GPU TECHNOLOGY CONFERENCE

Khronos Open API Standards
The Foundation for Mobile Innovation

Neil Trevett, President, Khronos Group

Why Do We Need Standards?

- Defines interoperability interfaces so compelling user experiences can be created cheaply to build a mass market
  - Don't slow growth with fragmentation that adds no value
- E.g. Wireless and IO standards
  - GSM/EDGE, UMTS/HSPA, LTE, IEEE 802.11, Bluetooth, USB …

Standards drive mobile market growth by expanding device capabilities

Khronos Connects Software to Silicon

ROYALTY-FREE, OPEN STANDARD APIs for advanced hardware acceleration

Low level silicon to software interfaces needed on every platform

Graphics, video, audio, compute. visual and sensor processing

Defines the forward looking roadmap for the silicon community

Shipping on billions of devices across multiple operating systems

Rigorous conformance tests for cross-vendor consistency

Khronos is OPEN for any company to join and participate

Acceleration APIs BY the Industry FOR the Industry

Khronos API Standards Evolution

DESKTOP

OpenGL

OpenCL

New API technology first evolves on high-end platforms

MOBILE

OpenSL|ES

OpenMAX

OpenGL|ES

Mobile is the new platform for apps innovation. Mobile APIs unlock hardware and conserve battery life

INTEROP, VISION AND SENSORS

OpenVX

StreamInput

EGL

Apps need interoperating APIs with rich sensory inputs for advanced use cases such as Augmented Reality

WEB

HTML 5

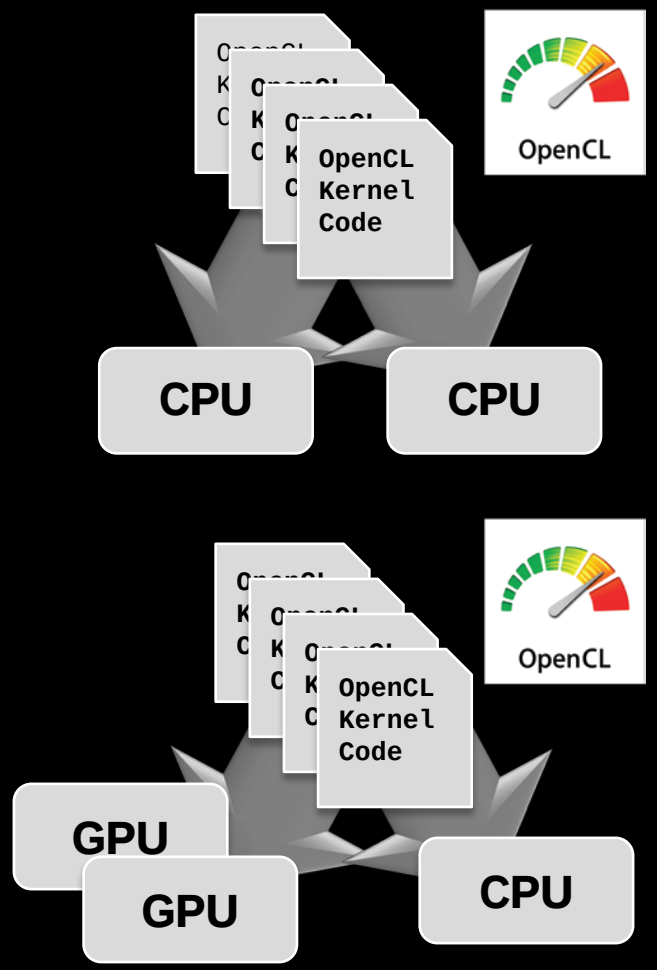
WebGL

WebCL

Diverse platforms – mobile, TV, embedded – means HTML5 will become increasingly important as a universal app platform

