is unheard of in previous automotive software—every OEM has different processes and we need software that we can customize to our needs."

Bulmer feels now is the time for the automotive industry to wake up to real-time technology. "There are so many parts of the development process that can benefit from real-time tech," he says. "We no longer need to wait to understand the impact of a design decision or change. It's just a smoother process all around."

For his team specifically, adopting Unreal Engine has opened up a world of possibilities. "Unreal goes against the grain compared to previous automotive software. With each new development and update, it keeps pushing the status quo of visualization in the automotive industry," he says. "It's the highest-quality real-time software currently out there, it renders faster than any of the competitors, and it's open source, which is often overlooked."

This last point is what makes the engine such a good choice for Geely Design UK's design visualization pipeline. "If we don't like how something works, we change it," Bulmer says. "Everyone's used to using a piece of software as a tool. We see Unreal Engine as a platform we can build on for the future."

> "It's the highest-quality real-time software currently out there, it renders faster than any of the competitors, and it's open source, which is often overlooked."

Warwick University

Image courtesy of WMG, University of Warwick

Self-driving vehicles must be road tested for several billions of miles before they can be considered safe. Researchers have different options when it comes to performing these tests: they can do them in the real world, or they can simulate them using real-time technology.

Real-world testing achieves the most accurate results—but can be extremely dangerous—while simulation is repeatable, safer, and more cost-effective. One team at the University of Warwick has built a system that combines the best of both approaches.

The Intelligent Vehicles Group is part of WMG, a multi-disciplinary department of the University of Warwick that works with industry to undertake applied research in engineering, management, manufacturing, and technology. It works on the testing and development of autonomous vehicles, including sensors, human factors, and communication.

The group's 3xD Simulator enables researchers to drive in real vehicles and link them up to a virtual environment, which is displayed on a full 360-degree screen. "We can drive any vehicle inside, connect it to the system, and do road testing and development," explains Juan Pablo Espineira, Project Engineer at WMG.

If you want to test out an autonomous emergency system, for example, you can put a person inside a physical car that they operate as if driving. The car thinks it's in the real world, and as an emergency scenario or accident occurs and the brakes are applied, you can test the reactions of both the human driver and the vehicle.

The simulator originally came with a custom-made visualization system that had been built by an external company. The team decided to complement the existing system by adding Unreal Engine to achieve greater graphical quality, and because they needed a way to modify and extend the simulator as required. "In research, we often have to provide new solutions or adapt previous solutions in short time scales, and that is something that we could not do in the previous system," says Espineira. Access to Unreal Engine's source code gives the team limitless flexibility to adapt their simulator—to implement specific sensor or noise models, for example.

Unreal Engine's Blueprint visual scripting system enables more team members to take a hands-on role in the project. "A lot of the time we have researchers who are very good at their specific field—like sensors or electronics or mechanics—but who have limited experience with coding and visual systems," says Espineira. Blueprint solves this by enabling non-programmers to script in a more visual way, by connecting nodes rather than writing lines of code.

To build the simulator, Espineira started with Unreal Engine's vehicle template and created a road network and environment around it. He used nDisplay to project the visualization onto the 360-degree screen via eight projectors.

He used the ObjectDeliverer plugin to flow data between Unreal Engine and the car, and CAN bus hardware to connect to the vehicle's physical components. Finally, he used Blueprint to create sensor models in Unreal Engine that could interpret data from the car's non-camera sensors, such as LiDAR and radar.

Read the full story on how WMG built its state-of-the-art real-time simulator.

Image courtesy of WMG, University of Warwick

Scania | GEISTT AB

Image courtesy of Scania CV AB / GEISTT AB

GEISTT AB is a highly specialized agency that provides consultancy services, practical methods and tools, and applied R&D to enhance overall human-system performance and safety.

The firm has been working with the interaction design team at heavy-vehicle manufacturer Scania since 2013, providing R&D services, concept development, and simulation-based testing. Scania uses these simulations to analyze the effects of human machine interface (HMI) concepts for everything from new UI features to procedures for interactions with autonomous vehicles.

