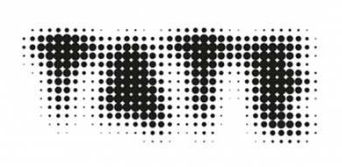


Developing a High Level Preservation Strategy for Virtual Reality Artworks

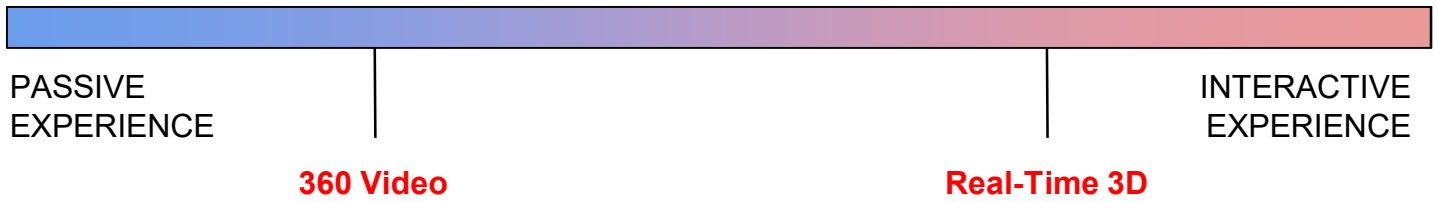
Tom Ensom & Jack McConchie

No Time To Wait 3, BFI, London
23 October 2018

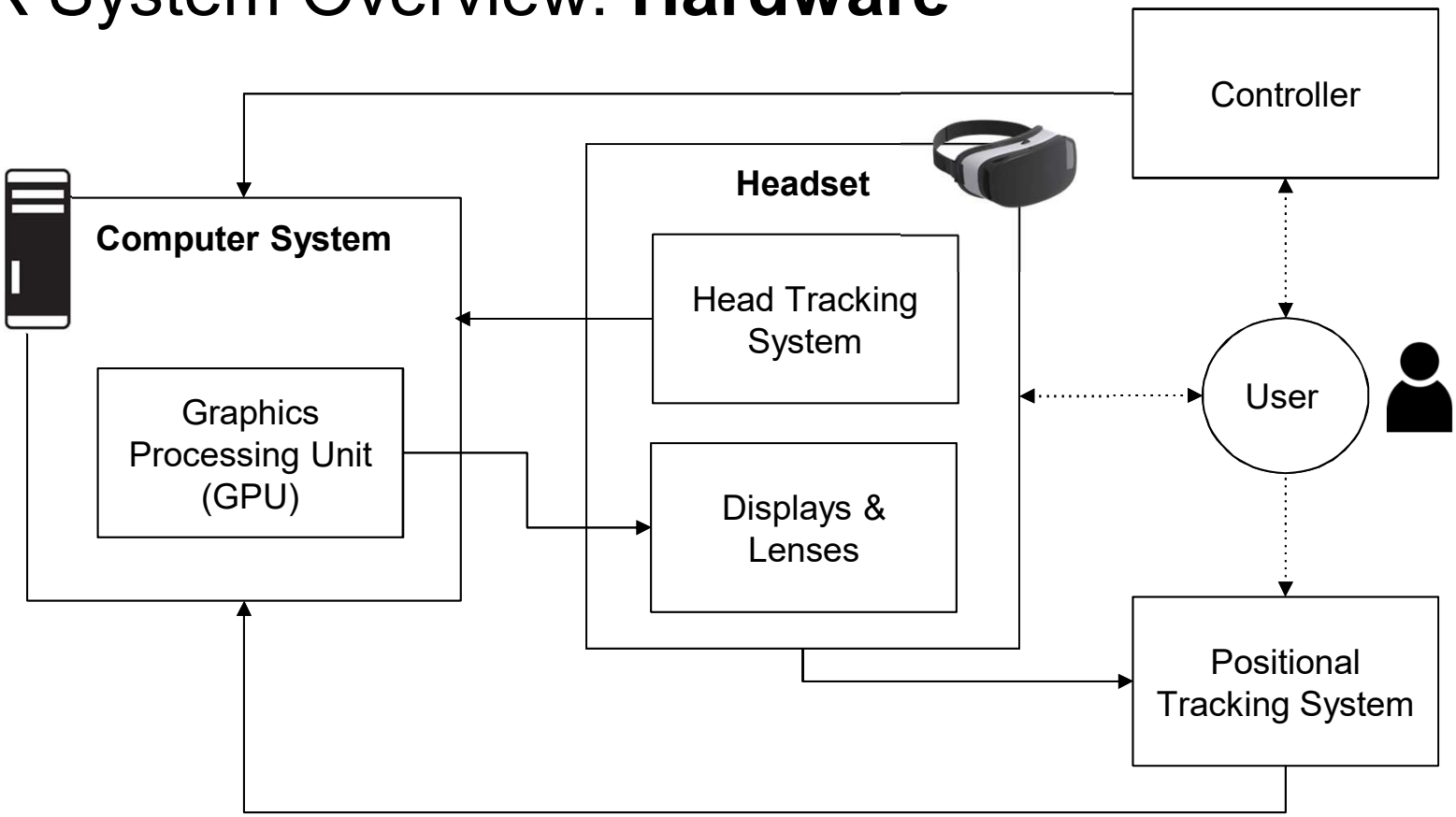
Supported by Carla Rapoport, Lumen Art Projects Ltd.

