# Experience with «Internet via Satellite»

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***«Internet via Satellite» is used to fulfill the requirements of the Swiss Government for country wide telephony and broadband Internet access since 2008. The corresponding universal service obligations (USO) were fulfilled with several generations of geostationary (GEO) satellite systems. We currently serve around 800 subscribers with Eutelsat Konnect Very High Throughput Satellite (KVHTS) with 10/1 Mbps and 80/8 Mbps download/upload plans.***

***This report outlines our experience and explains the processes to guarantee the USO quality of service. Our experience proves that Internet via GEO satellites can provide acceptable user experience. The 650ms GEO satellites system response time does not impose problems for Voice-over-IP and conferencing applications. However, certain Point-of-Sale (POS), IoT and video streaming applications may not be well enough configured to cope with such high response times.***

***Parallel to the GEO satellite tests we also run tests with Medium Earth Orbit (MEO) satellite systems (O3B, OneWeb) and with Low Earth Orbit (LEO) satellite systems (OneWeb, Starlink).***

## 1 UNIVERSAL SERVICE OBLIGATIONS (USO)

Switzerland was among the first countries to establish a universal service obligation (USO) with the objective to ensure a reliable, affordable universal service with a well-defined quality of service (QoS) throughout the country.

The Swiss government periodically adapts the USO to reflect changing needs and technological advancements. The Swiss Telecommunications Act of 30 April 1997 (TCA) [1] started with provisions for basic telephony services and special services for people with disabilities. In 2008 it was extended to broadband internet services with an advertised data rate of 0.6 Mbps download and 0.1 Mbps upload. In the following years, the advertised data rates were updated several times (see Table 1):

| Period | Advertised Download Data Rate | Advertised Upload Data Rate | Cost (including telephony services) |
|---|---|---|---|
| 01.01.2008 – 28.02.2012 | 0.6 Mbps | 0.1 Mbps | CHF 69 per month |
| 01.03.2012 – 31.12.2014 | 1 Mbps | 0.1 Mbps | CHF 55 per month |
| 01.01.2015 – 31.12.2017 | 2 Mbps | 0.2 Mbps | CHF 55 per month |
| 01.01.2018 – 31.12.2019 | 3 Mbps | 0.3 Mbps | CHF 55 per month |
| 01.01.2020 - today | 10 Mbps | 1 Mbps | CHF 55 per month |
| 01.01.2024 - today | 80 Mbps | 8 Mbps | CHF 71 per month |

*Table 1 Evolution of the Advertised Down- and Upload Data Rates and Cost defined by the Swiss Government*

Figure 1 shows the regular upgrades of the USO data rates, the satellite systems used and the measured download data rates. The upgrades reflect the continuous increase of the residential service access data rates with cabled connections. However, the satellite data rates are typically two orders of magnitude lower than the fastest residential service access offerings. The red dots show the results for the best 10% of the cnlab User Experience speed test. The dashed line shows the access rate evolution corresponding to Nielsen's Law. Nielsen's Law,

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formulated by Jakob Nielsen in 1998, predicts that the bandwidth available to high-end internet users grows by approximately 50% per year. Since about 2020 the data rate flattened at 1 Gbps, hence it didn't follow Nielsen's Law anymore.

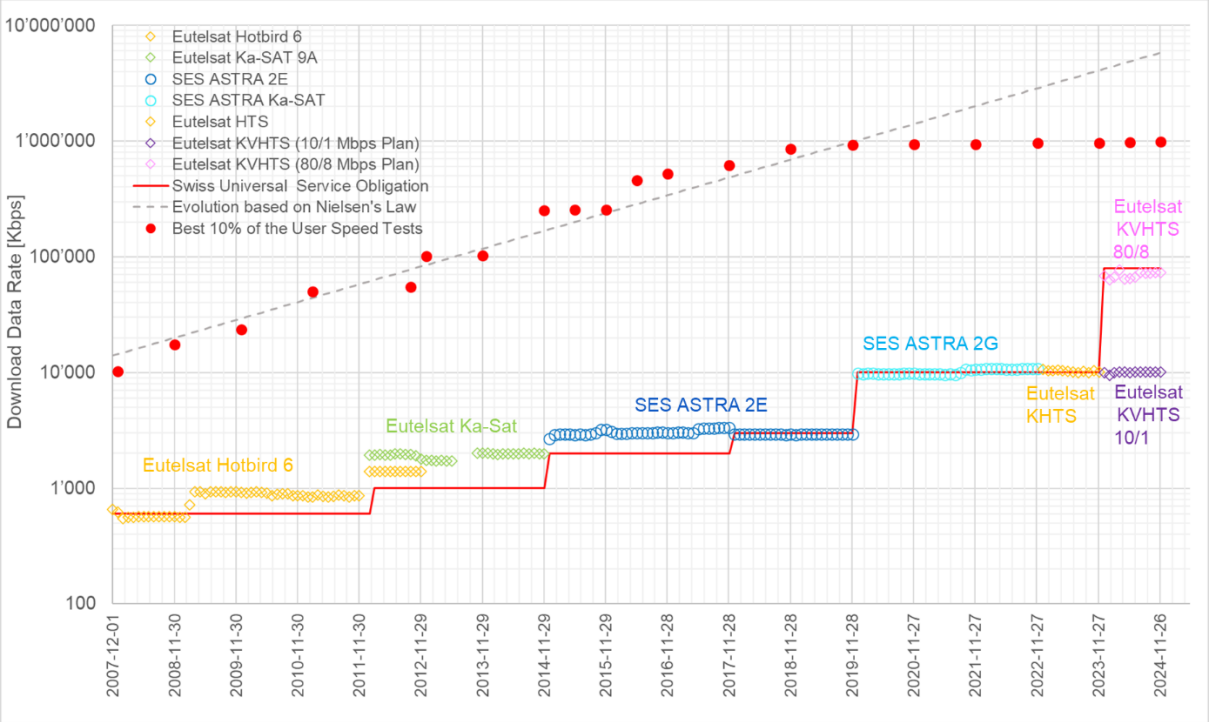



*Figure 1 Evolution of the download data rates, USO Data Rates defined by the Swiss Government and Internet-via-Satellite Systems used for Swisscom VNO.*

The Federal Office of Communications (OFCOM) designated the Swiss telecommunication operator Swisscom as the holder of the USO license. It is up to the licensee to decide whether to use cable (copper, fiber), mobile network (4G, 5G), satellite connections or other technologies. Swisscom chooses the most cost-effective solution for the specific location of the subscribers. In areas without cable or mobile coverage Swisscom uses «Internet via Satellite» to deliver the Internet service as a Virtual Network Operator (VNO). Up to 2025 the service was based on five different geostationary satellite systems operated by Eutelsat and SES ASTRA (subsidiary SES TECHCOM) (see Table 2).

| Name in Geostationary Orbit (NORAD ID) | In Use for USO | Satellite | | | | | Capacity assigned to Swisscom | Modem/Router (Maximum Down-/Upload Data Rate) |
|---|---|---|---|---|---|---|---|---|
| | | Launch Date | Mass with fuel (dry mass) [kg] | Solar Panel Power [kW] | Number of Beams | Total Capacity | | |
| **Eutelsat Hotbird 6 @ 13.0° Est** [2] (NORAD ID 27499) | 2008 - 2012 | 22.08.2002 | 3905 (3000) | 10.5 | 1 Super-Wide Beam | 600 Mbps | 45 Mbps | ViaSat TooWay Surfbeam (2/0.4 Mbps) |
| **Eutelsat Ka-SAT 9A @ 9.0° Est** [3] **(NORAD ID 37258)** | 2011 - 2014 | 26.12.2010 | 6150 (3170) | 15 | 82 Spot Beams | 900 Mbps (per beam) | 87 Mbps (total of 4 beams) | ViaSat TooWay Surfbeam 2 (30/10 Mbps) |
| **SES ASTRA 2E @ 28.2° Est** [4] **(NORAD ID 39285)** | 2015 - 2022 | 30.09.2013 | 6020 (4000) | 13 | 1 Beam | 1 Gbit/s | 360 Mbps | GILAT SkyEdge II-c Gemini-i (20/6 Mbps) |
| **Eutelsat Konnect High Throughput Satellite (HTS) @ 7.2° Est** [5] **(NORAD ID 45027)** | 2023 - 2024 | 16.01.2020 | (3619) | 20 | 92 Spot Beams | 75 Gbit/s | 550 Mbps (total of 2 beams) | Hughes HTS2010 (100/6 Mbps) |
| **Eutelsat Konnect Very High Throughput Satellite (VHTS) @ 3.0° Est** [6], [7] **(NORAD ID 53765)** | 2024 - | 07.09.2022 | 6396 | 20 | 230 Spot Beams | 500 Gbit/s | 1.5 Gbit/s (total of 3 beams) | Hughes WE3100/HT3200 (400/40 Mbps) |

*Table 2 Satellite Service Operators used with the Swisscom VNO USO Model*

The Very Small Aperture Terminal (VSAT) installation is done by specialized installation groups and companies. Swisscom customer care has a special team to handle questions of «Internet via Satellite» subscribers. They get 2nd-level support from cnlab and 3rd-level support from Eutelsat customer care.

# 2 «INTERNET VIA SATELLITE» NETWORK SERVICE QUALITY

## 2.1 OFCOM BROADBAND SERVICE QUALITY REQUIREMENTS

The Swiss Federal Office of Communications (OFCOM) defines the quality of service (QoS) and the procedures to monitor and prove the service fulfillment [8], but it does not define the technology to be used. The USO licensee Swisscom must provide a yearly report about the service fulfillment.

