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DLR

## ROLLING OUT THE RED CARPET

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# WHITE SPOTS MUST DISAPPEAR

Antenna at the DLR site in Weilheim. The optical ground terminal in the foreground is used to exchange data with a satellite.

Research into high-performance satellite communications is being conducted as part of the DLR cross-sectoral project 'Global Connectivity via Satellite'

By Sandro Scalise

**No network! High-speed internet? No chance. Complaints can be heard in the German state of Mecklenburg-Western Pomerania. Even in the greater Munich area, there are districts in which less than half of all households have broadband access. If it is less than 10 percent of households, these are referred to as 'white spots'. And what might be irritating within one's own home can threaten the very existence of companies. White spots must be eliminated. The various German political parties and authorities are united on this issue. The targets of 'ensuring that all regions in Germany have universal access to high-speed internet' and 'a legal right to this by 1 January 2025' were specifically addressed as essential elements for the creation of a 'gigabit society' in the 2018 coalition agreement between the CDU, CSU and SPD. DLR has initiated the 'Global Connectivity via Satellite' cross-sectoral project for this very purpose.**

Industry 4.0 is difficult to imagine without widespread, reliable broadband internet. Companies in regions with poor infrastructure should not be excluded from networked production processes and business models that rely heavily on the internet. In addition, people want to be able to access information, communicate and, increasingly, work online in a reliable fashion. In many cases, this is not yet possible in sparsely populated regions. A lack of broadband access hinders the economic development of such areas and contributes towards domestic migration to the major urban areas. Also, lives may be at risk if sufficient network capacity is not available during major events or when a disaster occurs.

Fibre optics and 5G technology are suitable techniques for closing the gaps in broadband coverage. 5G is not simply a more powerful mobile telecommunications system, but rather a network of networks with specific solutions tailored to individual key sectors such as transport, media and manufacturing. The 3rd Generation Partnership Project (3GPP), a global collaborative venture between various committees on standardisation in mobile communications, is responsible for 5G standardisation. In December 2019 it decided to make 'non-terrestrial networks' (NTNs) an integral part of 5G. NTNs are based on two types of technology, namely communications via airborne platforms and communications via satellite.

The German Federal Ministry of Transport and Digital Infrastructure (BMVI) maintains an interactive and openly accessible tool for monitoring actual broadband coverage in Germany. To date, the average availability of at least 16 MB/s internet access has ranged from 75 to 95 percent in most of the German federal states. However, a more detailed view of the Munich area reveals numerous scattered locations where availability extends to less than half of households and is, in some cases, lower than 10 percent.

