Preparing for a 5G Future

RF Planning of Millimeter Wave Frequencies for RAN Evolution

SOLUTION
BRIEF

Orchestrating Network Performance

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Expectations for 5G

According to the Global mobile Supplier's Association (GSA) there are 651 LTE networks around the world serving 2.54 billion subscribers (Source: Evolution from LTE to 5G -January 2018 Update, 1/18). The initial goals for the LTE standard were improved spectral efficiency, a simpler architecture built on internet protocol (IP) and greatly reduced latency. In December 2017, the 3GPP ratified the Non-standalone mode (NSA) standard for 5G in Release 15, with Standalone mode (SA) scheduled for completion later in 2018. These 5G networks will benefit from an OFDM-unified air interface, the ability to utilize millimeter wave (mmWave) frequencies that support much higher data rates as well as flexible deployment options.

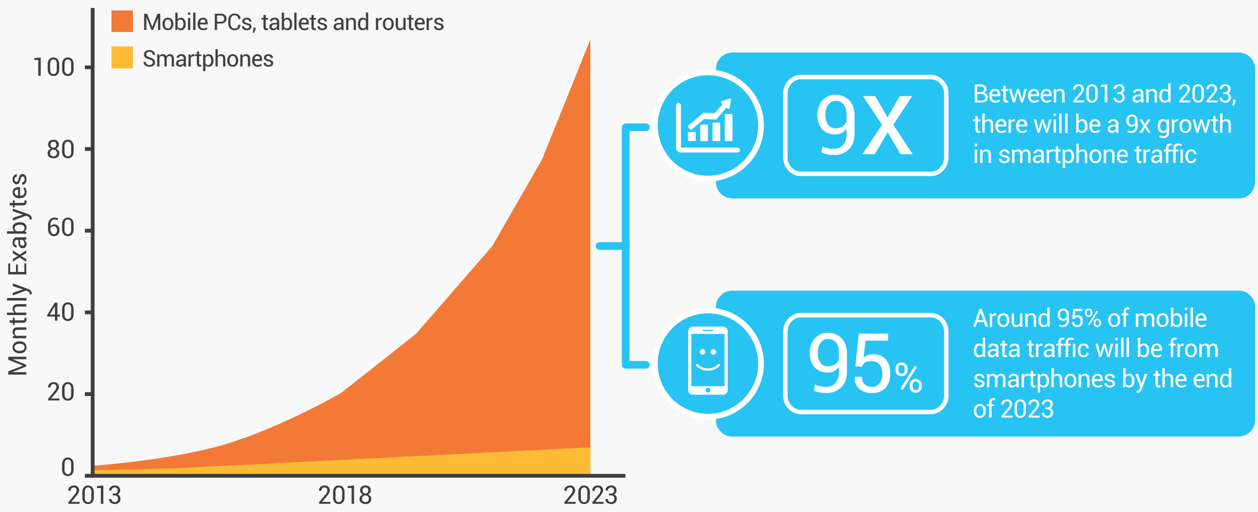


Figure 1. Market driver for 5G: around 95% of mobile data traffic will be from smartphones by the end of 2023, according to the Ericsson Mobility Report.

The next generation of telecommunications will have to support greater data demanded by global wireless subscribers. Ericsson predicts by 2023 global smartphone traffic will be 9x the amount consumed in 2013. As of today, there is no single "killer app" that is driving development. Expectations for 5G include delivery of greater capacity, with improved latency and reliability to meet requirements of all users – both human and machine-to-machine.