From 2008 until 2023 the service fulfillment requirement for Down- and Upload Data Rate was to achieve at least 80% of the advertised speed in 95% of the test measurements. Since 2024 the USO is fulfilled, if the average data rate of the test measurements is 90% of the advertised data rate for the 10/1 Mbps plan and 75% for the 80/8 Mbps plan respectively.

Swisscom uses several procedures to assure the QoS:

- **OFCOM Monitoring Probes:** The service fulfillment is monitored with probes from cnlab AG Rapperswil, Switzerland. Official monitoring probes are attached to two terminals on each satellite beam. The probes perform HTTP Down- and Upload Data Rate and Roundtrip Response Time (RTT) measurements every hour, availability test every 12 seconds, as well as tests to control further key performance indicators (e.g. UDP one way delay, throughput and packet loss, TCP packet loss, outage durations, HTTP/HTTPS web page load time).
- **Swisscom Monitoring Probes:** In addition to the OFCOM reporting probes there are multiple Swisscom monitoring probes installed at testing sites and at subscriber sites.
- **User Speed Tests:** All subscribers can test their quality of service with Speed Test of their choice (e.g. Ookla speedtest.net , Austrian Regulatory Authority for Broadcasting and Telecommunications (RTR) netztest.at , www.testmy.net). If they use the cnlab UXtest www.cnlab.ch/en/speedtest they can directly report their results to Swisscom customer care.
- **Customer Polls:** With a questionnaire for the users of satellite terminals at Swiss Alpine huts we collected information about end-user perception of the satellite QoS.

## 2.2 SPEED TESTS AND GEO SATELLITES

Typically, the focus of Speed Tests is on the access network and not on international connectivity. To determine the available data rates the time it takes to transfer a certain data volume from a reference system near the Internet Service Provider network to a client PC is measured. Response time is measured with ICMP Echo Request (Ping tests) and/or by measuring the time it takes to set up a TCP- or HTTP-Connection. Furthermore, one-way latency is measured with UDP packet streams and appropriate timestamps.

The comparison of results from different Speed Test is difficult because the measurement setup and test details are often not well enough defined. It is important to know details like:

- Endpoints i.e., reference system and client used for the connection (operating system, network interface, location, protocol stacks)
- Protocol to carry the traffic (IPv4/IPv6, TCP/UDP, HTTP/HTTPS)
- Number of parallel data streams (threads)
- Type of data (random data or structured files)
- Duration of the test (typically fixed e.g. 10 second transfer time)
- Number of measurements and statistical evaluation (average, median, percentiles)
- Advertised speed of the connection to be tested
- Timestamps of the measurements

Numerous Speed Tests are claiming to provide reliable QoS measurements. There are websites providing Speed Tests in the browser, programs (apps for Windows, MAC OS and Linux), and there are also Smartphone Apps typically measuring via WLAN interface. Many Internet Service Providers (ISP) and Access Device Manufacturers provide their own Speed Test. However, many of the Speed Tests are not designed for connections via GEO satellite with their intrinsic high round trip time. For Swisscom satellite network testing, we compared results from the following Speed Tests:

| Company, Speed Test | Link | Browser/App | Comment |
|---|---|---|---|
| Austrian Regulatory Authority for Broadcasting and Telecommunications (RTR) | www.netztest.at/en | Browser | Used for certified measurements in Austria, excellent functionality and test description. |
| cnlab UXtest | www.cnlab.ch/en/speedtest | Browser and Program | Recommended by Swiss ISPs, excellent functionality and test description, supports tuning of various parameters. |
| Eutelsat Konnect Speedtest | speedprobe.konnect.com | Browser | Reference system is in Eutelsat's backbone, measures data transfer during 60 sec. Runs only in Eutelsat's network. |
| Ookla Speedtest.net | www.speedtest.net | Browser and Program (Microsoft App) | Most widely used speedtest, discards fastest 10% and slowest 30% of the results are, funded by advertising and ISPs licences. |
| TMN | testmy.net | Browser | Good functionality, one person project (Damon Mueller, Colorado, USA), funded by advertising |
| iPerf3 | https://iperf.fr | Program | iPerf3 open-source speed test tool, supports tuning of various parameters. |
| Autorità per le Garanzie Nelle Comunicazioni (AGCOM) | misurainternet.it/misura-speedtest | Browser | This Speed Test fails to start measurements outside Italy! |

*Table 3 Speed Tests for «Internet via Satellite» Subscribers.*

The Eutelsat and Ookla test tend to deliver overly optimistic results. The RTR Austria test has problems with upload measurements.

There are differences between the various Speed Test tools of up to 30% for the download and 57% for the upload data rate results when comparing the measured download data rate in relation to the advertised data rate for a KVHTS terminal (see Figure 2 and Figure 3).

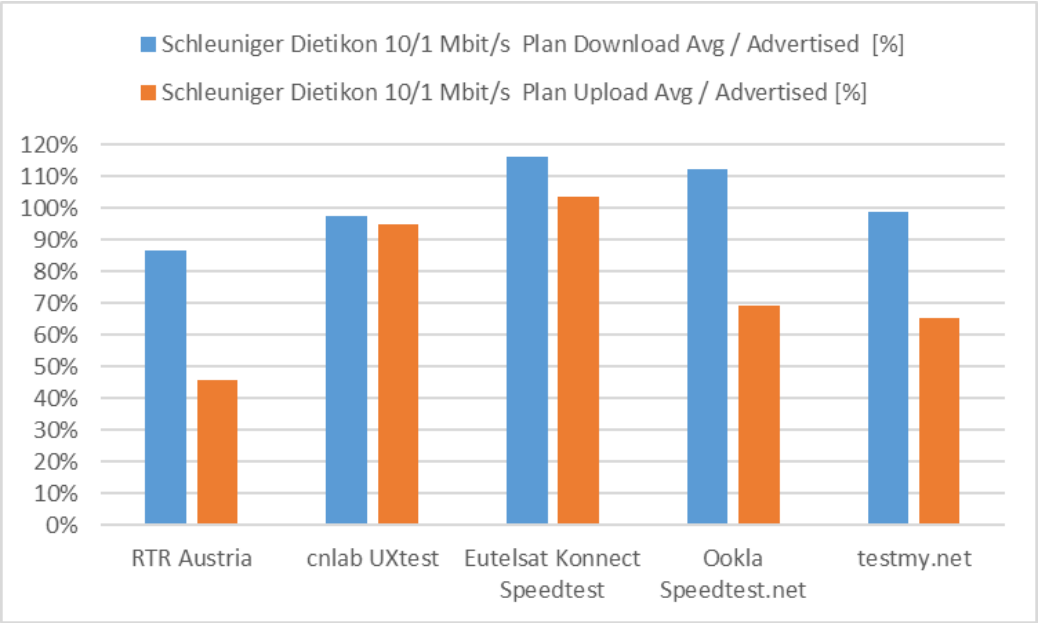



*Figure 2 Comparison of the results of different Speed Test programs for a KVHTS terminal with 10/1 Mbps plan.*

For a KVHTS terminal with 80/8 Mbps plan the differences are up to 35% for the download and 97% for the upload data rate results.

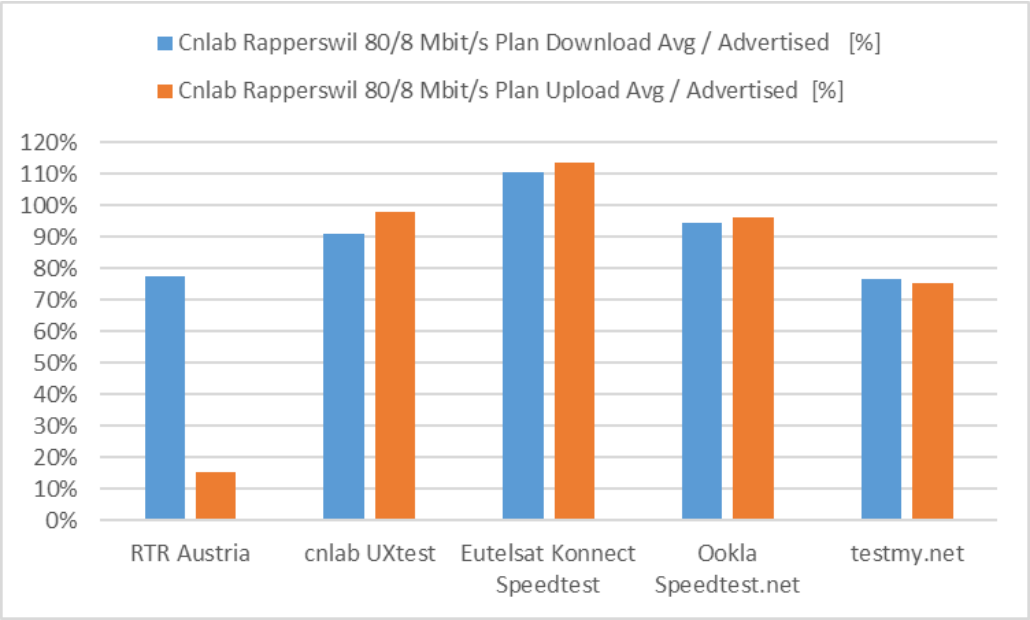



*Figure 3 Comparison of the results of different Speed Test programs for a KVHTS terminal with 80/8 Mbps plan.*

# 3 SERVICE FULFILLMENT 2024 (WITH EUTELSAT KVHTS)

## 3.1 NUMBER OF SWISSCOM VSAT, LOCATIONS, BEAMS

The Swisscom VNO with the Eutelsat Konnect Very High Throughput Satellite (KVHTS) System serves about 900 subscribers. Most of the subscribers are served via Spot Beam 73, but there are also subscribers on the beams 57, 72 and 74. The number of active subscribers varies with time. In wintertime only about two thirds of the subscribers are active.

