3GPP TSG-RAN WG2 Meeting #113 R2-20xxxxx

Elbonia, Online, 25 January – 5 February 2021

**Agenda item: 8.10.x**

**Source: Nokia, Nokia Shanghai Bell**

**Title: Report from [Post112-e][153][NTN] Idle mode aspects (Nokia)**

**WID/SID: NR\_NTN\_solutions-Core - Release 17**

**Document for: Discussion and Decision**

# 1 Brief scope of the paper

This document aims at collecting companies’ views regarding the Rel-17 NTN Idle mode:

* [Post112-e][153][NTN] Idle mode aspects (Nokia)

 Scope: Discuss: 1) options for "NTN indication" 2) provision of ephemeris and 3) cell (re)selection principles, trying to resolve the FFS from the meeting agreement

 Intended outcome: email discussion report

 Deadline: Long

The following sections discuss those listed topics, based on RAN2 contributions submitted so far.

# 2 Agreements related to NTN Idle mode

A good starting point would be to list the Rel-17 NTN Idle mode related agreements taken so far in RAN2. These are provided in the box below:

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| **RAN2#111:**1. Cell selection / reselection in NR is the baseline in NTN idle mode procedure.2. Satellite/HAPS ephemeris based cell selection and reselection should be defined for NTN (FFS what the term satellite/HAPS ephemeris actually means). FFS when this ephemeris based cell selection / reselection can be used. FFS whether UE location (and/or other information) based cell selection and reselection should be introduced for NTN3. The satellite ephemeris should be provided to UE, at least for Satellite/HAPS ephemeris based cell selection and reselection (FFS what the term satellite/HAPS ephemeris actually means).4. The network type (i.e. TN or NTN) should be known to UE. FFS whether to achieve this in an implicit or explicit way.5. The existing cell reselection priority configuration can be taken as a baseline in NTN. FFS on any further enhancement.6. Postpone the discussion on whether to introduce a new SIB until we have more progress on the content of NTN specific system information. |

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| **RAN2#112:**1. Existing cell reselection principles are considered as baseline and that information about when a cell is going to stop serving the area and information about new upcoming cell can be further considered. In which form and how this is exactly implemented in the cell reselection principles is FFS. |

The rapporteur believes this is a complete list of IDLE mode related agreements taken so far in Rel-17 NTN work. However, please indicate if something has been forgotten.

# 3 NTN indication

First topic to handle in this e-mail thread is whether there is a need to indicate explicitly the network is terrestrial or non-terrestrial. As quoted above in the agreement box, the network type (TN or NTN) should be known to the UE. However, it remains to be seen whether such indication is made in explicit or implicit way. Both approaches had their supporters and fair motivation behind. For instance, [1] states that TN and NTN will anyway likely use separate PLMN IDs (and this option is actually preferred in TR 38.821), so another (explicit) way of differentiating is not needed. In addition, [1] provides another way how this distinction could be done, claiming the NTN cell will likely broadcast NTN-specific system information, while such SI will be absent in the TN cell. In [2] another implicit way of indicating whether the cell is TN or NTN is provided, namely different scrambling of MIB. While this may be a workable solution, the rapporteur thinks it shall be perhaps discussed and decided by RAN WG1. The implicit way of indicating the NW type is also suggested in [3]. One the other hand, a different approach is favoured in [4], where the authors claim the existence of NTN SIB alone may not be sufficient, as TN cells may provide also the neighbour’s SIBs (such as NTN SIB).

Even thought similar questions have been already asked in the past, RAN2 should eventually decide on the type of this indication.