5G introduces a number of key technologies, including:

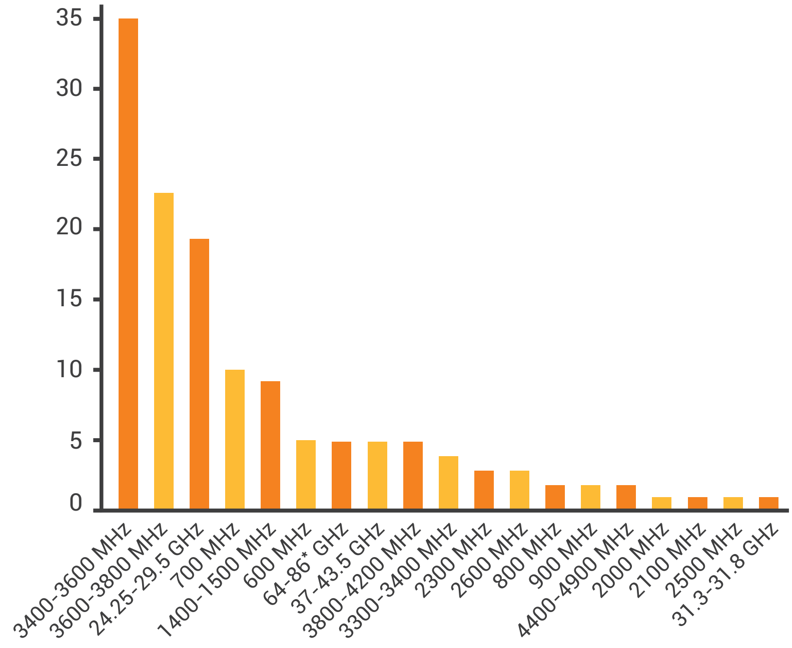
- Use of new mmWave frequencies up to 300 GHz (i.e., much higher than those used for 2-4G networks)
- Scalable OFDM–based interface to address different spectrum and deployment requirements
- Flexible slot-based structure to support low latency and ultra-reliable and low-latency communications (URLLC) requirements
- Adoption of Massive MIMO antenna techniques to deliver beamforming and MU-MIMO with massive antenna arrays

The World Radiocommunication Conference that is tasked with synchronizing global telecommunications bands meets only every 3-4 years.

The next meeting is not scheduled until 2019. In the interim, various national regulatory bodies (e.g., the FCC in the United States) are releasing mmWave frequencies for test systems and assigning spectrum. Vendors and operators working on 5G scenarios need to assess and simulate equipment at various frequencies in their RF planning software.

According to the GSA, 113 operators in 56 countries are investing in 5G technology in the form of demos, lab trials or field tests that are either under way or planned as of January 2018. With different spectrum being utilized around the world, operators and vendors are performing trials on traditional mobile frequencies, as well as sub 6 GHz and mmWave frequencies.

Now that the 5G New Radio (5G NR) standard has been agreed (at least for those with existing 4G networks), the work can begin for RF engineers tasked with planning upgrades. There are many variables to be analyzed: frequencies to employ, channel structures to utilize, where and how to use Massive MIMO antennas, etc. An accurate 5G RF planning application allows for the unique considerations of the new technologies to be simulated — and the dramatic propagation characteristics of mmWave frequencies to be factored in at the earliest stages of planning.



Source: GSA, January 2018

Figure 2. RF planning software is critical for assessing traditional mobile system frequencies (i.e., 600 MHz to 2.1 GHz) vs. mmWave options.

