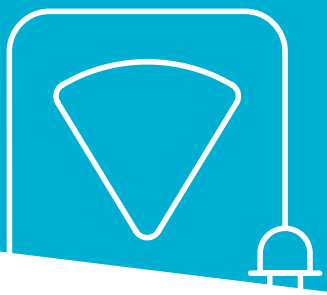

Is European residential fixed broadband ready for new internet challenges and competition against 5G?

In the European Gigabit era, Spain and Portugal lead the way in fibre deployment and have the best-prepared networks to compete with or complement 5G from the home.

The increase in dynamic, demanding Over The Top (OTT) services (e.g. Netflix in 4K or MMO[1] games like League of Legends), the arrival of 5G and even the necessity of new, real-time use cases and larger capacities continue to accelerate the evolution of fixed internet broadband.

Fibre to the home (FTTH) has been deployed extensively in several European countries, ensuring faster, more stable broadband connections with better features. One major unknown is whether the European Commission's 2025 objective will be achieved: that every household would have an internet connection of at least 100 Mbps upgradeable to one Gbps[2].

How do we, MedUX, analyse the state of fixed-broadband internet and whether it is ready for technological challenges and customers' needs? These are the main findings and other relevant aspects of the 'MedUX report about residential fixed broadband in Europe (1S 2019)':

- The performance of FTTH technology has certain advantages against other fixed-broadband technologies, in addition to having greater potential for the progressive improvement of service delivery conditions. FTTH technology delivers its commercial promises, with a compliance rate of 93% of contracted download speeds and 104% of contracted upload speeds and a lower average latency compared to other technologies.

- At the moment, the performance of first 5G deployments is generally comparable to that of the most advanced fixed-broadband It is not yet known whether future deployments will meet the promised values of over one Gbps with latency rates of a few milliseconds.

1 Massively Multiplayer Online
2 COM/2016/0587 of September 14th, 2016. Communication from the Commission to the European Parliament, 'Connectivity for a Competitive Digital Single Market – Towards a European Gigabit Society'.

About MedUX

MedUX is the next generation specialist in customers' digital-experience measurement and improvement, providing cutting-edge tools and innovative solutions for telecom operators, governments and companies. The company is present in more than 10 countries, with a strong presence in Latin America and Europe. Today, MedUX has been deployed for clients such as Telefónica, AT&T, Claro Colombia (Grupo América Móvil), Vodafone, Orange and the Colombian Regulation Commission, among others.

Our innovative system for the measurement, prediction and analysis of fixed and mobile telecommunications lines obtains reliable, real-time data on operators' networks and the quality of service offered. This enables our clients to stand out from their competitors, reduce costs and enhance their value propositions, keeping their customers happy and satisfied by anticipating problems and avoiding complaints.

Go beyond measurements and analytics, discover MedUX!

Fly with Data!

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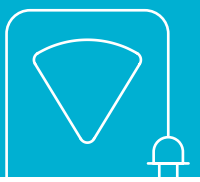

- The networks of Spain and Portugal are the best prepared to compete with or complement 5G due, in particular, to their vast fibre deployment and excellent upload and download speeds in the home environment. Both countries have a higher contracted speed compliance rate than countries such as Italy, UK or Germany, with percentages between 105% and 110%, and have outstanding results in latency, upload speeds and download speeds in the home environment, with delays lower than 20 ms, guaranteeing excellency in real-time service delivery, including video calls and streaming.

- Regular users of demanding internet services, such as real-time gaming, face some limitations according to contracted commercial offers, particularly in terms of latency. For the most part, technologies such as xDSL don't meet most users' requirements, and some countries, such as Greece and Italy, or even Germany and the United Kingdom, lag behind in internet performance, which could present a serious challenge if faster and more reliable fixed-broadband networks are not deployed soon.

The MedUX Ecosystem deployed in Europe performs consistent tests 24/7 in all countries for ADSL, VDSL, Hybrid Fibre-Coaxial (HFC) and FTTH technologies. MedUX makes more than three million tests every month from more than 5,000 MedUX HOME devices deployed in eight countries. Every test is performed and validated directly from the homes of users who collaborate with us in this project.

Our technology focuses on monitoring and improving telecommunications networks from the end-user's perspective, including basic metrics such as download and upload speeds, latency, jitter and packet loss. Knowing these technical parameters is important to evaluate the state and development of internet connections.

