HOOPS® and the Changing Graphics Landscape

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Table of Contents

Introduction

3D graphics development is changing rapidly due to the shift towards shader-based rendering and the emergence of Direct3D as the dominant rendering API. As a result, the bar for "professional grade" graphics is being dramatically raised. As with most technology shifts, these changes represent new competitive opportunities as well as serious challenges and risks. They especially have an impact on engineering software developers who want to improve their competitive position by adopting these technologies.

This paper will discuss in detail the emerging technologies that are shaping the graphics landscape. It will also describe how HOOPS helps engineering software developers address these challenges and improve their competitive standing as well as provide the results of hardware testing of both OpenGL and Direct3D on Windows XP and Vista.

Opportunities and Challenges:

The release of Windows Vista creates an opportunity for engineering software developers to pull ahead of the competition by taking full advantage of the Aero user interface, an optimized driver model and enhanced Direct3D API. By also moving to the new shader-based rendering approach, applications can maximize rendering performance and visual quality.

In the midst of the shifting graphics landscape, developers face a challenging situation as they seek to:

- Leverage the full advantages of Direct3D on Vista while still delivering a robust and stable experience for customers on XP and other platforms.
- Overhaul current graphics engines in order to migrate to a modern shader-based rendering model.
- Dedicate sufficient resources to keep pace with competitors in a complex technology area that has become a key source of market differentiation.

The Direct3D and OpenGL Situation

Since its introduction in 1995, one of Direct3D's primary objectives was to give developers more direct control of the rendering process. Working with graphics card manufacturers, each new version has delivered increased performance and stability. Direct3D now offers the most sophisticated and advanced rendering techniques available. Today, all the visual effects in Vista's Aero interface are made possible by Direct3D. By balancing the need for powerful performance against the desire for visual realism, Direct3D has become the dominant rendering API for the graphics-intensive video-game industry. Because it is widely used by the gaming industry and is integrated into Microsoft Vista, Direct3D also enjoys robust and stable hardware support, making applications built with this technology more stable and consistent across all classes of video cards.

Through much of its history, Direct3D lacked key features making it a less attractive alternative for engineering software firms who preferred OpenGL. Beginning with Direct3D 9.0, however, developers of 3D engineering software now have the capabilities they require. Consequently, as the engineering market's use of 3D matures, Direct3D is emerging as the optimal rendering API in this market, just as it has in the video-game market.

Historically, OpenGL has been the rendering API of choice for the engineering and academic communities. As a result, many of OpenGL's capabilities were specifically targeted towards the needs of these users. While Direct3D is evidently the preferred solution on Vista, OpenGL still remains the more high-performance solution on a majority of XP-era hardware. It is also the only 3D API available for Apple's OSX and UNIX-based systems, ensuring its importance for years to come.

Supporting both Direct3D and OpenGL

Because rendering performance and quality is highly dependent on the platform and hardware configuration of a given system, applications will need to support both OpenGL and Direct3D to provide all end users with optimized graphics performance.

For an application to choose one or the other at this stage in the technology shift would be to concede a significant set of potential customers to competitors whose graphics performance is more highly tuned to a certain class of hardware. Conversely, applications offering support for both OpenGL and Direct3D can fully serve end users no matter which API their hardware favors.

This need for dual API support creates major challenges for most engineering applications, whose home-grown graphics subsystems almost universally rely solely upon OpenGL. The effort involved in implementing Direct3D while still supporting OpenGL is substantial. Maintaining two distinct rendering pipelines increases the cost and complexity of the application development process. However, choosing one over the other can limit options and market opportunities, turning the support for both OpenGL and Direct3D from a simple technical choice into a strategic business imperative.

Requirements for Shader-Based Rendering

Shader-based rendering is the method for achieving superior performance and visual quality on current and future graphics hardware as compared to the traditional "fixed-function" approach. To leverage the entire range of Direct3D's feature set, application developers need to utilize the shader-based rendering available in Direct3D 9.0 (shader model 2 and 3). Furthermore, the recently released Direct3D 10.0 (shader model 4) and soon to be release OpenGL 3.0 are 100% shader-based.

The benefits of shader-based rendering include increased performance and the ability to implement complex rendering techniques such as advanced lighting models and sophisticated material properties. It is important to note that shader-based rendering also boosts performance and fidelity for common presentation styles such as gouraud-shading, line drawing, and texture mapping. Using shaders, developers can create logic for these visual effects using a broad spectrum of consumer and professional grade hardware. While a shader-based approach provides developers with the ability to closely direct graphics hardware rendering, this low-level control results in a far more challenging development environment.