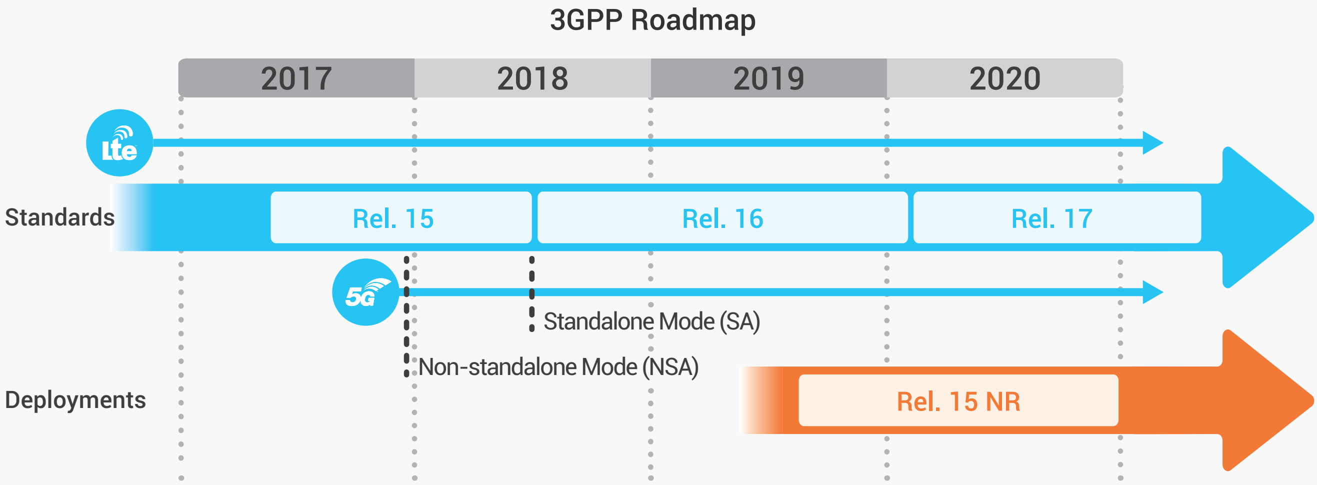


Figure 3. With Non-standalone Mode 5G NR finalized in late 2017, operators with existing networks can start planning for 5G. Standalone Mode — new networks based solely on 5G — will be standardized later in 2018.

Challenges for mmWave Frequency Planning

Engineers have planned networks using RF design software since the first digital networks in the 1990's. Typical 4G networks and earlier technologies have been designed with propagation models that are adapted to sub-6 GHz spectrum bands. Advanced propagation models that support diffraction, reflection and refraction based on ray tracing or ray launching technologies have been utilized in dense urban areas (e.g., cities) for the last five years. These models have evolved to a point where they can be used in everyday planning and optimization – but not all are capable of working with mmWave frequencies. Propagation distances will be dramatically less at mmWave frequency ranges. Recent studies, however, have shown that non-line-of-sight (NLOS) signals can contribute to propagation distances and potential related interference.

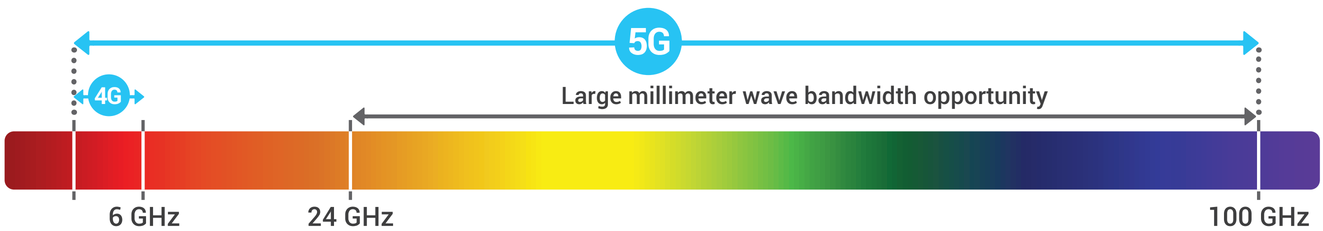


Figure 4. The untapped potential of mmWave frequencies will support the global deployment of 5G.

How are the propagation distances expected to be maximized between transmitter and receiver using mmWave frequencies? Part of the answer involves advanced antenna techniques such as Massive MIMO. Single User MIMO (SU-MIMO) and multi-user MIMO (MU-MIMO), as well as beamforming, that will be used to improve network coverage and capacity. Even so, 5G cells need to be closer to each other compared to 2G/3G/4G networks, to compensate for the fact that wireless signals attenuate very quickly in the mmWave spectrum.

Atmospheric effects on millimeter frequencies include absorption by gases as well as rain attenuation (i.e., rain fade). Gas absorptions are typically caused by oxygen and water vapor, with a minimal attenuation effect. Rain fade is the largest contributing factor to signal loss at higher frequencies. Another key variable to be considered for mmWave propagation is vegetation. It is important to leverage geographical data that accurately depicts individual trees and forests, and to compute the associated propagation loss correctly.