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| **Question 1: How should the UE be made aware of the network type (TN versus NTN)? In implicit or explicit way?** |
| **Company** | **Implicit/Explicit** | **Details of how to implement your favoured approach and why the other approach is not viable** |
| APT | Implicit | Implicit by separate PLMN IDs.If a UE temps to camp on an NTN cell, reading system information in an NTN cell, e.g., PLMN or NTN SIB, shall be sufficient.* Separate PLMN ID: it was agreed that a separate PLAN is beneficial, e.g., [R2- 1914070] Observation 1: All the companies are in favor to have separate PLMN for the NTN cells from TN cells, but is an implementation choice. Separate PLMN is likely needed.
* New NTN SIB: no clear evidence to show NTN SIB is essential, however [R2-2009774] pointed out single satellite’s ephemeris can consume 56 bytes while the NR System Information Block size is constrained to 372 bytes. In this case, NTN SIB is likely needed.
* New MIB: no discussion in RAN1 so far. We prefer not to introduce it for the minimum specs impact.

**However, if NW needs to prevent non-NTN capability UEs from camping an NTN cell**, e.g., prevent non-registers from camping or prevent Rel-15/Rel-16 UEs from ignoring NTN SIBs or other NTN information, then a separate PLMN would be the way to go.  |
| Ericsson | Implicit as default assumption | As stated, there are multiple implicit ways to indicate this. If, towards the end of the release, RAN2 concludes that none of these implicit ways does not work properly, the explicit option can be further discussed. |
| Lenovo | Implicit | Separate NTN PLMN ID, NTN-specific SIB or the ephemeris can do the work. |
| MediaTek | Implicit as default option | We agree with Ericsson that RAN2 can start with implicit ways and check if it is working. If “not” then explicit ways could be studied. |
| Qualcomm | Implicit | Some indication is needed as it seems likely that CT1 will define new PLMN selection rules for NTN. Use of separate PLMN IDs is problematic as some PLMNs may prefer to use the same PLMN ID for both TN and NTN in order to allow handover and cell reselection within the same PLMN and use a common 5GC. However, an indication does not necessarily require a flag and could use an NTN specific MIB. This is what is done for LTE MBMS, i.e., MIB-MBMS. An alternative would be to use separate NTN bands.However, if TN and NTN may use the same band, it will be necessary to prevent SIB1 access from existing TN UEs, which suggests an NTN specific MIB may be a good solution. We should send LS to RAN1 for NTN specific MIB. |

A somewhat related topic concerns another indication type – the specific NTN scenario (such as GEO, LEO, HAPS, etc.). It has been argued that also the specific LEO/GEO/HAPS scenario could be inferred from some typical values of the configuration parameters [1][2], so there is no need to signal such information separately. [5] proposes that satellite type (GEO vs. non-GEO) is determined implicitly, based on ephemeris data representation. On the other hand, [4] claims such NTN scenario type (e.g. LEO or GEO) is indicated along with the network type (TN or NTN).

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| **Question 2: Do you see the need to signal explicitly the NTN scenario information (e.g. LEO/GEO)? Please motivate your answer.** |
| **Company** | **Yes/No** | **Motivation** |
| APT | No | If UE temps to camp an NTN cell, ephemeris data for the target satellite would be needed for sending a PRACH preamble.  |
| Ericsson | No as default assumption | Similar to the first question, there are multiple implicit ways to indicate this. If, towards the end of the release, RAN2 concludes that none of these implicit ways does not work properly, the explicit option can be further discussed. |
| Lenovo | Implicit | The ephemeris can do the work. |
| MediaTek | No as default | The position information or ephemeris can be used to determine this. |
| Qualcomm | No as default | This can be implicit from broadcast parameters. However, we agree that an explicit indication is needed if an implicit solution is not agreed. |

If implicit way of indicating the NTN scenario is preferred, please provide the details how this shall be done. In the papers submitted to RAN2-112 various approaches have been presented (see e.g. [1][2][5]).

