3GPP TSG-RAN WG2 #121 R2-23XXXXX

Athens, Greece, February 27 – March 3, 2023

Agenda Item: 8.16.1

Source: Ericsson, vivo

Title: Outcome of [Post120][054][AIML18] Data Collection (Ericsson / vivo)

Document for: Discussion, Decision

# 1 Introduction

The intention of this document is to invite companies to share their views regarding *data collection* aspects for the SI on “AI/ML for NR Air Interface”. Taking these into account, the Rapporteur of the discussion provides a set of proposals to be further discussed during RAN2#121.

The scope of the discussion is given by the following email thread:

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| * [Post120][054][AIML18] Data Collection (Ericsson / vivo)   Scope: Long email discussion for next meeting, on data collection (focus on monitoring and training), on to what extent existing methods can be useful including also identifying these existing methods and their potential extensions  Intended outcome: Report  Deadline: Long |

**Deadline for comments: Friday Feb 10th, 2023, 1000 UTC**

**Inactive periods:**Dec 23 – Jan 6 Jan 23 – 27

Below you can find the list of participating companies and their respective responsible delegates.

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| **Company** | **Delegate name** | **Email address** |
| Apple | Peng Cheng | pcheng24@apple.com |
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# 2 Discussion

As per the Email Discussion description above, the intention of this document is to touch upon data collection for:

* model monitoring and,
* model training.

For this, RAN2 should then analyse whether existing methods could be (re)used or extended. Or whether there is a need for new methods.

On the above, the Rapporteur suggests considering the use cases under study, to later focus on their requirements and architecture-related aspects.

## 2.1 Use cases

The three different RAN1-agreed use cases and their respective sub use cases are listed below:

1. CSI feedback enhancement
   * Spatial-frequency domain CSI compression using **two-sided AI model**
   * Time domain CSI prediction using **UE-sided model**
2. Beam Management (BM) enhancement
   * Spatial-domain DL beam prediction, with **one-sided AI model** (i.e., either in UE or NW)
   * Temporal DL beam prediction, with **one-sided AI model** (i.e., either in UE or NW)
3. Positioning accuracy enhancement
   * Direct AI/ML positioning
     + *Note: this refers to the fact that the AI/ML model is directly producing the UE location as output*
   * Assisted AI/ML positioning
     + *Note: this refers to the fact that the AI/ML model is producing an existing or new measurement report that is used to estimate the UE location using legacy positioning methods (e.g., triangulation).*
   * For the above 2 points (i.e., direct/assisted AI/ML positioning), RAN1 have captured the following (sub)cases:
     + Case 1: UE-based positioning with **UE-sided model**, direct AI/ML or AI/ML assisted positioning
     + Case 2a: UE-assisted/LMF-based positioning with **UE-sided model**, AI/ML assisted positioning
     + Case 2b: UE-assisted/LMF-based positioning with **LMF-sided model**, direct AI/ML positioning
     + Case 3a: NG-RAN node assisted positioning with **gNB-sided model**, AI/ML assisted positioning
     + Case 3b: NG-RAN node assisted positioning with **LMF-sided model**, direct AI/ML positioning

Above, the Rapporteur have highlighted where the AIML model inference is located for each agreed use case, i.e., UE- or gNB/NW-sided AIML models.

In this sense, it seems important for to clarify the scope of RAN2’s discussion concerning the functionality-to-entity mapping within the network. This, since during RAN1#109-e the following was captured in the Session Notes (see [R1-2205695](http://www.3gpp.org/ftp//tsg_ran/WG1_RL1/TSGR1_109-e/Docs//R1-2205695.zip)):

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| Observation  Where AI/ML functionality resides depends on specific use cases and sub-use cases.  Conclusion   * RAN1 discussion should focus on network-UE interaction.   + AI/ML functionality mapping within the network (such as gNB, LMF, or OAM) is up to RAN2/3 discussion. |

On the above, the Rapporteur would like to start by stressing that RAN2 should limit their analysis and discussion to RAN2-specific aspects.