The 'MedUX report about residential fixed broadband in Europe (1S 2019)' analyses exclusively Ethernet metrics on fixed-broadband status, excluding home wireless-network performance. For this report in particular, data from June has been taken into account, being the most recent month of the first semester of that same year[3].

Unless otherwise mentioned, figures and graphics represent average performance nationwide, excluding details about network traffic, congestion-time distribution effects, regional differences in deployment and network technology and individual operators' performance.

3 Data obtained from MedUX´s massive deployment in Germany, Spain, Greece, Ireland, Italy, Portugal and the United Kingdom as well as early deployment in France (indicative figures are shown from deployment of the initial pilot project).

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Download and upload speed compliance

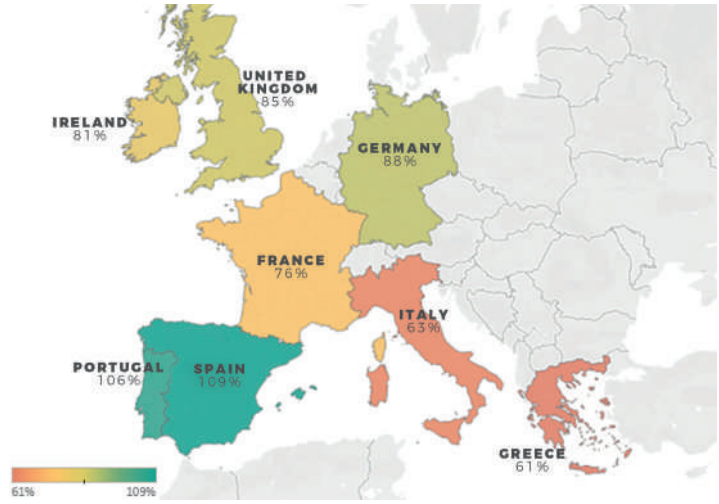
Average download speeds during the observation period are 10.34 Mbps, 56.3 Mbps, 188.06 Mbps and 226.88 Mbps for ADSL, VDSL, HFC and FTTH technologies, respectively. However, there was a high variation between countries. One of the report's key findings is identifying relevant differences between countries and technologies in terms of speed compliance, especially download speeds.

Broadly speaking, the average fibre speeds are comparable with those in the first 5G deployments—in South Korea for example, where average download speeds have been observed from 150 to 500 Mbps. However, it is expected that future deployments will comply with the technology's promise, approaching values over one Gbps.

The average download speed, regardless of the technology, represents 81% of the contracted speed at a pan-European level for the countries sampled[4]. Spain and Portugal stand out with a compliance percentage above expectations at 109% and 106%, respectively (see Figure 1). These numbers are due to the performance of fibre and cable technologies broadly deployed in both countries.

On the other hand, countries such as Greece and Italy had percentages of 61% and 63%, respectively, which are further from compliance with advertised commercial offers than other European countries.

Figure 1: Compliance performance of contracted download speeds by country.



Source: MedUX

MedUX results show that the compliance of HFC and FTTH technologies is very high, and the variability is especially limited for HFC, which means that providers that use this technology offer more consistent compliance with contracted speeds (see Figure 2). Average compliance values for HFC and FTTH technologies are at 100% and 93%, respectively. The median compliance value for both HFC and FTTH is 100%. For xDSL, however, and ADSL in particular, significantly worse values and higher variability are observed. VDSL has a compliance average of 82% and a median of 90%, and ADSL has the worst values: an average compliance of 51% and a median of 49%, with very few users receiving service equal to what they paid for.

4 This data corresponds with the general results of the monitored sample and does not need to correspond exactly with broadband market composition by technology and country.

