DRIVE TEST CAMPAIGN RESULTS 2019

bipt

Belgian Institute for Postal Services
and Telecommunications

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1 Introduction

The publication of information on network quality increases transparency and helps customers to make better informed decisions. It also helps BIPT to understand and monitor mobile network performance in Belgium. Besides, operators can rely on this information to prioritize their investment and provide an even better service.

Since 2015, BIPT publishes mobile coverage maps which are an independent source of information on the state of mobile coverage in Belgium. Since 2018, BIPT also publishes some indicators on the customer experience on mobile networks. The aim is to understand what customers experience when they watch a video, visit a website, download a file or make a phone call indoor.

This report explains the methodology and gives an overview of the BIPT 2019 measurement campaign on customer experience. It describes each indicator and compares the performance of the three mobile networks. To understand the overall network performance, the reader should consider all dimensions and indicators explained below.

2 Campaign methodology

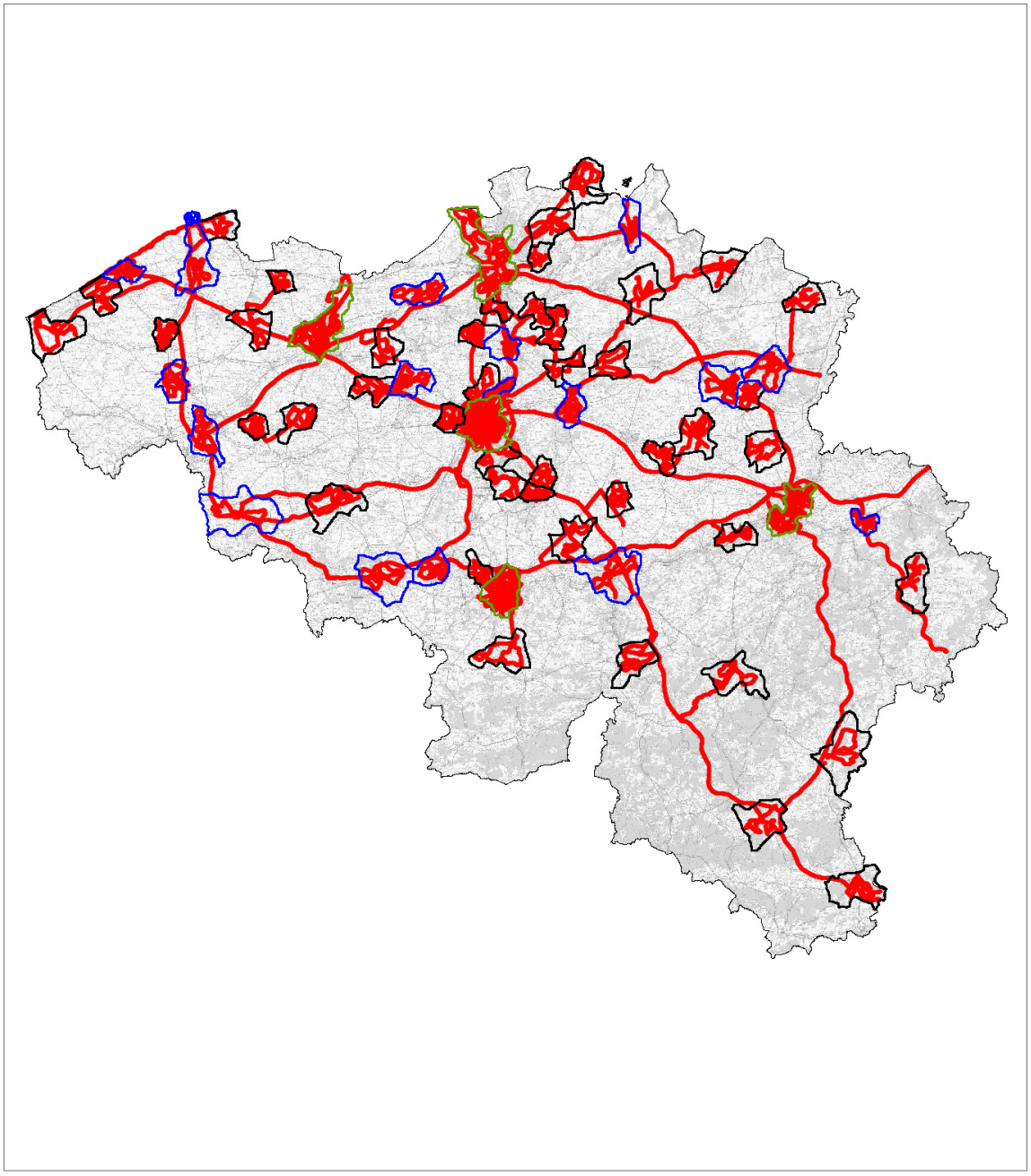
The main objective of the campaign was to measure customer experience. We measured performance as experienced by users using a 4G/LTE capable smartphone, simulating indoor radio conditions.