Introduction

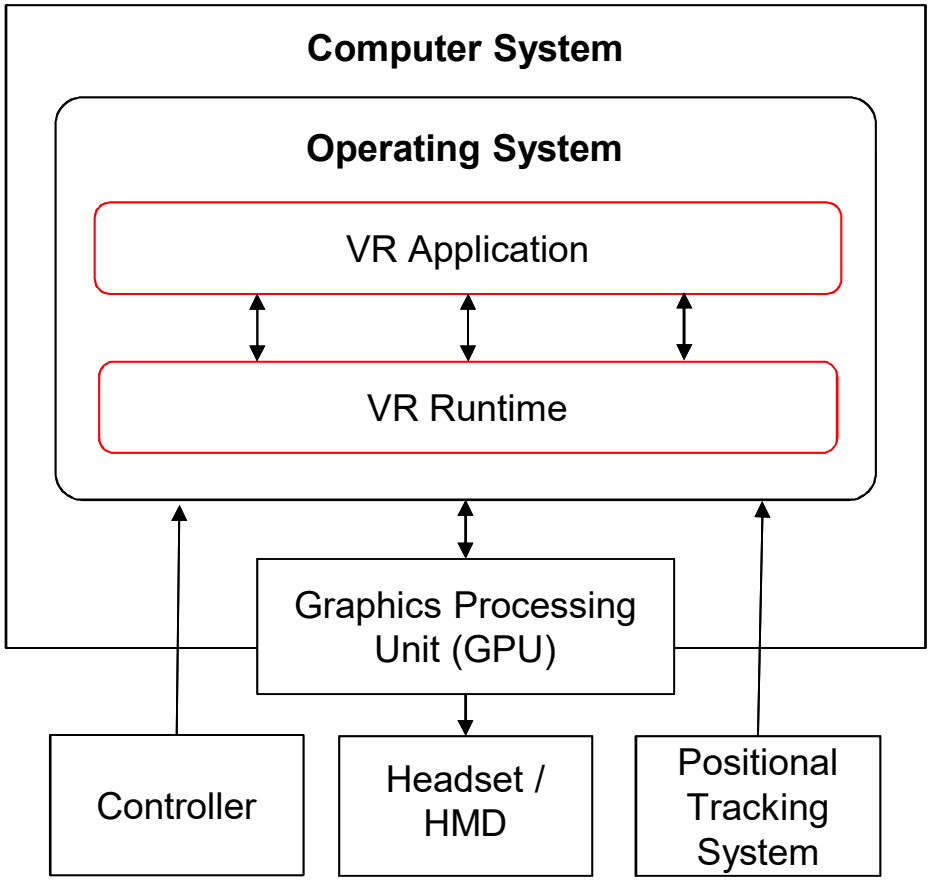
- Moving from exploratory research to strategy for acquisition and preservation
- First stages of project have explored:
  - The core components of VR systems (software and hardware) and their relationships
  - Production and playback of 360 video VR works
  - Production and playback of real-time 3D VR works
  - Initial exploration of preservation strategies for both the above



