KHRONOS GROUP

OpenXR™ WebGL™ glTF™ Vulkan®

Fast Forward

SIGGRAPH, Los Angeles, July 2019

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thrive SIGGRAPH2019
LOS ANGELES • 28 JULY – 1 AUGUST

Khronos Mission

Khronos members are industry leaders from around the world that join to safely cooperate - to advance their own businesses and the industry as a whole

KHRONOS GROUP

Software

Silicon

Khronos is an open, member-driven industry consortium developing royalty-free standards, and vibrant ecosystems, to harness the power of silicon acceleration for demanding graphics rendering and computationally intensive applications

Active Khronos Standards

HIGH PERFORMANCE 3D GRAPHICS

Vulkan, OpenGL ES, OpenGL, OpenGL SC, WebGL

3D ASSET AUTHORING AND DELIVERY

glTF, COLLADA

PORTABLE XR – VIRTUAL AND AUGMENTED REALITY

OpenXR

PARALLEL COMPUTATION, VISION, MACHINE LEARNING AND INFERENCING

OpenCL, SYCL, SPIR, OpenVX, NNEF

3D Commerce Working Group

Announced at SIGGRAPH!

KHRONOS GROUP

Khronos is an open, member-driven industry consortium developing royalty-free standards, to harness the power of silicon acceleration for demanding graphics rendering and computationally intensive applications

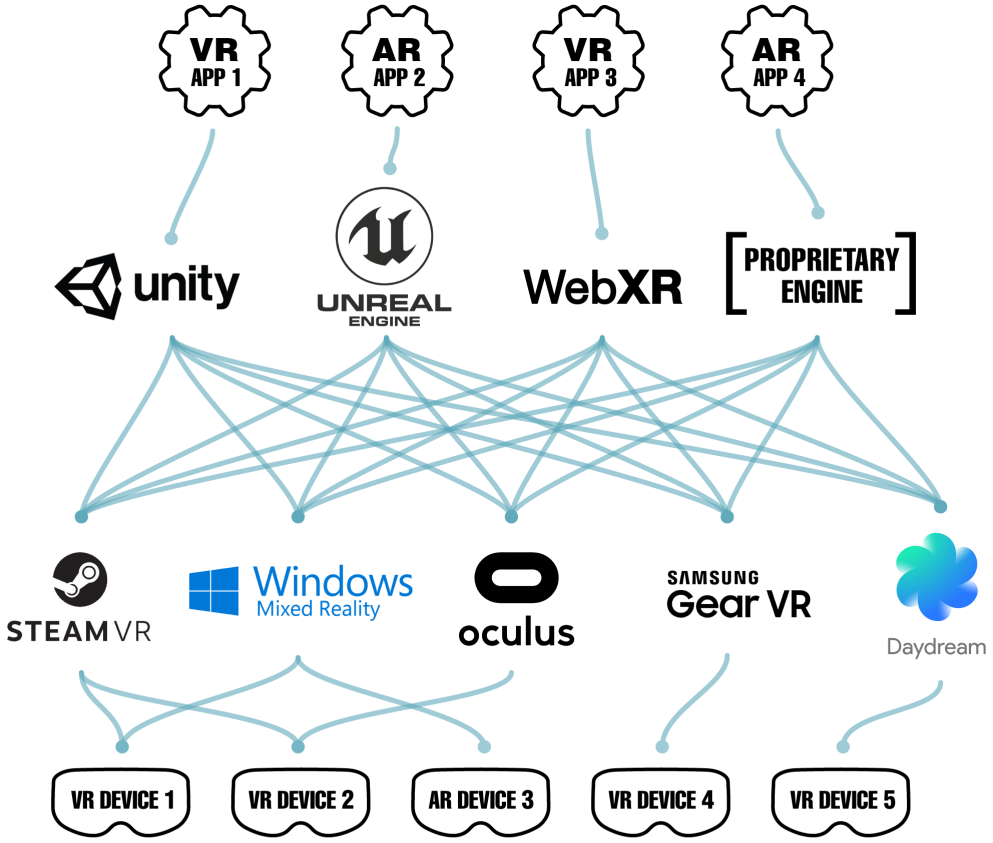
XR = AR + VR

Cross-platform, high-performance access to AR and VR platforms and devices

Virtual Reality

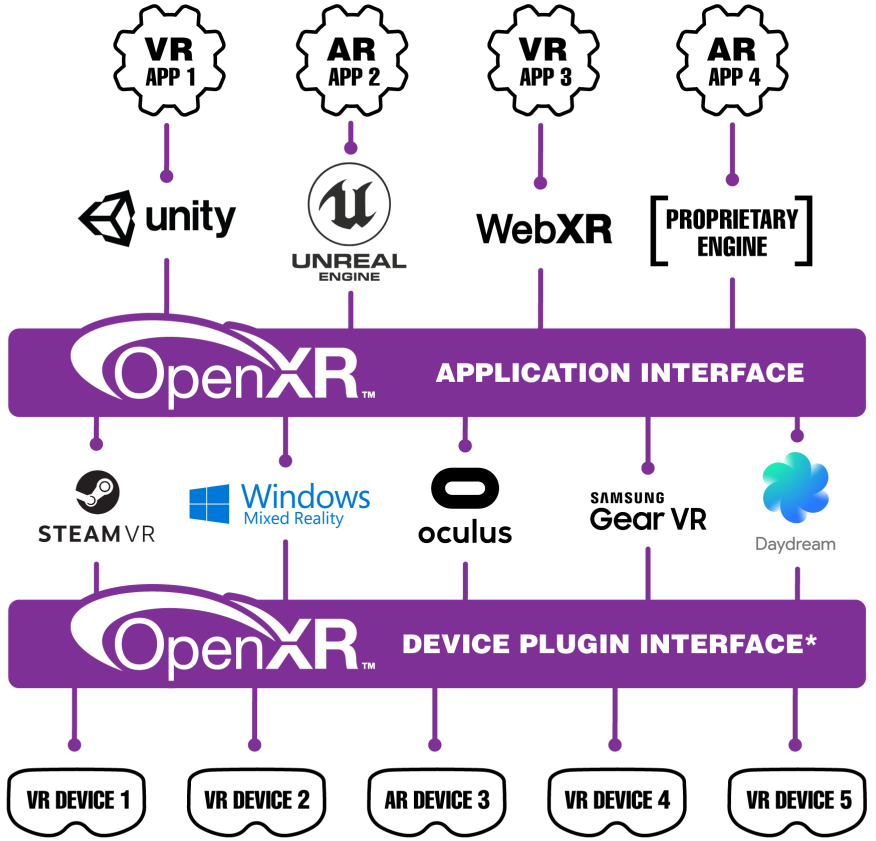
Augmented Reality

OpenXR - Solving XR Fragmentation



Before OpenXR

XR Market Fragmentation



After OpenXR

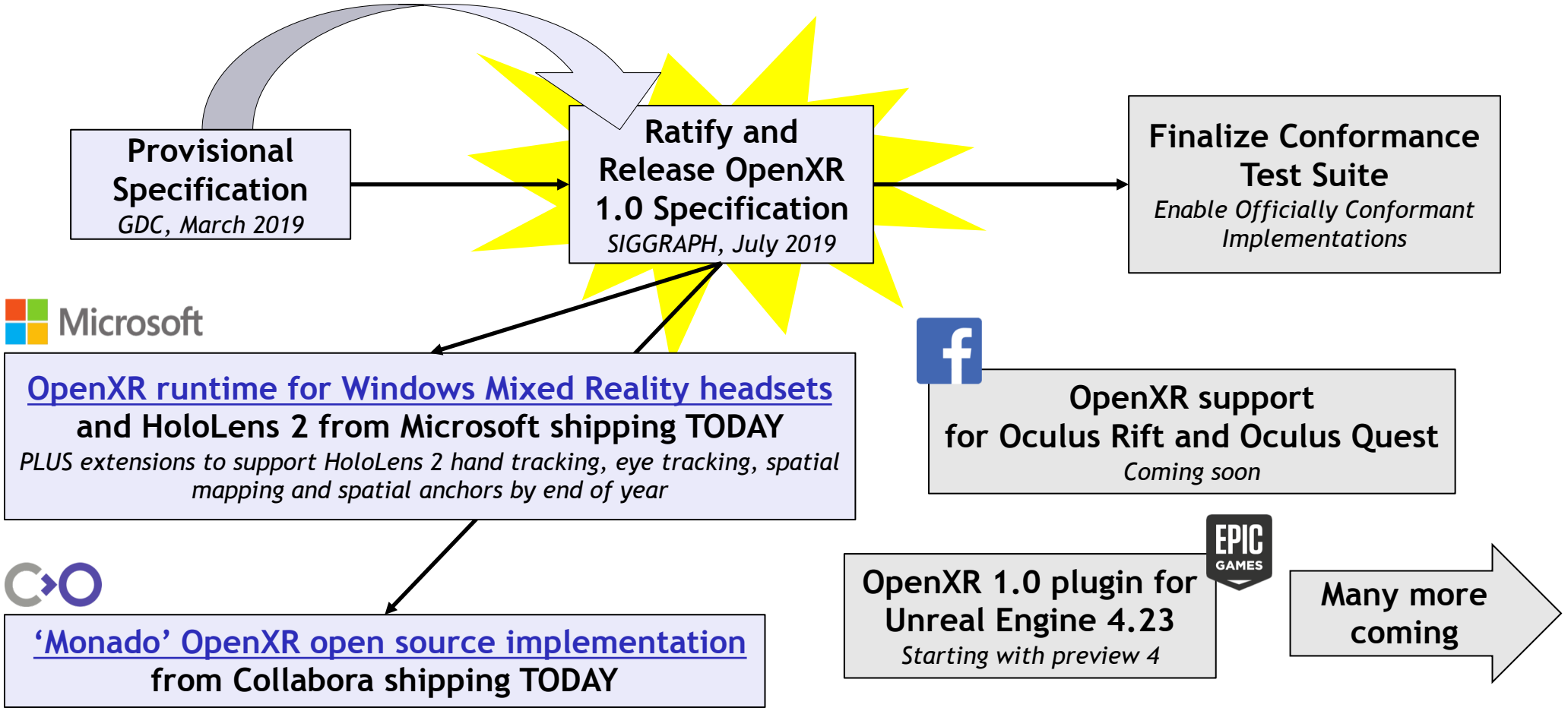
Wide interoperability of XR apps and devices

* OpenXR 1.0 is focused on enabling cross-platform applications. Optional device plugin interface will be supported post V1.0

** Check OpenXR Landing Page for exact availabiliy of OpenXR in shipping run-times and devices www.khronos.org/openxr

OpenXR 1.0 Released Here at SIGGRAPH!

