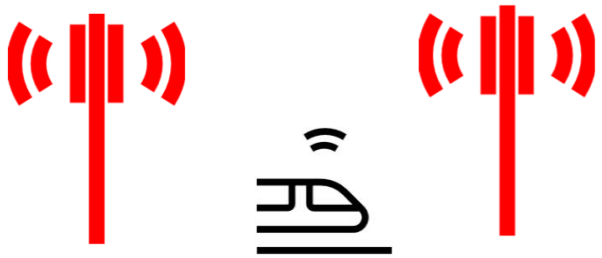
Executive summary Work Package 2.1

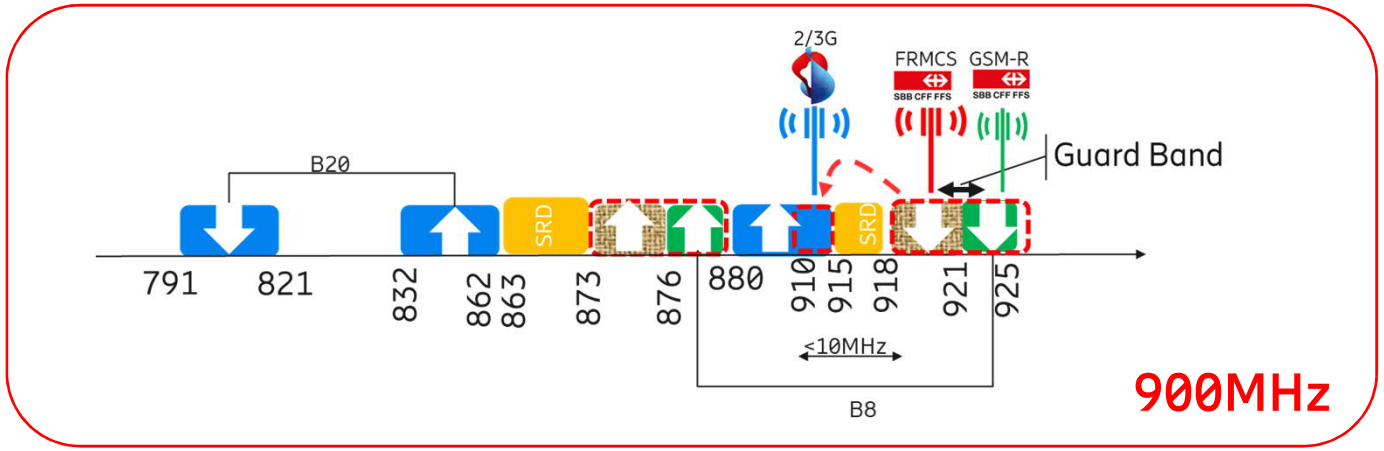


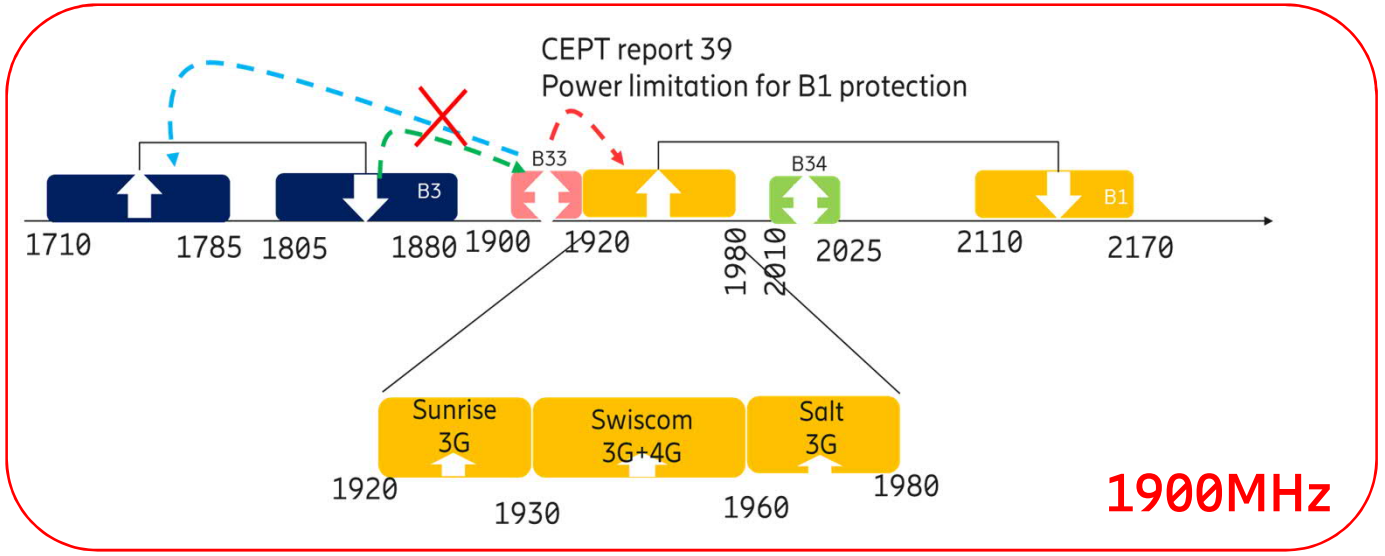
9th of May 2019

Working assumptions

- WP 2.1 investigates the inter-cell distance limits under the following assumptions:
  - E-UTRA (incl. different transmission bandwidths with appropriate DL power limitations)
  - 900MHz (FDD@1.4 / 3 / 5MHz) and 1900MHz (TDD@5MHz) spectrum parts
  - Normal and two levels of degraded railway operational traffic modes
  - Data throughput of 1 / 3 / 5 Mbps (for UL and DL) at the cell edge (handover zone)
  - Transmission modes , Modulation:TM3, MIMO 2x2, DL 256 QAM, UL 64 QAM, UE side 1TX/2RX
- Following assumptions are considered for the calculations: Propagation model, fading margins, radio link budget including the path loss criteria and CEPT coexistence studies.
