TDD Synchronization Testing Over Neighboring 5G Networks in a Cross-Border Corridor

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5GMOBIX

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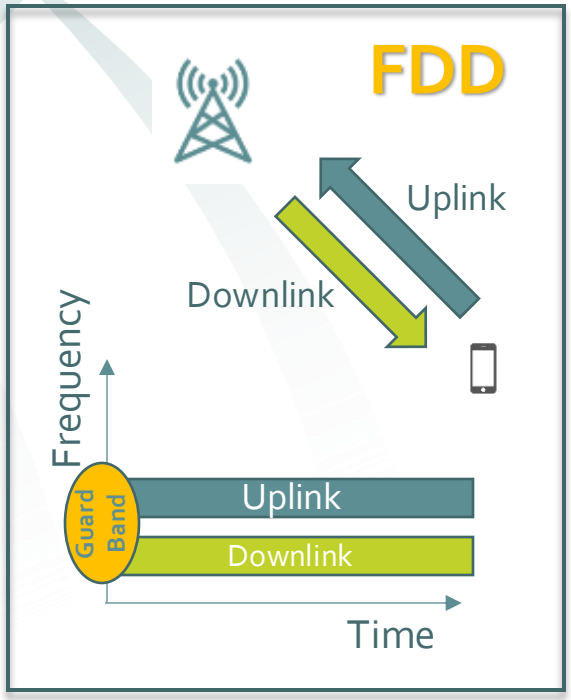
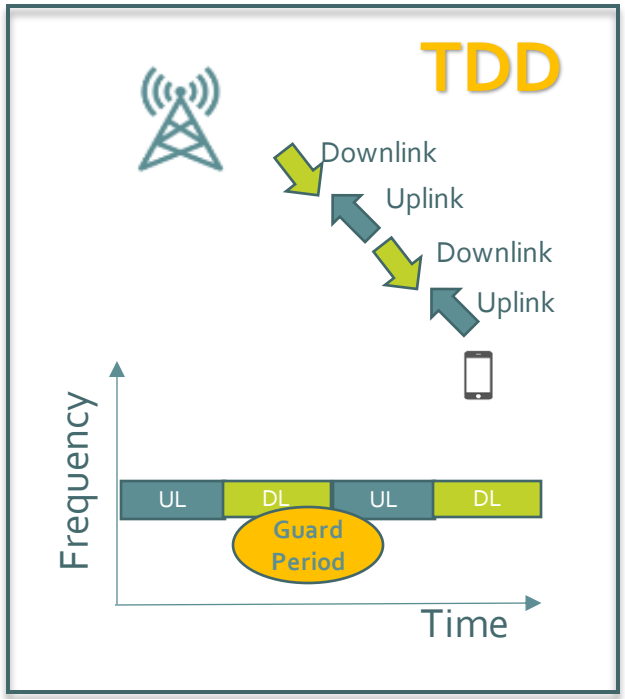
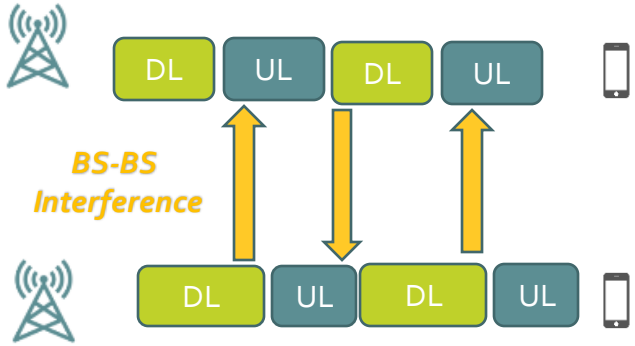
5G NR and the Need for Synchronization







- different frequencies for UL, DL
- for symmetric traffic
  (+) fewer BSs, less cost
  (-) spectrum waste

- same frequency for UL, DL
- For transmissions requiring different data rates
  (+) efficient usage of spectrum
  (-) phase/time synchronization

