




airmet and L3HARRIS | narda Safety Test Solutions presenting

# 5G IN A NUTSHELL

New Aspects and Peculiarities of EMF Testing -

Part I : Intro and Basics
Part II: Extrapolation to maximum EMF exposure

**July 9th, 2019**

Volker Brands, Dipl.-Ing. – Regional Sales Manager
Narda Safety Test Solutions GmbH – Pfullingen / Germany

# 5G in a Nutshell

- 5G (short for 5th Generation) is a frequently used term for certain advanced wireless systems.
- Industry association 3GPP defines any system using "5G NR" (5G New Radio) software as "5G“

# 5G in a Nutshell

## Typical physical parameter of mobile networks

| | 2G “GSM” | 3G “UMTS” | 4G “LTE” | 5G “NR” |
|---|---|---|---|---|
| RF Frequency | < 3 GHz | < 6 GHz | < 6 GHz | < 6 GHz & > 24 GHz |
| RF Bandwidth | 200 kHz / carrier | 5 MHz / carrier | Up to 20 MHz / carrier | < 6 GHz up to 100 MHz/carrier<br>> 24 GHz up to 400 MHz/carrier |
| DL Data rate | 9.6 kB/s | 384 kB/s | 150 MB/s | 10 GB/s |
| Latency | | ~ 100 ms | ~ 30 ms | ~ 1 ms |

# 5G in a Nutshell

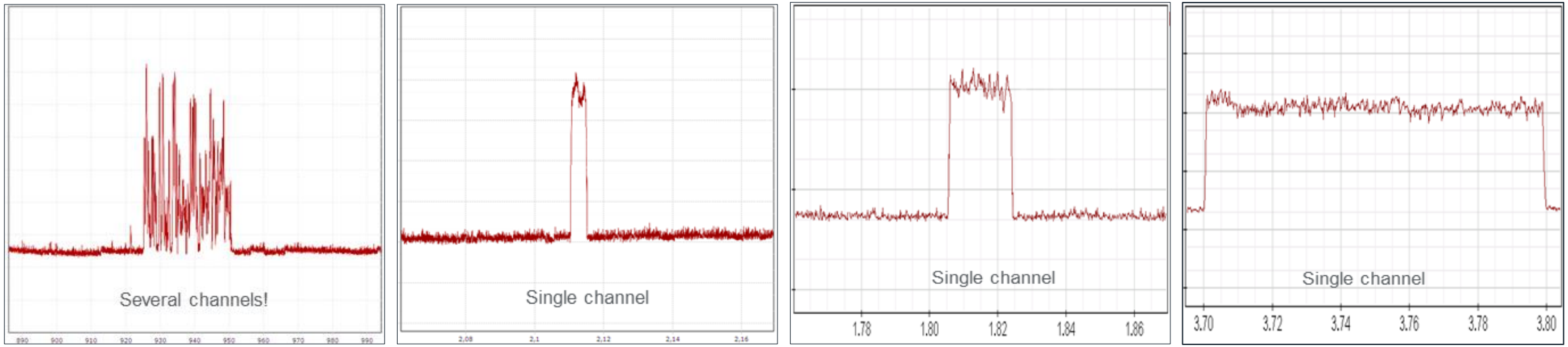
## Mayor focus of mobile networks

| | 2G “GSM” | 3G “UMTS” | 4G “LTE” | 5G “NR” |
|---|---|---|---|---|
| Application | • Voice<br>• Data<br>• SMS | • Voice<br>• Internet<br>• SMS | • Voice<br>• Video<br>• Fast mobile internet | • Voice<br>• 4K / 8K-Videos<br>• Ultra fast mobile internet<br>• Massive Machine Type Communications M2M<br>• Ultra-Reliable and Low Latency<br>• Industry 4.0<br>• Internet of Things IoT<br>• Car to car communication<br>• Broadcasting |
| Propagation | MIMO (base station only) | MIMO (base station only) | MIMO (Beamforming) | Massive MIMO Beamforming |

# 5G in a Nutshell

## Mobile networks in frequency domain

| 2G, 200 KHZ BANDWIDTH PER CARRIER | 3G, 5 MHZ MAXIMUM BANDWIDTH | 4G, 20 MHZ MAXIMUM BANDWIDTH | 5G, 100 MHZ MAXIMUM BANDWIDTH @ < 6 GHZ |
|---|---|---|---|




