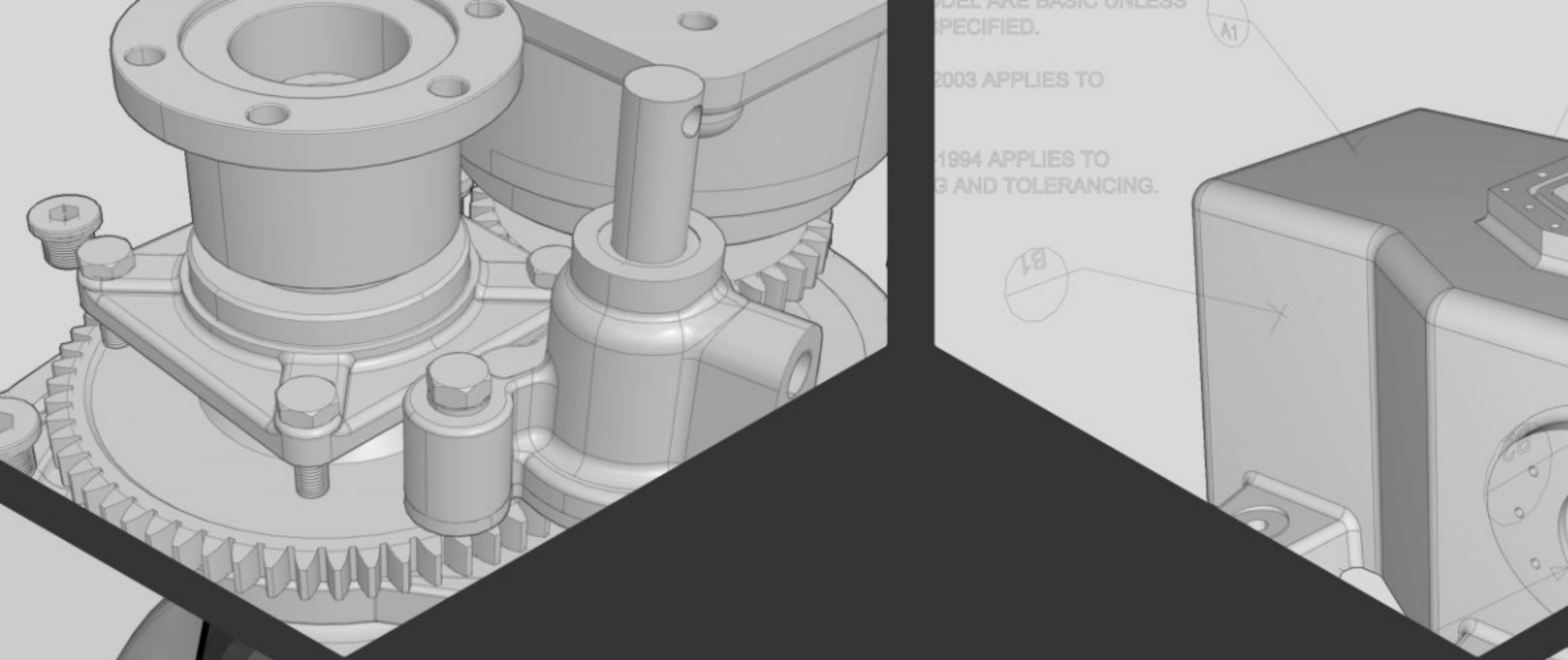
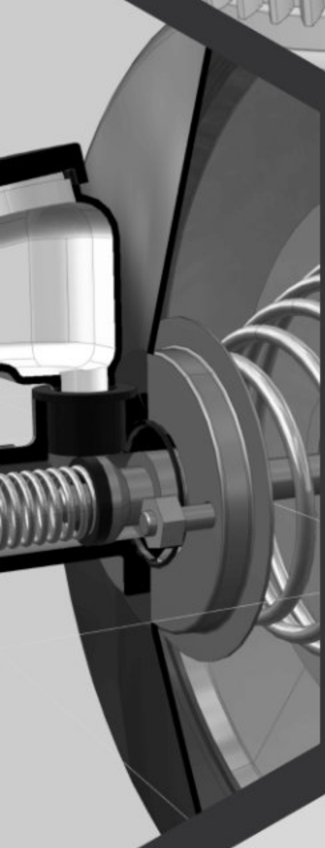
