



In-building propagation  
measurements for the  
coming fifth-generation  
mobile communication  
technologies (5G)

**Anritsu**  
envision : ensure

# In-building propagation measurements will become important for the coming fifth-generation mobile communication technologies (5G)

---

## 1 - Introduction

---

Spectrum regulators, world-wide, are recognizing the need to open up new spectrum to support the rapidly growing use of high speed data. In July, 2016, the US FCC opened up nearly 11 GHz of spectrum in the mmWave frequency range. Specifically; 27.5 to 28.35 GHz, 37 to 38.6 GHz, 38.6 to 40 GHz, and 64 to 71 GHz. Users will expect their devices, with this new spectrum, to function similarly to their current devices. New Machine-to-Machine (M2M) devices will need to work in closets and cabinets inside buildings.

While outdoor propagation of this mmWave spectrum is well known, few studies have been done in-building. Anritsu is a leader in mmWave measurement test equipment and offers the MG369xC Series Signal Generators and MS2720T Series of portable spectrum analyzers covering the new 5G frequencies to 40 GHz. This white paper outlines procedures to make mmWave in-building propagation predictions and measurements.

With the operational costs associated with 5G mmWave deployments of chief concern to operators, easy to use tools will be required to enable field technicians to quickly and economically map the coverage of future 5G mmWave radios. Complex and heavy engineering setups will not be practical. Test procedures and equipment need to be as economical and simple for 5G as those used to set-up WiFi networks today. The portable, Android-based solution presented below provides excellent first order coverage estimations suitable for real-world deployments.

## 2 - Office panel propagation loss measurements

---

Measurements of office material propagation loss were made to support the prediction of the coverage within the office. These measurements were done with the MG3694C Signal Generator sending a 28 GHz signal to a horn antenna and the MS2720T Spectrum Analyzer and horn antenna set to receive the 28 GHz signal. The two horn antennas were separated by 10 feet. Wall panels, glass panels, and doors were inserted in the path between the two horn antennas. Measurements were made with the panels perpendicular, 30, and 60 degrees with the transmission path.





*Anritsu MG3694C signal generator providing a +12 dBm signal into a 26.5 to 40 GHz waveguide to coax adapter and 10 dB gain waveguide horn antenna.*



*Anritsu MS2720T Spectrum Analyzer (on a cart) with flexible cable and 26.5 to 40 GHz waveguide to coax adapter and 10 dB gain horn antenna.*



Results of inserting a wall panel between the two horns separated by 10 feet vs. a pane of glass vs. having nothing in between.

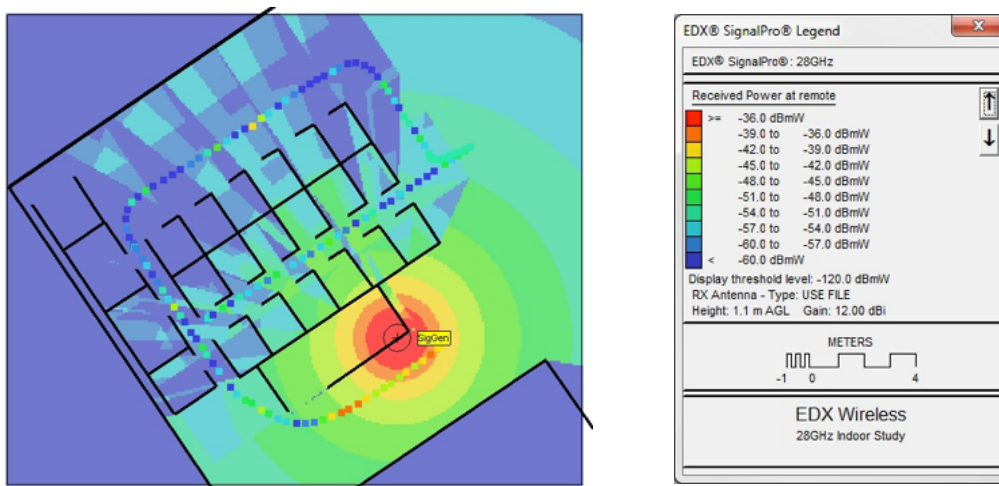
Rotation	Loss Results		
	No Wall Panel	Wall Panel	Pane of Glass
90 degrees	-23.5 dBm	-24.5 dBm	-26.5 dBm
60 degrees		-25.5 dBm	-30.5 dBm
30 degrees		-26.5 dBm	

### 3 - Office coverage predictions using EDX SignalPro prediction software

A wall layout plan was obtained for the office area, and was converted into a 3D structure database so that coverage predictions could be made using EDX SignalPro® software from EDX Wireless. The software incorporated the office materials loss characteristics as determined by the previous measurements. The path loss model used in the EDX software was their “EDX Simplified Indoor Model” which is similar to the COST 231 model in that it is a direct path multi-wall/floor model well suited for indoor environments.



