Minutes Workshop: Streamed Media in Immersive Scene Descriptions

# Introduction

MPEG and The Khronos Group hosted a joint workshop on Streamed Media in Immersive Scene Descriptions. The primary purpose of the workshop was the exchange of information on developments in MPEG that relate to Khronos specifications, primarily glTF 2.0, and to seek feedback on the approaches taken. In addition, the workshop aims to identify additional synergies and opportunities for cooperation regarding Khronos standard APIs for GPU processing and XR runtime APIs, MPEG’s work on digital representation of digital media, and 3GPP’s 5G-based advanced delivery of media.

The webinar was run under the umbrella of the MPEG-I Scene description Ad Hoc Group (AHG) and was open to the public under the MPEG AHG policies as available [here](https://www.mpegstandards.org/wp-content/uploads/2021/05/w0018_AhG.pdf). The workshop was run over two days with a three hour Zoom session each day. The detailed program is provided below.

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# Logistics

· Location: Zoom Webinar

· Time: September 29 and 30, 2021, 13:00 UTC to 16:00 UTC (15 – 18 CEST, 6 – 9 PDT)

· Registration:<https://iso.zoom.us/meeting/register/tJMudemvrT0uHtIybldEtiHzj3tF9Q6tloYy>

· For additional information and detailed program, refer to http://mpeg-sd.org.

# Program and Schedule

| **CEST** | **UTC** | **PDT** |  | **Speaker** |
| --- | --- | --- | --- | --- |
| **September 29, 2021: glTF and MPEG-I Scene Description** | | | | |
| 15:00 | 13:00 | 6:00 | [Welcome and Introduction](https://drive.google.com/file/d/1e2CbFlcB-qpXi04QTYaUS0vU_slMpa8w/view?usp=sharing) | MPEG & Khronos Moderators ([Thomas Stockhammer](https://www.linkedin.com/in/stockhammer/) and [Neil Trevett](https://www.linkedin.com/in/neil-trevett-748791/)) |
| 15:10 | 13:10 | 6:10 | [MPEG-I SD Architecture and glTF2.0 Extensions](https://drive.google.com/file/d/1nQqpNqNZ1fowzC2lvX9P2qKGslCRQdfl/view?usp=sharing) | MPEG ([Imed Bouazizi](https://www.linkedin.com/in/imedbouazizi/) and [Lukasz Kondrad](https://www.linkedin.com/in/lukasz-kondrad/)) |
| 16:10 | 14:10 | 7:10 | [Updates on glTF2.0 in Khronos](https://drive.google.com/file/d/1nQqpNqNZ1fowzC2lvX9P2qKGslCRQdfl/view?usp=sharing) | Khronos [(Brent Scannell)](https://ca.linkedin.com/in/brentscannell) |
| **September 29, 2021: Implementation Support** | | | | |
| 17:00 | 15:00 | 8:00 | [Industry Challenges on Immersive Media](https://drive.google.com/file/d/1nQqpNqNZ1fowzC2lvX9P2qKGslCRQdfl/view?usp=sharing) | [Rob Koenen](https://www.linkedin.com/in/rob-koenen/) (TiledMedia) |
| 17:20 | 15:20 | 8:20 | Implementation Support in Khronos & MPEG for Scene Description | MPEG & Khronos |
|  |  |  | [Tools in MPEG](https://drive.google.com/file/d/1nQqpNqNZ1fowzC2lvX9P2qKGslCRQdfl/view?usp=sharing) | MPEG ([Ahmed Hamza](https://www.linkedin.com/in/ahmedhmz/), [Imed Bouazizi](https://www.linkedin.com/in/lukasz-kondrad/) and [Lukasz Kondrad)](https://www.linkedin.com/in/lukasz-kondrad/) |
|  |  |  | [Tools in Khronos](https://drive.google.com/file/d/1G8JY5PimqEwqXqw5MUV-cHBNqnc6U71b/view?usp=sharing) | Khronos [(Brent Scannell)](https://ca.linkedin.com/in/brentscannell) |
|  |  |  | Discussion |  |
| 18:00 | 16:00 | 9:00 | End of Day 1 |  |
| **CEST** | **UTC** | **PDT** | [**Recording**](https://drive.google.com/file/d/1G8JY5PimqEwqXqw5MUV-cHBNqnc6U71b/view?usp=sharing) | **Speaker** |
| **September 30, 2021: Video and 3DG** | | | | |
| 15:00 | 13:00 | 6:00 | [Summary of Day 1](https://drive.google.com/file/d/1PPYLLI75c5X19Ds8G8YOHYTjpDDTk4EV/view?usp=sharing) | MPEG & Khronos Moderators ([Thomas Stockhammer](https://www.linkedin.com/in/stockhammer/) and [Neil Trevett](https://www.linkedin.com/in/neil-trevett-748791/)) |
| 15:10 | 13:10 | 6:10 | [MPEG-I 3DG and Video Updates](https://drive.google.com/file/d/1ioMemK49Q2xcXTxgu_CK_Xp7HFnHLVGU/view?usp=sharing) | MPEG 3DG and Video ([M. Preda](https://www.linkedin.com/in/marius-preda-815111193/), [V. Zakharchenko](https://www.linkedin.com/in/vladyslav-zakharchenko-ph-d-5ab30960/)) |
| 15:45 | 13:45 | 6:45 | [MPEG-I Video Decoding Interface and relation to OpenMAX/Vulkan](https://drive.google.com/file/d/1ioMemK49Q2xcXTxgu_CK_Xp7HFnHLVGU/view?usp=sharing) | MPEG Systems ([E. Thomas](https://www.linkedin.com/in/emmanueldrthomas), [I. Bouazizi](https://www.linkedin.com/in/imedbouazizi/), [Y.K. Lim](https://www.linkedin.com/in/youngkwon-lim-43a969b0/)) |
| 16:00 | 14:00 | 7:00 | [Vulkan Video](https://drive.google.com/file/d/1iPve5sgwENe_bxqt6M56DIgogUvNXZra/view?usp=sharing) | Khronos ([Ahmed Abdelkhalek](https://www.linkedin.com/in/ahmed-abdelkhalek-642b1825/)) |
| **September 30, 2021: XR and Systems** | | | | |
| 16:20 | 14:20 | 7:20 | [MPEG-I Scene Description Phase 2](https://drive.google.com/file/d/1pH6EldKiRf2HrrFhwQGOeuItFYFUnDjN/view?usp=sharing) | [Imed Bouazizi](https://www.linkedin.com/in/imedbouazizi/) (Qualcomm Incorporated) |
| 16:32 | 14:32 | 7:32 | [MPEG-I Haptics](https://drive.google.com/file/d/1Den8G1_emGDZvnwUHiaKjD1-a-Cz7Tiw/view?usp=sharing) | [Chris Ullrich](https://www.linkedin.com/in/cjullrich/) (Immersion Corporation) |
| 16:44 | 14:44 | 7:44 | [MPEG-I Audio](https://drive.google.com/file/d/1LjSN515P46xUGKVPa5qe0CbWI18-1dZt/view?usp=sharing) | [Schuyler Quackenbush](https://www.linkedin.com/in/schuylerquackenbush/) (MPEG Audio Convenor) |
| 17:00 | 15:00 | 8:00 | [Khronos OpenXR](https://drive.google.com/file/d/1KbdJtjDl9PUSrtqJwnAQgEo1OpN4s50E/view?usp=sharing) | [Brent Insko](https://www.linkedin.com/in/brent-insko-a553596/) (Khronos OpenXR Chair) |
| 17:20 | 15:20 | 8:20 | [Extended Reality in 5G](https://drive.google.com/file/d/1HgvYr0LA6Hrk92Dx7R5Zu44hpUiT2V0R/view?usp=sharing) | [Frederic Gabin](https://www.linkedin.com/in/fredericgabin/), [Gilles Teniou](https://www.linkedin.com/in/gilles-teniou-07655816/) (3GPP SA4 Leadership) |
| 17:45 | 15:45 | 8:45 | [Wrap-up and Next Steps](https://drive.google.com/file/d/1PPYLLI75c5X19Ds8G8YOHYTjpDDTk4EV/view?usp=sharing) | MPEG & Khronos Moderators ([Thomas Stockhammer](https://www.linkedin.com/in/stockhammer/) and [Neil Trevett](https://www.linkedin.com/in/neil-trevett-748791/)) |
| 18:00 | 16:00 | 9:00 | End of Day 2 |  |

