**3GPP TSG RAN WG1 Meeting #118 R1-240xxxx**

**Maastricht, Netherlands, August 19th – 23th, 2024**

**Source: Moderator (Intel Corporation)**

**Title: Summary of issues for RelSummary #1 of discussions for Rel-19 7-24 GHz Channel Modeling Validation**

**Agenda item: 9.8.1**

**Document for: Discussion**

# Introduction

In this contribution, moderator summarizes issues identified by the submitted maintanence contributions for RAN1 #118 agenda 9.8.1 regarding validation of channel models for 7 – 24 GHz. Based on the workplan presented in RAN1 #116-bis, R1-2402128, RAN1 should target the following for this meeting.

**RAN1 #118 - Objective #1 & #2:**

* Collection of measurement/simulated data and identification of channel modeling changes required.
* For the identified aspects and issues, discuss and study of potential updates of channel model based on data.
* Continuation of study on the methodology for modelling updates..

**RAN1 #118-bis -** **Objective #1 & #2:**

* Continuation of collection of measurement/simulated data and potential channel modeling changes required.
* For the identified aspects and issues, conclude the methodology for channel modeling updates.
* For the identified aspects and issues, continue study of details of required modeling updates.

# Suggested proposals for agreement/conclusion

This section will be completed by the moderator after offline discussions.

# Status summary of Proposal/TPs

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| **Proposal/TP** | **Status** | **Moderator Notes** |
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# Summary of issues

## 4.1 General Proposals

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| **Company** | **Proposals & Observations** |
| [7] vivo | **Proposal 1:** RAN1 studies how to judge whether to update the channel modeling based on the experiment results from different components.  **Proposal 2:** RAN1 studies how to update the channel modeling to meet the continuity at the frequency boundary of 7GHz and 24GHz. |
| [12] Nvidia | **Observation 1:** Wireless channel modelling needs to provide consistency and, above all, a correct representation of the frequency, spatial, and temporal correlation across base stations, devices, and objects in the environment.  **Observation 2:** Deterministic, physics-based modelling for wireless propagation, especially ray tracing, are essential for studying, evaluating, and developing key technologies in 5G-Advanced toward 6G, including ISAC, RIS, larger antenna arrays in new spectrum such as 7-24 GHz and sub-THz bands, AI/ML, etc.    **Observation 3:** Task Group IEEE 802.11bf has embraced ray tracing based channel model for WiFi sensing.  **Observation 4:** Ray tracing simulations offer a valuable complement by providing cost-effective, controlled, and flexible tools for studying signal propagation characteristics in diverse scenarios.  **Proposal 1:** Complement field measurements with ray tracing simulations to validate the channel model of TR38.901 at least for 7-24 GHz. |
| [13] Samsung | **Observation 1:** When examining frequency dependent properties of channel parameter, dynamic range of the measured data affect to results  **Proposal 1:** RAN1 discuss whether/how to apply dynamic range when it comes to frequency dependent properties for channel parameter |
| [17] AT&T | **Observation 12:** Coupling loss and geometry SINR distributions are not enough to evaluate the necessity of channel model changes.  **Observation 13:** Variation in the statistics in random variables may not be enough to evaluate the necessity of channel model changes  **Proposal 3:** Companies to agree on essential KPIs that may affect the system design and performance to evaluate the necessity of channel model changes. |

#### Summary of Issues

There were some general proposals from companies spanning from consideration of KPI for evaluating necessity of channel model changes to considering study of applying frequency continuity and leveraging ray tracing simulations for validation work. While moderator believes these are important aspects, it might be better to consider these aspects as part of the detailed model parameter update discussion. Companies are encouraged to provide further details of how the considerations could be applied, so the actual methodology or changes can be reviewed and discussed.

#### Round #1 Discussion

Please provide comments on any proposal on general aspects of the SI that requires discussion and approval. Moderator will draft the proposal numbers and list them for discussions.

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| **Company** | **Comments** |
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## 4.2 Discussion on Modeling Parameters

### 4.2.1 Penetration Loss

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| **Company** | **Proposals & Observations** |
| [7] vivo | **Observation 1:** The gap of penetration loss between the measurement and the empirical value for wood is within an acceptable range.  **Observation 2:** The penetration loss from measurement for concrete wall and glass are smaller than the empirical value with a large gap.  **Proposal 1:** RAN1 further validates the O-to-I penetration loss, with different materials in consideration of the thickness and the density. |
| [9] CATT | **Observation 1:** The gap between the penetration loss related measurement results for 7-24GHz and the model in TR38.901 is not evident.  **Proposal 1:** The assessment of the necessity for validation for channel model parameters in Table 1 can be considered.  Table 1. Potential list of parameters in the validation   |  |  | | --- | --- | | **Parameters** | **Whether validation is needed** | | Penetration loss | Not needed | |
| [15] BUPT, Spark NZ | **Proposal 1：**RAN1 needs to further model the frequency dependence of shadow fading under different scenarios.  **Observation 2:** The maximum difference between the measurement result of wood penetration loss and 3GPP is not more than 3 dB, while the concrete model has an error about 40 dB. Glass measurements do not exactly follow a linear distribution.  **Proposal 2**: RAN1 needs to further validate the O2I penetration loss considering materials of different thicknesses, especially concrete materials.  Table 4: The final measurement results of three different materials.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Material** | | **Slope** | **Intercept** | **Difference (Average of 3GPP and fitted model differences)** | | Glass | Standard multi-pane glass in 3GPP | 0.20 | 1.20 | - | | Glass 1 | 0.30 | 2.30 | 0.66 | | Glass 2 | -0.06 | 3.94 | -1.30 | | Concrete | Concrete in standard | 4.00 | 5.00 | - | | Concrete | 0.95 | 9.83 | 25.67 | | Wood | Wood in standard | 0.12 | 4.85 | - | | Wooden board 1 | 0.23 | 1.75 | 2.00 | | Wooden board 2 | 0.23 | 1.52 | 2.23 | | Wooden board 3 | 0.07 | 3.55 | 1.80 | |
| [19] Qualcomm | **Observation 6:** Standard Glass penetration losses at 13 GHz are in line with the expected losses from the penetration loss model in TR 38.901. For IRR glass, the measurements at multiple locations with IRR glass showed smaller losses at 13 GHz than that predicted by the model. At 3.4 GHz, IRR glass loss measurements align with that of the model.    **Proposal 12:** Further study penetration losses incurred due to IRR glass in FR3.  **Observation 7:** Average drywall/wood penetration losses at 13 GHz are in line with the expected losses from the penetration loss model in TR 38.901. |

#### Summary of Issues

From the measurements and provided by companies, penetration loss measurement loss seems to generally fit well with existing models.

The two exceptions to these observations seems to be penetration loss for concrete (based on measurement from BUPT, Spark NZ) and IRR glass (based on measurement from Qualcomm).

##### Proposal 2.1-1:

* Observation:
  + Wood and ‘standard’ Glass penetration loss model in TR38.901 seems to align well with measurements in 7-24 GHz conducted by companies.
  + Some exceptional cases are concrete and IRR glass penetration loss.
* Continue study on penetration loss for:
  + Concrete (e.g. Lconcrete = 0.95 *f* + 9.83)
  + IRR glass

#### Round #1 Discussion

Please provide comments on issues regarding penetration loss. Please provide comments on Proposal #2.1-1.

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| **Company** | **Comments** |
| Apple | Although we do not update our measurement results on “wood” in this meeting, we provided our measurement results in our earlier contribution (R1-2404304). In that contribution, we showed our measurement results on “wood” do not align with TR 38.901. Hence, we propose to continue studying the penetration loss for wood.  Also, we support to continue studying penetration loss for concrete, since our measurement results (R1-2404304) on concrete are not aligned with TR 38.901. |
| Ericsson | The existing building penetration loss model in 38.901 is based on several simplifying assumptions, including a fixed material thickness for each material and no internal reflections inside the material. The material thickness is implicit but has a large impact on the penetration loss, especially for high loss materials like concrete. Similarly, for IRR glass there is a metal layer on the glass with nm thickness, also here the exact thickness of this metal layer has a large impact. To align companies understanding of various measurement results it might be good to start by revisiting the material thickness assumptions. |
| vivo | Yes |
| ZTE | According to our simulation results, the material penetration loss highly depends on the thickness of materials, e.g. 20 cm concrete, 5cm wood, 3cm glass can well match the model in TR 38.901. We are fine to further study the penetration loss and should be clarified on the material thickness when we compare the simulation/measurement results with existing model. |

### 4.2.2 Pathloss

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| **Company** | **Proposals & Observations** |
| [2] Sharp | **Observation 1:** Based on the FI model fit, (path loss dependence on distance) for the measured data and 3GPP TR 38.901 model are similar (1.7 for measured data and 3GPP TR 38.901 in LOS and 3.6 for measured data and 3GPP TR 38.901 option 1 model [5] in NLOS) at 6.75 GHz for InH-Office scenario.  **Observation 2:** Based on the FI model fit, (path loss dependence on distance) for the measured data and 3GPP TR 38.901 model are similar (1.7 for measured data and 3GPP TR 38.901 in LOS, and 2.8 for measured data and 3.1 for 3GPP TR 38.901 option 2 model [5] in NLOS) at 16.95 GHz for InH-Office scenario.  **Proposal 1:** No further updates might be necessary in TR 38.901 path loss model for InH-Office scenario in LOS and NLOS channel condition based on measurements conducted at 6.75 GHz and 16.95 GHz.  **Observation 3:** Based on the ABG model fitting, for InH-Office scenario, (path loss dependence on distance) for the measured data and 3GPP TR 38.901 model are similar 1.7 (measured data) and 1.73 (3GPP TR 38.901) in LOS and 3.2 for measured data and 3.19 for 3GPP TR 38.901 option 2 model [5] in NLOS channel conditions. Similarly, based on ABG model fitting, (path loss dependance on frequency) for the measured data and 3GPP TR 38.901 model are similar 1.9 (measured data) and 2 (3GPP TR 38.901) in LOS channel condition. However, for NLOS channel condition, we observe a significant discrepancy in between the measured data (3.4) and 3GPP TR 38.901 (2.49/2). Just looking at 7-24 GHz it may seem like further investigation is required to model the frequency dependance on path loss ( in NLOS channel condition for 7-24 GHz. However, as shown later the multi-frequency path loss model over 0.5-100 GHz show a close agreement with 3GPP TR 38.901.  **Proposal 2:** No further updates might be necessary in TR 38.901 path loss model for InH-Office scenario in LOS and NLOS channel condition based on the analysis conducted over the entire 7-24 GHz frequency range based on measurement data. (path loss dependence on distance) and (path loss dependance on frequency) in the current 3GPP TR 38.901 path loss model for InH-Office scenario in LOS and NLOS channel condition exhibit close agreement with measured data.  **Observation 4:** Based on ABG model fitting, for InH-Office scenario, (path loss dependance on distance) for the measured data and 3GPP TR 38.901 model are similar 1.4 (measured data) and 1.73 (3GPP TR 38.901) in LOS and 3.4 for measured data and 3.19 for 3GPP TR 38.901 option 2 model [5] in NLOS. Similarly, based on ABG model fitting, (path loss dependance on frequency) for the measured data and 3GPP TR 38.901 model are similar 2.1 (measured data) and 2 (3GPP TR 38.901) in LOS channel condition. However, for NLOS channel condition, is 2.9 for measured data and 2.49/2 for 3GPP TR 38.901 model. The discrepancy in is not as significant over the entire 0.5-100 GHz frequency range when compared to 7-24 GHz only.  **Proposal 3:** No further updates might be necessary in TR 38.901 path loss model for InH-Office scenario in LOS and NLOS channel condition based on the analysis conducted over the entire 0.5-100 GHz frequency range based on measurement data. (path loss dependance on distance) and (path loss dependance on frequency) in the current 3GPP TR 38.901 path loss model in LOS and NLOS channel condition for InH-Office exhibit close agreement with measured data.  **Proposal 4:** Companies are encouraged to provide FI path loss model parameters (for single frequency) or ABG path loss model parameters (for multi-frequency) for analyzing and updating path the loss models, if necessary, in TR 38.901. |
| [4] Intel | **Observation 2:**   * Measured pathloss for scenario resembling UMi Street Canyon show good alignment with current TR. |
| [5] ZTE, Sanechips | **Proposal 4:** No need to update large scale parameters such as pathloss, LoS probability, penetration loss, shadow fading and spread of parameters. |
| [7] vivo | **Observation 1:** The pathloss gap between the measurement and the empirical formula is within the max range of 5dB under the LOS conditions in indoor scenario.  **Observation 2:** The pathloss gap between the measurement and the empirical formula is within the max range of 15dB under the NLOS conditions in indoor scenario, that can be considered under the agreeable level in between. |
| [9] CATT | **Observation 1:** The gap between the penetration loss related measurement results for 7-24GHz and the model in TR38.901 is not evident.  **Proposal 1:** The assessment of the necessity for validation for channel model parameters in Table 1 can be considered.  Table 1. Potential list of parameters in the validation   |  |  | | --- | --- | | **Parameters** | **Whether validation is needed** | | Pathloss | Not needed | |
| [13] Samsung | **Observation 1:** The marginal difference compared to pathloss for UMi scenario in existing channel model is confirmed  **Proposal 1:** RAN1 discuss whether the updates of pathloss in UMi scenario is needed |
| [16] Apple | **Observation 1:** The pathloss of indoor office LOS scenario in TR 38.901 is aligned with our measurement results at frequency of 13 GHz.  **Observation 2:** The pathloss of indoor office NLOS scenario in TR 38.901 is almost aligned with our measurement results at frequency of 13 GHz.  **Observation 3:** The pathloss of indoor factory scenario in TR 38.901 is aligned with our measurement results at frequency of 13 GHz. |
| [17] AT&T | **Observation 2:** Measurements conducted at 15 GHz over 650 RX locations on floors of an office building show that the PLE for LoS and NLoS environments agree with the previously proposed 3GPP SCM InH channel model.  **Observation 3:** Measurements at 8GHz and 11GHz (same locations) are ongoing and needed to draw the conclusion over FR3 for InH pathloss modelling |
| [19] Qualcomm | A diagram of a pathlose measurement  Description automatically generated  Figure 19 Pathloss measurements from a transmitter mounted at a height of 26 meters. Measurements were made at 13 GHz.  **Observation 4:** Pathloss measurements at 13GHz in a Rural Macro setting are in line with existing pathloss models in TR 38.901. There does not appear to be a need to update the Rural Macro pathloss models currently available in TR 38.901.   |  |  | | --- | --- | | A diagram of a pathlose measurement  Description automatically generated | A diagram of a pathlose measurement  Description automatically generated |   Figure 20 Pathloss comparison between FR1 and FR3. A 12 dB difference in pathloss is observed between FR1 and FR3 --- in line with theoretical expectations.  **Observation 5:** Pathloss comparison between measurements at 13GHz and 3.4 GHz are in line with expectations. A 12 dB difference in pathloss is observed between these frequency bands.  **Proposal 10:** RAN1 to consider extending the RMa pathloss models to 7-24 GHz frequency range.  **Proposal 11:** Generalize the pathloss models for UMa in TR 38.901 to accommodate different base station heights. Pathloss model in TR 36.873 can be used as a starting point. |