Significant community feedback - thank you!
Improved OpenXR input subsystem, game engine editor support, loader …



Companies Publicly Supporting OpenXR

OpenXR is a collaborative design

Integrating many lessons from proprietary 'first-generation' XR API designs

Khronos APIs for XR

Application or Engine

High-performance, low-latency 3D rendering and composition*
- Multiview
- Context priority
- Front buffer rendering
- Tiled rendering (beam racing)
- Variable rate rendering

Display, composition and optical correction parameters

Cross-platform access to XR HMDs and sensors
- XR application lifecycle
- Frame timing and display composition
- Sensor tracking and pose calculation
- Input device discovery and events
- Haptics Control

Vulkan®

OpenXR™

* OpenXR can be used with other 3D APIs such as Direct3D, OpenGL and OpenGL ES

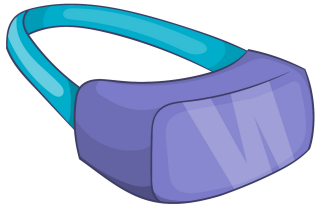
OpenXR Win-Win-Win

XR End-Users

Can run the apps they want on their system – reducing market confusion and increasing consumer confidence

XR Vendors

Can bring more applications onto their platform by leveraging the OpenXR content ecosystem



OpenXR™

XR ISVs

Can easily ship on more platforms for increased market reach

Bringing XR to the Web

Native XR Apps

Web XR Apps

Future versions of OpenXR will include cross-platform extended AR functionality

OpenXR

vuforia

UNREAL ENGINE

unity

3D Engines

ARCore

System-exposed AR Capabilities

WebXR

W3C

three.js

3D Engines

Close ongoing collaboration between WebXR and OpenXR

KHRONOS GROUP

Vulkan

OpenXR

WebGL

Khronos providing the foundation for 3D and XR in the Web and native stacks

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XR and 5G

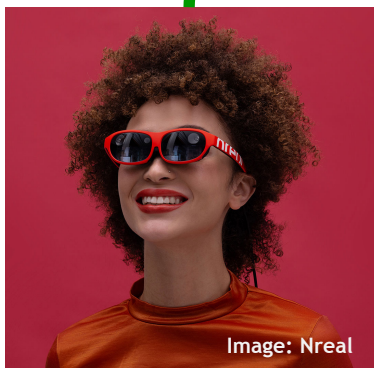
Leveraging High Bandwidth and Low Latency

MEC (Multi-access Edge Computing) Server
1. Processes sensor data, including machine learning for environmental lighting, occlusion, scene semantics, object reconstruction and UI
2. Generates imagery from 3D models, including stereo, foveal rendering, ray-tracing, optics pre-distortion, varifocal processing

5G

Rich Sensor Data

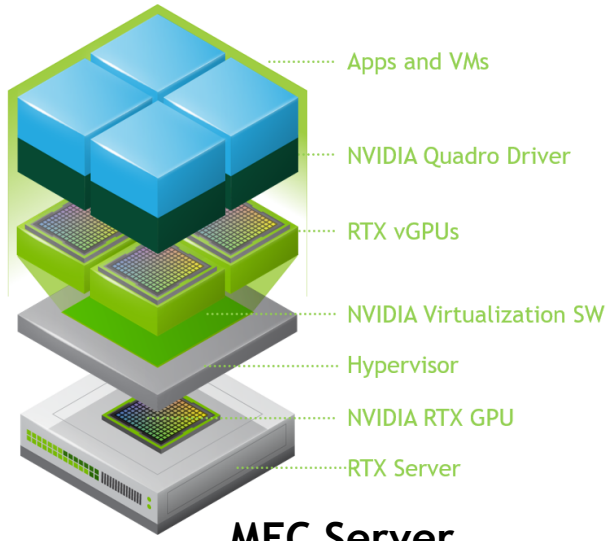
OpenXR
Sensor handling



Wireless mobile device with display and sensors

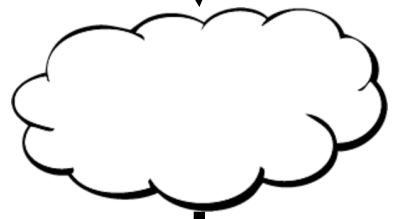
Vulkan

NVIDIA CUDA



MEC Server

Location-aware Content Requests



glTF

Apps
3D Assets

Any needed assets loaded from the cloud to edge server

OpenXR
Display composition

Generated Augmentations & Scenes

5G

OpenXR APIs can hide the 5G round trip from applications

Pervasive Vulkan

Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms

AMD arm BROADCOM Imagination intel NVIDIA QUALCOMM VeriSilicon

http://vulkan.gpuinfo.org/

Platforms

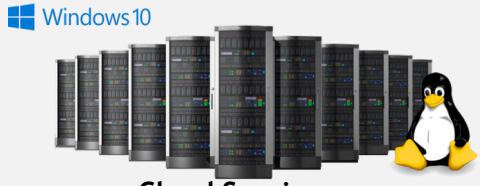
Desktop

Mobile
(Android 7.0+)

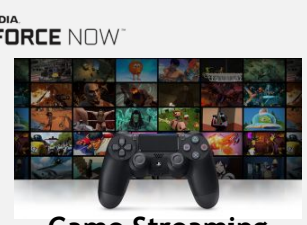
Media Players

Consoles

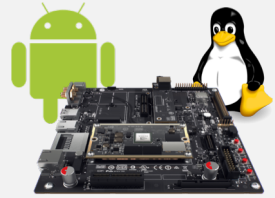
Virtual Reality



Cloud Services



Game Streaming

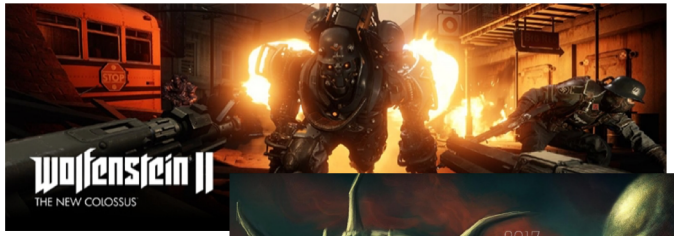


Embedded

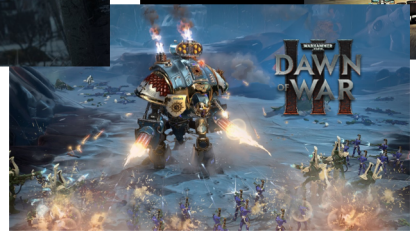
Game Engines

VALVE id CRYENGINE unity EPIC GAMES Croteam Serious Engine XENKO

Vulkan AAA Content Shipping on Desktop…

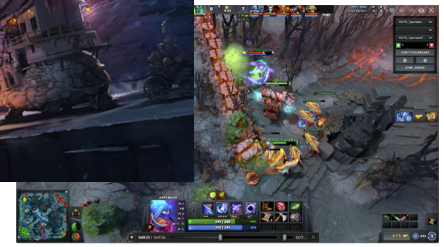


Vulkan-only AAA Titles on PC



AAA titles on Linux

FERAL
MAKE YOUR PLAY



Titles on PC AND macOS

Vulkan 1.1 Ecosystem Evolution

Strengthening Tools and Compilers

Improved developer tools (SDK, validation/debug layers)
Shader toolchain improvements (size, speed, robustness)
Shading language flexibility - HLSL and OpenCL C support
More rigorous conformance testing

February 2016
Vulkan 1.0

Vulkan 1.0 Extensions

Maintenance updates plus additional functionality

Multiview
Multi-GPU
Enhanced Windows System Integration
Increased Shader Flexibility:
16-bit storage, Variable Pointers
Enhanced Cross-Process and
Cross-API Sharing

March 2018
Vulkan 1.1

Integration of 1.0 Extensions
plus new functionality
e.g. Subgroup Operations

Building Vulkan's Future

Listen and prioritize developer needs
Drive GPU technology

Released Vulkan 1.1 Extensions

Reduced precision arithmetic types in shaders
Bindless resources
HLSL-compatible memory layouts
Formal memory model
Buffer references
https://www.khronos.org/registry/vulkan/specs/1.1-khr-extensions/html/vkspec.html#extension-appendices-list

