3GPP RAN 5G-ACIA Evaluations Week 1

October 12th – 16th 2020

Source: Moderator (Ericsson)

Title: Summary of company inputs on URLLC features and simulation assumptions

Document for: Discussion, Decision

# 1 Introduction

AT RAN#89, the following was agreed in [RP-202069](https://protect2.fireeye.com/v1/url?k=41a5db26-1f051960-41a59bbd-86fc6812c361-73f443258ff773bf&q=1&e=bc078f84-983d-45f3-ab31-19e60d911036&u=https%3A%2F%2Fwww.3gpp.org%2Fftp%2Ftsg_ran%2FTSG_RAN%2FTSGR_89e%2FDocs%2FRP-202069.zip) on providing evaluations for 5G-ACIA:

* Start an offline email-based activity to provide evaluation results for 5G-ACIA
* One company volunteers as moderator
	+ Proposes a work plan to follow
	+ Ericsson is willing do this
* Discussions are on the RAN1\_NR reflector
	+ Email activity only during short periods (< week) distributed across the time allocated to the activity
	+ No email activity in weeks before/during/after RAN1 meetings or RAN defined inactive periods
	+ All companies should strive to limit email activity as much as possible
	+ Outcome of the offline discussion will directly go to RAN without need for discussion in RAN1 nor need for LS from RAN1 to RAN
* Target completion by RAN#91
* At RAN#91, RAN will decide on a response LS to 5G-ACIA

The moderator made the following proposal on a timeline:

1. 12-16 October 2020
	* Discussion on which URLLC features to include in the evaluations and simulation assumptions
2. 14-18 December 2020
	* First round of simulation results
3. 22-26 February 2021
	* Second round of simulation results
4. 8-12 March 2021
	* Finalization of the report to RAN#91

This contribution is the summary of the inputs provided by companies with first proposals for agreements. The purpose is to establish a baseline of features and simulation assumptions that all companies will simulate. Companies are as always free to submit additional results that they find relevant to the evaluations.

The documents related to the evaluations can be found here:

[https://www.3gpp.org/ftp/tsg\_ran/TSG\_RAN/TSGR\_90e/Inbox/Drafts/5G-ACIA October/](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/)

The input contributions are also listed in the reference section.

