**3GPP TSG-RAN Meeting #93-e RP-21xxxx**

**Electronic Meeting, September 13-17, 2021**

**Agenda item:** 9.3.4.3

**Source:** Moderator (China Telecom)

**Title:** Moderator's summary for email discussion [93e-25-CRSIntfHandling]

**Document for:** Discussion

# Introduction

This document is the summary of email discussion [93e-25-CRSIntfHandling] on CRS interference handling for NR PDSCH in scenarios with overlapping spectrum for LTE and NR, and the discussion outcome (if any) will be reflected in the revised WID on “Rel-17 Further enhancement on NR demodulation performance”.

All the following 5 tdocs recommend to define NR PDSCH demodulation requirements for neighbouring cell LTE CRS-IM in Rel-17, and the main discussion point is whether network assistance signalling for CRS-IM is needed or not.

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| --- | --- | --- |
| Tdoc | Title | Source |
| [RP‑211835](file:///D:\0_Work\Standardization\RAN\RAN%2093%20(Sep%202021)\Tdoc%20list\docs\RP-211835.zip) | Revised WID: Further enhancement on NR demodulation performance | China Telecom |
| [RP‑211950](file:///D:\0_Work\Standardization\RAN\RAN%2093%20(Sep%202021)\Tdoc%20list\docs\RP-211950.zip) | CRS interference handling in NR | Apple, MediaTek |
| [RP‑212199](file:///D:\0_Work\Standardization\RAN\RAN%2093%20(Sep%202021)\Tdoc%20list\docs\RP-212199.zip) | Views on LTE CRS interference handling for NR UE | Nokia, Nokia Shanghai Bell |
| [RP‑212226](file:///D:\0_Work\Standardization\RAN\RAN%2093%20(Sep%202021)\Tdoc%20list\docs\RP-212226.zip) | Views on Rel-17 CRS-IM requirements in scenarios with overlapping spectrum for LTE and NR | Intel Corporation |
| [RP‑212490](file:///D:\0_Work\Standardization\RAN\RAN%2093%20(Sep%202021)\Tdoc%20list\docs\RP-212490.zip) | LS on RAN4 evaluation for LTE CRS interference handling for NR UE (R4-2115741; to: RAN; cc: -; contact: China Telecom) | RAN4 |

# Initial round

## Open issues and companies views’ collection

**Issue #1**: Except the network assistance signalling part (which is discussed separately in Issue #2), any comments on the other parts of RAN4 recommendations in LS RP-212490?

*RAN4 recommends to define NR PDSCH demodulation requirements for neighbouring cell LTE CRS-IM in scenarios with overlapping spectrum for LTE and NR in Rel-17:*

*• Use LLR weighting as baseline reference receiver, and further discuss the feasibility of CRS-IC receiver taking into account the UE complexity and PDSCH processing time.*

*• Synchronous network scenario is prioritized. The asynchronous network scenario will be discussed after RAN #93e meeting.*

*• 15 kHz SCS for NR is prioritized. The 30 kHz SCS scenario will be discussed after RAN #93e meeting.*

*• RAN4 will further discuss the necessity of ~~network assistance signaling and~~ UE capability signaling during requirements definition phase.*

