Update on 5G NR Measurement Solutions for EMF

Webinar of Airmet and Narda on April 29th, 2021
Volker Brands – Narda-STS Germany

Narda Safety Test Solutions - locations

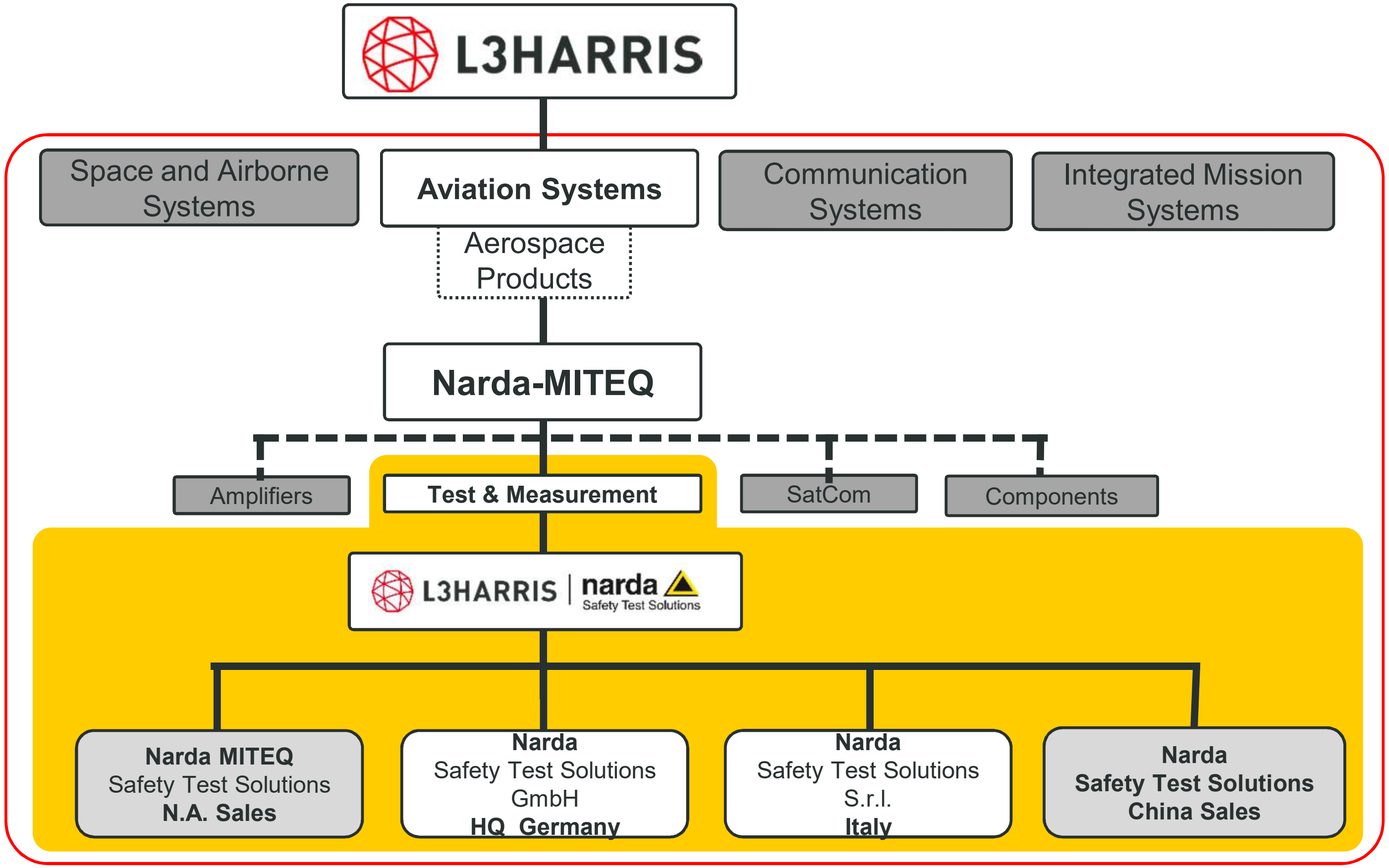
Pfullingen, Germany

Cisano, Italy

Beijing, China

Hauppauge, USA

Corporate Org Chart



L3Harris Technologies - Florida

- 2020 sales: $18,2 billion
- Employees: approx. 48,000
- 4 Business Segments

Aerospace Products Sector

- Narda-MITEQ
- Narda-West
- Datron
- …

Narda Safety Test Solutions GmbH

- Production Facilities: Germany, Italy
- Sales: Germany, Italy USA, China
- Spezialized in
  - EMF Safety Products
  - RF Test & Measurement
  - EMC Receivers

Production Sites Sales & Marketing > 120 employees

Sales Offices

Overview

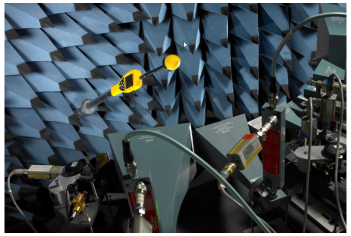
- Narda Safety Test Solutions founded on January 1, 2000, an offshoot of high-frequency measurement technology operation of Wandel & Goltermann group (W&G, then WWG, Acterna, JDSU, now: VIAVI) and has been a part of L3Harris Technologies (legacy L3 Communications) since it was founded.
- Narda is leading provider of test equipment for EMF Safety, RF Test & Measurement and EMC sector.
- The **EMF Safety** product range includes wideband and frequency selective measuring instruments for electromagnetic fields, full coverage wide area monitors, and personal safety monitors that are worn on the person.
- The **RF Test & Measurement** range includes analyzers and devices for measuring and identifying RF sources.
- Under the PMM brand, Narda offers instruments for determining the electromagnetic compatibility (**EMC**) of devices.

Portfolio

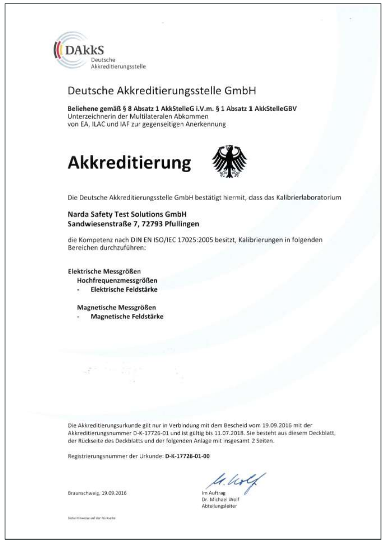
Business in more than 150 countries with ~55 Distributors

Customer Trainings

Service & Calibration



Accredited Calibration



DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Beliehene gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV
Unterzeichnerin der Multilateralen Abkommen
von EA, ILAC und IAF zur gegenseitigen Anerkennung

Akkreditierung

Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Kalibrierlaboratorium

Narda Safety Test Solutions GmbH
Sandwiesenstraße 7, 72793 Pfullingen

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Kalibrierungen in folgenden Bereichen durchzuführen:

Elektrische Messgrößen
Hochfrequenzmessgrößen
- **Elektrische Feldstärke**

Magnetische Messgrößen
- **Magnetische Feldstärke**

Die Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 19.09.2016 mit der Akkreditierungsnummer D-K-17726-01 und ist gültig bis 11.07.2018. Sie besteht aus diesem Deckblatt, der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 2 Seiten.

Registrierungsnummer der Urkunde: **D-K-17726-01-00**

Braunschweig, 19.09.2016

Im Auftrag
Dr. Michael Wolf
Abteilungsleiter

ISO 9001:2015 Certified

IQNet

THE INTERNATIONAL CERTIFICATION NETWORK

CERTIFICATE

IQNet and
DQS GmbH Deutsche Gesellschaft zur Zertifizierung von Managementsystemen
hereby certify that the company

Narda Safety Test Solutions GmbH
Sandwiesenstraße 7
72793 Pfullingen
Germany

has implemented and maintains a **Quality Management System**.

Scope:
Research, Development, Manufacturing, Marketing and Sales of Measuring Equipment and Electric Components in particular to detect and measure Electromagnetic Fields, and related services

Through an audit, documented in a report, it was verified that the management system fulfills the requirements of the following standard:

ISO 9001 : 2015

Valid from	2017-09-08
Valid until	2020-09-07
Date of certification	2017-09-08

Registration number: DE-099379 QM15

Michael Drechsel
President of IQNet

Frank Graichen
Managing Director of DQS GmbH

IQNet Partners**:

5G in a Nutshell – a brief recap

5G, Beam Steering and mMIMO

When talking about 5G, Beam Steering by Massive MIMO antenna technique are mentioned. What is the relationship between 5G, Beam Steering and mMIMO?

- Neither Beam Forming nor Massive MIMO are new technologies
- Beam Forming or MIMO are already used in modern WiFi-routers, some 4G installations etc.
- 5G is also been introduced without that technology :
  => DSS … dynamic spectrum sharing aka "5G in 4G"
- Increasingly 5G installations will be using Beam steering especially at hot spots with high traffic / throughput and low latency requirements
- Beam steering and mMIMO require an array of multiple antennas so they are used synonymously
- Use of phased arrays goes back to defence RADAR technology (electronically switched dipoles) in the late 70s and ultimately back to Karl Ferdinand Braun / 1905: three mono pole array with lambda/2 delay for fixed beam forming

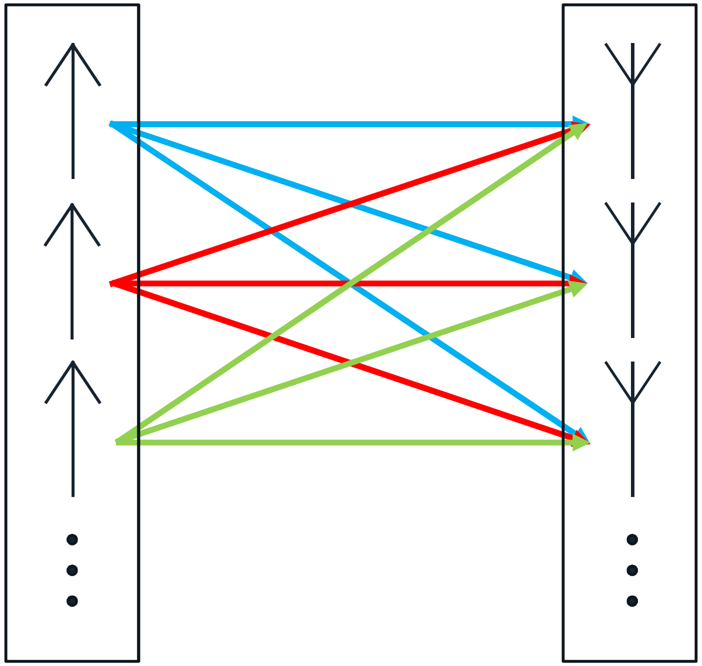
5G in a Nutshell

(Massive) MIMO

multiple input and multiple output
(e.g. co -45° and cross ol. + 45° arrays)
antennas increase sector throughput
and/or quality (by redundancy) and
offer more capacity by using large
numbers of antenna. It is been in
operation within mobile radio
applications since 2G era
(GSM base station).