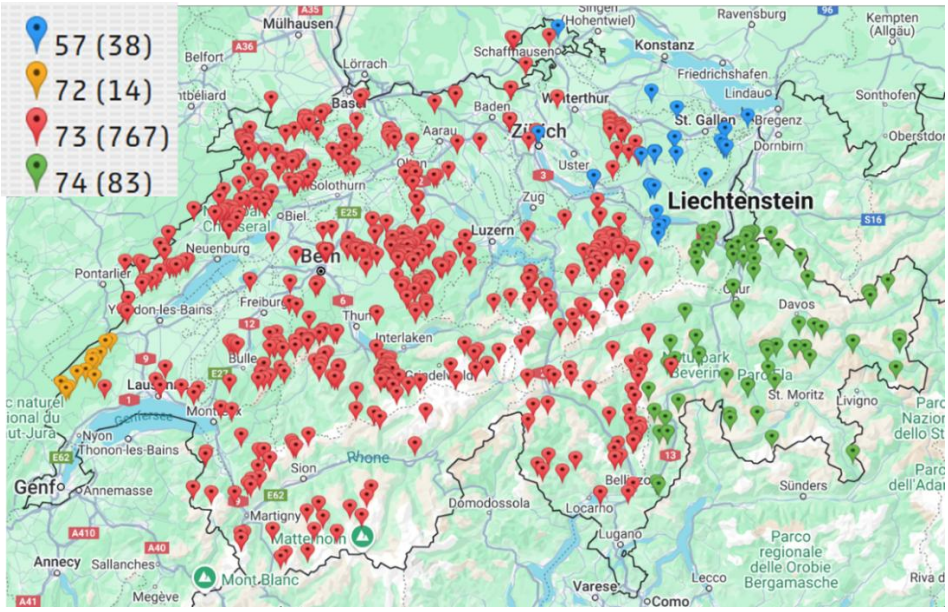



*Figure 4 Locations of active VSAT subscribers on the beams 57, 72, 73 and 74.*

Eutelsat does not provide beam patterns, but based on data from Satbeams [9] it looks like Eutelsat KVHTS Spot Beam 73 does cover most of Switzerland and also the northern part of Italy.

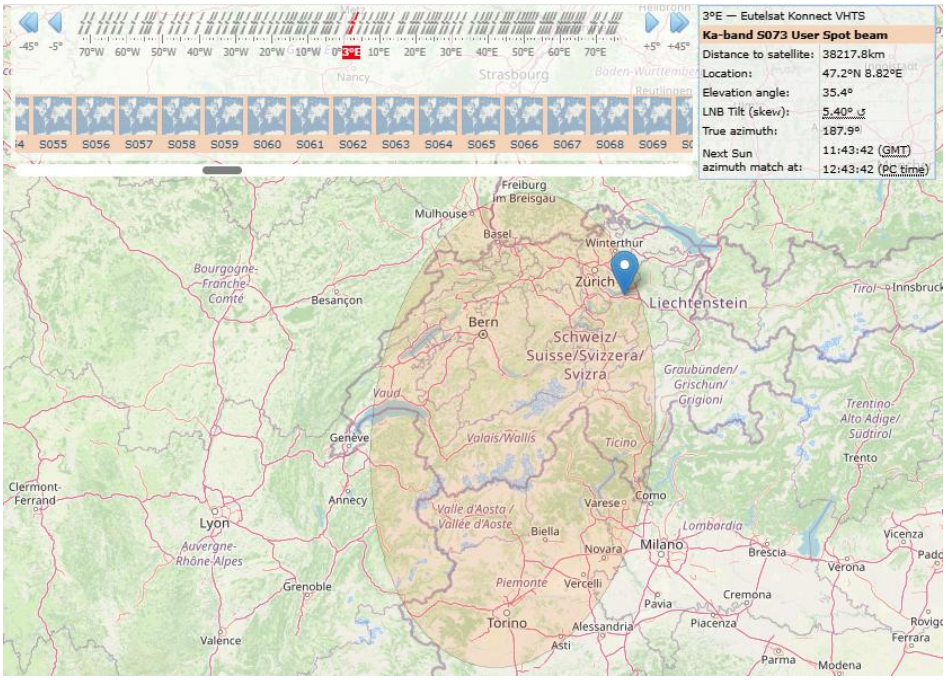



*Figure 5 Coverage map for Eutelsat KVHTS beam 73 (provided by Satbeams, [www.satbeams.com/footprints](www.satbeams.com/footprints)).*

## 3.2 SWISSCOM VNO SETUP

Figure 6 gives an overview of the Swisscom VNO setup. This is just a “best guess” of the engineers from cnlab. Eutelsat does not provide details about their satellite system.

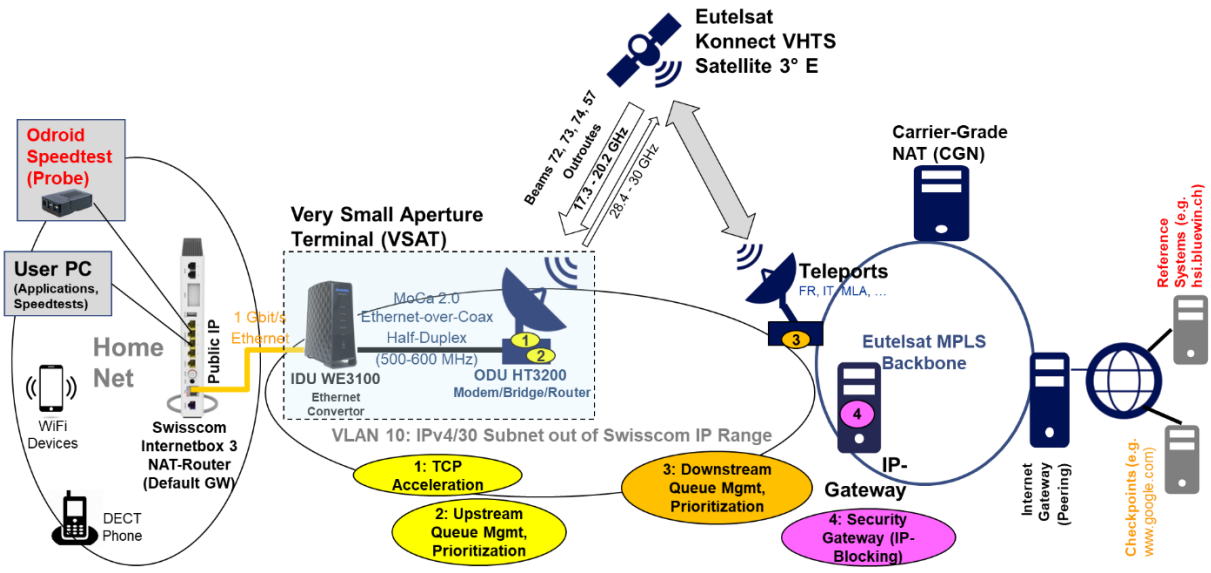



*Figure 6 Eutelsat Konnect VHTS Setup*

The **satellite network subscribers** are connected via the official Swisscom Internetbox [10] as it is used for all residential subscribers. This box needs a public IP out of a Swisscom IP-range, and it must be connected via a Virtual Local Area Network (VLAN) with VLAN-Tag 10. The Swisscom Internetbox sustomer premise equipment (CPE) provides 4 Ethernet ports, Wireless LAN (WiFi) and Voice-over-IP (VoIP). Phones can be connected via analog phone interfaces or via an integrated DECT base station.

The **Eutelsat Very Small Aperture Terminal (VSAT)** consists of the Hughes Indoor Unit (IDU) WE3100 and a 74cm Dish with the Hughes Outdoor Unit (ODU) HT3200 [11]. The IDU WE3100 is connected to the ODU HT3200 via coaxial cable. On the coaxial cable there is power-over-coax for the ODU powering and there is a half-duplex data transmission based on the Multimedia over Coax Alliance (MoCA) Version MoCA 2.0 standard. The WE3100 seems to be an Ethernet-to-MoCA converter. The HT3200 is acting as Modem/Bridge/Router. It terminates TCP-sessions from the Home Net side and performs TCP acceleration for the satellite segment. It contains queues and prioritization functions for upstream traffic. The upstream traffic is sent to the satellite in the 28.4-30 GHz frequency range.

The geostationary **Eutelsat Konnect Very High Throughput Satellite (KVHTS)** at 3° East is about 36’000 km above the equator [12]. It has an on-board digital processor providing flexible allocation of 500 Gbit/s Ka-band capacity on 230 spot beams. The downstream (forward) traffic is sent at 17.3-20.2 GHz to the VSAT. The traffic is organized in multiple “Outroutes”. There are multiple Teleports (Satellite base stations, hubs) for communication with the satellite. Switching between Teleports in case of outages or bad weather conditions is possible within sub seconds.

The **total assigned capacity** of 1.2 Gbit/s downstream and 220 Mbps upstream was sufficient to fulfill the QoS requirements on all beams and also during the peak traffic hour. The available capacity on beam 73 with the largest number of subscribers was 770 Mbps downstream and 154 Mbps Upstream.

