**3GPP TSG RAN WG1#104e R1-21XXXX**

**E-meeting, 25 January – 5 February 2021**

Agenda Item: **8.9.3**

Source: **Moderator (Sony)**

Title: **Feature Lead Summary [104-e-LTE-Rel17\_NB\_IoT\_eMTC-03] 1st check point**

Document for: **Discussion**

# Introduction

This document is the feature lead (FL) summary for the “ Support a maximum DL TBS of 1736 bits as a Rel-17 optional UE capability” agenda item 8.9.3 in RAN1#104e.

The LTE-MTC objective on support for Support a maximum DL TBS of 1736 bits as a Rel-17 optional UE capability was added to the Work Item (WI) on “Additional enhancements for NB-IoT and LTE-MTC” in RAN# 88-e [1]:

|  |
| --- |
| * *Add a Rel-17 optional UE capability to support* *a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A only. [LTE-MTC] [RAN1, RAN2]*   + *Determine soft buffer size [RAN1]*   + *Capability signaling without introducing a new UE category [RAN2]*   + *There shall be no changes to: DCI formats, TBS tables, CQI tables*   + *This objective begins work from RAN#90, i.e. December 2020* |

This document aims to provide a consolidated list of issues that have been identified for the support of a 1736 DL TBS in eMTC.

In the first round of email discussion, companies are invited to answer the questions in sections 2.x.1. The questions are highlighted in cyan.

Timeline: This topic is likely to be discussed at the GTW2 call on Thursday 28 January. There is an email discussion checkpoint on Wednesday 27 Jan. It would be appreciated if companies could provide their inputs by 1700 UTC on Wednesday 27 Jan.

Note for GTW online session on Thursday 28 January:

* Proposals to be discussed are in sections marked with [GTW1] in the name of the heading

# Overview of Issues from Tdocs

The following issues were identified in input Tdocs:

* Number of soft channels bits
* Combinations of features that support 1736 bit DL TBS
* Usage scenarios and potential benefits for 1736 bit DL TBS
* Specification changes required to support 1736 bit DL TBS
* Capability

## Issue#1: Number of soft channel bits

Table 1 lists the different identified potential methods for determining the number of soft channel bits and the rationales behind these methods.

Table – Proposed numbers of soft channel bits for support of 1736 bit DL TBS

|  |  |  |
| --- | --- | --- |
| **Number of soft channel bits** | **Rationale** | **companies** |
| 30720 | Based on number of soft channel bits in a physical allocation.  160\*NPRB\*Q\*N, where:  NPRB = 6  Q is max bits / symbol = 4 (16QAM)  N = number of HARQ processes  *FL note: does this account for incremental redundancy?*  *FL note2: does “160” assume no legacy control region and 1 antenna port?* | Sierra Wireless (section 3) |
| 43008 | Assume 8 HARQ processes.  Note that for the 10 HARQ process feature in Rel-14, 8 HARQ processes was used to determine soft buffer size. | HW-HiSi (section 2), ZTE (proposal 4),  Qualcomm (section 3) |
| 43998 | Scaling the Rel-13 soft buffer size by a factor of 1736 / 1000.  Note: assumes soft buffer size is based on 8 HARQ processes.  *FL note: this method does not take into account that CRC size and number of tail bits are constant and do not scale* | NOK-NSB (observation 3), Ericsson (obs 6) |
| 44352 | FBRM using  N = number of HARQ processes = 14  X = TBS = 1000  Note: if the “14 HARQ processes” AI agreed on FBRM with 14 HARQ processes, there would be 44352 soft channel bits. 1736 DL TBS could use the same number of soft channel bits with the larger TBS (and presumably with LBRM) | NOK-NSB (observation 4) |
| 53760 | FBRM using  N = number of HARQ processes = 10  X = TBS = 1736 | NOK-NSB (observation 4), Ericsson (obs 7) |
| 75264 | FBRM using  N = number of HARQ processes = 14  X = TBS = 1736 | NOK-NSB (observation 4), Ericsson (obs 7) |

**Tradeoffs**

The following tradeoffs are considered in input documents:

* Larger soft buffer size increases peak data rate
  + FL note: the peak data rate can be obtained without HARQ, so this benefit is not clear cut
* Larger soft buffer size increases UE complexity
* Larger soft buffer sizes (than Rel-13: 25344 bits) may require a hardware update
* Smaller soft buffer size reduces performance (LBRM)

**Specification change to support new soft buffer size**

Qualcomm propose the following specification change for support the new number of soft channel bits.

Since we are not introducing a new UE category in TS 36.306, we can specify the new soft buffer size directly in TS 36.212 as follows:

If the UE signals *ue-CategoryDL-v14xy* indicating UE category M2, *N*soft is the total number of soft channel bits according to the UE category indicated by *ue-CategoryDL-v14xy*. Otherwise, if the UE signals *ce-largerDLTBS-r17 N*soft = 43008. Otherwise, if the UE signals *ue-CategoryDL-v1310* indicating UE category M1, *N*soft is the total number of soft channel bits according to the UE category indicated by *ue-CategoryDL-v1310*.

### FL view on number of soft channel bits

Most companies prefer to base the number of soft channel bits on an FBRM (full buffer rate matching) equation. The equation has the form:

Where:

*N* = number of HARQ processes

*X* = DL TBS

The other alternatives are to base the number of soft channel bits on either (1) the number of physical bits in a 6 PRB allocation, (2) scale by a factor of 1736 / 1000 relative to the soft buffer size for TBS = 1000, or (3) the number of soft channel bits for 14 HARQ processes using TBS = 1000.