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| Company | Comment |
| Huawei | We are fine with the RAN4 recommendation part shown above. |
| OPPO | Fine with the recommendations as above. |
| MTK | The recommendation is fine to us. But we want to clarify that removing network assistance in the last bullet does not mean network assistance information is out of scope, even if we do not reach the conclusion in **Issue #2**. |
| ZTE | RAN4 recommendations are fine with us. |
| Apple | We would like to understand the reason for deleting network assistance signalling part. We think network assistance might still be in the scope pending the outcome of discussion on Issue #2. |
| China Telecom | Support to add the RAN4 recommendations in the WID, unless any technical errors are found. For the network signalling part, if additional agreements can be achieved, it can be updated; otherwise, the original wording can be kept. |
| Samsung | We support RAN4 recommendations as a package in original LS |
| Qualcomm | We agree to take the LLR weighting as baseline to define the requirements. We think that the scenarios which are deprioritized should be left out for now due to lack of time in RAN4. They could be further discussed after the requirements for the “baseline scenario” are finalized. Our understanding that assistance data is discussed separately and the fact that it was erased does not mean it is out. |
| CMCC | We are fine with the recommendation. |
| Ericsson | The recommendations are OK for us in general. Regarding the receiver assumption, we would have some preference to ease the RAN4 workload to derive the requirements based on LLR weighting and deprioritize or take out of scope CRS-IC. Regarding network signalling, we add our view for the second issue; the objectives should be aligned with the end decision for that issue. |
| Intel | Support recommendation from LS.  In our paper we suggest the following wording change for the last three bullets:   * Synchronous network scenario is prioritized. The asynchronous network scenario will be discussed further. * 15 kHz SCS for NR is prioritized. 30 kHz SCS scenario will be discussed further. * Study and if necessary, define network assistance signaling and UE capability signaling.   However, wording from LS is also fine for us.  The wording on network assistance can be updated based on conclusions on Issue #2. |
| Nokia, Nokia Shanghai Bell | In view of the RAN4 workload and timeframe of Rel-17, we do not consider it necessary to discuss further the CRS-IC receiver in Rel-17. It makes sense to use the LLR weighting receiver as the baseline reference receiver in Rel-17.  In view of the Rel-17 schedule, we should also limit the work to the synchronous network scenario only.  Otherwise, we are fine with the RAN4 recommendations shown above. It is OK to discuss the need for UE capability signalling in a later phase. |
| Vodafone | We are fine with the recommendation. |
| BT | We are fine to proceed with the recommendations captured above |
| KDDI | We are fine with the above RAN4 recommendation. |

**Issue #2:** Whether to assume network assistance information for PDSCH CRS-IM?

* Option 1: Yes (Apple, MediaTek)
* Option 2: No (Nokia - for Rel-17)
* Option 3: Task RAN4 to further discuss the necessity of network assistance signaling during requirements definition phase. (Intel, China Telecom)

