RANLOS

June
2024

Application note

RanLOS test technology -
A unique solution for cost-effective
OTA measurements

Executive summary

This application note emphasizes the critical need for a robust and cost-efficient testing approach for developing reliable wireless communication systems, especially in vehicles. It introduces the RanLOS test technology, a unique solution designed specifically for Over-the-Air (OTA) measurements.

RanLOS offers a reliable and cost-effective alternative to more expensive and advanced test solutions, enabling efficient testing and evaluation of antenna radiation patterns and communication system throughput. Its modular and upgradable design allows for easy adaptability and installation in diverse testing environments.

The application note also dives into RanLOS straightforward measurement process, outlining how to perform a measurement in only a few steps. Additionally, it highlights RanLOS compatibility with various industry instruments and communication standards, ensuring its versatility.

By using the RanLOS test system, users and car manufacturers get a powerful test solution that can guarantee high quality and performance of their wireless communication systems, ultimately leading to more reliable and safer connected vehicles.

The need for test systems: Methods and solutions

The importance of a robust test philosophy in the development of wireless communication systems, particularly those used in vehicles, is essential. The complexity of these systems, which involve digital and analog subsystems along with extensive software, requires thorough testing to ensure customer satisfaction and the overall quality of the communication system in cars.

To measure the communication system of a vehicle you need to simulate the environment in which the vehicle will be used. The communication to and from a vehicle is typically between a car and the surroundings, i.e. other cars, base stations, road-side systems, etc. what we call vehicle-to-everything communication or V2X-communication. Since the antennas used for the communication are far apart and the communication is wireless, the communication is said to be in Over-the-Air (OTA) far-field conditions.

For final system verification or measurements during the development phase, we want to create far-field conditions. This is because obtaining accurate measurement results requires the antenna's far-field conditions to be met. Therefore, the antenna under test (AUT) must be in the far field of the probe antenna, i.e. the antenna used for the measurement. This can be done in different ways.

This can be done in different ways. Perhaps the most obvious way is to use a large enough shielded room so that the AUT and the probe antenna is guaranteed to be at far-field distance for all frequencies of interest. The main disadvantage of this method is that the chamber must be very large, and therefore will be very expensive.

A commonly used alternative method is to measure in the near-field at a short distance from the AUT. For this, we need to sample the field in many points on a sphere surrounding the AUT and then use complicated mathematical transformations to get the far-field performance of the AUT. The main advantage with this so-called NF-FF (near-field to far-field) method is that the chamber can be made smaller. However, the disadvantages are that we need a mechanically precise positioning device for the probe antenna, and we need to sample in many points on the surrounding sphere, higher frequencies require more points. This in combination with the necessary mathematical transformations will result in long measurement times. Also, the method is not suitable for direct throughput measurements.

Besides the mentioned methods for creating far-field conditions for the AUT, there are other methods that do not require large distances and thus can be fitted into smaller chambers.

One such method is to use a two-dimensional array of antennas that are individually amplitude and phase controlled. With such a configuration it is possible to create a plane wave (far-field) at a short distance in front of the 2D array. However, since controllable attenuators and phase shifters are required for all antenna elements in the array it is a complex construction, and a complicated calibration procedure is required. Another limiting factor is the rather limited frequency bandwidth.

Instead of using a 2D array of antennas, a single antenna illuminating a shaped reflector can be used. This is a much more flexible solution which often is used in high-precision antenna test ranges, so-called compact antenna test ranges (CATR). In such a setup, the feed antenna is normally placed at floor level in a fully anechoic chamber and the double curved reflector is elevated to avoid the feed antenna blocking the field. The test zone where we will have the desired plane wave will therefore be at a certain height over the floor in the chamber, and thus the AUT must be placed on a tower.