# 

# Minutes

## Day 1 (no recording)

| 15:00 | [Welcome and Introduction](https://drive.google.com/file/d/1e2CbFlcB-qpXi04QTYaUS0vU_slMpa8w/view?usp=sharing) | MPEG & Khronos Moderators (Thomas Stockhammer and Neil Trevett) |
| --- | --- | --- |

Presentation Summary:

* Provides motivation of the workshop
* Logistics are provided
* Program overview

Discussion

* Recording? It seems that ISO Zoom does not allow recording

| 15:10 | [MPEG-I SD Architecture and glTF2.0 Extensions](https://drive.google.com/file/d/1nQqpNqNZ1fowzC2lvX9P2qKGslCRQdfl/view?usp=sharing) | MPEG (Imed Bouazizi and Lukasz Kondrad) |
| --- | --- | --- |

Presentation Summary:

* Provides an overview of the extensions.
* Provides an overview of the architectures

Discussion

* What is the relation between MPEG\_audio\_spatial with MPEG-H?
  + MPEG-H is a specification that includes many Tools for compression and a reference rendered for channels, objects and HOA. The Audio extensions in MPEG-I SD predominantly only address to attach "PCM" sources to a scene. So it is more or less complementary.
* Interfaces between media and presentation engine is a deployment question? Internal interfaces. When you would have a game engine, how would you integrate?
  + The media access function could be separate, for example allow different vendors to provide. The MAF API is not binding, but can be implemented.
* Are the extensions and the architecture at the same time?
  + At this stage yes, but we will address the separation
* Will there be profiles or levels?
  + At this stage it is not yet defined. On the extensions, we need to check what are core extensions.
* For example if I have multiple videos, how would this be handled.
  + Tight synchronization needed if they are jointly rendered
  + Other options need to be checked
  + Input is still needed on the exact details and may discussion at the upcoming work
* Maybe I have skipped this part,but what codecs can be used for video tracks?
  + Decoders can be independent from the presentation. So any codec can in general be used.

| 16:10 | [Updates on glTF2.0 in Khronos](https://drive.google.com/file/d/1QA62FPo9j4roc-gl4He9dyXepOle3kEt/view?usp=sharing) | [Khronos (Brent Scannell)](https://ca.linkedin.com/in/brentscannell) |
| --- | --- | --- |

Presentation Summary:

* Introduction to 3D formats that were developed in Khronos (Collada, gltf, etc.)
* Introduction of 3D formats working group
* Introduction to gltf Extensions
* glTF 2.0.0 will be submitted as JTC 1 PAS Submission soon. No technical changes to Khronos specification, Khronos will maintain PAS and IS version and avoid fragmentation
* Roadmap discussion