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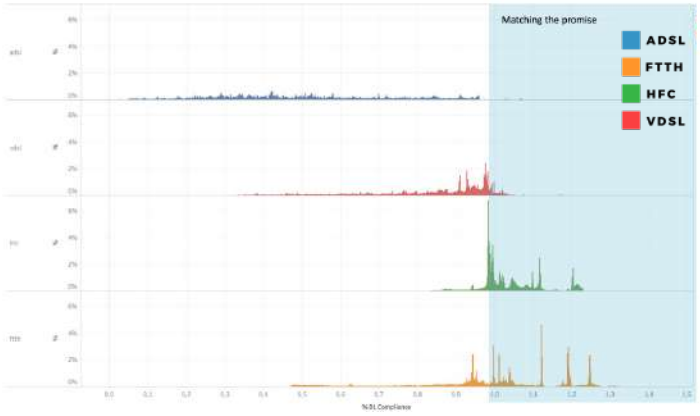
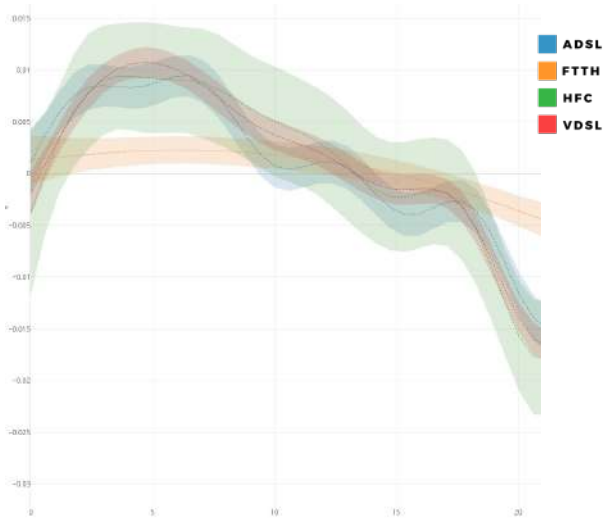
Figure 2: Statistical distribution of download-speed compliance percentages for each technology at a pan-European level.



Source: MedUX

Figure 3: Evolution of download-speed compliance percentages for each technology at different times of day at a pan-European level.



Source: MedUX

Figure 3 shows download speeds as a percentage of contracted speeds for each technology at different times of day. It can be observed that all technologies have a similar profile, with a speed decrease during the day followed by a stronger marked decline during peak hours.

HFC and xDSL show greater declines during peak hours at 3% and 2%, respectively, while FTTH only varies by 1%. FTTH surpasses other technologies in terms of compliance.

Figure 4 shows the statistical distribution of data obtained at a pan-European level for each technology with regards to compliance with contracted download speeds and relevant values by country (median percentage of compliance). Among the most compliant countries are Spain and Portugal, which actually exceed contracted speeds for both FTTH and HFC, followed by Germany, Ireland and the United Kingdom. In all of these cases, compliance rates are higher than 90%.

The scenario is significantly different with upload speeds. Broadband services are usually advertised with asymmetrical speeds, depending on the technology and service portfolio of each provider. During the observation period, average upload speeds were 1.35 Mbps, 14.53 Mbps, 24.18 Mbps and 97.18 Mbps for ADSL, VDSL, HFC and FTTH, respectively, but again, MedUX detects a high variation between countries and technologies.

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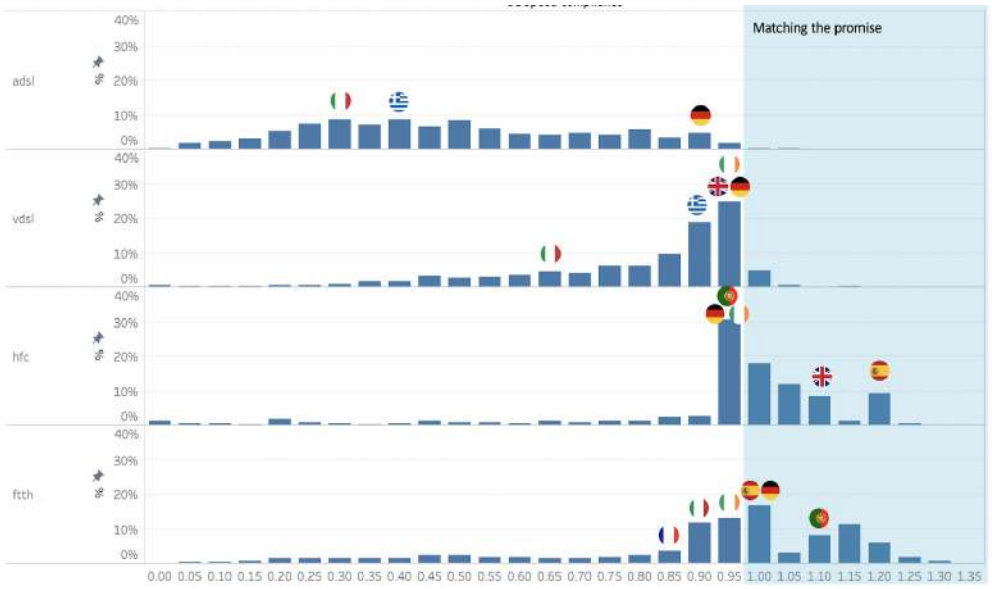
Figure 4: Statistical distribution of download-speed compliance for each technology at a pan-European level (medians are by country).



