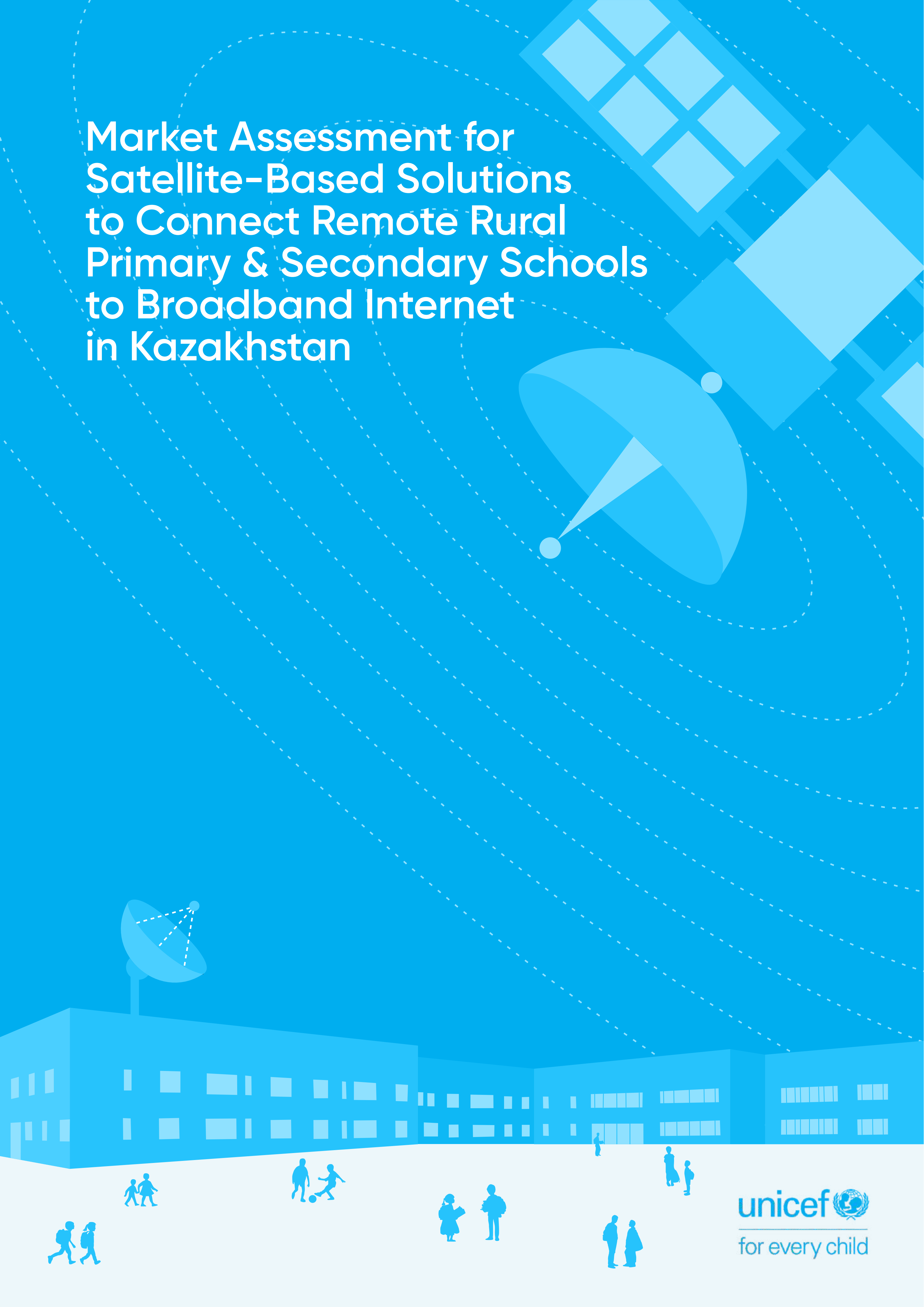

Market Assessment for Satellite-Based Solutions to Connect Remote Rural Primary & Secondary Schools to Broadband Internet in Kazakhstan

unicef
for every child

March 2025

The research was conducted by Terabit Consulting for UNICEF in Kazakhstan under the Global Giga Initiative on connectivity of schools to high speed Internet.

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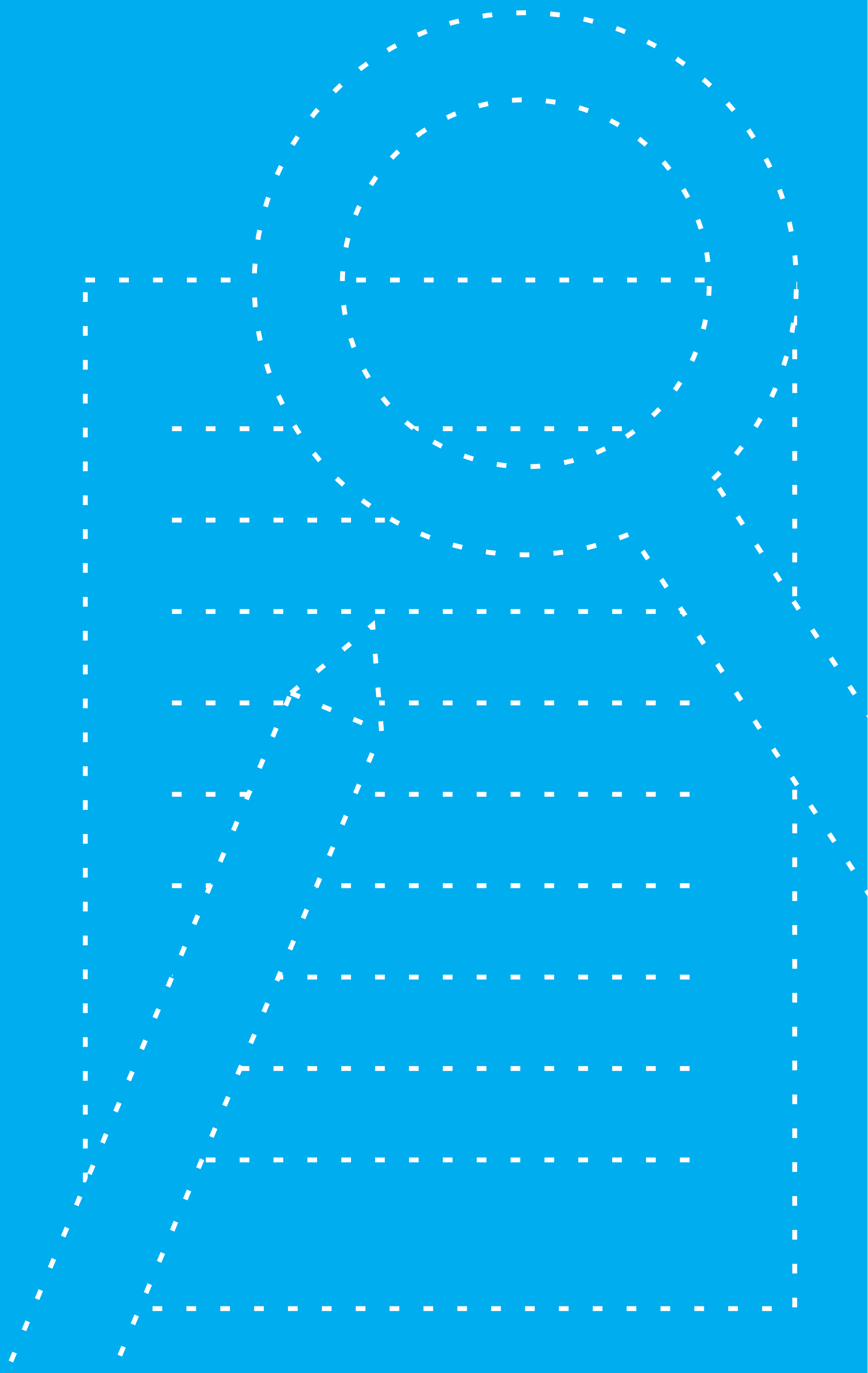
I. Executive Summary



This Market Assessment for Satellite-Based Solutions to Connect Remote Rural Primary and Secondary Schools to the Broadband Internet in Kazakhstan was commissioned by UNICEF Kazakhstan and by Terabit Consulting from January to June 2024 to support the Giga initiative, in partnership with Ministry of Digital Development of the Republic of Kazakhstan.

The primary purpose of the study was to evaluate satellite-based solutions for providing broadband connectivity to schools in Kazakhstan, focusing on practicality, technical superiority, and economic viability. In doing so, the study aimed to achieve three primary objectives: understanding the satellite connectivity solutions market in Kazakhstan; providing actionable recommendations to the government on the most effective satellite solutions for delivering high-speed, affordable connectivity to schools (especially in underserved or remote areas); and recommending interventions to maximize success including economies of scale and bulk purchasing. These objectives were designed to facilitate government decision-making on implementing the best connectivity solutions and to help Kazakh stakeholders determine optimal ways to connect unconnected and under-connected schools.

The methodology was multifaceted, combining existing knowledge base on Kazakhstan and Central Asian markets with primary data collected from Kazakh and international stakeholders.
The research process involved leveraging two decades of experience in satellite communications and connectivity infrastructure in the region, conducting remote videoconference interviews and email correspondence with expert sources, and analyzing published literature using a systematic approach.
The Feasibility Study of Potential Technical and Financial Solutions for Upgrading School Connectivity to Broadband Speeds in Kazakhstan in 2022 also served as a foundation of the analysis.
This comprehensive approach ensured a thorough examination of the satellite communications sector and educational environment in Kazakhstan, as well as relevant international markets.

The study represents the culmination of six months of research and analysis evaluating the Kazakh market as well as the global satellite industry and its technology. The study's methodology was based on both primary and secondary research. It comprised a review of resercher's own in-house intelligence on the region, insights from the completion of a prior feasibility study examining broadband connectivity to schools in Kazakhstan, and a literature analysis to understand market dynamics and technical considerations. At the primary level, videoconference interviews were conducted with key stakeholders, including telecom administrations and international organizations, ensuring a robust data collection process. To uphold data integrity, a cross-verification process was implemented, allowing for the resolution of inconsistencies and contributing to an unbiased review of existing knowledge on satellite internet solutions for schools in Kazakhstan.

The analysis reveals that the Kazakh government's assessment of satellite technology for enhancing connectivity in rural and remote schools is both logical and timely, taking advantage of groundbreaking advancements in the satellite communications sector that promise significant efficiencies. After experiencing a series of commercial and technological setbacks, along with a prolonged period of limited capital investment, the global satellite industry of the 2020s has emerged as an innovative and essential element of the telecommunications ecosystem and a logical enabler of school connectivity under certain circumstances.

While the satellite market was historically limited to Geostationary Earth Orbit (GEO) technology that was constrained in its ability to commercially and technologically compete with terrestrial networks on technological and commercial terms, the sector has been rejuvenated by ambitious new technologies and megaprojects focusing on non-GEO orbits, i.e. Low Earth Orbit (LEO) and Middle Earth Orbit (MEO). At the same time, GEO technology has continued to improve and innovate, surpassing its previous limitations.

LEO satellites have become essential for providing internet access to remote and underserved areas, significantly contributing to closing the digital divide and improving global connectivity. Typically, LEO satellites operate at altitudes ranging from 160 to 2,000 kilometers, but most current and upcoming systems are positioned between 500 and 1,300 kilometers. Major investments in the LEO satellite market, targeting both developed and developing regions, are being driven by prominent network operators such as SpaceX's Starlink, Eutelsat OneWeb, Amazon's Kuiper Systems, and Telesat. Using vast constellations of hundreds or thousands of satellites, the LEO operators are able to achieve widespread coverage, high bandwidth, and latency levels that rival or even beat terrestrial fiber, a first for the satellite industry.

Higher up, the MEO satellite communications sector constitutes a small portion of the overall satellite communications industry, with less than 1 percent of all commercial communications satellites operating in this orbit. MEO satellites are positioned at altitudes higher than those of Low Earth Orbit (LEO) satellites, typically above 2,000 kilometers, but below the geostationary orbit altitude of 35,786 kilometers. The MEO market is currently dominated by SES' O3b mPower project, which seeks to leverage the wider coverage capabilities of the MEO orbit and overcome the high latency of the GEO orbit.

In the farthest orbit, GEO, the traditional mainstay of the satellite industry which saw its historical importance as an intercontinental network pathway supplanted by the advent of transoceanic fiber optic cables more than 30 years ago, has leveraged technological innovation to reinvent and reposition itself not only as a primary option for connectivity but also as a complement to new non-GEO (LEO and MEO) constellations, addressing bandwidth demand that is less latency-sensitive as well as the market for broadcast-based services.

The conclusions of the study's technological analysis of GEO, and non-GEO orbits are summarized below.

Figure 1: Technical Comparison of LEO, MEO, and GEO Satellite Technologies

	Low Earth Orbit (LEO)	Middle Earth Orbit (MEO)	Geostationary Earth Orbit (GEO)
Active Provider(s)	SpaceX Starlink, Eutelsat OneWeb	SES O3b mPower	SES, Eutelsat, Viasat, Echostar, Telesat
Altitude	550 km – 1,200 km	8,000 km	35,786 km
Coverage	Requires hundreds of satellites for global coverage	Near-global coverage can be achieved with 6 satellites	Each satellite covers 1/3 of earth, excluding poles
Capacity	Starlink: 7/80/150 Gbps each, 88-200 Tbps total OneWeb: 1.1 Tbps total	Tbps total (e.g. mPower claims "Terabit-level")	Gbps each (currently up to 500 Gbps via VHTS)
Latency	30-50 ms	125-150 ms	600 ms
Jitter	High (lower network stability)	Average (average stability)	Low (higher stability)
Lifespan	5 years	5 years	15 years
Ground Infra-structure	Complex: Requires potentially hundreds of ground stations, with tracking movements approximately every 10 minutes and frequent handoffs	Dynamic but less complex: Multiple ground stations with tracking movements about once per hour but less frequent handoffs than LEO	Simple: Fixed earth stations, potentially only one per satellite, with no need for frequent tracking movements or handoffs
Cost (for Operators)	Relatively low cost per satellite, but constell-ations of hundreds of satellites required for global coverage	Moderate cost per satellite, 6-12 satellites required for global coverage	High cost per satellite, but global coverage from only 3 satellites reduces total constellation cost
Cost (to Consumers)	Terminals becoming more affordable, low cost per bit	Comparatively expensive terminals, medium cost per bit	Affordable fixed terminals, high cost per bit
Suitable App-lications	Almost all applications, especially interactive, real-time, latency-sensitive apps	Almost all applications except latency-sensitive apps such as online gaming	Applications that are not real-time or latency-sensitive; broadcasting
Major Strengths	Latency, capacity, coverage	Latency, capacity, coverage, cost efficiency	Cost efficiency, reliability, lifespan, simplicity of ground infrastructure
Major Weak-nesses	Complexity of constellations and ground infrastructure	Higher latency than LEO	Very high latency, lower bandwidth than constellations

Kazakhstan has established itself as a leader in the global satellite industry, known for both its domestic advancements and international partnerships. The country's space endeavors date back to 1955 with the opening of the Baikonur Cosmodrome, the world's largest operational space launch facility. In recent years, Kazakhstan has continued to build on this legacy with the formation in 2007 of the National Space Agency of the Republic of Kazakhstan, also known as KazCosmos.

Since 2006, Kazakhstan has successfully launched three telecommunications and broadcasting satellites to serve both domestic and regional markets: KazSat-1, KazSat-2, and KazSat-3. Additionally, the country has developed the KazEOS at series of remote sensing satellites for Earth observation. Through these efforts, Kazakhstan plays a crucial dual role in the satellite industry, acting as both a launch facilitator and a satellite operator, thereby driving the growth and development of the sector.

Kazakhstan has become an early adopter of non-GEO satellite technology for improved internet to rural and remote schools, through a pilot program with SpaceX's Starlink beginning in 2023. The trial initially included ten rural schools, eight of which were in the Almaty Region, and was subsequently expanded to cover 2,000 rural schools over a three-year paid "extended trial" lasting from 2024 to 2027. As of April 2024, a total of 447 rural schools had been connected, and 624 schools had been connected as of May 2024. The remaining schools were expected to be brought online by the end of 2024. The prices of the Starlink service used in Kazakhstan's trial have not been made public, but estimates range from USD$200 to $335 per month for maximum download speeds of 200 Mbps, based on feedback from interviewed sources; actual observed download speeds in similar markets and coverage zones typically exceed 100 Mbps, and throttling, which occurs after data caps are exceeded, usually results in temporary speed reductions of approximately 50 percent. Terminal and installation costs were estimated to range from $500 to $1,500.

One unexpected finding from the research was that some Kazakh schools along the border with Russia and China cannot connect to Starlink because of those country's prohibition against Starlink's services; the border areas have been erroneously included in Starlink's non-coverage area. Although this applies to only about 30 schools, appropriate solutions for these schools could potentially include LEO service offered by Chinese providers.

Although the potential 200 Mbps download speeds offered by non-GEO services is considerably faster than the previous connections in most of the pilot schools, schools' bandwidth demand will inevitably increase and the Kazakh government will need to ensure that chosen solutions are scalable and sufficiently future-proofed.

The market for non-GEO satellite services in Kazakhstan faces potential regulatory hurdles. Specifically, national security laws mandate that each satellite service provider in Kazakhstan must establish a ground station within the country's borders to ensure proper content monitoring and filtering.
As of mid-2024, among the three primary non-GEO operators, only OneWeb had pledged to build a ground station in Kazakhstan. However, it was anticipated that a temporary arrangement would be made with other operators, including Starlink, to adequately filter and monitor content sourced from foreign locations.
More specifically, Kazakh legislation permits trial services for satellite-based school connectivity by providers that do not have ground stations within Kazakhstan.

Overall, the study concluded that the adoption of non-GEO satellite internet service is an optimal solution for connecting rural and remote schools in Kazakhstan, and the Government of Kazakhstan has already made significant progress in implementing the technology. Based on its analysis, this study makes the following recommendations to maximize the success of rural school connectivity in Kazakhstan:

1. Collect Data from LEO Trial to Evaluate Its Suitability Vis-à-Vis Other Services

During its trial LEO program, the Government of Kazakhstan should leverage its position as a key early adopter to evaluate the underlying technology's real-world effectiveness in providing high-speed internet to rural and remote schools. During the trial evaluation process, the government should collect data about performance, reliability, ease of use, and support, in order to fully determine its appropriacy, scalability, and cost-efficiency, and compare this data to other services, both satellite and terrestrial.

2. Support Competition Among LEO and MEO Operators

Encouraging competition among existing LEO and MEO operators, such as OneWeb and O3b, can drive innovation and reduce costs.

3. Invest in KazSat Communications Satellites

Kazakhstan should maintain its regional and international leadership role in the space sector by continuing to invest in its own communications satellites, such as KazSat, to maintain and expand its national satellite infrastructure.

4. Monitor Planned Non-GEO Projects Such as Kuiper and Engage as Appropriate

The development and implementation of proposed non-GEO services, such as Amazon's Kuiper, should be regularly monitored and evaluated by the Kazakh government, to ensure that the country maintains its position on the cutting edge of satellite connectivity.

5. Monitor Internet Quality and Continuously Scale User Bandwidth Upward

Continuous monitoring and evaluation of the quality of internet connections in schools are essential to ensure that they meet or exceed international benchmarks through regular assessments of bandwidth, latency, and overall service reliability (Giga's tools can potentially be of assistance).

6. Centralize Funding for Satellite Services Procurement to Maximize Efficiencies

By consolidating resources, streamlining procurement processes, and minimizing financial risk, a centralized funding framework for school internet connectivity can reduce costs and ensure uniformity in bandwidth and service quality across all schools; it can also leverage bulk purchasing agreements to secure better pricing and enhanced service offerings.

7. Create a Universal Service Fund (USF)

The establishment of a Universal Service Fund (USF), which Kazakhstan does not currently have, could be a valuable tool for ensuring the long-term viability of initiatives aimed at providing internet connectivity to rural and remote schools in Kazakhstan (although a cost-benefit balance must be ensured to prevent constraints on digital development).

8. Engage Regional Partners

Engaging regional partners, such as the governments of Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan, can help ensure that Central Asia becomes a focus area for the satellite industry.

9. Engage International Partners

International partners, such as multilateral development banks, providers of relevant technical support (such as International Telecommunications Union and UNICEF) and bodies exploring new connectivity indicatives such as the European Union, should be engaged to evaluate possible collaborative projects.

10. Explore Sustainable Energy Sources

The government should explore sustainable energy sources, such as solar, hydroelectric, and wind, to power satellite internet equipment.

11. Implement Safety Protocols for Equipment

Kazakhstan should ensure the continuity of its current safety protocols which ensure that internet equipment does not pose any physical safety or radiation risk to students, faculty, staff, or other people present in schools.

12. Ensure Proper Content Filtering and Monitoring

The government should continue to ensure the proper filtering of internet content (particularly given that trial service provider Starlink imports bandwidth from foreign markets) as well as the monitoring

13. Maintain a Welcoming Regulatory Environment

To attract and promote satellite providers, Kazakhstan should consider relaxing its requirement that all satellite operators maintain ground stations within its territory, at least on an interim basis to accommodate new services and technologies; the government can also pursue other policy changes to enable and attract new investment and competition.

