


5G IN A NUTSHELL

L3HARRIS | narda Safety Test Solutions

5G NR, what it is and how to measure

5G in a Nutshell

Part 1: 5G, overview and comparison with former mobile phone systems

Part 2: 5G Wiki, which means:

- Massive MIMO
- Beamforming
- TDD & FDD

Part 3: What is the impact of 5G to measurement technology

Part 4: Why is actual maximum exposure so important and what is the status of a measurement procedure

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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“
- For Mobile communication, 5G, Beamforming and Massive MIMO will be launched over the next years and will pose new challenges to the measurement technology

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 > 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

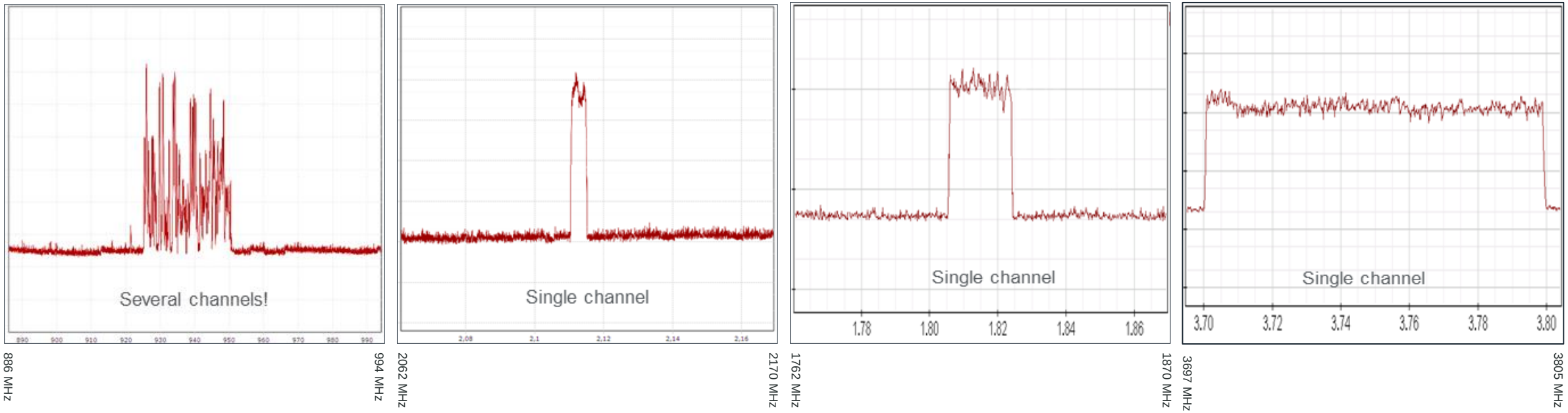
Major focus of mobile networks

	2G “GSM”	3G “UMTS”	4G “LTE”	5G “NR”
Application	• Voice • Data • SMS	• Voice • Internet • SMS	• Voice • Video • Fast mobile internet	• Voice • 4K / 8K-Videos • Ultra fast mobile internet • Massive Machine Type Communications M2M • Ultra-Reliable and Low Latency • Industry 4.0 • Internet of Things IoT • Car to car communication • 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

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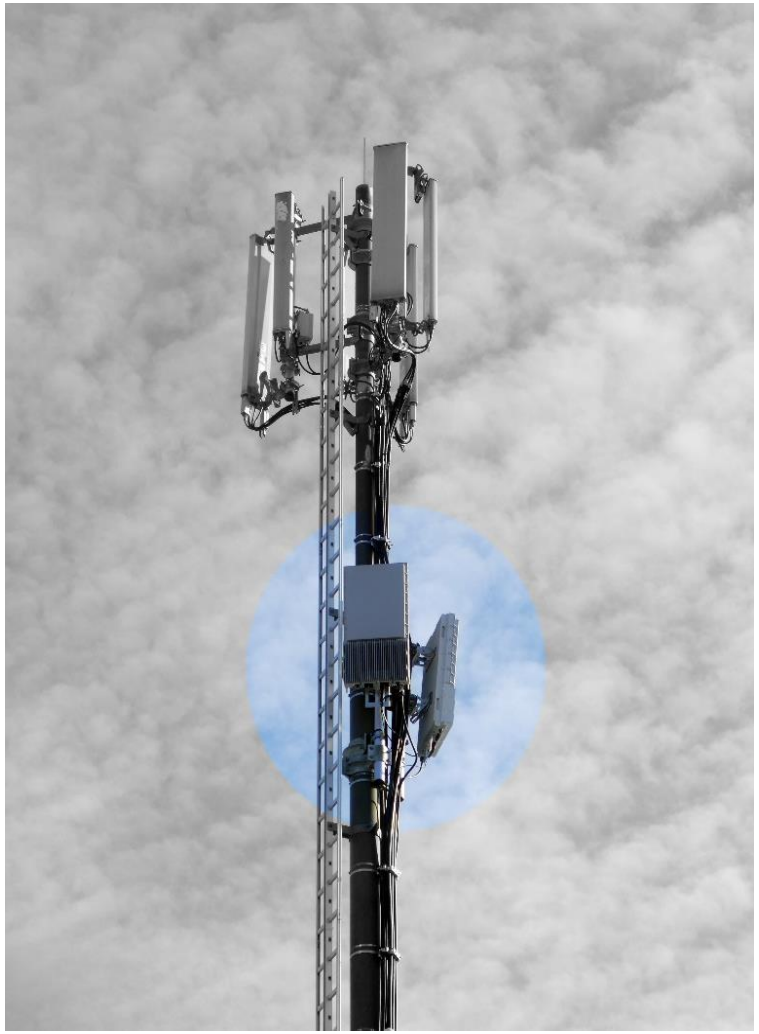
5G in a Nutshell

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?

