Starlink, OneWeb, Lynk…: how space broadband will transform telecoms in emerging countries

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Executive summary

After SpaceX in 2022, OneWeb will launch a satellite broadband Internet service in 2023. These services are aimed primarily at emerging countries, particularly in Africa, as well as areas hitherto inaccessible to traditional telecoms networks.

Other lesser-known players such as Lynk, Omnispace, or AST Spacemobile, are also working on the launch of satellite-to-phone services, enabling existing mobile phones to be connected directly from space, without the need for additional infrastructure.

These innovations can help combat the "digital divide" that persists between the most and least developed countries, and which is a particular handicap for many African economies.

This development will have a profound impact on incumbent telecom operators. While they weill face some new competition, they will also have the opportunity to extend their services to the most remote regions, with the prospect, in the long term, of eliminating the "white zones" that remain unserved.

Initially, these new telecoms players will not be able to offer broadband connections at affordable rates to the poorest sections of the developing world. However, these innovations still offer many opportunities for emerging countries. Some key applications do not necessarily require broadband access, such as mobile money, e-government, social services, agriculture, emergency alerts and so on.

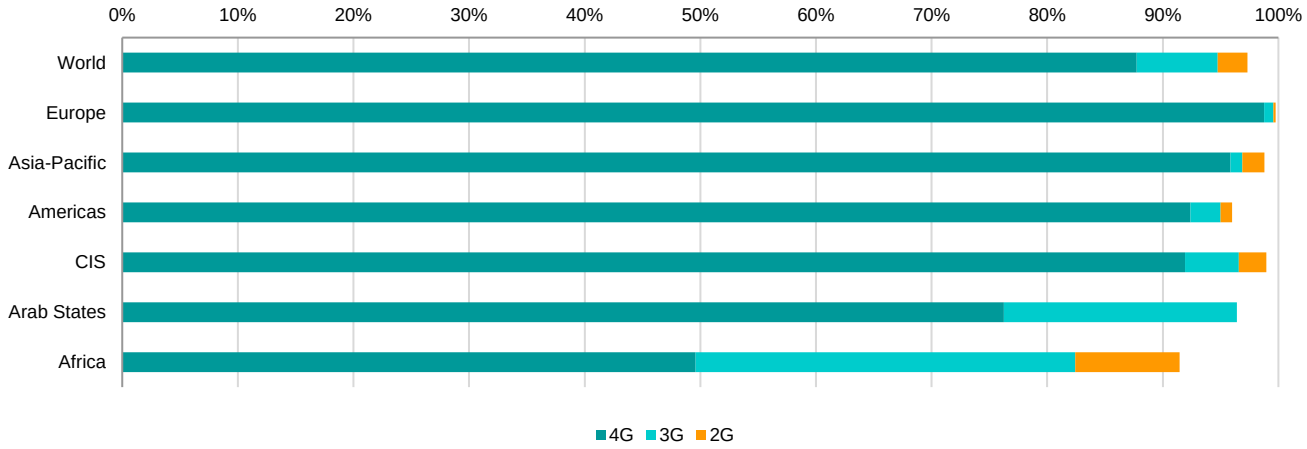
However, governments will need to define an appropriate regulatory framework to enable and control the development of these technologies in their national markets, while protecting tax revenues from the telecoms sector.

1. Persistent digital divides

1.1. Africa still under-connected

Despite rapid progress in the deployment of mobile broadband networks - 3G, 4G and now 5G - and fibre optic infrastructure, **2.9 billion people still have no Internet access**[1] . Asia-Pacific is the region most affected, with 1.7 billion people without Internet access, mainly in India and China, according to the International Telecommunications Union (ITU)[2] . But **it is Africa that is proportionally the least-connected continent**: **more than half its population** (738 million people) **has no Internet access at all**. According to the ITU, only 50% of the African population lives in an area with 4G coverage (without necessarily having the means to access it), the lowest percentage in the world (Figure 1). Overall, **the Internet penetration rate in Africa was 33% in 2021, compared with 61% in Asia-Pacific,** the second most disadvantaged region.

Figure 1: Population coverage by network type, 2022



Source: ITU

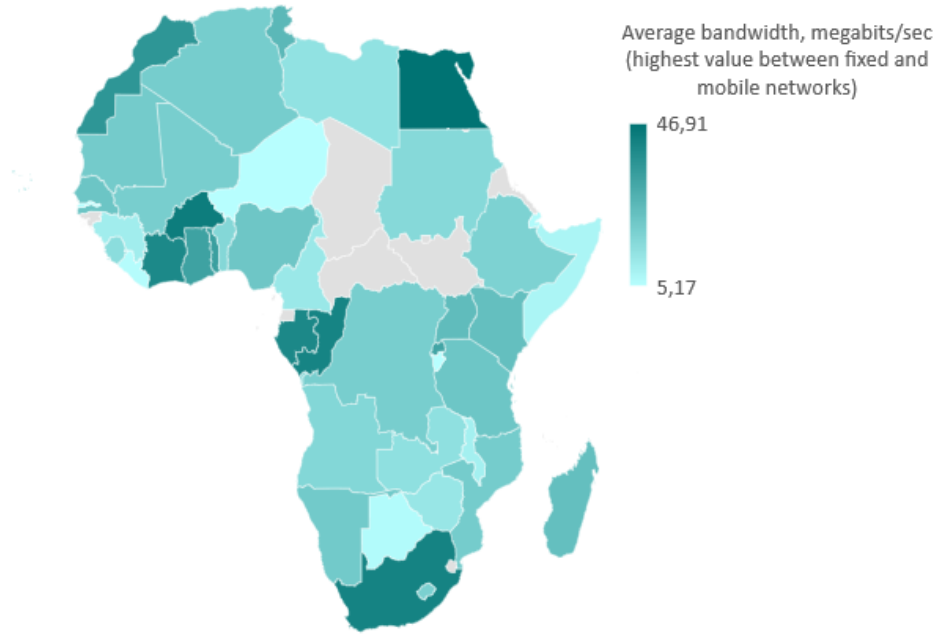
1.2. Geography at the heart of access inequalities