Measurements were conducted by driving 2 cars across Belgium, equipped with a Rohde & Schwarz system for mobile network benchmarking. Smartphones were installed in a ski-box, such that the measurements represent in-car and indoor performance (i.e. as experienced by a user in a building or house, close to the window).

The campaign was conducted between 25/Sep and 18/Oct/2019. Drive tests were conducted both during and outside "busy hours" periods; between 7am and 9pm; from Monday to Saturday (excl. public holidays).

2.1. Measurements location

A total of 250 hours of drive tests were made (i.e. 125 hours per car).
The selection of the cities and villages was based on their importance and population. The driven areas were chosen by BIPT and Commsquare and were not communicated upfront to the mobile network operators. This ensures a fair approach, i.e. the mobile network operators couldn't optimize or tweak their network in those places we planned to measure.
For details on the measurement locations, please refer to the map and its comments below.



Category	Description	Selection
Capital (1x)	Capital of Belgium	Brussels
Major cities (4x)	Population >150k inhabitants	Antwerpen, Charleroi, Gent, Liege
Medium cities (17x)	Population between 45k and 150k inhabitants	Aalst, Brugge, Genk, Hasselt, Kortrijk, La Louvière, Leuven, Mechelen, Mons, Namur, Oostende, Roeselare, Sint Niklaas, Tournai, Turnhout, Verviers, Vilvoorde
“Rural” areas (44x)	Population <45k inhabitants, the number of rural areas reflects the number of inhabitants per province	8x in the province of Antwerpen, 2x in Hainaut, 2x in Liège, 5x in Limburg, 4x in Luxembourg, 3x in Namur, 5x in Oost-Vlaanderen, 6x in Vlaams-Brabant, 4x in Brabant-Wallon, 5x in West-Vlaanderen
Highways	E-roads (driven in both directions), R-roads (not all) and N-roads	E17, E19, E40, E42, E25, E420, E429, E403, E313, E314, A4; N-roads based on driven “Rural” areas

2.2. Voice telephony tests

The Samsung S8, an Android smartphone, was used for the voice tests. The phone was operating in VoLTE-preferred mode, i.e. utilising the latest voice technology (VoLTE stands for Voice over LTE).

Voice calls were made between phones in both cars, i.e. a phone in the first car calling the phone in the second car. A new call was made every 2 minutes: the call holding time was 90s, with 30s pause between test calls.

During the call, the phone was allowed to make unrestricted and non-user-initiated data activity, as is typically the case by a smartphone.

2.3. Data tests

The Sony XZ2 was used for test in 4G-preferred-mode. This means the phone tries to use the 4G/LTE network, but in its absence, continues service on the 3G or 2G data network.

The data tests included a series of different tests: throughput tests in downlink and uplink (conducted as a down- or upload during 10s);

a file transfer in downlink of a 10MB file and a 5MB file in upload; a selection of 1 test page and 5 popular live pages for web browsing tests (Kepler reference page, 2dehands, Booking, Google, RTBF, Wikipedia), YouTube buffered streaming and Dropbox app testing.

Both measurement cars were conducting the same data tests. The data tests (similar to the voice tests) were executed whilst driving.

2.4. Known limitations

The approach is a valid approach but has some inherent known limitations.