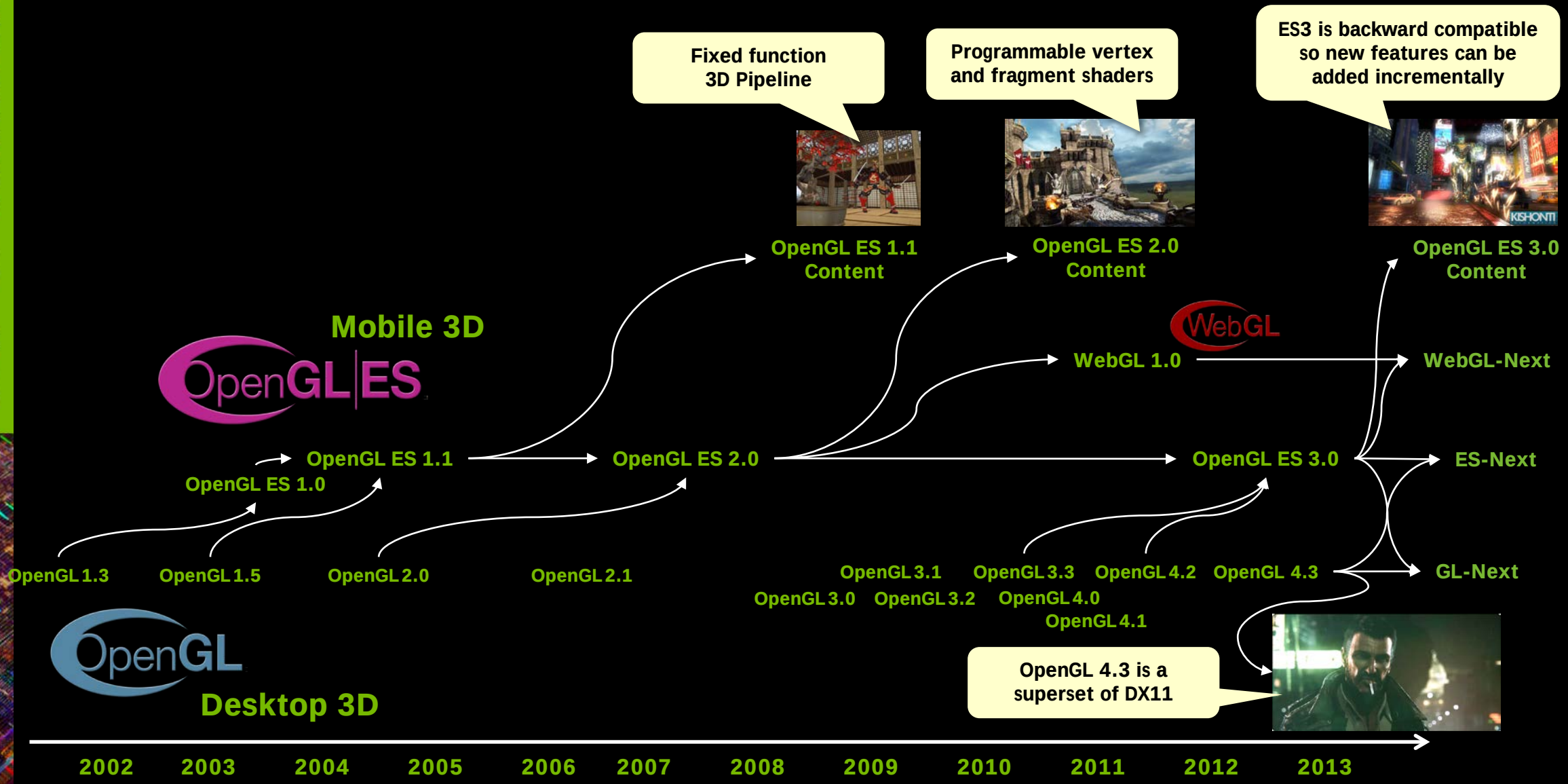
OpenCL – Heterogeneous Computing

- **A low-level, cross-platform, cross-vendor standard**
  - For harnessing all system compute resources
- **C Platform Layer API**
  - Query, select and initialize compute devices
- **Kernel Language Specification**
  - Subset of ISO C99 with language extensions
  - Well-defined numerical accuracy - IEEE 754 rounding with specified max error
  - Rich built-in functions: cross, dot, sin, pow, log …
- **C Runtime API**
  - Runtime or build-time compilation of kernels
  - Execute compute kernels across multiple devices



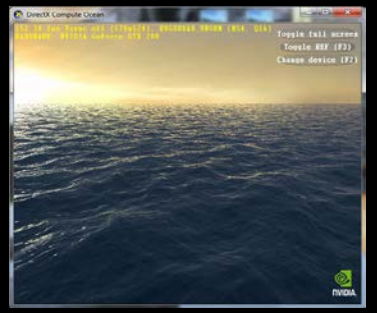
One code tree can be executed on CPUs or GPUs

