Hwanyong Lee, Ajou University
Khronos Group, Metaverse Standard Forum

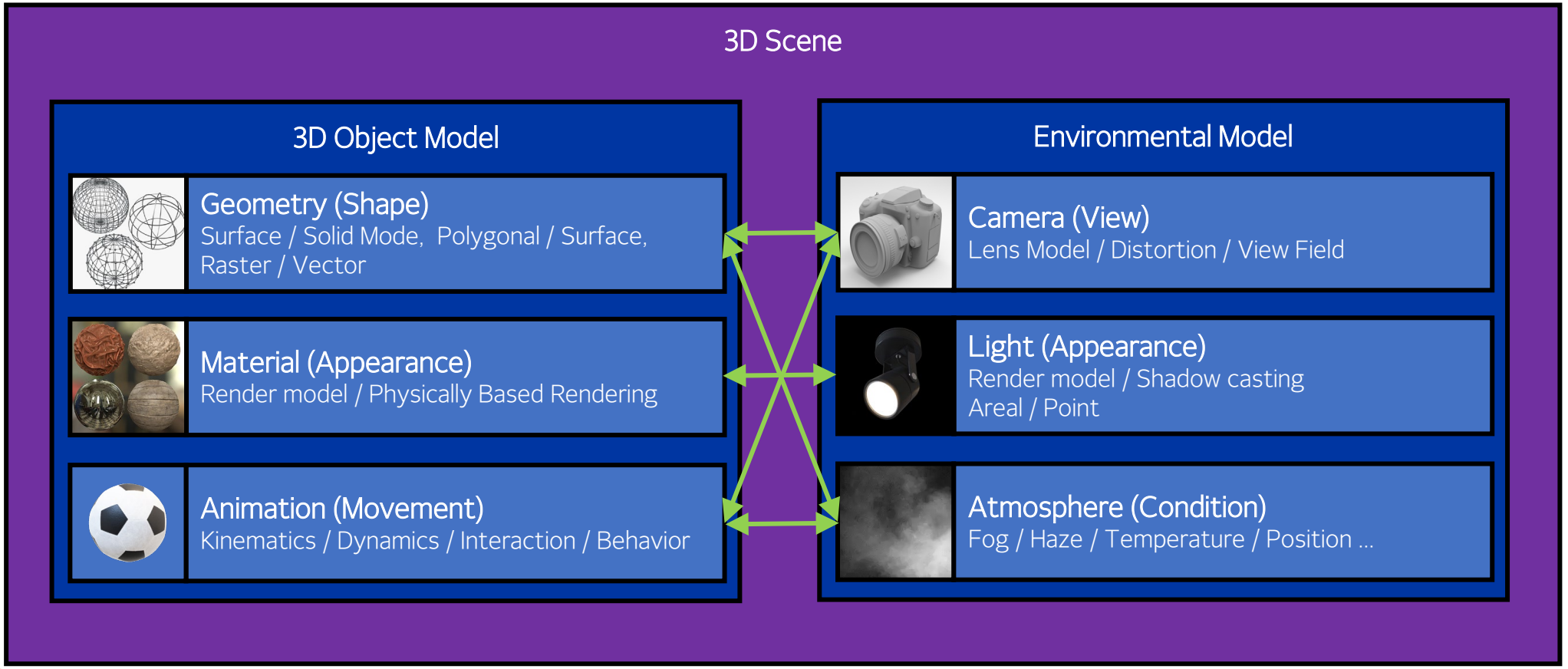
XR-Metaverse 3D Asset 포맷 – glTF 와 USD를 중심으로

Definition to 3D asset

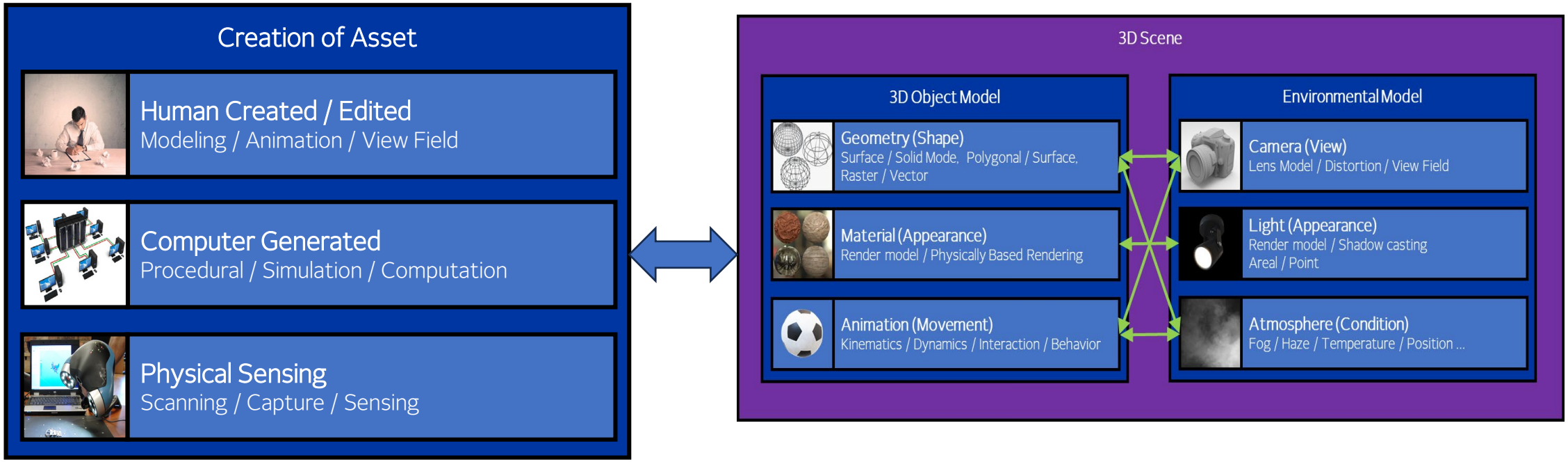
- 3D assets (3D model) are digital files that represent objects or elements in a three-dimensional space. These assets consist of data that defines the shape, texture, and appearance of these objects, allowing them to be rendered and animated in various software applications

(https://www.actionvfx.com/blog/what-are-3d-assets-learn-more-about-3d-models-alembics-vdbs-and-more)

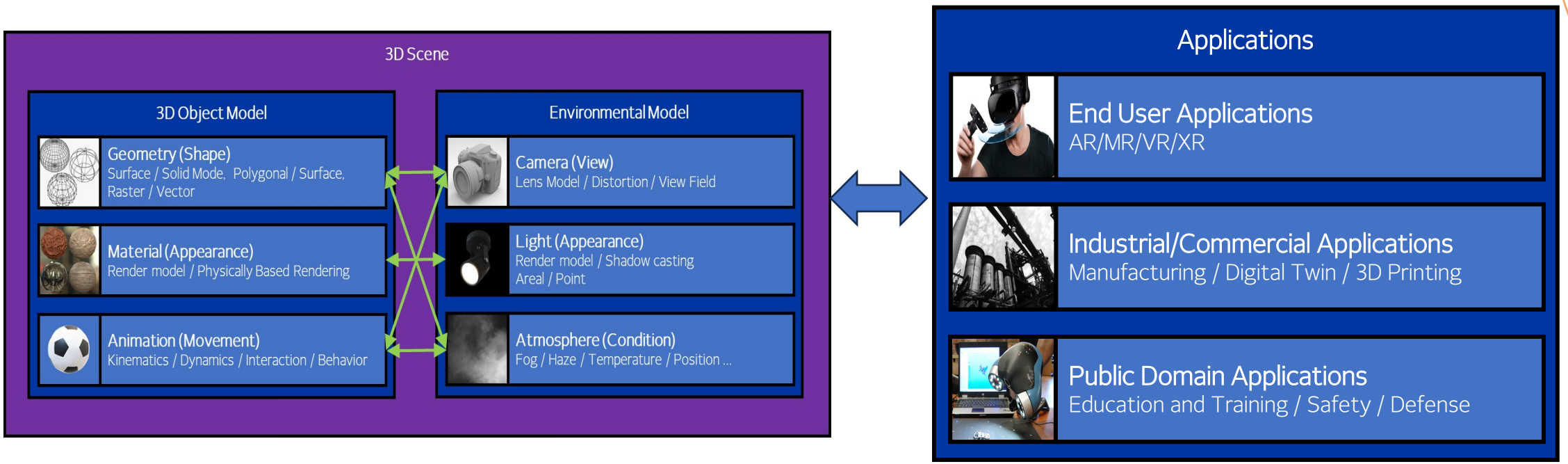
Component of 3D Assets



Creation of 3D Assets



Application of 3D Assets



3D Asset Interoperability is key of success for Metaverse, Digital Twin, Game, AR/MR/XR and ....

Because

Too many workflow, pipelines, tools...

glTF

By Khronos Group, 3D Format Working Group

glTF 2.0 Scene Description Structure

.gltf (JSON)

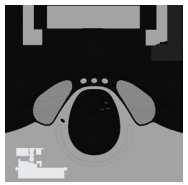
Node hierarchy, PBR material textures, cameras