Frequency-span 108 MHz

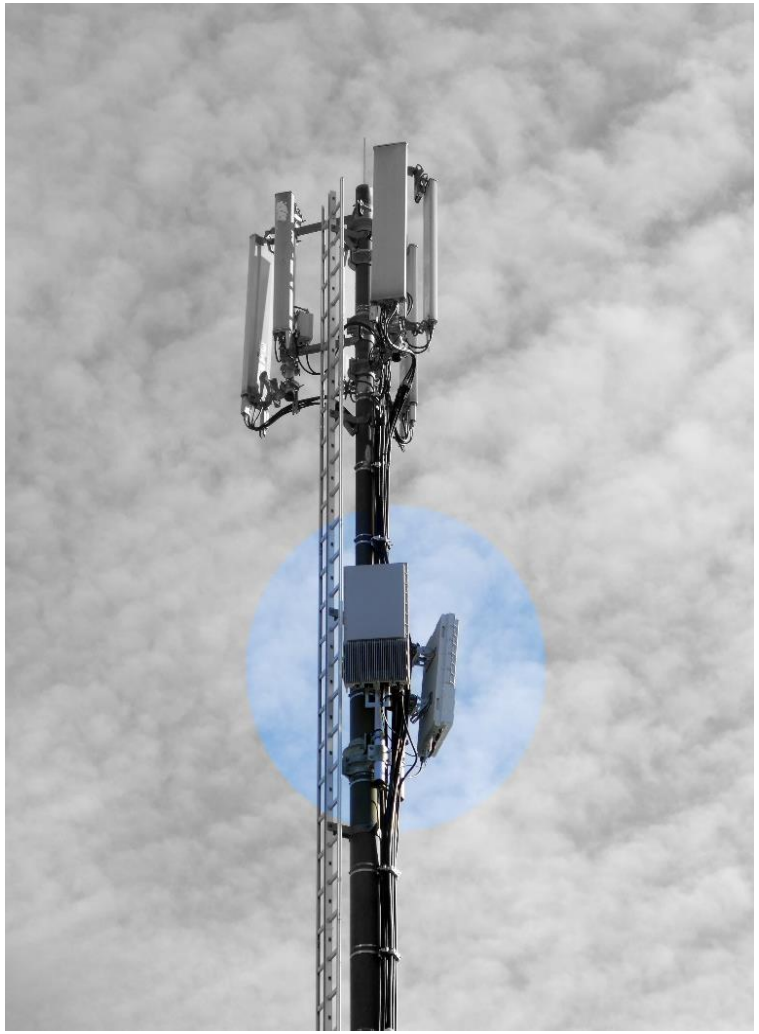
# 5G, Beam Forming and Massive MIMO

# 5G in a Nutshell

## 5G, Beam Forming and Massive MIMO

When talking about 5G also Beam Forming and Massive MIMO are mentioned. What is the relationship between 5G, Beam Forming and Massive MIMO?

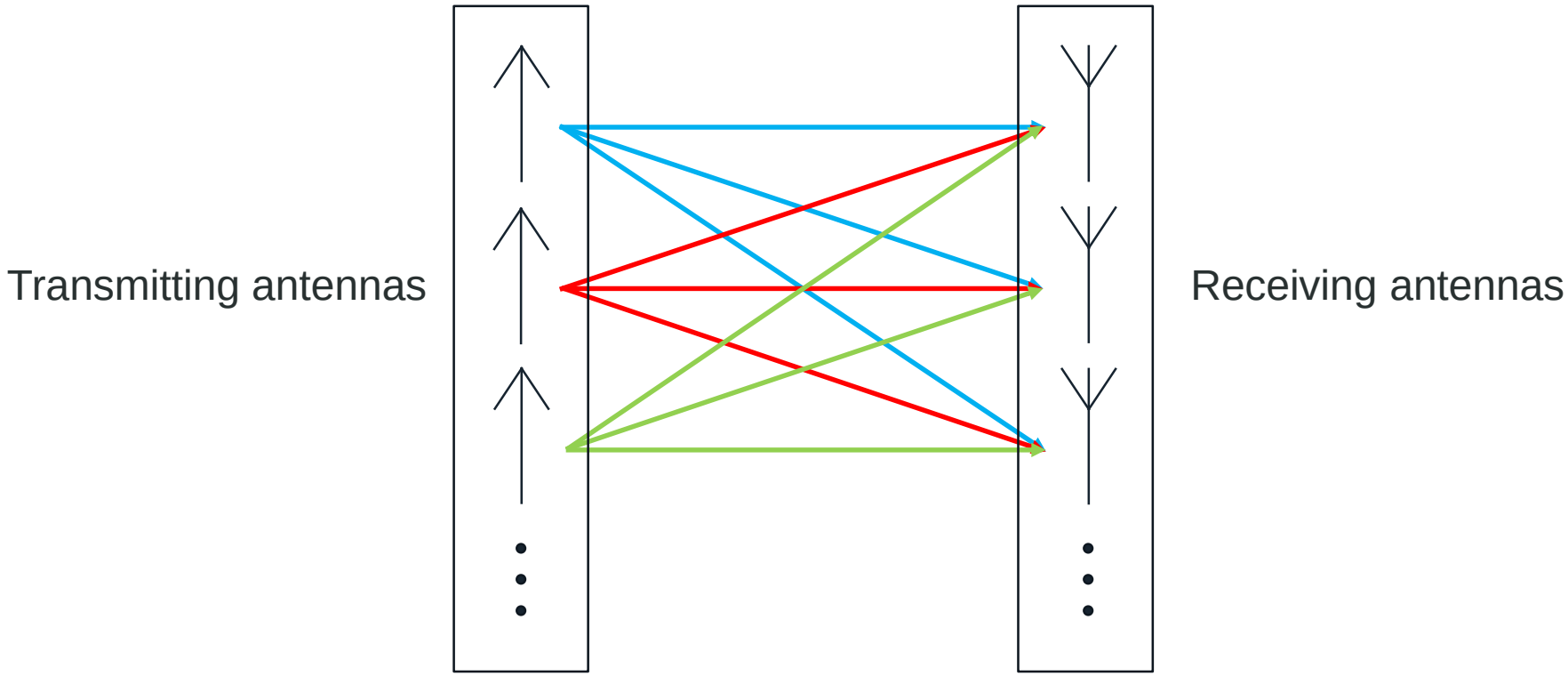
- Neither Beam Forming nor Massive MIMO are new technologies or depend on 5G
- Beam Forming or MIMO are already used in modern WiFi-routers, some 4G installations etc.
- 5G can be used also without those technologies
- But it is expected, that most 5G installations will be using at least Beam Forming
- Beam Forming and Massive MIMO require an array of multiple antennas so they are used synonymously



# 5G in a Nutshell

## (Massive) MIMO

- (multiple input and multiple output) antennas increases sector throughput and capacity density using large numbers of antenna. In service for mobile radio applications since 2G (GSM base station).