The factors behind this digital divide are both geographical and economic: **telecom operators are reluctant to make the heavy investments needed to cover sparsely populated areas**, a particularly decisive factor in Africa, where 60% of the population lives in rural areas. **Geographical barriers** (relief, forest cover) can also complicate the deployment of fibre optic networks serving GSM relay antennas. Island states are also faced with the high cost of interconnecting each island by submarine cable or microwave links.

Last but not least, **more than 90% of the world's Internet traffic passes through the undersea fibre optic network, the backbone of the international telecoms network**. Coastal regions, close to cable landing stations, are therefore, on average, better served than inland regions. The situation is even more complex for landlocked countries, which have to negotiate access rights to their neighbours' networks. As a result, average bandwidths are on average lower in landlocked countries (Figure 2), although economic, political, and regulatory factors also play an important role.

[1] Global Connectivity Report 2022, International Telecommunication Union (ITU), June 2022
[2] Ibid.

Figure 2: Average Internet speed in Africa, April 2023

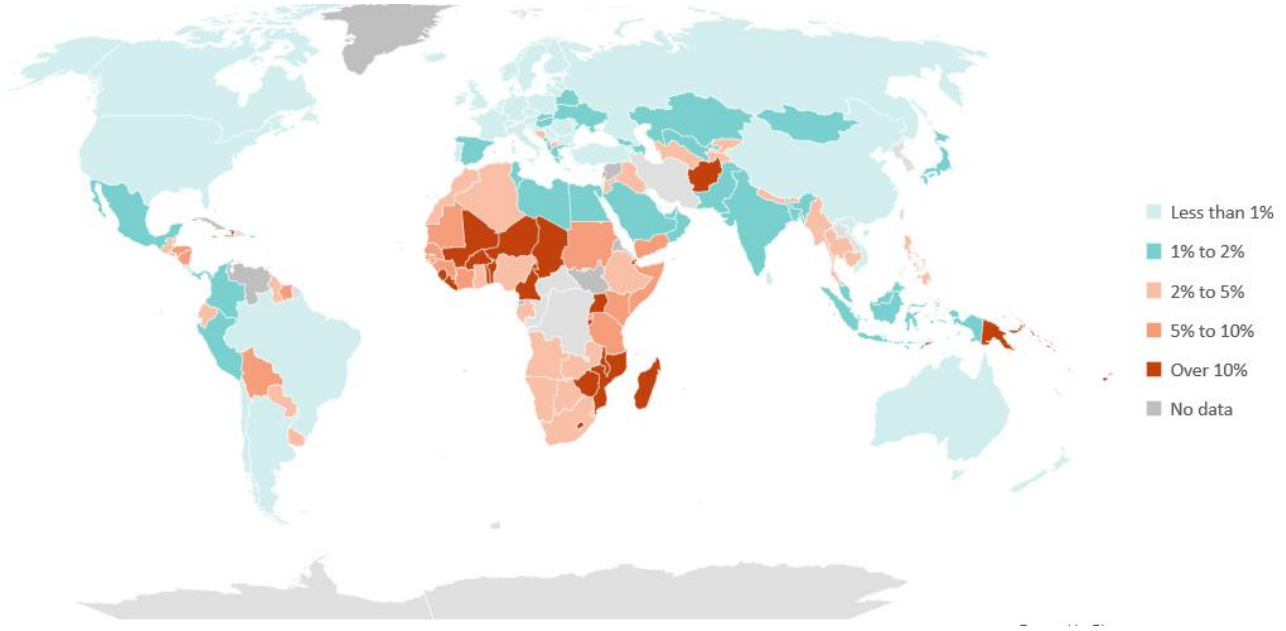


Data: Speedtest Global Index. Map: Global Sovereign Advisory

1.3. An economic divide

These geographical disparities, combined with economic inequalities, create an **additional divide, that of the price of Internet access**. Africa and certain Asia-Pacific countries have much higher real costs (in purchasing power parity or GDP/capita) than the rest of the world (Figure 3). And only 10 of the 45 African countries studied by the Alliance for Affordable Internet have "low-cost" internet access, i.e. when 1 gigabit of data costs 2% or less of the average monthly income. For example, downloading a gigabit of data cost around $2.16 in Timor-Leste or $5.1 in Chad in 2022, compared with $0.23 in France or $0.04 in Israel, according to ITU data.

Figure 3: Cost of a mobile and data package, as a % of gross national income (GNI)/inhabitant



Data: ITU. Map: Global Sovereign Advisory

1.4. A direct impact on development

However, improving access to the Internet and telecommunications networks quickly translates into almost immediate economic gains. In 2016, the World Bank estimated that **a 10 percentage point increase in Internet penetration generated 1.35% additional GDP in developing countries,** and 1.19% in developed countries[3]. The same year, a study jointly carried out by the International Finance Corporation (IFC) and Google estimated that **the digital economy of the African continent could potentially reach $180 billion in 2025** (5.2% of GDP) **and $712 billion in 2050** (8.5% of GDP)[4] . Broadband access also improves an individual's chances of finding a job by 7% to 13%, according to university research carried out in 2019 in several African countries[5] .