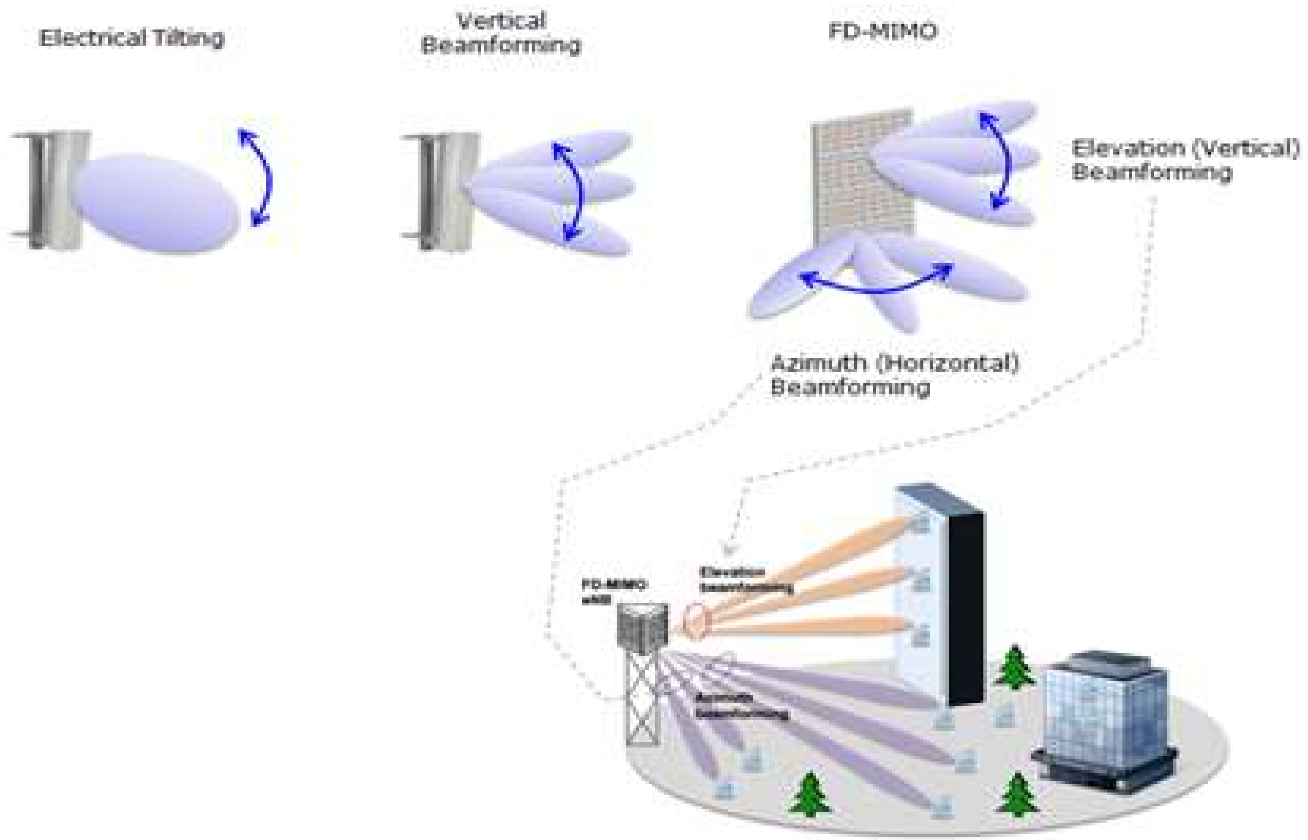
- Target :
  Increase signals‘
  quality (redundancy)
  and/or capacity
  by using multi paths

Transmitting antennas



Receiving antennas

5G in a Nutshell

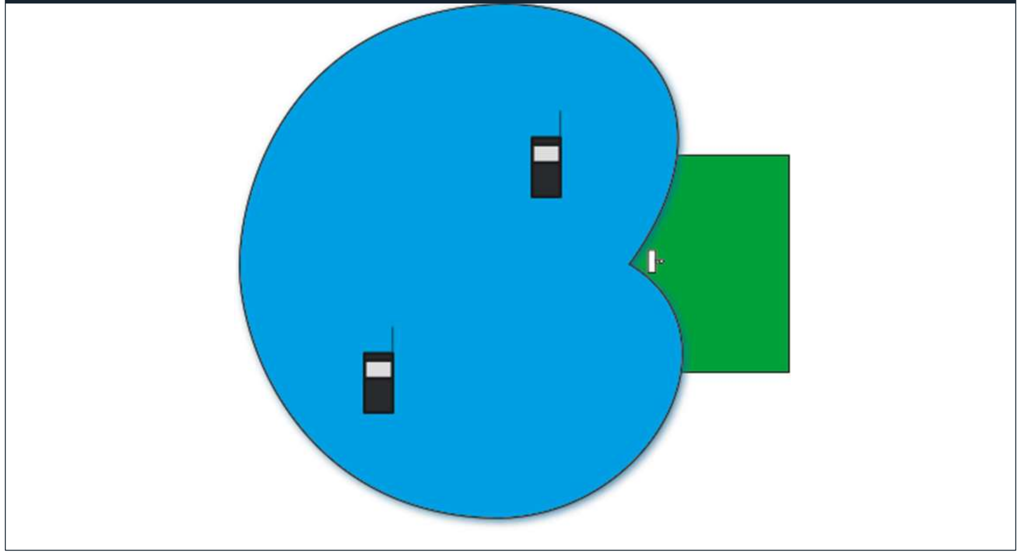


https://www.google.com
mimo.html&psig=AOvVaw3Ui2yO4UxGBa12mqWR9nbu&ust=1613570612148000&source=images&cd=vfe&ved=0CIoBEK-JA2oXChMI8JSki8nu7gIVAAAAAB0AAAAAEAo

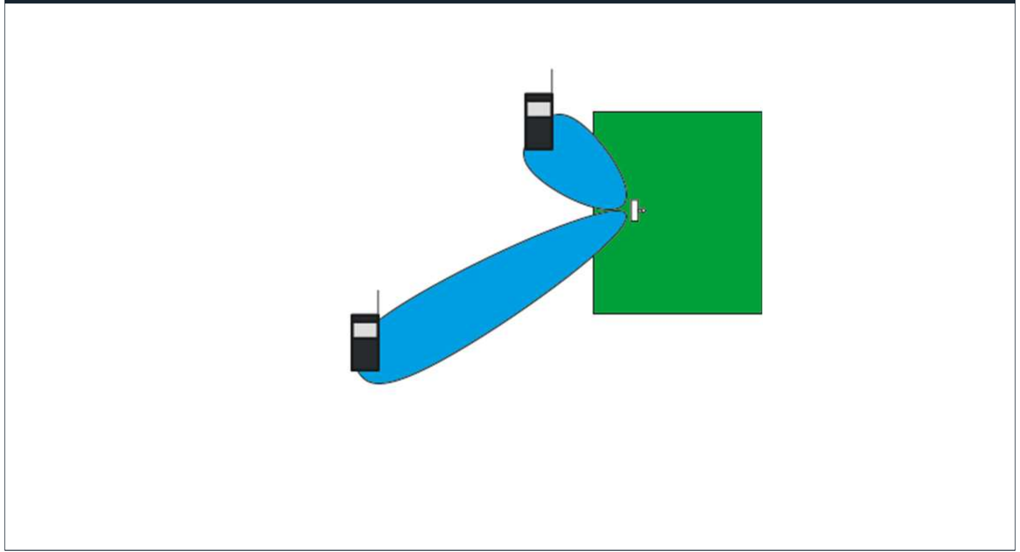
Beam Steering

Intended to direct radio waves to a target. This is achieved by combining elements (phased arrays) of antenna. This improves signal quality and data transfer speeds because of the improved signal quality and mitigates fading effects. Beam steering does also improve antenna's gain and reduces power per bit.

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



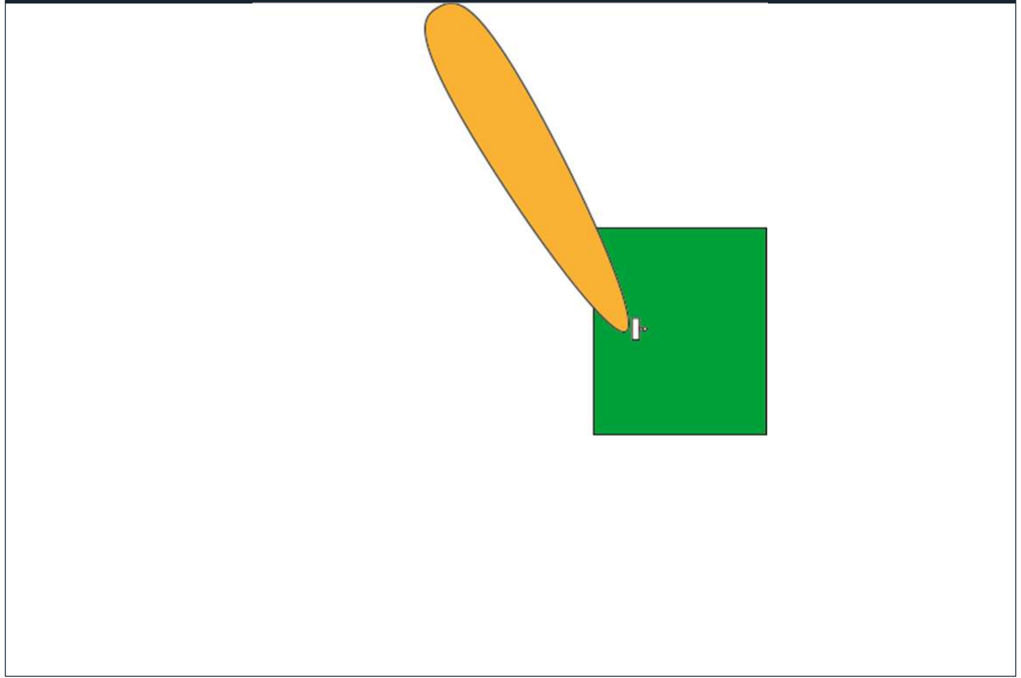
HORIZONTAL PATTERN OF A SEGMENT ANTENNA WITH BEAMFORMING



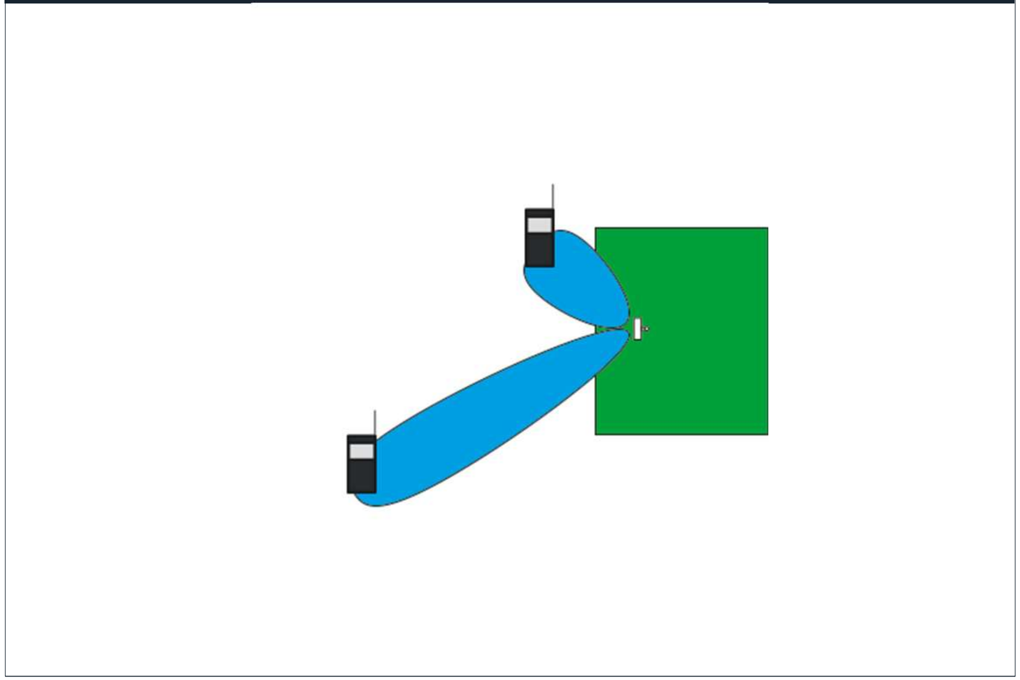
5G in a Nutshell

Beam Forming can be used for multiple purpose:

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

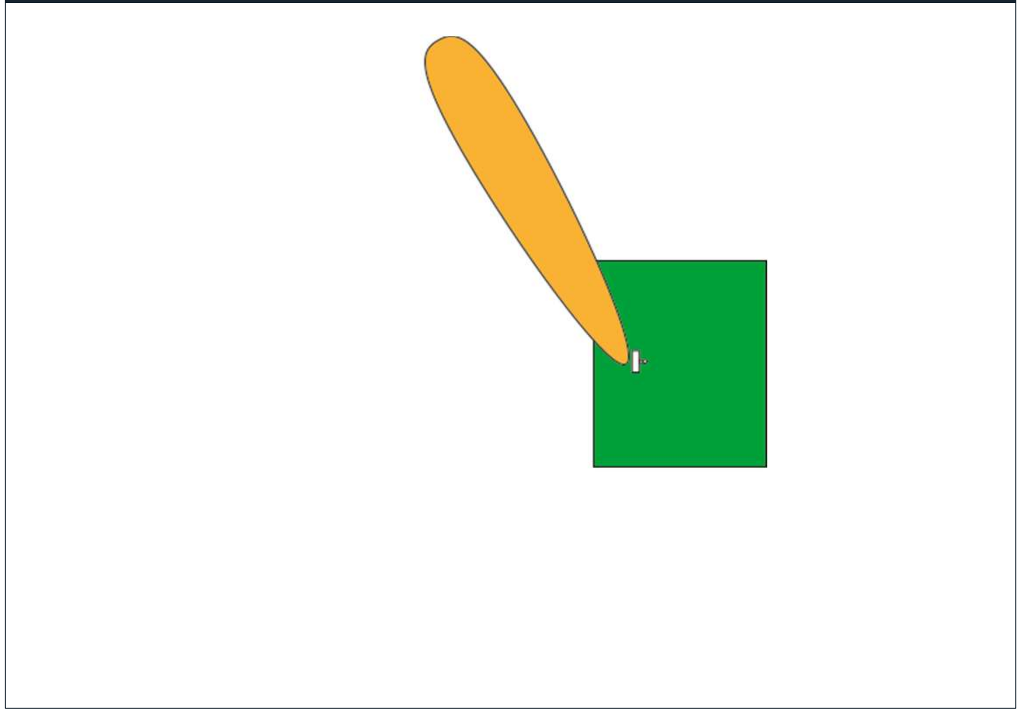
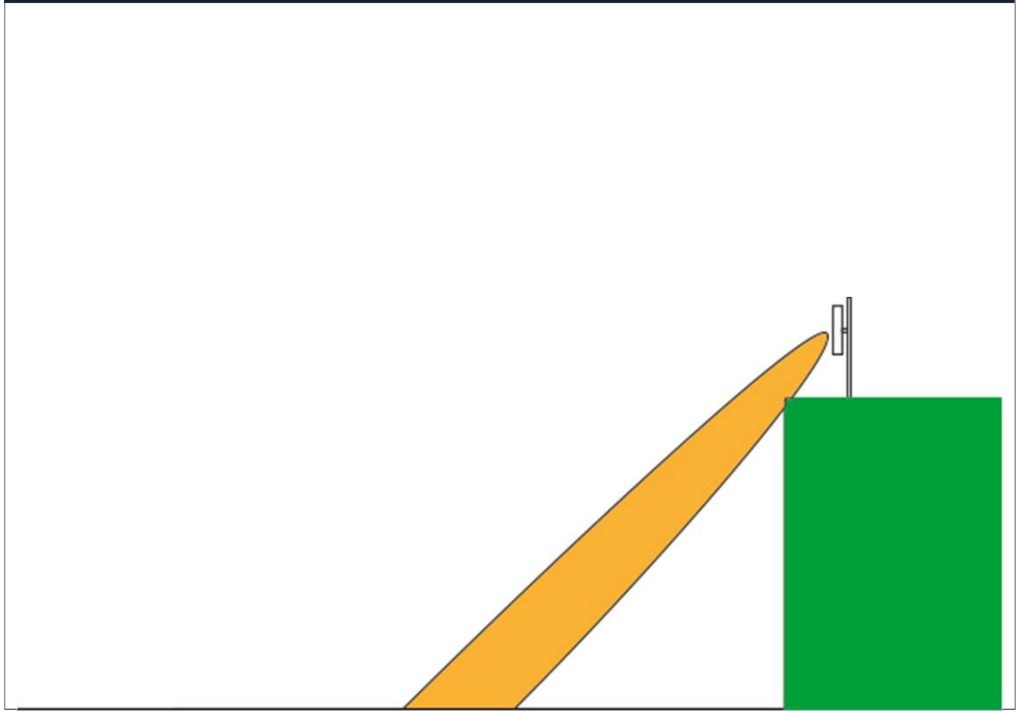


FOCUSING THE “TRAFFIC SIGNAL” TO THE TERMINAL DEVICE FOR OPTIMUM CONNECTIVITY



5G in a Nutshell

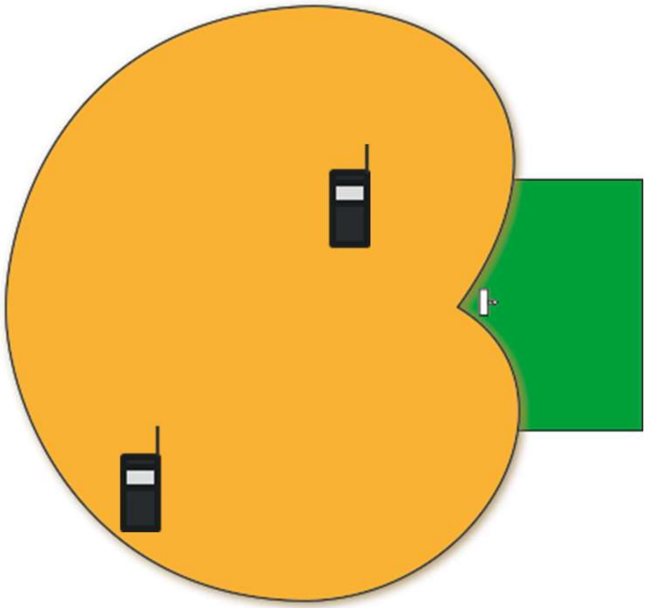
Beam steering available for traffic channels :

HORIZONTAL SCANNING	VERTICAL SCANNING
	

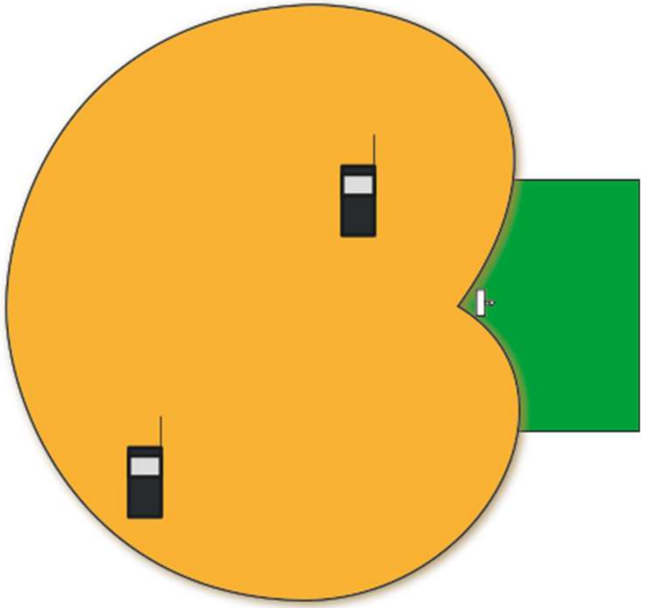
5G in a Nutshell

Following configurations are expected for 5G NR transmission :

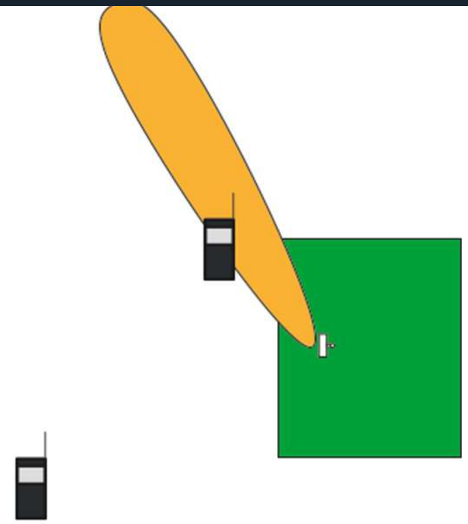
SIGNALIZATION WITHOUT BEAM STEERING
TRAFFIC WITHOUT BEAM STEERING



SIGNALIZATION WITHOUT BEAM STEERING
TRAFFIC WITH BEAM STEEERING



SIGNALIZATION WITH BEAM STEERING
TRAFFIC WITH BEAM STEERING



Calc. to max. EMF exposure based on ratio of field strengths between traffic and broadcast beams

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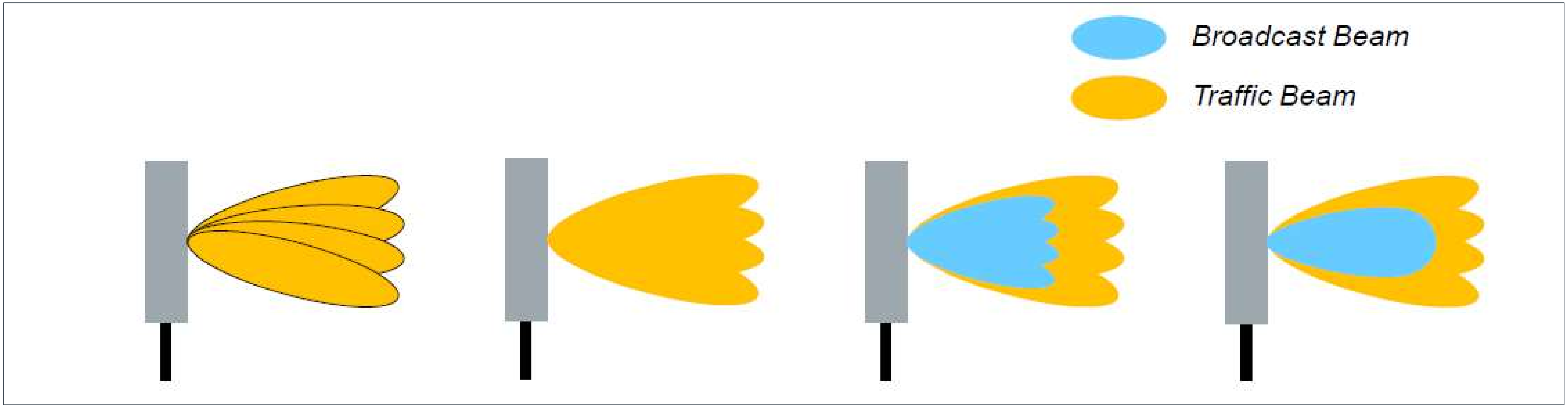


Four switched traffic beams

Envelope of beams

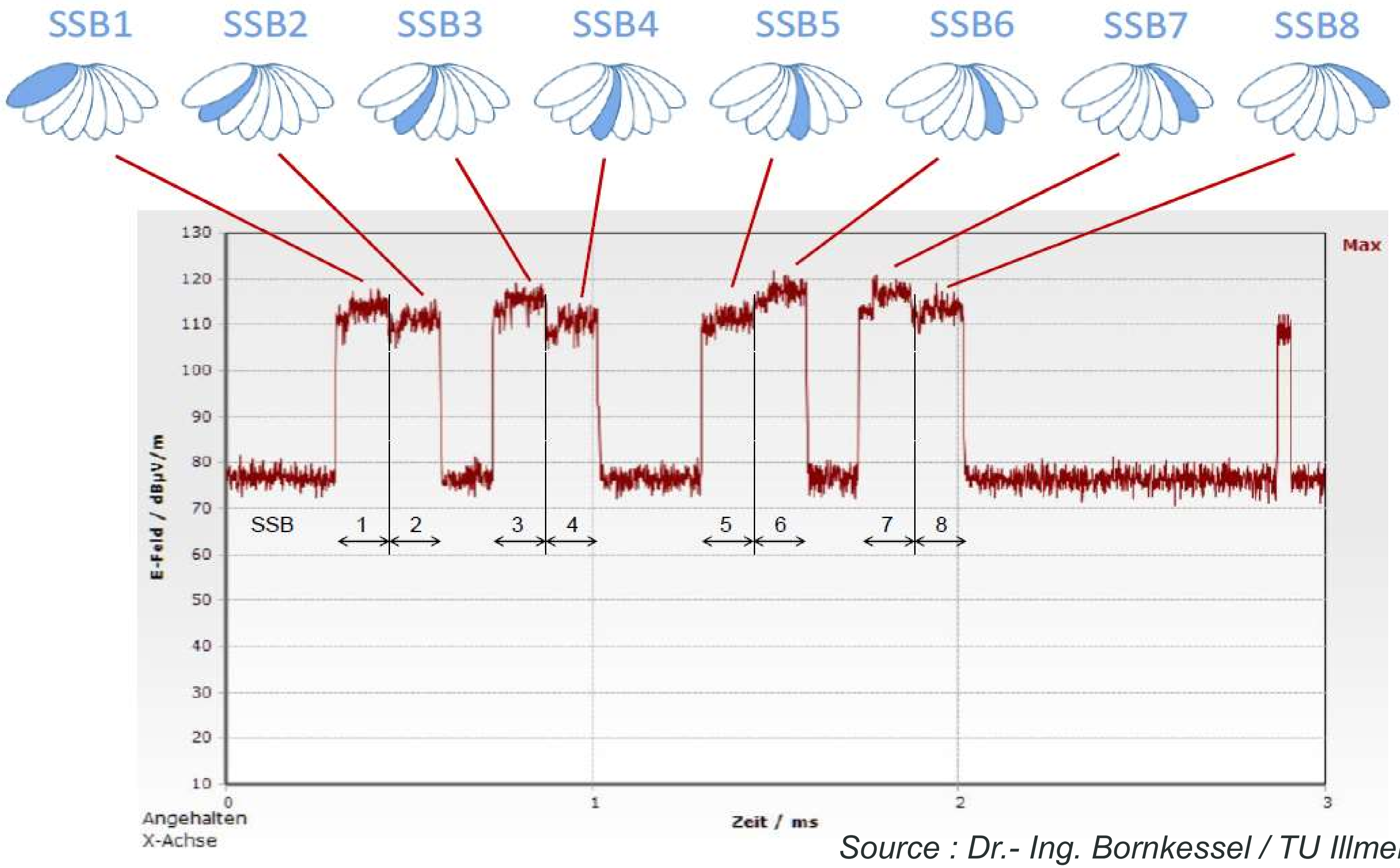
Envelopes with same beam shapes

Envelope with different beam shapes

=> Assess level difference from resp. antenna data sheet of Broadcast & Traffic beams (horiz. & vert. patterns) and calculate individual ratio (delta dB) for your resp. test position of SRM3006 analyzer (new decode option)