GSMA for 3.5 GHz TDD Synchronization #4 International Level

- Networks should be synchronized at an international level, by priority is given at the national level
- The preferred structure is (as in national level #3):
  - DDDSU, with 30 kHz SCS
  - Where incumbent systems exist, DDDDDDDSUU (with a 3ms shift) or DDDSUUDDDD

GSMA for 3.5 GHz TDD Synchronization #5
Cross Border Coordination

- When neighboring countries have selected same frame structure
  - limited coordination efforts are required at the border
- When neighboring countries have selected different frame structures
  - Bilateral, multilateral agreements are necessary on practical localized solutions

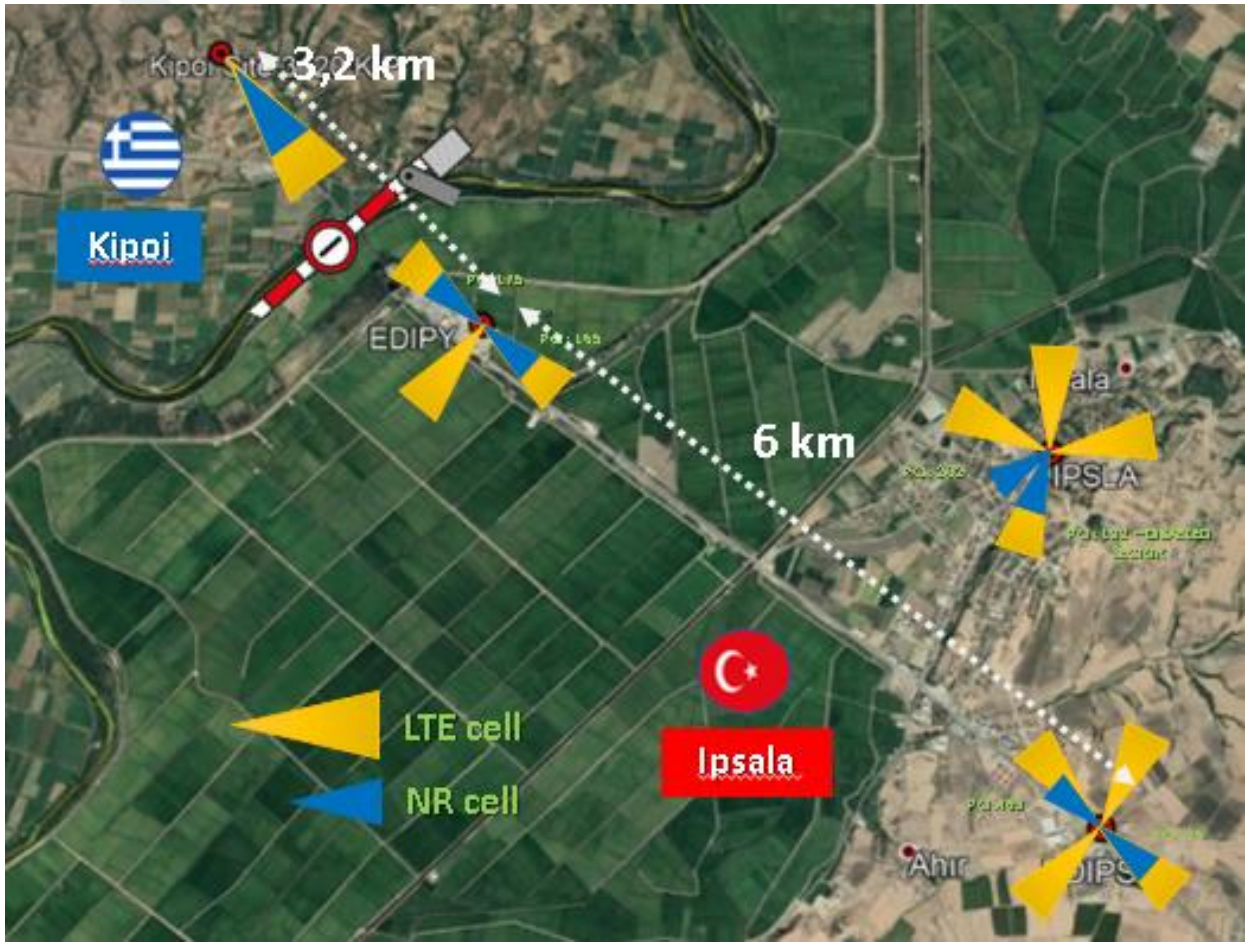
GSMA for 3.5 GHz TDD Synchronization #6
Co-existence of non-synchronized networks

