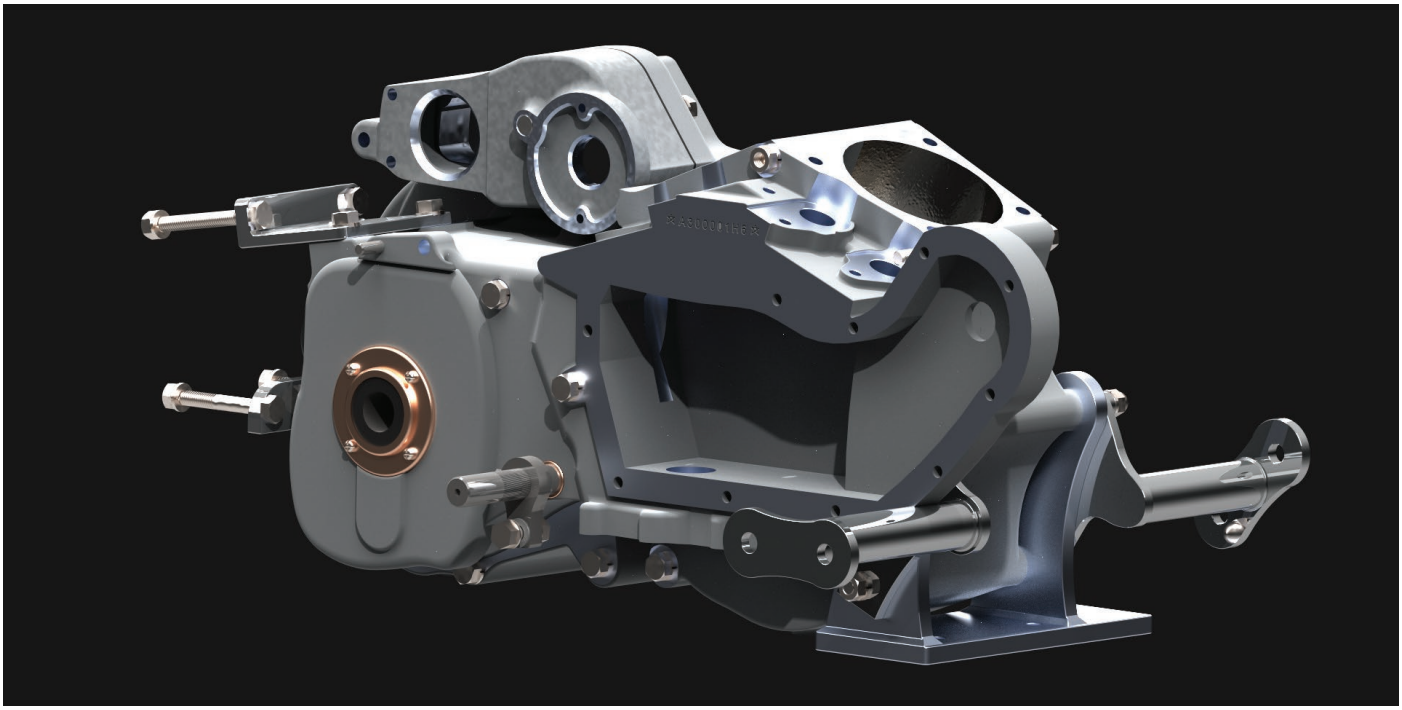
Advanced visualization solutions to optimize design to manufacture workflows



Rendered in Radeon ProRender

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Rendered in Radeon ProRender

With products complexity increasing and customers demanding industrial design everywhere, and not just in consumer, medical and automotive products, the challenges of bringing products to market faster have never been greater.

Design visualization is playing an increasingly important role in helping manufacturers streamline design to manufacture workflows. Advanced technologies, including real-time visualization, physically-based rendering and Virtual Reality (VR) give design and manufacturing firms a powerful arsenal of visualization tools that can be used at all stages of product development.

Visualization can deliver benefits in three main areas.

Precision design environment

Designers and engineers can visualize 3D models from any angle, in real time, as they design. Display accuracy and realism is of paramount importance with crisp geometry, transparency, realistic lighting, shadows and materials all helping optimize design workflows.

Communicating design

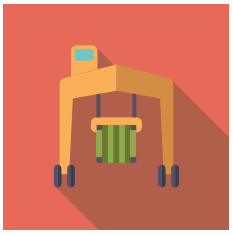
'A picture paints a thousand words' may be a cliché, but it certainly rings true in product development. Design visualization is essential for effective communication with multidisciplinary design teams, manufacturing supply chains and clients / customers. It can also break down language barriers with offshore partners. Communication of form and function is considered standard, but advanced visualization can also be used to accurately convey color and surface finish, as well as perceived quality.

Design review

As the complexity of products increases with assembly size, shape description and multi-disciplinary models (mechanical, electrical and electronics) - so does the potential for errors. Visualization can help identify issues long before costly physical prototypes are made or manufacturing production lines are set up. Virtual Reality is also set to play an even more important role here.