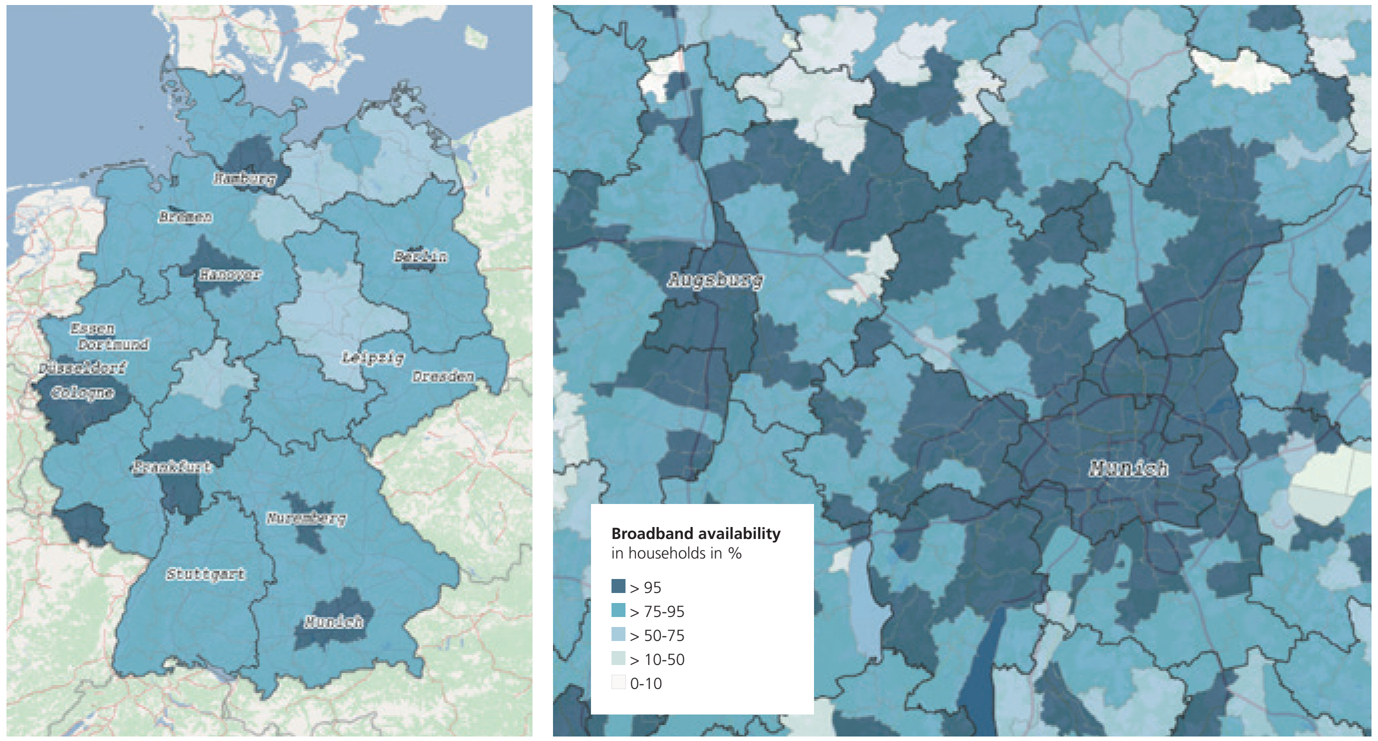



Image: Breitbandatlas des BMVI (edited)

Private broadband availability (≥ 16 Mbit/s) for Germany (left) and for the Munich area (right)

## Great expectations for space technologies

Until now, communications satellites have been used primarily for television and radio transmission, narrowband mobile services in remote areas and communications at sea. Broadband internet access via satellite has previously been a niche market (particularly in Europe) with proprietary solutions from various satellite operators that have not been integrated into 3G and 4G mobile networks. This situation is expected to change, mainly driven by two factors. Firstly, the inclusion of non-terrestrial networks as part of 5G will make the complete integration of satellite communications into the next-generation mobile network possible. Secondly, a completely new economic sector for space technology is currently being created with what is referred to as New Space. A large number of private space companies, which operate independently of governments and traditional telecommunications corporations, have been founded. These companies are developing faster, better and more economical access to space assets, thereby extending the scope of existing business models. Although not all the New Space initiatives that have been announced are likely to come to fruition, this trend is set to increase connectivity offered via satellite and lead to significant price reductions. This will remove one of the barriers to the use of satellite communications for broadband services.

## Data rates in the terabit range

DLR initiated its 'Global Connectivity via Satellite' cross-sectoral project in light of these future prospects. As part of this project, the institutes of Communications and Navigation, Atmospheric Physics and Flight Systems are investigating key technologies for what are referred to as Very High Throughput Satellites (VHTS). This next generation of satellites will enable throughputs in the order of terabits per second – enough to transmit approximately 62,500 video streams at 4K resolution simultaneously. Powerful feeder links for connecting satellites to terrestrial networks are an essential technological component. They allow communication satellites to meet the constantly increasing demand for high data rates and keep up with the corresponding expansion in the connectivity requirements for mobile communications systems.