Mobile money, made possible by the development of GSM networks - sometimes simply requiring access to a text messaging service - **considerably improves financial inclusion,** including for the poorest and unbanked populations**.** These services have developed rapidly, particularly in emerging economies, with 1.35 billion active accounts in 2021 (a 10-fold increase since 2012)[6].

These factors led the **United Nations to include, in 2015, universal access to broadband in the least developed countries among its Sustainable Development Goals for 2020**.

1.5. The prohibitive cost of the last mile

This objective is far from having been achieved, however, and for good reason: **the technologies that form the backbone of current networks** - fibre optics and GSM networks - **will not be able to bridge this global digital divide, given the colossal investment involved.** Installing a relay antenna requires an investment of between $50,000 and $200,000, while laying the optical fibre serving it costs, on average, more than $16,000 per kilometre[7]. The investment needed to connect the 3 billion or so "offline" individuals was estimated at $428 billion by the ITU[8], and even $2,000 billion by the World Bank[9]. More optimistically, the Organisation for Economic Co-operation and Development (OECD) puts the cost at $100 billion in Africa alone[10] .

2. 2023, the year of very high-speed satellite broadband

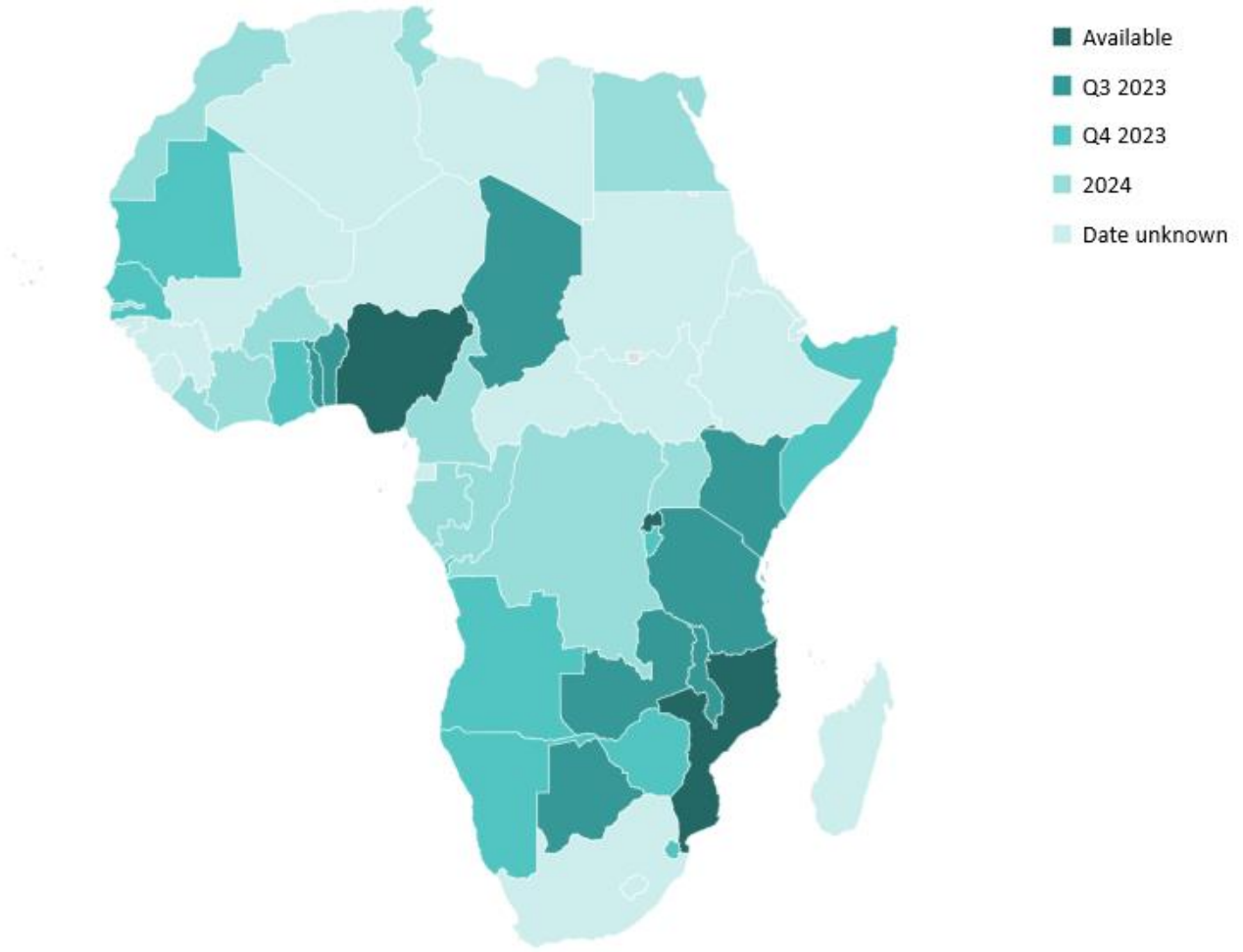
However, the global telecoms landscape is about to undergo an unprecedented upheaval with **the arrival on the market of low-cost satellite broadband**, itself made possible by **the collapse in the cost of low-earth orbit (LEO) launches** and the industrialised production of miniaturised telecoms satellites. **These breakthroughs are enabling the deployment of "megaconstellations" of several thousand satellites**, operated by private companies promising permanent broadband access from virtually anywhere on the globe.