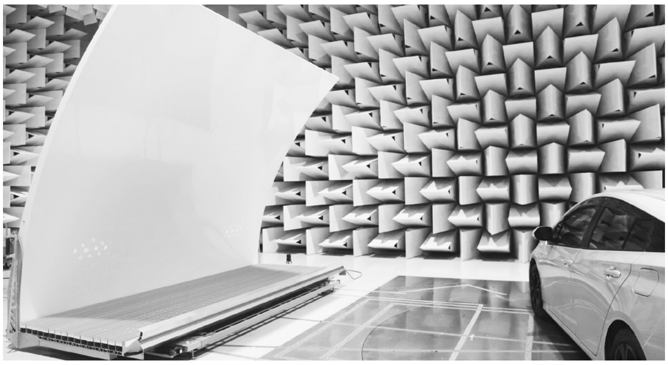
RanLOS test system is basically built on the same principle but instead of using a complicated double curved reflector, we use a single curved cylindrical reflector. The advantage is twofold. First, the reflector is less expensive to manufacture due to its simpler shape, and second, both the reflector and feed array can be placed on floor level in the chamber. The latter is an important advantage since the whole test system can be placed in a semi-anechoic chamber, e.g., an EMC chamber. Another important aspect is that the feed array and the reflector can be made as one unit, which makes it possible to make it mobile so that the test system easily can be rolled in and out of the chamber. Thus, allowing for the chamber to be used for dual purposes, e.g., EMC and antenna testing. The feed array in the RanLOS test system is a dual polarized passive antenna and as such can be used either as a transmitting or receiving antenna, allowing both antenna performance and throughput measurements.

So, although the RanLOS test technology is less complex, it can deliver the same high measurement quality as expensive and advanced test facilities. Additionally, with RanLOS accessibility users can easily perform daily measurements throughout the development process, saving costs and speeding up time to market.

In summary, types of measurement solutions:

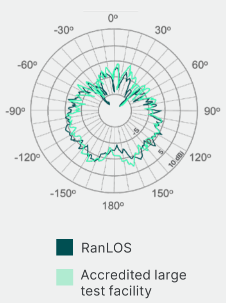
1. Far-field chamber, large and expensive
2. Near-field to far-field method, smaller chamber than the far-field chamber, complicated and advanced equipment, need post-processing, expensive and limited frequency bandwidth
3. Two-dimensional array of antennas, complicated design and calibration, expensive
4. Single antenna with double curved reflector, smaller chamber, rather complicated, expensive
5. RanLOS solution, smaller chamber, easy-to-use system that is easy to calibrate and very cost-effective compared to the other solutions

Illustration of RanLOS BeamForce 42 test system



RanLOS BeamForce 42 test system in Japan

RanLOS vs NF-FF test facility

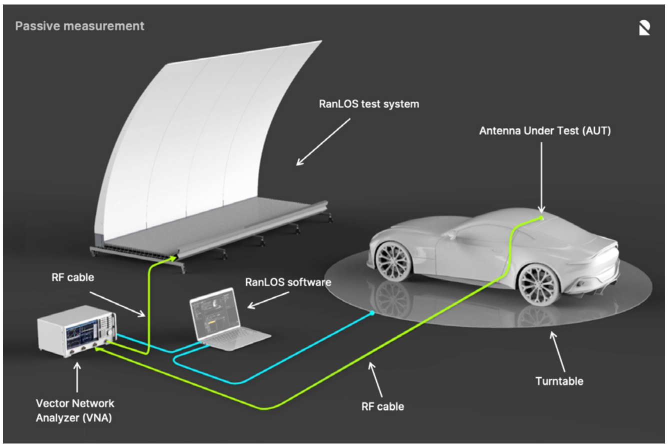


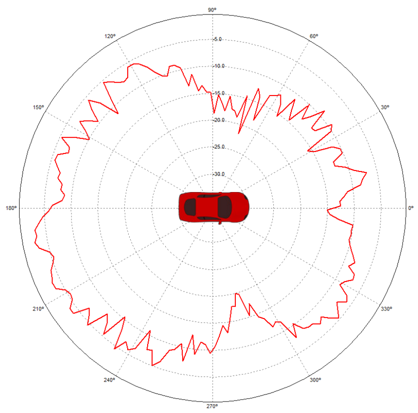
RanLOS test setup placed in a test tent compared with an advanced test facility in Denmark. These measurements were conducted as part of a three-year R&D project with Volvo Cars, among others, funded by the Swedish government agency Vinnova.