To illustrate how design visualization can influence the product development process, here are four different scenarios.

Scenario #1



An engineer from a heavy machinery manufacturer is working on a complex assembly. With thousands of parts, she needs to be able to see the geometry very clearly. By using cutaways and transparency she can quickly explore details in context inside the assembly. Realistic shading helps enhance shadows to give a better feeling of depth. A custom part needs to be made by a supplier in China so she shares the viewport of her CAD system over Skype. The interactive session is a huge aid to communication - much better than a 2D or 3D drawing alone. The prototype part arrives in one month – and performs to exact specifications.

Scenario #2

A product designer is working on a new consumer product. He focuses on geometry, aesthetics and material choice by changing display modes in the viewport of the CAD system. The display is instant and he can view the design from any angle, supporting a fully interactive design process. By using a 4K display with calibrated 10-bit color the edges of the model appear super sharp with smooth color gradation. Three design alternatives are worked up for a client presentation. These are rendered overnight with many different colorways using a physically-based renderer.

Scenario #3

A product design consultant develops three proposals for a large medical device. In order to get feedback from medical practitioners on ergonomics, styling and ease of use, he takes the design into a game engine and then into Virtual Reality (VR). Based on feedback, the design is refined and new iterations are developed. By keeping everything virtual there is no need for costly physical prototypes. Once the design is signed off, photorealistic images and animations are created using a physically-based renderer. Sales can start long before the first product rolls off the production line.

Scenario #4

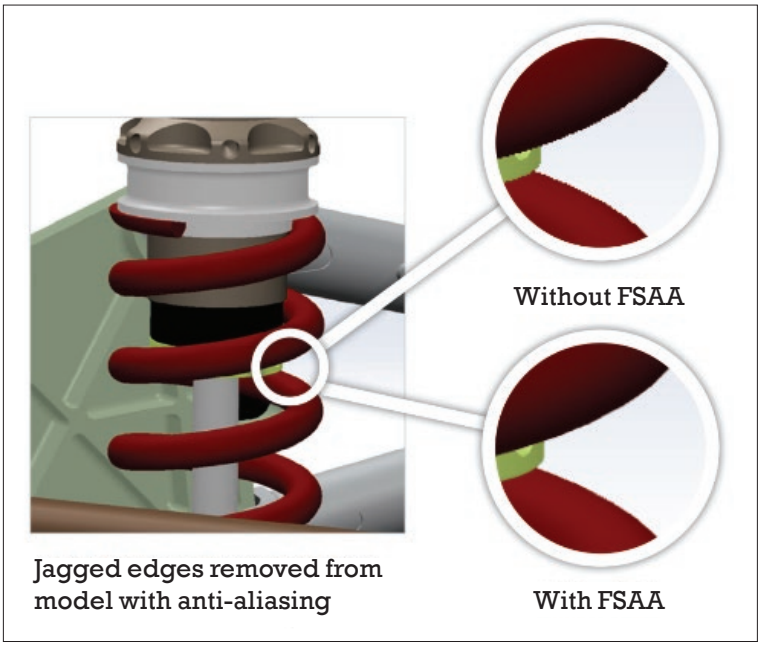
A manufacturing engineering team is designing a production line for a new industrial machine. A 'digital factory' is created to simulate the entire process. The data is then taken into VR for a fully immersive human scale evaluation. During design / review, ergonomic testing allows participants to interact naturally with the production line using body, head, arm and hand movements. Several process faults are identified, which are then analyzed and resolved long before they would have been encountered on the shop floor, saving time and money.

Over the next four pages we look at four key technologies that are being used in product development for design visualization.

Visualization Technology #1
CAD Visualization

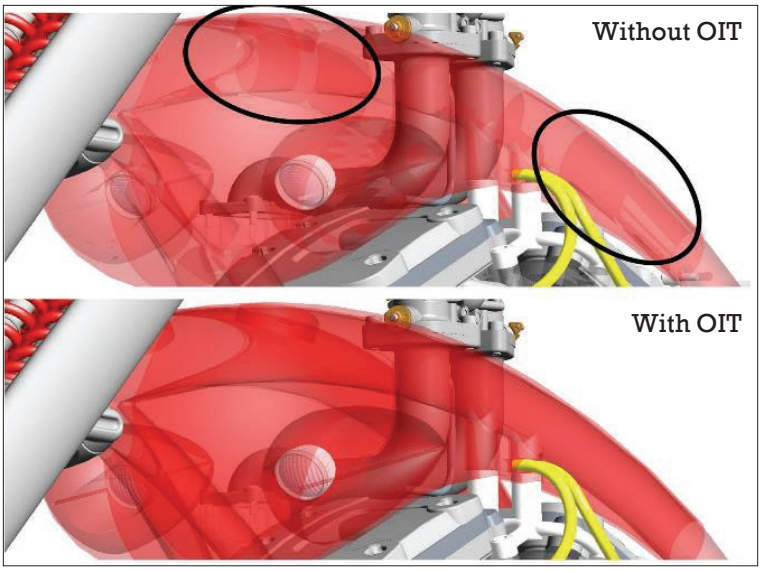
3D CAD applications including Dassault Systèmes SOLIDWORKS, PTC Creo, Siemens NX and Autodesk Fusion feature advanced graphics engines that, when accelerated by a professional Graphics Processing Unit (GPU), allow for a responsive design environment. For design visualization, 3D performance also needs to be backed up with high-quality visuals.