Roadmap Discussions

Video encode / decode
Machine Learning support
Ray Tracing
Timeline semaphores
Generalized subgroup operations

Widening Platform Support

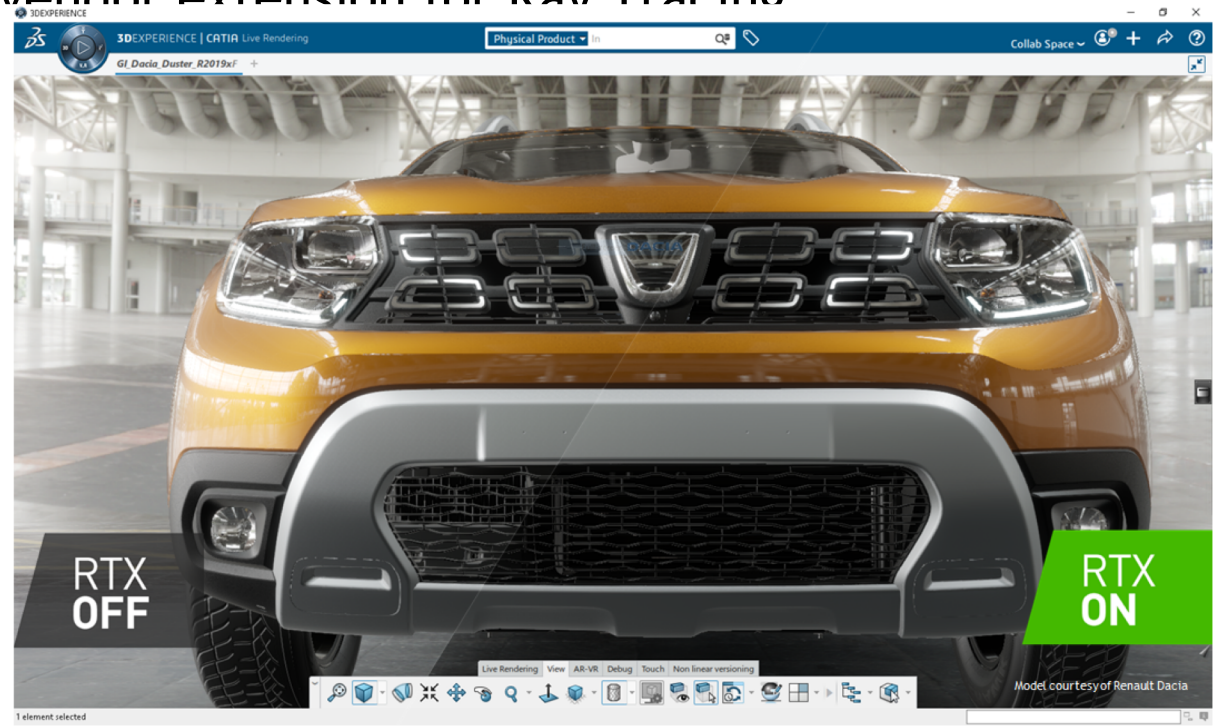
Pervasive GPU vendor native driver availability
Open source drivers - ANV (Intel), AMDVLK/RADV (AMD)
Vulkan Portability to macOS/iOS and DX12

Increasing Support for Professional Authoring Apps

OpenGL-class Line Rasterization
(stipple, smooth, Bresenham)
OpenGL/Vulkan Interop

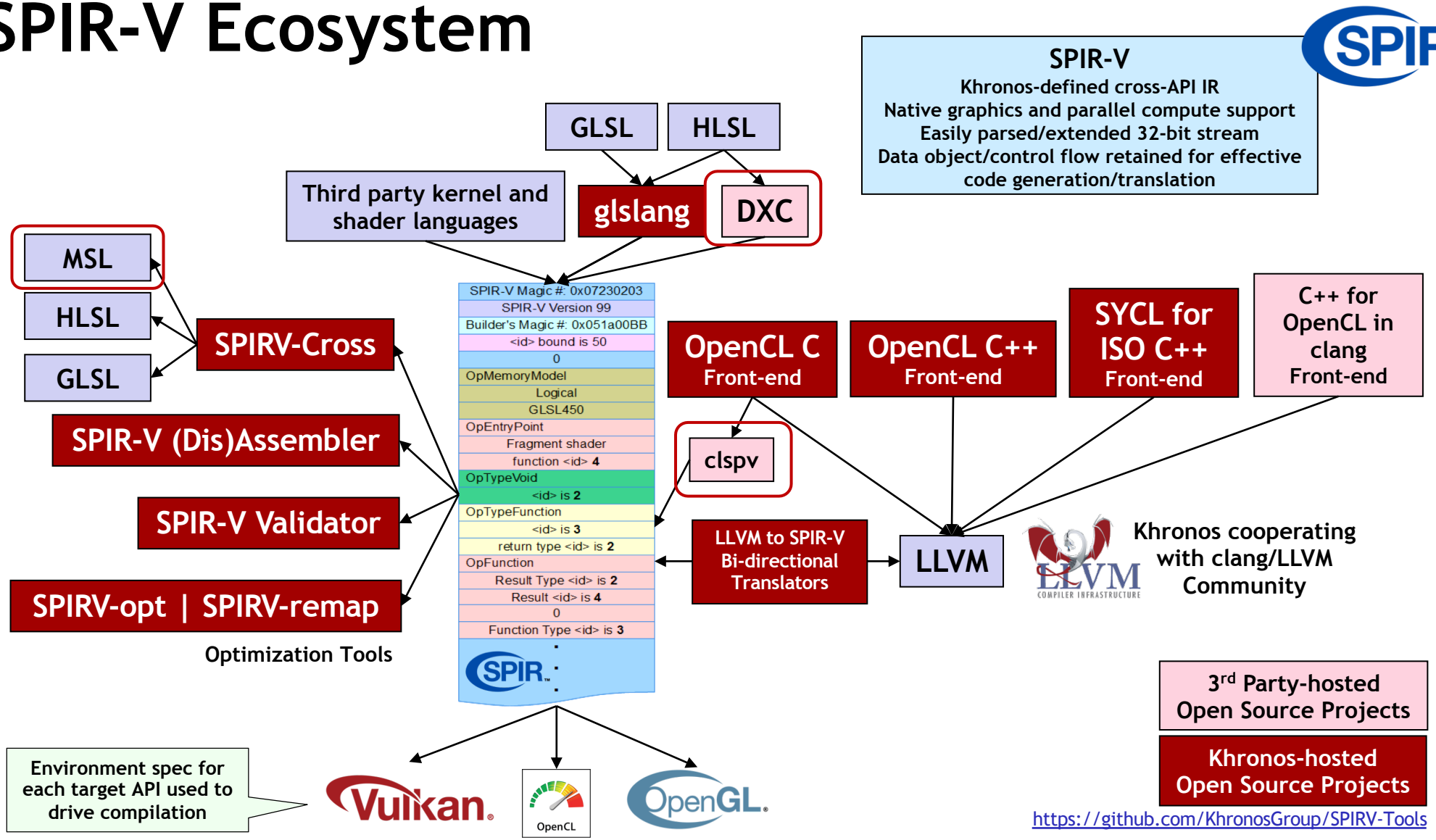
OpenGL Vulkan Interop

- **Enables OpenGL applications to incrementally leverage Vulkan functionality**
  - Shared explicit memory objects
- **Dassault Systèmes achieves interactive object space AO in CATIA, an OpenGL application**
  - Using the NVIDIA Vulkan VKRay vendor extension for Ray Tracing
  - See the Demo at the NVIDIA bo



DASSAULT SYSTEMES

SPIR-V Ecosystem



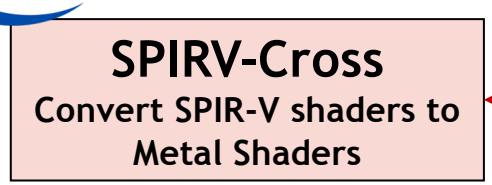
Vulkan Portability Initiative on Apple

Almost all mandatory Vulkan 1.0 functionality is supported:
No Triangle Fans
No separate stencil reference masks
Events are not supported

Selected Optional Features and Extensions are added as required - driven by industry input and feedback
Robust buffer access
BC texture compressed formats
Fragment shader atomics
Tesselation
https://github.com/KhronosGroup/MoltenVK

Khronos and MoltenVK/gfx-rs working on passing Vulkan Conformance Testing for all implemented functionality

Open source SDK to build, run, and debug applications on macOS - including validation layer support
https://vulkan.lunarg.com/



Open source beta release for macOS

MoltenVK supports macOS 10.11 / iOS 9.0 and up

Open source for MacOS and iOS
Free to use - no fees or royalties including commercial apps

Vulkan Apps Shipping On Apple

Forsaken Remastered was just updated with **Vulkan** support! If you're on Linux, you're probably hitting 60fps with the existing OpenGL renderer, but it's good to be future proof. If you're on a Mac, though, you *definitely* want to switch. On my MacBook, the framerate goes from around 15 to a solid 60!

Initial Vulkan Performance On macOS With Dota 2 Is Looking Very Good

Written by Michael Larabel in Valve on 1 June 2018 at 05:37 PM EDT. 34 Comments

Yesterday Valve released Vulkan support for Dota 2 on macOS. Indeed, this first major game relying upon MoltenVK for mapping Vulkan over the Apple Metal drivers is delivering performance gains.