14. Consider Increased Bandwidth Thresholds for Satellite-Linked Schools

If technically achievable and affordable using satellite-based solutions, the government should seek to achieve higher speeds than the modest 20 Mbps per school thresholds under consideration, and regularly reevaluate minimum school speeds to ensure that connectivity is suitable for students and staff.

15. Seek to Achieve Uniform Prices for All School Internet Subscriptions

To assist in the promotion of more equitable access to high-speed, reliable internet and mitigate disparities between urban and rural schools, uniform pricing should be established for school internet subscriptions, either through a direct regulatory approach that sets prices charged to schools, or alternatively through government-negotiated bulk contracts.

Ultimately, the use of broadband satellite technology to enhance internet connectivity in remote rural schools in Kazakhstan is expected to play a critical role in advancing poverty reduction strategies. Reliable and cost-effective internet access will enable students to access educational resources, online learning platforms, and digital tools that are essential for education. The connectivity will not only enhance the quality of education but will also open up opportunities for vocational training and skill development, which are vital for maximizing employment in remote and rural areas. The use of digital tools and content to improve education can also lead to better overall job prospects and economic growth, ultimately contributing to poverty reduction.

Promoting internet connectivity through satellite solutions also supports gender equality by ensuring that girls and women in rural areas have equal access to educational resources and opportunities. By providing a digital infrastructure that supports remote learning, satellite internet can empower girls to participate in bandwidth-intensive online education programs without distance constraints or other limitations.

Although the benefits and strategy of using satellite-based solutions to connect remote, rural schools to the internet in Kazakhstan are relatively straightforward, some cross-cutting issues do emerge for consideration. These include infrastructure development, particularly with respect to earth stations, cost-effectiveness compared to other connectivity solutions such as fiber and mobile broadband, regulatory and policy considerations, and sustainability.

There will inevitably be an opportunity for constant improvement and innovation, but the research clearly showed that Kazakhstan, though multilateral domestic and international cooperation with stakeholders in both the public and private sectors, is a leader in the adoption of next-generation satellite solutions for school connectivity, offering a model that can be followed by other countries seeking to achieve universal high-speed connectivity in schools.

Terabit Consulting wishes to acknowledge and thank all of the participants who agreed to be interviewed for this project, as well as the teams at UNICEF and Giga for their invaluable feedback.

The integration of broadband satellite technology also aligns with environmental protection efforts and promotion of human rights. In addition to increasing digital and social equity, improved internet connectivity across all regions can facilitate awareness and education about sustainable practices and environmental stewardship among young learners, which could potentially be put into practice through the use of sustainable energy sources for satellite internet connectivity. Moreover, ensuring that all citizens have access to information and communication technologies promotes human rights, reduces the digital divide, and fosters growth of the digital economy.

II. Introduction & Methodology

In November of 2023 Terabit Consulting was selected to carry out the Market Assessment for Satellite-Based Solutions to Connect Remote Rural Primary and Secondary Schools to the Broadband Internet.

The objective of the assignment was to support implementation of the Giga initiative of UNICEF and the ITU, in partnership with Kazakhstan's Ministry of Digital Development in Kazakhstan, by carrying out a market assessment of satellite-based solutions for broadband connectivity to schools in Kazakhstan, facilitating government decision-making on the implementation of the best connectivity solutions based on the criteria of practicality, technical superiority, and economic viability.

The assessment is intended to allow Kazakh stakeholders, both public and private, to determine how best to move forward with optimal connectivity solutions, including appropriate models, funding mechanisms, guidelines, and designs that prioritize the rapid connection of unconnected and under-connected schools.

Specifically, the Market Assessment for Satellite-Based Solutions to Connect Remote Rural Primary and Secondary Schools to the Broadband Internet sought to achieve the following primary goals, as identified in the Terms of Reference:

1

To better understand the satellite connectivity solutions market in Kazakhstan, focusing on available (and planned) solutions and technologies, practices (case studies) and lessons learnt from other countries on market shaping.

2

To provide the government with specific and actionable recommendations on which satellite solutions would be most effective for delivering high-speed, high-quality, affordable connectivity to schools (in particular to those underserved or located in remote areas).

3

To recommend interventions that can leverage economies of scale and bulk purchasing (if the government is willing to invest in satellite connectivity), thereby enabling the government to reduce costs and obtain better value for their investment.

Terabit Consulting completed its research and analysis for the Market Assessment for Satellite-Based Solutions to Connect Remote Rural Primary and Secondary Schools to the Broadband Internet during a six-month period between January and June 2024.

The methodology for this study comprised a multifaceted approach. The research process and the report creation were managed by Terabit Consulting's Cambridge, USA office. First, the research team began by leveraging its acquired knowledge base on Kazakhstan and neighboring Central Asian markets, accumulated over two decades of work on satellite communications and connectivity infrastructure in the region. This foundational understanding was supplemented with first-hand, primary data collected from Kazakh and international stakeholders, providing a deep situational background of the satellite communications sector and the educational environment in Kazakhstan, as well as in other international markets. Stakeholders were contacted through direct outreach and interviewed via remote videoconference and email. Terabit Consulting management ensured that all research and interviews were conducted independently and reliably, with transparent data-handling and record-keeping. The interviews conducted during the six-month period were reported to Terabit management upon completion and any necessary clarifications or follow-up concerns were addressed collaboratively by the management and researchers.

Contacts confirmed their willingness to participate prior to each interview. Although UNICEF and Giga provided appropriate assistance when requested, for ethical reasons to ensure the independence of the research, all interviews were the exclusive responsibility of Terabit Consulting, and Terabit determined the suitability of each interviewee and the input that they provided, with suitable cross-checking and verification performed exclusively by Terabit.

Research materials included Terabit Consulting's own collected intelligence on Kazakhstan and neighboring markets in Central Asia as well as other peer markets, which it has amassed in detail over the last 20 years while working on digital connectivity projects serving the region. The Feasibility Study of Potential Technical and Financial Solutions for Upgrading School Connectivity to Broadband Speeds in Kazakhstan delivered by Terabit in 2022 also served as a foundation of the analysis of Kazakh market dynamics. A detailed analysis of published literature was also undertaken, in order to provide a clearer understanding of market dynamics, technical considerations, and overall viability.

The methodology for analyzing published literature employed a systematic and comprehensive approach which involved a structured approach to identifying, evaluating, and synthesizing relevant published works, while ensuring the minimization of bias through the use of diversified and credible independent sources. This approach leveraged multilingual business and academic databases as the entry points for much of the literature review and reduced bias through the use of neutral search terms and Boolean operator structures covering relevant topics such as the global broadband satellite market, the Kazakh satellite market, broadband satellite technical considerations, and the Kazakh educational sector. The research collected from secondary sources was used to supplement and confirm/cross-check research collected through primary interviews.

Commercial sources such as satellite operators were only used for the research of specific services' technical specifications and pricing, and any satellite operators' claims about the technical and commercial advantages of their services were verified through independent research. Prioritization of sources was based on their credibility and independence, geographic applicability, publication date, relevance to the research questions, and methodological rigor. The collected data was collated and updated through a desk review and analysis using Terabit's analytical and modeling frameworks.

Terabit carried out remote videoconference interviews of multiple expert sources and engaged relevant sources through email correspondence. Expert sources included, among others: regional telecoms administrations in Kazakhstan, Kazakh space industry players including JSC Republican Center for Space Communications; Kazakh academic stakeholders; and international organizations including Giga (Kazakhstan & Mexico) and the World Bank. Although a framework of formal questions was typically prepared prior to each interview, the expertise, experience, and interests of each stakeholder varied greatly and interviews were often spontaneously adapted to maximize sectoral understanding and insight based on the specific feedback received. Some of the more general questions for industry experts and other stakeholders included the following:

- Can you share insights, case studies, or data from your experience with satellite-based connectivity projects to improve connectivity to rural schools?

- What have been the successful models in for connecting schools via satellite, including funding/financial models, cost effectiveness, technical models, services, equipment, providers, traffic management/control/monitoring, bulk purchasing strategies, diversification and redundancy, scalability and planning, etc.

- What are the key factors for the sustainability of connectivity projects in schools?

- How can we ensure that the connectivity solutions are equitable and inclusive?

- What are some of the socioeconomic impacts and considerations of satellite-based solutions?

- What are some important risk considerations?

- Are there any key lessons/ recommendations/strategies for Kazakhstan, i.e. key conclusions about which services/models are most effective from a financial and technical point-of-view for delivering high-speed, high-quality, affordable connectivity to schools (in particular, to underserved or located in remote areas)?

The above questions were effectively pre-tested during an interview with Giga that preceded interviews with other stakeholders, thereby confirming their validity, in Terabit's opinion. Nevertheless, these and questions were re-evaluated following interviews to ensure their relevance and ongoing validity.

Interviews were conducted exclusively with expert sources and stakeholders, as outlined in the scope of work, resulting in a significantly smaller sample size compared to what could have been achieved through broader surveys or interviews with the general public. Despite this, Terabit made a concerted effort to optimize gender balance within the expert sample to the extent possible. However, given the limited number of stakeholders/interviewees Terabit did not believe that it was appropriate or possible to perform an analysis of disaggregated data to show differences between groups.

As part of Terabit's Data Quality Assurance framework, the collected data was subject to a cross-verification process wherever possible. This process helped to identify and resolve any inconsistencies or conflicts in the information gathered from different sources, both primary and secondary. This also helped to ensure a comprehensive and unbiased review of existing knowledge relevant to satellite-based internet solutions for schools in Kazakhstan.

The research and analytical processes conformed to UNICEF's ethical procedures. Interviewees represented organizations, companies, and government agencies and were interviewed to ascertain the views and experiences of those entities, rather than of the individuals themselves. No individual end users were contacted or involved in the research. Consequently, official ethical approval was not typically applicable. Consent was obtained from all interviewees prior to their being interviewed, with interviewers offering clear explanations of the purpose and objectives of the project as well as the intended uses of their feedback. Terabit Consulting followed the "do no harm" principal; confirming in advance that by the very nature of the research drawing exclusively on the expertise and experience of stakeholders with respect to satellite communications, the interviews did not pose any risk to the participants in the study. Terabit did not interview any stakeholders with commercial interests in school satellite deployment, such as service providers.

Drafts of the study were submitted to UNICEF and Giga for peer review and the report was also submitted to UNICEF's quality review. Feedback and identified concerns from these reviews were taken into account by Terabit Consulting and integrated into the final version of the report.

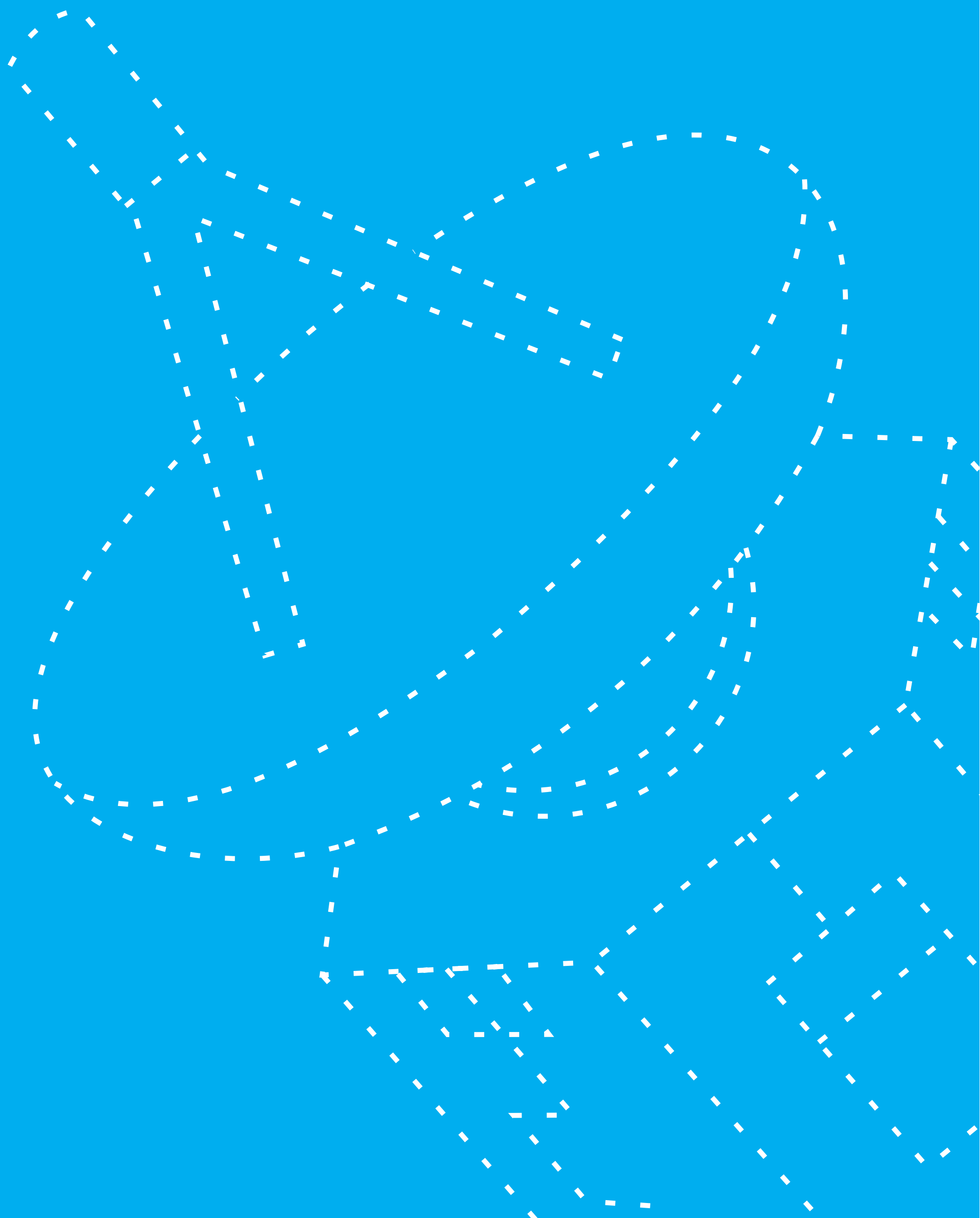
Additionally, findings of the study were presented for validation at the Technical Meeting of the Giga Steering Committee in the Republic of Kazakhstan in December 2024, allowing stakeholders to provide feedback and updates of market and technical conditions which were integrated into this final version of the study.

Although the methodology utilized a multifaceted approach that combined a literature review with primary data collection, the subject matter necessitated a primarily qualitative approach, with limited exceptions such as a straightforward pricing analysis of available services based on publicly-available data from service providers.

Overall, the study's research includes a comprehensive market assessment of satellite-based connectivity solutions specifically for schools in Kazakhstan and Central Asia based on primary and secondary research as well as a desk review of case studies from countries that have successfully implemented advanced satellite solutions. The study features analysis of the historical development, current status, and future trends of the satellite communication market. Key components of the assessment cover technological analysis, cost implications, funding mechanisms, and best practices gleaned from international examples.

With respect to limitations, the research does not extend to primary data collection beyond expert interviews, nor does it include a detailed examination of non-satellite internet options such as fiber optic links, digital subscriber line, cable modem, fixed wireless, 4G, or 5G technologies, which were analyzed in a previous study. It does not provide specific implementation plans tailored to individual schools or delve into technical specifications of satellite equipment. Additionally, aspects such as detailed legal and regulatory frameworks, environmental impacts, and staff training programs for effective use of satellite internet are outside the scope of this study. Overall, the study's focus was on market conditions, trends, and strategic recommendations rather than granular operational details. Future analysis could revisit the aforementioned non-satellite technologies and evaluate converged solutions including 6G. Additionally, further research could explore the long-term sustainability and scalability of the presented satellite-based solutions in the face of evolving technological advancements.

III. Satellite Market Assessment



a. Satellite Communications Market Overview

The satellite communications market continues to demonstrate impressive growth, technological advancement, and innovation that underscores and enhances the sector's critical role in global telecommunications. The sector is particularly vital for improving connectivity to markets and regions that have been previously overlooked or inadequately served by terrestrial and submarine technologies.

The satellite market has successfully capitalized on several key technological advantages. These include satellites' ability to provide efficient coverage in hard-to-reach and sparsely populated areas, the quick and easy implementation of services once satellites are launched, and satellite services' reliability and resilience in the face of natural disasters and conflicts that can disrupt other telecommunications networks. Additionally, satellite technology excels in distributing broadcast content efficiently and offers overall flexibility in deployment and operation.

Among the most transformative trends in the satellite communications market in recent years is the accelerating development and deployment of Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations which have significantly increased satellite's competitiveness with more established broadband technologies such as fiber and 5G.

Looking ahead, the satellite communications industry is poised for further growth driven by practical advancements, regulatory changes, and the integration of key technologies. The increasing demand for ubiquitous global internet coverage and higher data rates continue to drive the expansion of both LEO and MEO constellations.

Additionally, the convergence and integration of technologies such as artificial intelligence (AI), 5G, and Internet of Things (IoT) into satellite operations is expected to enhance network efficiency, improve service delivery, and enable new communications applications, from remote sensing to autonomous vehicle connectivity.

Regulatory bodies worldwide, at both the international and national levels, recognize the increasing importance of satellite communications in achieving universal connectivity and are implementing more favorable policies to promote the sector's growth, including faster licensing processes for new satellites, flexibility in spectrum allocation and management, and supportive measures for ground station development.

Moreover, the industry is likely to see increased collaboration between satellite operators and traditional telecom companies, aiming to create hybrid networks that leverage the strengths of (and compensate for the weaknesses of) satellite and terrestrial technologies, thereby enhancing the robustness and reach of global communication networks. This pragmatic and collaborative approach not only promises to address the world's connectivity challenges but also ensures that the satellite communications sector remains at the forefront of technological innovation.

b. Low Earth Orbit (LEO) Satellite Market

Low Earth Orbit (LEO) satellites have emerged as a critical tool for reaching remote and underserved regions, thereby serving to bridge the digital divide and enhance global connectivity. Although the defined altitudes of LEO satellites ranges from as low as 160 kilometers to as high as 2,000 kilometers, the altitudes of systems currently in orbit or under advanced development generally range between 500 and 1,300 kilometers.

Investments in the LEO market, aimed at serving both developed and less-developed markets, have been led by players such as SpaceX's Starlink, Eutelsat OneWeb, Amazon's Kuiper Systems, and Telesat.

As of 2024, SpaceX dominates the LEO market due to its rapid deployment of the Starlink constellation, which has already launched over 5,200 satellites into orbit.[1] Estimates of the constellation's capacity vary significantly, but the company's first stage of deployment could eventually provide 88 Tbps of usable capacity,[2] with theoretical increases to 200 Tbps in the second stage. SpaceX's ability to manufacture and launch satellites, coupled with a reusable rocket technology that significantly reduces launch costs, has allowed it to capture a significant market share of LEO satellite services, with a reported customer base that had grown from 10,000 customers in spring 2021 to more than 3 million as of spring 2024 [3] (approximately three-fifths of Starlink customers are in the United States).

Eutelsat OneWeb, the most serious SpaceX competitor to date, counted more than 630 operational satellites in orbit as of mid-2024.[4] OneWeb launched its first test satellites in 2019, and in 2020 it launched more than 100 satellites offering commercial service. OneWeb declared bankruptcy in March 2020 but three months later it was purchased by a consortium led by Indian conglomerate Bharti and the Government of the United Kingdom. In 2023 OneWeb merged with Eutelsat to form "the world's first GEO-LEO operator," with LEO services focused primarily on wholesale services including backhaul for telecom operators, as well as connectivity for corporate customers, government clientele, and mobile connectivity markets such as in-flight and maritime internet.

Beyond the two operational LEO constellations, other planned LEO networks in advanced stages of development include Project Kuiper and Telesat Lightspeed. Kuiper, a subsidiary of Amazon, is planning to invest more than $10 billion in the development of its network, which will comprise 3,236 satellites [5], half of which will be in orbit by July of 2026, with the remainder by July of 2029. In 2023 the company unveiled prototypes of its user terminals, including a 28 cm x 28 cm residential terminal offering download speeds of 400 Mbps, and a 76 cm x 48 cm terminal for corporate and government customers offering 1 Gbps connections. Canadian satellite operator Telesat has also announced a LEO constellation, Lightspeed, which would comprise 198 satellites[6]; although Telesat had initially intended to launch its LEO service by 2021, commercial launch has been delayed until at least 2026. Additionally, two major Chinese LEO constellations are under development: China Satellite Network Group's 13,000-satellite Guowang (SatNet) project ,[7] backed by the Chinese government, and the 12,000-satellite G60 Starlink initiative, backed by Shanghai's municipal government.[8]

Other proposed LEO constellations include the European Union's IRIS, announced in 2022 with expected commercial service in 2027; E-Space, which launched three demonstration satellites in 2022; and Rivada OuterNet, announced in late-2023.