Source : Dr.- Ing. Bornkessel / TU Illmenau / EMV2020

Beam Steering of Broadcast Signal:
Field Strength of sync signal in time domain



Source : Dr.- Ing. Bornkessel / TU Illmenau / EMV2020

Tests at 5G NR Systems

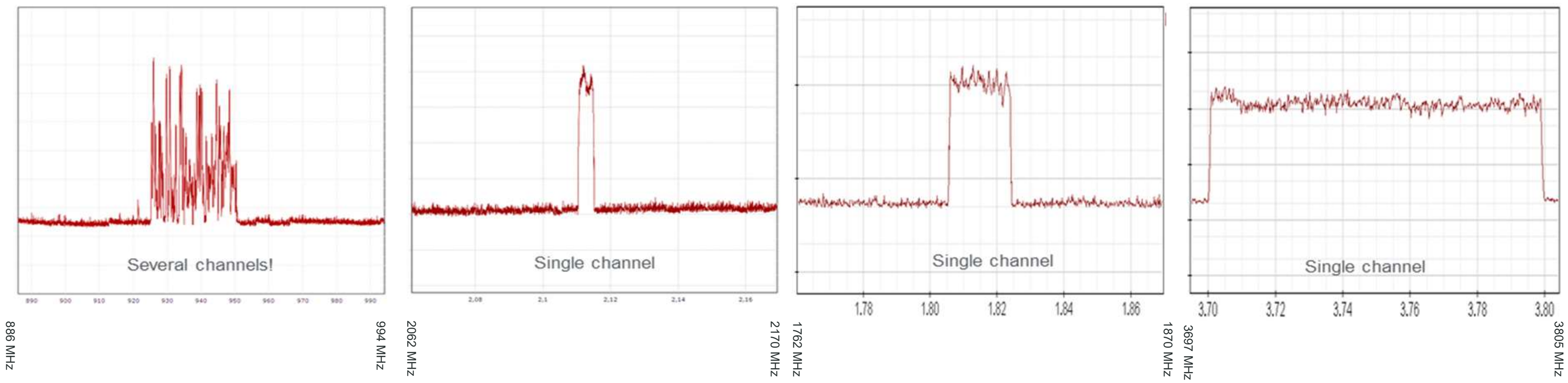
- At 5G, bandwidth of a transmission system can be up to 100 MHz. At frequencies > 20 GHz even 400 MHz.
- The maximum bandwidth of SRM-3006 is 20 MHz (RT-IB, Scope Mode) or 32 MHz (Level Meter) .
- So how to measure such a service?

2G: 200 kHz bandwidth per carrier

3G: 5 MHz maximum bandwidth

4G: 20 MHz maximum bandwidth

5G: 100 MHz maximum bandwidth @ < 6 GHz

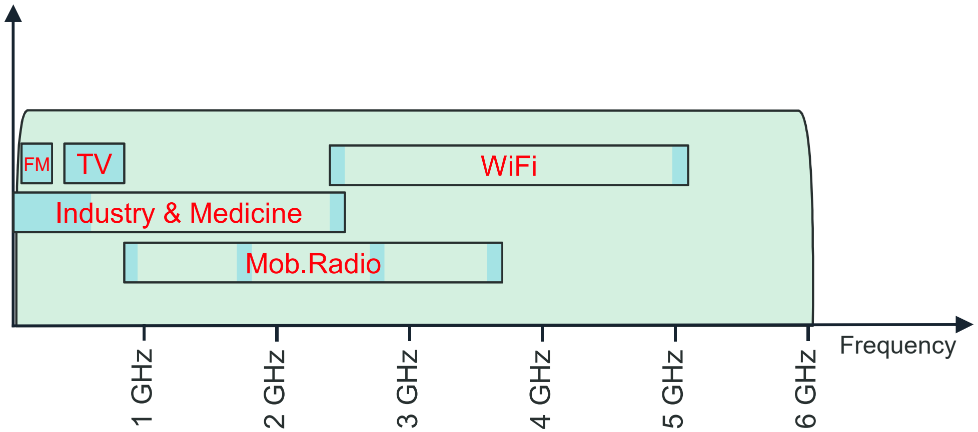


Frequency span 108 MHz

Broadband Measurement

Broadband probes, e.g. bandwidth 1 MHz to 6 GHz cuts out a large spectrum and provides single result:

- Total isotropically calculated field strength within total bandwidth - okay for <u>one</u> dominant field source

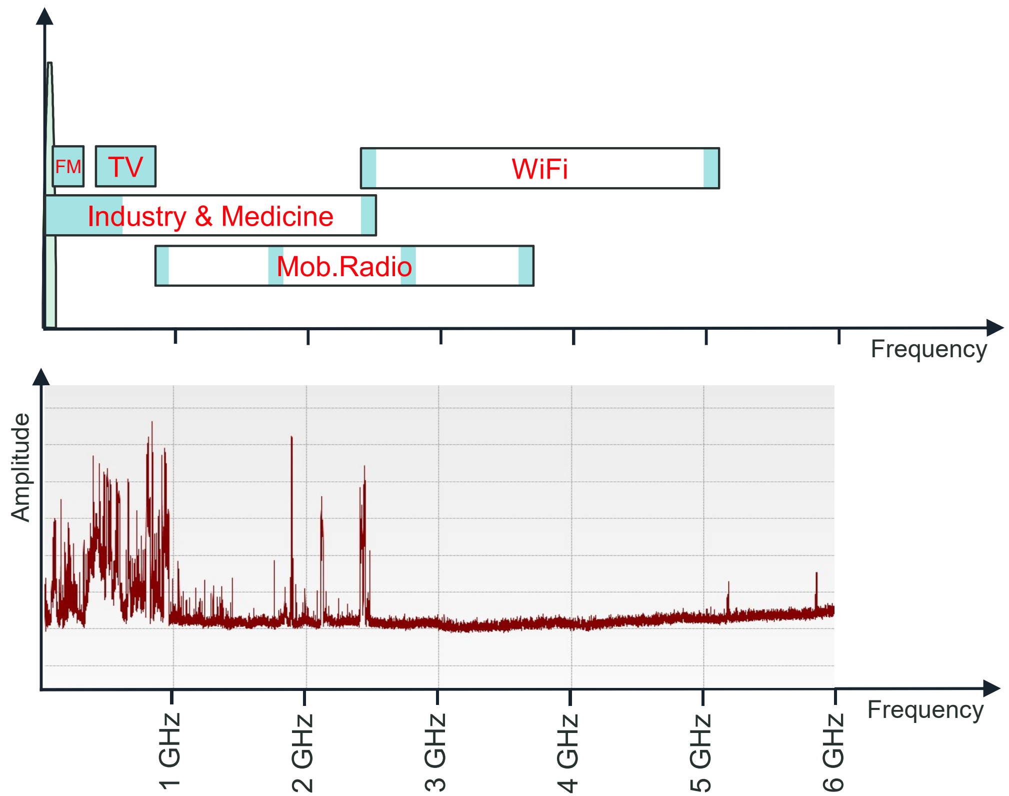


- As broadband probes have much larger bandwidth than any available services today, they have no problem to measure 5G services, correctly
- Advantages : relatively cheap, simple operation, small footprint, relatively simple M.U. calc.
  real-time acquisition (isotropic analogue dipole diode sensors) of max, avg, current values
  Disadvantages: relatively low sensitivity (mV/m vs µV/m) and dynamic (60 dB vs 120 dB) vs RT-SA

Selective Measurement

A selective meter like SRM-3006 scans the spectrum with a small, variable narrowband filter and measures:

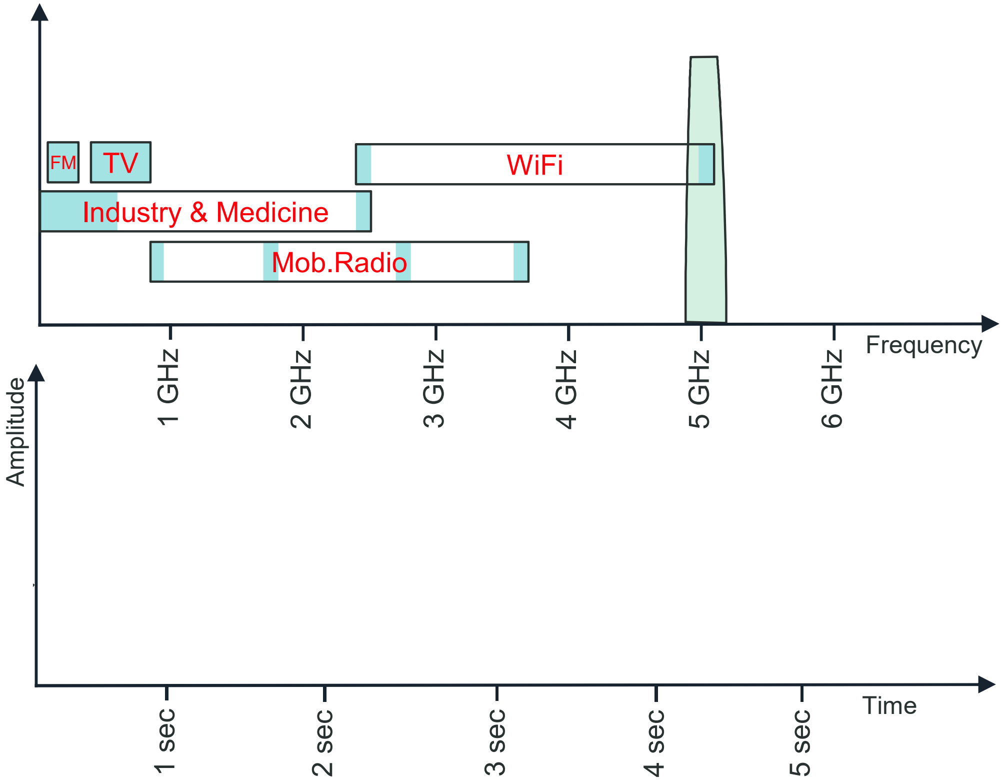
- Power level of all frequency components, individually (scanning / non-RT)



- Available filter in scan-mode for SRM-3006: 10 Hz to 20 MHz

Scan Mode and "Zero Span"

If scanning is stopped, it's possible to align the filter to any frequency and to measure a service now continuously versus time (Zero Span) … means in RT (real-time)



- Available filter in Zero Span-mode for SRM-3006: 100 Hz to 32 MHz

Which is the best bandwidth RBW for a service?