Today, most applications that utilize OpenGL or Direct3D are built on a "fixed-function" graphics pipeline. In the engineering software market, this fixed-function approach is a

standard graphics architecture, and how virtually all OpenGL-based graphics subsystems are architected today. With a fixed-function pipeline, Direct3D 9.0 renders passable results for 3D triangles but on many video cards, the rendering performance of lines, text and arcs suffers significantly, inhibiting its usefulness for engineering applications. A shader-based approach eliminates these problems. Thus, applications with a shader-based programmable pipeline reap the benefits of high performance and sophisticated visual effects.

This move toward shader-based rendering is already important today, but will become absolutely vital in the near term for Windows-based applications. The latest DirectX 10.0 hardware (already released) will be 100% shader-based, with no support for fixed-function rendering. Since OpenGL 2.0 also has a shader-based architecture, the likelihood is that the fixed-function APIs will become less widely supported resulting in a corresponding degradation in performance and stability. Therefore, for applications to support the latest hardware and remain competitive, migration to shaders is a requirement, not an option.

The HOOPS 3D Application Framework

The key benefit of building an application with HOOPS as the graphics subsystem is that the HOOPS framework sits well above the level of Direct3D and OpenGL without creating any overhead or performance penalty. HOOPS implements these, as well as numerous hardcopy APIs. Tech Soft 3D rigorously tests these API's on a wide range of graphics hardware to ensure compatibility, reliability and optimal performance.

Tech Soft 3D manages the ongoing changes within these API's so that HOOPS-based applications are insulated from shifts in various 3D display APIs and will perform optimally on any hardware configuration. This insulation frees software engineers to develop value-added features in their applications instead of consuming cycles maintaining multiple graphics pipelines. With HOOPS, developers can take advantage of a new 100% shader-based Direct3D 9.0 driver and traditional fixed-function OpenGL driver (still optimal on many graphics cards). Upcoming releases will include shader-based OpenGL 2.0 and Direct3D 10.0 drivers.

Some of the benefits delivered by the HOOPS DirectX 9.0 driver include:

- Real-time soft shadows with stochastic sampling, via shadow maps
- Fast generation of planar shadow and reflections
- Optimized line drawing, including wide/patterned lines, thus enabling much faster wireframe performance vs. a non-shader-based Direct3D implementation.
- High-performance rendering of full-screen anti-aliased scenes that also contain 3D sprited objects, via 'render to texture' techniques
- Accurate, high-performance transparency, made possible by a shader-based implementation of depth peeling.

Many additional techniques and algorithms are made possible due to a shader-based approach and Tech Soft 3D will continue to aggressively incorporate these into future HOOPS releases.

Direct3D and OpenGL Performance under Windows XP and Vista

Tech Soft 3D has performed testing of both Direct3D and OpenGL under Windows XP and Vista using the HOOPS Part Viewer application.

The test results show several trends:

- DirectX is comparable to or faster than OpenGL on Vista.
- DirectX performance on Vista is on par with its performance on XP.
- DirectX's performance is more consistent across consumer and professional grade cards than OpenGL.

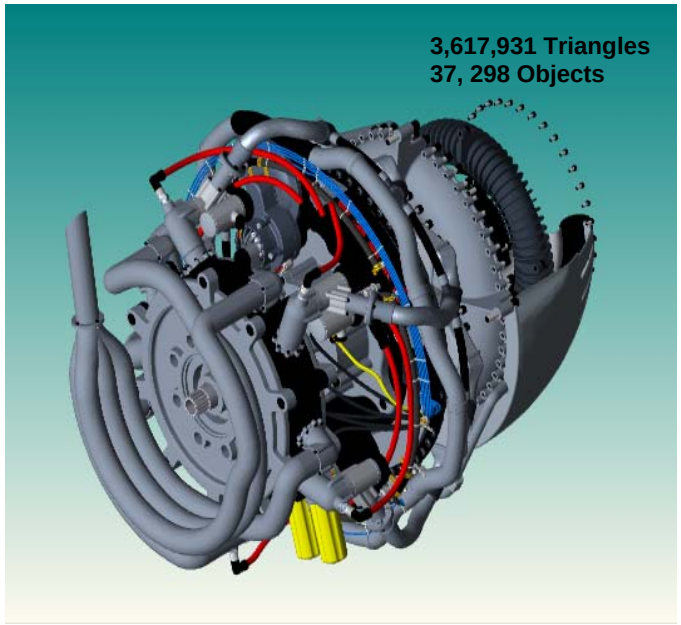
View the test results for a variety of graphics cards and datasets in the following Appendix A.