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[3] X. Starlink. https://x.com/Starlink/status/1792678386353213567
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[5] About Amazon. Project Kuiper. https://www.aboutamazon.com/what-we-do/devices-services/project-kuiper
[6] Telesat. Telesat Lightspeed LEO Network. https://www.telesat.com/leo-satellites/
[7] Jones, Andrew. China to Launch First Satellites for Megaconstellation in August. Spacenews, June 27, 2024. https://spacenews.com/china-to-launch-first-satellites-for-megaconstellation-in-august/
[8] Jones, Andrew. Shanghai Firm Behind G60 Megaconstellation Raises $943 Million. Spacenews, February 2, 2024. https://spacenews.com/shanghai-firm-behind-g60-megaconstellation-raises-943-million/

Major Low Earth Orbit (LEO) Broadband Satellite Constellations

	Starlink	Eutelsat OneWeb	Kuiper	Telesat Lightspeed
Ownership	SpaceX	Eutelsat (Bharti, Bpifrance, Softbank, UK Gov't., others)	Amazon	Telesat (Canada)
Launch Dates	Initial commercial launch 2019; >150 launches 2019-2024	Initial commercial launch 2020; 19 launches 2020-2024	Commercial launches planned for 2024 (Prototype 2023)	Commercial launches planned for 2026 (Prototype 2018)
Number of Satellites	>5,200 operational (2024) (Gen 1: 3,432; Gen 2: 1,802)	>630 operational as of mid-2024	3,236 planned	198 planned
Altitude	550 km	1,200 km	590-630 km	1,300 km
Investment	Estimated to be at least $10 billion	Not specified, but OneWeb was valued at $3.4 bil in 2022 merger	Planned to be more than $10 billion	$5 billion for the full constellation
Target Customer Groups	Residential, Enterprise, Government	Telcos/ISPs, Enterprise, Aviation/Transport	Enterprise, Gov't., Residential, Telcos/ISPs	Telcos/ISPs, Enterprise, Government
Technical Considera-tions	Uses small, flat-panel satellites with Hall-effect thrusters; includes inter-satellite links	Uses microsatellites with electric propulsion; inter-satellite links were planned but later removed	Advertised plan for compact, affordable customer terminals and a global network of ground stations	Advanced digital beamforming array antennas and integrated regenerative processors
Capacity	Gen 1 capacity: 20-25 Gbps each; Gen 2 capacity: 60-80 Gbps each; Constellation: 88 Tbps potential capacity (est.)	7.2 Gbps each; Constellation: reported 450 Gbps as of 2023, target "1.1 Tbps of usable capacity"	To be decided; prototype bandwidth of 100 Gbps each	Originally planned to be 15 Tbps prior to reduction of constellation size from 298 to 198
Latency	30-50 ms on land; 100 ms in oceans & remote areas	Sub-100 ms	Targeted latency of 30-50 ms	Targeted latency of 30-50 ms

c. Medium Earth Orbit (MEO) Satellite Market

The Medium Earth Orbit (MEO) satellite communications market accounts for a relatively small segment of the overall satellite communications market, representing less than 1 percent of all communications satellites in commercial service. MEO satellites orbit at altitudes above LEO satellites (i.e. at more than 2,000 kilometers above sea level) but below the geostationary orbit of 35,786 kilometers (i.e. the altitude at which a satellite would orbit the earth in one day); in practice, the altitudes of most existing and planned MEO satellites are between 8,000 and 14,000 kilometers.

Despite their limited share of the satellite communications market and an historical focus on GPS and other navigational applications, MEO satellites are playing an increasingly important role in the communications ecosystem, leveraging latency and throughput advantages over Geostationary Earth Orbit (GEO) satellites, as well as coverage superiority compared to LEO constellations. Consequently, existing and planned MEO constellations are able to offer competitive solutions that balance higher bandwidth, lower latency, and cost-efficient geographic coverage, enhanced by the capability of dynamically shapeable and steerable spot beams that adjust in real-time to meet changing bandwidth demand. MEO is particularly useful for higher-bandwidth coverage of high-altitude locations such as northern Russia, Alaska, and northern Canada.

MEO is also a cornerstone of multi-orbit concepts that combine the advantages of satellites in all three orbits; for example, MEO satellites can offer "failover" resiliency for customers on LEO networks; conversely, customers of high-throughput, low-latency MEO service such as cruise ships can be temporarily switched to GEO satellite service whenever MEO coverage is lost. As such, LEO, MEO, and GEO satellites can collectively ensure continuous, unbroken coverage. Furthermore, MEO satellites can provide "relay" services to LEO satellites that are out of range of ground stations, ensuring that LEO satellites have continuous real-time access to earth stations. With the tremendous growth of the LEO market, these satellite-to-satellite relays are expected to become an addressable market for MEO operators.

The only significant player in the MEO satellite communications market is currently Luxembourg-based SES, which acquired the O3b constellation in 2016, however as of mid-2024 it was unclear whether O3b would offer service in Kazakhstan. The first-generation O3b constellation comprises 20 commercial MEO satellites which were launched between 2013 and 2019.[9] In 2021 O3b partnered with cloud providers Amazon Web Services and Microsoft to provide satellite access to the AWS and Azure clouds, respectively. SES began launching its next-generation O3b mPower constellation in 2022, launching commercial service with 6 MEO satellites in April 2024, with a planned expansion to 13 satellites by 2026. The mPower satellites employ shapeable and steerable spot-beam technology that can serve the real-time bandwidth needs of individual users. In 2021 Kazakhstan's Republican Centre for Space Communications (RCSC), a subsidiary of the Ministry of Digital Development, Innovations and Aerospace Industry, signed a memorandum of understanding with SES to explore possible service agreements for mPower connectivity, including the construction of a gateway in the Almaty region. This followed previous demonstrations of O3b services in Kazakhstan, including connections for remote villages in 2021 and 3G/4G demos with Kazakh cell operators including Kcell in 2022.

[9] SES. Our History. https://www.ses.com/about-us/our-history

In addition to SES, other players in the MEO space have included Intelsat, SpaceLink, Mangata Networks, and Viasat. Intelsat announced plans for an 18-satellite MEO constellation that would have launched in 2027, but in 2024 the company said that it would be acquired by SES.[10] SpaceLink, a subsidiary of Electro Optic Systems (EOS), had planned to start deploying 4 MEO satellites in 2024 that would have provided relay services for LEO constellations, EOS announced in 2022 that SpaceLink would cease operations due to difficulty in raising capital.Mangata Networks had planned to launch as many as 791 satellites by 2026, but in April 2024 it scrapped plans for its major manufacturing facility in Scotland, citing challenging economic conditions and supply-chain issues. US-based Viasat had also explored the launch of MEO satellites but in May 2023 it completed its acquisition of satellite operator Inmarsat and redirected its focus to the GEO space.

Major Low Earth Orbit (LEO) Broadband Satellite Constellations

	SES O3b mPower
Ownership	SES (Luxembourg)
Launch Dates	First satellites launched in December 2022; commercial service expected to start in 2024
Number of Satellites	6 MEO satellites launched as of mid-2024; network operational in April 2024; additional 7 satellites planned
Altitude	8,000 km
Investment	Not specified, but SES' acquisition of Intelsat valued at $3.1 billion
Target Customer Groups	Mobility (cruise, commercial shipping, and aero), Telecom (telco, mobile network operators, and cloud providers), Government (military, government agencies, and non-governmental organizations), Enterprise (oil & gas, mining, and other sectors)
Technical Conside-rations	High-throughput, low-latency, software-defined satellites with flexible beam steering. The O3b mPOWER satellites feature a fully digitized processor-based payload, capable of generating over 5,000 beams per satellite, with dynamic routing and beamforming capabilities
Capacity	Terabit-level system capacity, capable of delivering thousands of uncontended managed services from tens of Mbps up to multiple Gbps per service. Each satellite can provide up to 5,000 beams.
Latency	150 ms

[10] Intelsat. SES to Acquire Intelsat in Compelling Transaction Focused on the Future. https://www.intelsat.com/newsroom/ses-to-acquire-intelsat/

d. Geostationary Earth Orbit (GEO) Satellite Market

Geostationary Earth Orbit (GEO) satellites, positioned at an altitude of 35,786 kilometers above the equator, have long been pivotal in enabling international telecommunications, including voice, data, and internet services. Up until the 2000s, they served as the primary telephony and data pathways for dozens of countries and territories.

In recent years, however, the prominence of GEO satellites in the telecommunications landscape has diminished. This shift is largely due to the widespread adoption of international submarine and terrestrial fiber infrastructure, which now connects almost all countries. Within the High-Throughput Satellite (HTS) industry itself, investment has increasingly shifted towards Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) constellations. These newer systems are often seen as more economically and technically advantageous for digital connectivity, particularly in terms of cost-effectiveness, latency, and bandwidth availability. For example, while GEO satellites can cost between $100 million and $400 million each, LEO satellites typically cost around $500,000. With respect to latency, GEO satellites have roundtrip delays of up to 600 milliseconds, compared to as little as 30 milliseconds for LEO satellites.[11] Additionally, LEO constellations can provide tens of terabits of capacity, whereas most standalone GEO satellites offer maximum capacities in the tens of gigabits range.

Despite this shift, GEO satellites continue to play a crucial role in telecommunications. They offer stable and reliable connectivity, can cover remote and underserved regions, and can be more straightforward to implement compared to complex LEO and MEO constellations. GEO satellites are also integral to multi-orbit solutions, benefiting from technological advancements such as real-time beam reconfiguration.

Furthermore, they remain essential for many defense and government applications and are competitive in the markets for in-flight and maritime connectivity.

The market positioning of GEO satellite operators has been significantly reshaped by a series of strategic mergers and acquisitions, as well as expansion into the MEO and LEO spaces. As a result of industry consolidation, more than two-thirds of the GEO HTS market is controlled by the five largest operators: SES, Eutelsat, Viasat, Echostar, and Telesat.

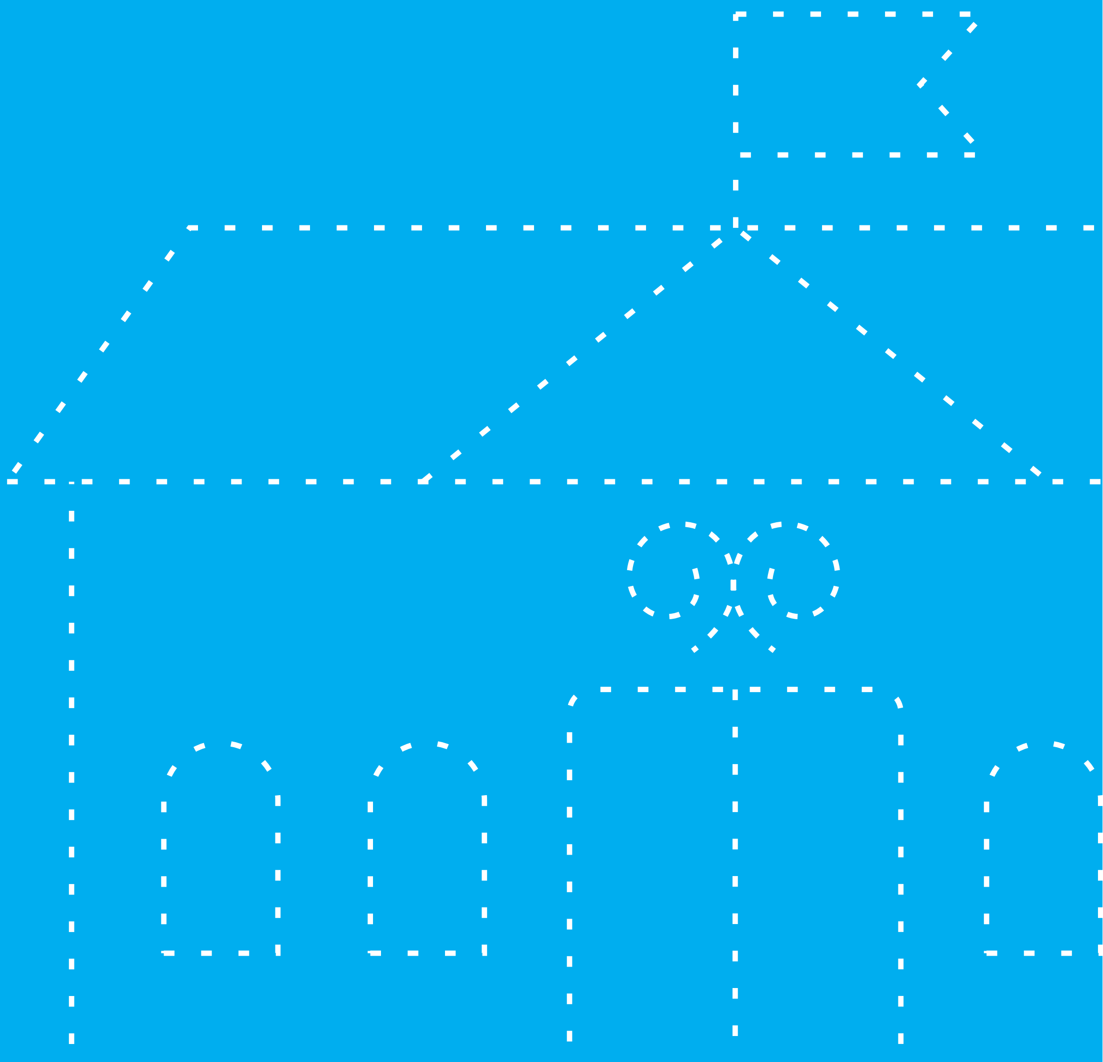
Specifically, in April 2024 market leader SES announced that it would acquire rival Intelsat in a transaction that was expected to close in the second half of 2025; the combined company will have a share of almost one-third of the market, and many observers expect SES to leverage its strong position in the GEO and MEO markets to eventually develop its own LEO constellation in competition with Starlink and Kuiper, positioning its GEO assets within a multi-orbit strategy. Eutelsat operates about three dozen GEO satellites and its 2023 merger with OneWeb created a unique GEO-LEO operator. Viasat purchased the operator Inmarsat in 2023 and its combined portfolio consists of 19 GEO satellites. EchoStar acquired Hughes Network Systems in 2011 and Dish Networks in 2023, with the latter acquisition giving the company access to a $6 billion 5G mobile network in the United States. Canadian GEO operator Telesat, meanwhile, has announced a $5 billion expansion into the LEO market with its Lightspeed constellation, scheduled for launch in 2026.

The future outlook for GEO services is more restrained compared to the growing market for MEO and LEO satellites. In 2024, manufacturers estimated that orders for new GEO communications satellites would average between 10 and 15 per year, down from historical highs of 20 to 25 units annually.[12] This contraction reflects the evolving dynamics of the satellite industry, where GEO satellites continue to adapt and strive for a continued position in the marketplace amidst the rise of LEO and MEO systems.

[11] Telesat. Real-Time Latency: Rethinking Remote Networks. https://www.telesat.com/resources/real-time-latency-rethinking-remote-networks/

[12] Foust, Jeff. Satellite Manufacturers Defend Diminished GEO Market. Spacenews, March 18, 2024. https://spacenews.com/satellite-manufacturers-defend-diminished-geo-market/

IV. Kazakh Satellite Market Overview & Options for Satellite Connectivity to Kazakh Schools



Kazakhstan is recognized as a pioneer in the global satellite industry, noted for its domestic achievements as well as its international collaborations. Leveraging a proud history dating to the inauguration of the world's largest operational space launch facility (the Baikonur Cosmodrome) in 1955, Kazakhstan's more recent progress in the space industry has been marked by the creation of the National Space Agency of the Republic of Kazakhstan (also known as KazCosmos, established in 2007). By law, Kazakhstan has established two distinct national satellite operators with different functions:

The Republican Center of Space Communications (RCSC), which is responsible for operating and managing Kazakhstan's communication satellites, including the KazSat series. RCSC focuses on providing satellite communication services and maintaining the country's satellite infrastructure.

JSC National Company Kazakhstan Gharysh Sapary (KGS), which has a primary focus on Earth remote sensing activities. KGS operates Kazakhstan's Earth observation satellites and provides geospatial data and services.

These two operators, while both under the umbrella of KazCosmos, serve complementary roles in advancing Kazakhstan's space capabilities and supporting its national space program objectives.

Since 2006, Kazakhstan has launched three satellites (KazSat-1, KazSat-2, and KazSat-3) to provide telecommunications and broadcasting services to Kazakhstan and other markets in the region (the country has also launched its own KazEOSat series of remote sensing satellites for Earth observation). As such, Kazakhstan plays a strategic dual role in the growth and development of the satellite sector, serving as both launch facilitator and satellite operator.

a. KazSat GEO Service

KazSat-1, Kazakhstan's first communications satellite, was launched into geostationary orbit in June 2006 at a cost of $65 million. It featured 12 Ku-band transponders and a total bandwidth of 72 MHz but in 2008 it experienced a failure in its onboard digital system and was removed from service the following year.

KazSat-2, launched in 2011 at a reported cost of $115 million, had 16 Ku-band transponders and was intended to supplement KazSat-1 but ultimately served in a replacement role following the loss of KazSat-1. Kazakh officials indicated that KazSat-2 yielded $30 million in annual savings that would have otherwise been spent by Kazakhstan's mobile operators on more expensive services from foreign satellite operators. The declared active life of KazSat-2 was set to expire in 2024 but some sources indicated that it might remain in service as late as 2026. In 2017 Kazakh officials announced plans for a successor satellite, KazSat-2R, to be launched into orbit in 2023 at a cost of $105 million, but in 2021 the KazSat-2R project was canceled.[13]

KazSat-3, featuring 28 Ku-band transponders and developed at a cost of $120 million, was launched in 2014 with an expected life of 15 years. In November of 2022 Kazakh officials signed a memorandum of understanding with Turkish Aerospace Industries for the development of a KazSat-3R replacement satellite,[14] with the expectation that additional Turkic countries would join in the project.

[13] Batyrov, Azamat. Kazakhstan Abandons Its KazSat-2R Communication Satellite Project. Caspian News, February 22, 2021.
https://caspiannews.com/news-detail/kazakhstan-abandons-its-kazsat-2r-communication-satellite-project-2021-2-22-0/
[14] Khassenkhanova, Galiya. Kazakhstan to Collaborate with Türkiye on Replacing KazSat Satellite. Astana Times, November 10, 2022.
https://astanatimes.com/2022/11/kazakhstan-to-collaborate-with-turkiye-on-replacing-kazsat-satellite/

The KazSat-2 and KazSat-3 satellites were reported to have served 176 rural villages as of 2024, offering coverage to 17,000 residents.[15]

In March 2024 the then-Minister of Digital Development, Innovation and Aerospace Industry called for the continued development and implementation of Kazakhstan's own indigenous communications satellites.[16] His statements reflected the Kazakh government's overall drive to increase digital sovereignty, reflecting the perceived risks that a reliance on foreign telecom service providers could pose to national security and economic development, as well as the perceived advantages that a strong Kazakh satellite sector could offer in the form of technological independence and robustness in the country's telecommunications ecosystem.

KazSat-2 and KazSat-3 served as the primary satellite connectivity used by Kazakh schools. As of 2024, more than 600 Kazakh schools rely on the two satellites, but their connections offer unsatisfactory speeds ranging from 0 to 4 Mbps, as well as other technical limitations. Additionally, the ground equipment required for KazSat service, comprising 1.8 m to 2.4 m Ku-band antennas, is comparatively expensive.

Over the long term, Kazakhstan plans to launch a new KazSat high throughput satellite into GEO orbit operating in the Ka- and Ku-bands at the 58.5° E orbital location. Commercial launch is planned to occur in 2029. The satellite would potentially provide connectivity to Kazah schools, among other roles.

[15] Ministry of Digital Development, Innovations and Aerospace Industry off the Republic of Kazakhstan. On the Development of the Space Industry of the Republic of Kazakhstan, Vienna 2023. https://www.unoosa.org/documents/pdf/copuos/stsc/2024/ListTechnicalPresentations/2024_STSC_technical_presentations_slides/d1_--_5_Kazakhstan_presentation_Iskakov_Oralmagambetovnew.pdf

[16] Omirgazy, Dana. Kazakhstan Needs Own Communication Satellites, Says Minister. Astana Times, March 19, 2024. https://astanatimes.com/2024/03/kazakhstan-needs-own-communication-satellites-says-minister/

Evaluation Dimension	KazSat GEO Service
Availability	Nationwide, with strong availability in rural villages and to rural schools.
Affordability	At the per-user level, the pricing of terminal equipment and service on a per-Mbps basis is significantly more expensive for GEO services including KazSat when compared to non-GEO pricing. However, KazSat reportedly saved Kazakh mobile operators $30 million per year compared to foreign GEO services.
Competition	KazSat is a key element in the promotion of Kazakhstan's digital sovereignty, reducing reliance on foreign telecom providers. However, its high program cost could prevent the proliferation of KazSat satellites.
Quality	Current connections provided by KazSat-2 and KazSat-3 offer unsatisfactory speeds ranging from 0 to 4 Mbps, but future satellites would offer much higher speeds.
Adaptability	The Kazakh government is planning to launch a new high throughput satellite by 2029 to improve connectivity and respond to market requirements. Planned collaboration with Turkish Aerospace Industries for KazSat-3R indicates adaptability through regional and international partnerships.
Delivery	KazSat-2 and KazSat-3 are the primary satellites providing connectivity to schools, but with limited speed and quality. A new planned satellite woiuld enhance delivery capabilities.
Funding Structure	KazSat-1, KazSat-2, and KazSat-3 were developed at significant cost ($65 million, $115 million, and $120 million respectively). The development of subsequent projects will depend on fiscal capacity and strategic priorities within the national space program.

b. Hughes Echostar GEO Service

Hughes Network Systems, a subsidiary of Echostar, announced in March 2024 that it would supply ground equipment to Kazakhstan's Republican Center of Space Communication to connect more than 200 rural villages via Hughes' Jupiter GEO satellite system.[17] The connectivity would provide for overall broadband internet access as well as access to e-Government services through the Digital Kazakhstan program.