Basing the number of soft channel bits on the FBRM equation seems reasonable, in keeping with legacy methods for determining the number of soft channel bits and the values derived are essentially similar to other methods.

Question 2.1.1-1: Should the number of soft channel bits be based on the FBRM equation:

?

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / disagree** | **Comment**  **(if not, what alternative; values of X, N)** |
| Qualcomm | See comments | While we agree with the question, we think it would be much easier to just agree on the number 43008 (i.e., assuming N = 8, as has been done since Release 8). The value of X is the maximum TBS as specified in the WID. |
| Ericsson | See comment | We are ok with the proposal/question but we should incorporate to it that the value of “” is FFS.  If we use “” the equation provides 43008 soft channel bits, which in principle seems useful towards reducing cost/complexity, but we need to be sure that the performance degradation is not too significant. If we keep “” as FFS we can evaluate the achievable throughput vs SNR for a given number of allocated PRBs for different values of “” as to compare the performance. |
| ZTE |  | According to the equation, the number of soft channel bits is (assuming N=8 and X= 1736) |
| Nokia, NSB | Yes | We agree on the proposed equation to determine the number of soft channel bits. We share similar view as Ericsson that we should discuss that value of N to be used. |
| Sierra Wireless | Yes | We agree on the proposal.  Since there is strong precedence to use N=8 when calculating soft buffer, it would be good to go further and also agree that N=8.  I would not like to have different soft buffers specified when enabled with other features e.g. 10 HARQs feature. |
| SONY | Yes | Agree with the proposal.  Our preference is to have N=8 to minimize the hardware impact. At this stage, we are OK to have N=FFS. The FFS is resolved by taking into consideration:   * Hardware impact * Performance impact * Compatibility with other features (e.g. 10 HARQs)   We think that X=1736 can be agreed. |
| FL summary |  | Companies seem fine with calculating the number of soft channel bits be based on the FBRM equation:  There seems to be agreement that X = 1736.  Some companies want to consider further the value of N, so it seems appropriate to leave this value as FFS.  The FL proposal should thus be:  The number of soft channel bits is calculated based on the equation:   * FFS: value of ‘N’ |

### [GTW1] Updated FL proposal on number of soft channel bits [update1]

**Background**

In Release-13, the number of soft channel bits is determined based on an FBRM (full buffer rate matching) equation. The equation has the form:

This FBRM equation is the equation that has been used in eMTC since Release-13. It is based on consideration of the number of bits produced at the output of the Turbo encoder over ‘N’ HARQ processes:

* X = maximum transport block size
* N = number of HARQ processes
* 28: accounts for CRC bits (24) and tail bits (4)
* 32: scales to a round number for memory accesses in implementation
* Ceil() function: creates an integer number of 32-bit words in memory
* 96: 32 (as before) \* 3 (mother code rate = 1/3)

In Release-13 for Cat-M1, application of this equation with X = 1000 bits and N = 8 leads to 25344 soft channel bits, as specified in TS36.306.

In Release-14, 10 HARQ processes were supported for Cat-M1 UEs, but the number of soft channel bits did not change (the number of soft channel bits was still based on 8 HARQ processes).

There is agreement that this FBRM equation should be used to determine the number of soft channel bits when there is a 1736 bit DL TBS. It is agreed that X=1736 bits should be applied in the equation. Companies have different views on the value of ‘N’ to apply: the number of HARQ processes used to calculate the number of soft channel bits. The main choices are:

* N = 8. This leads to 43008 soft channel bits
* N = 14. This leads to 75264 soft channel bits

The choice between these values of ‘N’ revolve around:

* Hardware impact
* Performance impact
* Logic / precedent (if N=8 was used in the “10 HARQ process” feature, then why wouldn’t we do the same now?).

Companies need some time to decide on a value of ‘N’, hence it is proposed to leave the value of ‘N’ as FFS.

**Proposed agreement**

The number of soft channel bits is calculated based on the equation:

FFS: value of ‘N’

Space to provide comments on updated proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
| Ericsson | The proposed agreement is ok with us. |
| Huawei, HiSilicon | Support the proposed agreement. From our understanding, N = 8 is sufficient even for 14 HARQ processes, there’s very low probability that more than 8 HARQ processes fail, and assuming N>8 increases UE complexity. |
| ZTE | Fine with the Proposal. Our preference is N=8. |

**Proposals and observations in input documents**

Proposal 1: The soft channel bits for UEs supporting maximum DL TBS of 1736 bits is 43008 bits. HW-HiSi

Observation 3: The total number of soft channel bits for supporting an increased maximum TBS of 1736 bits based on scaling the total number of soft channel bits specified for supporting a maximum TBS of 1000 bits is 43988. NOK-NSB

Observation 4: The total number of soft channel bits calculated based on a Turbo encoder with mother coding rate of 1/3 as

* 53760 for a maximum DL TBS of 1736 bits and 10 HARQ processes → a factor of ~2.12 increase compared to a legacy UE;
* 75264 for a maximum DL TBS of 1736 bits and 14 HARQ processes → a factor of ~2.97 increase compared to a legacy UE;
* 44352 for a maximum DL TBS of 1000 bits and 14 HARQ processes → a factor of 1.75 increase compared to a legacy UE; NOK-NSB

Proposal 4: Further study the tradeoffs between cost and benefits for different soft buffer size candidates for the increased maximum DL TBS of 1736 bits. Nokia-NSB