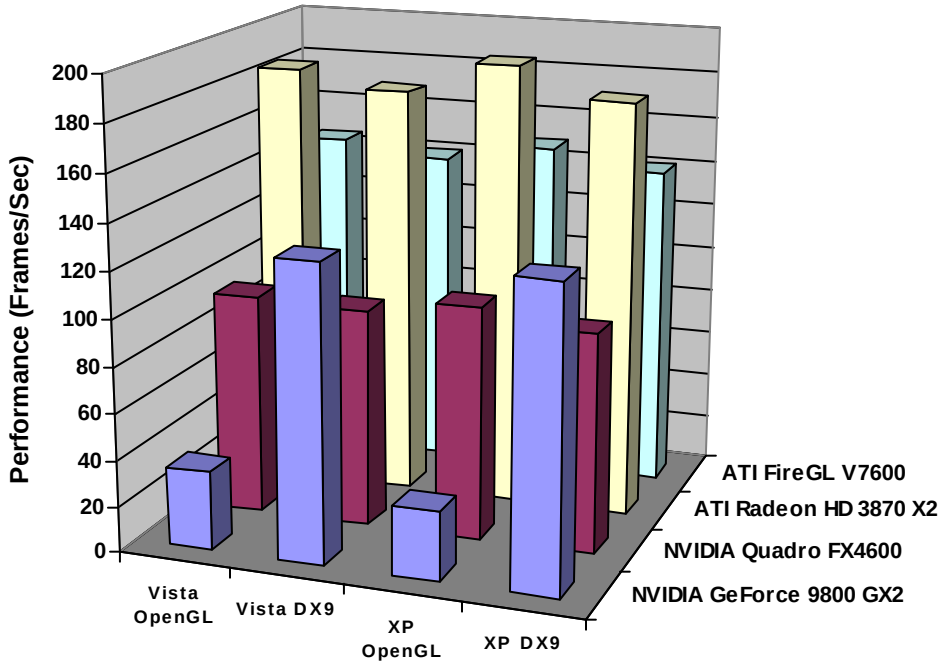
Summary

Applications developers need to offer their customers the advancements in Windows Vista while still addressing the needs of Windows XP and non-Windows users. To remain competitive, these developers must ensure optimal graphics performance, stability, fidelity and graphics API independence in a resource efficient and timely manner, with an eye toward flexibility as improvements in the industry continue at a rapid pace. Using HOOPS as a high-level graphics development platform will ensure that engineering applications realize the full benefit of the latest advances in graphics hardware and APIs, while still performing optimally on all existing hardware. With HOOPS, developers will be insulated from these ongoing changes and gain the freedom to focus on application features rather than graphics pipeline maintenance within a rapidly evolving technology environment.