[17] RCSC Selects Hughes JUPITER System to Help Bridge the Digital Divide in Kazakhstan," Hughes Network Systems. https://www.hughes.com/resources/press-releases/rcsc-selects-hughes-jupiter-system-help-bridge-digital-divide-kazakhstan

Evaluation Dimension	Hughes Echostar GEO Service
Availability	Nationwide, with equipment supplied to more than 200 villages
Affordability	Monthly consumer pricing is very competitive, at USD$75 for 50 Mbps and USD$90 for 100 Mbps.
Competition	Hughes could potentially put downward price pressure on non-GEO services such as Starlink.
Quality	Speeds of up to 100 Mbps are more than suitable for most users, but latency is a concern. Hughes offers hybrid solutions using mobile for lower latency.
Adaptability	Hughes says that its "system on a chip" in each user terminal can support increasingly higher speeds and a variety of services.
Delivery	The Hughes hybrid service using combined satellite and mobile network capabilities is an attractive service delivery option.
Funding Structure	Hughes Network Systems is a subsidiary of Echostar, and the Kazakh contract was awarded by the Republican Center of Space Communication.

c. Non-GEO (LEO and MEO) Service

In addition to its regional leadership in the development of GEO satellites, the Kazakh government has taken an active role in attracting international non-GEO (LEO and MEO) satellite service providers to offer service to the region. These include SpaceX Starlink, Eutelsat OneWeb, and SES O3b.

In particular, the Kazakh government has evaluated LEO and MEO options as lower-latency, higher-bandwidth alternatives to address the perceived shortcomings of GEO satellite service in the educational setting.

Kazakh law requires satellite operators to maintain ground facilities in Kazakh territory in order to maintain enable the monitoring and filtering of content.[18] Although this particular regulation has been viewed by some observers as burdensome, the Kazakh government has generally made a strong effort to attract non-GEO investment, offering tax incentives[19] and considering foreign operators to provide services without immediate activation of ground facilities, provided certain conditions are met. In early-2024 the Kazakh Mazhilis (Assembly) adopted a bill to implement favorable special regulations for the non-GEO sector until at least 2026.[20]

[18] "SpaceX refused to place a gateway station in Kazakhstan." Global CIO, May 27, 2024. https://globalcio.com/news/13841/
[19] Digital Ecosystem Country Assessment: Kazakhstan. US Agency for International Development, May 2024. https://www.usaid.gov/sites/default/files/2024-05/USAID_DECA_Kazakhstan.pdf
[20] "Kazakhstan adopts bill entailing special regulations for utilizing non-geostationary satellites." Daryo, February 2023. https://daryo.uz/en/2024/03/01/kazakhstan-adopts-bill-entailing-special-regulations-for-utilizingnon-geostationary-satellites

Non-GEO Operator	Confirmed Plans as of 2024 to Construct Gateway in Kazakhstan	Status of Kazakhstan Gateway
SpaceX Starlink LEO	No	SpaceX has so far refused to construct a gateway in Kazakhstan.
Eutelsat OneWeb LEO	Yes	OneWeb is constructing a gateway at the Kokterek Space Communications Center which is expected to be operational soon.
SES O3b mPower MEO	No	In 2022 SES and the Republican Centre for Space Communications planned a gateway in the Almaty region but the project was suspended.

d. SpaceX Starlink LEO Service

In 2023 Kazakhstan selected SpaceX to provide Starlink internet connectivity to schools in an initial pilot program overseen by the Republican Center for Space Communications (RCSC). The trial included ten rural schools, eight of which were in the Almaty Region; the trial reportedly proved to be very successful, especially with respect to speed and ease of equipment installation, connection speed, and reliability.

During the trial, reported download speeds were typically between 250 and 300 Mbps and upload speeds were 25 to 30 Mbps. Connectivity was provided by a Starlink proprietary terminal and LAN connectivity within the schools were provided via Wi-Fi.

Based on the positive feedback that the Starlink pilot program received, it was subsequently expanded to cover 2,000 rural schools during a three-year paid "extended trial" between 2024 and 2027.[21] The first 500 Starlink internet terminals were delivered in March 2024 and were initially distributed to schools in the Turkistan and Akmola Regions.

As of April 2024, a total of 447 rural schools had been connected, and 624 schools had been connected as of May 2024. The remaining schools were expected to be brought online by the end of 2024.

SpaceX had yet to construct ground facilities in Kazakhstan as of mid-2024, although it was reportedly evaluating sites offered for its use in Koktorek and Akkol (Akmola Region).

Consequently, the Starlink service distributes internet content originating from points-of-presence outside Kazakhstan; for this reason, consumer use of Starlink services remains illegal in Kazakhstan and individuals or businesses using or selling equipment are subject to a potential fine of $75.[22] Some sources expected Starlink to work with the Kazakh government to implement alternative filtering methods while the company transmits content from foreign POPs.

At the 2023 Digital Bridge forum in Astana, the Minister of Digital Development, Innovation and Aerospace Industry explained that the impetus for the government to move forward with SpaceX for rural school connectivity was a perceived lack of urgency on the part of Kazakh telecom operators.[23] The minister regretted having to use a foreign provider for connectivity, but the government determined that the SpaceX solution was the most suitable solution for speedy deployment to schools in the near-term. In the long-term, the planned KazSat GEO satellite expected to enter service in 2029 could eventually supplement or replace Starlink in the educational setting.

[21] Around 2000 Schools to Be Connected to Starlink Internet in Kazakhstan by Late 2024. Kazinform, June 18, 2024. https://en.inform.kz/news/around-2000-schools-to-be-connected-to-starlink-internet-in-kazakhstan-by-late-2024-b991f5/

[22] Pannier, Bruce. Central Asia in Focus: Kazakh Authorities Send Mixed Signals on Using SpaceX's Starlink. RadioFreeEurope/RadioLiberty, November 22, 2023. https://about.rferl.org/article/central-asia-in-focus-kazakh-authorities-send-mixed-signals-on-using-spacexs-starlink/

[23] Satbayeva, Aru. Пришлось обратиться к SpaceX - Мусин об интернете в селах. Tengri News, October 12, 2023. https://tengrinews.kz/kazakhstan_news/prishlos-obratitsya-k-spacex-musin-ob-internete-v-selah-513331/

Evaluation Dimension	SpaceX Starlink LEO Service
Availability	Initially piloted in 10 Kazakh schools, expanded to cover 2,000 during a 3-year "extended trial" from 2024 to 2027. As of May 2024, 624 schools had been connected, with the remainder expected by the end of 2024.
Affordability	Starlink's base 25-200 Mbps residential service ranges from USD$42 to USD$120 per month depending on country, but prices for the Kazakh school connectivity initiative reportedly range from USD$200 to $335 per month for maximum download speeds of 200 Mbps.
Competition	Starlink's participation in the marketplace is generally considered to promote a more competitive environment for satellite services.
Quality	The service has generally been described as successful with respect to service quality, download speed, reliability, and ease of installation.
Adaptability	Starlink is scalable, as evidenced by the expansion of the pilot program from 10 to 2,000 schools.
Delivery	The Starlink terminal is proprietary and Starlink uses points-of-presence outside of Kazakhstan for content distribution.
Funding Structure	Specific financing details of the school trial have not been made public.

e. Eutelsat OneWeb LEO Service

In 2021, Euteslat OneWeb ran one of Kazakhstan's first non-GEO satellite trial services, a pilot LEO-based service to provide 50 Mbps connections to business and institutional clientele.[24] Although regulatory uncertainty prevented the trial from moving to the commercial stage, OneWeb went on to sign a memorandum of understanding in 2023 with Kazakhstan Temir Zholy, the national rail operator, to provide broadband satellite internet service to railway stations and rolling stock. The same year, it signed another letter of intent to bring internet service to 340 rural post offices operated by the Kazakhstan National Post Service (Kazpost),[25] with telecom operator Beeline Kazakhstan serving as technical integrator. In a move that mitigated previous regulatory uncertainty, April 2024 the Kazakh government reported that Eutelsat OneWeb was in the process of constructing of a gateway at the Kokterek (Almaty Region) Space Communications Center, which would make it the only non-GEO operator to fulfill the government's requirements for ground stations in Kazakh territory and thereby enabling the company to offer internet service in Kazakhstan by the end of the year.

[24] Eutelsat OneWeb. Eutelsat Performs Successful Field Trials in Rural Kazakhstan. https://oneweb.net/resources/oneweb-performs-successful-field-trials-rural-kazakhstan

[25] "OneWeb signs LOI with Kazpost and Beeline Kazakhstan." Intelsat OneWeb, June 14, 2023. https://oneweb.net/resources/oneweb-signs-loi-kazpost-and-beeline-kazakhstan

Evaluation Dimension	Eutelsat OneWeb Service
Availability	Expected to offer internet service across Kazakhstan by the end of 2024, following the construction of a gateway at the Kokterek Space Communications Center
Affordability	As a primarily business-to-business service provider, pricing terms of Eutelsat OneWeb service are not generally made public.
Competition	Potentially one of the first legalized nationwide non-GEO service providers in Kazakhstan, positioning itself as a competitor to GEO, MEO, and LEO providers.
Quality	Generally perceived as having high quality of service due to requirements of its operator/corporate/institutional/governmental (non-consumer) customer base.
Adaptability	Showed adaptability by pledging to construct gateway in Kazakhstan. Able to serve varied customer groups.
Delivery	Ground infrastructure would make it the only non-GEO operator providing content via Kazakh points-of-presence.
Funding Structure	The Eutelsat-OneWeb merger was completed in 2023.

f. SES O3b mPower MEO Service

For its part, SES O3b has also failed to construct ground facilities in Kazakhstan despite earlier plans (announced in September 2022[26]) to offer O3b mPower satellite service in Kazakhstan as well as in Uzbekistan, Kyrgyz Republic, and Tajikistan. As such, it is unclear whether O3b will offer service in Kazakhstan. O3b's current standard-service coverage area excludes the northern third of Kazakhstan's land area (i.e. above 50° north latitude[27]), although the company has indicated that future expansion of its service area is possible.

V. Satellite Technological Analysis

Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO) satellites each carry distinct advantages and challenges, influencing their suitability for certain communications applications over others. It should be noted that at the school level, satellite services' terminals are easily integrated with existing school networks including LANs and standard Wi-Fi routers, allowing schools to maintain their network infrastructure and equipment. However, understanding the differences between the technologies used by the satellites themselves is crucial for selecting the appropriate satellite communications service.

LEO satellites like Starlink and OneWeb, positioned at altitudes below 2,000 kilometers and orbiting the earth in less than two hours, offer stronger signal strengths, collectively higher download speeds, and lower latency than the other two technologies. However, they require deployment of large constellations and complex ground infrastructure to ensure continuous and widespread coverage.

MEO satellites, such as O3b mPower, orbit at altitudes of between 2,000 and 35,786 kilometers and are able to strike a middle balance between the lower latency and higher data rates of LEO satellite constellations and the wider coverage superiority of GEO satellites.

GEO satellites, positioned at 35,786 kilometers above the equator, served as the dominant satellite communications technology for several decades, especially for long-haul telecom applications, with a single GEO satellite covering about one-third of the Earth's surface. However, GEO satellites have lower signal strengths and significantly higher latency than LEO and MEO satellite constellations, and typically have higher per-unit operational costs.

On an application-by-application basis, LEO satellites excel in providing low-latency, high-speed internet access. MEO satellites are ideal for broadband services in remote areas and are suitable for most internet applications aside from online gaming. GEO satellites, meanwhile, are best for point-to-multipoint broadcasting and data services that are less sensitive to latency.

As satellite technology evolves, the integration of LEO, MEO, and GEO satellites into a harmonized multi-orbit approach offers the ability to leverage the strengths of each, with a long-term possibility that customers will eventually be able to subscribe to altitude-agnostic services provided seamlessly by their satellite providers. Consequently, it is expected that customers will no longer be forced into either-or decisions about different orbital technologies, instead subscribing to services that adapt to their needs in real-time.

a. Low Earth Orbit (LEO)

Low Earth Orbit (LEO) satellites, operating at altitudes between 160 to 2,000 kilometers, offer several advantages that make them well-suited for internet connectivity to schools and other applications requiring low latency and high data rates for real-time, interactive applications. From a subscriber perspective, the key advantages of LEO satellites are their low latency and high bandwidth.

Low Earth Orbit (LEO) satellites' low latency is achieved by their close proximity to earth, and is almost always less than 100 milliseconds, with current commercial services achieving latencies of between 30 and 50 milliseconds. LEO satellites' extremely low delay makes them particularly well-suited for applications such as videoconferencing, online collaboration tools, and interactive learning platforms, which are crucial for educational use.

Current commercial LEO technology is capable of delivering high-speed bandwidth not previously available via satellite. On a per-satellite basis, a Starlink v1.0 satellite has an estimated capacity of 18 to 20 Gbps, while Eutelsat OneWeb satellites have usable capacity of 7.2 Gbps each.[28]

[28] SES. SES's O3b mPOWER System Starts Providing High-performance Connectivity Services. https://www.ses.com/press-release/sess-o3b-mpower-system-starts-providing-high-performance-connectivity-services

Next-generation satellites have even higher capacity, with Starlink's v2 Mini satellites offering up to 80 Gbps each, and full-sized v2 satellites estimated to be capable of more than 150 Gbps.
On a constellation-wide basis, Starlink's first-stage deployment could eventually provide 88 Tbps of usable capacity, potentially increasing to as much as 200 Tbps in the second stage; Eutelsat OneWeb's smaller constellation offers a total capacity of 1.1 Tbps.

Starlink and OneWeb both report average subscriber download speeds of 100 Mbps or more, with connections varying greatly depending on geography as well as the contention rate among simultaneous online users.

Evaluating the technology from a business-case perspective, the biggest drawback of LEO satellites is the requirement that hundreds or sometimes even thousands of individual satellites are needed to achieve global coverage. LEO constellations also require that their ground stations (which can potentially number in the hundreds) track the satellites very rapidly, with antennae movements once very ten minutes in order to maintain connectivity.

Once deployed, complete LEO constellations can offer superior geographic coverage, including in polar regions that cannot typically be reached by GEO satellites due to signal interference. Currently, the Starlink constellation has the highest number of satellites providing coverage to latitudes of 55° or less (in Kazakhstan this would exclude only a small part of the country north of Presnovka, North Kazakhstan, about 30 kilometers south of the Russian border). In theory, this should result in stronger coverage over southern areas, but in practice there are often fewer users contending for the fewer satellites in the far north, which can result in higher per-user download speeds than in Starlink's primary coverage area.

Cost is a complex consideration when comparing satellite technology. On the one hand, LEO satellites are smaller and their orbits are closer to earth, so on a per-unit basis they cost less to construct and can be launched using smaller, less-expensive rockets. LEO satellites cost an average of $500,000 each and can be produced in as little as 18 months; by comparison, individual GEO satellites are hundreds of times more expensive. However, full LEO constellations incur significantly higher costs than most GEO and MEO configurations, due to the vast number of LEO satellites required to achieve coverage as well as the complexity of the ground infrastructure that is required to maintain seamless connectivity.

LEO satellites have a significantly shorter lifespan than satellites at higher altitudes. LEO satellites are subject to greater atmospheric drag than satellites at higher altitudes, leading to more rapid fuel depletion; additionally, their batteries are subject to greater stress due to charging and discharging cycles. Space debris is also a threat. The average operational lifespan of a LEO satellite is around five years, compared to GEO lifespans of up to three times that. Although LEO operators plan for the replacement of retired satellites and replenishment of their constellations and Starlink operator SpaceX has an estimated valuation of over $200 billion, the long-term commercial viability of LEO satellite operators nevertheless merits case-by-case evaluation by internet subscribers seeking to ensure permanent connectivity solutions.

b. Middle Earth Orbit (MEO)

Middle Earth Orbit (MEO) satellites occupy a middle space between LEO and GEO technology, not only literally in terms of orbit but also by figuratively, balancing considerations such as cost, latency, bandwidth, and coverage.

The technical characteristics of MEO satellites is most practically demonstrated by the first and so far only major MEO communications satellite constellation, SES' O3b mPower network, which reported that its network had become operational in late-April 2024 with its first six MEO satellites.[29]

[29] SES. SES's O3b mPOWER System Starts Providing High-performance Connectivity Services. https://www.ses.com/press-release/sess-o3b-mpower-system-starts-providing-high-performance-connectivity-services

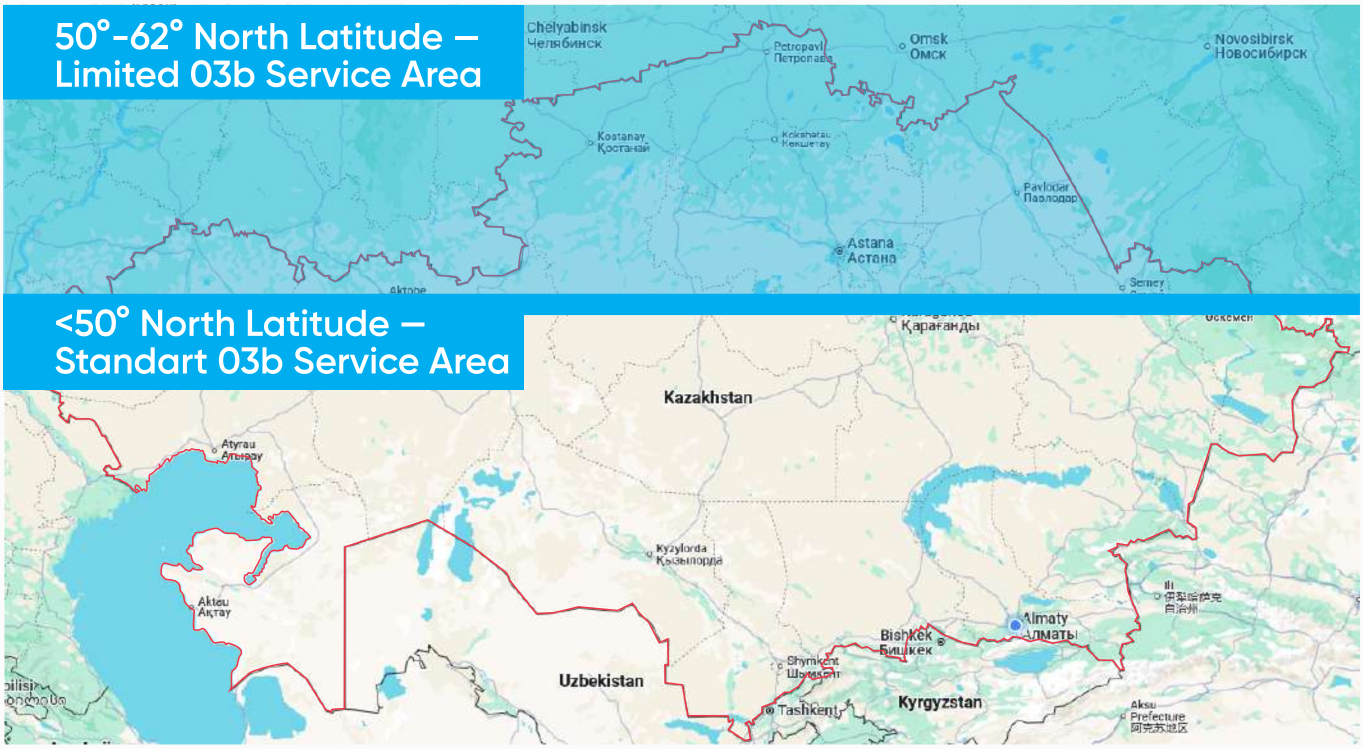
O3b reports a roundtrip data latency of approximately 125 to 150 milliseconds, approximately four times higher than LEO constellations but one-fourth the latency of GEO services. In most cases this delay is imperceptible to users, and with the exception of online gaming platforms, it is considered adequate for most uses in the residential, business, and educational spaces, including real-time and interactive applications used in digital learning.

MEO constellations' ground infrastructure is significantly less complex than that of LEO satellites, though not as straightforward as the stationary antennae of GEO satellites. MEO antennae have slow tracking which require movements only once per hour, versus six times per hour for LEO antennae. Because MEO constellations require fewer satellite handoffs than LEO constellations, they have lower network jitter, or variance in latency, and this predictability can partly compensate for MEO's higher latency levels by increasing the stability of real-time applications.

In practice, the bandwidth provided by O3b to its carrier, corporate, and government clientele is typically ranges from tens of megabits up to 1.5 Gbps of uncontented bandwidth for mobile backhaul customers. In theory, O3b's shapeable and steerable spot-beam technology, using phased array antennae, can accommodate single-user streams of up to 10 Gbps on demand and in real-time.

Notably, O3b mPower's standard-service coverage zone is currently limited to the area between 50° N and 50° S latitude, with limited coverage in the area between 50° and 63° latitude. In Kazakhstan, the limited-service area includes Astana and the northern one-third of the country's land area. SES has indicated that the mPower constellation could achieve global coverage through future expansion from its current equatorial orbits into inclined orbits. However, it is unclear whether O3b service will be available in Kazakhstan.