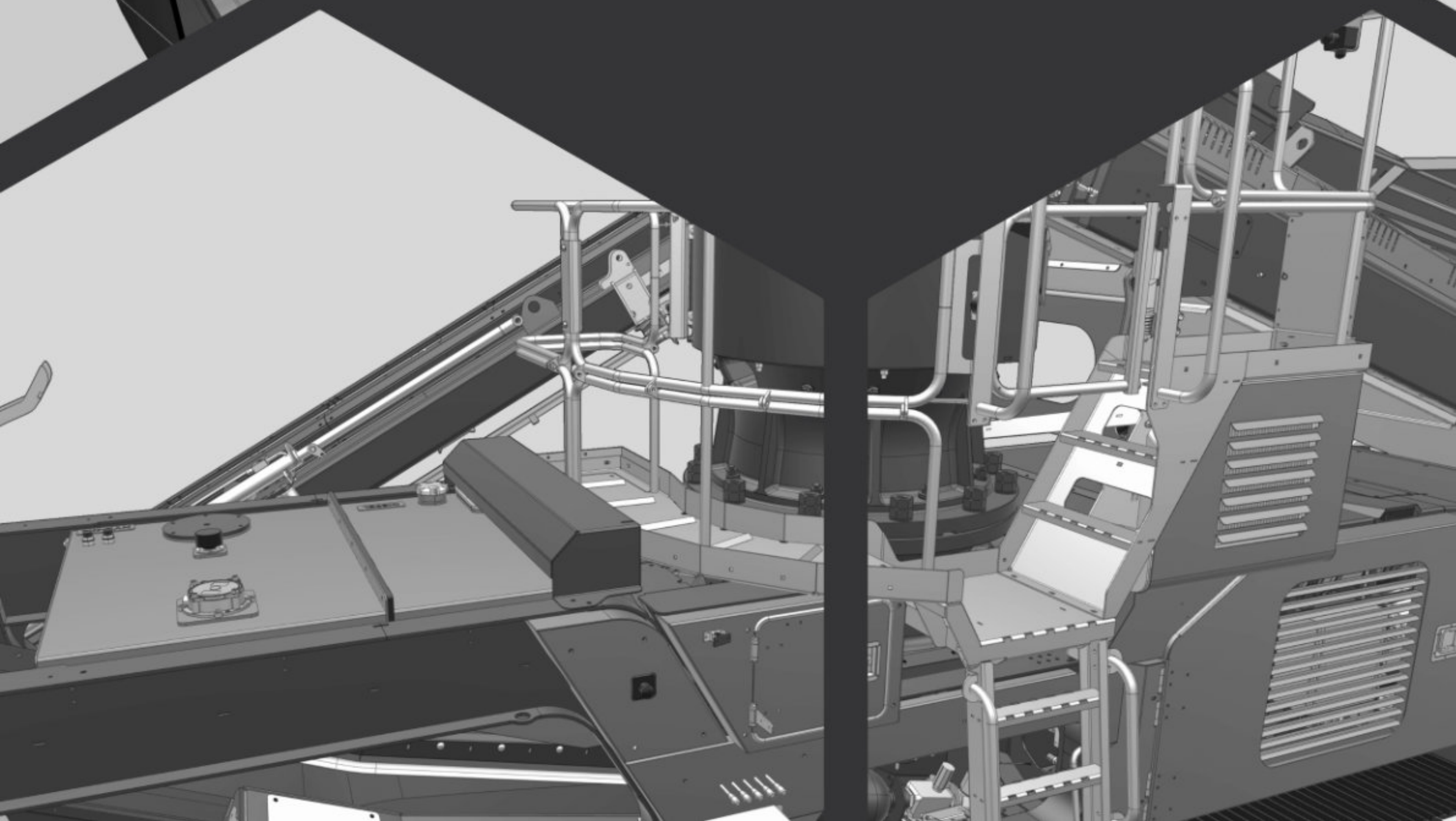