Clearly, the positioning (sub) use cases are likely to lead into discussions that may involve the LMF and, perhaps, other entities outside of RAN. This aspect is addressed further below in the document (see Section 2.2.2). However, for the other cases, it seems reasonable to start by assuming that RAN2 should focus on data collection information that is terminated in the gNB, LMF or UE.

Furthermore, the Rapporteur would like to continue by stressing that RAN3 does not have Time Units (TUs) allocated to this SI. Therefore, it is even more important to limit the scope of the functionality-to-entity mapping discussion (and here not only for data collection aspects) to RAN2 domains of expertise and not to that of other WGs.

1. RAN2 should not rely on RAN3 regarding architecture or functionality-to-entity mapping matters, since RAN3 does not have TUs assigned for this SI.

Further developing the above thread, the Rapporteur observes that UE-sided models based on data collection at the UE side have minor or no implications to RAN2 protocols, as a lot is proposed by companies to be left to implementation. As for these cases, the UE seems already capable of collecting data (e.g., by UE implementation). Indeed, the Rapporteur understands that some signalling, or specific configuration could eventually be needed by UEs for data collection purposes in UE-sided AIML models. However, for these cases it is our understanding that the UE does not need to report the collected data to the gNB. Hence, UE-based data collection for UE-sided AIML models appear to mostly be a RAN1 issue right now.

1. For UE-sided AIML models, UEs do not necessarily need to report the collected data for model training to the gNB/LMF.
2. RAN1 can later provide requirements (e.g., related to configuration, signalling, etc.) which could facilitate the process of UE data collection for UE-sided AIML models.

On the contrary, gNB/LMF-sided AIML models need to collect data gathered by UEs to monitor and train the models. This data may be UE measurements and performance metrics that are configured and reported to the gNB/LMF. One point which needs to be discussed, for example, is to which extent the characteristics of the data to be collected differs from existing measurements the UE may already be able to perform and report to the gNB. Hence, the Rapporteur observes that there is perhaps a need for RAN2 to start by focusing on gNB/LMF-sided AI/ML models.

1. There seems to be a need for RAN2 to start by focusing on gNB/LMF-sided AIML models. Since for these cases, the UE needs to be configured to report collected data (e.g., measurements, performance metrics) to the gNB/LMF.

The Rapporteur would like to understand companies’ views regarding the above. Hence the following question.

**Q1)** Based on the above: Do you agree that RAN2 should start discussing the solutions and specification impact analysis centered around UE measurements/reporting and data collection for gNB/LMF-sided models?

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| **Company** | **Answer** | **Comments** |
| Apple | No | First, we disagree observations 2-4 can lead to the proposal in Q1 (i.e. RAN2 can start the study UE reporting for NW-sided model):   1. Observation 2/3:We think both "UE-sided model" and "gNB/LMF-sided model" need to define measurement requirement because both models need UE's measurements. The difference is whether to define requirement for UE reporting (i.e. "UE-sided model" may not need to define reporting requirement). For UE measurement, both RAN1 and RAN2 have spec impacts to be analysed. 2. Observation 4:We think whether impacts on UE measurement/reporting should be studied by RAN1 or RAN2 depends on the related measurement is L1 measurement or L3 measurement. Even for "gNB/LMF sided model", if the related measurement is L1 measurement, RAN1 should first study it. Because CSI measurement, BM and measurement for positioning are all L1 measurement, we are not sure why the study should start from RAN2?   Secondly, we think Rapporteur seems to miss some aspects of data collection study. It is our understanding the on-going study on "data collection" in RAN1 include the following 4 parts:   1. The assistance signalling from gNB to UE on data collection 2. The assistance signaling from UE to gNB on data collection 3. The delivery of dataset from UE to gNB 4. The delivery of dataset from gNB to UE (being discussed in AI/ML based positioning)   Rapporteur only focus on c) but missed 1), 2) and 4). We think it is not correct. **We want to confirm that all above 4 aspects are in RAN2 scope of data collection. We see no reason to preclude/deprioritize any one of them at this stage without any RAN2 study.**  Thirdly, we have concern that the requirements for data collection is not clear at this stage. We are not sure how RAN2 can make progress without clear requirement? Thus, **we suggest RAN2 can currently confirm the scope but need to wait sufficient RAN1 input on data collection requirement before detailed data collection study.**  Finally, our suggestion on RAN2 study of data collection can be summarized as:  1) Confirm and agree RAN2 scope of data collection study.  2) Agree what kinds of requirements need to be considered in RAN2 data collection study and the requirements may be use case specific.  3) Then, wait sufficient RAN1 inputs on details of requirements.  4) Based on agreed requirements for AI/ML data collection, RAN2 can discuss whether to define a new data collection framework or extend existing framework.  5) As the final step, RAN2 specify detailed signalling and procedure of UE data collection. |
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Following the previous reasoning, the Rapporteur would then like to see whether it would be possible to assume the following.

