ADVANCED PRODUCT DESIGN FOR INDUSTRY 4.0

PART 3: DESIGN REVIEW

BETTER INFORMED DECISION MAKING, OPTIMIZED PRODUCT DESIGNS

NVIDIA

Image courtesy of **SOLIDWORKS Visualize**

INTRODUCTION

The world of product development, manufacturing and production is changing. With Industry 4.0 we're on the brink of a new dawn of automation and intelligence, with smart, connected products and the smart factories that produce them.

Autonomous drones capture progress as a new production cell layout is commissioned. Deep Learning-enabled devices with computer vision perform quality checks on the production line and provide data to continually improve processes. Intelligent, collaborative robots, "aware" of their environment, work alongside humans to assist with assembly tasks.

Advanced computing devices harvest huge amounts of data from products in the field to feed design and simulation systems and help ensure that next-generation products learn from those that have gone before.

Virtual reality (VR) presents everyone in the development process with the information they need in a rich, immersive, and collaborative environment. Ultra-powerful workstations are used to design, simulate, and visualize products, production cells, and factories. Then, once manufactured, virtual products—or "digital twins"—can be connected through the Internet of Things (IoT) to their real-world manifestations.

At the heart of all of these processes, NVIDIA plays a strategic role in empowering the manufacturing industry to implement Industry 4.0. For the past 20 years, NVIDIA has sustained investments in research and development (R&D) to continually push the boundaries of graphics processing unit (GPU) technology. The use of GPUs has, for some time, extended far beyond simply powering computer graphics displays and design software.

Today, a wide range of NVIDIA software and hardware solutions enables manufacturers to develop artificial intelligence (AI) capabilities for industrial collaborative robots and autonomous vehicles in the smart factory. In addition, advances in more GPU-accelerated workflows are powering productivity improvements and speeding time-to-market as manufacturing companies move forward with advanced product design for Industry 4.0.

The NVIDIA® Quadro® visual computing platform is helping product design teams radically transform the traditional product development process. The introduction of leading-edge technologies such as AI, virtual reality (VR), interactive physically based rendering, real-time engineering simulation, and 3D graphics virtualization, are driving the development of the next generation of smart, connected products.

DESIGN REVIEW: THE HEART OF COLLABORATION

The first part of this e-guide series looked at how visual computing improves decision making, accelerates concept generation, and captures design intent across dispersed groups more securely. Part two explored how those same computation technologies are applied to the world of detailed design, specifically looking at both engineering simulation and visualization.

Part three explores the pivotal role of advanced graphics computation, visualization systems and VR in design review.

Product development, engineering and manufacturing have always been collaborative processes. Today, that collaboration is more complex, teams are more distributed, and comprised of a more diverse group of specialists than ever before.

To ensure that a product delivered to market is the best, most efficient and most appropriate for its use, a new set of solutions is needed to bring together teams in an efficient workflow that allows everyone to participate with visually rich assets. By enhancing the design review process in this way, design review cycles become shorter, development costs can fall, and products can be delivered to market more quickly and efficiently than through traditional methods.

Image courtesy of **Audi**

TRADITIONAL DESIGN REVIEW

In order to better understand future demands for design review, it is important to look to the past.

Traditionally, a team of designers, engineers and managers would sit around a set of presentation imagery, technical drawings and physical prototypes. Then more digitally driven workflows were adopted, where display technology combined with richer CAD-based display techniques were the basis for making decisions on the direction of a project. Completed work would then be approved and proceed to manufacture and production. While the workflow changed to a digital one, the process and interaction were very much the same and typically, all team members were from the same company on the same site.

Today's world is dramatically different.

Modern products are more sophisticated and complex than ever before, with increasingly demanding development. Designers and engineers often work across different geographies, spanning multiple time zones and multiple languages. Supply chains are more complex and key team members come from different technical disciplines.

In addition, complex design systems need to share data seamlessly and all team members must make informed decisions based on the latest revisions. With continually moving goal posts, the assets required for design review need to be created in the shortest time possible.

CAD-BASED VISUALIZATION FOR DESIGN REVIEW

The point of entry for design review is a group discussion around a 3D CAD system and a desktop display. Graphically-rich models can include mechanical parts, as well as electronics, electrical and other inputs.

For a wider viewing perspective, a GPU accelerated workstation can be hooked up to a projector, a large 4K display or TV, an array of monitors or even a powerwall-like large scale projector in whatever configuration suits the product or available space. However, as display resolution increases, so do the demands on the GPU, so a higher-end workstation graphics card may be needed in order to smoothly pan, zoom and rotate 3D CAD models in the viewport.

In the past, 3D product development systems focused on the CAD-literate designer or engineer – the use of more advanced, graphically richer design features allowed a more efficient workflow, but still, the focus was on the expert user.