2.1. Starlink rolls out in Africa and worldwide

At the end of May, Mozambique became the third African country where the American operator SpaceX activated its Starlink service, after Nigeria in January and Rwanda in February. By the end of the year, the group owned by Elon Musk plans to activate its service in around fifteen other countries in sub-Saharan Africa, with a dozen more to follow in 2024 (Figure 4).

[3] Exploring the relationship between broadband and economic growth, World Bank, 2016
[4] e-Conomy Africa 2020 - Africa's $180 Billion Internet Economy Future, International Finance Corporation, Google, 2020
[5] The arrival of fast Internet and employment in Africa, Hjort, Jonas, and Jonas Poulsen, American Economic Review, 2019
[6] The State of Broadband 2022, Broadband Commission for Sustainable Development, September 2022
[7] Preparing for Affordable Space-Based communications, Center for Global Development, January 2022
[8] New ITU study estimates US$ 428 billion are needed to connect the remaining 3 billion people to the Internet by 2030, ITU, 2020
[9] Policy Options for Broadband Infrastructure Strategies, World Bank, December 2022
[10] ITU, Ibid.

Figure 4: Starlink deployment schedule in Africa, 2023-2024



Source: Starlink. Map: Global Sovereign Advisory

In addition to Africa, **SpaceX plans to market its service in most countries around the world by 2024**, particularly in Asia and Latin America. **This deployment depends solely on the group's speed in setting up local subsidiaries and its ability to obtain the necessary frequency operating authorisations** (also known as landing rights) from the national regulatory authorities. The group is awaiting approval from India and a number of other countries, while the Chinese, Russian, Iranian, North Korean, Cuban and Venezuelan markets are likely to remain out of reach for geopolitical reasons. In **technical terms, the Starlink constellation of more than 3,600 satellites is already operational, providing coverage of the entire globe**. And the American company plans to continue to expand this fleet to 12,000 - or even 42,000 in the longer term - to improve the throughput offered.

For a number of emerging markets, including Africa, Starlink's offer is a veritable revolution, if only in terms of price: for a subscription of less than 50 dollars a month - plus the 500 to 600 dollars needed to supply the antenna - the American operator promises speeds of between 50 and 150 megabits/second. This is significantly lower than the prices offered by operators offering traditional satellite access, known as VSAT (Very-small aperture terminal, graph 5).

Graph 5: Comparison of prices between Starlink and various VSAT operators, for 1 megabit/second

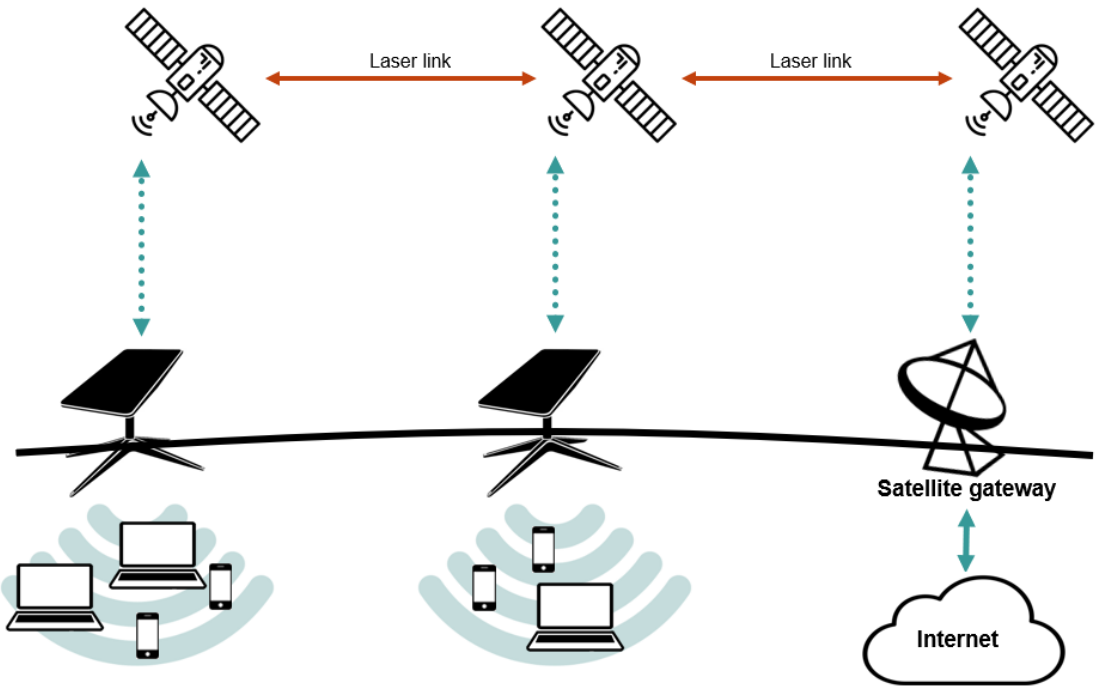
	Starlink	Starlink	Starlink	VSAT	VSAT	VSAT	VSAT	VSAT
Country or geographic area	Nigeria	Mozambique	Rwanda	South Africa	Nigeria	Africa (C-Band)	Africa (Ku-Band)	Africa (Ka-Band)
Opérateur	SpaceX	SpaceX	SpaceX	iSAT	Comternet	Global TT	Global TT	Global TT
Monthly price ($) per megabytes/sec (mbps)	0.41	0.48	0.42	136	28	17.8	6.7	1.4
Hardware purchase and shipping costs	565	672	503	171	330	≥ 6 500 and ≤ 18 000	≥ 1 200 and ≤ 4 500 $	≤ 400 $

Notes : Speed retained for Starlink: 100 mbps. The iSAT offer is aimed at private individuals, while the VSAT offers from Global TT and Comternet are aimed at businesses.

