**3GPP TSG-RAN WG2 #131 R2-25xxxxx**

**Bengaluru, India, 25th – 29th August, 2025**

Agenda Item: 8.1.x

Source: Ericsson, ZTE

Title: Report of email discussion [POST130][031][AI PHY] NW side data collection

Document for: Discussion

# Introduction

This paper summarizes the following email discussion:

* [POST130][031][AI PHY] NW side data collection (Ericsson/ZTE)

 Intended outcome: provide two TP(s) for data logging and configuration in RRC on how to capture this in a simple way to RAN2. Discuss impacts to RAN1 for each solution and RAN3.

 Deadline: long

The deadline for providing comments is **8 August 2025, 10:00 UTC**.

The rapporteur will provide two TPs for two solutions for data logging and configuration in RRC, as well as a summary of foreseen RAN1 and RAN3 impacts for each solution, based on the outcome of this email discussion.

Companies providing input to this email discussion are requested to leave contact information below.

|  |  |  |
| --- | --- | --- |
| **Company** | **Name** | **Email Address** |
| Samsung | Seung-Beom Jeong (Beom) | s90.jeong@samsung.com |
| Huawei, HiSilicon | Dawid Koziol | dawid.koziol@huawei.com |
| Nokia | Jerediah Fevold | jerediah.fevold@nokia.com |
| Apple | Peng Cheng | pcheng24@apple.com |
| Xiaomi | Xing Yang | Yangxing1@xiaomi.com |
| CATT | Tangxun | tangxun@catt.cn |
| OPPO | Jiangsheng Fan | fanjiangsheng@oppo.com |
| ZTE | Fei Dong | Dong.fei@zte.com.cn |
| Qualcomm | Rajeev Kumar | rkum@qti.qualcomm.com |
| Mediatek | Yuanyuan Zhang | Yuany.zhang@mediatek.com |
| LG Electronics | Soo Kim | soo.kim@lge.com |
| Interdigital | Oumer Teyeb | Oumer.teyeb@interdigital.com |
| Lenovo | Congchi Zhang, Tapisha Soni | zhangcc16@lenovo.com, tsoni@lenovo.com |
| BT | Salva Diaz | Salva.diazsendra@bt.com |
| Ericsson | Jens Bergqvist | jens.bergqvist@ericsson.com |
| T-Mobile USA | John Humbert | John.Humbert2@T-Mobile.com |
| China Telecom | Pei Lin | linp@chinatelecom.cn |
| vivo | Boubacar | kimba@vivo.com |
| CMCC | Ningyu Chen | chenningyu@chinamobile.com |
| NTT DOCOMO | Koki Yamashita | kouki.yamashita.dz@nttdocomo.com |

# Discussion

RAN2 has made the following agreements regarding logging and configuration for NW side data collection, that are relevant to this email discussion:

|  |
| --- |
| **From RAN2#130:**„As a starting point, the data logging is captured in RRC specs.“ „Data is collected on per data logging configuration basis and UE indicates data logging configuration ID. An indication of the “gap” is needed. “Gap” is time interval larger than the configured logging periodicity. FFS if timestamp and relative time stamp for each group is needed per “group”.“„The UE should report the CGI of the serving cell whenever feasible. If CGI is unavailable, the UE shall log PCI-ARFCN as a fallback.“**From RAN2#129bis:**„The measurement configuration of AI/ML data collection can configure measurements for multiple sets of resources and use cases (e.g. BM, Mobility, etc)“**From RAN2#129:**„Support the use of L3 measurement event triggered (i.e. L3 serving cell measurements becoming worse/better than a threshold for TTT) to determine whether the UE performs logging or not. L1 measurement event triggered will not be supported. FFS what to log“**From RAN2#127bis:**„For data collection for both NW-sided/UE sided BM model training, at least L1-RSRPs and/or beam-IDs needs to be collected by UE. FFS if other data needs to be collected based on RAN1 progress“ |

Based on the agreements above, two approaches were proposed in RAN2#130 for introducing the logging configuration for the beam management use case in RRC:

1. The logging configuration is introduced within the L1 CSI measurement framework, e.g. as a new list of configurations under *CSI-MeasConfig*, cf. Figure 1 and [1].
2. The logging configuration is introduced in a new L3 measurement framework, at the same level as *MeasConfig* and *CellGroupConfig*, cf. Figure 2 and [2].

The corresponding TPs for these two approaches are provided as a complement to this document and are based on the RRC changes from the endorsed running CR [R2-2504349], where the additional changes for the two approaches in this email discussion are marked with tracked changes (from Ericsson in the TP for approach 1 and from ZTE in the TP for approach 2).

The two TPs are intended to indicate the main directions of the changes and not to provide the final wording for the procedural text or the final ASN.1. Therefore, companies are kindly asked to focus on the major logging procedures and logging configuration content. Details like IE/parameter names will be revised by the RRC running CR rapporteur when merging the final TP with the running CR and thus do not need to be addressed in this email discussion.



Figure 1 RRC L1 logging configuration structure for approach (1).



Figure 2 RRC L3 logging configuration structure for approach (2).

## 2.1 Content of TPs for RRC

In this section we discuss the contents of the two TPs for RRC.

The TP for approach (1) captures the logging procedures in RRC in a new clause 5.5c, similarly as legacy logging in clause 5.5a. The TP for approach (2) captures the logging procedures in RRC in a new clause 5.5x.

###### **Q1-1: For approach (1), from RRC perspective, do you agree that it is sufficient to capture the logging procedures in the new clause 5.5c? Please comment if you think that the logging procedures should be moved elsewhere in the RRC specs or if you think that something is missing in the RRC procedures in the TP.**

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| --- | --- | --- |
| **Company**  | **Yes/No** | **Comment**  |
| Samsung | Yes |  |
| Huawei, HiSilicon | Yes, but see comments... | It is OK to keep logging action in the newly added section, but the description could be much simplified. In our understanding the performing of measurements needs to be captured in RAN1 specificaitons as for all other L1 measurements. Then logging of measurements should take place whenever there is a measurement provided from lower layer to higher layer. What we should capture in this section is that:1. For non-event based logging, higher layer should indicate to lower layers to perform measurements with a specific configuration continously (according to the resource periodicity).2. For event-based logging, higher layer should indicate to lower layers when it should start/stop measurements when the event is met or no longer met.Then in L1 specifications we should capture that once requested by higher layer, the UE performs L1 measurements according to the provided configuration and forwards the results to upper layer. |
| Nokia | Yes, but see comments… | Agree with Huawei. |
| Apple | Need to check with RAN1  | In legacy, the UE behavior when configured with *CSI-MeasConfig* is captured in RAN1 spec (TS 38.214). Thus, if logging configuration is introduced within *CSI-MeasConfig,* the corresponding UE behaviour (i.e. logging) may be needed to be captured in 38.214 if we follow previous RAN1/RAN2 spec work split. Then, on below RAN2#130 agreement:=>As a starting point, the data logging is captured in RRC specs.“ We think there are two different understanding:* Understanding 1: capture all UE logging behaviour in RRC spec (i.e. as current TP1).
* Understanding 2: capture in both 38.331 and 38.214
	+ TS 38.331: Capture how the UE reads the logging configuration, links logging config with its L1 measurement configuration and a reference to 38.214 (i.e. higher Layer indicates Lower layer to perform L1 measurements, as Huawei mentioned).
	+ TS 38.214: The detailed measurement and logging behaviour.

We agree that both Understanding 1 and Understanding 2 can work. However, since it is related to RAN1 spec change, we don’t think RAN2 can make the decision alone. Thus, RAN2 should check whether RAN1 is fine with Understanding 1.  |
| Xiaomi | Yes | We understand the trigger event and logging are specified in RAN2, however, since this logging procedure is combined with CSI-MeasConfig, how to capture it should be checked with RAN1. We also expect those measurement behaviors should be at least captured in RAN1 specification, which is the same as other CSI measurement behavior. |
| CATT | Yes | The reception of trigger event and the storing of logging data should be specified in RAN2, and how to capture the L1 logging measurement could be consulted with RAN1. |
| OPPO | Yes | We agree with above that trigger event and the storing of logging data should be specified in RAN2. |
| ZTE | Yes | We share the similar view with apple that the RAN1/RAN2 work split in this case becomes vague, as we already decided, for approach 1. the logging related procedure shall be captured in RAN2 while the measurement procedure could be captured in RAN1. In this sense, we tend to agree to inform RAN1 what is happening in RAN2 and see whether they can accept it or not. |
| Qualcomm | Yes, see comment  | RAN2 should capture the logging action in the RAN2 specification, but at the same time, performing the measurements should be captured in the RAN1 specification and should be referred to in the RAN2 specification. The specification impacts associated with performing the measurements are captured in the L1 specification. Irrespective of approach 1 or approach 2, RAN2 needs to coordinate with RAN1.  |
| Mediatek | Yes | From our perspective, both the triggering of logging and the logging procedures themselves should be captured within the RRC specifications. The primary goal of the specification is to better facilitate implementation, and since the processes of starting and stopping logging, performing the logging, and subsequent reporting are closely interconnected, separating these aspects across different specifications would hinder a coherent and comprehensive description of the overall procedure.Therefore, we believe it is most appropriate for the RRC to encompass the entire logging procedure, including triggering, logging, and reporting. At the same time, we agree that RAN2 should keep RAN1 informed of the standardized behavior captured in the RRC specification, so that RAN1 can address any measurement-related aspects as necessary. |
| LGE | Yes | We share a similar view with other companies. While the measurement operation can remain in the RAN1 specifications, logging conditions and control procedures, particularly those related to when and how logging is triggered, should be specified in the RRC layer. |
| Interdigital | Yes | We agree with the points raised by other companies that the logging/triggering should be captured in RAN2 specs while RAN1 involvement/impact is unavoidable.  |
| Lenovo | Yes | We also share similar view with other companies above. RAN2 needs to specify the logging, reporting aspects. RAN1 needs to specify the corresponding L1 measurement aspects. |
| BT | Yes | Similar views as Mediatek |
| Ericsson | Yes | The logging procedure should be captured in 38.331 for these L1 measurements part. This is similar to the Rel-19 L1 event triggered reporting for LTM where the configuration is within CSI-MeasConfig and the corresponding event evaluation is being specified in MAC (38.321). |
| T-Mobile USA | Yes | Agree with MediaTek, Nokia and Huawei’s comments |
| China Telecom | Yes |  |
| vivo | Yes, with comments | As this logging procedure is combined with *CSI-MeasConfig*, I think on how to capture it should be checked with RAN1.  |
| CMCC | Yes | We share similar view with other companies above that trigger event and the storing of logging data should be specified in RRC spec. |
| NTT DOCOMO | Yes | Agree with Apple and other companies. Coordinating with RAN1 is needed. |

##### Summary

19/20 companies think that, from an RRC perspective, it is sufficient to capture the logging procedures in a new clause (e.g. 5.5c) for approach (1). This is handled with the proposal for Q1-2 below.