Discussion

* Does the Khronos IP policy also apply to glTF vendor extensions?
  + No, it does not
  + The KHR extensions ARE developed under the policy
  + Vendor extensions are technically and legally under control of the entity creating them, MPEG is in this domain.
* Are the technologies adopted by MPEG-I SD royalty-free?
  + They follow the ISO/IEC JTC1 development process. So this is not a yes/no, that needs to be developed later.
* Are the technologies adopted by the Khronos Group royalty-free?
  + Yes, they are, this is a condition of Khronos participation
* We may say: 1) MPEG can use the Vendor Extension mechanism?; 2) can Khronos consider some MPEG extensions to be included in the core of glTF x.x?
  + 1) Yes absolutely. 2) Yes if there is royalty-free licensing clarity on the design contribution
* For lights, it is a complex and controversial discussion. People who want additional lighting
  + meshOpt is a second compression
  + glTF has Lights, also has IBL lighting
* Draco mesh compression:
  + It made sense to do and Draco extension has been widely adopted
  + This was done as a working group extension
  + More potential mesh compression extensions - possible - always need to consider the balance between flexibility and fragmentation (too much choice)
  + Draco was ratified under the the Khronos IP Framework - so guaranteed to be royalty free
* Is the complexity of processing mesh data and point cloud data different on glTF?
  + gltf-Geospatial group are investigating point-cloud, in order to provide guidance.
  + Currently glTF supports point-primitives and can be compressed well, (with meshOpt and Draco ). The point-clouds are chopped up into oct-tree tiles for streaming using something else ( ie. 3D-Tiles standard )
* Support for quads?
  + Does not come up often. We would like to understand the use cases.
  + If there are verticals such as CAD, we may enable such profiles.
* How does the work in glTF relate to other projects, environments and engines?
  + Keeping focused on delivery format mission, industry-wide coordination and encouraging participation of ecosystem
  + Industry is aligning, glTF is a delivery format, USD is an authoring format. glTF is necessarily at the cutting edge of enabling pervasive delivery that can reach all client devices. glTF aims to be the best distillation target for authoring formats such as USD and MaterialX
  + In order for glTF to have an ecosystem… it needs all the players… even if they are competitors. So when something is added to THREE.js , it also needs to be added to babylon.js and Unity… and unReal. Hopefully by the company who owns the engine.
* RGBD used in glTF?
  + Not yet - interested in the use case
* AR specific topics and low-latency?
  + Making sure that glTF can continue to run on mobile devices. Keep it simple and low-latency
  + Composability of objects in AR - anchor points, scaling, asset behaviours
  + Metaverse interest is an important aspect around this as well.
* More feedback:
  + Draco (mesh compression) and BasisU (texture compression) extensions are shipping
  + Point-cloud streaming is being increasingly used for consumer scene capture
  + Runtime distribution is glTF’s core mission
  + A number of XR companies are using glTF for distribution of models. At the basic (primarily static) level, it works well. Streaming is currently being investigated in the Geospatial group to handle large scale models. The concept works for XR too.
  + I’d love to know if there have been any discussions around streaming LOD representations? I could see the proposed MPEG extensions be flexible enough to handle this
  + Unreal has its own glTF plugin and a significant number of other 3d parties.
  + Khronos is working close with Open Geospatial Consortium to handle more recent AR concepts - e.g., OGC GeoPose

| 17:00 | [Industry Challenges on Immersive Media](https://drive.google.com/file/d/1fiv1H1Te5cDNbAVo_UFiJ1LSV87hYjrM/view?usp=sharing) | [Rob Koenen (TiledMedia)](https://www.linkedin.com/in/rob-koenen/) |
| --- | --- | --- |

Presentation Summary:

* Some Applications
* Explanation of the technologies of Tiled Streaming
* Requirements and challenges
* Video Clips
  + <https://www.oculus.com/experiences/quest/5060690107290136/>
  + <https://twitter.com/SkySports/status/1428377137401278470>

Discussion

* One of the inconveniences of using an HMD for a long time is that it can give you dizziness symptoms. How much do you think these shortcomings have been improved recently?
  + Seems to work better
  + Depends on production
  + Needs good tracking in headsets
* GPU vendors provide content security for 2D video - not sufficient?
  + Need secure pipeline to screen that includes viewpoint geometric processing.
  + Need to be able to manipulate pixels after decoding and before sending to screen - in the secure domain
* Are overlays and scenes an application, or is it something that needs a standard?
  + There is a boundary between what is application and what is standards.
  + Low-level primitives are important, applications not that much.

| 17:20 | Implementation Support in Khronos & MPEG for Scene Description | MPEG & Khronos |
| --- | --- | --- |
|  | [Tools in MPEG](https://drive.google.com/file/d/1LAB5spZ0GzxWxEsNwr24IasawoSdHKBo/view?usp=sharing) | MPEG (Ahmed Hamza, Imed Bouazizi and Lukasz Kondrad) |
|  | [Tools in Khronos](https://drive.google.com/file/d/1G8JY5PimqEwqXqw5MUV-cHBNqnc6U71b/view?usp=sharing) | [Khronos (Brent Scannell)](https://ca.linkedin.com/in/brentscannell) |

Presentation Summary:

* MPEG
  + Overview of tools
* Khronos
  + glTF Project Explorer
  + glTF Validator
  + glTF Sample Viewer
  + glTF Blender Importer
* Projects can be added to the Project Explorer repo by their developers
  + glTF tools can be and searched and filtered with multiple criteria
  + Feedback welcome - V2 development underway

Discussion

* Some MPEG software was listed as open source. Where is that hosted?
  + Gitlab.com hosts it right now for MPEG members
* Khronos actively maintains its core tools on public GitHub under Apache 2.0
* What about an Industry Forum looking at the best of all organizations for industry outreach, promotion, end-to-end workflows, implementer support?
  + possibly an interesting idea - more discussion needed.

| 18:00 | End of Day 1 |  |
| --- | --- | --- |

## Day 2 ([recording](https://drive.google.com/file/d/1WNacyOLiZMx6pKGr882yIcxaBlULZeHH/view?usp=sharing), [YouTube](https://youtu.be/Va43Nw9-n8w))

| 15:00 | Summary of Day 1 | MPEG & Khronos Moderators (Thomas Stockhammer and Neil Trevett) |
| --- | --- | --- |

Presentation Summary:

* In total we had 186 attendees on the first day
* glTF2.0 and MPEG-I Scene Description
  + MPEG extensions at this point can be viewed as vendor extensions, also from IP perspective
  + Khronos glTF core specifications and KHR extensions are available under Khronos royalty-free IP Policy
  + glTF extensions in both organizations are considered complementary
* Implementor and Tooling Support
  + Industry presentation points mostly to challenges in handling large amount of data efficiently and securely, standards are needed, but need to be carefully checked to have balance between what is needed and what is the application and implementation domain
  + MPEG and Khronos maintain tools to support implementors – promotion and accessibility and maintenance of these tools is a major challenge
  + What about an Industry Forum looking at the best of all organizations for industry outreach, promotion, end-to-end workflows, implementor support? – possibly an interesting idea

| 15:10 | [MPEG-I 3DG and Video Updates](https://drive.google.com/file/d/1ioMemK49Q2xcXTxgu_CK_Xp7HFnHLVGU/view?usp=sharing) | MPEG 3DG and Video (M. Preda, V. Zakharchenko) |
| --- | --- | --- |

Presentation Summary:

* Provides a history on 3DG coding in MPEG 3DG group - now in MPEG-4 Part 16/AFX
* Introduction to V-PCC
* Introduction to G-PCC
* Next step mesh coding
* Relation of MPEG 3DG and Khronos