The RanLOS test setup

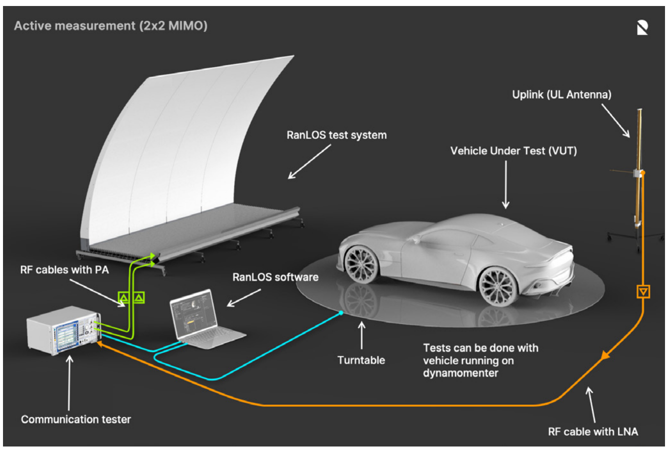
The RanLOS test system can be used in two configurations, **passive and active**. In both measurement set-ups, the RanLOS test software is controlling the whole measurement procedure. The test software is performing measurements and collecting data at the same time as it is rotating the turntable. The measurements and the positioning of the turntable are synchronized to optimize measurement quality and minimize measurement time. The passive configuration is used to measure the antenna radiation pattern and the active configuration is used to measure the throughput of the communication system.

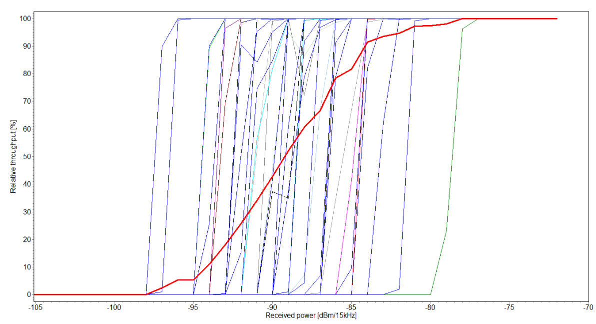
RanLOS test technology is based on practical parameters and is designed to be easy to use, cost-effective, and deliver excellent measurement quality. The test systems are designed to be used in anechoic chambers, semi-anechoic chambers, EMC chambers, open measurement areas, etc.





RanLOS BeamForce 42 test setup in passive configuration to measure antenna radiation pattern.



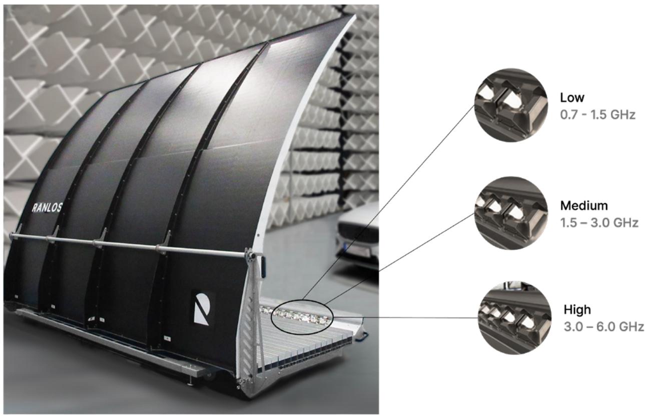


RanLOS BeamForce 42 test setup in active configuration to measure communication system throughput and receiver threshold. The throughput curves represent different rotations with variations in the antenna radiation pattern.

The RanLOS test system is built into three basic modules, the reflector, the base, and the antenna arrays. This makes it possible to upgrade both in terms of frequency and size. It is also possible to tilt the reflector to roll the system in and out of chambers with smaller doors.