Prior to Scania's use of modern real-time technologies, a typical development project would consist of a few early user tests with wireframes on paper, perhaps an interactive prototype on a computer, and then, at the end, a study conducted in a resource-consuming purpose-built simulator for concept validation.

This meant that a novel concept was tested only once in a simulator environment, and the designers could not test their concept again after receiving feedback from the simulator study. Now, using Unreal Engine, the team can test concepts in immersive simulations earlier and more often in the development process. The engine's strong connection to C++ and its open-source nature enables the team to easily adapt the technology for specific use cases.

The Scania interaction design team evaluates HMI concepts in areas such as driver interaction and human-automation interaction. This might include testing prototypes of advanced driver-assistance systems (ADAS); evaluating advanced HMI features for specific user groups such as timber drivers; exploring the relationship between the AI vehicle and a driver inside it; and researching how to remotely control automated vehicles.

Jon Friström, UX Researcher & Cognitive Design Engineer at GEISTT, consulting as Product Owner for Scania's HMI simulation team, notes that research projects like these are steadily on the rise. "We see a general increase in the number of projects that research and test the relationship between humans and highly automated systems in various industries," he says. "Due to the increasing complexity of the systems that interact in different scenarios, often with higher and higher degrees of artificial intelligence, we expect to see an increased use of human-in-the loop real-time simulations in the future."

Working on an open platform such as a game engine has considerable advantages for those testing different HMI concepts. "The biggest benefit for us has been the ability to use Unreal Engine as a flexible platform that we can integrate into several different closed systems," explains Friström.

His team's simulator makes use of Unreal Engine's built-in vehicle models combined with third-party software such as TruckSim by Mechanical Simulation and Wwise by Audiokinetic. "The flexibility to shape the real-time engine to accommodate and use separate modules is a great asset of Unreal Engine," says Friström.

The team also leverages nDisplay—the technology that renders Unreal Engine scenes on multiple synchronized display devices—to offload work to many computer nodes in a network instead of relying on only one computer. "By doing so, we can render the environment to an infinite number of projection screens," explains Friström.

Friström and his team have fully embraced the switch to Unreal Engine for their HMI concept testing. "Compared to the simulator platform we used before," he says, "Unreal Engine has a broader, more supportive community."

As for the future, Friström predicts simulations will play an increasingly important role in optimizing user experience for vehicles. "What we can see is that all automotive companies are using different forms of UX simulations to an increasing degree, and this trend is clear in other industries as well," he says.

Using Unreal Engine as a platform for concepting and testing, GEISTT and Scania are well-placed to meet the HMI challenges of the future.

Find out more about GEISTT AB's workflow in the full story.

Toyota

Image courtesy of Toyota Motor Corporation

In the 1960s, the testing of vehicle ergonomics relied solely on physical prototypes and mannequins to work out things like steering wheel position and the reachability of pedals.

Fast-forward 50-plus years, and not a whole lot has changed. Many automotive ergonomics studies today are still carried out on physical mock-ups of vehicles. These are costly and time-consuming to build as well as inefficient—the design has often changed by the time the physical mock-up is available.

At Toyota, however, one innovative team is using virtual ergonomics technology rather than physical prototypes. By testing the reactions of real people in a virtual environment, they can simulate human interaction with a vehicle far more realistically. What's more, the team can validate designs faster and at a far lower cost while capitalizing on the open nature of Unreal Engine to connect industry-leading software and technology.

Mikiya Matsumoto is the general manager of the Prototype Division, Digital Engineering Department at Toyota. His team leverages real-time technology to assess the user-friendliness of vehicle designs.

Testing starts with the import of a 3D vehicle model into a virtual environment. A person sits in a real car seat wearing a VR headset and experiences different simulated scenarios designed to test the usability of the vehicle. Scenarios involve common driving tasks like appraising the visibility of other road users out of the rear quarter window of a car. The team also employs the setup to perform accessibility checks, using tracking gloves to evaluate how easy it is to reach various buttons and controls.