RBW > bandwidth of service

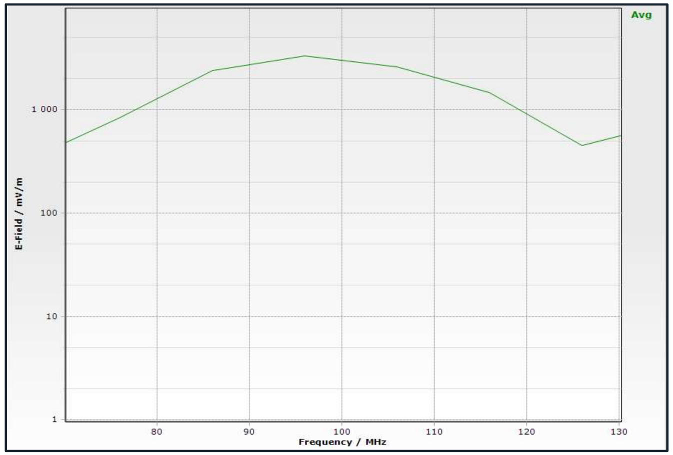
- If the bandwidth of the test equipment is higher than the bandwidth of a service or carrier, you measure correct levels but maybe you sum up several signals.
- E.g.:
  RBW = 20 MHz
  Result: the total amount of all FM-radio stations

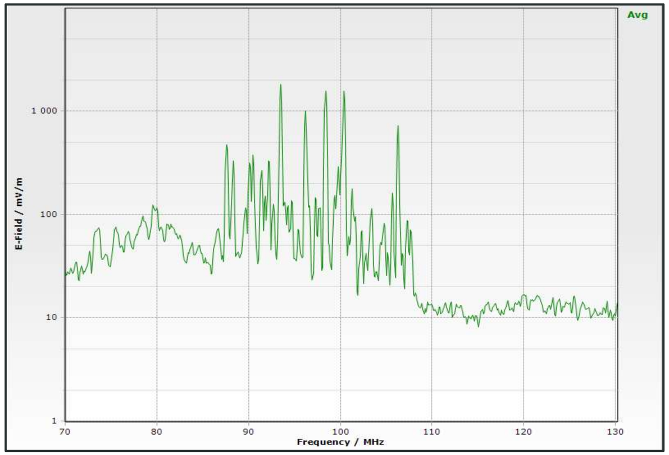
RBW = bandwidth of service

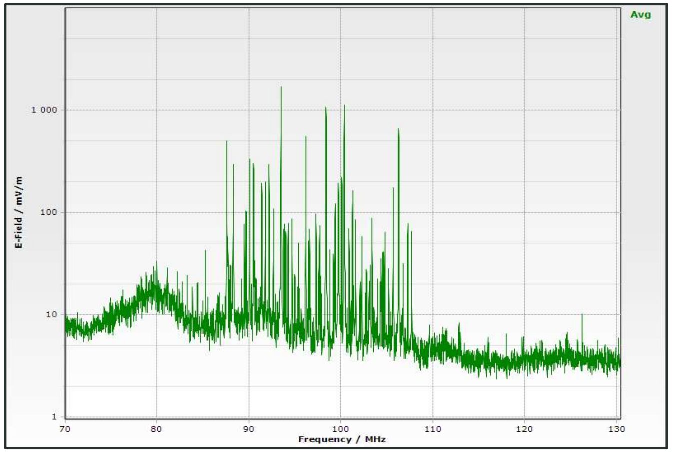
- Best way to measure each service separately as the displayed levels represent the exact level of each service
- E.g.:
  RBW = 200 kHz
  Result: perfect level measurement for each FM-station

RBW < bandwidth of service

- Now the analyzer is measuring only small parts of the power of a carrier and displayed levels are too small
- E.g.:
  RBW = 20 kHz
  Result = better separation of each carrier, low noise, but levels don't represent true carrier power

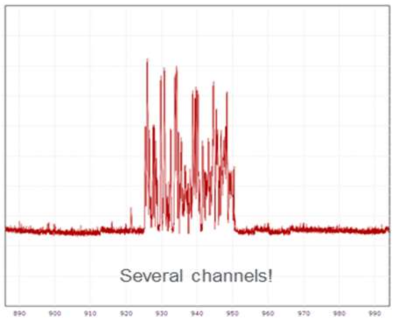


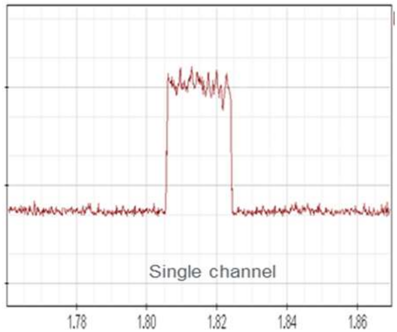


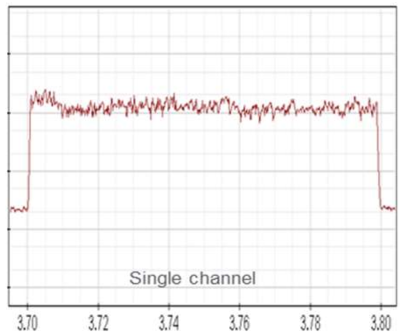


How to make 5G measurements correctly?

- For narrowband services, e.g. Tetra, P25, FM etc. SRM-3006 always has plenty bandwidth available
- Even for 4G/LTE with a maximum bandwidth of 20 MHz SRM-3006 has the correct RBW to make a perfect level measurement
- But with 5G NR the bandwidth of a channel can become 100 MHz or even 400 MHz. How to make a correct level measurement?

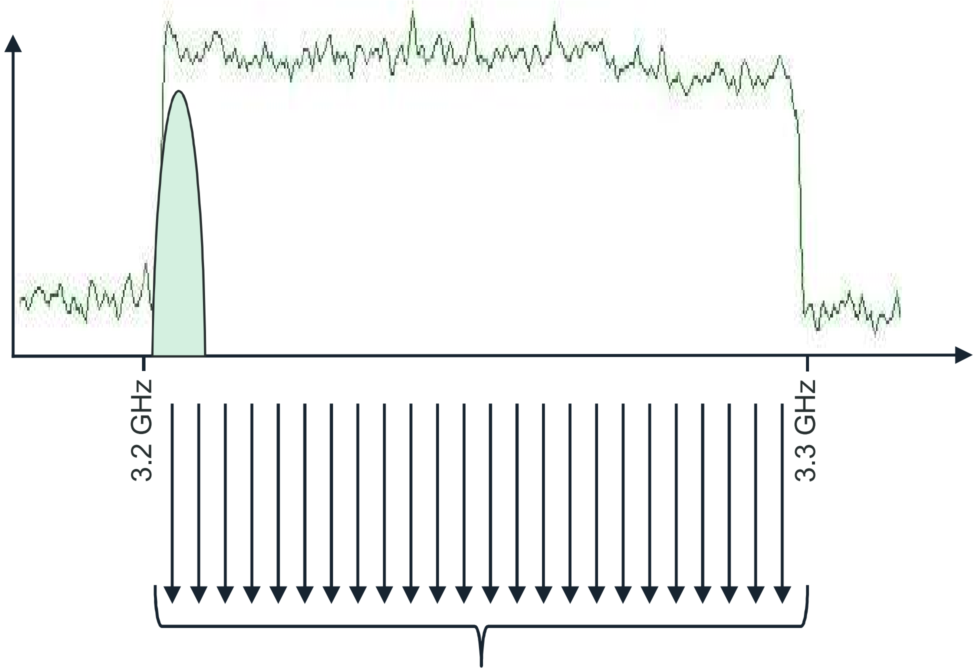






A proven measurement method is used

- Wideband service is measured in (fast) scan mode:
  all carrier power of service inside bandwidth are summed up to total amount



$$P_{int} = \frac{\Delta f}{NBW} \cdot \sum_{k=k_1}^{k_2+1} w(k) \cdot P(f_{start} + k \cdot \Delta f)$$

- By this, you can measure any broadband service with a narrow bandwidth
- Final result is independent of selected RBW
- E.g.: if RBW is reduced, each individual measurement result becomes smaller.
  But therefore scanning and integration produces more results to be added up
  Hence, final result will become equivalent

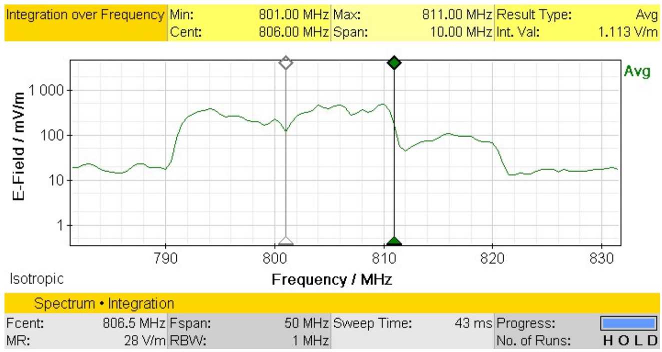
Two ways, to perform correct measurements of broadband signals, incl. 5G

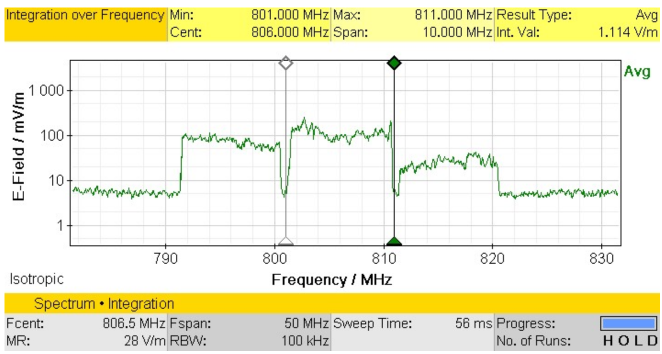
- Marker evaluation “Integration over frequency range” is one possibility to measure correct level of a communication service independent of its bandwidth
- Lower and upper marker are set to the boundaries of service. Marker calculates total channel power
- Proof: RBW is changed by factor 100, but (nearly) no change of measurement result

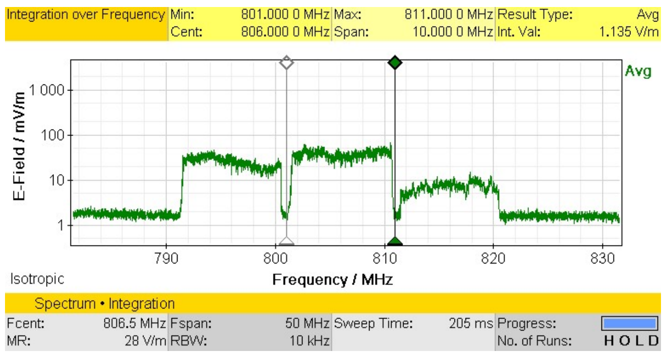
- RBW = 1 MHz
- Value = 1.113 V/m

- RBW = 100 kHz
- Value = 1.114 V/m

- RBW = 10 kHz
- Value = 1.135 V/m







Two ways, to perform correct measurements of broadband signals, incl. 5G

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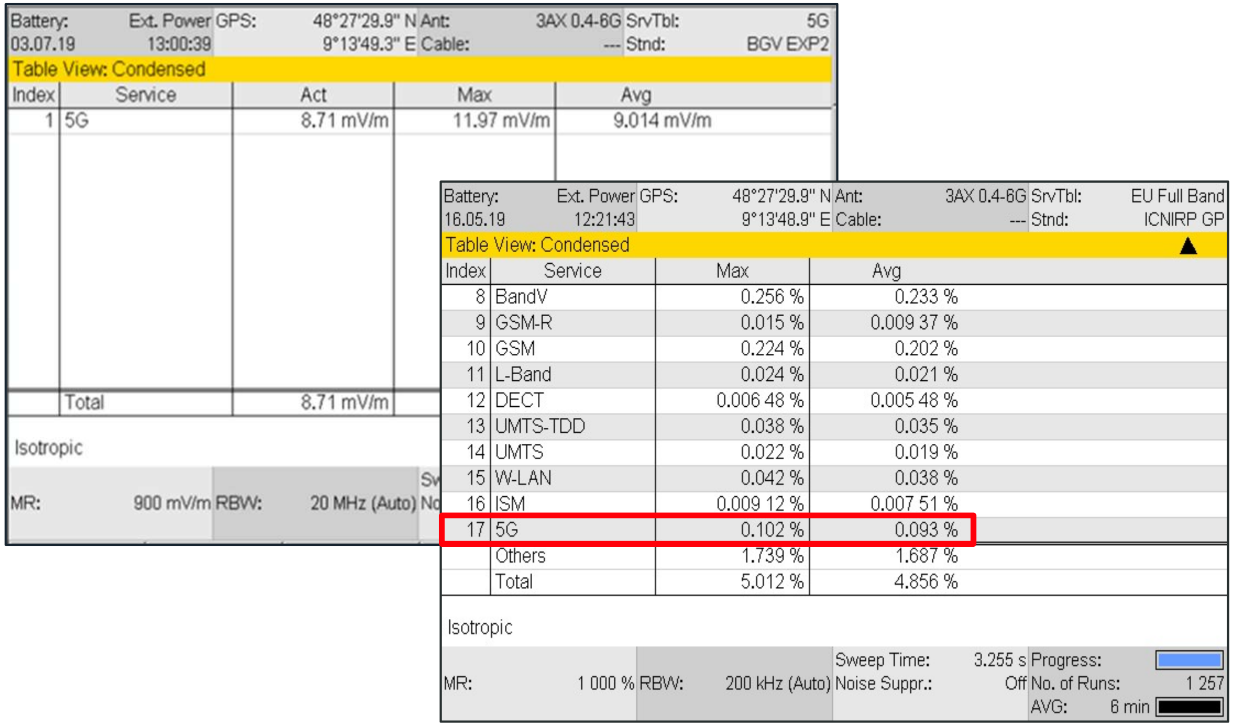
- Second possibility is the creation of service table acc. to boarder frequencies of each channel.
  By this, multiple channels can be measured and displayed at same time



- Service tables can be created by a PC-SW Tool which comes with instrument. After creation, service tables can be transferred (uploaded) to SRM-3006
- Service tables can be used not only for 5G but they can measure any kind of service independent from its bandwidth. By this, SRM is THE perfect tool to provide a measurement report at a glance.
- A code-selective measurement for 5G signals in FR1 will distinguish between different base stations in a single frequency environment. It also forms the base to calculate to the maximum possible traffic which makes the result independent from day, time, and traffic load.
- Additionally an antenna with down converter is developed extending frequency range of SRM-3006 to 5G FR2 / mm waves range !