zea™

CAD VISUALIZATION ON THE WEB

2021 Benchmark Report



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Introduction

Zea Inc. is a Montréal based software company that was founded in 2015 by Philip Taylor. Today, as a technology leader in enterprise 3D visualization and real-time rendering software, Zea helps companies of all sizes and industries communicate more effectively.

From back-office to the frontline, design to manufacturing, across desktop, VR, and mobile devices, Zea empowers people and organizations to work together more efficiently and use real-time visualization to stay ahead of the competition.

Foreword

The Zea Engine project started in 2017. Research papers at the time pointed to the ability to create a real-time rendering engine right in the browser and render the visuals using the GPU.

After building WebGL rendering technology for some major engineering companies, Zea migrated to building a new CAD-centric visualization engine designed around the needs of design and manufacturing. Starting with native CAD files, right to high-performance visualization in the browser, Zea develops an end-to-end solution that optimizes every step—working with visionary clients to fine-tune the engine for various use cases.

Those early clients all had very different and specific problems that needed solving, forcing our engine architecture to be the most extendable platform on the market.

At Zea, we obsess over how to make 3D on the web faster, easier, and more open. In response to the problems we kept getting hired to solve, we designed a web-based 3D rendering engine specifically for CAD instead of optimizing CAD for a 3D engine.

Current Issues in the Real-Time 3D Rendering Industry

As real-time 3D rendering evolves and visionary leaders brainstorm what the next generation of web applications will look like, we notice a discrepancy between project requirements and the product offering from the leading solutions on the market.

Struggle to render large datasets

- The most popular free and open-source web-based graphics engine in the study begins to suffer from scenes above 2,000 objects.
- The most popular commercial web-based graphics engine for CAD starts to struggle at 3,000 parts and begins dropping geometry from the rendering scene to maintain the desired framerate.
- The rendering performance of the current industry-leading desktop graphics engine for games begins to decline when working with assemblies that have more than 9,000 parts.

Are complicated to set up and customize

- Teams often lack the 3D development experience to build a home-grown solution.
- Historical data suggests an effort of between 4 and 18 developer-months[1] to switch to a commercial graphics engine.
- The primary objective of the product team is to focus on the product's unique value proposition, as opposed to build and maintain a graphics engine.

Don't support native CAD file formats

- Most graphics engines inherit their DNA from the gaming industry.
- Web browsers do not support native CAD file formats.

Commercial solutions are expensive

- The upfront cost and time spent negotiating licensing agreements are often barriers to entry for many small and medium-sized companies.
- The licensed technology supports legacy workflows that don't apply to web-first solutions.
- Royalty payments are a burden for organizations.

[1] 8 Reasons Why Developers Switch to HOOPS, published by Spatial Corp, retrieved 9/15/20

Independent Testing of the Performance of Real-Time 3D Graphics Engines

To analyze the top issues affecting CAD rendering on the web, Zea commissioned a study to the Centre de développement et de recherche en intelligence numérique (CDRIN), an independent research center focusing on assisting companies in developing their capacities in AI, Machine Learning, Computer Vision, and 3D Rendering. The study selected four platforms as the primary focus of testing comparison:

Platform #1

Open-source web-based 3D rendering library with a huge community and a decade of development.

Platform #2

Commercial software development kit (SDK) for advanced web-based CAD applications focused on high-performance engineering graphics.

Platform #3

Cross-platform game engine. It supports a variety of platforms across desktop, web, mobile, console, and virtual reality.

zea Engine

A web-based 3D rendering solution designed from the ground up for CAD and professional graphics, emphasizing power, speed, and ease of use.

CDRIN performed all tests on the same desktop workstation.

Component	Specification
CPU	Intel i7 5820k (3.30 GHz)
GPU	Nvidia GeForce 1070 8GB
RAM	16.0 GB (2133 MHz)
Disk drive	Intel SSD 730 (240GB, SATA 6Gb/s)
OS	Windows 10 Pro (Build 1809)
Browser	Google Chrome

The Methodology of the Test

The framerate measurement process focused on using each platform's most prevalent or built-in framerate counting tool, as well as enforcing similar scene complexity across all tests. The data used was from the LotsOfBoxes dataset, which is a collection of 15 3D models in the FBX file format, representing incrementally larger numbers of simple boxes of random dimensions with different topology (i.e., number of vertices per faces), custom made and provided for the benchmark by Zea Inc. The files represent 1k, 2k, 3k, 4k, 5k, 6k, 7k, 8k, 9k, 10k, 20k, 30k, 40k, 50k, and 100k premade boxes.