Source: MedUX

Upload speed plays an important role in broadband services, especially for apps that perform services such as file sharing, video calls or real-time gaming. The average upload speeds, regardless of technology, are 99% of the contracted speeds at a pan-European level for the countries sampled[5].

In this case, most countries are above the full compliance threshold. Only Italy, Great Britain and Ireland are slightly lower, with compliance percentages of 84%, 92% and 91%, respectively.

Figure 6 shows the European statistical distribution of upload speed compliance percentages and the medians for each country based on each technology. Most countries meet advertised upload speeds with a compliance range of 90–100%.

As the data shows, actual download and upload speeds vary significantly between countries, with the highest results generally being those that have a higher FTTH deployment footprint. This is mainly due to the evolution of technology and infrastructure in each country. Countries with worse performance are those dominated by xDSL. The

5 This data corresponds with the general results of the monitored sample and does not need to correspond exactly with broadband market composition by technology and country.

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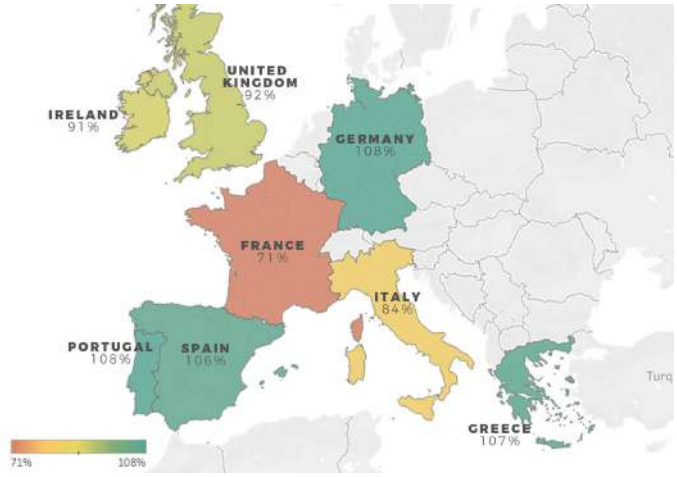
Figure 5: Compliance percentage of contracted upload speeds by country.



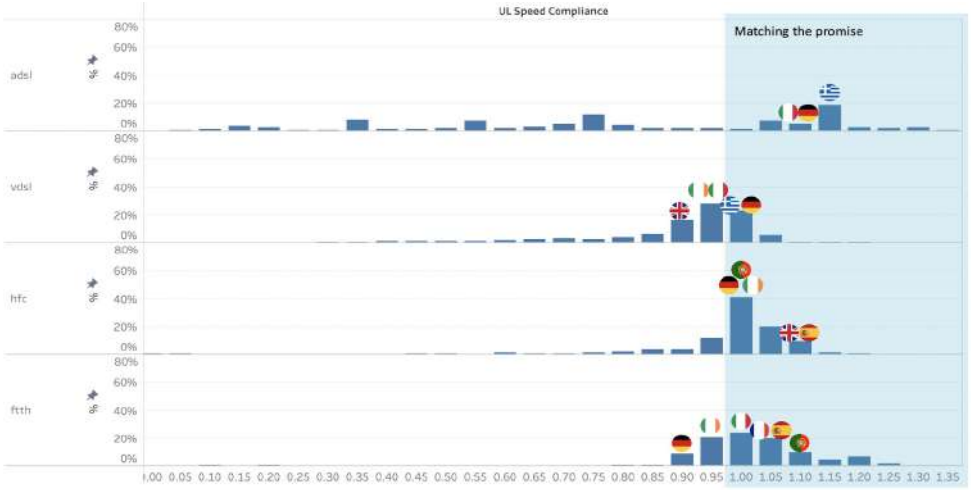
Source: MedUX

key factors affecting performance in these countries are geography, demographics, network structures, loop length, low population density and city extension.

Providers that use FTTH not only provide higher speeds, but they also have better technology usage in order to offer higher speeds than contracted. This is not common in xDSL technologies, affecting users' perceived quality.

According to data published in the March 2019 conference of the FTTH Council Europe, drawn from the FTTH Market Panorama made by IDATE, the number of FTTH and Fibre-To-The-Building (FTTB) subscribers in Europe increased by 15.7% in EU 39[6], surpassing 59 million users in September 2018.