# 2 Simulation assumptions

## 2.1 Company input

Companies’ input is summarized in the table below. Only proposals for parameter settings that differ from what is proposed in the 5G-ACIA LS are shown.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | 5G-ACIA LS | Ericsson | Huawei, HiSilicon | Intel | Nokia | Qualcomm | ZTE |
| Factory hall size  | 120x50 m |  |  |  |  |  |  |
| Room height  | 10 m |  |  |  |  |  |  |
| Inter-BS/TRP distance  | Depending on the number of TRPs, which are evenly deployed in the factory hall. Simulation company should provide the number of BSs/TRPs used in the simulation. | Reuse the factory automation use case layout from TR 38.824 |  | X = 20 m inter-TRP distanceY = 20 m inter-TRP distance (as in TS 38.824) | For the network layout, 12 BSs are assumed to be deployed in the 120x50x10 m3 area with the same 2D placement as in TR 38.901 and TR 38.824.  |  | 12 m |
| BS/TRP antenna height  | 1.5 m for InF-SL and InF-DL8m for InF-SH and InF-DH | 8 m |  |  |  |  |  |
| Layout – BS/TRP deployment | Depending on the number of TRPs | Reuse the factory automation use layout from TR 38.824 |  | 12 single-sector TRPsReuse Rel.15-16 evaluation assumption.As for 18 TRPs considered in InF channel model study, it seems more suitable for 120x60 m scenario while may provide excessive # of access nodes in 120x50 m | For the network layout, 12 BSs are assumed to be deployed in the 120x50x10 m3 area with the same 2D placement as in TR 38.901 and TR 38.824.  | 5G-ACIA with 12 service areas and one to two gNBs per service area to keep the simulation complexity low. | The layout used in Rel-16 URLLC SI. The BS/TRP is more uniformly located compared to the one suggested by 5G-ACIA. |
| Channel model  | UC-2: InF-DH > InD-DL > InF-SH > InF-SL | InF-DH | UC #2: InF-DH > InD-DL > InF-SH > InF-SL | Pick InF-DH as the most challenging as per geometry SINR, and InF-SL as the opposite in terms of clutter density and BS elevation |  | Simulate InF-SH and InF-SL if the number of UEs is less than 25 per service area and simulate InF-DH and InF-DL if the number of UEs is more than 25 per service area | InF-DH |
| Carrier frequency and simulation bandwidth | TDD4 GHz: 100 MHz30 GHz: 160 MHz | FR1: 2.6 GHz FDD with 50 MHz BW and 30 kHz SCSFR2: 30 GHz TDD with 160 MHz BW and 120 kHz SCS |  | TDDMandatory: 4 GHz: 100 MHzOptional: 30 GHz: 160 MHz |  |  |  |
| TDD DL-UL configuration  | Simulation company should report the used DL-UL configuration. |  | Simulation company should report the used DL-UL configuration.Due to symmetric DL/UL traffic, 1:1 DL-UL configuration is recommended. | ~1:1 UL-DL ratio7 symbols for DL, 7 symbols for UL, necessary gap for switching |  |  | DDDSUDDSUU (S: 10D:2G:2U) for 4GHz and DDSU (S: 11D:3G:0U) for 30GHz |
| Number of UEs per service area | Up to 50 per service area, e.g., 10, 20, 40, and 50 | {10, 20, 40, 50} | Up to 50 per service area, e.g., 10, 20, 40 and 50. | 10, 20, 40, 50Encourage companies to evaluate each density to show load dependency |  |  | Up to 50 per service area, e.g., 10, 20, 40, and 50  |
| UE distribution  | All UEs randomly distributed within the respective service area. |  |  |  |  |  |  |
| Message size  | 48 bytes |  |  |  |  |  |  |
| DL traffic model  | DL traffic arrival with option-1, option-2, and option-3. | Either Option 1 (the best case for the system) or Option 2 (the worst case) from 5G-ACIA. | Option 3 from 5G-ACIA | TI, TS, E2E:{0.5, 0.5, 0.45} ms{1, 1, 0.9} ms{2, 2, 1.8} msBurst model:Mandatory: Option-1Optional: Option-2, Option-3 | Option 1 (random distributed offset) is mandatoryOption 2 (simultaneous traffic arrival for all UEs) is optionalOption 3 (2 groups per service area and aligned traffic arrival per group) is optional with low priority | Option 2 | Option 1 |
| UL traffic model  | UL traffic is symmetric with DL, and DL-UL traffic arrival time relationship with option-1 and option-2 | Option 1 from 5G-ACIA. | Option1 from 5G-ACIA | Option1 from 5G-ACIA | Option 1 (random distributed offset) is mandatoryOption 2 (simultaneous traffic arrival for all UEs) is optionalOption 3 (2 groups per service area and aligned traffic arrival per group) is optional with low priorityBurstiness: Option 1 DL and UL traffic arrival time instants are independent. | Option 2 with x equal 4 -5 symbols | Same as UL traffic model, while the is traffic arrival is independent with DL. |
| CSA requirements  | UC-#2: 99.9999% | CSA = 99.9999%Or, equivalently: BLER <=1e-3 | CSA: 99.9999% (UC #2) | 99.9999% | Focus on UC#2 |  | 99.9999% packet reliability |
| Performance metrics | 1) CSA: single CDF of CSA distribution of all UEs in factory hall2) Latency: single CDF of latency distribution of all UEs in factory hall3) Percentage of UEs satisfying requirements 4) resource utilization | 1) CSA: single CDF of CSA distribution of all UEs in factory hall 2) Latency: single CDF of latency distribution of all UEs in factory hall |  | Metric 2 requires clarification how a given point in the CDF is obtained:- A point is for each packet in the system- A point is a function from all packets of a UE, e.g. average, maximum, etc.Metric 3) and 4) are low priority. |  |  | 1) CSA: single CDF of CSA distribution of all UEs in factory hall. Zero survival time could be the baseline. 2) Percentage of UEs satisfying requirements 3) Resource utilization  |
| E2E latency & air interface latency | - E2E latency: 1 ms for UC#2- Air interface latency: 1ms5G-ACIA assumes that the CN induced latency is negligible |  | E2E latency: 1 ms for UC #2Air interface latency: NA |  | For the selected use case #2 of motion control, the latency budget available to the air interface corresponds to the entire E2E latency budget of 1 ms.  | 1 ms air interface latency | 1 ms user plan latency  |
| UE speed | Linear movement |  | Linear movement: 75 km/h |  | Fast fading is modeled assuming a UE speed of 75 km/h. No explicit UE mobility (nor handovers) are modeled in the evaluations. | Simulate only rotational motion where the UE moving speed is to be agreed upon. | Linear movement  |

## 2.2 Highlights of views

In the following, the parameters where the is a difference of opinion are highlighted.