Below are three key design viz-focused technologies that you will find in 3D CAD applications when supported by professional GPUs. These features are generally not supported by consumer GPUs.



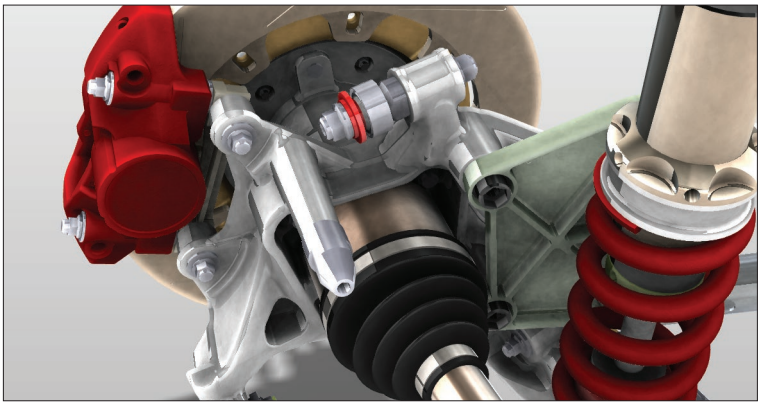
Full Scene Anti Aliasing (FSAA)

FSAA is a rendering technique that removes the jagged edges (stepped effect) from contours of geometry. It makes models appear smoother and more realistic and is very important for aesthetic decision making. FSAA is very GPU intensive. It can be switched on or off in the graphics driver or in the 3D application.



Order Independent Transparency (OIT)

Many CAD applications including SOLIDWORKS, PTC Creo and Siemens NX feature a display technology called Order Independent Transparency (OIT) that uses the GPU to render semi-transparent objects faster and more accurately. It is particularly useful for revealing details inside complex assemblies or rendering materials like glass or plastic.
Prior to OIT, transparent objects were sorted into order using the CPU, but this process could be slow and prone to errors. Every time the view changed the calculation needed to be redone and data had to be resent from GPU to CPU and back. Visual artifacts could also make it harder to perceive depth.

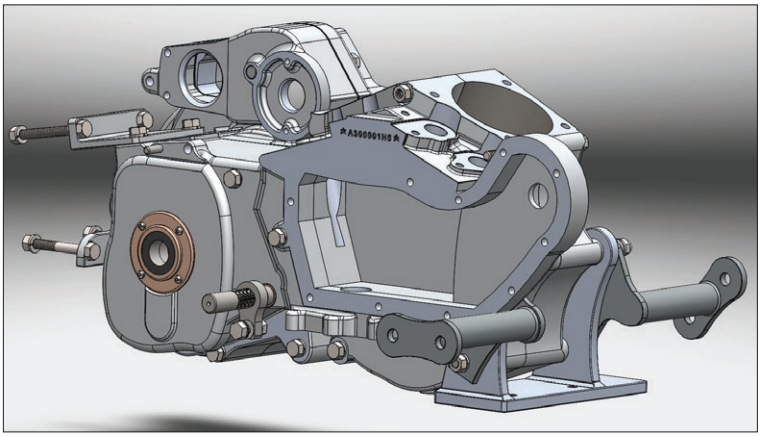


Ambient Occlusion (AO)

Ambient Occlusion (AO) is an increasingly common real-time viewport effect that mimics the way light radiates in the real world. It makes models appear more realistic and is great for aesthetic decision making and interactive presentations.

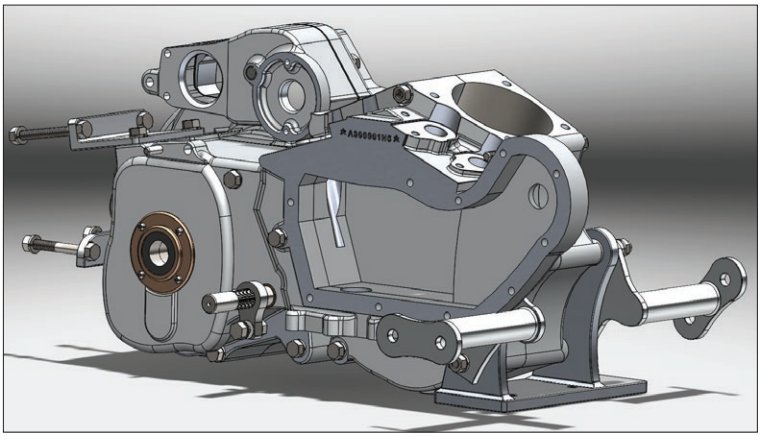
AO controls how ambient light impacts shadows in hidden (occluded) areas. More sheltered corners appear darker than those that are more exposed. The process can be very GPU intensive.

