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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# 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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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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*[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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*[Rapporteur to add summary of views]*

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### 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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### 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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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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### 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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## 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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*[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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## 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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**Q11)** Is there anything else companies would like to bring up concerning this email discussion? (e.g., discuss additional topics)

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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
2. [RP-221348](http://www.3gpp.org/ftp//tsg_ran/TSG_RAN/TSGR_96/Docs//RP-221348.zip), “Revised SID: Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR Air Interface”, TSG RAN, RAN#96, Budapest, Hungary, June 2022
3. [R1-2205695](http://www.3gpp.org/ftp//tsg_ran/WG1_RL1/TSGR1_109-e/Docs//R1-2205695.zip), “Session notes for 9.2 (Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface)”, Ad-hoc Chair (CMCC), RAN1#109-e, May 2022
4. [R1-2208145](http://www.3gpp.org/ftp//tsg_ran/WG1_RL1/TSGR1_110/Docs//R1-2208145.zip), “Session notes for 9.2 (Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface)”, Ad-hoc Chair (CMCC), RAN1#110, Toulouse, August 2022

1. [R2-2210677](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119bis-e/Docs//R2-2210677.zip), “RAN2 Work Plan for Rel-18 SI on AI/ML for NR air interface”, Ericsson, Qualcomm Inc., RAN2#119-e, Oct. 2022
2. [R1-2210690](http://www.3gpp.org/ftp//tsg_ran/WG1_RL1/TSGR1_110b-e/Docs//R1-2210690.zip), “Session notes for 9.2 (Study on AI/ ML for NR air interface)”, CMCC, RAN1#110bis-e, Oct. 2022
3. [R1-2212845](http://www.3gpp.org/ftp//tsg_ran/WG1_RL1/TSGR1_111/Docs//R1-2212845.zip), “Session notes for 9.2 (Study on AI/ ML for NR air interface)”, Ad-hoc Chair (CMCC), RAN1#1111, Toulouse, November 2022