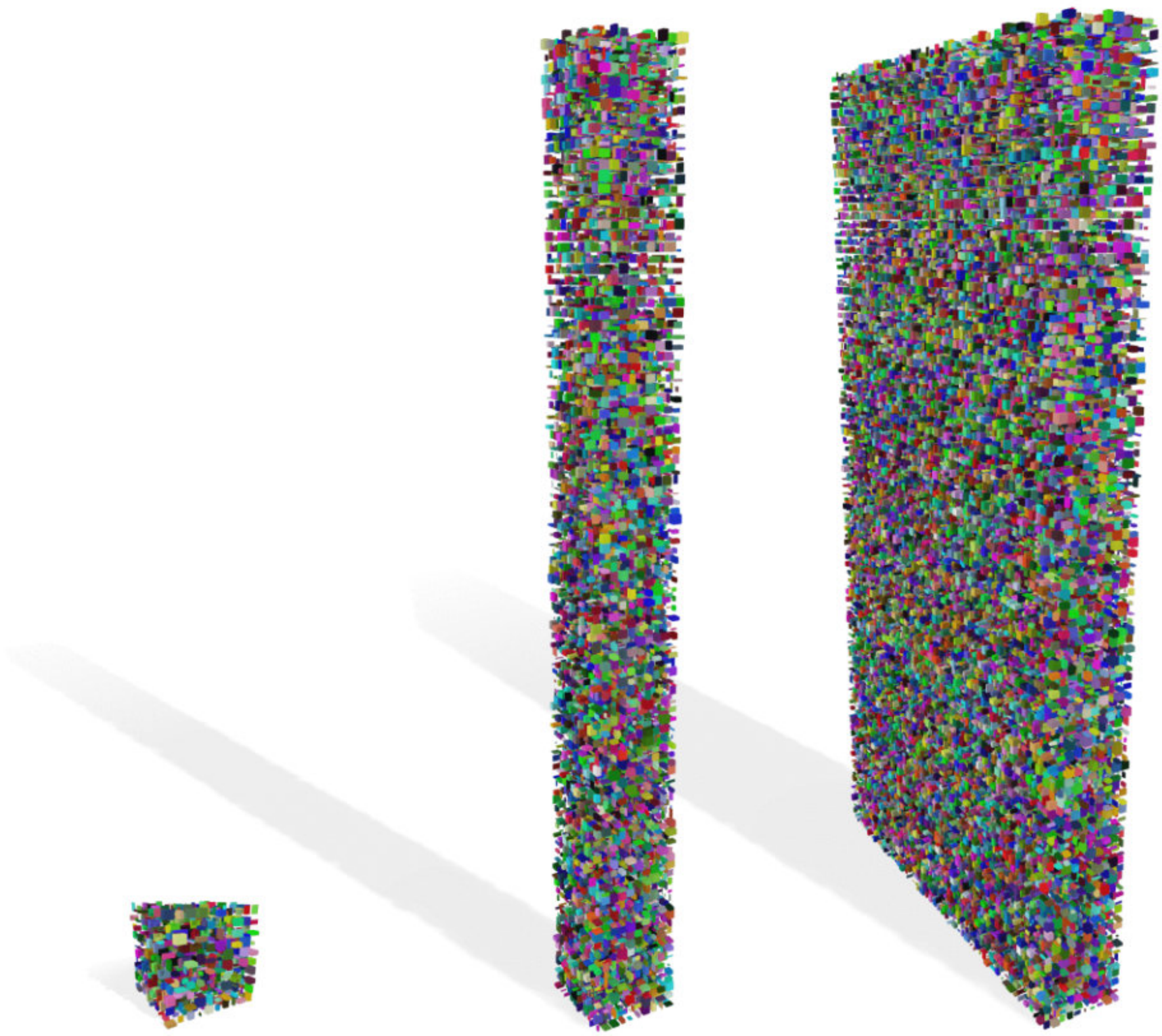


Image 1. Visual samples of LotsOfBoxes files at 1k, 10k, and 50k units (rendered in Microsoft 3D Viewer).

Benchmark

Platform #1

The benchmark used a complementary profiling library to display the current framerate. The stable framerate was noted once the models were fully loaded and displayed in the Chrome web browser.

Platform #2

The benchmark used the SDK's built-in FPS counter to display the current framerate. The stable framerate was noted once the models were fully loaded and displayed in the Chrome web browser.