Sources: operators

Starlink's technological (graph 6) and business model departs significantly from that of VSAT Internet access providers. Active for two decades, these rely on a handful of satellites placed in geostationary orbit 36,000 km from the Earth, serving large areas of the world (several hundred thousand to several tens of millions of km²), with their available bandwidth divided by the number of users. The result is low bandwidth and high latency (the signal transfer time), as well as prices that *de facto* reserve the use of VSATs for businesses, governments, the armed forces and a few wealthy individuals. In contrast, the Starlink fleet operates in low Earth orbit (just over 500 km), which means lower latency. The number of users served by a satellite is also much more limited, with each one covering just 380 km². This model should guarantee lower latency and higher bandwidth. From the outset, SpaceX has also developed an offer for private individuals, on a global scale, whereas most VSAT operators have long confined themselves to large corporate customers, and dividing up national or regional markets among themselves. The American operator is therefore hoping to achieve significant economies of scale.

Figure 6: Starlink network operating principle



Source: Global Sovereign Advisory

The collapse in the cost of access to space

The launch of Starlink - soon to be followed by its competitors - would not have been possible without **the vertiginous fall in the cost of missions to put satellites into low-Earth orbit**, which are themselves much cheaper than geostationary orbits, which mostly remains the prerogative of government operators (Arianespace, Roscosmos, NASA, etc.). This trend has largely been driven by SpaceX, a pioneer in commercial launches and the first operator to develop reusable rockets. In 2018, the year the company began deploying its Starlink constellation, NASA estimated that **the arrival of SpaceX's Falcon 9 launchers had cut the cost of launches to low-Earth orbit by a factor of twenty, to $2,720/kg**[11]. SpaceX's Starlink service is obviously the main beneficiary, but the American group is also responsible for putting into orbit the fleets of certain competitors, notably OneWeb[12].

At the same time, the **average throughput of satellites has exploded: around 20 gigabits/second for the first Starlink satellites put into orbit in 2018**, **and four times that for the second generation**, currently being deployed[13]. By comparison, Wildblue-1, the first satellite dedicated to consumer VSAT, launched in 2007, had a capacity of 7 gigabits/second[14]... to serve an area of more than 150,000 km². **ViaSat-2, one of the most powerful geostationary telecom satellites, operational since 2018, has an effective bandwidth of 260 gigabits/second, but covers the whole of North and Central America, as well as the North Atlantic**.

2.2. OneWeb targets operators, B2B markets and governments

Following in the footsteps of SpaceX, a second operator, OneWeb, plans to complete the orbiting of its "megaconstellation" during 2023 and launch its commercial service at the same time. With its latest two launches - 36 satellites at the end of March, carried by an Indian Space Research Organisation (ISRO) rocket[15] and a further 16 fired by SpaceX on 20 May[16] **- the operator now has 634 satellites in orbit, out of the 648 planned in its launch campaign.**

Founded in 2012 by Greg Wyler and backed by leading investors (Softbank, Airbus, Richard Branson, Coca-Cola...), OneWeb came very close to disappearing: it filed for bankruptcy in 2020, after the failure of its merger with Intelsat and a year after launching its in-orbit campaign. It is now majority-owned by the British government and the Indian conglomerate Bharti (owner of the international telecoms operator **Airtel**), which took it over after its bankruptcy. **OneWeb is due to change hands again in 2023 through a merger with Eutelsat, whose main shareholder is the French government**. This merger should enable Eutelsat, whose satellite TV broadcasting business is in decline, to **become a major player in satellite Internet.**

2.2.1 OneWeb satellites to connect GSM base stations

While OneWeb's technical plan is similar to that of Starlink, its commercial positioning is different: it favours - at least initially - a B2B model, reserving its network for corporate customers. Companies operating in remote areas (mining, logistics, farming, tourism, etc.) will also be able to take out subscriptions. Above all, **telecoms operators will be able to use its network to install GSM relay antennas in places that were previously impossible to serve, with the satellite connection replacing the optical fibre or radio links (known as *backhaul*)** connecting the relay antennas to the core network. OneWeb has signed several distribution

[11] The Recent Large Reduction in Space Launch Cost, Harry W. Jones, NASA Ames Research Center, 2018
[12] SpaceX just launched 21 satellites for OneWeb, Space.com, May 2023
[13] SpaceX unveils "V2 Mini" Starlink satellites with quadruple the capacity, ArsTechnica, February 2023
[14] Presentation of the Wildblue satellite, ViaSat
[15] OneWeb launch completes space internet project, BBC, March 2023
[16] OneWeb confirms successful deployment of 16 satellites including next-generation JoeySat, OneWeb, May 2023

agreements with regional players to facilitate this deployment: Now Telecom in the Philippines[17], Mu Space in South-East Asia, and iSat Africa, Paratus and Q-KON Africa, all of which specialise in supplying bandwidth to African telecoms operators. **OneWeb will also provide *backhaul* services directly to major operators, including Airtel[18] and Orange[19], in both cases with a particular focus on the African market.**