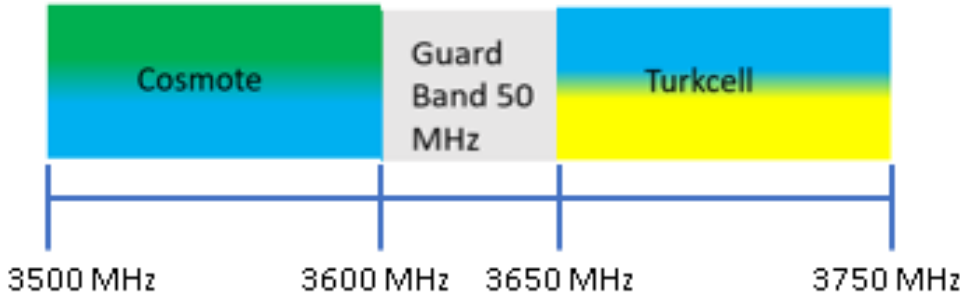
- Localized frame structure
- Network optimization
- **Downlink blanking**
- Reduce capacity near the borders, by using a part of allocated spectrum
- Use alternative bands in borders
- **Use adjacent channels**
- **Use club licenses, spectrum & infrastructure sharing**
- Step by step migration
- 4G networks to migrate to different band
- Commercial agreements between 5G and 4G operators including acquisitions, re-farming and re-programming

ECC/CEPT Recommendations

- **ECC Report 296**, "National synchronization regulatory framework options in 3400-3800 MHz", Network optimization
  - Proposes deployment of synchronized networks:
    - a common phase clock reference
    - a compatible frame structure
  - Denotes minimum separation distance between two unsynchronized macro base stations/networks:
    - up to 60km for co-channel configuration
    - up to 14km for adjacent channel operation
- **ECC Recommendation (15)01**, "Cross-border coordination for MFCN in 694-790 MHz, 1452-1492 MHz, 3400-3600 MHz and 3600-3800 MHz bands"
  - Defines field strength levels
    - mean field strength does not exceed 32 dBµV/m/5 MHz at a height of 3 m above ground level at the borderline
  - Denotes compatible frame structures:
    - DDDDDDDSUU (8+2), DDDSUUDDDD (4+2+4)
- **ECC Recommendation (20)03**
  - Recommends frame structures for CBC:
    - DDDSU (4+1), DDDSUUDDDD (4+2+4)

The 5G-MOBIX Greece-Turkey Cross Border





Inter-PLMN TDD Measurements

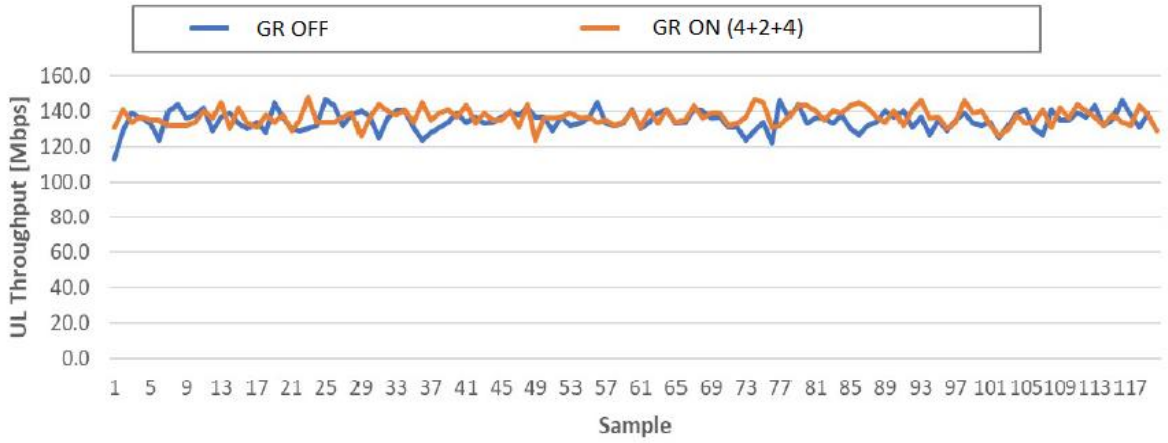
- Measure DL and UL (TCP/UDP) by both networks with:
  - Neighboring network activated and deactivated
  - For different TDD patterns
  - With Carrier Aggregation (CA)

