

Measurement of exposure to radiofrequency radiation from 5G-NR telephony in South Korea

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Objectives

Available data on 5G-NR technology in South Korea

- / General data of the 5G-NR network in South Korea
- / Coverage of the 5G-NR network in South Korea in November 2019

Exposure measurement for different services including 5G-NR

- / Geographic variability of exposure according to different typologies of environment
- / Geographic variability of exposure close to a 5G base station
- / Geographic variability of exposure on transport networks
- / Temporal variability of exposure at fixed point

Characterization of a 5G-NR base station

Questions?

Objectives

- ✓ The Ministry of Ecological and Inclusive Transition commissioned INERIS a study aimed at characterizing the exposure of people to non-ionizing radiation from these new 5G-NR networks in a context where its commercial exploitation is already effective.
 - mid 2019, only 2 countries entered the commercial exploitation phase of these new networks: Australia (since July 2019) and South Korea (since April 2019). Note that in Europe, Switzerland already has the infrastructure to initiate the commercial deployment of this technology but without putting it into service.
 - On the basis of these elements, it was decided to characterize the exposure of people to 5G-NR in South Korea since it has the greatest maturity in terms: of users, of coverage, etc. It was decided to make this assessment in November 2019 with its 3 Millions 5G-NR subscribers.

Available data on 5G-NR technology in South Korea

/ General data of the 5G-NR network in South Korea

- Operator bandwidth

| Operator | Bandwidth used |
|----------|---------------------|
| LGU+ | 3420 -3500 (630666) |
| KT | 3500 -3600 (636666) |
| SKT | 3600 -3700 (643334) |

- Base station manufacturer

| Manufacturer | LGU+ (Bandwidth 80) Central frequency (3459,99 (630666)) | KT (Bandwidth 100) Central frequency (3549,99 (636666)) | SKT (Bandwidth 100) Central frequency (3650,01 (643334)) |
|--------------|--|---|--|
| HUAWEI | -180 kHz (3459,81) | | |
| SAMSUNG | -31,15 (3428,84) | -41.22 (3508,77) | -41.22 (3608,79) |
| NOKIA | -630 kHz (3459,36) | 90 kHz (3550,08) | -570 kHz (3649,44) |
| ERICSSON LG | | -41.22 (3508,77) | -41.22 (3649,92) |

Available data on 5G-NR technology in South Korea

/ On November 24th, 2019

– Geographic repartition of base station

| Region | KT 5G base station number |
|--------------------------------------|---------------------------|
| All over the country | 38999 |
| Seoul | 9878 |
| Seoul metropolitan area (Incheon) | 11716 |
| Gangwon-do | 1107 |
| Chungcheong-do | 3529 |
| Jeolla | 3124 |
| Gyeongsang-do | 9241 |
| Ile de Jeju | 404 |

– Manufacturer repartition of base station

| Manufacturer | KT 5G base station number |
|--------------|---------------------------|
| SAMSUNG | 31464 |
| ERICSSON LG | 4317 |
| NOKIA | 3218 |

Coverage of 5G-NR technology in South Korea

/ Information source

– Operator source

» LGU + : <http://www.uplus.co.kr/css/iner/RetrieveCoverMapNoneSSL.hpi>

» SKT : <http://www.sktcoverage.com/html/sub01.html>

» KT : <https://coverage.kt.com/coverage>

– Governmental source

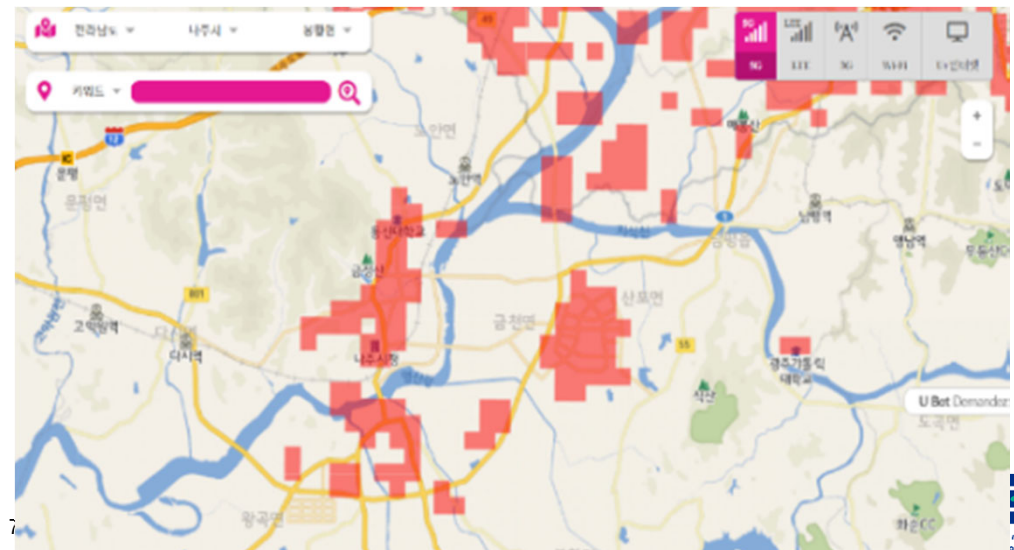
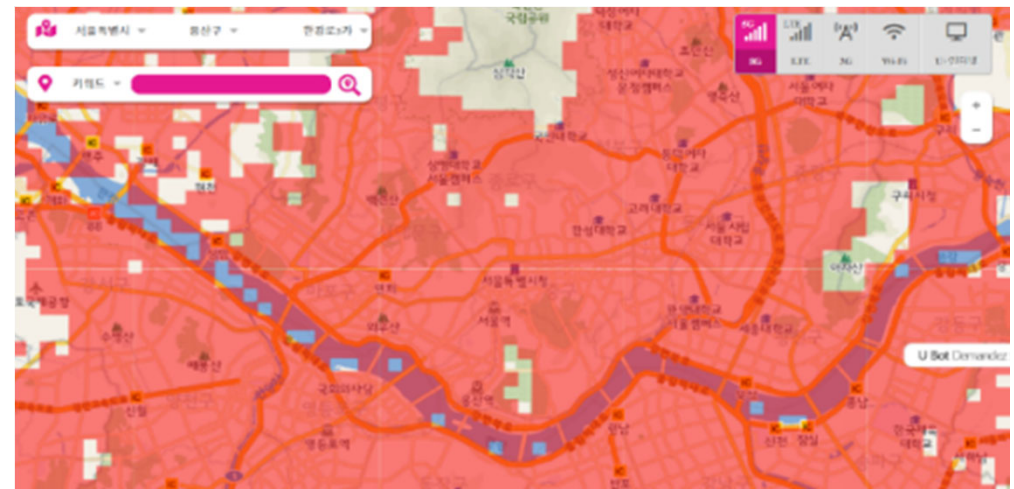
» www.spectrummap.kr

Available date

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Coverage of 5G-NR technology in South Korea

/ LGU+ coverage network on Seoul center and Naju (Old City and New City)