Wall layout for empty office area with the previously measured panels.

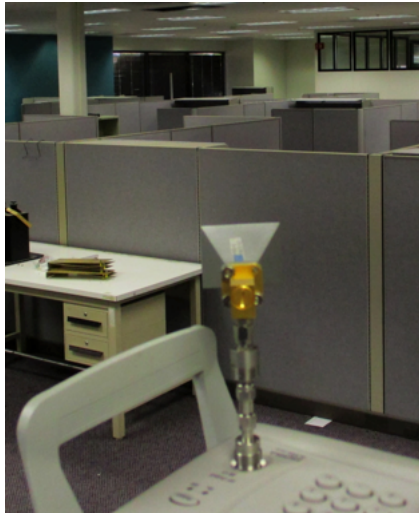


EDX SignalPro coverage predictions incorporating the 28 GHz panel loss measurements.



## 4 - Office coverage measurements using the Anritsu MS2720T Spectrum Master and MA8100A TRX NEON Signal Mapper

For coverage measurements, the MG3694C Signal Generator with horn antenna was placed on a cabinet with the horn antenna at 7 feet, simulating the location of a 5G hot spot. The MS2720T spectrum analyzer was placed on a wheeled cart and moved through the office area while the spectrum analyzer continuously made channel power measurements.

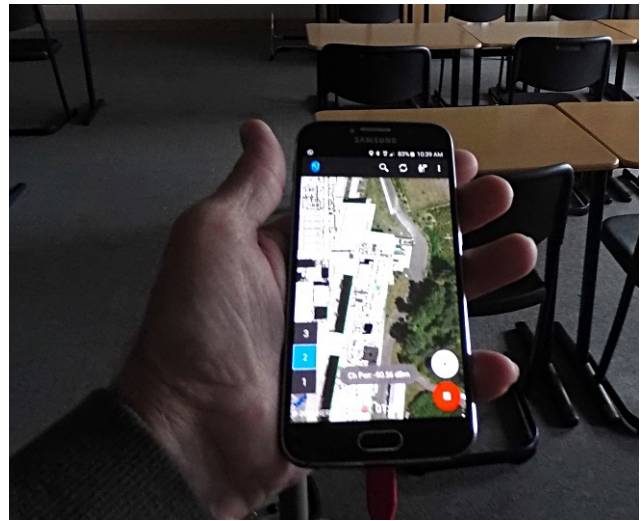


*The +12 dBm 28 GHz signal was set at 7 feet above the office area to simulate a 5G hot spot. The MS2720T was placed on a cart with a 42 inch high cable to the receive waveguide horn. Both horn antennas were kept aimed at each other during testing.*

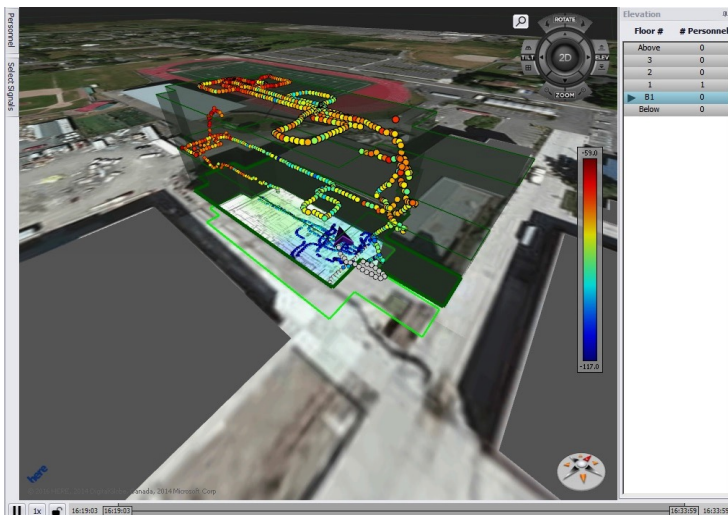
To support fast and easy in-building measurements, Anritsu partnered with TRX Systems to introduce the MA8100A NEON Signal Mapper, a coverage mapping solution that provides in-building coverage maps based on mmWave measurements from Anritsu's portable spectrum analyzers. The solution incorporated an Android phone as a controller (mobile connectivity can be disabled), connected via USB to the spectrum analyzer and via Bluetooth to the Neon tracking unit. This system works together to gather signal strength measurements correlated to building location. The NEON tracking unit contains a gyroscope, accelerometer, barometric pressure sensor, compass, and ranging sensors to accurately maintain location position without the need for GPS connectivity.