Many companies commented that how to perform the L1 measurements should be captured in the RAN1 specifications and several companies commented that there is a need to check with RAN1 regarding the specification of the associated L1 measurements. The RAN1 impact is addressed by the discussion for Q5.

One company commented that there is a need to check this with RAN1 since the logging configuration is included within CSI-MeasConfig and that this may mean that the logging would need to be captured in 38.214. It was pointed out by another company however that, for Rel-19 event triggered reporting for LTM, it has been agreed that the event configuration is within CSI-MeasConfig but the corresponding event evaluation is specified in MAC (38.321).

One company commented that it should be indicated to lower layers when the measurements should be performed including, for event-based logging, to start/stop measurements when the event is met or no longer met. The L1 specifications should then capture that the UE performs L1 measurements when requested by the higher layers.

###### **Q1-2: For approach (2), from RRC perspective, do you agree that it is sufficient to capture the logging procedures in the new clause 5.5x? Please comment if you think that the logging procedures should be moved elsewhere in the RRC specs or if you think that something is missing in the procedures in the TP.**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comment**  |
| Samsung | Yes |  |
| Huawei, HiSilicon | Yes, but see comments... | Similar comments as for approach 1. In particular, we should not capture L1 measurement actions in RRC specifications. We have a separation between PHY layer specifications and RRC specifications for a reason and mixing these things goes against layered approach of NR (and any other 3GPP RAN technology actually). |
| Nokia | Yes, but see comments… | Agree with Huawei. |
| Apple | Yes | Different from Approach 1), as the logging configuration is introduced in a new configuration (*loggedDataCollectionConfig*) in Approach 2), we think RAN2 can make decision to capture all the logging behavior in RRC spec without checking RAN1 view.On Huawei’s comment (“we should not capture L1 measurement actions in RRC specifications”), it can be addressed by adding RAN1 spec reference in Section 5.5x.2 of running CR. For example: “1> if not suspended, perform the measurement logging in accordance with the following:2> if the *loggingType* included in a *bm-DataLoggingConfig* is set to *periodical* for the *LoggedDataCollectionLinkage*:3> peform the Layer 1 measurement for the serving cell according to the corresponding *bm-DataMeasResource* as specified in Section 5.1.6 of TS 38.214 [19];3> perform the measurement logging at a time interval;”Please note that Rel-19 LTM has used above way to capture action of L1 measurement in latest running CR of 38.321:“5.x.2 Performing measurement An RRC\_CONNECTED UE obtains L1 beam level measurement results by measuring one or multiple RSs as configured by the network as specified in [RAN1 REF] for the LTM candidate cell(s) with the candidate ID configured in *ltm-CandidateReportConfigList*.” |
| Xiaomi | Yes | Since a new IE decoupled from CSI-MeasConfig is used in Approach 2, we understand at least trigger event and logging can be specified in RAN2, similar as RRM measurement. |
| CATT | Yes | The reception of trigger event and the storing of logging data are similar to the comment of approach1, and the L1 logging measurement could be specified to link with RAN1 specification. |
| OPPO | Yes |  |
| ZTE | Yes | ProponentOn Huawei’s comments:Apple’s suggestion is fine to us, which is to add a reference to the 38.214.Furthermore, as the measurement resources and logging related RRC parameter have been configured independent with the Layer 1 framework, there is no need to define UE behaviour (i.e: forward the measurement result to upper layer) in RAN1 as what we did for layer 3 measurement.In this sense, I think the th reference suggested by apple is sufficient from specification point of view. |
| Qualcomm | Yes | Similar comment as above. Irrespective of the approach, as the measured resources are L1, RAN2 should coordinate with RAN1. |
| Mediatek | Yes | As mentioned in our response to Q1-1, we believe it is most appropriate for the RRC specification to capture the entire logging procedure, including triggering, logging, and reporting. For details related to L1 measurements, we can refer to the relevant RAN1 specifications, as suggested by Apple. |
| LGE  | Yes | Same as the answer to Q1-1 |
| Interdigital | Yes |  |
| Lenovo | Yes | The suggestion from Apple looks also good to us. |
| BT | Yes | We are fine with Apple suggestion. Keep the triggering of logging and the logging procedures themselves within the RRC specifications |
| Ericsson | Yes, for the logging | Regarding the reference suggested by Apple we think this would be a possible solution for both approaches, but it needs to be checked with RAN1 whether there is any impact to their specifications. For both approaches there are L1 measurements performed where the results are to be logged according to RRC specification. The results should thus be sent to upper layers in either approach. The mentioned reference to a RAN1 specification, in the running MAC CR for Rel-19 LTM, is for the L1 event triggered reporting. That configuration is in LTM-CSI-ReportConfig within CSI-MeasConfig and the corresponding event evaluation is included in the MAC specification. This is thus rather similar to approach (1). |
| China Telecom | Yes |  |
| vivo | Yes | It would be better if the whole logging procedure, including triggering, logging, and reporting are captured in RRC specification  |
| CMCC | Yes | We are fine with Apple’s suggestion. |
| NTT DOCOMO | Yes |  |

##### Summary

All companies think that, from an RRC perspective, it is sufficient to capture the logging procedures in a new clause (5.5x) for approach (2).

It was commented by a company that we should not mix PHY layer and RRC specifications by capturing L1 measurement actions in RRC specifications. It was proposed by one company to add a reference to 38.214 from the RRC procedure, which was supported by some other companies. One company thought that even with such a reference there is a need to check with RAN1 regarding their impact. The RAN1 impact is addressed by the discussion for Q5.

Based on the above, rapporteurs propose the following:

1. RAN2 confirms that the network data logging is captured in a new clause (e.g. 5.5x) in the RRC specification.

In approach (1), for capturing event-triggered logging based on L3 measurements (i.e. L3 serving cell measurements becoming worse/better than a threshold for TTT), the *threshold* and *timeToTrigger* were added in the logging configuration under *CSI-MeasConfig.* Additionally, it was captured how to evaluate the entering and leaving conditions for the event in:

1. changes to clauses 5.5.4.2 and 5.5.4.3 and field description, or alternatively,
2. only in field description for *eventTriggeredConfig* in *CSI-LoggedMeasurementConfig* (similarly to the field description of *eventType* in the *LoggedMeasurementConfiguration* message for legacy logging)*.*