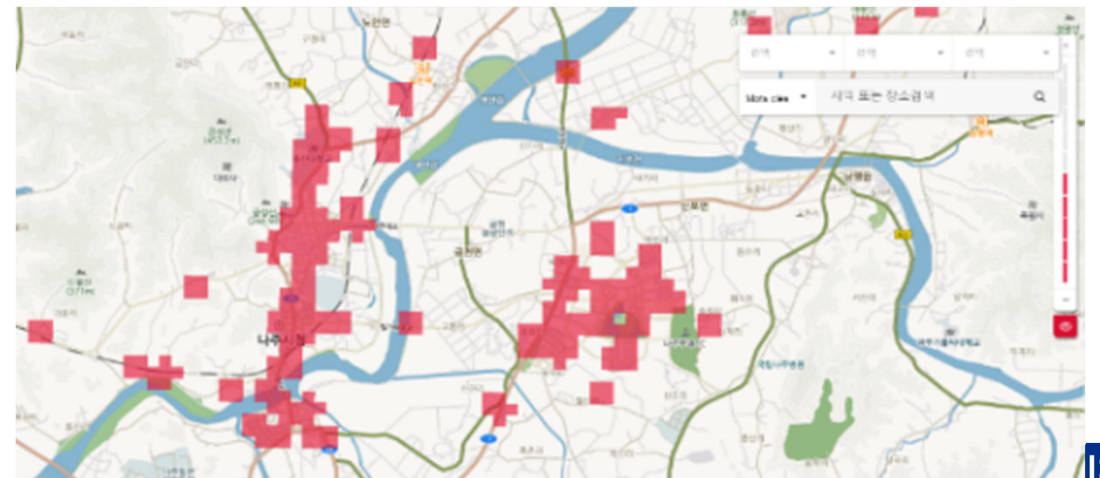
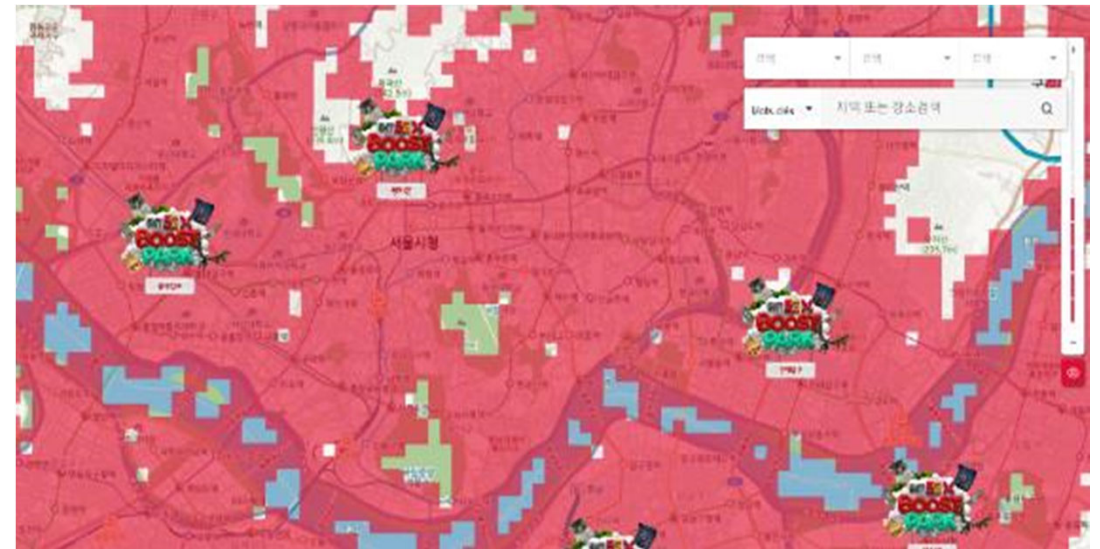
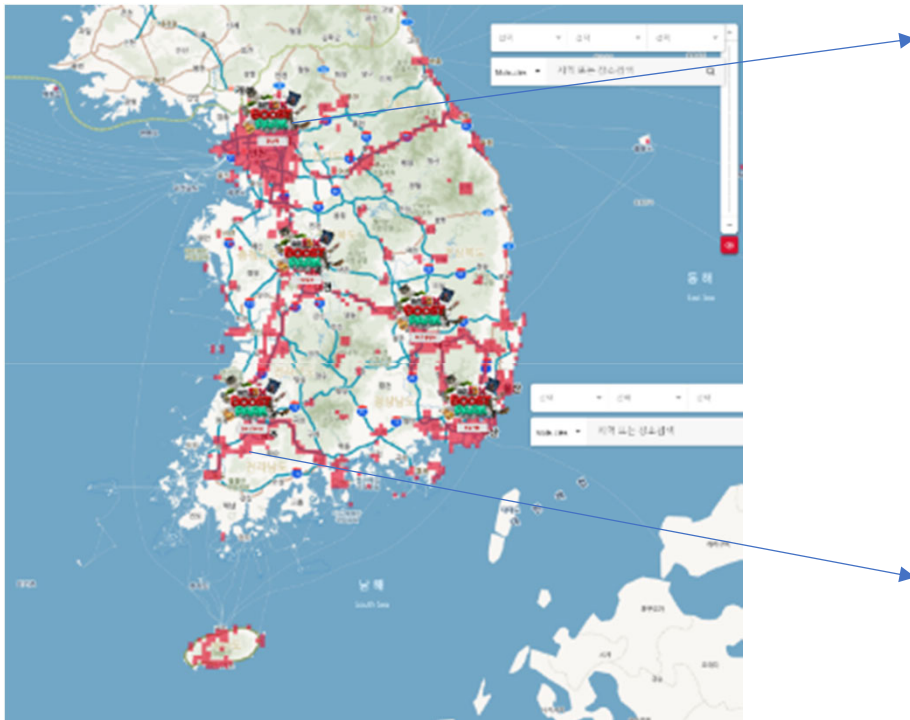


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Coverage of 5G-NR technology in South Korea

/ SKT coverage network on Seoul center and Naju (Old City and New City)