Proposal 4: New soft buffer size may be defined based on the maximum TBS of 1736 bits and 8 HARQ processes. ZTE

Observation 2: The soft buffer size for the support of a 1736 bit DL TBS should minimize impact on implementation. Ideally, it should be possible to support a 1736 bit DL TBS on existing hardware. SONY

Observation 3: The soft buffer size for the support of a 1736 bit DL TBS does not have to be directly related to the number of physical channel bits available in an allocation. SONY

Proposal 1: When calculating the soft buffer size for the 1736 DL TBS feature, 8 HARQs and 16QAM can be assumed. Sierra Wireless

Proposal 2: The soft buffer size for the 1736 DL TBS feature should be set to 30720 bits. Sierra Wireless

Proposal 2: LBRM is not applied for UEs supporting 1732 max TBS. Qualcomm

Proposal 3: The soft buffer size for category M1 UEs supporting 1732 bits TBS is 43008. Qualcomm

Observation 6 If the current soft buffer size designed for 8 processes, upgraded in Rel-14 to support the 10 processes were simply scaled up according to the larger TBS, then 43998 soft channel bits are estimated to be required. Ericsson

Observation 7 Using an equation that accounts for the number of HARQ processes and the coding rate of the turbo encoder, the required soft buffer size was estimated:

* For 10 HARQ processes: In principle, 53760 soft channel bits are estimated to be required.
* For 14 HARQ processes: In principle, 75264 soft channel bits are estimated to be required. Ericsson

Observation 8 The total number of soft channel bits for Rel-13 Cat-M1 is 25344. In Rel-17, the soft buffer size is at most expected to be increased about 2.12 times for 10 HARQ processes and 2.96 times for 14 HARQ processes to provide peak data rates of ~1.02 Mbps and ~1.23 Mbps respectively. Ericsson

Proposal 2 Discuss the soft buffer size estimated to be required for 10 and 14 HARQ processes (53760 and 75264 soft channel bits respectively), and the feasibility and advantages (e.g., cost reduction) of using a smaller soft buffer size than the ones derived theoretically. Ericsson

## Issue#2: Combinations of features that support 1736 bit DL TBS

Some companies discussed which features should be supported in combination with a 1736 bit DL TBS, as listed in Table 2.

Table – Features that may be supported in combination with 1736 bit DL TBS

|  |  |
| --- | --- |
| **Feature supported in combination with 1736 bit DL TBS** | **Comments** |
| 64QAM | 1736 bits and 64QAM are both features that operate in good coverage  64QAM allows both MPCCH and PDSCH in the same subframe, improving data rates  Widespread support among companies |
| Multi-TB scheduling | Required to support a 1Mbps data rate, according to envisaged use cases.  What is the spec impact? |
| HARQ-ACK bundling | Required to support a 1Mbps data rate, according to envisaged use cases.  What is the spec impact? |
| 14 HARQ process capability | Required to support a 1Mbps data rate, according to envisaged use cases.  What is the spec impact (soft buffer size?) |

Some of the features listed in the table above are required to support a 1Mbps data rate, or at least to enhance data rates.

At the end of the work item, there will need to be a “UE features” discussion, where it is discussed with which existing UE features the 1736 bit DL TBS feature should work. It would be useful to determine if there are other spec impacts at this stage of the work.

### FL view on combinations of features that support 1736 bit DL TBS

64QAM should be assumed as baseline for 1736 bit DL TBS.

Multi-TB scheduling, HARQ-ACK bundling and 14 HARQ process capability are all useful for increasing the data rate and so should be considered in combination with a 1736 bit DL TBS. The issue is whether there are any specification impacts from these combinations, other than to UE feature lists and the impact on soft buffer sizes?

Question 2.2.1-1: Should 64QAM be supported with 1736 bit DL TBS?

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / disagree** | **Comment**  **(if not, why not?)** |
| Qualcomm | Yes | Unless something is broken, we do not think we have to agree one by one to all the features we have to support / not support. By default, and in line with the WID scope, this is just the introduction of a new capability and a soft buffer size determination. |
| Ericsson | Yes |  |
| ZTE | Yes | Similar view as Qualcomm |
| Nokia, NSB | Yes | We share similar view as Qualcomm |
| Sierra Wireless | Yes | We share similar view as Qualcomm so perhaps we can make a WA stating that this feature should be compatible with all other features. As a WA this allows companies to then go and check something is broken which are not acceptable.  WA: |
| SONY | Yes | We are also OK with a working assumption that the 1736 but DL TBS feature is compatible with all other features. |
| SONY2 |  | There are some very minor things in the specs which might need updating, such as the “.” issue in question 2.4.1-2. This is related to 64QAM support. |

Question 2.2.1-2: What are the potential specification impacts of supporting 1736 bit DL TBS in combination with Multi-TB scheduling?

|  |  |
| --- | --- |
| **Company** | **Potential impact**  **(e.g. UE feature list, soft buffer size)** |
| Ericsson | Perhaps we can have a single Working Assumption encompassing all the features that have been explicitly considered to be used “in combination with a 1736 bit DL TBS” (i.e., 64-QAM, Multi-TB scheduling, HARQ-ACK bundling and 14 HARQ processes), so companies can check if there are any potential specification impacts that could make any of the proposed features unfeasible to be supported, and if that were not the case then we can just confirm the WA in the next meeting. |
| SONY | We are OK with the “working assumption” approach from Ericsson. |
|  |  |

Question 2.2.1-3: What are the potential specification impacts of supporting 1736 bit DL TBS in combination with HARQ-ACK bundling?