Discussion

* Is the technology required to get to the multiple video streams and back out available royalty free?
  + It is available as an ISO/IEC Standard, 23090-6 and it was develop under ISO FRAND rules to my best Knowledge.
  + ISO/IEC 23090-5, one can find the latest version of the reference software of V-PCC here: <https://github.com/MPEGGroup/mpeg-pcc-tmc2>
  + The decoder and redeemer implementation for mobile phones is here: <https://github.com/nokiatech/vpcc>
* Why did the 3DGC group decide to switch from point cloud coding to mesh coding?
* If this transition is due to rendering and safes bandwidth, could you elaborate more?
  + I would not call it a switch but the next step. One advantage of meshes is indeed the rendering (graphics cards know how to render well triangles:) ). In terms of compression only, my expectation is that the stay at similar bitrate range.
  + On the other hand, the transformation from point clouds to meshes (needed because in the reconstruction process we get points first) may come with some artefacts. My expectation is that both PC and Meshes will be used (depending on the application requirements)

| 15:45 | [MPEG-I Video Decoding Interface and relation to OpenMAX/Vulkan](https://drive.google.com/file/d/1T-s-h44JweIOD2zJXBeSGPSbbdJMYQS1/view?usp=sharing) | MPEG Systems (E. Thomas, I. Bouazizi, Y.K. Lim) |
| --- | --- | --- |

Presentation Summary:

* The MPEG-4 System decoder model
* Challenges for video decoding in XR
* What VDI brings to XR applications
* Finishing OpenMAX and Vulkan VDI extensions
* Conclusion

Discussion

* See below

| 16:00 | [Vulkan Video](https://drive.google.com/file/d/1iPve5sgwENe_bxqt6M56DIgogUvNXZra/view?usp=sharing) | [Khronos (Ahmed Abdelkhalek)](https://www.linkedin.com/in/ahmed-abdelkhalek-642b1825/) |
| --- | --- | --- |

Presentation Summary:

* Vulkan Video: What is it
* Vulkan Video Decode Process Details
* Vulkan Video Encode Process Details
* Vulkan Video Core and Codec Extensions
* Next Steps

Discussion

* How does VDI and Vulkan video align?
  + Seems to be the case, but we need to look through all the details
  + Vulkan Video provides already quite some control functions
* I agree with you Thomas, there seems to be clear opportunity for fruitful follow-up discussions between VDI and Vulkan Video - lets arrange an appropriate forum to enable that

| 16:32 | [MPEG-I Haptics](https://drive.google.com/file/d/1Den8G1_emGDZvnwUHiaKjD1-a-Cz7Tiw/view?usp=sharing) | [Chris Ullrich (Immersion Corporation)](https://www.linkedin.com/in/cjullrich/) |
| --- | --- | --- |

Presentation Summary:

* Overview of haptic use cases
* Key challenges of haptic device heterogeneity
* Key challenges of haptic media coding and presentation
* Status of MPEG-I haptics ad-hoc-group

Discussion

* Chris at Immersion - it is great you are participating in both MPEG and Khronos - how should the two organizations best collaborate over haptics do you think?

| 16:44 | [MPEG-I Audio](https://drive.google.com/file/d/1LjSN515P46xUGKVPa5qe0CbWI18-1dZt/view?usp=sharing) | [Schuyler Quackenbush (MPEG Audio Convenor)](https://www.linkedin.com/in/schuylerquackenbush/) |
| --- | --- | --- |

Presentation Summary:

* What is Audio for Immersive Experiences?
* Localization of Virtual Sources
* Directivity of Sources
* Ambience and Reverberation
* Technology in MPEG-I Audio
* MPEG-I Encoder Input Format
* Evaluation of Technology
* Timeline for Standardization

Discussion

* MPEG-I Audio will also support channels, e.g. for bringing in legacy content.

| 16:20 | [MPEG-I Scene Description Phase 2](https://drive.google.com/file/d/1pH6EldKiRf2HrrFhwQGOeuItFYFUnDjN/view?usp=sharing) | [Imed Bouazizi (Qualcomm Incorporated)](https://www.linkedin.com/in/imedbouazizi/) |
| --- | --- | --- |

Presentation Summary:

* Interactivity
* Support for XR
* Actions, Haptics, and Uplink Data

Discussion

* See below

| 17:00 | [Khronos OpenXR](https://drive.google.com/file/d/1KbdJtjDl9PUSrtqJwnAQgEo1OpN4s50E/view?usp=sharing) | [Brent Insko (Khronos OpenXR Chair)](https://www.linkedin.com/in/brent-insko-a553596/) |
| --- | --- | --- |

Presentation Summary:

* What is OpenXR?
* Why was it needed?
* What has been going on with OpenXR?
* Where are we going next?

Discussion

* What applications currently use OpenXR with the highest number of users?
  + Chrome and Edge browsers would be the widest distributed applications using OpenXR today for supporting WebXR applications

| 17:20 | [Extended Reality in 5G](https://drive.google.com/file/d/1HgvYr0LA6Hrk92Dx7R5Zu44hpUiT2V0R/view?usp=sharing) | Frederic Gabin, Gilles Teniou (3GPP SA4 Leadership) |
| --- | --- | --- |

Presentation Summary:

Discussion

* Globally, it seems that 5G is not yet active. When do you expect 5G to become active?
  + 5G has been deployed and is commercially available in many countries. there are many 5G enabled devices on the market. Coverage is progressing.
  + In my opinion, not many countries have infrastructure for 5G networks. 5G network infrastructure requires a lot of cost, so it is difficult to activate it quickly. What do you think?
  + I agree that the situation with regards to mobile network infrastructures is very different depending on countries. But the 5G deployment trends are faster than 4G.

| 17:45 | [Wrap-up and Next Steps](https://drive.google.com/file/d/1PPYLLI75c5X19Ds8G8YOHYTjpDDTk4EV/view?usp=sharing) | MPEG & Khronos Moderators (Thomas Stockhammer and Neil Trevett) |
| --- | --- | --- |

Presentation Summary:

* Complementary work – many touch points - collaboration seems to be beneficial
* Specific topics identified, but may be digested further
  + glTF and extensions by MPEG-I Scene description
  + MPEG codecs for elementary media (immersive video, point clouds, dynamic meshes) can be added by defining new glTF extensions
  + Tools and implementation support
  + Vulkan Video and VDI
  + Extended Realities: OpenXR, MPEG-I Phase 2 incl. AR, Interactivity and Haptics
  + Systems and Split Rendering: OpenXR, 3GPP connectivity, MPEG codecs
* Challenges: Timelines, publication rules, IPR policies, membership
* Opportunities: complementary expertise, implementation and developer support, joint promotion, focus
* Proposed next steps:
  + continue the discussion
  + set up some kind of discussion platform

Thanks:

* Neil Trevett (Khronos president) and Frederic Gabin (3GPP SA4 chair)
* All speakers for presentations and answering questions
* All Participants for attending and for the discussions
* Survey: https://forms.gle/om6VreEE6h2MivJk9

# Chats

## Day 1

15:05:15 From Michael Ivanov to Everyone:

Hi Everyone!