###### **Q2-1: For approach (1), from RRC perspective, do you agree that, to configure the event-triggered logging based on L3 measurements, it is sufficient to add *threshold* and *timeToTrigger* in the logging configuration under *CSI-MeasConfig*? If no, please explain the reason and where the *threshold* and *timeToTrigger* should be included. Please comment also on whether you prefer option a) or b) for capturing the event evaluation.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company**  | **Yes/No** | **Preferred option for capturing event evaluation:****a)/b)** | **Comment**  |
| Samsung | Yes | b |  |
| Huawei, HiSilicon | Yes | a) | It is simplest to reuse existing event definitions which allows to reuse current implementations. To make specs changes even simpler, the parameters could be renamed as a1-threshold and a2-threshold and Hys parameter could be added to the event configuration. Then the changes to Hys would not be needed while changes to threshold description could be limited to:*“a1-Threshold* as defined within *reportConfigNR* or in *eventTriggedConfig* in a CSI logged measurement configuration in *csi-LoggedMeasurementConfigToAddModList*” |
| Nokia | No | a) Include NOTEs to associate Events A1 and A2 descriptions with the new events.b) If we decide to keep hysteresis as 0, then the field description can include that caveat. | **1.** We should reuse the existing definition and use the same approach as was used to describe the “condEvents” for conditional handover (CHO). The following note was added to the bottom of the description for Event A3.NOTE 2: The definition of Event A3 also applies to CondEvent A3.See our response to Q2-2 for an explanation of the note we could add to Event A1 and Event A2 in sections 5.5.2 and 5.5.3, respectively.NOTE 1: The definition of Event A1 also applies to Logging Event A1.NOTE 1: The definition of Event A2 also applies to Logging Event A2.**2.** We disagree that hysteresis is not required. Without hysteresis, a minor fluctuation in RSRP could trigger the UE to disable logging and the log would lose all samples until the TTT was met again. The purpose of hysteresis is to avoid ping-ponging and we should still avoid that. Every time the UE disables logging, there will be a gap in the log, which will also require the inclusion of a new absolute timestamp.If we do not end up including hysteresis, we think it is acceptable to include the caveat that the hysteresis should be assumed to be 0 for the new events in their respective field descriptions. |
| Apple | No (MO parameter of *ServingCellMO* is also needed for split gNB) | b), or new event N1/N2 in Approach (2)  | First, we think *MeasObjectNR* of *ServingCellMO* also needs to be introduced under *eventTriggeredConfig.* Otherwise, it doesn’t work for split gNB*.* Please note that *CSI-MeansConfig* is generated by DU, but MO configuration is generated by CU. One may argue that *ServingCellMO* is already included in DU generated *ServingCellConfig*. However, please note that *ServingCellMO* is just a 6-bit ID (as indicated in TS 38.473), which is not sufficient for DU to obtain its corresponding MO parameter in *MeasObjectNR.*We also agree with Nokia that hysteresis is needed.Then, regarding a) vs b), we don’t agree to touch the legacy A1/A2 text in clauses 5.5.4.2 and 5.5.4.3. These text was introduced from beginning in Rel-15 without any change till Rel-19. We don’t see any motivate to touch the base just for a Rel-19 optional feature. On Huawei’s comment of reusing current implementation, we are confused why drafting 3GPP specification needs to consider UE implementation. And isn’t touching the legacy base will cause legacy UE impact? All in all, we think a separate event procedure (N1/N2 in Approach 2) or a separate field description as b is cleanest solution. We can accept either one. But we do have strong concern to touch legacy Rel-15 text for an optional feature and don’t accept a).   |
| Xiaomi | No | New event | We would like to avoid mixing the logging event and the legacy MR event. The two types of event are designed for different purposes. We would prefer to define a new event, Similar as CondEvent Ax. The definition of new eventsc can refers to the legacy MR event, while the new event can allow more flexibility for NW to configure independent events. |
| CATT | No | a) | We think the simpliest way is to reuse the legacy definition of Event A1 and A2 with description, e.g. new added NOTE, and legacy parameters of threshold, hysteresis and timeToTrigger should all be reused. |
| OPPO | No | b) | This is L3 defined event, the event configuraition should not be captured in L1 measurement framework. |
| ZTE | No | New event | As apple’s explain, the CU need to provide the MeasObject to the DU in order for configuring the event triggered logging. Assuming there is no any MO configuration present in the CSI-MeasConfig for the loggingConfig, it means the MO for Layer 3 measurement which is configured in *ServingCellConfig* shall be coupled with the data logging. However, in our understanding, they do not share the same target, one is for Layer 3 measurement, the other one is for data logging, in this sense, the MO configuration for the layer 3 event evaluation shall be present in CSI-MeasConfig for approach 1.Regarding the event configuration method, in our understanding, it is better to define the new events for NW side data collection specifically which can improve the specification readability. Otherwise, it will turn out that some further new events for NW side data collection will be defined as new events if there is no any identical legacy event can be reused, but some events for NW side data collection for NW side data collection reuse the legacy ones. |
| Qualcomm | No  | a | Fromm 5.5.4.2, we have5.5.4.2 Event A1 (Serving becomes better than threshold)The UE shall:1> consider the entering condition for this event to be satisfied when condition A1-1, as specified below, is fulfilled;1> consider the leaving condition for this event to be satisfied when condition A1-2, as specified below, is fulfilled;1> for this measurement, consider the NR serving cell corresponding to the associated *measObjectNR* associated with this event.Inequality A1-1 (Entering condition)*Ms – Hys > Thresh*Inequality A1-2 (Leaving condition)*Ms + Hys < Thresh*In approach 1, if the measurement configuration is provided under the CSI measurement config, then the highlighted clause needs to be updated.We prefer not to introduce a new event that is slightly different from the existing A1 / A2. We can add notes, modify the clause, and the field description to properly capture it. |
| Mediatek | No | with Note | We prefer to reuse existing event definitions and add a note to clarity that the event can be used to trigger data logging for network data collection.  |
| LGE | No | New event | We think a separate report type (CHO-like) can be introduced to not include report related configuration (e.g., report interval, report amount, etc). When considering future extensions for mobility-related use cases, introducing a new event for event-based logging may be a suitable approach. |
| Interdigital | No | New event | Slight preference for new event, as that will enable easier future extensions (the same way we separated condEvents, even though we could have reused the legacy events) |
| Lenovo | No | a) or new event | Either reusing the existing event or defining new event is fine with us.  |
| BT | No | With Note | A note, as used in the case of CondEvents (e.g., 'NOTE 2: The definition of Event A3 also applies to CondEvent A3' or 'NOTE: The definition of Event A4 also applies to CondEvent A4'), seems sufficient. We consider it necessary to include hysteresis in addition to threshold and timeToTrigger. |
| Ericsson | Yes | a) | Both options are fine but we tend to prefer option a) and reuse the existing event definitions.The UE knows the serving cell MO needed for the event evaluation, from the ServingCellConfig. A clarification, e.g. as commented by Qualcomm, could be added to avoid any ambiguity. It is unclear why the DU would need to know the actual MO to set the event parameters, but the MeasConfig is present in the UE Context Setup Request message sent to the DU. |
| China Telecom | No | New event | Prefer introducing new event, which will be easy to be extended for future. |
| vivo | No | New event | We should try to avoid the spec impact for existing event definition for RRM measurement report. Define new events for data collection makes the spec clearer. If other cases (such as AI Mob) requrie new events in the future, it will also be easier to extend. |
| CMCC | No | New event | We prefer to introduce new event to avoid mixing the logging event and the legacy MR event. |
| NTT DOCOMO | No | With note | We have similar view as Nokia and other companies who proposes hysteresis is needed.  |

##### Summary

3 companies think that, to configure the event-triggered logging based on L3 measurements, it is sufficient to add *threshold* and *timeToTrigger* in the logging configuration under CSI-MeasConfig.

A majority of the companies (16) companies think that this is not sufficient. 4 of those companies commented that they consider the hysteresis to be needed, which is discussed separately in Q3. The inclusion of hysteresis is handled with the proposal for Q3 below.

5 companies say that a NOTE can be added, such as to add a CHO like note (in A3/A5) to the existing A1/A2 events. This is then similar to option a) but with a different update to 5.5.4.2 and 5.5.4.3.

9 companies prefer to instead introduce new events, as in the TP for approach (2), discussed in Q2-2 below.

For the options to capture the event evaluation (2 companies answered new event or one of the options here):

* 5 companies prefer option a)
* 3 companies prefer option b)
* 4 companies prefer a note to A1/A2 events, e.g. similar to the notes introduced for conditional events
* 9 companies prefer to introduce new events, as in the TP for approach (2)

There is no consensus on where to capture the event evaluation for the event-triggered logging. A majority of the companies however prefer to capture it either in an existing event (A1/A2) or in new events. Rapporteur propose to decide among those alternatives at the RAN2 meeting.

1. RAN2 to decide on whether to capture the event evaluation for the event-triggered logging in the existing A1/A2 events (in sub-clauses 5.5.4.2 and 5.5.4.3) or in new events.

In approach (2), for capturing the L3 measurement event that triggers logging (i.e. L3 serving cell measurements becoming worse/better than a threshold for TTT), two new events N1 and N2were added in clauses 5.5.4.x and 5.5.4.y, respectively, and in the logging configuration (in *eventTriggeredLogging*, in *BM-DataLoggingConfig*).

###### **Q2-2: For approach (2), do you agree that, to configure the event-triggered logging based on L3 measurements, it is sufficient to define and configure the new events N1 and N2 as in the TP? If no, what do you think would be missing in the RRC specs?**

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| --- | --- | --- |
| **Company**  | **Yes/No** | **Comment**  |
| Samsung | Yes |  |
| Huawei, HiSilicon | No | We are against defining new events for this purpose. These events are virtually the same as A1/A2 and there is no need to overcomplicate things and define new events. |
| Nokia | No | **1.** While we agree with Huawei that the existing Events A1 and A2 should be reused, our preference on how to use them differs. We still prefer that the UE sends a *MeasurementReport*, triggered by Event A1 or A2, to the gNB and that the gNB uses the report to decide whether or not to enable or disable one or more NW-side logging configurations based on the measurements. Our proposal was rejected, however.**2.** As a compromise, we propose to reuse but redefine the events as was done in the implementation of Conditional Handover (CHO). An example ASN.1 implementation is shown below. Note that we have added hysteresis and prepended “L3” to the name of the EventTriggerConfig-r19 for clarity.L3EventTrigger~~ed~~Config-r19 ::= SEQUENCE { loggingEventId-r19 SEQUENCE { loggingEventA1-r19 SEQUENCE { a1-Threshold MeasTriggerQuantity, hysteresis Hysteresis, timeToTrigger TimeToTrigger }, loggingEventA2-r19 SEQUENCE { a2-Threshold MeasTriggerQuantity, hysteresis Hysteresis, timeToTrigger TimeToTrigger }, ... }}  |
| Apple | Yes | We think it is the cleanest way to define new events. We are not sure why it is overcomplicating things. The UE behavior in legacy A1/A2 (report MR when entering condition is met) is different from new logging event (start logging when entering condition is met). To reuse procedure text of legacy A1/A2, we have to hack these procedure text (as option a in Approach 1). We have strong concern that it will lead to more UE behavior ambiguity and legacy UE impacts. As a compromise, we can also accept Nokia proposed solution 2 (i.e. redefine the events as was done in the implementation of CHO).  |
| Xiaomi | Yes | In CHO, CondEvent A3/5 were introduced, whose definitions are exactly the same as legacy Event A3/5, but with different purposes and UE behavior. Only NOTEs are introduced to say the legacy definition also applies to CondEvent A3/A5. Furthermore, the new event allows more complexity for NW to configure independent events for legacy MR and CHO, without impacting UEs without AI/ML features, including legacy UEs. We prefer the similar way by introducing a new event and don’t see the complexity issue. |
| CATT | No  | Agree with Huawei. |
| OPPO | Yes |  |
| ZTE | Yes | ProponentDefining new events for new features is a clearest way from specification perspective, and we can follow this for the future AI/ML features. |
| Qualcomm | No | No need to introduce new events  |
| Mediatek | No | Agree with Huawei and Qualcomm. When considering the balance between simplicity and redundancy in the specification, we prefer to minimize unnecessary redundancy, even though some may already exist. Fundamentally, since we are using existing events such as A1 and A2 to trigger logging, there is no need to define new events. This approach allows straightforward UE implementations by reusing of existing modules. |
| LGE | Yes | We support Nokia’s suggestion to redefine events. We think a separate report type (CHO-like) can be introduced to not include report related configuration (e.g., report interval, report amount, etc). When considering future extensions for mobility-related use cases, introducing a new event for event-based logging may be a suitable approach. Compared to the new Logging configuration (i.e., BM-DataLoggingConfig) in the current TP2 framework, this event redefinition approach would likely be more straightforward. |
| Interdigital | Yes | We prefer new events for future proofness to enable us the events for logging to evolve independently from legacy events, if needed. |
| Lenovo | Yes | Either reusing the existing event or defining new event is fine with us. |
| BT | No | New events are unnecessary if they reflect the same behavior.Nokia’s compromise proposal works for us |
| Ericsson | See comment | We do not see the need to introduce new event definitions, which are the same as the existing A1/A2 events, for this. |
| T-Mobile USA | No | Support Nokia’s compromise proposal |
| China Telecom  | Yes |  |
| vivo | Yes | Defining new events is clearer than reusing existing ones and offers better extensibility. |
| CMCC | Yes |  |
| NTT DOCOMO | No | We also think CHO-like approach is sufficient. |