NOTE: The target frame rate was disabled to make the scene render all geometry and force adaptive rendering to be on par with the other platforms.

Platform #3

The benchmark ran the scene in the editor, using the editor's play function and built-in statistics display, which includes FPS. The study capped the framerate at 60 frames per second to account for current browsers bearing the same browser-imposed limitation. The stable framerate was noted once the models were fully loaded and displayed in the play window.

NOTE: Some technical optimizations could have been implemented to improve performance; however the goal of the study was to measure performance with generally out-of-the-box settings.

Zea Engine

The Zea engine benchmark used its provided FPS counter to display the current framerate. The stable framerate was noted once the models were fully loaded and displayed in the Chrome web browser.

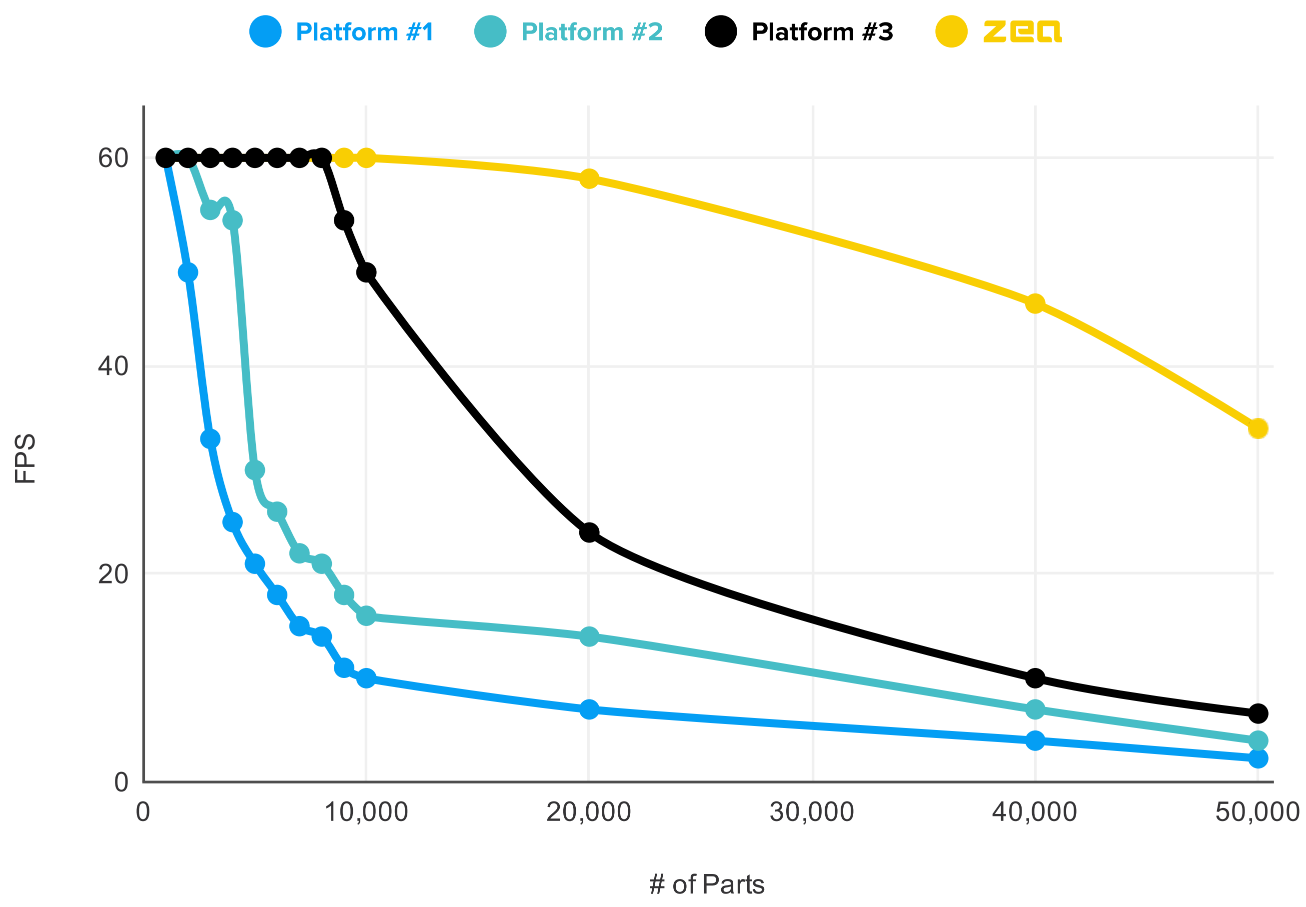
Note: The culling system was disabled during the test to force the engine to render all parts in the sample dataset.