#### Summary of Issues

InH-Office LOS, NLOS: No change identified (Sharp, Apple, AT&T, vivo)

UMi Street Canyon LOS, NLOS: No change identified (Intel, Samsung)

InF LOS, NLOS: No change identified (Apple)

RMa LOS, NLOS: No change identified (Qualcomm)

So far companies seems to generally providing inputs that pathloss update may not be needed. There are several inputs that may not strictly fall under existing scenarios (e.g. SMa), which will be discussed under Section 4.3.

##### Proposal 2.2-1:

* Observation:
  + Preliminary study shows updates may not be needed at least for the following scenarios:
    - InH-Office, UMi Street Canyon, InF, RMa
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.
* Continue study on pathloss for applicable scenarios

#### Round #1 Discussion

Please provide comments on issues regarding path loss. Please provide comments on Proposal #2.2-1.

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| **Company** | **Comments** |
| Apple | We are generally fine with the proposal. For the second bullet, we think it is better to clarify the remaining scenarios (e.g., UMa LOS, UMa NLOS). Also, we may consider the building clutter in the measurements in UMa NLOS scenario. |
| InterDigital | * For the first bullet, need to say “update on pathloss computation” * A general suggestion for Proposals 2.2-1 to 2.2-7 that, we could drop the “may”, and use definite wording “are”, and make the proposal as a Working Assumption. |
| Ericsson | We are supportive of the proposal.  Note: The first bullet in the proposal should mention that it relates to path loss. |
| DOCOMO | We support the proposal |
| Mediatek | We support the proposal. |
| vivo | Support |
| ZTE | We are fine with the proposal with modification on main bullet “updates on pathloss” |

### 4.2.3 Delay Spread

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| **Company** | **Proposals & Observations** |
| [1] Huawei, HiSilicon | Table 1 Fast fading parameters   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Scenario** | | **InH @10 GHz** | | | | **UMi @10 GHz** | | | | **UMa @6.5 GHz** | | | | **UMa @13 GHz** | | | | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | | Delay spread (DS) lgDS=log10(DS/1s) | lgDS | -7.7 | -7.46 | -7.79 | -7.45 | -7.39 | -7.08 | -7.47 | -7.37 | -7.03 | -6.45 | -7.32 | -7.01 | -7.06 | -6.51 | -7.59 | -7.12 | | [ns] | 20 | 34.7 | 16.2 | 35.5 | 40.7 | 83.2 | 33.9 | 42.7 | 93.3 | 354.8 | 47.9 | 97.7 | 86.6 | 311 | 25.3 | 76.2 | | lgDS | 0.18 | 0.16 | 0.11 | 0.07 | 0.38 | 0.45 | 0.28 | 0.1 | 0.66 | 0.39 | 0.38 | 0.28 | 0.66 | 0.39 | 0.5 | 0.42 |   **Observation1:** The sparsity characteristics can be observed at least for 6-13 GHz:   * The measured DSs are smaller than that in 3GPP TR 38.901 at 6-13 GHz   **Proposal 1:** At least the following fast fading parameters require updates for 6-24 GHz frequencies:   * Delay spread (mean, variance) |
| [2] Sharp | **Observation 5:** Based on the observations at 6.75 GHz and 16.95 GHz for InH-Office scenario in LOS channel condition, the difference in the mean delay spread between TR 38.901 and measured data is not significantly large. Specifically, TR 38.901 predicts a mean delay spread that is only 1.7 times smaller than the measured value at 6.75 GHz, and exhibits a similar mean delay spread at 16.95 GHz.  **Observation 6:** The standard deviation of delay spread in the LOS channel condition for InH-Office scenario at 6.75 GHz is 3 times lower in TR 38.901 compared to the measured values. Similarly, at 16.95 GHz, in the LOS channel condition for InH-Office scenario TR 38.901 exhibits a standard deviation that is 2 times smaller than that observed in the measurements.  **Observation 7:** Consistent with our previous analysis in [5], we observed a dependency of the standard deviation of delay spread on frequency in the InH-Office scenario. The difference in the standard deviation of delay spread between 6.75 GHz and 16.95 GHz in the LOS channel condition for InH-Office scenario is 6 ns based on measured data, whereas TR 38.901 predicts a difference of only 0.1 ns.  **Proposal 5:** No adjustment may be necessary for the mean delay spread values in the LOS channel condition for InH-Office scenario based on measurements conducted at 6.75 GHz and 16.95 GHz. Additionally, further investigation may be necessary to determine whether the standard deviation of delay spread in the LOS channel condition needs to be updated and made frequency-dependent in TR 38.901 for InH-Office scenario.  **Observation 8:** The difference in the mean delay spread between TR 38.901 and measured data is not significantly large at 6.75 GHz and 16.95 GHz in NLOS channel condition for InH-Office scenario. Specifically, TR 38.901 predicts a mean delay spread that is only 1.2 times smaller than the measured value at 6.75 GHz and 16.95 GHz. Furthermore,the standard deviation of delay spread in the NLOS channel condition at 6.75 GHz is 1.5 times lower in TR 38.901 compared to the measured values. Similarly, at 16.95 GHz, TR 38.901 exhibits a standard deviation that is 1.4 times smaller than that observed in the measurements.  **Proposal 6:** No adjustment may be necessary in TR 38.901 for the mean delay spread and standard deviation of delay spread in the NLOS channel condition for InH-Office scenario based on measurements conducted at 6.75 GHz and 16.95 GHz. |
| [4] Intel | **Observation 1:**   * Measurements observed mean of 18 ns RMS delay spread for scenario resembling UMi Street Canyon. However, measurements only represent a specific scenario and its is unclear if it warrants changes to the DS of the current TR. |
| [9] CATT | **Observation 2:** The gap between the delay spread measurement results in some scenarios for 7-24GHz and the model in TR38.901 cannot be ignored.  **Proposal 1:** The assessment of the necessity for validation for channel model parameters in Table 1 can be considered.  Table 1 Potential list of parameters in the validation   |  |  | | --- | --- | | **Parameters** | **Whether validation is needed** | | Delay spread | Needed | |
| [10] Keysight | **Observation 1**: In 10.25 GHz outdoor measurement, all estimated large-scale parameter statistics indicated substantially smaller dispersion as compared to those in TR 38.901.  Table 1. Large scale parameter comparison between measured UMi values at 10 GHz in Santa Rosa and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Outdoor LOS measured | UMi LOS 38.901 | Outdoor NLOS measured | UMi NLOS 38.901 | | # of paths | m | 36.5 | (12 clusters) | 13.6 | (19 clusters) | |  | s | 15.7 | - | 13.6 | - | | Delay spread [ns] | m | 20.2 | 59.7 | 30.5 | 140.1 | |  | s | 15.2 | 63.9 | 29.5 | 193.0 | |
| [17] AT&T | **Observation 6:** Measurements conducted at 15 GHz over 650 RX locations on floors of an office building show that the mean delay spread for LoS and NLoS environments agree with the 3GPP SCM InH channel model.  **Observation 7:** Measurements at 8GHz and 11GHz (same locations) are ongoing and needed to draw the conclusion over FR3 for InH delay spread mean and standard deviation |

#### Summary of Issues

Companies observed lower delay spread in the frequency ranges of interest for following scenarios:

* UMi LOS (Keysight)
  + @10.25GHz: mean log DS -7.22 -> -7.695
* UMi NLOS (Huawei, Keysight, Intel)
  + @10GHz: mean log DS -7.08 -> -7.37
  + @10.25GHz: mean DS -6.714 -> -7.53
  + @10GHz: mean log DS -7.08 -> -7.746
* UMa NLOS (Huawei)
  + @6.5GHz: mean log DS -6.458 -> -7.01
  + @12GHz: mean log DS -6.51 -> -7.12

Companies observed aligned delay spread in the frequency ranges of interest for following scenarios:

* InH LOS, NLOS (Huawei, Sharp)
* UMi LOS (Huawei)
* UMa LOS (Huawei)

##### Proposal 2.3-1:

* Observation:
  + Preliminary study shows updates may not be needed at least for the following scenarios:
    - InH-Office LOS and NLOS, UMa LOS
  + Preliminary study shows updates may be needed at least for the following scenarios:
    - UMi LOS and NLOS,
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.
* Continue study on delay spread for applicable scenarios. Following are some example of potential changes:
  + UMi LOS
    - @10.25GHz: mean log DS -7.22 -> -7.695
  + UMi NLOS
    - @10GHz: mean log DS -7.08 -> -7.37
    - @10.25GHz: mean DS -6.714 -> -7.53
    - @10GHz: mean log DS -7.08 -> -7.746
  + UMa NLOS
    - @6.5GHz: mean log DS -6.458 -> -7.01
    - @12GHz: mean log DS -6.51 -> -7.12

#### Round #1 Discussion

Please provide comments on issues regarding delay spread. Please provide comments on Proposal #2.3-1.