**Q2)** Would it be possible to agree on the following: RAN2 assumes that for gNB/LMF-sided AIML models, the data collection information is terminated in the gNB/LMF?

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| **Company** | **Answer** | **Comments** |
| Apple | No | This proposal may mistakenly preclude the SON/MDT framework because it is terminated in TCE rather than gNB/LMF, although we think it is not the intention of Rapporteur. Meanwhile, this proposal also precluded the option that termination in OAM, which is conflicted with RAN3 agreement.  Without any study in RAN2, we don't think RAN2 can make this assumption now. |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

## 2.2 Requirements

For RAN2 to design data collection solutions for the (sub)use case, one should first focus on the requirements needed for each. Given the questions above and since we now focus on model training and model monitoring, the Rapporteur considers that there are 4 main aspects to consider:

1. The content of the data
2. The data size (e.g., for model training)
3. Latency, periodicity, or “efficiency” requirements that could differentiate model training from model monitoring
4. Configuration-related requirements

Considering the different (sub)use case of this SI, one could possibly further extend the 4 aspects above as follows:

1. **The content of the data**
   * radio measurements
   * non-radio measurements, e.g., assistance data, monitoring metrics (e.g., accuracy, predicted outcome)
2. **The data size**
   * how many time instances are needed per UE or/and per cell?
   * the amount of UEs or/and cells needed in the data collection step to accurately train the model,
   * payload size of UE report.
3. **Latency, periodicity, or “efficiency”**
   * is the model performance monitoring a time critical matter?
   * are there latency requirement differences between types of training?
   * how often does the data need to be collected?
   * what is the validity period for data? (i.e., how quickly does it become outdated)
4. **Configuration-related requirements**
   * how to eventually configure a UE to e.g., measure, store, and report data
   * whether there is a need to have periodic or event-triggered data collection,
   * RRC-state linked to data collection/reporting
   * scenarios/conditions for which the data can be discarded

**Q3)** Do companies agree to start by focusing on data collection requirements related to: a) content of the data, b) data size, c) latency, periodicity, or “efficiency”, d) configuration-related requirements?

Note: Companies are also encouraged to provide comments on other aspects that need special attention at this stage of the SI.

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| **Company** | **Answer** | **Comments** |
| Apple | See comments | First, we think the discussion should differentiate between model training and data monitoring (i.e. inference). Rapporteur seem to mix them together or think they share the same requirement. But our understanding is their requirements may be different. For example, the data size for training should be much larger than data monitoring. And the latency requirement for training is much loose than data monitoring (i.e. inference).  Secondly, we think RAN2 can first agree that a) b) c) can generally be considered, but their details for each use case should be further studied. For d), our understanding is that it is a stage 3 signaling detail rather than requirement. So, we don't think d) should be included as one requirement.   * Here, we have a clarification question on c): what is "efficiency" means? our understanding is to reduce redundancy of data collection, but rapporteur please confirm.   Thirdly, before RAN2 study, we think RAN1 inputs on a) b) c) are required and maybe RAN4 input on c) is also required.  Finally, we think a missed requirement is security and UE privacy, which is an very important aspect.  As summary, we suggest to agree below 4 general requirements of data collection design, but their details should be further study (i.e. current sub-bullets need further study):   1. **The content of the data** 2. **The data size** 3. **Latency, periodicity, [or “efficiency”]** 4. **Security of data and UE privacy** |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

### 2.2.1 Beam Management enhancements

The Rapporteur acknowledges that RAN1 have not provided explicit input to RAN2 concerning requirements for the Beam Management use cases. However, by focusing on NW-sided AIML models and considering the above “initial requirements”, the Rapporteur understands that the following could be considered to design solutions:

1. **The content of the data**
   * Radio measurements:
     + L1-RSRP measurements and/or SSBRI/CRI (beam ID) of a set of beams at one- or multiple-time instances
   * Non-radio measurements:
     + Cell ID, area ID, carrier frequency, UE/NW antenna beam configuration/ID, time stamp, UE location/mobility/rotation, measurement accuracy, or measurement resolution, etc…
   * Monitoring metrics:
     + Prediction accuracy
2. **The data size**
   * Data should be collected from multiple UEs, at one- or multiple-time instances
   * The number of bits needed for reporting measurements per time instance depends on the number of beams a UE is configured to measured and report
3. **Latency, periodicity, or “efficiency”**
   * As per RAN1#111’s agreement:
     + For NW-sided AIML model monitoring, study the necessity and potential spec. impact from the following aspects:
       - UE reporting of beam measurement(s) based on a set of beams indicated by gNB,
       - Signaling, e.g., RRC-based, L1-based
4. **Configuration-related requirements**
   * It should be possible to configure a UE to store measurements on multiple occasions and then report the accumulated data to the NW
   * Periodic and event-triggered data collection approaches could be considered for further study

**Q4)** Companies are invited to comment on the above requirements, and whether these could be considered for designing data collection solutions for NW-sided beam management use cases.

Note: Companies are encouraged to provide further views or other aspects that should be considered.

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| **Company** | **Answer / Comments** |
| Apple | See our comments to Q3. For now, we don't think RAN1 details on a) b) c) related to BM are clear. Thus, RAN2 should wait further RAN1 input. |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

### 2.2.2 Positioning accuracy enhancement

The Rapporteur acknowledges that RAN1 have not provided explicit input to RAN2 concerning requirements for the positioning use cases.

Now, as per what has been described in Section 2.1, if we limit the scope of the current discussion to gNB/LMF-sided AIML models, then, only Case 2b (i.e., UE-assisted/LMF-based positioning with LMF-sided model, direct AI/ML positioning) and 3a (i.e., NG-RAN node assisted positioning with gNB-sided model, AI/ML assisted positioning) should be considered for this email discussion.

Starting with, Case 3a, we observe that arguably this seems not to need/include UE reporting data to the gNB. As for this case, the UE the gNB can perform measurements for model training/monitoring according to Sounding Reference Signals (SRS) in the uplink.Taking this and the above “initial requirements” in consideration, the Rapporteur understands that the following aspects could potentially be considered to design solutions:

1. **The content of the data**
   * Radio measurements:
     + Channel Impulse Response (CIR) information
   * Non-radio measurements:
     + UE location (ground truth label, which can be obtained from LMF)
2. **The data size** 
   * Data should be collected from multiple TRPs, at one- or multiple-time instances
   * The number of bits needed for collecting a single channel measurement (CIR) depends on how the channel is represented, i.e., the data format and preprocessing/quantization
3. **Latency, periodicity, or “efficiency”**
   * No latency requirements for training, unclear for monitoring
4. **Configuration-related requirements**
   * Existing configuration seems to fulfil the requirements (i.e., UE is configured to transmit SRS for gNB to perform SRS-based channel measurements)

**Q5)** Companies are invited to comment on the above requirements and whether these could be considered for designing data collection solutions for NG-RAN node assisted positioning with gNB-sided model?

Note: Companies are encouraged to provide further views or other aspects that should be considered.

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| **Company** | **Answer / Comments** |
| Apple | See our comments to Q3. For now, we don't think RAN1 details on a) b) c) related to AI/ML based positioning are clear. Thus, RAN2 should wait further RAN1 input. |
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*[Rapporteur to add summary of views]*

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Continuing with Case 2b, the Rapporteur understands that the following aspects could potentially be considered to design solutions:

1. **The content of the data**
   * Radio measurements:
     + DL-PRS based CIR measurements (reported from UE to LMF over LPP)
   * Non-radio measurements:
     + UE location (ground truth label, obtained at LMF)
2. **The data size** 
   * Data should be collected from multiple UEs, at one- or multiple- UE locations
   * For each UE report for a single UE location
   * For each UE report, the number of bits needed to be reported per UE location will depend on e.g., the type of measurements a UE should report, how the measurement is represented, and how many TRPs are involved
3. **Latency, periodicity, or “efficiency”**
   * There appears to be a relaxed latency requirement for model training
4. **Configuration-related requirements**
   * To study how/whether enhancements are needed

**Q6)** Companies are invited to comment on the above requirements and whether these could be considered for designing data collection solutions for UE-assisted/LMF-based positioning with LMF-sided model?