O3b mPower Service Coverage in Kazakhstan



Map Data © 2024 Google, Graphic: Terabit Consulting

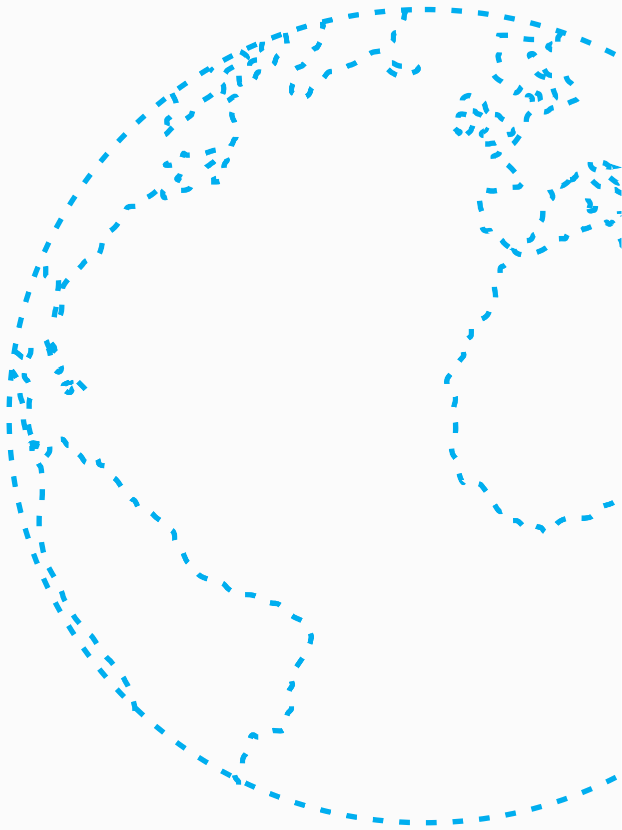
c. Geostationary Earth Orbit (GEO)

Geostationary Earth Orbit (GEO) satellites have formed the historical backbone of the global satellite communications industry. The satellites, which weigh over a ton, can cost between $100 million and $400 million and take years to produce. However, they typically show the highest levels of reliability and the longest lifespans, remaining in service for up to 15 years. Present-day GEO technology benefits from decades of research and a long history proven data, especially compared to the younger and sometimes experimental technologies implemented in the LEO and MEO spaces. GEO satellites, while disadvantaged by high latency, are competitive in terms of download speeds and offer more efficient geographic coverage than LEO and MEO.

Although older GEO satellites offered only a few gigabits per second of capacity, High Throughput Satellites (HTS) rival even the most advanced individual LEO satellites with capacities of as much as 500 Gbps or more. GEO satellites can offer much more efficient signal utilization than LEO satellites, which spend extended periods of time over oceans, effectively rendering much of the constellations' capacity inaccessible to users. However, even with efficiencies, the capacity of GEO satellites pales in comparison to the tens of terabits of capacity that entire LEO constellations can provide.

A single GEO satellite can provide coverage to almost one-third of the Earth. Three satellites spaced at 120° intervals can provide near-global coverage, with the notable exception of the polar regions. Geostationary satellites' orbits over the equator translates to smaller antenna angles that are susceptible to interference at higher latitudes and the horizon blocks GEO satellites entirely at latitudes of higher than 81° (there are no permanent, non-scientific/research settlements north of 81° north latitude or south of 81° south latitude).

Latency is by far the biggest weakness of GEO satellites. Given GEOs' altitude of 35,786 above the equator, the theoretical minimum roundtrip latency of a GEO satellite signal, calculated at the speed of light in a vacuum, would be approximately 240 milliseconds. In practice, signal processing and routing increases GEO latency to an average of 600 milliseconds, up to 20 times higher than LEO satellite services and unsuitable for most real-time internet applications. They do excel in point-to-multipoint broadcasting applications and internet applications with lower sensitivity to latency, however.



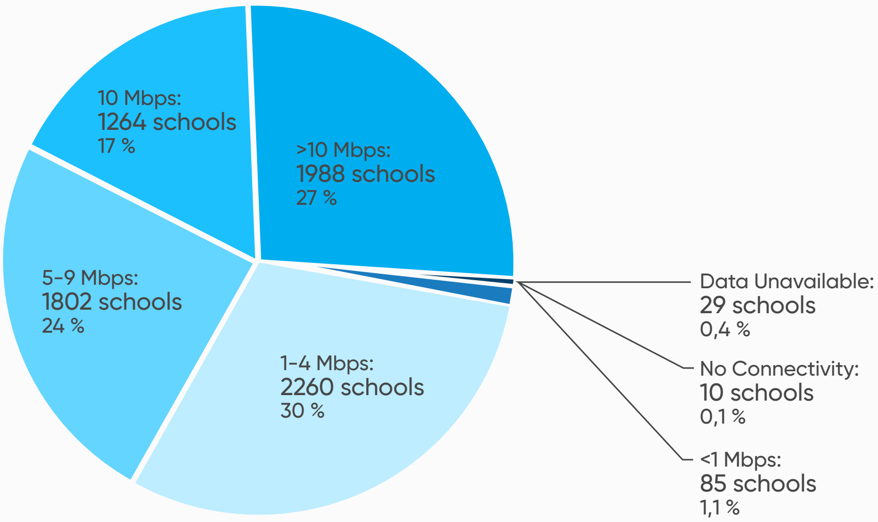
VI. Status of Kazakh School Connectivity

Kazakhstan is considered a leader in digital learning in Central Asia, with strong government support of initiatives promoting high-speed, reliable internet to all of the country's schools. Although almost all Kazakh schools are connected to the internet, average download speeds, particularly in rural areas, are currently considered insufficient for the Government of Kazakhstan's long-term digital learning strategy.

Low connection speeds to Kazakh schools are primarily the result of missing and insufficient middle- and last-mile connections. Although fiber optic and wireless networks such as 5G have been identified as the preferred options for improved connectivity, in some cases challenges and obstacles such as topography, distance, and low population density have reduced the viability of such deployments. Meanwhile, recent advancements in non-GEO satellite technologies and services have made available viable, cost-effective, low-latency connectivity options for the country's rural schools that finally provide suitable download speeds.

UNICEF's 2022 Feasibility Study of Potential Technical and Financial Solutions for Upgrading School Connectivity to Broadband Speeds in Kazakhstan revealed that 56 percent of all Kazakh schools connected at speeds of less than 10 Mbps,[30] which at the time was considered by Giga to be the absolute minimum threshold for adequate per-school download speeds.

Kazakhstan Schools' Internet Access by Connection Speed, 2022

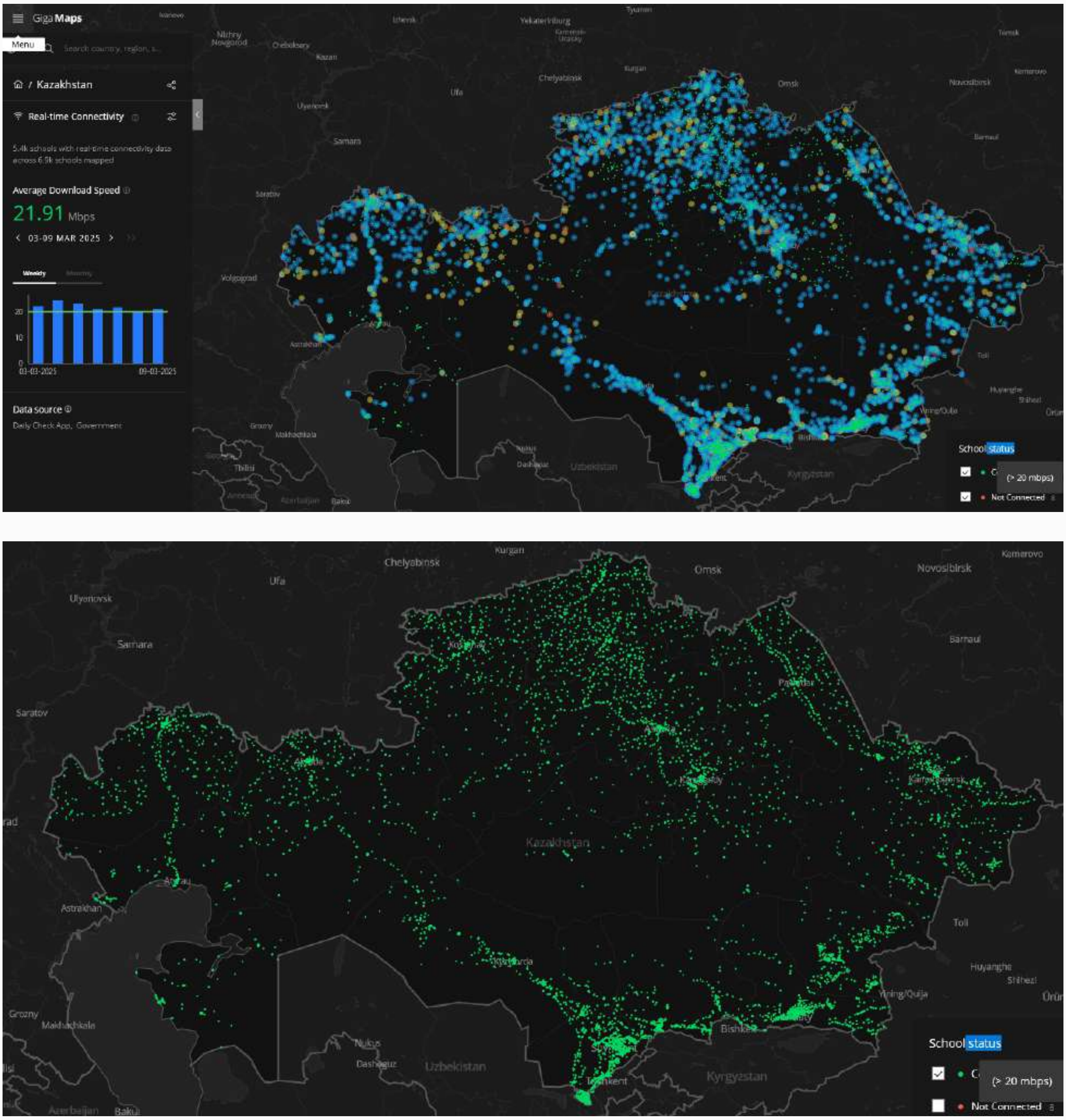


Source: Giga, Terabit Consulting analysis

As of June 2024, Giga statistics showed that the number of schools in Kazakhstan without internet connectivity (11) remains negligible, representing less than two-tenths of one percent of the 6,931 schools reporting (in fact, sources have indicated that the data for these schools were possibly subject to reporting errors or that some of the schools may have closed, implying that there may possibly be no schools that are entirely unconnected). The average download speed per school reported by Giga remains low, at only 14.2 Mbps per school,[31] less than Giga's recommended minimum of 20 Mbps.

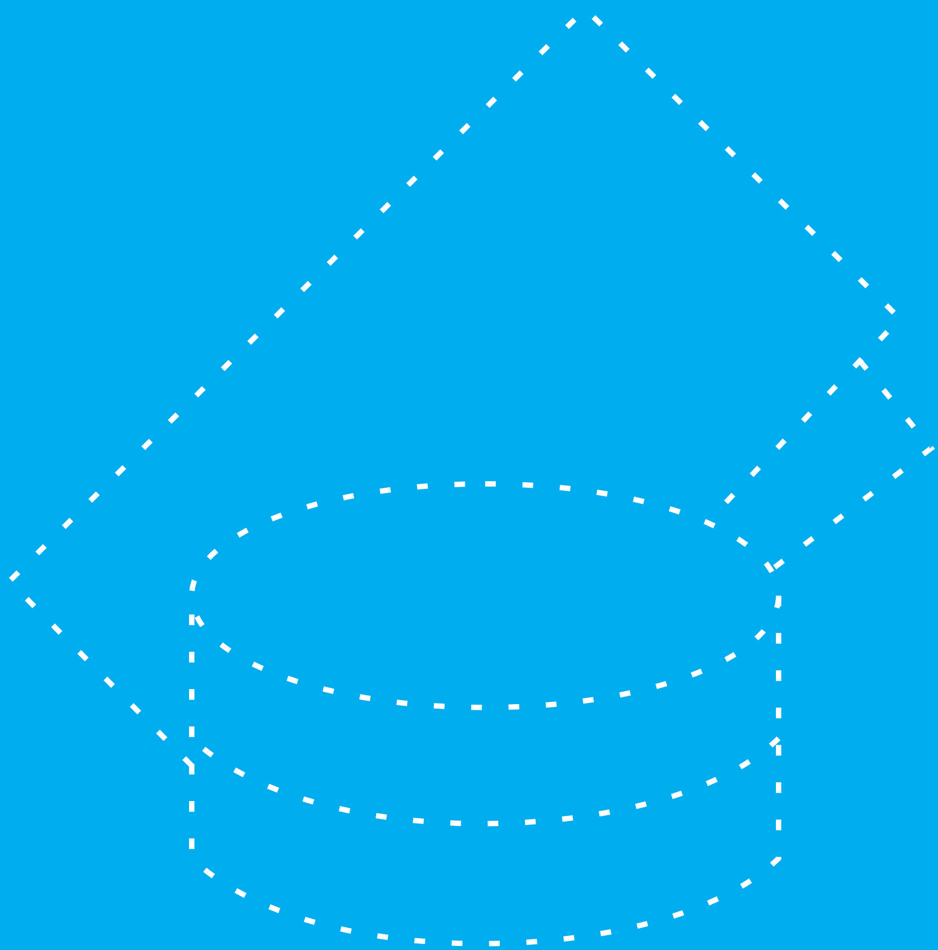
[31] Giga. Giga School Connectivity Maps. https://maps.giga.global/map

Kazakhstan Schools' Internet Access by Connection Speed, 2022



Source: Giga, https://maps.giga.global

VII. Cost Analysis and Funding Mechanisms



a. Starlink LEO Pricing

Starlink's official prices in the sample markets of the United States, Germany, and Japan, as well as the case study markets of Canada and New Zealand, are shown below (Starlink is not available in the third case study market of China).

Starlink Pricing in the United States, 2024

Source: Starlink

	Price / Mo. ($USD)	Download Speed (Mbps)	Download Limit	Equipment Price ($USD)
Residential	$120	25 - 220	Unlimited	$299 ($499 in some states)
Business 40 GB	$140	100 - 220	Unlimited; 40 GB of priority download	$2,500
Business 1 TB	$250	100 - 220	Unlimited; 1 TB of priority download	$2,500
Business 2 TB	$500	100 - 220	Unlimited; 2 TB of priority download	$2,500

Starlink Pricing in Germany, 2024

Source: Starlink

	Price / Mo. ($USD)	Download Speed (Mbps)	Download Limit	Equipment Price ($USD)
Residential	$54 (EUR €50)	25 - 220	Unlimited	$374 (EUR €349)
Business 40 GB	$64 (EUR €60)	100 - 220	Unlimited; 40 GB of priority download	$3,047 (EUR €2843)
Business 1 TB	$180 (EUR €193)	100 - 220	Unlimited; 1 TB of priority download	$3,047 (EUR €2843)
Business 2 TB	$360 (EUR €386)	100 - 220	Unlimited; 2 TB of priority download	$3,047 (EUR €2843)

Starlink Pricing in Japan, 2024

Source: Starlink

	Price / Mo. ($USD)	Download Speed (Mbps)	Download Limit	Equipment Price ($USD)
Residential	$42 (JPY ¥6600)	81 - 185	Unlimited	$349 (JPY ¥5500)
Business 40 GB	$61 (JPY ¥9600)	100 - 185	Unlimited; 40 GB of priority download	$2,319 (JPY ¥365000)
Business 1 TB	$178 (JPY ¥28000)	100 - 185	Unlimited; 1 TB of priority download	$2,319 (JPY ¥365000)
Business 2 TB	$356 (JPY ¥56000)	100 - 185	Unlimited; 2 TB of priority download	$2,319 (JPY ¥365000)

Starlink Pricing in Indonesia, 2024

Source: Starlink

	Price / Mo. ($USD)	Download Speed (Mbps)	Download Limit	Equipment Price ($USD)
Residential	$48 (IDR 750,000)	81 - 185	Unlimited	$377 (IDR 5,900,000)
Business 40 GB	$70 (IDR 1,100,000)	100 - 185	Unlimited; 40 GB of priority download	$2,793 (IDR 43,721,590)
Business 1 TB	$193 (IDR 3,025,000)	100 - 185	Unlimited; 1 TB of priority download	$2,793 (IDR 43,721,590)
Business 2 TB	$391 (IDR 6,116,000)	100 - 185	Unlimited; 2 TB of priority download	$2,793 (IDR 43,721,590)

Starlink Pricing in Canada, 2024

Source: Starlink

	Price / Mo. ($USD)	Download Speed (Mbps)	Download Limit	Equipment Price ($USD)
Residential	$101 (CAD$140)	25 - 220	Unlimited	$215 (CAD$299)
Business 40 GB	$134 (CAD$185)	100 - 220	Unlimited; 40 GB of priority download	$2,255 (CAD$3,170)
Business 1 TB	$231 (CAD$320)	100 - 220	Unlimited; 1 TB of priority download	$2,255 (CAD$3,170)
Business 2 TB	$459 (CAD$635)	100 - 220	Unlimited; 2 TB of priority download	$2,255 (CAD$3,170)

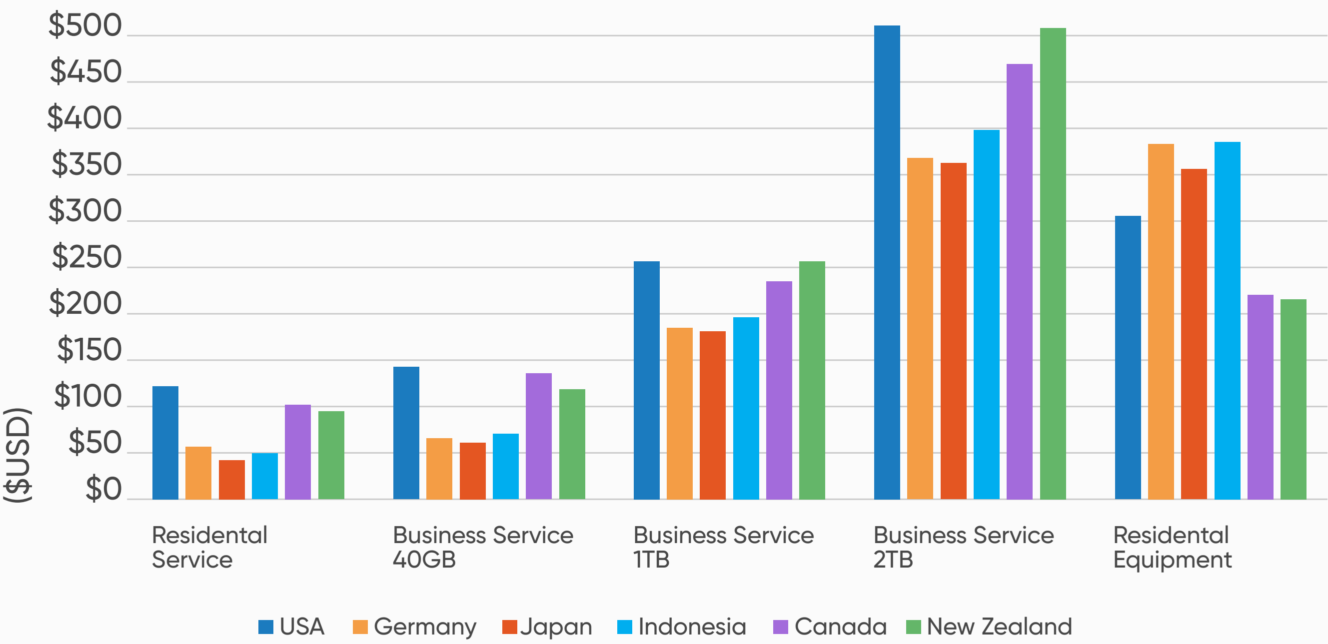
Starlink Pricing in New Zeland, 2024

Source: Starlink

	Price / Mo. ($USD)	Download Speed (Mbps)	Download Limit	Equipment Price ($USD)
Residential	$94 (NZ$159)	81 - 185	Unlimited	$212 (NZD$359)
Business 40 GB	$116 (NZ$196)	100 - 185	Unlimited; 40 GB of priority download	$2,695 (NZD$4,567)
Business 1 TB	$251 (NZ$426)	100 - 185	Unlimited; 1 TB of priority download	$2,695 (NZD$4,567)
Business 2 TB	$496 (NZ$840)	100 - 185	Unlimited; 2 TB of priority download	$2,695 (NZD$4,567)

Comparison of Starlink Pricing in USA, Germany, Japan, Indonesia, Canada, and New Zealand

Source: Terabit Consulting Analysis



Starlink's base service, for both residential and business customers, is significantly cheaper in many markets outside the United States, while equipment costs are generally more expensive. In Kazakhstan, Starlink is not yet available to residential or business customers, so the service and equipment pricing has not yet been determined.