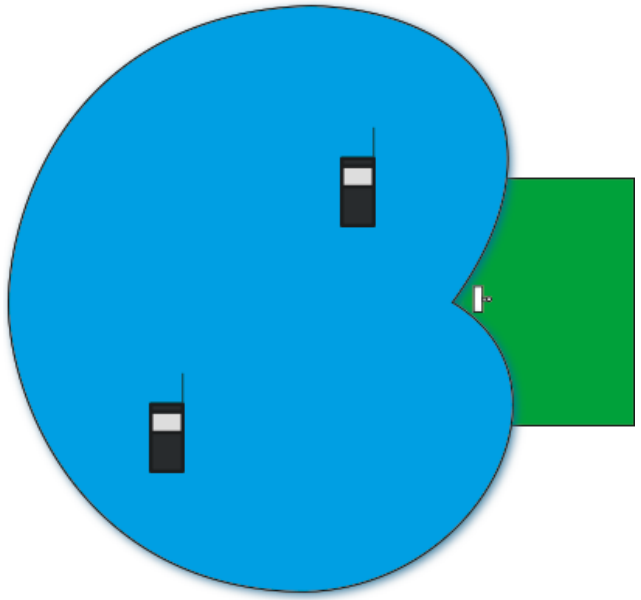


# 5G in a Nutshell

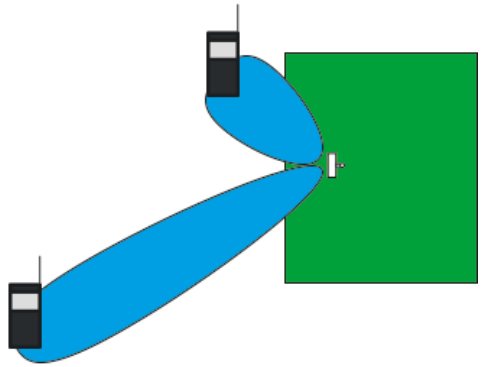
## Beam Forming

is used to direct radio waves to a target. This is achieved by combining elements in an antenna. This improves signal quality and data transfer speeds because of the improved signal quality and avoids fading effects. Beamforming can also improve the antenna gain.

**HORIZONTAL PATTERN OF A SEGMENT ANTENNA (120°) WITHOUT BEAMFORMING**



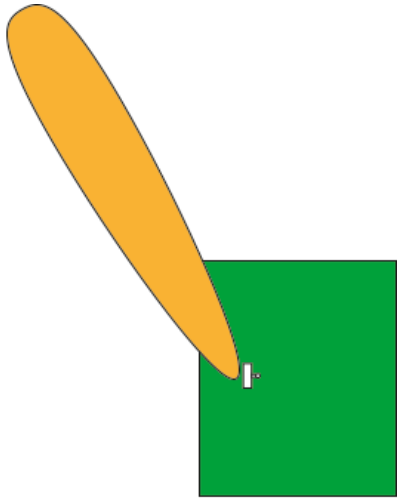
**HORIZONTAL PATTERN OF A SEGMENT ANTENNA WITH BEAMFORMING**



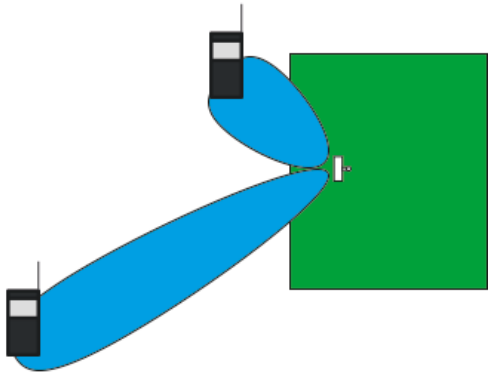
# 5G in a Nutshell

## Beam Forming can be used for multiple purpose:

**E.G.: SCANNING THE SECTOR WITH THE "SIGNALIZATION" TO BUILT UP COMMUNICATION**

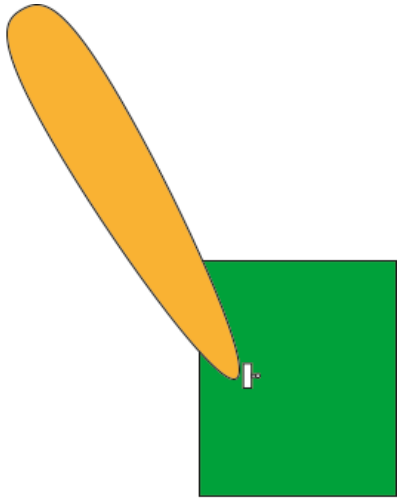
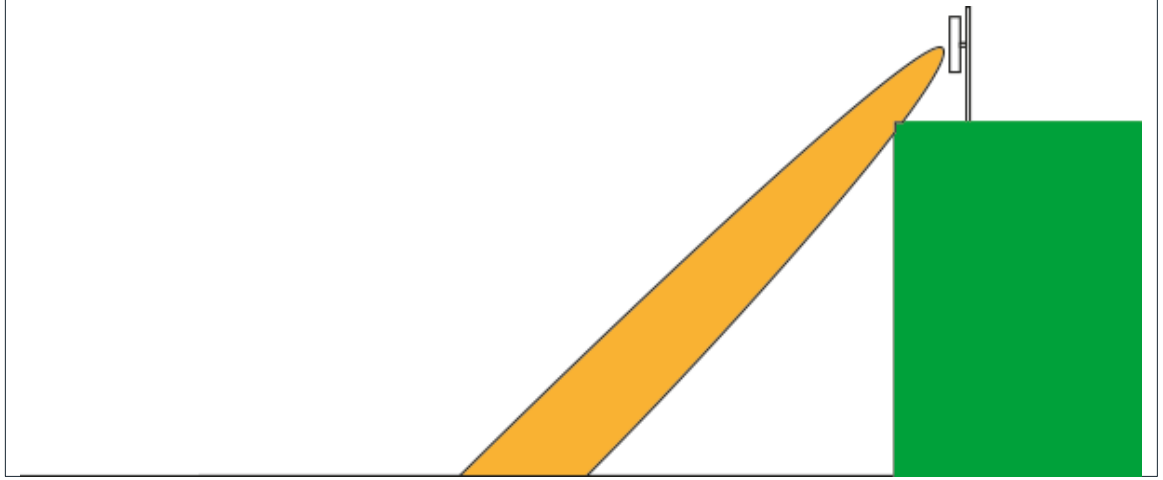


