**3GPP TSG-RAN WG4 Meeting # 99-e R4-210XXXX**

**Electronic Meeting, 19th – 27th May 2021**

**Agenda item:** 9.6.2

**Source:** Moderator (Ericsson)

**Title:** Email discussion summary for [99-e][311] NR\_DL1024QAM\_BSRF

**Document for:** Information

# Introduction

This thread continues the discussion on 1024QAM link level simulations and BS requirements.

For the link level simulations, there is divergence between the details of the assumptions made by different companies and so the results are not directly comparable. The discussion aims to narrow down to a single agreed set of parameters, which will enable a focussed discussion on the appropriate TX EVM requirement.

For the requirements discussion, some further details of the EVM requirement should be discussed. Also, there is a need to clarify whether the 1024QAM requirements should be made applicable for the WA BS class or not.

# Topic #1: Link level simulations

Several companies have submitted link level simulation results, but there is divergence between the details of the assumptions. Since the link level simulations should provide input to decide on the TX EVM requirement, there is a need for simulations to be comparable. In this topic, it is proposed to narrow down the simulation assumptions to a single agreed set.

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2109111 | CATT | **Observation 1: Regarding crossover SNR between 1024QAM and 256QAM for Rank 1, the following is observed:** * + The crossover SNR for rank 1 with 3%/4% TX/RX EVM in TDL-A is ~35.7dB.
	+ As TX/RX EVM decreases, crossover SNR for rank 1 also decreases
	+ For the same TX/RX EVM, the crossover SNR for rank 1 in TDL-D is lower than that in TDL-A.
	+ When TX/RX EVM is configured down to 2%/1.5%, crossover SNR for rank 1 is less than ~27dB.

**Observation 2: Regarding performance gain of 1024QAM compared to 256QAM for rank 1, the following is observed:** * + As TX/RX EVM decreases, throughput gain of 1024QAM compared to 256QAM increases, if TX/RX EVM decreases to 3%/3%, the throughput gain of 1024QAM compared to 256QAM for rank 1 in TDL-A is increased by ~19.8%.
	+ For the same TX/RX EVM, the throughput gain of 1024QAM compared to 256QAM for rank 1 in TDL-D is larger than that in TDL-A.
	+ When TX/RX EVM is configured down to 2%/1.5%, the throughput gain of 1024QAM compared to 256QAM for rank1 in TDL-A is increased by ~29%.
 |
| R4-2110141 | Nokia | ***Proposal: Agree simulation assumptions in Table 1 for further work in 1024QAM work item in RAN4.******Observation: Initial simulation results for 1024QAM show higher throughput compared to 256QAM for higher, but still reasonable SNR conditions and reasonable EVM requirements*** |
| R4-2110606 | ZTE | **Observation 1:** with Tx EVM requirement ranging rom 2%-3%, NR 1024QAM could have more than 20% performance gain than NR 256QAM; |
| R4-2110663 | Huawei | **Observation: from link level simulation, 3% TX EVM can provide observed gain for 1024 QAM compared to 256 QAM.** |
| R4-2110482 | Ericsson | **Observation: txEVM considers all components along the transmitter chain for EVM evaluation.****Proposal 1:** **Evaluate only total EVM in RAN4 simulation parameters, not individual EVM contributions of individual components****Observation: Power efficiency of FR1 LO generation is high in the FR1 frequency range and consequently phase noise levels are low** **Observation: Even considering different archetiture design choices (distributed vs single LO generation) the impact will not worsen****Proposal 2: No need to further consider phase noise as a significant source of impairment when deriving EVM for 1024 QAM in FR1** |

## Open issues summary

### Sub-topic 1-1

Sub-topic description: This topic deals with detailed link level simulation assumptions

**Issue 1-1: How many carrier frequencies to consider**

There is some difference between companies as to which carrier frequencies should be considered. The outcome for this issue should resolve a list of carrier frequencies that all interested companies should cover.