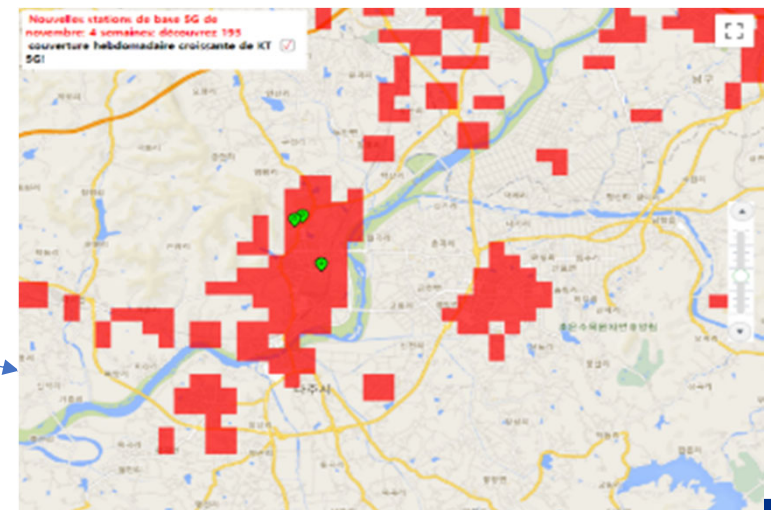
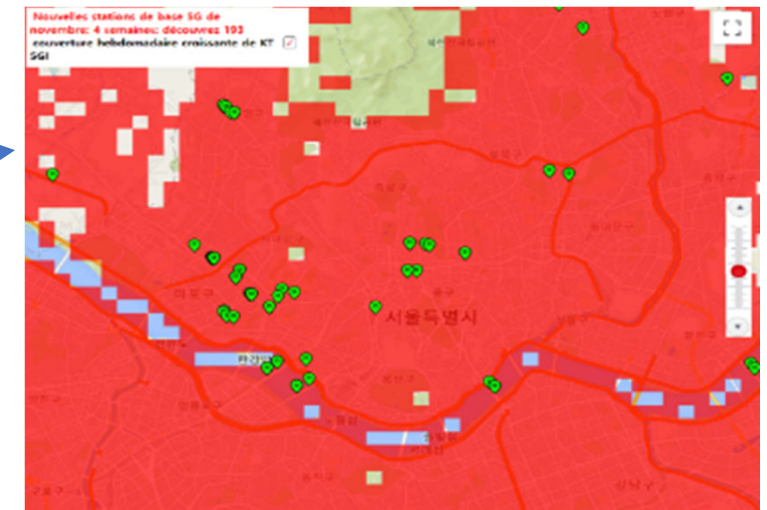
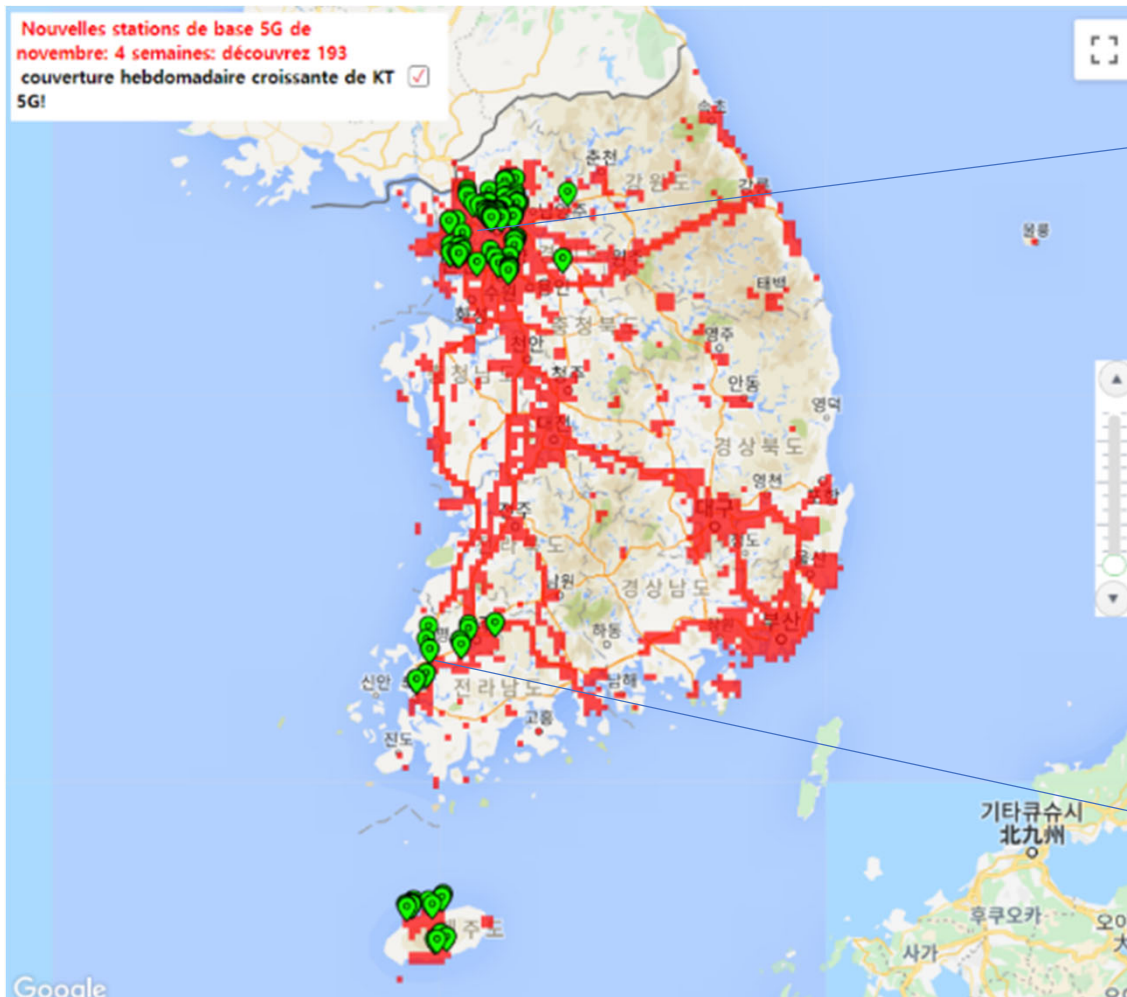


Available date

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Coverage of 5G-NR technology in South Korea

/ KT coverage network on Seoul center and Naju (Old City and New City)



Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Equipment used, and which services are measured

| Designation | Exposimeter 88 - 5875 | | Exposimeter 88 – 6000 | |
|----------------------------|---------------------------------|-------------|-------------------------|-------------|
| Manufacturer / Model | Fields at Work / ExpoM-RF (MHz) | | MVG / EME SPY 200 (MHz) | |
| Setup for measured service | FM | 87.5 - 108 | FM US | 88 - 108 |
| | | | VHF TV | 174 - 223 |
| | | | TETRA1 | 380 - 400 |
| | DVB-T | 470 - 790 | TV45 | 470 - 615 |
| | LTE 800 U L | 791 - 821 | LTE 700 UL | 703-748 |
| | LTE 800 D L | 832 - 862 | LTE 700 DL | 758 - 803 |
| | GSM -R 900 U L | 880 - 915 | GSM -R 900 U L | 880 - 915 |
| | GSM -R 900 D L | 925 - 960 | GSM -R 900 D L | 925 - 960 |
| | GSM / LTE 1800 UL | 1710 - 1785 | GSM / LTE 1800 UL | 1710 - 1785 |
| | GSM / LTE 1800 DL | 1805 - 1880 | GSM / LTE 1800 DL | 1805 - 1880 |
| | DECT | 1880 - 1900 | DECT | 1880 - 1900 |
| | UMTS / LTE 2100 UL | 1920 - 1980 | UMTS / LTE 2100 UL | 1920 - 1980 |
| | UMTS / LTE 2100 DL | 2110 - 2170 | UMTS / LTE 2100 DL | 2110 - 2170 |
| | | | 4G TDD | 2300 - 2400 |
| | W2G | 2400 - 2483 | W2G | 2400 - 2483 |
| | LTE 2600 UL | 2500 - 2570 | LTE 2600 UL | 2500 - 2570 |
| | LTE 2600 DL | 2620 - 2690 | LTE 2600 DL | 2620 - 2690 |
| | 5G TDD (Low Band) | 2400 - 2600 | 5G TDD (Low | 2400 - 2600 |

Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Different types of environnement measured

- / Dense urban residential area - Seoul,
- / Dense urban trade area - Seoul,
- / Dense urban commercial area - Seoul.