OpenGL 3D API Family Tree



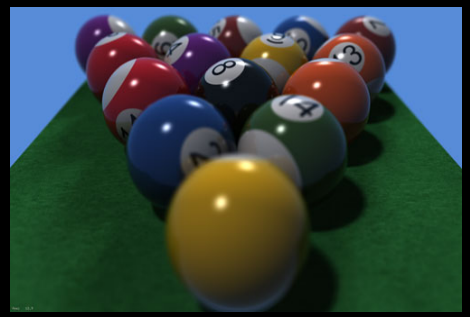
OpenGL 4.3 Compute Shaders

- Execute algorithmically general-purpose GLSL shaders
  - Can operate on uniforms, images and textures
- Process graphics data in the context of the graphics pipeline
  - Easier than interoperating with a compute API IF processing ‘close to the pixel’
- Standard part of all OpenGL 4.3 implementations
  - Matches DX11 DirectCompute functionality



Physics

AI Simulation



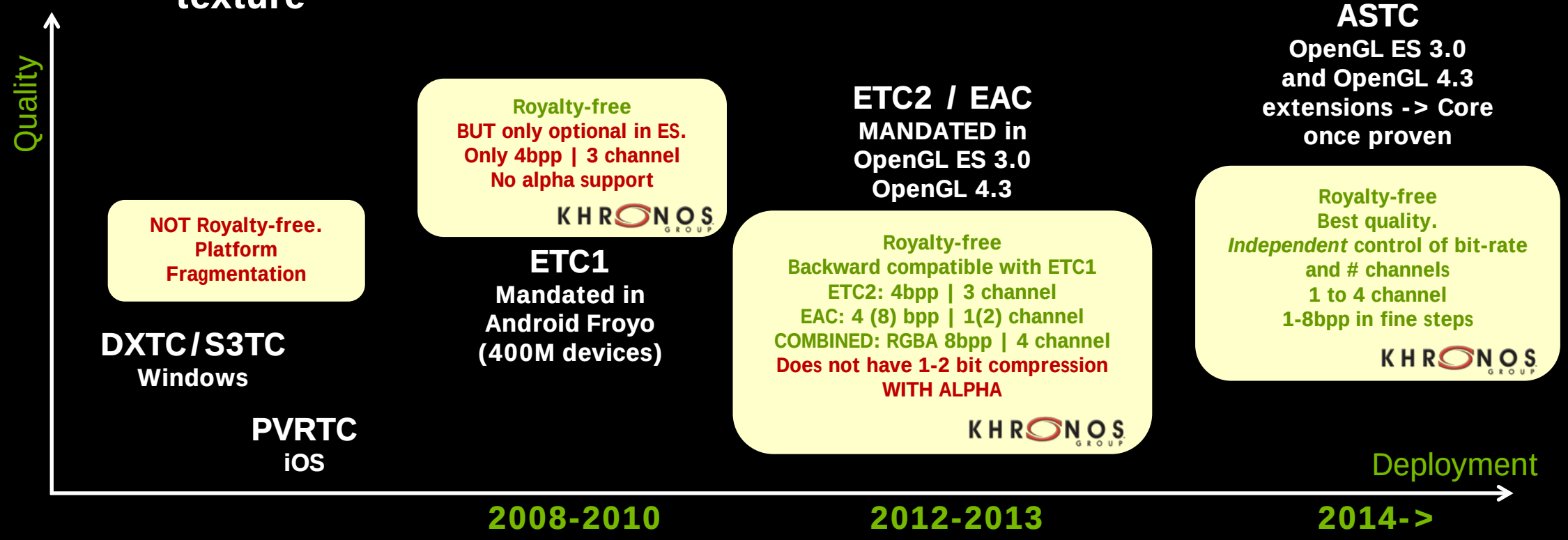
Ray Tracing

Imaging

Global Illumination

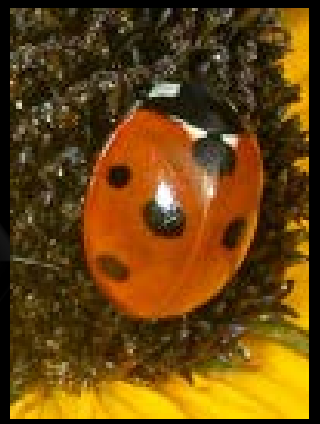
Texture Compression is Key

- Texture compression saves precious resources
  - Network bandwidth, device memory space AND device memory bandwidth
- Developers need the same texture compression EVERYWHERE
  - Otherwise portable apps – such as WebGL need multiple copies of same texture