|  |  |
| --- | --- |
| **Company** | **Potential impact**  **(e.g. UE feature list, soft buffer size)** |
| Ericsson | See Ericsson’s comment above. |
|  |  |
|  |  |

Question 2.2.1-4: What are the potential specification impacts of supporting 1736 bit DL TBS in combination with 14 HARQ process capability?

|  |  |
| --- | --- |
| **Company** | **Potential impact**  **(e.g. UE feature list, soft buffer size)** |
| Ericsson | See Ericsson’s comment above. |
| SONY | While we are OK with the working assumption approach, our concern is whether 14 HARQ processes should be considered when determining soft buffer sizes. |
|  |  |

### Updated FL proposal on combination of features [update1]

**Background**

Some input documents considered whether a 1736 bit DL TBS should work with certain other features from previous releases and Rel-17, namely:

* 64QAM
* Multi-TB scheduling
* HARQ bundling
* 14 HARQ processes

There was general agreement that the 1736 bit DL TBS should work with all existing eMTC features. Hence it is proposed to add a note in the chairman’s notes:

“NOTE: It is RAN1 assumption that 1736 DL TBS feature is compatible with all other eMTC features.”

**Proposed agreement**

Capture in the chairman’s notes that:

“NOTE: It is RAN1 assumption that 1736 DL TBS feature is compatible with all other eMTC features.”

Space to provide comments on updated proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
| Ericsson | Please append the word “bits” to 1736.  Moreover, I believe is better to state “… is compatible with all other eMTC features applicable for HD-FDD Cat. M1 UEs in CE mode A”. |
| Huawei, HiSilicon | We agree with Ericsson’ modification. Noting the scope of this objective in the WID as below. We suggest to add this in the note as : “… is compatible with all other eMTC features applicable for HD-FDD Cat. M1 UEs in CE mode A if there’s no changes to DCI formats, TBS tables and CQI tables.”   * + *There shall be no changes to: DCI formats, TBS tables, CQI tables*   Then the modification is as below:  “NOTE: It is RAN1 assumption that 1736 DL TBS feature is compatible with all other eMTC features applicable for HD-FDD Cat. M1 UEs in CE mode A if there’s no change to DCI formats, TBS tables and CQI tables.” |
| ZTE | Fine with Ericsson and Huawei’s update |
| FL comment | In the [update2] below, I have tried to account for Ericsson’s comments, which seem to be OK for ZTE and Huawei too.  I think that adding the “if there’s no change to DCI formats, TBS tables and CQI tables” from Huawei doesn’t move us forwards. The WID is clear that there are no changes to DCI formats, TBS tables and CQI tables, so there is no ambiguity that requires an “if”. Additionally, if we have the “if statement” here, then it implies that RAN1 needs to look at compatibility for any case where there was a change to DCI formats / TBS tables / CQI tables.  I am confident that everyone is in line with the WID.  Hopefully the updated proposal below is acceptable to all. |

### [GTW1] Updated FL proposal on combination of features [update2]

**Background**

Some input documents considered whether a 1736 bit DL TBS should work with certain other features from previous releases and Rel-17, namely:

* 64QAM
* Multi-TB scheduling
* HARQ bundling
* 14 HARQ processes

There was general agreement that the 1736 bit DL TBS should work with all existing eMTC features. Hence it is proposed to add a note in the chairman’s notes:

“NOTE: It is RAN1 assumption that 1736 DL TBS feature is compatible with all other eMTC features.”

**Proposed agreement**

Capture in the chairman’s notes that:

“NOTE: It is RAN1 assumption that the 1736 bits DL TBS feature is compatible with all other eMTC features applicable for HD-FDD Cat. M1 UEs in CE mode A.”

Space to provide comments on updated-2 proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
|  |  |
|  |  |
|  |  |
|  |  |

**Proposals and observations in input documents**

Proposal 3: A maximum DL TBS of 1736 bits is supported both with and without configuration of 64-QAM for PDSCH. NOK-NSB

Observation 1: The following features can be used for determining the soft buffer size for a 1736 bit maximum DL TBS:

* Multi-TB scheduling
* Increased number of HARQ processes with HARQ bundling. Either 10 or 14 HARQ processes can be supported
* 64QAM SONY

Proposal 3: The 1736 DL TBS feature shall support the HARQ-ACK bundling Capability Sierra Wireless

Proposal 4: The 1736 DL TBS feature shall support the Multi-TB grant Capability. Sierra Wireless

Proposal 5: The 1736 DL TBS feature shall support the 64 QAM feature *ce-PDSCH-64QAM-Config-r15* Sierra Wireless

Proposal 6: The 1736 DL TBS feature shall support the 14 HARQ Capability Sierra Wireless

Proposal 1 The new larger DL TBS of 1736 bits should be usable along with the following combinations:

• The Rel-13 TBS table (6 PRBs) should be used with Rel-16 Multi-TB scheduling along with Rel-14 HARQ-ACK bundling and up to 8 HARQ processes. Ericsson

• The Rel-15 (64QAM) TBS table (3 or 4 PRBs) should be used with 1) Single-TB scheduling along with Rel-14 HARQ-ACK bundling and up to 10 or 14 HARQ processes, 2) Multi-TB scheduling along with Rel-14 HARQ-ACK bundling and up to 8 HARQ processes. Ericsson

## Issue#3: Usage scenarios and potential benefits for 1736 bit DL TBS

Ericsson and Sierra Wireless considered some of the usage scenarios and potential benefits of supporting a 1736 bit DL TBS. While these usage scenarios may not impact the design of the baseline 1736 bit DL TBS feature, they may impact the combination of features that can be applied together with a 1736 bit DL TBS.