Valve Releases Artifact As Its Cross-Platform, Vulkan-Powered Digital Card Game

Written by Michael Larabel in Valve on 28 November 2018 at 04:16 PM EST. 29 Comments

Valve managed to ship their latest game today as planned and without any major delays.

Artifact is now available with launch-day support for Linux, macOS, and Windows. Artifact is a competitive digital card game game is targeting Dota 2 players as well as card gaming enthusiasts. Valve still plans to evolve Artifact and its gameplay mo

DOTA 2 — Production Dota 2 on Mac Ships - up to 50% more perf than Apple's OpenGL

First iOS Apps using MoltenVK ship through app store

Qt — Qt Running on Mac through MoltenVK

Multiple iOS and macOS apps shipping e.g. Forsaken Remastered

Filament — Google Filament PBR Renderer on Mac

WINE — Initial ports of DX games in progress using Vulkan on Mac

ARTIFACT — Artifact from Steam ships on MoltenVK on macOS - first Vulkan-only Valve app on Mac

RPCS3 — RPCS3 PlayStation 3 Emulator on Mac

Dolphin GameCube and Wii Emulator working on MacOS

Diligent Graphics — Diligent Engine runs on MacOS

DOTA UNDERLORDS — Artifact from Steam ships on MoltenVK on macOS - second Vulkan-only Valve app on Mac

June 2018 | September 2018 | November 2018 | January 2019 | June 2019

Running DX Games on Linux Over Vulkan

- **DXVK – Direct3D 10/11 emulator running over Vulkan**
  - Open source on GitHub - developed by Philip Rebohle with support from Valve
- **Vulkan has added multiple extensions to support efficient layering of D3D**
  - Removing impedance mismatches between the two APIs
- **DXVK, Wine Windows Emulator and Valve Proton tool**
  - Enable thousands of PC games on Linux

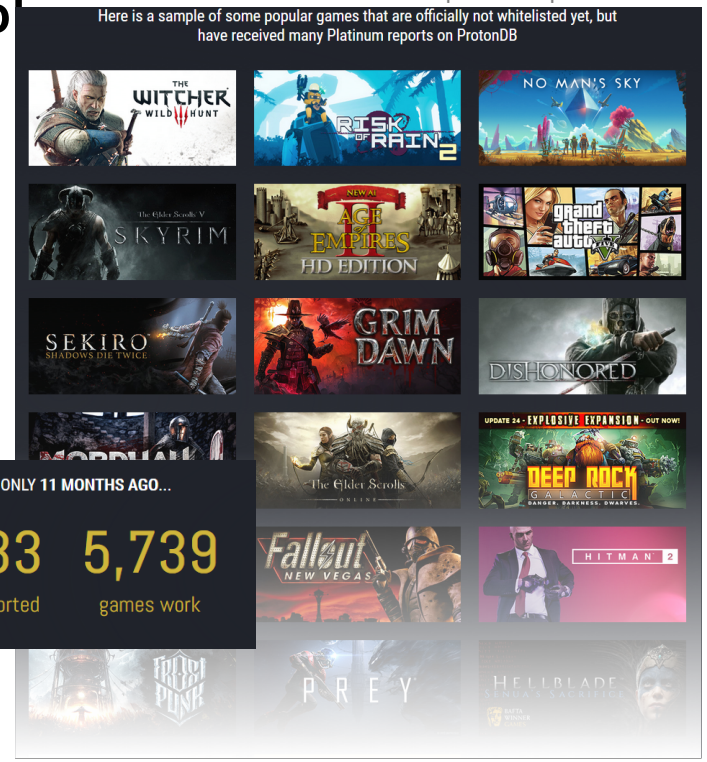
Extensions created in response to DXVK issues

VK_EXT_transform_feedback
VK_EXT_depth_clip_enable
VK_EXT_host_query_reset
VK_EXT_texel_buffer_alignment
VK_EXT_shader_demote_to_helper_invocation

Other extensions used by DXVK

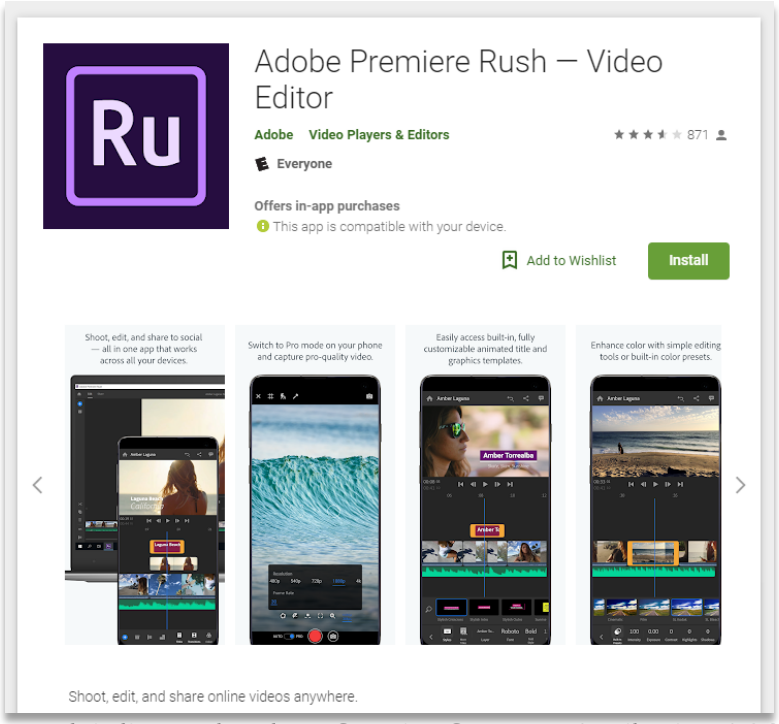
VK_EXT_conditional_rendering
VK_EXT_memory_budget
VK_EXT_memory_priority
VK_EXT_shader_viewport_index_layer
VK_EXT_vertex_attribute_divisor
VK_KHR_draw_indirect_count
VK_KHR_shader_draw_parameters

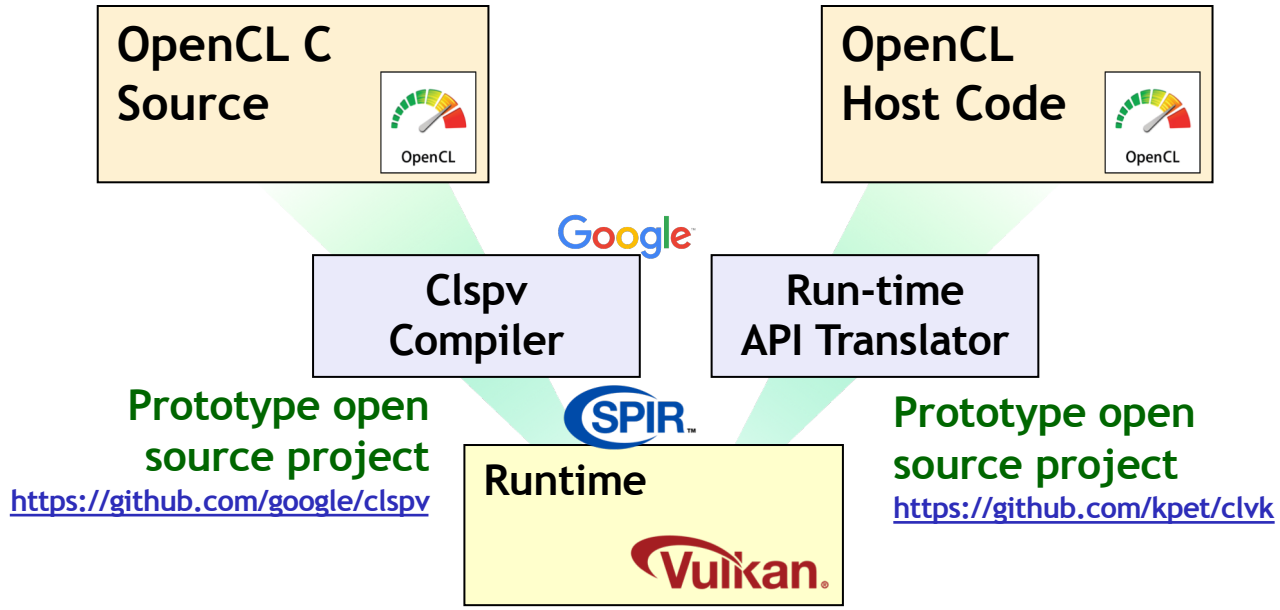
https://www.protondb.com



Deploying OpenCL C Over Vulkan

- **Clspv - Google's experimental compiler for OpenCL C to Vulkan SPIR-V**
  - Open source - tracks top-of-tree LLVM and clang, not a fork
- **Adobe Premiere Rush has 200K lines of OpenCL C kernel code**
  - Professional-quality, cross-platform video capture and editing system
  - Now shipping on Android on Vulkan





OpenCL Heterogeneous Computing

A programming and runtime framework for heterogeneous compute resources
Low-level control over memory allocation and parallel task execution
Simpler and relatively lightweight compared to GPU APIs
More flexible computer capability than GPU APIs

OpenCL 2.2-11 maintenance: bug fixes, clarifications, improved formatting, linking and integration with Ref Pages: https://www.khronos.org/registry/OpenCL/