One critical aspect of the system is the open nature of the technology that powers it. Hardware and plugins that can be integrated into the setup include HTC Vive headsets, CarSim for vehicle dynamics, Leap Motion controllers for hand tracking, and a combination of physical prototype parts and VR simulation.

Many software providers connect their tools and systems to Unreal Engine via plugins—like the Mechanical Simulation CarSim plugin the team uses. That means Matsumoto's team doesn't have to jump through hoops to work with industry-leading third-party tools.

The team imports car model data into the engine via Datasmith, enabling the team to go straight from CAD to Unreal Engine in a couple of clicks without using any third-party software in between.

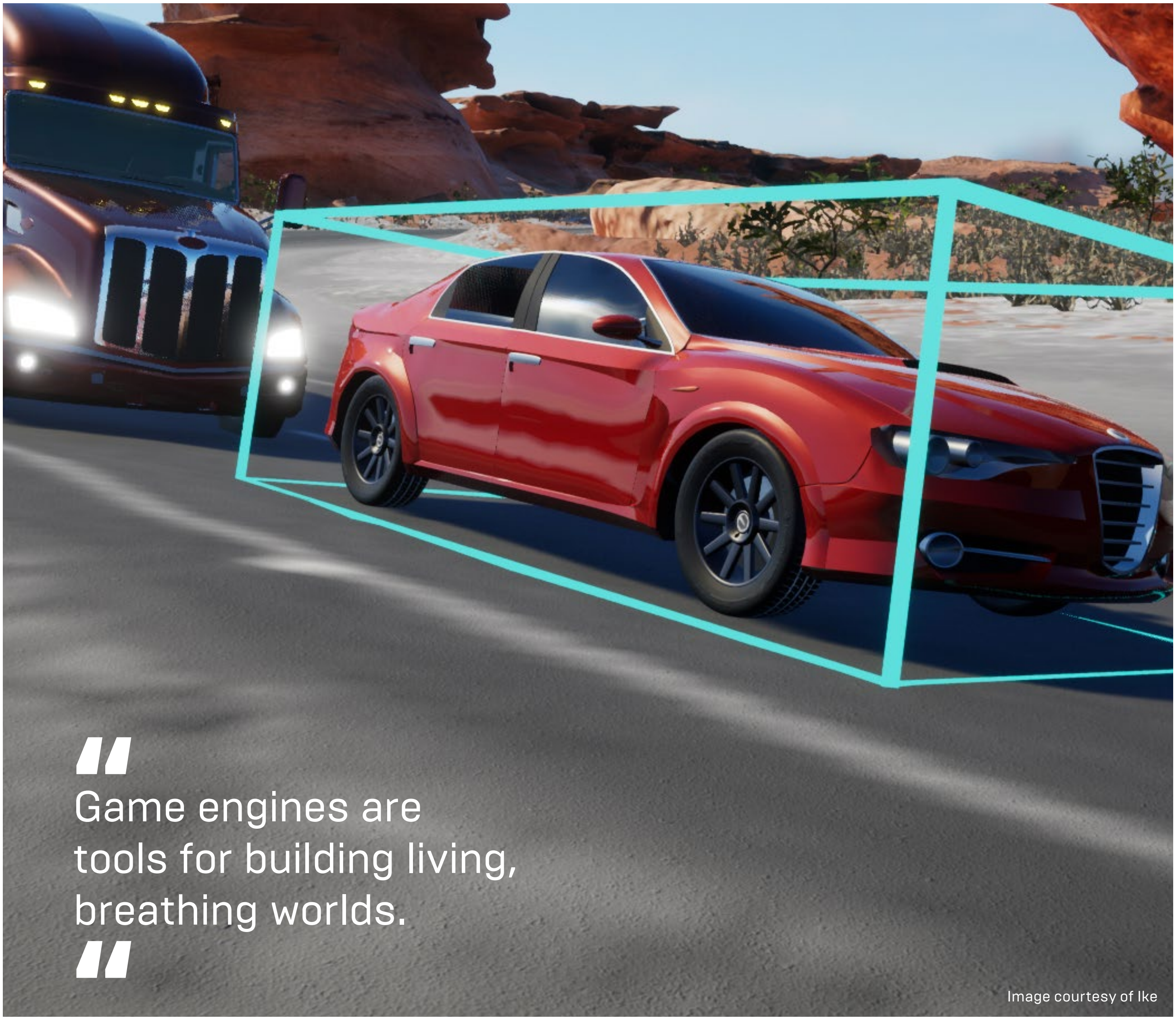
Game engines make it easy to create complex scenarios that include virtual vehicles and human characters. The Toyota team makes use of the Blueprint visual scripting system in Unreal Engine to create these virtual scenarios for each test.