A peak data rate target of 1Mbps was identified as a goal. Some combinations allowing support for a peak data rate of 1Mbps were identified.

The following potential additional benefits of the 1736 bit DL TBS feature were envisaged:

* Higher spectral efficiency
  + Reduction in the number of HARQ processes to complete a transmission
  + More efficiently handle RRC reconfiguration messages of over 1000 bits
* Power consumption reduction

### FL view on usage scenarios for 1736 bit DL TBS

In order to aid the design of the 1736 bit DL TBS feature, it might be useful to have a common goal for the peak data rate. This peak data rate would be achieved in combination with other Rel-16 [and potentially Rel-17 features].

Question 2.3.1-1: Should the 1736 bit DL TBS feature strive to achieve a peak data rate of 1Mbps?

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / disagree** | **Comment**  **(if not, what should be the peak data rate goal?)** |
| Ericsson | See comment | The use of a TBS = 1736 bits is not strictly tied to achieving a higher UE throughput, since it provides an spectral efficiency increase, and even gains in terms of UE power consumption.  But talking about “achieve a peak data rate”, in RAN# 88e (See RP-201288) a set of use cases were discussed to justify the support of “a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A”, where 1 Mbps was the peak data rate required for the identified use cases. |
| ZTE |  | No need to discuss the peak data rate |
| Nokia, NSB |  | We share similar view as ZTE |
| Sierra Wireless |  | Agree with ZTE. |
| SONY |  | We are OK with not discussing a peak data rate. |

### Conclusion on usage scenarios [update1]

**Conclusion**

There is no need to discuss the peak data rate that is achieved with the 1736 bit DL TBS. Such a discussion would consume time and not impact the specification.

Space to provide comments on updated proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
| Huawei, HiSilicon | We agree that there’s no need to discuss this. |
| FL comment | Thanks. I think there is no need to bring this up in GTW or to discuss this point further in future meetings. |

**Proposals and observations in input documents**

Observation 1 Enabling the use of a TBS = 1736 bits is not strictly tied to achieving a higher UE throughput, since the spectral efficiency increase it provides is useful for other scenarios, e.g., to reduce the number of required HARQ processes to complete a transmission, to handle more efficiently RRC reconfiguration messages over 1000 bits, etc. Ericsson

Observation 2 The use of a larger TBS provides gains in terms of UE power consumption, since a less amount of time having the UE’s transmitter/receiver active translates into battery savings. Ericsson

Observation 3 In RAN# 88e a set of use cases were discussed to justify the support of “a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A”, where 1 Mbps was the peak data rate required for the identified use cases. Ericsson

Observation 4 The Rel-13 TBS table with 6 PRB and Rel-16 multi-TB scheduling with HARQ-ACK bundling can support ~1 Mbps (992 kbps). Ericsson

Observation 5 The Rel-15 (64QAM) TBS table with 3 or 4 PRBs and single-TB scheduling with Rel-14 HARQ-ACK bundling can support ~1.02 Mbps with 10 HARQ processes and ~1.23 Mbps with 14 HARQ processes. Ericsson

## Issue#4: Specification changes to support a 1736 DL TBS using current MCS tables

A 1736 bit DL TBS can be supported using the combinations of *ITBS*, modulation order and *NPRB* below:

* 16QAM, *ITBS* = 14, *NPRB* = 6
* 64QAM, , *NPRB* = 3,4

Note that other values of *ITBS* and *NPRB* provide TBS values between 1000 bits and 1736 bits.

For 16QAM, Table 3 below shows in yellow the {*ITBS*, *NPRB*} combinations that lead to a DL TBS of 1736 bits. The entries in green show the {*ITBS*, *NPRB*} combinations that lead to a DL TBS of greater than 1000 bits.

Table From Table 7.1.7.2.1-1 in TS36.213v16.4.0: Transport block size table showing increased TBS sizes for Rel-17 with 16QAM

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | 16 | 32 | 56 | 88 | 120 | 152 |
| 1 | 24 | 56 | 88 | 144 | 176 | 208 |
| 2 | 32 | 72 | 144 | 176 | 208 | 256 |
| 3 | 40 | 104 | 176 | 208 | 256 | 328 |
| 4 | 56 | 120 | 208 | 256 | 328 | 408 |
| 5 | 72 | 144 | 224 | 328 | 424 | 504 |
| 6 | 328 | 176 | 256 | 392 | 504 | 600 |
| 7 | 104 | 224 | 328 | 472 | 584 | 712 |
| 8 | 120 | 256 | 392 | 536 | 680 | 808 |
| 9 | 136 | 296 | 456 | 616 | 776 | 936 |
| 10 | 144 | 328 | 504 | 680 | 872 | 1032 |
| 11 | 176 | 376 | 584 | 776 | 1000 | 1192 |
| 12 | 208 | 440 | 680 | 904 | 1128 | 1352 |
| 13 | 224 | 488 | 744 | 1000 | 1256 | 1544 |
| 14 | 256 | 552 | 840 | 1128 | 1416 | 1736 |
| 15 | 280 | 600 | 904 | 1224 | 1544 | 1800 |
| 16 | 328 | 632 | 968 | 1288 | 1608 | 1928 |
| 17 | 336 | 696 | 1064 | 1416 | 1800 | 2152 |
| 18 | 376 | 776 | 1160 | 1544 | 1992 | 2344 |
| 19 | 408 | 840 | 1288 | 1736 | 2152 | 2600 |
| 20 | 440 | 904 | 1384 | 1864 | 2344 | 2792 |
| 21 | 488 | 1000 | 1480 | 1992 | 2472 | 2984 |
| 22 | 520 | 1064 | 1608 | 2152 | 2664 | 3240 |
| 23 | 552 | 1128 | 1736 | 2280 | 2856 | 3496 |
| 24 | 584 | 1192 | 1800 | 2408 | 2984 | 3624 |
| 25 | 616 | 1256 | 1864 | 2536 | 3112 | 3752 |
| 26 | 712 | 1480 | 2216 | 2984 | 3752 | 4392 |
| 26A | 632 | 1288 | 1928 | 2600 | 3240 | 3880 |