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| **Question 3: How to provide the NTN scenario indication using implicit means?** |
| **Company** | **Answer** |
| APT | Implied from the common parameters provided in SIB, e.g., ephemeris data. |
| Ericsson | Implied from parameters giving the characteristics of the system, e.g. ephemeris. |
| Lenovo | By parameters provided in the ephemeris e.g. orbit. |
| MediaTek | The position information or ephemeris can be used to determine this. |
| Qualcomm | Yes from parameters broadcast in SIB1. |

# 4 Ephemeris

Another important topic that shall be addressed in RAN2 during NTN Rel-17 WI is how to provide the UEs with satellite ephemeris information and what is should contain. As argued in [1] the satellite ephemeris could have an excessive size, quickly overloading the capacity offered by System Information Block (SIB) in NR. Before deciding how to deliver the satellite ephemeris to the UE, it shall be discussed how the ephemeris is actually represented. Two main approaches have been identified and captured during the NTN SI in Rel-16:

* Orbital parameters (including orbital and satellite related parameters)
* Satellite coordinates, e.g. ECEF coordinates to represent satellite’s position (x, y, z), time, velocity, etc.

As usual, both options have pros and cons. The orbital parameters are better in terms of their size and signalling overhead, while the ECEF representation may provide increased accuracy, but at the expense of the need to update them frequently [6].

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| **Question 4: How should the ephemeris be represented (e.g. PVT coordinates or orbital plane parameters)?** |
| **Company** | **Answer** |
| APT | PVT (ECEF representation) to support HAPS/HIBS.Only instant orbital state vector format has the ability for implicit compatibility to support HAPS/HIBS and ATG scenarios since the orbit concept is meaningless in HAPS/HIBS and ATG scenarios.As a price, enhancement on signaling overhead can be FFS, e.g., update more frequently on satellite’s position (x, y, z) and time, but update less frequently on satellite’s velocity. Also, enhancement on RRM can be FFS, e.g., orbital parameters can be pre-stored in u-sim as assistant information to predict long-term satellites’ positions. |
| Ericsson | First aspect to know is what is the precision needed. The maximum allowed error of the TA, while preserving OFDM/OFDMA orthogonality, is determined by the length of the cyclic prefix (CP). Besides TA error, the CP also absorbs other effects such as multipath delay spread to preserve OFDM/OFDMA orthogonality. In 5G NR, the length of the CP is not fixed, but depends on the subcarrier spacing (SCS). For FR1, SCS of 15 kHz and 30 kHz are allowed, resulting in CP lengths of 4.69 µs and 2.34 µs, corresponding to a distance of 1.4 km and 700 m, respectively. Since the TA handles RTT, however, these distances have to be divided by 4 for the transparent case. In the worst case (transparent architecture and 30 kHz SCS), the CP length of 2.34 µs would thus allow the satellite to be 175 m away from its nominal position, where the UE expects it to be. As this is very much a RAN1 topic, the discussion about ephemeris data format and accuracy requirement should start in RAN1.While the information content of all possible formulations might be equivalent, the amount of data needed to encode the information varies. The choice of format should strive to minimize the amount of data that needs to be transmitted or stored in the UE, e.g. by choosing a convenient coordinate system. |
| Lenovo | Both can be considered for different platforms or purposes, e.g. orbital parameters for satellites and ECEF coordinates for HAPS. For either option we need to consider minimizing the amount of ephemeris data and avoid too frequent provision, e.g. ephemeris data of a group of satellites on the same orbit can be represented as the common part (e.g. orbit plane) that can be pre-provisioned and individual part (e.g. anomaly or difference of satellite level parameters) that can be broadcasted/signalled. |
| MediaTek | For initial access and uplink synchronization, where high precision is required, PV information is appropriate. For cases with low precision, e.g. long-term ephemeris for mobility, either options (i.e. PV or orbital parameters) can be used.Note: RAN1 is also discussing this topic with relation to initial access and uplink synchronization. |
| Qualcomm | We also think RAN1 is discussing this topic and we can wait for RAN1 progress. |

After selecting how to represent the NTN ephemeris, it is worth checking the details, i.e. what it shall actually contain, (e.g. what parameters and how many bits those would consume, etc.). Please share your view to the following question.