For Safety@Work :
5G Personal Monitors

23.1 RadMan, still the first choice for Telstra, Australia, even after 25 years

The first RadMan came on to the market some 25 years ago. Back then, we were still Wandel & Goltermann Safety Test Solutions. To optimize the design of the RadMan to meet user requirements, we asked telecommunications operators around the globe for their input. This also included in-depth discussions with the Australian network operator Telstra.

Telstra is still Telstra, we have become Narda Safety Test Solutions / L3Harris, and RadMan 2 has been developed from the original RadMan. Many in the two teams on both sides of the world are still active and in touch with each other. So, it comes as no surprise that RadMan 2 also contains DNA from Telstra.

Telstra has always been a pioneer in workplace safety, and emphasizes the need for their staff working on radio towers to be certain that antennas are actually turned off before they start to climb the equipment. That's why Narda has implemented the "tone search function" in the RadMan 2XT. This gives proof of whether the antenna is switched off or not. This is just one example of what we call global cooperation – over generations.

As a result, the RadMan 2 has also received "preferred product" status from Telstra just like its predecessor.

If you would like to watch how Testra's engineers use "their" RadMan devices in their everyday work, you're just one click away.

>> Click here for the video.

- Continous real-time assessement of EMF
- For safety @ workplace / occupational health

- Unique combination of 'Tone Search Function' & fast integration time :

  => check if antenna is 'ON'

  => leakage localization tests

  When analyzing EMF / EME by 30 ms integration time (vs standard 1 sec) RadMan will even pick-up signals from low capacity traffic 5G/NR sites, as well as steered beams

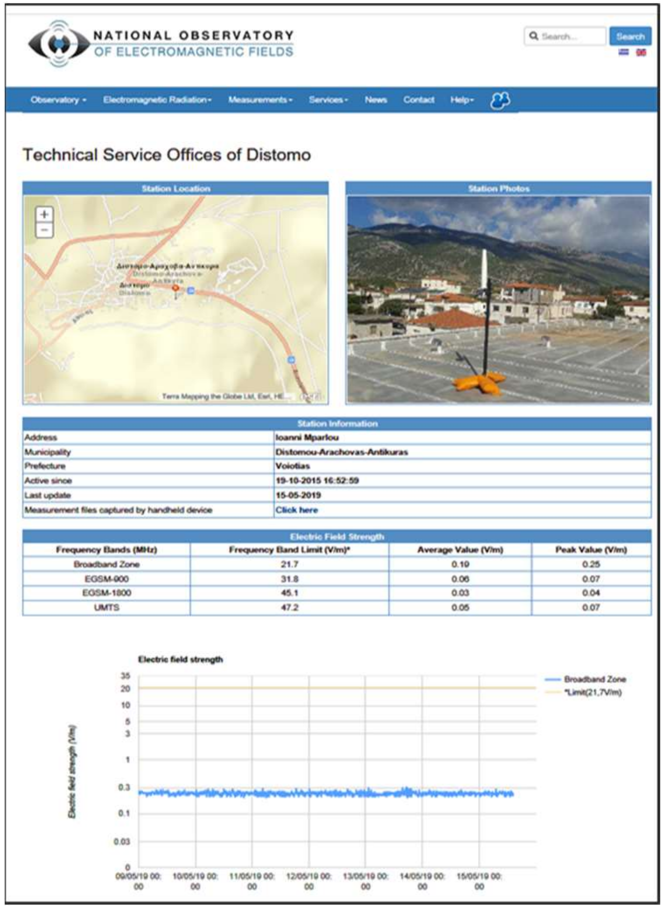
=> Ensuring 100% safety in 5G NR environments for FR1 (sub 6 GHz) + FR2 (mm Waves) !

For public health: 5G EMF Monitoring
– real time assessement of instantaneous EMF

Environmental measurements, 24/7 exposure

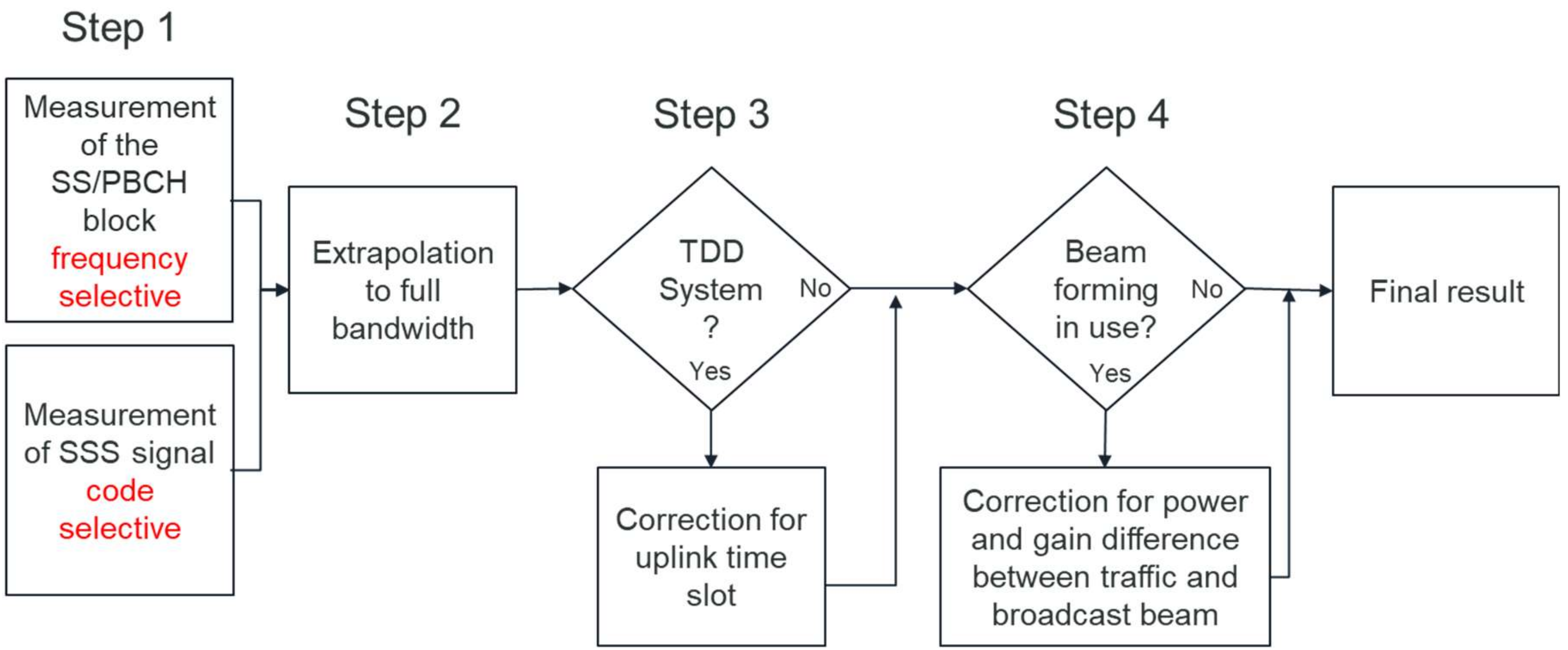
- EMF area monitoring probes AMB / AMS measure up to 40 GHz (broadband) or up to 6 GHz 5G/NR FR1 (selective).

  On-Line Web publishing of results to inform public proactively on instantaneous radiation levels - any time – any place !



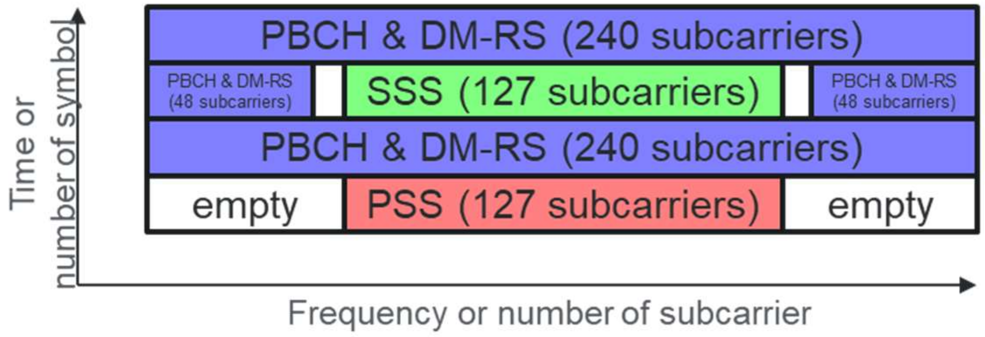
Extrapolation

For extrapolation of 5G signals to max. exposure several parameters have to be considered. Even though there might be slightly varying extrapolation methods, basic principle can be described as follows, whereby starting points are either time or frequency or code domain field strengths test results :

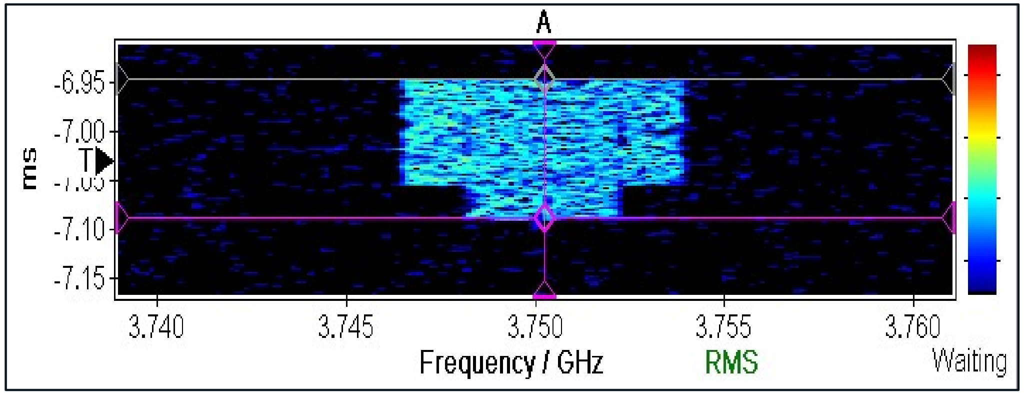


Structure of SS/PBCH block

Schematic Presentation



- Signal measured by I/Q-recorder of IDA-2

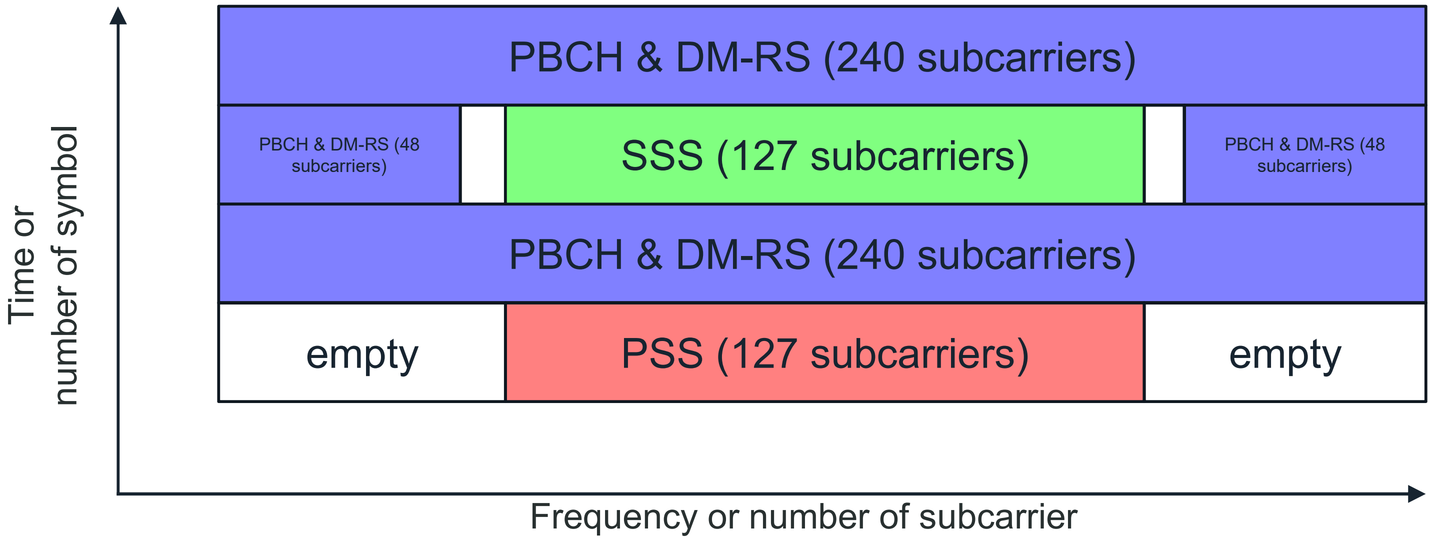


Structure of SS/PBCH block

PSS (red) and SSS (green) are signals inside the physical broadcast channel (SS/PBCH) block