Today's systems are much richer in their display capabilities. 3D geometry can be viewed with physically realistic materials, with real world lighting applied and shadows calculated. Design teams are beginning to use head mounted displays (HMD) to view 3D models in VR for a more immersive experience, which helps them get a more intuitive understanding of their design modifications. These are important developments that allow all members of a design review, even those without a technical background, to understand instantly how a final product might look and function. This can be incredibly empowering and allows every stakeholder in the process to engage from a common, visually rich, baseline.

CAD-based design review is not restricted to the design office on a personal workstation. Recent advances in graphics virtualization now mean designers can get a smooth 3D CAD experience on virtual or cloud workstations. With NVIDIA Quadro Virtual Data Center Workstation (Quadro vDWS) software and NVIDIA Tesla® GPUs, design reviews can take place anywhere - in a manager's office, or between multiple locations, hundreds or thousands of miles apart.

With Quadro vDWS all of the heavy-duty processing, including the graphics, is done in the data center. This makes it possible to access a powerful virtual workstation from any PC, laptop or thin client device, while designs and intellectual property are secured in the data center. There is no need to move heavy desktop workstations around the office or invest in a powerful workstation for the meeting room that only gets used once a week.

Leading companies are using Quadro vDWS to connect distributed teams and make design reviews more efficient. By instantly accessing up-to-date models and datasets during design reviews, these companies are dramatically reducing cost and time associated with travel.

While the display richness of CAD systems improves each year, there will always be a desire for more sophisticated representations of a product during development. Using dedicated visualization software like Autodesk VRED, Lumiscaphe, SOLIDWORKS Visualize or Unreal Engine, design review can focus not only on form and function, but also on color, texture and appearance. Manufacturing enterprises count on high-end workstation-class graphics cards to deliver these enhanced levels of realism.

Image courtesy of **Lumiscaphe**

MOVING FROM CAD TO VR

When design review techniques, photorealism and high levels of interactivity are combined with VR, it offers a sense of scale and physical connection to a product that cannot be experienced through a 2D image. Inspecting and interacting with a product, at full scale, in an immersive VR environment, makes identifying design flaws easier, ergonomic evaluation more effective and provides a deeper understanding of your project.

Getting data into VR can still be a challenge, as CAD models are very complex and detailed, and the geometry often needs to be simplified in order to deliver a comfortable experience with a VR headset. But this is getting easier all the time. Tools like Virtalis VR4CAD offer optimized routines. VR is also starting to appear in design applications, such as SOLIDWORKS, Siemens NX and Autodesk VRED.

There are also moves from mainstream VR players to ease the process of taking heavy CAD data into a virtual world. Epic Games is looking to optimize the process with its Datasmith application which handles much of the heavy lifting of data from your CAD tool to into its Unreal Studio authoring system.

Image courtesy of **Zerone**

RISE OF THE RENDERERS

The use of physically-based rendering and visualization technology to move beyond 3D CAD for design review has been growing in recent years. Photorealistic representations of a product in development are a very powerful tool. They allow the (re)viewer to instantly see how the product will look in real life, without the need for visual interpretation or abstraction of technical drawings.

The workflow is commonplace. Start with a technical 3D model, apply materials, textures and other items, then light the scene, add background or content detail and hit render. In years gone by, this process has been very involved and could take anything from hours to days, depending on the complexity of the scene, the output requirements and the available hardware. But this is changing with the advent of new generation of GPU-accelerated physically-based rendering tools, which simulate real world physics, and advanced visual computing technologies.

Today's rendering systems can take advantage of high-quality materials, taken from a library or measured from the physical material. Previously, materials and textures would have had to be chosen from basic, general purpose presets or built by hand.

Modern materials are also becoming more easily shareable between systems using formats like the NVIDIA Material Definition Language (MDL).

In terms of lighting set-up, the rise of the physically-based rendering system, which can take full advantage of high-dynamic range imagery as the primary lighting source, has made the set-up process much quicker and easier. Realistic lighting schemes, either created digitally or captured from the real world, can assist with the production of realistic images. When combined with realistic materials, this allows digital visualization to move from a specialist, expert-led process to one that almost every CAD user can use effectively for generating high-quality assets for design review.

RISE OF THE RENDERERS (CONT.)

That said, there has been a common bottleneck within these workflows; the time taken to compute such imagery - whether that's static images or animated shots with CAD-integrated systems or standalone rendering tools.

Physically-based rendering supports decision making on both mechanical function and visual aesthetic properties (color, surface treatment, etc.) but to do that, the assets on which design reviews are based need to be iterated as quickly as possible.

For more simple products, this can be handled effectively, but once you begin to factor in different product variants, different colorways or customization options, asset requirements grow exponentially.