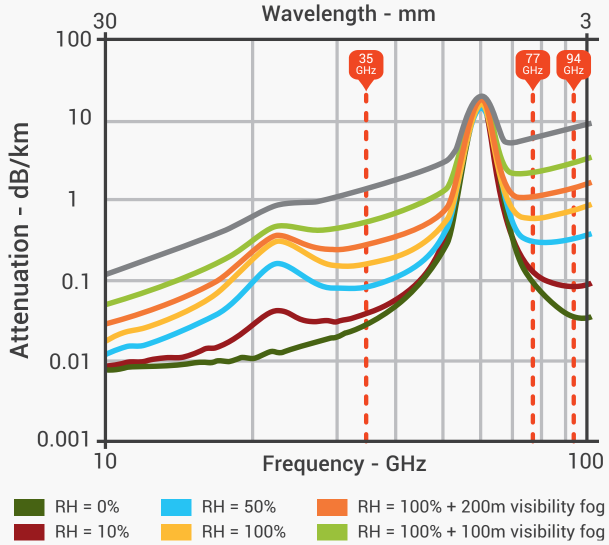


Figure 5. Signal attenuation caused by fog and rain at different frequencies.

Planet 5G mmWave Modeling Capabilities

Planet was the first RF planning platform to deliver support for 5G mmWave frequency modeling before the standard was finalized. With Planet 7 for 5G planning now available, it leads the way again with support for key new technologies including flexible numerology and Massive MIMO. Accessible through the Propagation module, the Planet 3D model supports frequencies up to 100 GHz. With Planet 7, it is possible today to run predictions in different frequencies to see the net effect on coverage.

Flexible Software Deployment Options

Planet has multiple deployment models to fit users' needs and budgets. New options include public and private cloud implementations – with leased 3D building data and 2D DEMs and clutter – that let customers add new user licenses and privileges in real time. Of course, traditional desktop, client-server and enterprise deployment models are still available.

Advanced Simulation Capabilities

The real value of any simulation software is its ability to reproduce the real world. The Planet 3D Model (P3M) supports NLOS predictions and atmospheric loss calculations including rain fade.

Propagation Modeling at mmWave Frequencies

In combination with the advanced simulation capabilities offered, Planet is able to provide a reliable simulation of mmWave propagation for frequencies up to 100 GHz. While assumptions can be made about the expected propagation attenuation from frequencies in use today (900 MHz, 1800 MHz, 2.1 GHz) to proposed mmWave frequencies, the impacts of MU-MIMO and SU-MIMO will also have a dramatic impact. For 5G to live up to its potential requires a great deal more spectrum to be made available around the world; this will be achieved by utilizing the mmWave spectrums above 30 GHz. Performing simulations in advance within Planet at these mmWave frequencies helps avoid disappointing results in the field.

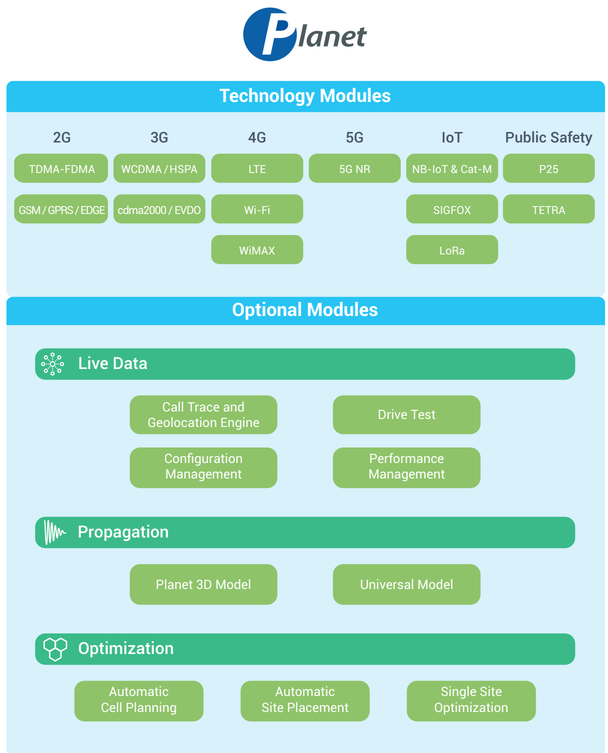


Figure 6. The Planet Propagation module, including the Planet 3D Model and related 3D viewing capabilities, supports mmWave frequency modeling.