The Results

The study provides insight into the issues affecting rendering CAD models on the web that we identified at the beginning of this paper.

1 Currently, real-time 3D rendering solutions struggle to render large datasets.

Here are the results obtained in the study of the performance
by the number of boxes and engine, in Frames Per Second (FPS).



Platform #1

The decrease in FPS is instantaneous, and with 9,000 parts, the FPS is 18% of what it was at 1,000 parts. At 40,000 parts, the platform performs at 7% of its rendering capability.

Platform #2

The decrease in FPS between 4,000 and 5,000 parts is significant. At 9,000 parts, the FPS is at 30% of what it was at 1,000 parts. At 40,000 parts, the platform operates at 12% of its rendering capability.

Platform #3

The decrease in FPS begins between 8,000 and 9,000 parts. At 20,000 parts, performance is at 49% of what it was at 10,000 parts. At 40,000 parts, the platform performs at 17% of its initial capacity.

Zea Engine

There is no significant decrease in FPS for the Zea platform before 20,000 parts; the engine performs at 97% of its performance at 10,000 and drops 2 FPS. At 40,000 parts, the Zea platform performs at 77% of its capability.

Analysis

As more and more parts are rendered in a scene, the observed decrease in FPS for each platform in the study makes it very clear when performance drops off. The drop in FPS negatively impacts the user experience when working with more complex objects or in extended reality environments. Furthermore, with some platforms struggling to render high-quality scenes, it's no surprise that current best practices reduce the number of geometries, either by merging or deleting them.

2 Are complicated to set up and customize

Platform #1

The platform is open source and boasts a large community of users and developers. It also has a wide range of modules to support custom formats or tasks and has a large body of previous works and examples. Backward compatibility is not a priority, increasing upgrade workloads. It is quite common to find solutions in production environments that are 30 releases behind the latest release.

Platform #2

It has extensive documentation and tutorials to build a basic application using its libraries. Out-of-the-box, it works exclusively with a proprietary file format for assets, requiring a conversion process using provided tools before the test. Also, there is no direct access to source code to modify or extend built-in features; the interaction is only through the API.

Platform #3

The platform has in-depth documentation and a large community of users/developers. Moreover, it boasts a wide range of modules to support custom formats or tasks and a large body of previous works from which users draw examples. This platform is desktop-based and deprecated its web-viewer. This platform is a desktop platform and can build content for web visualization.

Zea Engine

The Zea Engine is open source (with a license for commercial use), has essential documentation, demos, and project templates. Since it is a relatively new platform, there isn't a large community base of users/developers. Zea works with a proprietary file format, zcad, for CAD-specific features and workflows. Zea also natively supports the glTF open format through a plugin.

Deployment into production is quick with embeddable viewing solutions. Teams are free to customize their user experience and user interface tools, making use of the open-source viewers and templates. A complete engine SDK is available for advanced users to build a custom web application from the ground up.

3 Can't directly support native CAD file formats

Here are the comments made by the researcher at CDRIN on each platform.

Platform #1

The library natively supports various file formats out-of-the-box: FBX, 3DM, gltTF, OSM and OBJ. Notably, it does not support CAD out-of-the-box; the community's recommended approach to work with CAD assets is to either export them into another format from the start or transform them into one of the supported formats, possibly at the cost of losing data or requiring a lot of preparation time to set up scenes or objects with the appropriate workarounds before exportation or transformation.

Platform #2

Works exclusively with a proprietary file format for assets, requiring a conversion process using provided tools.

Platform #3

As a complete game engine, it supports features beyond rendering, such as physics and scripting engines. Still, it requires custom C# implementation or third-party plugins to support CAD format.

Zea Engine

Zea also boasts its exclusive file format (zcad) optimized for efficient and fast data compression and decompression while supporting other critical CAD features such as PMI, metadata, measurements, and model trees. Zea Engine also supports glTF and Obj file formats.