The results in this report are based on measurements in September-October 2019. Mobile networks are dynamic and undergo changes and improvements. Therefore, the observations and conclusions are a valid snapshot of mobile network performance in Belgium during the measurement period.

All tests are conducted whilst driving. This approach allows making tests across the entire country. However, it is known most users use their mobile phone in static conditions, i.e. when not moving. It is generally assumed moving users experience a worse experience than non-moving users. Nevertheless, the approach is generally considered best-practice to simulate indoor customer experience.

All tests were conducted using Android phone, which is the most popular operating system for mobile phones. As mobile phones themselves impact user experience, users with older models or different operating systems might experience a different performance.

Tests were configured to simulate performance in indoor conditions. When using a mobile phone in deep-indoor locations (e.g. in basements, far away from a window, in highly-insulated houses, or concrete building), performance will be worse. Coverage is the main driver for obtaining good performance in such deep-indoor conditions.

3 Voice results

The performance of voice services is expressed in 3 categories of service indicators.

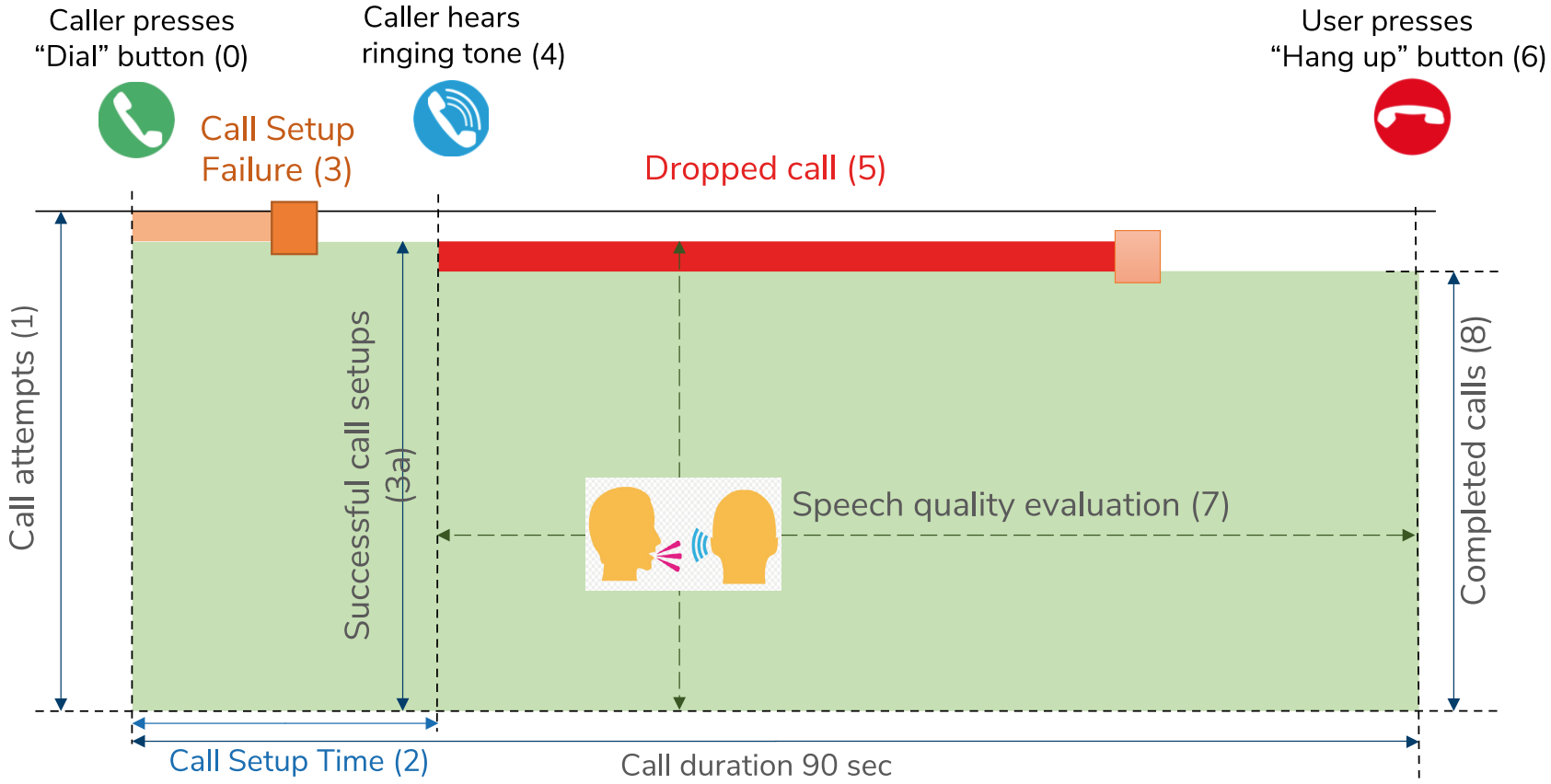
Results are summarized in the table below.