For 64QAM, Table 4 below shows in yellow the {*ITBS*, *NPRB*} combinations that lead to a DL TBS of 1736 bits, after a “min(TBS’, 1736)” function is applied. The orange entries show how a DL TBS of exactly 1736 bits is achieved. The entries in green show the {*ITBS*, *NPRB*} combinations that lead to a DL TBS of greater than 1000 bits.

Table From Table 7.1.7.2.1-1 in TS36.213v16.4.0: Transport block size table showing increased TBS sizes for Rel-17 with 64QAM

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | 16 | 32 | 56 | 88 | 120 | 152 |
| 1 | 24 | 56 | 88 | 144 | 176 | 208 |
| 2 | 32 | 72 | 144 | 176 | 208 | 256 |
| 3 | 40 | 104 | 176 | 208 | 256 | 328 |
| 4 | 56 | 120 | 208 | 256 | 328 | 408 |
| 5 | 72 | 144 | 224 | 328 | 424 | 504 |
| 6 | 328 | 176 | 256 | 392 | 504 | 600 |
| 7 | 104 | 224 | 328 | 472 | 584 | 712 |
| 8 | 120 | 256 | 392 | 536 | 680 | 808 |
| 9 | 136 | 296 | 456 | 616 | 776 | 936 |
| 10 | 144 | 328 | 504 | 680 | 872 | 1032 |
| 11 | 176 | 376 | 584 | 776 | 1000 | 1192 |
| 12 | 208 | 440 | 680 | 904 | 1128 | 1352 |
| 13 | 224 | 488 | 744 | 1000 | 1256 | 1544 |
| 14 | 256 | 552 | 840 | 1128 | 1416 | 1736 |
| 15 | 280 | 600 | 904 | 1224 | 1544 | 1800 |
| 16 | 328 | 632 | 968 | 1288 | 1608 | 1928 |
| 17 | 336 | 696 | 1064 | 1416 | 1800 | 2152 |
| 18 | 376 | 776 | 1160 | 1544 | 1992 | 2344 |
| 19 | 408 | 840 | 1288 | 1736 | 2152 | 2600 |
| 20 | 440 | 904 | 1384 | 1864 | 2344 | 2792 |
| 21 | 488 | 1000 | 1480 | 1992 | 2472 | 2984 |
| 22 | 520 | 1064 | 1608 | 2152 | 2664 | 3240 |
| 23 | 552 | 1128 | 1736 | 2280 | 2856 | 3496 |
| 24 | 584 | 1192 | 1800 | 2408 | 2984 | 3624 |
| 25 | 616 | 1256 | 1864 | 2536 | 3112 | 3752 |
| 26 | 712 | 1480 | 2216 | 2984 | 3752 | 4392 |
| 26A | 632 | 1288 | 1928 | 2600 | 3240 | 3880 |

### FL view on how 1736 bit DL TBS can be supported using current MCS tables

In order to avoid additional changes to TBS tables, MCS tables and DCI formats, the maximum *ITBS* for 16QAM should remain as ITBS = 14.

* If a higher *ITBS* were supported, a 5-bit modulation and coding scheme field in a DCI format would be required.
* If a 4-bit modulation and coding scheme were reused with different TBS values for Rel-17, new TBS tables or MCS tables would be required

**FL proposal: For support of a 1736 bit DL TBS with 16QAM:**

* **a 4-bit modulation and coding scheme field is used in DCI**
* **maximum ITBS = 14**
* **no change to TBS table relative to Rel-16**
* **no change to CQI table relative to Rel-16**
* **no change to MCS table relative to Rel-16**

In order to avoid additional changes to TBS tables, MCS tables and DCI formats, the maximum TBS for 64QAM should be 1736 bits. There are various value of *ITBS* and *NPRB* that enable a 1736 bit TBS to be supported. The TBS can be determined based on the minimum of (1) 1736 bits and (2) the TBS derived from the TBS tables in TS36.213.