.bin

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

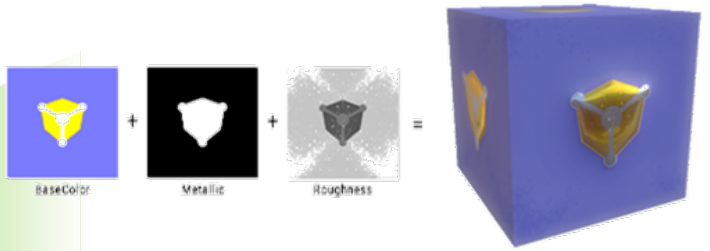
.png
.jpg
.ktx2
Textures

Geometry

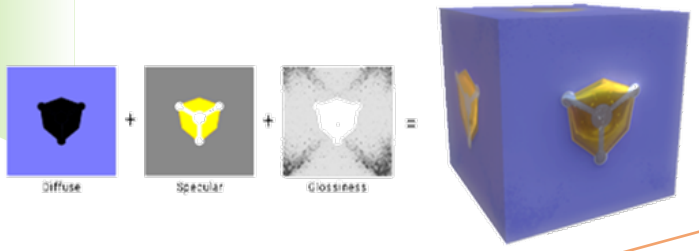


Texture based
PBR materials

Mandatory Metallic-Roughness Materials

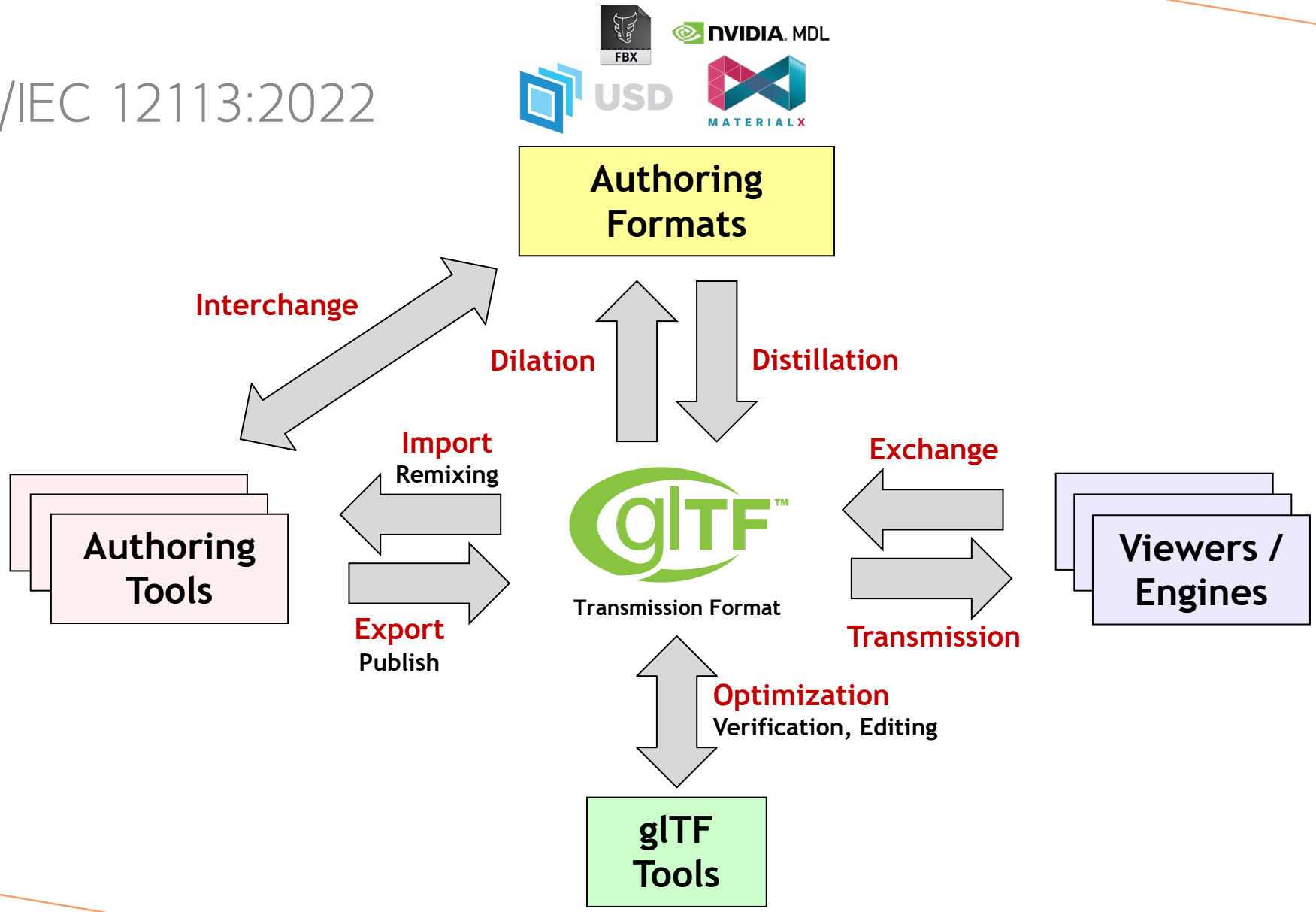


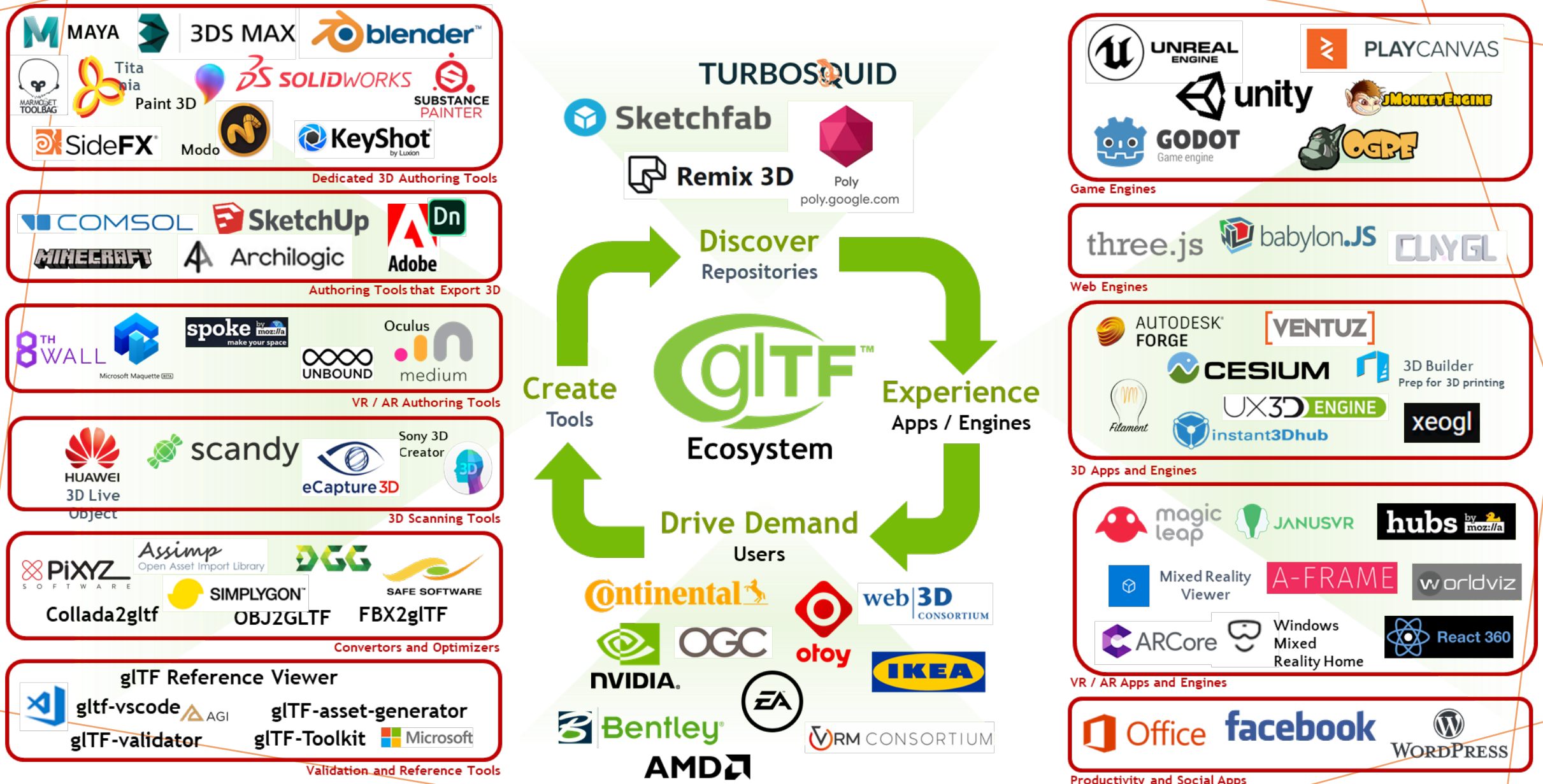
Optional Specular-Glossiness Materials



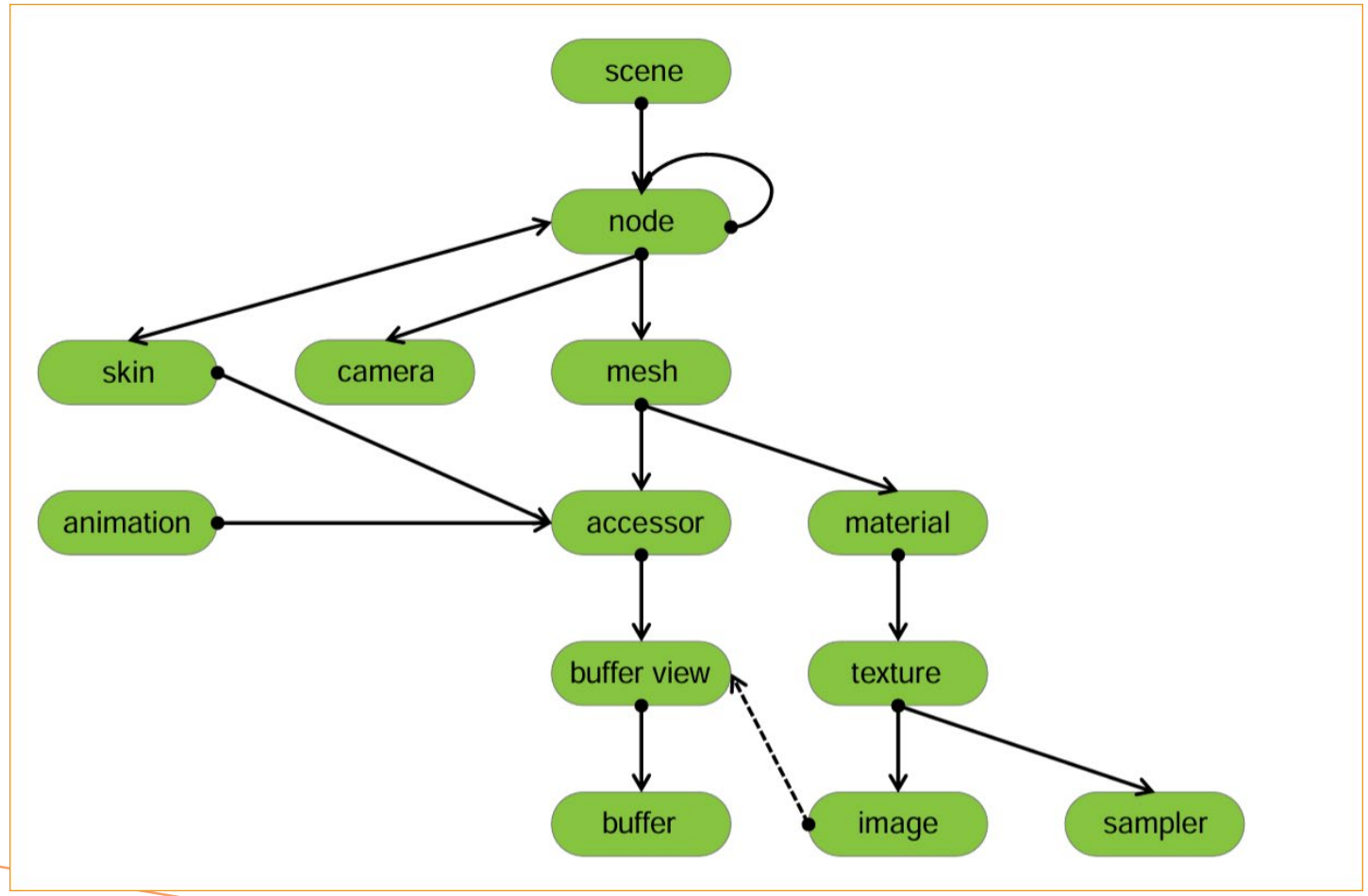
glTF

- ISO/IEC 12113:2022




MAYA
3DS MAX
blender
Tita
nia
Paint 3D
SOLIDWORKS
SUBSTANCE PAINTER
MARMOSET TOOLBAG
SideFX
Modo
KeyShot
Dedicated 3D Authoring Tools
COMSOL
SketchUp
MINECRAFT
Archilogic
Adobe
Authoring Tools that Export 3D
8TH WALL
Microsoft Maquette
spoke
UNBOUND
Oculus
medium
VR / AR Authoring Tools
HUAWEI
3D Live
Object
scandy
eCapture 3D
Sony 3D Creator
3D Scanning Tools
PiXYZ SOFTWARE
Assimp
Open Asset Import Library
SIMPLYGON
DGG
SAFE SOFTWARE
Collada2gltf
OBJ2GLTF
FBX2glTF
Convertors and Optimizers
glTF Reference Viewer
gltf-vscode
AGI
gltf-validator
glTF-asset-generator
glTF-Toolkit
Microsoft
Validation and Reference Tools
TURBOSQUID
Sketchfab
Remix 3D
Poly
poly.google.com
Discover
Repositories
Create
Tools
glTF™
Ecosystem
Experience
Apps / Engines
Drive Demand
Users
Continental
NVIDIA
OGC
otoy
web3D CONSORTIUM
IKEA
Bentley
AMD
VRM CONSORTIUM
UNREAL ENGINE
PLAYCANVAS
unity
JMONKEYENGINE
GODOT
Game engine
OGRE
Game Engines
three.js
babylon.JS
CLAYGL
Web Engines
AUTODESK FORGE
VENTUZ
CESIUM
3D Builder
Prep for 3D printing
Filament
UX3D ENGINE
instant3Dhub
xeogl
3D Apps and Engines
magic leap
JANUSVR
hubs by moz://a
Mixed Reality Viewer
A-FRAME
worldviz
ARCore
Windows Mixed Reality Home
React 360
VR / AR Apps and Engines
Office
facebook
WordPress
Productivity and Social Apps

Scene Graph of glTF



glTF PBR

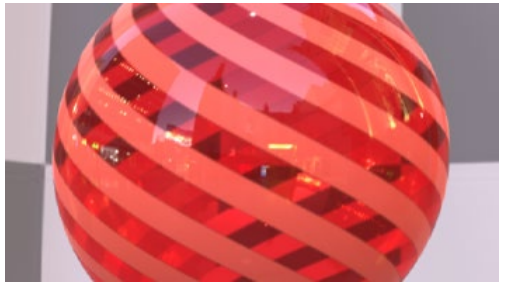
- https://github.khronos.org/glTF-Sample-Viewer-Release/

Metal / Rough

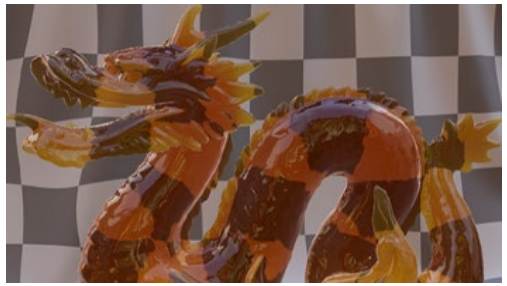
Clearcoat

Sheen

Transmission



Volume

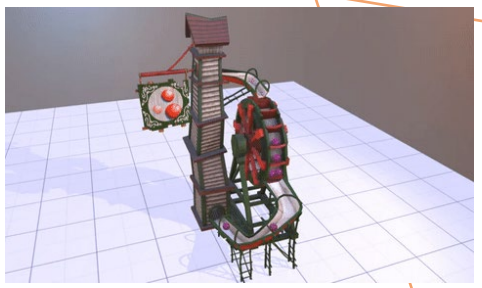


Index of Refraction

Specular

More ...