Figure 6: Statistical distribution of compliance with contracted upload speeds (%) for each technology at a pan-European level (medians are by country).



Source: MedUX

6 EU 39 includes Andorra, Austria, Belarus, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, Malta, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom.

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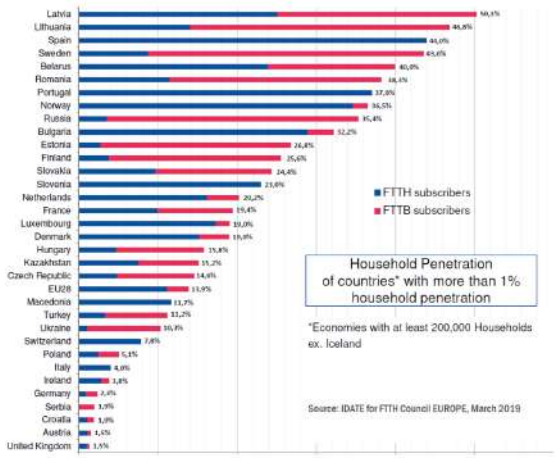
Figure 7: European rankings on FTTH and FTTB deployment.



Source: IDATE for FTTH Council Europe, March 2019

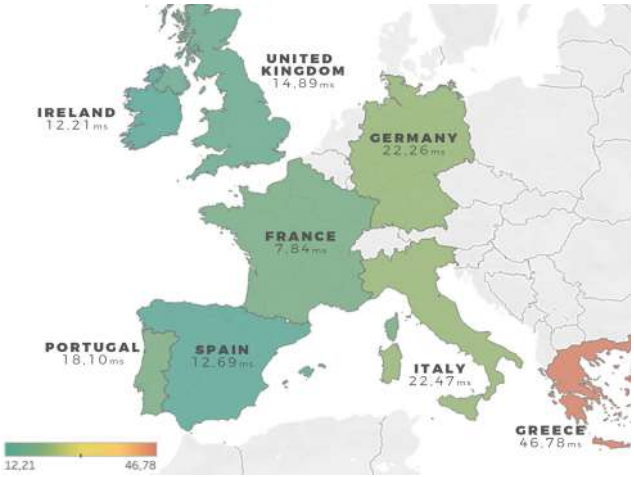
Among the countries sampled in this report, Spain and Portugal lead the way in European FTTH deployment with a penetration of 44% and 37%, respectively. As can be seen in Figure 7 , Latvia and Lithuania will surpass Spain in market penetration but only if FTTB deployments are considered in addition to FTTH.

Latency, jitter state and their impact on users

The rest of the metrics addressed in this report offer a general view of other internet-broadband performance indicators. However, service providers don't advertise compromised levels, so the comparison isn't made against contracted values. Rather, the figures are presented in absolute terms, and we show what certain values can mean for users.

Latency is as important if not more important for the user experience in real-time services than download speed. This metric is directly related to the technology used and, to some extent, the international connectivity to reach the servers against which the measurement is performed. The average latency values in Europe are 22.84 ms with significant variation between countries. Ireland, Spain and Great Britain present the lowest values with 12.21 ms, 12.69 ms and 14.89 ms, respectively. On the other end, Greece has an average latency of 46.78 ms.

Figure 8: Latency by country (in ms)



Source: MedUX

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ADSL has the worst latency with 40.21 ms on average, characterized by high variability. FTTH, HFC and VDSL show substantially lower latencies, with average values of 12.57 ms, 21.11 ms and 21.33 ms, respectively. FTTH, in particular, also has low dispersion values.