Visualization Technology #1
CAD Visualization example (Inside the SOLIDWORKS viewport)



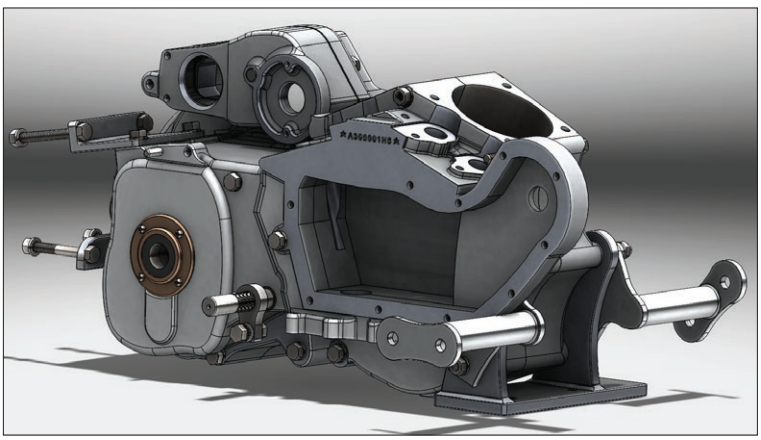
Shaded with edges

Shaded with edges is a popular rendering mode for SOLIDWORKS. It helps highlight the topology of a model, how geometry is constructed and gives visual clues to form and how parts interact with each other. In this engine casing model users can get a very good understanding of the different surfaces.



RealView

RealView delivers more realistic effects inside the viewport. This helps bring SOLIDWORKS models to life in an interactive 3D environment ideal for presentations or design / review. RealView supports environment reflections, floor shadows, and multi-colored effects such as car paint. It excels when rendering colored plastics and paint, so this engine casing model does not really do it justice. However, shiny metal and copper is rendered more accurately.



Ambient Occlusion (AO)

Ambient Occlusion (AO) can be switched on in addition to RealView to add more realism to models through enhanced shadows.
With our engine model the shadows cast as a result of AO add more drama to the scene. This is particularly noticeable around the holes and cavities where darker shadows appear in more occluded (hidden) areas.

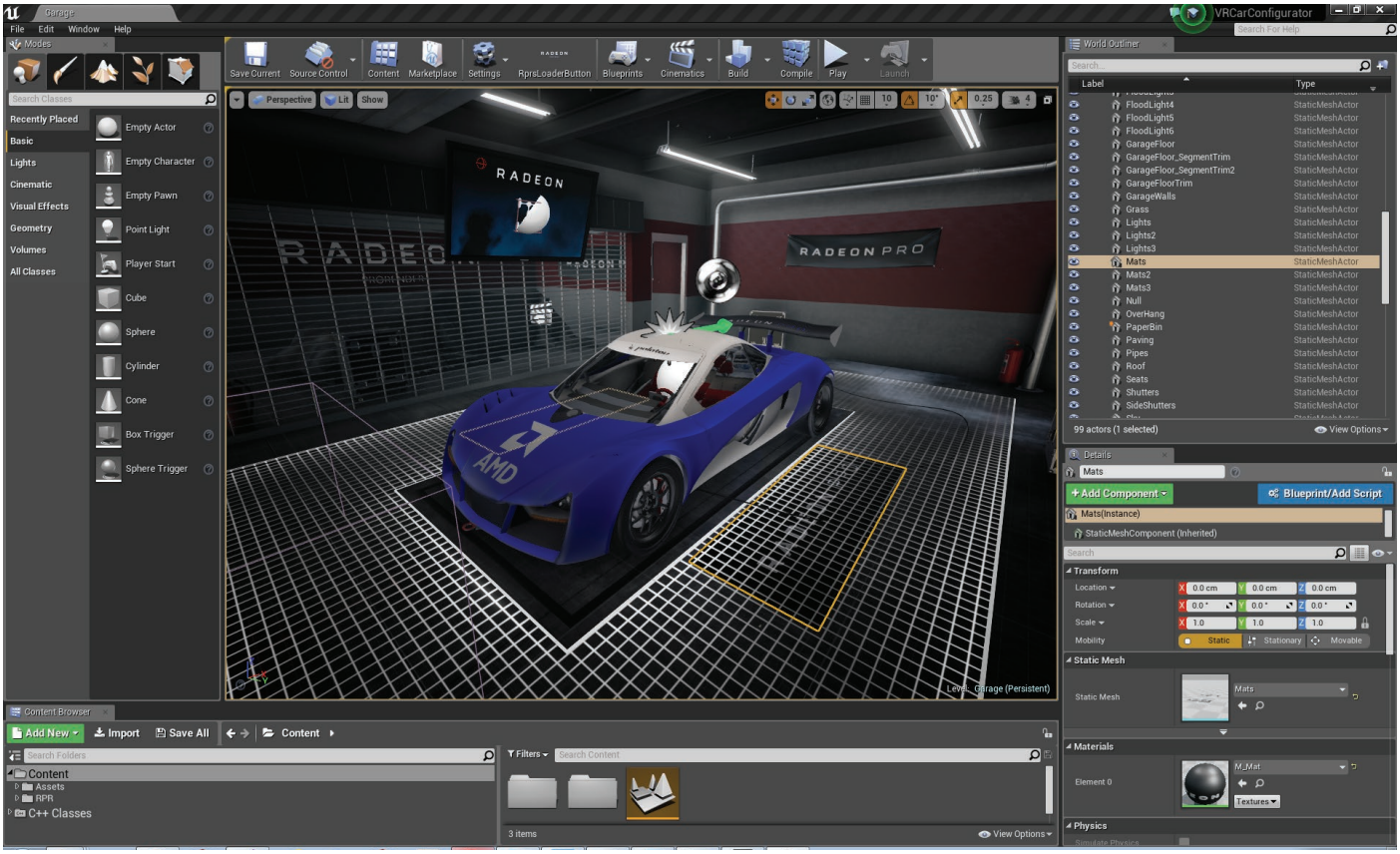
Visualization Technology #2
Game Engine Visualization