Consider a new line of headphones which might have 20 or more different color, material and finish options. To generate assets for design review for each of those options, with multiple views, would take a very long time using a CPU rendering tool on a typical CAD workstation.

Here the new generation GPU-accelerated renderers make a difference. SOLIDWORKS Visualize, Redshift, CATIA Live Rendering, Siemens NX Ray Traced Studio, and Chaos V-Ray for Rhino all leverage GPU acceleration which enables interactive photorealistic visualization of complex models for design reviews.

The highly parallel GPU architecture, which means modern GPUs can have thousands of cores, is ideally suited to ray trace rendering. GPUs are also highly scalable. One or more GPUs can be used inside a personal workstation or shared in a render farm, thus saving on time, money, and power used.

Organizations that need flexibility to give teams access to high levels of GPU power on demand are turning to virtual workstations powered by NVIDIA Quadro vDWS software. Customers are able to stand set up a virtual workstation in as little as ten minutes, with a computing configuration that is ideally sized for their needs. Additionally, contractors can access models to create photoreal renders while the dataset remains secure in the data center.

GPU virtualization also enables manufacturing industries to improve resource utilization and time to market. With support for GPU live migration, IT organizations can run mixed workloads on the same set of infrastructure, where designers perform 3D renders of models in their VDI environment during the day. At night, when most users have logged off, this same infrastructure can be repurposed to run HPC-driven big data analysis to optimize manufacturing workflow and improve decision making. This data center agility that NVIDIA GPU virtualization provides enables the cost effectiveness and accessibility of high-performance computing to many organizations.

With the appropriate access to required levels of GPU performance, a design team has the horsepower it needs to quickly respond to design review feedback and deliver new visual assets in a timely manner.

Image courtesy of **Lightworks**

Image courtesy of **SOLIDWORKS Visualize**

FROM MINUTES TO REAL-TIME

Cutting render times in half may be impressive but a new generation GPU technology from NVIDIA promises to take ray tracing to an entirely new level, delivering results in real time. This is intended to revolutionize design review, as any changes made to the design will be able to be visualized instantly in cinema quality.

Quadro RTX leverages the latest NVIDIA Turing™ architecture to introduce the latest advancements in GPU technology. The addition of all-new RT Cores accelerate real-time ray tracing operations while Tensor Cores harness the power of deep learning, a subset of Artificial Intelligence (AI), to cut down on the amount of work the GPU needs to do in order to generate photorealistic results.

This includes AI-based denoising, which predicts what a final image will look like by filling in the spots that the rays haven't yet reached, and deep learning anti-aliasing (DLAA)—a technique that trains a neural network to take a lower resolution image and subsequently turn it into a higher quality image.

RTX technology is already starting to gain traction with software developers. Chaos Group, the developer of V-Ray, has demonstrated the technology in Project Lavina. Meanwhile, Dassault Systèmes has already incorporated AI-based denoising in SOLIDWORKS Visualize and plans to use RTX in CATIA for rendering with life-like quality materials for design validation. Siemens will add AI-accelerated denoising to Siemens NX Ray Traced Studio.

IMMERSIVE DESIGN REVIEW

To take things to the next level, collaborative tools that allow teams to review design and engineering data in a much more holistic and immersive way have a huge role to play.

Firms can assess form, function, aesthetics, serviceability and production at 1:1 scale using large displays or virtual or augmented reality headsets.

For many years it was only the multinational automotive and aerospace OEMs that had access to large scale visualisation through powerwalls or immersive CAVE (computer aided virtual environment) installations, but this is no longer the case.

New generation HMDs, including the HTC Vive and Oculus Rift, are affordable and easy to implement. When combined with powerful professional GPUs, many more firms can take advantage of the benefits of true scale visualization, design review and collaboration.

This new immersive method for design review begins with full scale visualization in a graphically rich environment. Rather than looking at a rendered image on a screen or projected on a wall, team members can put on headsets and immerse themselves in the product: They can walk around it, inspect it, and view it just as they would in the real world, even in the context of where it will be used.

Participants are not just looking at a static image or predefined animation but interacting directly with a high quality visual representation of the product. Colors and finishes can be switched in and out and the assembled team can hide parts, measure lengths, take sections, and compare with competitive products - all in a single digital session. And of course, with a digital session, that team doesn't need to be in the same room or even on the same continent.

Moving beyond the core of design review, teams can also to start to simulate how the product will fit into downstream processes. Using tools such as ESI IC.IDO there is huge potential to simulate how the workforce will interact with the product as it moves through assembly and manufacture, ensuring that parts can be accessed for assembly and then disassembled for maintenance and repair.

This, of course, is conducted at a much earlier stage than has traditionally been the case – which means the vital information is fed directly into the product development process, avoiding such errors much later in the process and truly guiding product development.