- Physics - Collision geometry, Motion, Materials, Joints, Filters
- Geospatial collaboration for transmission and display of 3D models, scenes, and interfaces for geospatial applications.
- Compression of mesh and texture
  - Draco - https://github.com/google/draco/tree/gltf_2.0_draco_extension
  - KTX - https://www.khronos.org/ktx/
- Tone mapping - https://modelviewer.dev/examples/tone-mapping

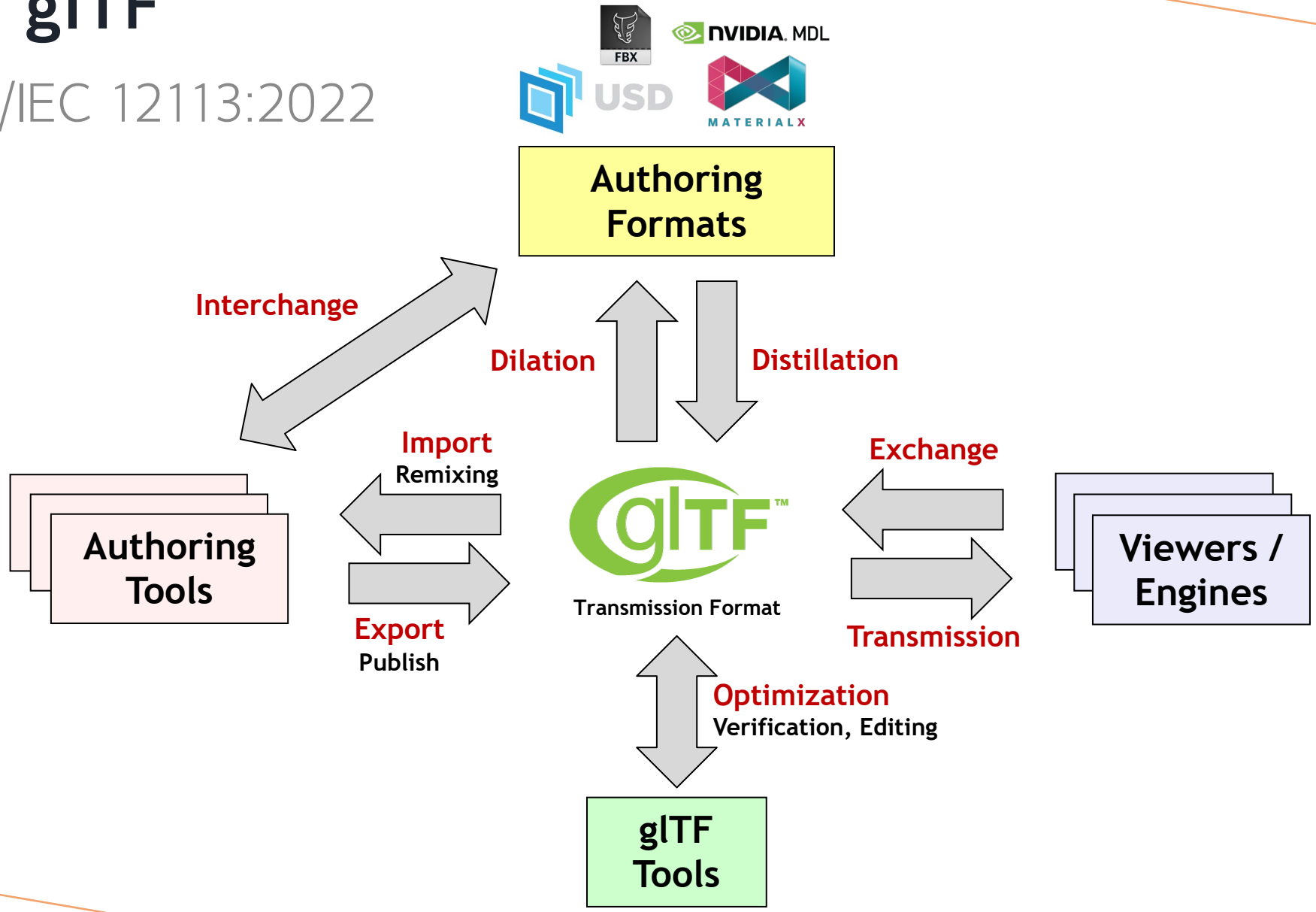


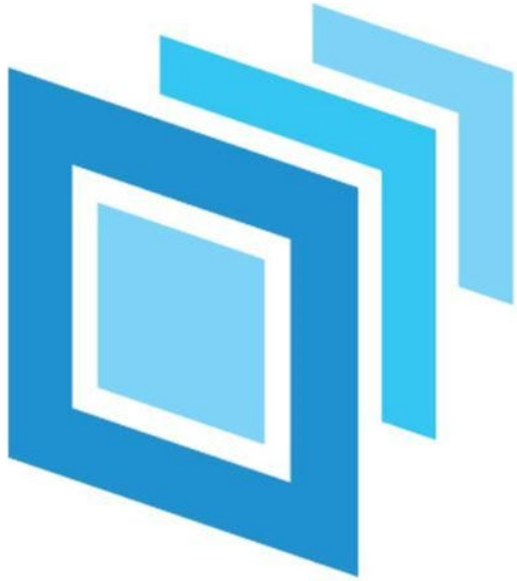
DRACO
3D DATA COMPRESSION

KTX™

Again glTF

- ISO/IEC 12113:2022





USD

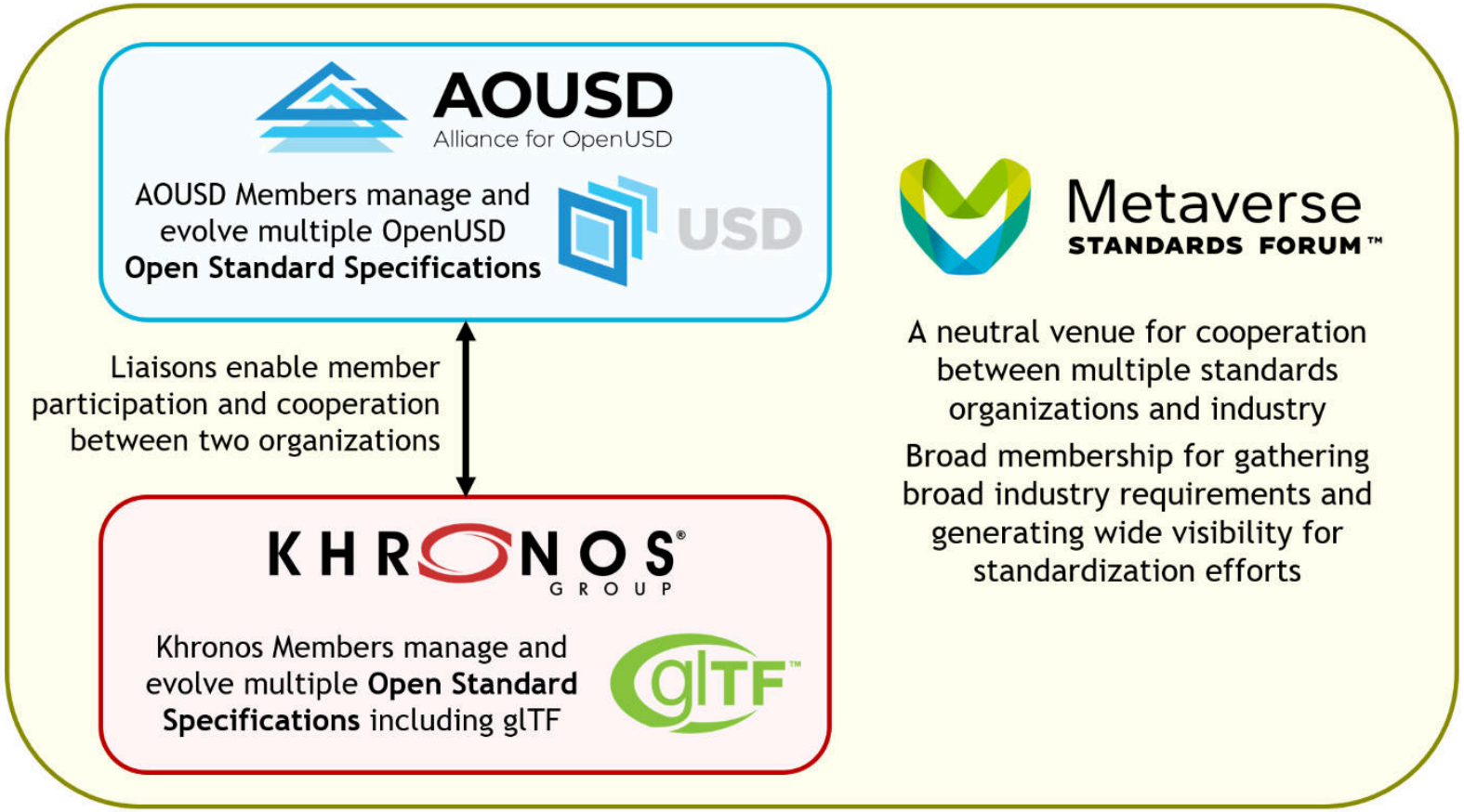
AOUSD

Alliance for OpenUSD

What is USD

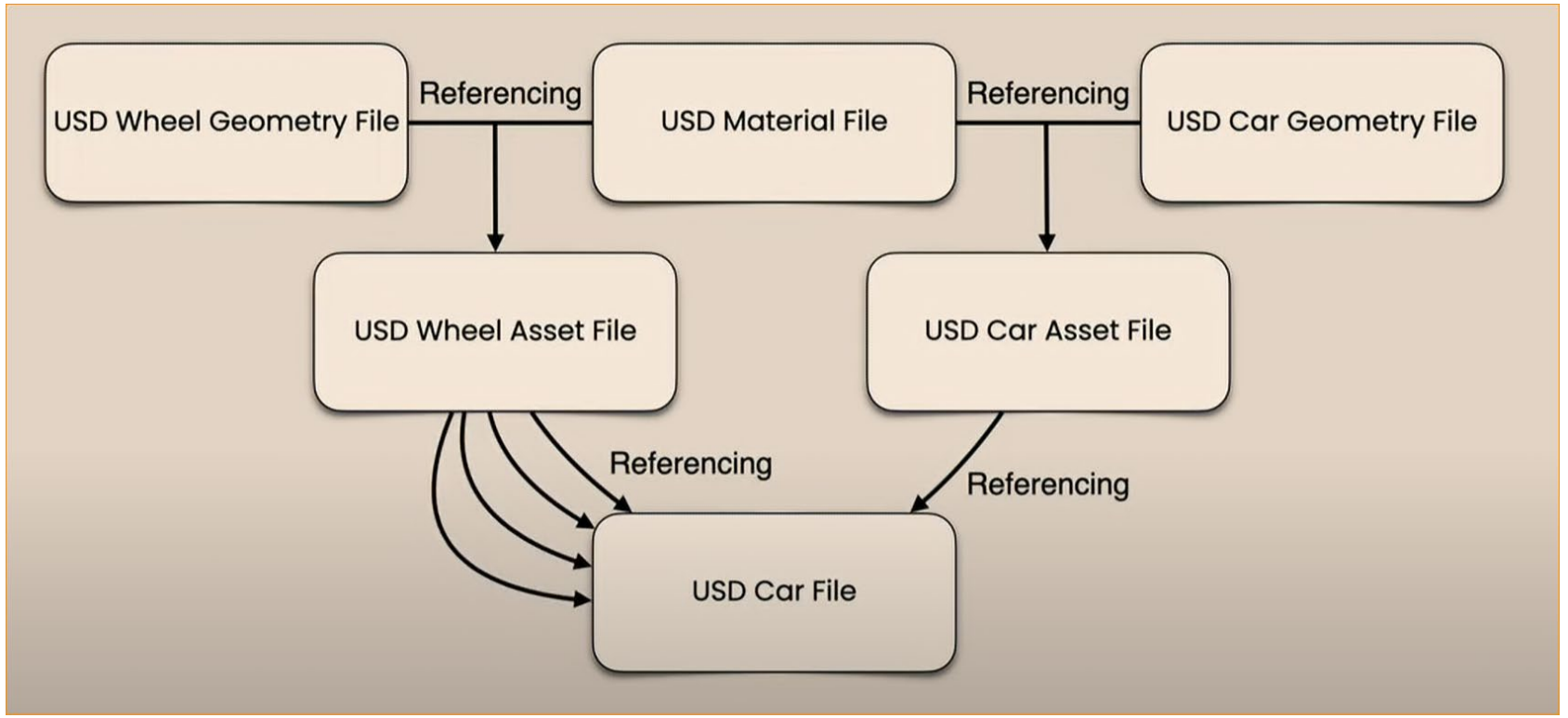
- Universal Scene Description by Pixar
- Open Source Project - OpenUSD (openusd.org)
  - License - Modified Apache License
  - Schema and API's
- Standardization Project - AOUSD (aousd,org)
  - standardization, development, evolution, and growth

