**3GPP TSG SA WG4#115-e meeting S4-211033**

**18th– 27th August 2021**

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| *CR-Form-v12.0* | | | | | | | | |
| **PSEUDO CHANGE REQUEST** | | | | | | | | |
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|  | **26**.**998** | **CR** | pseudo | **rev** |  | **Current version:** | **0.8.0** |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network |  |

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|  | | | | | | | | | | |
| ***Title:*** | **[FS\_5GSTAR] KPIs and Metrics** | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Qualcomm Incorporated | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | FS\_5GSTAR | | | | |  | ***Date:*** | | | 11/08/2021 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **B** |  | | | | | ***Release:*** | | | 17 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12)* *Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  |  | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

**===== CHANGE =====**

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document in the same Release as the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[x] 3GPP TR 26.928: “Extended Reality (XR) in 5G”

[4.3.0] ETSI GS ISG ARF 003 v1.1.1 (2020-03): “Augmented Reality Framework (ARF) AR framework architecture”

[4.3.a] 3GPP TR 26.928: “Extended Reality (XR) in 5G”

[4.3.b] 3GPP TS 22.261: “Service requirements for the 5G system”

[4.3.c] 3GPP TR 22.873: “Study on evolution of the IP Multimedia Subsystem (IMS) multimedia telephony service”

[4.3.d] 3GPP TS 26.114: “IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction”

[4.3.e] 3GPP RP-193241: “New SID on XR Evaluations for NR”

[4.3.f] ISO/IEC 23090-2:2019: “Information technology — Coded representation of immersive media — Part 2: Omnidirectional media format”

[4.3.g] ISO/IEC 23090-3:2020 FDIS: “Information technology — Coded representation of immersive media — Part 3: Versatile video coding”

[4.3.h] ISO/IEC 23090-5:2020 FDIS: “Information technology — Coded representation of immersive media — Part 5: Visual Volumetric Video-based Coding (V3C) and Video-based Point Cloud Compression (V-PCC)”

[4.3.i] ISO/IEC 23090-8:2020 FDIS: “Information technology — Coded representation of immersive media — Part 8: Network based media processing”

[4.5.a] Khronos Group, The OpenXR Specification, 1.0, <https://www.khronos.org/registry/OpenXR/specs/1.0/html/xrspec.html>

[4.5.b] W3C, WebXR Device API, W3C Working Group Draft, <https://www.w3.org/TR/webxr/>

[4.5.c] ISO/IEC 23090-14:2021 DIS: “Information technology — Coded representation of immersive media — Part 14: Scene Description for MPEG-I Media”

[4.5.d] Khronos Group, The GL Transmission Format (glTF) 2.0 Specification, <https://github.com/KhronosGroup/glTF/tree/master/specification/2.0/>

[4.6.a] Daniel Wagner, Louahab Noui, Adrian Stannard, "Why is making good AR displays so hard?", LinkedIn Blog, August 7, 2019, <https://www.linkedin.com/pulse/why-making-good-ar-displays-so-hard-daniel-wagner/>

[4.6.b] Daniel Wagner, "MOTION TO PHOTON LATENCY IN MOBILE AR AND VR", Medium Blog, August 20, 2018, https://medium.com/@DAQRI/motion-to-photon-latency-in-mobile-ar-and-vr-99f82c480926

[4.6.c] Yodayoda, "Why loop closure is so important for global mapping", Medium Blog, December 24, 2020, https://medium.com/yodayoda/why-loop-closure-is-so-important-for-global-mapping-34ff136be08f

[A.1] Google Draco: <https://google.github.io/draco/>

[A.2] T.Ebner, O.Schreer, I. Feldmann, P.Kauff, T.v.Unger, “m42921 HHI Point cloud dataset of boxing trainer”, MPEG 123rd meeting, Ljubljana, Slovenia

[A.3] Scene understanding, <https://docs.microsoft.com/en-us/windows/mixed-reality/scene-understanding>

[A.4] Serhan Gül, Dimitri Podborski, Jangwoo Son, Gurdeep Singh Bhullar, Thomas Buchholz, Thomas Schierl, Cornelius Hellge, “Cloud Rendering-based Volumetric Video Streaming System for Mixed Reality Services”, Proceedings of the 11th ACM Multimedia Systems Conference (MMSys'20), June 2020

[A.5] Scene lighting: <https://docs.microsoft.com/en-us/azure/remote-rendering/overview/features/lights>

[A.6] PBR material: <https://docs.microsoft.com/en-us/azure/remote-rendering/overview/features/pbr-materials>

[A.7] Color Material: <https://docs.microsoft.com/en-us/azure/remote-rendering/overview/features/color-materials>

[A.8] S. N. B. Gunkel, H. M. Stokking, M. J. Prins, N. van der Stap, F.B.T. Haar, and O.A. Niamut, 2018, June. Virtual Reality Conferencing: Multi-user immersive VR experiences on the web. In Proceedings of the 9th ACM Multimedia Systems Conference (pp. 498-501). ACM.

[A.9] Dijkstra-Soudarissanane, Sylvie, et al. "Multi-sensor capture and network processing for virtual reality conferencing." Proceedings of the 10th ACM Multimedia Systems Conference. 2019.

[A.10] VRTogether, a media project funded by the European Commission as part of the H2020 program, <https://vrtogether.eu/>, November 2020.