- / Urban trip - Seoul,
- / Extra urban trip - Seoul to Incheon,
- / Railways trip – Seoul to Naju

- / Rural residential area - Old town of Naju,
- / Rural administrative area - Old town of Naju,
- / Rural commercial area - Old town of Naju,

- / Urban residential area - New city of Naju,
- / Urban trade aera - New city of Naju,
- / Urban commercial area - New city of Naju,



Exposure measurement

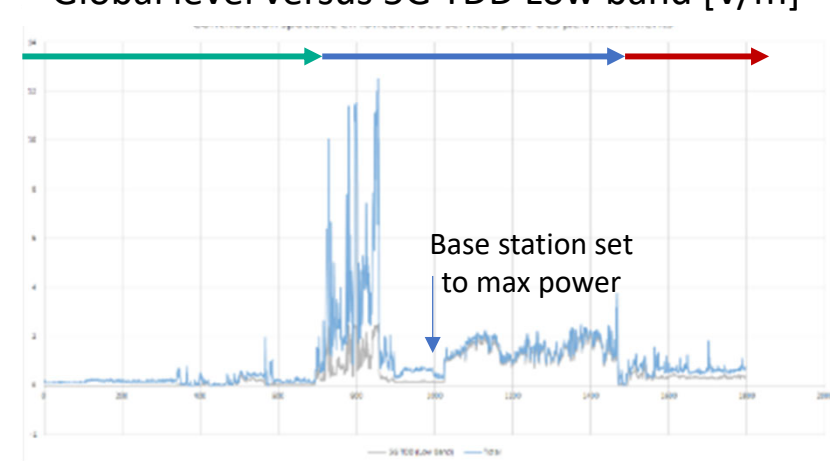
Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Three significant levels measured –
1st : Close to 5G-NR Base station

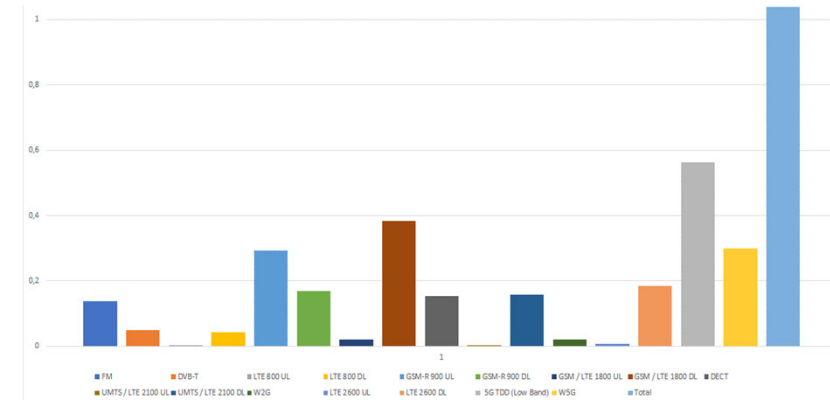
- / On the roof of building – Naju new city ,
- / In the main beam – Naju new city,
- / Building close to it (NRRA) – Naju new city.



ExpoM-RF results
Global level versus 5G TDD Low band [V/m]

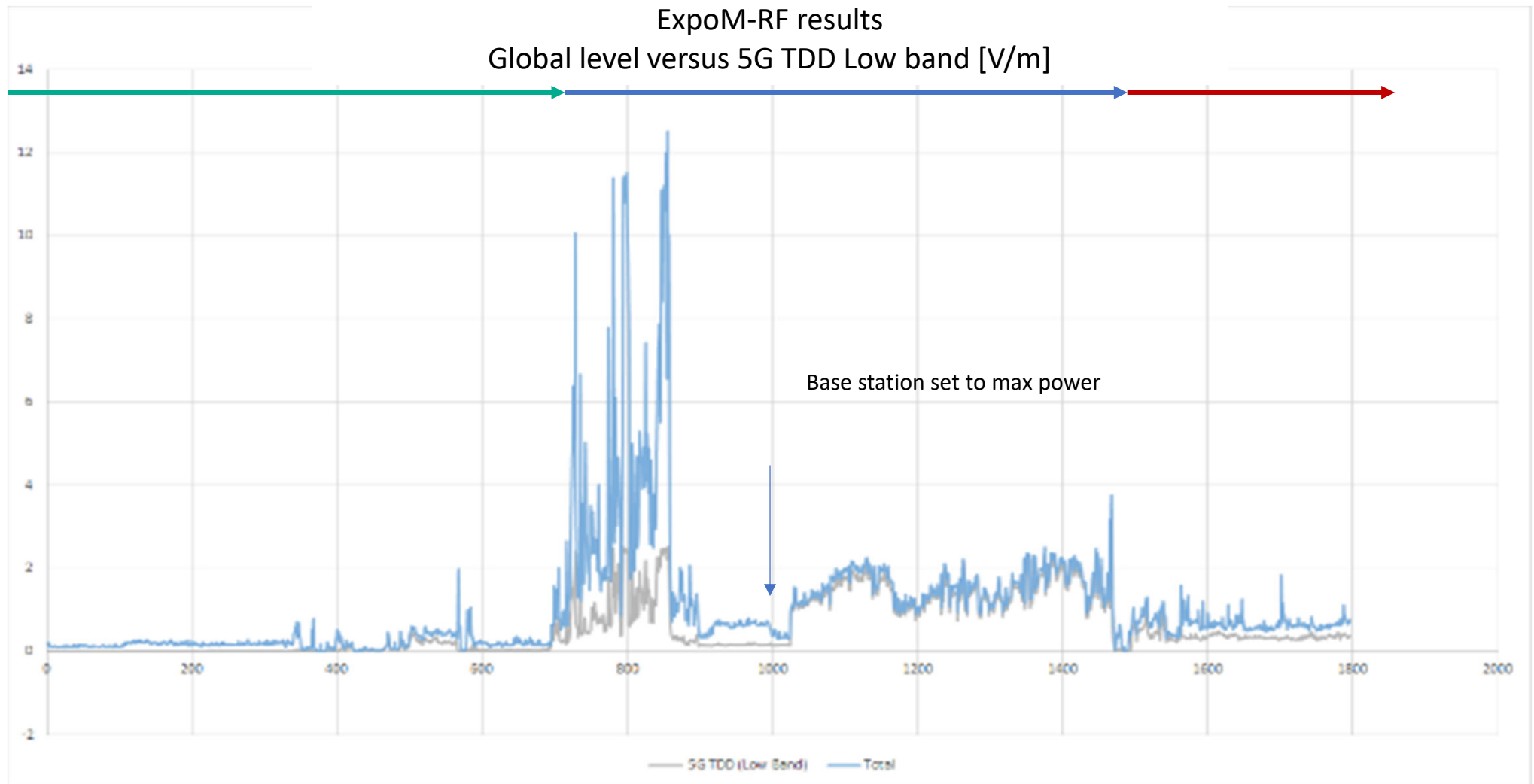


ExpoM-RF results
Global level versus other services [V/m]