*Anritsu portable spectrum analyzer, Android phone and NEON Tracking unit*



*Observing the location and measurement results on an Android phone in a high school classroom*



*Using the NEON Command Software to see a 3D view of the signal strength*



*The NEON tracking unit contains a gyroscope, accelerometer, barometric pressure sensor, compass, and ranging sensors.*

## 5 - Set up of the MA8100A TRX NEON Signal Mapper

---

The MA8100A includes the NEON Command Software, a PC-based software package that supports adding detailed floor plans and reviewing the measurement results.

Preparing a map with the NEON Command Software requires a few easy steps:

1. Floor plans for each building should be located and converted to a graphics format (i.e., jpg, bmp, gif, etc.).
2. The address of the building should be entered into the NEON Command Software and the building to be mapped located on the PC screen.
3. The floor plan should be linked to the building following the NEON Command Software user guide.

## 6 - Set up of the Anritsu MS2720T Spectrum Master

---

Prior to conducting in-building mapping, the analyzer itself must first be configured to properly measure the signals of interest. Knowledge of various parameters, such as anticipated signal strength and variation, potential presence of interfering signals, and noise sources, should be used in determining analyzer settings. A brief summary of the main analyzer setups used in this white paper procedure is shown below. However, the user may want to refer to the instrument user manual for more detailed guidance.

### 1. Frequency

The MS2720T center frequency was set to 28 GHz to match the signal generator frequency.

### 2. Span

The span was set to 1 MHz for easy viewing the signal in a 10 kHz RBW.

### 3. Resolution Bandwidth

The resolution bandwidth was set to 10 kHz to provide a -90 dBm noise floor.

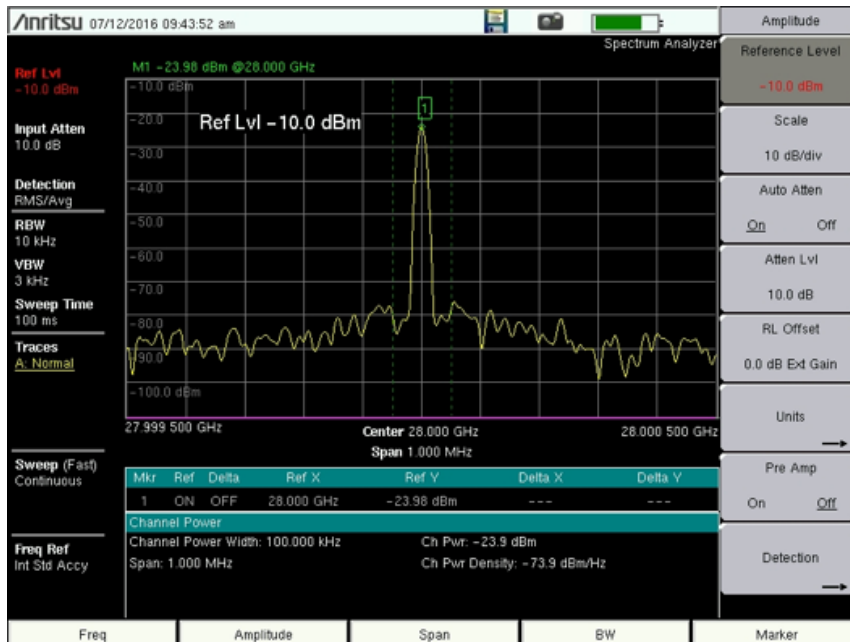
### 2. Reference Level, Pre-Amplifier and Attenuator

The reference Level was set to -10 dBm with 10 dB attenuation to prevent overload when very close to the generator.

### 5. Measurement Mode

The NEON Signal Mapper application (run on an Android device) accepts channel power measurements from the MS2720T. To set up channel power measurements press "Shift" "Measure" and "Channel Power". A channel width of 100 kHz was used. The Android device displays the measurement values as they are taken.