**Layout – BS/TRP deployment**

4 out of 6 companies prefer to adopt the layout used in the Rel-16 study that can be found in TR 38.824.

**Carrier frequency and simulation bandwidth**

One company prefers to simulate FDD at 2.6 GHz instead of TDD at 4 GHz.

**DL traffic model**

4 companies stated option 1, one company either option 1 or 2, one company option 2 and one company option 3

**UL traffic model**

5 companies wanted option 1 and one company wanted option 2.

## 2.3 Proposal

Based on the company inputs, the proposals for each parameter is listed in the table.

|  |  |  |
| --- | --- | --- |
| Parameters | 5G-ACIA LS | **Proposal for agreement** |
| Factory hall size  | 120x50 m | As in 5G-ACIA LS |
| Room height  | 10 m | As in 5G-ACIA LS |
| Inter-BS/TRP distance  | Depending on the number of TRPs, which are evenly deployed in the factory hall. Simulation company should provide the number of BSs/TRPs used in the simulation. | According to proposed layout below |
| BS/TRP antenna height  | 1.5 m for InF-SL and InF-DL8m for InF-SH and InF-DH | As in 5G-ACIA LS |
| Layout – BS/TRP deployment | Depending on the number of TRPs | 12 TRPs within area with the same 2D placement as in TR 38.901 and TR 38.824.  |
| Channel model  | UC-2: InF-DH > InD-DL > InF-SH > InF-SL | Mandatory: InF-DHOptional: InD-DL, InF-SH, InF-SL |
| Carrier frequency and simulation bandwidth | TDD4 GHz: 100 MHz30 GHz: 160 MHz | As in 5G-ACIA LS |
| TDD DL-UL configuration  | Simulation company should report the used DL-UL configuration. | Companies should report the used DL-UL configuration. 1:1 DL-UL configuration is recommended. |
| Number of UEs per service area | Up to 50 per service area, e.g., 10, 20, 40, and 50 | As in 5G-ACIA LS |
| UE distribution  | All UEs randomly distributed within the respective service area. | As in 5G-ACIA LS |
| Message size  | 48 bytes | 48 bytes |
| DL traffic model  | DL traffic arrival with option-1, option-2, and option-3. | 5G-ACIA Option 1 is mandatory |
| UL traffic model  | UL traffic is symmetric with DL, and DL-UL traffic arrival time relationship with option-1 and option-2 | 5G-ACIA Option 1 is mandatory |
| CSA requirements  | UC-#2: 99.9999% | UC-#2: 99.9999% |
| Performance metrics | 1) CSA: single CDF of CSA distribu-tion of all UEs in factory hall2) Latency: single CDF of latency distribution of all UEs in factory hall3) Percentage of UEs satisfying requirements 4) resource utilization | As in 5G-ACIA LS with 3) and 4) as low priority |
| E2E latency & air interface latency | E2E latency: 1 ms for UC#2Air interface latency: 1ms | As in 5G-ACIA LS |
| UE speed | Linear movement | Linear movement: 75 km/hNo explicit UE mobility (nor handovers) are modeled in the evaluations. |

1. Agree on the proposals for simulation assumptions given in the table

Intel also raised additional simulation parameters that should be agreed on, like antenna configuration, noise figures, TX power etc. Those seem to be already captured in TR 38.824 and can then be reused.

1. Additional simulation parameters are taken from TR 38.824.

## 2.4 Companies comments to proposals

Companies can add comments on the proposals in the table.

|  |  |
| --- | --- |
| Company | View |
| HW/HiSi | We have some questions for our understanding of the proposals. It would be great if that could be clarified before agreeing on the assumptions, so that we are all on the same page what we would be agreeing to:**CSA requirements.**We think the proposed CSA *= 99.9999%* requirement seems fine. But we have questions to Ericsson on the “*equivalently: BLER <=1e-3”** One question is if you please could elaborate on the equivalent BLER requirement? Is the understanding correct that you obtained the value of 10^-3 by assuming uncorrelated errors? If errors would appear in bursts, then the BLER <= 10^-3 would not be valid, is this understanding correct?
* Could you please clarify on the intention of using BLER = 10^-3? Is the purpose to shorten the simulation time so that substantially less packets are generated than what would be done when using CSA=99.9999%?