**FOCUSING THE "TRAFFIC SIGNAL" TO THE TERMINAL DEVICE FOR OPTIMUM CONNECTIVITY**



# 5G in a Nutshell

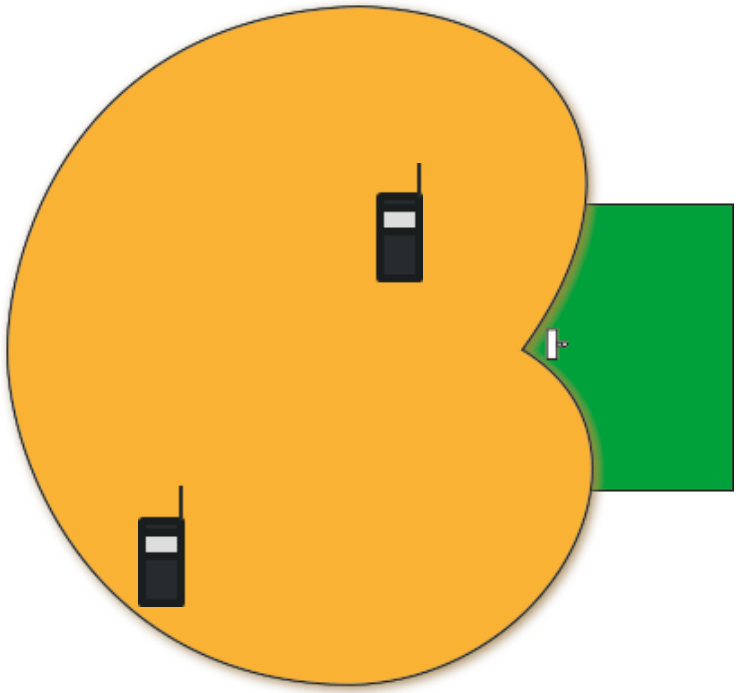
## Beam Forming is available for:

| HORIZONTAL SCANNING | VERTICAL SCANNING |
| --- | --- |
|  |  |

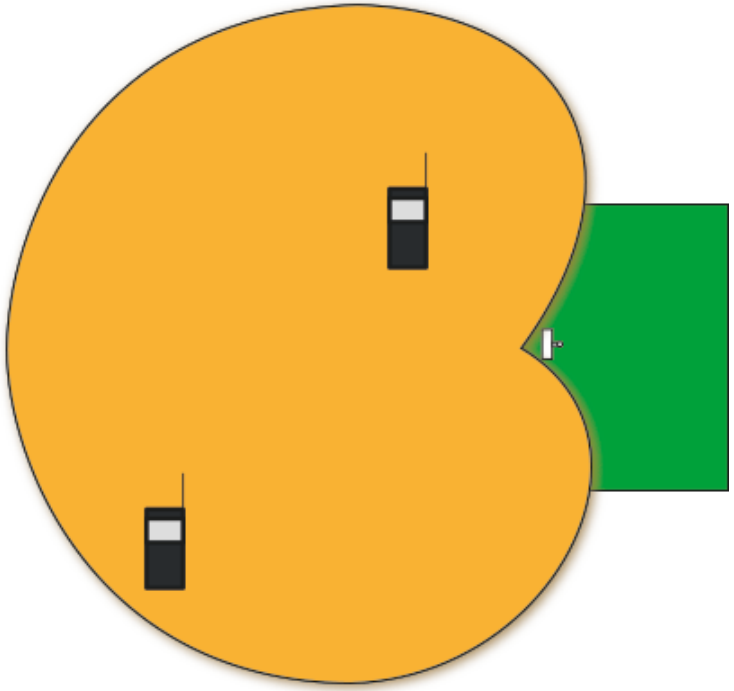
# 5G in a Nutshell

## For 5G the following configurations are expected:

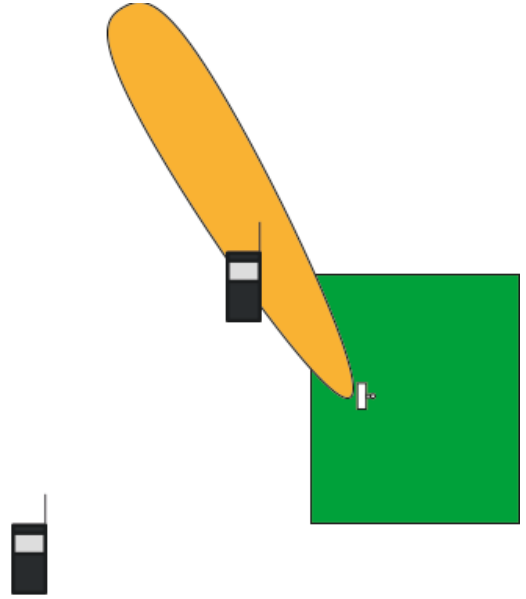
**SIGNALIZATION WITHOUT BEAM FORMING**
**TRAFFIC WITHOUT BEAM FORMING**



**SIGNALIZATION WITHOUT BEAM FORMING**
**TRAFFIC WITH BEAM FORMING**



**SIGNALIZATION WITH BEAM FORMING**
**TRAFFIC WITH BEAM FORMING**



# What is the impact of 5G to measurements of electromagnetic fields?

# 5G in a Nutshell

## Personal protection at workplace

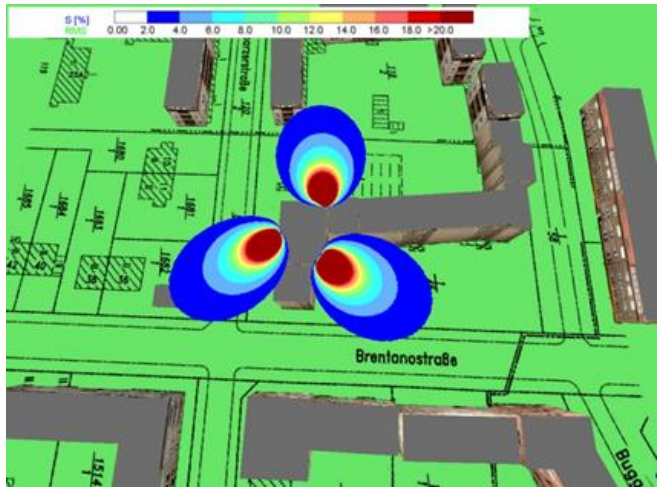
- Signal parameters as: modulation, crest factor and signal shape are not critical to Narda NBM, RadMan 2 or
  Nardalert S3
- As 5G will use also frequencies > 24 GHz with relevant output power, models with an upper frequency limit of 6 or 8 GHz only are not recommended
- As the beam can change its direction, the personal monitor should always be worn on the body

# 5G in a Nutshell

## Definition of safety zones

Typically the actual maximum scenario is base for defining safety or exclusion zones

- Rough estimation by calculation
- Precise simulation by simulation software EFC-400TC
- For a measurement based on extrapolation to the actual maximum Narda has proposed two measurement procedures based on SRM-3006 (more information see next pages “Environmental measurements”).




# 5G in a Nutshell

## Environmental measurements, current exposure

- NBM-550 and 520 are able to cover all future frequencies of 5G up to 90 GHz
- NBM products are able to measure the current fieldstrength and are able to present the result in e.g. V/m of mW/cm² or directly in % of standard
- SRM-3006 can perform selective measurements up to 6 GHz, and is also able to distinguish between different services
- An extension of SRM-3006 to frequencies > 24 GHz is foreseen on the roadmap

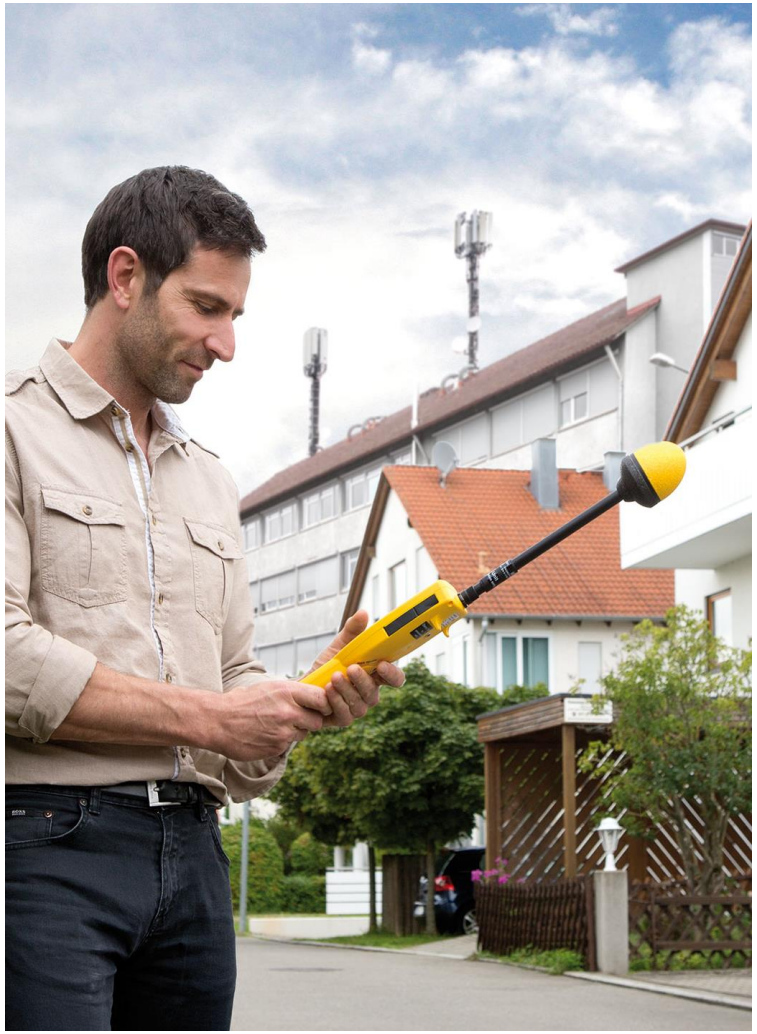
| Battery: | Ext. Power | GPS: | 48°27'29.9" N | Ant: | 3AX 0.4-6G | SrvTbl: | EU Full Band |
|---|---|---|---|---|---|---|---|
| 16.05.19 | 12:21:43 | | 9°13'48.9" E | Cable: | --- | Stnd: | ICNIRP GP |