Related SDO's



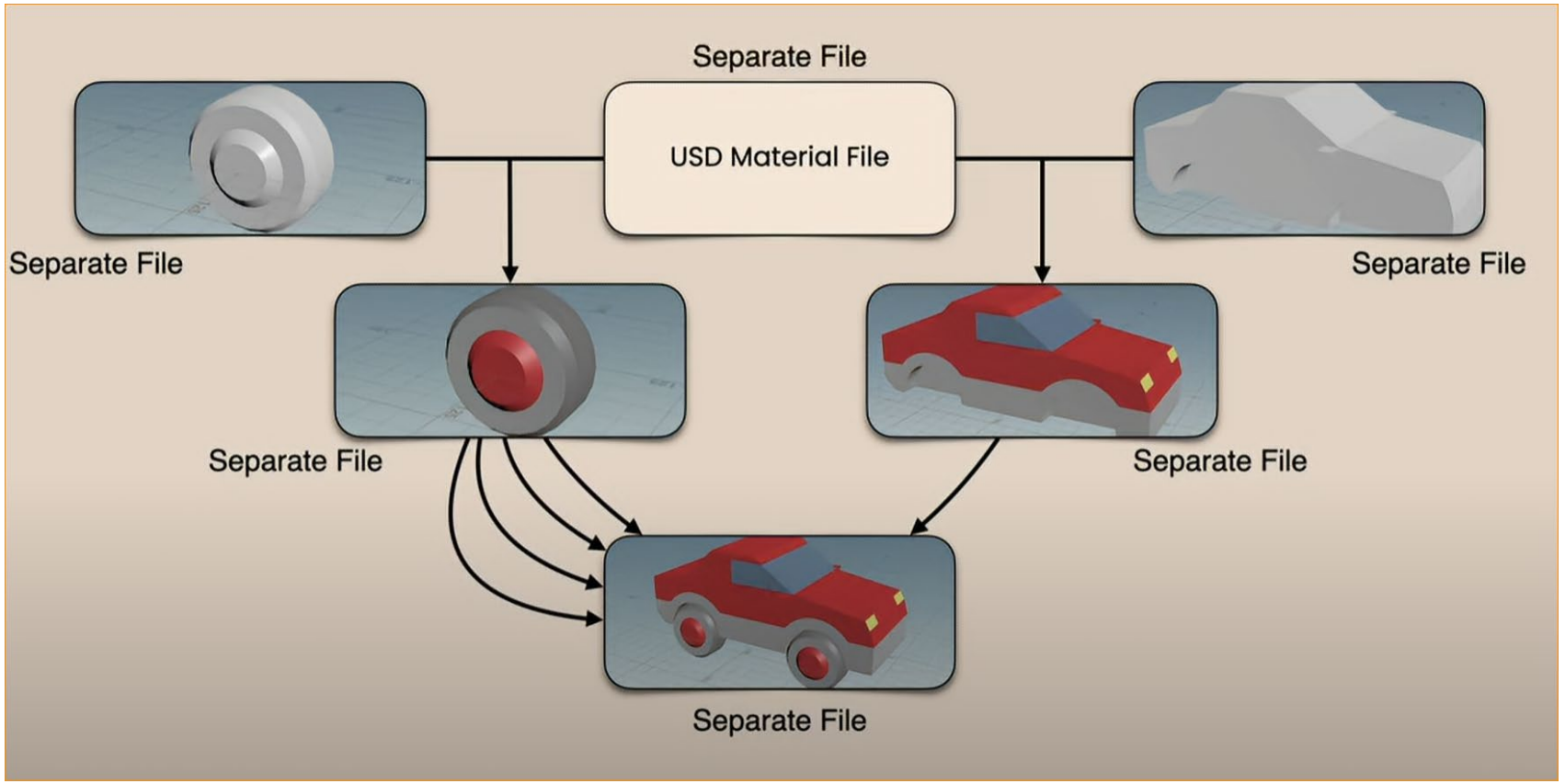
- 3D Asset Interoperability
- Digital Fashion Wearables for Avatars
- Industrial Metaverse Interoperability
- Interoperable Characters/Avatars

Elementary USD



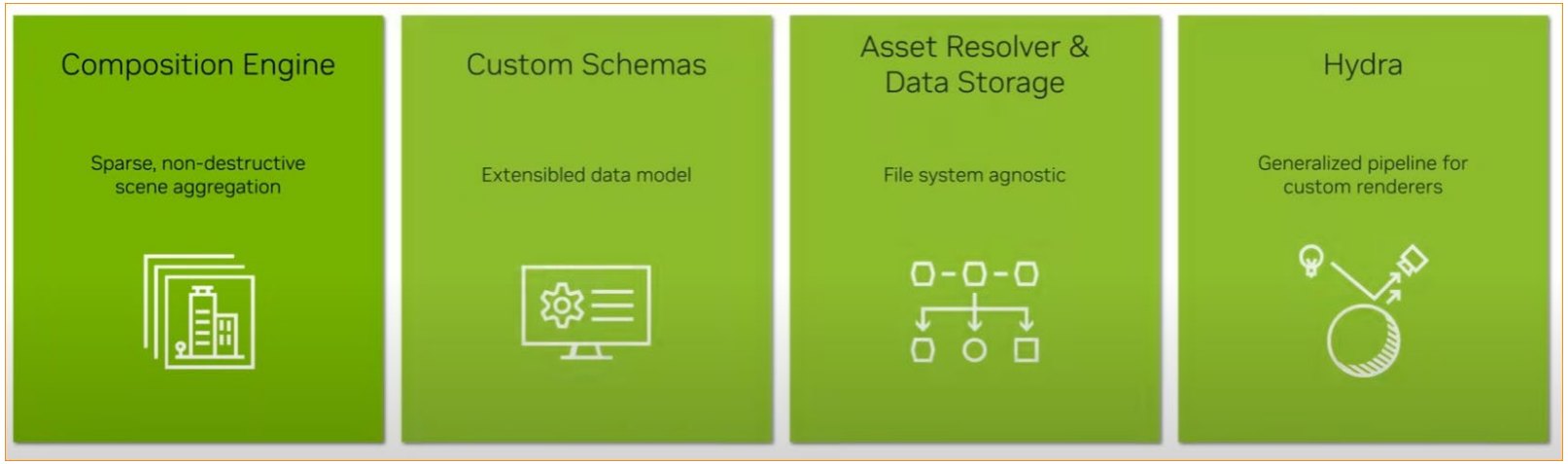
https://www.youtube.com/watch?v=JixC53cQn5U

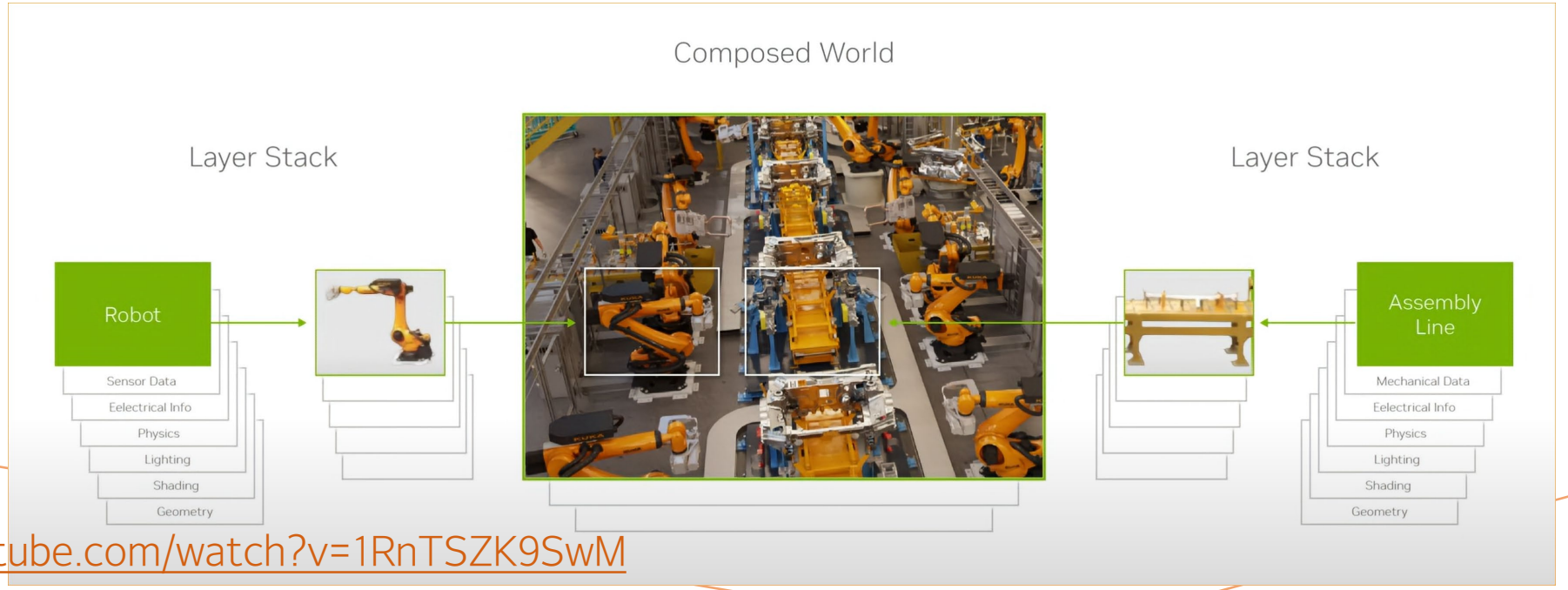
Elementary USD



https://www.youtube.com/watch?v=JixC53cQn5U

USD 4 key features (by NVIDIA)





https://www.youtube.com/watch?v=1RnTSZK9SwM

AOUSD Core Spec. WG

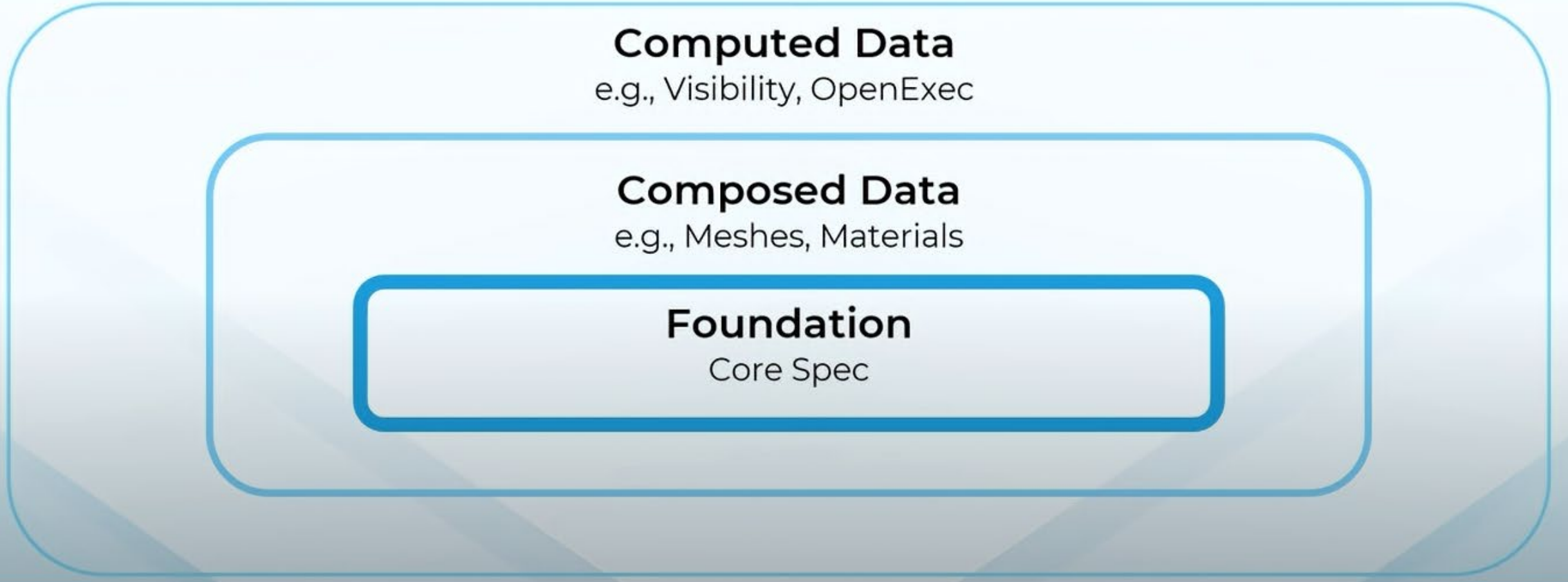
Mission

Core Specification WG

Formalize **foundational data models & predictable behaviors of OpenUSD composition & population** in **normative specifications** as an **international cross-industry standard** for **interop & interchange of aggregate datasets** describing **virtual worlds**

OpenUSD Specification “Layer Cake”

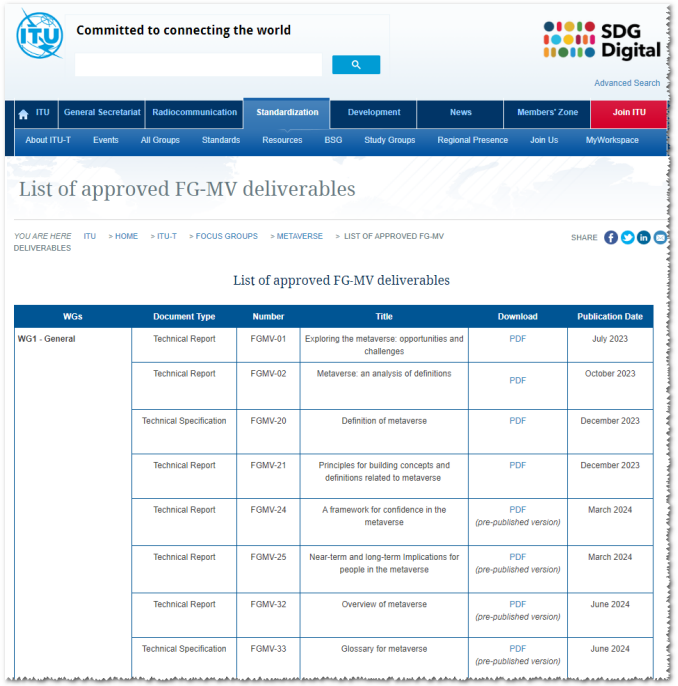
Longer-term Multi-Part Specification Roadmap



Update of MSF

ITU Update

- The ITU recently concluded its Metaverse Focus Group (FG-MV) activities
  - List of approved FG-MV deliverables
- The Forum was invited to present at the closely-related UN Virtual Worlds Day
  - Discussing how to build meaningful standardization cooperation for XR and the metaverse
- Telecommunication Standardization Advisory Group (TSAG) is the parent of FG-MV
  - Meeting on 29 July – 2 August 2024 to discuss the metaverse and FG-MV deliverables
- Landscape and use cases for the industrial metaverse
  - FGMV-37