**Teleports / IP-Gateways** [13] terminate the satellite segment, handle TCP acceleration, queueing, prioritization of traffic and manage the TCP sessions to the internet destinations. There might also be various security measures (e.g., to block malicious traffic, mitigate denial-of-service attacks).

## 3.3 Performance Tests with the CNLAB UX Application

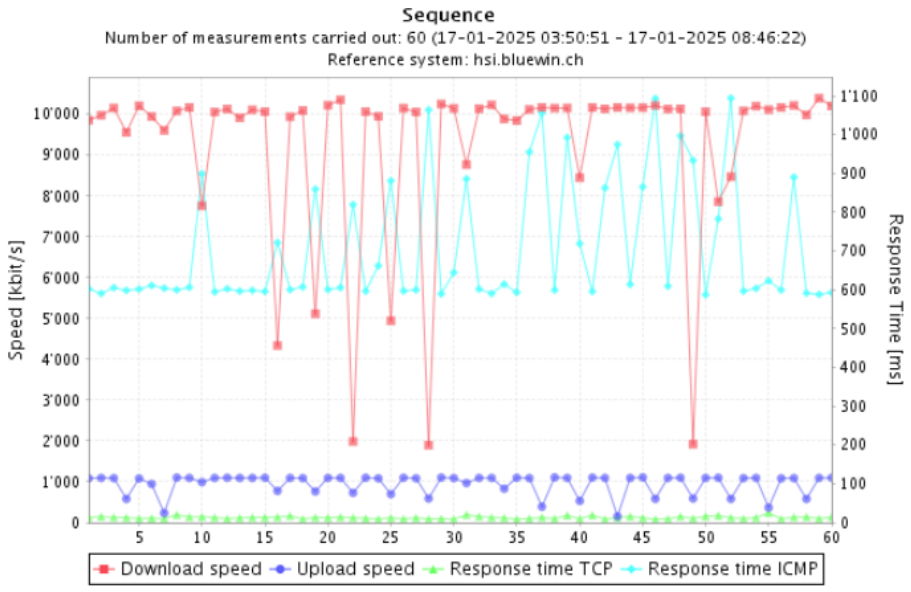
For «Internet via Satellite» performance testing, we recommend the subscribers to use the cnlab UXtest [14] (see Figure 7). It provides excellent control of the different parameters of the measurement (e.g. test duration, reference system, number of parallel TCP-streams, HTTP and HTTPS protocol). Furthermore, it shows the data rates measured at the reference system (server) side and at the client (VSAT) side. There is also an indication about TCP packet loss and TCP window size.


*Figure 7 cnlab UXtest User Interface*

Subscribers (and customer care) get insights into all the measurements carried out at a given VSAT (see Figure 8 to Figure 11).

The results can be analyzed by measurement number, chronological sequence or by time-of-day the measurements were conducted. The variations in the results are mainly due to local parallel traffic, network load, packet losses or reception signal variations (due to bad weather conditions).

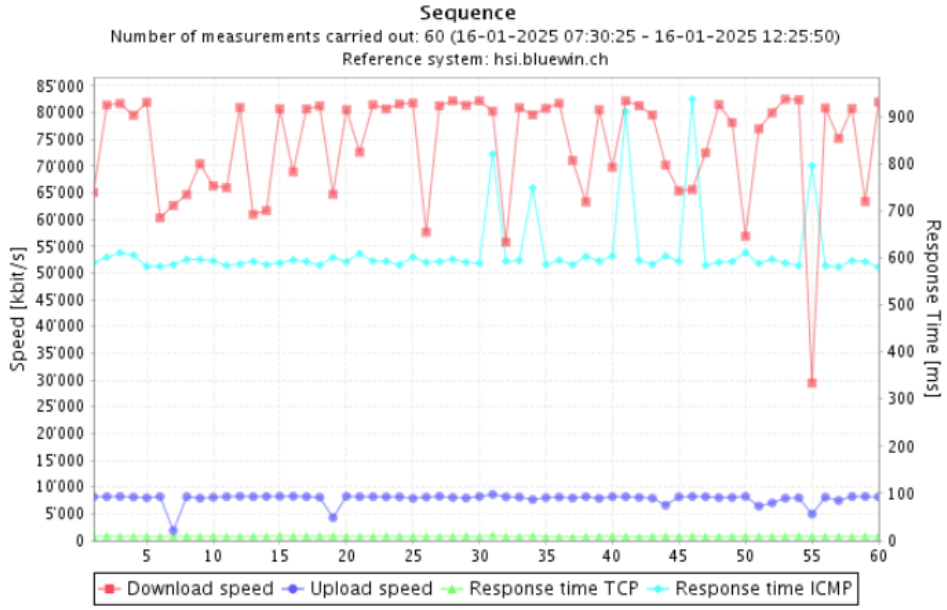
The statistics in Figure 8 show, that the required average data rate is higher than 90% of the advertised data rate for the 10/1 Mbps plan VSAT tests. Hence, Eutelsat KVHTS fulfills the requirements of the Swiss Federal Office of Communications (OFCOM) for 10/1 Mbps plans.




| | Minimum | Average | Maximum |
|---|---|---|---|
| Download speed [kbit/s] | 1'896 | 9'269 | 10'401 |
| Upload speed [kbit/s] | 151 | 945 | 1'105 |
| Response Time (Round Trip Time, TCP RTT) [ms] | 8.4 | 12.9 | 25.1 |
| Response Time (Round Trip Time, ICMP RTT) [ms] | 587.0 | 707.7 | 1094.3 |

*Figure 8 Overview of the cnlab UXtest results at a Konnect VHTS terminal with 10/1 Mbps plan.*

The statistics in Figure 9 show, that the required average data rate is higher than 75% of the advertised data rate for the 80/8 Mbps plan VSAT tests. Hence, Eutelsat KVHTS also fulfills the requirements of the Swiss Federal Office of Communications (OFCOM) for 80/8 Mbps plans.




| | Minimum | Average | Maximum |
|---|---|---|---|
| Download speed [kbit/s] | 29'422 | 73'907 | 82'553 |
| Upload speed [kbit/s] | 1'831 | 7'809 | 8'600 |
| Response Time (Round Trip Time, TCP RTT) [ms] | 7.7 | 9.1 | 11.4 |
| Response Time (Round Trip Time, ICMP RTT) [ms] | 580.3 | 613.4 | 937.4 |

*Figure 9 Overview of the cnlab UXtest results at a Konnect VHTS terminal with 80/8 Mbps plan.*

A look at individual tests provides deeper insight into the performance situation on «Internet via Satellite» connections.

Figure 10 shows the download data rate for a single measurement (with 100ms resolution). The grey line (1) is for the download data rate measured at the reference system (server) side. The red dots (2) show the download data rate measured at the client (VSAT) side. From the download request it takes around 650ms until the first Bytes arrive at the VSAT side (3). The download data rate then increases according to the TCP slow start control. The receive window size (4) signaled to the reference server is constant at about 280kB, hence the window flow control is not slowing down the connection. There are no Duplicate Acknowledgements (DupAcksIn) arriving at the server side. This indicates that all data packets were correctly received and there is no need to retransmit Bytes (BytesRetrans).

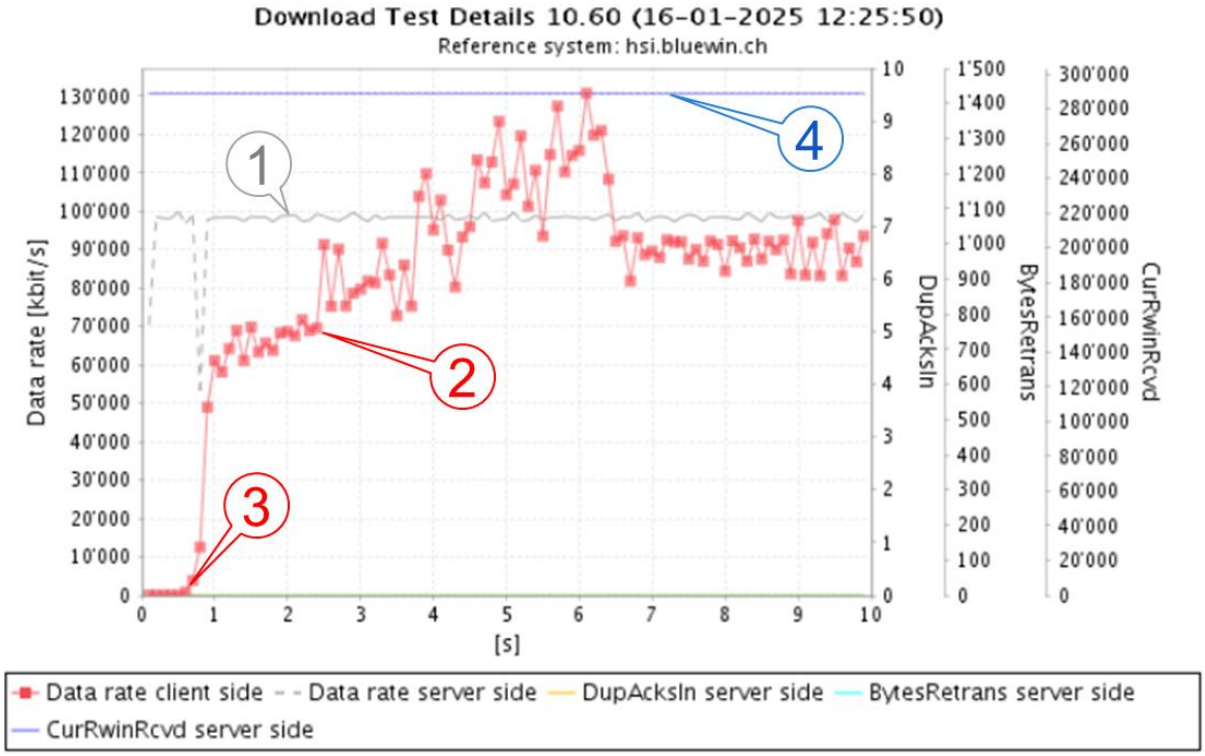



*Figure 10* *Download data rate for a single measurement of 10 seconds duration.*

Figure 11 shows the download data rate for a single measurement (with 100ms resolution) with packet losses. At around 3.8 seconds Duplicate Acknowledgements (DupAcksIn) arrive at the server side (1). The server retransmits Bytes (2) and TCP congestion control goes into slow start which leads to fewer Bytes being transmitted. The data rate at the VSAT side drops (4) which results in a lower data rate for this measurement. The reason for such packet losses is yet unclear. Eutelsat does not provide enough insight into their systems to do a deeper analysis.