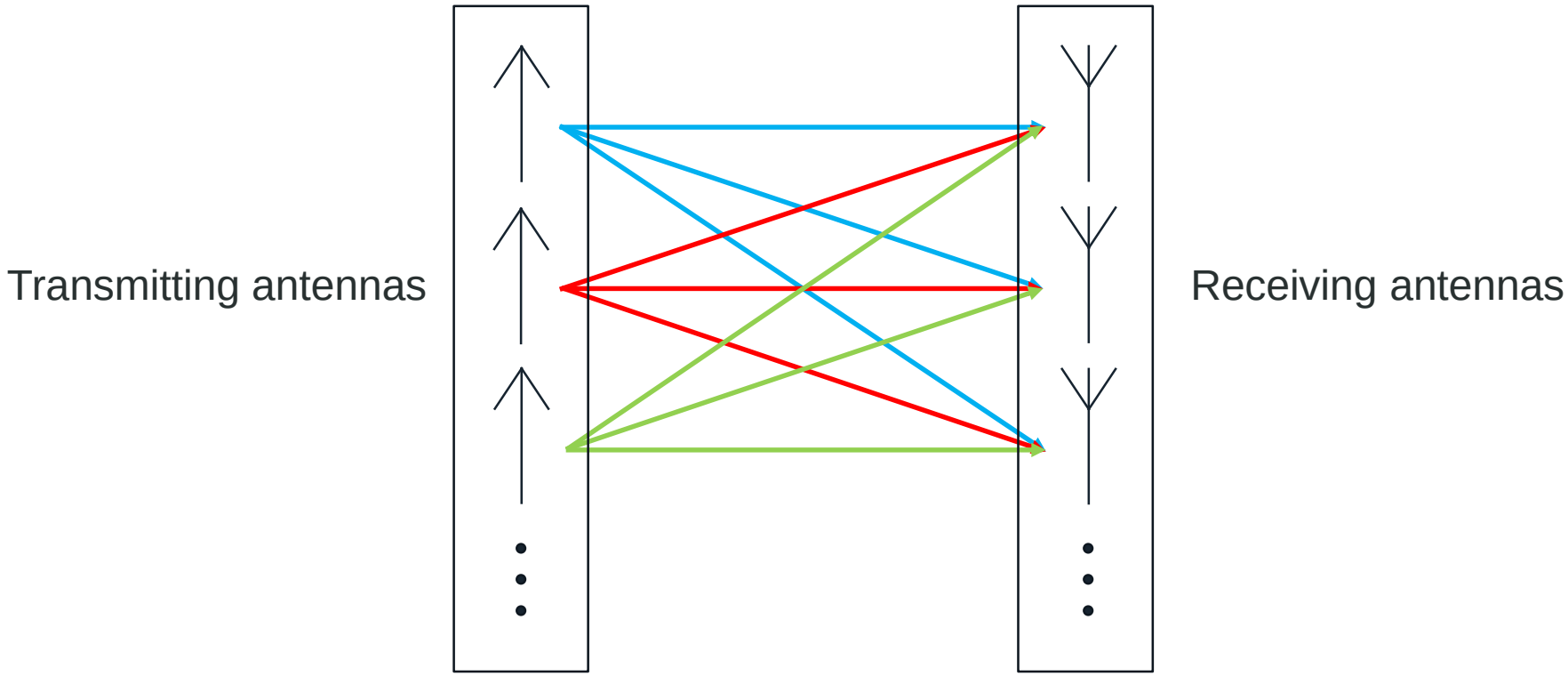
- Neither Beam Forming nor Massive MIMO are new technologies or depend on 5G
- Beam Forming or MIMO are already used in modern WiFi-routers, some 4G installations etc.
- 5G can be used also without those technologies
- But it is expected, that most 5G installations will be using at least Beam Forming
- 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).

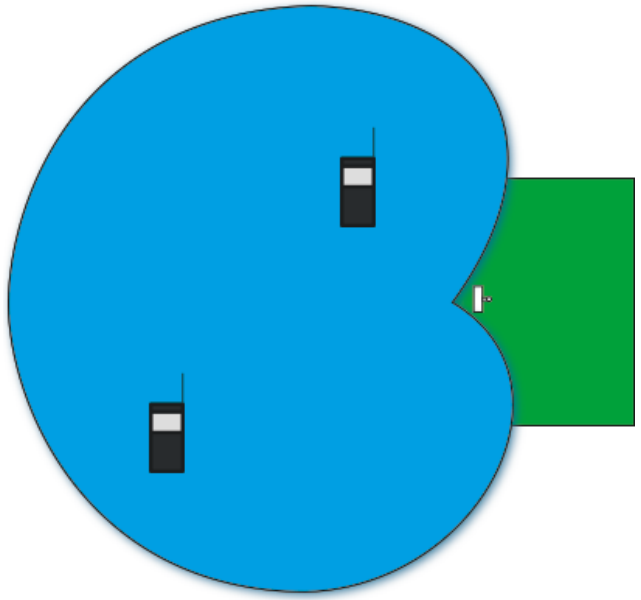


5G in a Nutshell

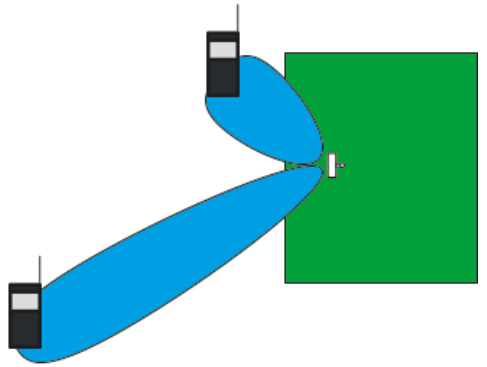
Beam Forming

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



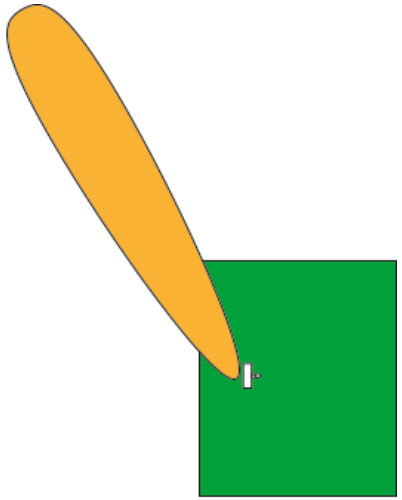
HORIZONTAL PATTERN OF A SEGMENT ANTENNA WITH BEAMFORMING



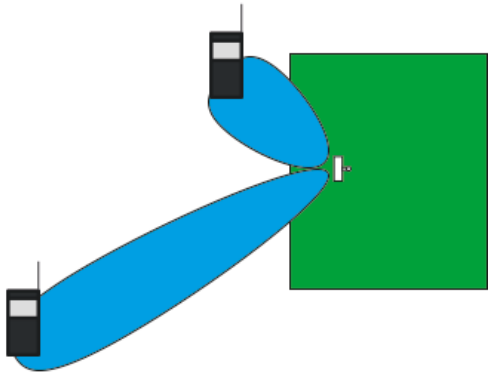
5G in a Nutshell

Beam Forming can be used for multiple purpose:

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

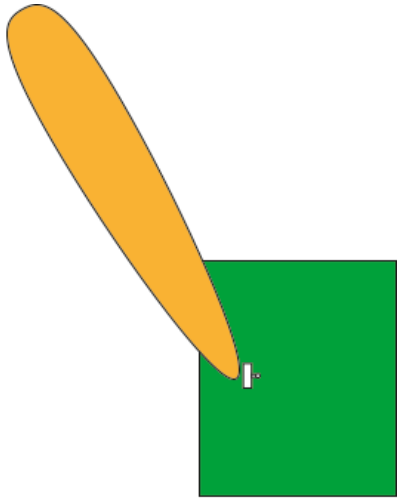
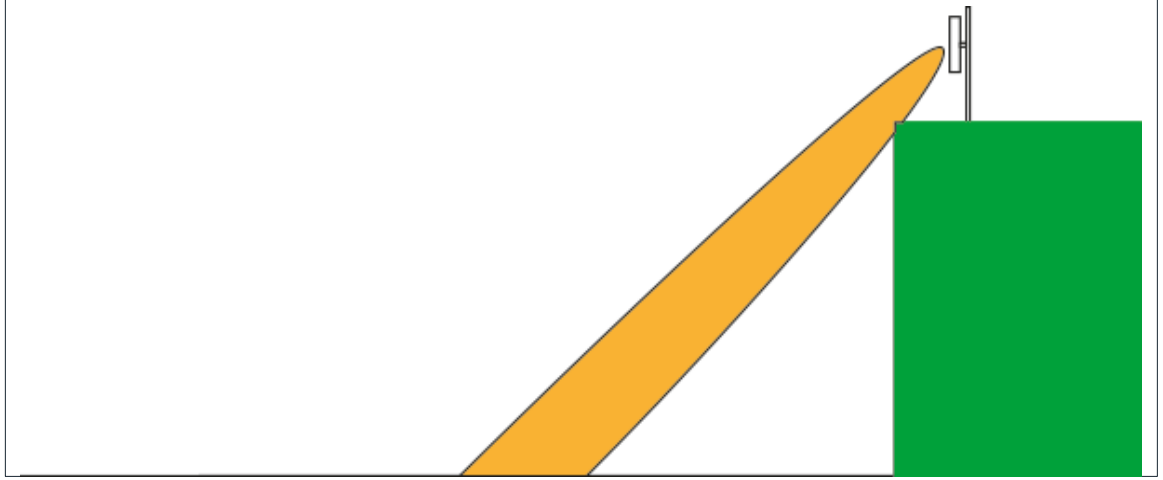


FOCUSING THE "TRAFFIC SIGNAL" TO THE TERMINAL DEVICE FOR OPTIMUM CONNECTIVITY



5G in a Nutshell

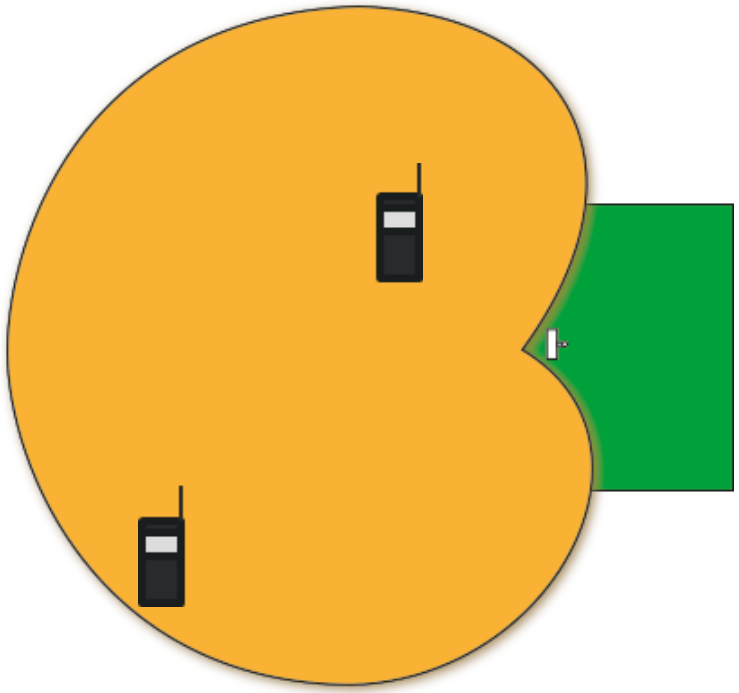
Beam Forming is available for:

HORIZONTAL SCANNING	VERTICAL SCANNING
	

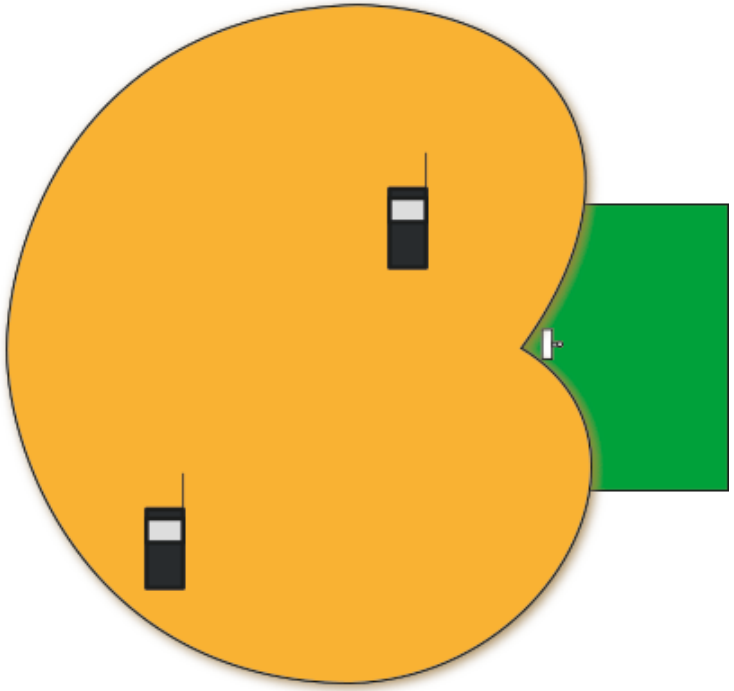
5G in a Nutshell

For 5G the following configurations are expected:

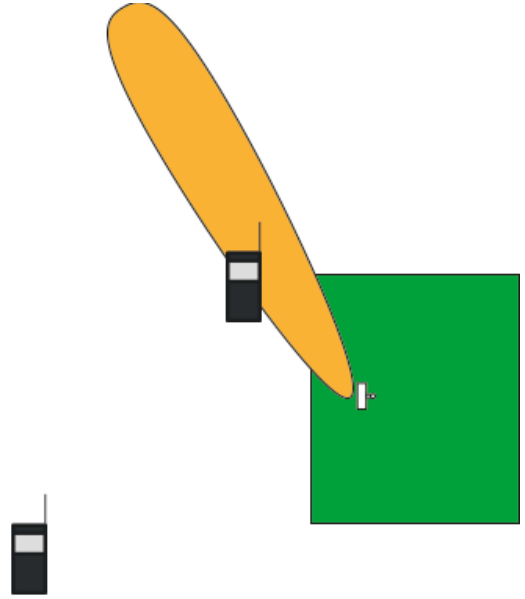
SIGNALIZATION WITHOUT BEAM FORMING
TRAFFIC WITHOUT BEAM FORMING



SIGNALIZATION WITHOUT BEAM FORMING
TRAFFIC WITH BEAM FORMING



SIGNALIZATION WITH BEAM FORMING
TRAFFIC WITH BEAM FORMING



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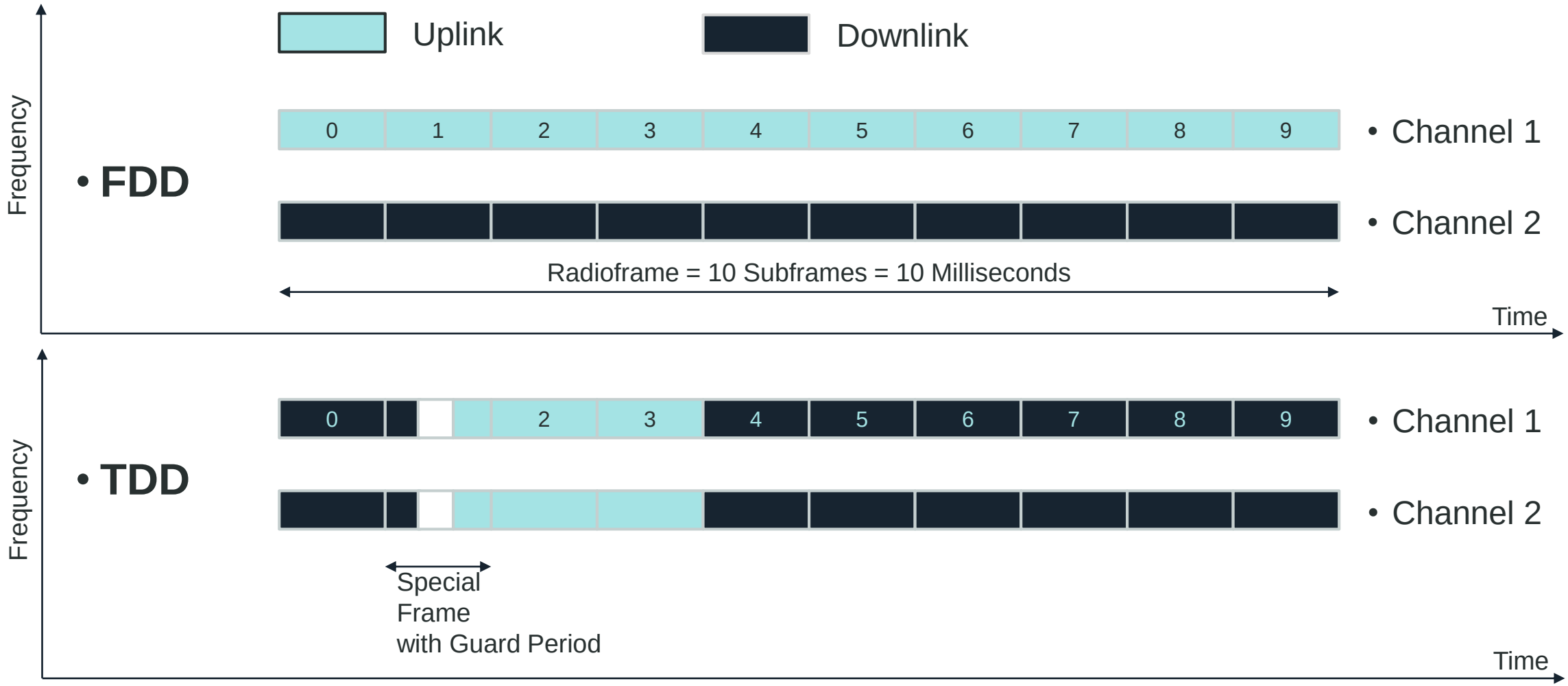

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5G in a Nutshell

Personal protection at workplace

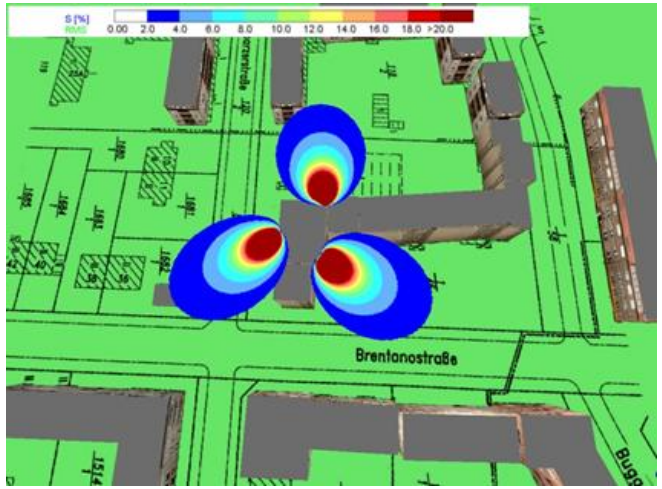
- Signal parameters as: modulation, crest factor and signal shape are not critical to Narda NBM, RadMan 2 or Nardalert S3
- As 5G will use also frequencies > 24 GHz with relevant output power, models with an upper frequency limit of 6 or 8 GHz only are not recommended
- As the beam can change its direction, 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 definition of safety zones by measurement it is essential to bring the base station into an “Max-Output” and “Max-Antenna gain” mode



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

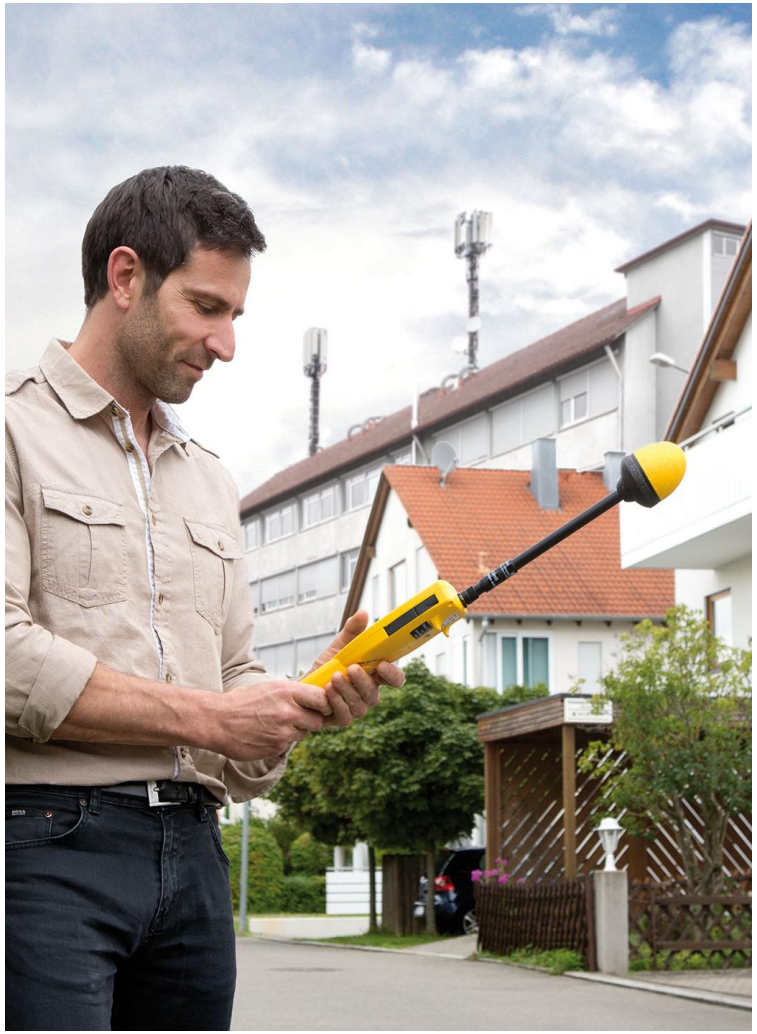
Battery:	Ext. Power	GPS:	48°27'29.9" N	Ant:	3AX 0.4-6G	SrvTbl:	EU Full Band
16.05.19	12:21:43		9°13'48.9" E	Cable:	---	Stnd:	ICNIRP GP