##### Summary

There is no consensus on whether to introduce new events (11 companies) or reusing existing A1/A2 events (9 companies). This is handled with the proposal for Q2-1 above.

RAN2#129 agreed explicitly that event-based logging is based on a threshold and TTT. The hysteresis is another typical parameter for legacy events, but there is no explicit RAN2 agreement to capture it for event-based logging for NW-side data collection.

###### **Q3: For both approaches, do you agree that the *hysteresis* should be configured and used (alongside *threshold* and *timeToTrigger*) for event-triggered logging? If no, please explain why.**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comment**  |
| Samsung | Yes |  |
| Huawei, HiSilicon | Yes | We should reuse existing definitions of events A1/A2 which is the simplest way and allows to reuse existing implementations. |
| Nokia | Yes | As stated in Q2-1, we disagree that hysteresis is not required. Without hysteresis, a minor fluctuation in RSRP could trigger the UE to disable logging and the log would lose all samples until the TTT was met again. The purpose of hysteresis is to avoid ping-ponging and we should still avoid that. Every time the UE disables logging, there will be a gap in the log, which will also require the inclusion of a new absolute timestamp. |
| Apple | Yes | Same view as Nokia. |
| Xiaomi | Comment | The logged data should be self-contained, i.e. a sample of data shall at least include a paired input and output data. For temporal domain prediction, a sample of data shall include measurement results during OW+PW. TTT can be used to ensure the data logging would continue for OW+PW. Hysteresis may not be useful as TTT, since Hysteresis is based on signal strength and may not be able to align with OW and PW length.But we can accept hysteresis as optional configuration and NW can still set hysteresis as zero if needed. |
| CATT | Yes | To reuse the legacy measurement event and to prevent frequent logging due to fluctuation of measurement result, it is necessary to configure the parameter of hysteresis. |
| OPPO | Yes |  |
| ZTE | Yes |  |
| Qualcomm  | Yes |  |
| Mediatek | Yes |  |
| LGE | Yes |  |
| Interdigital | Yes | Probably not as necessary is legacy mobility events, but it is a parameter that can be set to zero if not needed |
| Lenovo | Yes |  |
| BT | Yes | Same view as Nokia. |
| Ericsson | Yes | We are fine to include a configurable hysteresis. |
| T-Mobile USA | Yes | Agree with Nokia |
| China Telecom | Yes |  |
| vivo | Yes |  |
| CMCC | Yes |  |
| NTT DOCOMO | Yes |  |

##### Summary

19/20 companies agree to support a configurable hysteresis for the event-triggered logging for NW-side data collection. One company commented that the hysteresis is not as useful as TimeToTrigger, which is anyway used, but can accept it in the configuration considering that the network can anyway set the value to 0.

Based on the above, rapporteurs propose the following:

1. A *hysteresis* should be configured and used (alongside threshold and timeToTrigger) for event-triggered logging for NW-side data collection.

###### **Q4: For approaches (1) and (2), are there any other aspects that you think are missing from any of the two TPs? If yes, please explain what you think is missing.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company**  | **TP for approach (1)****Yes/No** | **TP for approach (2)****Yes/No** | **Comment**  |
| Samsung | Yes | Yes | For approach 1Better to follow the same way for UE-side data collection agreed in RAN1? i.e., separate resources for Set A and B

|  |
| --- |
| AgreementFor UE-sided model, for configuring the resource for data collection purpose, support* *CSI-ReportConfig* can used for configuring the resources for data collection purpose without CSI report.
	+ **One *CSI-ResourceConfigId* is configured for Set A.**
	+ **One *CSI-ResourceConfigId* is configured for Set B**.
	+ Note: UE performs measurement on all resources
	+ One or two associated IDs can be configured in *CSI-ReportConfig*
		- When Set B is equal or a subset of set A (i.e., *NZP-CSI-RS-ResourceId*/*SSB-Index* in the resource setfor Set B is within the *NZP-CSI-RS-ResourceId*/*SSB-Index* in the resource setfor Set A), one associated ID is configured,
		- Otherwise, one associated ID is configured for Set A and another one associated ID is configured for Set B
* FFS: whether/how to support 'aperiodic' CSI RS

Note: This is not related to whether/how to support delivery/transmission of the collected data for training for UE-sided model.  |

For approach 21) We support approach 2 in that configuration is defined directly under RRCReconfiguration for future proof (e.g., AI/ML mobility). However, we do not think separate configuration for measurement resource (i.e., *BM-DataMeasResource*) and logging configuration (i.e., *BM-LoggingConfig*) is essential. It requires additional configuration binding (i.e., *LoggedDataCollectionLinkage*). We understand approach 2 has similar configuration structure for legacy RRC measurement reporting (i.e., MeasObject, ReportConfig, and MeasConfig) where a single MeasObject could be used for multiple ReportConfigs. However, we believe it is not the case for NW-sided data collection. i.e., it would not be common that a single resource (i.e., *BM-DataMeasResource*) would be associated to multiple logging configurations (i.e., *BM-LoggingConfig*).2) We assume not only RRCReconfiguration but also RRCResume could be used for configuration.3) It should be specified in spec the configuration for NW-side data collection is released during RRE.

|  |
| --- |
| **5.3.7 RRC connection re-establishment****5.3.7.2 Initiation**Upon initiation of the procedure, the UE shall:<…>1> if UE is not configured with *attemptCondReconfig*;and1> if UE is not configured with *attemptLTM-Switch*:2> **release *spCellConfig***, if configured;**2> release the logged measurement configuration for network data collection.****5.3.7.3 Actions following cell selection while T311 is running**Upon selecting a suitable NR cell, the UE shall:<…>1> else:2> if UE is configured with *attemptCondReconfig*;or2> if UE is configured with *attemptLTM-Switch*:3> **release *spCellConfig***, if configured;**3> release the logged measurement configuration for network data collection.** |