WGs	Document Type	Number	Title	Download	Publication Date
WG1 - General	Technical Report	FGMV-01	Exploring the metaverse: opportunities and challenges	PDF	July 2023
	Technical Report	FGMV-02	Metaverse: an analysis of definitions	PDF	October 2023
	Technical Specification	FGMV-20	Definition of metaverse	PDF	December 2023
	Technical Report	FGMV-21	Principles for building concepts and definitions related to metaverse	PDF	December 2023
	Technical Report	FGMV-24	A framework for confidence in the metaverse	PDF (pre-published version)	March 2024
	Technical Report	FGMV-25	Near-term and long-term implications for people in the metaverse	PDF (pre-published version)	March 2024
	Technical Report	FGMV-32	Overview of metaverse	PDF (pre-published version)	June 2024
	Technical Specification	FGMV-33	Glossary for metaverse	PDF (pre-published version)	June 2024

Wavefronts of Innovation and Standardization

Metaverse STANDARDS FORUM™

Established products and services

Industry and Academia Innovate

Seeks to encourage and assist standardization opportunities that fall across 'silo boundaries'

Pragmatic cooperation and projects to accelerate availability and testing of interoperability standards

Multiple Domain Groups

3D Assets | Asset Management and Web3
Avatars and Wearables | Industrial Metaverse | Volumetric Media
XR and Portable Immersive Experiences | Web Stack
Real/Virtual Integration | Networking | Privacy, Security, Identity
Ethics | Accessibility | Education

Interop requirements driven by use cases and testbeds

Strong mutual benefit drives industry participation & relevance

SDOs and Consortia Create Standards

Increased market opportunity through leveraging pervasive interoperability

Darwinian experimentation and innovation

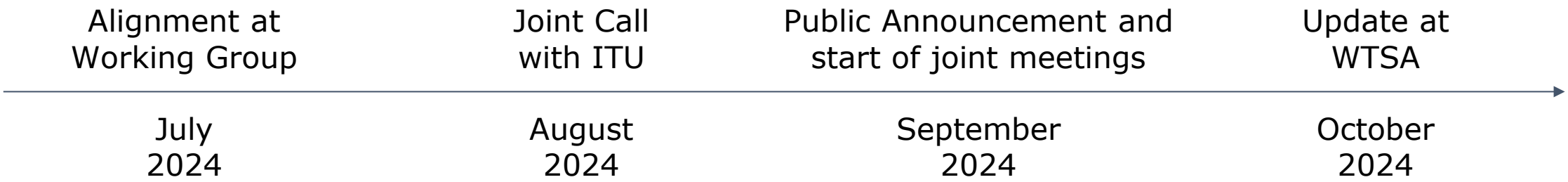
Pre-standardization
Window of opportunity when disruptive technologies become ready for standardization

Standardization and pervasive use of proven technology

Cycle of innovation

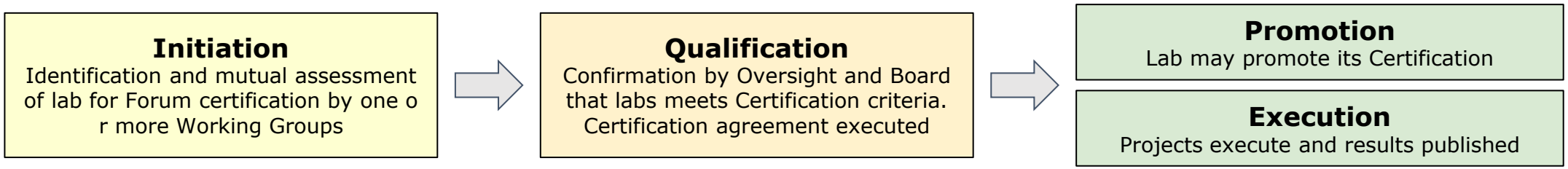
ITU Offer to Collaborate on Industrial Metaverse

- The ITU recognizes that the Forum can be an effective venue to bring real-world industry input into the ITU standardization process that will be highly relevant to the industrial metaverse
  - Pragmatic approach - organize a series of meetings with industry experts
- Explore potential use cases and future technical directions and publish a joint white paper
  - Featuring both Forum and ITU logos on the cover page
- Suggested schedule
  - Joint organizational conference call shortly after TSAG meeting at end of July to discuss the next steps
  - Announce at ITU World Telecommunication Standardization Assembly (WTSA-24)
    - Quadrennial event sets the stage for the ITU-T's study periods - New Delhi, India, from 15 to 24 October 2024
- ITU does not require a formal agreement for this type of collaboration
  - A press release to inform the industry about the joint initiative and encourage wider industry participation



Forum Labs Cooperative Initiative

- Many Forum projects will benefit from cooperation with labs active in metaverse domains
  - Resources and expertise for **practical, tangible, real-world testbeds**
  - **Refine and validate requirements and standards** needed for Metaverse interoperability
  - **Accelerate the application of concepts** captured/developed in Forum Working Group reports
- Offer the opportunity for labs to become Forum certified
  - Relevant expertise, legal entity, interest and ability to contract with the Forum for interoperability projects
- In return - a Forum Certified Lab enjoys multiple benefits
  - Promotion and networking with Forum membership, industry credibility including for grant applications
  - Visibility and industry insights into industry use cases and requirements – not working in a vacuum
  - Ability to apply for Funded projects
- There are already multiple labs interested in pre-funding collaboration
  - 'Cycle stealing' model that has been proven in programs such as Open Geospatial Consortium Testbeds
- Board discussing establishing Lab Certification Working Group to create and initiate detailed processes
  - For refinement and approval by the Board and Oversight - **reach out if you would like to be involved**



Forum Domain Groups

Metaverse STANDARDS FORUM™

3D Interoperability

glTF/USD 3D Asset Interoperability
Cooperation between USD and glTF to increase synergy and reduce duplication of effort, gaps, fragmentation

Interoperable Avatars
Cross-platform avatars and characters for film, gaming, fashion and social platforms

Digital Fashion/Wearables
Clothing (including layering), shoes, hats, accessories

Volumetric Media Interoperability
Capture, transport and display

Digital Twins and Geospatial

Real/Virtual World Integration (Digital twins, IOT)
Constructs to describe and integrate the physical world and created representations

Industrial Metaverse
Enabling collaboration between geographically dispersed teams through virtual environments, expert avatars, digital twins, data visualization, AR/VR and the emerging concept of Shared Reality

Key

Working Groups

Exploratory Groups

Exploratory Group Proposals

Domain Group activities on Forum Public Web Page
Domain Group pipeline on the Member Portal Wiki
Domain Group Charters on the Member Portal

Ecosystem Navigation and Discovery

Metaverse Standards Register
Publicly available database mapping the landscape of metaverse-relevant standardization activities, organizations, standards & specifications, use cases, and terms

Mapping Virtual World Platforms
Understanding of the evolution and trajectory of the upcoming Metaverse

Metaverse Ontology
Discuss/formalise Metaverse sector-specific words / meanings and define the relationships between them.

Technology Stack

Network Requirements and Capabilities
Industry requirements for seamlessly transitioning traffic on multiple wireline and wireless technologies for deploying metaverse applications at scale

3D Web Interoperability
Enable the broadest possible interoperability of Metaverse Content using the Web

XR Device Interoperability
Establishing a platform for facilitating the discussion between identified stakeholders and working on identifying and recommending solutions to XR ecosystem issues to help accelerate the time-to-market, performance, and usage of XR experiences.

Base interoperable communication layer via IPSME
When two disparate systems want to speak with each other, there needs to be at least a fundamental basis of communication to start negotiation.

Distributed Web3.0 Services requirements and capabilities to support Metaverse applications
Aims to drive the rapid adoption and success of Web3.0 Metaverse applications. By providing essential infrastructure, tools, and protocols, these services enable the creation of scalable, interoperable, and feature-rich applications.

Legal

Asset Management (web3, protection, digital rights)
Digital rights, protection, portability, access, availability

Privacy, Cybersecurity & Identity
Recommendations for responsible innovation that mitigates human and societal harm from objective and subjective privacy risks – including cybersecurity and identity risk management

Ethical principles for the metaverse and its implementation
Define a set of ethical principles and an implementation methodology for the development, use, procurement and commercialization of the metaverse

Ownership and Identity
Decentralized identify and ownership

Use Case Verticals

Metaverse Use in the Real Estate Industry
How Metaverses can be used in the real estate industry

Urban Design & Development
The Urban Design and Development involve large but localized community and stakeholders along designated areas and corridors to organize, manage, operate, regularize and optimize the interactions. The stakeholders include Property Owners, Architects, Planners, construction companies, service providers, AEC professionals, traders, manufacturers, supply-chain etc.

Engagement and Education

End-User Technical Troubleshooting
Enabling end-users to ensure reliable metaverse experiences

Metaverse Educational Register
Using the metaverse for education

Accessibility
Ensuring the metaverse is accessible to all

Metaverse
STANDARDS FORUM™

Back-Up

XR Device Interoperability

Exploratory Group Proposal (circulated for review on 2/7, updated 3/13)

Feedback channels:
Draft Exploratory Group Proposal
Exploratory Group Brainstorm Sheet
Discord Channel

- **Current status**
  - Exploratory Group proposal refined based on input from Plenary #10 & Oversight #27
  - Conclusion from MSF Chair meeting (3/27) is to start with exploring two focus areas (see next slide):
    i. API Stack Interoperability
    ii. Experience Portability

- **Next Steps**
  - Propose to send XR Device Interoperability to Exploratory Group Proposal
  - Investigate the focus area for vertical stack
  - Investigate the experience portability friction as seen by Developers via Survey
  - Engage with XR Device OEMs and cross device solution providers to poll interest in becoming co-proposers
  - Get general MSF member feedback via Discord channel
  - Report progress in next Plenary

XR Device Interoperability Exploratory Group: Focus areas

XR Exploratory Group Proposal

Legal and Eco system

Experience Dis covery

Location-based services

Real/Virtual

XR Privacy a nd Security

PCI

XRSI | XRA

XR Health a nd Safety

XRA

API Stack Intero perability

Web Engines (e.g., WebXR)

3D Web

W3C

Native Engines (e.g., Unity)

Native APIs (e.g., OpenXR)

Khronos

XR Devices

Experience Portability

System/Device capabilities

Networking

CTA | AREA

Interaction and HMI

Real/Virtual World Integration

3D Asset Imp ort

3D Assets

Avatar Import

Avatars

Methodology

Use Case Dev elopment

Register

AREA

Developer Sur veys

Register

Invited Speak ers

Whitepapers and Reports

Organizations and Working Groups

SDOs

W3C | Khronos | Web3D
Spatial Web | OpenAR Cloud
NIST | ISO | IEEE | OGC

Advocacy

Area | XRA | CTA
XR Guild | XRSI

Forum WGs

Register
3D Assets | Avatars
3D Web | Networking
Real/Virtual | Industrial MV
PCI

Companies

Meta | Qualcomm | HTC | Apple …
Epic | Unity …
ManageXR | VMWare | ArborXR …

1 *Vertical Stack WebXR-OpenXR*

2 *Experience Portability: Run survey about de veloper friction to evaluate focus area.*

3 *Co-Proposer(s) active in XR Devices (OE M or cross device solution providers)*

Metaverse Education Exploratory Group

Education and training in the Metaverse are becoming vital for many organizations

Review & Comment on the Group's Charter

Mission

Compile information from diverse sources to inform stakeholders about the current **landscape of Metaverse education** - best practices, challenges, and emerging trends

Generate insights and action on how educational content could be presented, stored, and taught within this new environment

Next Meeting

8am PDT on April 4th 2024

Volumetric Media Interop Exploratory Group

Draft Working Group Charter

Because of the widespread interest and isolated initiatives, the volumetric media ecosystem is becoming fragmented

Building understanding on various volumetric media solutions would be beneficial for the industry to try and identify possible interoperability points between different systems or contribute to harmonizing them. Establishing a platform for facilitating the discussion between multiple SDOs and industry forums as well as working on identifying and solving interoperability issues w ould help accelerate adoption of volumetric media services.