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| **Company** | **Comments** |
| Apple | For UMa LOS scenario, our measurement results (R1-2404304) show the delay spread is not aligned with TR 38.901. Hence, we propose to update delay spread for “UMa LOS”.  For UMa NLOS scenario, our measurement results show the delay spread is aligned with TR 38.901with building clutter. Hence, we need to check more on this scenario.  Also, we think it is pre-mature to provide example values in the second bullet. Furthermore, these example values are only at certain frequency, which is comprehensive. |
| InterDigital | * For the first bullet, need to say “update on delay spread” * A general suggestion for Proposals 2.2-1 to 2.2-7 that, we could drop the “may”, and use definite wording “are”, and make the proposal as a Working Assumption. |
| Ericsson | In our previous contribution R1-2402613 we performed measurements and concluded that the delay spread in UMa LOS/NLOS/O2I was not in need of an update.  Note: The first bullet in the proposal should mention that it relates to delay spread. |
| ZTE | We think it’s premature to list the exact values for the change of delay spread, more measurement results are needed on the potential scenarios that may require updates. |

### 4.2.4 Angle Distribution

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| **Company** | **Proposals & Observations** |
| [1] Huawei, HiSilicon | Table 1 Fast fading parameters   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Scenario** | | **InH @10 GHz** | | | | **UMi @10 GHz** | | | | **UMa @6.5 GHz** | | | | **UMa @13 GHz** | | | | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | | AOD spread (ASD) lgASD=log10(ASD/1°) | lgASD | 1.6 | 1.62 | 1.21 | 1.27 | 1.16 | 1.29 | 1.04 | 1.14 | 1.15 | 1.41 | 0.82 | 1.26 | 1.18 | 1.37 | 1.08 | 1.25 | | [deg] | 39.8 | 41.7 | 16.2 | 18.6 | 14.5 | 19.5 | 11 | 13.8 | 14.1 | 25.7 | 6.6 | 18.2 | 15.3 | 23.6 | 12.1 | 17.9 | | lgASD | 0.18 | 0.25 | 0.18 | 0.14 | 0.41 | 0.44 | 0.2 | 0.07 | 0.28 | 0.28 | 0.28 | 0.27 | 0.28 | 0.28 | 0.21 | 0.3 | | AOA spread (ASA) lgASA=log10(ASA/1°) | lgASA | 1.58 | 1.75 | 1.29 | 1.5 | 1.65 | 1.73 | 1.19 | 1.37 | 1.81 | 1.86 | 1.67 | 1.72 | 1.81 | 1.78 | N/A | N/A | | [deg] | 38 | 56.2 | 19.5 | 31.6 | 44.7 | 53.7 | 15.5 | 23.4 | 64.6 | 72.4 | 46.8 | 52.5 | 64.6 | 60.2 | N/A | N/A | | lgASA | 0.24 | 0.18 | 0.13 | 0.23 | 0.29 | 0.35 | 0.13 | 0.08 | 0.2 | 0.11 | 0.19 | 0.15 | 0.2 | 0.11 | N/A | N/A | | ZOD spread (ZSD) lgZSD=log10(ZSD/1°) | lgZSD | 0.74 | 1.08 | 0.99 | 1.1 | 0.11 | -0.11 | 0.54 | 0.61 | 0.54 | 0.69 | 0.7 | 0.78 | 0.54 | 0.69 | 0.68 | 0.83 | | [deg] | 5.5 | 12 | 9.8 | 12.6 | 1.3 | 0.8 | 3.5 | 4.1 | 3.5 | 4.9 | 5 | 6 | 3.5 | 4.9 | 4.8 | 6.8 | | lgZSD | 0.44 | 0.36 | 0.13 | 0.12 | 0.35 | 0.35 | 0.12 | 0.09 | 0.4 | 0.49 | 0.33 | 0.34 | 0.40 | 0.49 | 0.31 | 0.35 | | ZOA spread (ZSA) lgZSA=log10(ZSA/1°) | lgZSA | 1.17 | 1.23 | N/A | N/A | 0.63 | 0.88 | N/A | N/A | 0.95 | 1.25 | 1.08 | 1.15 | 0.95 | 1.15 | N/A | N/A | | [deg] | 14.8 | 17 | N/A | N/A | 4.3 | 7.6 | N/A | N/A | 8.9 | 17.8 | 12 | 14.1 | 8.9 | 14.2 | N/A | N/A | | lgZSA | 0.22 | 0.65 | N/A | N/A | 0.3 | 0.34 | N/A | N/A | 0.16 | 0.16 | 0.17 | 0.12 | 0.16 | 0.16 | N/A | N/A |   **Observation1:** The sparsity characteristics can be observed at least for 6-13 GHz:   * The measured ASDs/ASAs are smaller than that in 3GPP TR 38.901 at 6-13 GHz   **Proposal 1:** At least the following fast fading parameters require updates for 6-24 GHz frequencies:   * AoD spread (mean, variance) * AoA spread (mean, variance) |
| [5] ZTE, Sanechips | **Observation 6:** To model the Laplace distribution of cluster, unequal power rays with equal angle offset (MED) is equivalent to equal power rays with unequal angle offset (MEA). |
| [9] CATT | **Observation 3:** The gap between the angular spread measurement results in some scenarios for 7-24GHz and the model in TR38.901 cannot be ignored. |
| [10] Keysight | **Observation 1**: In 10.25 GHz outdoor measurement, all estimated large-scale parameter statistics indicated substantially smaller dispersion as compared to those in TR 38.901.  Table 1. Large scale parameter comparison between measured UMi values at 10 GHz in Santa Rosa and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Outdoor LOS measured | UMi LOS 38.901 | Outdoor NLOS measured | UMi NLOS 38.901 | | Azimuth spread of arrival [°] | m | 36.7 | 55.7 | 17.4 | 73.9 | |  | s | 20.4 | 42.6 | 24.0 | 71.3 | | Azimuth spread of departure [°] | m | 19.2 | 22.4 | 31.7 | 32.9 | |  | s | 11.0 | 27.0 | 9.3 | 44.6 |   **Observation 3**: Some of the target angle spread values of 39.901 LOS models are in contradiction with the K-factor of the model and not feasible when LOS component is included into the angle spread calculation.  **Observation 4**: In 10.1 GHz outdoor and indoor measurement, almost all estimated distribution values of large-scale parameters indicated substantially smaller dispersion as compared to those in TR 38.901. The only exception is ZSA in the UMi scenario.  Table 4. Large scale parameter comparison between measured UMi values in [3] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | UMi LOS measured | UMi LOS 38.901 | UMi NLOS measured | UMi NLOS 38.901 | | ASD [˚]​ | m | 16.6 | 22.4 | 22.8 | 32.9 | |  | s | 15.8 | 27.0 | 19.3 | 44.6 | | ASA [˚]​ | m | 32.8 | 55.7 | 60.2 | 73.9 | |  | s | 16.0 | 42.6 | 12.6 | 71.3 | | ZSD [˚]​ | m | 6.8 | - | 7.9 | - | |  | s | 2.8 | - | 1.3 | - | | ZSA [˚]​ | m | 13.5 | 5.3 | 12.6 | 10.2 | |  | s | 3.2 | 4.1 | 3.8 | 9.3 |   Table 5. Large scale parameter comparison between measured Indoor values in [4] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Indoor LOS measured | Indoor LOS 38.901 | Indoor NLOS measured | Indoor NLOS 38.901 | | ASD [˚]​ | m | 8.3 | 43.4 | 24.0 | 49.2 | |  | s | 4.8 | 18.8 | 13.7 | 30.9 | | ASA [˚]​ | m | 28.4 | 44.8 | 47.6 | 61.3 | |  | s | 7.3 | 27.3 | 20.6 | 27.3 | | ZSD [˚]​ | m | 10.5 | - | 6.6 | - | |  | s | 8.6 | - | 10.5 | - | | ZSA [˚]​ | m | 4.4 | 16.8 | 8.3 | 52.3 | |  | s | 1.8 | 9.2 | 6.2 | 155.6 | |
| [13] Samsung | **Observation 1:** Slight difference compared to mean and standard deviation of ASD for UMi scenario in the existing channel model were confirmed.  **Observation 2:** Significant difference compared to mean and standard deviation of ASA for UMi scenario in the existing channel model were confirmed  **Proposal 1:** RAN1 discuss whether the updates of azimuth spread of departure/arrival angles in UMi scenario is needed |
| [14] Ericsson | **Observation 3** The measured angular ASD at 13 GHz and 28 GHz is lower than expected from 38.901, similar to previous measurements at 3.5 GHz.  **Observation 4** The ASD and ZSD for 13 and 28 GHz are very similar, which is in line with 38.901.  Table 4 Suggested updates to the TR 38.901 UMa ASD model   | Scenarios | | UMa | | | | --- | --- | --- | --- | --- | | LOS | NLOS | O2I | | AOD spread (ASD)  lgASD=log10(ASD/1°) | *µ*lgASD | 0.39 + 0.1114 log10(*fc*) | 0.83 - 0.1144 log10(*fc*) | 0.58 | | *σ*lgASD | 0.4 | 0.7 | 0.7 | | Cluster *ASD* () in [deg] | | 1.5 | 1.5 | 1.5 |   **Proposal 5** The ASD parameters for the UMa model are adjusted according to Table 4 to better represent measurements at 3.5 GHz in two different cities, and at 13 GHz and 28 GHz in a third city. |
| [17] AT&T | **Observation 8:** Measurements conducted at 15 GHz 650 RX locations on floors of an office building show that the mean angular spread (ASA) for LoS and NLoS environments agree with the 3GPP SCM InH channel model.  **Observation 9:** Measurements at 8GHz and 11GHz (same locations) are ongoing and needed to draw the conclusion over FR3 for InH ASA mean and standard deviation  **Observation 10:** Measurements conducted at 15 GHz 650 RX locations on floors of an office building show that the mean angular spread (ZSA) for LoS and NLoS environments do not agree with the 3GPP SCM InH channel model.  **Observation 11:** Measurements at 8GHz and 11GHz (same locations) are ongoing and needed to draw the conclusion over FR3 for InH ZSA mean and standard deviation  Table 1: Channel parameters comparison between AT&T indoor measurements at 15GHz and 3GPP InH model in TR38.901   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Parameter** | | **LOS** | | **NLOS** | | | **3GPP Model** | **AT&T Measurements** | **3GPP Model** | **AT&T Measurements** | | PLE | | 1.7 | 1.5 | 3.8 | 3.4 | | Shadow Fading | | 3.0 | 2.4 | 8.0 | 7.3 | | log(Delay Spread/1s) |  | -7.70 | -7.94 | -7.51 | -7.57 | |  |  | 0.18 | 0.34 | 0.17 | 0.22 | | log(ASA/1o) |  | 1.55 | 1.57 | 1.73 | 1.78 | |  |  | 0.26 | 0.15 | 0.20 | 0.15 | | log(ZSA/1o) |  | 1.13 | 0.94 | 1.21 | 0.94 | |  |  | 0.22 | 0.05 | 0.64 | 0.06 | |

#### Summary of Issues

Companies observed lower angular spread in the frequency ranges of interest for following scenarios:

* InH LOS/NLOS ASD, ASA (Huawei)
* InH LOS/NLOS ZSA, ZSD (Keysight, AT&T)
* UMi LOS/NLOS ASA (Huawei, Keysight, Samsung)
* UMi LOS/NLOS ASD (Keysight, Samsung)
* UMa LOS/NLOS ASA, ASD (Huawei)

Companies observed aligned delay spread in the frequency ranges of interest for following scenarios:

* InH LOS/NLOS ASA (AT&T)
* InH LOS/NLOS ZSA, ZSD (Huawei)
* UMi LOS/NLOS ZSA, ZSD (Huawei)
* UMa LOS/NLOS ZSA, ZSD (Huawei)

##### Proposal 2.4-1:

* Observation:
  + Preliminary study shows some updates may be needed for cluster angular distribution for at least following scenarios:
    - InH LOS/NLOS, UMi LOS/NLOS, UMa LOS/NLOS
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.
* Continue study on angular distribution for applicable scenarios

#### Round #1 Discussion

Please provide comments on issues regarding angle distribution. Please provide comments on Proposal #2.4-1.