Game Engines are starting to play an increasingly important role in design visualization for product development. As the name suggests, these real-time 3D engines, which include Unreal Engine and Unity, are adapted from the consumer games sector.

Without the precision design environment overhead of a 3D CAD tool, game engines offer excellent performance and very high quality interactive visuals. Navigation is intuitive so they can be used by marketing, sales and clients, as well as CAD users.

The workflow usually requires data to be exported from a CAD program followed by some form of geometry optimization. Materials and lighting also need to be applied. This can be a highly skilled process but new tools are being developed for use by non-experts. These include the Radeon ProRender Game Engine Importer, currently in development at AMD, that will offer a push button workflow to import geometry and materials from SOLIDWORKS and other applications into Unreal Engine.

Unreal Engine is a powerful game engine for real time visualization and VR



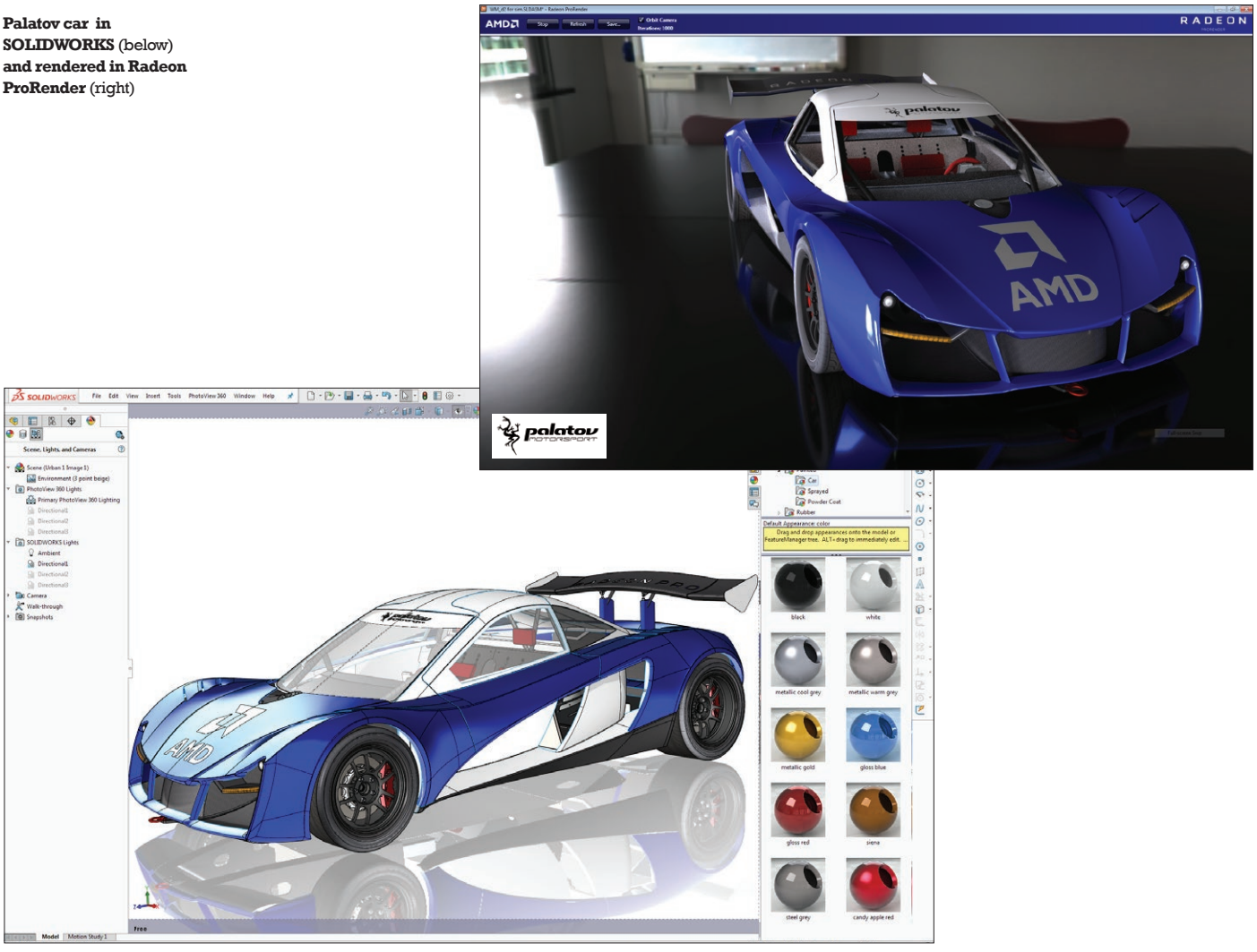
Visualization Technology #3
Physically-based Rendering (PBR)