We remind the reader that voice calls were made using the latest voice technology, called VoLTE, which is only available to 4G and VoLTE capable smartphones. In our tests in 2018, voice calls were tested using an older voice technology, called CSFB. The newer VoLTE technology results in overall better customer experience for voice services.

Voice Summary		Orange	Proximus	Telenet
Success Rates				
Call setup success rate	%	99.5	99.8	99.5
Successfully established calls completion rate	%	99.8	99.8	99.8
Call Setup Time				
Call Setup Time (s)	Average	2.3	2.6	4.0
Call Setup Time (s) long samples	10% longest	2.8	3.2	5.2
Voice Quality				
Voice Quality score	Average	4.0	4.0	4.0
Voice Quality Score low samples	10% lowest	3.4	3.4	3.6

The diagram below explains the voice service indicators.

- A call is initiated by the caller pressing the “Dial” button (0). The call setup time (2) is the time until the caller hears ringing tone (4).
- A call setup failure (3) means the user making the call doesn’t receive ringing tone and the call is not started.
- Successful call setups (3a) indicate the proportion of calls that reach ringing tone. The caller considers this a successful call setup.
- Once the call has started, it sometimes drops (5). A dropped call means the conversation is unexpectedly aborted and the conversation can’t be completed.
- Completed calls (8) are the proportion of calls that obtain ringing tone and manage to complete the entire conversation, i.e. the call is not prematurely terminated. Note some completed calls might experience a temporary interruption during the conversation, but the network can often fix such problems and continue the call.
- Voice speech quality is evaluated (7) for all calls that were successfully set up, and the analysis includes all dropped calls.



This is a description of the voice quality indicators:

- The **call setup success rate** denotes the proportion of success call setups, i.e. calls that receive ringing tone[1].

  All operators demonstrate a high call setup success rate, with Proximus (99.8%) ahead of Orange (99.5%) and Telenet (99.5%).

- The **successfully established calls completion rate** measures the proportion of successfully established calls that reach the end of the conversation.[2]

  The successfully established calls completion rate is high and equal in all networks (99.8%).

- **Call setup time** is the time it takes from pressing the dial button until the user making the call hears ringing tone.

  Orange (2.3s) has the fastest average call setup time, followed by Proximus (2.6s) with Telenet (4.0s) the slowest.

- **Call setup time long samples** indicates the minimum time it takes to set up the 10% slowest calls.

  For the 10% slowest call setups, Orange (2.8s) is faster than Proximus (3.2s) and Telenet (5.2s).

- **Voice quality score** measures the quality of the conversation on a scale from 5 (excellent) to 1 (poor). Good speech quality means clarity of the call, i.e. the speech clearness, fidelity, intelligibility and absence of distortion (such as metallic voice).

  All operators offer “high-definition” voice, a technique that leads to major improvements in speech quality.

  All operators have a similar voice quality score (4.0) on average.

- **Voice quality score low samples** corresponds to the maximum speech quality a user experiences for the 10% worst speech samples.

  For the 10% worst speech samples, Telenet (3.6) scores better than Orange (3.4) and Proximus (3.4).

1. A successful call setup means the calling user will hear ringing tone a few seconds after he/she has pressed the dial button. The calling user will consider this a success start of the call. With reference to the call diagram in previous page, this is calculated as (3a) divided by (1).