VR System Overview: **Hardware**



VR System Overview: **Software**



VR Platform Fragmentation

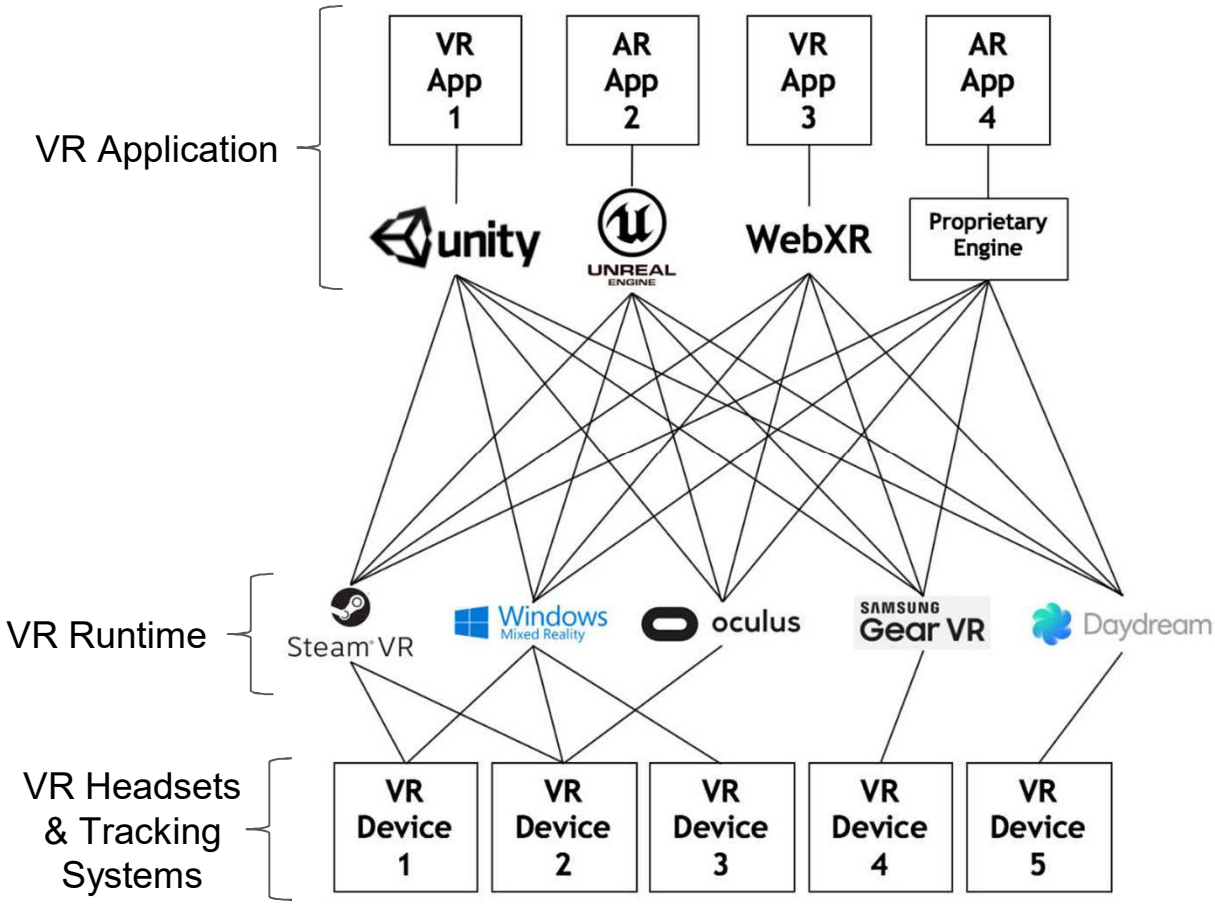


Image credit: Khronos Group
https://www.khronos.org/openxr/

360 Video: **Production**

Capture: Monoscopic 360 with dual fisheye lenses

Image credit: http://theta360.guide/plugin-guide/fisheye/

360 Video: **Production**

Capture: Stereoscopic 360 with multiple lenses

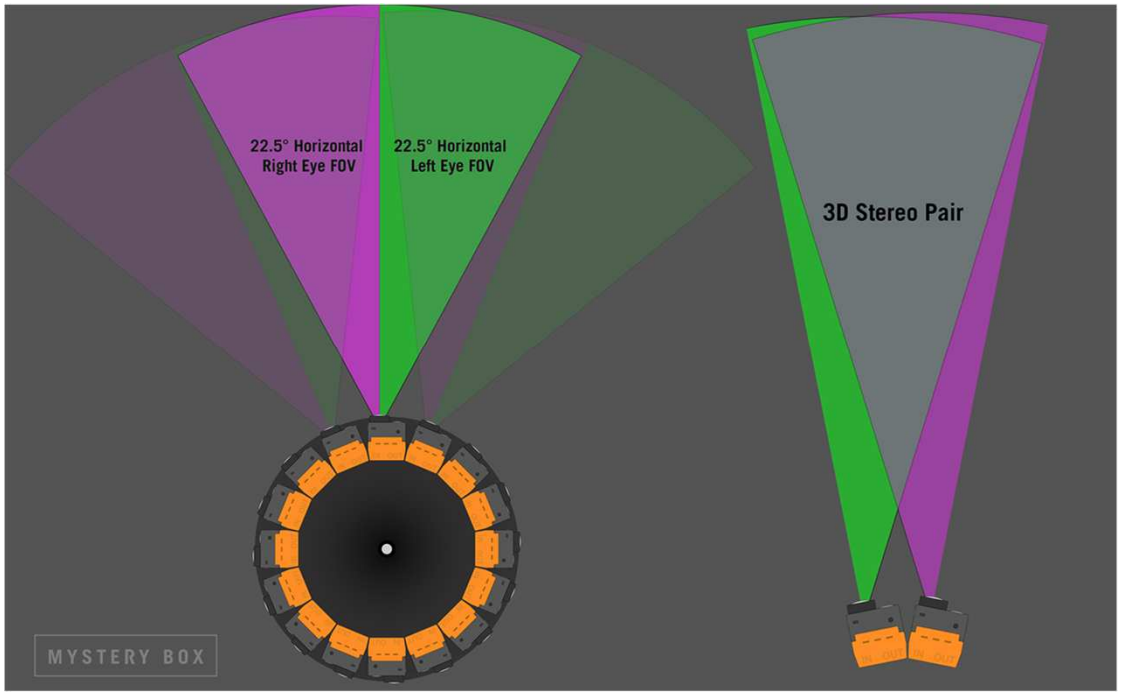
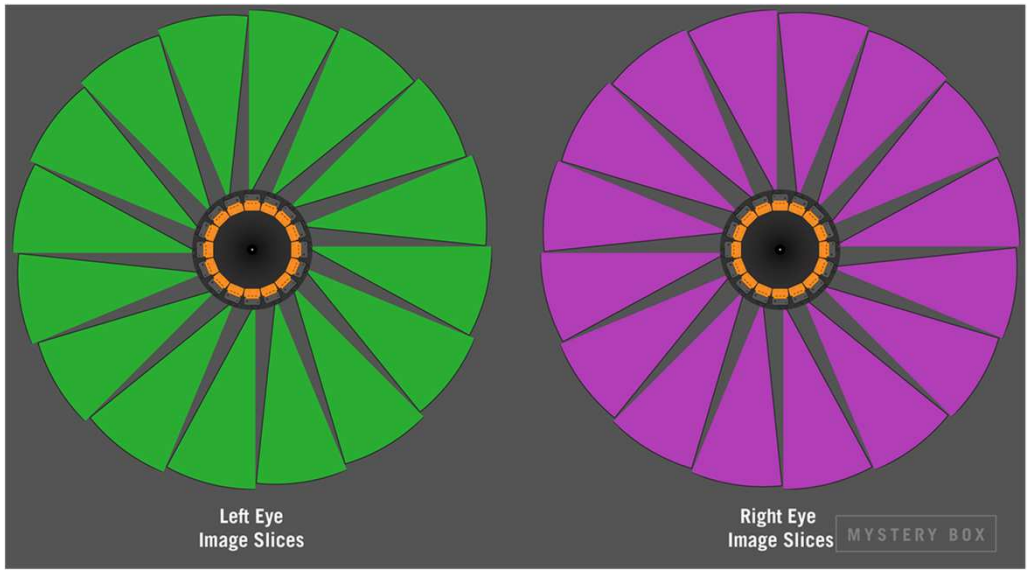


Image credit: https://www.mysterybox.us/blog/2017/1/31/shooting-360-vr-with-gopro-odyssey-and-google-jump-vr

360 Video: **Production**

Capture: Stereoscopic 360 with multiple lenses



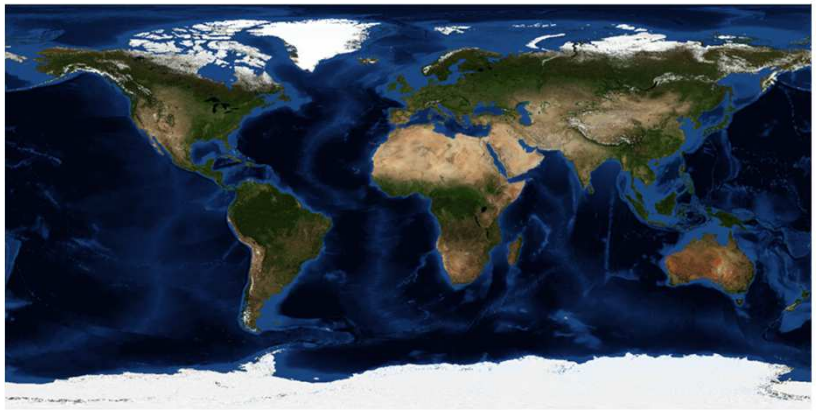
360 Video: **Production**

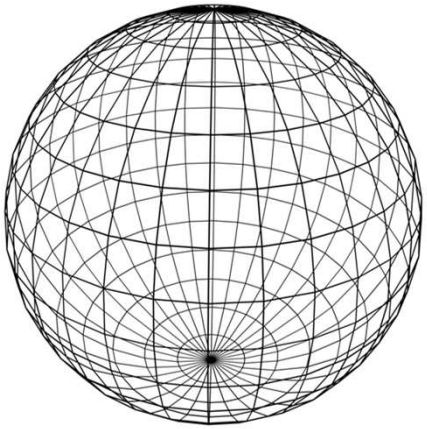
Common file characteristics

Containers	MP4, MKV
Aspect Ratio	Equirectangular 2:1
Frame rates	Commonly 60 fps
Resolution	4096 x 2048- equivalent to 1024 FOV
Compression	H264, H265