**Performance metric**In our view metric#1 from 5G-ACIA is clear and should be agreed. We think on the other hand, that metric #4 is more important than metric#2. Or at least the importance of metric#2 depends on which strategy shall be adopted for the packet transmission. Intel provided two options that are copied below, If option 2 is adopted (which we think would be meaningful), then the latency is cut after the deadline, and it would not be useful to adopt metric 2) in this case.

|  |
| --- |
| From Intel’s input. * + Option 1: a packet transmission can be performed after the latency deadline. The collected statistics can exceed the latency requirement.
	+ Option 2: a packet transmission cannot be performed after the latency deadline. The collected statistics cannot exceed the latency requirement. The packets exceeding the deadline are visible in the UE packet error statistics
 |

**On E2E latency and air-interface latency**We are not sure if the LS can be interpreted as that the entire E2E latency should be given to the air interface. In our understanding, 5G-ACIA has not done such a breakdown. We would like to discuss it further and clarify.5G-ACIA has written in their LS in Section 5.1.3: “*Typically, end-to-end latency in service application level is affected by both core network latency and RAN part latency. It is assumed that the CN included latency can be negligible in this WI. As a result, this WI focuses on the latency performance of the RAN. The RAN latency performance is affected by multiple RAN system parameters, e.g. system capacity, user load,….,the wireless communication system is controlled to achieve different desired performance trade-offs* ”In our understanding, this paragraph is not about the latency requirement and how to divide the requirement between CN and RAN. Instead it is about the latency performance and describes which latency part shall be modeled in the simulations. The CN part will not change due to different resource allocation strategies. 5G-ACIA has not performed a split of the E2E delay budget into the CN part and the air-interface part. Still some portion should be reserved for the CN and some portion for the air-interface. When it is said that in this WI the CN latency is negligible, it means in our understanding that the latency performance evaluation shall focus on impact the air-interface part (since the CN latency will remain constant). In other words the CN latency shall not be studied or simulated, it is constant but not zero.**UE speed**Is it common understanding that in simulations the 75 km/h linear movement are only used for the fast fading modeling, the object positions are not changing?**DL traffic model**Our observation is that companies might have a different understanding about Option 1. We are not sure about this and would like to clarify. Possible understandings about Option 1:* Understanding #1: The data to each UE has a random offset that has no relationship to other UE’s offset. That means that traffic to two UEs could happen at the same time if they happen to have the same offset, it could have a slightly different offset or large offset. Once the randomly chosen offset to one UE is set, it will be the same in each slot for this UE.
* Understanding #2: In the feedback from Nokia it is written ”*option 1 uniformly ‘spreads’ the traffic across all available TTIs/mini-slots thus significantly better performance is expected*”. We read this that the traffic to the UEs is evenly distributed throughout the slot. For example, if the cycle time is 1ms and there are K UEs being served, then the packet arrival time of UE #n is (n-1)/K\*1ms. @Nokia: Have we understood your intention correctly?

In case that Option1 is described by Understanding #1, we would expect significant disadvantages coming with this model, e.g like shown below, and would not prefer it.* The timing offsets between Ues is different and random. It will be hard to calibrate results across companies. We think it would be better to start with something more deterministic and fully random offsets cold be added optionally.
* The simulation effort of such an approach is more intense
* In realistic applications at least some devices are synchronized
 |

# 3 Features to include in simulations

## 3.1 Company input

Companies’ input is summarized in the table below.

|  |  |
| --- | --- |
| Company | View |
| Ericsson  | Rel-15 is baseline. Rel-16 enhancements can be considered.The following to be simulated for FR1:* UL CG with one configuration is assumed to achieve 1 ms latency in UL.
* DL SPS with one configuration is assumed to achieve 1 ms latency in DL.
* UE Capability: Capability #2
* (Optional) PDCCH performance of monitoring span (7,3) for FDD.
	+ If TDD has to be used for FR1, PDCCH performance of monitoring span (2,2)

The following to be simulated for FR2:* UL CG with one configuration is assumed to achieve 1 ms latency in UL.
* DL SPS with one configuration is assumed to achieve 1 ms latency in DL.
 |
| Huawei, HiSilicon  | The following Rel-16 URLLC enhancements are included in the evaluations.* DCI enhancements,
* UCI enhancements, sub-slot based HARQ-ACK codebook,
* DL SPS with one slot periodicity.
 |
| Intel  | * A set of URLLC features for evaluation include any feature specified in NR Release 15 and 16.
	+ Being studied and/or specified Release 17 features are not considered for this activity
 |
| Nokia | For the performance evaluation of the motion control use case, the following NR features are considered:* With high priority:
	+ UL and DL mini-slots of 2, 4 or 7 OFDM symbols
	+ Configured UL grants
	+ UE Processing capability 2
* With medium priority:
	+ URLLC MCS table and CQI reports with 1E-5 BLER target
	+ DL Semi-persistent scheduling
* With low priority:
	+ PDCP duplication / joint multi-TRP DL transmissions