Exploratory group status and timeline

- ~~WK 8: First EG call - introductions~~
- ~~WK 10: Agreement on ways of working~~
- ~~WK 12: First draft of WG charter - Initial definition of volumetric media agreed~~
- ~~WK 14: Volumetric Format Association + Definition of volumetric media agreed~~
- ~~WK 16: Moving Pictures Experts Group + Representation formats agreed (non-exhaustive)~~
- ~~WK 18: Streaming Video Technology Alliance + Full WG charter review (ready for initial oversight review)~~
- WK 20: 5G Media Action Group + Addressing Oversight feedback
- WK 22: Final WG charter review
- WK 24: External SDO views
- WK 26: Approved WG charter and setting up WG

Get involved:

Join the Volumetric Media Interop Expl oratory Group in the Portal

Next Meeting:

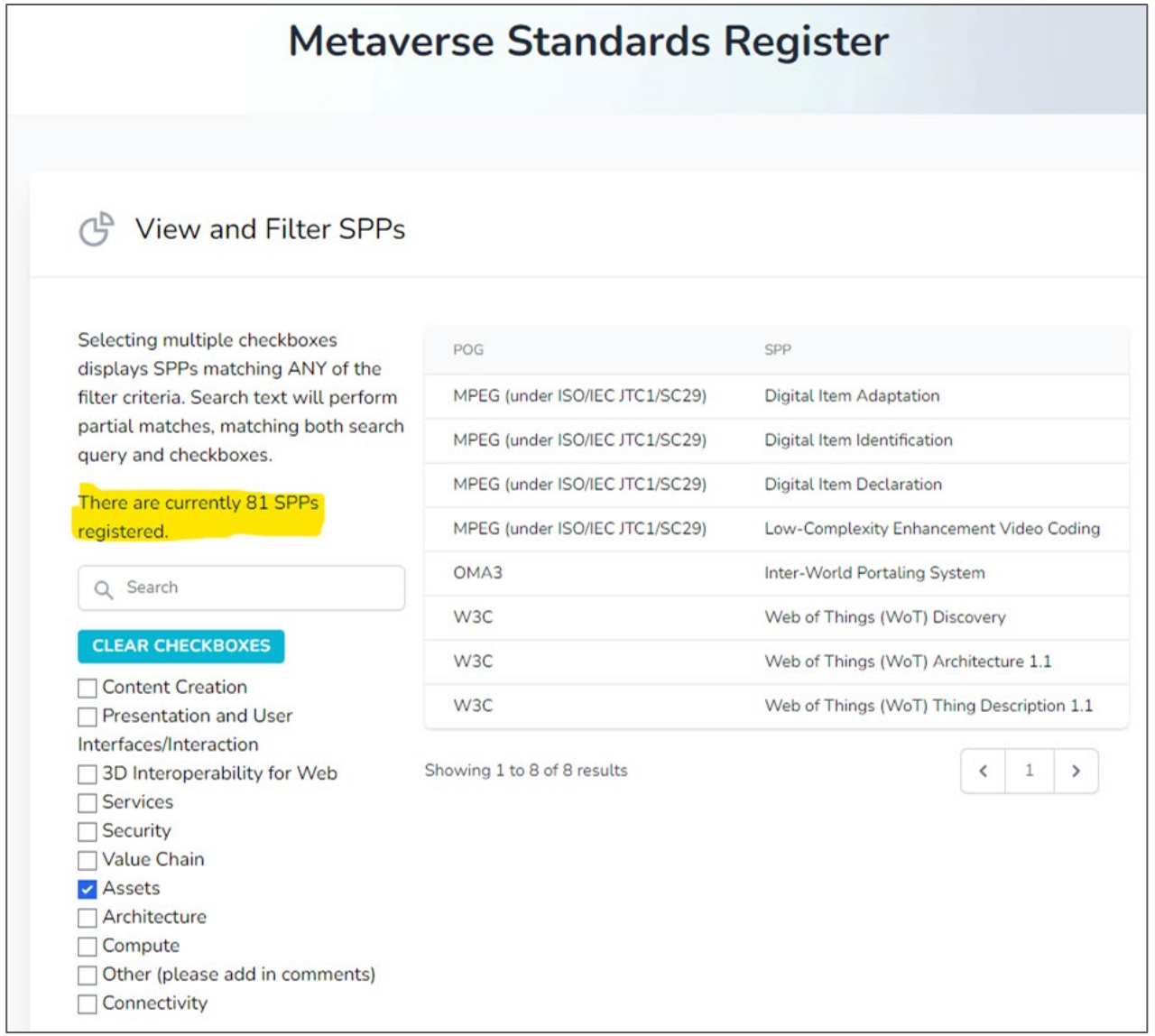
7am PDT on May 16th 2024

Volumetric media is a technology, which enables capture of an obje ct or scene in three dimensions and its playback independent from t he original capture position(s) or orientation(s)

Standards Register WG

Please help ensure standards organizations that are relevant to your mission have applied to submit information about their Standardization Publications and Projects

- Domain WG Website
- Register
  - Organizations (POG)
  - Specifications (SPP)
- Beta version is available
  - Uses Github workflow
- Ongoing work (with James)
  - Development of managed CRUD workflow
  - User management
  - Creation of indexing
- Other ongoing work
  - Use Cases
  - Glossary



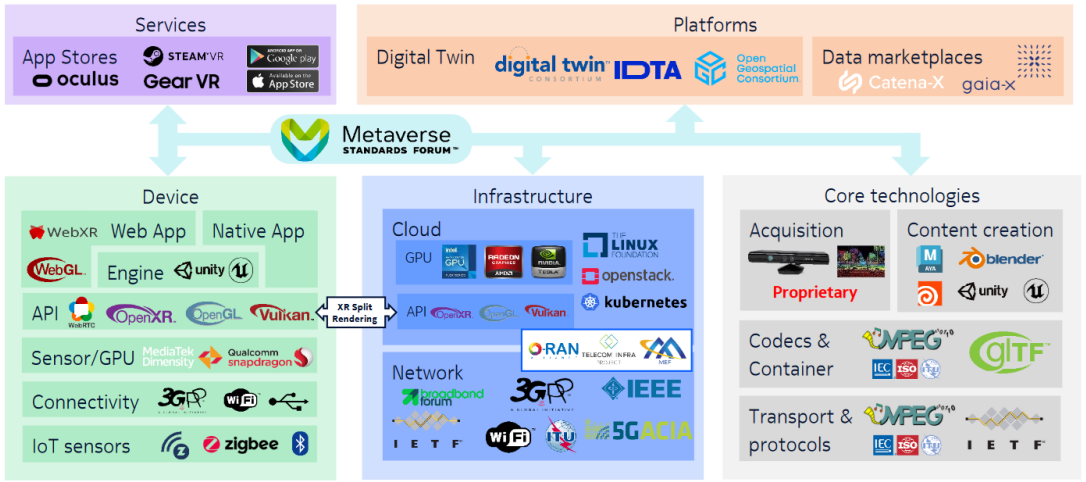
Industrial Metaverse Working Group

Working Group Charter

- Chaired by Siemens and NVIDIA - **meetings have started (every Tuesday)**
  - Multiple Sponsors - Bosch, Nokia, exxar.cloud, Perey consulting
  - 2 sub groups (IMv use cases and definitions) were set up to work focused on planned key deliverables
- Industrial Metaverse has the potential to enter the mainstream earlier than consumer applications
  - Immediate/clear return on investment
  - Favorable cost/benefits trade off through increased safety and productivity, etc.
- Industrial Metaverse is wide in scope
  - Requires multiple value chain players to be involved (device, applications, platforms, networks, etc.)
- Identifying use cases and minimal interoperability requirements

The Metaverse Standards Forum is Uniquely Positio ned to enable industry-wide cooperation

Multiple standards-related organizations:
Catena-X, Gaia-X, Manufacturing-X, Digital Twin Consorti um, IDTA, Open Industry 4.0 alliance,
OPC Foundation …

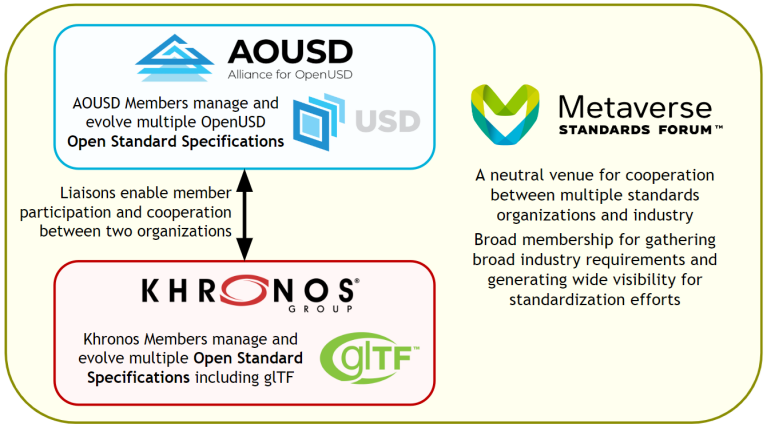


glTF USD Asset Interoperability Working Group

- Meeting every other Wednesday at 11AM PT - including today
  - Including diverse industry expert speakers
- Encouraging cooperation between USD and glTF
  - Leveraging each others strengths and ecosystems
  - Avoiding friction points through needless divergence and avoiding duplicated effort
- Roadmap Alignment discussions
  - PBR Materials | Physics | Subdivision surfaces | Interactivity

Proposed glTF/USD Roundtripping Project
Creating test assets and exercising tools and engines gene rates real-world insights and encourages standards cooper ation and alignment between key asset formats

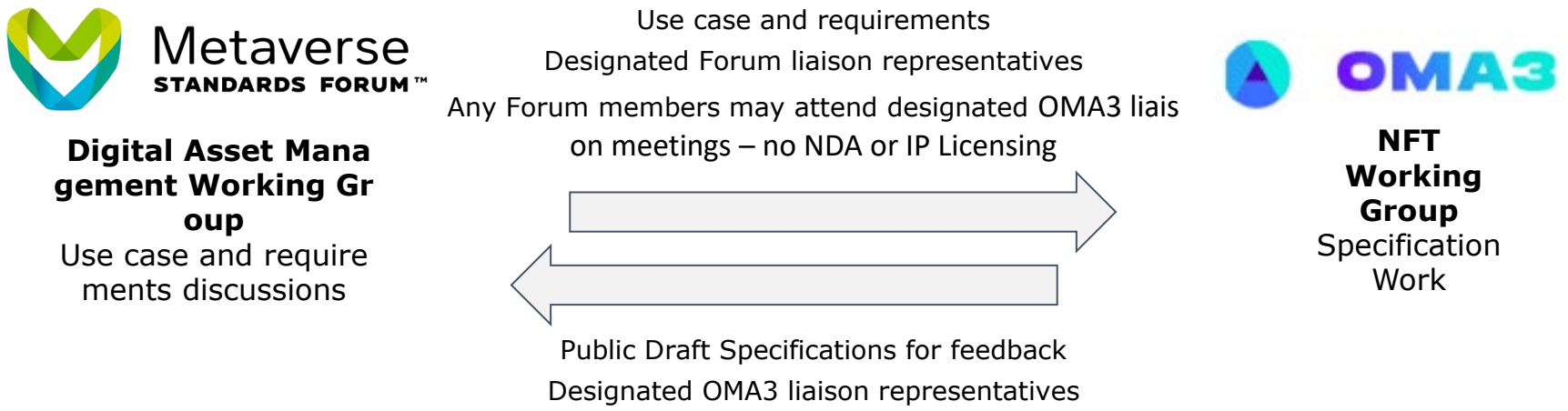
FBX Transition Project
Studying how glTF and USD can evolve to satisfy use cases curre ntly requiring FBX



AOUSD/Khronos Liaison Announcement

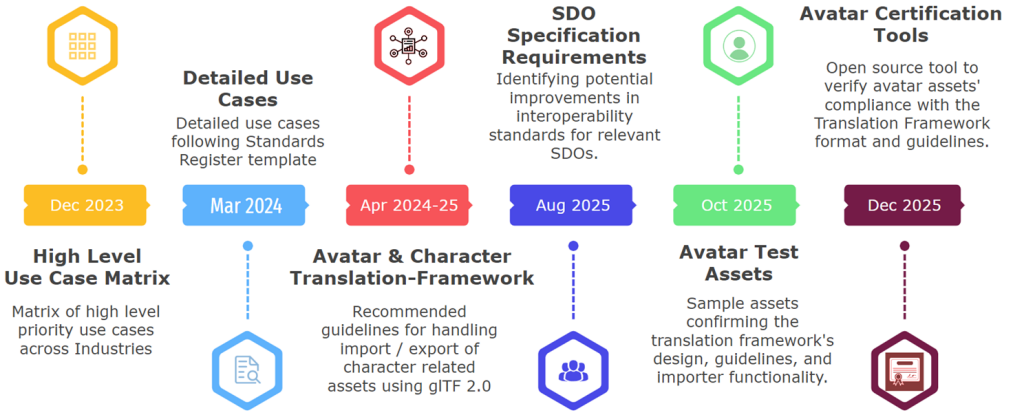
Digital Assets Management Working Group Update

- OMA3 has initiated an NFT Working Group
  - The first project is to create a framework that will solve the NFT royalty problem
  - The first step in the OMA3 process is to define use cases
- OMA3 and the Forum have started collaboration on developing use cases
  - Leveraging the Forum / OMA3 Liaison - more details from OMA3 perspective
- This work falls under the Digital Asset Management Working Groups Charter
  - Meetings have already started - every other Thursday - details in the Forum Calendar
- Both organizations encouraging joint membership in the other



Interoperable Characters/Avatars Working Group

Encouraging non-invasive cooperation between platforms and frameworks to create guidelines and frameworks to enable character/avatar interoperability



[Working Group Activity Summary]

[Educational Session Highlights]

including updates from Roblox, Second Life, VRM, Snapchat and Pixar

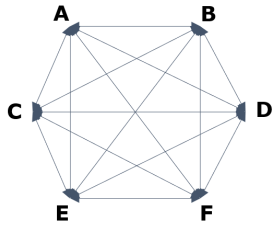
Hideaki Eguchi
Working Group Chair
VRM Consortium

Zeno Saviour
Working Group Chair
Character Labs

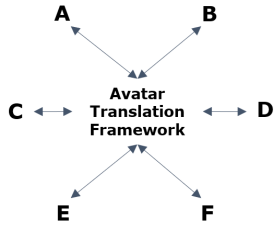
Priscilla Angelique
Working Group Chair
Creative Technologist

Use Case Matrix

Multiple Avatar Tools and Platforms



Before
Each tool or platform must import or export every other proprietary avatar format