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| **Company** | **Comments** |
| InterDigital | - For the first bullet, need to say “update on angle distribution”  - A general suggestion for Proposals 2.2-1 to 2.2-7 that, we could drop the “may”, and use definite wording “are”, and make the proposal as a Working Assumption. |
| Ericsson | Suggest using the words “azimuth angular spread (ASD)” or “angular spread ” instead of “cluster angular distribution”. |
| ZTE | We are open to study, but “cluster angular distribution” is confusing. |

### 4.2.5 Clusters

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| **Company** | **Proposals & Observations** |
| [1] Huawei, HiSilicon | Table 1 Fast fading parameters   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Scenario** | **InH @10 GHz** | | | | **UMi @10 GHz** | | | | **UMa @6.5 GHz** | | | | **UMa @13 GHz** | | | | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | **TR 38.901** | | **Measurement** | | | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | **LOS** | **NLOS** | | Number of clusters | 15 | 19 | 10 | 11 | 12 | 19 | 5 | 7 |  |  |  |  |  |  |  |  |   **Observation1:** The sparsity characteristics can be observed at least for 6-13 GHz:   * The measured numbers of clusters are smaller than that in 3GPP TR 38.901 at 10 GHz   **Proposal 1:** At least the following fast fading parameters require updates for 6-24 GHz frequencies:   * Number of clusters |
| [2] Sharp | **Observation 10:** TR 38.901 does not model the number of clusters and the number of rays per cluster as frequency-dependent variables. This is a significant oversight given the substantial evidence in the literature showing that both the number of clusters and rays per cluster decrease with increasing frequency. Accurate modeling of this frequency dependence is crucial to capturing channel sparsity effectively. The current approach in TR 38.901 uses a -25 dB threshold to remove weak clusters. However, this method has proven insufficient to capture channel sparsity accurately. Various simulation studies have demonstrated that despite the application of this threshold, TR 38.901 still falls short in representing the true sparse nature of channels, particularly at higher frequencies.  **Proposal 12:** RAN1 to study alternate approaches for modelling channel sparsity other than the intra-cluster K-factor, such as modelling the number of clusters and number of rays per cluster as frequency dependent and allocating unequal powers to different rays within a cluster based on a certain stochastic distribution. |
| [5] ZTE, Sanechips | **Observation 7:** The different number of clusters for LoS UE can be achieved by assigning different power offsets in the removal of paths, but the number of clusters for NLoS UE may need further study. |
| [7] vivo | **Proposal 1:** RAN1 studies the impact of channel sparsity on the existing channel model based on the experiment result. |
| [8] OPPO | **Proposal 2:** For modeling of intra-cluster K factor,   * The definition of “first intra-cluster ray” in RAN1 #117 agreement should be clarified. * The exact modeling motivation of intra-cluster K-factor should be clarified, e.g., between modeling a “close-to-LOS” ray and modeling a “close-to-dominant ray”.   + For modeling of “close-to-LOS” ray, RAN1 should consider impacts to ray-level delay, ray-level angle modeling and ray-level coupling.   + For modeling of “close-to-dominant” ray, it should be clarified why there is only one ray being close-to-dominant. |
| [9] CATT | **Observation 4:** The gap between the number of clusters measurement results for 7-24GHz and the model in TR38.901 cannot be ignored.    **Proposal 1:** The assessment of the necessity for validation for channel model parameters in Table 1 can be considered.  Table 1 Potential list of parameters in the validation   |  |  | | --- | --- | | **Parameters** | **Whether validation is needed** | | Number of clusters | Needed | | Number of rays per cluster | FFS | |
| [10] Keysight | **Observation 2**: In 10.1 GHz outdoor and indoor measurement, almost all estimated per cluster parameters indicated substantially smaller dispersion and smaller number of clusters as compared to those in TR 38.901*.*  Table 2. Per cluster parameter comparison between measured UMi values in [3] and those in TR 38.901.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | UMi LOS measured | UMi LOS 38.901 | UMi NLOS measured | UMi NLOS 38.901 | | # of Clusters​ | 8​ | 12​ | 10​ | 19​ |   Table 3. Per cluster parameter comparison between measured Indoor values in [3] and those in TR 38.901.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | Indoor LOS measured | Indoor LOS 38.901 | Indoor NLOS measured | Indoor NLOS 38.901 | | # of Clusters​ | 6 | 15 | 11 | 19 | |
| [14] Ericsson | **Proposal 7:** Encourage companies to perform measurements to further study whether the existing mechanisms for generating clusters and rays are inaccurate when simulating large antenna arrays. |
| [15] BUPT, Spark NZ | Table 6 Cluster number   |  |  |  |  | | --- | --- | --- | --- | |  | | Cluster number | Cluster number with -25 dB | | LOS | Simulated results based on 3GPP | 12 | 7 | | Measured results | 9 | \ | | NLOS | Simulated results based on 3GPP | 20 | 19 | | Measured results | 14 | \ |   **Observation 3:** The measured cluster number is smaller than the 3GPP model, and there is still a gap after interception using the threshold of -25 dB.  **Proposal 3**: The number of clusters in TR 389.01 needs modification.  **Observation 4:** The value of ICP is different in each cluster, and it is related to the cluster delay and delay spread.  **Observation 5:** The ICP model has been proved to be applicable to indoor [2] and UMa scenarios. When ICP is introduced into the 3GPP model, the level of sparsity is closer to the measured results.  **Proposal 4:** To distinguish the intra-cluster K-factor (ICK) from Ricean K-factor, ICK is renamed as the intra-cluster power factor (ICP). |
| [19] Qualcomm | **Proposal 5:** Do not introduce an intra-cluster K factor in the spatial channel model. |

#### Summary of Issues

Companies observed lower cluster numbers in the frequency ranges of interest for following scenarios:

* InH LOS/NLOS (Huawei, Keysight)
  + LOS: 15 -> 10, 6
  + NLOS: 19 -> 11
* UMi LOS/NLOS (Huawei, Keysight)
  + LOS: 12 -> 5, 8
  + NLOS: 19 -> 7, 10
* UMa LOS/NLOS (BUPT/Spark NZ)
  + LOS: 12 -> 9
  + NLOS: 20 -> 14

One company commented that changes to -25dB threshold to remove clusters could be one method to achieve lower cluster density for frequency of interest. One company commented the -25dB threshold to remove the lower powered clusters in the channel model may not be sufficient to replicate the reduction in clusters for frequencies of interest.

##### Proposal 2.5-1:

* Observation:
  + Preliminary study shows some updates may be needed for number of cluster and/or threshold for removing lower powered clusters in the channel model for at least following scenarios:
    - InH LOS/NLOS, UMi LOS/NLOS, UMa LOS/NLOS
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.
* Continue study on handling of number of clusters for applicable scenarios. The following are some examples of changes:
  + InH LOS/NLOS
    - LOS: 15 -> 10, 6
    - NLOS: 19 -> 11
  + UMi LOS/NLOS
    - LOS: 12 -> 5, 8
    - NLOS: 19 -> 7, 10
  + UMa LOS/NLOS
    - LOS: 12 -> 9
    - NLOS: 20 -> 14

#### Round #1 Discussion

Please provide comments on issues regarding cluster modeling. Please provide comments on Proposal #2.5-1.

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| **Company** | **Comments** |
| Ericsson | When comparing measurements with the existing model it is important to make an unbiased comparison. The nominal number of clusters in 38.901 will almost certainly result in a lower number of resolvable clusters in any channel realization. One reason is the dropping of weak clusters, another is that some clusters may be overlapping and not resolvable to an estimator. We therefore encourage companies to generate channel realizations from 38.901 using the same bandwidth, antenna modeling, and SNR as the measurements, and then use the same estimator (super-resolution method + clustering algorithm) on these synthetic channel realizations as done for the measurements. This will remove some of the bias that would otherwise occur. |
| vivo | According to the experiment results in terms of channel response, indeed, reducing the number of clusters seems necessary. However, thanks to the minimum -25dB level compared to the strongest cluster, the impact on the number of clusters after clipping could be much smaller. Therefore, the decision on whether to reduce the number of clusters should rely on the impact of geometry SINR, SE or throughput, other than the observation of channel response. |
| ZTE | In TR 38.901, a number of clusters is provided firstly, such as 15 clusters for indoor LoS UE, then after the cluster power calculation with exponential delay distribution, the clusters with less than -25 dB power compared to the maximum cluster power will be removed. We have performed the simulation and found that the number of clusters for LoS UEs after the removal by power offset can be aligned with the measurement results from companies. But for NLoS UEs, we are open to study the number of clusters for NLoS UEs. |

### 4.2.6 LOS Probability

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| **Company** | **Proposals & Observations** |
| [5] ZTE, Sanechips | **Proposal 4:** No need to update large scale parameters such as pathloss, LoS probability, penetration loss, shadow fading and spread of parameters. |

#### Summary of Issues

LOS probability largely depends on the deployment scenario building and obstruction layout with respect to UE positions. Comanpies have mentioned that there may not be a need to update the LOS probability for existing scenarios.

The one exception could be if SMa scenario is adopted or if SMa like scenario is applied to either UMi and/or UMa scenarios.

##### Proposal 2.6-1:

* Observation:
  + Preliminary study shows LOS probability do not need to be updated for the frequency range of interest for all existing scenarios. Further study is needed on LOS probability if existing scenario building/node deployment statistics are updated or if new deployment scenario(s) are adopted.
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.

#### Round #1 Discussion

Please provide comments on issues regarding LOS probability. Please provide comments on Proposal #2.6-1.

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| **Company** | **Comments** |
| Apple | Fine |
| Ericsson | Support |
| Mediatek | We support the proposal. |
| ZTE | Support |