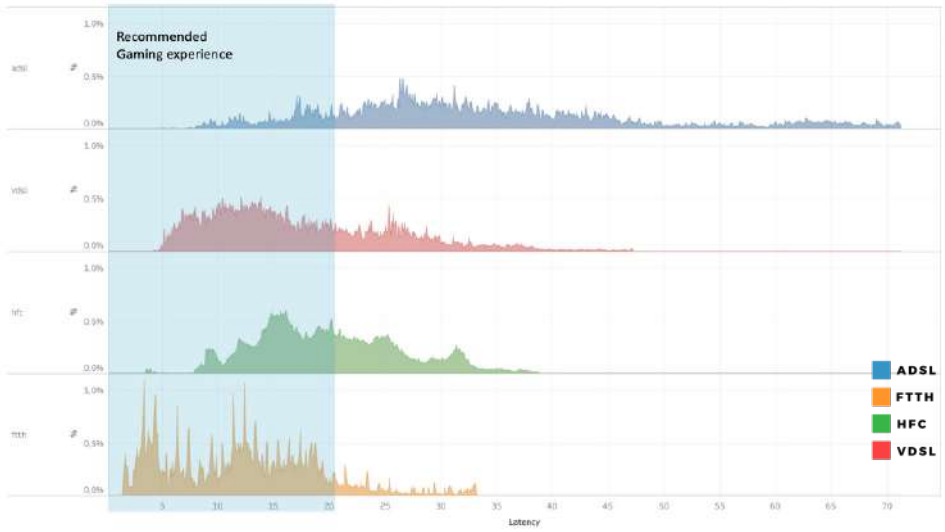
These latency values can generally be compared with results recently obtained from former 5G deployments—in South Korea for instance, where latencies have been observed ranging from 50 to 200 ms. However, it is expected that future deployments will comply with the technology's promise and will approach values within a few milliseconds.

In the near future, 5G may be a real threat in environments with massive 5G deployment and where the performance of fixed technologies does not meet customer needs in terms of upload speeds, download speeds and latency.

Latency is especially important for applications that are sensitive to temporary deviations, such as online gaming, video streaming and voice communications. These applications are particularly sensitive because of strict demand from the user's point of view. FTTH has the highest number of measurements below the 20-ms threshold (see Figure 9), which is recommended in terms of excellence for the real-time gaming experience.

It is observed that FTTH has the lowest median at 12.31 ms, while VDSL, HFC and ADSL medians are significantly higher (16.5 ms, 19.9 ms and 31.91 ms, respectively). Figure 9 shows a comparison of statistical distributions for each technology at the pan-European level.

Figure 9: Statistical distribution by technology in Europe.



Source: MedUX

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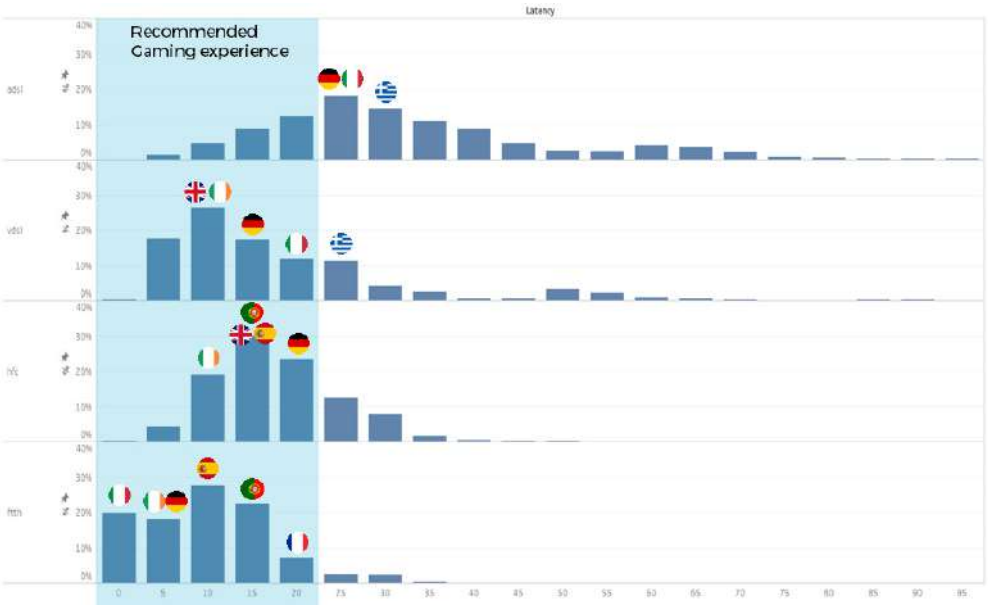
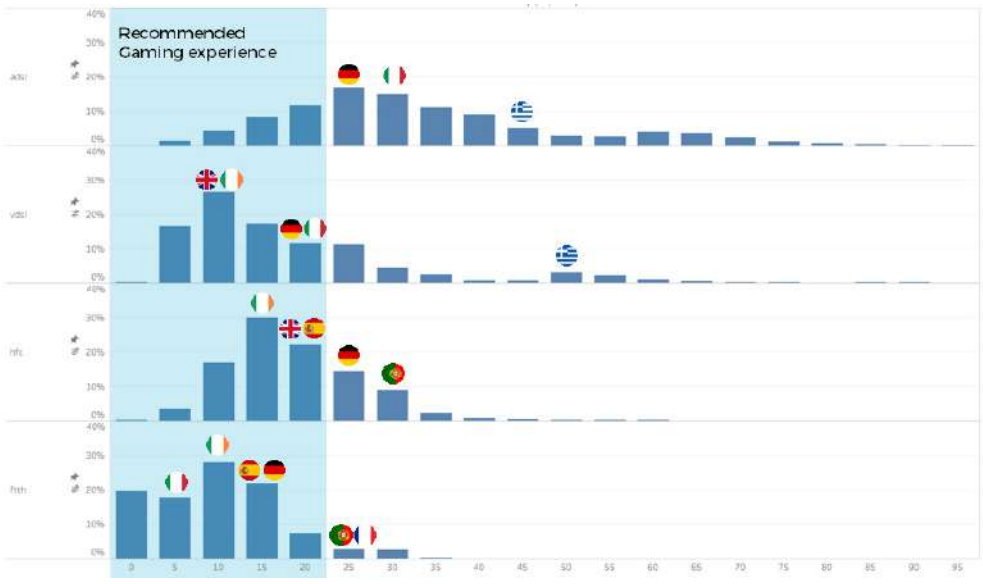
Figure 10: Statistical distribution of latency (in ms) for each technology in Europe during the day (median value by country)