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| Company | Comment |
| Huawei | Option 2.  From RAN4 discussion, companies have common understanding that it is feasible for UE to acquire the related CRS configuration information by blind detection and PBCH decoding. Also to speed up the feature application in the real network as early as possible and avoid network and UE upgrade to support any additional signalling, it is more valuable not to introduce any network assistance signalling. |
| OPPO | Prefer option 1.  Considering UE complexity and realistic network deployment, we support to include network assistance information, along with other signalling/capabilities for Rel-17 UEs. We do not see that much of overhead. Besides, since this NW assistance will only be supported by Rel-17 UEs, there still exists enough time period for BSs to implement this before Rel-17 UEs will be launched in the market. |
| MTK | Support Option 1  UE complexity needs to be considered. As we mentioned during GTW, UE complexity cannot be seen from the throughput simulation results. The observation of similar UE performance between with and without assistance information should not be used as an argument to preclude network assistance information.  We also want to take this chance to discuss a bit about the definition of network assistance information. In our view, it is impossible for UE to do CRS-IM if network does not provide any piece of information (not even provide the LTE MO for UE to do cell search). Without MO, UE has no idea about the LTE center frequency and will need to blindly scan all possible LTE PSS/SSS frequency locations. The process is time-consuming, and the complexity is huge. With this understanding, we believe that the network assistance information is anyway needed. The discussion point is only about its content. |
| ZTE | We support Option 2.  RAN4 has confirmed that LLR weighting without network assistance can achieve better performance, thus for the time being RAN4 can focus on specifying enhanced PDSCH demodulation requirements based on LLR weighting receiver without network assistance for synchronous scenarios with 15kSCS. After that, RAN4 can work with asynchronous cases and other SCSs. In such a way, the performance improvement demands can be satisfied under the current stage.  Further potential optimization with network assistance can be deferred to a later stage. |
| Apple | We support option 1.  We would like to understand why it would be difficult for network to implement this assistance information in Rel-17, while UEs are expected to implement CRS-IM. The time frame this will be deployed would be when Rel-17 UEs and gNBs are available. To speed up the feature application in real network, rate matching schemes can be used without additional impact to UE processing.  RAN4 has not confirmed that LLR weighting without network assistance can achieve better performance.  During the GTW discussion, companies expressed their views that LLR weighting doesn’t need network assistance and that NR UE can get all the information from inter-RAT measurements. Firstly, we would like to understand if UE would always be configured with inter-RAT measurements for the LTE cells with overlapping NR spectrum. For inter-RAT measurements, the UE doesn’t need to do PBCH/MIB decoding which is necessary to know number of CRS ports and bandwidth for CRS-IM. Also, additional information like MBSFN subframe configuration, CRS muting information are not known unless this information is provided. In case UE is supposed to do CRS-IM on cell(s) other than those configured for inter-RAT measurements, there is an additional level of complexity as pointed out by MTK above and also in our paper RP-211950.  Also, there is no way to assess the the UE processing or complexity and just comparing simulation results with and without network assistance doesn’t sufficiently reflect the additional UE complexity involved without network assistance.  Given the above, we think it is necessary to have network assistance for CRS-IM and the content of such assistance information should be further discussed. |
| China Telecom | Option 2 or Option 3.  As several companies commented on Monday GTW, the network signalling aspect can be discussed separately for the two implementations of CRS-IM, i.e., LLR weighting and CRS-IC.  1) For LLR weighting  Only the power level of interference CRS needs to be estimated and UE can estimate the power of all REs in the OFDM symbols containing CRS, assuming the same number of CRS ports in the serving and neighbouring cells. So, CRS location is not needed to be signalled. For the presence of the CRS interference, it can be known by the ON/OFF of serving cell CRS-RM in DSS scenario.  If needed, we are also fine to limit the requirements to the typical scenarios, e.g., without CRS muting (i.e., network based CRS interference mitigation), and aligned MBSFN configuration among the serving and neighbouring cells, instead of considering all the scenarios supported in the specs but not used in the network.  2) For CRS-IC  For CRS-IC, in order to obtain the CRS sequence, UE may need to perform inter-RAT neighbouring cell detection and PBCH reading. The feasibility can be discussed separately.  In summary, we suggest:  1) Discuss the network signalling for LLR weighting and CRS-IC separately  2) Further align which parameters are needed to be known at UE for LLR weighting and CRS-IC respectively  3) Then discuss whether these parameters can be obtained by any means at UE |
| Samsung | We support option 3.  RAN shall respect WG decision on the recommendations including both baseline as well as further study on network assistance signalling as a package. RAN do not need to re-confirmed the baseline receiver and further discuss the network signalling necessity for baseline receiver and other receiver type which has been well/extensive discussed in RAN4. We do not need to repeat the discussions in RAN.  We suggest to follow what RAN4 recommended in the next quarter discussions. |
| Qualcomm | We support Option 1. Even though implementation of the feature without assistance data is feasible, there will be a clear increase in complexity(and consequently power consumption). The UE will have to do inter-RAT measurements and decoding of PBCH with the NR modem. Also, there will be a performance degradation because because of errors associated with detection and PBCH decoding of neighbor cells. Also, it is possible that PBCH decoding is not possible at certain levels (PBCH will always be colliding) even though interference mitigation could provide performance gains. Nokia’s proposal to consider assistance information in the future does not make much sense since Rel.17 UEs will carry the burden of additional complexity anyway.  Option 3 implies that RAN4 will have further discussion which will likely take a long time. performance evaluation without assistance data will be difficult and cumbersome because it will imply making certain assumptions about whether a cell is detectable or not, after how much delay, etc.  Irrespective of what the decision will be, there will be a loss in performance in the field if assistance data is not provided to UEs. |
| CMCC | Option 2 for LLR weighting and Option 3 for CRS-IC.  Firstly, based on the simulation results from companies, when using CRS-IM without network assistance, the performance gain can be achieved.  Secondly, only the power level of interference CRS needs to be estimated for LLR weighting, UE does not need to know the CRS location or sequence to do the mitigation. It is feasible for UE to do the blind detection without too much complexity. And the presence of interference can also be obtained from existing signalling, e.g. CRS-RM, 7.5KHz shift, inter-RAT MO configuration…  Considering of the companies’ concerns about processing timeline and UE complexity for CRS-IC receiver, we are open to further discuss the necessity of network assistance signaling during requirements definition phase. |
| Ericsson | We support option 2. We are fine to base the requirements on LLR weighting to reduce the complexity burden on the UE. Lack of a need for network signalling will widen the scenarios in which there is a benefit form the feature. Considering that CRS-IM is useful when the UE is in connected mode and receiving data anyhow, we would like to understand just how much incremental UE complexity detecting the co-channel neighbour PBCH is in these circumstances. |
| Intel | Support Option 3, which is aligned with RAN4 WG recommendation.  Same time, we see clearly two camps supporting and not supporting definition of network assistance and an alternative option, which can be further discussed in RAN4, is to define two sets of requirements for the cases with and without network assistance.  As for separate discussion on network assistance signalling for different CRS-IM receivers. Based on our understanding, same information is required for CRS-IC and LLR weighting receivers and UE needs information on CRS REs positions for both types of receivers. |
| Nokia, Nokia Shanghai Bell | Option 2. Especially with LLR-weighting receiver, there is no need for NWA. We agree with the comments from Huawei. Furthermore, it would be too late in Rel-17 to start debating the network assistance. |
| Vodafone | We prefer option 2 but can consider option 3. It seems the complexity of LLR without network assistance is manageable and this would speed up the feature application within the network as per Huawei’s comments. |
| BT | Option 2  As a result of the study, we consider it is a good compromise select LLR weighting over CRS-IC based on performance vs complexity.  LLR weighting without network assistance is the best compromise between time to market and complexity.  We are facing the end of Rel-17 and WGs are still overloaded. The introduction of network assistance will impact several WGs and due to the severity of the problem observed in real networks by different operators, it is not possible to wait until Rel-18. In addition, with network signalling, more elements of the networks need to implement the solution and the IOT/IODT will require extra time.  It is accepted that without network assistance, the UE complexity will increase but as many other things in 3GPP, the fact that PDSCH CRS-IM works without network assistance will be a good differentiator among vendors. In that sense, this is business as usual. More complexity does not mean it is broken or it will not work. Once the problem is solved, we are open to further enhancements if required.  Therefore, by adding network assistance, we are putting in severe risk the completion of the work in Rel-17 and therefore NR SA will be delayed in countries where refarming is not an option. |
| KDDI | Option2  Nokia’s proposal makes sense considering the current WGs situation. We are reluctant to impose additional work on RAN4 and other WGs to develop the network assistance feature within Rel-17 time frame. We think that we should identify advantages and disadvantages of having the enhancement for network assistance in next Rel-18. |