2.2.2 Support for governments and public operators

In partnership with telecoms operators, OneWeb is also offering its **services to governments to serve schools, hospitals and even local communities**, or to roll out certain public services. On 14 June, for example, the group signed **a letter of intent with state-owned Kazpost and telecoms operator Beeline to provide all post offices in Kazakhstan with a broadband connection**[20] . The British government - currently a shareholder in the group - is also testing OneWeb's solutions for its "Very Hard to Reach Premises" programme to **roll out broadband in the country's most isolated villages**. OneWeb is also a member of the **Connecting Alaska Consortium**, alongside a number of Alaska Native Corporations, dedicated to rolling out broadband to the most remote villages in the state[21] .

2.3. E-Space's African ambitions

After founding O3b Networks in 2007 (sold to SES in 2016) and then OneWeb in 2012, Greg Wyler founded **E-Space** in February 2022, again with the aim of creating a constellation of **several hundred thousand LEO satellites.** To date, the company has launched three satellites in May 2022, and obtained its first landing rights in Saudi Arabia in November 2022[22]. But E-Space is **counting on Africa in particular** for its growth. At the end of 2022, the company signed a **memorandum of understanding with Botswana[23]** as part of the country's Vision 2036. Botswana intends to use E-Space technologies to develop digital agriculture services (monitoring, control of crop management systems), helping to ensure its food security. **Nigeria** has also recently granted landing rights to E-Space, to provide connectivity throughout the country for a range of potential uses (digitised agriculture, health, energy)[24]. The company has attracted particular interest from Rwanda. In fact, it is Kigali that has applied to the ITU, on behalf of E-Space, for authorisation to put 300,000 satellites into orbit in 2021[25]. Relations between Greg Wyler and the authorities in Kigali go back a long way, as do Rwanda's space ambitions. In 2019, the Rwandan Ministry of Telecommunications formed a partnership with OneWeb, Wyler's former company, to launch its "Icyerekezo" satellite from the French base at Kourou. Wyler is also highlighting the possibility of helping governments to create their own **sovereign constellations** for military, police and judicial applications.[26]

2.4. Education, healthcare, private sector: an infinite number of uses

The commercial launch of Starlink and OneWeb could **rapidly transform the telecoms landscape in the most disadvantaged countries**. The American operator's subscription is still too expensive for most of the population, but it is within the reach of governments and development aid organisations. With the support of the Tony Blair Institute for Global Change, **Rwanda has carried out a pilot project to provide high-speed Internet access to 50 schools**[27]. A **further 450 schools are set to benefit thanks to funding from the World Bank**. In April 2023, El Salvador's Ministry of Health announced that it had connected all the country's hospitals using Starlink[28], and the country's schools could follow suit.

[17] OneWeb and NOW Corp to boost connectivity for critical infrastructure in the Philippines, OneWeb, May 2023
[18] OneWeb and Airtel Africa collaborate to provide enhanced connectivity services in Africa, OneWeb, November 2022
[19] Orange and OneWeb sign agreement to improve and extend global connectivity, Orange, March 2023
[20] OneWeb signs LOI with Kazpost and Beeline Kazakhstan, OneWeb, June 2023
[21] Connecting Alaska Consortium, consulted in June 2023
[22] Saudi Arabia's Communications, Space & Technology Commission Welcomes E-Space to Enter Saudi Market, E-Space, Nov. 2022
[23] Botswana, E-Space sign MoU to advance country's fourth industrial revolution, E-Space, December 2022
[24] E-Space secures landing rights from Nigeria, E-Space, March 2023
[25] Rwanda's 300'000 satellite ITU filing made noise for all the good reasons, Space Intel Report, January 2023
[26] Presentation page, Constellation-as-a-service, E-Space
[27] The Tomorrow Partnership, Tony Blair Institute for Global Change, accessed in June 2023
[28] Tenemos el 100 % de hospitales con conectividad, y mucho más rápida con los dispositivos de Starlink, Diario El Salvador, April 2023

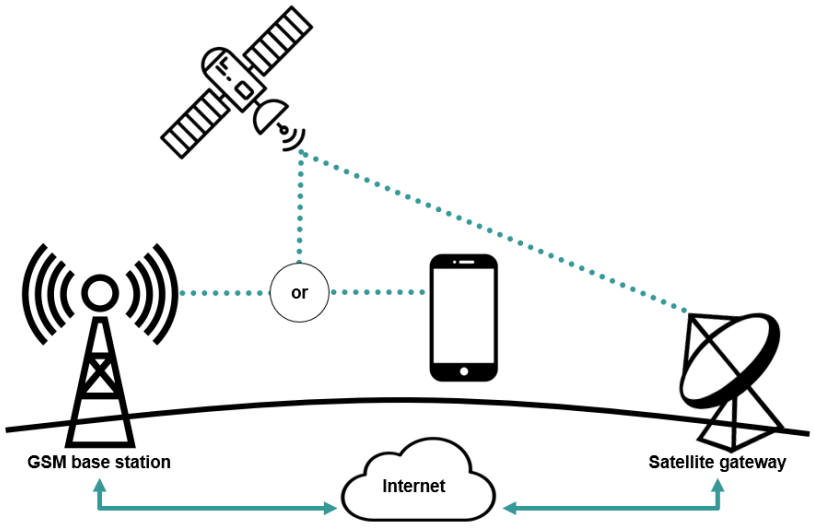
2.5. Accelerating the roll-out of cellular networks