- Focus on two target TDD Patterns
  - **DDDSUUDDDD** (3: 8: 3) [**4+2+4**]
  - **DDDSUDDSUU** (10: 2: 2) [**4+1+3+2**]

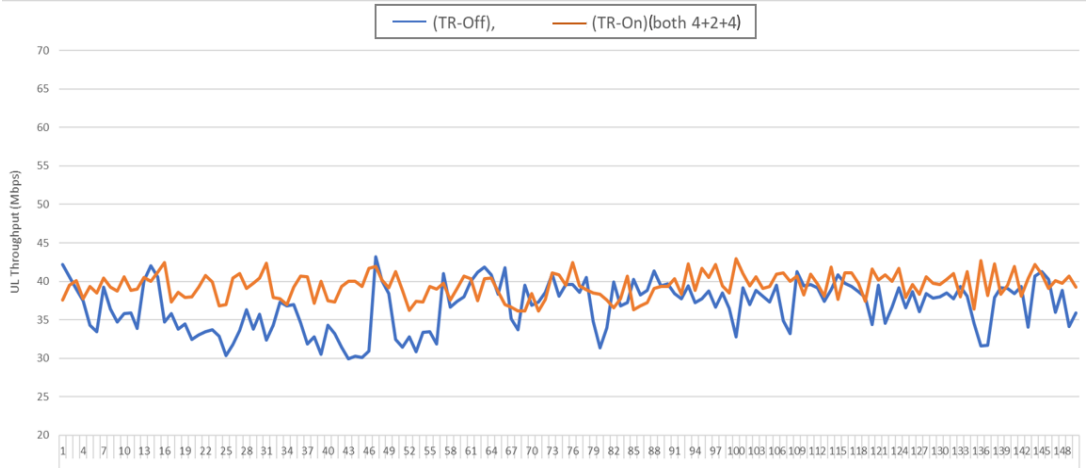
TDD Frame Pattern	Peak UL Throughput	Peak DL Throughput
[4+2+4]	86Mbps	1517Mbps
[4+1+3+2]	129Mbps	1355Mbps

Performance Results
Neighboring PLMN On/Off

Turkcell Network (with CA ON)