Application

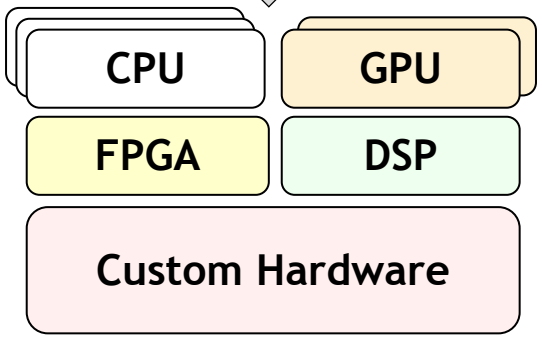
Fragmented GPU API Landscape

GPU

Application

OpenCL

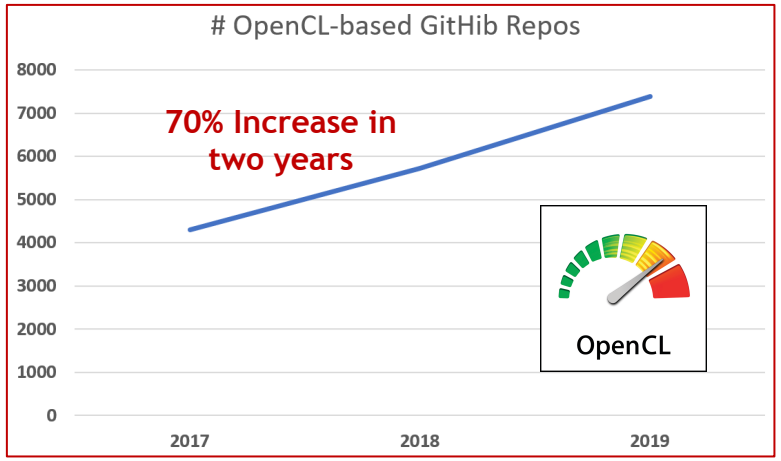
Growing number of optimized OpenCL libraries
Vision and Imaging
Machine Learning and Inferencing
Linear Algebra and Mathematics
Physics



Heterogeneous Compute Resources

Many mobile SOCs and Embedded Systems becoming increasingly heterogeneous
Autonomous vehicles
Vision and inferencing

OpenCL User Adoption



OpenCL is Pervasive!

Desktop Creative Apps

Parallel Computation Languages

Linear Algebra Libraries

Vision and Imaging Libraries

Math and Physics Libraries

Machine Learning Libraries

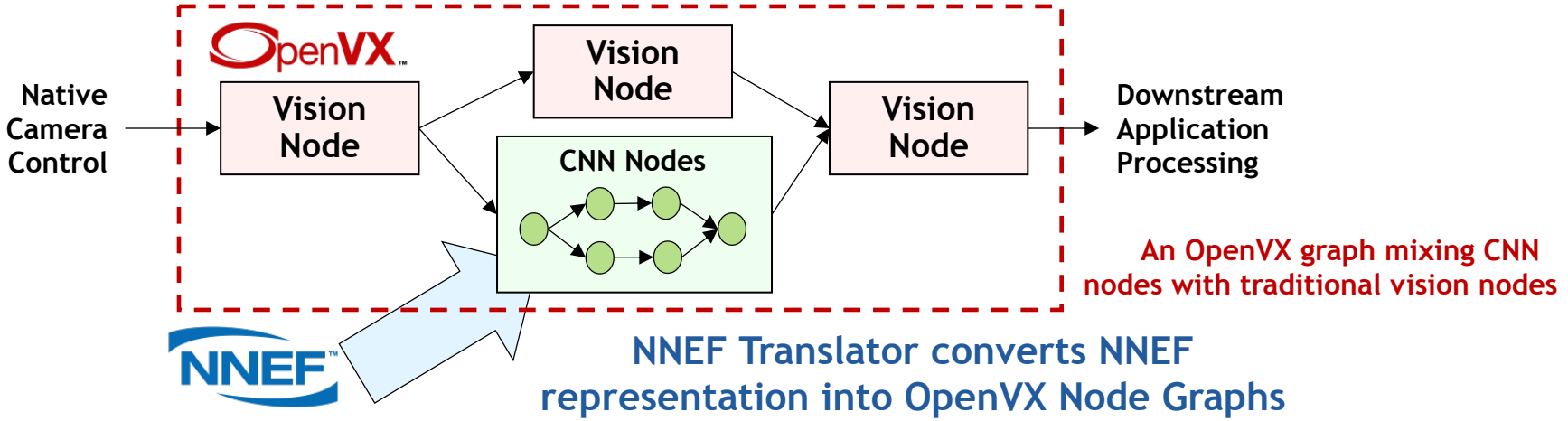
Machine Learning Inferencing Compilers

https://www.khronos.org/opencl/resources/opencl-applications-using-opencl
https://www.iwocl.org/resources/opencl-libraries-and-toolkits/

Khronos OpenVX and NNEF for Inferencing

OpenVX

A high-level graph-based abstraction for Portable, Efficient Vision Processing
Can be implemented on almost any hardware or processor



NNEF (Neural Network Exchange Format)

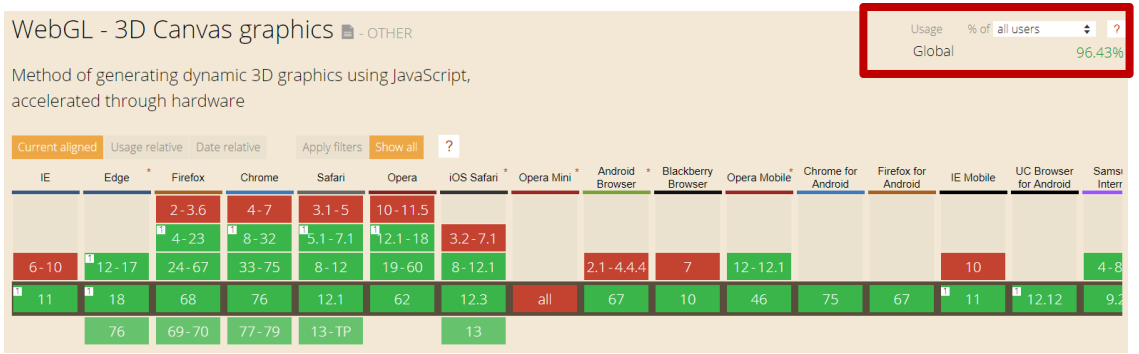
For transferring trained Neural Networks into inferencing accelerators
Provides stability needed by hardware vendors through true multicompany governance

WebGL Deployment - WebGL 2.0 is Here!

Pervasive, portable access to OpenGL ES 2.0-class mobile graphics

WebGL 1.0

96.43% Globally

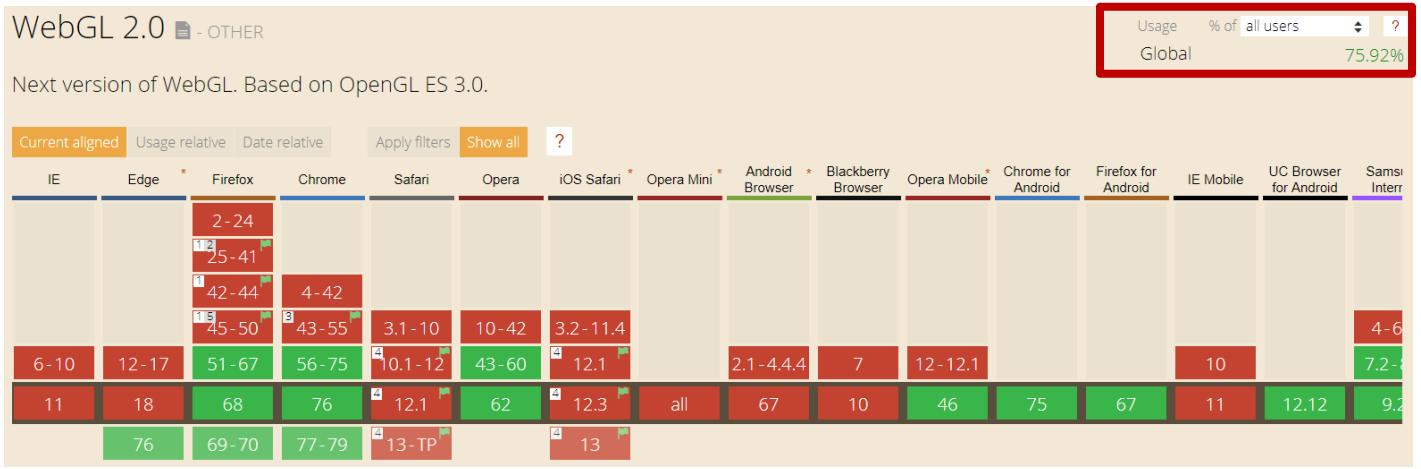


http://caniuse.com/#feat=webgl

OpenGL ES 3.0-based desktop-class graphics comes to the Web!

WebGL 2.0

75.92% Globally



https://caniuse.com/#search=webgl%202.

WebGL 2.0 will reach WebGL 1.0 levels of availability when Safari and Edge ship enabling a new class of Web-based AR/VR 3D Apps!

