**Summary of parameters used in compatibility studies for the FSS DL – Mobile Service scenario in 3600-3800 MHz under WRC-23 AI.1.3**

**(29/5/2022)**

| **Parameters** | | **Study 5A/553 China** | **Study 5A/574 Nokia** | **Study 5A/566  GSMA** | **Study 5A/564  Nig, SA, Zimbabwe** | **Study 5A/562  Ericsson** | **Study 5A/584 Burkina et al (STUDY A)** | **Study 5A/584 Burkina et al (STUDY B)** |
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| **Methodology** | |  |  |  |  |  |  |  |
| Type of analysis (In-band / Adjacent band) | | In-band | In-band | In-band | In-band | In-band | In-band | In-band and adjacent band |
| Number of MS stations considered (Single-entry or Multiple-entry (aggregated)) | | 19 Multiple-entry (aggregated) | Multiple-entry (aggregated), 57 MS base stations | Multiple-entry (aggregated), 57 MS base stations | Multiple-entry (aggregated)  Number of MS stations is 57 | Multiple-entry  (57 BSs and 3 UEs per BS) | Single entry and Multiple-entry (aggregated) | Multiple-entry (aggregated) |
| Type of interference evaluation method | Deterministic study or statistical study | Statistical | Statistical | Statistical study | Statistical study | Statistical study | Deterministic and statistical | Statistical study |
| If statistical, based on Rec. ITUR M.2101? | Yes | Yes | Yes | Yes, based on Rec. ITUR M.2101 | Yes | Yes | Yes |
| **Technical and operational characteristics of MS systems** | |  |  |  |  |  |  |  |
| Type of station considered (AAS/non AAS BS/UE) | | AAS | AAS | AAS | AAS | AAS | Non AAS BS | AAS BS |
| Deployment scenario | | urban, suburban | Urban / Suburban | Cluster of 57 base stations at 19 sites | Urban macro | Urban | Urban/surburban | Urban/ Suburban/ Rural |
| Network loading factor for BS and UE (%) | | 50% | 50% | 20% and 50% | 50% | 50% | 50% | 50% |
| TDD activity factor (%) | | 75% | 75% BS  25% UE | 75% | 75% | BS: 75%, UE: 25% | 75% | 75% |
| UE power control factor (dB) | | - | As per ITU-R M.2101-0 |  | NA | Yes | N/A | N/A |
| UE body loss (dB) | | - | 4 |  | NA | 4 | N/A | N/A |
| MS Antenna pattern | | Extended AAS: Refer to Table A of Annex 3 of 5A/378 | Extended AAS model in Table A of Annex 3 of Doc 5D/716 Annex 4.4 | Extended AAS | Refer to the extended AAS model in Table A of Annex 3 of 5A/378 | Extended AAS (sub-array model) | Non-AAS: F.1336 | Extended AAS: Refer to Table A of Annex 3 of 5A/378 |
| Antenna characteristics | | Extended AAS BS: See Table 9 of 5A/378 | Element gain = 6.4 dBi  H/V 3dB element beamwidth = 90°H, 65°V  Front/Back ratio = 30dB for both H/V  Polarisation = Linear/±45 degrees  Array config = 4x8 elements  H/V radiating element/sub-array spacing = 0.5 λ H, 2.1 λ V  No. of element rows in sub-array = 3  Vertical radiating element spacing in sub-array = 0.7λ of V  Pre set sub-array downtilt = 3o | Extended AAS | Refer to the extended AAS model in Table A of Annex 3 | Extended AAS (sub-array model) | Non-AAS BS:  For urban and suburban macro in Table 6-1 of 5A/378 | Extended AAS BS: See Table 9 of 5A/378 |
| **Technical and operational characteristics of the FSS** | |  |  |  |  |  |  |  |
| Antenna diameters (m) | | 1.2, 3, 32 | 3m | 3 m | Earth Station #1: 5 m  Earth Station #2: 3.8 m  Earth Station #3: 7.3 m | 3 and 32 | 2.4-12 m  Multiple stations in Guinea, Mali, Niger | 1.2-32 m |
| Peak antenna gains (dBi) | | 31.5, 39.5, 60 | 39.5 | 39.5 dBi |  | 39.5 and 60 | 37-51 dBi | 31.5-60 dBi |
| Earth station elevation angle (degrees) | | 10˚ | 10, 15, 48 | ~30, ~68 degrees | Earth Station #1: 24.8°  Earth Station #2: 50°  Earth Station #3: 25.3° | 1. Range: [26 - 55]  (Uniform distribution)  2. Fixed: 26 deg  (maximum longitude offset of ±50 degrees between the FSS earth and space stations) | Varies depending on the different ES and their pointing towards a given GSO satellite  Ranges from: 17-77 degrees | 10 m |
| Antenna reference pattern | | ITU-R S.465 | ITU-R S.456-6 | ITU-R S.465 | ITU-R S.465 | ITU-R S.465  (3dB scale factor to account for more realistic FSS characteristics) | ITU-R S.465 | ITU-R S.465 |