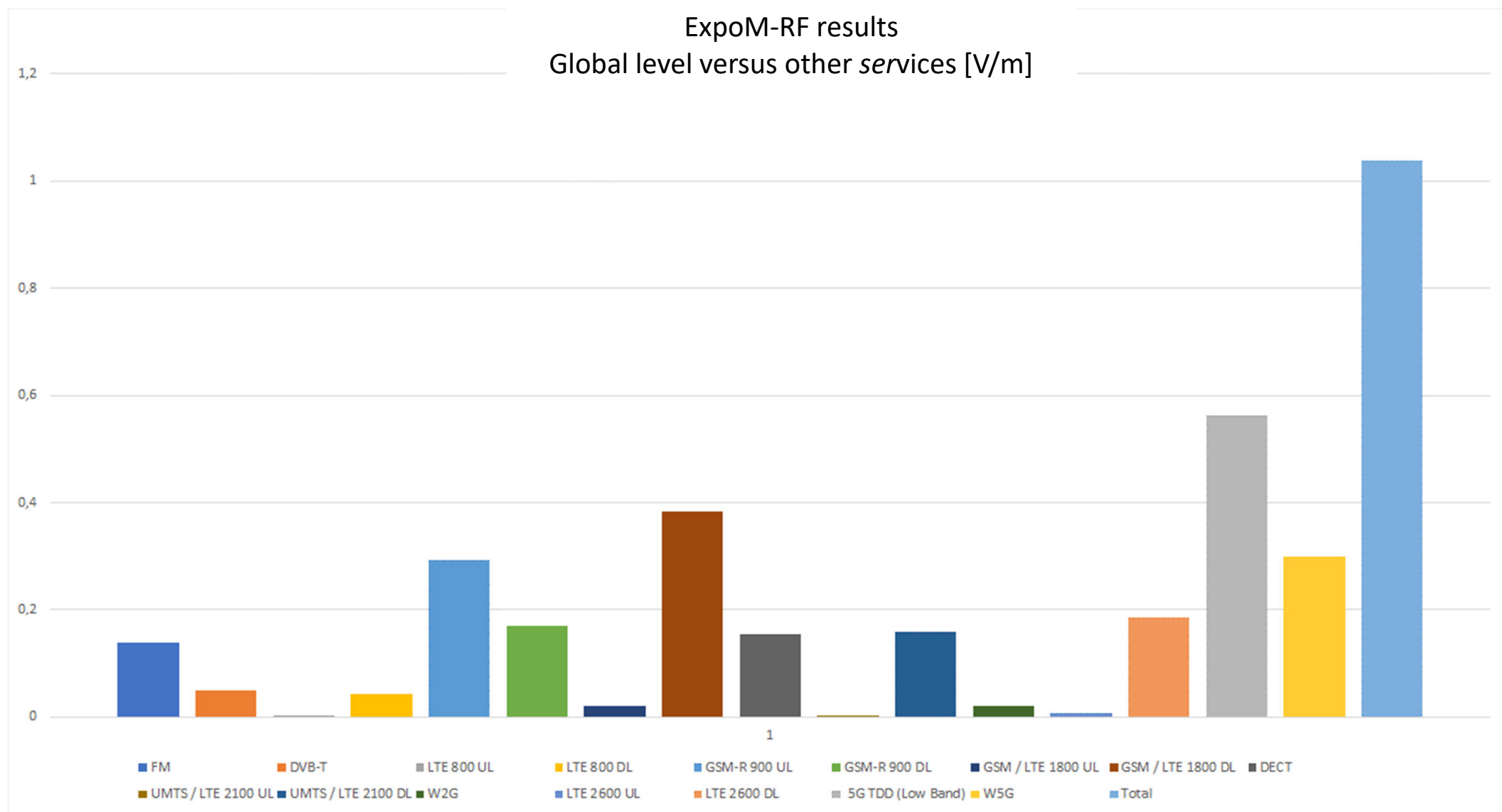
Exposure measurement

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Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

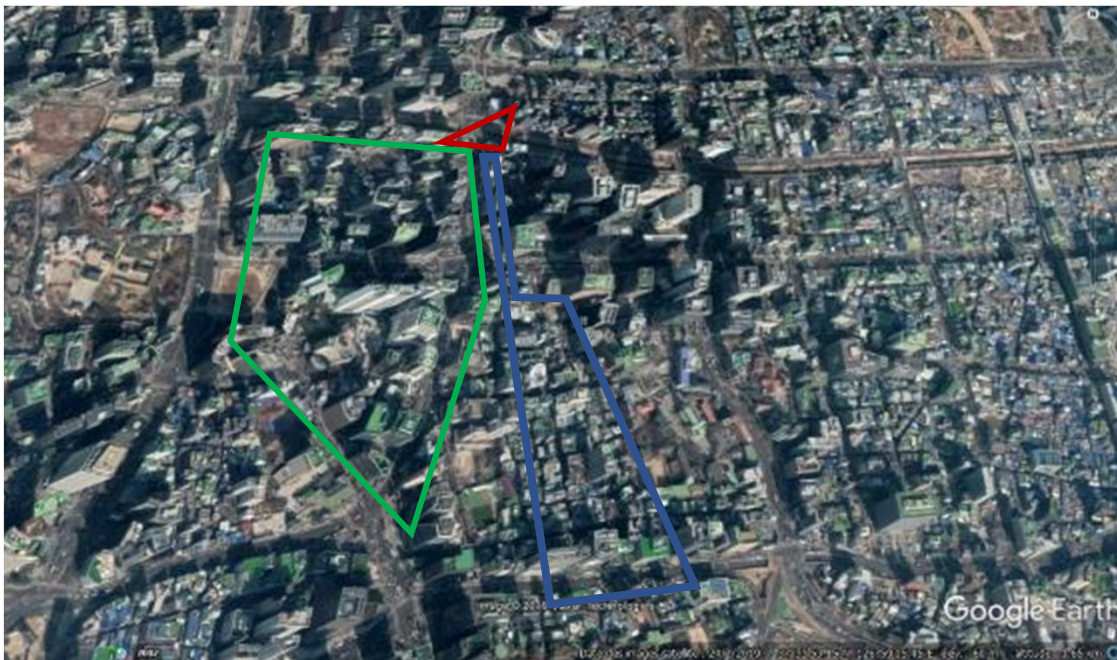


Exposure measurement

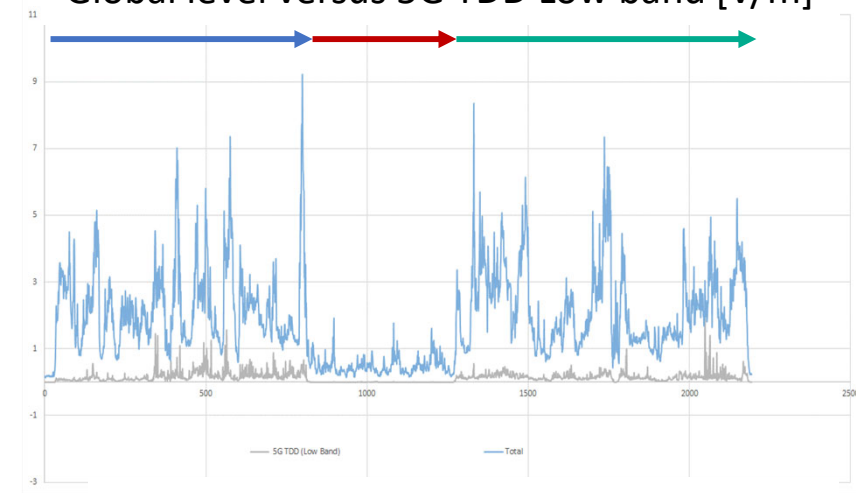
Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Three significant levels measured – 2nd : Seoul center