## Initial round summary

**Issue #1**: Phase II objective (excepting the network assistance signalling part)

Except the network assistance signalling part (which is discussed separately in Issue #2), any comments on the other parts of RAN4 recommendations in LS RP-212490?

*RAN4 recommends to define NR PDSCH demodulation requirements for neighbouring cell LTE CRS-IM in scenarios with overlapping spectrum for LTE and NR in Rel-17:*

*• Use LLR weighting as baseline reference receiver, and further discuss the feasibility of CRS-IC receiver taking into account the UE complexity and PDSCH processing time.*

*• Synchronous network scenario is prioritized. The asynchronous network scenario will be discussed after RAN #93e meeting.*

*• 15 kHz SCS for NR is prioritized. The 30 kHz SCS scenario will be discussed after RAN #93e meeting.*

*• RAN4 will further discuss the necessity of ~~network assistance signaling and~~ UE capability signaling during requirements definition phase.*

**Summary of initial round discussion:**

1. All companies support to proceed with the above recommendations, with additional clarification on the network signalling part: if further agreements for Issue #2 can be reached, the signalling part can be updated accordingly; otherwise the original RAN4 recommendation will be added back.
2. Majority companies agree to keep the RAN4 recommendation without any additional update, while there are also some suggestions on the deprioritized scenarios or FFS part in order to reduce the RAN4 workload:

* One company (QC) suggests to discuss the deprioritized scenarios (asynchronous network, 30 kHz SCS) after the requirements for the baseline scenario (synchronous network and 15 kHz SCS) are finalized.
* One company (Nokia) suggests to only focus on synchronous network scenario.
* Two companies (E///, Nokia) suggest to only focus on LLR weighting.