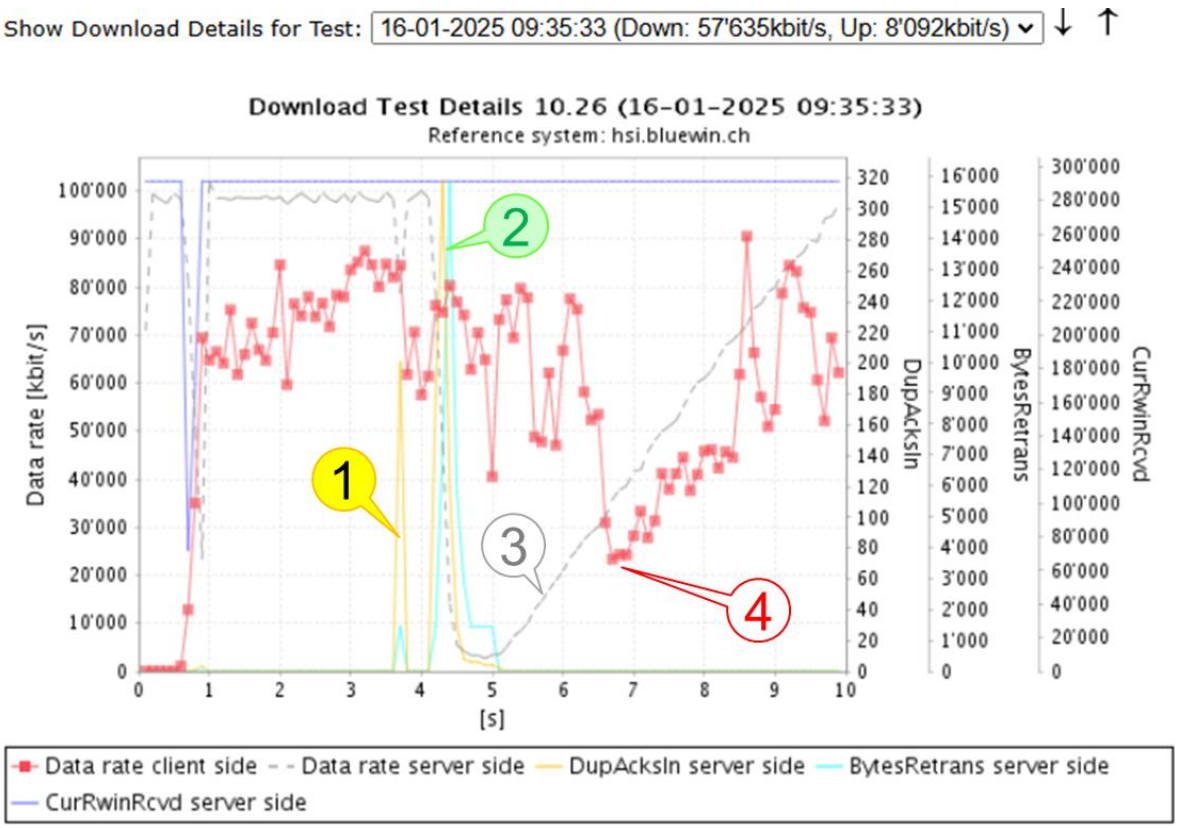



*Figure 11 Download data rate for a single measurement of 10 seconds duration when packet losses occurred.*

## 3.4 Performance Tests with cnlab Performance Benchmarking Probes

Cnlab provides performance benchmarking probes based on Odroid hardware with a 1 Gbps Ethernet interface. The probes contain special cnlab measurement software for data rate and response time measurements.

The following analysis of around 80'000 probe measurements from multiple monitoring probes provides deeper insights on the QoS of Internet via Satellite using the Konnect Very High Throughput (KVHTS) system. The results are for the year 2024.

### 3.4.1 Up- and Download Data Rate for probes with Eutelsat KVHTS 10/1 Mbps plan

With the 10/1 Mbps plan 90% of the measurements with four download and four upload TCP streams[2] achieved more than 849 Kbps upload and 9.7 Mbps download data rate (see Figure 12).

[2] Most Speed Test programs use multiple TCP-streams. Measurements with only one TCP-stream achieve lower data rates on links with packet losses.

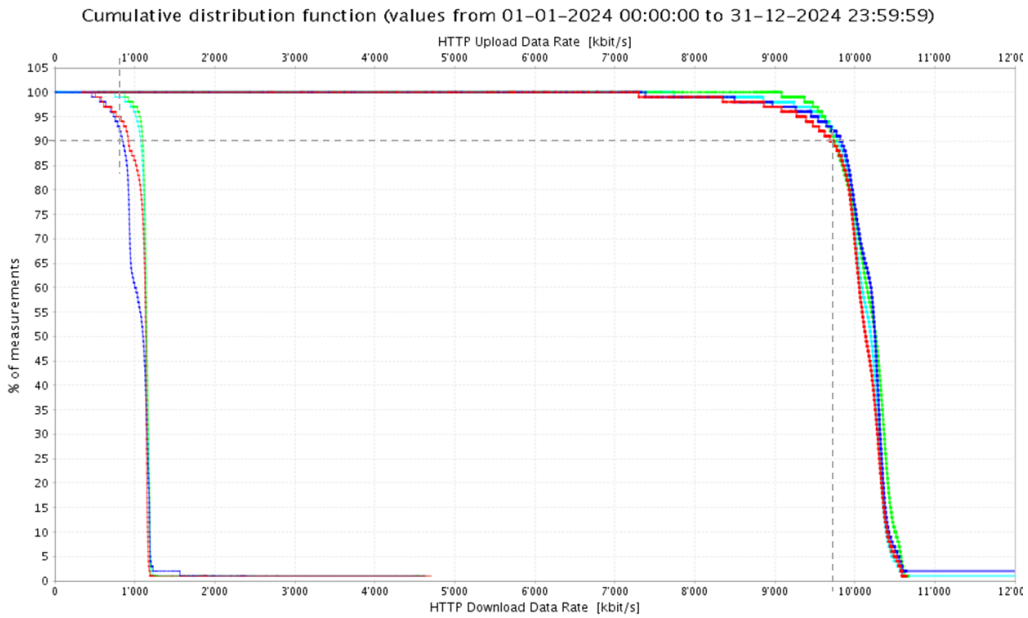



*Figure 12 Up- and download results (cumulative distribution) for three probes with Eutelsat KVHTS 10/1 Mbps plan.*

The Time-of-Day analysis of the results demonstrates that there were no overload situations (see Figure 13). In systems with overload situations, we would see drops during the busy hours.

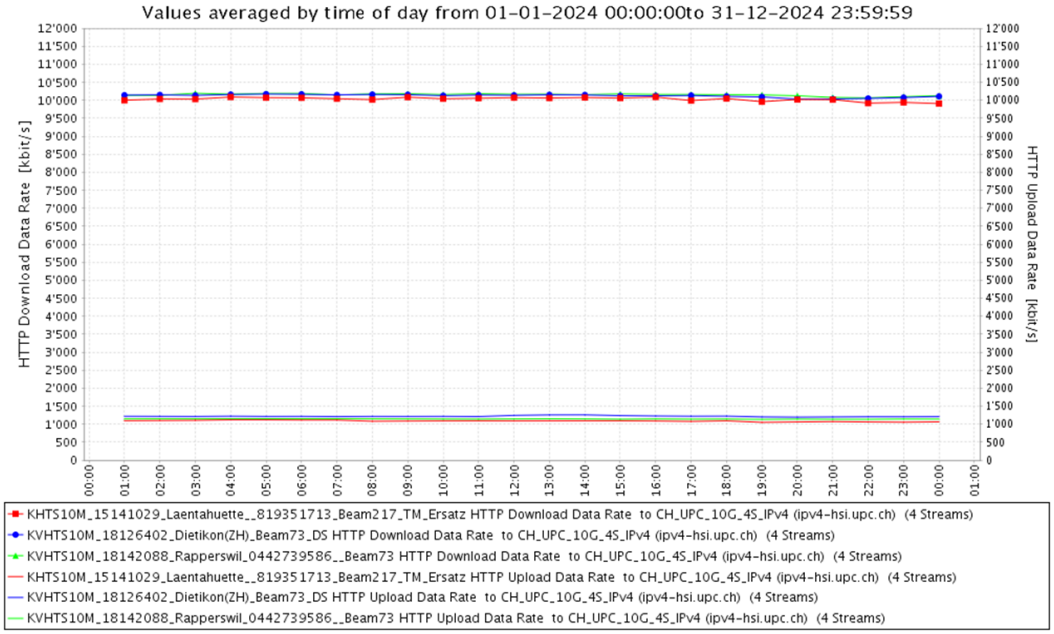



*Figure 13 Average Up- and download data rate by time-of-day for three probes with Eutelsat KVHTS 10/1 Mbps plan.*

### 3.4.2 Up- and Download Data Rate for probes with Eutelsat KVHTS 80/8 Mbps plan

With the 80/8 Mbps plan 90% of the measurements achieved more than 4.9 Mbps upload and 64.9 Mbps download data rate (see Figure 14).