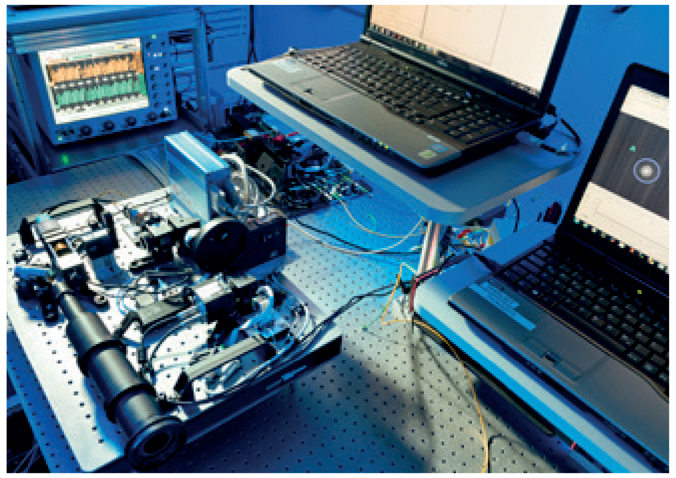
It is likely that non-terrestrial 5G networks will be formed using satellites in different orbits, with Low Earth Orbit (LEO) satellites being the preferred choice for delay-sensitive applications such as voice services or online gaming. Geostationary Earth Orbit (GEO) satellites are, in turn, well-suited for bandwidth-intensive applications, such as streaming or video uploading. Unlike LEO satellites, GEO satellites do not require tracking antennas on the ground. As a GEO satellite rotates at the same angular velocity as the Earth, it can always be seen from Earth in a fixed position. To achieve high data rates with LEO or Medium Earth Orbit (MEO) satellites, ground antennas with tracking capabilities are required.

## Advantages of laser technology

The DLR cross-sectoral project is investigating the use of optical feeder links. Existing high-performance satellites such as Eutelsat's KA-SAT and ViaSat-1 can now offer throughputs in the range of 100 to 150 gigabits per second. However, the existing satellite system architecture is not arbitrarily scalable, and the current generation of high-throughput satellites is already nearing its limits. Due to the limited spectrum availability in the microwave frequency range, such satellites require too many ground stations to be able to offer throughputs in the terabit-per-second range.

Optical communications technologies can provide point-to-point connections with very low power consumption. More importantly, the available bandwidth is almost unlimited and is not subject to any licensing or frequency-related regulatory hurdles. This makes laser communication an ideal candidate to replace microwave-based technologies in feeder links. Since a single optical link can provide a sufficiently high data rate to support the entire satellite throughput, a single optical ground station would be sufficient – provided it is visible to the satellite. The number of necessary ground stations would then be based solely on cloud coverage statistics. This is because at least one ground station in the network needs clear sky conditions. Simulation results show that approximately 10 optical ground stations can achieve an availability of 99.9 to 99.99 percent. This is the range required for commercial satellite communication systems.

Laser communication technologies are already being successfully used in the European Data Relay System (EDRS) to transmit the Earth observation data collected by LEO satellites to a GEO relay satellite, and from there to Earth via a microwave link. However, its use in direct connections between space and Earth and vice versa still poses a number of technical challenges, mainly due to the

Satellite terminal emulator at Hohenpeißenberg, Upper Bavaria, near Weilheim. DLR scientist Juraj Poliak prepares the testbed for the next communications experiment.

propagation through the atmosphere. Along with the effect of clouds, atmospheric turbulence causes severe signal distortion. Even if the sky is clear, this can lead to significant fluctuations in the received signal power. This effect must be mitigated by countermeasures such as signal predistortion combined with adaptive optics, a technique used in astronomy to correct wavefront distortions using a deformable mirror. The uplink from the ground station to the satellite is particularly challenging due to the physical limits on the size of the telescope on the satellite. In other words, a higher received signal power cannot be achieved by simply using a larger telescope.

## Companies are on board

In their work on the 'Global Connectivity via Satellite' cross-sectoral project, DLR's team of researchers is able to draw upon the findings from previous projects. In 2017, for example, the THRUST (Terabit-throughput satellite system technology) project demonstrated a stable optical connection at 13.16 terabits per second between DLR's Weilheim site and a virtual satellite terminal in Hohenpeißenberg. The propagation characteristics of this 10.5-kilometre test route are comparable with a satellite uplink at a low elevation angle. This experimental test system is now being further developed as part of the cross-sectoral project, with more advanced modulation schemes and new reception techniques. These will increase the spectral efficiency, stability and reliability of the connection.

The DLR researchers are also working with industry. One example of this collaboration is the development of a suitable satellite payload for converting optical signals into electrical signals and vice versa, while satisfying the requirements regarding power, mass and volume. Companies such as Tesat Spacecom, a leading German manufacturer of laser communications terminals, ADVA Optical Networking, a provider of telecommunications equipment, especially fibre-optic transmission technology, and Airbus Defence and Space, one of the largest European satellite manufacturers, are all partnering with the DLR in this field. Together, they are pursuing the goal of demonstrating broadband access via GEO satellites with optical feeder links, thus paving the way for a major technological breakthrough in the provision of broadband connectivity via satellite. This would be an important element in being able to offer broadband internet access to citizens across Germany.