But it is perhaps the ability of satellite constellations **to offer a *backhaul* service to mobile phone operators that could ultimately have the greatest impact**, enabling them to extend their networks at lower cost without the need for costly fibre optic installations or terrestrial microwave links, which require an unobstructed line of sight. Satellite backhaul is not new, but until now it has been provided by geostationary satellites, at high cost and relatively low data rates. This service should be one of OneWeb's main activities. And although SpaceX has kept mum on the use of its constellation as a backhaul infrastructure, In Japan, KDDI has been using it since the end of 2022 to serve the island of Hatsushima, and plans to equip more than 1,200 isolated relay antennas to improve connectivity for rural populations[29] .

3. With satellite-to-phone, relay antennas are moving into space

However, satellite broadband access requires expensive equipment: up to $600 for Starlink's consumer antenna, and probably at least as much for those of OneWeb, which has not yet announced its prices. This cost, like that of subscriptions, will remain beyond the reach of most potential users. A number of companies such as **Lynk**, **Omnispace** and **SpaceMobile**, recently joined by SpaceX, are therefore considering another model: **direct connection between 'standard' smartphones** (complying with the 3GPP standard governing 3G, 4G and 5G) **and satellites in low Earth orbit, which take the place of terrestrial relay antennas when the user is in an area not served by the normal mobile network** (Figure 7).

Figure 7: Operating principle of a satellite-to-phone network



Source: Global Sovereign Advisory

This hybrid scheme enables **connectivity to be deployed worldwide, complementing existing telecoms networks, without any additional equipment or infrastructure, and regardless of topographical constraints.** It does, however, require **partnerships with GSM network operators**, so that they can integrate the service into their telephone packages, share their radio frequency slots, and negotiate with national regulatory authorities if necessary. The situation could evolve rapidly: in the United States, the Federal Communications Commission (FCC) has submitted for public debate a proposal for a regulatory framework for the extension of satellite coverage[30] .

[29] KDDI launches the 1st Mobile Tower powered by SpaceX's Starlink in Japan, KDDI, December 2022
[30] FCC proposes framework to facilitate supplemental coverage from space, Federal Communications Commission, March 2023

3.1. Lynk Global texts from space

The pioneer of this technology is the American company **Lynk Global**, which boasts that it was the first to send an SMS between a standard smartphone and a satellite in 2020. The group deployed its first three commercial satellites between the end of 2022 and January 2023, with seven more “Lynk Towers” to follow by the end of the year to ensure global coverage. With this fleet of "GSM base stations in space", Lynk is not seeking to offer broadband access, however: **the service will initially be limited to sending text messages - on a delayed basis, due to the small size of the constellation - before eventually being extended to include telephone calls**. Lynk has already signed preliminary agreements with a number of local operators, including in the Bahamas, Ghana, the Central African Republic, Mongolia, Papua New Guinea, the Solomon Islands[31], Canada and New Zealand[32].

However, the actual commercial launch will depend on **partner operators' ability to negotiate landing rights with national regulatory authorities.** This will fill a **regulatory gap**, as no legislation has made provision for a direct connection between a telephone and a satellite. From a technical point of view, Lynk intends to use the frequency ranges of its local partner in each market. But it will have to ensure that it does not cause any interference in the areas covered.

3.2. SpaceX sets its sights high to make up for lost time

SpaceX is also positioning itself in the nascent satellite-to-phone market. The group has announced the signature of two agreements with operators, for the moment only in developed markets: T-Mobile in the United States, Rogers in Canada and Salt in Switzerland.

SpaceX's service will initially be limited to sending text messages, but the American group wants to offer voice and then data services as soon as possible. However, this development will largely depend on the operational launch schedule for SpaceX's next generation of rockets, comprising the Falcon Heavy booster and the Starship heavy launcher. The "Starlink V2" satellites, which will have the necessary bandwidth for voice and data services, will be much larger than those in the current constellation: weighing more than a tonne compared with 290 kg, they will have to be equipped with antennae measuring more than 5 metres on each side. As a result, they will not be able to be launched into orbit by Falcon 9, the rocket that carries out most of SpaceX's launches. **However, the first commercial launches of Starship - which will be capable of placing 100 to 150 tonnes into low-Earth orbit - could be several years behind schedule.** SpaceX hopes to carry out another test in August[33] , after a prototype was destroyed in flight in April. These delays have prompted SpaceX to develop an intermediate version, "Starlink V2 Mini", identical in size to its current satellites, but with improved throughput. More than 80 have already been placed in orbit since February 2023.

3.3. Outsider Omnispace targets 5G

Meanwhile Omnispace, a US company founded in 2012, aims to build the **world's first 5G satellite network**. By exploiting the 2GHz frequency range, Omnispace claims to be able to offer unlimited connectivity, including in underserved and hard-to-reach areas. **The company already has an embryonic satellite infrastructure in place**, having **launched two satellites in 2022**, out of a planned total of around 200.