After
Each tool or platform can import/export using a single agreed asset format and guidelines

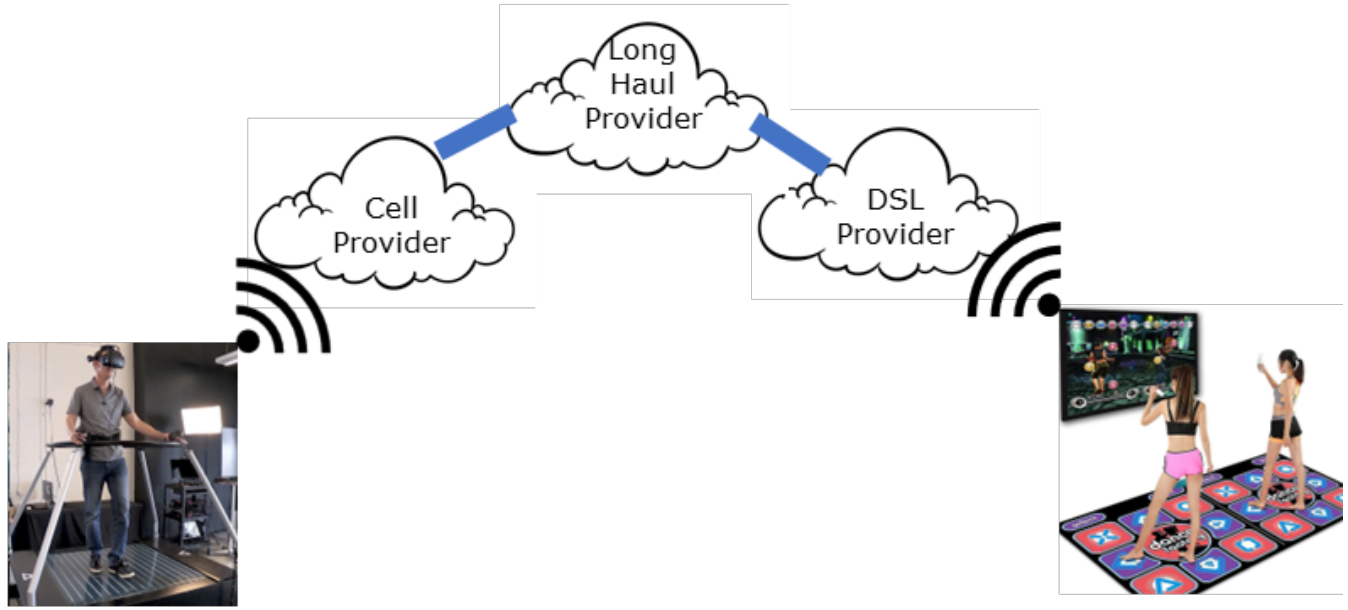
Avatar Translation Framework

Guidelines and tooling for handling import and export of meshes, materials, skeletons, animations, physics, and metadata enables interoperability and encourages platform alignment

End User Technical Troubleshooting WG

Parts to be managed include, but are not limited to:

- Metaverse Environment (underlying cloud infrastructure)
- VR goggles
- Headset/Bluetooth audio
- Avatar repository or other 3rd party avatar tool being used for cross network consistency
- Consoles / platforms / Mobile phone / operating system
- In house networks (Wi-Fi, ethernet, Bluetooth, etc.)
- Carrier network (Cellular, DSL, Fiber, Cable, etc.)
- Long haul network (between carriers/countries)



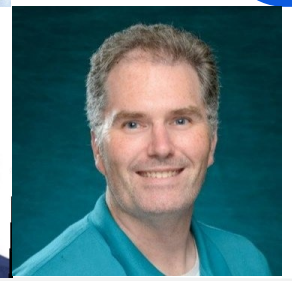
PCI and DAM | Reputation in the Metaverse

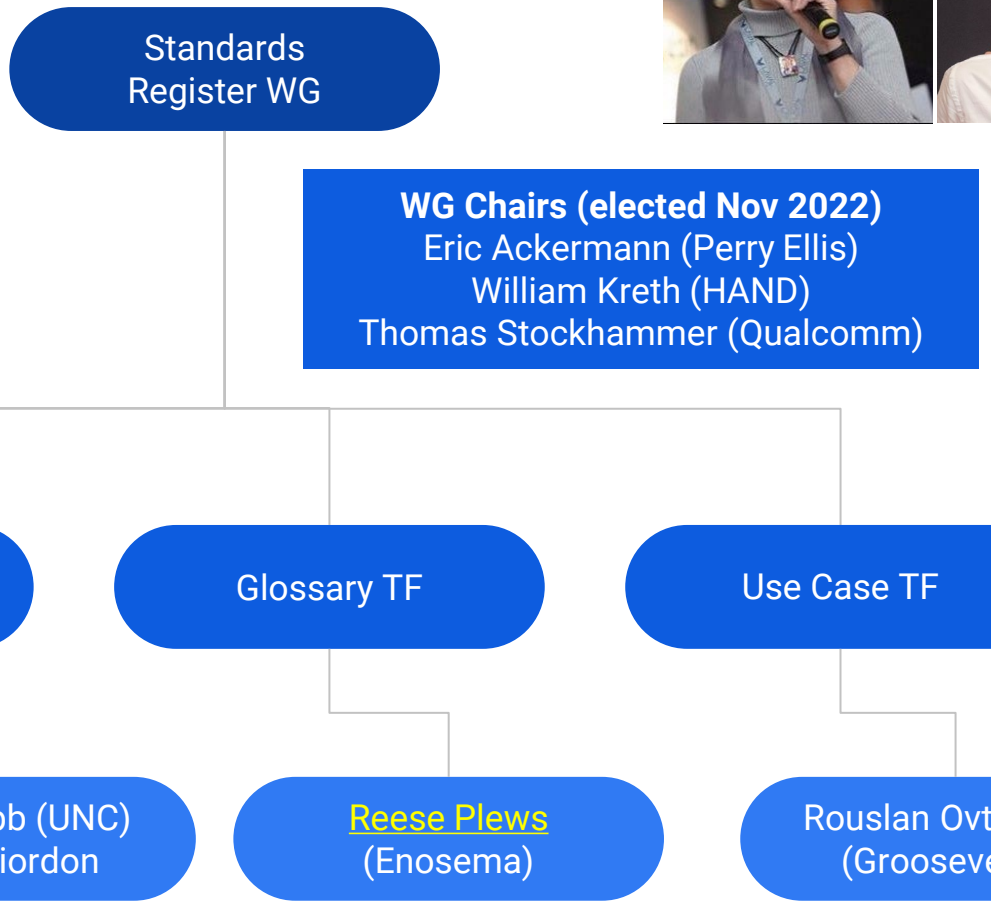
- Sharing reputation is an important part of enabling the open metaverse
  - Helps users trust if they can see an avatar's reputation
  - Helps users differentiate between humans and AI
  - Helps platforms identify bad actors
  - If metaverse KYC/AML becomes a requirement, need to easily share "Verified Credentials"
  - Used in OMA3's IWPS to give users more information on teleportation to other worlds
  - Used in OMA3 to track member contributions
- Can we build an interoperable reputation system that works for all types of platforms?
  - Centralized and decentralized
  - Web2 and Web3
  - Portable across platforms or tied to a platform
  - Humans, machines, and AI
  - Private and public data
  - User permissions vs platform permissions
- Unanswered questions
  - Cross WG cooperation as Identity is a critical part of reputation and part of the PCIWG charter
  - Cross SDO cooperation with DIF, W3C, OMA3, Lumian Foundation, etc.
  - OMA3 and Lumian Foundation are committed to standardization of reputation. Others?

Standards Register - Who and how?

- **WG Calls:**
  - Bi-weekly calls Tuesday 7am pacific
  - We just completed strategic review
  - Typical attendance between 15 - 25 people
  - Supported by Kendra Casper (thanks)
- **Task Forces**
  - report into Standards Register WG
  - All task forces are open to all members
  - get mandates for deliverables
  - Work organization up to the leader



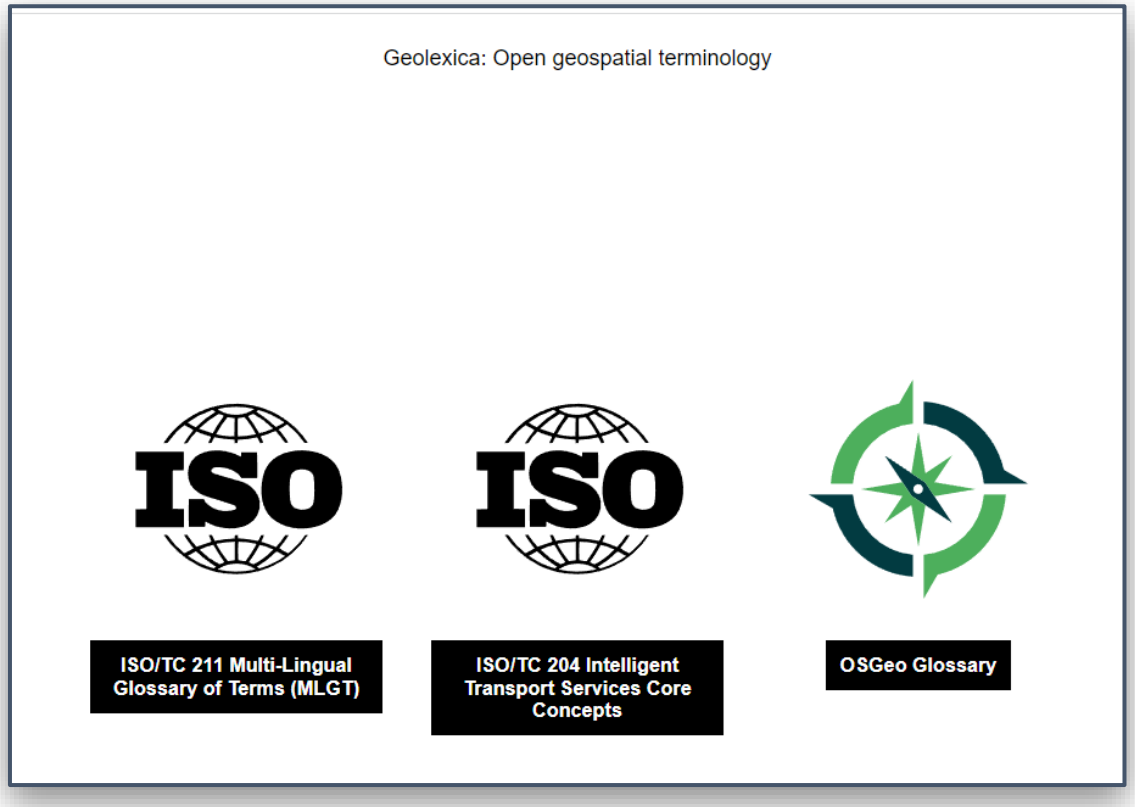


MSF Glossary - Internal / External

INTERNAL

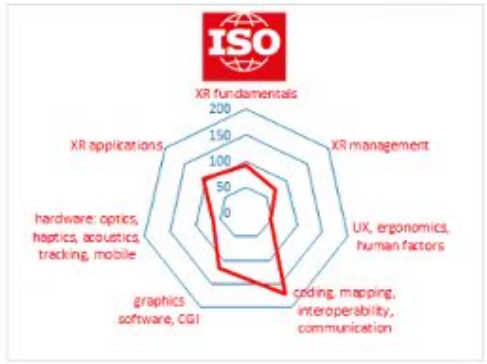
MediaWiki

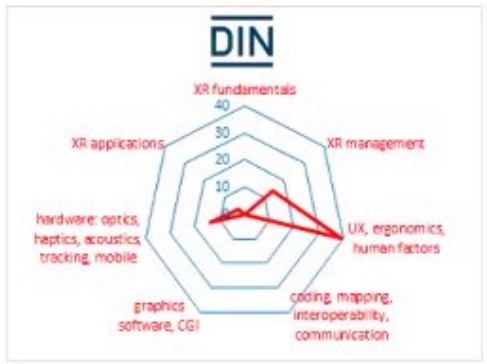
EXTERNAL

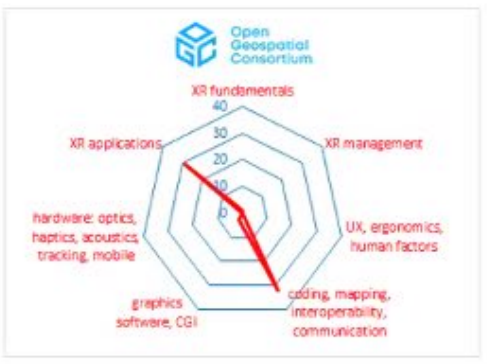


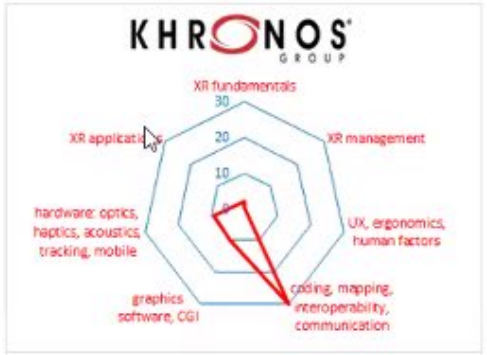
Presentation Christoph Runde - VDC

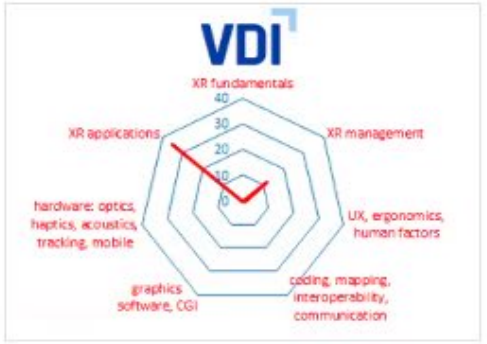
Focuses of XR standardization organizations varying











3D Web Interoperability Working Group

Enable the broadest possible interoperability of Metaverse Content using the Web

Working Group Meeting - Thursdays @ 8am PT Bi-weekly - We welcome you to join us and participate!