* Proposals
	+ Option 1 (Ericsson): 2GHz, 4GHz
	+ Option 2 (Nokia, CATT, Huawei): 2GHz only
	+ Option 3 (ZTE): 3.5GHz
* Recommended WF
	+ TBA

**Issue 1-2: Bandwidth and SCS for 2GHz carrier frequency**

The outcome for this issue is only relevant if it is decided to include 2GHz in issue 1-1.

* Proposals
	+ Option 1 (CATT): 20MHz for large EVM, 50MHz for small EVM, 15kHz SCS
	+ Option 2 (Nokia, Huawei): 40MHz, 15kHz SCS
	+ Option 3 (Ericsson): 20MHz, 15kHz SCS
* Recommended WF
	+ TBA

**Issue 1-3:** **Bandwidth and SCS for 4GHz carrier frequency**

The outcome for this issue is only relevant if it is decided to include 4GHz in issue 1-1.

* Proposals
	+ Option 1 (Ericsson): 100MHz, 30kHz SCS
* Recommended WF
	+ TBA

**Issue 1-4: Bandwidth and SCS for 3.5GHz carrier frequency**

The outcome for this issue is only relevant if it is decided to include 3.5GHz in issue 1-1.

* Proposals
	+ Option 1 (ZTE): 100MHz, 30kHz SCS
* Recommended WF
	+ TBA

**Issue 1-5:** **How to apply precoding**

* Proposals
	+ Option 1 (Nokia): Random
	+ Option 2 (CATT, Huawei, Ericsson): Follow PMI
* Recommended WF
	+ TBA

**Issue 1-6: Number of HARQ transmissions**

* Proposals
	+ Option 1 (CATT): 4
	+ Option 2 (Nokia, Ericsson): 8
		- Moderator question: Maybe 8 refers to the number of HARQ processes not the number of transmissions ? Please clarify
* Recommended WF

**Issue 1-7:** **Number of BS TX**

* Proposals
	+ Option 1 (CATT, Nokia, Huawei, Ericsson, ZTE): 1 and 2
* Recommended WF
	+ TBA

**Issue 1-8: Number of UE RX**

* Proposals
	+ Option 1 (): 2 and 4
	+ Option 2 (Nokia, Huawei, Ericsson, ZTE, CATT): 4
* Recommended WF
	+ TBA

**Issue 1-9: PDSCH configuration**

* Proposals
	+ Option 1 (ZTE): Type A mapping, Start symbol 2, Duration 12 (for D slots)
	+ Option 2 (Nokia, Huawei, Ericsson): Type A mapping, Start symbol 1, Duration 13 (for D slots)
	+ Option 3 (CATT):
		- Type A mapping, Start symbol 1, Duration 13 (for D slots) for Larger EVM configuraion.
		- Type A mapping, Start symbol 2, Duration 12 (for D slots) for Smaller EVM configuraion.
* Recommended WF
	+ TBA

**Issue 1-10: DM-RS configuration**

* Proposals
	+ Type 1, single symbol
	+ Option 1 (ZTE): One DM-RS symbol
	+ Option 2 (CATT, Nokia, Huawei, Ericsson): Two DM-RS symbol
* Recommended WF
	+ TBA

**Issue 1-11: Rank**

* Proposals
	+ Option 1 (ZTE): One
	+ Option 2 (CATT, Nokia, Huawei, Ericsson): One and two
* Recommended WF
	+ TBA

**Issue 1-12: Channel model**

* Proposals
	+ Option 1 (CATT, Nokia, Huawei, Ericsson): TDL-A, 10nsec, 5Hz
	+ Option 2 (ZTE): TDL-A, TDL-D, 30nsec
* Recommended WF
	+ TBA

**Issue 1-13: TX EVM range**

* Proposals
	+ Option 1 (CATT):
		- Larger EVM configuraion: txEVM: 2%, 2.5%, 3%
		- Smaller EVM configuraion: txEVM: 1%, 1.5 %, 2%
	+ Option 2 (Nokia): 2.5%, 3%
	+ Option 3 (ZTE, Huawei, Ericsson): 2%, 2.5%, 3%
* Recommended WF
	+ TBA