Details of the contracts for the Kazakhstan's school connectivity trial project with Starlink have not been made public, but the prices cited by interviewed sources ranged from USD$200 to $335 per month for maximum download speeds of 200 Mbps (the $200 price point is similar to the price of 1 TB business services in other international markets). Some sources cited a price of $200 per month for a 40 Mbps committed information rate (CIR) with burstable bandwidth to 200 Mbps. Other sources cited a price of $200 per month for a 150 Mbps service, and still others cited a price of $335 per month for a 200 Mbps downlink. Terminal and installation costs were reported to range from $500 to $1,500, with installation and maintenance performed by local Kazakh system integrators at regulated prices.

Although the 200 Mbps speed of the Starlink service is generally considered to be robust, particularly in underserved areas when compared to existing services with speeds of as low as 2 Mbps per school, some have questioned the long-term viability of 200 Mbps connections in schools with high enrollment, where per-pupil bandwidth could potentially be less than 1 Mbps. Consequently, many stakeholders expressed hope that service would be scalable in the future.

The outlook for improved Starlink speeds is mixed: as more satellites are deployed, more network capacity will become available; however, as the service grows in popularity, more simultaneous users will be online, increasing the contention rates for that capacity.

b. Other LEO & MEO Pricing

Eutelsat OneWeb terminals are priced at approximately $10,000 each, according to sources. OneWeb does not sell its LEO-based internet service directly to consumers; instead, it partners with service providers who offer packages that differ significantly in price.

Although O3b declared its MEO constellation to be fully operational in April 2024, actual rollout of service was not scheduled to take place until several months afterward, and as of mid-2024 no pricing had been released (it is not clear whether O3b service will be available in Kazakhstan).

c. GEO Pricing

Prior to 2023, subscriptions to geosynchronous services serving Kazakhstan, such as Hughes and iDirect, were reported to have cost approximately $100 per month for modest 1-Mbps connections, with bandwidth caps of between 10 GB and 20 GB.

Elsewhere, in countries with similar satellite connectivity projects such as Kenya, Rwanda, and Sierra Leone, sources recently reported that monthly costs have typically averaged USD$50 to $70 per month for 10 to 20 Mbps connections via GEO satellites.

In general, GEO pricing is significantly more expensive on a per-Mbps basis than LEO services.

d. Funding Mechanisms for School Connectivity

Typically, funding for broadband service in government-sponsored schools in Kazakhstan is provided at two levels. Hardware installation and capital costs (capex) are managed by the Ministry of Education at the central government level, while operational expenses (opex) including monthly service costs are the responsibility of the Akimat, i.e. regional executive authority. Private schools are often eligible for subsidies or grants.

As indicated in UNICEF's previous analysis of internet connectivity to Kazakh schools, it is recommended that all expenditure and procurement associated with school internet connectivity, i.e. capex as well as opex, eventually be administered by the central government under the purview of the Ministry of Education, with possible participation of the Executive Office of the President as appropriate. This would help to ensure uniformity and ubiquity of internet service, and maximize negotiating power for procurement and purchasing. It would also avoid potential budgeting pitfalls and delays at the local and school levels, including a perceived disincentive for savings by schools to have leftover budgetary surpluses since their budgets are typically allocated as a function of the previous year's spending.

Kazakhstan could also consider the development of a Universal Service Fund (USF), which it does not currently have. USFs can be funded through levies on operators, income from spectrum auctions and the sale of licenses, contributions from external donors such as multilateral development banks, or taxes on consumers. While they can provide a significant source of funding, it is essential to assess the potential impact of any taxes or increased costs on end-users, as these could hinder digitalization efforts before moving forward with implementation.

Connectivity projects for under-connected schools typically benefit from multinational technical support and guidance, led by organizations such as Giga, UNICEF, and the International Telecommunications Union (ITU) who contribute expertise. This is especially true for satellite connectivity projects, where Giga and UNICEF provide financial and technical expertise to identify and implement the most cost-effective, technologically-viable solutions while the ITU contribute regulatory and policy expertise as well as technical guidance including frequency allocation and international standards.

e.Cost-Effectiveness of Satellite vs. Alternative Options

For the majority of Kazakh schools in urban and suburban areas, traditional fixed and mobile internet services such as fiber-to-the-building, asymmetric digital subscriber line (ADSL), and mobile services are the most cost-effective means of providing internet connectivity, particularly given Kazakhstan's regional leadership in fiber-to-the-home (FTTH) and 5G deployment. The prices offered by Kazakhstan's fixed and mobile operators are extremely competitive, with bundled packages (often pairing 200 Mbps internet service with either television or mobile telephony service) typically less than 10000 TG (USD$22).

However, Kazakh operators' fiber and 4G/5G coverage is not ubiquitous, leaving many Kazakh schools unconnected or under-connected at speeds of 20 Mbps or less. For remote, rural schools in geographically- or topologically-challenging locations, broadband satellite internet access is an increasingly cost-effective option.

This is especially true since the advent of new non-GEO satellite constellations. The cost of internet access via satellite has decreased significantly since 2023. At the time of UNICEF's last analysis of school connectivity options in Kazakhstan in 2022, subscriptions to geosynchronous services serving Kazakhstan, such as Hughes and iDirect, were reported to have cost approximately $100 per month for 1-Mbps connections, with bandwidth caps of between 10 GB and 20 GB. LEO service via Starlink, while not available in the Kazakh consumer market, is available in some regions for as little as $42 for 200 Mbps connections.

Although generally not as competitive as the terrestrial services offered by Kazakh fixed and mobile operators in populated areas, non-GEO satellite service can be a cost-effective solution for sparsely populated regions that cannot be connected to backbone fiber networks or reliable mobile signals.

VIII. Case Studies, Best Practices, and Implementation Guidelines

Case studies of the use of internet satellite connectivity to rural and remotes schools were evaluated for Canada, New Zealand, and China.

The results of these evaluations, together with input from additional analyses, were used to develop best practices and implementation guidelines.

a. Canada

As the second-largest country on Earth by area, and with a widely dispersed population, Canada faces significant challenges in providing universal broadband connectivity to its schools. Many villages and settlements are geographically isolated, including Nunavut's 25 communities, which are inaccessible by road or rail. Satellites are often the most logical and in any cases only solution for providing internet connectivity, particularly in the Far North.

Consequently, Canada was an early adopter of internet satellite connectivity to rural and remote communities and schools, dating to the 1990s. GEO satellite connectivity provided by Telesat Canada, which was a state-owned Crown corporation until 1998, formed the backbone of the federal government's SchoolNet initiative, launched in 1993.

By 1997, SchoolNet had successfully linked all 433 First Nations schools under federal jurisdiction.[33] SchoolNet leveraged satellite capacity to offer reliable video streaming, enriched video-conferencing, and high-speed internet access to schools for the first time. The program also included the development of innovative local content such as the SchoolNet MOO (Object Orientated Multi-User Domain, an early real-time, text-based "virtual reality" application for learning) and the Special Needs Education network. Initially promoted by Industry Canada, Schoolnet was overseen by the Education Branch of Indigenous and Northern Affairs Canada before eventually being wound down in the 2000s due to budget cuts (thereby highlighting the importance of sustainable, long-term funding models).

Satellite-Dependent Communities in Canada

[33] Indian and Northern Affairs Canada. Evaluation of the First Nations SchoolNet Program.
https://www.rcaanc-cirnac.gc.ca/ForcePDFDownload?url=https%3a%2f%2fwww.rcaanc-cirnac.gc.ca%2fDAM%2fDAM-CIRNAC-RCAANC%2fDAM-AEV%2fSTAGING%2ftexte-text%2ffns_1100100011858_eng.pdf

As of 2024, the Government of Canada has continued to take an active role in the development of high-speed internet connectivity to rural and remote communities, with a focus on schools and digital learning. Although Canada has robust fiber- and wireless-based telecommunications infrastructure, more than 60 communities remain dependent exclusively on satellite connectivity.

Consequently, the government has worked to expand the availability of next-generation satellite service across the country through multiple programs and initiatives, including Connect to Innovate and the Universal Broadband Fund.

The Connect to Innovate (CTI) program was launched by Innovation, Science And Economic Development Canada (ISED) in late-2016 with a total commitment of more than CAD$500 million to improve broadband connectivity in rural and remote communities, of which CAD$57.7 million was ultimately appropriated for satellite projects As of 2023 this included CAD$49.9 million for satellite connectivity in 25 communities in Nunavut, $5.6 million for two communities in northwestern Ontario, and CAD$2.2 million for nine communities in Northwest Territories.[34]

The CTI grants for Nunavut and Northwest Territory were awarded to Canadian telco Northwestel, which had initially partnered with Telesat using capacity on Telesat's Anik F2 GEO satellite, and intending to transition to Telesat's planned LEO constellation by 2023. However, in summer 2022 Telesat said that Anik F2 would begin experiencing service degradation; at the same time, it became clear that Telesat's LEO constellation was unlikely to enter service on schedule. Consequently, Northwestel transitioned its satellite capacity to OneWeb's LEO constellation over a five-month period in late-2022 and early-2023. In mid-2023 OneWeb said that it was expanding its ground presence in Canada after awarding a ten-year contract for the construction and operation of a OneWeb Satellite Network Portal (SNP) in Yellowknife, Northwest Territories, Northwestel would was selected to provide fiber backhaul connectivity to the facility.

The Universal Broadband Fund (UBF) was launched by the Government of Canada in 2019 with an initial commitment of CAD$ 1 billion, later increased to CAD$1.75 billion in response to the COVID-19 pandemic. As of 2024 funding stood at CAD$3.225 billion.[35] Although the UBF supports a wide range of broadband technology, satellite has been a key recipient of funding. In November 2020 the government committed $600 million from the fund for the purchase of capacity on Telesat's planned Lightspeed LEO satellite constellation, representing the largest single investment in broadband ever made by the federal government. Additionally, in 2024 the Ministry of Innovation, Science, and Industry announced a CAD$2.14 billion investment in Telesat for Lightspeed's development, comprising a repayable loan as well as warrants equivalent to 10 percent of Telesat's common stock.

Telesat Lightspeed is expected to provide high-speed, reliable, low-latency Internet capacity to the most challenging rural and remote communities in Canada, particularly in the far north. Notably, Telesat operates primarily at the wholesale level and does not sell directly to end-users such as consumers or schools; instead, the company sells satellite capacity to local internet service providers who are responsible for providing end-user solutions.

Lightspeed's development has been significantly delayed; Telesat launched a prototype LEO satellite in 2018 with the expectation that a 120-satellite LEO constellation would enter service in 2021; as of 2024 the 198-satellite Lightspeed constellation is scheduled to enter service in 2026.[36]

[34] Innovation, Science and Economic Development Canada. Selected Connect to Innovate Programs. https://ised-isde.canada.ca/site/connect-to-innovate/en/selected-connect-innovate-projects

[35] Innovation, Science and Economic Development Canada. Universal Broadband Fund. https://ised-isde.canada.ca/site/high-speed-internet-canada/en/universal-broadband-fund

[36] Rainbow, Jason. Telesat Q&A: Getting Back to Lightspeed. Spacenews, September 11, 2023. https://spacenews.com/telesat-qa-getting-back-to-lightspeed/

In the meantime, communities and schools in rural and remote Canada are served by SpaceX's Starlink service. Since late-2022 Starlink's service has been available across Canada, including in the northern territories of Yukon, Northwest Territories, and Nunavut, with advertised download speeds of between 63 and 184 Mbps, and many actual users reporting average speeds of 100 Mbps or more, although some users also report problems with dropped connections. The service costs USD$100 per month with an installation cost of USD$365; "prioritized" services cost between USD$135 and USD$635 depending on volume, plus $2,300 for installation.

b. New Zealand

New Zealand is considered to be a model for the successful implementation of LEO satellite connectivity for rural and remote schools. The country's challenging geography, with vast rural expanses, rugged and challenging topography, and isolated communities, often makes the deployment of traditional fiber and 5G-based networks impractical. To address this, the Government of New Zealand has taken an innovative approach to connecting schools to internet via next-generation satellite, providing high-speed, reliable, and cost-effective connections.

In 2023 New Zealand launched the Satellite for Schools program, a government-backed initiative to connect 40 rural schools (out of the country's more than 2,500 total schools) via SpaceX's Starlink LEO satellite service.[37] The program is sponsored by the Ministry of Education and administered by the Crown agency Network for Learning (N4L)[38], which in turn engaged the New Zealand telco (and Vocus Group subsidiary) 2degress, which is a Starlink reseller and operator of three Starlink's New Zealand ground stations.

Satellite for Schools provides Starlink connections to selected schools that have had demonstrated challenges with internet connectivity. Prior to enrollment in the Satellite for Schools program, schools reporting weak or unreliable internet connections were first evaluated for possible improvements or upgrades to fiber or terrestrial wireless networks. Schools with typical download of 10 to 50 Mbps and which could not be connected to fiber were assigned priority, and the program launched in approximately 40 schools in late-2023.

The entire cost was born by the New Zealand government as part of the N4L's Managed Network program, which receives funding of NZ$45 million per year to provide connectivity to more than 2,500 schools. Consequently, the service is free of cost to the schools themselves. The Starlink connections were considered to be an "upgrade change of service" for remote schools with slower or unreliable connections.[39]

The Starlink connections to schools are all business-grade, with higher speeds of up to 350 Mbps, as well as better reliability than residential Starlink connections, with more resiliency during bad weather.

Starlink's equipment costs and monthly subscriptions are more expensive for the business-grade service. A larger dish with higher gain is provided at a cost of NZ$4,200 (the standard residential dish costs NZ$650. Monthly subscriptions cost NZ$426 per month for 1 terabyte of monthly data volume, NZ$840 for 2 terabytes, and NZ$2,507 for 6 terabytes (residential service is priced at NZ$159 per month).

Rather than using the standard $650 Starlink dishes offered to residential subscribers, the program uses a larger $4,200 business-grade dish with higher gain. This equipment is capable of providing faster download speeds of up to 350 Mbps, as well as more resilient connections during adverse weather conditions.

[37] New Zealand Ministry of Education Gazette. Satellite for Schools Transforming Digital Learning in Remote Locations.
https://gazette.education.govt.nz/articles/satellite-for-schools-transforming-digital-learning-in-remote-locations/

[38] Network for Learning.
https://www.n4l.co.nz/

[39] Keall, Chris. Free Starlink for 40 Rural Schools. New Zealand Herald, September 19, 2023.
https://www.nzherald.co.nz/business/free-starlink-for-40-rural-schools/WWIWDPMR7BFTVGVTBHP4CGB5JY/

From a practical perspective, the dishes are installed on the roofs of the schools, and standard installation is performed by the program's installation contractor Downer, typically in four hours or less, with a network outage of approximately 30 minutes as the school's existing connection is migrated to Starlink. Configuration and remote testing is carried out by N4L's Network Management Team. A school representative is required to be present before and after installation to formally accept and sign off on the new connection.

The service includes cybersecurity, content filtering, and a toll-free 0800 helpdesk to provide a strong support system school administrators and teachers. The satellite dishes have an expected lifespan of five years.

Meteorological conditions can negatively impact the satellite connections, with heavy downpours potentially taking the connection offline temporarily. Heavy, wet snow that brings higher density of water in the air can also degrade and possibly interrupt the signal. The Starlink terminals do include "Snow Melt" functionality which uses electricity to heat the dishes and melt the snow. The satellites themselves are also offline during solar flare events when the satellites engage protective solar shielding. Overall, however, the links are considered to be more resilient to meteorological evens than standard microwave-based wireless connections.

The program has been praised for finally bringing reliable high-speed internet to the remaining under-served New Zealand school population, allowing those schools to partake in a wide range of internet-enabled activities, including access to online libraries and software; real-time communication with other teachers, students, and schools; remote learning; virtual field trips; professional development of teachers and staff; and administrative efficiencies.

Mr. Reno Skipper, the tumaki (principal) of one remote school, Te Kura Kaupapa Māori (TKKM) o Ngāringaomatariki, said that prior to the Starlink program, the school's internet previous wireless connectivity was so slow and vulnerable to meteorological conditions that it was sometimes barely suitable for accomplishing basic online tasks such as reporting attendance. Internet workstations were limited to one or two per classroom. "The staff were teaching and trying to bring in different ideas and different resources, but they couldn't be accessed because of poor internet connectivity. It really limited our ability to teach the kids... We were teaching and trying to bring in different ideas and different resources that are available to us, but we couldn't access them because we didn't have good internet service," said Tumaki Skipper, joking that Network for Learning "probably had their own special book for us, because of all the times we'd called them for help!"[40]

Beyond the obvious educational deficit, poor internet connectivity in schools can often give rise to health and safety concerns, since it is often accompanied by weak mobile coverage that may leave the school unable to contact emergency services or to call parents in urgent situations.

Tumaki Skipper said that the activation of the Starlink service in July 2023 was "life-changing" and that "we've purchased subscriptions to [online] maths programs that we previously weren't able to use. Even in the space of a month, it's made a huge difference to how we teach, and there's been noticeable improvement in the engagement of the kids. They're now able to take full ownership of their own learning."

In addition to its use in New Zealand's schools, Starlink had a reported 2 percent share of the country's residential broadband market as of 2023, with subscribership rapidly expanding in rural areas. Starlink was also selected by Air New Zealand to provide inflight internet connectivity on domestic flights.

As a result of New Zealand's Ultra-Fast Broadband initiative, almost all of the country's public schools had access to fiber internet connections by 2016.[41] However, the Satellite for Schools program launched in 2023 was a critical tool for ensuring that 40 rural schools with demonstrated connectivity challenges were able to offer an optimal internet experience to students and faculty, in line with their peer institutions across the country.

[40] Ibid.
[41] Grimes, Arthur & Townsend, Wilbur. The Effect of Fibre Broadband on Student Learning. Motu Economic and Public Policy Research, April 2017.
https://motu-www.motu.org.nz/wpapers/17_03.pdf

c. China

The percentage of Chinese primary and secondary schools with internet access rose from 25 percent in 2012 to 96 percent in 2019 and 100 percent by 2021, with 99.9 percent of the country's half-million schools connected at download speeds of 100 Mbps or higher.[42] Satellite is considered to be the key enabler that allowed the country to finally achieve universal school connectivity.

The China Education Broadband Satellite Transmission Network (CEBsat) was launched in 2000 and initially focused on television and radio broadcasting services to enable distance learning in partnership with the China Education and Research Network (CERNET). The service subsequently developed its IP data transmission capabilities to provide internet connectivity to schools.[43]

The CEBsat program has allowed students in rural schools to connect with urban educators and take online classes with urban peers that would not have otherwise been available. Much of the investment in satellite connectivity targeted western provinces and autonomous regions including Tibet, Xinjiang, Gansu, and Shaanxi.

In 2004, the Chinese Ministry of Education formally launched the CNY 11.1-billlion Modern Distance Education Program in Rural China, which has been described as the "largest ed-tech intervention in the world," linking more than 100 million students via 246,905 satellite receivers. Through a coherent distance-learning strategy, the program served to overcome many of the key challenges facing China's rural schools, including poor connectivity, a lack of teachers, and outdated technology.[44]

School connectivity in China is supported by a strong digital ecosystem; the Smart Education Platform for Primary and Secondary Schools covers 53 topics, 44,000 resource entries, and a "course teaching" section with 25,900 class-hours of online courses, including 446 textbooks in 30 editions. In addition to allowing students to access information, knowledge, and digital content, it also serves for teacher training, enrichment, and evaluation as well as improved dialogue among educators, administrators, and education experts.

Going forward, China's use of satellite connectivity in education will be closely linked to its progress in developing and implementing LEO satellite communications technology.

China's entry into the LEO satellite communications market initially lagged behind other regions such as North America, with its US-based 5,200-satellite Starlink constellation and Europe, with its 630-satellite UK-based Eutelsat OneWeb constellation. However, the industry in China has benefited from strong government investment and support and is rapidly catching up, with China poised to achieve a leadership position in non-GEO satellite connectivity by 2030.

In 2020 the Chinese government announced the merger of two planned projects into a single national LEO network known as Guowang ,[45] submitting spectrum allocation filings with the ITU for 12,992 satellites at altitudes of between 500 and 1,145 kilometers. The first satellites of the constellation were launched in 2023.

Another LEO initiative known as G60 Starlink, spearheaded by the Shanghai municipal government, completed the manufacture of its first satellite in late-2023; its developer Shanghai Spacecom Satellite Technology (SSST) raised $925 million in financing and plans to launch 108 satellites into orbit in 2024, with an ultimate planned constellation size of 12,000 satellites.