| System noise temperature (K) | | 120K, 120K, 70K | 120 | 120 K | Earth Station #1: 70 K  Earth Station #2: 100 K  Earth Station #3: 70 K | 120K (3m diameter) and 70K (32m diameter) | 120 K for small antennas (1.2-3 m)  70 K for large antennas (4.5 metres and above) | 70-120 K |
| Protection criterion *I/N* (dB) | | long-term 10.5dB, short-term -1.3dB | -10.5 (long-term 20% time) | Various I/N values (-10 dB as example) | long term interference criteria (I/N = –10.5 dB)  short-term criterion (I/N = –1.3 dB) | -10.5 (20%) | I/N = -10.5 (20%)  I/N = -1.3 (0.005%) | In-band:  I/N = -10.5 dB (20%)  I/N = -1.3 (0.005%)  Adjacent band  I/N = -20 dB (20%) for MS OOBE into FSS  Imax = -59dBm for LNB saturation |
| FSS Earth station height (m) | | 10, 10, 17 | 5 | 1.8 m | Earth Station #1: 3 m  Earth Station #2: 4 m  Earth Station #3: 3 m | 5m (3m diameter)  18m (32m diameter) | 10 m | 10 m |
| Other remarks, if any | |  |  |  | NA | FSS ES located in Cairo Area (Egypt) (30° N, 31° E) | Specific existing operating FSS ES considered.  Actual location considered as well as terrain data |  |
| **Propagation model** | |  |  |  |  |  |  |  |
| Propagation model  (with time percentage) | | P.452 with 50% time percentage | ITU-R P.2001-4  Random time % | ITU-R P.452 (random %) | ITU-R P.452-16  (Time percentage is 20%) | P.2001 using a uniformly distributed random time percentage | P.452  Since this analysis is for non-AAS antenna for which the pointing is non-time variant, the percentage of time associated to protection criterion was taken (20% for long-term and 0.005% for short term). | P.452  Randomised time percentage |
| Clutter loss (How to apply clutter loss to BS and FSS ES) | | P.2108  clutter loss is applied at both sides and only BS side. The location probability ‘p%’ of clutter loss model is considered and the ‘p%’ is random distribution. | ITU-R P.2108 (Section 3.2) applied using uniformly distributed random percentage of locations to:   * 50% and 100% of MS at urban environment * 0% of ME at suburban environment * As well as to the FSS Earth station end. | ITU-R P.2108 (Section 3.2) applied at one end of link. | P-2108 Clutter loss is used on both the Earth station and Mobile BS side since they are both modelled for urban areas. The location probability ‘p%’ of clutter loss model is considered, and the p% is random distribution. | P.2108-1 using a uniformly distributed random percentage of locations (applied to all MS base stations) | P.452 clutter model since real terrain data considered | P.2108-1 using a uniformly distributed random percentage of locations (applied to BS below rooftop, therefore assumed to be in clutter) |
| Building entry loss | | - | - | N/A | NA | P.2109-1 using a uniformly distributed random probability that loss is not exceeded (traditional building class) | N/A since outdoor deployment considered | N/A since outdoor deployment considered |
| Polarization loss (dB) | | 3dB | 3 | 3 dB | 3 | 3  (aggregated interference) | 0 dB | 0 dB |
| **Results of studies** | |  |  |  |  |  |  |  |
| Level of interference | |  |  | CCDFs give probabilities that different I/N values are exceeded for different scenarios | long term: (I/N = –10.5 dB)  short-term: (I/N = –1.3 dB) |  |  |  |
| Level of exceedance of the protection criteria (higher value corresponds to higher interference)  Or  Required protection distance (km) | | When considering the both sides clutter loss, the range of distances are from <1km to 11.7km to meet the long-term criteria, and from 1.5km to 27km to meet the short-term criteria.  When considering only BS side clutter loss, the range of distances are from 9km to 39.3km to meet the long-term criteria, and from 7.5km to 39km to meet the short-term criteria. | Urban (50%)  10o = 24 km  15o = 22 km  48o = 13 km  Urban (all)  10o = 8 km  15o = 4 km  48o = 1 km  Suburban (0%)  10o = 30 km  15o = 27 km  48o = 18 km | Probability that I/N > -10 dB is below 0.01 for all scenarios (separation distance = 20, 40, 60, 80 km) | Separation distance results for the long-term protection criteria:  Earth Station #1 Mmabatho, South Africa β = 0°: <7.5 km, β = 180°: <4.5 km  Earth Station #2 Lagos, Nigeria β = 0°: < 4.5 km, β = 180°: < 4.5 km  Earth Station #3 Lagos, Nigeria β = 0°: <7.5 km, β = 180°: <4.5 km  