**Issue 1-14: RX EVM range**

* Proposals
	+ Option 1 (CATT):
		- Larger EVM configuraion: rxEVM: 2%, 3%, 4%
		- Smaller EVM configuration rxEVM: 0.5%, 1%, 1.5%
	+ Option 2 (Nokia): 0.5%, 1%, 2%
	+ Option 3 (ZTE, , Ericsson): 2%, 3%, 4%
	+ Option 4 (Huawei): 1%, 1.5%, 2%
* Recommended WF
	+ TBA

**Issue 1-15: Allocated RB**

* Proposals
	+ Option 1 (Nokia, CATT, Huawei, Ericsson): Full allocation
	+ Option 2 (ZTE): 273 (200 for data)
* Recommended WF
	+ TBA

**Issue 1-16: Other parameters**

For the following parameters, there is no divergence between companies proposals. Please comment if you think any of these parameters should be clarified or changed.

* Proposals
	+ Waveform: CP-OFDM
	+ RV sequence {0, 2, 3, 1}
	+ Antenna correlation: Low
	+ MCS:
		- 256QAM: MCS 24 in TS 38.214 Table 5.1.3.1-2: MCS index table 2 for PDSCH, and other MCSs are not precluded
		- 1024QAM: MCS 24 in the following Table accroding to the agreement in RAN1 #104, and other MCSs are not precluded
	+ Channel estimation: Practical
	+ Receiver: MMSE
* Recommended WF
	+ Agree the above parameters

## Companies views’ collection for 1st round

### Open issues

Sub topic 1-1 How many carrier frequencies to consider

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | Option 2Will the carrier frequencies has any impact to the link simulation results?  |
| Nokia | We support option 2,  |
| CATT | Option 2. |
| Intel | Option 2 is fine. There should be no impact on PDSCH performance in case different CF is considered for FR1 in case we fix Doppler spread for propagation conditions. |

Sub topic 1-2 Bandwidth and SCS for 2GHz carrier frequency

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | Option 2 |
| Nokia | We support option 2,  |
| -CATT | Because the DMRS is configured in full bandwidth, so the performance variation due to bandwidth can be small. So we can accept the option1, option2, and option3. To compare with LTE 1024QAM, 20MHz 15kHz SCS might be possible option. |
| Intel | Agree with CATT comment. To reduce simulation work load we suggest to take Option 2 or 3. |

Sub topic 1-3 Bandwidth and SCS for 4GHz carrier frequency

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| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | The simulation time for 100 MHz is much longer if no big impact to the link simulation results, we prefer not to do it. |
|  |  |
|  |  |

Sub topic 1-4 Bandwidth and SCS for 3.5GHz carrier frequency

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| --- | --- |
| **Company** | **Comments** |
|  |  |

Sub topic 1-5 How to apply precoding

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | We support option2, which is also used in FR2 256QAM WI. |
| Intel | In case we consider scenarios with number of Tx antennas not higher than 2. Follow PMI does not have big impact on performance. Same time, random PMI simplifies test setup. Therefore, we slightly prefer Option 1 |

Sub topic 1-6 Number of HARQ transmissions

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | Support Option 2, yes this is 8 processes and the usual RV sequence |
| CATT | We support option1. |
| Intel | At current stage, 4 HARQ transmissions and 4 HARQ processes is typical configuration for FR1 FDD. Therefore, we support Option 1. |

Sub topic 1-7 Number of BS TX

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | In RAN1 link-level simulation, 8TX is used which is more suitable for BS, since we already assume 4RX for UE. |
| Nokia | We support option 1 |
| CATT | Option 1 |
| Intel | Option 1 is fine |

Sub topic 1-8 Number of UE RX

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | Option 2 |
| Nokia | We support option 2 |
| CATT | Option 2 |
| Intel | We can focus on 4 Rx case. Same time, interested companies can check the performance for 2 Rx. |

Sub topic 1-9 PDSCH configuration

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | We support option 2. |
|  CATT | We can compromise to option 2, it is typical PDSCH configuration.  |
| Intel | Option 1 is typical configuration for FR1 scenarios based on TS 38.101-4. Therefore, we support this option. |