360 Video: **Playback**

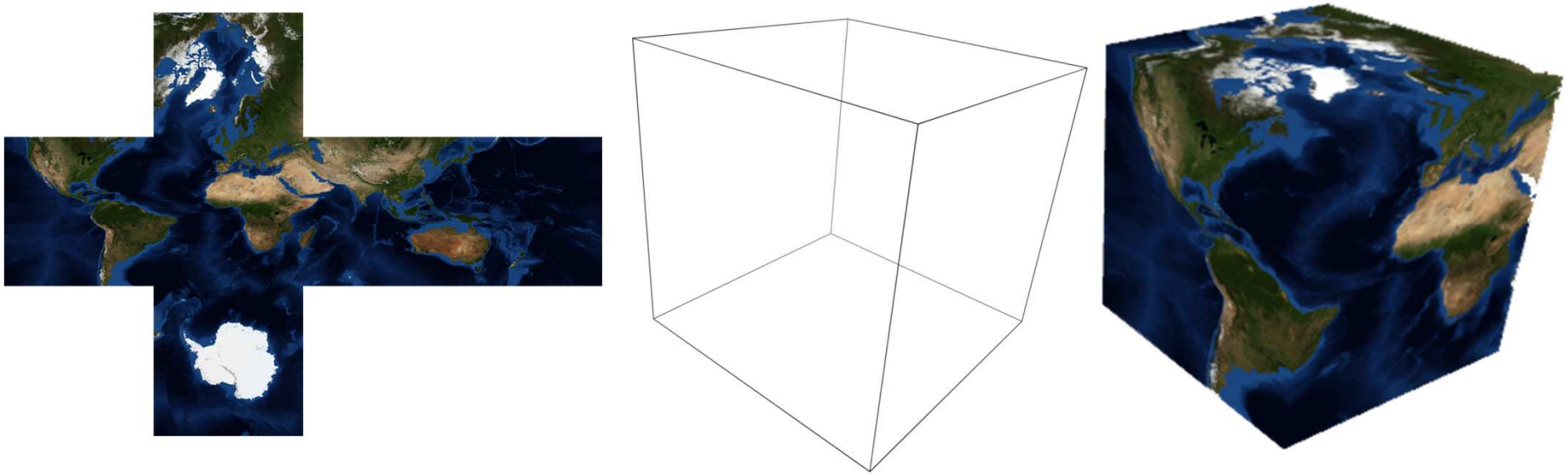
Equirectangular





360 Video: **Playback**

Cubemap



360 Video: **Playback**

Pyramid

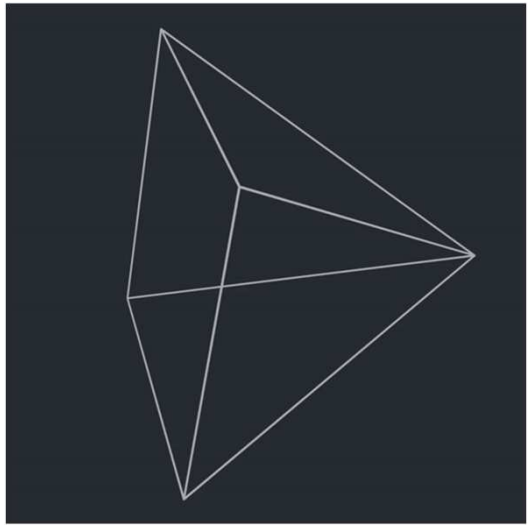


Image credit: https://code.fb.com/virtual-reality/next-generation-video-encoding-techniques-for-360-video-and-vr/

360 Video: **Playback**

Top bottom stereoscopic 360 equirectangular projection

Identifying string: “3dv” or “_tb”

examplemedia_3dv_.mp4

Left right stereoscopic 360 equirectangular projection

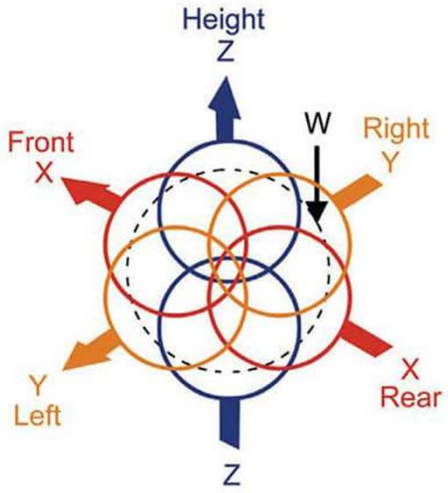
Identifying string: “3dh” or “_lr”

examplemedia_3dh_.mp4

360 Audio: **Production**

“A” Format
Raw audio

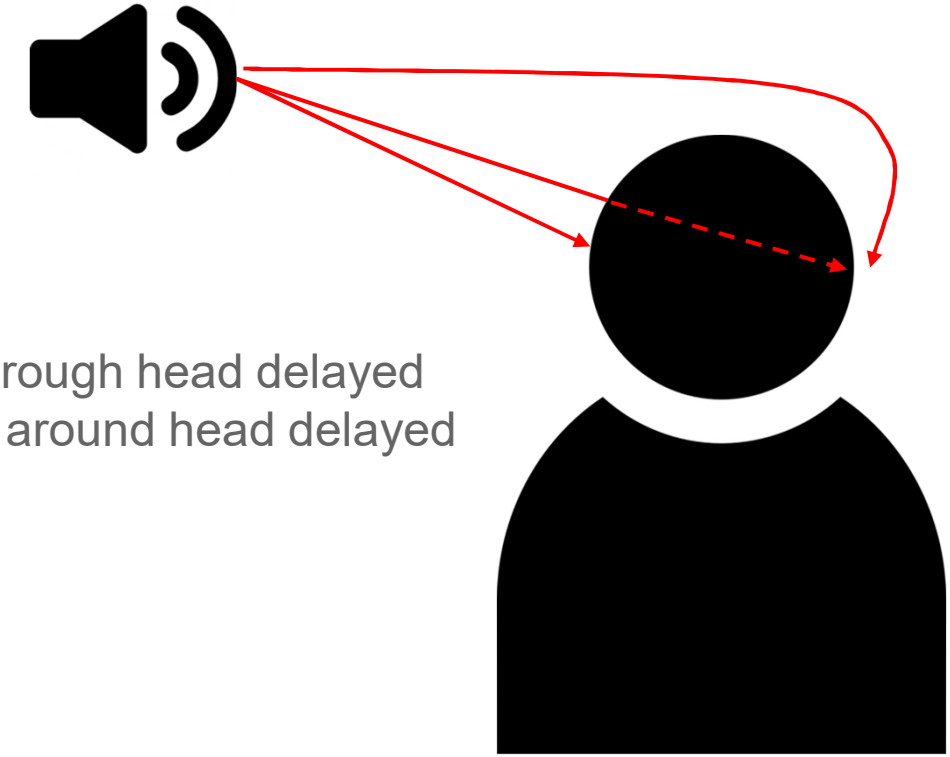
“B” Format
Amplitude and spatial information



360 Audio: **Production**

Audio encoding	WAV, AIFF, AAC
Ambisonic “order” or number of channels	4, 9, 16
Audio channel ordering	Furse-Malham, ACN
Audio channel spherical normalisation	SN3D, maxN, N3D.