- Performance capabilities of the TDD (fixed slot allocation) and FDD duplex mode (mode of operation) considering symmetrical configuration approach between UL and DL.
- Multiple deployment scenarios were evaluated considering 900MHz (FDD) and 1900MHz (TDD) spectrum blocks.

SBB Spectrum options





Blocking and co-existence impact to adjacent spectrum blocks determine the guard bands and maximum allowed DL power that can be transmitted.

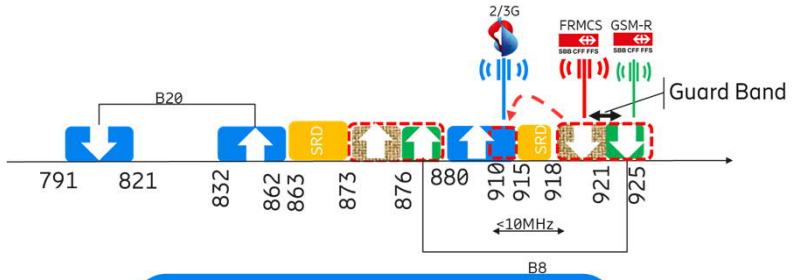
- co-existence with GSM-R
- impact to adjacent public commercial access networks.
- No additional (band-stop/notch) filters are considered in public commercial access networks.

Assumed coupling distance between SBB access network and public commercial access network impacts the allowed maximum DL power (100m).

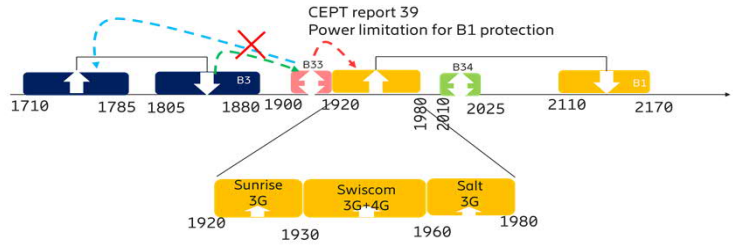
Assumptions made according to:

- CEPT report 40 – Applicable for 900Mhz
- CEPT report 39 - Applicable for 1900Mhz
- UIC O-8788 / FM56(18)009 for 900Mhz