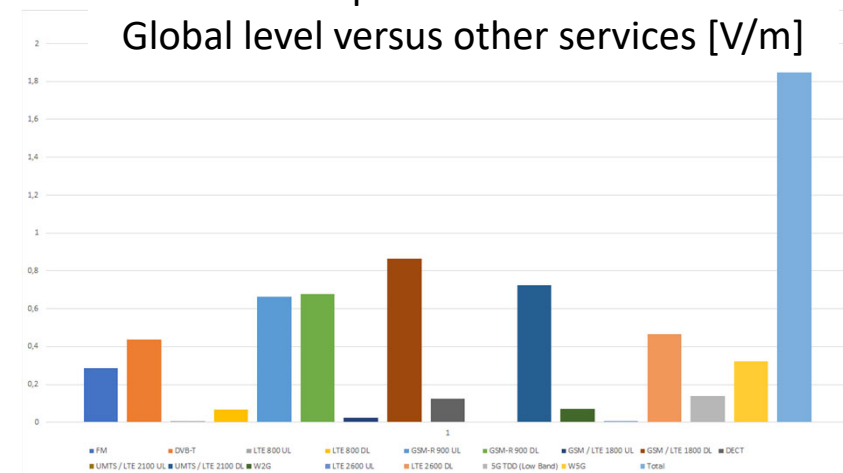
- / Dense urban commercial area - Seoul,
- / **Dense urban commercial area (underground) - Seoul,**
- / Dense urban trade area - Seoul.



ExpoM-RF results
Global level versus 5G TDD Low band [V/m]



ExpoM-RF results
Global level versus other services [V/m]



Exposure measurement

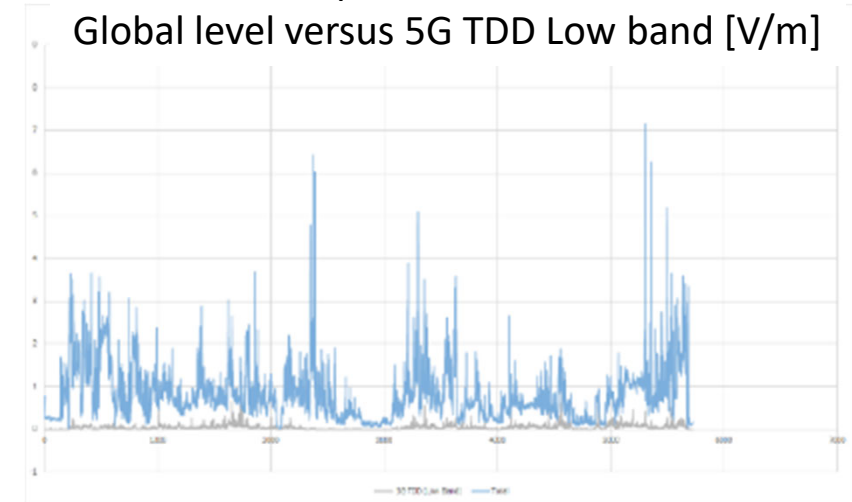
Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Three significant levels measured – 3rd : Seoul trip

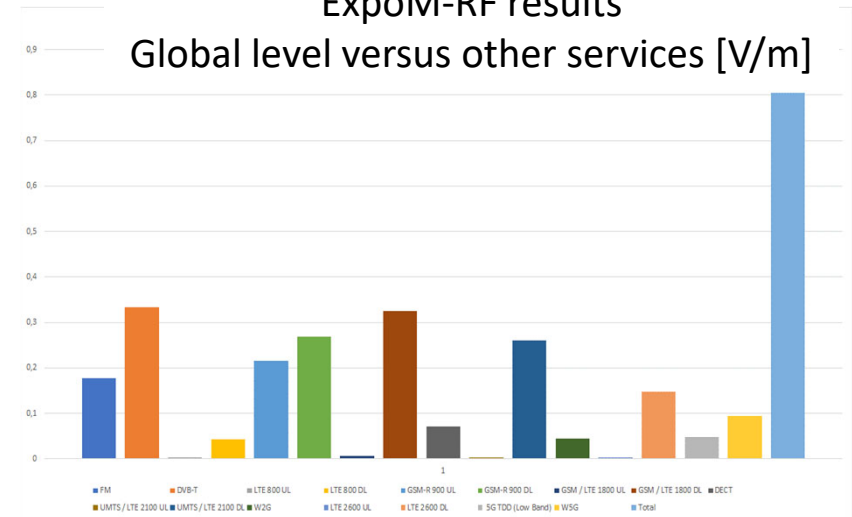
✓ Dense urban area (underground) – Seoul trip,



ExpoM-RF results
Global level versus 5G TDD Low band [V/m]



ExpoM-RF results
Global level versus other services [V/m]



Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Summary of geographic measurements

/ For 5G TDD low band (EME Spy 200 and ExpoM-RF)

| Evaluation type | Global level for all the services [mV/m] | 5G TDD (Low Band) Average level [mV/m] | 5G TDD (Low Band) Maximum level [mV/m] | 5G TDD (Low Band) Standard deviation [mV/m] |
|---------------------------------|--|--|--|---|
| Dense urban zone | 1850 | 140 | 2140 | 160 |
| | 1740 | 70 | 2060 | 130 |
| Rural zone | 340 | 20 | 800 | 50 |
| | 120 | 20 | 90 | 2 |
| Urban zone | 470 | 20 | 260 | 30 |
| | 120 | 20 | 100 | 7 |
| Close to 5G-NR base station | 1040 | 560 | 2580 | 670 |
| | 300 | 50 | 2550 | 170 |
| Railways line (Seoul – Naju) | 370 | 20 | 730 | 30 |
| | 500 | 20 | 90 | 3 |
| Urban trip | 810 | 50 | 1550 | 60 |
| | 190 | 20 | 300 | 10 |
| Extra urban trip | 280 | 20 | 500 | 40 |
| | 120 | 20 | 90 | 4 |

Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Summary of geographic measurements

/ For 5G TDD high band (EME Spy 200),

| Evaluation type | Global level for all the services [mV/m] | 5G TDD (High Band) Average level [mV/m] | 5G TDD (High Band) Maximum level [mV/m] | 5G TDD (High Band) Standard deviation [mV/m] |
|------------------------------|--|---|---|--|
| Rural zone | 120 | 30 | 150 | 20 |
| Urban zone | 120 | 30 | 520 | 20 |
| Close to 5G-NR base station | 300 | 170 | 4090 | 550 |
| Railways line (Seoul – Naju) | 500 | 20 | 160 | 8 |
| Urban trip | 190 | 30 | 3440 | 60 |
| Extra urban trip | 120 | 30 | 350 | 20 |

Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

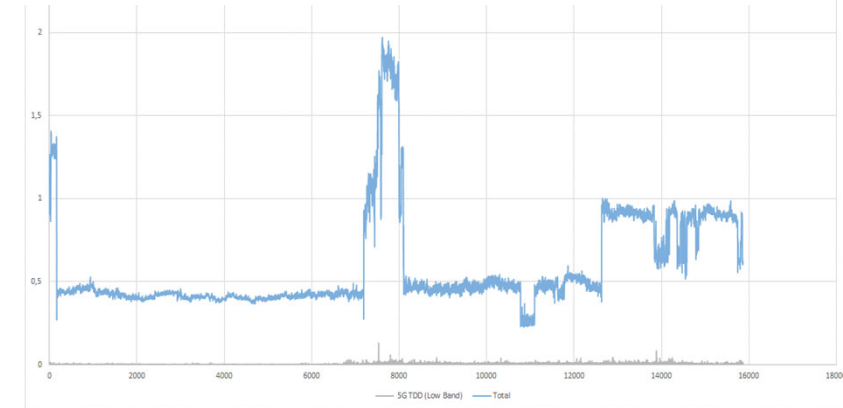
Temporal variability at fixed point exposure during 24 h