Similarly, while other ergonomics tools used in the automotive industry generally do not offer VR functionality, VR is ingrained in game engine DNA. Instead of validating ergonomic tasks from a third-person perspective, users can perform the task themselves in the immersive realism of a VR experience generated by a game engine.

The workflow developed by Matsumoto's team saves time and money over traditional methods of ergonomic assessment, and provides a more flexible development path. "Real-time technology allows us to perform virtual user experience testing," explains Matsumoto. "This reduces the cost of and time taken for proof-of-concepting, leading to a more agile way of development."

Read the full story to find out more about Toyota's human factors engineering.

Ike



> "Game engines are tools for building living, breathing worlds."

Image courtesy of Ike

Based in Silicon Valley, automation technology company Ike is currently working in partnership with the trucking industry to automate long-distance freight transportation. With decades of experience in robotics, its team is confident that it can bring a safe, scalable solution to market.

The key challenge is proving that safety aspect. In order to prove with statistical confidence that a truck can deal with myriad rare and unexpected events, it would have to be driven tens of millions of miles.

Rather than spend all that time on the road, the team elected to use simulation as their primary validation tool. The team uses two types of simulation for autonomous driving: log simulation, which involves feeding data from real driving into the automation system, and virtual simulation, which uses fabricated scenarios and responsive Actors (objects), like a video game.

To develop its virtual simulation tool, the team turned to Unreal Engine, spending a year extending the many relevant out-of-the-box features for its specific needs. As a first step in that process, Ike customized the Unreal Engine Level Editor to be its scenario design tool.

Each of Ike's trucks calculates its position in the world using high-definition maps consisting of LiDAR intensity and elevation data, which is collected and processed into lane centers and boundaries. That same map data is streamed into Unreal Engine using the Landscape API so the team can design and run their scenarios on it.

The automation system requires higher-resolution map data than is easily found in open-source data formats; to capture the necessary data, Ike uses a special mapping vehicle fitted out with two LiDAR scanners and physically drives it down the highway. This makes the company completely self-sufficient, giving it the power to simulate anywhere it can drive its mapping vehicle.

Once the maps are imported, most of the building blocks for scenario design are available out of the box: triggers based on time or distance, splines for scene objects to follow, an efficient environmental query system, a fully featured and customizable GUI, and a scripting language for designing arbitrarily complex choreographies.

"Game engines are tools for building living, breathing worlds—levels in which the player makes decisions and the world reacts realistically," says Simulation Lead Pete Melick. "That's all a scenario is, except the player is a robot."

Ike also uses the Unreal Engine AI Perception system to add intelligent behaviors to its simulated agents. To enable designers to extend the range of scenarios, the team exposes functionality to Blueprint, Unreal Engine's visual scripting system.

Using Blueprint, designers create new behaviors and choreography. For example, they can make another car in the environment weave left and right about its lane with a parameterized period and amplitude. Or they can add simulated noise to the detections fed to the autonomy software to test its sensitivity to imperfect inputs.

Blueprint is also the key to Ike's variations system. A designer adds a variable parameter by adding a Component to an Actor, such as another car, and implementing a Blueprint function that defines the effect of varying that parameter.

This workflow enables the team to tweak scenarios in an infinite number of ways, including the position, orientation, speed, or size of objects—and even behavioral elements like how aggressively vehicles drive. "If it can be expressed in Blueprint, it can be varied," says Melick.

While we may still be some time away from seeing driverless trucks safely navigating our highways, every scenario that Ike creates in Unreal Engine brings that goal one step closer.