(Please note it is not needed for approach 1, as it is the configuration is included in ***spCellConfig***)For both approach 1 and 2,1) We agreed NW-side data collection is not configured via SN. Therefore, it should be specified in spec e.g., via conditional presence or field description for the configuration for NW-side data collection (i.e., *csi-LoggedMeasurementConfigToAddModList* in apporoch 1 and *loggedDataCollectionConfig* in approach 2).2) When UE releases configuration for NSDC, UE should discard logged data together. |
| Huawei, HiSilicon | Yes | Yes | As indicated above, L1 measurements should be captured in L1 specifications. Then in RRC we just need to capture that those measurements are logged in dedicated variables whenever they are received from lower layer. |
| Nokia | Yes | Yes | **1.** Regarding Samsung’s response**1.1** Set A and Set B measurements are required for training a UE-side model because Set B is the input to the model and Set A is the ground truth and output of the model. To train the UE-side model, both must be known by the UE-side server.For a NW-side BM model, the gNB, knowing the nature of the Set A and Set B which would be used for its model, a single *CSI-ResourceConfig* could be configured with *csi-RS-ResourceSetList* set to *nzp-CSI-RS-SSB*. Multiple *nzp-CSI-RS-ResourceSets* and *csi-SSB-ResourceSets* can be configured simultaneously and the gNB will be able to categorize them appropriately. Set A and Set B are only useful for UE-side models.**1.2** There are many ways to “unify” things and we think that one version of that unification is to describe in the specification which logging configurations should enter samples into the NW-side data collection buffer. The version of unification shown in Approach 2 also “de-unifies” the CSI configurations. Inference, monitoring, and UE-side data collection are all in *CSI-ReportConfig*, but Approach 2 proposes to disaggregate the *CSI* configuration for NW-side data collection.**2.** Approach 1The following ASN.1 can be used to guide our discussion. Need codes are not included and field names have been marked in blue for readability. CSI-LoggedMeas~~urement~~Config-r19 ::= SEQUENCE { csi-LoggedMeasConfigId-r19 CSI-LoggedMeasConfigId-r19, csi-LoggedResourceConfig-r19 CSI-ResourceConfigId, csi-LoggedMeasQuantityConfig-r19 CSI-LoggedMeasQuantityConfig-r19, sCellIndex SCellIndex OPTIONAL, l3EventTriggerConfig-r19 L3EventTriggConfig-r19 OPTIONAL, ...}**2.1** Where to put *CSI-LoggedMeasurementConfig-r19*We need to determine in which configuration, that for the SpCell or that for each SCell, the *CSI-LoggedMeasurementConfig-r19* should go. There are a few aspects to consider.**a.** the *L3EventTriggerConfig* makes measurements based on a *MeasObjectNR*, and all *MeasObjectNR* are configured only in the SpCell in *RRCReconfiguration*->*MeasConfig*.**b.** The *csi-LoggedResourceConfig* points to *CSI-ResourceConfig*, which is configured per SCell.*CSI-LoggedMeasurementConfig-r19* configured per SCellIf the *L3EventTriggerConfig* is to be configured per SCell, in their respective *CSI-MeasConfig* configurations, then the specification needs to make it clear that the NW-side data collection log collects inputs from all SCells part of the Cell Group and not into individual SCell buffers, for all NW-side data collection configurations, even for other CSI-based use cases such as CSI Compression.In addition to the *CSI-LoggedMeasurementConfigId-r19*, the eventual log would need to include the *SCellIndex* since the *Csi-LoggedMeasurementConfigId-r19* could be repeated across SCell configurations.*CSI-LoggedMeasurementConfig-r19* configured per SpCellIf the *L3EventTriggerConfig* is to be configured per SpCell, then the SCellIndex will be required such that the UE will know which *MeasObjectId* to use for the evaluation of the *L3EventTriggerConfig* and which *CSI-ResourceConfigId* to use for capturing measurements, since the CSI resoruces are configured per SCell.We see no significant advantage or disadvantage to eithe approach, but we must choose one so that we can continue checking for correctness.**2.2** Logging quantity is missingWe will be supporting multiple CSI-based use cases and they will have different logging quantities. We think the logging quantity or quantities should be explicitly configured. More than one logging quantity is possible. An ASN.1 example is shown below.CSI-LoggedMeasQuantityConfig-r19 ::= SEQUENCE { cri-RSRP ENUMERATED {enable}, ssb-Index-RSRP ENUMERATED {enable}}**2.3** Modification of a logging configurationThe following content is copied from the TP for Approach 1.for each CSI logged measurement configuration included in *csi-LoggedMeasurementConfigToAddModList*:2> if the *csi-LoggedMeasurementConfigId* associated to the CSI logged measurement configuration included in *csi-LoggedMeasurementConfigToAddModList* and the cell identity of the serving cell for which the measurements shall be logged, i.e. the serving cell associated with the serving cell configuration in which *csi-LoggedMeasurementConfigToAddModList* is received, are included in an entry in *csi-LogMeasInfoList* in *VarCSI-LogMeasReport*;3> modify the CSI logged measurement configuration according to the configuration received in *csi-LoggedMeasurementConfigToAddModList*;We need to discuss whether or not to allow modification of a data collection configuration. The reason is that the samples in the log do not contain the necessary context information for the gNB and/or a training entity to decipher the meaning of the data without having the configuration. If the configuration can change, then the gNB needs to keep a record of the historical configurations and the UE needs to mark when a configuration changes so that it can indicate to the gNB to which version of a configuration the samples are associated.We think that if the gNB is finished with a configuration, it can de-configure it and the UE can keep the samples associated with the configuration. The gNB would need to keep the configuration available until the data is retrieved. If the gNB configures a new logging configuration with the same ID, the UE should delete unretrieved samples.**2.4** Because the measurements are enabled and disabled in layer 3 based on RSRP measurements, the lower layer will need to be informed to make measurements. The procedural text should take this into account wherever relevant.**2.5** CommentWe think that the *CSI-ReportConfig* already includes all the necessary fields to instruct the UE what to log. It includes which CSI resources to measure, the quantity to measure, and the *SCellIndex* to which the reporting configuration applies. All that is missing is the triggering functionality.To implement triggering, an RRC or MAC command could be used to enable logging based on the reception of a *MeasurementReport* triggered by an *A1* or *A2* event having been triggered and disable logging based on the reception of a *MeasurementReport* triggered by *reportOnLeave* from an *A1* or *A2* event condition no longer being satisfied.We do not think that any significant amount of samples would be lost in the time it would take for the gNB to enable or disable logging.**3.** Approach 2**3.1** Many of the IEs in this approach use naming specific to beam management, but this logging can apply to all CSI-based data collection for NW-side and 2-sided use cases. If Approach 2 is selected, it should be generalized.**3.2** As stated in item 1 of our reply to this question, Set A and Set B references are not required for NW-side data collection.**3.3** This approach essentially recreates the structure for configuring RRC Measurement Reporting and is thus complicated and verbose, requiring three separate *AddMod* and *Release* lists, for each of the following, respectively.**a.** BM-dataMeasResource mimics *MeasObjectNR***b.** BM-LoggingConfig mimics *EventTriggerConfig***c.** LoggedDataCollectionLinkage mimics *MeasId*.**3.4** As in Approach 1, the logging quantity is missing and it cannot be implicit unless we decide to recreate this entire structure for every single new use case.**4.** Overall commentsWe think that both approaches introduce significant risk that we implement broken features that will require CRs to fix throughout Release 19. Aspects such as which quantity to measure, future expansion to new use cases measuring the same type of RS, e.g., CSI-RS, and reuse of existing features were missed.For UE-side data collection, we agreed that it was possible to include the configuration as part of the *CSI-ReportConfig*, which will include new *reportQuantity-r19* values for BM and CSI Prediction use cases, respectively. When the UE is configured for UE-side data collection with *reportQuantity-r19*=*bm-none-r19* or *reportQuantity-r19*=csi*-none-r19*, it is understood that the UE will not generate a report.We could do the same for NW-side data collection by adding a *loggingQuantity-r19* to *CSI-ReportConfig*. There is precedent for enabling and disabling CSI reporting features using a MAC-CE and we think that the delay incurred by using a MAC-CE to control the activation state of logging is insignificant and that there is no risk of losing a significant number of samples. If we prefer to avoid configuration interactions between the CU and DU, we could use an RRC message instead. |
| Apple | Yes | Yes | Approach 1):* Splitting between RAN1 spec (TS 38.214) and RAN2 spec (TS 38.331) needs further discussion, and it is not a decision which can be made by RAN2 alone, as we explained in Q1-1. RAN1 input is needed.
* If RAN1 agree to capture UE logging behavior in 38.331, we still need to add a reference in 38.331 to RAN1 spec on UE actions on L1 measurements, as Huawei mentioned.
* If RAN1 disagree to capture UE logging behavior in 38.331 (i.e. they still want to capture in 38.214), we need to modify 38.331 to only include how the UE applies the RRC configuration on L1 measurement and logging and then put a reference in 38.331 to RAN1 spec.

Approach 2):* As we showed example in Q 1-2, we need to add a reference of RAN1 spec on UE actions on L1 measurements in Section 5.5x.2.
* On Samsung comment:

“it would not be common that a single resource (i.e., *BM-DataMeasResource*) would be associated to multiple logging configurations (i.e., *BM-LoggingConfig*)”It seems a misunderstanding. We understand that the linkage configuration is intended to mimic similar association mechanism in legacy L1 CSI framework (via *csi-ResourceConfigId*) and L3 RRM framework (via *MeasID*). It is target for RRC signaling overhead reduction because two (or more) resource configurations may have same logging config. For example, both CSI-RS set 1 and set 2 need to log periodically with 80ms interval. Then, these two resource sets can link to the same logging config. Otherwise, same logging config has to be repeated for each resource set. |
| ZTE | Yes | Yes | Regarding Nokia’s comments 1.2:We are not crystal clear about the reason for the ‘unify’. In our understanding, the inference/monitoring/UE side data collection can be integrated together, A.K.A: unify, into the CSI framework which is just because all of them are for UE side model training/inference. For NW side model training, we do not see any reason to integrate the feature from NW side model into the UE side model as this configuration method would introduce more spec effort as the logged configuration is configured in CSI framework (i.e.which is generated by DU) but the logged data is reported via layer 3 signaling (i.e.which is triggered and received by CU)Regarding Samsung’s comments on approach 2:1. The mimic of RRM measurement, our intention is for the case where the multiple measurement resource configuration can be associated with one logging configuration in order for signaling saving, in this sense, the RRM design is a convenient way to be followed which has been explained by apple. Besides, by considering the AI mobility case, this design is also futureproof, and there is no any hurt to support the NW side data collection for AI mobility naturally.
2. For other suggestions from Samsung, we tend to share the same view with samsung, which can be discussed further during ASN.1 checking stage or maintenance stage.

Regarding the apple comments on approach 1:1) Assuming the logging configuration is configured in the CSI framework, We also have some concern on the RAN1/RAN2 work split, it is really risky that introduces further troubles if RAN1 does not fully understand the mechanism of logging, the round trip discussion is really time-consuming and not efficient.Regarding the Apple comments on approach 2:1. We agree to add a reference into the text procedure for L1 measurement description to link the RAN2 spec to the RAN1 spec.