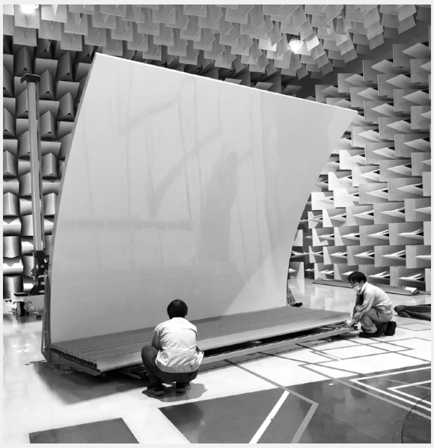
Because the test set-up is portable (equipped with wheels), foldable and easy to install and calibrate, it can be stored outside the measuring chamber and easily rolled into the chamber when it is to be used. In this way, the EMC chamber can be supplemented with RanLOS equipment if necessary and thus increase the EMC chamber's ability to meet the future requirements of the automotive industry.

The RanLOS test system is designed to be used together with a number of ancillary components and units. Examples of such units are turntables, positioners, base station testers, vector network analyzers, etc. The test software, RanLOS BeamLab, which is a part of the test set-up, has interfaces for a large number of instruments, positioners, and turntables and is upgradeable to all standard needed ancillary components on the market today and in the future.



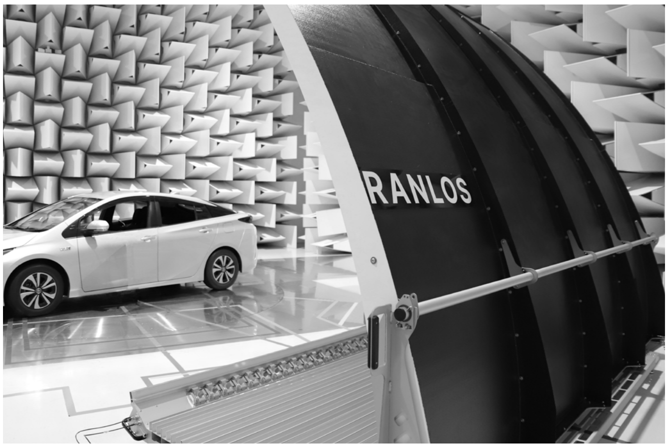
RanLOS BeamForce 42 test system with modules

Installation of the RanLOS BeamForce 42 test setup in an EMC chamber

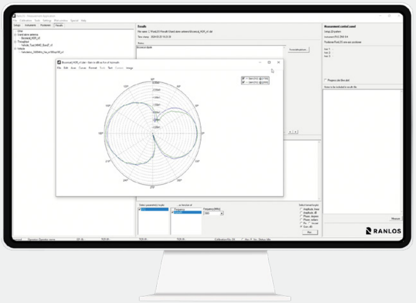


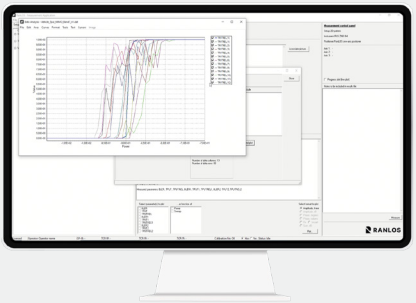
In addition to that the RanLOS measurement software is being used to control external ancillary devices, it also helps with calibration, measurement set-up, execution of measurements, collection and storage of measurement results and their analysis.

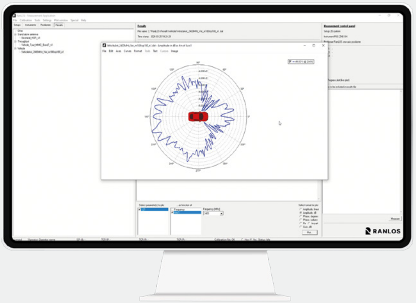
Because the measurements are performed in a far-field environment, the measurement results can be analyzed and interpreted immediately, thus speeding up the measurement process considerably compared to other measurement methods.