Workflow process for W2.1 study-First Step

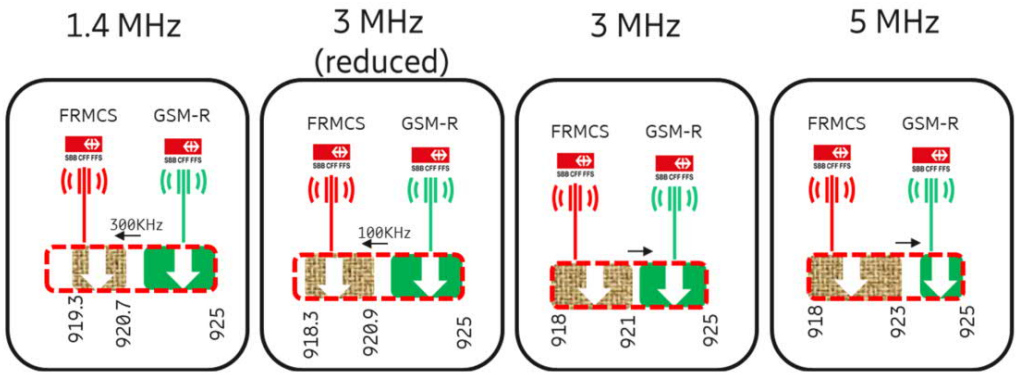


900MHz coexistence and Blocking B8 Band



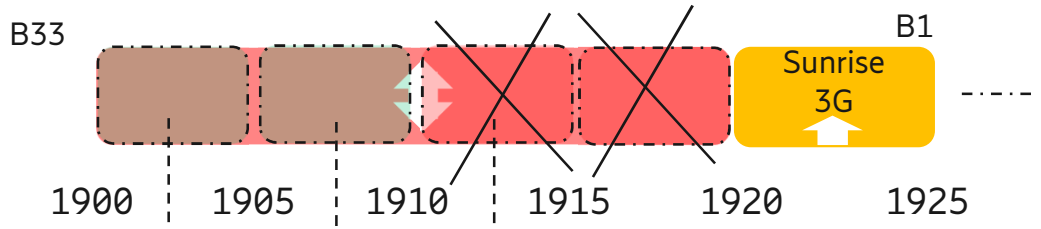
1900MHz coexistence and Blocking B1 Band