WebGL Extensions

- **Delivering requested features from the developer community**
- **KHR_parallel_shader_compile extension**
  - Asynchronous shader compilation times – does not block the main WebGL thread
- **multi-draw and instanced multi-draw extensions – on track for all browsers**
  - Command batching and significantly decrease CPU overhead for larger scenes
- **Compressed texture extensions - already available in browsers**
  - RGTC (BC4 / BC5) and BPTC (BC6H / BC7) extensions
- **Extensions coming soon**
  - WebGL 2.0 GPU Compute contributed by Intel
  - WEBGL_video_texture accelerated real-time video processing
  - BaseVertex and BaseInstance flexible indexing into vertex arrays
- **WebGL 2.0 public demonstrations**
  - Including how-to enable prototype features with command-line flags in Chrome Canary

glTF - The JPEG of 3D!

Audio	Video	Images	3D
MP3	H.264	JPEG	glTF
napster	YouTube	facebook	New market opportunities for 3D content creation and deployment!

glTF

- Compact to Transmit ✓
- Simple and Fast to Load ✓
- Describes Full Scenes ✓
- Runtime Neutral ✓
- Open and Extensible ✓

Efficient, reliable transmission
Bring 3D assets into 1000s of apps and engines

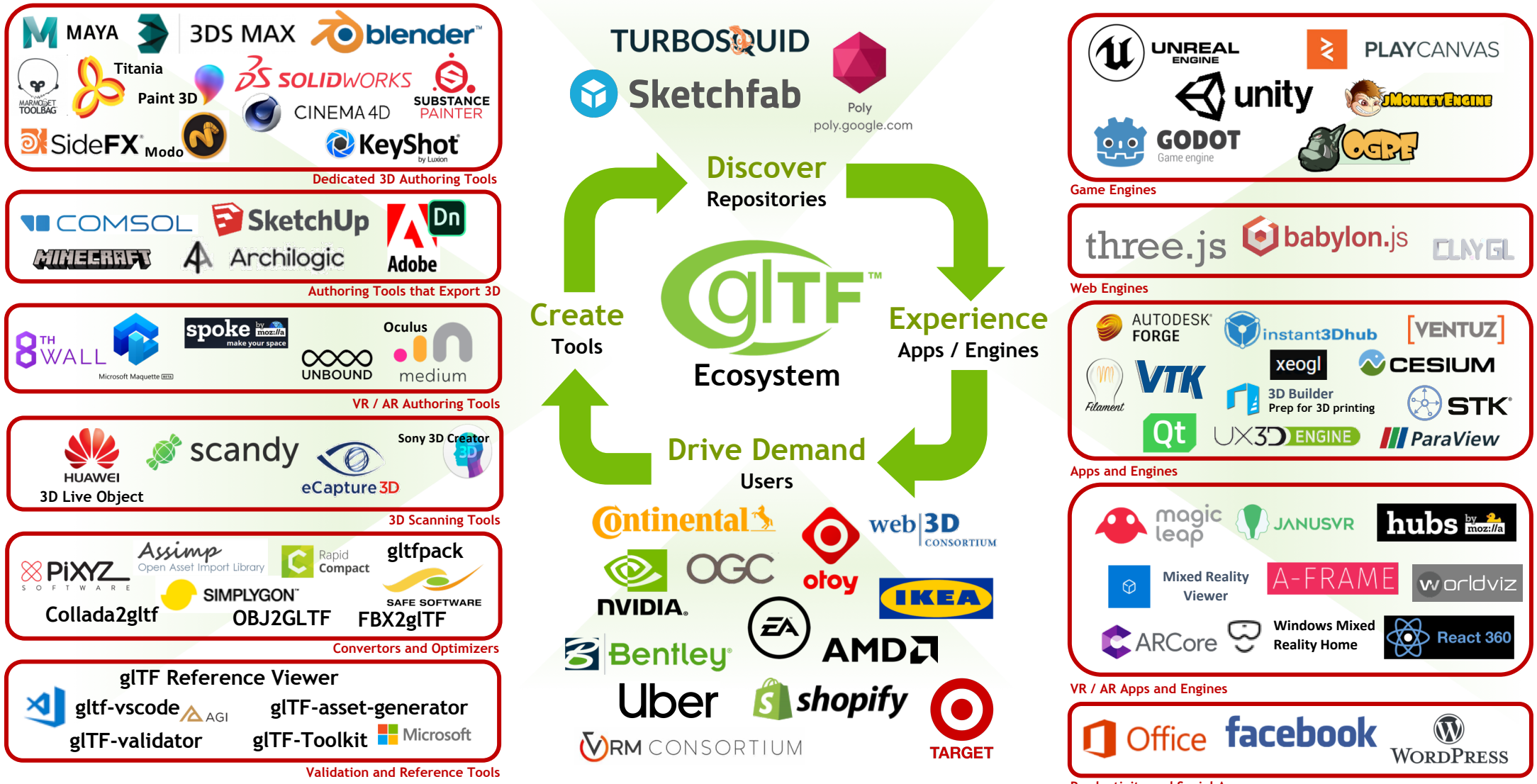
glTF

WebGL

glTF 1.0 - December 2015
Primarily for WebGL
Uses GLSL for materials

glTF spec development on open GitHub - get involved!
https://github.com/KhronosGroup/glTF

glTF 2.0 - June 2017
Native AND Web APIs
Physically Based Rendering
Metallic-Roughness and Specular-Glossiness



glTF 2.0 Scene Description Structure

.gltf (JSON)

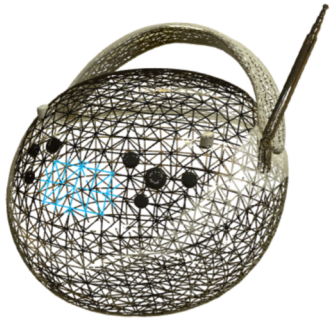
Node hierarchy, PBR material textures, cameras

.bin

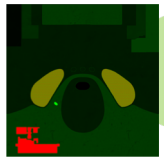
Geometry: vertices and indices
Animation: key-frames
Skins: inverse-bind matrices

.png
.jpg
.ktx2
Textures

glTF™

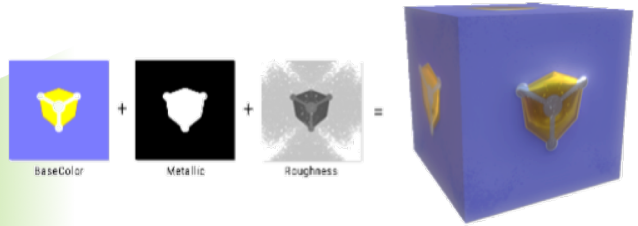


Geometry

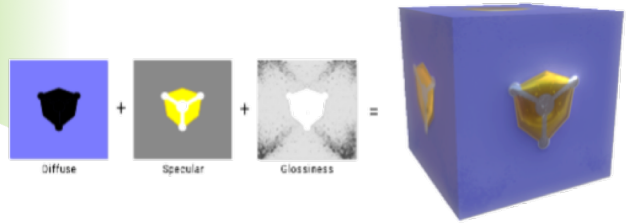


Texture based
PBR materials

Mandatory Metallic-Roughness Materials



Optional Specular-Glossiness Materials

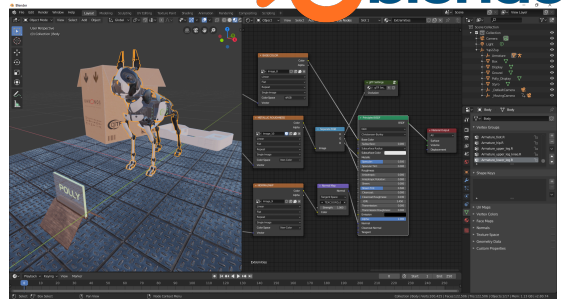


glTF Ecosystem Evolution

glTF 2.0 – June 2017

Tools!

Striving for native glTF import and Export from every tool. Catalyzed Blender IO as exemplar



glTF 2.0 import/export with Blender 2.80

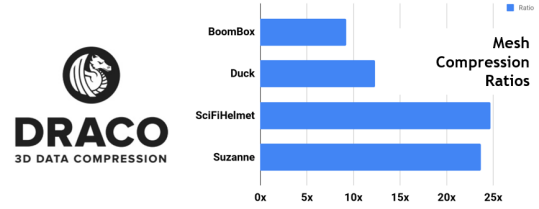
Consistency!

Avoid dialects at all costs! Sample viewer and Asset Validator in open source. Sample models and asset generator for unit tests

Sample Viewer for accurate Ground Truth glTF renderings

Functionality!