Table View: Condensed

| Index | Service | Max | Avg |
|---|---|---|---|
| 8 | BandV | 0.256 % | 0.233 % |
| 9 | GSM-R | 0.015 % | 0.009 37 % |
| 10 | GSM | 0.224 % | 0.202 % |
| 11 | L-Band | 0.024 % | 0.021 % |
| 12 | DECT | 0.006 48 % | 0.005 48 % |
| 13 | UMTS-TDD | 0.038 % | 0.035 % |
| 14 | UMTS | 0.022 % | 0.019 % |
| 15 | W-LAN | 0.042 % | 0.038 % |
| 16 | ISM | 0.009 12 % | 0.007 51 % |
| 17 | 5G | 0.102 % | 0.093 % |
| | Others | 1.739 % | 1.687 % |
| | Total | 5.012 % | 4.856 % |

Isotropic

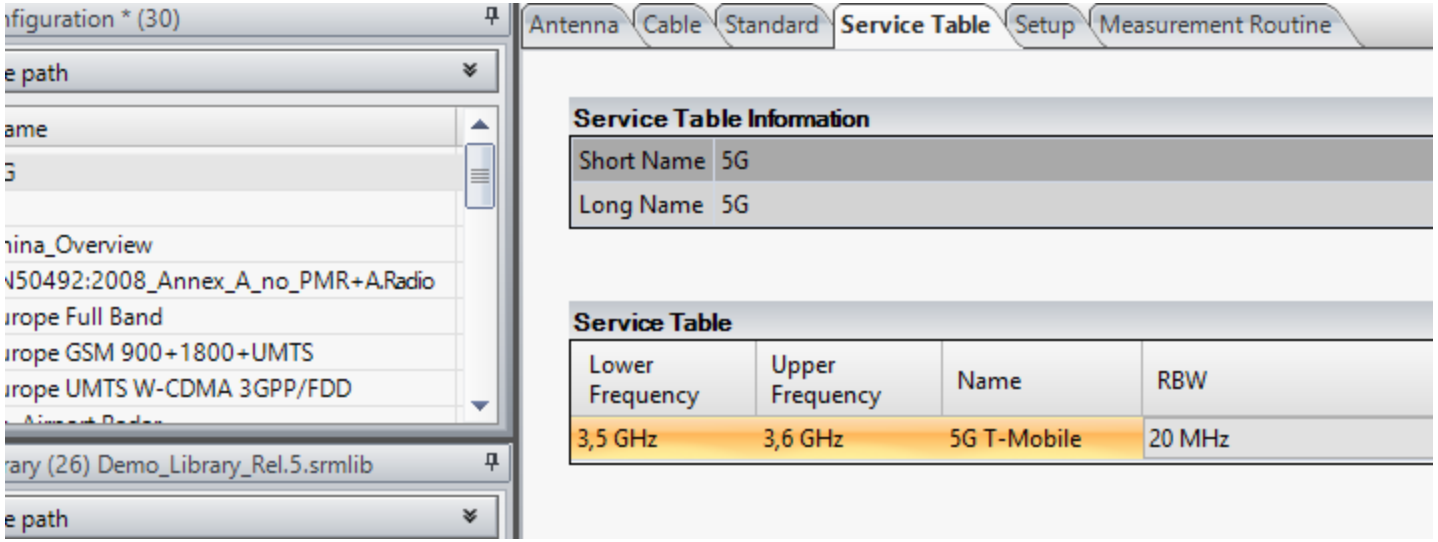
| | | | | Sweep Time: | 3.255 s | Progress: | |
|---|---|---|---|---|---|---|---|
| MR: | 1 000 % | RBW: | 200 kHz (Auto) | Noise Suppr.: | Off | No. of Runs: | 1 257 |
| | | | | | | AVG: | 6 min |