Appendix A – Graphics Card Test Results

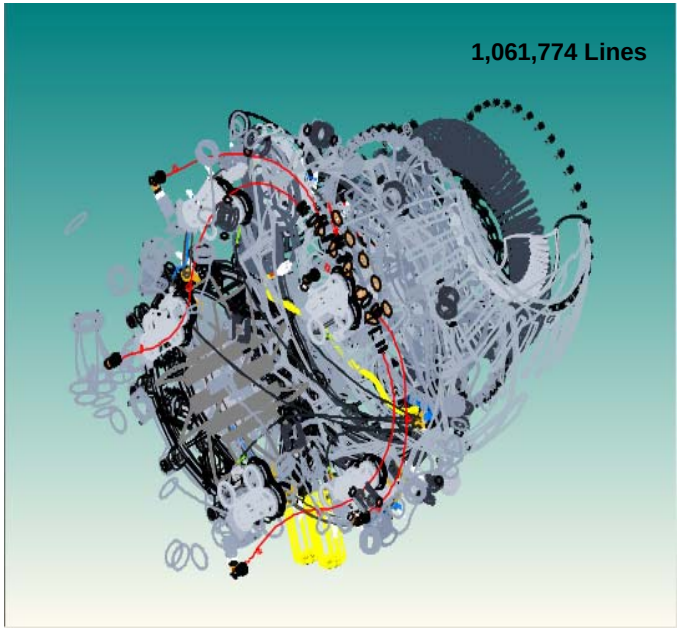
Gouraud Turbine

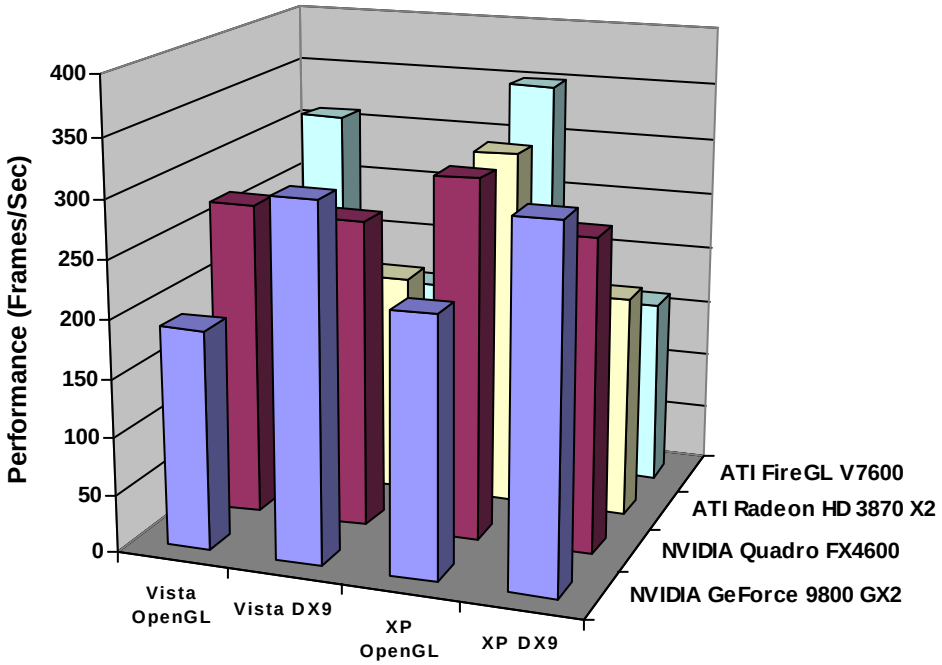




	Vista OpenGL	Vista DX9	XP OpenGL	XP DX9
NVIDIA GeForce 9800 GX2	34.34	128.21	30.00	129.36
NVIDIA Quadro FX4600	95.60	94.25	101.04	94.58
ATI Radeon HD3870 X2	185.43	178.39	192.93	180.00
ATI FireGL 7600	144.93	139.49	147.69	140.49