Scenario selection and max EIRP evaluation



$27.8\,dBm$ $22.8\,dBm$ $19.5\,dBm$ $21.7\,dBm$

EIRP

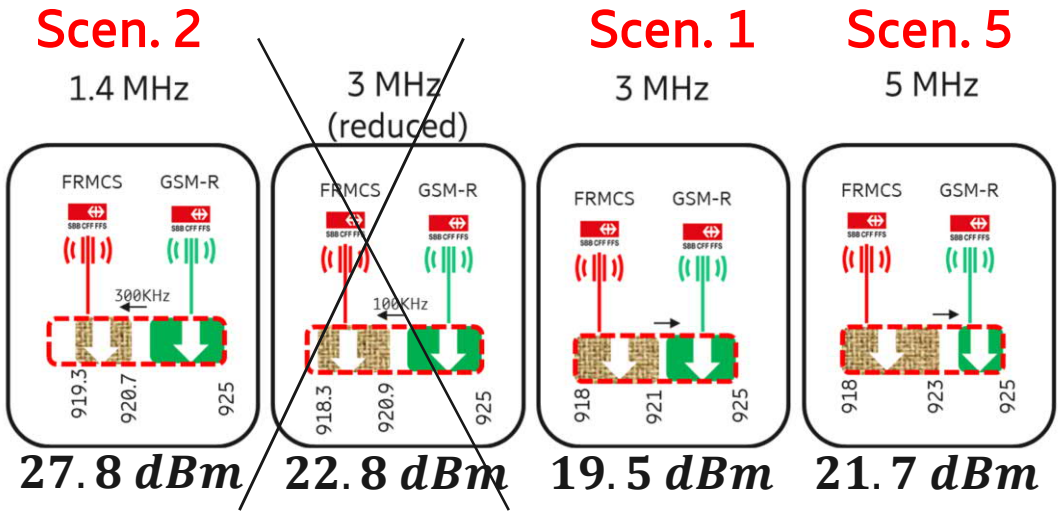


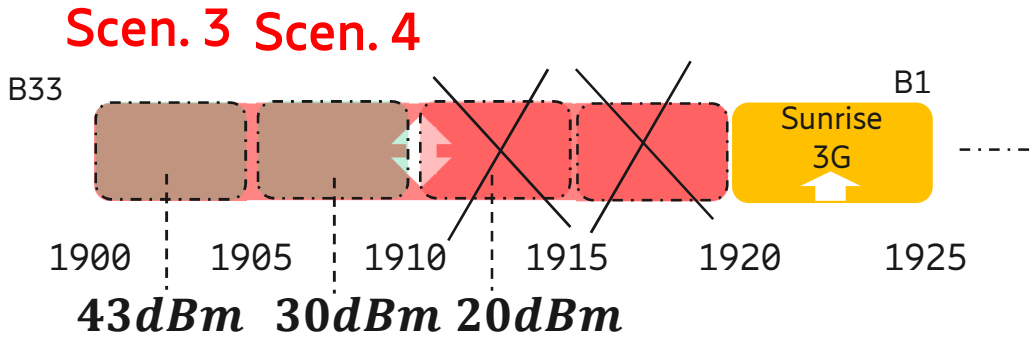
$43dBm$ $30dBm$ $20dBm$

Final selected scenarios

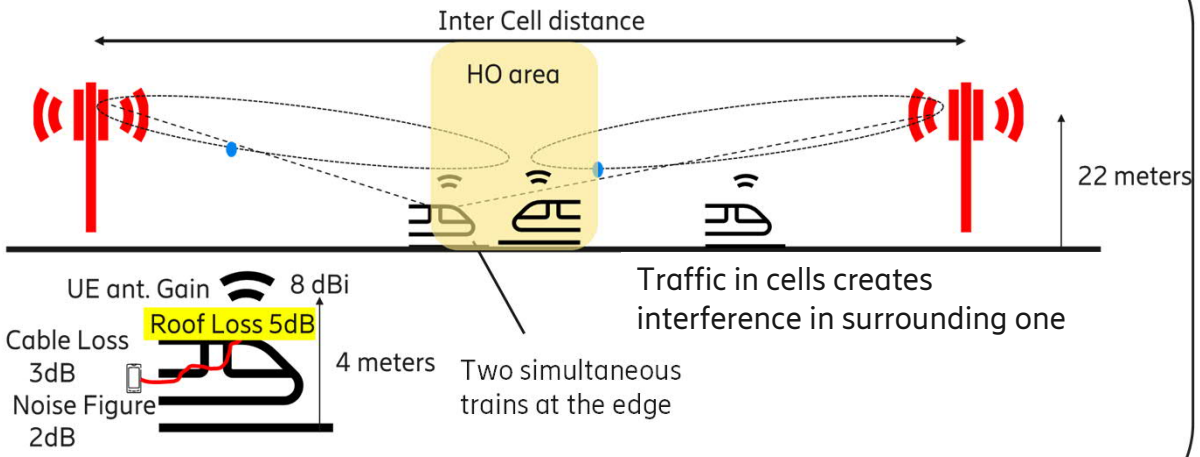
- The following 5 options are considered;
  - Scenario 1 918-921MHz/3MHz 19.5dBm
  - Scenario 2 919.3-920.7MHz/1.4MHz 27.8dBm
  - Scenario 3 1900-1905MHz/5MHz 43dBm
  - Scenario 4 1905-1910MHz/5MHz 30 dBm
  - Scenario 5 918-923MHz/5MHz 21.7 dBm

- Scenario 3 and 4 (1900Mhz) can be operated simultaneously without affecting existing GSM-R deployment.
- Each of the scenarios 1,2 and 5 (900Mhz) can only be operated individually.
- GSM-R carrier reductions needed when deploying scenarios 1 and 5 (3/5MHz FDD @900MHz).