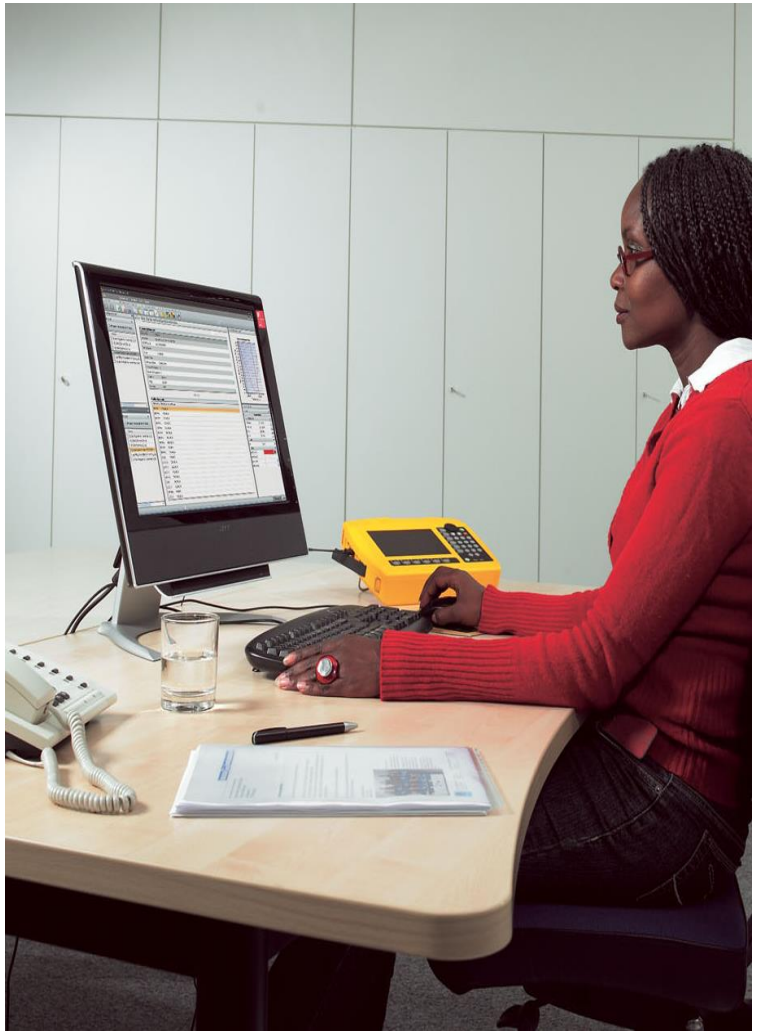


# 5G in a Nutshell

## Environmental measurements, current exposure

- Selective measuring equipment has a limited upper RBW
- SRM-3006 is able to perform measurements on services with 40 MHz, 100 MHz or higher bandwidth by the “Safety Evaluation Mode”
- With the analyzer Narda provides a PC-software by which the user is able to define a service with any bandwidth, e.g. a 5G service with 100 MHz bandwidth:

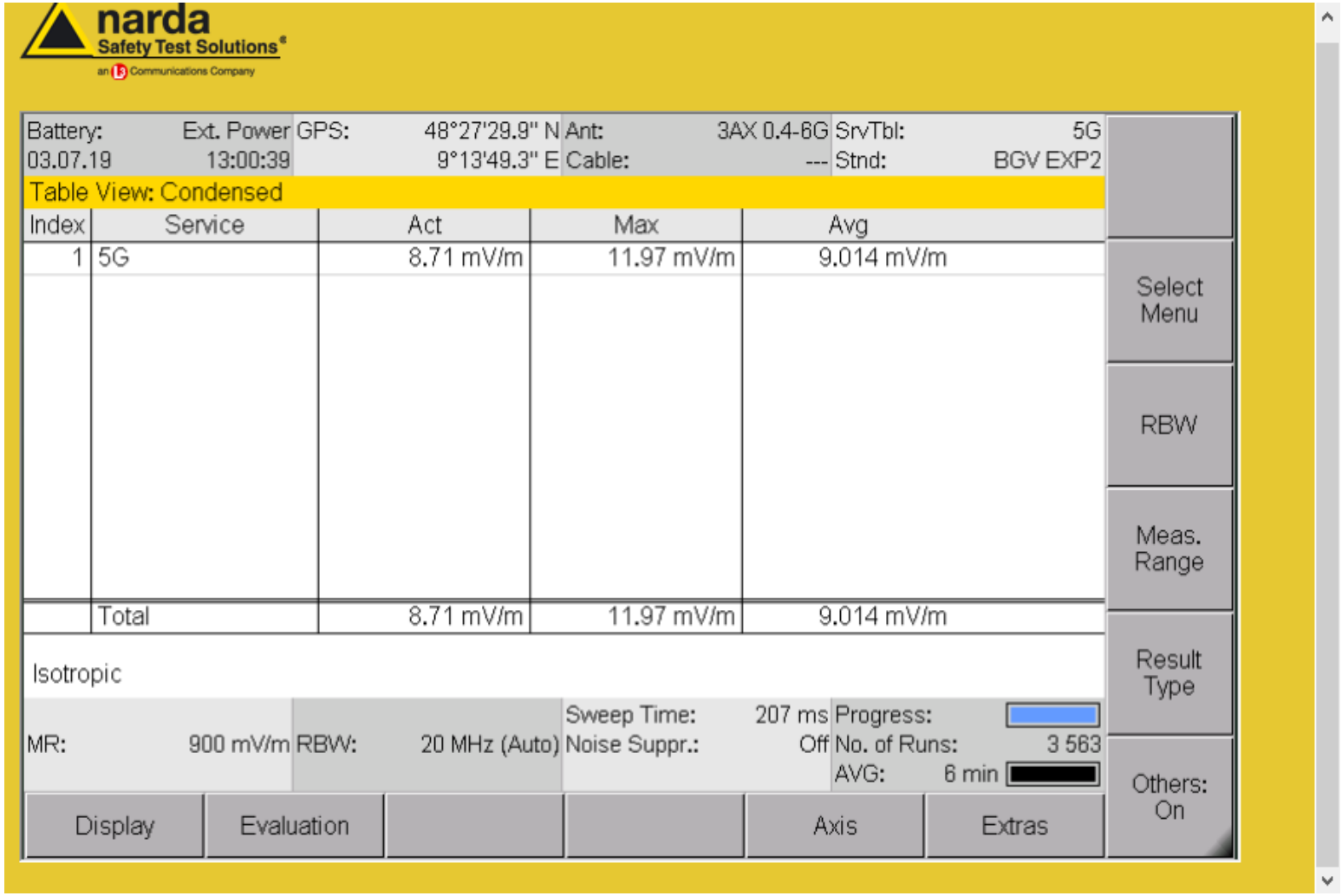


# 5G in a Nutshell

## Environmental measurements, current exposure

- This service table can be transferred to the analyzer and the SRM is able to measure the service accordingly



# 5G in a Nutshell

**Environmental measurements, current exposure**

- It is also possible to integrate it into any service table and to measure e.g. all wireless networks and to present the final result in % of standard

| Battery: | Ext. Power | GPS: | 48°27'29.9" N | Ant: | 3AX 0.4-6G | SrvTbl: | EU Full Band |
|---|---|---|---|---|---|---|---|
| 16.05.19 | 12:21:43 | | 9°13'48.9" E | Cable: | --- | Stnd: | ICNIRP GP |