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

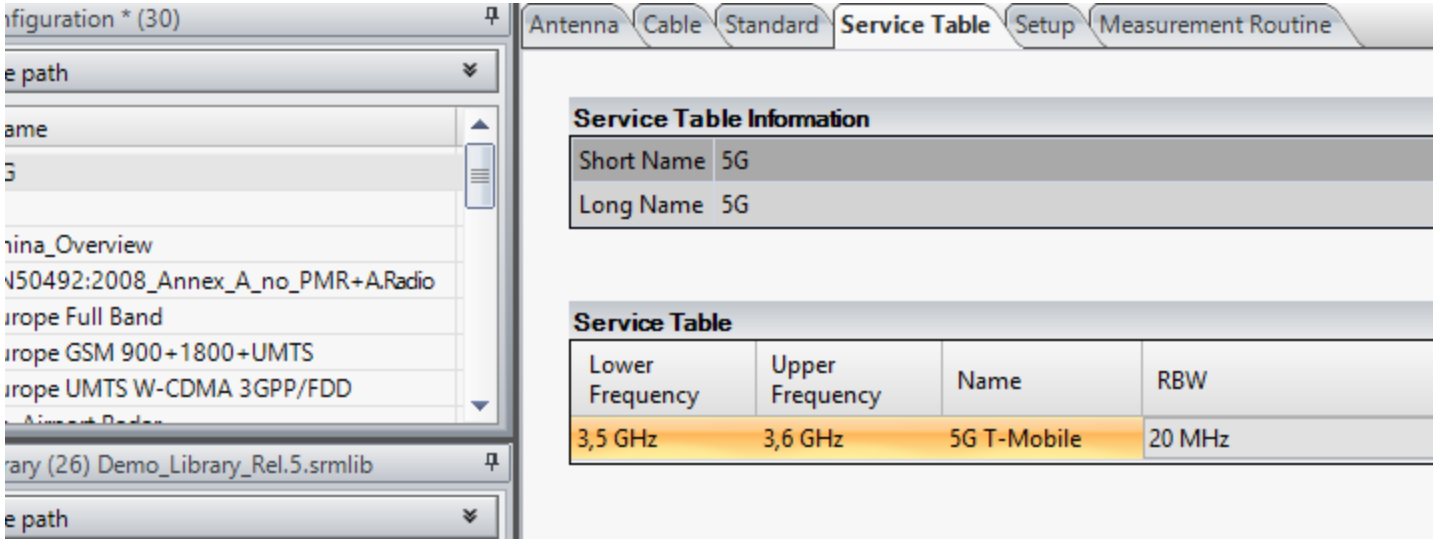
MR:	1 000 %	RBW:	200 kHz (Auto)	Sweep Time:	3.255 s	Progress:	
				Noise Suppr.:	Off	No. of Runs:	1 257
						AVG:	6 min

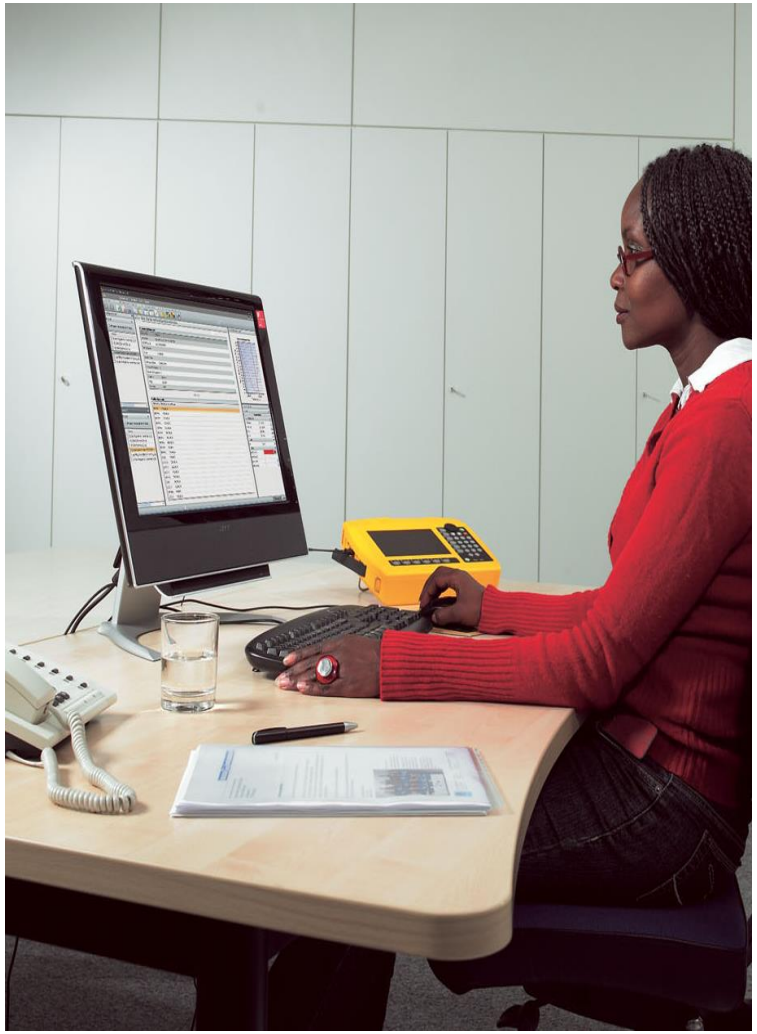


5G in a Nutshell

Environmental measurements, 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:

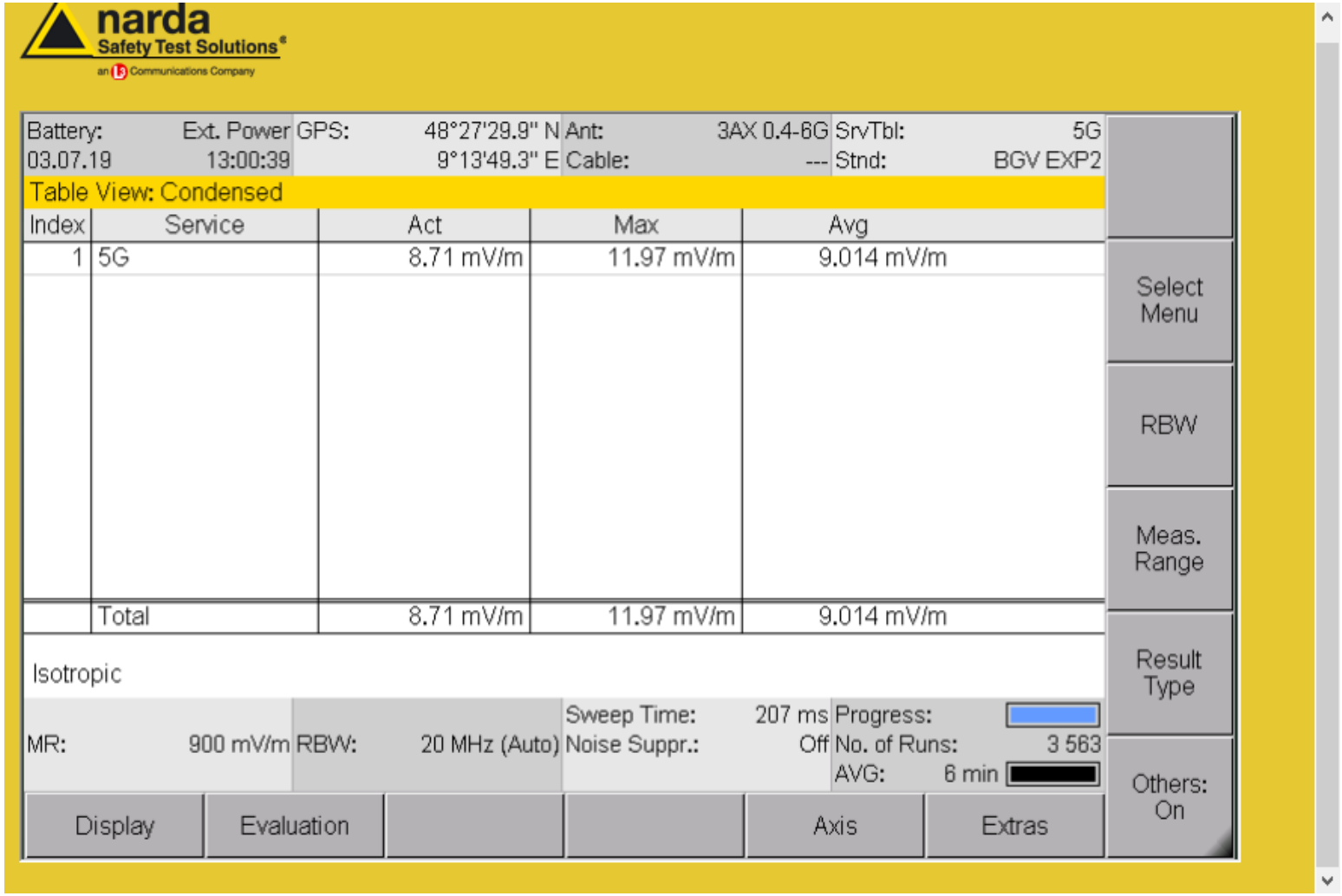




5G in a Nutshell

Environmental measurements, current exposure

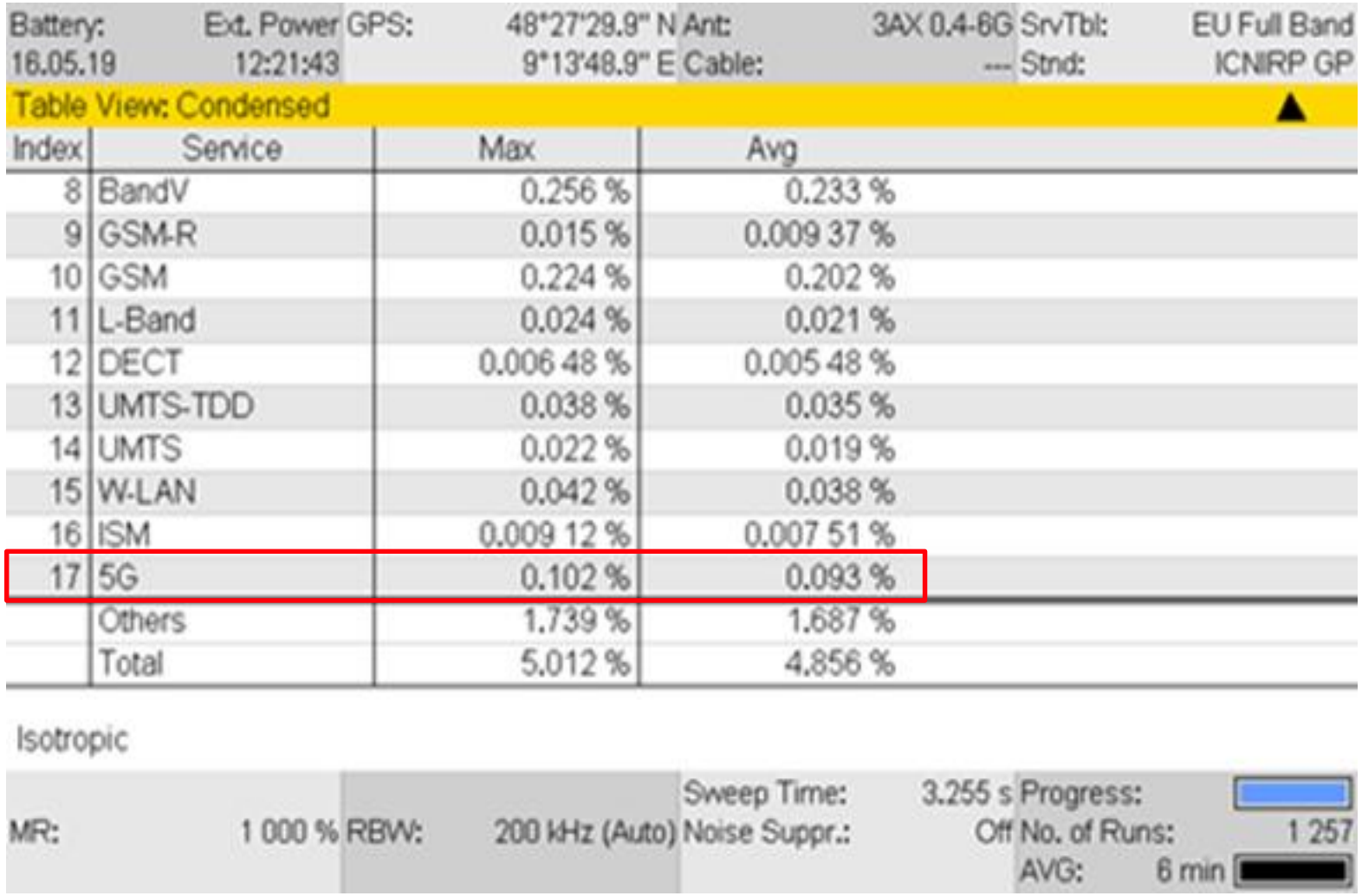
- This service table can be transferred to the analyzer and the SRM is able to measure the service accordingly