360 Audio: **Playback**



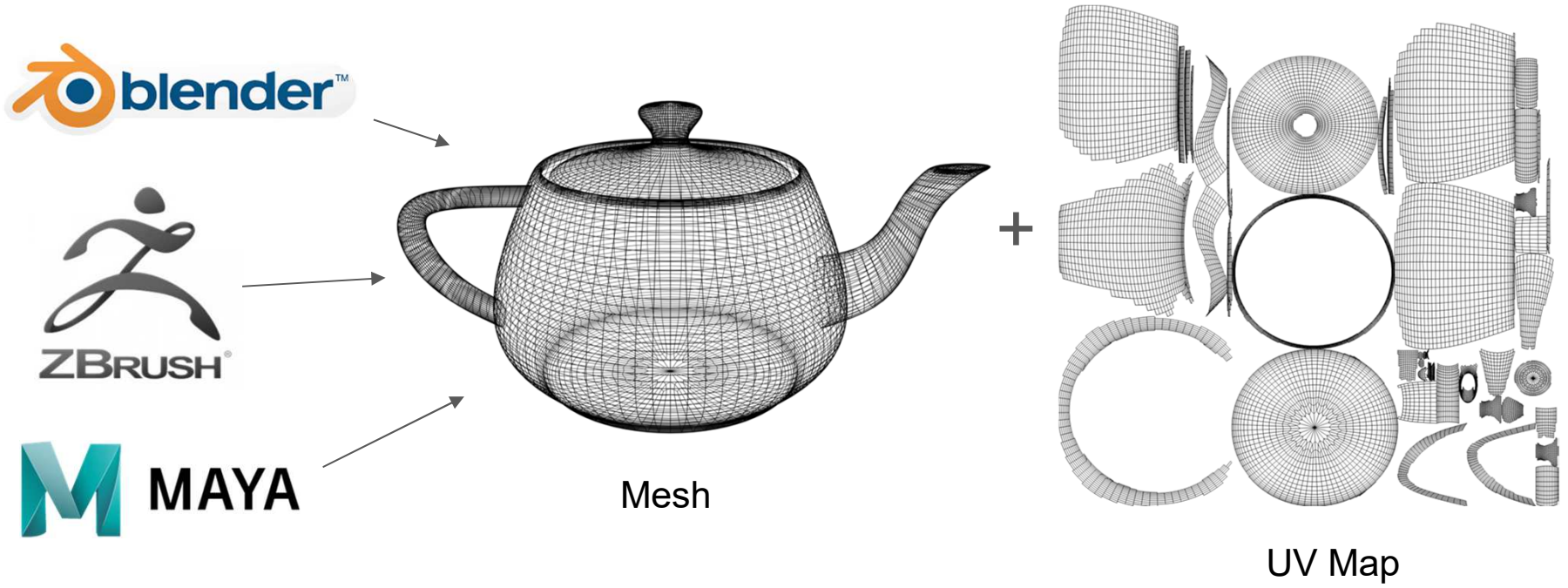
- Direct sound
- Filtered sound through head delayed
- Diffracted sound around head delayed

Real-Time 3D: **Production**

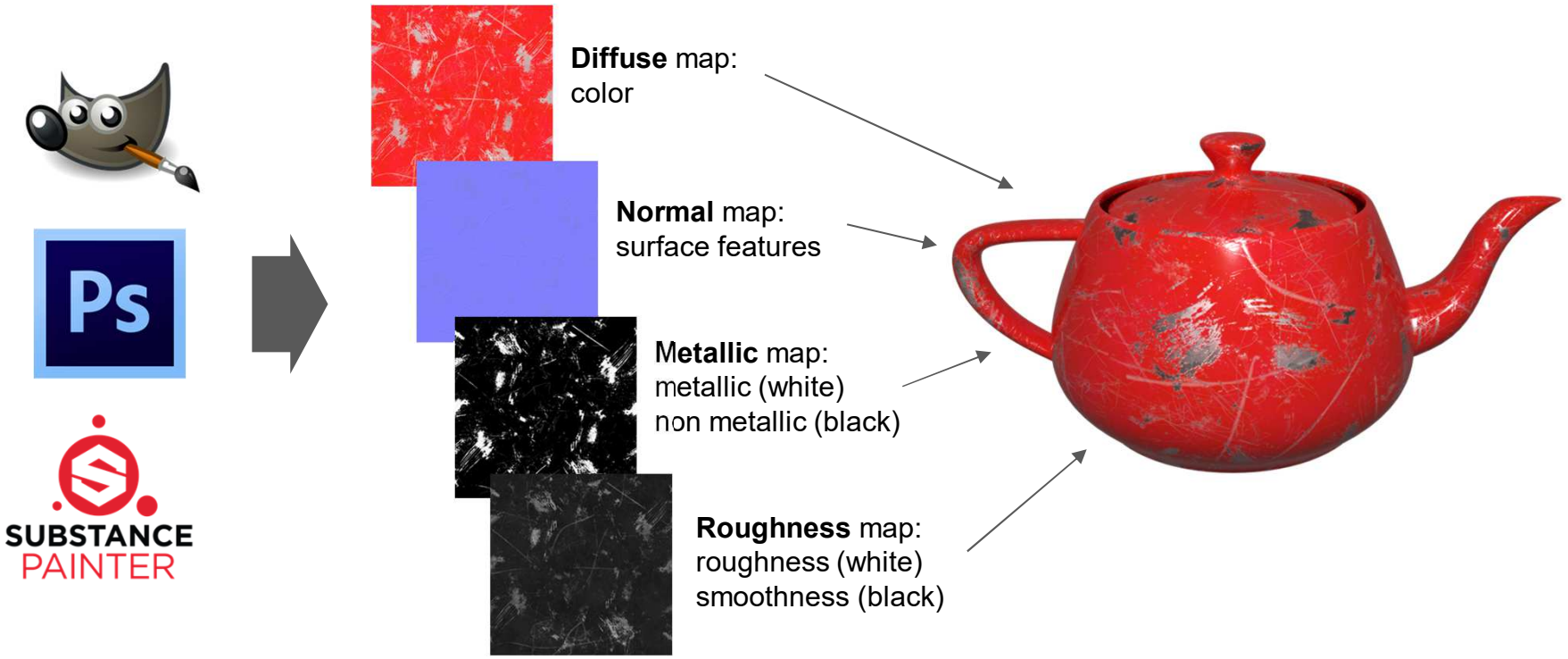
- **Assets** created using various proprietary and open-source tools and brought together in an engine
- Assets typically portable with open file format potential in some cases:
  - **3D models**: meshes and materials
  - **Textures**: texture maps (raster images)
  - **Sounds**: Ogg Vorbis and WAV
- **glTF** as open standard for archiving?