### 4.2.7 Polarization

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| **Company** | **Proposals & Observations** |
| [2] Sharp | **Observation 9:** There is substantial evidence in the literature indicating variability in power between co-polarized (V-V and H-H) and cross-polarized (V-H and H-V) antennas. Notably, the variability between co-polarized (V-V or H-H) and cross-polarized (V-H or H-V) antennas is more significant. Despite this, the current TR 38.901 model assumes equal power for V-V and H-H polarizations, as well as for V-H and H-V polarizations. In TR 38.901 only the difference in power between the V-V and V-H or H-V and H-H is modeled using the XPR κ, which follows a log-normal distribution characterized by a mean and standard deviation.  **Proposal 9:** RAN1 to study the modelling of XPR in TR 38.901 as frequency dependent in LOS and NLOS channel condition instead of frequency independent for the entire frequency range of 0.5-100 GHz. XPR in general tends to increase with frequency in both LOS and NLOS channel condition.  **Proposal 10:** Model the variability of co- and cross polarization power on a ray level.  **Proposal 11:** Generate variability in powers for each ray *m* of each cluster *n* as described in 7.5-21b [19]. However, in general for mathematical consistency, minor modifications are needed in 7.5-22 and 7.5-28 [19] as shown below.  (6.1-1)  (6.1-2) |
| [3] Interdigital | **Observation 2:** In the conducted measurement [6], the receive antennas were installed on a moving van having a fixed polarization. However, there is no fixed positioning of a UE in practice.  **Proposal 2**: RAN1 deprioritize study of random power variability in each polarization. |
| [5] ZTE, Sanechips | **Observation 4:** The power ratio for co-polarization and cross-polarization is influenced by the depolarization effects of the environment and the antenna assumptions.  **Observation 5:** Under assumption, the ratios of cross-polarization received power to co-polarization received power have a consistent mean value. For co-polarization, the power for - co-polarization and the power for + co-polarization can be assumed the same as existing TR 38.901.  **Proposal 3:** Based on existing assumption of antenna polarization in TR 38.901, i.e., assumption, for both co-and cross-polarization, the modelling and channel realization procedure for polarization can be assumed the same, i.e., unchanged polarization matrix in existing TR 38.901. |
| [8] OPPO | **Proposal 1:** For the study of variations to be added to co-polar and cross-polar components, RAN1 takes the following into consideration:   * Whether the variations to be added to co-polar and cross-polar components should leave impacts to the relative powers among polar components or absolute powers on polar components, where the impact to relative powers does not change the cluster power and overall power in small scale Tx-to-Rx channel impulse response while the impact to absolute powers may do. * Whether the new polar variation modeling, if applied to ray level, should be considered jointly with intra-cluster K factor. |
| [9] CATT | **Proposal 1:** The assessment of the necessity for validation for channel model parameters in Table 1 can be considered.  Table 1 Potential list of parameters in the validation   |  |  | | --- | --- | | **Parameters** | **Whether validation is needed** | | XPR | Needed |   **Proposal 3:** Variability of the co- and cross polar powers can be further validated and then modelled for 7-24GHz. |
| [14] Ericsson | **Observation 5:** In the TR 38.901 model, the two co-polar components in the channel always have exactly equal power, and the two cross-polar components are equally attenuated according to a stochastic XPR.  **Observation 6:** Measurements show a slow variability around the mean co-polar and cross-polar power that is independent between different components.  **Proposal 6:** Introduce a random variability of the co- and cross polar powers in the TR 38.901 model, such as an i.i.d zero-mean Gaussian with 3 dB standard deviation, via the following changes to step 9 and eqs (7.5-22) and (7.5-28) in clause 7.5 in TR 38.901.  Step 9: Generate the cross polarization power ratios  Generate the cross polarization power ratios (XPR) for each ray *m* of each cluster *n*. XPR is log-Normal distributed. Draw XPR values as  , (7.5-21)  where  is Gaussian distributed with and  from Table 7.5-6.  Note:  is independently drawn for each ray and each cluster.  Generate polarization variability powers , , and for each ray *m* of each cluster *n*. is log-Normal distributed. Draw values as  , (7.5-21b)  where is Gaussian distributed. Note that is independently drawn for each ray, cluster, and polarization component.  --    (7.5-22)  --  (7.5-28)  -- |
| [19] Qualcomm | **Observation 1:** In FR3, at a centre frequency of 13 GHz, a difference in received power across polarizations is observed in an outdoor UMi-like scenario, where it is seen that median difference is about 1 dB, with the 90th percentile difference around 3 dB. Polarization power imbalance are sufficiently represented.  **Observation 2:** Ground reflection model in 38.901 offers a mode to realize polarization power imbalance in the channel realizations. Whether additional other factors such as specular reflections cause polarization power imbalance needs more study.  **Proposal 3:** Study whether the ground reflection model in 38.901 is adequate to model the observed polarization power imbalance before introducing any explicit variations directly in the polarization matrix of the channel. |

#### Summary of Issues

Companies provided inputs on variability of polarization power in the frequency ranges of interest:

* Introduce variability of polarization power matrix: Sharp, Ericsson
* Do not introduce changes to polarization power matrix: Interdigital, ZTE
* Study further if ground reflection model can provide the effective behavior for polarization power variability: Qualcomm

##### Proposal 2.7-1:

* Continue study on handling of polarization for applicable scenarios. The following are some examples of changes (if they are concluded to be updated):
  + Generate polarization variability powers , , and for each ray *m* of each cluster *n*. is log-Normal distributed. Draw values as , (7.5-21b),where is Gaussian distributed. Note that is independently drawn for each ray, cluster, and polarization component.
  + Option 1)

(7.5-22)

(7.5-28)

* + Option 2)

(7.5-22)

(7.5-28)

#### Round #1 Discussion

Please provide comments on issues regarding polarization modeling. Please provide comments on Proposal #2.7-1.

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| **Company** | **Comments** |
| InterDigital | Don’t support. We have already agreed to study. Until the need of such enhancement is not agreed, listing details as how it should be captured is irrelevant. |
| Ericsson | Support |
| vivo | The decision on whether to modify polarization coupling matrix (PCM) should rely on the impact of geometry SINR, SE or throughput, other than the observation of each PCM component. |
| ZTE | Not support.  According to our ray tracing simulation results, power variability only happens with H-V polarization due to ground reflection, but existing TR 38.901 assumes +-45 degrees polarization slant angle, each polarization direction includes both H-polarization and V-polarization components, which helps mitigate the effects of ground reflection, the power variability for polarization does not exist based on the simulation results, so the polarization matric does not need modification. |

### 4.2.8 Shadow Fading

|  |  |
| --- | --- |
| **Company** | **Proposals & Observations** |
| [2] Sharp | **Proposal 8:** Shadow fading should remain frequency-independent, as defined in TR 38.901. Based on our current measurements at 6.75, 16.95, 28, and 73 GHz, the shadow fading values, are frequency-independent, and mostly align with those specified in TR 38.901 InH-Office scenario. The discrepancies in shadow fading values are less than 0.3 dB for LOS and less than 2 dB for NLOS channel conditions across the entire frequency range of 0.5-100 GHz. These small discrepancies in shadow fading values can be considered negligible. Hence, there is no need to update shadow fading values in TR 38.901 for 7-24 GHz specifically. |
| [10] Keysight | **Observation 2**: In 10.1 GHz outdoor and indoor measurement, almost all estimated per cluster parameters indicated substantially smaller dispersion and smaller number of clusters as compared to those in TR 38.901*.*  Table 2. Per cluster parameter comparison between measured UMi values in [3] and those in TR 38.901.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | UMi LOS measured | UMi LOS 38.901 | UMi NLOS measured | UMi NLOS 38.901 | | Per cluster shadowing std [dB] ​ | 6​ | 3​ | 3​ | 3​ |   Table 3. Per cluster parameter comparison between measured Indoor values in [3] and those in TR 38.901.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | Indoor LOS measured | Indoor LOS 38.901 | Indoor NLOS measured | Indoor NLOS 38.901 | | Per cluster shadowing std [dB] ​ | 6 | 6 | 4 | 3 |   **Observation 4**: In 10.1 GHz outdoor and indoor measurement, almost all estimated distribution values of large-scale parameters indicated substantially smaller dispersion as compared to those in TR 38.901. The only exception is ZSA in the UMi scenario.  Table 4. Large scale parameter comparison between measured UMi values in [3] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | UMi LOS measured | UMi LOS 38.901 | UMi NLOS measured | UMi NLOS 38.901 | | SF [dB] | s | 2.0 | - | 1.5 | - |   Table 5. Large scale parameter comparison between measured Indoor values in [4] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Indoor LOS measured | Indoor LOS 38.901 | Indoor NLOS measured | Indoor NLOS 38.901 | | SF [dB] | s | 1.5 | - | 2.7 | - | |
| [15] BUPT, Spark NZ | **Observation 1：**The measurement results in the UMa scenario show that the shadow fading exhibit frequency dependence, increasing with frequency.  **Proposal 1：**RAN1 needs to further model the frequency dependence of shadow fading under different scenarios. |
| [17] AT&T | **Observation 4:** Measurements conducted at 15 GHz over 650 RX locations on floors of an office building show that shadow fading distribution for LoS and NLoS environments agree with the previously proposed the 3GPP SCM InH channel model.  **Observation 5:** Measurements at 8GHz and 11GHz (same locations) are ongoing and needed to draw the conclusion over FR3 for InH shadow fading. |

#### Summary of Issues

Companies observed aligned shadow fading related parameters in the frequency ranges of interest for following scenarios:

* InH LOS/NLOS (Sharp, AT&T)

Companies observed changes to shadow fading related parameters in the frequency ranges of interest for following scenarios:

* InH LOS/NLOS per cluster SF (Keysight)
  + LOS: 6 dB -> 3 dB
  + NLOS: 6 dB -> 4 dB
* UMi LOS SF (Keysight)
  + 1.5 dB -> 2.7 dB
* UMi LOS per cluster SF (Keysight)
  + LOS: 6 dB -> 3 dB
* UMi LOS SF (Keysight)
  + 2 dB -> 1.5 dB

One company observed dependency of SF with respect to frequency and suggest further study on the matter.

##### Proposal 2.8-1:

* Observation:
  + Preliminary study shows some updates may be needed for shadow fading parameters of the channel model for at least following scenarios:
    - InH LOS, UMi LOS
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.
* Continue study on handling of shadow fading parameters for applicable scenarios. The following are some examples of changes:
  + InH LOS/NLOS per cluster SF
    - LOS: 6 dB -> 3 dB
    - NLOS: 6 dB -> 4 dB
  + UMi LOS SF
    - 1.5 dB -> 2.7 dB
  + UMi LOS per cluster SF
    - LOS: 6 dB -> 3 dB
  + UMi LOS SF
    - 2 dB -> 1.5 dB

#### Round #1 Discussion

Please provide comments on issues regarding shadow fading modeling. Please provide comments on Proposal #2.8-1.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | OK |
| Ericsson | To fairly reflect the input from all companies the first bullet should acknowledge that there are also studies showing that there is not a need for any update of shadow fading parameters. |
| vivo | The decision on whether to modify shadow fading should rely on the impact of geometry SINR, SE or throughput, other than the intermediate metric. |
| ZTE | It’s premature to list the examples of changes. We also encourage companies to justify the reason behind the differences. |

### 4.2.9 K-Factor

|  |  |
| --- | --- |
| **Company** | **Proposals & Observations** |
| [10] Keysight | **Observation 3**: Some of the target angle spread values of 39.901 LOS models are in contradiction with the K-factor of the model and not feasible when LOS component is included into the angle spread calculation.  **Observation 4**: In 10.1 GHz outdoor and indoor measurement, almost all estimated distribution values of large-scale parameters indicated substantially smaller dispersion as compared to those in TR 38.901. The only exception is ZSA in the UMi scenario.  Table 4. Large scale parameter comparison between measured UMi values in [3] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | UMi LOS measured | UMi LOS 38.901 | UMi NLOS measured | UMi NLOS 38.901 | | KF [dB] | m | 5.1 | 9 | - | - | |  | s | 3.2 | 5 | - | - |     Table 5. Large scale parameter comparison between measured Indoor values in [4] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Indoor LOS measured | Indoor LOS 38.901 | Indoor NLOS measured | Indoor NLOS 38.901 | | KF [dB] | m | 8.5​ | 7 | - | - | |  | s | 3.5​ | 4 | - | - | |

#### Summary of Issues

Companies observed changes to K-Factor parameters in the frequency ranges of interest for following scenarios:

* InH LOS KF (Keysight)
  + Mean 9, stddev 5 -> Mean 5.1, stddev 3.2
* UMi LOS KF (Keysight)
  + Mean 7, stddev 4 -> Mean 8.5, stddev 3.5

##### Proposal 2.9-1:

* Observation:
  + Preliminary study shows some updates may be needed for K-Factor parameters of the channel model for at least following scenarios:
    - InH LOS, UMi LOS
  + Note that these are initial observations from RAN1 #118 and study is expected to continue.
* Continue study on handling of K-factor parameters for applicable scenarios. The following are some examples of changes:
  + InH LOS KF
    - Mean 9, stddev 5 -> Mean 5.1, stddev 3.2
  + UMi LOS KF
    - Mean 7, stddev 4 -> Mean 8.5, stddev 3.5

#### Round #1 Discussion

Please provide comments on issues regarding K-factor. Please provide comments on Proposal #2.9-1.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | OK |
| vivo | The decision on whether to modify K-factor should rely on the impact of geometry SINR, SE or throughput, other than the intermediate metric. |