[A.11] MPEG131 Press Release: Point Cloud Compression – WG11 (MPEG) promotes a Video-based Point Cloud Compression Technology to the FDIS stage: https://multimediacommunication.blogspot.com/2020/07/mpeg131-press-release-point-cloud.html

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[x] <doctype> <#>[ ([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

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## 4.6 Key Performance Indicators and Metrics for AR

### 4.6.1 Summary of TR 26.928

In TR 26.928, clause 4.2 quality experience for XR is summarized. In order to provide the feeling of presence in immersive scenes, this clause provides a summary. TR 26.928 has some focus on VR and HMDs.

|  |  |
| --- | --- |
| **Feature** | **KPI from TR 26.928** |
| **Tracking** | |
| Freedom Tracking | 6DoF |
| Translational Tracking Accuracy | Sub-centimeter accuracy - tracking accuracy of less than a centimeter |
| Rotational Tracking Accuracy | Quarter-degree-accurate rotation tracking |
| VR Games tracking space | roughly 2m cubes |
| Tracking frequency | At least 1000 Hz |
| **Latency** | |
| motion-to-photon latency | Less than 20 ms |
| pose-to-render-to-photon latency | 50ms for render to photon in order to avoid wrongly rendered content |
| Interaction delay for games | 50 to 1000ms |
| **Video Rendering** | |
| Persistence – Duty time | Turn pixels on and off every - 3 ms to avoid smearing / motion blur |
| Display refresh rate | 90 Hz and beyond to eliminate visible flicker |
| Spatial Resolution | * 2K by 2K required * 4K by 4K desired |
| **Optics** | |
| Field of View | typically 100 - 110 degrees FOV is needed |
| Eye Box | the minimum and maximum eye-lens distance wherein a comfortable image can be viewed through the lenses.  at least 10mm, ideally rather 20mm |
| Calibration | correction for distortion and chromatic aberration that exactly matches the lens characteristics |
| Depth Perception | Avoid vergence and accommodation conflict (VAC) for accommodation at fixed same distance (e.g. 2m) |
| **Physics** | |
| Maximum Available Power | VR/AR HMD: 3-7 W  AR Glass: 0.5 – 2W |
| Maximum Weight | VR HMD: several 100 grams  AR Glass: 70g - if that weight is well distributed |

### 4.6.2 Updated KPIs for AR

In TR 26.928, some high-level statements on experience KPIs for AR are provided. To achieve Presence in Augmented Reality, seamless integration of virtual content and physical environment is required. Like in VR, the virtual content has to align with user's expectations. For truly immersive AR and in particular MR, it is expected that users cannot discern virtual objects from real objects.

Also relevant for VR and AR, but in particular AR, is not only the awareness for the user for the environment. This includes, safe zone discovery, dynamic obstacle warning, geometric and semantic environment parsing, environmental lighting and world mapping.

Based on updated information, Table 4.6.2-1 provides new KPIs with focus on AR. For some background and additional details refer for example to [4.6.a] and [4.6.b].

Table 4.6.2-1 KPIs from TR 26.928 with focus on AR

|  |  |
| --- | --- |
| **Feature** | **KPIs for AR glasses** |
| **Tracking** | |
| Freedom Tracking | 6DoF |
| Translational Tracking Accuracy | Sub-centimeter accuracy - tracking accuracy of less than a centimeter |
| Rotational Tracking Accuracy | Quarter-degree-accurate rotation tracking is desired |
| AR tracking space | In AR, the tracking space is theoretically unlimited. However, when moving, tracking accuracy may not be assured beyond a certain level of space or trajectory distance. SLAM based methods quickly introduce a large drift in large scale mapping. To correct the scaling issues, a loop closure technique [4.6c] needs to be applied in order to continuously harmonize the local coordinate systems with global ones. |
| Tracking frequency | At least 1000 Hz |
| **Latency** | |
| motion-to-photon latency | Less than 20 ms, and preferably even sub 10ms for AR as you may observe movement against the real world. |
| perception-to-render-to-photon latency | This latency is relevant for realizing the world for augmenting the scene correctly in the rendering an needs to be in the range of 50ms from perception of the environment to rendering, specifically for AR. |
| pose-to-render-to-photon latency | 50-60ms for render to photon is desired in order to avoid wrongly rendered content with late warping applied. |
| **Video Rendering and Display** | |
| Persistence – Duty time | Turn pixels on and off every 2 - 4 ms to avoid smearing / motion blur |
| Display refresh rate | 60 Hz minimum  90 Hz acceptable  120 Hz and beyond desired  240 Hz would allow always on display at 4ms |
| Color | RGB colors  Accurate colours independent of viewpoint. |
| Spatial Resolution per eye | for 30 x 20  - 1.5K by 1K per eye is required  - 1.8K by 1.2K per eye is desired  for 40 x 40  - 2K by 2K required  - 2.5 K by 2.5 K desired  ultimate goal for display resolution is reaching or going slightly beyond the human vision limit of roughly one arcmin (1/60°) |
| Content frame rates | Preferably matching the display refresh rate for lowest latency  Lower frame rates for example 60 fps or 90 fps may be used, but add to overall end to end delay. |
| Brightness | 200-500 nits for indoor  10K to 100K nits for outdoor |
| **Optics** | |
| Field of View | Augmentable FoV   * typically 30 by 20 degrees FOV acceptable * 40 by 40 degrees desired   maximize the non-obscured field of view |
| Eye Relief | the minimum and maximum eye-lens distance wherein a comfortable image can be viewed through the lenses.  at least 10mm, ideally rather 20mm |
| Calibration | correction for distortion and chromatic aberration that exactly matches the lens characteristics |
| Depth Perception | Avoid vergence and accommodation conflict (VAC) for accommodation being different for the real and virtual object |
| **Physics** | |
| Maximum Available Power | AR Glass: below 1 W, typically 500mW  For less design-oriented devices, additional power may be available. |
| Maximum Weight | AR Glass: around 70g. However, if the weight is well distributed, several hundred grams may be acceptable. |

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No other changes are proposed yet. However, it may be simpler to not repeat KPIs for each architecture in detail in clause 6, but only refer to instantation requirements. We are happy to provide updates as needed.