**FL proposal: For support of a 1736 bit DL TBS with 64QAM:**

* **a 5-bit modulation and coding scheme field is used in DCI**
* **TBS is calculated as**
* **no change to TBS table relative to Rel-16**
* **no change to CQI table relative to Rel-16**
* **no change to MCS table relative to Rel-16**

Question 2.4.1-1: Should 1736 bit DL TBS be supported with 16QAM as follows:

* a 4-bit modulation and coding scheme field is used in DCI
* maximum ITBS = 14
* no change to TBS table relative to Rel-16
* no change to CQI table relative to Rel-16
* no change to MCS table relative to Rel-16

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / disagree** | **Comment**  **(if not, what alternative?)** |
| Qualcomm | See comment | There is no need to agree to this, since it is in the WID:  *There shall be no changes to: DCI formats, TBS tables, CQI tables* |
| Ericsson | See comment | Unless we are missing something, as Qualcomm mentioned the WID seems to account for it already. |
| ZTE |  | agree maximum ITBS = 14 for 16QAM |
| Nokia, NSB |  | Similar view as Qualcomm / Ericsson |
| Sierra Wireless |  | Similar view as Qualcomm / Ericsson / Nokia,NSB |
| SONY |  | Agree with other companies that these are all specified in the WID |

Question 2.4.1-2: Should 1736 bit DL TBS be supported with 64QAM as follows:

* a 5-bit modulation and coding scheme field is used in DCI
* TBS is calculated as
* no change to TBS table relative to Rel-16
* no change to CQI table relative to Rel-16
* no change to MCS table relative to Rel-16

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / disagree** | **Comment**  **(if not, what alternative?)** |
| Qualcomm | See comments | The only thing we need to agree is to change the . The rest of the bullets are in the WID. |
| Ericsson | See comment | Similar view as Qualcomm, we need to incorporate the new max of 1736 in TS 36.213. The exact details on how to do it need to be discussed. |
| ZTE |  | For 64QAM, TBS less than or equal to 1736 bits can be used for each NPRB |
| Nokia, NSB |  | Similar view as Qualcomm / Ericsson |
| Sierra Wireless |  | Similar view as Qualcomm / Ericsson / Nokia,NSB |
| SONY |  | Agree with Qualcomm view.  Our thinking is that the only “variable” item is the “.” An alternative approach, that we do not favour, would be to have some complicated list that said:   * *for NPRB = 6, ITBS\_max = 14* * *for NPRB = 5, ITBS\_max = 16* * *etc*   So we are OK with the proposal. |

### [GTW1] Updated FL proposal on specification changes [update1]

**Background**

The current MCS / TBS tables in TS36.213 already supports indicating a larger TBS size, so no changes are needed. The WID also states that the MCS and TBS tables will not be changed.

For 64-QAM, however, the following text is captured in the current TS36.213 specification:

TS 36.213, Section 7.1.7.2

- if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,

- set  to the TBS determined by the procedure in Subclause 7.1.7.2.1,

-

- otherwise

- TBS is determined by the procedure in Subclause 7.1.7.2.1

This part of the specification states that the TBS is:

* first determined by looking up a TBS’ value in a table (Table 7.1.7.2.1-1) that is indexed by parameters *ITBS* and *NPRB*
* then (second step), if the value TBS’ calculated in the first step is greater than 1000 bits, a TBS of 1000 bits is applied

It is clear that for the 1736 bit DL TBS feature, the TBS should be capped at 1736 bits, rather than 1000 bits.

**Proposed agreement**

In TS36.213 section 7.1.7.2, when the 1736 bits DL TBS feature is applied, the TBS is capped at 1736 bits using the function:

TBS = min{TBS’, 1736}

Space to provide comments on updated proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
| Ericsson | The proposed agreement is ok with us. |
| Huawei, HiSilicon | Although the text proposal seems to be OK, we don’t think we need to spend time discussing this, editors can easily prepare the CR when it’s needed. |
| ZTE | OK |
| FL comment | I would like to retain the above as a proposed agreement.  While I fully agree with Huawei that editors can prepare the CR, I think that there is more than one approach that could be taken to how 1736 bits is supported. The two approaches that have been identified are:   * [first] “.” * [second] some complicated list that said: * *for NPRB = 6, ITBS\_max = 14* * *for NPRB = 5, ITBS\_max = 16* * *etc*   The TBSs that are applied are different in some cases in the two approaches.  All companies support the first approach. No companies support the second approach.  I think it would be good if we could close this issue by just making the simple agreement above. |

**Proposals and observations in input documents**

Observation 1: The existing TBS table enables the use of the increased maximum DL TBS of 1736 bits with 16-QAM only with and . NOK-NSB

Observation 2: The increased maximum DL TBS of 1736 bits can be used with 64-QAM with all TBS indices in the range . NOK-NSB

Proposal 1: For DL TBS increase for 16QAM, TBS less than or equal to TBS14 can be used for each NPRB. ZTE

Proposal 2: For DL TBS increase for 64QAM, TBS less than or equal to 1736 bits can be used for each NPRB. ZTE

Proposal 1: In TS 36.213, Subclause 7.1.7.2, the line does not apply for UEs that support a TBS of 1732. Qualcomm

## Issue#5: Capability

The proposals on UE capability boil down to:

* A capability is introduced for Rel-17 Cat-M1 UEs (BL/CE UEs with DL PDSCH bandwidth of 1.4 MHz) supporting a maximum DL TBS of 1736 bits in CEModeA.
* The use of a maximum DL TBS of 1736 bits for a Rel-17 Cat-M1 UE with the corresponding capability is enabled through higher layer configuration.

### FL view on capability issues

Capability support for the 1736 bit DL TBS feature can be considered at the end of the work item, in the usual way.

Question 2.5.1-1: Can UE capability for the 1736 bit DL TBS feature be considered at the end of work item:

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / disagree** | **Comment**  **(if disagree, what are the pressing issues?)** |
| Qualcomm | See comment | No need to discuss, this is in the WID: *Add a* ***Rel-17 optional UE capability*** *to support a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A only* |
| Ericsson | See comment | This aspect has already been settled from the WID. |
| ZTE |  | The 1736 bit DL TBS feature requires larger soft buffer size. It should be an optional capability for NB-IoT UEs. |
| Nokia, NSB |  | We are fine to discuss UE capability issues (if any needs to be addressed) later. |
| Sierra Wireless |  | Similar view as Qualcomm / Ericsson. |
| SONY |  | Agree that this is defined in the WID. Let’s remember to include this in the capability list at the end of the release. |

### Updated FL proposal on capability [update1]

**Background**

The WID already states “ *Add a* ***Rel-17 optional UE capability*** *to support a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A only”.* Hence it is not necessary to make further agreements in RAN1 on UE capability.