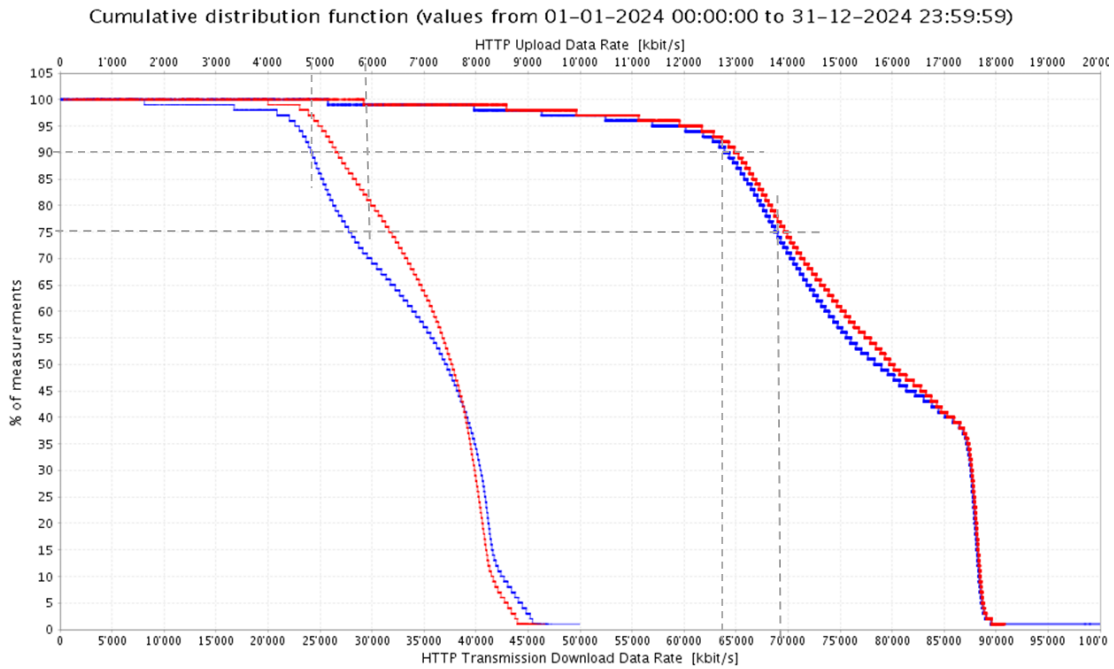



*Figure 14 Up- and download results (cumulative distribution) for two probes with Eutelsat KVHTS 80/8 Mbps plan.*

The Time-of-Day analysis of the results demonstrates that there were no overload situations (see Figure 15). In systems with overload situations, we see drops during the busy hours.

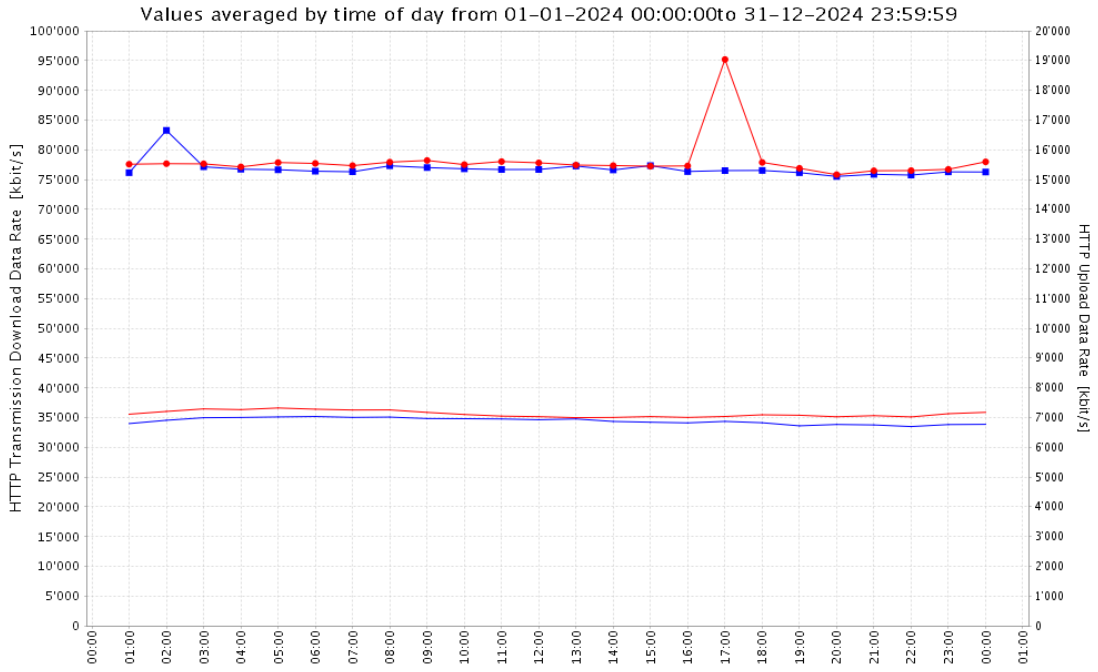



*Figure 15 Average Up- and download data rate by time-of-day for two probes with Eutelsat KVHTS 80/8 Mbps plan.*

### 3.4.3 Response Time

The ICMP response time (see Figure 16) was the most difficult parameter to control. There were several periods with higher values and not all VSAT always showed the same behavior. Eutelsat customer care provided several fixes without giving details about the reasons for abnormal

behavior. It looks like the response time problems had something to do with the configuration of the prioritization of packets.

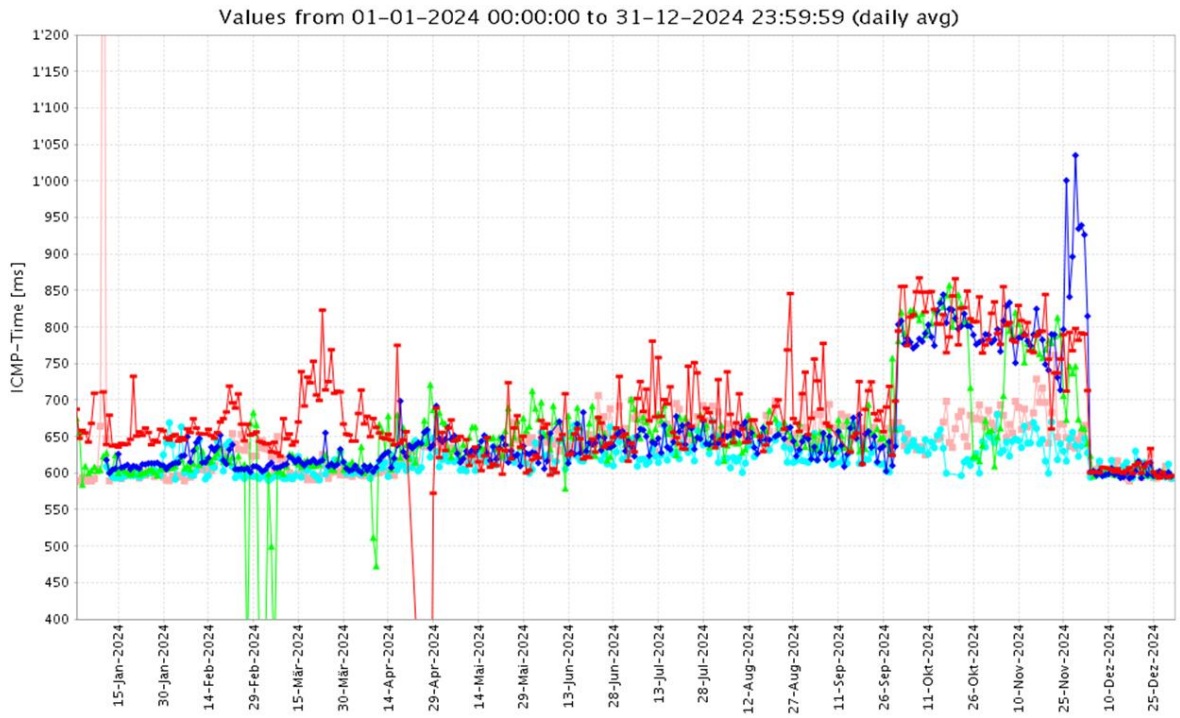



*Figure 16 ICMP Response Time (Round Trip Time, RTT) from a Reference System for five probes.*

### 3.4.4 Internet Service Availability

Internet Service Availability is determined by the percentage of successful ICMP Echo Reply (Ping) tests. The probes send every 12 seconds Ping tests to Swisscom reference systems, to checkpoints in the Eutelsat backbone and to other Internet checkpoints.