### 4.2.10 Other Parameters

|  |  |
| --- | --- |
| **Company** | **Proposals & Observations** |
| [3] Interdigital | **Observation 1:** The implementation based on the third alternative exhibits the most consistent performance among the proposed alternatives.   * Alt1 [Ericsson] [3] * Alt2 [Intel] [4]   where,   * Alt3 [ZTE] [5]   where,  **Proposal 1:** Support the third alternative that is based on finding x, the angle scaling factor, that makes . |
| [4] Intel | **Proposal 2:**   * RAN1 to consider correcting the angle handling for MIMO simulation extension for CDL as part of the 7 – 24 GHz channel model validation SI. |
| [5] ZTE, Sanechips | **Observation 8:** The issue caused by the azimuth angle discontinuity at 180° and -180° can be fixed by wrapping azimuth angles to [0, 360] degree.  **Observation 9:** In the commonly used range of angular spread in 3GPP simulation work, the error of angular spread and mean angle caused by the linear scaling is small enough to ignore.  **Proposal 5:** The modification to angle scaling formula in TR38.901 is unnecessary.  **Proposal 6:** If accurate angular spread and mean angle are needed, adopt draft CR in appendix A-2 to TR38.901 Section 7.7.5.1.  *,*  (7.7-5)  where  *,*  and |
| [9] CATT | **Observation 5:** The difference between the accurate desired angle spread and the model in TR38.901 is not evident.  **Proposal 7:** There is no need to update the scaling of the angles in TR38.901 section 7.7.5 to enable accurate desired angle spread. |
| [10] Keysight | **Observation 3**: Some of the target angle spread values of 39.901 LOS models are in contradiction with the K-factor of the model and not feasible when LOS component is included into the angle spread calculation.  **Observation 4**: In 10.1 GHz outdoor and indoor measurement, almost all estimated distribution values of large-scale parameters indicated substantially smaller dispersion as compared to those in TR 38.901. The only exception is ZSA in the UMi scenario.  Table 4. Large scale parameter comparison between measured UMi values in [3] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | UMi LOS measured | UMi LOS 38.901 | UMi NLOS measured | UMi NLOS 38.901 | | KF [dB] | m | 5.1 | 9 | - | - | |  | s | 3.2 | 5 | - | - |   Table 5. Large scale parameter comparison between measured Indoor values in [4] and those in TR 38.901.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  |  | Indoor LOS measured | Indoor LOS 38.901 | Indoor NLOS measured | Indoor NLOS 38.901 | | KF [dB] | m | 8.5​ | 7 | - | - | |  | s | 3.5​ | 4 | - | - | |
| [19] Qualcomm | **Proposal 6:** To reflect the absolute delays between different UE-TRP links, introduce a new correlation type called “physically consistent” that takes the individual UE-TRP distances into account when generating the link-specific delays.  **Proposal 7:** To address the angle-scaling issue when generating CDL channels for link-level evaluations, clarify whether the formula used to calculate angular is accurate and whether the scaling operation is performed per cluster.  **Proposal 8:** To address the angle-scaling issue when generating CDL channels for link-level evaluations, consider one of the following options:   1. Decouple the desired angular spread and the linear scale factor into two separate parameters. Provide a finite list of values for desired angular spread along with the corresponding linear scale factor to realize each of them. 2. Move away from angular spread and instead focus on angular range. Use linear scaling to achieve the desired range.   **Proposal 9:** To address the angle-scaling issue when generating CDL channels for link-level evaluations adopt the following two-step approach to compute the scaled angles:  *,*  and  where s is a scale factor. |

#### Summary of Issues

Companies suggested some other misc. changes to the channel model.

* Angle calculations for CDL channel model:
  + Support updates: Interdigital, Intel, Qualcomm
  + Do not think updates are necessary: ZTE, CATT

##### Proposal 2.10-1:

* Continue study on handling of other channel modeling aspects. The following are some examples of changes (if concluded to be necessary):
  + Angle calculation for CDL model:
    - Option 1)
      * , (7.7-5)
      * where
      * ,
      * and
    - Option 2)
      * , and
      * where s is a scale factor to achieve desired angular spread.

#### Round #1 Discussion

Please provide comments on issues regarding other channel modelling aspects. Please provide comments on Proposal #2.10-1.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | OK |
| Ericsson | We are ok to further study. |
| Mediatek | We are ok to further study angle calculations for CDL. |
| ZTE | OK to study if accurate value is pursued. |

## 4.3 Discussions on SMa

|  |  |
| --- | --- |
| **Company** | **Proposals & Observations** |
| [1] Sharp | **Proposal 7:** The LOS probability models in the 3GPP TR 38.901 are frequency-independent for all existing scenarios and do not require any changes. However, if a Sub-urban Macro (SMa) scenario is added as a new scenario in TR 38.901, a LOS probability model specific to SMa may be required. |
| [5] ZTE, Sanechips | **Observation 1:** The LoS probability with non-zero value in case of large Tx-Rx distance (e.g., over 1000m) can be achieved for the scenario with lower building density at the edge of the map and open areas in the distant region (e.g., as Map-1).  **Observation 2** The simulation results of SMa scenario highly depend on the assumption of environment (e.g., building density, building height, the presence of open square).  **Observation 3:** In case of LoS UEs, the pathloss of SMa scenario can well match the pathloss model of UMa in TR 38.901.  **Proposal 1:** the following options can be considered to study the large-scale characteristics of interested scenario:   * Option-1: Define a sub-scenario for UMa with different assumption on building density * Option-2: Define a new scenario, e.g., SMa. |
| [6] Nokia | **Proposal 1:** Confirm the following model assumptions as applicable for a newly considered suburban macro deployment scenario:   * Typical building heights: Up to two floors for residential buildings, up to five floors for commercial buildings * UT height: 1.5 or 4.5 m for residential buildings, 1.5/4.5/7.5/10.5/13.5 m for commercial buildings * UT distribution: Uniform horizontally, 70% indoor residential users are on ground floor, 30% are on upper floor * Indoor/Outdoor: 80% indoor and 20% outdoor   Proposal 2: Further study is needed before confirming modeling assumptions related to BS height and ISD.  **Observation 1:** Measured building penetration loss in SMa scenarios are significantly lower than the suggested building penetration loss by the low-loss model in 3GPP TR 38.901. These differences might come from the different building materials used in urban and suburban, e.g., concreate and wood, respectively.  **Proposal 3:** Introduce a new O2I building penetration loss model for suburban deployments.  **Observation 3:** In LOS conditions, TR 38.901 Umi LOS path loss model underestimate the pathloss due to partial blockage by vegetation, which is common in suburban scenarios.  **Proposal 4:** NLOS path loss model for UMi deployment scenario can be re-used as NLOS path loss model for a suburban macro deployment scenario.  **Proposal 5:** Further study needed on whether LOS path loss modelling for UMi can be reused for suburban macro deployment. |
| [9] CATT | **Proposal 8:** Sub-urban use case can be modelled as a sub-case of UMa scenario if necessary.  The value of ISD can be used to differentiate whether the use case is suburban or not. |
| [14] Ericsson | Proposal 1: A potential new Suburban Macro scenario can be based on the WINNER II suburban scenario model but with updates reflecting more recent measurements.    **Proposal 2:** The following parameters are used as a starting point for aligning companies understanding of channel model parameters related to suburban use cases.   * BS height: ~~[~~22.5~~]~~ m * Layout: Hexagonal grid, 19 Macro sites, 3 sectors per site, ISD = ~~[~~500 or1732~~]~~ m * Typical building heights: ~~[~~Up to two floors for residential buildings, up to five floors for commercial buildings~~]~~ * UT height: ~~[~~1.5 or 4.5 m for residential buildings~~]~~, ~~[~~1.5/4.5/7.5/10.5/13.5 m for commercial buildings~~]~~ * UT distribution: ~~[~~Uniform horizontally, 70% indoor residential users are on ground floor, 30% are on upper floor~~]~~ * FFS: ratio between residential and commercial buildings * Indoor/Outdoor: ~~[~~80% indoor and 20% outdoor, FFS on in-car users~~]~~ * LOS/NLOS: LOS and NLOS * Min BS - UT distance(2D): ~~[~~25~~]~~ m   **Observation 1** In a suburban residential scenario, new measurements show that the path loss has a 10⋅log\_10 (f) frequency dependence up to 10 GHz and a rather flat frequency dependence above 10 GHz.  **Observation 2** The NLOS path loss model in the WINNER II Suburban Macro scenario has a simpler linear frequency dependence that isn’t supported by the new measurements.  Table 1 Path loss model for a generic Suburban Macro (SMa) scenario.   | Scenario | LOS/NLOS | Pathloss [dB], *fc* is in GHz and *d* is in meters | Shadow  fading  std [dB] | Applicability range,  antenna height  default values | | --- | --- | --- | --- | --- | | SMa | LOS | TBD | TBD | TBD | | NLOS |  | TBD |   **Proposal 3** The parameters in Table 1 may be considered as a starting point for specifying the path loss for a generic Suburban Macro (SMa) scenario, where and are FFS.  Table 2 LOS probability for a generic Suburban Macro (SMa) scenario.   |  |  | | --- | --- | | Scenario | LOS probability (distance is in meters) | | SMa |  |   **Proposal 4** The parameters in Table 2 may be considered as a starting point for specifying the LOS probability for a generic Suburban Macro (SMa) scenario. |
| [16] Apple | **Proposal 1:** RAN1 to add a new deployment scenario for suburban.  **Observation 4:** In a typical suburban scenario, 99% of buildings are below 11.8 meters and 99.5% of buildings are below 14.5 meters.  **Proposal 2:** Consider the following parameters for suburban scenario:   * BS height: 15 m * Layout with ISD: 1000 m * Typical building heights: Up to two floors for residential building and up to five floors for commercial buildings * UT height: 1.5 or 4.5 m for residential buildings, 1.5/4.5/7.5/10.5/13.5 m for commercial buildings * UT distribution: Uniform horizontally * Indoor/Outdoor: 40% indoor in residential buildings, 40% indoor in commercial buildings, and 20% outdoor * 90% buildings are residential buildings and 10% buildings are commercial buildings * UT height: 1.5 m for outdoor; 1.5+3(-1) m for indoor, where is the floor and is uniform (1, 2) for residential buildings or is uniform (1, 5) for commercial buildings. * Min BS - UT distance (2D): 10 m |
| [17] AT&T | **Observation 1:** Deployment scenarios identified to develop the channel models in 3GPP TR38901 do not include typical urban scenarios in North America.  **Observation**   * Some companies provided information that sub-urban deployments cannot be represented by existing deployments in TR38.901 (such as UMi, UMa, RMa).   **Proposal 1:** For the SI on channel models for 7-24GHz, RAN1 studies the addition of a suburban (SMa)deployment scenario that captures typical deployment scenarios outside of UMa and UMi  **Proposal 2:** The following parameters are used as a starting point for defining an SMa channel model:   * BS height: 25 m * Layout: Hexagonal grid, 19 Macro sites, 3 sectors per site, ISD = 1732 m * Typical building heights: [Up to two floors for residential buildings, up to five floors for commercial buildings] * UT height: [1.5 or 4.5 m for residential buildings], [1.5/4.5/7.5/10.5/13.5 m for commercial buildings] * UT distribution: [Uniform horizontally, 70% indoor residential users are on ground floor, 30% are on upper floor] * Indoor/Outdoor: [80% indoor and 20% outdoor] * LOS/NLOS: LOS and NLOS * Min BS - UT distance (2D): [25] m |
| [18] NTT Docomo | **Proposal 1:** Change the value of the BS height or ISD as below:   * + Option 1: BS height=22.5 m, ISD = 1299 m   + Option 2: BS height=35 m, ISD = 1732 m   + Option 3: BS height=35 m, ISD = 1299 m   **Proposal 2:** Remove brackets as below:   * + BS height: [22.5] m   + Layout: Hexagonal grid, 19 Macro sites, 3 sectors per site, ISD = [1732] m   + Typical building heights: ~~[~~Up to two floors for residential buildings, up to five floors for commercial buildings~~]~~   + UT height: ~~[~~1.5 or 4.5 m for residential buildings~~]~~, [1.5/4.5/7.5/10.5/13.5 m for commercial buildings~~]~~   + UT distribution: ~~[~~Uniform horizontally, 70% indoor residential users are on ground floor, 30% are on upper floor]   + FFS: ratio between residential and commercial buildings   + Indoor/Outdoor: ~~[~~80% indoor and 20% outdoor, FFS on in-car users~~]~~   + LOS/NLOS: LOS and NLOS   + Min BS - UT distance(2D): ~~[~~25~~]~~ m     **Proposal 3:** The path loss model of the SMa scenario in ITU-R M.2135-1 can be used with frequency extension up to 24 GHz  (1) |
| [19] Qualcomm | **Proposal 1:** RAN1 to consider introducing SMa model for 7-24 GHz, with potential extension to sub-7 GHz frequencies using one of the two following options as a starting point:   * Option 1: Use WINNER II * Option 2: Use UMa model in 38.901   **Proposal 2:**  Scenario-specific parameters for SMa can be configured as follows:   * BS height: 20m - 25m * Layout: Hexagonal grid, 19 Macro sites, 3 sectors per site, ISD = 500m – 1000m * UT height distribution follows the framework in 36.873 for UMa with changes to distribution of (number of floors). * Min BS - UT 2D distance: 35m (follow guidance in 36.873/38.901 for UMa) * Indoor/Outdoor split: 80% indoor and 20% outdoor * Penetration model: low-loss penetration model |
| [20] Vodafone, Ericcson | **Observation 1** The measured ZSDs at 3.4 GHz in a suburban 5G NR macrocell are very similar to the ZSDs in urban macrocells, however at the upper percentiles there are less high outlier values.  **Observation 2** The measured suburban ZSD can be well represented by a lognormal distribution with mu lgZSD = 0.14 and sigma gZSD = 0.16.  **Observation 3** The measured ASDs at 3.4 GHz in a suburban 5G NR macrocell are very similar to the ASDs in urban macrocells, however at the upper percentiles there are less high outlier values.  **Observation 4** The WINNER II Suburban Macro channel model overestimates the ASD by 2-3 times.  **Observation 5** The measured suburban ASD can be well represented by a lognormal distribution with µlgZSD = 0.55 and σlgZSD = 0.25.  **Proposal 1** If RAN1 agrees to add a Suburban Macro scenario, then use the ASD and ZSD parameters according to Table 1 and Table 2 as a starting point.  **Proposal 2** Further measurements of ASD and ZSD in a Suburban Macro scenario, including measurements that distinguish LOS vs NLOS vs O2I, can later be used to refine the suggested parameter values.  Table 1 Proposed ASD parameters for a SMa scenario   | Scenarios | | SMa | | | | --- | --- | --- | --- | --- | | LOS | NLOS | O2I | | AOD spread (ASD)  lgASD=log10(ASD/1°) | *µ*lgASD | 0.55 | 0.55 | 0.55 | | *σ*lgASD | 0.25 | 0.25 | 0.25 | | Cluster *ASD* () in [deg] | | 1.5 | 1.5 | 1.5 |   Table 2 Proposed ZSD parameters for a SMa scenario   | Scenarios | | SMa | | | | --- | --- | --- | --- | --- | | LOS | NLOS | O2I | | ZOD spread (ZSD)  lgZSD=log10(ZSD/1°) | *µ*lgZSD | 0.55 | 0.55 | 0.55 | | *σ*lgZSD | 0.25 | 0.25 | 0.25 | |