The rise of physically-based rendering has put 'photorealistic' visualization into the hands of non-experts. PBR simulates the way light reflects off and refracts through materials. As it is based on the laws of physics the process is very computationally intensive. In a typical CAD workstation, it can take minutes to deliver test renders at low resolutions or tens of minutes to render images with more pixels.

In recent years, there has been a big rise in GPU rendering. GPUs are very powerful parallel processors so are great at doing the complex ray trace rendering calculations needed for PBR. GPUs are also flexible and scalable. To cut render times simply add more GPUs to your desktop workstation, which takes a matter of minutes. Examples of GPU renderers include Radeon ProRender and V-Ray RT, both of which are available (or will soon be available) for several leading 3D CAD applications.

As of May 2017, Radeon ProRender for SOLIDWORKS is in beta. It will be available at no cost once it ships.

Radeon ProRender is based on OpenCL, an open compute standard that runs on GPUs and CPUs from a variety of manufacturers. AMD has produced a short video to explain how it works. It can be viewed at bit.ly/2pwrP7i



Palatov car in SOLIDWORKS (below) **and rendered in Radeon ProRender** (right)

Visualization Technology #4
Virtual Reality (VR)

VR has played an important role within product development for many years. However, with systems historically costing hundreds of thousands of dollars the technology was only applicable to large manufacturing enterprises. Now, with the advent of low-cost Head Mounted Displays (HMDs) like the Oculus Rift and HTC Vive, as well as powerful, affordable professional GPUs like Radeon Pro, design, engineering and manufacturing firms of all sizes can take advantage.

VR with an HMD delivers a fully immersive environment for human scale testing of products before they are built. In many workflows, the focus is on functional and ergonomic testing but VR can also be used for aesthetic evaluation. Here the emphasis is on visual quality with realistic materials, lighting and anti-aliasing playing a big role. However, effects such as these place even bigger demands on the powerful GPUs which are needed for VR. In order to have a flicker free VR experience, GPUs must be able to deliver 90 frames per second.

CAD models can currently be experienced in VR in three main ways.

- In VR-capable game engines like Unreal Engine.
- In traditional design viz applications like Autodesk VRED.
- In dedicated pro VR applications like Virtalis VR4CAD.

CAD to VR workflows are continually being optimized, to make it easier to jump between CAD and VR and promote iterative design processes. Performance can also be increased through geometry, material and lighting optimization. AMD, for example, is developing a push button workflow from CAD > Radeon ProRender > Unreal Engine > VR.

Powered by workstations

Product designers, engineers and manufacturers need a reliable computing platform on which to run professional 3D software. Workstations are specifically designed to run CAD, design viz and professional VR tools and are optimized and certified for hundreds of different professional 3D applications.

With a workstation, users not only get a fast, reliable experience but should any issues arise, they can be assured of full software support from ISVs (Independent Software Vendors). In general, such support is not available if the software is run on consumer grade hardware.

A workstation has five key components. Follows are our recommended specifications for 3D workflows.

- **CPU** – high frequency for general application and system performance. Less emphasis on CPU cores, unless you are using a physically-based CPU renderer.
- **GPU** – entry-level to mid-range GPU for CAD workflows. High-end GPU for design viz, VR and GPU rendering.
- **Storage** – SSDs (SATA for mainstream workflows / NVMe for best performance).
- **Memory** – 16GB minimum. 32GB or 64GB for larger datasets.
- **Display** – FHD (1,920 x 1,080) for mainstream 3D CAD. 4K (3,840 x 2,160) or higher for design visualization — though higher resolutions may need a more powerful GPU to maintain 3D performance.