ASTC – Universal Texture Standard

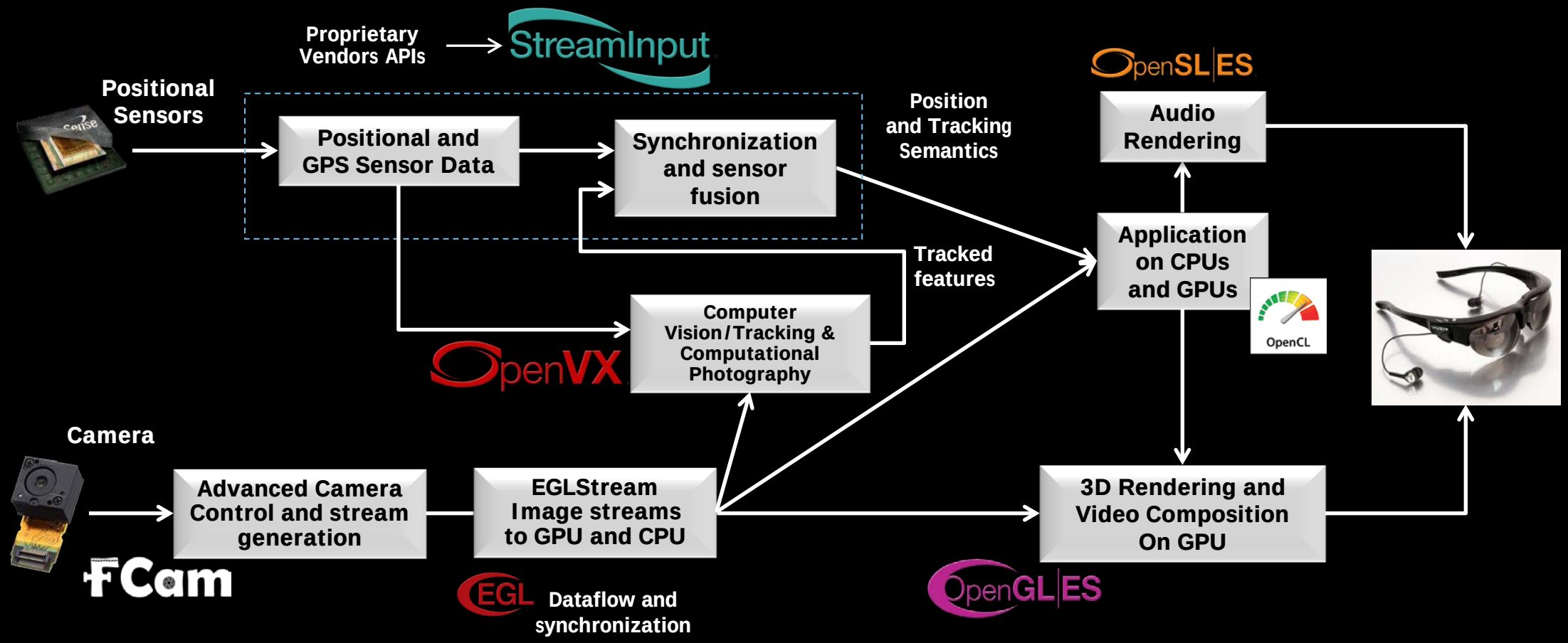
- Adaptive Scalable Texture Compression (ASTC)
  - Quality significantly exceeds S3TC or PVRTC at same bit rate
- Industry-leading orthogonal compression rate and format flexibility
  - 1 to 4 color components: R / RG / RGB / RGBA
  - Choice of bit rate: from 8bpp to <1bpp in fine steps
- ASTC is royalty-free and so is available to be universally adopted
  - Shipping as OpenGL/OpenGL ES extension today for industry feedback
  -