GOALS

Asset Interoperability: Drive Interoperability of networked 3D assets

Tooling: Document how to Enable mixed-use of a diversity of asset formats in a single virtual world

Browser Capabilities: Encourage Browser capabilities to support 3D experiences

Networking and the Internet Protocol Stack: Explore if Networking services or Internet Protocol Suite need upgrading

DELIVERABLES

Scenario/Use Case - Build Use cases

Technology Pattern Inventory - Document Technology patterns

Gap Analysis - Create a catalog

Research and Experimentation - Initiate test bed projects

Forum Domain Group Coordination

Collaboration with other Forum Domain Groups, Capturing potential shared interests. Table

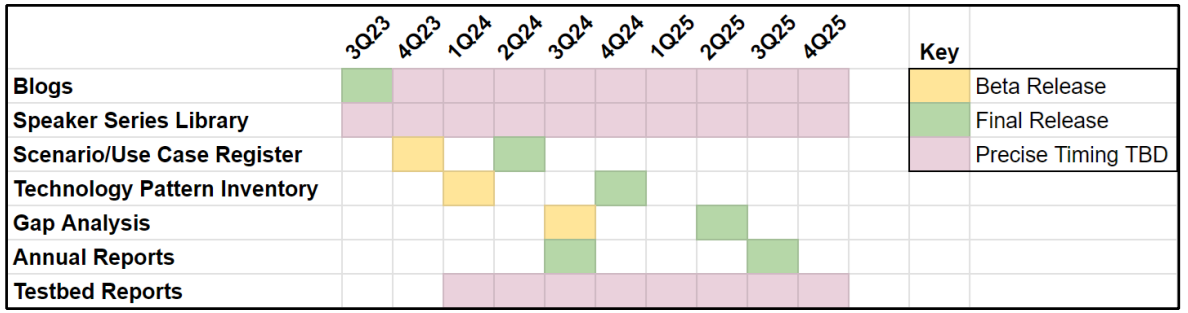
Key Standards Organizations

Active participation of key SDOs, and others that have interest in the Working Group mission. World Wide Web Consortium, Khronos, Web3D Consortium, Open Geospatial Consortium, IEEE, MPEG and others

PROGRESS

Release staged deliverables to demonstrate sustained progress and build increased interest and participation while building consensus

TIMELINE



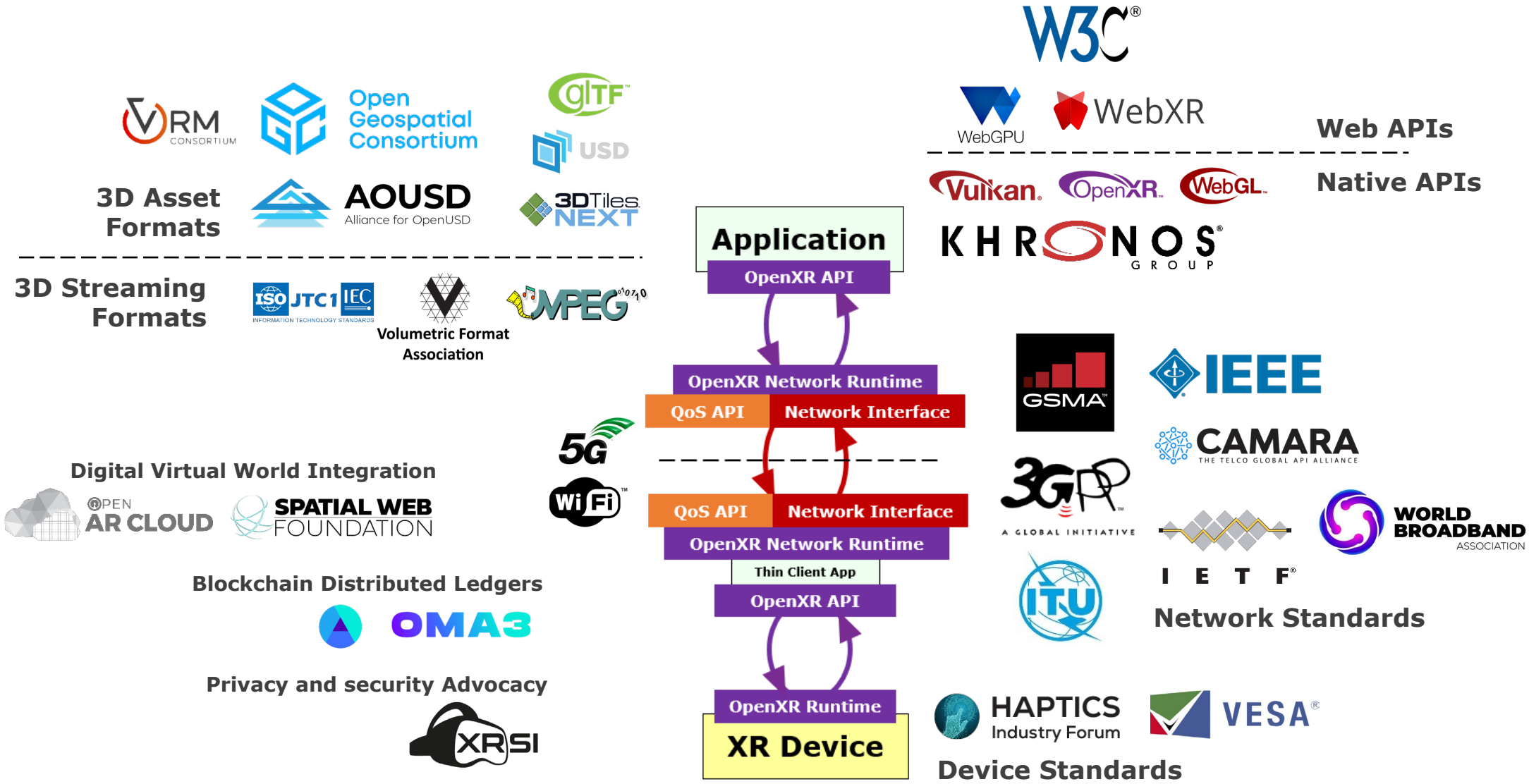
Network Requirements and Capabilities Working Group

Developing industry requirements for seamlessly transitioning traffic on multipl
e wireline and wireless technologies for deploying
metaverse applications at scale

208 Members including

And a developing liaison with 3GPP A GLOBAL INITIATIVE

A Constellation of Standards



Real/Virtual World Integration

Members and Meetings

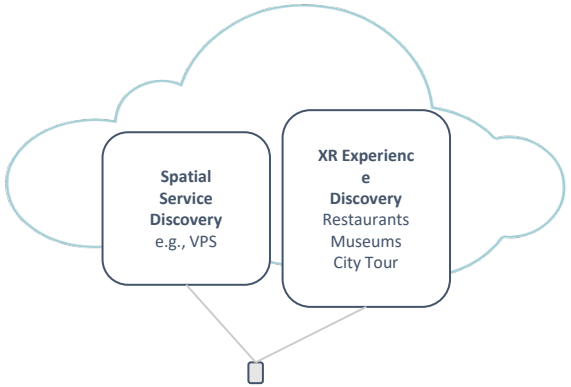
- How many? 534
- When & where? Meeting every other Thursday via Zoom at 10AM PT

Current Topics

- Ride Hailing Use Case
  - OGC data collection
  - Top-level Results: Architecture
  - Inter-Service Results: Interfaces/Message Content
  - Low-level Results: Algorithm validation and benchmarking

Visual positioning services

- Broker and real-world scene graph
- Virtual experience overlay
- Spatial discovery



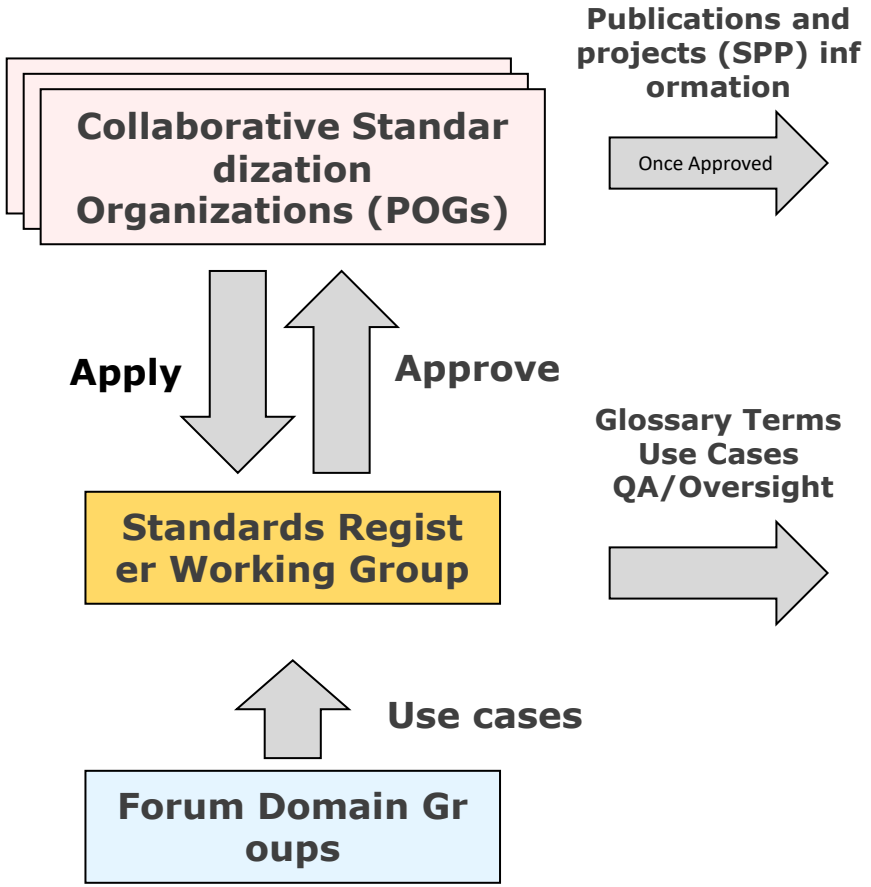
Possible Sponsored Project

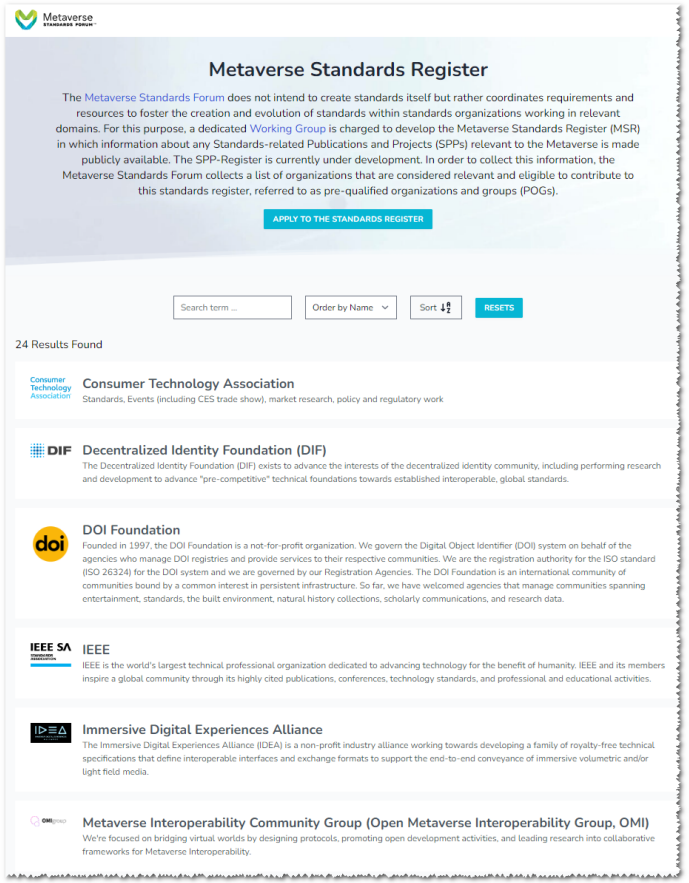
Visual Positioning System Tooling and Test Bed

Generalized VPS service with swappable localization algorithms simplifying R&D
User-friendly map creation pipeline
Map alignment and registration tools
Map management tools
Web-based content creation tools

Standards Register Process

Please help ensure standards organizations that are relevant to your mission have applied to submit information about their Standardization Publications and Projects





A publicly-accessible, searchable database of pre-qualified organizations and groups (**POG**s), standards-related publications and projects (**SPP**s), **glossary** terms and **use cases** relevant to Metaverse interoperability

Searching and filtering

Currently POGs only, SPPs coming soon

General Public