5G in a Nutshell

Environmental measurements, current exposure

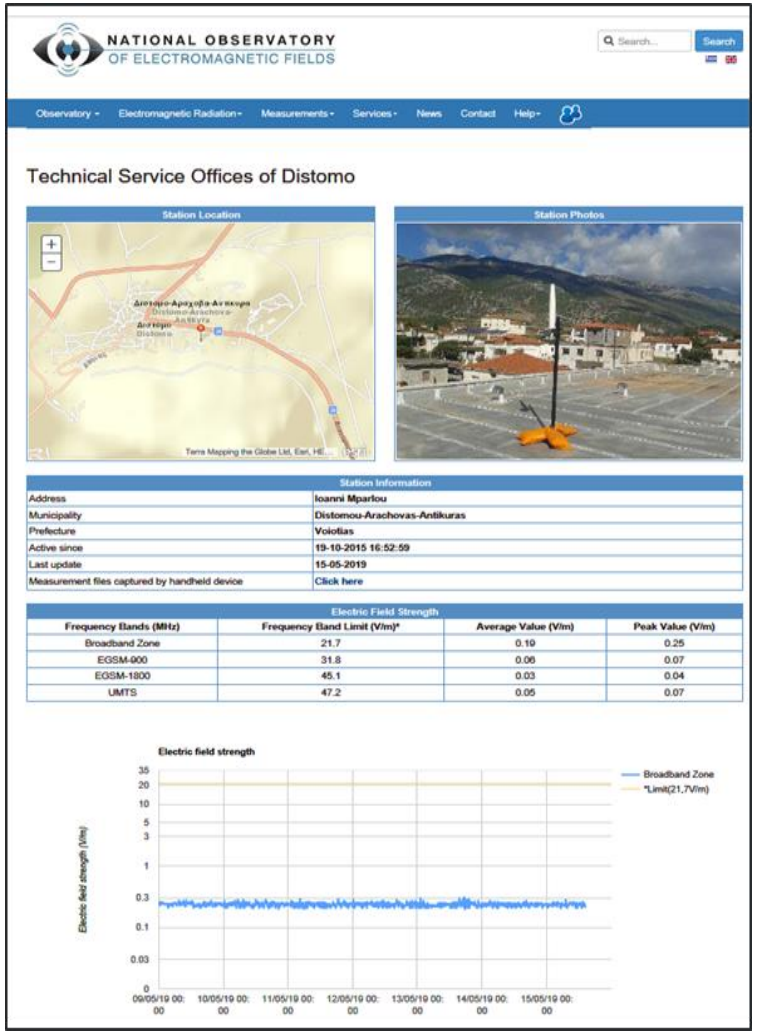
- It is also possible to integrate it into any service table and to measure e.g. all wireless networks and to present the final result in % of standard



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



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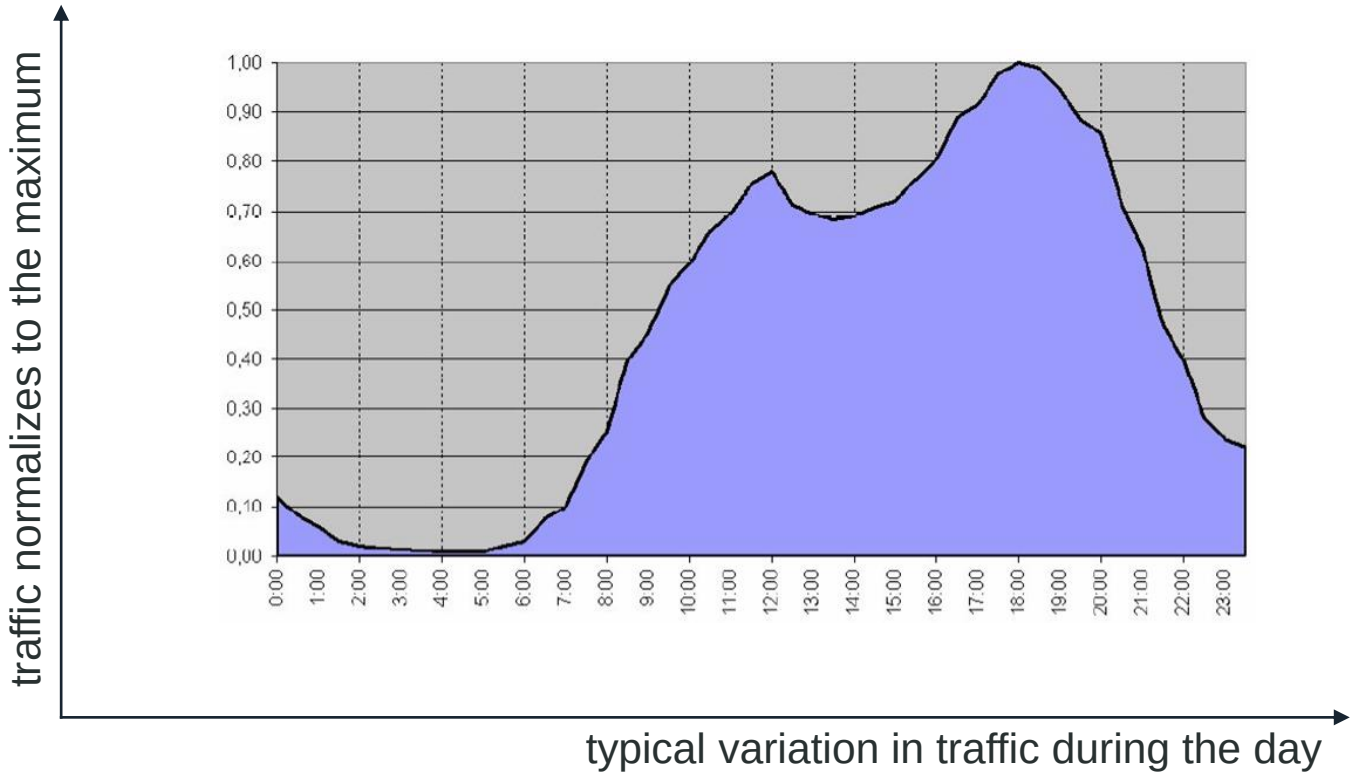
Dynamic Range	6 – 8 dB	7 – 10 dB	> 20 dB	> 20 dB



5G in a Nutshell

Extrapolation

The extrapolation to actual maximum exposure for 2G to 4G mobile networks is described by e.g.:
ITU-T K.100, IEC 62232 or EN 50492

For 5G Narda proposes two different methods to measure and to extrapolate to the actual maximum exposure:

- frequency selective measurement
- demodulation based measurement

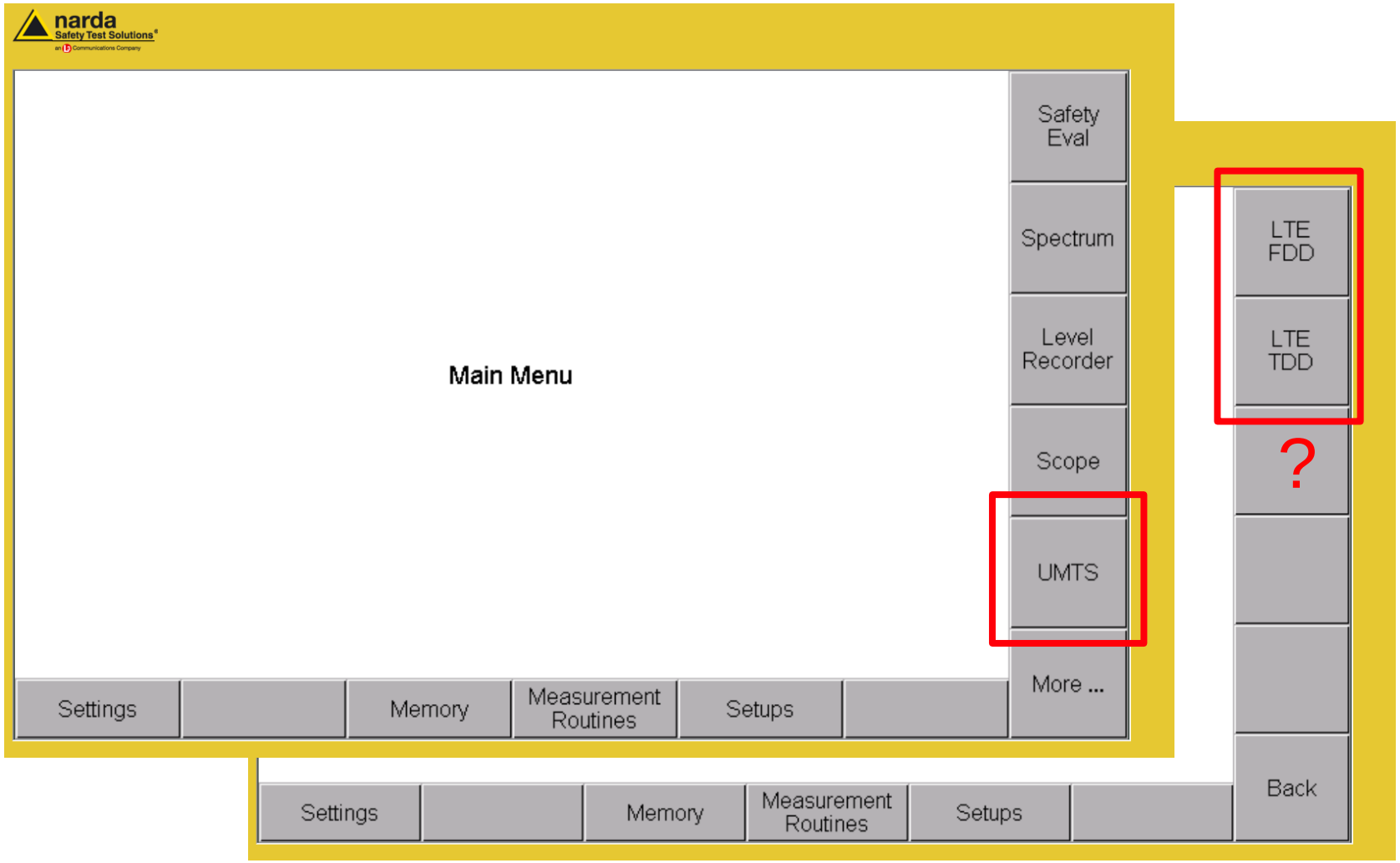
Both methods are based on measurement of one of the following signalization components:

- Primary signalization Signal PSS and
- Secondary Synchronization Signal SSS

The full description is available under:

https://journals.lww.com/health-physics/Abstract/publishahead/On_The_Assessment_of_Human_Exposure_to.99882.aspx

5G in a Nutshell



5G in a Nutshell

OPEN

Note

ON THE ASSESSMENT OF HUMAN EXPOSURE TO ELECTROMAGNETIC FIELDS TRANSMITTED BY 5G NR BASE STATIONS

Helmut Keller[1]

Abstract—The fifth-generation new radio cellular network will be rolled out within the next few years. Several assessment methods of human exposure to electromagnetic fields transmitted by fifth-generation new radio base stations are discussed. Currently no method exists that allows extrapolation to the maximum theoretical exposure. Thus two new extrapolation methods are proposed. A 95th percentile exposure can be derived from the maximum theoretical exposure by an agreed-upon reduction factor if a more realistic exposure assessment is required.
Health Phys. 00(00):000–000; 2019

Key words: electromagnetic fields; exposure, occupational; exposure, population; health effects

INTRODUCTION

THE FIFTH-GENERATION new radio (5G NR) cellular network is the fifth generation of cellular networks. Its rollout all over the world is supposed to start within the next few years. Release 15 of the third-generation partnership project (3GPP) standard has been available since the end of 2017. It already defines the main aspects of 5G NR. Like its precursor the Long-term Evolution (LTE) standard, 5G NR will use orthogonal frequency division multiple access (OFDMA) in the downlink. Like LTE, it can be used in frequency divi-

interactive, and agile beam forming and the reduction of the amount of signals transmitted independently of the current traffic load and user behavior. It seems to be a good idea to discuss exposure assessment methods of 5G NR base stations before the rollout begins.

ASSESSMENT OF CURRENT TOTAL EXPOSURE

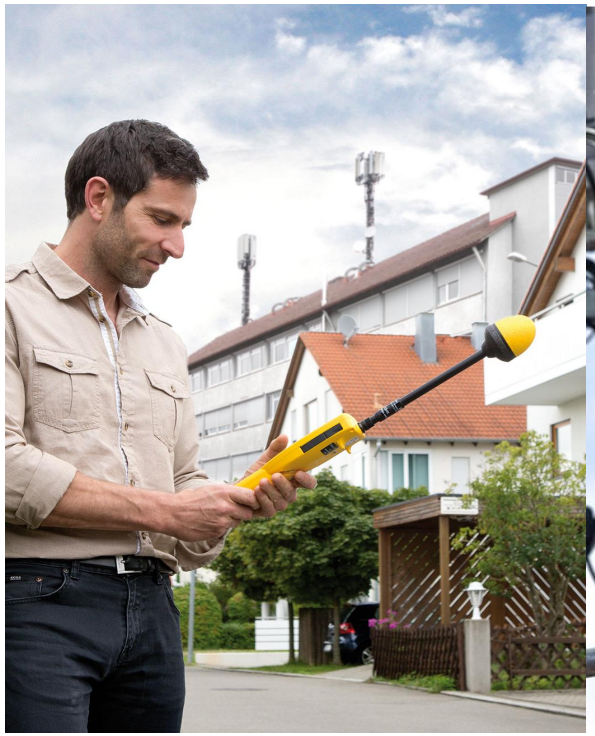
The current total human exposure due to the thermal effects of electromagnetic fields at a specific point in space and during a specific observation time is always assessable with the general assessment method described here. This method is applicable to any kind of signal and therefore also to 5G NR signals.

The general assessment method for exposure due to the thermal effect of external electromagnetic fields is described by eqns (9) and (10) of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines from 1998 (ICNIRP 1998). These equations mean that one should measure the square of the root-mean-square (rms) value of the weighted external electric and magnetic field strength. The results are two normalized exposure values. Exposure values up to unity are permissible. The frequency response

https://journals.lww.com/health-physics/Abstract/publishahead/On_The_Assessment_of_Human_Exposure_to.99882.aspx

5G in a Nutshell

- Newsticker: https://www.narda-sts.com/en/meta/newsticker/
- YouTube: https://www.youtube.com/channel/UCxerYxUbG0bYG5pfONhSHNQ





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