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Motivation for WI: LTE-based 5G terrestrial broadcast

Background

- TR 36.776 captures the “gap analysis” of Rel-14 MBMS with respect to the 5G requirements.

Requirement	Required simulations	Relevant to dedicated networks	Met by Rel-14	Notes
1	No	Yes	Yes	
2	No	Yes	Yes	
3	No	Yes	Yes	
4	No	No	-	
5	No	Yes	Partially	
6	No	Yes	Yes	
7	Yes	Yes	No/can be improved	Enhancements needed to meet the requirement proposed in sc. 6.8.6
8	Yes	Yes	No/can be improved	Enhancements needed to meet the requirement proposed in sc. 6.9.4
9	No	Yes	Partially	
10	No	Yes	Yes	

Enhancements for:

- Support of larger ISD
- Support of high speed

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Studied enhancements

- The TR contains study for the following enhancements:
  - Longer CP for HPHT and MPMT networks
  - Coverage analysis of CAS
  - Superposition coding / MUST
  - 100us CP for mobility
  - Use of non-uniform constellations
  - Support of car-mounted receivers in MPMT setting

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Longer CP

- Large SE and SNR gains reported in the TR:

For MPMT networks:

- Longer T_{cp} ≥300μs, combined with a longer T_u >= 2,600μs, provides significant improvement in SNR and SE for rooftop scenarios compared to the Rel.14 1.25kHz numerology:
  - the observed SNR gain is between 5dB and 10 dB;
  - the observed SE gain is ~100%.
- Longer T_u would further improve the SE in the MPMT network by reducing the CP overhead.

HPHT-1 networks:

- Longer T_{cp} ≥300μs, ideally in the order of 400μs, combined with a longer T_u >= 2,600μs would improve the in SNR in the HPHT-1 network of between 8dB and 15dB for rooftop scenarios compared to the Rel.14 1.25kHz numerology.
- Longer T_{cp} ≥300μs, ideally in the order of 400μs, combined with a longer T_u >= 2,600μs would improve the SE in the HPHT-1 network of 500% for rooftop scenarios compared to the Rel.14 1.25kHz numerology.
- Longer T_u would further improve the SE in the MPMT network by reducing the CP overhead.

- Given the magnitude of the observed gains, the support of longer CP is **essential** for supporting of MPMT and HPHT scenarios.

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Coverage analysis of CAS

- For CAS, the conclusion is that, depending on the model, the channels are decodable or not:
  - For 50%/1%, all channels seem to be below the target SNR limit
  - For 50%/50%, the observed SNR is higher and all channels are above the SNR limit
  - A realistic scenario for CAS reception may lie in between the 50/50 time model and the 50/1 time model.

- Without CAS reception (which contains system information), it is not possible to decode PMCH
  - Thus, CAS performance is **essential** for the system to properly work.

- In view of the conclusion, which depends on the time-model used for interference, we propose to enhance the CAS (if necessary), and further consider the modelling of interference during WI phase.

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Other enhancements captured in TR

- MUST:
  - Observed gains of 10-79% depending on the scenario
  - Differentiated coverage between enhancement and base layer
- 100/400 numerology:
  - Observed gains in high SNR regime with respect to 200/800 numerology in high Doppler
  - Similar SE as 200us CP achieved for 95% SNR in LPLT
- Enhancements for car-mounted receivers (120km/h) in MPMT scenario
  - Baseline evaluated, no specific enhancements proposed. Interest from operators on this scenario.
- Non-uniform constellations:
  - Additional gain of 0.1-0.5dB with respect to uniform QAM.

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Objectives

- Specify new numerology(ies) for PMCH for support of rooftop reception in MPMT and HPHT-1 scenarios as described in TR 36.776 [RAN1, RAN4]
  - The new numerology(ies) shall have a cyclic prefix length of at least 300us and a core OFDM symbol duration (excluding cyclic prefix) of 2.4ms.
  - The definition of the new numerology, apart from link/system level performance, shall consider factors such as UE complexity and frame structure alignment with the cell acquisition subframes (CAS).
  - This objective includes specifying associated RS pattern(s), MCS, TBS, UE capabilities.
- Specify, if found necessary, enhancements to the physical channels and signals in the CAS [RAN1, RAN4]
  - This objective includes determining a realistic modelling for the time variation of the desired and interfering signals (e.g. a model between the 50%/50% and 50%/1%), and identifying based on the modelling what channels and signals (if any) need to be enhanced.
  - For the specified enhancements (if any), specify related RRM core requirements (if needed) [RAN4]
- Specify new base station class for high power and medium power deployments [RAN4]
- Specify signalling related to the features above [RAN2, RAN3]

- Objectives related to other features (as presented in previous slide) can be considered to be added based on support.

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Appendix - Conclusions for CAS from TR

- With respect to the CAS, in lieu of LLS in the appropriate channel models and antenna configurations:
  - Under the 50/50 channel model, and based on extrapolation of the minimum performance requirements from [21], all channels in CAS perform adequately except for PDCCH in rooftop MPMT and HPHT. For PDCCH, and based on extrapolation from the link level results presented in [16], the PDCCH performance is adequate for rooftop MPMT and HPHT.
  - Under the 50/1 channel model, and based on extrapolation of the minimum performance requirements from [21], all channels in CAS may not perform adequately. Improvements in all the component channels of the CAS may be beneficial in order to support the use cases studied under the 50/1 time model.
  - A realistic scenario for CAS reception may lie in between the 50/50 time model and the 50/1 time model.

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Appendix – Conclusions for MUST (mobility part)

- For certain differentiation of coverage between the base layer and the enhanced layer, MUST can increase system spectral efficiency for both SC-PTM and MBSFN in the range between 25-79% depending on factors such as target coverage for the enhanced layer. As the target coverage of the enhancement layer decreases, the spectral efficiency gain is larger.
    - For the case where the baseline scenario is 100% power and time allocation to the base layer:
        - In most of the evaluated cases, there is a loss in spectral efficiency for the base layer (which may be marginal).
        - For the case where the SNR loss due to introduction of the base layer allows to keep the same MCS, MUST improves the system spectral efficiency without reducing performance of the base layer.

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Appendix – Conclusions for non-uniform constellations

- 16/64 NUCs can provide additional SNR gains over 16/64 QAM, which can extend the coverage by 0.1-0.5dB. As the order of constellation increases, the gain is larger.

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Appendix – Observations on MPMT car-mounted scenario

MPMT networks:

- The spectral efficiency for MPMT scenario with Rel-14 numerology (200/800) provides the following spectral efficiencies at 120km/h:
  - Nominal transmitter height (100m): 0.88bps/Hz
  - 150m transmitter height: >1.14bps/Hz
- The spectral efficiency for MPMT scenario with Rel-14 numerology (200/800) provides the following spectral efficiencies at 250km/h:
  - Nominal transmitter height (100m): 0.68bps/Hz

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Appendix - Conclusions for 100us CP

- New numerology with 100µs T_{cp} and 400 µs T_u shorter than the Rel.14 1.25 kHz numerology is found to be beneficial in some cases and would support the use case of car-mounted reception in the LPLT networks with the following:
  - For high SNR regime (corresponding SE larger than 1.3 bps/Hz), 100/400/0.33 may outperform Rel.14 1.25 kHz numerology from a link level perspective for the same SNR level, but 1.25kHz achieves higher SNR from a system level perspective
  - For the SNR point corresponding to 95% coverage in LPLT, 100/400/0.33 has similar performance as Rel.14 1.25 kHz numerology.

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