Entire block of 240 subcarriers (frequency domain) and 4 symbols (time domain)

PSS and SSS are 127 subcarriers broad and 1 symbol long



Measurement Bandwidths

The bandwidth of the SS/PBCH block and the SSS/PSS signal are defined as follows:

SS/PBCH block has a bandwidth of 240 x Δf

The SSS/PSS signal bandwidth is 127x Δf

The subcarrier spacing of the PBCH block “Δf” can have the following values for carrier frequencies ≤ 6 GHz:

15 kHz, 30 kHz, 60 kHz

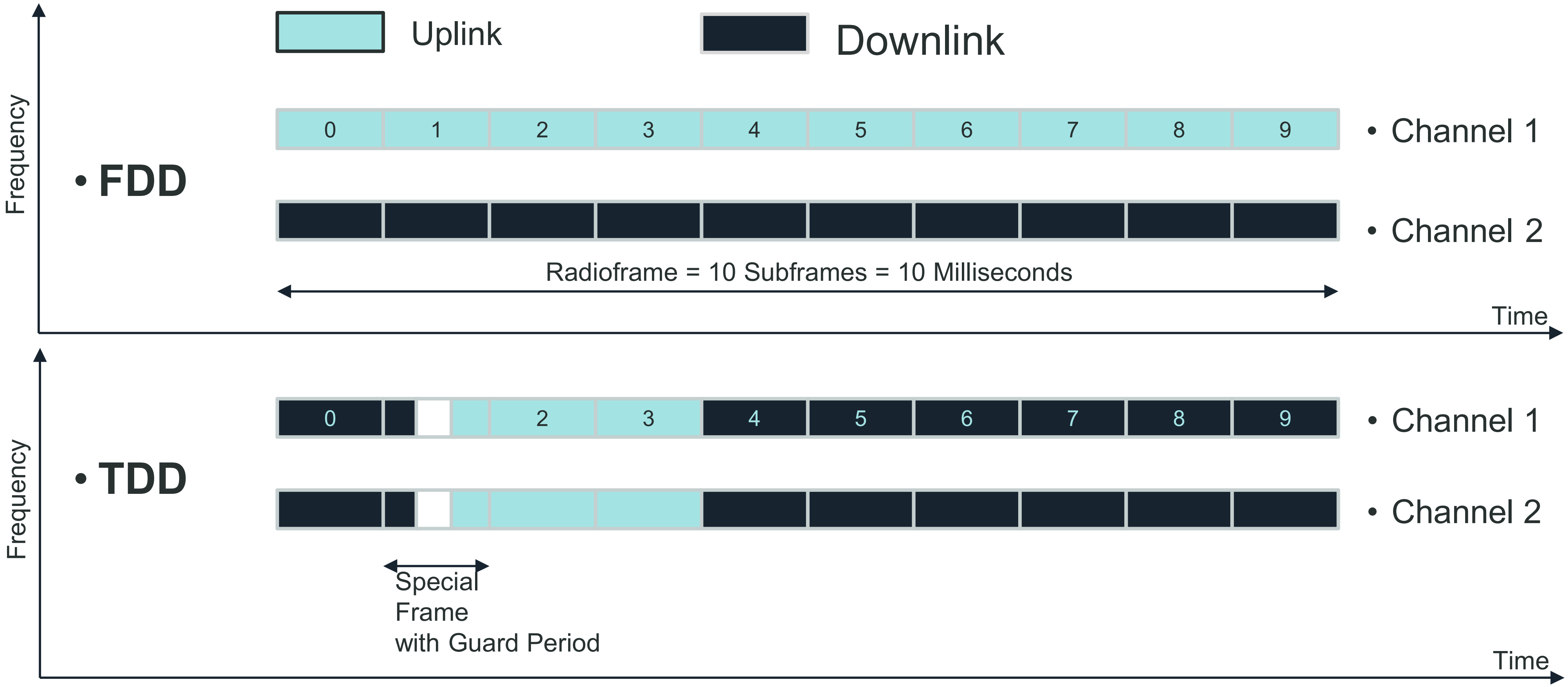
This results in the following bandwidths:

Δf	0,015 MHz	0,030 MHz	0,060 MHz
SS/PBCH	3,600 MHz	7,200 MHz	14,400 MHz
SSS	1,905 MHz	3,810 MHz	7,620 MHz
PSS	1,905 MHz	3,810 MHz	7,620 MHz

Note:

2nd FW release will offer stepping through 5G band and automatically detect center frequency of SS/PBCH

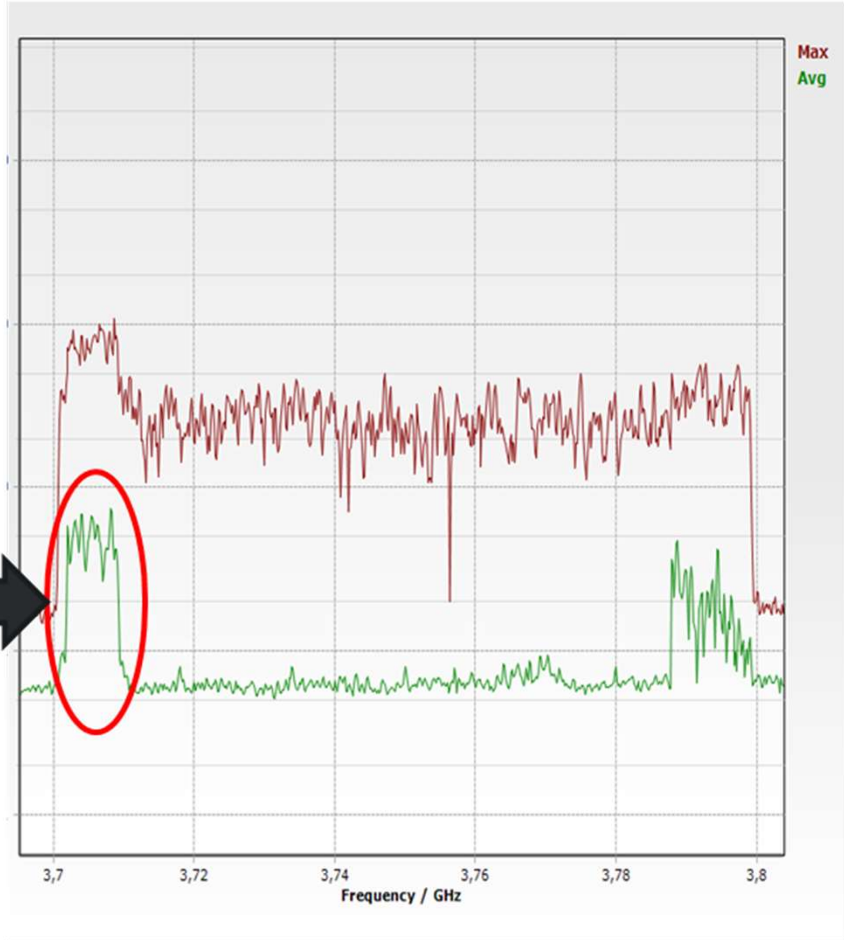
FDD vs TDD Modes



SS/PBCH Frequency

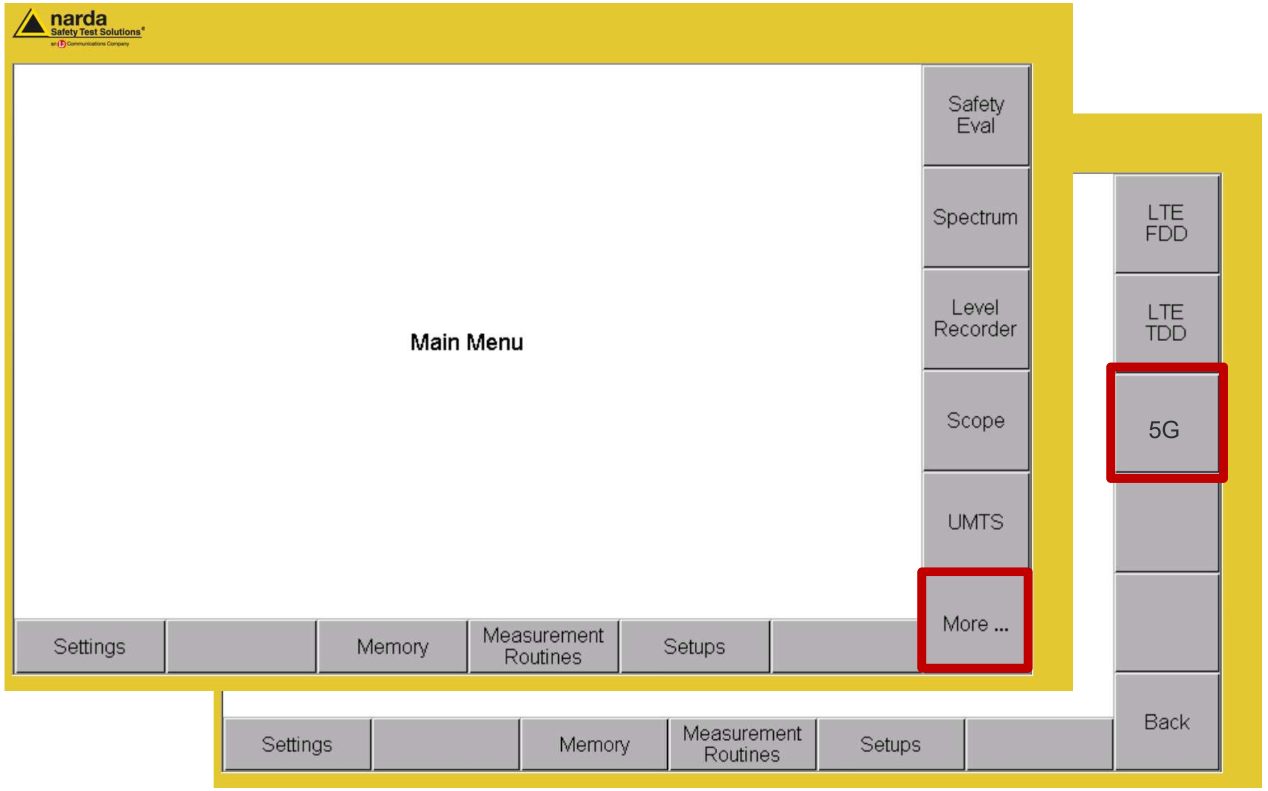
In contrast to 4G, 5G synchronization SS/PBCH can be shifted individually by the operator inside the frequency band.
So if frequency of the synchronization is unknown, it has to be located by a spectrum measurement or automatically by the measurement device.