#### Summary of Issues

Several companies have provided inputs on support of SMa deployment scenario.

##### Proposal #3-1

* Support new deployment scenario that corresponds to sub-urban macro (SMa) deployments. SMa can be considered by one of the following options:
  + Option-1: Define a sub-scenario for UMa with different assumption on building density
  + Option-2: Define a new scenario, e.g., SMa.
  + FFS parameter difference between UMa and SMa
  + FFS on how to enable frequency continuity beyond 7-24 GHz for SMa

##### Proposal #3-2

The following parameters are channel model parameters related to suburban use cases. For aspects with multiple options, FFS which options to support. Support of multiple options is not precluded.

* BS height:
  + Option 1: 22.5 m
  + Option 2: 20m - 25m
* Layout: Hexagonal grid, 19 Macro sites, 3 sectors per site,
  + Option 1: ISD = 1732 m
  + Option 2: ISD = 500 or1732 m
  + Option 3: ISD <= 1000 m
  + Option 4: 500 ~ 1000 m
* Typical building heights: Up to two floors for residential buildings, up to five floors for commercial buildings
* UT height: 1.5 or 4.5 m for residential buildings, 1.5/4.5/7.5/10.5/13.5 m for commercial buildings
* UT distribution:
  + Option 1: Uniform horizontally, 70% indoor residential users are on ground floor, 30% are on upper floor
  + Option 2: 0.5 m for outdoor; 1.5+3(-1) m for indoor, where is the floor and is uniform (1, 2) for residential buildings or is uniform (1, 5) for commercial buildings.
  + Option 3: framework in 36.873 for UMa with changes to distribution of (number of floors).
* FFS: ratio between residential and commercial buildings
* Indoor/Outdoor:
  + Option 1: 80% indoor and 20% outdoor, FFS on in-car users
  + Option 2: 40% indoor in residential buildings, 40% indoor in commercial buildings, and 20% outdoor
* LOS/NLOS: LOS and NLOS
* Min BS - UT distance (2D):
  + Option 1 : 25 m
  + Option 2 : 10 m
* Penetration model: low-loss penetration model

##### Proposal #3-3

Study the following channel modelling aspects of suburban use case and the examples for consideration:

* Pathloss
  + NLOS:
  + LOS:
  + A white sheet with black text and numbers

    Description automatically generated
* LOS probability
* ASD

| Scenarios | | SMa | | |
| --- | --- | --- | --- | --- |
| LOS | NLOS | O2I |
| AOD spread (ASD)  lgASD=log10(ASD/1°) | *µ*lgASD | 0.55 | 0.55 | 0.55 |
| *σ*lgASD | 0.25 | 0.25 | 0.25 |
| Cluster *ASD* () in [deg] | | 1.5 | 1.5 | 1.5 |

* ZSD

| Scenarios | | SMa | | |
| --- | --- | --- | --- | --- |
| LOS | NLOS | O2I |
| ZOD spread (ZSD)  lgZSD=log10(ZSD/1°) | *µ*lgZSD | 0.55 | 0.55 | 0.55 |
| *σ*lgZSD | 0.25 | 0.25 | 0.25 |

#### Round #1 Discussion

Please provide comments on issues regarding support of suburban use case. Please provide comments on Proposal #3-1, #3-2, #3-3.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Proposal 3-1: we prefer Option 2 to avoid the mixture between UMa and SMa  Proposal 3-2: our analysis shows the BS height could be only 15 meters. We propose to include this option.  Proposal 3-3: we think it is pre-mature to determine these parameters, without a clear definition of SMa scenario. |
| Ericsson | Support proposal #3-1. Considering that there may be many parameter value differences compared to e.g. UMa it seems better to go with Option 2, i.e. a new scenario. That would also avoid any confusion regarding the existing UMa scenario.  Support proposal #3-2. More discussion may be needed to align companies’ views on the different options.  Support proposal #3-3. We encourage other companies to also bring studies and measurements for the SMa scenario. |
| DOCOMO | Proposal #3-1: Option 2 is fine with us  Proposal #3-2: More discussion should be need.  Proposal #3-3: More discussion should be need. |
| ZTE | Proposal #3-1: Option 1 is preferred to reduce the workload since some large scale parameters of SMa scenario are aligned with existing UMa scenario.  Proposal #3-2: The main difference between SMa scenario and UMa scenario is mainly due to the building density, so building density should be clarified in the assumption.  Proposal #3-3: More discussion and measurement/simulation results are needed. |

## 4.4 UE Antenna Modeling

|  |  |
| --- | --- |
| **Company** | **Proposals & Observations** |
| [9] CATT | **Proposal 4:** The following UE antenna modelling aspects can be considered in the modelling:   * UE antenna placement. * UE antenna orientation of individual antenna elements. * Antenna radiation pattern. * Antenna imbalance.   **Proposal 5:** In UE antenna orientation modeling, different antenna panels may have different orientations.   * Random orientation can be modelled for each antenna panel. * The orientation of the first panel is defined as the UE orientation.   **Proposal 6:** In UE antenna radiation pattern modeling, the radiation pattern in TR 38.802 can be studied as a starting point. |
| [11] Sony | Observation 1: UE antenna modelling assumptions from previous MIMO studies may not accurately model real antennas in the 7-24GHz band. Antenna patterns are generally wide directive patterns.  **Proposal 1:** Consider a realistic UE smartphone antenna model more specifically considering the smartphone UE case in 7-24 GHz range and using a realistic UE smartphone antenna model with a reasonably directive radiation pattern and fixed, well-defined spacings between elements.  **Observation 2:** The antenna model proposed in Table 2 is in reasonably good agreement with measurements of the antennas at 15GHz. The maximum gain is about 5dBi, and the 3dB beamwidth varies depending on the antenna type and implementation. Since frequency 7-24GHz is a wide range, the antenna in a smart phone chassis may have different behaviors, more validation measurements or simulations are required.  Proposal 2: Further evaluating of the parameters the model in Table 2 as baseline assumption for UE modelling in 7-24 GHz band.  Observation 3: The current portrait blockage model results in a performance gap when compared to measurements with an actual person in use cases in the 7-24 frequency range.  Observation 4: The self-blockage of the UE antenna depends on the distance between the UE and the human body. This should have an impact on near-field channel modelling.  Proposal 3: Collect more simulations and measurement results for element-wise hand and body blockage loss for different use cases and hand gripings.  Observation 5: The current blockage model in TR 38.901 does not capture the near-field effect, and does not provide proper element-wise channel blockage modelling for UEs. Further discussion should be included in 9.8.2  Proposal 4: Further study spatial non-stationarity of UEs due to body blockage.  Observation 6: The body loss will be considerable when the phone is close to the body and when the antennas are located at the bottom due to the hand grip. Hand grip loss has certain uncertainty depending on the hand grip details.  Proposal 5: Collect more body loss data on the measurements and simulations of single-hand grip, dual-hand grip, and head with one-hand grip, considering antenna locations. |
| [19] Qualcomm | **Observation 3:** UE antenna orientations can play an important role in determining the beamforming gains from UL-MIMO operations.  **Proposal 4:** For more realistic UE antenna modeling (at least for calibration), RAN1 to provide support for the following aspects:   * UE antenna placement   + E.g. placement along edges of a rectangle reflecting UE form factor. * UE antenna orientation   + E.g. randomize UE antenna orientation * Antenna radiation pattern   + E.g. consider more realistic antenna patterns, including a phase component   + Consider reusing the parabolic pattern * Antenna imbalance |

#### Summary of Issues

Few companies provided inputs on UE antenna modeling. Further discussions seem needed on the issues.

##### Proposal #4-1

* For calibration purposes, introduce new UE antenna model that potentially provides updates to following parameters:
  + UE antenna placement
    - E.g. placement along edges of a rectangle reflecting UE form factor.
  + UE antenna orientation
    - E.g. randomize UE antenna orientation
  + Antenna radiation pattern
    - E.g. consider more realistic antenna patterns, including a phase component
    - Consider reusing the parabolic pattern
  + Antenna imbalance
* Note: not all parameters are necessarily updated from current calibration antenna model.

#### Round #1 Discussion

Please provide comments on issues regarding penetration loss. Please provide comments on Proposal #2.1-1.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| InterDigital | OK. These may be okay from calibration perspective.  However, if the intention is revisit and enhance UE antennas modeling, then we should also add hand gripping effects, as part of third bullet (Antenna radiation pattern).   * + Antenna radiation pattern     - E.g. consider more realistic antenna patterns, including a phase component     - Consider reusing the parabolic pattern     - Consider hand gripping effects |
| Ericsson | We are open to consider UE antenna modeling, but we prefer to limit the discussion to UE antenna placement/rotation/pattern and avoid other aspects that depends on hardware implementation. |
| Mediatek | We are open to further study UE antenna modelling including placement/rotation/pattern. |
| vivo | We are fine with the proposal, however the definition of new antenna model may be not only for the purpose of calibration but also for the advanced technology evaluation. |
| ZTE | We are open to study. |

## 4.5 Other Modeling Aspects

#### Summary of Issues

Moderator will capture any other modeling aspects that could not be categorized above and missing from the initial version of the discussion document.