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| **Question 5: What information and parameters should be conveyed in the NTN ephemeris? Please indicate on the content, bit consumption and the required periodicity of broadcasting such information.** |
| **Company** | **Answer** |
| APT | Satellite position and velocity.Based on [R1-2008809] given sufficient accuracy on UL time and frequency pre-compensation, e.g., error ranges for satellite position and velocity are ∆U < ±120m and $∆V<\pm 1.5 m/sec$* Parameters: Satellite position {X, Y, Z} and satellite velocity {Xvel, Yvel, Zvel}
* Bit consumption: 18 Bytes (144 bits)
* Required periodicity: 1 second.

[R1-2008809] Assuming serving satellite ephemeris is broadcast every second. The payload on NTN SIB to indicate serving satellite cell position and velocity is (84+60)/8 = 18 Bytes

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| Information | Range | Resolution | #bits |
| Satellite Location | ±43000 km | 0.33m  | 3\*28=84  |
| Satellite Velocity | ±8 km/s | 0.015 m/s  | 3\*20=60  |

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| Ericsson | We actually think it is the other way around. RAN2 should study(should have studied in SI phase..) the practical difference between these format options and the ways to represent the needed data in most efficient way enabling the accuracy that is needed(RAN1 work).Another aspect discussed during the study item and captured in TR 38.821, is the validity time of ephemeris data. Predictions of satellite positions in general degrade with increasing age of the ephemeris data used, due to atmospheric drag, maneuvering of the satellite, imperfections in the orbital models used, etc. Therefore, the publicly available TLE data are updated quite frequently, for example. The update frequency depends on the satellite and its orbit and ranges from weekly to multiple times a day for satellites on very low orbits which are exposed to strong atmospheric drag and need to perform correctional maneuvers often. |
| Lenovo | The ephemeris of neighboring satellites or a group of satellites on the same orbit, which can help in mobility management and reduce signalling/broadcast overhead. |
| MediaTek | For the serving cell to meet the high precision requirements for uplink synchronization, satellite position and velocity (PV) information are required and needs to be updated frequently. For mobility purposes we can use either PV information or orbital plane parameters, and these parameters do not need to be updated frequently as high precision is not required. |
| Qualcomm | The ephemeris should probably be related to UTC/GNSS time which would be available to a GNSS capable UE and enable prediction of future satellite location for the duration of satellite visibility to a UE. The exact format can be left to RAN1 based on required accuracy needed. |

In [7] it is argued there is a need to provide the UE with the ephemeris for both the camped/serving cell and the neighbours. As per [7] the ephemeris for the neighbours is necessary for the UE to re-adjust the pointing direction towards the neighbouring satellite before performing inter-satellite HO or inter-satellite cell reselection. The camped/serving cell’s ephemeris is claimed to be necessary for maintaining the UL timing and frequency synchronization [7]. It also seems to be important to know whether the cell belongs to the same satellite, in order to avoid potential signalling overhead. Do companies see a need to have a split and provide camped/serving cell’s and neighbour’s ephemeris plus the information on any other association of the cell?

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| **Question 6: Should the ephemeris be divided into camped normally cell’s and neighbour’s part? Is the information on any other association of the cell needed? Please motivate your answer.** |
| **Company** | **Yes/No** | **Motivation** |
| APT | No | Yes, the ephemeris for the target cell is necessary.No, the association of a neighboring cell is not necessary. It can be associated with RA configuration.For random-access (RA), UE needs valid/updated ephemeris data to calculate UL timing and frequency for PRACH preambles. If ephemeris data is only used for RA, then it may only be associated with RA configuration. |
| Ericsson | Most likely yes | We should start by defining the camped normally cell’s emphemeris and see then what is needed about neighbour cells/satellites. |
| Lenovo | Yes | See answer in Question 5, at least ephemeris of neighboring satellites can help in mobility management and reduce signalling/broadcast overhead. |
| MediaTek | Yes | We definitely require high precision ephemeris information for the serving cell for uplink synchronization. The level of details required for the neighbour cells can be investigated further. Details are mentioned in our response to Question 5. |
| Qualcomm | Yes | It is better to have information of neighbour cells for idle mode mobility and RRM and handover support in connected mode. We may need to wait for RAN1 progress on the details. |