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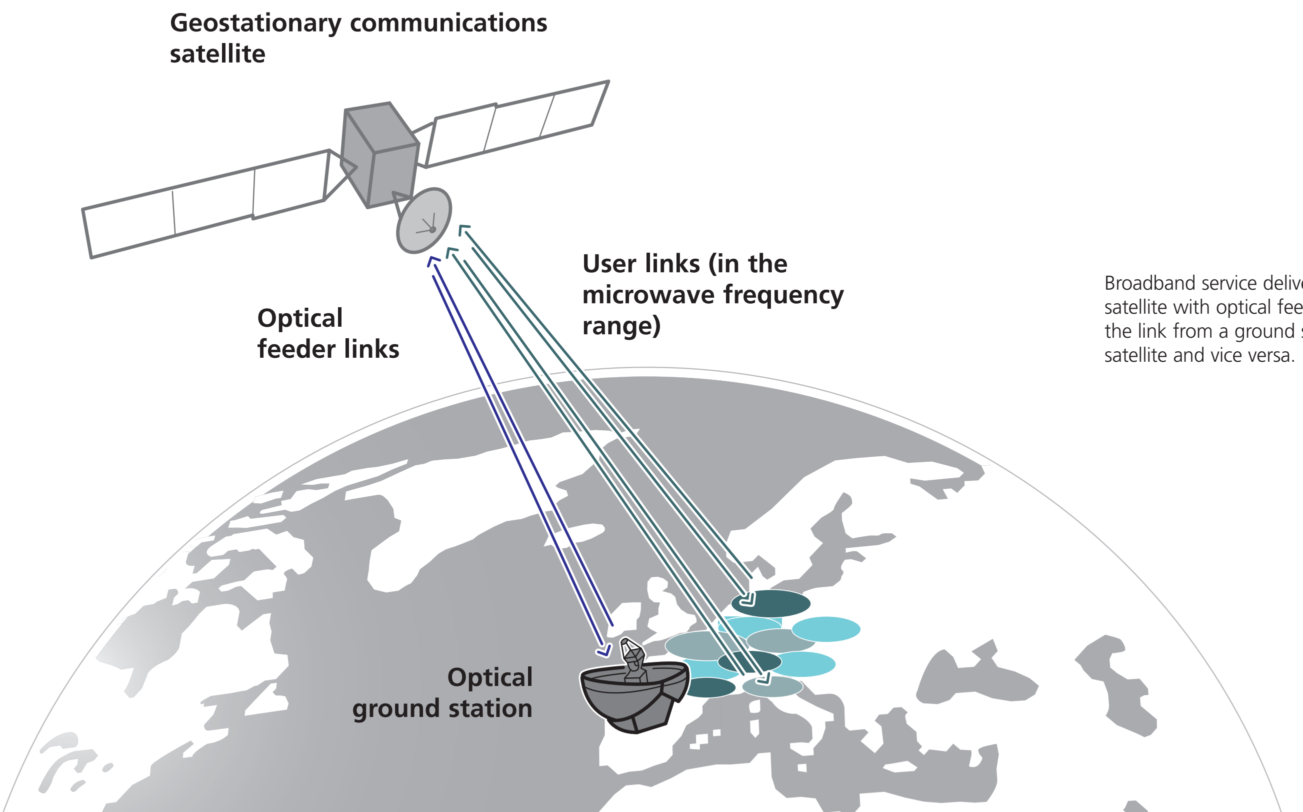


Broadband service delivery via GEO satellite with optical feeder links – that is, the link from a ground station to the satellite and vice versa.

## Cover image

When the curtain is drawn back to reveal an aircraft, it has to be something special. This is how ISTAR made its entrance. The new addition to the DLR fleet, now stationed at Braunschweig, is a flying laboratory. Its name stands for 'In-flight Systems and Technology Airborne Research'. ISTAR is being expanded, step-by-step, with highly specialised measurement technologies. It will be able to simulate the flight characteristics of any aircraft – while in the air. Researchers will investigate new technologies for quieter engines and innovative assistance systems, among other things.

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