Viasat response to the Body of European Regulators of Electronic Communications (BEREC) draft report on the use of satellite broadband for universal service (Consultation)

15 August 2022

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Introduction

Viasat applauds the Body of European Regulators of Electronic Communications (BEREC) for recognizing the benefits of connecting the unserved and underserved in Europe with satellite broadband. The economic benefits of connecting to the Internet are clear. Satellite broadband has unique advantages in delivering broadband services—including the ability to efficiently deliver a quality broadband user experience in an expeditious, cost-effective manner to unserved and underserved populations. As Europe considers the appropriate support to promote the extension of broadband, Viasat also encourages Europe to focus efforts on improving the adoption of services by the end user.

To support Viasat's response to the Consultation, please find the enclosed "Assessment of Geostationary Satellite (GSO) Satellite Capabilities vs. Alternative Internet Access Technologies," prepared by Roberson & Associates ("Roberson Report"), to demonstrate how geostationary satellite orbit (GSO) delivered broadband is a proven, reliable way to expand broadband connectivity that surpasses the "gold standard" for broadband consumers' technical requirements for critical broadband applications. In addition to the Roberson Report, Viasat includes a video that demonstrates the ability of GSO satellites to deliver quality broadband using the applications outlined in Annex V Directive (EU) 2018/1972 ("Annex V"). Annex V outlines "a minimum set of services which the adequate broadband internet access service shall be capable of supporting."

By way of background, Viasat is a global communications company that connects homes, businesses, governments, and militaries with high-speed broadband services and secure networking systems. We extend critical broadband connectivity to the unserved and underserved locations in many areas at a much lower cost per home served than many other technologies, quickly extend service to the hardest to reach communities (typically within a day) and provide consistently high-quality and reliable broadband services. As an example of Viasat's ability to deliver broadband in areas like those that BEREC is addressing in Europe, Viasat has received accolades for providing high-quality broadband service to rural areas.[1]

Throughout the COVID-19 pandemic, we were proud to support many millions of hours of critical broadband applications, such as telemedicine, distance learning, video streaming,

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[1] *See, e.g.*, Sarah Shelton, Best Internet Service Providers of 2021, U.S. News & World Report (Apr. 28, 2021), https://www.usnews.com/360-reviews/internet-providers (naming Viasat to as one of the top internet service providers (ISPs) in the United States); David Anders, The Best Rural Internet Providers of 2021, CNET (Apr. 7, 2021), https://www.cnet.com/home/internet/best-rural-internet/ (naming Viasat the best satellite provider of 2021 for rural connectivity in the United States); Kristin Toussaint, Here's how one company is delivering the internet to remote villages, Fast Company (Apr. 28, 2020), https://www.fastcompany.com/90490840/heres-how-one-company-is-delivering-the-internet-to-remote-villages (including Viasat in Fast Company's 2020 World Changing Ideas list).

video conferencing, voice, interactive applications, social networking, web (including online sales), messaging (including email), file transfer, security, cloud services, and internet of things applications. The applications that Viasat supported during the pandemic are consistent with the applications outlined in Annex V.

Today's GSO Ultra High Throughput ("UHTS") satellites make it possible to provide cost-effective high-speed broadband to customers featuring increased speeds, dramatically increased capacity, and smaller end-user terminals.

Viasat is completing construction of our UHTS ViaSat-3 satellite for Europe, delivering a total throughput of over 1 Terabit per second. Each of our next-generation UHTS ViaSat-4 satellites under development will offer 5-7 times that amount of throughput.

As explained in the Roberson Report, GSO satellite technology surpasses consumer expectations for mission critical broadband applications[2] (including those discussed above) and is capable of doing so at speeds in excess of 150 Mbps; with extremely low jitter and packet loss; and with coverage of 100 percent of Europe.[3] And, as the Roberson Report concludes, GSO technology handles these tasks in a manner where the end-user's flow of thought stays uninterrupted and the end-user's attention stays focused without distraction.[4]

Critically, GSO technology also exceeds the gold standard for consumer applications for key latency requirements.[5] This includes transmission time, queueing delay, processing time at the source, destination and intermediate switches, buffering delay at nodes, and packet retransmission - both at the link level and end-to-end.[6] In other words, GSO broadband access technology solutions meet the gold standard for latency criteria in every critical user application when properly analyzing latency within the full context of the entire network path. As the Roberson Report makes clear: "The key requirement is that an access technology meets the application requirement when all delay elements are considered."[7] Focusing on one limited element of latency, such as link or propagation delay over one discrete element of the network, is not an independently accurate assessment that reflects internet users' experience.[8]

The Roberson Report also concludes, accurately, that no one internet access technology solution "uniformly dominates the rest along various metrics."[9]

There are tradeoffs for all technologies for universal service. Thus, all technologies, including GSO satellites, should be considered to achieve the goal of universal service.

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2 *See*, "Assessment of Geostationary Satellite (GSO) Satellite Capabilities vs. Alternative Internet Access Technologies," prepared by Roberson & Associates ("Roberson Report") (15 August 2022), at 2.

3 *Id.* at 13.

4 *Id.* at 11.

5 *Id.* at 16.

6 *Id.*

7 *Id.* at 16 (emphasis added).

8 *Id.*

9 *Id.* at 2.

There is limited funding that is available for universal service, and it needs to be spent wisely. To that end, Viasat encourages BEREC to consider the following when implementing universal service programs in member states:

- Subsidies should fund broadband service that can satisfy the needs of EU citizens like those outlined in Annex V.
- Subsidies should not skew the market by picking winners and losers but rather should improve the user experience by encouraging all technologies to compete for the opportunity to provide broadband to EU citizens.
- Subsidies should be applied to proven, viable business models that are not solely reliant on subsidies for their viability.

User Experience

Real-time User Experience of Annex V Applications + Video Streaming

As stated earlier, Viasat has been proud to deliver countless hours of the applications outlined in Annex V to many hundreds of thousands of our existing customers. A demonstration video of the user experience over Viasat's GSO broadband system, providing speeds in excess of 100 Mbps, can be found here[10] and a chart of the applications demonstrated can be found below in Figure 1.

Application	Application Provider
Email	Google Mail (Gmail)
Search	Google
Online newspapers	Euronews
Buying online	Amazon
Job search	Manpower
Professional networking	LinkedIn
Internet banking	BofA
eGovernment service use	Poste Italiane (Poste.it)
Social media instant messaging	Instagram
Video VoIP Calls	Zoom
Video Streaming	YouTube

Figure 1: Real-time experience applications

As you can see in the video demonstration of the real-time applications, GSO satellites like those of Viasat deliver a quality user experience, as detailed in the Roberson Report.

Evaluating the User Experience; Technology tradeoffs.

There are tradeoffs for all technologies considered for universal service. Fibre and other terrestrial based technologies are cost prohibitive to deploy in some markets where satellite is more affordable and efficient due to its rapid deployment and superior coverage ability. Viasat respectfully disagrees with the suggestion that satellite technology has limited capacity.[11] Satellite technology is scalable to meet the demands of the marketplace, just like every other technology, including fiber and terrestrial wireless. Viasat also respectfully disagrees with the suggestion in the Consultation that GSO satellites cannot provide a good end user experience[12] for the reasons provided above. Below, Viasat highlights additional points for BEREC to take into consideration when evaluating the use of satellite technology for universal service.

Strengths of GSO

Coverage. As the Consultation points out, satellite coverage of Europe is strong and is only growing. ViaSat-3 will cover 100% of the European territory 100% of the time. In contrast, and as pointed out in the Roberson Report, the capacity of one particular LEO system that is over the European territory will be a mere 1.25% of its total system capacity.[13]

Rapid deployment. Another satellite's strong point is rapid, trenchless deployment. Satellite broadband can be provisioned to almost any location in less than a day, avoiding the extended provisioning times featured in terrestrial based solutions.

High performance including 100 Mbps plus speeds. GSO satellites like those at Viasat are capable of over 100 Mbps speed today. We expect to continue to provide competitive offerings to meet the performance needs of end users in Europe.

Capacity, capital efficiency. As mentioned earlier, GSO satellites like ViaSat-3 will offer unprecedented total capacity of 1 Terabit per second per satellite and the next generation is planned to offer 5-7 times that level of throughput in a single satellite.[14]

Satellite innovation: capacity density. GSO satellites like ViaSat-3 cover 100% of the European territory 100% of the time and are designed to deliver targeted broadband to unmet demand like the European locations BEREC seeks to connect with universal service. Also, GSO satellites feature steerable beams that can target capacity to where it is needed. Finally, GSO satellites intensively reuse spectrum to increase capacity. All these innovations are strengths of GSO satellites.

Resiliency and satellite's ability to operate during a natural disaster. With little dependence on ground infrastructure, satellite technology operates through a natural disaster for our existing customers and delivers broadband to end users in a natural disaster when terrestrial-based services are down. As the Consultation points out, "Satellite services may serve as an

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11 Consultation: "Draft Report on Satellite Connectivity for Universal Service" (BEREC BoR (22) 83 (9 June 2022), Section 2.2.2 Page 8 https://www.berec.europa.eu/en/public-consultations/ongoing-public-consultations-and-calls-for-inputs/public-consultation-on-the-draft-berec-report-on-satellite-connectivity-for-universal-services,

12 Consultation, Section 2.1.6, Page 7.

13 *Id*. at 14.

14 Consultation, Section 3.1.5, Page 19.

immediate fallback in case of terrestrial network breakdown (e.g., for disasters relief purposes but also to provide network access to the people in disaster-struck areas)."[15]

Evaluating the User Experience

Many factors impact the user experience.[16] The most important factor is how a particular network is designed. Relevant factors that should be taken into account in how the network is designed to include speeds offered, data allowances, the ability to support real-time applications, jitter, packet loss, service interruptions/availability, price, and end-to-end latency including transmission time, queueing delay, processing time at the source, destination, and intermediate switches, buffering delay at nodes, and packet retransmission.[17]

Viasat would like to highlight the following points to address the focus in one part of the Consultation on link latency, or propagation delay, in the path to and from an end user to a satellite. Focusing on one limited element of latency, such as link or propagation delay over one discrete element of the network, is not an independently accurate assessment that reflects the internet users' experience.

Latency across the total communications path. When considering latency, Viasat emphasizes that the potential for introducing latency at every point in the communications path to and from the Internet should be considered, rather than focusing on simply link latency. As Figure 2 below from the Roberson Report outlines, latency can be introduced at many points in the communications path of all modern communications systems, regardless of technology used. The components of end-to end latency include transmission time, number of hops in an end-to-end communications path, queuing delay at nodes, processing time at source destination and switches, propagation, buffering delay, and packet retransmission delay.[18]

15 Consultation, Section 2.4.1, Page 7.

16 *Id*. at 2.

17 *Id.* at 16.

18 *Id.* at 16.

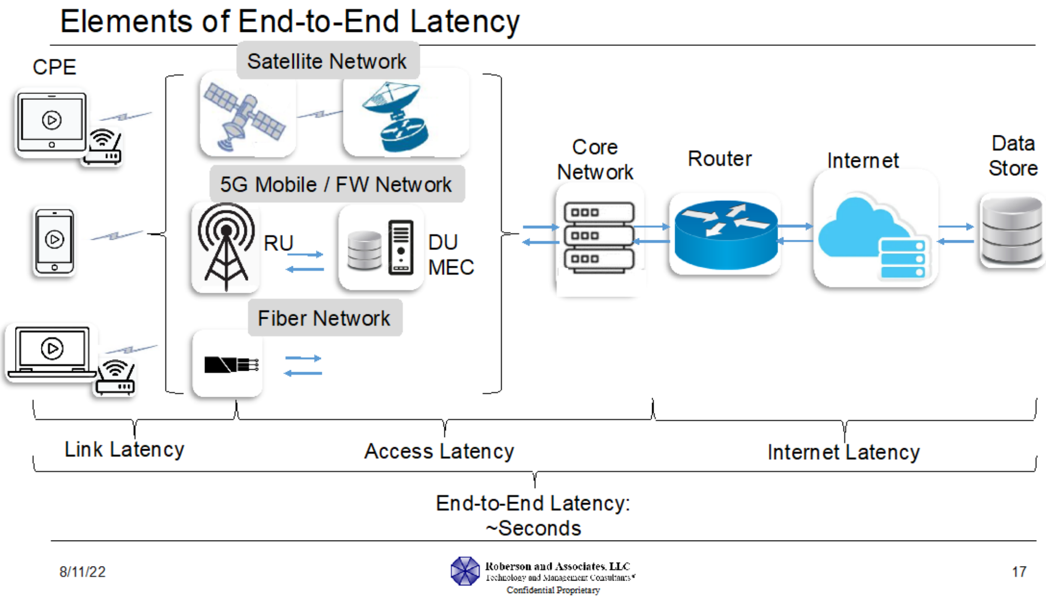

Figure 2: Elements of end-to-end latency

Modern GSO satellites are designed to offset latency. As the video described above demonstrates, modern GSO satellite systems are designed to offset the impact of latency on the user experience with a number of innovations including addressing congestion with unprecedented increases in capacity, network management tools including machine learning and artificial intelligence, and increasing VoIP quality using scheduling traffic algorithms and enhancing the codec to efficiently encode/decode signals. This innovation operates at all phases of the end-to-end communications path and provides the user experience shown in the video demonstration.

Video dominates Internet traffic and is not latency sensitive. For most applications including the real-time video applications in Annex V, the latency simply does not matter. As the Roberson Report states, video is the dominant use of Internet bandwidth at 53.72% globally as measured in the first half of 2021.[19] For Europe, the Digital Economy and Society Index (DESI) 2020 states that video on demand grew from 21% to 31% between the DESI 2018 and 2020 DESI reports and video calls grew 46% to 60% between the same DESI report period.[20] To match user demand and to maintain quality of service, it should be noted that Viasat's GSO satellites are specifically designed for video applications. The quality of video is demonstrated in the real-time user experience video discussed earlier.

[19] *Id.* at 10.

[20] *Id.* at 5.

Environmental Impact

We applaud BEREC for considering the environmental impact of communications technology on universal service deployment. In space, there are several concerns related to the dramatic growth in NGSO satellites. An example of this concern was outlined in the Dutch response to the BEREC questionnaire which included concerns about space debris due to the number of NGSO satellites and their short design lives.

The EU economy and society are increasingly reliant on space services (such as location services, satellite-based media services, weather forecasting, and emergency services). For example, approximately 10% of the EU's GDP – more than €1,100 billion – is enabled by satellite navigation signals.[21] This growing reliance of GDP on space comes with the need to avoid and mitigate risks of disruption to space-based assets and infrastructure.

The increase in the number of space objects – from 2,000 active satellites in late 2018 to approximately 4,000 today and likely 100,000 or more by the end of the decade– a growing amount of orbital debris, and the resulting growing congestion in certain NGSO orbits increases the likelihood of collision events that can disable and even destroy satellites, and also generate more orbital debris.[22] Each collision will statistically lead to more collisions and ultimately can lead to a "belt of debris around the Earth,"[23] leading to a series of self-sustaining collisions referred to as the Kessler syndrome, which could make certain orbits unusable for critical civil, military and commercial space services. One notable study commissioned by the U.S. National Science Foundation (NSF) indicates that it may not be feasible to sustain the deployment of one large NGSO system over time because of these dynamics. That NSF study forecasts a dramatic increase in both space collisions and new debris, starting within just a few years. In the longer term, "satellites are destroyed [by collisions with debris] faster than they are launched."[24]

Collision and orbital debris generation risks also are materially affected by the mass and cross-sectional area of NGSO satellites, as well as just the number of satellites in a constellation and the particular orbits they employ.[25] BEREC therefore should encourage European regulators at the market access stage to: (i) require NGSO applicants to disclose

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21 *See* European Commission, Commission Staff Working Document, Impact Assessment, Proposal for a Regulation of the European Parliament and of the Council, establishing the space programme of the Union and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013, (EU) No 377/2014 and Decision 541/2014/EU (6 June 2018), EUR-Lex - 52018SC0327 - EN - EUR-Lex (europa.eu).

22 *See* "The case for space environmentalism," (22 April 2022), https://www.nature.com/articles/s41550-022-01655-6.

23 *See* "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt," by Donald Kessler and Burton Cour-Palais.

24 *See* G. Long, "The Impacts of Large Constellations of Satellites," JASON – The MITRE Corporation, JSR-20-2H, Nov. 2020, (Updated: Jan. 21, 2021), at 97, https://www.nsf.gov/news/special_reports/jasonreportconstellations/JSR-20-2H_The_Impacts_of_Large_Constellations_of_Satellites_508.pdf.

25 *See* M. A. Sturza and G. Saura Carretero, 2021 Advanced Maui Optical and Space Surveillance Technologies Conference (AMOS), "Design Trades for Environmentally Friendly Broadband LEO Satellite Systems," (2021), https://amostech.com/TechnicalPapers/2021/Poster/Sturza.pdf.

those values so the aggregate risk presented by a constellation can be evaluated, and (ii) require that an applicant not make changes that increase the mass or cross-sectional area of its satellites, the number of its satellites, or the orbits it plans to use, without providing notice to and obtaining approval from the member state regulator. This information is essential to allow the calculation and management of an NGSO constellation's total contribution to collision and orbital debris risk.

As a recent report by the EPFL International Risk Governance Centre emphasizes, it is imperative that preventative action be taken now at the national level, because we just will not reach international consensus in the short term on a new framework for regulating large NGSO constellations.[26] Viasat urges BEREC and member state regulators to consider space safety and sustainability in relation to any current and future NGSO license applications and take appropriate action at the licensing stage to mitigate risks associated with large NGSO systems.

We also note the growing calls for assessing the impact of NGSO constellations on climate change, radio and optical astronomy, and the dark and quiet night sky.[27][28] As to concerns with the effect on climate change of the increasing numbers of satellite launches required to launch and sustain NGSO constellations,[29] a few points bear emphasis.

- A single GSO satellite covering Europe within a year (ViaSat-3) will provide over 1 Tbps of throughput and require a single launch over its 15-year design life.
- To provide an equivalent amount of throughput over Europe,[30] one particular NGSO constellation will require 4,408 satellites and over 90 launches just to deploy, and an untold number of additional launches to fully replace each of its satellites every five years over the same 15-year time period.[31]
- That same operator seeks authority to deploy a total of over 34,000 NGSO satellites, which would involve deploying approximately 90,000 (or more) satellites over 15 years, using a launch every six days.[32]

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[26] *See* Buchs, R., "Policy Options to Address Collision Risk From Space Debris," Lausanne: EPFL International Risk Governance Center (2021).

[27] *See* "The case for space environmentalism," (22 April 2022), https://www.nature.com/articles/s41550-022-01655-6.

[28] *See* "The worst case Starlink scenario? We could be 'right on the edge' of Kessler syndrome, https://apple.news/Am4ykTREqTACjf_oeUNcb9w.

[29] *See Martin N. Ross, Karen Jones* "Implications of a growing spaceflight industry: Climate change" (6 June 2022) https://www.sciencedirect.com/science/article/abs/pii/S2468896722000386.

[30] *See* Roberson Report at page 13.

[31] To date, the Starlink has about 2,794 satellites on orbit, and has used 57 launches. Deploying an additional 1,614 satellites will require about 35 more launches, assuming all satellites launched operate as intended, and based on recent trends to launch 46 satellites on each launch vehicle.

[32] *See* Jeff Baumgartner, "Starlink's daunting deployment plan 'leaves no margin for error' – analyst," BROADBAND WORLD NEWS (Jan. 18, 2022), https://www.broadbandworldnews.com/author.asp?section_id=733&doc_id=774668, citing "Starlink: Go Big or Go Home," MOFFETTNATHANSON (Jan. 18, 2022). "Even using Starship, at 100 satellites per launch,

Moreover, as observed by the Chief Executive Officer of one satellite launch provider,[33] the continued crowding of LEO orbits reduces the number of viable launch windows available, and thus increases the costs and delays associated with launch activities of all types, for satellites in all orbits.

Conclusion

In conclusion, Viasat urges BEREC to continue to recognize the value of satellite broadband in delivering universal service to European citizens. In particular, Viasat encourages BEREC to:

1. Avoid installing artificial, disqualifying metrics that exclude technologies from competing to provide broadband to EU citizens. No single factor determines the quality of the end user experience. Also, focusing on one limited element of broadband network design is not an independently accurate assessment that reflects internet users' experience.
2. Take note of the real-time user demonstration that GSO satellites like those designed by Viasat deliver a high-quality user experience for all the applications listed in Annex V.
3. Recognize that video is the dominate use of the Internet, video is not latency sensitive, and today's GSO broadband satellites are designed for video applications.
4. Incorporate the strengths of GSO satellites when considering universal service. These advantages include coverage, rapid deployment, and quality of service.
5. Ensure a technology neutral approach to subsidy support. There are disadvantages to some technologies (*e.g*., fibre high deployment cost in some markets) and advantages of other technologies (*e.g*., satellite quick deployment and robust coverage). Maximize the limited funding that is available for universal service and encourage all technologies to compete for the opportunity to provide broadband to European citizens.
6. Continue to recognize the environmental impact of provisioning telecommunications services to meet universal service objectives. While the advantages of satellite on the ground are clear (*e.g*., trenchless, wireless deployment) the impact of certain NGSO constellations on the environment deserves special attention. Just as we measure carbon footprints, prior to granting any market entry authorization we urgently need to determine the environmental footprint of emerging LEO mega-constellations—from collision risk to the impact on astronomy, to the impact on the Earth's atmosphere,

achieving a 30,000-bird constellation and sustaining it through, say, 2030, would require launching fifty thousand satellites, or five hundred rockets, between now and then," Moffett estimates. "That's a rocket launch roughly every six days... for nine years. Simply maintaining the constellation thereafter, if one assumes 20% annual attrition (de-orbiting), would require a new launch every six days. Forever."

[33] *See* Jackie Wattles, "Space is becoming too crowded," Rocket Lab CEO Warns, CNN (8 October 2020), https://www.cnn.com/2020/10/07/business/rocket-lab-debris-launch-traffic-scn/index.html ("Satellite constellations can be particularly problematic," he said, "because the satellites can fly fairly close together, forming a sort of blockade that can prevent rockets from squeezing through.").

Viasat appreciates BEREC's consideration of the information above and commitment to the development of satellite broadband services throughout Europe. We remain at your disposal to answer any further questions or provide further details as requested.

Assessment of Geostationary Satellite (GSO) Capabilities vs. Alternative Internet Access Technologies

Nat Natarajan
Tom MacTavish
Pepe Lastres
Ken Zdunek
Dennis Roberson

15 August 2022

Roberson and Associates, LLC
Technology and Management Consultants ®

Executive Summary

- Proven GSO technology is a reliable way to expand broadband connectivity and provide universal service.
- No single technology solution uniformly dominates the others along various metrics.
- There is no one size fits all solution for broadband deployment for all of the European Union.
- Decisions regarding optimal technology solutions are best made on a regional or local basis.

Assessment Approach

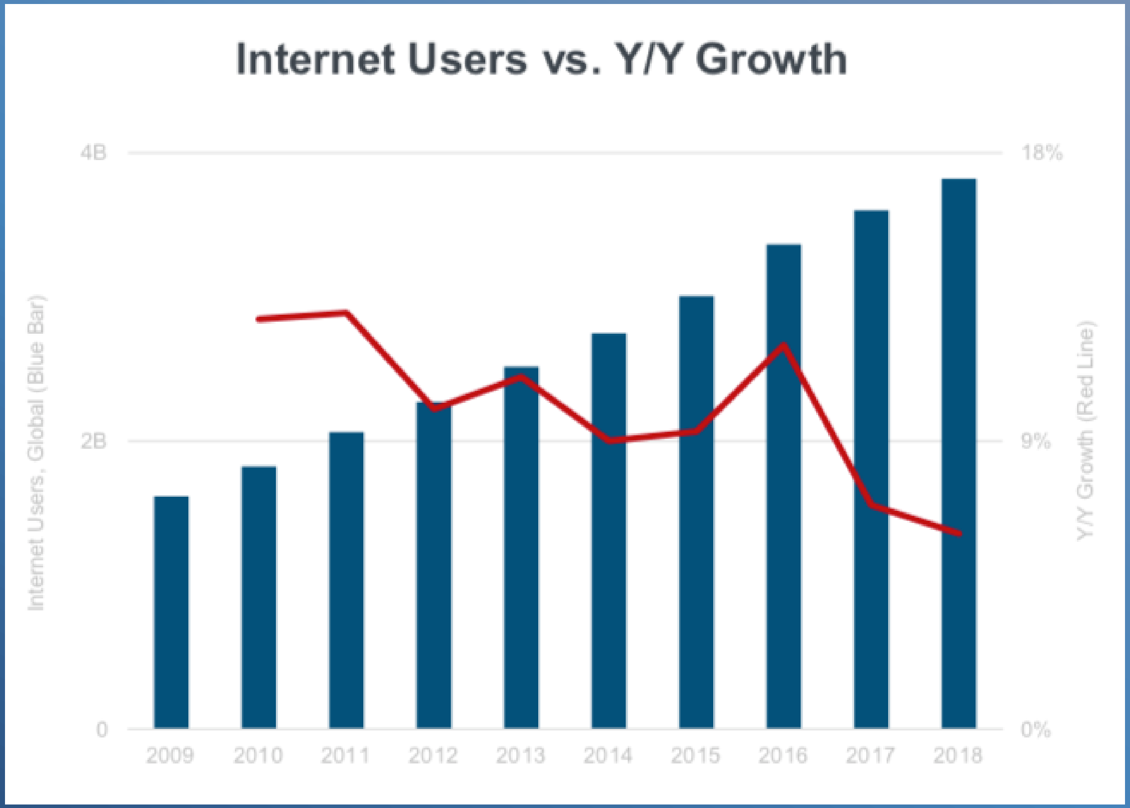
- Analyze Internet Application Categories and Identify Technical Requirements
- List and Compare Technical Characteristics of Internet Access Technologies
- Assess Internet Access Technologies Ability to Meet Application Requirements
- Conclusion

Application Categories: Internet Trends

Internet Trends

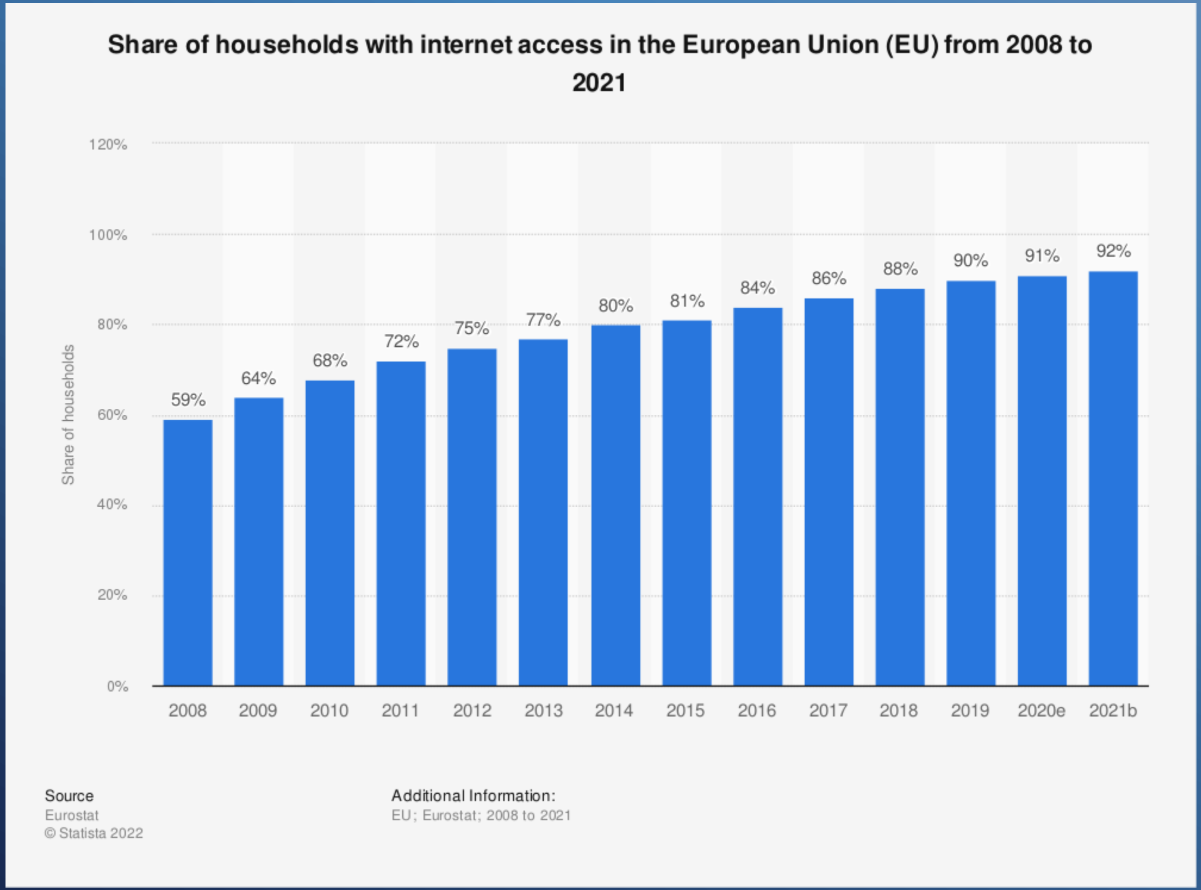
- Users
- E-Commerce
- Usage …
- Freemium Business Models
- Data Growth
- …Usage
- Work
- Education
- Immigration
- Healthcare

Global Internet User Growth = Solid But Slowing +6% vs +7& Y/Y



>> The last Internet Trends report by Meeker opens by noting that Internet User growth is steady…

Application Categories: In the EU, Digital Media Usage is Strong



https://www.statista.com/statistics/377585/household-internet-access-in-eu28/

Table 1 Use of internet services indicators in DESI

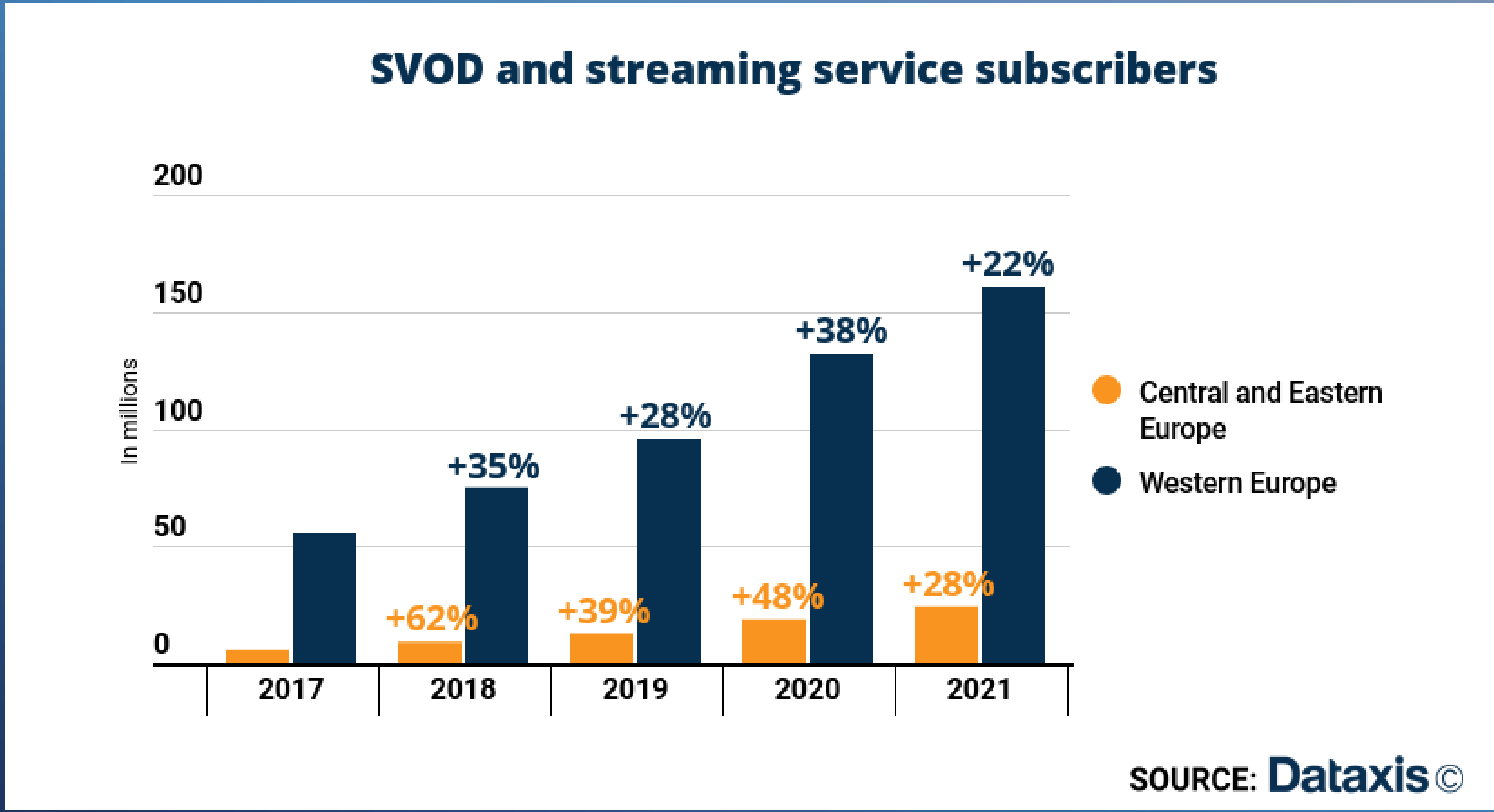
	EU		
	DESI 2018	DESI 2020	
3a1 People who have never used the internet % individuals	**13%** 2017	**9%** 2019	
3a2 Internet users % individuals	**81%** 2017	**85%** 2019	
3b1 News % internet users	**72%** 2017	**72%** 2019	2
3b2 Music, videos and games % internet users	**78%** 2016	**81%** 2018	1
3b3 Video on demand % internet users	**21%** 2016	**31%** 2018	
3b4 Video calls % internet users	**46%** 2017	**60%** 2019	
3b5 Social networks % internet users	**65%** 2017	**65%** 2019	
3b6 Doing an online course % internet users	**9%** 2017	**11%** 2019	
3c1 Banking % internet users	**61%** 2017	**66%** 2019	
3c2 Shopping % internet users	**68%** 2017	**71%** 2019	3
3c3 Selling online % internet users	**22%** 2017	**23%** 2019	

Source: DESI 2020, European Commission.

Digital Economy and Society Index (DESI) 2020
https://digital-strategy.ec.europa.eu/en/policies/desi-use-internet

>> and digital media is consumed as it is integrated into more category offerings.

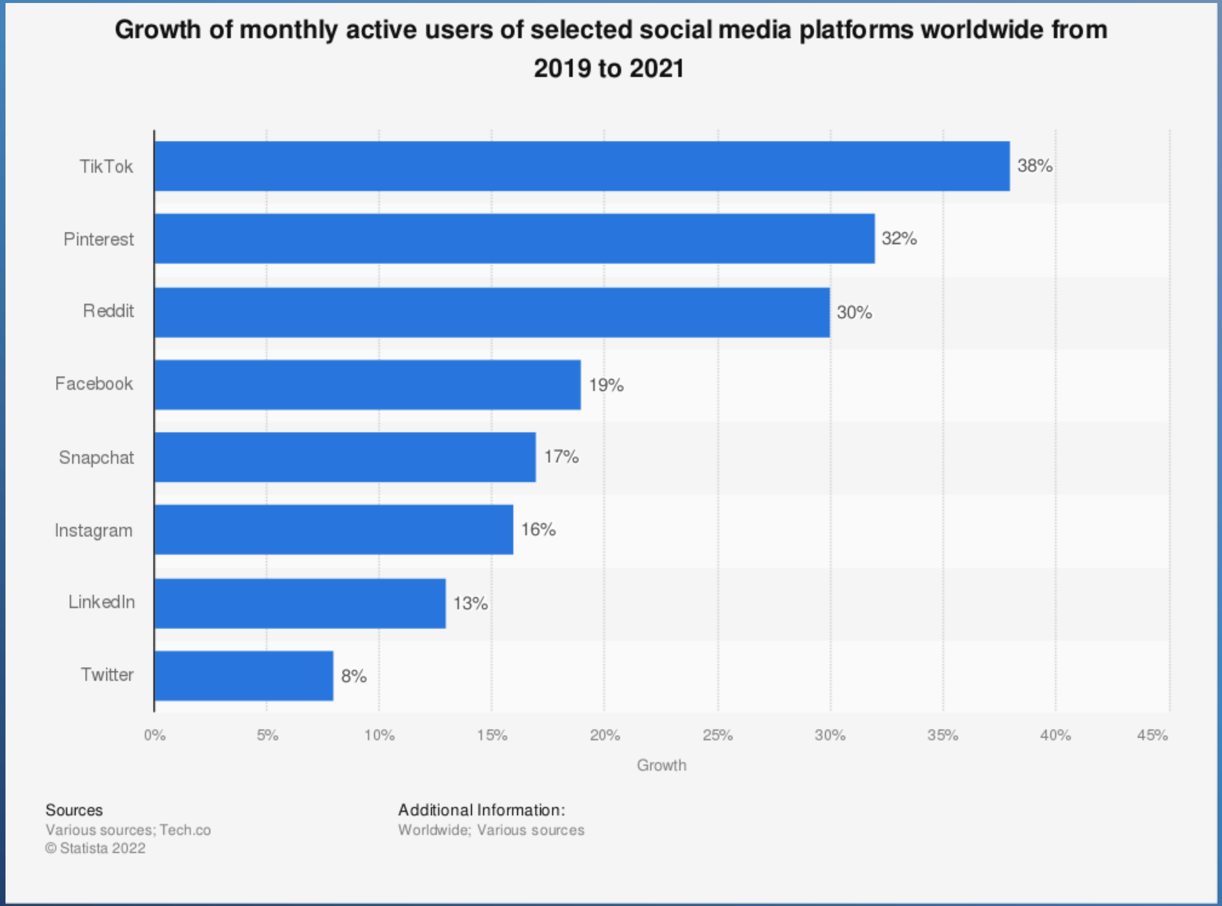
Application Categories: In the EU, Digital Media Usage is Strong



https://dataxis.com/researches-highlights/680634/the-streaming-war-intensifies-in-cee/

And, video on demand and streaming service subscribers are growing strongly.

Application Categories: On-line Platforms and Internet Tasks



https://www.statista.com/statistics/1219318/social-media-platforms-growth-of-mau-worldwide/

Global growth of social media platforms is strong

Application Categories: On-line Platforms and Internet Tasks

On-line Platforms

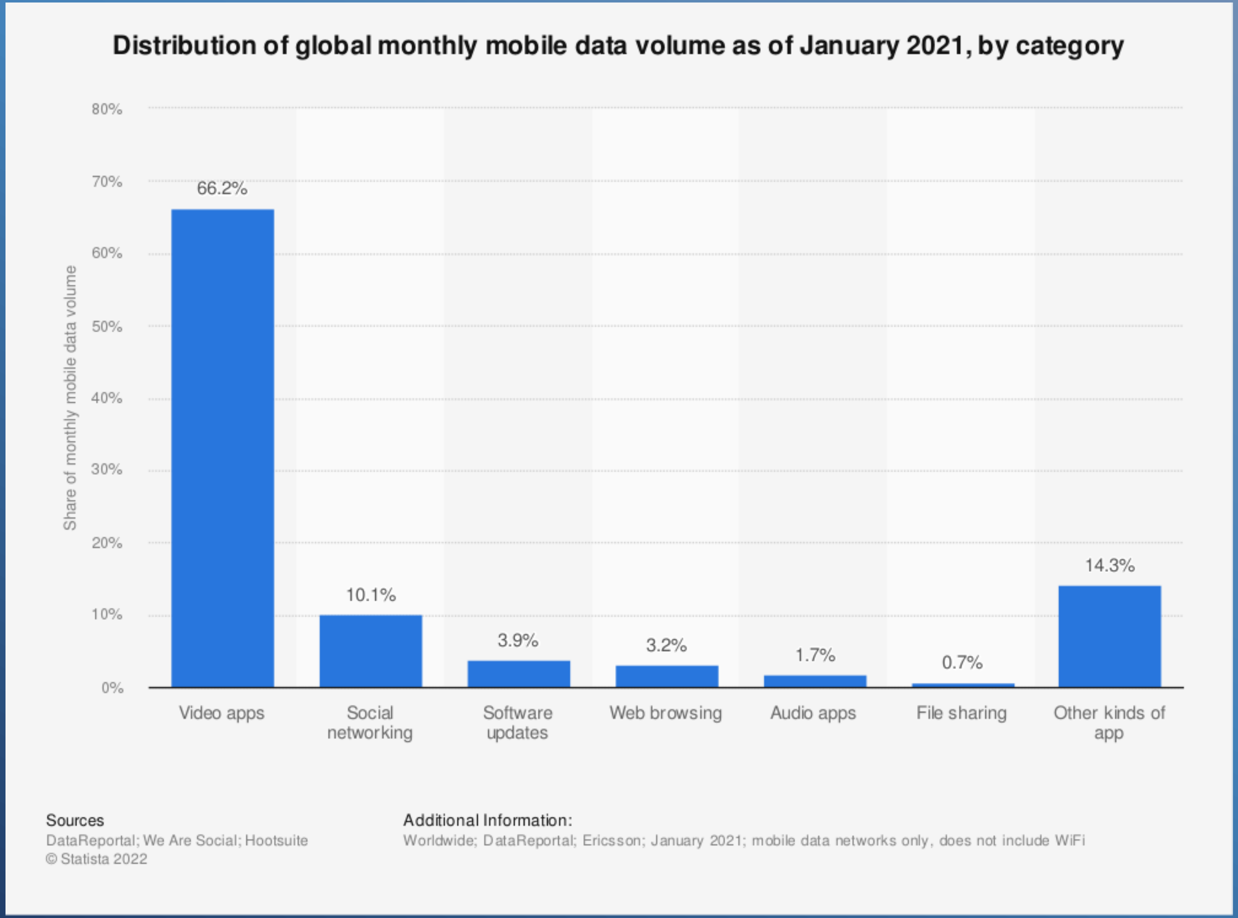
- TikTok
- Pinterest
- Reddit
- Facebook
- Snapchat
- Instagram
- LinkedIn
- Twitter

Internet Related Tasks

- Video
  - -- Streaming (unicast, multi-cast, broadcast)
  - -- Conferencing Tools
  - -- Integrated in On-line Platforms
- Interactive Applications
- Web Browsing
- Messaging (email, SMS, DM, images, chat)
- Mixed Reality: AR/VR
- File Transfer
- Audio
- Internet of Things
- Interactive Haptic/Tactile

>> …common internet related tasks shows that On-line Platforms commonly access four key tasks

Application Categories: Mobile Data Volume



https://www.statista.com/statistics/383715/global-mobile-data-traffic-share/

>> The top four categories produce 83.4% of mobile data volume.

Application Categories: Video is everywhere

"Our data show in the first half of 2021 bandwidth traffic was dominated by streaming video, accounting for 53.72% of overall traffic, with YouTube, Netflix, and Facebook video in the top three. "

The Global Internet Phenomena Report, January 2022, page 12-13

CATEGORY TRAFFIC SHARE — TOTAL TRAFFIC

	Category	Total Volume
1	Video	53.72%
2	Social	12.69%
3	Web	9.86%
4	Gaming	5.67%
5	Messaging	5.35%
6	Marketplace	4.54%
7	File Sharing	3.74%
8	Cloud	2.73%
9	VPN	1.39%
10	Audio	0.31%

GLOBAL APP TRAFFIC SHARE — TOTAL TRAFFIC

	Category	Total Volume
1	YouTube	14.61%
2	Netflix	9.39%
3	Facebook	7.39%
4	Facebook video	4.20%
5	Tik Tok	4.00%
6	QUIC	3.98%
7	HTTP	3.58%
8	HTTP Media Stream	3.57%
9	BitTorrent	2.91%
10	Google	2.79%

>> The top four categories produced 82% of all traffic.

Technical Requirements: Interactive User Experience

User Attention	Gold Standard
The end-user feels that the system is reacting instantaneously. Applies to direct manipulation interactions such as data/text entry and drop/dragging.	100 ms
The end-user's flow of thought stays uninterrupted, even though they will notice the delay. Applies to local application functions such as large table sorting.	1 second
The end-user's attention stays focused on the dialogue. Applies to steps within a coherent task.	10 seconds

>> The standard for interactive response times for various tasks has been well established.

Nielsen, Jakob, Usability Engineering, 1993
https://www.nngroup.com/articles/response-times-3-important-limits/

Internet Application Tasks: Technical Requirements

Internet Tasks	2-way Response Times (to the End-User)
Video - Broadcast Streaming - Two Way Conferencing	< 4 seconds for stream initiation Maintain 25-30 FPS video
Interactive Applications	< 100 ms for real time data/text entry apps < 2 seconds for clicks and browsing
Web Browsing	< 5 sec page load times
Messaging: Email, SMS, Social Media	< 2 sec for user acknowledgement < 10 sec for delivery
Mixed Reality: AR/VR	< 100 ms for low latency environments (e.g. shooter games, simulations)
File Transfer	< 2 sec acknowledging task initiation
Internet of Things	< 1 sec for Interactive displays < 10 sec for data collection

>> Based on those response times, GSO systems can serve the dominant share of internet traffic and provide good user experiences

Technical Characteristics of Internet Access Technologies

Estimates as of end of 4th Quarter 2023	GSO Satellite	LEO Satellite Constellation (Best case estimates for an evolving mega-constellation) (see Note 1)	Terrestrial Wireless FWA	Wireline (Fiber)
Capacity (over European Union)	> 1.5 Tbps	~ 1.1 Tbps (see note 7)	(20 X No. of 5G BS) Gbps @ 20 Gbps (DL)/10 Gbps (UL)	~ 130,000 Tbps
Speed per customer	150 Mbps	150 Mbps (see Note 8)	> 100 Mbps	> 1 Gbps
Link Latency (propagation only)	240 milli-seconds	3.66 - 8.84 milli-seconds (best case)	< 10 - 50 micro-seconds (ISD 6 - 30 Km)	5 micro-seconds per Km
2-way Latency	570 milli-seconds	~100 - 110 milli-seconds (best case)	60 - 80 milli-seconds (measured speed)	80 milli-seconds
Jitter	GSO end-to-end path typically use fewer hops and fixed route from source to destination. LEO constellations likely use multiple hops with varying path lengths resulting in potentially larger jitter.		10 – 100 micro-seconds	< 10 micro-seconds
Coverage (in European Union)	~ 100%	~ 100% (See Note 4)	~ 67 % households (Very High Capacity Networks) (Notes 5, 6)	
Mean Link Interruption Frequency (Note 2,3)	3.8×10^{-6} events/sec (1 event every ~3 days)	5.5×10^{-4} events/sec (1 event every 30 minutes)	1×10^{-5} events/sec	1×10^{-7} events/sec
Mean Link Interruption Duration (Note 2)	~60 seconds	~60-300 seconds	60 seconds	~ 10 seconds

Technical Characteristics of Internet Access Technologies - Notes

Note 1: a) Percentage of LEO satellites providing useful capacity over EU is assumed 1.25%. The surface area of EU is only 0.83% of earth's surface but a greater percentage is used for the inclination of orbital planes. Specifically a 50% increase in satellite coverage over EU is assumed. b) Satellite capacity is assumed to be 20 Gbps. The usable capacity will be considerably lower due to factors such as the size of the phased array antenna dimensions, size of solar power, available spectrum, frequency reuse limitations, density of covered locations and other LEO satellite parameters. c) Sunny case scenario, i.e., based on past record of launch and success is assumed with respect to launching and moving the LEO satellites into final operational orbits over the next 17 months (till end of 2023). The long-term challenge to consistently maintain and operate such large constellations, given the 5-year (or less) lifetime of each satellite, is ignored.

Note 2: Mean service interruption frequency and mean service interruption duration – The user experience is adversely impacted due to handover and line of sight issues at low terminal elevation angles (both satellite and terrestrial wireless systems). Wireline media (fiber) suffers service interruption due to factors such as fiber cuts. These factors manifest themselves in user experience acceptability.

Note 3: Subject to change as LEO constellations are fully deployed. Sampling of articles on user experiences are below.

a) https://blog.beerriot.com/2021/02/06/rural-internet-starlink-outage-data/
b) https://istheservicedown.in/problems/starlink
c) https://www.datacenterdynamics.com/en/news/spacexs-starlink-experiences-brief-but-significant-outage/ SpaceX's Starlink experiences "brief but significant" outage, April 11, 2022

Technical Characteristics of Internet Access Technologies - Notes Continued

Note 3: (continued)

d) https://downdetector.com/status/starlink/

e) https://www.cablefree.net/pdf/CableFree%20AN13%20Fibre%20Cuts.pdf

Note 4: Local capacity constrained by limits on frequency reuse and density of covered locations.

Note 5: A Closer Look at Fibre Penetration in APAC, EU and the USA, INSIGHT Magazine, 2022 from the Prysmian Group. https://www.prysmiangroup.com/en/insight/telecoms/nexst/a-closer-look-at-fibre-penetration-in-apac-eu-and-the-usa

Note 6: BEREC Guidelines on Very High Capacity Networks,, BoR (20) 165, October 1, 2020. https://www.berec.europa.eu/sites/default/files/files/document_register_store/2020/10/BoR_%2820%29_165_BEREC_Guidelines_VHCN.pdf

Note 7: This calculation assumes 4408 satellites distributed over multiple shells with each shell having an assumed number of orbital planes, number of satellites per plane and angle of inclination of the orbital plane. Addition of another 648 satellites (each 7.5 Gbps) in near-polar orbit (such as OneWeb) will contribute additional 0.04 Tbps capacity over EU.

Note 8: https://www.fcc.gov/document/fcc-rejects-ltd-broadband-starlink-bids-broadband-subsidies
FCC REJECTS APPLICATIONS OF LTD BROADBAND AND STARLINK FOR RURAL DIGITAL OPPORTUNITY FUND SUBSIDIES, Applicants Failed to Meet Program Requirements and Convince FCC to Fund Risky Proposals

Latency Explained

- Transmission Time (Packet Size / Capacity of Link)
- Queueing Delay at nodes
- Processing Time at nodes
- Propagation Time = distance / (α * speed of light)   α=1 (free space), 0.7 (fiber)
- Number of round-trip hops from source to destination (usually same as source)
- Buffering Delay at nodes
- Packet Retransmission delay (at link level and end-to-end) for reliable communication

← Elementary Network Analysis 101*

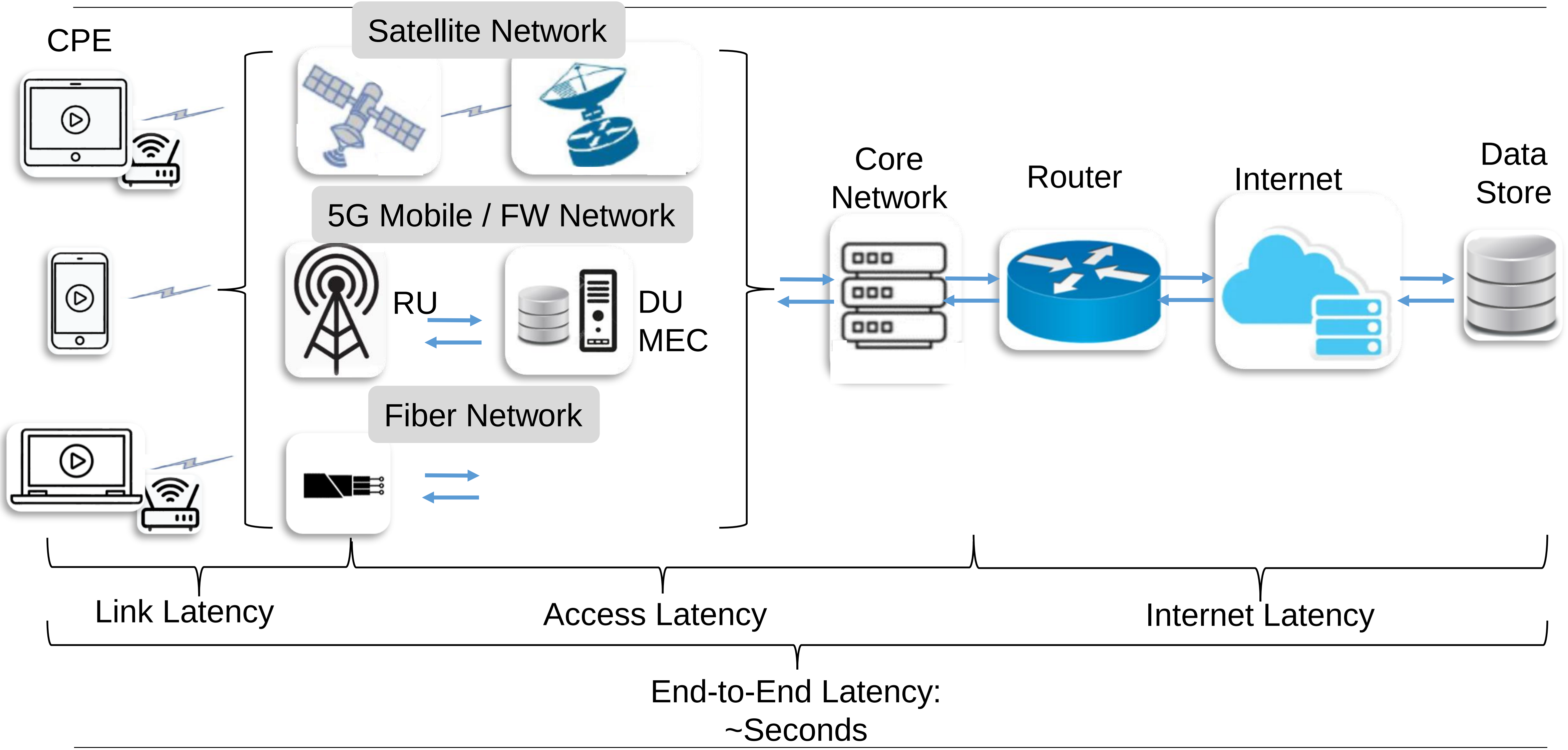
Notes

a) Application-level requirement for human acceptable latency is important which is the full 2-way latency rather than just one component (e.g. propagation time)
b) 2-way latency is application specific with mitigation techniques available to minimize impact

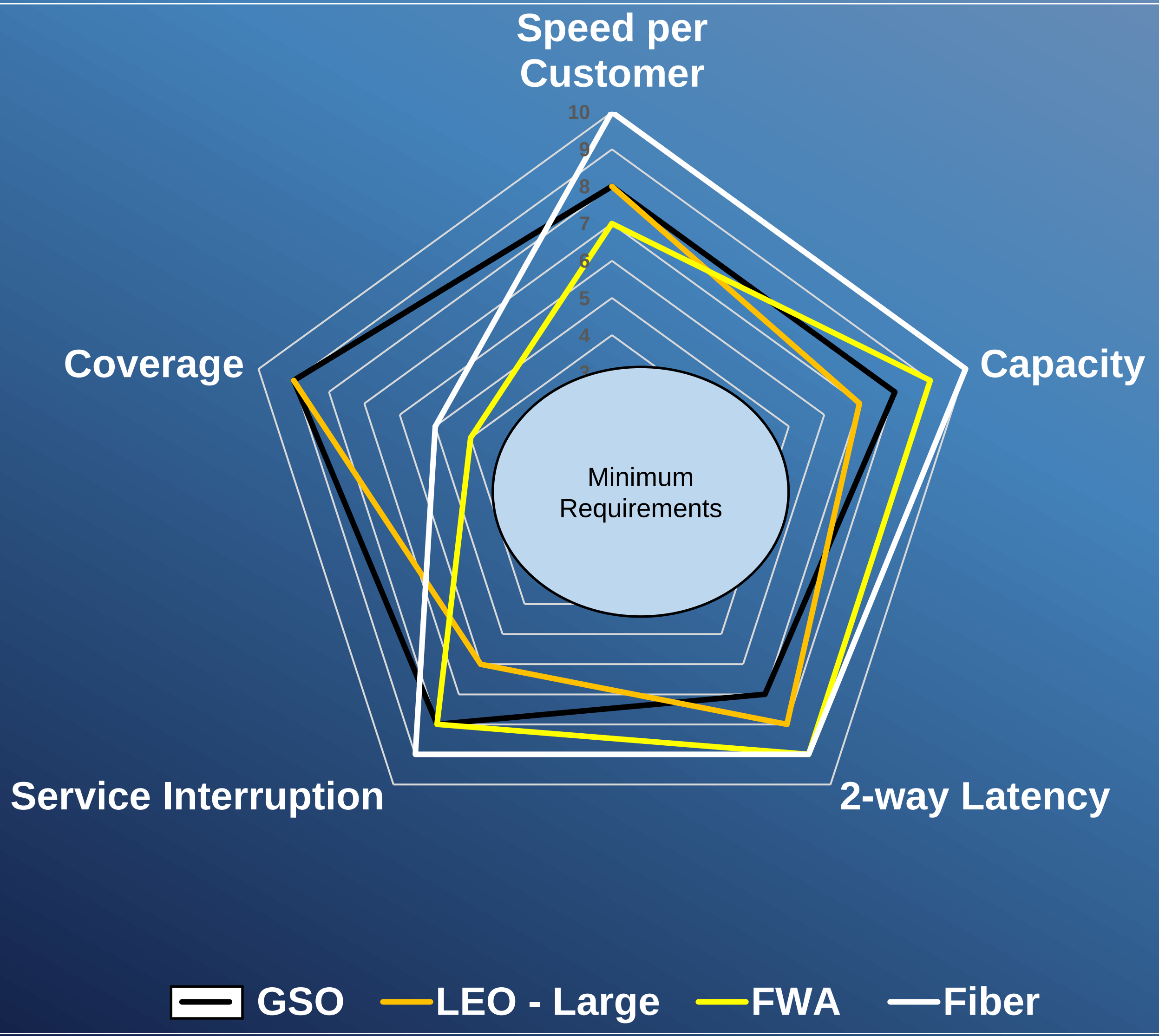
>> The key requirement Is that an Access Technology meets the human acceptable application requirement when all the delay elements are considered and accounted for. It is more than just meeting a number based on Link Propagation Time alone.

*L. Kleinrock Queueing Systems, Vol. I, Theory, Wiley Inter-science (New York), 1975.

Elements of End-to-End Latency



Internet Access Technologies –
All Technologies Exceed the Requirements



>> There Is No Technology That Dominates All the Technical Performance Categories.

>> There is no clear winner.

Additional Characteristics of Internet Access Technologies

- System reliability (e.g., Service interruption frequency and duration due to line of sight and other factors)
- System availability
- Scalability and number of EU customers potentially served
- Relative deployment cost
- Maturity of service (How long has solution been in operation)
- People served globally since inception of service
- Robustness to environmental and/or natural catastrophes (geomagnetic storms, earthquakes, forest fire, blizzard, floods, tsunamis)

>> These Characteristics Are Just as Important to Users as Capacity and Throughput

Additional Factors in Comparison of Solution Alternatives

	GSO	LEO Large Constellations	Terrestrial FWA	Wireline (Fiber)
Satellite and System reliability (including. line of sight issues)	Reference 71, 74	Link Interruptions (handoffs, blockages)		
System availability		Partial deployment now; Likely improve in few years		
Scalability and number of EU Customers **potentially** served (having access to the technology)	~100%	~100%	198 Million (FTTP/FTTH /FWA)	
Relative deployment cost (in billions of Euros €)	~ 0.75 per HTS satellite	Expected to be few tens of billions		> €100
Maturity of service (How long has solution been in operation)	Since 1970's	Early stage of deployment	Nascent (use 5G cellular expertise)	Decades of urban deployment
Customers served globally since inception of service	Several Million	< 1 Million	Few million Rural Urban	130 Million Rural Urban
Robustness to environmental and/or natural catastrophes (geo- magnetic storms, earthquakes, forest fire, blizzard, floods, tsunamis)	Decades of deployment experience	Potential for disturbances in low altitude, politics, debris		
Time to Deploy broadband Internet	Now	Multiple years (for stable configuration and replacement launches)	Several years to reach all users	Many years to reach all users

Excellent (5)	Good (4)	Average (3)	Below Average (2)	Poor (1)

>> GSO Meets or Exceeds Service Requirements Compared to Other Technologies

Comparison of Internet Access Technologies and Application Requirements

Underlying Tasks	GSO	Large LEO	Terrestrial Wireless (FWA)	Wireline (Fiber)
Video - Broadcast Streaming -Two Way Conferencing	YES	YES	YES	YES
Interactive Applications	YES	YES	YES	YES
Web Browsing	YES	YES	YES	YES
Messaging: Email, SMS, Social Media	YES	YES	YES	YES
Mixed Reality: AR/VR -- moderate latency (e.g. strategy games) -- low latency (e.g. 1st person shooter)	YES NO	YES NO	YES YES	YES YES
File Transfer	YES	YES	YES	YES
Internet of Things	YES	YES	YES	YES

>> GSO Meets Requirements for All Applications Except Extremely Low Latency AR/VR and Shooter Game

Summary

- Terrestrial wireless and wireline offer high performance and capacity but are limited in coverage. These solutions, especially wireline fiber, are significantly more expensive and take much longer to deploy.

- GSOs offer performance and capacity for most applications and users and excel in coverage with proven capability to connect the unconnected in an economical manner.

- NGSO systems are new and immature (Ref. 1). They may ultimately offer adequate capacity for many applications and good coverage but take a long time to deployment (multiple years). Many serious challenges and risks remain:
  - Technical challenges (good and consistent quality of service)
  - Operational challenges (launch, grow and sustain a large constellation)
  - Successful business case

Ref. 1: https://www.fcc.gov/document/fcc-rejects-ltd-broadband-starlink-bids-broadband-subsidies

FCC REJECTS APPLICATIONS OF LTD BROADBAND AND STARLINK FOR RURAL DIGITAL OPPORTUNITY FUND SUBSIDIES, Applicants Failed to Meet Program Requirements and Convince FCC to Fund Risky Proposals

Conclusion

- Among satellite solutions, a critical comparison of High-Throughput (HTP) GSO and planned NGSO constellations reveals no definitive superiority of one over the other.
- HTP GSO can address most of the applications & use cases; unlike NGSO systems they carry little risk of technical viability or uncertainty of business success

- **In summary:**
  - **Proven GSO technology is a reliable way to expand broadband connectivity.**
  - **No single technology solution uniformly dominates the rest along various metrics.**
  - **There is no one size fits all solution for broadband deployment at a national scale.**
  - **Decisions regarding optimal technology solutions are best made on a regional or local basis.**

Thank You

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