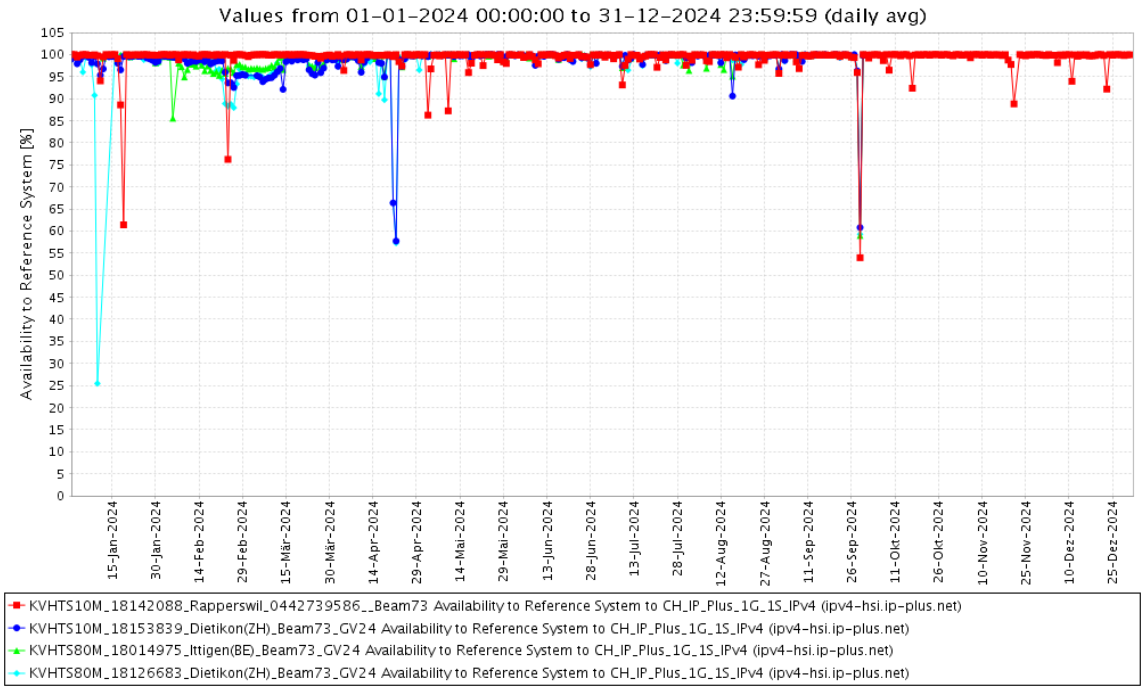



*Figure 17 Percentage of successful Pings to a Swisscom (ip-plus.ch) Reference System for four probes.*

The cnlab probes also determine “Minutes without any successful Ping test” which are counted as “Not-OK-Minutes (NOK)”. This is a great measure for service availability (see Figure 18).

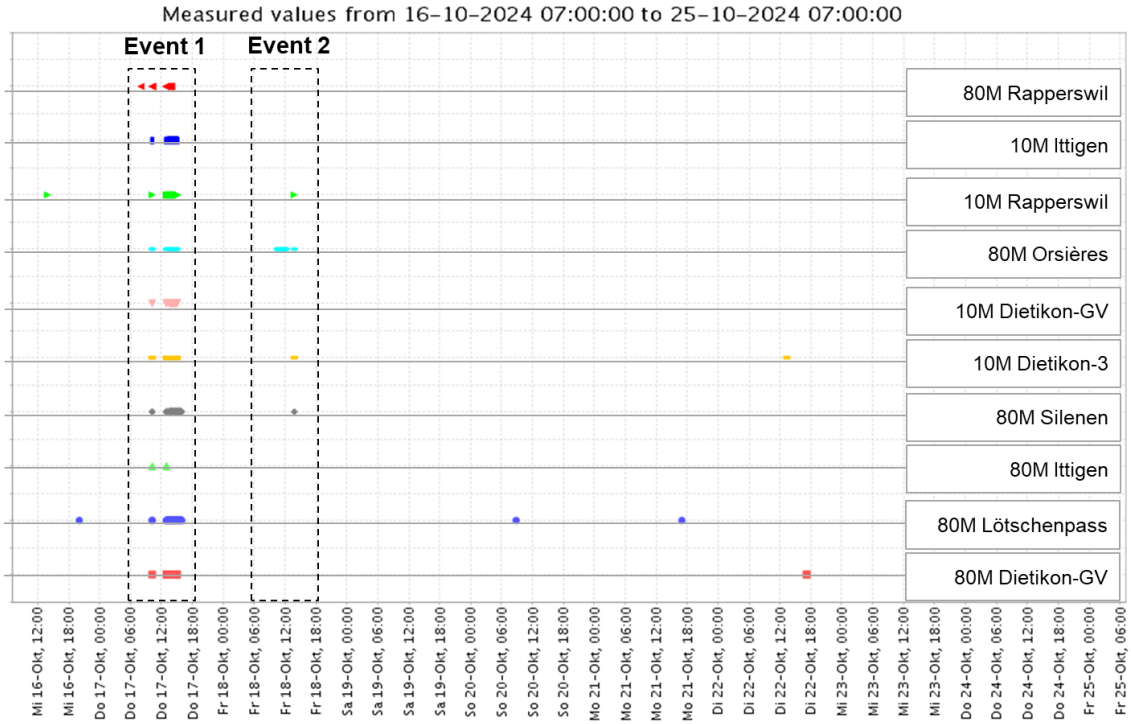



*Figure 18 Example of 10 Day Period Not-OK-Minutes.*

A probe may experience Not-OK-Minutes because of real issues in the satellite network affecting multiple terminals like maintenance, bad weather at the hub or gateway problems (see Figure 18 Examples Event 1 and Event 2). Other Not-OK-Minutes are due to local issues like reboots, power failures or local bad weather situations.

## 3.5 2024 Annual Report on Fulfillment of the OFCOM requirements

### 3.5.1 Internet Service (IPv4 Service) Quality

The fulfillment of the Swiss Federal Office of Communications (OFCOM) QoS requirements is monitored with cnlab probes measuring availability, down- and upload data rates and many other parameters 7x24. The results of the monitoring probes on Eutelsat KVHTS beam 73 for 2024 show that the Swisscom VNO service fulfills all requirements of the OFCOM for the 10/1 Mbps and for the 80/8 Mbps plan.

| **Internet Service via Satellite** | **Regulator's Requirement** | **Jan 24** | **Feb 24** | **Mar 24** | **Apr 24** | **Mai 24** | **Jun 24** | **Jul 24** | **Aug 24** | **Sep 24** | **Oct 24** | **Nov 24** | **Dec 24** | **2024 Overall** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Reporting Probes for Ping Response Time Measurements | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Service Availability [%]** | **≥ 98.9%** | **99.2%** | **97.4%** | **97.4%** | **99.1%** | **99.9%** | **99.6%** | **99.7%** | **99.5%** | **99.8%** | **99.6%** | **98.8%** | **99.8%** | **99.1%** |
| Number of Pings OK | | 674'240 | 825'186 | 861'776 | 799'957 | 892'516 | 801'009 | 833'692 | 728'055 | 772'699 | 739'184 | 714'299 | 774'949 | 9'417'562 |
| Number of Pings NOK | | 5'629 | 21'411 | 22'558 | 7'025 | 1'383 | 3'074 | 2'898 | 3'577 | 1'669 | 3'294 | 8'529 | 1'928 | 82'975 |
| **ICMP Ping Response Time (RTT) [ms]** | **( ≤ 650 ms )** | **603** | **617** | **614** | **621** | **631** | **639** | **651** | **648** | **642** | **730** | **726** | **611** | **647** |
| Number of Ping Response Time Measurements | | 26'889 | 32'803 | 34'433 | 37'913 | 47'463 | 42'135 | 45'667 | 37'369 | 44'769 | 44'118 | 42'889 | 47'296 | 483'744 |
| | | | | | | | | | | | | | | |
| **10/1 Mbit/s Profile Service** | | | | | | | | | | | | | | |
| Number of "Reporting Probes" (for Regulator Monitoring) | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **10/1 Mbit/s Download Data Rate Average [Mbit/s]** | **≥ 9 Mbit/s** | **10.0** | **9.4** | **10.0** | **10.1** | **10.1** | **10.0** | **10.1** | **10.1** | **10.0** | **10.0** | **10.0** | **10.1** | **10.0** |
| Number of Download Measurements | | 9'278 | 11'035 | 11'288 | 9'898 | 11'853 | 10'077 | 11'156 | 10'275 | 11'105 | 11'806 | 9'455 | 11'548 | 128'774 |
| **10/1 Mbit/s Upload Data Rate Average [Mbit/s]** | **≥ 0.9 Mbit/s** | **1.0** | **1.1** | **1.0** | **1.0** | **1.1** | **1.1** | **1.1** | **1.1** | **1.1** | **1.1** | **0.9** | **1.0** | **1.0** |
| Number of Upload Measurements | | 9'294 | 11'046 | 11'301 | 9'923 | 11'837 | 10'069 | 11'147 | 10'315 | 11'091 | 11'805 | 9'455 | 11'019 | 128'302 |
| | | | | | | | | | | | | | | |
| **80/8 Mbit/s Profile Service** | | | | | | | | | | | | | | |
| Number of "Reporting Probes" (for Regulator Monitoring) | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **80/8 Mbit/s Download Data Rate Average [Mbit/s]** | **≥ 60 Mbit/s** | **68.5** | **63.1** | **66.5** | **76.5** | **63.9** | **64.7** | **66.8** | **73.0** | **72.3** | **72.5** | **72.8** | **72.8** | **69.7** |
| Number of Download Measurements | | 4'264 | 5'349 | 5'760 | 8'409 | 11'759 | 10'475 | 11'594 | 8'103 | 10'988 | 10'113 | 10'843 | 11'661 | 109'318 |
| **80/8 Mbit/s Upload Data Rate Average [Mbit/s]** | **≥ 6 Mbit/s** | **6.4** | **6.8** | **6.9** | **6.5** | **6.4** | **6.0** | **6.0** | **7.5** | **7.6** | **7.6** | **7.5** | **7.2** | **6.9** |
| Number of Upload Measurements | | 4'269 | 5'366 | 5'759 | 8'460 | 11'751 | 10'493 | 11'588 | 8'190 | 11'002 | 9'308 | 10'846 | 11'084 | 108'116 |

*Table 4 «Internet via Satellite» performance benchmarking results for Eutelsat KVHTS on beam 73.*

The regulator allows Swisscom to exclude measurements during special event periods (e.g. bad weather conditions, hardware and software failures, planned maintenance).