glTF succeeds Collada as an open spec file format for 3D asset/scene

3D Modelling: Meshes and UVs

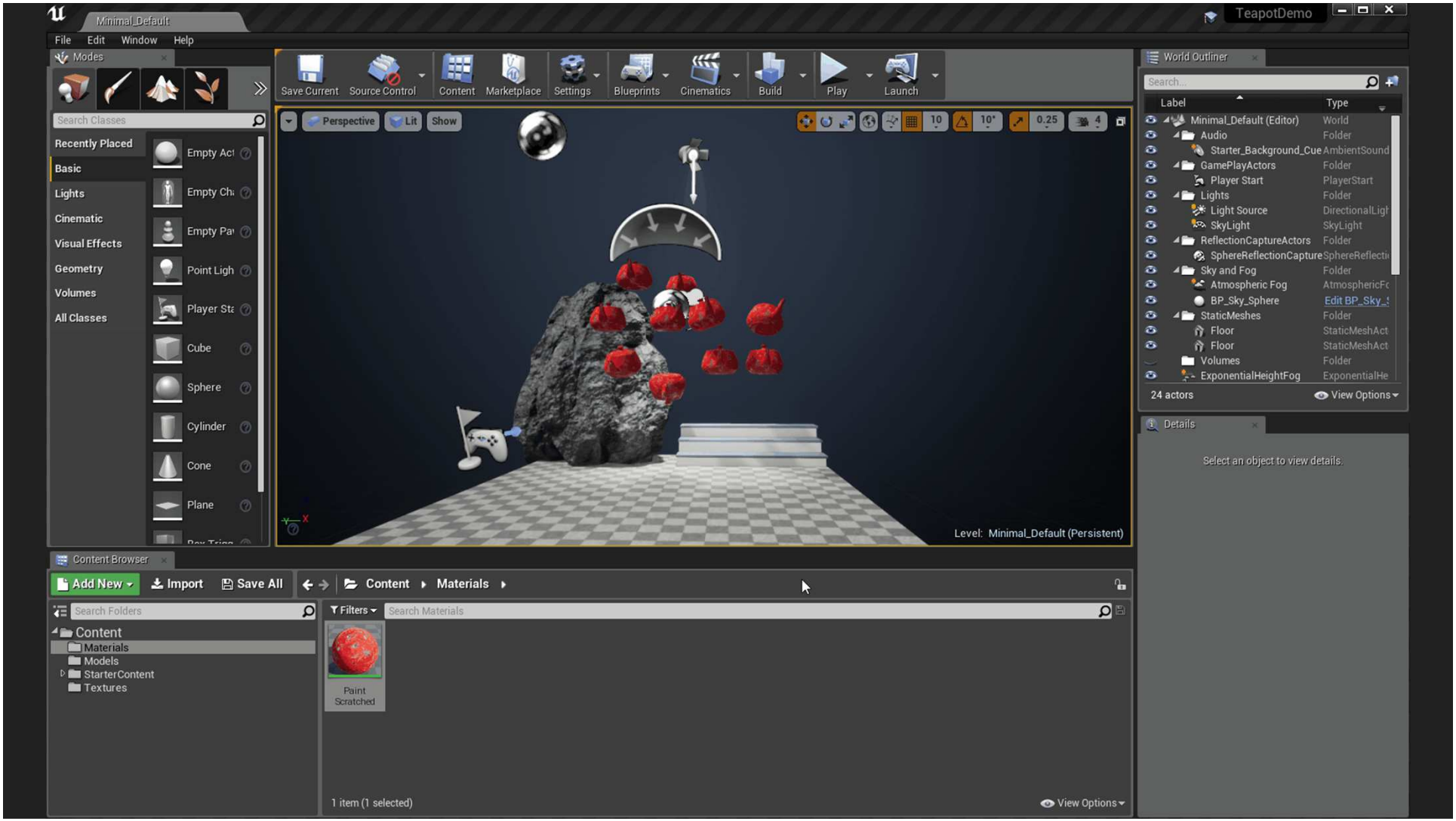


3D Modelling: Materials and Textures



Real-Time 3D: **Production**

- **Engines** typically non-portable and proprietary/licenced
- Engines integrate assets and engine features in scenes/levels and include:
  - Lighting
  - Material shaders
  - Physics
  - Visual or typed scripting
  - Sound engine
  - Plugins and extensions