Models for link budget calculation

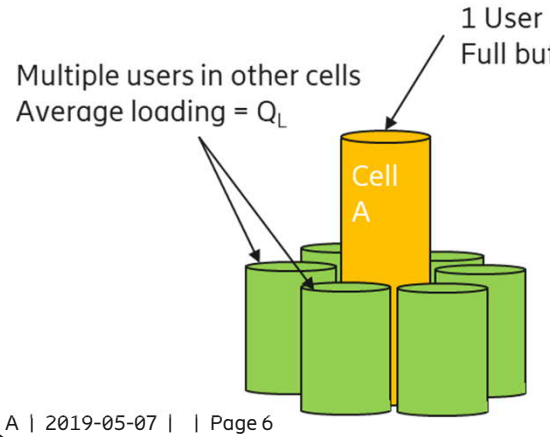


Terminal

Symmetric access stratum traffic requirements
DL=UL at cell edge

1Mbps
3Mbps
5Mbps

Traffic



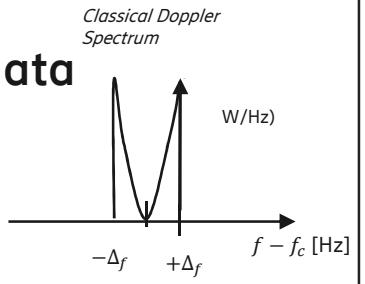
Three Radio Network utilisation levels were simulated:

- Normal Load
- High Load
- Very High Load

Radio Network Load

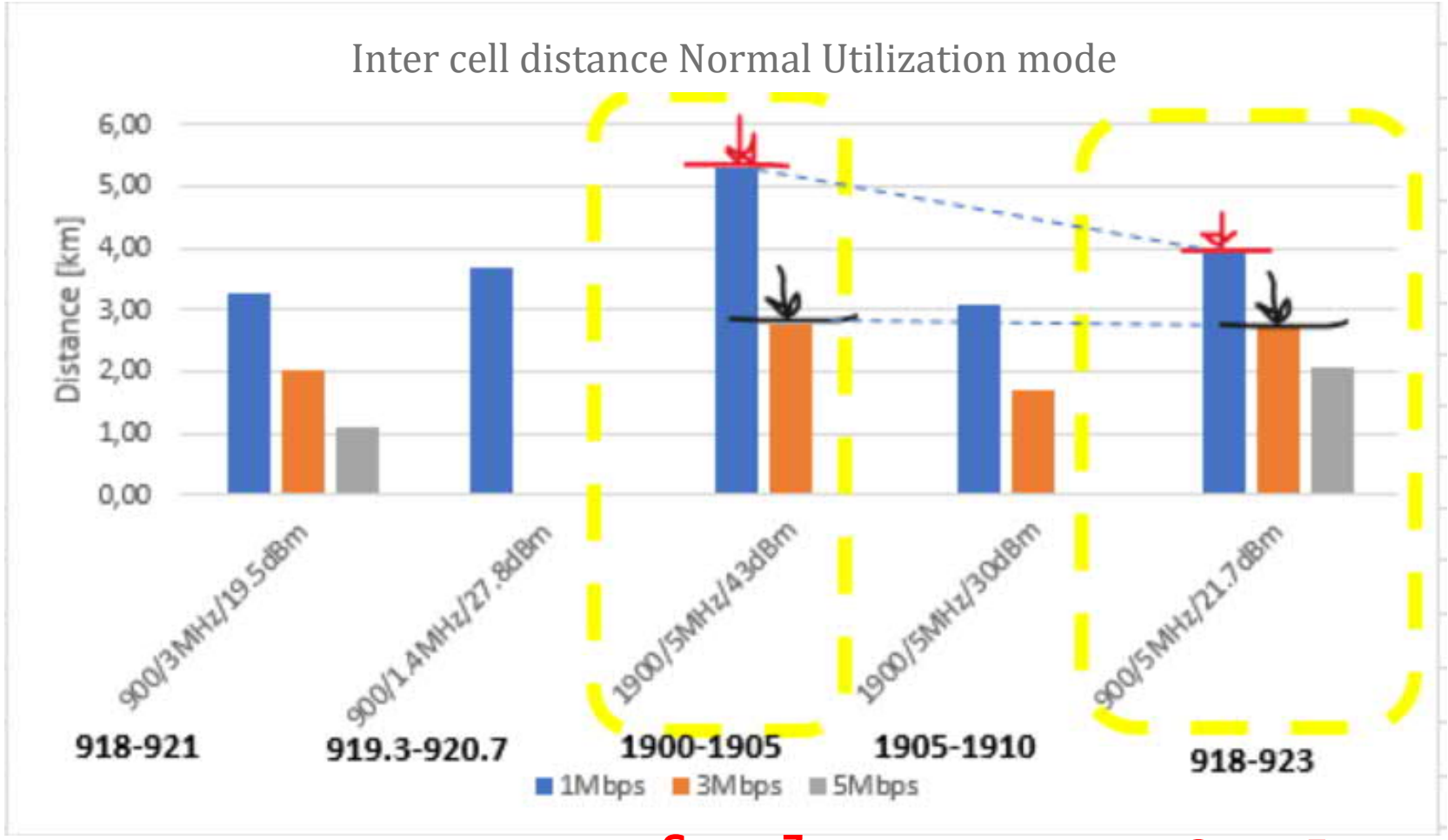
Environment adjusted for Railway

Propagation Model	**Ericsson Hata**
Environment	**Suburban**
Channel Model	**EVA 70**