Source: MedUX

Figure 11: Statistical distribution of latency (in ms) for each technology in Europe during peak hours (median value by country)



Source: MedUX

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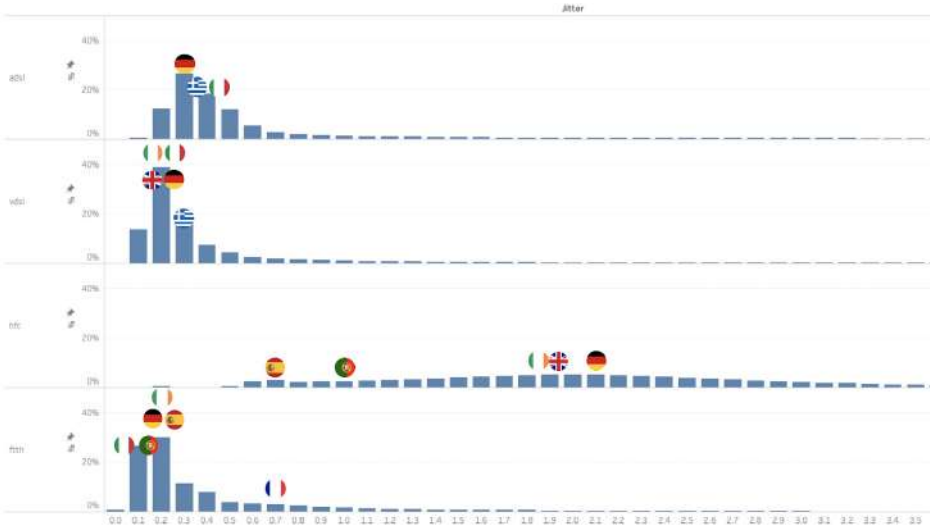
The results of this report first show the median latency in each country throughout the day (Figure 10) and, second, the median in each country during peak hours (Figure 11). For this analysis, peak hours are considered to be between 7 p.m. and 10 p.m.

Greece, Italy, Portugal and Germany are the most affected countries by the congestion effect, and the average performance of their networks would not entirely meet the demands of most gaming users. User experience with several technologies could be affected in these countries, since the median value during peak hours is lower than the recommended value needed for excellence in gaming (i.e., less than 20 ms).

The effects of peak hours have a greater impact on HFC technologies due to their topology in which congestion happens closer to the end user—that is, in the access network instead of the transmission or transport networks. The resolution of these problems usually requires a significant outlay to add capacity and reduce congestion effects.

Lastly, the results show jitter, understood as the variation of latency or the arrival time between packages and the loss of packages. It is observed that FTTH and VDSL present average daily values at 0.92 ms and 1.64 ms, respectively. HFC and ADSL values are markedly higher (4.84 ms and 5.97 ms, respectively). During peak hours, HFC and ADSL jitter rises to approximately 6 and 10 ms, respectively. However, when the median is observed, only HFC has lower performance, with 2.27 ms compared to 0.27 ms, 0.3 ms and 0.53 ms for FTTH, VDSL and ADSL, respectively.