Note: Companies are encouraged to provide further views or other aspects that should be considered.

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| **Company** | **Answer / Comments** |
| Apple | See our comments to Q3. For now, we don't think RAN1 details on a) b) c) related to AI/ML based positioning are clear. Thus, RAN2 should wait further RAN1 input. |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

### 2.2.3 CSI feedback enhancement

The Rapporteur acknowledges that RAN1 have not provided explicit input to RAN2 concerning requirements for the CSI use cases.

The Rapporteur understands though, that the following could be considered for the initial design of solutions for two-sided CSI feedback compression use case:

1. **The content of the data**
   * Radio measurements:
     + CSI-RS measurements (target H or target precoder for model training/monitoring)
   * Non-radio measurements:
     + Cell ID, area ID, carrier frequency, UE/NW antenna beam configuration/ID, time stamp, UE location, measurement accuracy, measurement resolution, etc. …
   * Monitoring metrics:
     + Intermediate KPIs, e.g., SGCS
     + Legacy CSI based monitoring, additional legacy CSI reporting
2. **The data size** 
   * Data should be collected from UE(s), at one- or multiple-time instances
   * The number of bits needed for reporting a single channel measurement (a target H) depends on how the target channel is represented, i.e., the data format and preprocessing/quantization.
3. **Latency, periodicity, or “efficiency”**
   * Data collection for model monitoring could eventually be a time-sensitive procedure when compared to the model training procedure
4. **Configuration-related requirements**
   * It should be possible to configure a UE to store measurements on multiple occasions and then report the accumulated data to the NW
   * Periodic and event-triggered data collection approaches could be considered for further study
   * Pre-processing may need configuration, depending on how the target channel is represented

**Q7)** Companies are invited to comment on the above requirements and whether these could be considered for designing data collection solutions for spatial-frequency domain CSI compression?

Note: Companies are encouraged to provide further views or other aspects that should be considered.

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| **Company** | **Answer / Comments** |
| Apple | See our comments to Q3. For now, we don't think RAN1 details on a) b) c) related to AI/ML based CSI enhancement are clear. Thus, RAN2 should wait further RAN1 input. |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

## 2.3 Data collection methods

As discussed online during RAN2#120 and as seen in a few of the companies’ contributions to the previous WG meeting, the MDT framework and mechanisms has been brought up as a candidate.

As per the scope of this email discussion, RAN2 should now focus:

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| [...] on to what extent existing methods can be useful including also identifying these existing methods and their potential extensions [...] |

In this regard, the Rapporteur understands that the following frameworks can also potentially be considered:

* MDT,
* UE assistance information (defined in RRC-spec.),
* early idle/inactive measurements,
* RRC measurement reports,
* CSI reporting framework.
* LPP Provide location information

These are all existing procedures/methods that rely on configuration to collect data. It would then be beneficial to understand companies views on this matter. Hence the following question.

**Q8)** Do you agree to consider the above candidate frameworks as starting points to be considered for data collection in this SI?

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| **Company** | **Answer / Comments** |
| Apple | 1. We have some concern on "early idle/inactive measurement". In current RAN2 identified 3 scenarios, only RRC\_CONNECTED UEs are the target. We are not sure why measurement performed by IDLE/INACTIVE UEs can help. Thus, we suggest to remove it.  2. We are a little confused with the intention of this proposal. Our understanding on the intention of this proposal is:   * RAN2 will analyze and compare these existing framework for data collection. * Based on specific requirements of data collection for AI/ML (discussed in Q3), RAN2 will study whether these existing framework can be reused/extended, or a new framework is required to be introduced.   Maybe rapporteur can confirm whether our understanding is correct. |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

If existing methods (as a whole) could not be suitable for the use cases covered in this SI, new approaches might be needed to fulfil the requirements of these.