Zea offers a cloud platform that securely automates the conversion workflow with simple triggers and actions to convert native CAD files into zcad files compatible with web browsers.

Analysis

Preparing 3D CAD files for real-time rendering on the web is not a trivial process due to the interoperability constraints between file formats, lack of backward compatibility concerns of the free solutions, and the closed-source nature of the leading commercial solutions.

Furthermore, large CAD assemblies such as automobiles are often over 1 GB in size. On the web, load times are a significant concern, and reducing file size is key to faster load times and improving user experience. [2]

[2] We expect new technologies like 5G networks, WebGPU, and more prevalent use of WebAssembly to also contribute to reducing load times in the future.

4 The industry-leading software can be expensive

Platform #1

The first platform is open-sourced under the MIT license and is free to use. It is also the least efficient platform we studied at rendering large CAD datasets.

Platform #2

The second platform incurs annual fixed fees in the range of $12,000 to $50,000. Products that commercialize on this platform also bear a 5 to 25% royalty. This platform had the third-best performance metrics in our analysis.

Platform #3

The third platform charges annual fixed fees in the range of $400 to $2,000 per developer for commercial use and generates significant revenue from in-game advertising. Using this platform requires additional plugins to support CAD, and it is built for desktops. It can create builds for the web, but this makes updating projects more difficult. This platform had the second-best performance metrics in our analysis.

Analysis

For small and medium-sized companies, the costs of the second platform are often cited as a barrier to entry. Therefore, teams choose platform one or three to build their product. The result is sub-optimal performance, a significant increase of technical debt, and a risky supply chain of components responsible for supporting various CAD file formats, and in most cases licensing conflicts. As noted earlier, replacing a graphics engine within a production product is a 4 to 18 developer-month undertaking so it's best to get it right the first time.

THE ZEA PLATFORM

Coming back to the objectives of next-generation 3D web applications, the Zea platform addresses the top challenges facing CAD on the web today.

One of the factors differentiating the Zea platform is the highly-optimized zcad file format which allows for quick load times due to the smaller file sizes.

When compared to the most commonly used file format for viewing 3D files on the web, glTF, zcad files are just over 13 times smaller and offer 48x compression VS the 3.7x compression offered with glTF.

Characteristic	glTF	ZEA
Large CAD model **970 Mb** ~17,000 parts	3.7x compression **260 Mb**	**48x compression** **20 Mb**

Also, according to self-published results, Zea has one of the most efficient compression algorithms in the world. During internal tests, optimized zcad files achieve compression ratios of up to 121:1.