Other features can be ‘implicitly’ modeled as follows:* Short DCI format x\_2 resulting in reduced PDCCH overhead as compared to legacy x\_0 and x\_1 DCI formats.
* Sub-slot HARQ-ACK for potentially faster HARQ-ACK retransmission delay
 |
| Qualcomm | We would like to highlight the last two features as they have high potential to enhance performance of Factory automation:* Setting 1ms periodicity for configured scheduling (CS) of DL IIoT traffic is an effective method to reduce control overhead given that most of IIoT data traffic is deterministic and periodic.
* Using Multi-TRP as an optional feature to be considered, which has been shown useful if blocking is modeled
 |
| ZTE | Our views on possible Rel-16 URLLC features to be included in the evaluations are:* PDCCH enhancement
* Multiple HARQ-ACK transmission in one slot
* PUSCH repetition type B
* Multiple SPS configurations/Shorter SPS periodicities
* Multiple CG configurations
 |

##  3.2 Discussion and proposals

Most companies only address which Rel-16 enhancement to include in the evaluations while there is less discussion on the Rel-15 URLLC features. However, it is assumed that all companies assume Rel-15 as the baseline.

1. Rel-15 URLLC features are assumed as baseline for the simulations

Regarding what Rel-16 features to include in the simulations, the views seems rather scattered, though there seems to be rather good support for the following:

1. Include the following Rel-16 features in simulations:
* UL configured grant
* DL SPS
* Multiple HARQ-ACK transmission in one slot

Further discussion on refinement of these can be done during the week. Again, companies are as always free to submit additional results that they find relevant to the evaluations.

## 3.3 Companies comments to proposals

Companies can add comments on the proposals in the table.

|  |  |
| --- | --- |
| Company | View |
| HW/HiSi | Regarding the first bullet of Proposal 4, is it meant “multiple CG configurations”? In that case we are wondering if the benefit of having multiple configurations could be clarified when only one service is assumed to be supported in the UE? |

# 4 Conclusions

This document provided a summary of the input on 5G-ACIA simulation assumptions and features. The following proposals are made:

Proposal 1 Agree on the proposals for simulation assumptions given in the table

Proposal 2 Additional simulation parameters are taken from TR 38.824.

Proposal 3 Rel-15 URLLC features are assumed as baseline for the simulations

Proposal 4 Include the following Rel-16 features in simulations:

 UL configured grant

 DL SPS

 Multiple HARQ-ACK transmission in one slot

# References

1. [RP-202069](https://protect2.fireeye.com/v1/url?k=41a5db26-1f051960-41a59bbd-86fc6812c361-73f443258ff773bf&q=1&e=bc078f84-983d-45f3-ab31-19e60d911036&u=https%3A%2F%2Fwww.3gpp.org%2Fftp%2Ftsg_ran%2FTSG_RAN%2FTSGR_89e%2FDocs%2FRP-202069.zip), “Way forward on RAN work for 5G ACIA requested simulations“, Ericsson
2. “[Simulation Assumptions and URLLC Features for 5G-ACIA Performance Evaluation](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Company%20Inputs/Ericsson%205G-ACIA%20URLLC%20simulation%20assumptions%20%26%20features.docx)”, Ericsson
3. “[Discussion on URLLC and IIoT features for performance evaluation in response to 5G-ACIA”,](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Company%20Inputs/HWHiSi%20-%205G%20ACIA%20URLLC%20simulation%20assumptions%20and%20features.docx) Huawei, HiSilicon
4. “[5G-ACIA LS – Phase 1 input](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Company%20Inputs/INTEL%20-%205G-ACIA%20LS%20-%20Phase%201%20inputs.docx)”, Intel Corporation
5. “[Features and simulation assumption for 5G ACIA URLLC LS response](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Company%20Inputs/NOKIA%20-%205G-ACIA%20URLLC%20features%20and%20sim%20assumptions.zip)”, Nokia, Nokia Shanghai Bell
6. “[Features and simulation assumption for 5G ACIA URLLC LS response](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Company%20Inputs/QUALCOMM-5G-ACIA%20URLLC%20features%20and%20simulation%20assumptions%20.docx)”, Qualcomm CDMA Technologies
7. “[Views on URLLC features and simulation assumptions for 5G-ACIA evaluations](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_90e/Inbox/Drafts/5G-ACIA%20October/Company%20Inputs/ZTE-Views%20on%20URLLC%20features%20and%20simulation%20assumptions%20for%205G-ACIA%20evaluations.docx)”, ZTE