[42] "100% of Chinese elementary and secondary schools connected to internet." Ministry of Education of the People's Republic of China, February 9, 2023
http://en.moe.gov.cn/features/2023WorldDigitalEducationConference/News/202302/t20230213_1044334.html

[43] Wang, Tom. Satellite Distance Education in China. Online Journal of Space Communication: Vol. 6 : Iss. 12 , Article 2.
https://ohioopen.library.ohio.edu/spacejournal/vol6/iss12/2

[44] Nicola Bianchi, Yi Lu, and Hong Song. The Effect of Computer-Assisted Learning on Students' Long-Term Development. NBER Working Paper No. 28180, December 2020.
https://www.nber.org/system/files/working_papers/w28180/w28180.pdf

[45] Clark, Robert. China's first LEO satellite constellation close to liftoff. Light Reading, February 13, 2024.
https://www.lightreading.com/satellite/china-s-first-leo-satellite-constellation-close-to-lift-off-

China's historical commitment to the use of satellite to achieve universal connectivity to schools was evident through GEO-based initiatives like the China Education Broadband Satellite Transmission Network (CEBsat) and the Modern Distance Education Program in Rural China, which significantly improved access to quality education in remote and rural areas. Future improvements to connectivity are likely to be enabled by China's LEO satellite capabilities, including the Guowang and G60 Starlink initiative.

d. Best Practices & Implementation Guidelines

When considering the use of LEO, MEO, and GEO satellites for internet connectivity to rural and remote schools, it is essential to evaluate the factors of cost, data rate, latency, reliability, and geographic coverage. Other considerations unique to the educational sector include the need for scalable bandwidth to accommodate varying numbers of users, the ability to support interactive and multimedia-rich educational content, and the ease of installation and maintenance of ground equipment in challenging environments. Additionally, ensuring cybersecurity and data privacy for students and educators is critical, as is the potential for integrating satellite connectivity with existing terrestrial networks to create a seamless and robust educational infrastructure.

While satellite solutions often provide download speeds that exceed those of many existing terrestrial and wireless options connections to rural and remote schools in Kazakhstan, it remains uncertain whether a single satellite connection can consistently achieve the recommended best-practice speed thresholds. Giga's most recent recommendations call for a minimum of 20 Mbps per school, but guidelines are higher in many markets. For example, in its March 2024 Report to Congress "Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion," the US Federal Communications Commission set a standard of 1 Gbps of downstream capacity per 1,000 students and staff, i.e. 1 Mbps per potential user.[46]

Enrollment data for Kazakh schools indicates an average of 500 pupils per school, plus staff. Consequently, Kazakhstan's schools are considered by at least one standard to be under-connected by a factor of 35.

Despite the promising results of initial trials, the market for non-GEO satellite services in Kazakhstan does face some regulatory challenges. Notably, national security legislation requires each provider of satellite services in Kazakhstan to install a ground station within Kazakh territory to ensure that content be appropriately monitored and filtered.[47] As of mid-2024 among the three major non-GEO operators, only OneWeb had committed to the construction of a ground station in Kazakhstan. However, it was expected that an interim arrangement would be reached with other operators including Starlink to appropriately filter and monitor content originating from foreign points-of-presence. More specifically, Kazakh legislation allows for trial services of satellite-based school connectivity by providers without ground stations in Kazakhstan.[48]

Also at the regulatory level, best practices include specific restrictions and safety norms for the deployment of satellite and radio-relay communications in school settings, such as limitations on high power amplifier (HPA) output, requirements for the placement of ground equipment at a fixed distance from school premises or on rooftops, and safety requirements ensuring proper fencing, security, and cable infrastructure, as well as equipment maintenance.

[46] United States Federal Communications Commission. Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion. https://docs.fcc.gov/public/attachments/FCC-01-223A1.pdf

[47] "SpaceX refused to place a gateway station in Kazakhstan." Global CIO, May 27, 2024. https://globalcio.com/news/13841/

[48] "Kazakhstan adopts bill entailing special regulations for utilizing non-geostationary satellites." Daryo, February 2023. https://daryo.uz/en/2024/03/01/kazakhstan-adopts-bill-entailing-special-regulations-for-utilizingnon-geostationary-satellites

Key Considerations for the Successful Implementation of Satellite-Based Solutions to Connect Remote Rural Schools to Internet in Kazakhstan

Consideration	
Bandwidth & Speed Requirements	Giga recommends a minimum of 20 Mbps per school, but the US Federal Communications Commission has set a target of 1 Gbps per 1,000 students & staff (1 Mbps per user). The UK is targeting 1 Gbps for all schools by 2025.
Hybrid Network Solutions	Over the long-term, it is likely that satellite services will be positioned within hybrid network solutions which will optimize connectivity by, for example, being able to switch between GEO and non-GEO services (multiorbit solutions), and more importantly, between satellite and terrestrial wireless (6G) and even wireline solutions. It is important that any selected service be able to accommodate this evolution.
Content Filtering & Security	The chosen service should easily support filtering, security, and monitoring to protect students and faculty from unwanted or inappropriate content, as well as cyberattacks. The use of virtual private networks (VPNs) can ensure data privacy and security.
Equipment	Equipment should also be selected with consideration of meteorological conditions which may require ruggedization, as well as availability of alternative energy sources such as solar in areas where electricity distribution is unreliable.
Training, Maintenance, and Support	User-friendly interfaces can allow for easier use and troubleshooting. Appropriate training programs for teachers should be implemented, and remote monitoring and management systems can allow for quick problem resolution.
Program Evaluation	The program should be regularly evaluated and improved to ensure that services are appropriate for users' needs. The World Bank's SABER-ICT framework can offer guidelines for evaluating ICT in education initiatives.

IX. Conclusion & Recommendations

b. Other LEO & MEO Pricing

The satellite communications industry has undergone a complete transformation in the last five years. Until then, satellite technology had been considered inferior for almost all commercial non-broadcast applications, hindered by high latency, low bandwidth, and high costs. Major investments in the sector, such as the Iridium, Teledesic, and Globalstar ventures, were unable to effectively compete with terrestrial fixed and wireless technologies and were deemed to be commercial and financial failures. These failures significantly deterred capital investment in the sector, hindering the financing and development of satellite megaprojects for the first two decades of the twenty-first century.

However, the advent of ambitious technological and commercial endeavors such as Starlink, OneWeb, and O3b mPower has revitalized the satellite communications industry. Starlink, with its constellation of more than 5,000 LEO satellites, has noticeably disrupted the market by offering high-speed, low-latency internet services at competitive prices, particularly in underserved and remote areas. OneWeb, despite its initial financial struggles and bankruptcy, has rebounded with substantial backing from investors like Bharti Global and the UK government, and following its 2023 merger with Eutelsat is now on track to provide global coverage with its 600+ satellite constellation, focusing on carrier, enterprise and government clientele. Meanwhile, SES's O3b mPower system, operating in medium Earth orbit, promises to deliver a balance of high-throughput, low-latency connectivity that addresses the perceived weaknesses of LEO and GEO technologies.

At the same time, other proposed non-GEO initiatives such as Amazon's Kuiper and Telesat's Lightspeed are expected to increase competition, while GEO technology continues to advance significantly. Combined, these existing and planned initiatives are driving a new era of innovation and investment in the satellite communications sector, offering unprecedented opportunities for global connectivity and bridging the digital divide in even the most remote regions.

Consequently, the emerging satellite connectivity trends show a significant shift toward non-GEO constellations, particularly LEO and MEO. These new networks are increasingly competitive with other broadband technologies across almost every key consideration including speed, reliability, latency, and price. The trend is reinforced by massive investments in large satellite constellations facilitating economies of scale, allowing for cost-effective delivery of services to remote and underserved areas. This shift is particularly relevant for connecting rural and remote schools, as demonstrated by successful implementations not only in Kazakhstan but other markets such as New Zealand. Additionally, a growing trend towards multi-orbit solutions that combine LEO, MEO, and GEO satellites to leverage the strengths of each orbit, as well as converged satellite-terrestrial solutions such as 6G, offer the promise of further service improvements, making satellite connectivity an increasingly viable and attractive option for bridging the digital divide in education, offering speeds and reliability previously unattainable through satellite technology.

From the perspective of connecting remote and rural schools in Kazakhstan, satellite connectivity has never been more appropriate, technologically suitable, reliable, and cost-effective. Consequently, the Kazakh government's trial of non-GEO satellite service in the rural education space is considered to be both an optimal solution for remote and rural schools' immediate and near-term requirements, but also a critical means of becoming an early adopter and evaluating an evolving technology which will inevitably become a key component of the future telecommunications ecosystem, including 6G.

To that end, the following recommendations are made:

Collect Data from LEO Trial to Evaluate Its Suitability Vis-à-Vis Other Services (Government of Kazakhstan)

During its LEO pilot program, the Government of Kazakhstan should leverage its position as a key early adopter to evaluate the underlying technology's real-world effectiveness in providing high-speed internet to rural and remote schools. During the trial evaluation process, the government should collect data about performance, reliability, ease of use, and support, in order to fully determine its appropriacy, scalability, and cost-efficiency, and compare this data to other services, both satellite and terrestrial.

Support Competition Among LEO and MEO Operators (Government of Kazakhstan)

Encouraging competition among existing LEO and MEO operators, such as OneWeb and O3b (if O3b ultimately becomes available in the Kazakh market), can drive innovation and reduce costs. A competitive marketplace ensures that service providers strive to offer the best possible services at the lowest prices. This can lead to improved service quality and more affordable options for schools. By supporting multiple operators, Kazakhstan can also ensure redundancy and reliability in its satellite internet services.

Invest in KazSat Communications Satellites (Government of Kazakhstan)

Kazakhstan should maintain its regional and international leadership role in the space sector by continuing to invest in its own communications satellites, such as KazSat, to maintain and expand its national satellite infrastructure. This investment can provide a reliable backbone for internet services, ensuring that the country has greater control over its communications infrastructure and digital sovereignty. By continuing to develop its satellite capabilities, Kazakhstan can reduce its reliance on foreign providers and ensure that its specific connectivity requirements are fulfilled, not only in the educational sector but across its entire economy.

Monitor Planned Non-GEO Projects Such as Kuiper and Engage as Appropriate (Government of Kazakhstan)

The development and implementation of proposed non-GEO services, such as Amazon's Kuiper, should be regularly monitored and evaluated by the Kazakh government, to ensure that the country maintains its position on the cutting edge of satellite connectivity. Engaging with these companies can provide Kazakhstan with additional competitive options for satellite internet services, potentially offering superior performance or lower prices. Keeping abreast of technological advancements and market developments will ensure that Kazakhstan selects and implements the best available internet solutions for its schools.

Monitor Internet Quality and Continuously Scale User Bandwidth Upward (Government of Kazakhstan, Schools)

Continuous monitoring and evaluation of the quality of internet connections in schools are essential to ensure that they meet or exceed international benchmarks. This involves regular assessments of bandwidth, latency, and overall service reliability (using Giga's tools to monitor the real-time connectivity experienced by students in schools could assist in this respect, with Giga Maps serving as a valuable platform by making data uniformly available to stakeholders). By scaling bandwidth as needed and meeting per-student benchmarks such as the 1-Mbps-per-student recommendation of the US Federal Communications Commission in March 2024, the government can ensure that all students have access to the digital resources that underpin modern education. This proactive approach can help identify and address issues with digital learning infrastructure before they become significant problems, ensuring a consistent and high-quality internet experience for all students.

Centralize Funding for Satellite Services Procurement to Maximize Efficiencies

Centralizing funding for satellite services can lead to significant efficiencies in procurement processes. By consolidating resources, the government can leverage bulk purchasing agreements to secure better pricing and enhanced service offerings. This approach not only reduces overall costs but also ensures uniformity in service quality across all regions, including remote areas. Centralized funding guarantees that even the most isolated schools receive reliable connectivity comparable to urban institutions, thereby bridging the digital divide and promoting more equitable access to educational resources.

Create a Universal Service Fund (USF) (Government of Kazakhstan)

The establishment of a Universal Service Fund (USF), which Kazakhstan does not currently have, would be a valuable tool for ensuring the long-term viability of initiatives aimed at providing internet connectivity to rural and remote schools in Kazakhstan. A USF, which can be funded through various models including levies on telecom operators (and potentially hyperscalers) and fees on end-users, is a widely-used means of pooling and leveraging resources to ensure more uniform connectivity and equitable access to services, especially in areas and regions where commercial operators find it unprofitable to invest. USFs have been successfully implemented in almost half of the world's countries, representing a wide range of economies, including Afghanistan, Colombia, France, Malaysia, South Africa, Turkiye, and the United States.
In Kazakhstan, a USF could enable the government to unlock a new source of funding, pursue a more targeted approach for ICT development projects such as school connectivity, engage in broader economic development, and facilitate public-private partnerships. Success in USF implementation would be maximized by having clear objectives, transparent management and oversight, technology neutrality, regular impact assessments and evaluations, and a collaborative public-private framework that ensures balanced contributions and involvement of stakeholders.

Engage Regional Partners (Government of Kazakhstan)

Engaging regional partners, such as the governments of Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan, can help ensure that Central Asia becomes a focus area for the satellite industry. Collaborative cross-border efforts in the satellite space can lead to shared infrastructure, reduced costs, and improved coverage across the region. By working together, the countries of Central Asia can attract more investment and attention from satellite service providers, maximizing the regional benefits of improved connectivity.

Engage International Partners (Government of Kazakhstan)

International partners, such as multilateral development banks, providers of relevant technical support (such as International Telecommunications Union and UNICEF), and bodies exploring new connectivity indicatives such as the European Union, should be engaged to evaluate possible collaborative projects. These partnerships can provide additional funding, technical expertise, and political support for Kazakhstan's connectivity initiatives. International collaboration can also ensure the alignment of Kazakhstan's efforts with global standards and best practices, ensuring that its schools benefit from the latest advancements in satellite technology.

Explore Sustainable Energy Sources (Government of Kazakhstan, Schools)

The government should explore sustainable energy sources, such as solar, hydroelectric, and wind, to power internet equipment including the terminals used in the Starlink trial program. Renewable energy sources can potentially reduce operational costs and ensure that internet services are environmentally sustainable, and in some cases, more reliabl, particularly in remote areas where traditional power infrastructure may lack redundancy. Additionally, sustainable, green energy is increasingly viewed as a necessity for the digital sector and will be expected by more and more international investors in the internet and computing sectors.

Implement Safety Protocols for Equipment (Government of Kazakhstan, Schools)

Safety protocols should be in place to ensure that internet equipment does not pose any physical safety or radiation risk to students, faculty, staff, or other people present in schools. Kazakhstan already has appropriate measures in place but these should be regularly updated, given the rapid technological advancement of satellite technology and its equipment. Equipment and components should potentially be subject to regular inspections, adherence to international safety standards, and proper training for personnel installing, repairing, and handling the equipment. Ensuring the safety of students and staff is paramount, and robust safety protocols can prevent accidents and health issues related to the use of satellite internet equipment.

Ensure Proper Content Filtering and Monitoring (Government of Kazakhstan, Schools)

The government should continue to ensure the proper filtering of internet content (particularly given that trial service provider Starlink imports bandwidth from foreign markets) as well as the monitoring and guidance of students' internet usage to minimize social risks. Implementing robust content filtering systems can protect students from harmful or inappropriate material. Additionally, providing guidance on safe internet practices can help students use the internet responsibly and effectively, fostering a safe and productive online learning environment.

Maintain a Welcoming Regulatory Environment (Government of Kazakhstan)

To attract and promote satellite providers, Kazakhstan should consider relaxing its requirement that all satellite operators maintain ground stations within its territory. For instance, neither Starlink nor O3b have ground stations in Kazakhstan, but the government could accommodate such operators, at least on an interim basis, by negotiating substitute frameworks to ensure that the services' internet content is adequately filtered and monitored. This regulatory flexibility could make Kazakhstan a more attractive market for satellite internet providers. Additionally, the government could offer other regulatory advantages, such as streamlined licensing processes and reduced bureaucratic hurdles. These measures can create a more welcoming environment for satellite operators, encouraging them to invest in and expand their services within Kazakhstan, ultimately benefiting rural and remote schools with improved internet connectivity.

Consider Increased Bandwidth Thresholds for Satellite-Linked Schools (Government of Kazakhstan, Schools)

The speeds of satellite services could potentially enable connection speeds higher than the benchmark target of 20 Mbps per school or 1 Mbps per 20 students. As applications and web environments become more bandwidth intensive, it will be important to regularly reevaluate per-school and per-pupil bandwidth thresholds. For example, depending on availability and budgeting, Kazakhstan could seek to achieve the higher targets set by some international markets, such as the United States, which has established a near-term target of 100 Mbps per 1,000 students and staff (more than twice the effective per-pupil speed of 1 Mbps per 20 students) and a long-term target of 1 Gbps per 1,000 students and staff.

Seek to Achieve Uniform Prices for All School Internet Subscriptions (Government of Kazakhstan, Schools)

To assist in the promotion of more equitable access to high-speed, reliable internet and mitigate disparities between urban and rural schools, it is recommended that uniform pricing be established for school internet subscriptions. This could be achieved through a direct regulatory approach that sets prices charged to schools, or alternatively through government-negotiated bulk contracts. Additionally, ensuring that contracts include clauses for regular review and adjustment based on market conditions will help maintain fair pricing over time and prevent cost disparities from rematerializing.

Appendix 1: Project Terms of Reference

UNITED NATIONS CHILDREN'S FUND in KAZAKHSTAN TERMS OF REFERENCE

National or International Institutional consultancy to conduct market assessment for satellite-based solutions to connect remote rural primary and secondary schools to the broadband internet

1. Programme information:

Programme (Outcome WBS & Name):	Outcome 2: By 2025, children and adolescents, in particular the most vulnerable, are equipped with skills and knowledge to be healthy, resilient and ready for adult life.
Project (Output WBS & Name):	Output 2.2: By 2025, education for primary and secondary school age children and adolescents provide inclusive, quality, equitable access and supportive learner-centred approach.
Activity:	2.2.3. Develop connectivity business models to connect remote schools and areas in Kazakhstan (Giga) to have access to the internet, benefit from digital learning tools, on-line safety and other learning platforms that are in line with DPG standards
Funding source	Sc229909

UNICEF is mandated by the United Nations General Assembly to advocate for the protection of children's rights, to help meet their basic needs and to expand their opportunities to reach their full potential. Guided by the Convention on the Rights of the Child, UNICEF strives to establish child's rights as international standards of behaviour towards children.

2. Background Information

UNICEF Kazakhstan is seeking for consultancy services provided by institutions that possess extensive experience in conducting market assessments and feasibility case studies for satellite-based connectivity projects in medium and higher income countries.

Nearly 3.7 billion people remain unconnected from the internet, and by extension, unconnected to digital products and services that could dramatically improve their lives. Approximately 29% of 18-24 year-olds, most of them in Sub-Saharan Africa, do not have digital access (~360m people) and thereby lack access to the same information, opportunity and choice as their more-connected peers1. Unless things change, a big part of this rapidly growing group of young people is in danger of being left behind, excluded from the modern digital world.

Kazakhstan is a pathfinder country for the global Giga initiative2 in Central Asia. In 2019 UNICEF, ITU and the Ministry of Digital Development have launched "Giga" initiative to connect every school to the internet, and every young person to information, opportunity and choice. Giga is anchored in the findings 1A and 1B of the Secretary-General's High-level Panel on Digital Cooperation, which state, respectively, that by "2030 every adult should have affordable access to digital networks" and calls for "a broad, multi- stakeholder alliance, involving the UN, create a platform for sharing digital public goods." In 2021 a total of 7,400 schools were mapped for Project Connect to show their connectivity status. UNICEF conducted a feasibility study presenting the best technical and economically sustainable solutions for school connectivity in Kazakhstan. In support of the Giga acceleration, UNICEF Kazakhstan explores satellite-based solutions, but also development or improvement of the existing technical solution for monitoring of internet speed in schools. In advanced eco-systems of other countries, satellite-based solutions cover 5-15% of rural and remote schools. One of the innovative solutions, country would like to test are any Non- Geostationary Orbit (NGSO) satellite-based solutions in schools. This would be a unique opportunity to improve the speed of connectivity in many unconnected remote schools in the country.

The market assessment shall contribute to the implementation of the Giga initiative in Kazakhstan. The study shall be conducted by the consultancy service institution.

3. Purpose of the assignment

To achieve its goal in Kazakhstan and connect all schools in the country, Giga requires to carry out an in- depth market assessment of the satellite-based connectivity solutions for schools that are available in Central Asia region with focus on Kazakhstan3, to provide the government with information to support strategic decision making for the most practical, superior technical, and economically viable solution. The market assessment is a technical, economic and financial review of available satellite-based connectivity service providers and solutions which provides stakeholders with the comprehensive information and analyses to decide upon the best technical and financial options amongst a list of appropriate scenarios and case studies which include different technical, economic, and financial assumptions.

The conclusions and recommendations contained in the market assessment should provide government policy-makers, businesses and investors with the knowledge readily available to make an informed decision about the viability of the satellite communication (SatCom) internet connectivity models, help create funding strategies, design policies, guidelines and decide on priorities for school connectivity improvement.

The outputs from the case studies should also demonstrate how satellite solutions enables economic and social development in the country (i.e. expand the reach and increase the use of satellite broadband ICTs to reap the developmental and economic benefits they facilitate) and assist key stakeholders in identifying and exploring various potential private and public sector partnership models.

The primary goals for this market assessment are:

1. To better understand the satellite connectivity solutions market in Kazakhstan (and if within budget, in Central Asia), focusing on available (and coming) solutions and technologies, practices (case studies) and lessons learnt from other countries on market shaping.

2. To provide the government with specific and actionable recommendations on which satellite solutions would be most effective for delivering high-speed, high-quality, affordable connectivity to schools (in particular to those underserved or located i n remote areas).

3. To recommend market influencing / shaping interventions that can leverage economies of scale and bulk purchasing (if the government is willing to invest in satellite connectivity), thereby enabling the government to reduce costs and obtain better value for their investment.