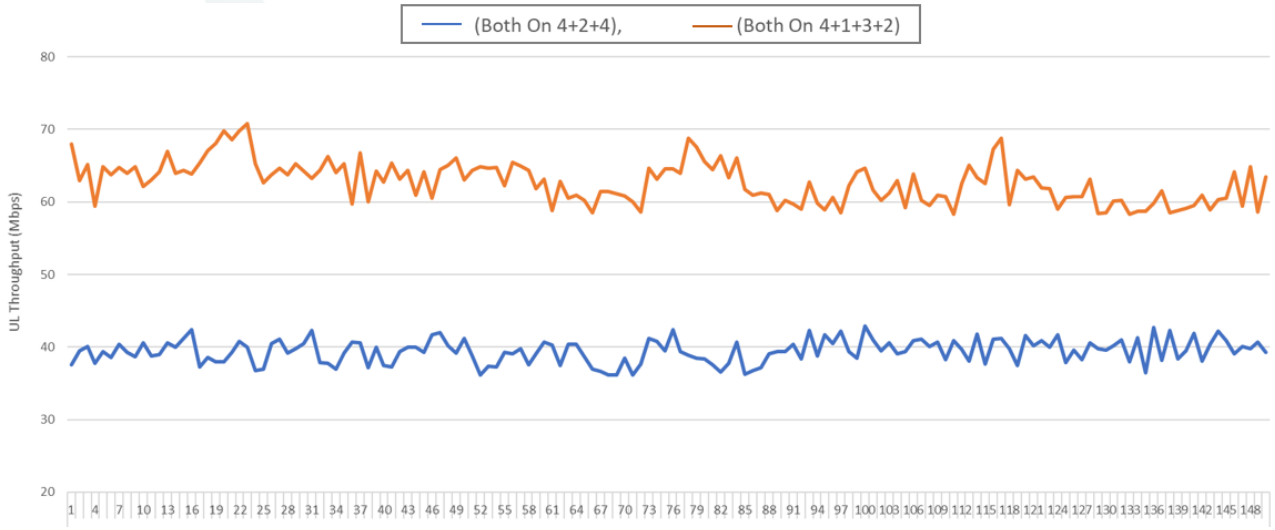
COSMOTE Network (with CA OFF)



- No interference has been observed from neighboring PLMN's operation

Performance Results
Neighboring PLMN with Same TDD patterns

COSMOTE Network (with CA OFF)



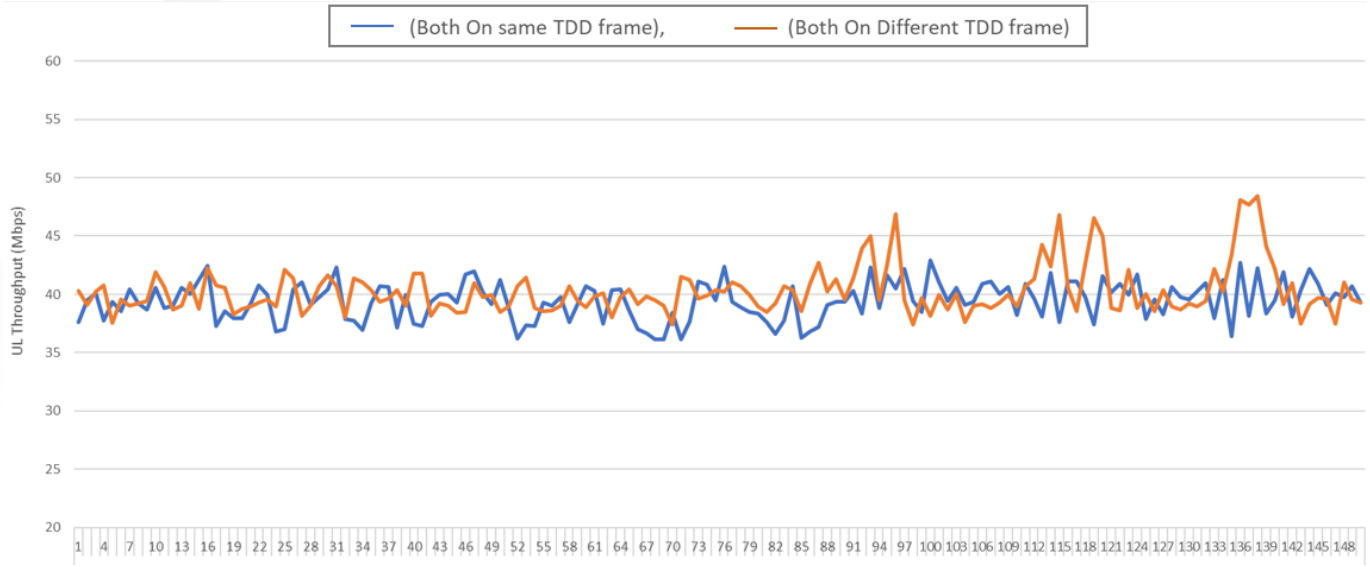
Both networks on with (4+1+ 3 + 2)