.  |
| LGE | Yes | Yes | For Approach 1. Regarding linking event configuration, we also think *measId* can be linked to the *eventTriggeredConfig* (like CHO execution condition)For Approach 1/2, We think a separate report type (CHO-like) can be introduced to not include report related configuration (e.g., report interval, report amount, etc). When considering future extensions for mobility-related use cases, introducing a new event for event-based logging may be a suitable approach. Compared to the new Logging configuration (i.e., BM-DataLoggingConfig) in the current TP2 framework, this event redefinition approach would likely be more straightforward.e.g., |
| Interdigital |  |  | For approach 2, Our understanding of the RAN2 agreements so far is that the logging of the data will be controlled based on the event fulfilment and whenever the event conditions are fulfilled, the measurements are logged periodically.However, the way approach 2 is described in the TP, a similar approach seem to have been used as in legacy report configuration wherein the logging can be periodic or event based*loggingType-r19 CHOICE {* *eventTriggerdLogging-r19 FFS,* *Periodic BOOLEAN**},*In our understanding this choice structure is incorrect (as the UE doesn’t need to choose periodic logging versus event based logging but rather log periodically when the event is fulfilled).Another aspect is that even though we are making this for the BM case, it would be good to define it in such a way that we don’t have to reduplicate the whole structure for each new use case (i.e., why not have a generic *DataLoggingConfig* that can be used for BM or other use cases, wherein IEs within this will be linked to the particular measurements that will be logged). |
| Ericsson | Yes | Yes | Addition of hysteresis parameter for the event triggered logging should be added for both approaches if that is agreed based on Q3.Both in case of approach (1) and approach (2) the measurements will be L1 measurements, which are to be logged by the UE. The discussion about split between the L1 measurements and logging, as commented by Apple and ZTE, is common for both approaches. |
| China Telecom | Yes | Yes |  |
| vivo | Yes  | Yes | On Approach 1): ssplitting between RAN1 spec and RAN2 spec needs further consideration.  |

##### Summary

**Resource configuration**

One company proposed to configure the network data collection for approach (1) with separate resources for Set A and B, as for UE-side data collection. It was commented by another company that this is only required for training a UE-side model whereas for the NW-side model this is only needed for the network. It was instead commented that separate resources for Set A and B should not be used in the approach (2).

Rapporteur understanding is that there is no need to configure the UE with separate resources for Set A and B in case of network data collection. This is something that is needed for the UE-side model but for network-side models the network gNB will do this categorization. It is proposed that a single *CSI-ResourceConfig* is configured, i.e. the resource configuration does not have separate resources for Set A and Set B.

1. The resource configuration consists of a single *CSI-ResourceConfig*, i.e. the resource configuration does not have separate resources for Set A and Set B.

For approach (2) two companies commented that having separate configurations for measurement resources (*BM-DataMeasResource*) and for logging (*BM-LoggingConfig*), which in turn requires an additional configuration to bind them together (*LoggedDataCollectionLinkage*) is not needed. It makes the configuration larger and more complex. Two companies answered that the reason is to support that multiple measurement resource configurations can be associated with one logging configuration in order for signaling saving.

Rapporteur propose that this is discussed in case it is decided to use approach (2).

One company commented that for approach (1) it should be decided whether the *CSI-LoggedMeasurementConfig-r19* for an SCell should be included in the SCell configuration or in the associated SpCell configuration. If it is included within the SCell configuration, it should be clear that network data collection log can have inputs from all cells in the Cell Group. The log would then need to include also the *ScellIndex*, in addition to the *CSI-LoggedMeasurementConfigId-r19*. According to rapporteur understanding the *CSI-LoggedMeasurementConfig-r19* is in the SCell configuration and the cell id is already included in the reported logs.

One company commented there is a need to discuss whether or not to allow modification of a data collection configuration. The reason is that there is a need to have a mapping between the data and associated configuration, when doing the model training. If the gNB is finished with a configuration, it can de-configure it and the UE can keep the samples associated with the configuration. The gNB would need to keep the configuration available until the data is retrieved. What is proposed is that if the gNB configures a new logging configuration with the same ID, the UE should delete any unretrieved samples. Rapporteur believes this is an optimization to tackle a bad network implementation and that there is no need to discuss this now.

One company commented that for approach (2) there is a need to explicitly release the configuration for NW-side data collection at the RRC Re-establishment procedure. For approach (1) this release is done implicitly.

One company commented that we should be supporting multiple CSI-based use cases, with different logging quantities, and that the logging quantity/-ies therefore should be explicitly configured.

One company commented that the “*loggingType-r19*” in the TP for approach (2) is incorrect since it includes a choice between periodic logging versus event based logging. It is commented as incorrect due to that the UE would use a periodic logging when the event conditions are fulfilled. Rapporteur understanding is that all the logging would be configured **either** as event-based or that it is done as soon as the configuration is received, i.e. without any events. To be more clear on this the TP for approach (2) could however e.g. use just an optional event configuration instead of a choice between “event configuration” or “periodic”, in case approach (2) is adopted. The periodicity of the logging is being discussed for RRC-27.

## 2.2 Impacts on RAN1

In both approaches for sending the logging configuration for beam management, upon receiving a logging configuration, the UE needs to log CSI related measurements (L1-RSRP and beam index) for the serving cell, without sending any measurements at L1.

###### **Q5: For approaches (1) and (2), do you think there may be RAN1 impact (e.g. in TS 38.214) for ensuring that the UE performs measurements according to the logging configuration and does not trigger L1 reports? If yes, please comment on what RAN1 impacts you foresee.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company**  | **Approach (1)****Yes/No** | **Approach (2)****Yes/No** | **Comment**  |
| Samsung | Up to RAN1 | Up to RAN1 | We think it could to good to send an LS to RAN1 inclduing our agreements or agreed TP so that RAN1 decides/specifies what is needed (if any).  |
| Huawei, HiSilicon | Yes | Yes | For both approaches the impact is exactly the same, but very limited. In our view, RAN1 needs to capture that upon receiving logging configuration / indication that an event is met the UE performs L1 measurements and provides the results to higher layers. |
| Nokia | Yes | Yes | Normally, *CSI-Resources* are only expected to be measured if they are referred to by a *CSI-ReportConfig*. Because neither approaches incldue the logging configuration in *CSI-ReportConfig*, the lower layers need to know that the measurements are necessary. Thus, RAN1 needs to be aware that the UE should be measuring CSI resources pointed to by an \*active\* logging configuration. That is, when the UE determines not to log, it also doesn’t need to measure the CSI-RS.The specification 38.214 alludes to this point.* Section 5.2.1.1 implies that measurements are taken on resources configured in *CSI-ResoruceConfig* when associated with a *CSI-ReportConfig*.Each Reporting Setting **CSI-ReportConfig** is associated with a single downlink BWP (indicated by higher layer parameter BWP-Id) given in the associated **CSI-ResourceConfig for channel measurement**
 |
| Apple | Yes | No, but need to inform RAN1 | In general, we think Approach 1) needs more RAN1 spec impacts than Approach 2). In detail, Approach 1) needs:1. As it is configured in *CSI-MeasConfig* to reuse legacy L1 CSI framework, RAN1 may think it is within their expertise and prefer to capture UE logging behavior in their spec (38.214).
2. As it is configured in *CSI-MeasConfig,* TS38.214 needs to at least specify how the UE performs L1 measurement without reporting via UCI. The detailed spec impact is similar to what Nokia mentioned (i.e. clarify whether / how the UE performs L1 measurement when CSI resource is associated with logging config rather than *CSI-ReportConfig*).
3. In legacy L1 CSI framework, the rule of calculating occupied CSI Processing Unit (CPU) is specified Section 5.2.6.1 of TS 38.214 and maximum number of CPU is a UE capability (***csi-ReportFramework***) to restrict UE CSI processing complexity. As it is configured in *CSI-MeasConfig,* we think RAN1 has to discuss the rule of calculating CPU occupancy for L1 measurement logging in NW-side data collection. Please note that how to calculate CPU occupancy for UE-side data collection has been agreed in RAN1#121.