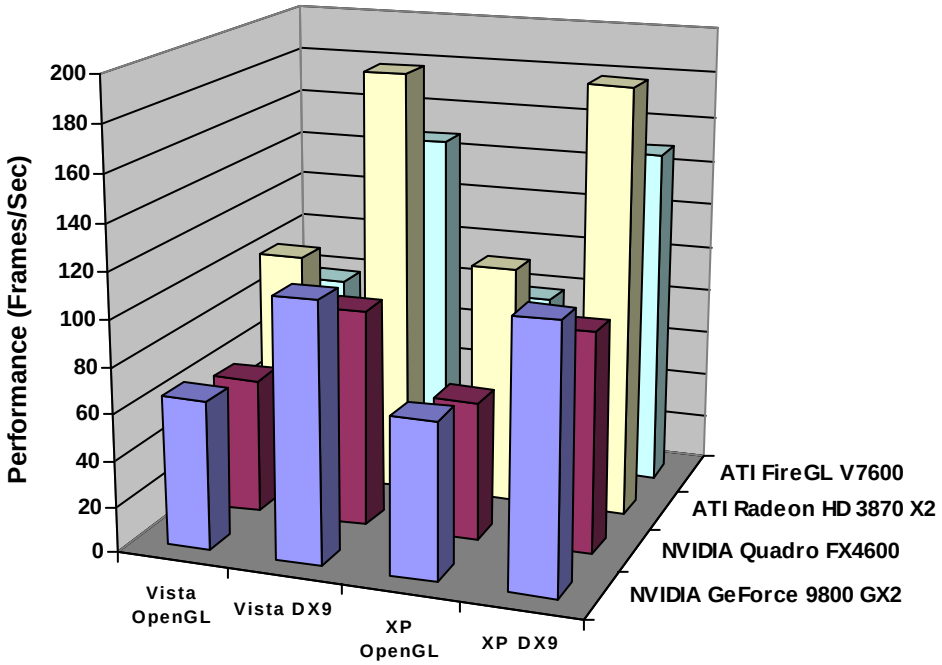
Wireframe Turbine





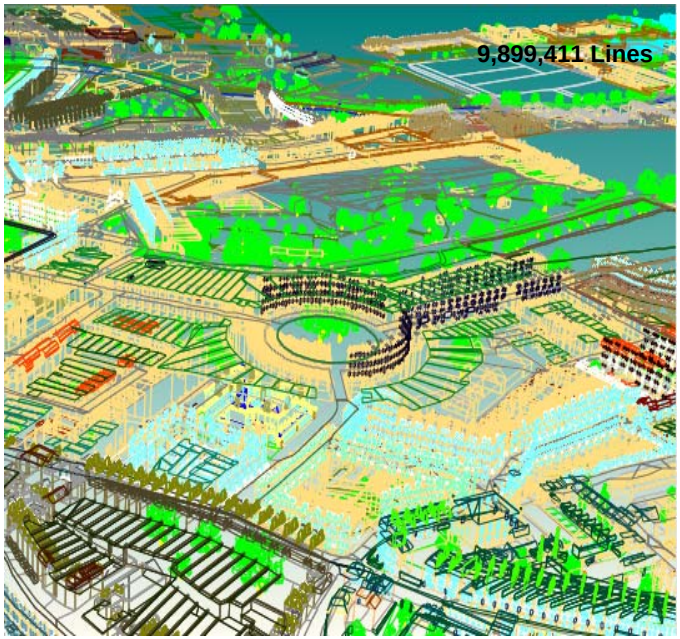
	Vista OpenGL	Vista DX9	XP OpenGL	XP DX9
NVIDIA GeForce 9800 GX2	189.37	305.72	223.01	306.83
NVIDIA Quadro FX4600	272.02	266.27	310	270.09
ATI Radeon HD3870 X2	139.49	192.31	310.00	192.00
ATI FireGL 7600	310.77	160.23	350.88	160.83

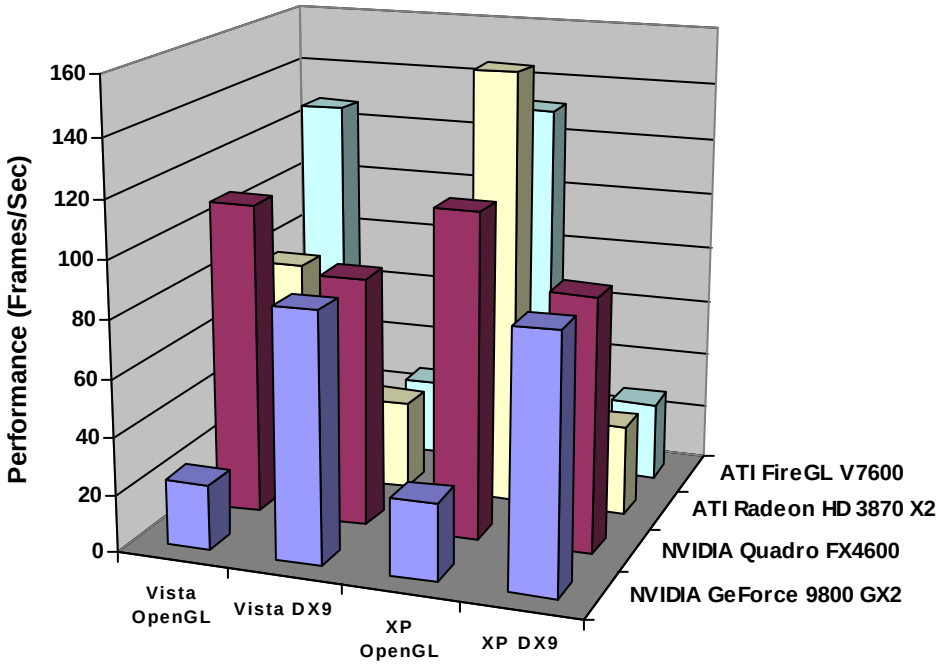
Gouraud Small City



	Vista OpenGL	Vista DX9	XP OpenGL	XP DX9
NVIDIA GeForce 9800 GX2	65.04	112.57	67.87	114.07
NVIDIA Quadro FX4600	58.86	94.25	60	95.51
ATI Radeon HD3870 X2	101.20	186.46	104.56	187.07
ATI FireGL 7600	77.30	147.20	78.38	148.47