Sub topic 1-10 DM-RS configuration

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | We support option 2. |
| CATT | Support option 2. |
| Intel | Option 2 |

Sub topic 1-11 Rank

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | We support option 2. |
| CATT | Support option 2 |
| Intel | Option 2 |

Sub topic 1-12 Channel model

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| --- | --- |
| **Company** | **Comments** |
| CATT | Support option 1. |
| Intel | We can focus on TDL-A. Same time, interested companies can bring analysis for TDL-D. |

Sub topic 1-13 TX EVM range

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| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | Option 3: : 2%, 2.5%, 3% |
| Nokia | We support option 2. |
| CATT | We can accept Option 3. |
| Intel | Option 3 is fine for us. |

Sub topic 1-14 RX EVM range

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | Option 4: 1%, 1.5%, 2% |
| Nokia | We support option 2. |
| CATT | Either option 2 or option 4 |
| Intel | Support Option 3. Based on our understanding, the UE EVM should be not less than BS EVM, because it rather challenging to achieve very low EVM at the UE side. |

Sub topic 1-15 Allocated RB

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| --- | --- |
| **Company** | **Comments** |
| Nokia | We support option 1. |
| CATT | Support option1. |
| Intel | Support Option 1 |

Sub topic 1-16 Other parameters

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| --- | --- |
| **Company** | **Comments** |
| CATT | Support the recommended WF. |
| Intel | Most of parameters are fine for us. We would like to clarify the receiver type. For DL requirements, the baseline receiver is MMSE-IRC (i.e. not just MMSE). Therefore, we suggest to consider MMSE-IRC receiver. |

### CRs/TPs comments collection

No CRs or TPs

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

# Topic #2: BS requirements

This topic deals with BS requirements capturing some more discussion points for EVM and the question of the applicable BS class.

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2110481 | Ericsson, Nokia, Nokia Shanghai Bell, Verizon, KDDI, SoftBank, NTT DOCOMO | **Observation 1: Higher over modulation can be used as opportunistic when channel conditions are favorable.****Observation 2: Deployment scenarios would change from LTE to NR if 1024 QAM does not support same BS classes in both generations.****Observation 3: 5G should not be less maximum throughput compared to 4G when similar technology basis is concerned.****Proposal:** Define 1024QAM RF requirements for all BS classes |
| R4-2109112 | CATT | **Proposal 1: Phase noise does not need to be considered in the link level simulation.****Proposal 2: Option 1 (do not define 1024QAM for WA BS) is preferred unless a performance gain for 1024-QAM in WA deployment scenario is observed.** |
| R4-2110607 | ZTE | **Proposal 1:** to start with scenarios (LA, MR) where no coverage issue or power back off is not needed to support 1024QAM firstly. **Proposal 2**: propose the EVM requirement for NR 1024QAM as 2.5%. |
| R4-2110664 | Huawei, HiSilicon, CMCC, China Unicom | **Observation 1**: for Macro scenarios, 1024-QAM cannot provide notable performance gain**Observation 2**: for Macro scenarios, few UEs can use 1024-QAM MCS**Proposal 1:** it is proposed that 1024-QAM RF requirements is not defined for Macro BS. **Proposal 2:** 3% TX EVM is proposed for DL 1024 QAM |

## Open issues summary

### Sub-topic 2-1: EVM

Sub-topic description: Some further issues for deciding EVM

**Issue 2-1: Whether to consider phase noise when deciding EVM**

* Proposals
	+ Option 1 (CATT, Ericsson): No
	+ Option 2: Yes
* Recommended WF
	+ TBA

**Issue 2-2: Evaluate EVM components individually or not**

* Proposals
	+ Option 1 (Ericsson): Evaluate only total EVM in RAN4 simulation parameters, not individual EVM contributions of individual components
	+ Option 2:
* Recommended WF
	+ TBA

**Issue 2-3: EVM requirement**

One company has proposed an EVM requirement value. Please comment on whether it is agreeable, or alternative proposals, or whether more analysis is needed to decide (and if so, which analysis).