15:20:27 From Thomas Stockhammer (Qualcomm) to Everyone:

Online Minutes: https://docs.google.com/document/d/10wrBrc0Dt1pVcpRquSjd7lJrsy\_OII-GhyjWASalqlM/edit?usp=sharing

15:39:55 From Alan Guedes to Everyone:

What it the relation between MPEG\_audio\_spatial with MPEG-H?

15:45:51 From Thomas Stockhammer (Qualcomm) to Everyone:

Alan, MPEG-H is a specification that includes many Tools for compression and a reference rendered for channels, objects and HOA. the Audio extensions in MPEG-I SD predominantly only address to attach "PCM" sources to a scene. So it is more or less complementary.

15:54:00 From Alan Guedes to Everyone:

Thanks.

16:09:06 From Michael Ivanov to Everyone:

Hi. Maybe I have skipped this part,but what codecs can be used for video tracks? Thanks.

16:12:29 From Michael Ivanov to Everyone:

I see.Thanks.

16:15:28 From Thomas Stockhammer (Qualcomm) to Everyone:

Can I ask People to add their affiliation to the Name. Go to your Name in the participant list. there is a more button and then it says rename - thanks

16:19:28 From Max Weber to Everyone:

Are the talks recorded? Didn’t see any further correspondence from the Emails. Thanks!

16:20:19 From Thomas Stockhammer (Qualcomm) to Everyone:

I am sorry, currently they are not recorded. The ISO zoom seems to explicitly forbid it. I will try to find a Version tomorrow

16:21:51 From Leonard Daly Independent (Khronos) to Thomas Stockhammer (Qualcomm)(Direct Message):

The control for recording is in the host login on the Zoom account.

16:30:12 From PEREY Research & Consulting: Christine Perey to Everyone:

Not on this slide but Khronos has great connection and cooperation with W3C and OGC

16:34:29 From Min Ku Lee to Everyone:

1. Are the technologies adopted by MPEG-I SD royalty-free?

2. Are the technologies adopted by the Khronos Group royalty free?

16:37:24 From Marius Preda (IMT) to Everyone:

Thanks Neil

16:39:35 From Bruno Fanini (CNR ISPC) to Everyone:

is there a glTF roadmap for paged multiresolution, or is the 3D Tile OGC by Cesium the current direction developers should embrace for presenting large datasets?

16:39:40 From Marius Preda (IMT) to Everyone:

We may say: 1) MPEG can use the Vendor Extension mechanism; 2) if Khronos considers some MPEG extensions correspond to Khronos IP policy, Khronos may decide to include « some » extensions in the core of glTF x.x

16:39:58 From Min Ku Lee to Everyone:

Thanks to Thomas and Neil!

16:41:13 From Autodesk: Michael Beale to Everyone:

meshOpt is a second compression

16:41:32 From Autodesk: Michael Beale to Everyone:

Gltf Lights, also has IBL lighting

16:41:59 From Khronos: Neil Trevett to Everyone:

Hi Marius 1) Yes absolutely. 2) Yes if there is royalty-free licensing clarity on the design contribution

16:42:42 From Imed Bouazizi to Everyone:

Thanks Michael

16:44:18 From Min Ku Lee to Everyone:

Is the complexity of processing mesh data and point cloud data different on glTF?

16:45:21 From Autodesk: Michael Beale to Everyone:

gltf-Geospatial group are investigating point-cloud, in order to provide guidance.

16:47:17 From Autodesk: Michael Beale to Everyone:

Currently glTF supports point-primitives and can be compressed well, (with meshOpt and Draco ). The point-clouds are chopped up into oct-tree tiles for streaming using something else ( ie. 3D-Tiles standard )

16:50:19 From Min Ku Lee to Everyone:

Thanks Michael

16:50:20 From Leonard Daly Independent (Khronos) to Everyone:

Thanks @Michael

16:54:49 From Autodesk: Michael Beale to Everyone:

In order for glTF to have an ecosystem… it needs all the players… even if they competitors. So when something is added to THREE.js , it also needs to be added to babylon.js and Unity… and unReal. Hopefully by the company who owns the engine.

16:57:39 From Autodesk: Michael Beale to Everyone:

Draco compression and BasisU significantly improved glTF distribution

16:58:48 From Autodesk: Michael Beale to Everyone:

For point-cloud streaming, a scene format, like 3d-tiles, would handle distribution

16:58:58 From Autodesk: Michael Beale to Everyone:

Runtime distribution

16:59:13 From Leonard Daly Independent (Khronos) to Everyone:

A number of XR companies are using glTF for distribution of models. At the basic (primarily static) level, it works well. Streaming is currently being investigated in the Geospatial group to handle large scale models. The concept works for XR too.

16:59:21 From [Shopify] Mikko Haapoja to Everyone:

I’d love to know if there have been any discussions around streaming LOD representations? I could see the proposed MPEG extensions be flexible enough to handle this

16:59:57 From Michael Ivanov (Code Artworks Ltd) to Everyone:

Unreal has its own glTF plugin and a number of 3d parties.

17:00:16 From Leonard Daly Independent (Khronos) to Everyone:

Khronos is working close with Open Geospatial Consortium to handle more recent concepts - e.g., GeoPose

17:21:30 From Min Ku Lee (Hanyang University) to Everyone:

One of the inconveniences of using an HMD for a long time is that it can give you dizziness symptoms. How much do you think these shortcomings have been improved recently?

17:23:24 From Min Ku Lee (Hanyang University) to Everyone:

Thanks Rob

17:34:30 From Leonard Daly Independent (Khronos) to Everyone:

Some s/w was listed as open source. Where is that s/w found?

17:51:15 From Khronos: Neil Trevett to Everyone:

Project Explorer on the Khronos Website: https://github.khronos.org/glTF-Project-Explorer/

17:58:50 From Leonard Daly Independent (Khronos) to Everyone:

@Thomas: Will the slides from today and tomorrow be available to all attendees?

18:00:27 From michael luby to Everyone:

It would be really useful if these session could be recorded!!