Besides the format and split of ephemeris, it needs to be discussed and decided how this information is provided to the UE. As argued in [1], the size of ephemeris can be extensive, if orbital plane parameters and satellite parameters are signalled, these can consume 56 bytes for a single satellite (including its orbital related parameters), while the allowable size of NR SIB is 372 bytes. It can be easily noticed the entire SIB’s capacity can be exhausted by the ephemeris for just several satellites. Thus, e.g. [7] discusses other means to provide the UE with the ephemeris, such as storing constellation ephemeris in the uSIM or in the UE. This is expected to work if the network is able to send periodical updates to such static ephemeris, kept at the UE. As a reference, in case of GPS, the almanac is updated every 12.5 minutes while the ephemeris can be updated within 30 s. Companies are asked to provide their views in this area.

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| **Question 7: How should the ephemeris be provided to the UE (e.g. pre-provisioning via uSIM, SIB, and other aspects like how to divide into a static and dynamic part, if necessary)?** |
| **Company** | **Answer** |
| APT | New NTN SIBs to support the PVT (ECEF representation). |
| Ericsson | Pre-provision, NAS, RRC(SI or dedicated) should all be considered. Further different ways to quantize the data needs to be considered. Some examples, orbital info can be given as orbital planes/sub planes and SI can point with index to orbital sub plane. Division can be in time, given sparsely finer data and more frequently updates. |
|  | Pre-provisioning, SIB and RRC can be considered at this stage. For either option we need to consider minimizing the amount of ephemeris data and avoid too frequent provision, e.g. ephemeris data of a group of satellites on the same orbit can be represented as the common part (e.g. orbit plane) that can be pre-provisioned and individual part (e.g. anomaly or difference of satellite level parameters) that can be broadcasted/signalled. |
| MediaTek | For the serving cell, we definitely need it to be provided in the SIB, as it will be updated frequently. For neighbour cells, a mix of pre-provisioned and broadcast information could be used.  |
| Qualcomm | Pre-provisioning in uSIM does not need to be excluded. A new SIB can be considered to provide ephemeris for UEs in IDLE state. For UEs in CONNECTED state, unicast message by the serving gNB can be used. |

# 5 Cell reselection

As stated in section 2, the NR cell reselection framework, including the existing cell reselection priority configuration, is taken as a baseline for NTN. However, at RAN2#112 further decisions have been made: the information concerning when a cell is going to stop serving the area and information about new upcoming cell can be further considered. However, the exact form and its use in cell reselection process is FFS. Here we attempt to discuss more details of this information, also considering that this has been already partially done in [8] and in the e-mail discussion preceding RAN2#112.

In [8] there were different views expressed how this additional information can be expressed:

* A list of neighbour cells, provided in the system information
* Ephemeris and resulting calculations done by the UE (i.e. no additional separate information provided/broadcasted)
* Separate broadcasting of time left in the camped/serving cell or time until a new cell becomes available

If any other means were considered and are missing in the list above, please indicate in the table below, for Question 8. Companies are kindly asked to first answer if this additional information on ’when a cell is going to stop serving the area and information about new upcoming cell’ should be a mandatory part of the cell reselection for NTN. Current agreement states this information ‘can be further considered’, which does not seem to be binding in any way.