Original
24bpp

ASTC Compression
8bpp 3.56bpp 2bpp

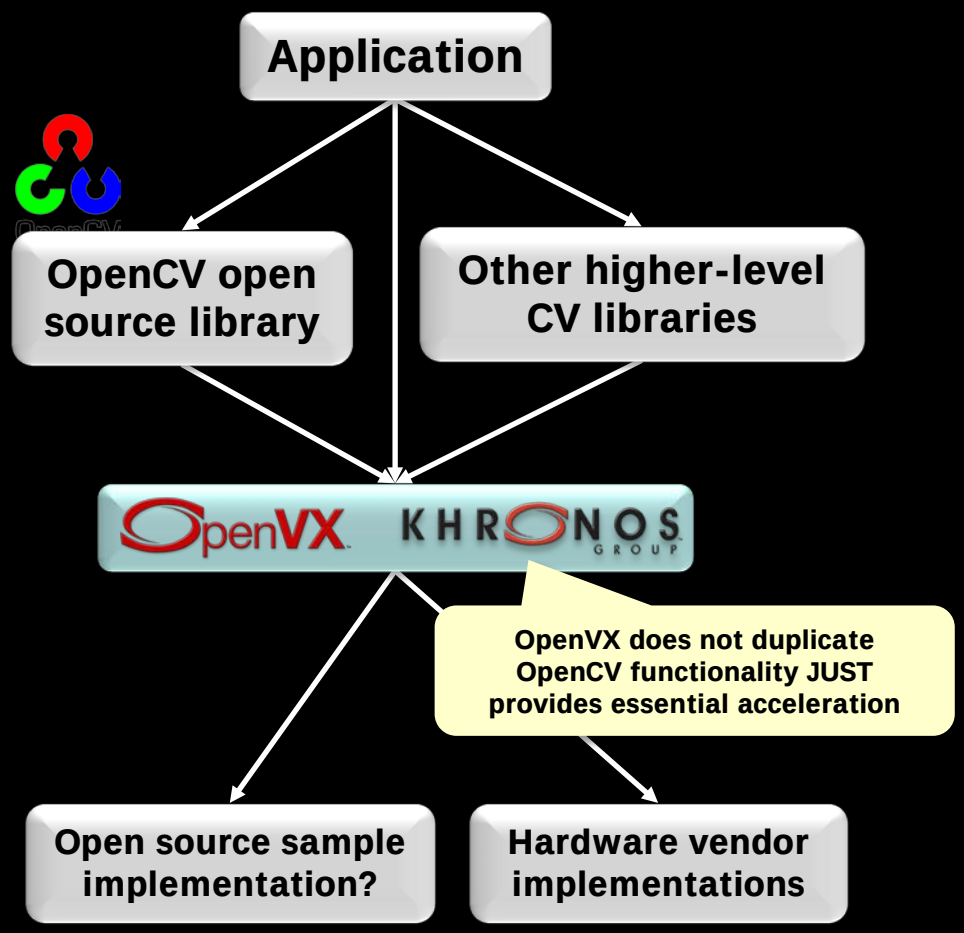
Native APIs for Augmented Reality



OpenVX

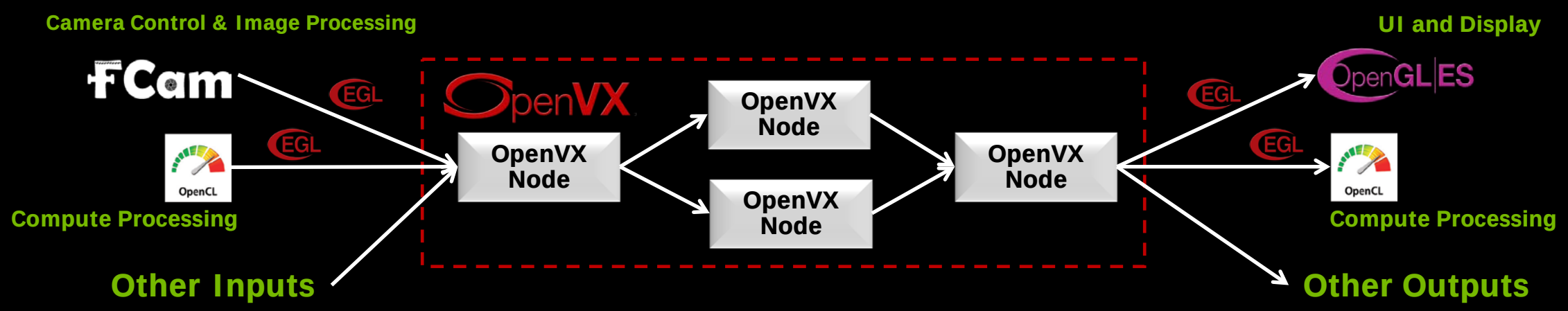
- **Vision Hardware Acceleration Layer**
  - Enables hardware vendors to implement accelerated imaging and vision algorithms
  - For use by high-level libraries or apps
- **Focus on enabling real-time vision**
  - On mobile and embedded systems
- **Diversity of efficient implementations**
  - From programmable processors, through GPUS to dedicated hardware pipelines

Dedicated hardware can help make vision processing performant and low-power enough for pervasive 'always-on' use