Dell Precision Tower 3420 and Dell Precision Tower 3620 (left)
Radeon Pro WX 7100 (below)

Powered by workstations

Graphics Processing Units (GPUs)

For design visualization, the GPU is arguably the most important component as this helps deliver visually rich interactive models at high frame rates. If frame rates drop it can make it hard for a designer or engineer to position a 3D model on screen quickly and accurately, which impacts productivity. In a customer presentation, it can break the illusion of the virtual prototype. In VR, slow frame rates can lead to motion sickness.

Radeon Pro is a new generation of GPUs from AMD that are specifically designed for professional 3D applications and continue the legacy of AMD FirePro. In addition to featuring powerful graphics processing units, the Radeon Pro Unified Enterprise graphics driver is tuned to get the most out of individual CAD applications. In Dassault Systèmes Catia®, for example, year on year performance due to driver optimizations has increased by up to 30%.

Radeon Pro GPUs also give users access to advanced design visualization features in 3D applications. For example, the SOLIDWORKS RealView display mode, which renders models with realistic materials, lights and shadows, is not available when using a consumer GPU. Order Independent Transparency (OIT) is also not available with a consumer GPU.

There are currently four Radeon Pro GPUs to suit different requirements.

- **Radeon Pro WX 4100** – low profile GPU for Small Form Factor (SFF) workstations optimized for 3D CAD. (4GB GDDR5)
- **Radeon Pro WX 5100** – single slot GPU optimized for high-end 3D CAD and 'game engine' visualization. (8GB GDDR5)
- **Radeon Pro WX 7100** – single slot GPU optimized for high-end design viz, GPU rendering and entry-level pro VR. (8GB GDDR5)
- **Radeon Pro Duo** – dual slot, dual GPU graphics card optimized for high-end design viz, GPU rendering and multi-GPU aware pro VR applications. (32GB GDDR5)

Radeon Pro WX 4100
Optimized for 3D CAD in SFF workstations

4GB GDDR5 memory

Radeon Pro WX 5100
Optimized for high-end CAD and 'game engine' visualization

8GB GDDR5 memory

Radeon Pro WX 7100
Affordable, single slot GPU for visualization and VR

8GB GDDR5 memory

Radeon Pro Duo
Powerful, dual GPU card for high-end viz, VR and rendering

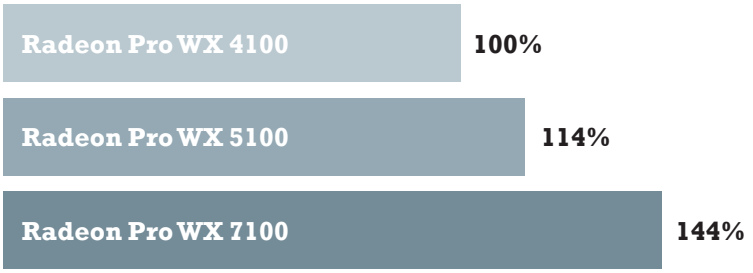
32GB GDDR5 memory

Powered by workstations

Radeon Pro GPU benchmarks

3D CAD - performance in SOLIDWORKS

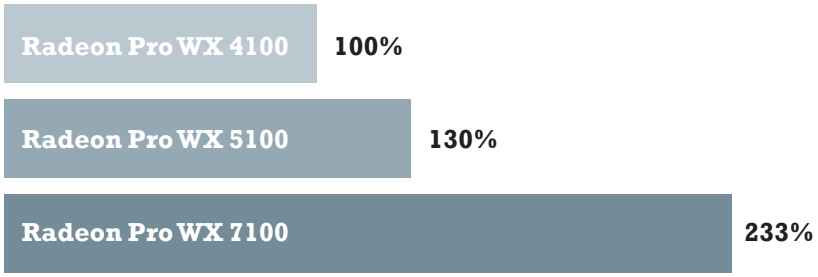
SPECapc for SOLIDWORKS 2015 benchmark (FSAA) Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-composite



Testing conducted by AMD Performance Labs on a test system comprising of Intel E5-1650 v3 3.50GHz, 16GB RAM, Win7 64-bit SP1, AMD 16.50 RC14 for SPECapc for SolidWorks 2015 (FSAA) benchmark. Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-composite. Radeon Pro WX 4100 score: 16.58. Radeon Pro WX 5100 score: 19.03. Radeon Pro WX 7100 score: 23.93. Performance Differentials: 23.93/16.58 = ~44% higher score on Radeon Pro WX 7100. 19.03/16.58 = ~14% higher score on Radeon Pro WX 5100
PC manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers.