There is different functionality on the method of determining TBS (in TS36.213 section 7.1.7.2), depending on (1) whether the UE supports the optional capability for a 1736 bit DL TBS and (2) whether the eNodeB wishes to apply this feature. Hence there maybe be a need for a unicast RRC flag to enable the 1736 bit DL TBS feature. The flag could be used in the following way in TS36.213:

- if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,

- set  to the TBS determined by the procedure in Subclause 7.1.7.2.1,

- if the UE is configured with higher layer parameter *ce-PDSCH-DLTBS1736-Config-r17*

-

- otherwise

-

- otherwise

- TBS is determined by the procedure in Subclause 7.1.7.2.1

**Proposed Agreement**

A unicast RRC flag enables the 1736 bit DL TBS feature or not.

Space to provide comments on updated proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
| Ericsson | We believe we should follow the usual principle in LTE-M and have an RRC configuration parameter for enabling the feature. Thus, the proposed agreement is ok with us. Please add “s” to the word “bit”. |
| Huawei, HiSilicon | We don’t think the configuration is needed as there’s no change to the DCI, there’s no ambiguity on DCI size etc. between eNB and UE. As we commented in section 2.4.2, we prefer to leave the CR to Editors. |
| ZTE | Change the proposal to:  The 1736 bits DL TBS feature is enabled by unicast RRC configuration. |
| FL comment | I think the ZTE text is better than the original proposal, so I have adopted that in [update2]. The ZTE text also addresses the proposed modification from Ericsson.  Huawei> The proposal does not propose any text for a CR. The box above (with pseudo-track changes) is not part of the proposal. It is just an example of where the RRC configuration could be applied. I think that because there is no change to DCI size etc, we need this RRC configuration. If there had been some “special DCI”, the UE would have understood that it had received the “special DCI” and could have determined the TBS based on some separate text associated with the “special DCI”. |

### [GTW1] Updated FL proposal on capability [update2]

**Background**

The WID already states “ *Add a* ***Rel-17 optional UE capability*** *to support a maximum DL TBS of 1736 bits for HD-FDD Cat. M1 UEs in CE mode A only”.* Hence it is not necessary to make further agreements in RAN1 on UE capability.

There is different functionality on the method of determining TBS (in TS36.213 section 7.1.7.2), depending on (1) whether the UE supports the optional capability for a 1736 bit DL TBS and (2) whether the eNodeB wishes to apply this feature. Hence there maybe be a need for a unicast RRC flag to enable the 1736 bit DL TBS feature. The flag could be used in the following way in TS36.213:

- if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,

- set  to the TBS determined by the procedure in Subclause 7.1.7.2.1,

- if the UE is configured with higher layer parameter *ce-PDSCH-DLTBS1736-Config-r17*

-

- otherwise

-

- otherwise

- TBS is determined by the procedure in Subclause 7.1.7.2.1

**Proposed Agreement**

The 1736 bits DL TBS feature is enabled by unicast RRC configuration.

Space to provide comments on updated-2 proposal:

|  |  |
| --- | --- |
| **Company** | **Comment on updated proposal** |
|  |  |
|  |  |
|  |  |

**Related proposals**

Proposal 1: A capability is introduced for Rel-17 Cat-M1 UEs (BL/CE UEs with DL PDSCH bandwidth of 1.4 MHz) supporting a maximum DL TBS of 1736 bits in CEModeA. NOK-NSB

Proposal 2: The use of a maximum DL TBS of 1736 bits for a Rel-17 Cat-M1 UE with the corresponding capability is enabled through higher layer configuration. NOK-NSB

## AOB: other comments

Question 2.6.1-1: Are there any other issues that should be addressed in RAN1#104e, other than those listed above?

|  |  |
| --- | --- |
| **Company** | **Other issue** |
|  |  |
|  |  |
|  |  |

# References

1. [RP-201306](http://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_88e/Docs/RP-201306.zip), “WID revision: Additional enhancements for NB-IoT and LTE-MTC”, RAN #88e, Electronic Meeting, June 29th – July 3rd, 2020.

The following documents were submitted to RAN1#104e before the Tdoc deadline:

|  |  |  |
| --- | --- | --- |
| [R1-2100255](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100255.zip) | Support of a max DL TBS of 1736 bits in LTE-MTC | Huawei, HiSilicon |
| [R1-2100509](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100509.zip) | Support of a maximum DL TBS of 1736 bits for eMTC | Nokia, Nokia Shanghai Bell |
| [R1-2100569](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100569.zip) | DL TBS increase for eMTC | ZTE |
| [R1-2100869](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100869.zip) | Support of 1736 bit maximum DL TBS for eMTC | Sony |
| [R1-2101326](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101326.zip) | Design considerations to support DL TBS of 1736 bits for LTE-M | Sierra Wireless, S.A. |
| [R1-2101511](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101511.zip) | Support of larger TBS for eMTC | Qualcomm Incorporated |
| [R1-2101700](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101700.zip) | Support of a maximum DL TBS of 1736 bits in LTE-MTC | Ericsson |