* Proposals
	+ Option 1 (Huawei): 3%
	+ Option 2 (ZTE): 2.5%
* Recommended WF
	+ TBA

### Sub-topic 2-2 BS class applicability

This topic addresses the question of whether to apply the 1024QAM requirements to the WA BS class. The moderator has attempted to briefly summarize the arguments for/against. In responding, please try to comment on why you propose the option you do or why you do not support the other option.

**Issue 2-4: BS class applicability**

* Proposals
	+ Option 1 (Ericsson, Nokia, Nokia Shanghai Bell, Verizon, KDDI, SoftBank, NTT DOCOMO): Applicable for all BS classes
		- 1024QAM can be used opportunistically for high SNR
		- Deployment scenario possibilities should be the same as for LTE
		- 5G maximum throughput should not be inferior to 4G
	+ Option 2 (Huawei, HiSilicon, CMCC, China Unicom, CATT, ZTE (initially)): Not applicable for WA BS class
		- 1024QAM cannot provide significant performance gain for macro
		- 1024QAM not often used by UEs in simulation
		- Power back-off needed but WA is for coverage
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

Sub topic 2-1 Whether to consider phase noise when deciding EVM

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | We do not quite understand the question. Phase noise may not need to be considered in the link simulation but it of course need to be considered in the EVM budget. |
| CATT | Option 1. The impact is not as obvious as for FR2. |

Sub topic 2-2 Evaluate EVM components individually or not

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | In the link simulation we make assumption for the total TX EVM and total RX EVM |
|  |  |

Sub topic 2-3 EVM requirement

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Option 1: 3% |
| Huawei | Option 1 |
| CATT | FFS. |
| Intel | More analysis is needed |

Sub topic 2-4 BS class applicability

|  |  |
| --- | --- |
| **Company** | **Comments** |
| AT&T | Option 1. The BS class should not be limited as the performance benefits of 1024QAM should be achievable in high-SNR areas with WA BS class. NR performance in the same operating frequency range should not be diminished when migrating from LTE to NR. |
| CMCC | We can accept Option2, and we expect to see some performance gain analysis for WA BS |
| Huawei | We support Option 2Comments to the arguments for option 1:* 1024QAM can be used opportunistically for high SNR

Huawei: The possibility to schedule 1024QAM is low from our simulation results. And also from the perspective of field deployments, the use case of 1024QAM are limited. It is also questionable that single layer MIMO with 1024 QAM will be more optimal than 2 layer 256 QAM. The additional power back-off is needed for 1024 QAM which will cause many issues.* Deployment scenario possibilities should be the same as for LTE

Huawei: this is not an issue since 1024QAM WA BS is not commercially deployed in LTE* 5G maximum throughput should not be inferior to 4G

Huawei: from the perspective of satisfying the KPI, such as 20Gbps peak data rate, 1024QAM with only 2 layer in the downlink cannot bring the KPI even higher. The throughput for 1024QAM with 2-layer would be less than 256QAM with 3-layer or 4-layer actually. |
| Nokia | We don’t see further arguments to limit 1024QAM modulation only to some BS classes, if for LTE we don’t have limitation and 1024QAM is available for all BS classes than in NR this should be allowed. |
| SoftBank | Support option 1 mainly for the second and third items. And is there a reason that 1024QAM could be agreed in LTE-A but not in NR? |
| China Unicom | Option 2.From the current simulation results, we saw limited gain and some performance loss on average throughput under different traffic models for Urban Macro scenarios. Some more analyses could be carried out for other assumptions.And in our commercial network, we can find 16QAM operating but modulation scheme of 64QAM and higher are very rarely observed. So we prefer to keep the 1024QAM under small cell scenario, where they are more likely to be used. |
| CATT | Performance evaluation might be needed. If no performance gain, we prefer not to have unnecessary for WA BS. |

### CRs/TPs comments collection

No CRs or TPs

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
|  |  |  |  |  |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents