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Satellite Internet Performance Measurements

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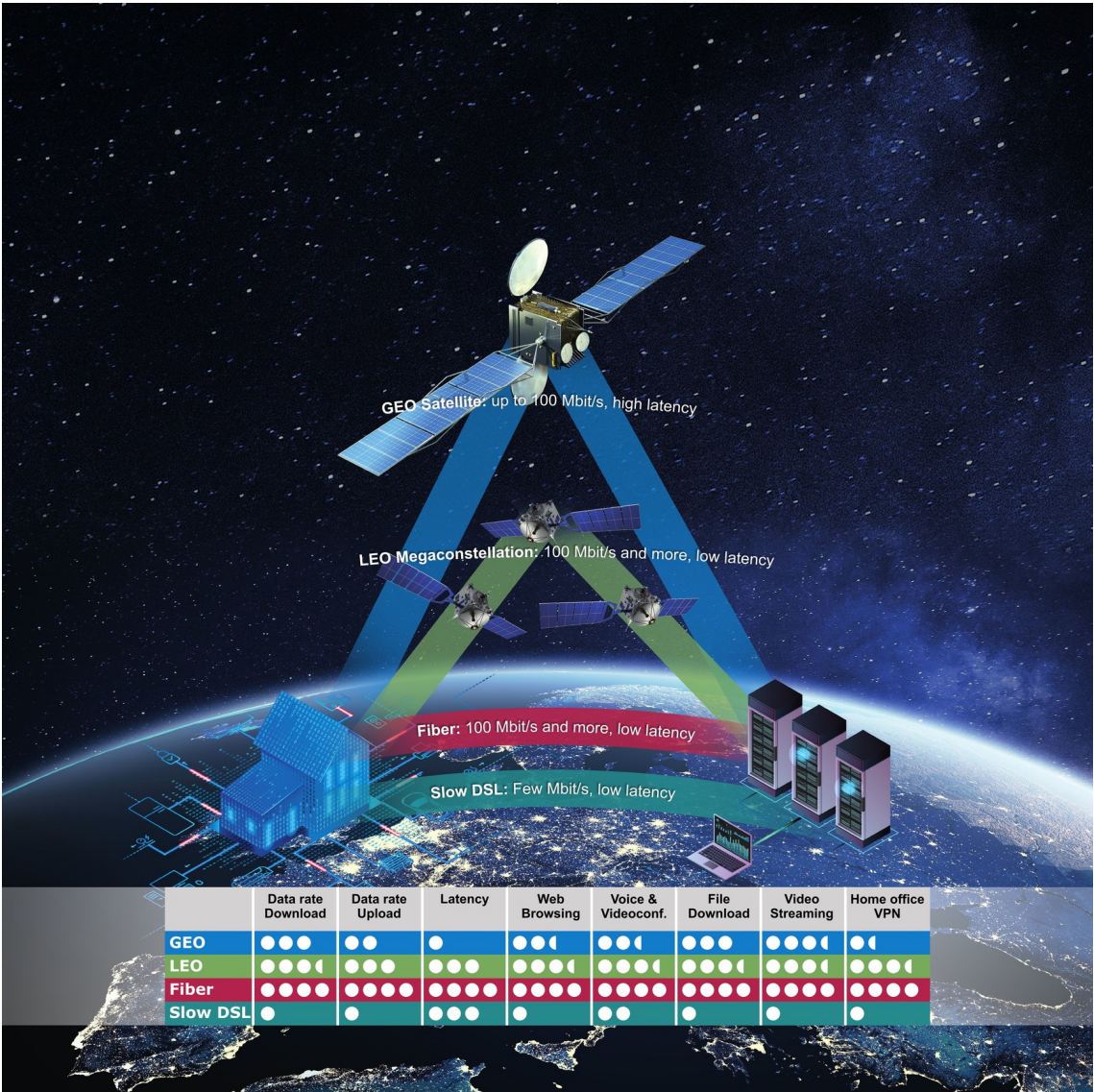


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Executive Summary

This report evaluates the performance of different applications over different Internet access technologies, with focus on Internet access via satellite.



Rating of different applications over different Internet access technologies based on measurements done by FAU Erlangen-Nürnberg. Image copyright: Deutsches Zentrum für Luft- und Raumfahrt.