Both networks on with (4+2+4)

- as long as the same TDD pattern is used, irrespectively of the particular selection, no significant impact is observed

Performance Results
Neighboring PLMN with Different TDD patterns

COSMOTE Network (with CA OFF)



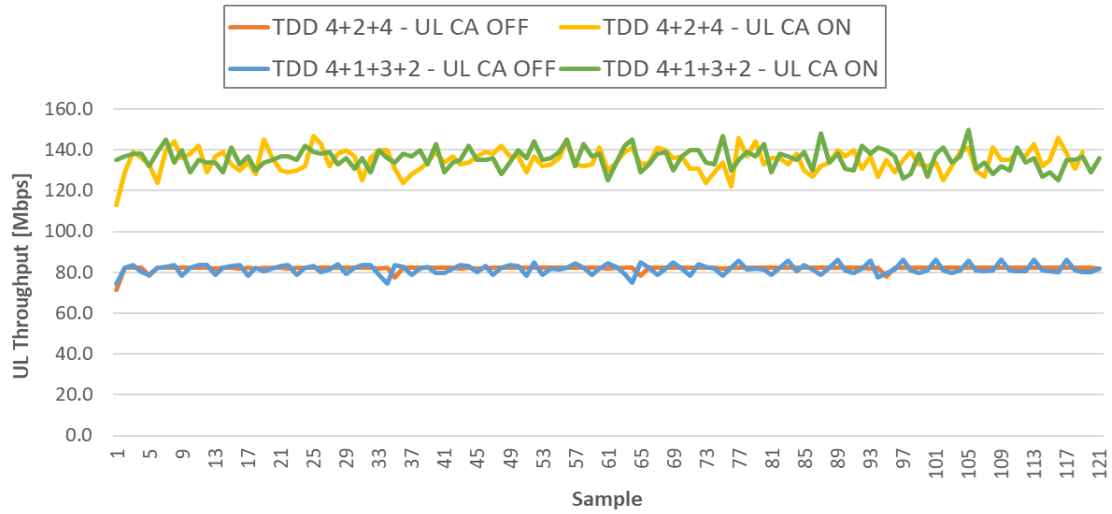
COSMOTE ON with (4+2+4),
Turkcell ON with (4+1+ 3 + 2)

Both networks ON with (4+2+4)

- the use of adjacent frequencies with a significant guard band in between is sufficient to minimize interference, irrespectively of the TDD patterns selected by the two MNOs

Performance Results
Carrier Aggregation

Turkcell Network (with CA ON/OFF)



CA ON

CA OFF

- significant increase of the experienced UL throughput is observed when CA is activated
- The use of different TDD patterns does not affect the CA performance boost

5G-MOBIX GR-TR CBC Conclusions

- The adjacent channel unsynchronized operation is possible with careful installation and planning of the outdoor gNBs deployed in areas which address macro cellular coverage
- No impact noticed on the performance of the serving network when both networks operate with a common TDD frame structure
- NR TDD DDDSUUDDDD (4+2+4) SFS 3:8:3 that is used widely in 5G commercial network deployments, is proven suitable for V2X applications
- NR TDD DDDSUDDSUU (4+1+3+2) SFS 10:2:2, is offering better UL performance important for CAM applications
- Both networks fully synchronized using NR TDD DDDSUUDDDD (4+2+4) SFS 3:8:3 for the 2022 CAM trials

5G-MOBIX GR-TR CBC Technical Insights

- Follow the recommendations provided by ECC rec 15(01) that safeguards the operation of unsynchronized TDD systems
- The best coexistence method is to synchronize all networks following the GSMA recommendations and the ECC/CEPT 20(03) frame structures
- Future coming technologies, such as downlink symbol blanking and cross-link interference cancellation, will certainly improve the flexibility of operating different NR TDD frames in a local fashion or in a more wide-area network deployment
- Advanced radio functionality such as LTE-NR aggregation, AAS beamforming and scheduling enhancements, can further improve both user plane and control plane connectivity

Thank you

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