For Approach 2), we think: * Above 1) is not needed because it is configured under a new L3 configuration (*loggedDataCollectionConfig*), which is out of RAN1 scope.
* Above 2) is also not needed because CSI resource under *loggedDataCollectionConfig* is a new casewhich was not specified in RAN1 spec anyway.
* For above 3) (i.e. whether L1-RSRP logging is counted as CPU), our understanding is that it doesn’t occupy CPU because it is configured in a new L3 configuration and can be handled by UE similar to L3 RRM (current L3 RRC doesn’t occupy CPU). But we agree that it needs RAN1 confirmation.
 |
| Xiaomi | Yes | UP to RAN1 | In approach 1, the logging configuration is mixed with legacy *CSI-MeasConfig*. RAN1 may need to identify resource set is for logging or legacy measurement to perform measurement, also logging behavior needs to be considered.In approach 2, the logging configuration is separate from legacy *CSI-MeasConfig*. The legacy L1 measurement procedure can be reused when logging event is fulfilled.We understand approach 2 would introduce less RAN1 impact. LS to RAN1 is needed for both approaches. |
| CATT | Yes | Yes | The L1 measurement behavior should be specified in RAN1 specification. LS to RAN1 is needed. |
| OPPO | Yes | Yes | For periodic logging, RAN1 needs to capture that upon receiving logging configuration, UE performs L1 measurements and provides the results to higher layers periodically.For event based logging, RAN1 needs to capture that after receiving logging configuration from high layer, if high layer indicates to start data logging, UE performs L1 measurements and provides the results to higher layers periodically; else if high layer indicates to stop data logging, UE stops to performs L1 measurements. |
| ZTE | Yes | Yes, the impact can be minimized | For approach 1, as the Logging configuration is configured in the CSI framework which is dropped into RAN1 scope, RAN1 need to know what is the relationship between logging configuration and CSI resource configuration, and shall be specified start/stop measurement upon the event or some abnormal case in RAN1 spec. For approach 2, as the logging configuration is defined in the RAN2 scope, the RAN1 impact is just to quote the CSI Resource configuration for the logging configuration, we can just inform RAN1 such information. And in our understanding, the RAN1 impact from this approach 2 is quite limited, one small update on 38.214 is sufficient, for example:5.1.6.1 CSI-RS reception procedureThe CSI-RS defined in Clause 7.4.1.5 of [4, TS 38.211], may be used for time/frequency tracking, CSI computation, L1-RSRP computation, L1-SINR computation, mobility, data logging as specified in [X, TS 38.331]and tracking during fast SCell activation.  |
| Qualcomm | Yes | Yes | Measurement targets are L1 RS. Therefore, for both approach 1 and approach 2, there can be RAN1 impact |
| Mediatek | Yes | Yes | We believe it is most appropriate for the RRC to encompass the entire logging procedure, including triggering, logging, and reporting for both approach 1) and approach 2). At the same time, we agree that RAN2 should keep RAN1 informed of the standardized behavior captured in the RRC specification, so that RAN1 can address any measurement-related aspects as necessary. |
| LGE | Yes | Yes | Agree with Samsung to send LS to RAN1 including RAN2 agreement/decision.  |
| Interdigital | Yes | Yes | We agree with ZTE that the impact to RAN1 can be minimized in the L3 based solution. |
| Lenovo | Yes | Yes |  |
| Ericsson | Yes | Yes | For both approaches there may be a need for RAN1 to capture that the UE performs L1 measurements and provides the results to higher layers. The impact to RAN1 should thus be the same for both approaches.Regarding the comment from Apple on CSI Processing Unit (CPU), even if the logging configuration is included under CSI-MeasConfig it should not be relevant for CPU occupancy, given that it is not configured within CSI-ReportConfig and there is no reporting via UCI. |
| China Telecom | Yes | Yes |  |
| vivo | Yes | Up to RAN1 | For approach 1, RAN1 need to consider the correlation between logging configuration and CSI resource configuration, and shall be specified start/stop measurement upon the event or some abnormal case in RAN1 spec. For approach 2, the logging configuration is defined in the RAN2 scope, RAN2 needs to inform RAN1 and RAN1 can address any measurement-related aspects as necessary. |
| CMCC | Yes | Yes | We share similar view with ZTE that the impact to RAN1 can be minimized for approach 2. |

##### Summary

All companies think that there is either RAN1 impact, or that there is a need to check the impact with RAN1, for both approaches. Five companies think that the impact to RAN1 for approach (2) is smaller than for approach (1). Rapporteur propose that an LS is sent to RAN1 to inform about the RAN2 agreement on configuration approach, i.e. the RAN2 solution for network data logging, so that they can do needed updates, if any.

1. RAN2 to send an LS to RAN1 to inform about the RAN2 agreements on solution for network data logging

## 2.3 Impacts on RAN3

The logging configuration (for both approaches) needs to contain:

* references to the resources to be measured for logging (for both periodic and event-triggered logging), which for the beam management use case are *CSI-ResourceConfigId*(s); and
* event-triggered logging configuration based on L3 measurements, including threshold and TTT.

Furthermore, with approach (1) the logging configuration would be generated by the gNB-DU under *CSI-MeasConfig*, whereas with approach (2) the logging configuration would be generated by the gNB-CU at L3.

###### **Q6: For approaches (1) and (2), do you think there may be RAN3 impact? If the answer is yes, please describe. Possible aspects to consider are: 1) CU-DU interaction for configuring the event; 2) CU-DU interaction for configuring the measurement resources; 3) CU-DU interaction for retrieving logged data, 4) CU-DU interaction for de-configuring logging configurations upon low power state indication, etc. In the comments, companies also can provide other potential RAN3 impacts in addition to above mentioned.**

Note: In the rapporteur’s view, RAN3 impacts are present also in other components of AIML for PHY (besides NW-side data collection).

|  |  |  |  |
| --- | --- | --- | --- |
| **Company**  | **Approach (1)** **Yes/No** | **Approach (2)****Yes/No** | **Comment**  |
| Samsung | Up to RAN3 | Maybe, but up to RAN3 | In our understanding, in approach 2, some CU-DU interaction is needed for configuring resoureces and deconfiguration. However, it would not trigger so much work in RAN3. More importantly, regardless of either option, we should ask RAN3 and all the impact should be discussed/decided by RAN3. |
| Huawei, HiSilicon | Perhaps | Perhaps | According to our analysis, both approaches may have some RAN3 impacts:1. Approach 1: CU should indiate to the DU the requested logging configuration and DU includes this in CSI-MeasConfig. In our view existing singalling could be reused for this as DU already today generates CSI-MeasConfig.2. Approach 2: CU also needs to provide logging configuration to DU so that DU can provide the required CSI-RS signals. DU needs to confirm the request to CU. This would probably require a new procedure to be specified by RAN3.In any case, RAN3 aspects are not necessarily essential to make a decision. We can first decide in RAN2 and request RAN3 to analyze their signalling afterwards.  |
| Nokia | Maybe | Maybe | We agree with Huawei’s last statement. Once we decide on an approach, we should send an LS to RAN3 describing the work we have done.Because we are discussing MDT, the logging configuration would initially enter the gNB at the CU-CP, not the CU-DU. This is necessary since the L3 measurement configuration aspects, e.g., *MeasObjectNR*, are configured in the CU-CP. The CU-CP would need to coordinate the resources used for configuring the L3-based event trigger, and the CU-DU would need to coordinate the resources for configuring the L1 measurement and logging.Additionally, we need to send an LS to SA5 to update the MDT specifications such that the logging can be configured from OAM. |
| Apple | Yes | Yes | To support split gNB, we think both approaches need RAN3 spec changes on configuration exchange between CU and DU. However, RAN3 impact of Approach 1 is larger than Approach 2. We provide a comparison from 4 aspects identified by the Rapporteur:

|  |  |  |
| --- | --- | --- |
| Impacted aspects | Approach 1 | Approach 2 |
| 1) CU-DU interaction for configuring the event | CUDU:1) L3 MO parameter of *ServingCellMO,*2) *threshold* and *timeToTrigger.*  | N/A  |
| 2) CU-DU interaction for configuring the measurement resources; | N/A | DUCU:1) NZP CSI-RS resource configuration ID(s) (*CSI-ResourceConfigId*).  |
| 3) CU-DU interaction for retrieving logged data | DUCU:1) *CSI-MeasConfig* (Otherwise, CU can’t understand the reported logged data) | N/A |
| 4) CU-DU interaction for de-configuring logging configurations upon low power state indication | CUDU:1) Indication to request DU to de-configure data collection config and release CSI resource.  | N/A |

Please note that our understanding on above comparison:1. Approach 1: DU generates logging configuration and provides/manages whole data collection config via *legacy CSI-MeasConfig* to the UE as L1 CSI.
2. Approach 2: CU generates logging configuration and provides/manages whole data collection config via new IE *loggedDataCollectionConfig* to the UE.
3. L3 MO, TTT and Threshold shall be generated by CU in both Approach 1 and Approach 2 because DU does not touch any L3 measurement result and consequently has no ability to generate the suitable L3 event.
4. UAI message (with low power bit and indication of buffer > threshold) is received by CU in both Approach 1 and Approach 2.
5. *UEInformationRequest/Response* for data retrieving are transmitted/received by CU in both Approach 1 and Approach 2.
 |
| Xiaomi | Up to RAN3 | Up to Ran3 | We understand it depends whether CU-DU split is supported in AI use cases. Up till now, RAN3 has not considered CU-DU split yet. We also notice that, even for AI/ML NG-RAN use cases studied by RAN3, supporting CU-DU split was separated into two different releases, where non-split architecture is supported as prioritized feature in first release. But if companies see the need to support CU-DU split, we can send LS to RAN3 and ask the architecture assumption. |
| CATT | Yes | Yes | As mentioned above, the configuration of resource, the MO parameters and report configuration are all need interaction between CU and DU for CU-DU split scenario. LS to RAN3 is needed after RAN2’s decision on approach 1 or 2. |
| OPPO | Yes | Yes | 1. Approach 1: CU should indiate to the DU the requested logging configuration and DU includes this in CSI-MeasConfig. 2. Approach 2: DU needs to indicate *CSI-ResourceConfigId*(s) to CU and CU puts this into RRC L3 logging configuration structure. |
| ZTE | Yes | Yes | For approach 1:The impact 1), 3), 4) can be foreseen which has been indicated by AppleFor approach 2:Only impact 2) can be foreseen. |
| Qualcomm | Yes | Yes | As events are determined by CU and L1 resources or resource sets for measurements are determined by the DU, there may be RAN3 impact associated with the configuration.  |
| Mediatek | Up to RAN3 | Up to RAN3 | We should select either approach 1) or approach 2) from the RAN2 perspective and then request RAN3 to determine the necessary signaling and procedures for the chosen approach. However, we tend to agree that approach 2) may have less impact on RAN3 compared to approach 1).  |
| LGE | Up to RAN3 | Up to Ran3 | Agree with Samsung |
| Interdigital |  |  | Agree with Samsung |
| Lenovo | Yes | Yes | For both approaches, some exchanges of info between CU and DU are needed as analyzed by companies above. But we see it is business as usual, nothing supper complicated.**On the other hand, at this stage, we should avoid making RAN2 decision based on RAN3’s reply/analysis, since this topic is not in RAN3’s scope in Rel19.** RAN2 need to simply make the decision and inform RAN3.  |
| BT | Up to RAN3 | Up to RAN3 | Wait until RAN2 decides on the approach, and then send a LS to RAN3 for them to discuss |
| Ericsson | Yes (but up to RAN3) | Yes (but up to RAN3) | In case of split architecture there would be RAN3 impact for both approaches.We don’t agree with the following points in the table from Apple regarding the impact for the 2 approaches:1) The DU can set the *threshold* and *timeToTrigger* since the measurements to be logged are in the scope of the DU responsibility and the DU is also the consumer of the trained model based on the logged data. As commented for Q2-1, the servingCellMO should not be needed by the DU for this but would be available there already.3) The CU can understand the received data and it is questionable whether it needs to understand the related configuration.4) The “release of CSI resources”, when logging is to be stopped for a UE, is common for both approaches and would thus impact both approaches. It is anyway up to the DU to decide whether to then release the CSI resource or not. |
| China Telecom | Yes | Yes |  |
| vivo | Yes | Yes | There should be coordination between CU and DU for the data collection event configuration and CSI measurement resource config. |
| CMCC | Up to RAN3 | Up to RAN3 | We can send LS to RAN3. |

##### Summary

All companies think that, for both approaches, there is either an impact to RAN3 and/or that they should be informed about the RAN2 decision so that RAN3 can decide on their own. Some companies however indicate that there is only RAN3 impact in case of a split architecture (CU-DU split).