Minimal_Default
TeapotDemo
File
Edit
Window
Help
Modes
Save Current
Source Control
Content
Marketplace
Settings
Blueprints
Cinematics
Build
Play
Launch
Search Classes
Recently Placed
Basic
Lights
Cinematic
Visual Effects
Geometry
Volumes
All Classes
Empty Act
Empty Cha
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Cube
Sphere
Cylinder
Cone
Plane
Perspective
Lit
Show
Level: Minimal_Default (Persistent)
World Outliner
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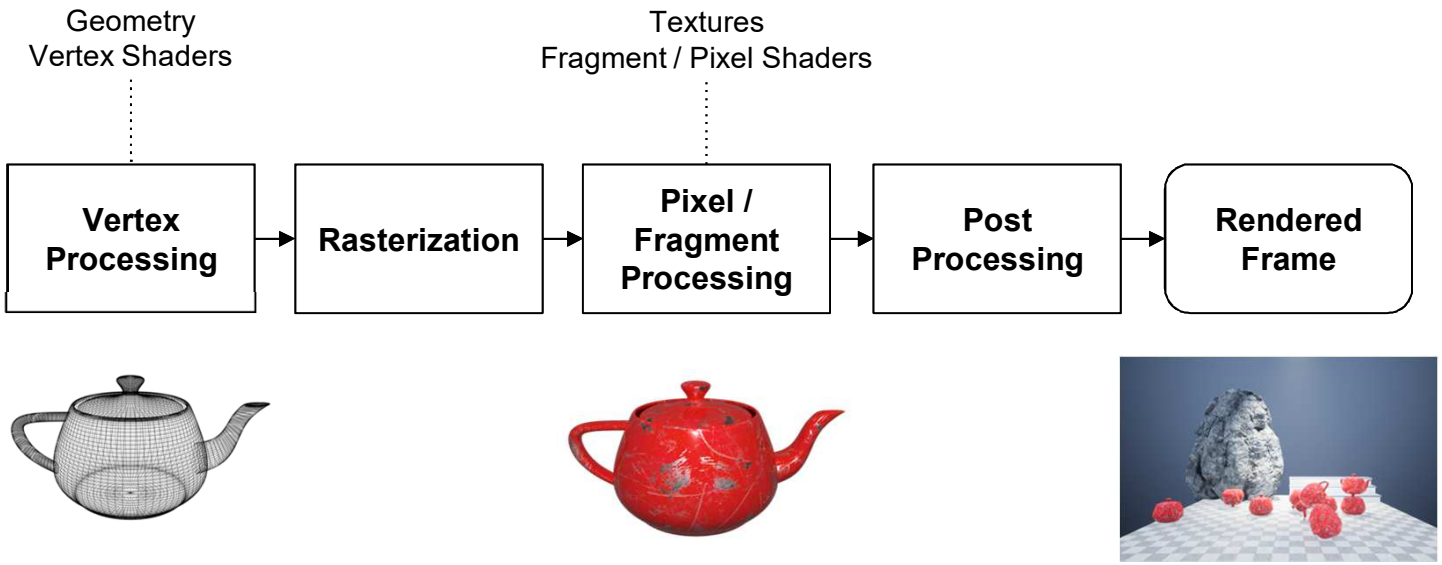
Label
Type
Minimal_Default (Editor)
World
Audio
Folder
Starter_Background_Cue
AmbientSound
GamePlayActors
Player Start
PlayerStart
Lights
Light Source
SkyLight
ReflectionCaptureActors
SphereReflectionCapture
Sky and Fog
Atmospheric Fog
BP_Sky_Sphere
Edit BP_Sky_S
StaticMeshes
Floor
StaticMeshAct
Volumes
ExponentialHeightFog
24 actors
View Options
Details
Select an object to view details.
Content Browser
Add New
Import
Save All
Content
Materials
Search Folders
Filters
Search Materials
Content
Materials
Models
StarterContent
Textures
Paint Scratched
1 item (1 selected)
View Options

Real-Time 3D: **Playback**

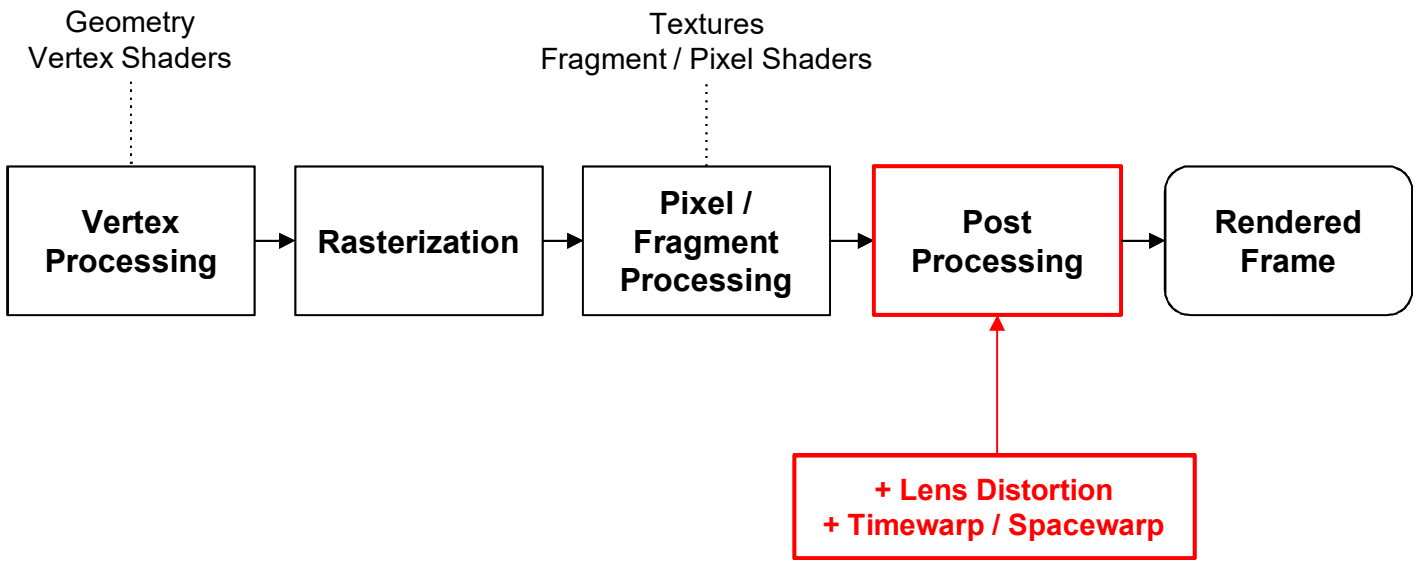
- Built as executable software package
- Usually consists of executable file(s) and packaged assets
- Can be executed in a specific technical environment which might include:
  - **VR Runtimes** e.g. SteamVR, Oculus Runtime, OpenXR, WebVR etc.
  - **Graphics API** e.g. DirectX, Metal, OpenGL, Vulkan etc.
  - **Graphics Processing Unit (GPU)** and **driver**