As there are no clear requirements for the use cases and as per the status of the SI, it is perhaps too early to describe or agree a particular solution (or a set of solutions) that could be used to collect data. However, it would be beneficial to understand whether companies think something is missing from the previous question, or whether there are already some thoughts regarding the procedures/mechanisms that should be used.

**Q9)** Is there any aspect(s) missing in this part that should be addressed by RAN2? Do companies have further views concerning the data collection mechanism(s) that should be used?

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| **Company** | **Answer/Comments** |
| Apple | Security of data and UE privacy should be considered. |
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*Rapporteur to add summary of views]*

1. To be added according to companies’ views…
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## 2.4 RAN1 input and additional comments

Until this point, there has not been any clear collaboration between RAN1 and RAN2. This has created some confusion regarding the WG split and, arguably, it has also slowed-down RAN2 progress.

In this regard, an option would be for RAN2 to directly ask RAN1 for further information that could help RAN2 in the design of solutions for this SI. Alternatively, RAN2 could continue the work within their scope and inform RAN1 of concerning RAN2 agreements.

**Q10)** What approach do you think RAN2 should adopt concerning the collaboration with RAN1? Do you think RAN2 should ask for RAN1 input in particular areas? Do you think RAN2 should simply keep progressing and inform of concerning agreements to RAN1 when necessary? Should another or no different approach as the one followed now should be taken?

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| **Company** | **Answer/Comments** |
| Apple | We prefer "RAN2 should simply keep progressing and inform of concerning agreements to RAN1 when necessary". Specifically for data collection:   * Our understanding is RAN1 need more work to discuss and define requirement. And RAN2 should wait RAN1's progress. Even if RAN2 send LS to RAN1, we don't think it can speed up RAN1's work. * Of course, if RAN2 can identify some specific questions for RAN1 to speed up progress, we are open to it. But for now, we don't identify any useful questions. |
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**Q11)** Is there anything else companies would like to bring up concerning this email discussion? (e.g., discuss additional topics)

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| **Company** | **Answer/Comments** |
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*[Rapporteur to add summary of views]*

1. To be added according to companies’ views…

# 3 Conclusion

In the previous sections we made the following observations:

[Observation 1 RAN2 should not rely on RAN3 regarding architecture or functionality-to-entity mapping matters, since RAN3 does not have TUs assigned for this SI.](#_Toc122071371)

[Observation 2 For UE-sided AIML models, UEs do not necessarily need to report the collected data for model training to the gNB/LMF.](#_Toc122071372)

[Observation 3 RAN1 can later provide requirements (e.g., related to configuration, signalling, etc.) which could facilitate the process of UE data collection for UE-sided AIML models.](#_Toc122071373)

[Observation 4 There seems to be a need for RAN2 to start by focusing on gNB/LMF-sided AIML models. Since for these cases, the UE needs to be configured to report collected data (e.g., measurements, performance metrics) to the gNB/LMF.](#_Toc122071374)

[Observation 5 To be added according to companies’ views…](#_Toc122071375)

Based on the discussion in the previous sections we propose the following:

[Proposal 1 To be added according to companies’ views…](#_Toc122071362)

[Proposal 2 To be added according to companies’ views…](#_Toc122071363)

[Proposal 3 To be added according to companies’ views…](#_Toc122071364)

[Proposal 4 To be added according to companies’ views…](#_Toc122071365)

[Proposal 5 To be added according to companies’ views…](#_Toc122071366)

[Proposal 6 To be added according to companies’ views…](#_Toc122071367)

[Proposal 7 To be added according to companies’ views…](#_Toc122071368)

[Proposal 8 To be added according to companies’ views…](#_Toc122071369)

[Proposal 9 To be added according to companies’ views…](#_Toc122071370)

# 4 References

1. [RP-213599](http://www.3gpp.org/ftp//tsg_ran/TSG_RAN/TSGR_94e/Docs//RP-213599.zip), “New SI: Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR Air Interface”, TSG RAN, RAN#94-e, Dec 2021
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