Examples of measurement result in RanLOS BeamLab







The measurements

Measurements are performed in a few easy steps:

1. Select measurement set-up
   - Align RanLOS measurement system
   - Choose type of measurement set-up:
     - Passive – Antenna radiation pattern
     - Active – Wireless system throughput and performance
   - Select instrumentation, Vector Network Analyzer, or Communication Tester
   - Select positioner, turntable, etc.

2. Perform calibration
   - Place the calibration antenna at the centre of the turntable
   - Follow the guidelines in the software

3. Perform measurements
   - Place the device under test (DUT) in front of RanLOS BeamForce 42
   - Initiate RanLOS measurement software, select frequencies, angles, etc.
   - Perform the measurements with the help of the software

4. Analyze and visualize measurement results
   - Tables
   - Plots
   - Graphs
   - 1D, 2D, or 3D
   - Mathematical analyzes
   - Export to other software, etc.

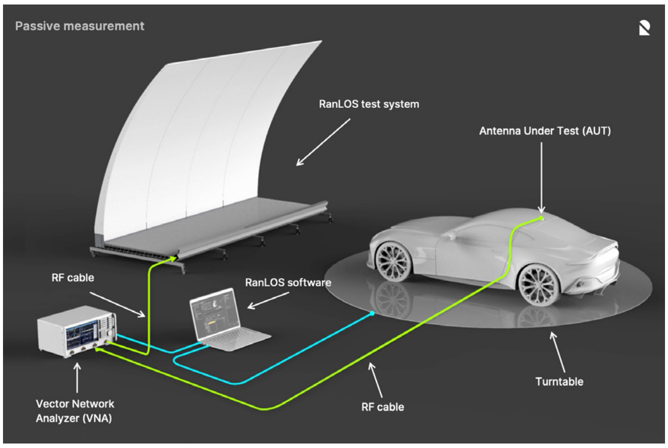
1. Select measurement set-up

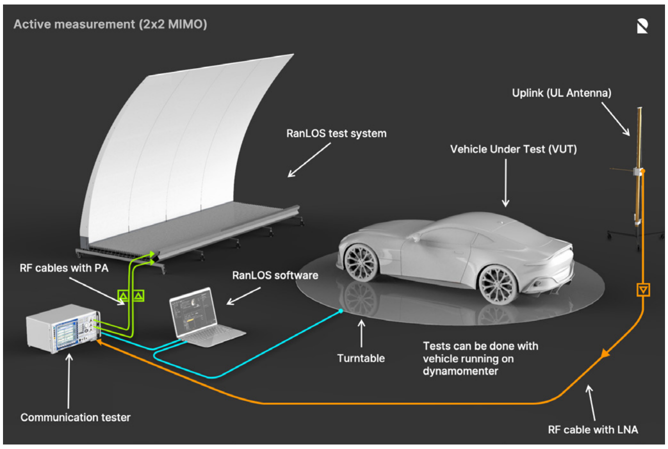
Depending on what to measure the set-up of the RanLOS test system will be different. The possibilities are many and both the antenna itself and the complete car with antennas can be measured. The car itself can be standing still in front of the test system, or driving on a test bench (dynamometer) with full functionality and function. This is very useful in order to fully understand the communication system developed for the vehicle. It is also possible to study and measure the deterioration of the communication quality when there is an external interferer, i.e. EMI disturbing the system.

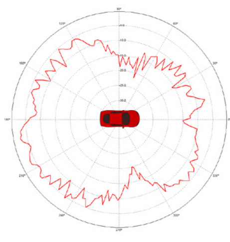
As described earlier in this application note, different measurement setups are used to measure different parameters. The antenna radiation pattern is used to better understand the antenna performance, as a stand-alone device or as an integrated sub-system of the car. For example, the position of the antenna will have a large impact on the performance, and the antenna radiation pattern can visualize this. The antenna radiation pattern is measured with the passive setup for the RanLOS test system.