Companies are encouraged to provide inputs on any other modeling issues that should be discussed but missing in this section.

#### Round #1 Discussion

Please provide comments on issues not covered by issues in Section 4.2, 4.3, and 4.4.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | Regarding the following agreement on studying the correlation type or absolute delay, at least 3 companies [ZTE, Qualcomm, CATT] provide proposals on this issue, this part should also be discussed.   |  | | --- | | Agreement   * Further study whether/how to reflect absolute delay between links, or whether/how correlation type of the delay needs to be changed from site-specific to all-correlated type in the model   + Note: site-specific and all-correlated definitions are provided in TR38.901 Section 7.6.3.4.   + FFS: impact of ISD on correlation type for the deployment scenario |   After further research, it turns out that it’s better to reuse existing absolute delay procedure in Table 7.6.9-1 in TR 38.901 and extend the applicable scenarios from InF to Umi and UMa, and with the usage of absolute delay, the impact of ISD does not need to be considered. The following is proposed in our contribution.  ***Proposal:*** *The existing model of absolute delay can be reused for multi-TRPs simulation with extension for different scenarios, i.e., Table 7.6.9-1 in TR 38.901 can be revised as:*   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Table 7.6.9-1: Parameters for the absolute time of arrival model   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Scenarios | | InF-SL, InF-DL | InF-SH, InF-DH | UMi | UMa | |  |  | -7.5 | -7.5 | -7 | -6.8 | |  | 0.4 | 0.4 | 0.4 | 0.6 | | Correlation distance in the horizontal plane [m] | | 6 | 11 | 15 | 50 | | |

## 4.6 Capturing measurement data

Companies are asked to provide inputs to the data source collection based on the template provided in R1-2403969.

Each company may update the excel sheet in ftp://tsg\_ran/WG1\_RL1/TSGR1\_118/Inbox/drafts/9.8(FS\_NR\_7\_24GHz\_CHmod)/source data collection

Moderator will time to time clean up the excel sheet updates and ask companies to clarify information. The following table will be used to request updates or clarifications to the companies. Company do not need to fill in the table unless there is a request from the moderator.

|  |  |  |  |
| --- | --- | --- | --- |
| **Data Entry Row** | **Company** | **Moderator Comment/Request for Update/Clarification** | **Company Response** |
| 19, 20, 21 | Apple | In v11,  Tdoc R1-2404303 seems to be the Tdoc for ISAC and does not seem to contain information listed.  Should the Tdoc number be updated to R1-2404304?  It would be good if Apple can update the Tdoc number with the correct one. | The Tdoc number is R1-2404304. We updated it in version 12 of the file. |
| 8, 9, 10 | Keysight? | Company who provided input for the IEEE publications, it would be great if they can submit a tdoc that adds these references into the tdoc along with a short description of what results should be referenced or looked into for our SI.  While it is possible to directly reference non-3GPP publications, it would be far better if there is a corresponding 3GPP tdoc that provides some information on what is being looked at, a short summary. |  |

# Summary of Agreements/Conclusions from RAN1 #118

To be filled by moderator.

# Reference

1. R1-2405865, “Considerations on the 7-24GHz channel model validation,” Huawei, HiSilicon
2. R1-2405884, “On Angle Scaling for MIMO CDL Channel,” InterDigital, Inc.
3. R1-2405895, “Channel Model Validation of TR 38.901 for 7-24 GHz,” Sharp
4. R1-2406007, “Discussion on channel modeling verification for 7-24 GHz,” Intel Corporation
5. R1-2406128, “Discussion on the channel model validation,” ZTE Corporation, Sanechips
6. R1-2406139, “Discussion on Channel model validation of TR38.901 for 7-24GHz,” Nokia
7. R1-2406198, “Views on channel model validation of TR38.901 for 7-24GHz,” vivo
8. R1-2406252, “Discussion on channel model validation for 7~24GHz,” OPPO
9. R1-2406384, “Views on channel model validation of TR38.901 for 7-24GHz,” CATT
10. R1-2406393, “New measurement results for TR38.901 channel model validation and adaptation/extension consideration,” Keysight Technologies UK Ltd
11. R1-2406485, “Further discussion on channel model validation of TR38.901 for 7-24 GHz Sony
12. R1-2406490, “Channel model validation of TR 38901 for 7-24 GH,” NVIDIA
13. R1-2406666, “Discussion on channel model validation of TR38.901 for 7 - 24 GHz,” Samsung
14. R1-2406717, “Discussion on validation of channel model,” Ericsson
15. R1-2406744, “Discussion on channel model validation of TR38.901 for 7-24GHz,” BUPT, Spark NZ Ltd
16. R1-2406858, “Discussion on validation of channel model,” Apple
17. R1-2406869, “Discussion on Validation of the Channel Model in 38901,” AT&T
18. R1-2406946, “Discussion on channel model validation for 7-24 GHz,” NTT DOCOMO, INC.
19. R1-2407045, “Channel Model Validation of TR38.901 for 7-24 GHz,” Qualcomm Incorporated
20. R1-2407106, “Measurements of the angular spread in a suburban macrocell,” Vodafone, Ericsson

# Appendix A: RAN1 Agreements

## RAN1 #116-bis (April-2023)

**Conclusion**

* To provide measurement data, and/or simulation results, and/or available publications with measurement information for frequencies 7 to 24 GHz to validate/update the channel model.
* For frequency continuity of the channel models, Measurement information outside 7 to 24 GHz is also encouraged

**Agreement**

The following provides list of modelling parameters for 7 – 24 GHz frequencies that could be further studied for validation. The parameters listed are starting point for further discussions and does not imply the parameters require validation nor imply parameters require updates for 7 – 24 GHz frequencies.

* Antenna modelling parameters (e.g. radiation power patterns, directional gain values, etc.)
* Pathloss
* LOS probability
* O-to-I penetration loss
* Delay spread (mean, variance)
* AoD spread (mean, variance)
* AoA spread (mean, variance)
* ZoA spread (mean, variance)
* ZoD spread (mean, variance)
* ZoD offset
* Angle distribution characteristics (e.g. exponential, Gaussian, Laplacian distributions)
* Shadow fading
* K factor (mean, variance)
* LSP cross correlations
* Delay scaling parameter
* XPR
* Number of clusters
* Number of rays per cluster
* Cluster delay spread
* Cluster ASD
* Cluster ASA
* Cluster ZSD
* Cluster ZSA
* Per Cluster shadowing
* Correlation distances
* LSP correlation type (e.g. site-specific or all correlated)
* Oxygen absorption
* Correlation distance for spatial consistency
* Blockage region parameters/blocker parameters
* Spatial correlation for blockages
* Material properties for ground reflector model
* Spatial consistency model A/B

**Conclusion**

RAN1 to continue discussion on the need for new modelling parameters/scenarios and modelling procedure. The following modelling parameters/aspects for 7 – 24 GHz frequencies that are currently not available in TR38.901 have been identified by companies in RAN1#116bis. At least the following is for further study, but does not imply parameters/scenarios and modelling procedure are required for 7 – 24 GHz frequencies.

* Intra-cluster K factor
* Random power variability in each polarization
* Addition of SMa deployment scenario

**Conclusion**

* RAN1 to compile measurement/simulation descriptions from companies into a Tdoc to be added as reference to TR38.901.
  + Rapporteur to update the Tdoc in each meeting based on inputs from companies.
* Rapporteurs to provide a template for the measurement/simulation descriptions capture to RAN1 #117 for initial review and endorsement.

## RAN1 #117 (May-2024)

**Agreement**

To check and review the following results and measurement data provided in RAN1 #117 and RAN1#116bis for further discussion in next RAN1 meeting. R1-2405646 contains the list of data sources for the results and measurements provided in RAN1 #117.

* measurements for penetration loss for various materials, including drywall/wood, clear glass, IRR glass, and concrete
* measurements for pathloss for following scenarios: InH\_office LOS, InH-Office NLOS, InF LOS, InF NLOS, UMi LOS, UMi NLOS, UMa LOS, UMa NLOS, [Outdoor courtyard], RMa LOS, RMA NLOS, SMa NLOS
* measurements for polarization for UMa deployment scenario
* measurements for DS for following scenarios: InH-Office LOS, InH-Office NLOS, UMi LOS, UMI NLOS, UMa LOS, UMa NLOS, InF LOS, Inf NLOS.
* Measurements for angular distributions, such as ZOD, ZOA, AOD, AOA for following scenarios: InH, UMi, UMa
* Measurements for number of clusters for following scenarios: InH, UMi
* Simulations for LOS probability for SMa deployment scenario
* Measurement results regarding near-field model for following deployment scenarios: InH-Office LoS, UMa
* Measurement results regarding spatial non-stationarity for following deployment scenarios: UMa, [UE side]
* Simulation results regarding spatial non-stationarity for UMa deployment scenario

**Observation**

* Some companies provided information that sub-urban deployments cannot be represented by existing deployments in TR38.901 (such as UMi, UMa, RMa).

**Conclusion**

The following parameters are used as a starting point for aligning companies understanding of channel model parameters related to suburban use cases.

* BS height: [22.5] m
* Layout: Hexagonal grid, 19 Macro sites, 3 sectors per site, ISD = [1732] m
* Typical building heights: [Up to two floors for residential buildings, up to five floors for commercial buildings]
* UT height: [1.5 or 4.5 m for residential buildings], [1.5/4.5/7.5/10.5/13.5 m for commercial buildings]
* UT distribution: [Uniform horizontally, 70% indoor residential users are on ground floor, 30% are on upper floor]
* FFS: ratio between residential and commercial buildings
* Indoor/Outdoor: [80% indoor and 20% outdoor, FFS on in-car users]
* LOS/NLOS: LOS and NLOS
* Min BS - UT distance(2D): [25] m

**Conclusion**

* To provide information about motivation and reasons why changes to the channel model are essential.

**Agreement**

* Further study whether the following parameters for existing deployment scenarios is necessary to be updated:
  + Delay spread, pathloss, penetration loss, AoD/AoA/ZoA/Zod spreads, ZoD offset, Angle distribution characteristics (e.g. exponential, Gaussian, Laplacian distributions), XPR, number of clusters, number of rays per cluster, LSP correlations type (e.g. site-specific or all correlated), UE antenna modeling parameters, K factor (mean, variance)
* Study of updates to other parameters are not precluded and subject to further study.

**Agreement**

* Further study whether/how to reflect absolute delay between links, or whether/how correlation type of the delay needs to be changed from site-specific to all-correlated type in the model
  + Note: site-specific and all-correlated definitions are provided in TR38.901 Section 7.6.3.4.
  + FFS: impact of ISD on correlation type for the deployment scenario

**Agreement**

* Further study on correcting the scaling of the angles and other alternative to address angle scaling in TR38.901 Section 7.7.5 to enable accurate desired angle spread.

**Agreement**

* Further study of whether/how to model the variability of the co- and cross polar powers, in both diagonal and anti-diagonals of the polarization matrix, in the TR 38.901 model.
  + FFS: variability is applied for per ray or per cluster or per link
  + FFS: impact of antenna configurations
  + For example, variability may be random with an i.i.d. zero-mean Gaussian with some standard deviation, via changes to step 9 and eq (7.5-22) and (7.5-28) in clause 7.5 in TR 38.901.

**Agreement**

* Further study whether/how to model intra-cluster K factor to the TR38.901 models, such as power re-normalization among intra-cluster rays of a cluster so that first intra-cluster ray has K times more average power compared to rest of the intra-cluster rays.
  + FFS: whether same or different intra-cluster K factor is applied for each clusters
  + FFS: which applicable deployment scenarios

**Agreement**

* Further study whether/how following UE antenna modelling aspects should be considered in the modelling:
  + UE antenna placement, e.g. placement along edges of a rectangle reflecting UE form factor,
  + UE antenna orientation of individual antenna elements, e.g. randomize UE antenna element orientation,
  + Antenna radiation pattern, e.g. consider more realistic antenna patterns, including a phase component, potential reuse the parabolic pattern,
  + Antenna imbalance
* Note: this is only used for calibration.