Table View: Condensed

| Index | Service | Max | Avg |
|---|---|---|---|
| 8 | BandV | 0.256 % | 0.233 % |
| 9 | GSM-R | 0.015 % | 0.009 37 % |
| 10 | GSM | 0.224 % | 0.202 % |
| 11 | L-Band | 0.024 % | 0.021 % |
| 12 | DECT | 0.006 48 % | 0.005 48 % |
| 13 | UMTS-TDD | 0.038 % | 0.035 % |
| 14 | UMTS | 0.022 % | 0.019 % |
| 15 | W-LAN | 0.042 % | 0.038 % |
| 16 | ISM | 0.009 12 % | 0.007 51 % |
| 17 | 5G | 0.102 % | 0.093 % |
| | Others | 1.739 % | 1.687 % |
| | Total | 5.012 % | 4.856 % |

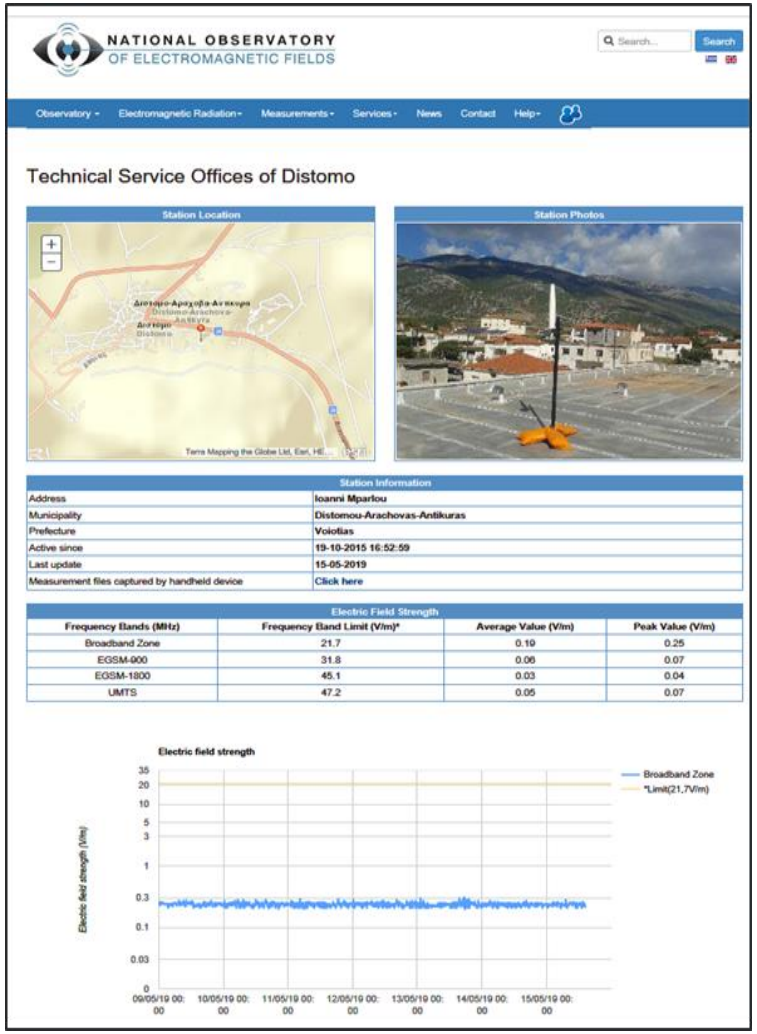
Isotropic

| MR: | 1 000 % | RBW: | 200 kHz (Auto) | Sweep Time: | 3.255 s | Progress: | |
|---|---|---|---|---|---|---|---|
| | | | | Noise Suppr.: | Off | No. of Runs: | 1 257 |
| | | | | | | AVG: | 6 min |

# 5G in a Nutshell

## Environmental measurements, 24/7 exposure

- For 24/7 measurements area monitoring probes AMB / AMS measure up to 40 GHz (broadband) / up to 6 GHz (selective) and allow for publishing test results on-line so that public has access to instantaneous radiation level at any time



# 5G in a Nutshell

## Environmental measurements, actual maximum exposure

- The transmitted power of a 5G NR base station depends strongly on the current traffic load and the user behavior
- This means in practice that the current exposure measured within a specific observation time could be much lower than the actual maximum exposure
- Many regulators enforce the extrapolation to the maximum load and to compare this result vs. allowed local limits. By this it can be assured, that the exposure will not exceed the limits

# 5G in a Nutshell

## Environmental measurements, actual maximum exposure

- Today, Narda proposes two methods to extrapolate to the actual maximum exposure by SRM-3006
- Both methods are based on the measurement of signal components inside the signalization block which are independent from the current load of the base station
- This measurement result can be used to extrapolate to the actual maximum exposure
- First method is based on a frequency selective measurement. A similar method is already established for LTE Signals

# 5G in a Nutshell

**Environmental measurements, actual maximum exposure**

- The second method is called demodulation based extrapolation.
- The demodulation based measurement is similar to the options UMTS and LTE of SRM-3006. A description of this method is published under:
- https://journals.lww.com/health-physics/Abstract/publishahead/On_The_Assessment_of_Human_Exposure_to.99882.aspx
- This method is not implemented in SRM-3006 yet as the approval of this method by national and international bodies is still pending

# Australian Distributor


**Air-Met Scientific Pty Ltd**
**Sales | Service | Rental**

OHS & Environmental Monitoring Equipment Specialists

W: www.airmet.com.au
E: sales@airmet.com.au
P: 1800 000 744
F: 1800 000 774


L3HARRIS™