The throughput measurement is used to better understand the quality of the whole wireless communication system. Since the throughput clearly shows the threshold, or sensitivity, of the communication system it gives us a quality figure to be used to understand the performance. The complete receiver and transmitter channel is measured, receiver/transceiver, modulator/demodulator, cables, antennas etc. which means that this quality figure will give us a good understanding of the whole wireless system performance. The throughput is measured with the active setup for the RanLOS test system.

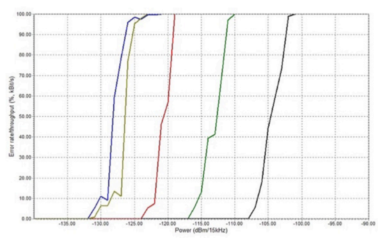
The RanLOS test system is designed to be used together with all standard instruments on the market that can be controlled via serial or parallel busses, such as Ethernet or GPIB-buses, or similar. This means that the measurement system can measure existing communication standards today and in the future, since the instruments are fulfilling these standards. The interface to the RanLOS test system is via the test software which is designed with an upgradable interface structure. By changing a command file in the software new instrument interfaces can be integrated.







Passive measurement
- Antenna radiation pattern



Active measurement
- Throughput

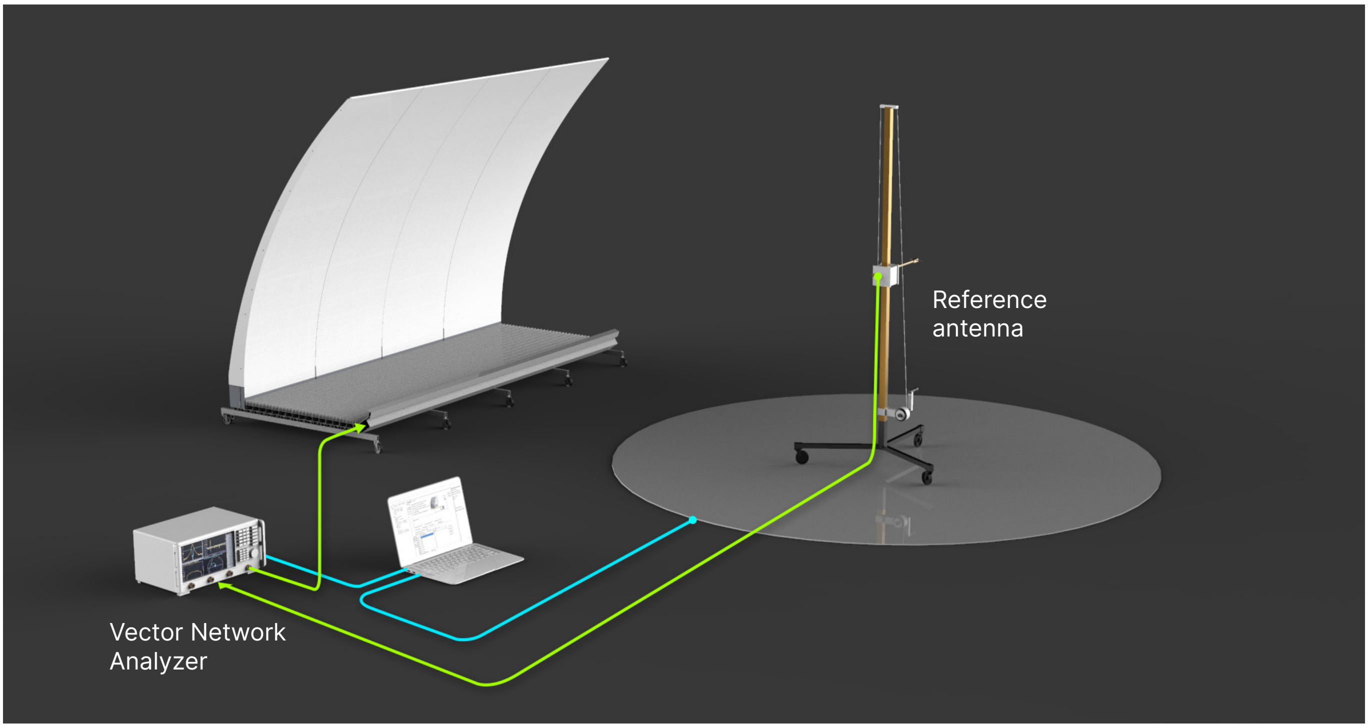
2. Perform calibration