**Issue #2:** Whether to assume network assistance information for PDSCH CRS-IM?

**Summary of initial round discussion:**

* Option 1: Yes (Apple, MediaTek, OPPO, QC)
* Option 2: No (Nokia, HW, ZTE, China Telecom, CMCC for LLR weighting, E///, VDF, BT, KDDI)
* Option 3: Task RAN4 to further discuss the necessity of network assistance signaling during requirements definition phase (Intel, China Telecom, Samsung, CMCC for CRS-IC, Intel, VDF)
* Option 4 (NEW): Define two sets of requirements for the cases with and without network assistance. (Intel)

The need of network signalling has been debated repeatedly, and companies’ positions are not changed since RAN #91e. For the intermediate round, it might be helpful to first align the understanding on:

* 1) Which parameters are needed to be known for LLR and CRS-IC respectively?
* 2) How could UE obtain the information if not signalled by the network?
* 3) Deadline to make the decision on the need of network signalling

# Intermediate round

## Open issues and companies views’ collection

**Issue #1**: Phase II objective (excepting the network assistance signalling part)

*RAN4 recommends to define NR PDSCH demodulation requirements for neighbouring cell LTE CRS-IM in scenarios with overlapping spectrum for LTE and NR in Rel-17:*

*• Use LLR weighting as baseline reference receiver, and further discuss the feasibility of CRS-IC receiver taking into account the UE complexity and PDSCH processing time.*

*• Synchronous network scenario is prioritized. The asynchronous network scenario will be discussed after RAN #93e meeting.*

*• 15 kHz SCS for NR is prioritized. The 30 kHz SCS scenario will be discussed after RAN #93e meeting.*

*• RAN4 will further discuss the necessity of ~~network assistance signaling and~~ UE capability signaling during requirements definition phase.*

*Note: if further agreements for Issue #2 can be reached, the signalling part can be updated accordingly; otherwise the original RAN4 recommendation will be added back.*

**On top of the RAN4 recommendation, if any of the following additional updates are acceptable?**

* 1) Discuss the deprioritized scenarios (asynchronous network, 30 kHz SCS) after the requirements for the baseline scenario (synchronous network and 15 kHz SCS) are finalized.
* 2) Only focus on synchronous network scenario.
* 3) Only focus on LLR weighting.

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| Company | Comment |
| Intel | 1. We think it is rather reasonable to focus on scenario with synchronous network and 15 kHz SCS to balance the workload. Performance benefits and feasibility of CRS-IM processing is already analysed and confirmed for this scenario. The proposed prioritization (i.e., handle asynchronous network and 30 kHz SCS scenarios after completion of work on 15kHz SCS) is acceptable for us. 2. Based our understanding, CRS-IM for async case may require multi-FFT processing and leads to complicated Rx processing. Therefore, we think that only sync case should be considered for requirements definition. Taking into account that we didn’t have a detailed discussion on CRS-IM for async case in RAN4, we are fine to keep it for further discussion. 3. We prefer to keep both receiver candidates open since CRS-IC provides better performance comparing to LLR weighting (based on results from TR 38.833). Also, CRS-IC is the baseline CRS-IM method for LTE UE. |
| Nokia, Nokia Shanghai Bell | It is very important to manage the workload in RAN4. Therefore we should focus on the synchronous network scenario and on only LLR-weighting receivers. |
| Qualcomm | We agree with the additional updates to better focus the work. |
| Apple | 1. Given the remaining time, it would be good to focus on defining requirements for synchronous and 15KHz SCS scenario and discuss deprioritized scenarios later. 2. Asynchronous (and also 30KHz SCS) requires multiple FFT for CRS-IM which would further impact UE processing and complexity. We support to focus only on synchronous network. 3. We support to only focus on LLR weighting as it is less complex than CRS-IC for interference mitigation. |
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**Issue #2:** Whether to assume network assistance information for PDSCH CRS-IM?