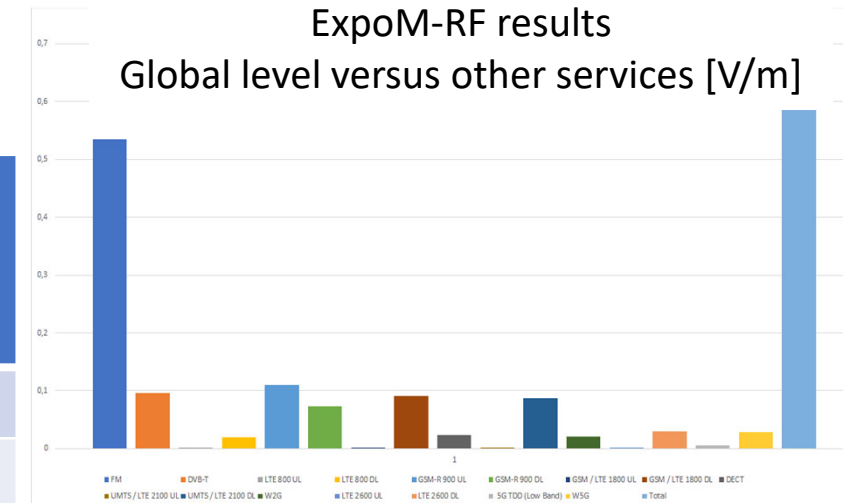
/ For 5G TDD low band (EME Spy 200 and ExpoM-RF)

| Evaluation type | Global level for all the services [mV/m] | 5G TDD (Low Band) Average level [mV/m] | 5G TDD (Low Band) Maximum level [mV/m] | 5G TDD (Low Band) Stand dev [mV/m] |
|-----------------|--|--|--|------------------------------------|
| At fixed point | 590 | 5 | 130 | 4 |
| | 340 | ≤20 | ≤20 | 0,0 |

ExpoM-RF results
Global level versus 5G TDD Low band [V/m]



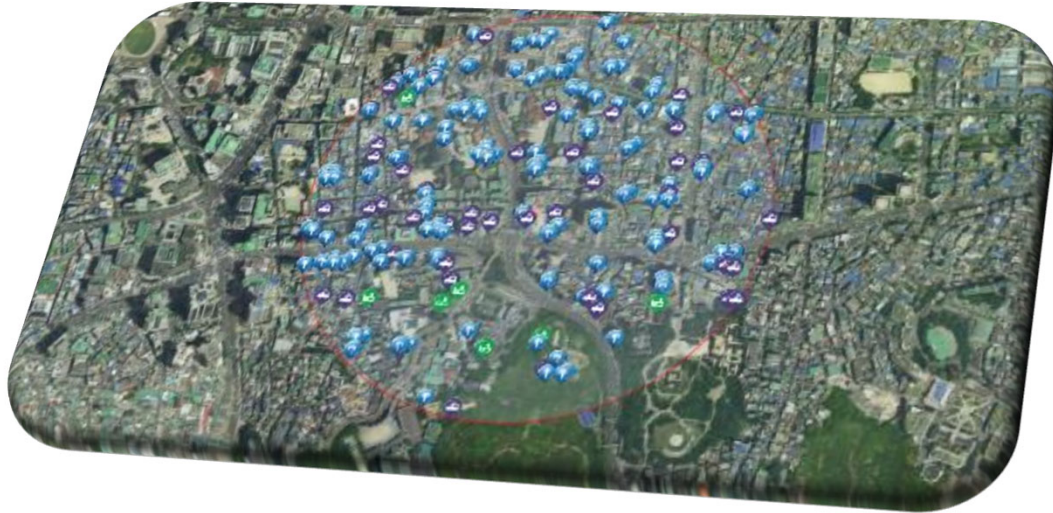
ExpoM-RF results
Global level versus other services [V/m]



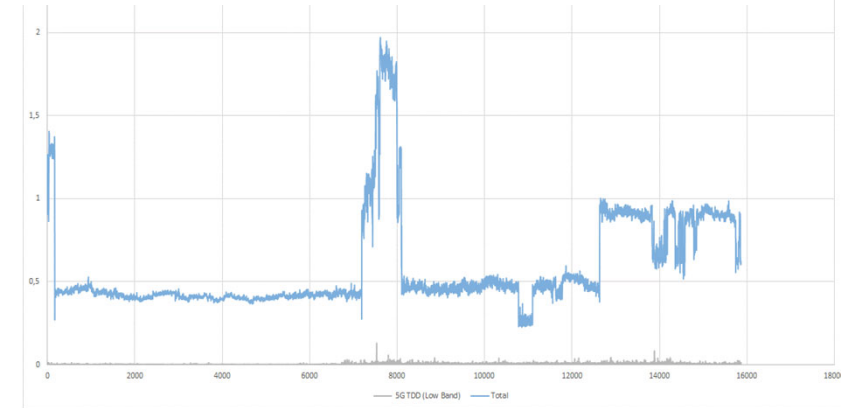
Exposure measurement

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

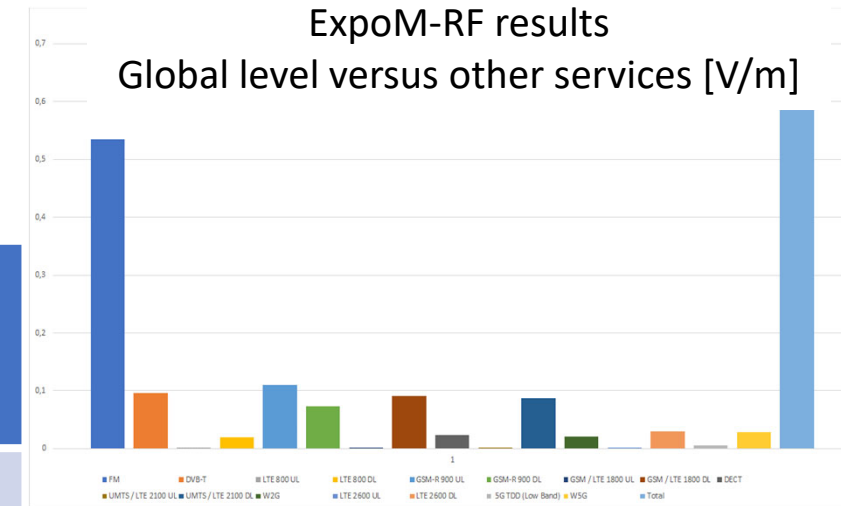
Temporal variability at fixed point exposure during 24 h



ExpoM-RF results
Global level versus 5G TDD Low band [V/m]



ExpoM-RF results
Global level versus other services [V/m]