OpenVX Execution Flow

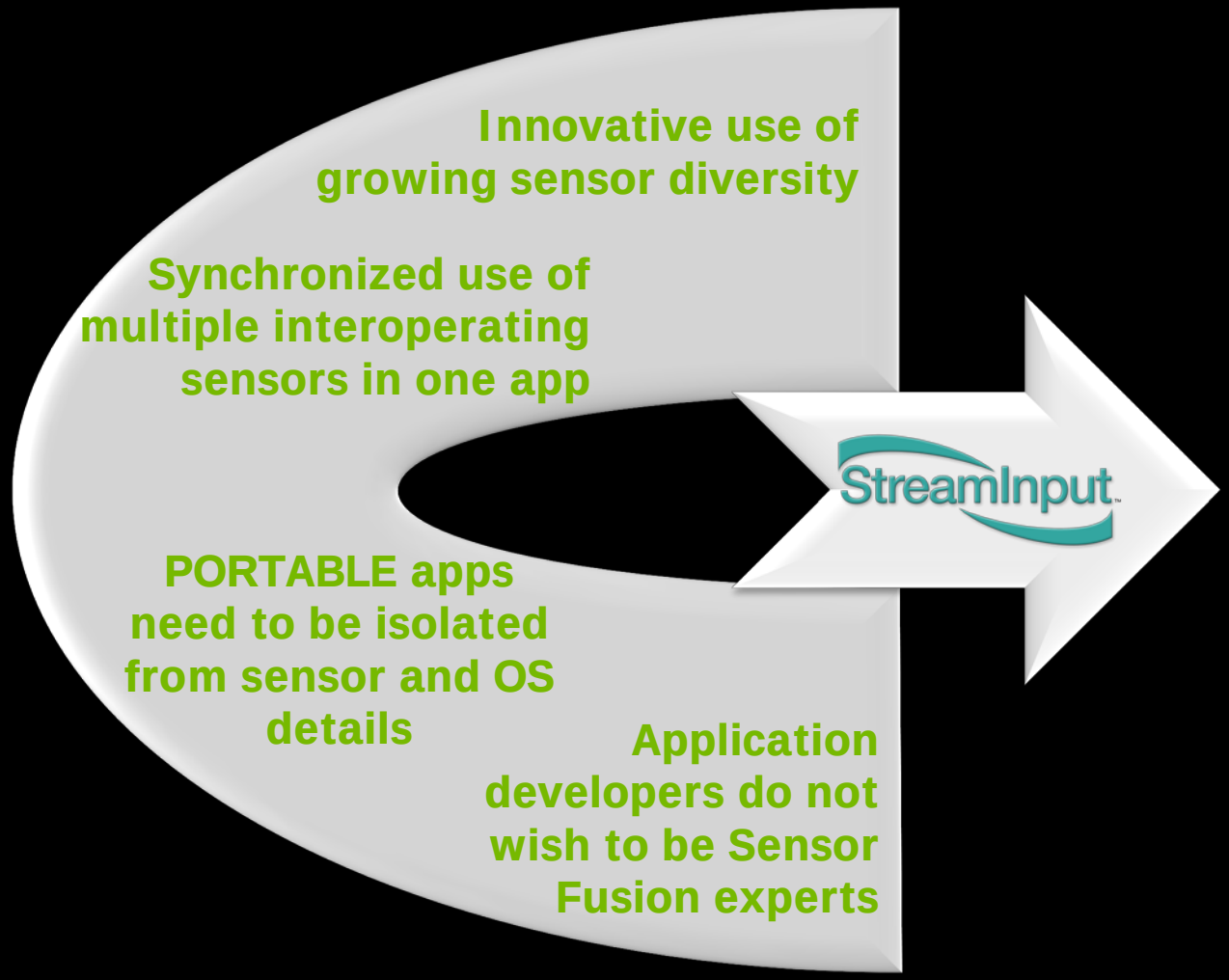
- OpenVX Graph for efficient execution
  - Each Node can be implemented in software or accelerated hardware
- EGL provides data and event interop – with streaming
  - BUT use of other Khronos APIs are not mandated
- VXU Utility Library provides efficient access to single nodes
  - Open source implementation



OpenVX Participants and Timeline

- Aiming for provisional specification in 2H 2013
  - Itseez is working group chair