4. Scope of work

The market assessment will consist of two main components:

1) a desk review of available case studies from countries implementing advanced satellite-based connectivity solutions for schools; and a 2) comprehensive overview of the satellite communication market in Kazakhstan and Central Asia, considering its historical development, present situation, and forecasting future trends in technology, supply and demand.

The market assessment report with the case studies should include the following components and research questions:[4]

1. Executive Summary:

- An overview of the study, including its objectives, and scope.
- The key findings and recommendations for decision-makers.

2. Introduction

- Background and significance of satellite-based broadband internet access for schools, considering the relevance of the technology to connect the hardest-to-reach schools and its economic sustainability.

3. Methodology:

- Detailed description of the research protocol, such as primary research (expert interviews only) and secondary research (industry reports, databases) on satellite-based broadband internet access for schools and case studies.

- Analysis of the economic advantages, benefits and challenges of satellite-based internet for educational institutions in Kazakhstan based on examples from the case studies.

4. Market Assessment:

- An overview of the satellite communication market, present situation, and forecast on future trends in relation to the technologies used, the supply and demand side.
- Overview of the available satellite connectivity solutions in the Kazakhstan market, with a special emphasis on the Low Earth Orbit (LEO)/ Medium Earth Orbit (MEO) solutions and the suitability of these solutions for country-specific coverage of schools. This analysis should consider the capital and operational expenses required to implement these solutions, recommend models for these technologies to be used financially sustainably in the country, and assess if these solutions are (or not) vendor locked.
- Provision of insights into the key market drivers, market failures, shortcomings, challenges, and opportunities to deliver affordable and quality connectivity for schools.
- Market assessment should consider the following dimensions that UNICEF typically uses to assess shortcomings: availability, affordability, competition, quality, adaptability, delivery, funding structure:[5]

a) Technological Analysis:

- Overview of satellite communication technologies.
- Review of different satellite constellations (Low Earth Orbit (LEO)/ Medium Earth Orbit (MEO) Geostationary Equatorial Orbit (GEO)) and their applications, as well as their status in the country and region.
- Advantages and limitations of each technology, with consideration to connecting schools with quality and affordable internet.
- Review of the availability and reliability of satellite infrastructure and equipment.
- Exploration of the compatibility of satellite systems with existing school networks and devices.

b) Cost Analysis and Funding Mechanisms:

- Assessment of pricing strategies, adaptability of the product for schools and cost implications of satellite-based broadband internet access.
- Identification of potential funding sources and mechanisms for schools.
- Cost-effectiveness comparisons with alternative internet connectivity options.
- Financial projections and risk analysis.

5. Best Practices, Case Studies and Implementation Guidelines

- Compilation of best practices for implementing satellite-based broadband in schools in at least 3 countries (a selected range from Finland, Canada and China).
- Guidelines for selecting satellite internet service providers and equipment.
- Recommendations for ensuring sustainable and reliable satellite connectivity in schools (market shaping recommendations for government).

6. Conclusion, Opportunities and Recommendations:

- Provide actionable recommendations for schools, education institutions, policymakers, and stakeholders.
- Discuss potential strategies for market entry, expansion, or school connectivity diversification.
- Emphasize the feasibility, potential risks and benefits of satellite communication in schools.

5. Research Methodology

After selection of the service institution, the research approach, data sources and research questions will be agreed in consultations with UNICEF and its national partners. The interviews with key informants will be held on the central and regional decision-making levels, academia, non-governmental organisations and businesses with reaching at least 20 – 30 specialists in the area of space, communication, governance and education.

The report must be submitted in English, but the consultancy service provider should be able to work also in the official national languages of the Republic of Kazakhstan (Kazakh and Russian). The assessment's executive summary with recommendations should also be provided in Russian.

Methodological limitation and issues to be considered:

- Research questions need to be narrowed down during the inception phase.
- Reach out to the key informants will be organized by the consultancy service provider, if the key informants are high level government officials, the reach out will be also supported by UNICEF
- The interviews will be conducted in English, Russian or Kazakh, depending on the proficiency level of the key informant
- The qual number of female and male respondents should be recruited for the interviews
- The desk review analysis of the case studies would be based on the open source data as well as other sources shared by key informants or UNICEF

Ethical considerations:

Even though this particular assignment does not foresee any direct interaction with beneficiaries UNICEF recommends following the ethical principles[6] and standards when doing research. In addition, UNICEF follows Procedures for Quality Assurance in Research that are an important guide in ensuring high quality of its studies and research.[7]

When engaging human subjects, informed consent must be sought from all participants (including assent from children if needed). The nature of the informed consent and assent must be noted in the ethics section of the proposal and final report. The sample consent and assent forms are attached in the Annex C.1. to these TOR.

Protection protocols for children and, where relevant, other groups, must be developed during the inception phase in consultation with UNICEF and in place to provide safe environments for data collection, to respond to any safety concerns or grievances, and to refer them to local supports both during and after the evidence generation activity if necessary, given due consideration to the particular vulnerability of children and young people.

UNICEF will be responsible for arranging a review of the agreed with UNICEF methodology by an Ethical Review Board (if needed) and Quality Assurance Review. The checklists for this process will be shared by UNICEF at the inception phase. The selected contractor will be responsible for addressing the comments by Ethical Review Board (if needed) and Quality Assurance Review.

The approval letter from the External review board should be included in the annex of the final report.

Analytical findings and recommendations should take into account gender perspective and consider gender trends in the regions.

Administrative issues:
Prior to submitting their offer, institutions are strongly encouraged to:

- Review the standard UNICEF Contractual Provisions and the UNICEF General Terms and Conditions of Contract (Services) for the supply of services publicly available on the UNICEF Supply website.[8]
- Review the UNICEF policies publicly available on the UNICEF Supply website.

Offerors should familiarize themselves with the obligations imposed on suppliers and their personnel and sub-contractors under the UNICEF Policy Prohibiting and Combatting Fraud and Corruption[9] and the UNICEF Policy on Conduct Promoting the Protection and Safeguarding of Children[10]

Appendix 2: Data Collection Tools

a. Primary Research Tools

- Interviews via videoconference
- Conducted with expert sources and stakeholders
- Based on pre-tested framework questions
- Flexible approach allowing adaptation based on stakeholder expertise
- Interviews documented and reported to management with follow-up clarifications as needed

b. Secondary Research Tools

- Literature review
- Systematic analysis using multilingual business and academic databases
- Structured approach using neutral search terms and Boolean operators
- Focus on diverse, credible independent sources
- Priority given to sources based on:
    - Credibility and independence
    - Geographic applicability
    - Publication date
    - Relevance to research questions
    - Methodological rigor

c. Internal Resources

- Existing knowledge base
- Terabit Consulting's collected intelligence on Kazakhstan and Central Asian markets
- 20+ years of accumulated data from digital connectivity projects
- Previous feasibility studies in the region

d. Quality Assurance Tools

- Data Verification Framework
- Cross-verification process for all collected data
- Resolution of inconsistencies between sources
- Peer review process through UNICEF and Giga
- Validation through Giga Steering Committee Technical Meeting

e. Documentation Tools

- Record-Keeping Systems
- Transparent data-handling procedures
- Systematic documentation of interviews

Appendix 3: Research Questions

a. Government Authorities

- Can you share insights, case studies, or data from your experience with satellite-based connectivity projects to improve connectivity to rural schools?
- What have been the successful models in for connecting schools via satellite, including funding/financial models, cost effectiveness, technical models, services, equipment, providers, traffic management / control / monitoring, bulk purchasing strategies, diversification and redundancy, scalability and planning, etc.
- What are the current challenges in providing internet connectivity to schools, especially in remote areas?
- How does internet connectivity align with the government's digital education strategies?
- Are there existing policies or plans that could support the integration of non-GSO satellite services in educational settings?
- How do you perceive the impact of improved internet connectivity on local communities and schools?
- What local logistical or infrastructural challenges might impact the implementation of satellite internet services?
- What legal considerations must be addressed when implementing satellite connectivity in schools?
- Are there any international regulations or standards that we should be aware of?
- How can policies be shaped to support the widespread adoption of satellite internet in educational institutions?
- What policy challenges could potentially arise with this initiative?

Please provide details of the Digital Bridge pilot program connecting 10 schools via Starlink.

1. Available services
2. Technical characteristics
3. Costs and cost-effectiveness
4. Equipment
5. Traffic management
6. Associated platforms and content
7. Reception in schools
8. SWOT Analysis

- Are there any key lessons/recommendations/strategies for Kazakhstan, i.e. key conclusions about which services/models are most effective from a financial and technical point-of-view for delivering high-speed, high-quality, affordable connectivity to schools (in particular, to underserved or located in remote areas)?

b. Satellite and Telecom/IT Industry Experts

- Can you describe the coverage capabilities and limitations of your non-GSO satellite services in Kazakhstan?
- What would be the estimated cost for providing services to schools, particularly in rural or remote areas?
- How might existing telecommunications infrastructure be integrated with satellite services to enhance connectivity in schools?
- What technical challenges do you foresee in connecting schools via satellite services?
- What are the latest technological advancements in non-GSO satellite services that could benefit educational connectivity?
- How do we ensure long-term technical sustainability and scalability of satellite connectivity solutions?
- What are the essential IT infrastructure requirements at schools for effective use of satellite internet services?
- How can we ensure the security and privacy of internet connections in schools?
- What are some important risk considerations?

c. Educational Institutions and Representatives

- What are the key factors for the sustainability of connectivity projects in schools?
- What are the specific internet connectivity needs in your school for educational purposes?
- How might enhanced internet connectivity impact teaching and learning in your school?
- What are the best practices for implementing satellite internet connectivity in educational environments?
- How can satellite connectivity be optimized for educational content delivery and access?
- Please provide details of the Digital Bridge pilot program connecting 10 schools via Starlink.

    1. Available services
    2.Technical characteristics
    3. Costs and cost-effectiveness
    4. Equipment
    5. Traffic management
    6. Associated platforms and content
    7. Reception in schools
    8. SWOT Analysis

d. International Organizations and NGOs

- What have been successful models in other countries for connecting schools via satellite internet?
- What are some of the socioeconomic impacts and considerations of satellite-based solutions?
- How can we ensure that the connectivity solutions are equitable and inclusive?
- Can you share insights or case studies from your experience in similar connectivity projects?
- What are the key factors for the sustainability of such connectivity projects in schools?

e. Financial Experts and Funding Agencies

- What are viable funding models for such a large-scale connectivity project?
- How do you assess the financial risks and returns of investing in educational c onnectivity projects?
- Are there funding opportunities or partnerships available for projects that aim to enhance educational connectivity?
- What are the criteria for funding such technological initiatives in the education sector?

f. Current Satellite Service Subscribers

- Can you describe your experience with the reliability and quality of current satellite internet services?
- What challenges have you faced in terms of cost, installation, or service quality?

Appendix 4: Informed Consent Form

Mr. / Ms Name: ....

Location: ....

Is invited to participate in the market assessment that is implemented in partnership with UNICEF in 2023. This market assessment aims to the review of satellite-based connectivity solutions for schools that are available in Central Asia region with focus on Kazakhstan, to provide the government with information to support strategic decision making for the most practical, superior technical, and economically viable solution and case studies of countries experience. Once completed, the market assessment report will be provided to UNICEF and other stakeholders, including the Ministry of Digital Development, Innovations and Aerospace Industry and Ministry of Education. This assessment will be conducted from August to December 2023 in Kazakhstan. The research team is composed of (names of researchers).

The participant is invited to participate in interviews (30 min to 1h30). There will be no financial compensation to participate in the study.

The participant certified that he/she accepts to participate freely in this study. He/she could decide to withdraw from the study at any time, without having to justifying him/herself. He/she has the right to refrain from answering to certain questions, without having to justify him/herself. This will not have any harmful consequence.

The participant allows the research team to take written notes during the interview. The research team will ensure that the participant's name or function will not appear in the report, except in the case that the respondent is a public official who is willing to provide his/her title and position, and if it is considered important for the evaluation.

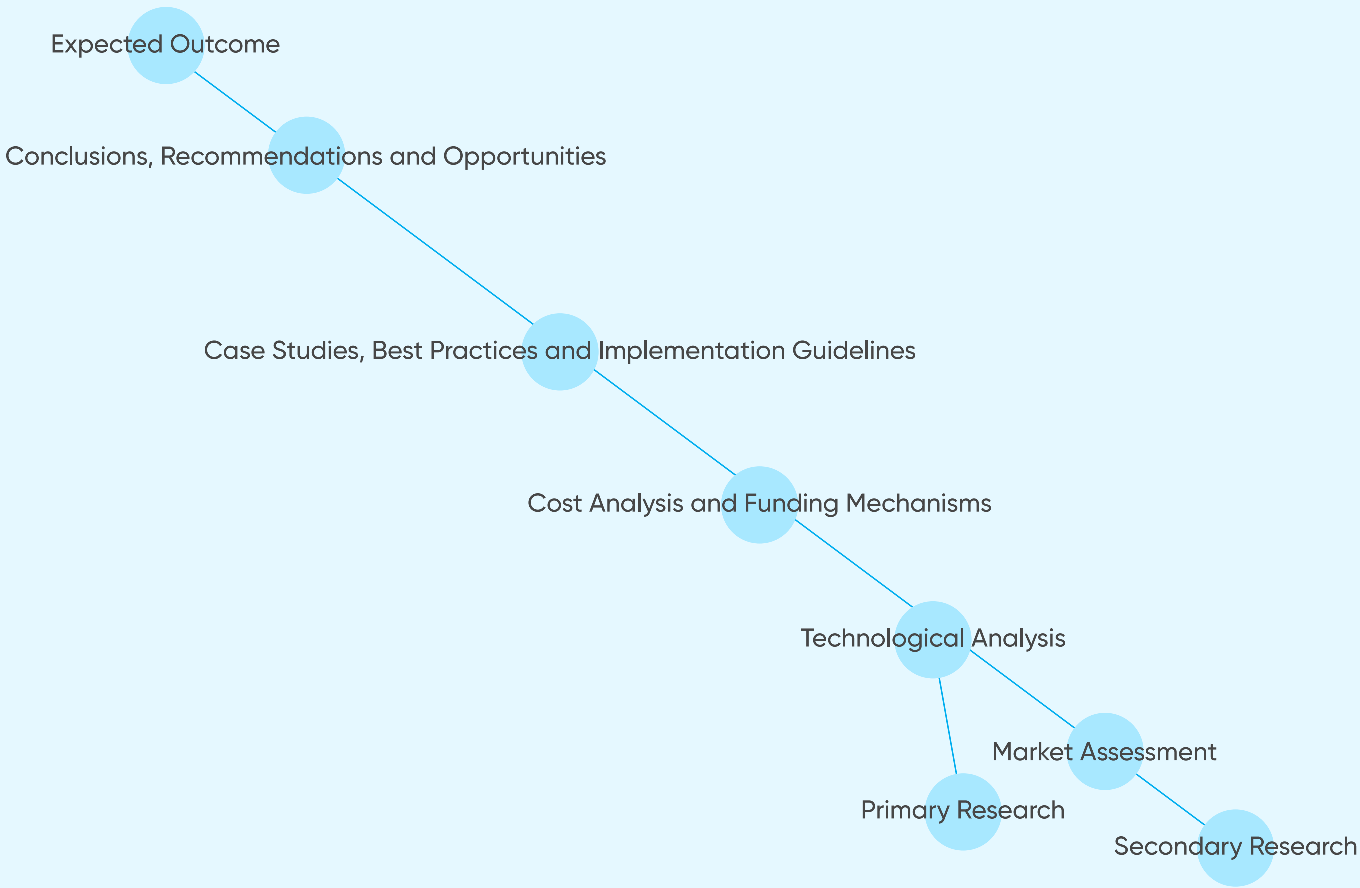
Those data will not be used in another manner than the one described in the present document. This form is signed by the participant. A copy is provided if the participant wishes.

Date:

Signature of participant:

Signature of research team:

Appendix 5: Research/Conceptual Framework



Independent Variables

1. Satellite Technology Specifications: Specifications and capabilities of LEO and MEO satellite technologies.
2. Market Dynamics: Key drivers, current status, and future trends in the satellite communications market.
3. Regulatory Environment: Regulatory policies and environment in Kazakhstan affecting satellite communications.

Dependent Variables

1. School Connectivity Quality: Quality, reliability, and suitability of satellite internet for schools.
2. Educational Outcomes: Impact on educational access and effectiveness in rural schools.

Moderating Variables

1. Satellite Technology Specifications: Specifications and capabilities of LEO and MEO satellite technologies.
2. Market Dynamics: Key drivers, current status, and future trends in the satellite communications market.
3. Regulatory Environment: Regulatory policies and environment in Kazakhstan affecting satellite communications.

Control Variables

1. Existing Infrastructure: Current state of connectivity and technological infrastructure in rural schools.
2.Economic Conditions: General economic conditions in Kazakhstan affecting implementation and sustainability.

Mediating Variables

1. Vendor Solutions: Vendor-locked vs. open satellite connectivity solutions.
2. Market Challenges and Opportunities: Challenges, opportunities, and UNICEF dimensions impacting market strategy.

Primary Research Sources

1. Interviews with government ministries and international organizations.
2. Feedback from participants in satellite connectivity trials.
3. Stakeholder perspectives in case study countries.

Secondary Research Sources

1. Independent reports on satellite technology and education connectivity.
2. Company data from satellite operators.
3. News sources reporting on satellite communications and rural education.

Outcome Variables

1. Feasibility and Risk Analysis: Analysis of the feasibility, risks, and benefits of satellite connectivity for schools.
2. Optimal Connectivity Solutions: Determination of the best satellite connectivity solutions based on technology, cost, and coverage suitability.

Research Methodology

1. Utilizing a combination of secondary data (market reports, academic literature) and primary data (interviews, case studies).

Expected Outcome

1. A comprehensive understanding of the most appropriate satellite connectivity solution for rural schools in Kazakhstan, considering both technological and financial perspectives.

Strategic recommendations for implementing satellite connectivity in rural education settings.

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UNICEF in Kazakhstan

Republic of Kazakhstan,
Z10K8H4, Astana,
Beibitshilik 10, Block 1
+7 (7172) 32-28-78

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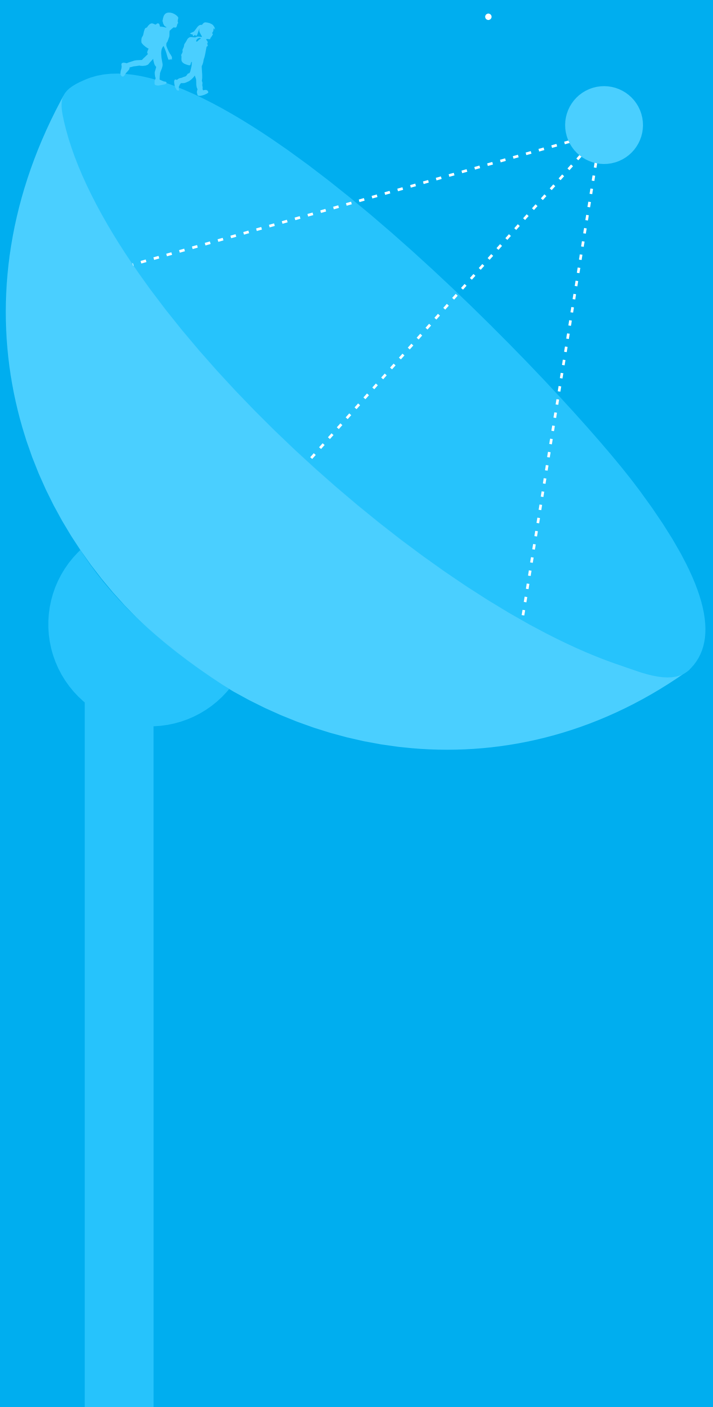

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