*MS2720T display with the settings used for coverage mapping of the office. Channel power measurements are taken from the MS2720T into the Android phone and passed to the NEON Software for processing. Cloud storage is available if desired.*

## 7 - Making Measurements with the Anritsu MS2720T Spectrum Master and MA8100A NEON Signal Mapper

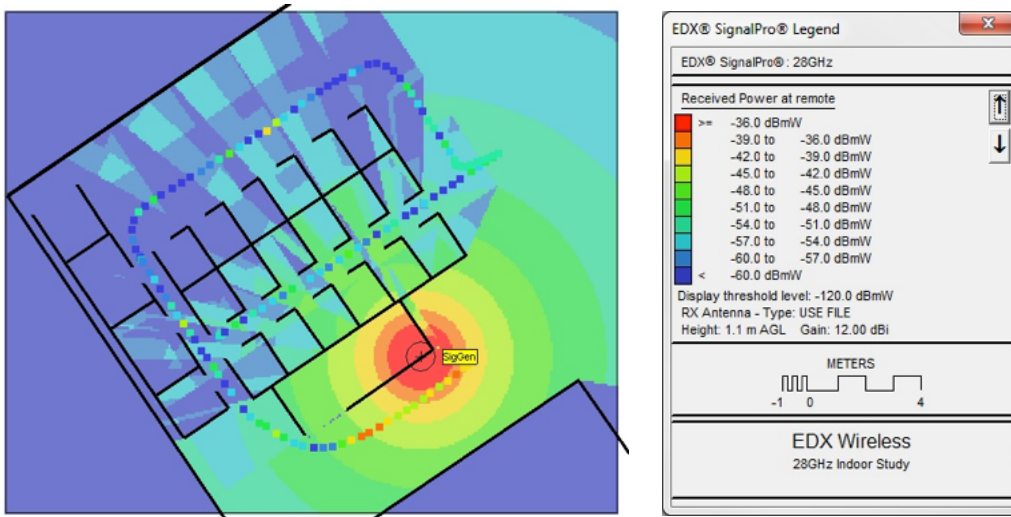
1. The operator follows the NEON location calibration procedures shown on the Android smart phone or tablet.
2. The operator walks the office, observing the location on the smart phone or tablet. When the walk is complete the operator uploads the measurement results with locations to the included NEON cloud storage or locally on the smart phone or tablet.
3. The measurement results can be reviewed using the NEON Command Software in 2D, 3D or as a comma-separated values (.csv) file. The NEON Command Software provides a heat map display which uses an average of the measurements made to predict coverage around the walking path.

## 8 - Measurement results



Using the NEON Command Software to see a 3D view of the signal strength

The 178 measurement points results were then compared with the EDX SignalPro area study's received power predictions. The mean error between prediction and measurement was 0.8dB with a standard deviation of 7.5dB showing good correlation between the two analyses.



## 9 - Summary

---

Understanding in-building propagation will be important for the success of the coming 5G mobile communication technologies. Anritsu is a leader in mmWave measurement test equipment and offers both equipment and software to make it easy to measure in-building coverage of the new 5G spectrum.

We thank EDX Wireless ([www.edx.com](http://www.edx.com)) for providing technical consultation as well as performing a prediction vs. measurement analysis that shows the validity of our measurement techniques at this frequency.

## 10 - Author

---

**Tom Brinkoetter**

Anritsu M3 Division Marketing





**• United States****Anritsu Company**

1155 East Collins Blvd., Suite 100, Richardson,  
TX 75081, U.S.A.  
Toll Free: 1-800-267-4878  
Phone: +1-972-644-1777  
Fax: +1-972-671-1877

**• Canada****Anritsu Electronics Ltd.**

700 Silver Seven Road, Suite 120, Kanata,  
Ontario K2V 1C3, Canada  
Phone: +1-613-591-2003  
Fax: +1-613-591-1006

**• Brazil****Anritsu Eletrônica Ltda.**

Praça Amadeu Amaral, 27 - 1 Andar  
01327-010 - Bela Vista - São Paulo - SP - Brazil  
Phone: +55-11-3283-2511  
Fax: +55-11-3288-6940

**• Mexico****Anritsu Company, S.A. de C.V.**

Av. Ejército Nacional No. 579 Piso 9, Col. Granada  
11520 México, D.F., México  
Phone: +52-55-1101-2370  
Fax: +52-55-5254-3147