Vulkan is an open standard for cross-platform 3D graphics which succeeds OpenGL

Rendering Pipeline



VR Rendering Pipeline



Lens Distortion

- Lenses used in headset to achieve wide field of view at close range
- Distortion must be corrected for in the frames send to headset
- Usually carried out as post processing
- Process specified by VR runtime

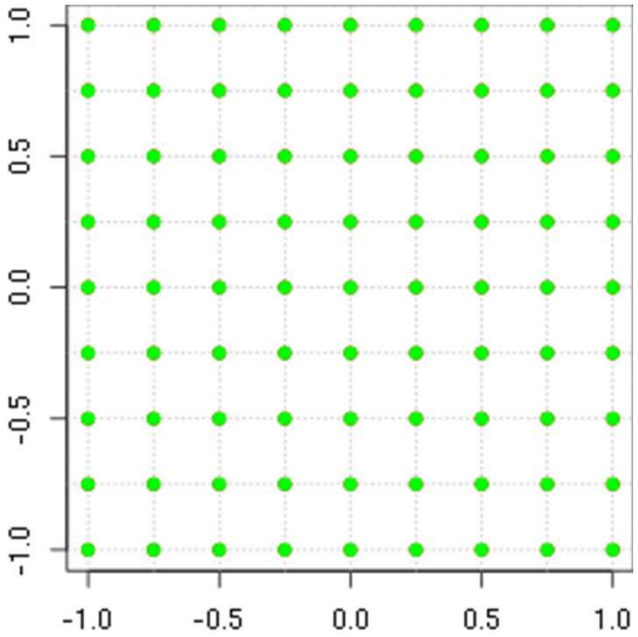


Image credit: Christian Pötzsch https://www.imgtec.com/blog/speeding-up-gpu-barrel-distortion-correction-in-mobile-vr/

Timewarp & Spacewarp

- Predictive interpolation of frames
- Distorts previously generated frame based on movement of user and scene
- Low cost tricks to maintain high framerate and low latency
- Process specified by VR runtime

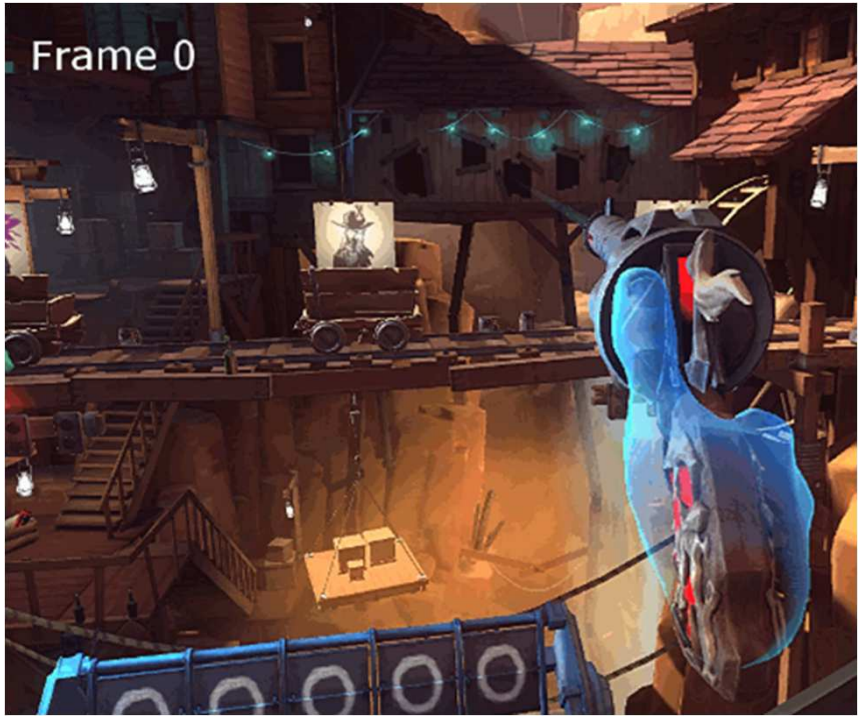


Image credit: Neo222
https://xinreality.com/wiki/Asynchronous_Spacewarp

An Open Standard for VR Runtimes?

- The Khronos Group is a consortium of industry partners who develop open standards for 3D graphics
- **OpenXR** is working group attempting to develop a VR runtime standard
- All the big players in the VR industry are involved
- Like glTF and Vulkan, could also benefit preservation efforts… if it is adopted

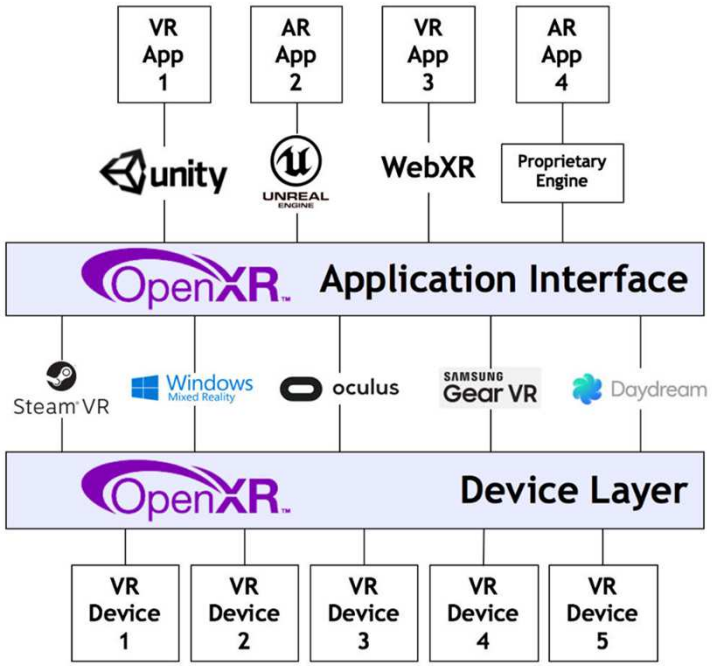


Image credit: Khronos Group https://www.khronos.org/openxr/

Next Steps: Exploring Preservation Strategies

	General	360 Video	Real-Time 3D
Migration	● Headset lens distortion algorithms	● Moving between projection types ● Variability in players	● How reliable are the open 3D asset standards ● Re-creating a 3D scene in different engines
Emulation	● Emulating VR runtimes	● Emulating 360 video players	● Paravirtualization and passthrough for real-time 3D VR
Documentation	● Field of view video capture ● Accounts of experience	● Documenting projection type	● 360 video capture

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