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| **Question 8: Should the additional information on when a cell is going to stop serving the area and information about new upcoming cell become a mandatory part of the cell reselection in NR? Please motivate the answer, especially if you think legacy reselection is not sufficient (please state why).**  |
| **Company** | **Yes/No** | **Motivation** |
| APT | No | The dwell time is good to have, but not essential to us. |
| Ericsson | Yes | This is a network planning outcome and there is no other way for the UE to know when cell is about to leave and new is coming. Especially for soft feeder/service link switch, there is no point to have all IDLE mode UEs wait for the camped normally cell to actually vanish in order to trigger cell reselection. |
| Lenovo | No | The information is not mandatory as an NTN cell ceasing to serve will trigger neighboring cell measurement for the UE (legacy can work). Meanwhile other enhancement like time/location-based cell reselection can also solve the issue so the information can be optional. |
| MediaTek | No | As a baseline we can rely on the measurement mechanisms. When the serving cell leaves and a neighbour cell covers an area RSRP/RSRQ measurements could be used for cell reselection. It could be useful to have information about when an upcoming cell will serve the area, e.g. if there is any impending coverage-hole. |
| Qualcomm | Yes | If the cell is going to be switched off, cell expiry time is needed. Additionally, information on next serving cell(s) is very useful. |

In case you have answered ‘Yes’ to Question 8 (or have other insights in this area), please provide further details in what form is this information provided and how it is employed in the NTN cell reselection procedure. Please describe how the potential solution differs between Earth-moving and Earth-fixed scenario.

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| **Question 9: In what form and how is this additional information employed in NTN’s cell reselection process? Please underline the differences between Earth-moving and Earth-fixed scenario.** |
| **Company** | **Answer** |
| Ericsson | Especially for soft feeder/service link switch, there is no point to have all IDLE mode UEs wait for the camped normally cell to actually vanish in order to trigger cell reselection.The exact form can be e.g. time stamp associated with PCI. Other forms can be discussed as well. This is needed for service/feeder link switch for Earth fixed cells and feeder link switch for Earth moving cells. |
| MediaTek | During initial NTN deployment it is not expected to have full coverage at all time. It could be useful to have information about when an upcoming cell will serve the area, e.g. if there is any impending coverage-hole. |
| Qualcomm | Simply, SIB1 can broadcast expiry time of current cell and next cell ID(s) to cover the area. |
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Somewhat different aspect, still related to cell reselection in NTN, was discussed in [1], namely the number of reselection priorities. It was observed that up to 40 different priorities can be provided, thanks to the existence of up to 8 different values of *cellReselectionPriority* and up to 5 different values of *cellReselectionSubPriority*. Companies are invited to comment whether such reselection means are sufficient.

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| **Question 10: Is the existing NR cell reselection prioritization, in terms of the number of different priorities that maybe configured, sufficient for NTN?**  |
| **Company** | **Yes/No** | **Motivation** |
| APT | Yes | The reselection means based on RSRP/RSRQ measurement shall be the baseline. |
| Ericsson |  | Would start discussing how the cell selection/reselection needs to work and then see if more priorities are needed. |
| APT | Yes | The existing NR cell reselection prioritization shall be the baseline. |
| MediaTek | Yes | Priority mechanism is the baseline for inter-frequency reselection, as in Rel. 16. |
| Qualcomm | Yes | Existing mechanism should work. |

# 6 Conclusions

Based on the views expressed in the previous sections, we propose the following:

# 7 List of referenced documents

[1] R2-2009774 *IDLE mode aspects for Non-Terrestrial Networks (NTN)*  Nokia, Nokia Shanghai Bell, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[2] R2-2009454 *Cell selection and reselection enhancements* Qualcomm Incorporated, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[3] R2-2009597 *Control Plane for Idle mode UE*  Xiaomi, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[4] R2-2010578 *Idle mode issues in NR NTN*  LG Electronics Inc, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[5] R2-2010453 *Satellite ephemeris in NTN*  InterDigital, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[6] R2-2008837 *Remaining Issues of IDLE and Inactive Mode for NTN* CATT, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[7] R2-2009255 *Idle mode procedures in NR NTN* Thales, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[8] R2-2010765 *[AT112-e][104][NTN] Misc CP issues (Ericsson)* Ericsson, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

# Contact information

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