Two companies think that there may be less RAN3 impact for approach (2) than for approach (1). One company thinks that, for approach (1), there is an impact due to that the serving cell MeasObject needs to be sent down from the CU to the DU for the event configuration. Another company commented that it is already available in the DU (and not needed for this purpose).

11/18 comments that an LS can be sent to RAN3. Some companies commented that the LS should be sent once RAN2 has decided on the approach, so that RAN3 can decide whether they should do any updates. Rapporteur proposal is to send an LS to RAN3 to inform about the RAN2 agreement.

1. RAN2 to send an LS to RAN3 to inform about the RAN2 agreements on solution for network data logging

## 2.4 Final questions

###### **Q7: Among approach (1) and (2), considering the complexities and impacts of the approaches, which one is acceptable/not acceptable?**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Acceptable (approach 1/2)** | **Not acceptable (approach 1/2)** |
| Samsung | Apporach 2 and 1 (We prefer apporach 2 considering aligned configuration framework including AI/ML mobility, but there is no technical issue with either approach) |  |
| Huawei, HiSilicon | Approach 1 | Approach 2 – looking at the provided TP, this approach is overly complex. It introduces a whole new structure while the same goal can be achieved with much less changes as in approach 1. Furthermore, it was argued before this is done for the sake of future compatibility, but the introduced IEs are BM case specific and cannot be reused, e.g. for AIML for mobility use case. |
| Nokia | Approach 1. Please also consider reading point 4 in our response to Q4. | Approach 2 – for reasons explained previously, and in agreement with Huawei’s comment. |
| Apple | Approach 2 | Approach 1:* As indicated in Q1-1, we think RAN1 may not be happy to see that RRC spec captures UE behavior on logging L1 measurement if the logging framework is built on top of their expertise of L1 CSI framework (i.e. Approach 1). It may cause further confusion and cross-WG work.
* As indicated in Q5, whether/how to count CPU occupancy for logging L1 measurement on top of L1 CSI framework may lead to a lot of RAN1 work.
* As indicated in Q6, , RAN3 impact of Approach 1 is much larger than Approach 2.
* We agree with Samsung that Approach 2 can integrate AI mobility as a general L1/L3 measurement logging framework (e.g. including required L3 MO IDs under IE *loggedDataCollectionConfig*). If RAN2 adopt Approach 1, we have to re-visit all the discussion in Rel-20 for AI mobility.
 |
| Xiaomi | Approach 2 | Approach 1* Require additional RAN1 work. RAN1 may not be able to finish the work considering the limited time.
* Not forward compatible for AI mobility data collection, since AI mobility data is based on L3 measurement results
 |
| CATT | Approach 2Since it seems a bit complex to use RRC approach for the introduction of training data collection, it will be a base for the subsequent high layer use case, e.g. AI based mobility in R20. |  |
| OPPO | Approach 2 is more future proof |  |
| ZTE | Approach 2 bring less RAN1 and RAN3 impact and is more future proof | Approach 1:As described above, approach 1 has more risks to introduce more round trip discussion between RAN1 and RAN2 as the logging configuration being configured into CSI framework. Besides, normally, for measurement and reporting at gNB side, who generates the measurement configuration shall be responsible to receive the measurement report. But for approach 1, the DU configure measurement and logging configuration, but the logged data reporting goes to CU, which is a brand new things in NR.And considering approach 1 would introduce more RAN3 impact than approach 2, and such impact may be complexed to be resolved in RAN3, it is better to be avoided in order for RAN2 to complete the WI in time. |
| Qualcomm | Approach 2 | We believe both approaches have RAN1, RAN2, and RAN3 impacts. But, we prefer approach 2, as it is more future-proof.  |
| Mediatek | Approach 2It is more future-proof and provides greater flexibility for future extensions, such as supporting additional use cases like AI-based mobility. |  |
| LGE | Approach 1 and 2 (prefer Approach 1) | The impact of additional specifications can vary depending on the use case expansion being considered. If we consider future expansions in CSI-related use cases, such as CSI compression, Approach 1 might be simpler. We prefer Approach 1 (considering that it is a CSI related use case), but both approaches remain feasible. |
| Interdigital | Approach 2 | Our understanding is that approach 2 is a more scalable/re-usable approach that can be easily generalized to any use case, and will have the least specification impact on other WGs. |
| Lenovo | Approach 2. From modular design and future proof point of view. |  |
| BT | Approach 1.  |  |
| Ericsson | Approach 1 | Approach 2The motivation of having a L1/L3 unified framework for the AIML logging configuration is not consistent with the current ASN.1 signalling architecture, in which the L1 and L3 measurement configurations are natively split. L3 data collection configuration for the future AI mobility use case naturally fits into the legacy MeasConfig, we do not need to import/copy the MeasConfig in a new structure at the same level, since it would be just redundant from signalling design point of view. Rel-20 AI Mobility SI has not taken any agreement to use a completely new framework for logging, that is outside MeasConfig.Since some companies raised the issue of using RRCResume for configuring logging, with the TP for approach (1) NW data collection configuration can be included also in the RRC Resume message (i.e. it comes for free). For approach (2) there would then however be a need to update the RRCResume message.Regarding the comment from Apple on CSI Processing Unit (CPU), even if the logging configuration is included under CSI-MeasConfig it should not be relevant for CPU occupancy, given that it is not configured within CSI-ReportConfig and there is no reporting via UCI. This is the same situation as for approach (2), with the same L1 measurements being performed and logged. |
| T-Mobile USA | Approach 1 |  |
| China Telecom | Approach 2 |  |
| vivo | Approach 2. Approach 2 offers better scalability and future proof. |  |
| CMCC | Approach 2It is more future-proof. |  |
| NTT DOCOMO | Approach 1 and 2 are acceptable, but Approach 2 is better considering future proof (e.g., AIML for Mobility) |  |

##### Summary

|  |  |
| --- | --- |
| **Approach (1)** | **Approach (2)** |
| Acceptable (8/20) | Acceptable (15/20) |
| Not acceptable (3/20) | Not acceptable (3/20) |

8/20 companies find approach (1) acceptable and 15/20 companies find approach (2) acceptable. For both approaches the same amount of companies (3) consider it to not be acceptable. There is thus no consensus and a discussion in RAN2 is needed before taking the decision on which alternative to use in the specifications.

Based on the above, rapporteurs propose the following:

1. RAN2 to discuss and decide on alternative to introduce logging configuration for network data collection:
	1. logging configuration is introduced as a new list of configurations under *CSI-MeasConfig*, based on TP1, (Acceptable 8/20, Not acceptable 3/20)
	2. logging configuration is introduced in a new L3 measurement framework, at the same level as *MeasConfig* and *CellGroupConfig*, based on TP2, (Acceptable 15/20, Not acceptable 3/20)

# Conclusion

Based on the discussions above, we propose the following:

[Proposal 1 RAN2 confirms that the network data logging is captured in a new clause (e.g. 5.5x) in the RRC specification.](#_Toc205984468)

[Proposal 2 RAN2 to decide on whether to capture the event evaluation for the event-triggered logging in the existing A1/A2 events (in sub-clauses 5.5.4.2 and 5.5.4.3) or in new events.](#_Toc205984469)

[Proposal 3 A *hysteresis* should be configured and used (alongside threshold and timeToTrigger) for event-triggered logging for NW-side data collection.](#_Toc205984470)

[Proposal 4 The resource configuration consists of a single *CSI-ResourceConfig*, i.e. the resource configuration does not have separate resources for Set A and Set B.](#_Toc205984471)

[Proposal 5 RAN2 to send an LS to RAN1 to inform about the RAN2 agreements on solution for network data logging](#_Toc205984472)

[Proposal 6 RAN2 to send an LS to RAN3 to inform about the RAN2 agreements on solution for network data logging](#_Toc205984473)

[Proposal 7 RAN2 to discuss and decide on alternative to introduce logging configuration for network data collection:](#_Toc205984474)

[a. logging configuration is introduced as a new list of configurations under *CSI-MeasConfig*, based on TP1, (Acceptable 8/20, Not acceptable 3/20)](#_Toc205984475)

[b. logging configuration is introduced in a new L3 measurement framework, at the same level as *MeasConfig* and *CellGroupConfig*, based on TP2, (Acceptable 15/20, Not acceptable 3/20)](#_Toc205984476)

# References

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