There were a few months with lower service availability values and with higher response time. Together with Eutelsat customer care those problems could be solved so that the requirements for the whole year could be fulfilled.

### 3.5.2 VoIP Service Quality

The VoIP service quality is monitored by Swisscom with dedicated Voice Quality Test Systems from Mobileum (formerly SIGOS) [15] performing active real-time end-to-end testing. The VoIP Connections setup time is around 2.5 seconds. The calculated Mean Opinion Score (MOS) value is around 4.3. The one-way audio delay is around 330ms. These results show, that the VoIP Service on KVHTS fulfills the requirements of the Swiss Federal Office of Communications (OFCOM). However, there were terminals with VoIP intelligibility problems. In order to solve these problems interactions of Eutelsat engineering were needed.

# 4 USER EXPERIENCE WITH KONNECT HTS AND MOBILE INTERNET

## 4.1 USED INTERNET SERVICES

User experience depends on much more than just download, upload data rates and round-trip times. User experience basically depends on the availability and responsiveness of the Internet services (applications) used.

A survey of universal service subscribers about user experience with Internet via Konnect HTS satellite and with Internet via mobile networks in 2023 with about 60 respondents gives coarse indications about user experience.

The following Internet services are important for the Swisscom universal service subscribers:

- More than 90% use **telephony, web (surfing) and e-mail**.
- More than 50% of the respondents use **messaging** (e.g. WhatsApp) and **Internet Radio**.
- **Video streaming** is used by 40% of respondents with mobile and 60% of the respondents with satellite network.
- **Conferencing services** (e.g. Teams, Zoom) are used by 20% of the respondents with mobile and 40% of the respondents with satellite network. The higher proportion of satellite connection conferencing users is because they live in very remote locations where office work and learning is only possible via Internet.
- Universal service subscribers running businesses like restaurants, hotels or alpine cabins need reliable **Point-of-Sale (POS)** and **online reservations services**. They also rely on the availability of **remote control** and **remote access services** (e.g. monitoring and control of solar systems).

## 4.2 PERCEIVED QUALITY OF INTERNET SERVICES

The rating of the respondents about the quality of their Internet services, averaged across all services shows a mediocre rating and a surprisingly small difference between mobile (3.7) and satellite connections (3.0).

It is possible that certain problems are due to local settings or to service provider's side settings and therefore occur with both mobile network and satellite connections. But it may also be that people are reluctant to give "very good" ratings. A comparison with a similar survey of users of fixed network connections (fiber optic and copper cable) would be interesting but could not be done yet.

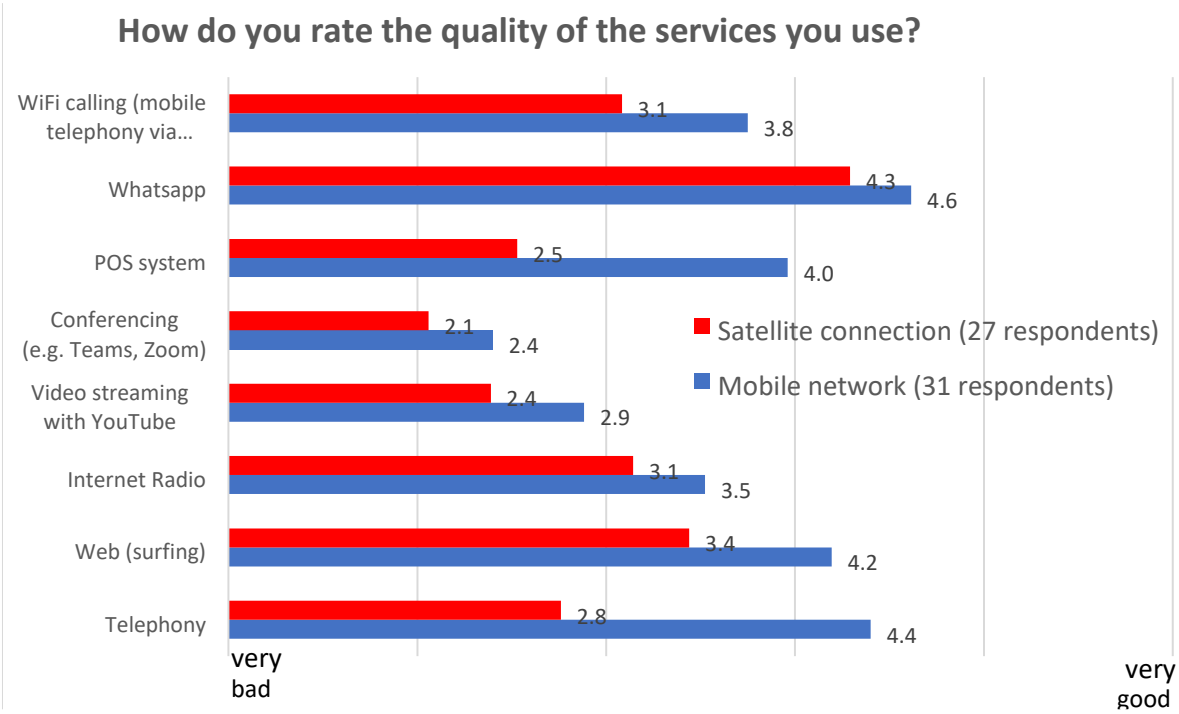



*Figure 19 Assessment of the quality of the services used from "1 = very poor" to "6 = very good".*

Qualitatively the results confirm the expectations:

- **Web (surfing):** The better rating for mobile network connections than for satellite connections is in line with slower response times due to the high round trip time for connections via geostationary satellites.
- **Telephony:** The significantly lower rating for telephony with satellite connections is due to the initial configuration problems of the satellite provider. In the meantime, the telephone does also work well with satellite connections. The complaints were about VoIP-service interruptions, dropped calls and situations where callers could hardly understand the other party. To our surprise there were no complaints about high latency i.e. 650ms response time. In our own “blind test” calls the called parties only realized the latency when we told them, that this was a call via satellite.
- **WhatsApp:** WhatsApp works similarly on mobile and satellite connections, which is confirmed by the results of the surveys.
- **Internet radio:** Internet radio works similarly on mobile and satellite connections, which is confirmed by the results of the surveys.
- **Special Applications:** There are special applications that have problems with long response times (e.g. certain point-of-sales (POS) and Virtual Private Network (VPN) applications). Some of these problems could be solved by the service providers by adopting applications timeouts.
- **Video streaming:** Video streaming requires different download data rates depending on the picture resolution. For the lowest picture resolution, 0.7 Mbps (standard definition, SD, 360p) is sufficient. Higher image resolutions require 1.2 Mbps (standard definition, SD, 480p), 5 Mbps (high definition, HD, 1080p) and 20 Mbps (ultra-high definition, UHD, 4K). Most video streaming applications automatically adjust the resolution to reduce the data rate when necessary. Unfortunately, not all video streaming programs can cope with the high round trip times of geostationary satellite connections. While some

reduce the resolution unnecessarily (e.g. Play SRF), others only deliver stuttering images (e.g. Zattoo). YouTube works very well even with high round trip times.

The surveys show that the basic service via the mobile network has advantages over the geostationary satellite solution. But the surveys also show that Internet via geostationary satellites can provide satisfactory user experience.

It is important to note that measuring Internet packet transmission quality (download, upload data rates and response time) is not sufficient to determine user experience. Operators must also check how various Internet applications work. However, the quality of experience with Internet applications also depends on subscribers' local settings, which are beyond the control of the Internet service provider. A case-by-case assessment of these problems is very important but time-consuming.

# 5 CONCLUSIONS

From "17-years" experience with Internet via GEO satellites we learned that it is always possible to achieve acceptable user experience. Due to the regular data rate requirements increases Swisscom had to switch to the most modern satellite system about every four years. Hence, the systems were brand new, and it took some time to manage the teething troubles. In some cases, we achieved an open and fruitful collaboration with the key developers of the system providers. In other cases, we had to operate without detailed information about the systems. In those cases, we had to wait until the system providers presented new configurations and software releases.

The Eutelsat KVHTS platform became fully operational beginning 2024. Thanks to thorough system monitoring and continuous exchange with Eutelsat customer care all requirements of the Swiss Federal Office of Communications (OFCOM) could be fulfilled achieving a good user satisfaction.

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