Planet 5G Use Cases

- Evaluate mmWave cell coverage
- Assess Massive MIMO coverage and capacity gains
- Investigate cable/MSO fiber vs. 5G fixed wireless access (FWA)
- Dimension new equipment requirements

Continuing Innovation

Planet R&D and product management keep a close eye on the standards discussions for 5G. Working closely with innovating operators and vendors, the software continues to evolve and extended support for standalone mode will be added once that standard is finalized.

Dense Urban Environments in 3D

Planet offers an extensive small-cell planning capability. Small cells are expected to play an important growing role in getting capacity closer to the subscriber for 5G. Building on existing small-cell planning functionality in Planet, the mmWave capabilities will allow for nominal designs and CAPEX plans for HetNet designs.

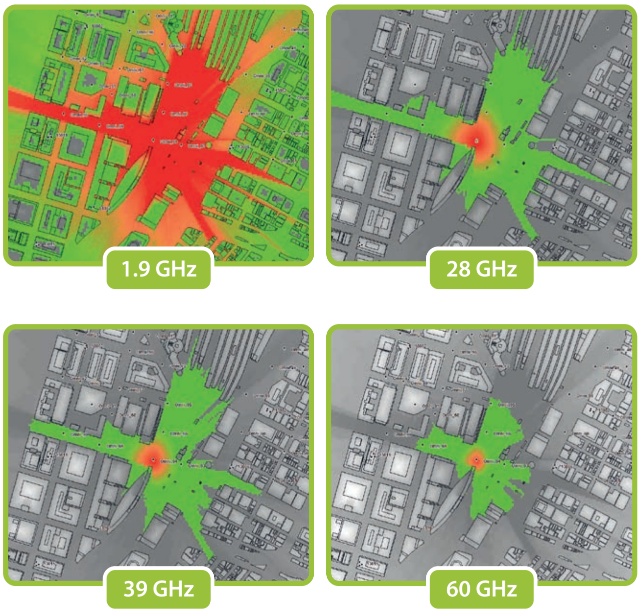


Figure 7. Evaluate the propagation characteristics of different frequency bands with Planet. These plots compare mmWave frequencies against a traditional 1900 MHz frequency using the Planet 3D Model.

Expert Customer Support 24x7

Our global support team is ready to help around the clock. As a provider of planning software with a leading research group for new wireless technologies, InfoVista is the ideal partner for your 5G technology investigations.

Summary

Wireless operators and the vendor community that serves them have worked tirelessly to develop the technologies that make up the new 5G NR standard. The Planet team has been working as part of this ecosystem to improve their RF planning software and build on its leading 5G mmWave propagation modeling capabilities. To be clear: 5G is an RF planning challenge. The diverse spectrum options under consideration — and their dramatically different propagation characteristics — mean that simply overlaying existing 4G sites with 5G radios is not a viable option.

Planet 7 for 5G is an RF planning application proven on pre-standard 5G networks that is ready for the challenge of planning 5G commercial networks. With simulation software, accuracy matters. There is no more accurate 5G planning software on the market today than Planet 7.

Cable operators can do their business case assessments for 5G as a last mile alternative to fiber.

ABOUT INFOVISTA

InfoVista is the leading provider of cost-effective network performance orchestration solutions at the service of a better connected and collaborative world. Our award-winning solutions empower communications service providers and large enterprises to ensure a high-quality user experience by achieving optimal network performance and guaranteeing business-critical application performance. InfoVista's expertise and innovations provide a new level of actionable network, application and customer intelligence, visibility and control across all services, all technologies, and all domains of both the fixed and mobile networks. Using our solutions, eighty percent of the world's largest service providers and leading global enterprises deliver high-performing and differentiated services, plan and optimize networks to match application and service demands, and streamline network operations while keeping total cost of ownership as low as possible.