## Day 2

15:39:01 From Leonard Daly | Independent (Khronos) : Is the technology required to get to the multiple video streams and back out available royalty free?

15:41:31 From Thomas Stockhammer (Qualcomm) : It is available as an ISO/IEC Standard, 23090-6 and it was develop under ISO FRAND rules to my best Knowledge.

15:43:26 From Lukasz Kondrad (Nokia) : ISO/IEC 23090-5, one can find the latest version of the reference software of V-PCC here: https://github.com/MPEGGroup/mpeg-pcc-tmc2

15:44:23 From Lukasz Kondrad (Nokia) : The decoder and redeemer implementation for mobile phones is here: https://github.com/nokiatech/vpcc

15:53:56 From Min Ku Lee (Hanyang University) : Why did the 3DGC group decide to switch from point cloud coding to mesh coding?

If this transition is due to rendering and safes bandwidth, could you elaborate more?

15:57:35 From Marius Preda (IMT) : I would not call it a switch but the next step. One advantage of meshes is indeed the rendering (graphics cards know how to render well triangles:) ). In terms of compression only, my expectation is that the stay at similar bitrate range.

15:58:17 From Min Ku Lee (Hanyang University) : Thanks Marius

16:01:59 From Marius Preda (IMT) : On the other hand, the transformation from point clouds to meshes (needed because in the reconstruction process we get points first) may come with some artefacts. My expectation is that both PC and Meshes will be used (depending on the application requirements)

16:06:45 From Min Ku Lee (Hanyang University) : Thanks for your kind reply! Marius

16:30:59 From Khronos: Neil Trevett : I agree with you Thomas, there seems to be clear opportunity for fruitful follow-up discussions between VDI and Vulkan Video - lets arrange an appropriate forum to enable that

16:49:57 From Yuki Shimada : I have to sign out for some tasks. very interesting discussion. thank you everyone.

17:08:16 From Schuyler Quackenbush (WG6, ARL) : MPEG-I Audio will also support channels, e.g. for bringing in legacy content.

17:09:29 From Max Weber (Lofelt) : Thanks for clarifying Schuyler!

17:22:52 From Min Ku Lee (Hanyang University) : What applications currently use OpenXR with the highest number of users?

17:27:00 From Brent Insko (Intel / OpenXR Chair) : Chrome and Edge browsers would be the widest distributed applications using OpenXR today for supporting WebXR applications

17:27:31 From Min Ku Lee (Hanyang University) : Thanks Brent

17:29:38 From Thomas Stockhammer (Qualcomm) : Can I ask everyone to please answer the Survey here: https://forms.gle/Rs1d5BA86A9Xxi92A

17:37:46 From Min Ku Lee (Hanyang University) : Globally, it seems that 5G is not yet active. When do you expect 5G to become active?

17:39:58 From Frédéric Gabin (Dolby/3GPP SA4 Chair) : 5G has been deployed and is commercially available in many countries. there are many 5G enabled devices on the market. Coverage is progressing.

17:44:02 From Min Ku Lee (Hanyang University) : In my opinion, not many countries have infrastructure for 5G networks. 5G network infrastructure requires a lot of cost, so it is difficult to activate it quickly. What do you think?

17:46:39 From Khronos: Neil Trevett : Chris at Immersion - it is great you are participating in both MPEG and Khronos - how should the two organizations best collaborate over haptics do you think?

17:47:00 From Frédéric Gabin (Dolby/3GPP SA4 Chair) : I agree that the situation with regards to mobile network infrastructures is very different depending on countries. But the 5G deployment trends are faster than 4G.

17:47:48 From Min Ku Lee (Hanyang University) : Thanks for your kind reply! Frédéric