zcad compression ratio
up to **121:1**

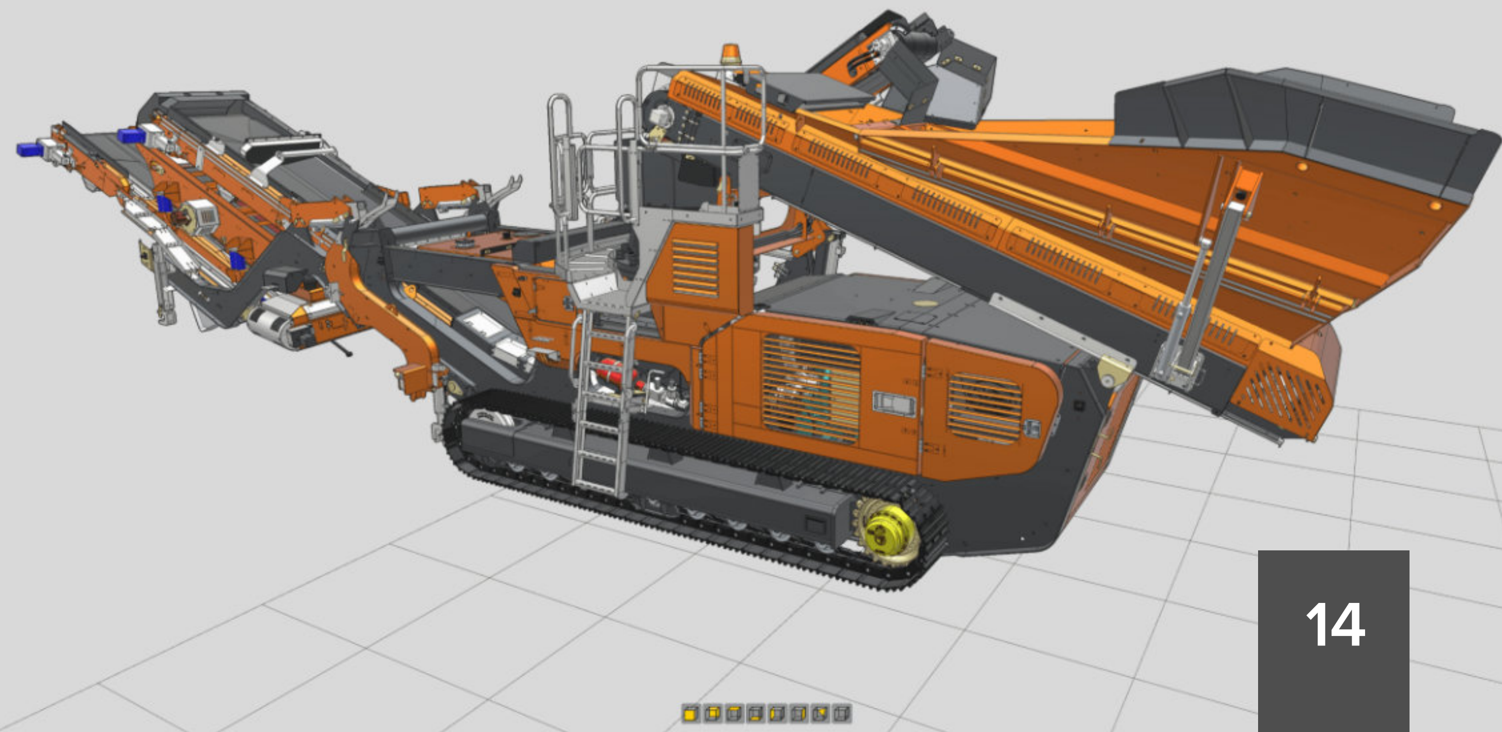
As shown in the CDRIN study, even with complex assemblies with thousands of parts, the Zea engine provides seamless experiences with out-of-the-box settings.

In sum, Zea offers a platform for quickly adding 3D support to existing web applications and templates for building the next generation of CAD applications. Powered by a unique purpose-built WebGL rendering engine, supported by cloud infrastructure, and extended by a plugin ecosystem, the platform provides an affordable subscription model for small teams to get started and the robustness to scale up with demand.

The Zea platform is entirely web-based, VR compatible, built for speed (it is the fastest on the market), especially with large data sets. It allows developers to quickly add support for native CAD file formats to their applications. It comes with CAD-specific features like product manufacturing information (PMI), metadata, measurements, various render modes, and more. Also, Zea's open-source code and modular architecture allow extensions to be built around the engine, allowing developers to extend their capabilities to an unlimited number of use-cases. There are no lengthy product authentication and connections to set up, and teams can get started with a free trial.

Pulse

As a practical example, Pulse PLM has offered this CAD model rendered with the ZEA engine for Portafill International Ltd, a world-leading manufacturer and supplier of a range of cost-effective, innovative and highly mobile screens, crushers, trommels, wash systems and conveyors.



The Benefits of the Zea Platform

Instantly add support for 3D CAD, PMI, metadata, measurements, and CAD-specific rendering modes to existing web applications.

Easy setup for developers, no complicated authentication to configure.

Affordable subscription-based plans remove barriers to entry for small and medium-sized businesses.

Performance and modularity to power the most demanding enterprise applications.

Remove the risk of adding technical debt and creating licensing conflicts associated with building in-house solutions.

Highly efficient zcad file format decreases file sizes and load times.

Can enable plugins for multi-user collaboration.

Zea's open architecture and open-source code allow you to work with your existing service providers to build custom plugins.

No software to install or update.

In closing, the CDRIN study provided an independent comparative basis for assessing the performance of today's industry-leading graphics engines. The study was conducted in April 2021. The test can be performed and results verified by others with the same public dataset.

- Download the LotsOfBoxes dataset here.

We hope you've gained a few new insights into the current state of the industry. We leave you with this conclusion: rendering CAD models on the web is best performed by an engine designed for CAD.

Contact Zea for more information, review the test methodology, discuss the results in further detail, or determine if Zea is a good fit for your projects.

Contact

We make 3D technical communication fast, easy, and open.

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