The following Internet access technologies and operators have been selected for evaluation:

- Geostationary satellites (GEO)
Konnect/Eutelsat, skyDSL/Eutelsat, Bigblu/Eutelsat, Novostream/Astra Connect
- Satellite megaconstellations in low Earth orbit (LEO)
Starlink
- Terrestrial systems as reference
o2 DSL, Congstar LTE

Internet access via satellite, like terrestrial Internet access, is based on the Internet Protocol (IP), which means that all Internet applications and Voice over IP can be used in principle. The data rates of the selected systems are roughly comparable. One notable difference between geostationary satellites (GEO) and other systems is the high signal propagation delay and thus latency, which can affect the performance of applications.

Geostationary Satellites

The evaluation of applications using geostationary satellite Internet access is summarized as follows:

Application	Rating	Remarks
E-mail	⊕⊕	Full performance
File downloads, software updates	⊕⊕	
Video streaming	⊕⊕	
Web browsing	⊕	Minor performance degradation
Voice over IP, video conferencing	⊕	
Virtual Private Network (VPN)	○	Performance degradation
Latency-critical applications	⊖	Unusable or severe performance degradation; depends on specific application

- Full performance

E-mail, file downloads, software updates, video streaming

The high latency is irrelevant for these applications, Internet access via geostationary satellites can be used without restrictions. The data rates are sufficient for high-resolution video streaming.

- Minor performance degradation

Web browsing, voice over IP (VoIP), video conferencing

For these applications, the higher latency can have an impact on performance. An Internet connection with a high data rate and low latency loads a website within a few seconds while loading a website via a geostationary satellite connection can take several seconds. In the subjective perception of a user, this might be irrelevant.

VoIP achieves high voice quality and video conferencing is practicable. This was rated based on data rate, latency, and VoIP results. Referenced literature shows that with high latency some users are dissatisfied.

- Performance degradation

Virtual Private Networks (VPNs)

VPNs are an important application for home office users. Stable VPN connections are possible, but due to the design and parameters of Internet protocols and the system architecture of geostationary satellite networks, the performance of common VPN software can be problematic. The high latency impacts interactive tasks (e.g., navigating the file system) and also results in low data rates (especially at the beginning of transmissions).

- Unusable or severe performance degradation; depends on specific application

Latency-critical applications

Latency-critical applications (e.g., online multiplayer games or cloud gaming) are not usable in general.

When using VPNs and, to a lesser extent, with web browsing, VoIP, and video conferencing, terrestrial Internet access with low data rate and low latency may achieve better performance than geostationary satellite Internet access with high data rate and high latency, however, it is difficult to specify a threshold value regarding data rate and latency. For applications like file downloads, software updates, and video streaming, Internet access via geostationary satellites offers significant advantages compared to low data rate connections.

Satellite megaconstellations in low Earth orbit

Compared to geostationary satellites, megaconstellations in low Earth orbit (LEO) have low signal propagation delays and thus latency. Such mega-constellations are currently being planned and tested for broadband Internet access. SpaceX's Starlink currently runs a public beta test for its new satellite megaconstellation and was also included in this measurement campaign. First results show that low latencies and high data rates can be achieved, similar to terrestrial systems. Yet there are fluctuations in the achieved data rates, therefore it is important to carry out further measurements in the near future. The costs for hardware, monthly fees, and power consumption are currently rather high compared to other German broadband providers.

General remarks

Hardware und installation: Geostationary satellite systems require a parabolic antenna with direction to the south. One provider includes assembly and mounting, other providers include instructions on how to set up the hardware or offer contacts for setting up the antenna by specialists (additional charges apply). The Starlink antenna requires a clear 360-degree view towards the sky which can be checked using a smartphone app. All providers provide a modem or router to connect one or more PCs.

Shared resources: With radio-based systems (GEO and LEO satellites, LTE), multiple users share existing resources). As an effect, when the network load is high, there may be bottlenecks and reduced data rates. Besides the network capacity, this effect depends on the location, tariff, and the number of participants. During our measurement campaign, it was possible to observe time-dependent bottlenecks due to shared resources. However, a solid assessment would require large-scale measurements.

Weather-dependent performance: Two geostationary satellite networks suffered from a degradation in performance due to heavy snowfall in early February 2021. Despite that, no other weather-related impacts were measured.

Disclaimer: All Internet access services were ordered non-anonymously in the name of the FAU. Due to the limited selection of providers/tariffs, location, and time period, the measurement results presented in this report describe the current state of broadband access systems. Moreover, computer networks and applications are subject to continuous changes which can alter the outcomes of experiments.