**• United Kingdom****Anritsu EMEA Ltd.**

200 Capability Green, Luton, Bedfordshire, LU1 3LU, U.K.  
Phone: +44-1582-433200  
Fax: +44-1582-731303

**• France****Anritsu S.A.**

12 avenue du Québec, Bâtiment Iris 1- Silic 612,  
91140 VILLEBON SUR YVETTE, France  
Phone: +33-1-60-92-15-50  
Fax: +33-1-64-46-10-65

**• Germany****Anritsu GmbH**

Nemetschek Haus, Konrad-Zuse-Platz 1  
81829 München, Germany  
Phone: +49-89-442308-0  
Fax: +49-89-442308-55

**• Italy****Anritsu S.r.l.**

Via Elio Vittorini 129, 00144 Roma, Italy  
Phone: +39-6-509-9711  
Fax: +39-6-502-2425

**• Sweden****Anritsu AB**

Kistagången 20B, 164 40 KISTA, Sweden  
Phone: +46-8-534-707-00  
Fax: +46-8-534-707-30

**• Finland****Anritsu AB**

Teknobulevardi 3-5, FI-01530 VANTAA, Finland  
Phone: +358-20-741-8100  
Fax: +358-20-741-8111

**• Denmark****Anritsu A/S**

Kay Fiskers Plads 9, 2300 Copenhagen S, Denmark  
Phone: +45-7211-2200  
Fax: +45-7211-2210

**• Russia****Anritsu EMEA Ltd.****Representation Office in Russia**

Tverskaya str. 16/2, bld. 1, 7th floor.  
Moscow, 125009, Russia  
Phone: +7-495-363-1694  
Fax: +7-495-935-8962

**• Spain****Anritsu EMEA Ltd.****Representation Office in Spain**

Edificio Cuzco IV, Po. de la Castellana, 141, Pta. 8  
28046, Madrid, Spain  
Phone: +34-915-726-761  
Fax: +34-915-726-621

**• United Arab Emirates****Anritsu EMEA Ltd.****Dubai Liaison Office**

P O Box 500413 - Dubai Internet City  
Al Thuraya Building, Tower 1, Suit 701, 7th Floor  
Dubai, United Arab Emirates  
Phone: +971-4-3670352  
Fax: +971-4-3688460

**• India****Anritsu India Private Limited**

2nd & 3rd Floor, #837/1, Binnamangla 1st Stage,  
Indiranagar, 100ft Road, Bangalore - 560038, India  
Phone: +91-80-4058-1300  
Fax: +91-80-4058-1301

**• Singapore****Anritsu Pte. Ltd.**

11 Chang Charn Road, #04-01, Shriro House  
Singapore 159640  
Phone: +65-6282-2400  
Fax: +65-6282-2533

**• P.R. China (Shanghai)****Anritsu (China) Co., Ltd.**

Room 2701-2705, Tower A,  
New Caohejing International Business Center  
No. 391 Gui Ping Road Shanghai, 200233, P.R. China  
Phone: +86-21-6237-0898  
Fax: +86-21-6237-0899

**• P.R. China (Hong Kong)****Anritsu Company Ltd.**

Unit 1006-7, 10/F, Greenfield Tower, Concordia Plaza,  
No. 1 Science Museum Road, Tsim Sha Tsui East,  
Kowloon, Hong Kong, P.R. China  
Phone: +852-2301-4980  
Fax: +852-2301-3545

**• Japan****Anritsu Corporation**

8-5, Tamura-cho, Atsugi-shi, Kanagawa, 243-0016 Japan  
Phone: +81-46-296-6509  
Fax: +81-46-225-8359

**• Korea****Anritsu Corporation, Ltd.**

5FL, 235 Pangyoyeok-ro, Bundang-gu, Seongnam-si,  
Gyeonggi-do, 463-400 Korea  
Phone: +82-31-696-7750  
Fax: +82-31-696-7751

**• Australia****Anritsu Pty. Ltd.**

Unit 20, 21-35 Ricketts Road,  
Mount Waverley, Victoria 3149, Australia  
Phone: +61-3-9558-8177  
Fax: +61-3-9558-8255

**• Taiwan****Anritsu Company Inc.**

7F, No. 316, Sec. 1, NeiHu Rd., Taipei 114, Taiwan  
Phone: +886-2-8751-1816  
Fax: +886-2-8751-1817