18:05:17 From Gi-Mun Um : Thanks

# Participants

## Day 1 (186 in total)

| Carlos Cosme (Carlos Ribeiro) |
| --- |
| Lu Yu (ZJU) (Lu Yu) |
| Emily Duan |
| Li Song (SJTU-CN) (Li Song) |
| Ying Hu |
| Zhao Wu |
| Zehui Lin |
| Wenjie Zou |
| Arvind Iyer |
| Dong Wang (OPPO) (Dong Wang) |
| Qiuting Li |
| Yanwei Liu (CAS) (IIE) |
| Louay Bassbouss (Fraunhofer FOKUS) (Louay Bassbouss) |
| Adam Morris (Target) (Adam Morris) |
| Xavier de Tinguy |
| Wo Chang |
| Aleksei Martemianov |
| Basel Salahieh |
| Miska Hannuksela |
| andrew krupiczka |
| Thomas Stockhammer (Qualcomm) (Thomas Stockhammer) |
| Vladyslav Zakharchenko (Oppo) (Vladyslav Zakharchenko) |
| Lulin Chen (MediaTek - US) (Lulin Chen) |
| Rohit Abhishek |
| Koohyar Minoo (Koohyar مینو) |
| Wen Gao： Tencent US (Wen Gao) |
| Youngkwon Lim (Samsung - KR) (Youngkwon Lim) |
| Junghyun Ahn |
| michael luby |
| Igor Curcio |
| Autodesk: Michael Beale (Michael Beale) |
| Angeliki Katsenou |
| Iraj Sodagar |
| Rajan Joshi |
| Yeshwant Muthusamy (Immersion (Yeshwant Muthusamy) |
| Jizheng Xu |
| Yu You - Nokia FI (Yu You) |
| Ping Liu |
| Isaac Muñoz (Qualcomm) |
| Richard Webb |
| Gang Shen |
| Geert Van der Auwera (Qualcomm - US) |
| Darragh Burke |
| Brian Lee (Dolby - US) (Brian Lee) |
| johanny montiton |
| Tim Lewis |
| Alan Guedes |
| Stephane RAGOT |
| Maja Krivokuca (InterDigital) (Maja Krivokuca) |
| Jeremy Foss |
| Bruno Fanini (CNR ISPC) (Bruno Fanini) |
| Bart Kroon (Philips - NL) (Bart Kroon) |
| Martin Pettersson |
| Sergei Novikov |
| Khronos: Alexey Knyazev ([Independent] Alexey Knyazev) |
| Mauricio Aracena |
| Joel Jung |
| Marius Preda (IMT) (Marius Preda) |
| Silvino Presa (Dimenco) (Silvino Presa) |
| Robert Simpson (Qualcomm) (Robert Simpson) |
| Haitao Yang (Yanghaitao y00485151) |
| Nicolas Ramin |
| Karsten Grüneberg |
| Frederik Voncken |
| Renaud Doré (Interdigital) (Renaud Doré) |
| Yago Sanchez (Fraunhofer - HHI) (Yago Sanchez de la Fuente) |
| Didier Doyen |
| iole moccagatta |
| Loginov Fedor (Huawei - RU) (maxiang m00357881) |
| Caroline Baillard (Interdigital) (caroline baillard) |
| Emmanouil Potetsianakis |
| Valerie Allie (InterDigital) (Valerie Allie) |
| Emmanuel Thomas (Xiaomi) (Emmanuel Thomas) |
| Cornelius Hellge |
| Fabien Danieau (InterDigital) (Fabien Danieau) |
| Lukasz Kondrad (Nokia) (Lukasz Kondrad) |
| Mohammed Dadas |
| Yann Kowalczuk |
| Christof Fersch |
| Jaehyeon Bae |
| Jan Holub (Mesaqin.com) (Jan Holub) |
| Patrice Hirtzlin (InterDigital) (Patrice Hirtzlin) |
| Lauri Ilola |
| Hu Chen (Huawei) (Hu Chen h00437106) |
| Quentin Galvane (InterDigital) (Quentin Galvane) |
| Gilles Teniou |
| Thomas Begeot - Actronika (Thomas Begeot) |
| Abdellatif Salah (Mediatek) (Abdellatif Salah) |
| Patrice Rondao Alface (Nokia - BE) (Patrice Rondao Alface) |
| Madhukar Budagavi |
| UX3D: Norbert Nopper (Norbert Nopper) |
| vincent Alleaume |
| Leon Terentiv |
| Vincent Lepec (Orange/VO) (Vincent Lepec) |
| Daniel Fischer |
| christoph stevens |
| Tao Luo (InterDigital) (Tao Luo) |
| Elfed Howells (Elfed Howells ewx974112) |
| Mary-Luc Champel |
| Petteri Hiisilä |
| Panji Setiawan |
| Arnold Pötsch |
| Gábor Sörös |
| Gunnar Heikkila |
| Franck Denoual (FR) |
| Jonathan TAQUET |
| Sam Jelfs |
| Rob Koenen (Tiledmedia) (Rob Koenen) |
| Jean Le Feuvre |
| Christian Timmerer |
| Donny Tytgat |
| Hadi Amirpour |
| Max Weber (Lofelt) (Max Weber) |
| Bernhard Feiten |
| PEREY Research & Consulting: Christine Perey (Christine Perey) |
| Rong Wei(Hua Wei) (Rong Wei) |
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| Antonio Pinheiro |
| Stephan Steglich |
| HUAWEI:CAIKangying (caikangying c00476782) |
| hui yuan |
| Huan-yu Su (Huan-yu Su) |
| 彥丞 陳 |
| Seong Yong Lim(ETRI) (Seong Yong Lim) |
| Jaeyeon Song |
| Sooyeon Lee(LGE) (Sooyeon Lee) |
| Jaehyeon Bae (samsung) (Jaehyeon Bae) |
| Mitsuhiro Hirabayashi (Sony) (Mitsuhiro Hirabayashi) |
| Hyunkoo Yang |
| Jae-Shin Han |
| Masato Shima |
| Ryohei Takahashi (Sony) (Ryohei Takahashi) |
| Daniel Lee |
| Jin Lee |
| WOONKI PARK |
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| Kwijung Nam |
| Sergey Ikonin (Sergey Ikonin i00741616) |
| Junsik Kim(KyungHee Univ.) (Junsik Kim) |
| Sungryeul Rhyu |
| Woongil Choi |
| Mujtaba (Eun-Seok Ryu) |
| Min Ku Lee (Hanyang University) (Min Ku Lee) |
| Kazushi Sato (Oppo) (Kazushi Sato) |
| Tim Lo |
| Katsuya Furusho |
| HC Kim |
| Ryuichi Namba (Sony) (Ryuichi Namba) |
| Gi-Mun Um |
| Alan Ruberg |
| Khronos: Neil Trevett (Neil Trevett) |
| Leonard Daly Independent (Khronos) (Leonard Daly) |
| Christopher Ullrich (Immersion) (Christopher Ullrich) |
| Scott Houchin |
| Adrian Grange - Google (Adrian Grange) |
| Mohamad Raad (LIU) (Mohamad Raad) |
| Jill Boyce |
| Xin Wang (MediaTek (Xin Wang) |
| Yolanda Prieto |
| Camille Moussette |
| Jun Tian (Tencent - US) (Jun Tian) |
| Brian Murray |
| Imed Bouazizi |
| Igor Vytyaz |
| Michael Isnardi |
| Holochip: Steven Winston (Steven Winston) |
| Ed Mackey (AGI) (Ed Mackey) |
| Madhukar Budagavi |
| padhu sub |
| Ravi Chaudhary |
| Stephan Wenger (Tencent) (Stephan Wenger) |
| Frédéric Gabin (Dolby - 3GPP SA4 chair) (Frédéric Gabin) |
| Randy Sharpe (Nokia) (Randy Sharpe) |
| Michael Ivanov (Code Artworks Ltd) (Michael Ivanov) |
| Henry da Costa @ Immersion (Henry da Costa) |
| Stephan Leroux (Shopify) (Stephan Leroux) |
| Khronos: Brent Scannell (Brent Scannell) |
| Gurdeep Bhullar (Interdigital) (Gurdeep Bhullar) |
| [Shopify] Mikko Haapoja (Mikko Haapoja) |
| Ahmed Hamza (InterDigital Canada) (Ahmed Hamza) |
| Srinivas Gudumasu (InterDigital) (Srinivas Gudumasu) |
| Jake Beju (AMD) (Jake Beju) |
| Milan Jelinek |
| MIKHAIL MIRONOV |