Market Demand for Sensor Fusion API



StreamInput
A High-level Sensor Fusion API

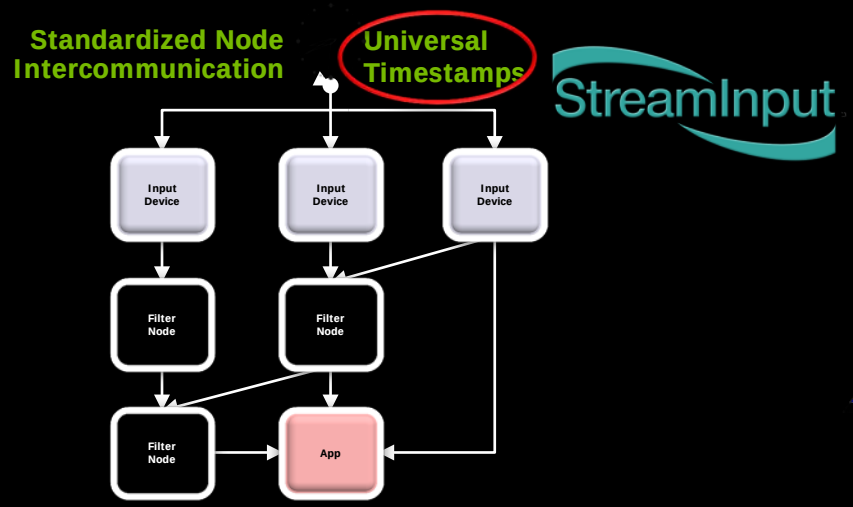
Do NOT force the application developer to access individual sensors (unlike almost all other sensor APIs)

High-level API enables sensor vendors to drive and deliver competitive sensor fusion innovation

StreamInput - Portable Access to Sensor Fusion

Apps request semantic sensor information
StreamInput defines possible requests, e.g.
"Provide Skeleton Position" "Am I in an elevator?"

Advanced Sensors Everywhere
RGB and depth cameras, multi-axis motion/position, touch and gestures, microphones, wireless controllers, haptics keyboards, mice, track pads

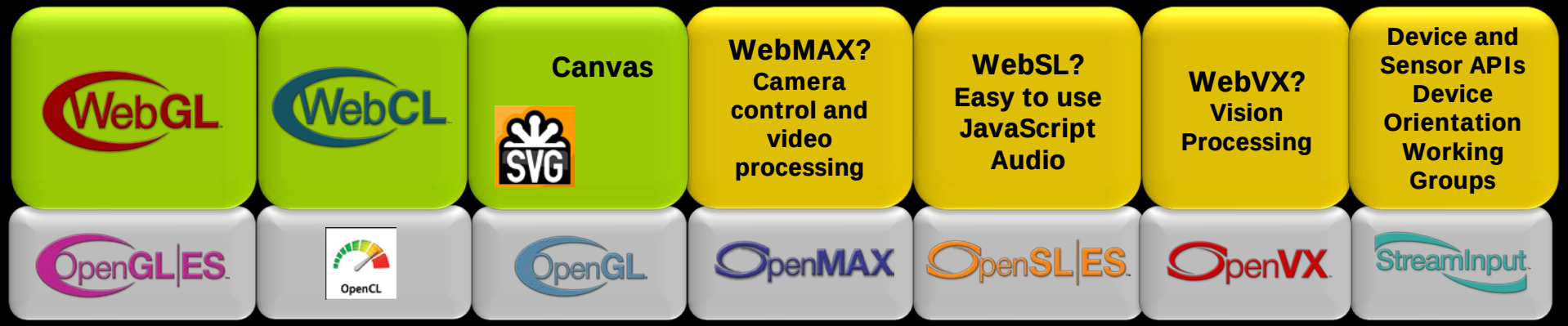


Apps Need Sophisticated Access to Sensor Data
Without coding to specific sensor hardware

Processing graph provides sensor data stream
Utilizes optimized, smart, sensor middleware
Apps can gain 'magical' situational awareness

Leveraging Proven Native APIs into HTML5

- Leverage native API investments into the Web
  - Faster API development and deployment
  - Familiar foundation reduces developer learning curve
- Khronos and W3C exploring liaison
  - Multiple potential joint projects