2. A dropped call is the event whereby a call that was initially successfully established, is unexpectedly and prematurely aborted before the end of the conversation and beyond the control of the calling parties. Completed calls are calls that were successfully set up and don't drop. With reference to the call diagram in previous page, this is calculated as (8) divided by (3a).

4 Data results

The performance of data services is expressed in 5 categories of service indicators.
Results are summarized in the table below.

Data Summary			Orange	Proximus	Telenet
Throughput					
HTTP DL fixed duration	DL throughput (Mbps)	Average (Mbps)	50.3	67.6	70.9
		Slowest 10% (Mbps)	8.2	11.3	14.9
HTTP UL fixed duration	UL throughput (Mbps)	Average (Mbps)	23.1	21.9	26.8
		Slowest 10% (Mbps)	3.3	3.7	3.1
File Transfer					
HTTPS DL fixed size 10MB	File download	Median time (s)	2.8	2.3	3.0
		Success rate (%)	98.5%	99.2%	98.7%
HTTPS UL fixed size 5MB	File upload	Median time (s)	2.3	2.5	2.4
		Success rate (%)	96.9%	97.9%	96.0%
Web Browsing					
All web pages (blended KPI)	Web page browsing	Median time (s)	2.1	2.1	2.2
		Success rate (%)	99.4%	99.4%	99.4%
YouTube Video					
YouTube – buffered streaming	Success Rate	Success rate (%)	99.5%	99.7%	99.4%
	Time to 1st picture	Average time (s)	1.4	1.4	1.6
	Video Quality	Average MOS	4.4	4.4	4.4
Cloud storage (Dropbox)					
Dropbox UL 1MB	Upload	Median time (s)	1.7	1.7	1.7
		Success rate (%)	98.1%	98.8%	97.3%

This is a description of the data quality indicators:

- **Throughput** (expressed in Mbit/sec) measures the speed the network can offer to a single user. An individual user will benefit from high throughput in case he/she wants to download big amounts of data.

  Telenet has the highest average **download throughput** (70.9Mbps), followed by Proximus (67.6Mbps) and Orange (50.3Mbps). Telenet has also the highest download throughput performance (14.9Mbps) when considering the 10% of slowest test cases, followed by Proximus (11.3Mbps) and Orange (8.2Mbps).

  Telenet has the highest average **upload throughput** (26.8Mbps), followed by Orange (23.1Mbps) and Proximus (21.9Mbps).

  The picture changes for the worst 10% of upload throughput tests: Proximus has the highest throughput (3.7Mbps), followed by Orange (3.3Mbps) and Telenet (3.1Mbps).

- **File transfer** tests measure the performance of downloading a 10MB file or uploading a 5MB file.[3] The performance of file transfers is measured by 2 service indicators: (1) the **time to complete the transfer** and (2) the **success rate**. The latter is an indicator of the integrity or reliability of the service.[4]

3. File transfers are very common, such as in picture uploads or downloads in popular apps, email attachments, etc.
4. Success rate denotes the proportion of download or upload tests that were successfully completed within 40s.

For a **download** of a 10MB file, Proximus has the fastest download time (2.3s), followed by Orange (2.8s) and Telenet (3.0s). Proximus has the highest success rate (99.2%), followed by Telenet (98.7%) and Orange (98.5%).

For an **upload** of a 5MB file, Orange has the fastest upload time (2.3s) followed by Telenet (2.4s) and Proximus (2.5s).

- **Web browsing** or surfing to web pages is a popular activity of mobile phone users. A selection of 1 static and 5 popular web pages in Belgium was used for the aggregated results. Web browsing results are summarised into 2 service indicators: (1) the time to view the web page (web page browsing time) and (2) the success rate.

  Web page browsing time is almost identical in all networks, with values of 2.1s to 2.2s.

  Web success rate denotes the percentage of web pages that is completely downloaded within 20s. All operators present similar success rate for web browsing (99.4%).