In order to get accurate measurements, calibration of the system is needed. A reference antenna, with documented performance, shall be used when performing the calibration. The antenna shall be placed in the front of the measurement equipment and be measured as a device under test. The whole procedure is supported by the RanLOS measurement software (RanLOS BeamLab), and an embedded tutorial can be followed to simplify the procedure. The measurement result is compared with the antenna specification and a calibration file is created. This file shall be used during the measurements of the antenna or communication system, i.e. vehicle or similar, that shall be tested.

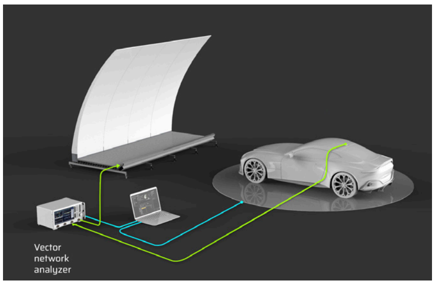
3. Perform measurement

The measurements are performed in a manual or an automatic mode. The automatic mode is fully controlled by the RanLOS BeamLab. The automatic mode is preferred, and several different modes are pre-defined in the software. It is also possible to define modes that are tailored to better suit the specific needs that may exist for certain product tests. Depending on which type of measurements shall be performed a number of set-ups and modes are possible, see some examples on the next page.

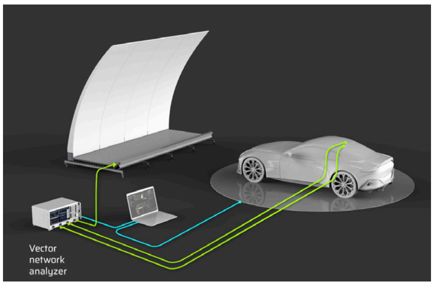
RanLOS BeamLab will control the instrument and positioner in use. If the device under test is a vehicle the positioner is most probably a turntable.



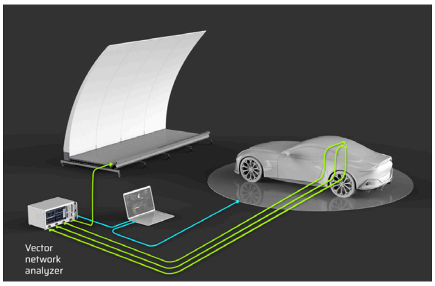
Examples of antenna radiation pattern measurements:



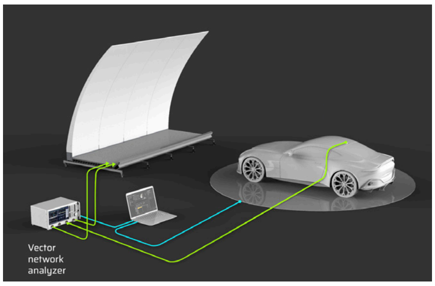
Single polarization - One antenna on vehicle



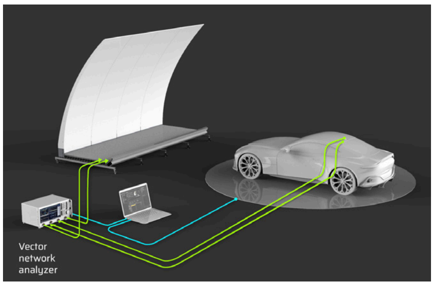
Single polarization - Two antenna on vehicle