HOLODECK: SCIENCE FICTION TO SCIENCE NOW

NVIDIA Holodeck™ is a next generation tool for design review that allows teams to bring 3D designs into a highly realistic, physically simulated collaborative VR environment. Each participant wears a VR headset and is represented in the virtual world by a customizable digital avatar. This helps teams collaborate from anywhere in the world, conveying ideas and communicating effectively not just through conversation, but also through body language. Participants can also add annotations and comments to the design or even sketch out new concepts. Additionally, Holodeck includes tools for real-time sections and measuring and the ability to change materials on the fly.

Frank Delgado, Lead for NASA's Hybrid Reality Lab, explains how Holodeck has the potential to transform design review, "During our design process, teams of our engineers and scientists work together to imagine an idea, plan a design, create that model, experiment and test that solution, then take time to reiterate and improve the original—all steps that are crucial to mission success at NASA."

"With Holodeck, we will be able to clearly visualize our models, easily collaborate in a physically simulated environment, and review to ensure the efficiency and safety of our designs."

Holodeck currently works with Autodesk 3ds Max, Maya, as well as SOLIDWORKS Visualize.

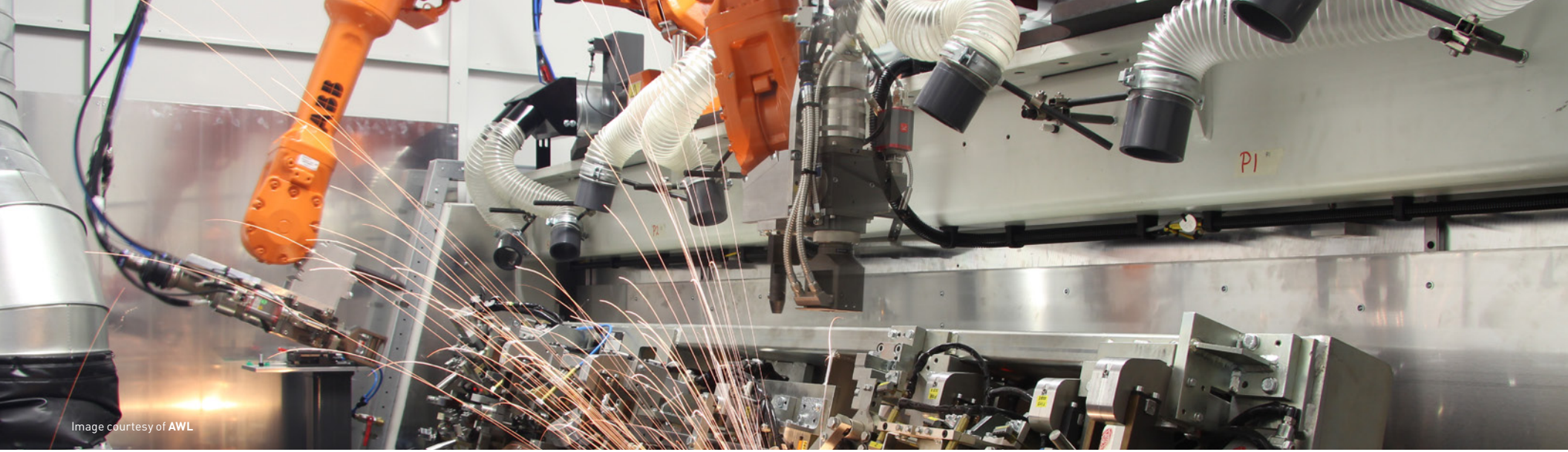

Image courtesy of **AWL**

CONCLUSION

Design review is a critically important part of the product development process and is starting to change dramatically. Teams are now able to take engineering accurate 3D data and quickly produce cinema-quality photorealistic assets that communicate design intent more effectively than ever before.

The use of physically-based rendering technology, combined with powerful GPUs to crunch through complex ray trace calculations means product designs can be reviewed quickly, in true context, with realistic materials, lighting and animation. This allows everyone involved in the process to gain a deep and rich understanding of the state of play.

Graphics virtualization can also put these capabilities on anyone's desk, regardless of physical location, instantly connecting distributed design teams with the latest product revisions.

Collaborative design review does not have to take place on a 2D screen. Globally dispersed design and management teams can now connect to a single VR review session each with their own unique view of the product.

These technologies are available now and within reach of not just the cash rich, multinational OEMs, but the small to medium enterprises as well.

But it doesn't stop there. In the future, the potential for real-time ray tracing in VR will also help firms review designs in a fully photorealistic, physics-based environment, where every part of the product looks and feels real.

This is the third part of the Advanced Product Design for Industry 4.0. e-guide series.

The fourth and final part of the series will cover the use of visual computing technology in the production, installation, and servicing of products. It will also explore how visually compelling techniques are being used to great effect in the marketing and sales of manufactured products.