E.g.: 100 MHz bandwidth system with synchronization at lower edge of spectrum

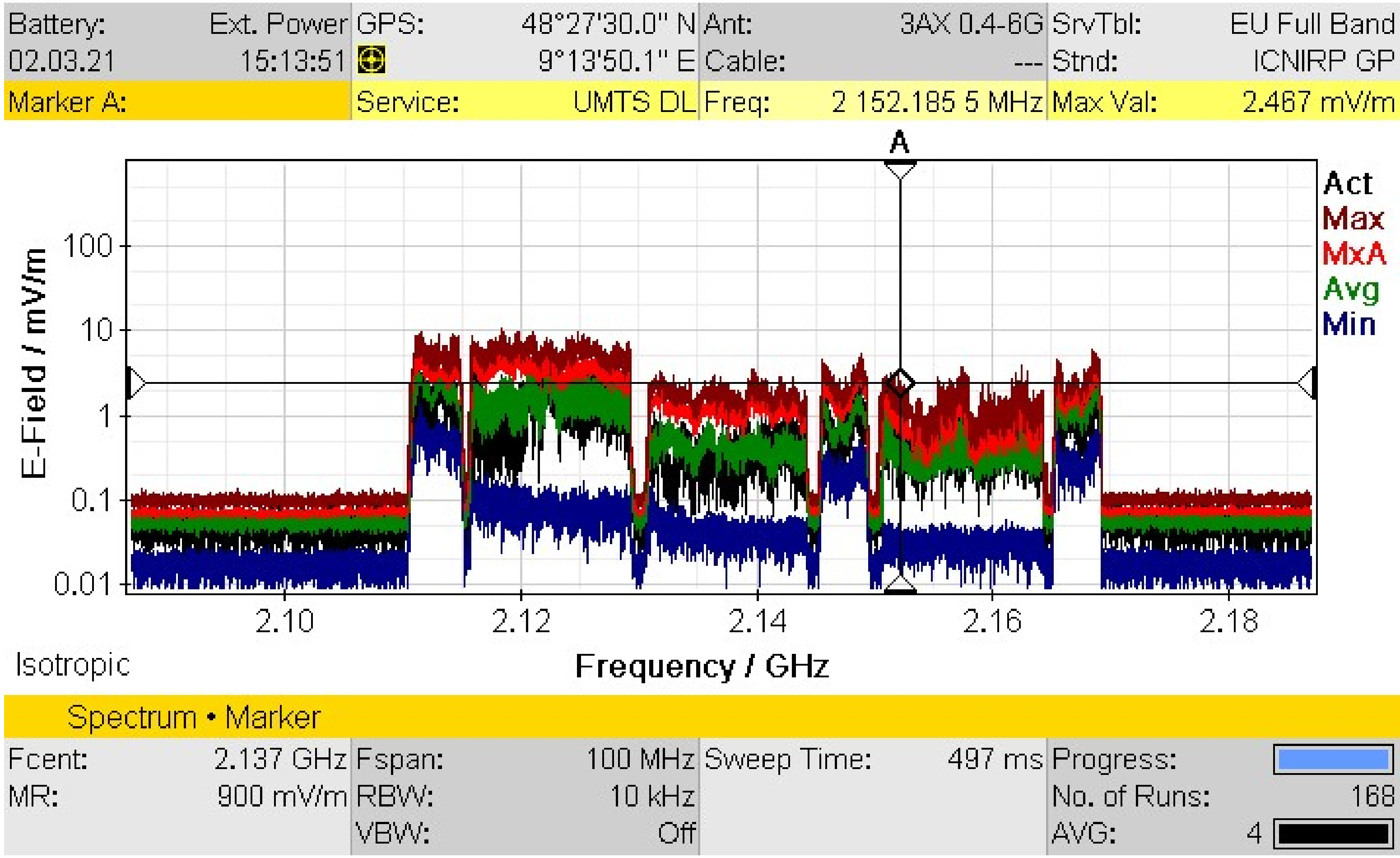


Upcoming SRM-3006 5G Measurement Mode(s)

Access via "More" button.
TDD/FDD will be set via a parameter within mode.



3G /4G / 5G DSS (Dynamic Spectrum Sharing) in SA Mode



Individual EMF results gathered from Sec. Sync. Signal

Battery:		GPS:	48°27'29.0" N	Ant:	3AX 0.4-6G	SrvTbl:	EU Full Band
02.03.21	17:34:20		9°13'49.1" E	Cable:	---	Stnd:	ICNIRP GP

Table View

Index	Cell ID	No. SSSs	Act (SSS0)
1	874	1	0.000 V/m
2	873	1	4.286 mV/m
3	875	1	3.854 mV/m
	Total		5.76 mV/m
	Analog		35.39 mV/m

Isotropic

5G NR

Fcent:	2.152 19 GHz	SCS:	15 kHz	Sweep Time:	1.745 s	Progress:	
MR:	800 mV/m	Sens.	Normal	Noise Suppr.:	Off	No. of Runs:	49
						AVG:	6 min

Individual values : ACT (instantaneous), SUM and MAX

Battery:		GPS:	48°27'30.3" N	Ant:	3AX 0.4-6G	SrvTbl:	EU Full Band
13.03.21	09:14:52		9°13'49.4" E	Cable:	---	Stnd:	ICNIRP GP

Table View

Index	Cell ID	No. SSSs	Act (SSS Sum)	Act (SSS0)	Max (SSS Sum)	Max (SSS0)
1	873	1	74.28 dBµV/m	74.28 dBµV/m	81.47 dBµV/m	81.47 dBµV/m
2	875	1	999.00 dBµV/m	999.00 dBµV/m	76.54 dBµV/m	76.54 dBµV/m
3	874	1	999.00 dBµV/m	999.00 dBµV/m	68.30 dBµV/m	68.30 dBµV/m
	Total		74.28 dBµV/m	74.28 dBµV/m	82.68 dBµV/m	82.68 dBµV/m
	Analog		82.14 dBµV/m		97.16 dBµV/m	

Isotropic

5G NR

Fcent:	2.152 19 GHz	SCS:	15 kHz	Sweep Time:	1.871 s	Progress:	
MR:	119 dBµV/m	Sens.	Normal	Noise Suppr.:	Off	No. of Runs:	44
						AVG:	6 min

Act / Max / Min

Battery:		GPS:	48°27'29.3" N	Ant:	3AX 0.4-6G	SrvTbl:	EU Full Band
13.03.21	09:08:52		9°13'52.5" E	Cable:	---	Stnd:	ICNIRP GP

Table View

Index	Cell ID	No. SSSs	Act (SSS0)	Max (SSS0)	Min (SSS0)
1	873	1	80.09 dBµV/m	83.74 dBµV/m	999.00 dBµV/m
2	875	1	999.00 dBµV/m	73.16 dBµV/m	999.00 dBµV/m
3	874	1	999.00 dBµV/m	74.27 dBµV/m	999.00 dBµV/m
	Total		80.09 dBµV/m	83.74 dBµV/m	999.00 dBµV/m
	Analog		91.88 dBµV/m	97.25 dBµV/m	82.05 dBµV/m

Isotropic

5G NR

Fcent:	2.152 19 GHz	SCS:	15 kHz	Sweep Time:	1.921 s	Progress:	
MR:	119 dBµV/m	Sens.	Low	Noise Suppr.:	Off	No. of Runs:	61
						AVG:	6 min

SSS results with Sensitivity set to „HIGH“

Battery:		GPS:	48°27'30.9" N	Ant:	3AX 0.4-6G	SrvTbl:	EU Full Band
13.03.21	09:05:25		9°13'50.2" E	Cable:	---	Stnd:	ICNIRP GP

Table View

Index	Cell ID	No. SSSs	Act (SSS0)
1	874	1	999.00 dBµV/m
2	873	1	74.57 dBµV/m
3	875	1	71.91 dBµV/m
4	911	1	999.00 dBµV/m
5	957	1	999.00 dBµV/m
6	593	1	999.00 dBµV/m
7	538	1	999.00 dBµV/m
8	159	1	999.00 dBµV/m
9	624	1	999.00 dBµV/m
	Total		76.45 dBµV/m
	Analog		86.10 dBµV/m

Isotropic

5G NR

Fcent:	2.152 19 GHz	SCS:	15 kHz	Sweep Time:	2.476 s	Progress:	
MR:	119 dBµV/m	Sens.	High	Noise Suppr.:	Off	No. of Runs:	11
						AVG:	6 min

SRM 5G Rel.1

Currently two to three different 5G extrapolation methods are being pursued

In order to speed-up market entry, SRM will initially support:

Code selective measurement of SSS (secondary sync. signal)

within 120° antenna segment SSS of all 8 broadcast beams (from # 0 ….. #7) will be measured isotropically (x/y/z plane)

calculation of summed and maximum SSS value

We also plan to make an Excel calculator available offering selectable extrapolation methods

Time and frequency domain tests are still possible with trial systems (mMIMO) and or low traffic cell load
– however code-selective tests can also being applied with high traffic and even in a environment with multiple cells !

SRM 5G Rel.2

This version will include extrapolation methods to display the extrapolated values directly*.

The extrapolation calculation will be either offered in SRM-3006 and/or as post-processing function in SRM-TS PC software*

* Availability depending on issuing of measurement guidelines of standardization bodies

SRM-3006‘s Roadmap to 5G

Preliminary Beta-Release

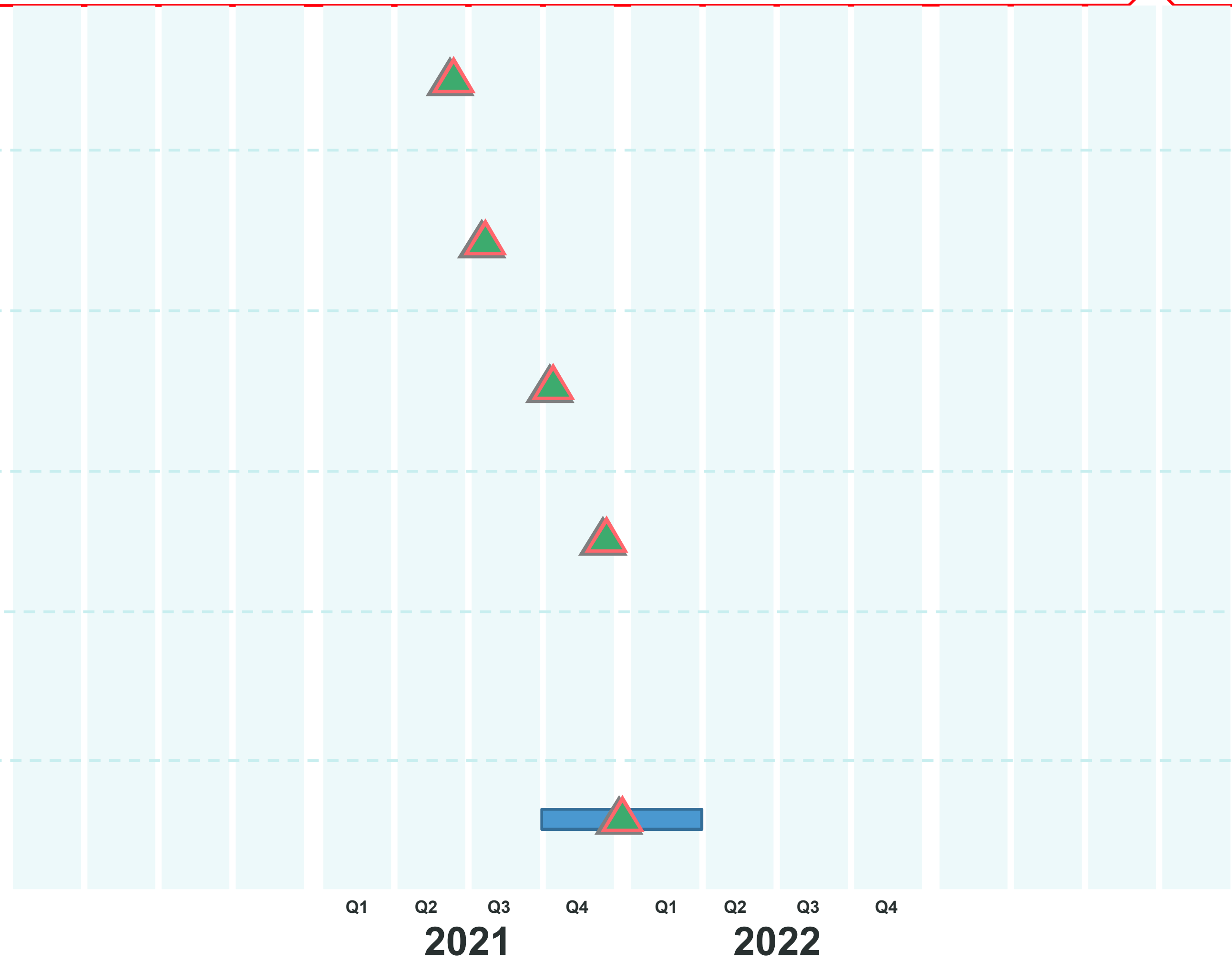
SRM 5G Code Selective Measurement (Firmware Update)

SRM-TS (code-selective measurement)

SRM 5G Extrapolation*

…

SRM 5G- down converter antenna (24.5 - 30 GHz)



*Availability depending on issuing of measurement standards


Omni and / or Horn
Antenna Versions
Several Down converter
ranges
5G Antenna
SRM
narda

Questions, Feedback, Comments?

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