Environment

Simulation results: inter-cell distance vs. DL transmission power and throughput



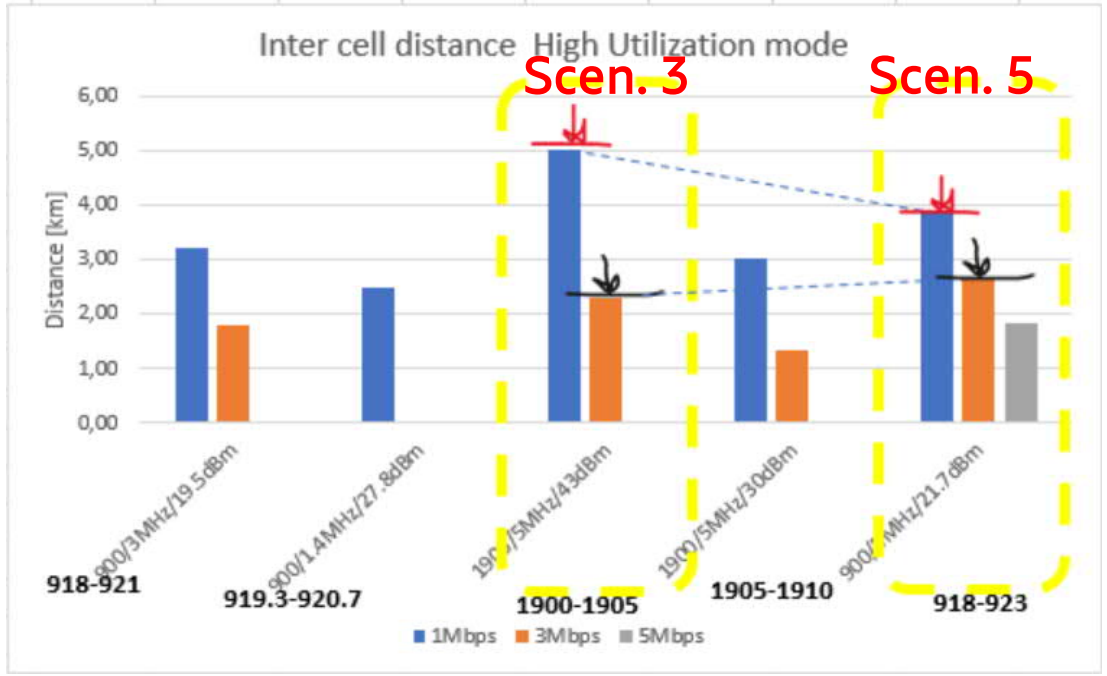
Scen. 3
$43dBm$

Scen. 5
$21.7dBm$

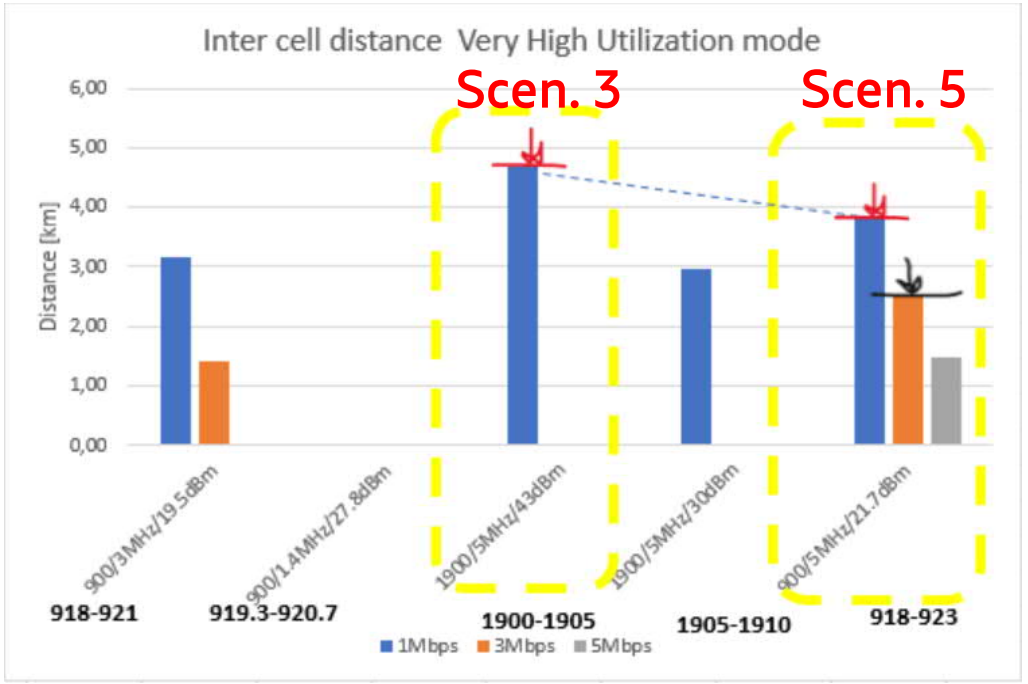
- Throughput and DL power determines the inter-cell distance
- The biggest inter-cell distance is offered by Scenario 3 1900MHz for both 1 and 3 Mbps throughput case.
- Scenario 5 (@900MHz) satisfies the high traffic requirement i.e. 5Mbps

Note: further optimization can be provided with features, functionalities and TDD frame structure to accomplish the desired service requirement, made in this study symmetric for assumption.

Simulation results: inter-cell distance vs. DL transmission power and throughput



- The biggest inter-cell distance is achieved with Scenario 3 and 1Mbps requirement
- For 3 and 5Mbps 900/5MHz/21.7dBm (Scenario 5) offers a solution in the range of up to 2.6Km and 1.8km respectively.



- Again the case of 1900MHz at max DL power (43dBm) offers the biggest inter-cell distance solution for 1Mbit/s requirement while the 900/5MHz/21.7dBm offers a solution in the range of up to 2.6Km for 3Mbps.

Summary

- Preferred scenarios are **5MHz TDD band @1900MHz** and **5MHz FDD @900MHz.**
  - **Biggest inter cell distance** is achieved with 5MHz TDD band @1900MHz under normal and high load traffic conditions:
    - ~5 km with 1 Mbit service requirement.
    - ~3 km with 3 Mbit service requirement.
  - **Highest cell edge throughput** is achieved with 5MHz FDD @900MHz, also with very high load with an inter cell distance of ~1,5 km.
  - 5Mhz Bandwidth **is 5G NR capable**.
  - **High allocated DL power** improves significantly cell range.

- **GSM-R carrier reductions** are required when deploying 3/5MHz FDD **@900MHz** .

- **Further improvements are possible** with features, functionalities and TDD frame structure to accomplish the desired radio access stratum service requirement.

- With exact access stratum service level requirements and traffic forecast the scenario can be optimized. Symmetrical cell edge service level requirements have been used in this study.

- Radio deployment redundancy options can be evaluted upon these results.