Read the full article to find out more about Ike's virtual simulation tool.

CARLA

Image courtesy of CARLA

The autonomous vehicles industry is already big business, with billions of dollars invested to date. The notable lack of fully self-driving cars on our roads today, however, illustrates that far more research and validation are needed before the technology is deemed wholly safe.

Enter CARLA, a free, open-source simulator powered by Unreal Engine, designed to support the development, training, and validation of autonomous driving systems.

The desire to freely distribute CARLA was a key factor in the development team's choice of Unreal Engine, which is also free and comes with full source-code access. "We really wanted to share it with people," says CARLA Team Lead Germán Ros. "We wanted people to be able to modify everything. So the idea was to have something that was completely open, and have access to all the source code of the engine and the source code of our platform. We believe that having something that is totally open is helpful for the community, since it enables them to adapt it for different use cases and scenarios."

Ros claims that virtually every university that is currently researching autonomous driving is using CARLA in some way, as are virtually all corporations large enough to have an R&D unit. From the beginning of the simulator's development, the team understood the importance of the open-source model in helping it democratize autonomous vehicle travel.

"Having the progress of autonomous driving be dependent on just the huge corporations with big pockets is not good enough," says Ros. "We also need academics and small companies to participate in this if we really want to expedite and accelerate autonomous driving. We want autonomous driving—we think it's important, it's going to save lives, it's going to make our lives better—so why don't we try to make it happen as soon as possible? For that, we need the collaboration of the community."

CARLA levels the playing field by giving those without the time or budget, or those who can't find available talent to build a fully staffed simulation team, the ability to build on an existing platform instead of starting from scratch.

The team also wants CARLA to serve as a common language. "Okay, you can have your own internal simulator, you can have very sophisticated tools, and that's fine," says Ros. "At some point you're going to need to share with your competitors, you're going to need to share results with legislators. Why don't you use an open-source tool for that—one that speaks all the standards that need to be spoken and allows you to send your data to the community in a transparent way so that they can understand its current status?

"That's why we decided to deliver CARLA in an open-source format where you can take everything from the assets, to the code, to everything, and do anything you want with it, including commercial use. Whatever you want, you're free to take CARLA and do the best you can with it."

The CARLA team strives to offer the best possible simulator to anyone who wishes to use it, modify it, or build on top of it. It's become a powerful tool for those in the autonomous driving simulation community, helping prepare the way for fully autonomous vehicles.

Read the full article to find out more about how CARLA democratizes autonomous vehicle R&D.

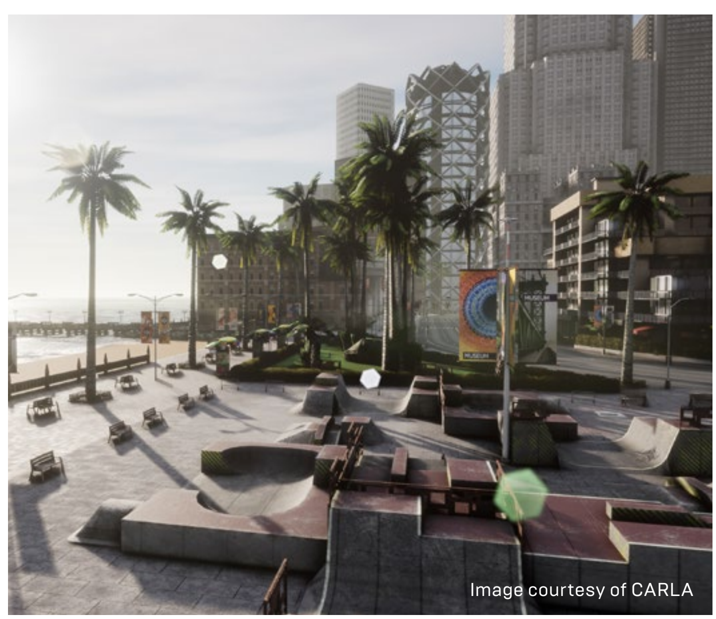


Image courtesy of CARLA

CarSim

Image courtesy of Rikei Corporation

Mechanical Simulation has been making software for accurate ground vehicle simulation since 1996. Their CarSim, TruckSim, and BikeSim product portfolio includes modules for different types of passenger and commercial vehicles.

These products are focused on aggregating everything about a vehicle, its environment, and its motion to visualize or predict its behavior in a wide range of driving conditions.

CarSim, TruckSim, and BikeSim use vehicle data that describes suspension behavior, powertrain properties, active controller behaviors, tire properties, and also road slope, obstacles, weather conditions, and asphalt type. At the core of the software is a simulation solver that can predict how the vehicle will react—for example, whether it will tip or skid under specific conditions, or whether it will brake quickly enough on a wet surface. The software also produces a visual representation of the vehicle's motion from the solved data.

On the flip side, the software can also import real-world vehicle and map data and analyze for speed, response time, and other aspects of the driving experience. While this application has obvious uses for accident reconstruction and training simulators, a new use has emerged in recent years—data-gathering and machine learning for autonomous vehicles.

"As autonomous driving came on and people wanted to incorporate physics-based sensors, we started presenting our technology as a general-purpose vehicle simulation tool for vehicle dynamics and autonomous driving engineers," says Robert McGinnis, Senior Account Manager at Mechanical Simulation.

At the same time, for the software's visual representations, Mechanical Simulation was aware that it needed to keep pace with advances in computer graphics. The company found that to gain more options for visualization, many customers were starting to port the CarSim and TruckSim solvers' results to Unreal Engine, along with their own car models and environments. Unreal Engine's readily available source code, C++ support, coupled with its Blueprint visual scripting system, made it an attractive choice for processing the volume of data that driving tests generate.

That's when Mechanical Simulation decided to integrate more of its product into Unreal Engine. "It was pretty obvious that we could get the information from the road and the sensors and interface tools like MATLAB/Simulink, and let people integrate their own active controllers," says McGinnis.

This gave Mechanical Simulation a clear path to upgrading its offerings using Unreal Engine, leaving the company more room to focus on its core technology: the solver inside its products. "Early on, our software did not have a good way to build complex scenes for visualization," says McGinnis. "One approach we took was to add an Unreal Marketplace plugin that allows a CarSim vehicle solver to be loaded into the Unreal Editor. It allows people to create scenes and scenarios using that tool all by themselves."

The VehicleSim Dynamics plugin gives CarSim and Trucksim users a powerful tool for generating visual representations with all the advantages Unreal Engine has to offer, such as physically based rendering (PBR) materials, realistic lighting, landscape and foliage packs, and cityscape items. The plugin works by converting the solver data to Blueprints, which can then be easily queried to produce data about both the terrain and the vehicle.

Mechanical Simulation sees the simplicity of the Unreal Engine plugin as a huge plus for their customers. "They don't want to be running $200,000 worth of software on a single machine that requires another engineer just to help the prime engineer get his job done," says Jeremy M. Miller, Lead Developer.

The plugin has also proven to be useful for training, testing, and previsualization of newly designed vehicles. The team is constantly looking to improve it to better serve their customers, for example recently adding an FBX converter to bring in physical terrain models that will work with the plugin.

Read the full article to find out more about how automotive companies are leveraging CarSim to perform autonomous vehicle testing.

CHAPTER 6

The future

Courtesy of Ferrari S.p.A. | Mackevision

We hope you've found this guide useful. By now, you should have a good grasp of the different opportunities real-time technology provides across the automotive pipeline.

But more than this, we hope you can see why the future of the automotive pipeline lies in an open-platform approach.

By replacing the process of pushing data through individual tools for tessellation, data repair, and modeling, an open automotive platform sets you free from the restrictions of traditional tools, offering an easier way of connecting them, and unlocking more ways of working.

Players in the automotive industry are at a crossroads. Sweeping digital change is set to transform traditional pipelines and workflows, making them smarter, faster, and more cost-efficient. The core functionality of real-time game engine technology means it will be a crucial pillar of this digital transformation.

This is where Unreal Engine can play a key role in the automotive industry: as the standard data simulation and visualization platform across digital transformation, extended reality, and digital collaboration.

Because Unreal Engine is an open platform, there are endless possibilities to enrich its functionality. With full, unfettered access to the source code, automotive companies have the freedom and control to customize the engine to their exact requirements.

There's no need to wait for development by Epic Games or to hire an external company. The power to achieve the results you need is in your hands.

Unreal Engine is completely free to download and use. If you'd like a closer relationship with the Unreal Engine team at Epic Games, along with the potential for custom terms, premium support, private training, and more, we also offer the flexibility of licensing agreements tailored to your specific needs.

Glossary

Advanced driver-assistance systems (ADAS)
Electronic systems in vehicles that assist drivers when driving and parking.

Augmented reality (AR)
A technology that integrates CG elements into a physical environment.

Autonomous vehicle
A vehicle that is capable of sensing its environment and moving safely with little or no human input.

Autonomy levels
A measure of the extent to which a self-driving vehicle can be said to be truly autonomous. Levels of driving automation range from 0 (fully manual) to 5 (fully autonomous).

Building Information Modeling (BIM)
An intelligent 3D model-based process used extensively in the architecture, engineering, and construction (AEC) industry.

Blueprint
A script created from the Blueprint visual scripting language in Unreal Engine which defines how an asset interacts.

C++
A popular general-purpose programming language used to create computer programs. One of the methods of programming in Unreal Engine, the others being Blueprint visual scripting and Python scripting.

Computer-aided design (CAD)
The use of computers to create, modify, analyze, or optimize a design. Used by designers and engineers to create 2D and 3D models of physical components.

Cave Automatic Virtual Environment (CAVE)
An immersive virtual reality environment where imagery is projected onto three to six of the walls of a room-sized cube.

Collab Viewer
An Unreal Engine project template that joins multiple people together in a shared experience of the same 3D content.

Configurator
A program that enables the user to personalize a virtual model of a car, swapping colors, materials, trims, and custom features instantly. Configurators are found both on car maker websites and on the dealership floor.

Datasmith
A collection of tools and plugins that help you bring content into Unreal Engine, significantly reducing data import times.

Decimation
The process of reducing the polygon/face count of a 3D model for better performance.

Digital twin
A mathematically perfect representation of a physical object and all its variants in a digital space. Digital twins are used in the automotive sector for creating the virtual model of a connected vehicle. They can capture the behavioral and operational data of the vehicle and analyze the overall vehicle performance.

Extended reality (XR)
An umbrella term for VR, AR, and MR, and all future realities such technology might bring.

FBX
A file format (.fbx) used to provide interoperability between digital content creation applications.

Final pixels
Images of high enough quality to be the final output for film or TV.

Game engine
A software development environment designed for the creation of real-time interactive content, initially intended for video games but now used in many other applications.

Graphics processing unit (GPU)
A specialized type of microprocessor optimized to display graphics and do very specific computational tasks. Modern real-time engines rely heavily on GPUs for performance.

Hardware-in-the-loop (HIL)
A type of real-time simulation used in the development and testing of complex real-time embedded systems.

Head-mounted display (HMD)
A device used to display CG content for VR, AR, or MR.

High dynamic range (HDR)
Reproduction of a greater dynamic range of luminosity than is possible with standard digital imaging techniques. HDR images retain detail in a fuller range of lights and darks than standard images.

HoloLens Viewer
An adaptation of the Collab Viewer Template that works on the Microsoft HoloLens 2. You can use it to see your 3D content overlaid on your actual surroundings.

Human-machine interface (HMI)
An interface that enables humans to interact with a machine. In an automotive context, HMIs enable drivers to interact with the car's systems using touchpads, multi-touch dashboards, built-in screens, control panels, push buttons, and traditional keypads. As well as providing a bridge between the driver and the car itself, HMIs also connect the driver and outside world.

Industry 4.0
The Fourth Industrial Revolution (or Industry 4.0) is the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology that includes machine-to-machine communication (M2M), the internet of things (IoT), and real-time technology.

Internet of things (IoT)
The network of physical objects that are embedded with sensors and software for the purpose of connecting and exchanging data with other devices and systems over the internet.

Latency
The delay between when a signal is sent and when it is received at its destination.

LED stage
A stage purpose-built for real-time production that includes LED walls, tracking systems, and real-time capabilities.

Level 5
See Autonomy Levels.

Level of detail (LOD)
A lower-resolution representation of an object that can be used to improve performance when an asset is distant from the camera. Typically, several different levels of detail will be produced, each at a different resolution. LODs are produced from a high-resolution object through decimation.

LiDAR
A method for measuring distances by illuminating the target with laser light and measuring the reflection with a sensor.

Location-based entertainment
Any form of entertainment that takes place in a specific location outside of the user's home.

Machine learning
An application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning computer programs can access data and use it to learn for themselves.

Mixed reality (MR)
The process of anchoring virtual objects to the real world and allowing users to interact with them.

nDisplay
An Unreal Engine system that renders a scene on multiple synchronized display devices.

NURBS
Non-uniform rational basis spline (NURBS) is a mathematical model commonly used in computer graphics for generating and representing curves and surfaces.

Original equipment manufacturer (OEM)
The original producer of a product's components. OEM car parts are identical to the parts used in producing a vehicle.

Over-the-air (OTA) updates
Software updates that are distributed wirelessly to mobile devices.

Pixel Streaming
A feature that enables you to run your Unreal Engine application on a server in the cloud, and stream its rendered frames and audio to browsers and mobile devices.

Product data management (PDM)
The use of software to manage product data and process-related information in a single, central system. This information includes computer-aided design (CAD) data, models, parts information, manufacturing instructions, requirements, notes, and documents. PDM is responsible for managing the actual digital product files that move through that product lifecycle management (PLM) process.

Product lifecycle management (PLM)
The management of data and processes used in the design, engineering, manufacturing, sales, and service of a product across its entire lifecycle and across the supply chain. PLM is responsible for the process and the system that product development happens in.

Python scripting
A high-level and general-purpose programming language popular for its ease of use and shallow learning curve.

Quixel Megascans
High-quality photorealistic 3D scans that can be used to add materials, textures, and objects to CG scenes.

Ray tracing
A rendering technique for generating an image by tracing the path of light as pixels in an image plane and simulating the effects of its encounters with virtual objects.

Real-time rendering
The translation of a scene into display pixels fast enough for instantaneous playback at real-time (live) speeds. In contrast, traditional offline rendering may take minutes or even hours to produce each frame, with 24 frames required to display a second's worth of animation for film.

Static Mesh
In Unreal Engine, a piece of geometry that consists of a set of polygons that can be cached in video memory and rendered by a graphics card.

Telematics
Technology that combines navigation, safety, security, and communication into one piece of technology that fits in a vehicle's dashboard.

Tessellation
The method used to represent 3D objects as a collection of triangles or other polygons.

Unreal Motion Graphics UI Designer (UMG)
A visual UI authoring tool which can be used to create UI elements such as in-game heads-up displays (HUDs), menus, or other interface-related graphics.

UV mapping
The process of transforming a 2D image onto a 3D model's surface. The letters 'U' and 'V' denote the axes of the 2D texture because 'X', '"Y', and 'Z' are already used to denote the axes of the 3D object in model space.

Virtual production
A broad term referring to a spectrum of computer-aided methods for filmmaking production and visualization.

Virtual reality (VR)
An immersive experience using headsets to generate the realistic images, sounds, and other sensations that replicate a real environment or create an imaginary world.

Visual Dataprep
A system that enables you to take full control over what happens inside the Datasmith import process, and reduce the manual work it takes to prepare your 3D scenes for real-time visualization in Unreal Engine.

Volume
The physical space in which live capture is recorded.

Additional resources

Here are some additional resources about the use of real-time technology across the automotive industry.

Unreal Build: Automotive

Unreal Engine Automotive Industry Hub

Unreal Engine Automotive News

The Pulse

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