## Day 2 (156 in total)

| Srinath Kumarapuram (NVIDIA) (Srinath Kumarapuram) |
| --- |
| Yanwei Liu (CAS) |
| Qiuting Li |
| Zhe Wang (Huawei-CN) (Wangzhe w00288223) |
| Ying Hu |
| Loginov Fedor (maxiang m00357881) |
| Lu Yu |
| Li Song |
| Thomas Stockhammer (Qualcomm) (Thomas Stockhammer) |
| Victor Jaquez (Igalia) (Igalia: Victor Jaquez) |
| Marius Preda (IMT) (Marius Preda) |
| Jonathan TAQUET (Xiaomi) (Jonathan TAQUET) |
| Aaron Zhang |
| Jeremy Foss |
| Fabien Danieau (InterDigital) (Fabien Danieau) |
| Mukesh Chouhan |
| Emmanuel Thomas (Xiaomi) (Emmanuel Thomas) |
| Patrice Hirtzlin (InterDigital) (Patrice Hirtzlin) |
| CN:HUAWEI:CAIKangying |
| Haitao Yang (Yanghaitao y00485151) |
| caroline baillard |
| Emmanouil Potetsianakis |
| vincent Alleaume |
| Khronos: Alexey Knyazev |
| Gilles Teniou (Tencent/3GPP SA4) (Gilles Teniou) |
| Didier Doyen |
| Lukasz Kondrad (Nokia) (Lukasz Kondrad) |
| Hu Chen (Huawei) (Hu Chen h00437106) |
| Sam Jelfs (Philips - NL) (Sam Jelfs) |
| Bart Kroon |
| Lauri Ilola |
| Stephane RAGOT |
| Thomas Begeot - Actronika (Thomas Begeot) |
| Jean Le Feuvre |
| Mary-Luc Champel |
| Call-In User\_1 |
| Frédéric Gabin (Dolby/3GPP SA4 Chair) (Frédéric Gabin) |
| Panji Setiawan |
| Julien Lemotheux (Orange) (Julien Lemotheux) |
| Maja Krivokuca (InterDigital) (Maja Krivokuca) |
| Donny Tytgat |
| Yago Sanchez de la Fuente |
| Vincent Lepec (Orange - VO) (Vincent Lepec) |
| Franck Denoual (FR) |
| Abdellatif Salah ( Mediatek UK) (Abdellatif Salah) |
| Tao Luo |
| Renaud Doré (Interdigital) (Renaud Doré) |
| Tim Lewis |
| Stephan Steglich |
| Nils DUVAL |
| Rob Koenen |
| Louay Bassbouss |
| Max Weber (Lofelt) (Max Weber) |
| Elfed Howells ewx974112 |
| Saeed Mahmoudpour |
| Silvino Presa (Dimenco) (Silvino Presa) |
| Adrián Rodrigo |
| Sebastian Schwarz |
| Christian Timmerer |
| Iole Moccagatta |
| Matthieu Fradet |
| jaehyeon bae (samsung) |
| Norbert Nopper |
| Martin Pettersson |
| Christof Fersch |
| Celine Guede |
| Jeroen Koppens |
| Cornelius Hellge |
| Hossein Najaf-Zadeh |
| 彥丞 陳 |
| Woongil Choi |
| Eric Yip |
| Sooyeon Lee (LGE) (Sooyeon Lee) |
| Ryohei Takahashi (Sony) (Ryohei Takahashi) |
| Sungryeul Rhyu |
| jaehyeon bae (samsung) (jaehyeon bae) |
| Junsik Kim(KyungHee Univ.) (Junsik Kim) |
| Yuki Shimada |
| Mitsuhiro Hirabayashi (Sony) (Mitsuhiro Hirabayashi) |
| Masato Shima |
| Hyunkoo Yang |
| Jae-Shin Han |
| Min Ku Lee (Hanyang University) (Min Ku Lee) |
| Naotaka Morita |
| Jin Lee |
| Tim Lo |
| Kwijung Nam |
| Soonbin Lee (Eun-Seok Ryu) |
| Ryuichi Namba |
| Gi-Mun Um |
| WOONKI PARK |
| Daniel Lee |
| Schuyler Quackenbush (WG6 (Schuyler Quackenbush) |
| Khronos: Tony Zlatinski (Tony Zlatinski) |
| Leonard Daly | Independent (Khronos) (Leonard Daly) |
| Khronos: Neil Trevett (Neil Trevett) |
| Brian Murray |
| Mauricio Aracena |
| Christopher Ullrich |
| Youngkwon Lim (Samsung - KR) (Youngkwon Lim) |
| Vladyslav Zakharchenko (Oppo) (Vladyslav Zakharchenko) |
| Ed Mackey (AGI) (Ed Mackey) |
| Jun Tian (Tencent) (Jun Tian) |
| Ping Liu |
| Gunnar Heikkila |
| Camille Moussette (Apple) (Camille Moussette) |
| Lulin Chen |
| Xavier de Tinguy |
| Stephan Wenger |
| Ravi Chaudhary |
| Imed Bouazizi - Qualcomm (Imed Bouazizi) |
| Yeshwant Muthusamy (Immersion (Yeshwant Muthusamy) |
| Wen Gao (Tencent-US) (Wen Gao) |
| Wo Chang |
| Basel Salahieh |
| Miska Hannuksela |
| Adam Morris (Target) (Adam Morris) |
| Holochip: Steven Winston (Steven Winston) |
| Michael Isnardi |
| Alan Ruberg |
| Xin Wang (MediaTek (Xin Wang) |
| michael luby |
| Igor Curcio |
| Yu You |
| Iraj Sodagar |
| Sujeet Mate |
| Aleksei Martemianov |
| andrew krupiczka |
| padhu sub |
| Jong-Beom Jeong |
| Dennis Duncan |
| Igor Vytyaz |
| Yolanda Prieto |
| Charles Lo |
| Geert Van der Auwera |
| Brent Insko (Intel / OpenXR Chair) (Brent Insko) |
| Isaac Muñoz (Qualcomm) |
| Mats Lundgren |
| Jill Boyce |
| Junghyun Ahn |
| Richard Webb |
| Rémi Arnaud |
| Huan-yu SU (Huawei) |
| Brent Scannell (Autodesk/Khronos) (Brent Scannell) |
| Stephan Leroux (Shopify) (Stephan Leroux) |
| Ahmed Abdelkhalek (AMD) (Ahmed Abdelkhalek) |
| Mikko Haapoja |
| Jake Beju (AMD) (Jake Beju) |
| Gurdeep Bhullar (interdigital) (Gurdeep Bhullar) |
| Ahmed Hamza |
| Srinivas Gudumasu (InterDigital) (Srinivas Gudumasu) |
| Henry da Costa |
| Adrian Grange |
| Milan Jelinek |
| Emily Duan |
| Wenjie Zou |
| Dong Wang (OPPO) |