For 5G TDD high band (EME Spy 200)

| Evaluation type | Global level for all the services [mV/m] | 5G TDD (High Band) Average level [mV/m] | 5G TDD (High Band) Maximum level [mV/m] | 5G TDD (High Band) Stand dev [mV/m] |
|---------------------------|--|---|---|-------------------------------------|
| A point fixe urbain dense | 340 | ≤20 | ≤20 | 0,0 |

Characterization of a 5G-NR base station

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

Wide band level with a 100 kHz – 6 GHz fieldmeter

/ GPS coordinates: 35 ° 01'17.45"N / 126 ° 47'37.50 " E

At the corner of Hanbit road and Bitgaram road

Level R + 6

NAJU - SOUTH KOREA



| Measurement point | Level [V/m] in the bandwidth 100 kHz – 6GHz | Comments |
|---------------------------------|---|-------------------------------|
| 1 (at 15m far from the antenna) | 12,1 | KT base station initial power |
| 1 | 21,0 | KT base station max power |
| 2 | 8,8 | KT base station max power |
| 3 | 3,8 | KT base station max power |
| 4 | 4,7 | KT base station max power |

Characterization of a 5G-NR base station

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

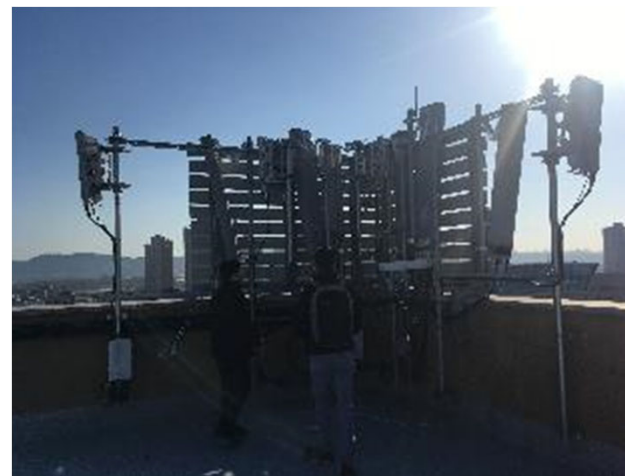
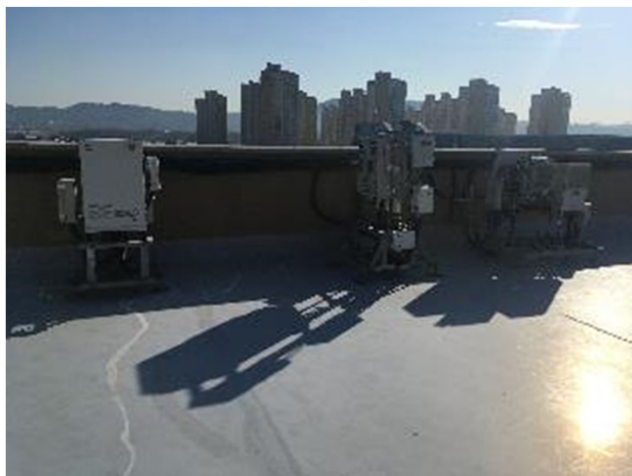
Spatial variability and services measurement

/ Spatial variability at max point, for a 100 kHz – 6 GHz bandwidth:

- at 1,70 m, $E = 20,9$ V/m
- at 1,50 m, $E = 21,0$ V/m
- at 1,10 m, $E = 21,0$ V/m

/ Services measurement at max point, above 300 mV/m

- Mobile 1,8 GHz DL $E = 330$ mV/m
- Mobile 5 GHz TDD $E = 1470$ mV/m
- WiFi 5 G $E = 360$ mV/m

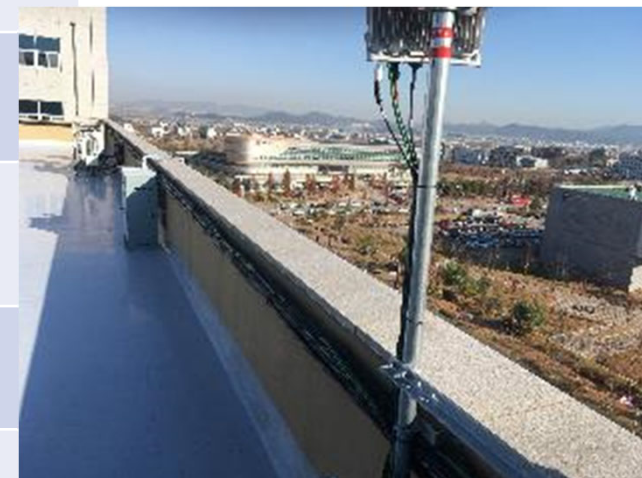


Characterization of a 5G-NR base station

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

5G Max level and 5G Power channel measurement

| Measurement | Max level measured (mV/m) | Power Channel (mV/m) BW around 3,55GHz | |
|--|---------------------------|--|--------|
| | | BW 20 | BW 100 |
| On the roof at 15m far from the 5G antenna | | | |
| RMS measurement around KT central frequency with an horn antenna | 47 | 300 | 680 |
| RMS measurement around KT central frequency with an horn antenna (Max hold mode) | 51 | 590 | 1310 |
| RMS measurement around KT central frequency with an isotropic antenna | 63 | 290 | 850 |
| RMS measurement around KT central frequency with an isotropic antenna (Max hold mode) | 85 | 650 | 1160 |
| Power channel measurement around KT central frequency at 5G base station max power | | 290 | |
| Power channel measurement around KT central frequency at 5G base station initial power | | 170 | |

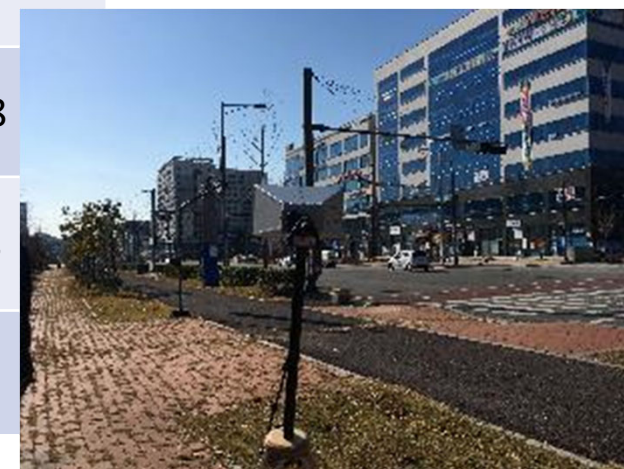


Characterization of a 5G-NR base station

Measurement of exposure to radio frequency radiation from 5G-NR telephony in South Korea 11-2019

5G Max level and 5G Power channel measurement

| Measurement | Max level measured (mV/m) | Power Channel (mV/m) BW around 3,55GHz | |
|---|---------------------------|---|--------|
| | | BW 20 | BW 100 |
| In the main lobe of the 5G antenna, in the street at 150m from the 5G antenna | | | |
| RMS measurement around KT central frequency with an horn antenna | 2,2 | 14 | 37 |
| RMS measurement around KT central frequency with an horn antenna (Max hold mode) | 3,2 | 17 | 73 |
| RMS measurement around KT central frequency with an isotropic antenna | 0,8 | 4,6 | 9,8 |
| RMS measurement around KT central frequency with an isotropic antenna (Max hold mode) | 0,9 | 8,3 | 18 |
| Power channel measurement around KT central frequency at 5G base station max power | | 15 | |





Questions?