Figure 12: Statistical distribution of jitter for each technology in Europe (median by country)



Source: MedUX

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Figure 12 shows jitter numbers obtained by country, specifically the median values, for each technology.

Regarding the loss of packages, all technologies have values below the generally acceptable threshold (1%) for most applications and services, even during peak hours. It is observed that FTTH and VDSL have the lowest average values below 0.05%, while the values for HFC and ADSL are markedly higher, rising to 0.20% and 0.35%, respectively.

Packet loss and jitter are the most important parameters for gaming users, consumers of streaming video and audio and users of voice over IP (VoIP) applications, since these applications require real-time response speeds. Timely packet loss and instability events due to high jitter values are usually acceptable for end users but not when these incidents occur over an extended period of time, interrupting a streaming video, for example.

VoIP applications are the most susceptible to packet loss and jitter, since these parameters degrade voice quality and affect audio. However, most applications that make use of VoIP technology have ways to reduce the impact of jitter and packet loss so that call quality is not affected. In general, jitter values of 20–25 ms and packet loss of less than 1% are acceptable and correctable by software.

MedUX´s next reports on residential fixed broadband in Europe

The data in this report shows the most relevant parameters impacting network performance according to our study. Nevertheless, it is essential to round out the analysis with additional indicators that can be found in our product and services portfolio. The analysis can be completed with stress tests performed to test real end-user experiences.

In future reports, the reader will find more valuable information about Quality of Experience (QoE). MedUX will analyse broadband performance with the most used services by people: OTT applications, web-browsing services, cloud services and video streaming, among others.

In addition to this, MedUX will analyse broadband performance based on wireless networks in the home environment (Wi-Fi), the challenges that 5G poses to current fixed-broadband deployments and telecom operators' rankings by country according to the needs and expectations of end users (real QoE).

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MedUX Ecosystem – Measure and improve fixed broadband

At MedUX, we contribute to improve fixed broadband in Europe with real-time QoE data. Approximately 350 million users benefit from these improvements.

The MedUX Ecosystem analyses and compares more than 30 Internet Service Providers (ISPs) in Europe. MedUX´s aim is to become the primary reference in measuring Quality-of-Service (QoS) and QoE for fixed-broadband networks.

Our methodology is to obtain robust data and comply with a statistical model that validates the information gathered. Our MedUX HOME devices—agnostic and all-router compatible—collect data independently from the access technology (e.g., xDSL, FTTx, HFC), without integration from the end user perspective.

The average user connects to the internet via cable or Wi-Fi depending on their specific needs. The information gathered by MedUX HOME devices is for both Wi-Fi (2.4GHz and 5GHz) and Ethernet connections, so the service provider can better understand their customers and have a complete view of home network performance.

MedUX HOME devices perform tests (24/7) in accordance with a test program designed specifically to match real user experiences, and the devices work regardless of country, internet provider, access technology or commercial plan. This guarantees that the data is comparable and allows MedUX to consistently analyse performance variability at any time frame for every ISP covered in MedUX research.

MedUX list of KPIs is as follows:

- HTTP Download
- HTTP Upload
- Service availability
- DNS Resolution
- Web Browsing (including web loading time, bits and number of resources)
- Streaming (including average speed, buffering, streaming interruptions and video resolution, among others)
- Cloud Storage (including service availability, transmission speed and success rate)
- Gaming (including performance indicators for the most important gaming servers worldwide)
- Ping Test (including latency, jitter and packet loss)
- HTTP Test (including download speed test, upload speed test, speedtest and success rate)

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This report´s objective is to measure the user´s actual Quality of Experience (QoE). For this purpose, MedUX places MedUX HOME devices in the homes of users that voluntarily collaborate with MedUX and are selected as part of a representative sample of fixed-broadband consumers in target European countries.

At MedUX, we guarantee the panelist privacy 100%, since our devices do not access personal data or information. MedUX devices simulate end-user behaviour and are just one more traffic source in the user's network. All data used by MedUX is anonymous and aggregated. Thus, compliance with the European General Data Protection Regulation (GDPR) is guaranteed at all times.

ISPs and commercial offers that fall within the scope of this project are considered to be the most relevant or have the largest number of subscribers in their national markets. Based on our methodology, there is no minimum number of consumers required per country, but a minimum of 45 MedUX HOME users per technology and commercial offer are recommended in order to achieve at least 80% statistical significance. The consumers' panel has been designed to enable the comparison of real-user experiences at a national level as well as the comparison of ISP performance within and between countries for each technology and commercial offer.

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