Single polarization - Three antenna on vehicle

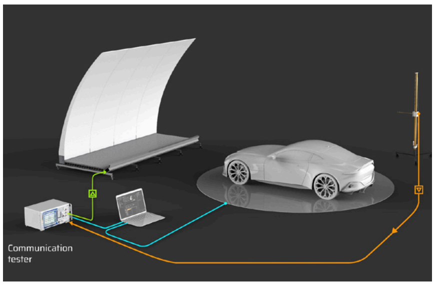


Dual polarization - One antenna on vehicle

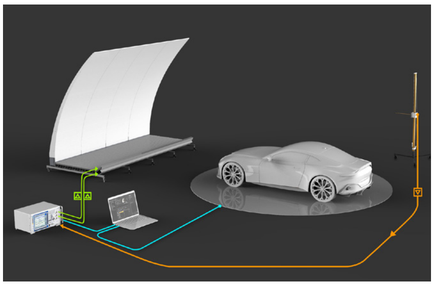


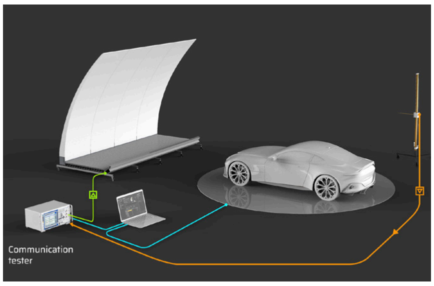
Dual polarization - Two antenna on vehicle

Examples of wireless communication system throughput measurements:

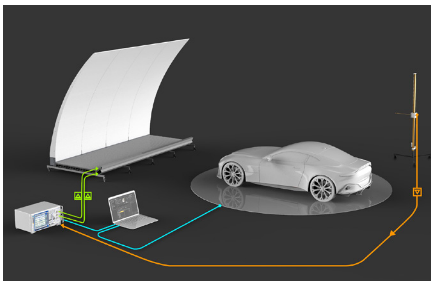


SISO 1×1


MISO 2×1



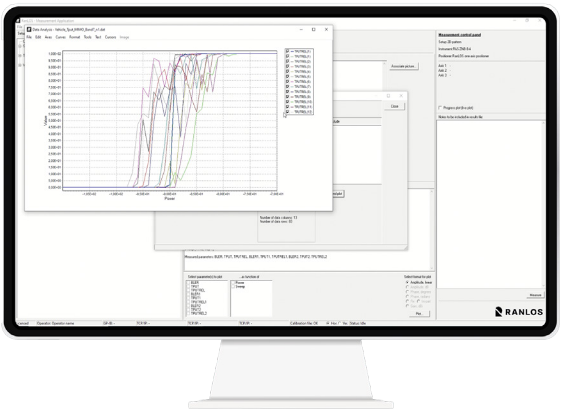
SIMO 1×2


MIMO 2×2

4. Analyze and visualize measurement results

The measurements are saved in a test file and can be presented as a table or be analyzed immediately, if needed. The antenna radiation pattern can be presented in a number of different graphs, for example polar, logarithmic, 2D, 3D, etc.

The RanLOS software has built-in powerful tools to be used during the analyses of measurements. With these tools, it is possible for the engineer and the operator to get answers to complicated problems immediately at the test site. This means that it is possible to adapt or add measurements to use the measurement time in the most optimum way to save time and cost.



Throughput measurement of a wireless communication system

Summary

In conclusion, the RanLOS test technology emerges as a compelling solution for the intricate testing requirements in the development of wireless communication systems for vehicles. With a focus on providing accurate Over-the-Air (OTA) measurements, the system's passive and active configurations address key aspects such as antenna radiation patterns and communication system throughput. The modular and upgradable design enhances its versatility, making it suitable for deployment in a variety of testing environments.

The application note underscores the system's cost-effectiveness compared to advanced chambers, without compromising on measurement quality. The RanLOS test technology's compatibility with a diverse range of instruments and communication standards positions it as a flexible and future-ready choice for the automotive industry.

In essence, the RanLOS test technology offers a user-friendly, flexible, and cost effective test solution, demonstrating its efficiency in ensuring the robustness and quality of wireless communication systems in vehicles. Its potential to streamline testing processes, enhance efficiency, and meet evolving industry requirements makes it a noteworthy contender in the landscape of communication system development for vehicles.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