THE **YARD**
V F X

TECHNOLOGY
WHITE PAPER

RENDER ENGINE
BENCHMARK

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INTRODUCTION

The Yard, an independent French VFX company, undertook a technical audit to evaluate and compare several industry-leading render engines. The methodology is being shared to contribute to the broader USD (Universal Scene Description) community particularly in the context of rendering workflows and performance optimization.

This white paper outlines the methodology used in this evaluation, employing open-source datasets, industry-standard tools, and custom benchmarks developed by The Yard. The goal is to foster knowledge-sharing within the VFX community and to shed light on the technical challenges and opportunities associated with USD-based workflows and MaterialX integration.

As part of this initiative, The Yard has released the USD Render Benchmark project on GitHub, encouraging discussion on rendering techniques, performance, and the technical strengths of various render engines—primarily those focused on ray tracing.

PURPOSE
OF THE AUDIT

The primary goal of this audit was to conduct a technical evaluation of the following leading render engines:

- Karma (Houdini)
- Renderman (Pixar)
- Arnold (Autodesk)
- Moonray (DreamWorks)
- Cycles (Blender)

The audit was designed to benchmark these engines using consistent metrics, focusing on key performance indicators such as rendering speed, memory usage, and output fidelity. This comparative analysis was performed using standardized scenes, enabling an accurate and fair assessment of each engine's strengths and weaknesses.

METHODOLOGY

Datasets

To ensure consistency and reproducibility, the evaluation relied on widely available, open-source datasets, chosen for their complexity and suitability for real-world VFX workflows. The datasets included:

- Moana Island Scene from Disney Animation
- ALab Scene from Animal Logic
- Additional assets from the USD Working Group repository

These datasets provided diverse environments with complex lighting, geometry, and materials, making them ideal for stress-testing render engines.

Tools and Technologies

The following technologies and systems were employed during the audit to facilitate a robust benchmarking process:

- USD (Universal Scene Description): USD was used as the standard format for describing scene hierarchies, including geometry, lights, cameras, and other assets. Its widespread adoption in the VFX industry makes it an ideal foundation for multi-engine comparisons.
- MaterialX: MaterialX, in conjunction with USD, was utilized for defining and manipulating materials across the different render platforms. Its ability to standardize material descriptions enabled more direct comparisons of shading and material performance across engines.

- <u>Rez</u>: A package management system was used to configure the testing environments and manage software dependencies efficiently, ensuring a consistent setup across different render engines.
- <u>Hydra Render Delegates</u>: The audit focused on evaluating different Hydra delegates to standardize the comparison across various engines. Hydra's modularity allowed for streamlined integration and testing of multiple render engines within the same environment.

USD Render Benchmark

To automate and standardize the testing process, The Yard developed a custom USD Render Benchmark suite. The key components of this benchmark included:

- Automated Rendering: Predefined scenes and cameras were rendered across multiple engines, ensuring uniform conditions for each test.
- Performance Metrics: Data such as memory usage, rendering time, and success/failure status were logged for every combination of scene and renderer.
- Summary Report: A Python script generated concise summaries of the results, highlighting key performance metrics for each engine and scene combination. This provided clear, actionable insights into each engine's capabilities.

The USD Render Benchmark suite, available on <u>GitHub</u>, offers a replicable and extendable framework for the VFX community to explore the performance and visual output differences between render engines.

CHALLENGES AND OBSERVATIONS

Integration with Solaris/Houdini

One of the primary challenges encountered during the audit was the integration of various renderers into Solaris, Houdini's USD-based look development and lighting toolset. While USD offers a consistent framework for assets, materials, and scene descriptions, some render engines required specific adjustments to operate within Houdini's Solaris/Hydra ecosystem. These technical obstacles were particularly noticeable with engines that did not fully support certain USD features or had incomplete Hydra delegate implementations.

Material Consistency across Renderers

Maintaining consistent material representation was another challenge. MaterialX provides a powerful and flexible framework for defining materials, but variations in implementation across different render engines created inconsistencies in the rendered results. Despite MaterialX's goal of cross-engine compatibility, discrepancies arose when different engines interpreted material properties in slightly different ways. This posed a significant hurdle in achieving an apples-to-apples comparison.

THE PROMISE OF USD AND MATERIALX

Despite the challenges identified, both USD and MaterialX offer immense potential for the future of the VFX industry:

- Interoperability: USD establishes a unified format for scene description, enabling a seamless workflow across different 3D applications and rendering engines. This interoperability promises to streamline production pipelines, reduce friction between teams, and simplify collaboration.
- Material Flexibility: MaterialX further enhances this workflow by allowing rich, customizable material definitions that can be reused and modified across multiple platforms. It facilitates consistent material behavior in complex, multi-render engine environments.
- Scalability: USD and MaterialX offer scalability across projects of varying complexity and size, allowing studios to manage large-scale scenes and asset libraries more effectively.

However, challenges remain in the form of incomplete feature sets and inconsistent implementations across engines. By sharing this methodology, we hope to empower other studios and developers to perform similar audits and address these issues in their workflows, ultimately driving improvements across the industry.

CONCLUSION

The Yard remains committed to supporting the growth of open-source technologies such as USD and MaterialX. The USD Render Benchmark is intended to provide the VFX community with a valuable tool for assessing, comparing, and improving the performance and output of different render engines.

We encourage developers, studios, and researchers to explore the benchmark, experiment with new scenarios, and contribute to the ongoing conversation surrounding USD-based workflows. By working together, we can continue to push the boundaries of what is possible in rendering and visual effects.

For more information on the USD Render Benchmark, please refer to the README file in the GitHub repository.

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ABOUT THE YARD

THE YARD is an independant creative company founded in 2014, specializing in film and series digital special effects services for cinema and streaming platforms.

With an experienced international team, THE YARD works with some of the world's largest studios.

Its teams develop tools and talents to provide creative expertise that meets the demands of national and international markets.

Our objective has remained the same since our creation: to offer creative visual solutions through France's best artists and the most innovative technologies.

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