Several telecom operators have already approached the company, particularly in island states. In August 2022, **Smart Communications** announced a proposed agreement with Omnispace to study possible applications in the Philippines: 5G connectivity in remote areas, emergency services, maritime telematics, etc.[34]. **NCINGA**, an operator services provider working for several operators in Asia and the Pacific, has also signed an

[31] Lynk reveals mobile network contracts, Space News, February 2022
[32] Lynk + 2degrees initiate satellite-to-cell trial, SatNews, April 2023
[33] SpaceX aims to launch Starship again in 6 to 8 weeks, Elon Musk says, Space.com, June 2023
[34] Smart, Omnispace team-up to explore space-based 5G technologies, Omnispace, August 2022

agreement with Omnispace to serve the Maldives, Fiji and Sri Lanka[35]. In India, satellite communications service provider **Nelco** (part of the Tata group) announced a strategic cooperation agreement with Omnispace from 2021[36].

Omnispace has also turned its attention to the Saudi market, signing a memorandum of understanding in February 2023 with STC (Saudi Telecommunication Company)[37] to provide voice and data services to its customers throughout Saudi Arabia, beyond the terrestrial network. The partnership is all the more strategic for STC as the group works with major players covering various areas of the Saudi economy (agriculture, finance, oil, government services).

3.4. AST SpaceMobile makes the first satellite voice call

Founded in 2017, American company **AST SpaceMobile** aims to **provide a high-speed global cellular service from space**, including in the most remote areas. In 2022, the company deployed its BlueWalker 3 prototype, which enabled it to **make the first two-way voice call via space with a standard smartphone in April 2023**. The company plans to launch a constellation of around a hundred BlueBird satellites by the end of 2024. The first five could be launched at the end of 2023 by SpaceX. These devices will provide connectivity to smartphones outside cellular coverage, in partnership with GSM network operators. Several strategic partnerships have been signed with **Vodafone**, **Rakuten**, **Telefonica**, **AT&T** and, in February 2023, the Brazilian telecommunications giant **TIM**[38] . The first technical tests are due to take place in northern Brazil in the first half of 2023. Earlier this year, two memorandums of understanding were also signed with Saudi operators **Zain**[39] and **STC**[40].

3.5. Despite limited data rates, many applications

No satellite-to-phone operator will be able to offer broadband services to as many people as possible **for several years**. But even a bandwidth of a few kilobits per second means that many digital services can be deployed in previously inaccessible areas. **The ability to send text messages, for example, will give users access to mobile money services**. Similarly, it will be possible to set up **information systems for farmers**: weather forecasts, early epidemic alerts, selling prices for agricultural products or inputs, etc. Finally, various **e-government** services - from registration with a social insurance fund to electronic voting and the targeted distribution of subsidies - can also be envisaged without the need for a broadband service.

3.6. "Internet of Things": from critical infrastructure control to herd management

Several operators have also developed LEO constellations specialising in the Internet *of Things (*IoT), i.e. connecting objects together. In 2021, SpaceX acquired **Swarm Technologies**, which already has a fleet of more than 180 picosatellites (400 grams, 11 x 11 x 2.8 cm) dedicated to IoT applications. For 5 dollars a month per connected object, the service enables various types of sensors, GPS beacons, etc. to be connected. In April, the Spanish start-up Sateliot launched its first satellite (10 kg) into orbit, also dedicated to IoT applications and using 5G standards. Sateliot is working with the South African group Streamline on the mass production of cattle identification tags, which will make it possible to locate herds in real time to **combat cattle theft** - a recurring source of conflict in many countries - and **fight epizootics** such as foot-and-mouth disease[41] .

[35] Omnispace Announces Strategic Agreement with NCINGA to Collaborate on Development of 5G NTN based Solutions, Omnispace, June 2022
[36] Omnispace and Nelco Announce Strategic Partnership, Omnispace, March 2021
[37] STC lands on Omnispace for 5G satellite play, Mobile World Live (GSM Alliance), February 2023
[38] AST Spacemobile announces collaboration with TIM, February 2023
[39] AST SpaceMobile Announces Collaboration with Zain KSA, Zain, February 2023
[40] AST SpaceMobile and stc partner on connectivity services, Capacity Media, March 2023
[41] Halting livestock diseases + cattle theft with 5G-IoT devices connected to satellites, SatNews, December 2022

4. 6G may integrate satellite-to-phone communications from the get go

Although it has just begun its transition to 5G, the telecoms industry is already laying the foundations for 6G. This sixth generation of cellular network technology, which is not expected to be deployed before 2030, will offer ever higher connection speeds, reduced latency times, better support for new uses (IoT, artificial intelligence, metaverse, etc.), and so on. Above all, 6G could also **directly integrate satellite-to-phone connections**. Industry, governments and regulatory authorities are still holding preliminary discussions on technical standards, and the drafting of these standards could fall outside the remit of the 3GPP consortium, with several competing alliances having emerged. But it already seems certain that the 6G standard will take account of the development of LEO satellite telecoms networks, by allowing direct association between them and terrestrial networks, a possibility that was not taken into account in the 4G and 5G standards. At the forefront of this field, China has launched its first '6G' satellite into orbit in 2020, using the terahertz frequency band, which enables speeds of 115 gigabits/second[42]. Chinese telecoms giant Huawei is also conducting research into the integration of satellite constellations into the 6G network[43], as is Japan's Docomo and a number of other manufacturers. Finally, the US FCC is already considering the ideal mix of frequencies to accommodate terrestrial and space-based uses of 6G[44] .

[42] China Launched a 6G Satellite - So What, Australian Computer Society, 2020
[43] Very-Low-Earth-Orbit Satellite Networks for 6G, Huawei, December 2022
[44] FCC reserves parts of 12GHz for satellites, Mobile World Live, May 2023