Balancing functionality versus complexity. glTF is extensible – only bring widely adopted extensions into core

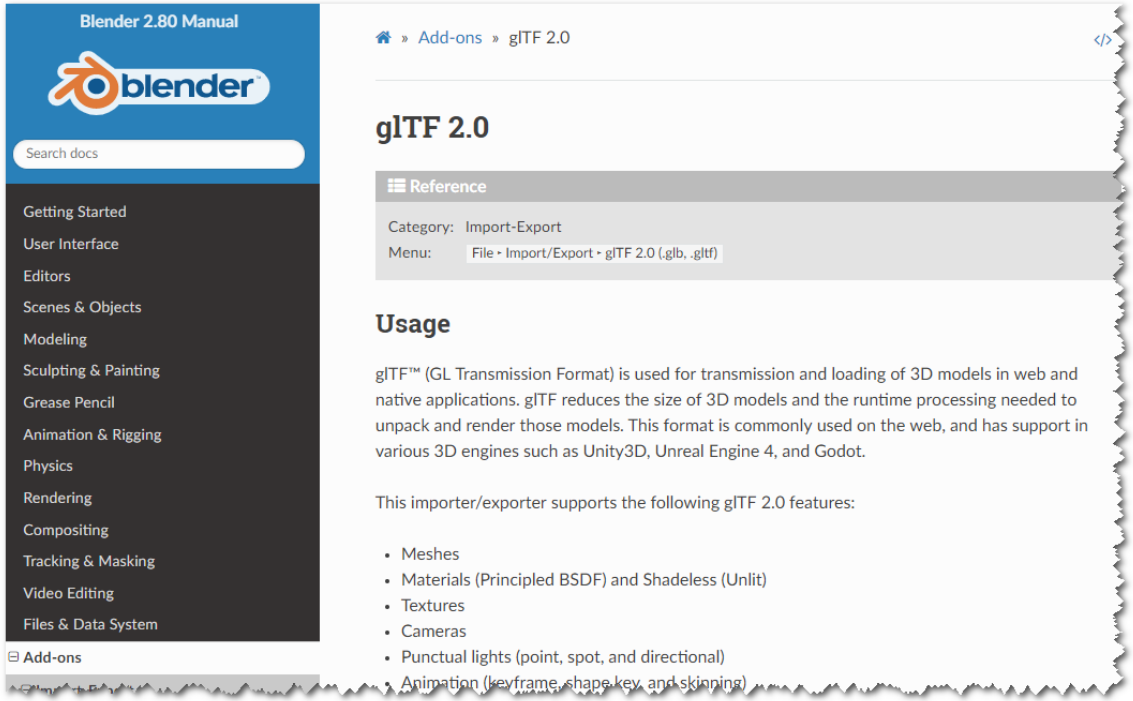


glTF Mesh compression extension provides up to 25x geometry compaction

glTF/Draco-enabled apps and engines

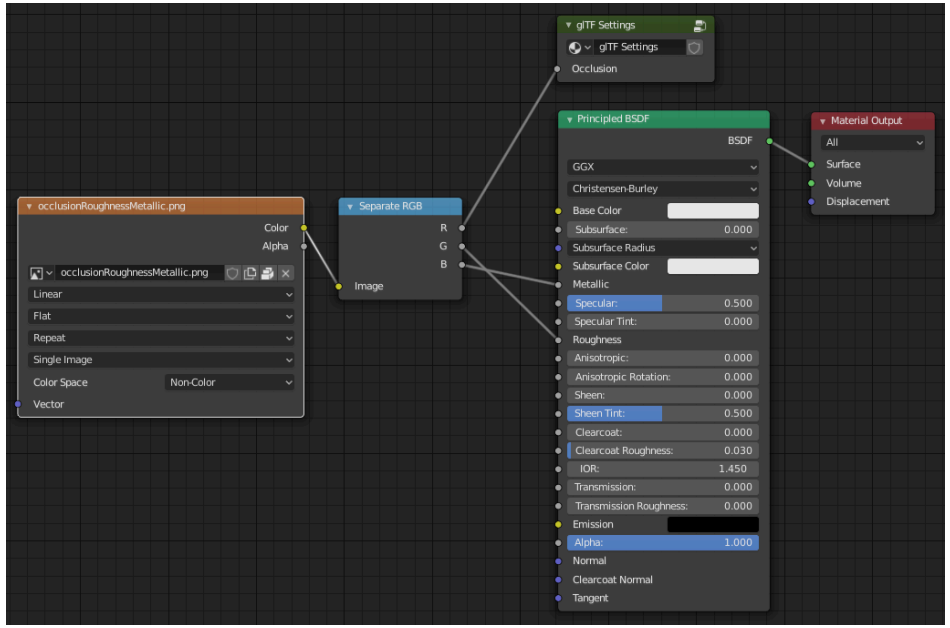
Blender 2.80 Supports Full glTF Import/Export

Project driven by Mozilla, Khronos and the glTF community



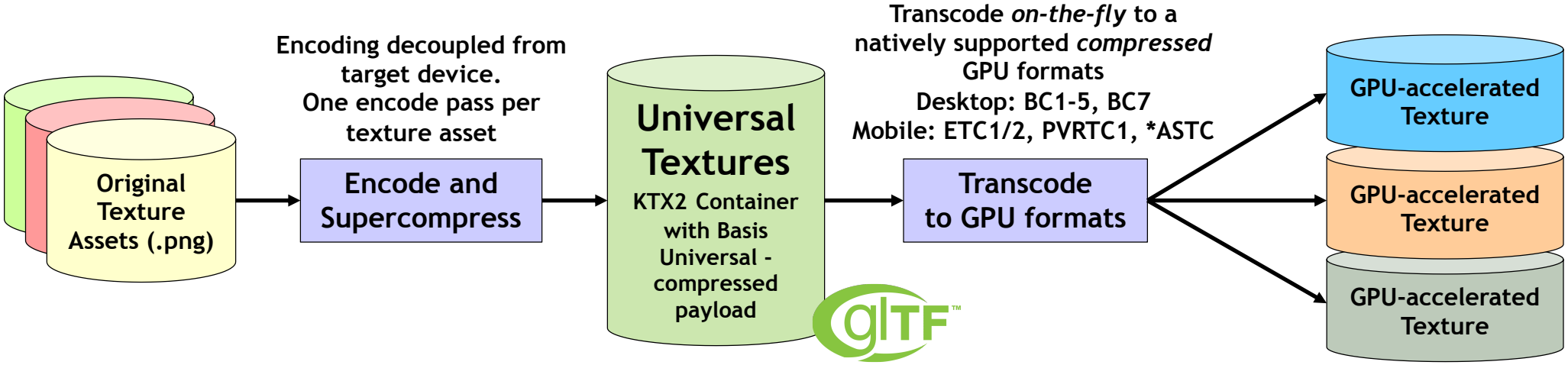
https://docs.blender.org/manual/en/2.80/addons/io_scene_gltf2.html

Blender's Principled BSDF Shader node maps to glTF's PBR materials



Universal Textures for glTF

- **Fragmentation of GPU texture formats is significant issue for developers**
  - Binomial's 'Basis Universal' technology enables JPEG-sized texture assets
  - Transcodable on-the-fly to natively supported compressed GPU formats
- **glTF Universal Texture extension uses KTX2 as a flexible container**
  - Precisely defined specification for consistent, cross-vendor generation and validation
  - Can contain wide range of texture formats used in Vulkan/DirectX/Metal
  - Supports streaming and full random access to MIP levels
  - Subset of full KTX2 - mandating supercompressed textures using Basis Universal technology



*ASTC support in development

Universal Textures - Get Involved!

- **Design discussions**
  - https://github.com/KhronosGroup/glTF/pull/1612
- **Khronos open source tools**
  - https://github.com/KhronosGroup/KTX-Software/tree/ktx2
  - toktx - create a KTX2 file from a set of .png images
  - ktxsc - convert images in KTX2 file to supercompressed images using Basis transcoder
- **Ecosystem forming around KTX2**
  - Khronos glTF texture tool with GUI for generating supercompressed textures
  - Increasing number of run-times integrating prototype KTX2 support

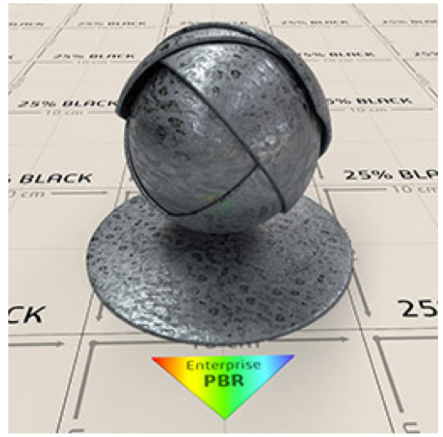
Applications and engines with prototype KTX2 support

Next Generation glTF PBR Materials

- **Demand for advanced PBR for photorealistic assets**
  - Beyond current ‘Metallic-Roughness’ and ‘Specular-Glossiness’
  - E.g. Absorption/attenuation, clear coat, subsurface scattering, anisotropy
- **Extending Metallic-Roughness parameters**
  - Consistency and fallbacks for performance for any device
- **Inspiration from Dassault Systèmes Enterprise PBR Shading Model (DSPBR)**
  - https://github.com/DassaultSystemes-Technology/EnterprisePBRShadingModel/tree/master/gltf_ext
- **Wide industry collaboration for compatibility**
  - Dassault Systèmes
  - Google Filament
  - Microsoft BabylonJS
  - NVIDIA MDL
  - OTOY Octane

Join the GitHub Discussion!
https://github.com/KhronosGroup/glTF/issues/1442

Images from https://dassaultsystemes-technology.github.io/EnterprisePBRShadingModel/