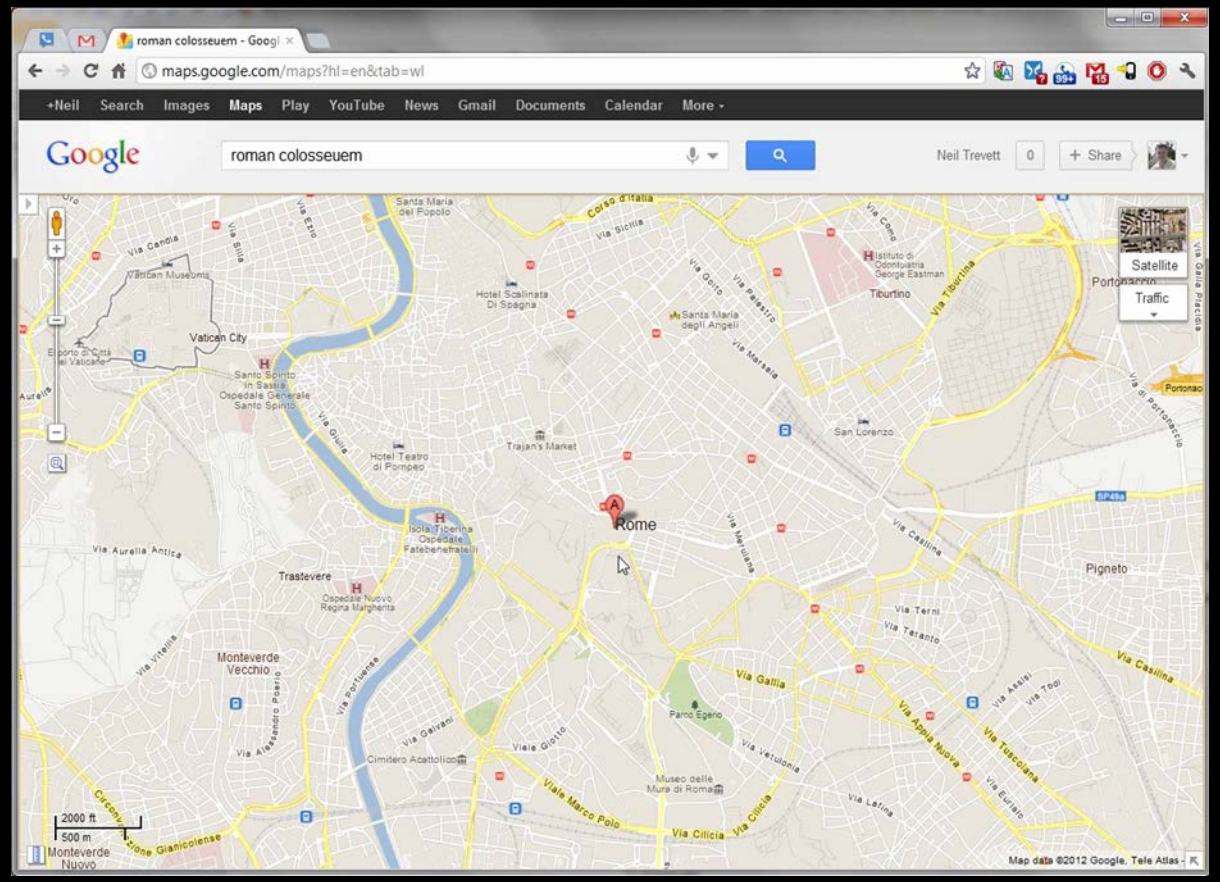
Native APIs shipping or working group underway

JavaScript API shipping or working group underway

Possible future JavaScript APIs

WebGL – 3D Browser Visualization

- **JavaScript Binding to OpenGL ES 2.0**
  - 3D rendering into the Canvas
- **Shipping on desktop browsers last year**
  - Mobile browsers this year
- **Enables the browser to access the full power the GPU**



WebCL – Parallel Computing for the Web

- JavaScript bindings to OpenCL APIs
  - Enables initiation of Kernels written in OpenCL C within the browser

http://www.youtube.com/user/SamsungSISA#p/a/u/1/9Ttux1A-Nuc

Busting Some Standardization Myths

- "Standards are slow to develop"
  - Time to productive multi-vendor ecosystem is the key rather than minimizing time to a proprietary specification
  - Cooperative refinement can be highly effective - OpenCL 1.0 took just 6 months – intensive cooperation
- "If I particpate in standards I 'lose' my IP"
  - Khronos IP Framework fully protects Members IP and the specification - Members agree not to assert claims against other Members for essential IP in conformant imple
- "Using a Standard means that I can't differentiate"
  - Well designed standards enable strong implementation diversity
- "Standards are boring"
  - An effective standard is industry coming together to solve real issues

In Summary

- APIs are key to enable compelling applications on advanced hardware – APIs developed on high-end hardware are now enabling mobile devices
- APIs no longer exist alone – they interoperate and provide input AND output processing to form a complete platform for advanced content
- Significant cooperation underway between native and Web APIs to bring advanced visual computing to HTML5

- Khronos is driving open standards for hardware acceleration
  Participate, change the industry AND get the inside edge for your products!

KHRONOS GROUP

Connecting Software to Silicon