- **Video streaming**, and YouTube in particular, is amongst the most popular mobile apps. Buffered video streaming was tested, as opposed to live streaming. YouTube performance is measured as (1) a success rate, i.e. the proportion of tests that had a complete play-out of the video; (2) the time-to-first-picture, i.e. how long it takes for the play-out to start; and (3) the video quality during the entire play-out.

  Proximus (99.7%) offers the highest **success rate**, closely followed by Orange (99.5%) and Telenet (99.4%).

  Orange and Proximus have the fastest "**time to 1st picture**" (1.4s), followed by Telenet (1.6s).

  Video quality is the same on all networks (4.4). It captures the effect of low video resolution, freezing of the play-out, etc. When the networks offer sufficient throughput and capacity (5-10Mbps on average), and coverage is present, video quality is expected to be the same in all networks.

- **Cloud storage service** (Dropbox) performance is measured as (1) the time to upload a 1MB file and (2) the success rate to complete the transfer.

  All networks require a similar **time to complete** the 1MB file upload, i.e. 1.7s.

  Proximus has the highest **success rate** (98.8%) for Dropbox performance, followed by Orange (98.1%) and Telenet (97.3%).

5 Conclusions

The performance of Belgian mobile networks was assessed, simulating indoor customer experience. The measurements were conducted by driving 2 cars during 250 hours across the entire country in September-October 2019. Performance was measured in all major cities and highways, as well as in a selection of medium size cities, villages and roads.A total distance of approx. 10,000 km was driven; over 8,000 voice calls were made on each network; and roughly 60,000 data tests were conducted per network. The measurements were configured such that these are representative of customer experience in indoor conditions (i.e. meaning in houses and buildings, close to a window, or in-car).

For **voice performance**:

- All operators demonstrate a high **call setup success rate**, with Proximus (99.8%) ahead of Orange (99.5%) and Telenet (99.5%).
- The **successfully established calls completion rate** is high and equal in all networks (99.8%).
- Orange (2.3s) has the fastest **average call setup time**, followed by Proximus (2.6s) with Telenet (4.0s) the slowest. For the 10% slowest call setups, Orange (2.8s) is faster than Proximus (3.2s) and Telenet (5.2s).

- All operators have a similar **voice quality score** (4.0) on average. For the 10% worst samples of voice quality, Telenet (3.6) scores higher than Orange (3.4) and Proximus (3.4).

For **data performance**:

- Telenet has the highest average **download throughput** (70.9Mbps), followed by Proximus (67.6Mbps) and Orange (50.3Mbps). Telenet has the highest average **upload throughput** (26.8Mbps), followed by Orange (23.1Mbps) and Proximus (21.9Mbps).

- For the **download of a file**, Proximus has the fastest download time (2.3s), followed by Orange (2.8s) and Telenet (3.0s). Proximus has the highest success rate (99.2%), followed by Telenet (98.7%) and Orange (98.5%). For the upload of a file, Orange (2,3s) is faster than Telenet (2.4s) and Proximus (2.5s); and Proximus (97.9%) has the highest success rate followed by Orange (96.9%) and Telenet (96.0%).

- **Web page browsing** time is almost identical in all networks, with values of 2.1s to 2.2s. Web success rate denotes the percentage of web pages that is completely downloaded within 20s. All operators present similar success rate for web browsing (99.4%).

- For **video streaming**, Proximus (99.7%) offers the highest success rate, closely followed by Orange (99.5%) and Telenet (99.4%). Orange and Proximus have the fastest "time to 1st picture" (1.4s), followed by Telenet (1.6s). All operators present similar video quality.

- For **Dropbox performance**, Proximus has the highest success rate (98.8%), followed by Orange (98.1%) and Telenet (97.3%). All networks require a similar time to complete the 1MB file upload on Dropbox, i.e. 1.7s.

Commsquare observed performance differences between the different networks. However, there is not a single network outperforming the other networks on all service indicators we have measured. These conclusions are valid based on the measurements made in September-October 2019, simulating indoor coverage conditions. Customer experience deep into buildings will be different.

Based on our international experience and considering the combination of all service indicators we have measured, we can conclude that all mobile networks in Belgium demonstrate a very good performance.

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