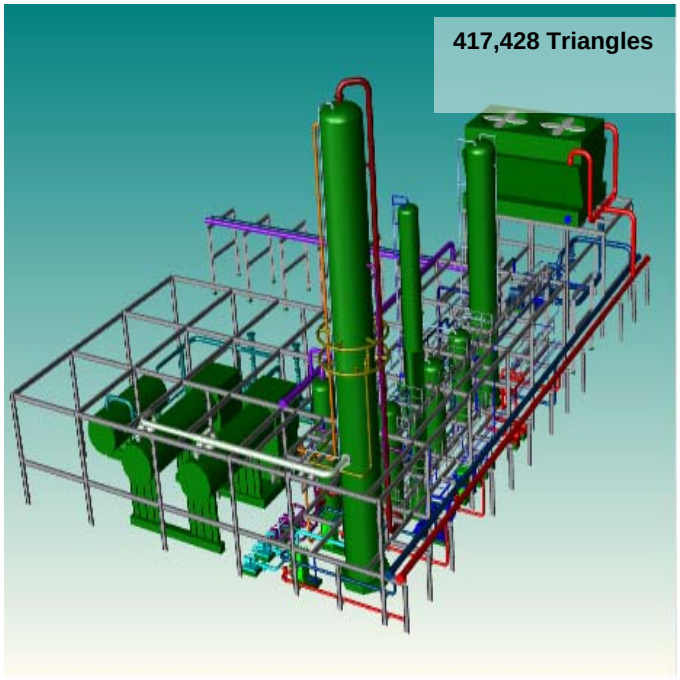
Wireframe Small City

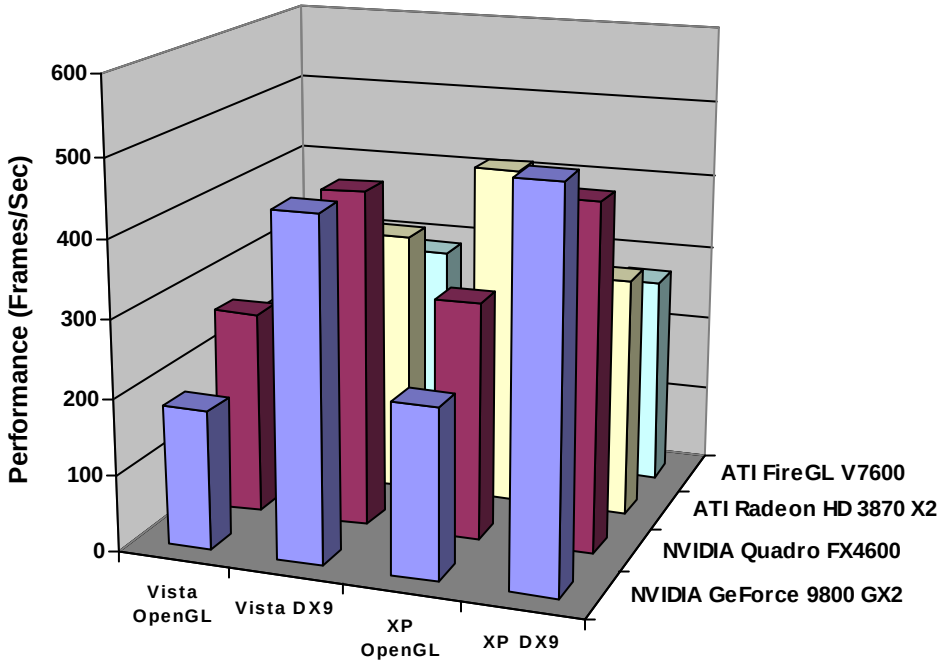




	Vista OpenGL	Vista DX9	XP OpenGL	XP DX9
NVIDIA GeForce 9800 GX2	22.89	86.54	27.04	88.15
NVIDIA Quadro FX4600	108.48	86.54	112.92	88.18
ATI Radeon HD3870 X2	78.10	31.02	152.04	31.47
ATI FireGL 7600	127.58	26.71	131.74	27.30