Further discuss the 3 points below:

* 1) Which parameters are needed to be known for LLR and CRS-IC respectively?
  + For LLR weighting:
    - Option 1: presence and location of interference CRS
    - Option 2: presence of interference CRS
  + For CRS-IC:
    - Option 1: presence, location and sequence of interference CRS
  + Note: the presence information includes the presence of LTE cell, MBSFN configuration, CRS muting information, and the CRS location information includes LTE carrier frequency, bandwidth, v-shift, CRS port number.
* 2) How could UE obtain the information if not signalled by the network?
  + For LLR weighting:
    - Option 1: By inter-RAT measurement and PBCH decoding
    - Option 2: By the configuration of serving cell CRS-RM, 7.5KHz shift, inter-RAT MO
  + For CRS-IC:
    - Option 1: By inter-RAT measurement and PBCH decoding
* 3) Deadline to make the decision on the need of network signalling

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| Company | Comment |
| Intel | 1. Based on our understanding, the set of information required for LLR weighting and CRS-IC receivers is same (i.e., presence, location and sequence of interference CRS). We assume that UE needs to know CRS sequence, number of CRS APs, CRS shift, MBSFN pattern, and CRS bandwidth.   For LLR weighting receiver we assume that UE needs to estimate the power of CRS interference and one of the ways is to make it based on channel estimation for which CRS sequence is required.   1. Based on our understanding, for most parameters inter-RAT measurement and PBCH decoding should be sufficient except MBSFN configuration and CRS muting information. The latter information can be obtained via SIB reading or via CRS presence detection. 2. Taking into account that Rel-17 ASN.1 freeze is in June 2022, we think that the final deadline to define the signalling and provide information to RAN2 should be February 2022. The decision on whether signalling should be introduced needs to be made in November 2021 or January 2022 RAN4 meetings.   In addition, we prefer to handle the discussion on specific required information and how UE can obtain it in RAN4. RAN can task RAN4 to identify required information for different reference receivers. |
| Nokia, Nokia Shanghai Bell | 1) No parameters are strictly needed for either LLR-weighting or CRS-IC, though the impact of not having signalling might be greater with a CRS-IC receiver.  2) The UE can obtain what is needed by blind detection, similar to LTE cell search. (As a compromise, if any signalling were to be provided, it should be confined to reusing the Rel-15/16 semi-static signalling of LTE CRS RM patterns that can be used inform the UE of the locations of the CRS REs.)  3) The decision should be made at RAN#93e. |
| Qualcomm | 1) Our understanding is that the same information is needed for LLR weighting or CRS-IC. Knowing the actual sequence could be useful for LLR weighting as well.  2) Option 1 for both.  3) we would prefer to make a decision as soon as possible or at least have a clear criteria for making a decision(if the decision is left to RAN4, how to evaluate the impact).  Infra vendors have not explained why is it so difficult to provide the assistance information. This entire work was triggered by the need to improve the performance with DSS. In order to maximize the gains in the field, assistance information is clearly useful so everyone should do their part and contribute to the possible improvements. |
| Apple | 1. For both CRS-IC and LLR weighting the same set of LTE parameters are needed for interference mitigation: LTE cell ID, number of CRS ports, LTE center frequency, CBW, MBSFN configuration. For both presence CRS-IC and LLR weighting presence, location and sequence of interference CRS information is needed. 2. In case no information on LTE interferer is available to the UE, the UE would need to rely on LTE inter-RAT measurement and would only be aware of the frequency layers configured in the LTE-MO. Also, inter-RAT measurements are restricted to measurement gaps and might be limited to single CRS port measurements. For additional information on CRS ports and LTE BW PBCH decoding is needed. For information on MBSFN configuration SIB decoding is needed. If LTE-MO is not configured, then it is very complex since a frequency scan is needed to detect LTE center frequency first. For DSS scenario even if the same configuration as serving cell is assumed for number of CRS ports, BW and center frequency and MBSFN c config, cell detection is still needed for LTE interferer to obtain the cell ID. In scenario 2 there is no such LTE serving cell information. 3. There is a necessity for network assistance as already expressed by UE vendors and propose not to continue the discussion on whether NWA is necessary or not, otherwise we would continue to hear the same arguments. We propose to start the work in RAN4 for demod requirements for CRS-IM with the assumption of network assistance information and discuss the details of what NWA information is included as part of RAN4 work. We would also like to understand why providing NWA is not feasible for R17 when UEs are expected to implement CRS-IM. If UEs don’t support this feature due to additional complexity with no NWA, then there would be no benefit in the end. |
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## Intermediate round summary

# Final round

## Open issues and companies views’ collection

## Final round summary

# Final conclusions

# Annex: Contacts

Please provide a company contact that the email discussion moderator can contact if required.

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