Game Engine - 3D performance in Autodesk LIVE

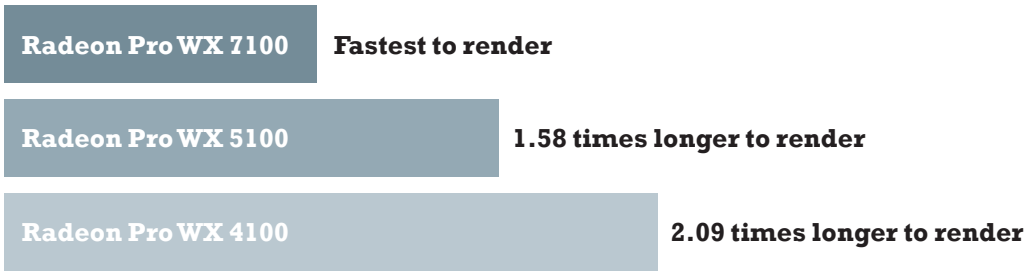
Villa Enhanced Scene



Testing conducted by AEC Magazine on a test system comprising of Intel E5-1650 v3 3.50GHz, 16GB RAM, Win7 64-bit SP1, AMD 16.50.2701 driver for internal Autodesk LIVE benchmark. Frames per second (FPS) for 'Villa Enhanced Scene' captured by FRAPS on FHD (1,920 x 1,080) display. Radeon Pro WX 4100 : 40. Radeon Pro WX 5100: 52. Radeon Pro WX 7100 : 93. Performance Differentials: 93/40 = ~133% higher score on Radeon Pro WX 7100. 52/40 = ~30% higher score on Radeon Pro WX 5100.

GPU Rendering - Render times in Radeon ProRender

Ship model in Radeon Pro Render for Maya



*Testing conducted by AMD Performance Labs on a test system comprising of Intel E5-1650 v3 3.50GHz, 16GB RAM, Win7 64-bit SP1, AMD 16.50 RC14 for internal Autodesk Maya 2017 ProRender benchmark. Render time (secs) for ship new (32AA). Radeon Pro WX 4100 : 544. Radeon Pro WX 5100: 412. Radeon Pro WX 7100 : 260. Performance Differentials: (412-260)/260 = ~58% higher score on Radeon Pro WX 5100. (544-260)/260 = ~109% higher score on Radeon Pro WX 4100

Matching workstations and GPUs to workflows

Workflow	Mainstream 3D CAD user Predominantly part and assembly modeling.	3D CAD user focused on industrial design Assembly modelling with emphasis on aesthetics / finish.	3D CAD user producing 'photoreal' content GPU-accelerated physically-based renderer.	Product designer focused on CAD and VR Presentations, design / review and virtual prototyping.
Key applications	SOLIDWORKS, Autodesk Inventor, PTC Creo.	SOLIDWORKS, Rhino, Siemens NX, Catia, Autodesk Fusion.	Radeon ProRender, V-Ray RT.	Unreal Engine, Unity, Autodesk VRED. Radeon Pro Render (workflow to Unreal).
				
Desktop workstation	**Dell Precision Tower 3420 or 3620** High GHz quad core CPU, SATA SSD, 32GB RAM	**Dell Precision Tower 3620 or 5810** High GHz quad core CPU, NVMe SSD, 32GB RAM	**Dell Precision Tower 5810** High GHz quad core CPU, NVMe SSD, 32GB RAM	**Dell Precision Tower 5810** High GHz quad core CPU, NVMe SSD, 32GB or 64GB RAM
Desktop workstation GPU	Radeon Pro WX 4100 or Radeon Pro WX 5100 GPU.	Radeon Pro WX 5100 or Radeon Pro WX 7100 GPU.	Radeon Pro WX 7100 or 2 x Radeon Pro WX 7100* or Radeon Pro Duo.*	Radeon Pro WX 7100 or 2 x Radeon Pro WX 7100* or Radeon Pro Duo.*
				
All In One (AIO) workstation	**Dell Precision 5720** Radeon Pro WX 4150 High GHz quad core CPU, SATA SSD, 32GB RAM	**Dell Precision 5720** Radeon Pro WX 7100 High GHz quad core CPU, NVMe SSD, 32GB RAM	**Dell Precision 5720** Radeon Pro WX 7100 High GHz quad core CPU, NVMe SSD, 32GB RAM	**Dell Precision 5720** Radeon Pro WX 7100 High GHz quad core CPU, NVMe SSD, 32GB RAM
				
Mobile workstation	**Dell Precision 7520** Radeon Pro WX 4150 High GHz quad core CPU, NVMe SSD, 32GB RAM 15.6" Ultrasharp FHD or UHD	**Dell Precision 7520** Radeon Pro WX 4150 High GHz quad core CPU, NVMe SSD, 32GB RAM 15.6" Ultrasharp FHD or UHD	**Dell Precision 7720** Radeon Pro WX 7100 High GHz quad core CPU, NVMe SSD, 32GB RAM 17.3" Ultrasharp FHD or UHD	**Dell Precision 7720** Radeon Pro WX 7100 High GHz quad core CPU, NVMe SSD, 32GB RAM 17.3" Ultrasharp FHD or UHD

* Dual Radeon Pro WX 7100 and Radeon Pro Duo configs are not offered directly by Dell and are an after market config

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