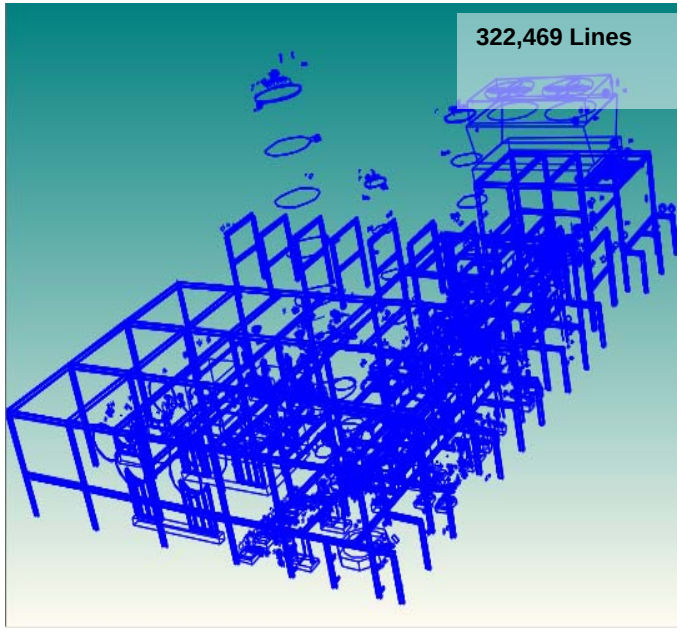
Gourand Piping Plant

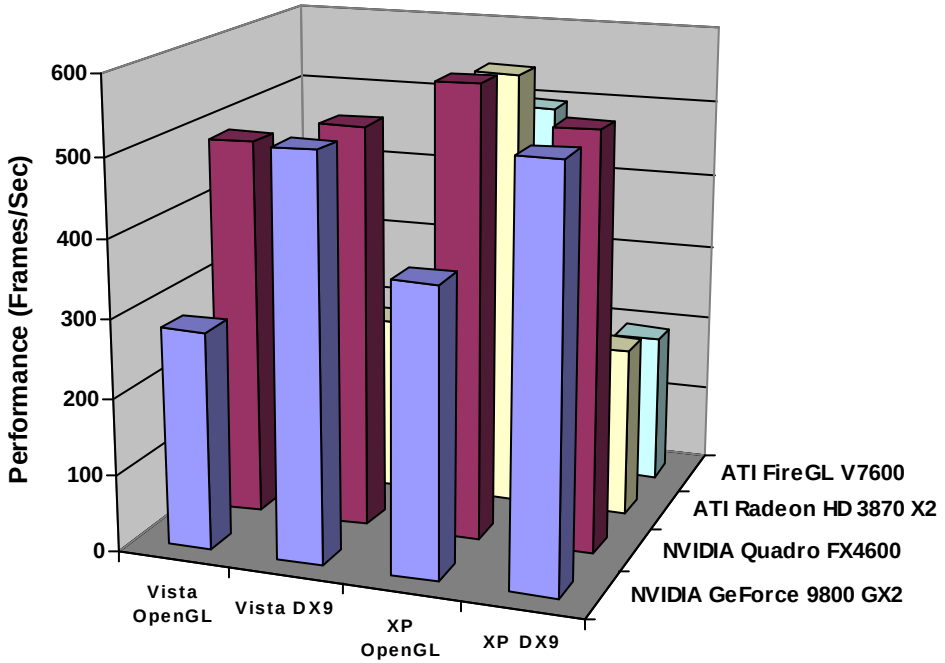




	Vista OpenGL	Vista DX9	XP OpenGL	XP DX9
NVIDIA GeForce 9800 GX2	181.76	443.78	220.80	504.78
NVIDIA Quadro FX4600	264.88	436.22	308.36	447.76
ATI Radeon HD3870 X2	215.91	343.38	443.06	311.89
ATI FireGL 7600	250.01	286.00	374.14	272.89

Wireframe Piping Plant





	Vista OpenGL	Vista DX9	XP OpenGL	XP DX9
NVIDIA GeForce 9800 GX2	281.74	517.98	370.00	530.00
NVIDIA Quadro FX4600	488.37	518.10	580	534.30
ATI Radeon HD3870 X2	276.13	228.03	567.00	220.00
ATI FireGL 7600	307.22	194.23	497.33	192.92

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