Separation distance results for the short-term protection criteria:  Earth Station #1 Mmabatho, South Africa β = 0°: < 7.5 km, β = 180°: < 4.5 km  Earth Station #2 Lagos, Nigeria β = 0°: < 4.5 km, β = 180°: <4.5 km  Earth Station #3 Lagos, Nigeria β = 0°: <7.5 km, β = 180°: <4.5 km | In the case of applying clutter loss only to the MS side, the aggregated interference in urban macro scenarios from MS BSs to a FSS ES is able to satisfy the FSS long-term protection criterion for all cases considered at a separation distance of 20 km for FSS ESs with small antenna diameters (3 m) and at a separation distance of 30 km for FSS ESs with large antenna diameters (32 m). In addition, if the FSS ES has natural and/or artificial shielding, the separation distances required are below 1 km. | Sharing study presented two different methodologies at specific locations in Africa:  –A single-entry study presenting the required separation distances to protect operational FSS ES in Africa. The study concludes on required separation distance of 79.5 km to 149 km for long-term interference and from 248 km to 420 km for short-term interference. This study raises the need for cross-border regulation and coordination given the large separation distances required.  –An aggregate interference study showing the I/N aggregate impact at the Niamey FSS ES for urban and suburban deployment cases around the ES. The results corroborate the single-entry sharing study by showing a large exceedance of the FSS ES protection criteria even for small MS deployment around the FSS ES.  These studies have only addressed protection of FSS ES at a known location and do not address ubiquitous FSS deployment delivering services directly to consumers (for example direct-to-home, DTH). Such deployment cannot be protected based on geographical separation but other protection measures, such as frequency separation, are required. | **For in-band:**  –To meet the long-term protection criteria of the FSS receiving earth station (I/N = −10.5 dB not to be exceeded for more than 20% time): required separation distance of 150-218 km.  –To meet the short-term protection criteria of the FSS receiving earth station (I/N = −1.3 dB not to be exceeded for more than 0.005% time): required separation distance of 460-505 km.  **For adjacent band:**  –For the impact of the mobile service emissions falling within the FSS receiver LNB range 3.4-4.2 GHz: results show that without appropriate mitigation measures implemented, the FSS receiver LNB would be driven into saturation from the perceived in-band emissions of the mobile BS deployment. Even at separation distances of 100 km, the −59 dBm (= −89 dBW) criteria is exceeded by 5.4 dB, 10 dB, 11.5 dB for the urban, suburban and rural case respectively. When looking at short separation distances, i.e. 100 m, between the FSS ES and the mobile BS cluster, the exceedance of the LNB saturation threshold goes all the way up to 64 dB, 66 dB, 66 dB for the urban, suburban and rural case respectively.  – For the impact of the mobile service out-of-band emissions falling within the FSS operating range: For lowest OOBE specification of the 3GPP for the MS BS, exceedance of the FSS adjacent band protection criteria for distances of 41, 58, 67 km for the urban, suburban and rural case respectively. |
| Sensitivity analysis, if any | |  |  | Results for multiple scenarios | NA |  |  | Sensitivity analyses consider application of clutter on both BS and FSS side |
| Results of sensitivity analysis | |  |  |  | NA |  |  | With consistent clutter on FSS ES side and clutter on BS below rooftop:  • required separation distance of 45-82 km to meet long term protection criteria  • required separation distance of 275-325 km to meet long term protection criteria  With consistent clutter on both FSS ES side and BS side:  • required separation distance of 19-29.5 km to meet long term protection criteria  • required separation distance of 43-55 km to meet long term protection criteria  Conclusion: Results with clutter were still provided as a reference to show the importance of this assumption and its significant impact on the final result of the simulation |