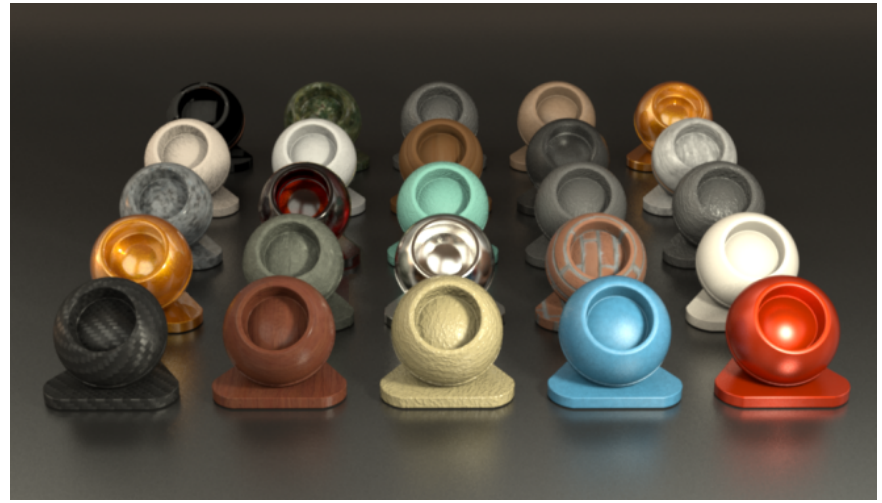


Roadmap Discussions

- **Many of these topics are being discussed on GitHub**
  - https://github.com/KhronosGroup/glTF
  - Come and give your views!
- **Animation 2.0**
  - Advanced Avatars and Face emoji, with compression
- **LOD and Streaming**
- **Point Clouds (with compression)**
- **Cross-asset linking**
- **Enhanced Metadata**

glTF Roadmap is Driven by Developer Feedback and Requirements

NVIDIA MDL Physically Based Rendering



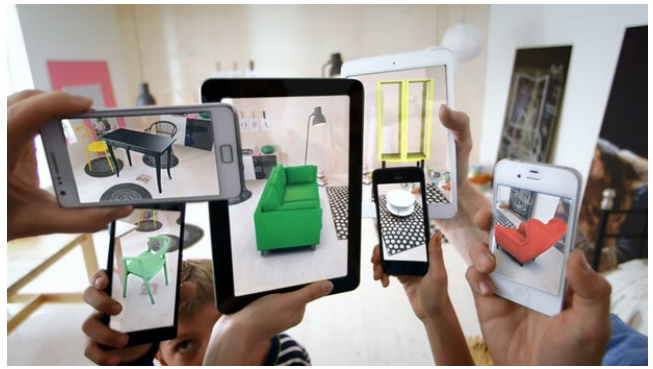
Khronos 3D Commerce Initiative

The Opportunity

Retailers have been experimenting with 3D product representations on the Web, and in Virtual and Augmented Reality applications, to enable users to view and interact with products. The results have been exciting, but thus far

NOT ACTIONABLE at an INDUSTRIAL SCALE

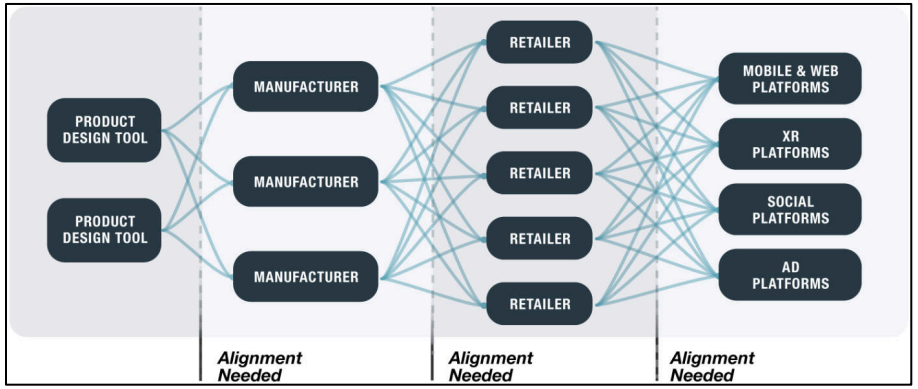
IKEA Communications AB



IKEA catalog uses augmented reality to give a virtual preview of furniture in a room - August 2013

Products don't come with 3D data - and I can't physically scan them all fast enough!

CAD tools don't let me easily generate the data I need for E Commerce!



The green couch looks blue on some devices - lots of product returns are expensive!

Many models on my e-commerce web-site first appear upside down! I have to hand tune everything!

I wish I had high quality, realistic 3D models for virtual promotional photoshoots!

Everyone defines their product data for sizes and colors differently - nothing is consistent!

Khronos New Initiative Process

Proposal
March 2019

A group of companies including Google, Unity, IKEA, Wayfair and Target identify the need for industry cooperation and makes proposal to Khronos

Initiative Proposal

KHRONOS GROUP
Exploratory Group
March-July 2019

Khronos invites any company to join an Exploratory Group to drive industry consensus on what is the problem, and what how can we work together to fix it?

Scope of Work

Working Group Announced
SIGGRAPH 2019

Detailed design work to execute SOW will start by Khronos Members

https://www.khronos.org/3dcommerce/

Broad Industry Participation

Over 70 retail AND technology companies creating an agreed Scope of Work

Open to any company under NDA, no membership fee or IP commitment

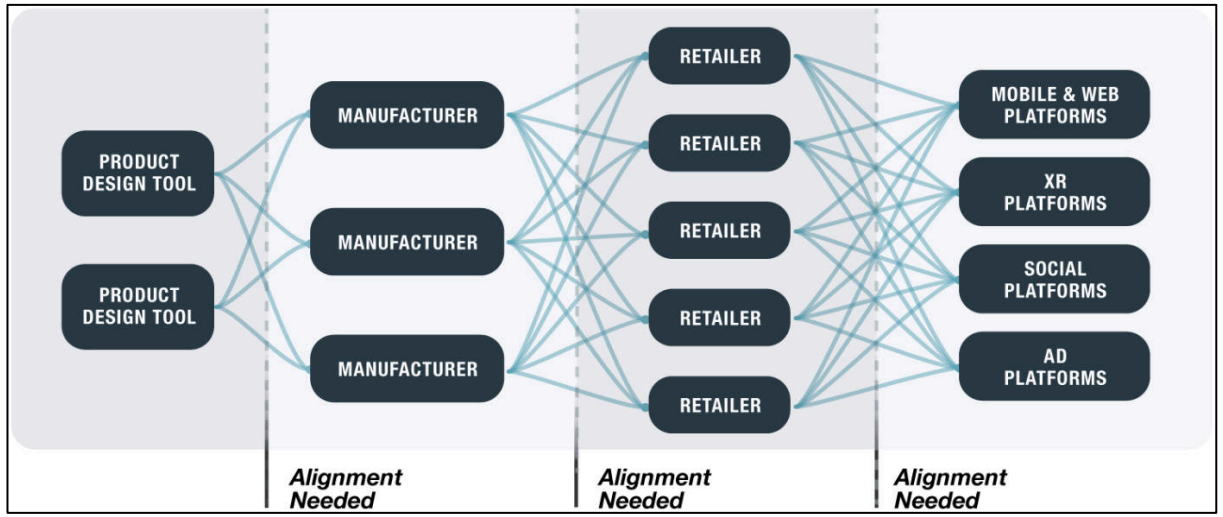
Khronos 3D Commerce Working Group Goals

Create specifications and guidelines to align the 3D asset workflow from product design through manufacturing, through each stage of retail to end-user delivery platforms

Guidelines for tools and product designers to create assets with consistent data to be used through the 3D Commerce pipeline

Structured metadata for product management and configurability of viewing

Visual realism and consistency no matter where the model is displayed



Reduce production, distribution and marketing costs

Product display configurability with consistency and authenticity

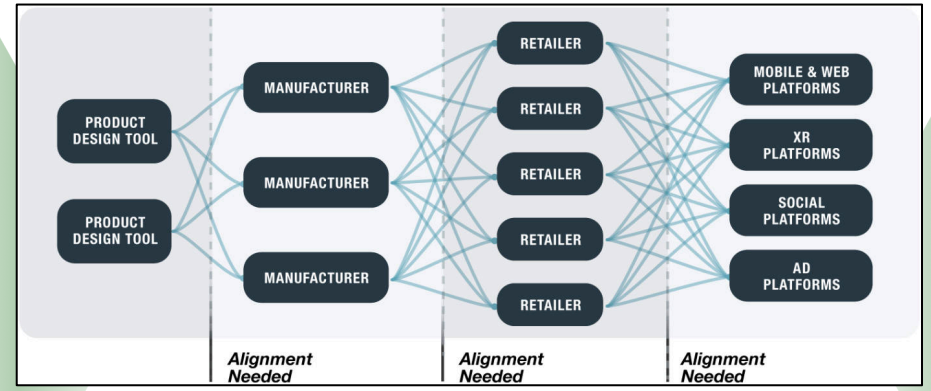
3D Commerce Khronos Synergy

glTF™

3D Asset Format

WebGL™

Interactive 3D on the Web



Khronos 3D Commerce

OpenXR™

Portable AR and VR Apps

Vulkan®

High-performance cross-platform 3D graphics

OpenVX™

Vision processing and inferencing for AR and scanning

KHRONOS® GROUP

Khronos at SIGGRAPH 2019

- **Khronos BOF Sessions**
  - 10AM glTF
  - 11AM WebGL
  - 1PM OpenXR
  - 2PM Vulkan
- **5:30PM Khronos Networking Reception**
  - All welcome!
- **3D Commerce BOF**
  - 10AM Thursday, August 1 in Room 507 of the Convention Center
  - SIGGRAPH badge is needed for the Thursday 3D Commerce session
- https://www.khronos.org/events/2019-siggraph

All slides will be posted at www.khronos.org in 1-2 days