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Geopolitics in space:

How Starlink and satellite internet are reshaping the future

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Contents

Cover image design: Daniel Hua Jing Chan

Introduction

The internet space race transforming global commerce is increasingly being driven by geopolitical considerations.

The US-China superpower rivalry is fueling an internet space race that is altering the course of global commerce. A technology revolution involving low earth orbit (LEO) satellites promises to bring highspeed internet to every square inch of the planet. By 2030, constellations comprising some 60,000 LEO satellites will envelope the earth. Geopolitics, not inclusive economic development, will drive this historic transformation.

Nowhere has this been more obvious than in the Ukraine war, where everyday technologies are redefining military strategy. Even as Moscow's cyber-attacks incapacitated Ukraine's internet and the Russian military destroyed Ukrainian telecommunications and power infrastructure, Ukrainians have been able to connect to the world via the satellite-based internet service known as Starlink.

That connectivity has helped Ukraine locate, target, and destroy Russian military assets, all with the help of a small Starlink satellite dish and a toaster box-sized Starlink receiver,[1] purchased on eBay and Amazon and delivered via local last-mile logistics providers, sometimes within plain sight of the battlefront.

Key themes

- First-mover advantages in LEO technology and rocket science have conferred strategic advantage to a small number of companies such as Elon Musk's Starlink, controlled by his spacecraft tech company SpaceX. High barriers to entry in the LEO sector will present challenges to other governments as they seek to develop their own secure national LEO ecosystems.

- To compete with the likes of Starlink, China is building its own LEO constellation, GuoWang, which will polarize global markets. Just as geopolitics bifurcated the telecommunications landscape around the Chinese telecom giant Huawei and 5G networks, LEO constellations will be subject to increasing export controls, sanctions, international traffic in arms regulations (ITAR), and blacklisting. Decoupling, ring-fencing, and friend-shoring will shape the growth of space-based internet ecosystems.

- The Ukraine war has showcased space-based internet connectivity and the asymmetric power multipliers it confers though open-source digital warfare. The use of commercial products provided by Starlink and China's DJI, the world's leading maker of consumer drones, for lethal purposes has prompted calls for prohibitions and new rules to govern the increasing convergence of commercial and military assets.

LEO satellite technologies and their related architecture add to a growing list of strategic industries affected by techno-nationalism, including semiconductors, hypersonics, quantum and supercomputing, electric vehicles, and 5G.

Trends in satellite technology and space geopolitics

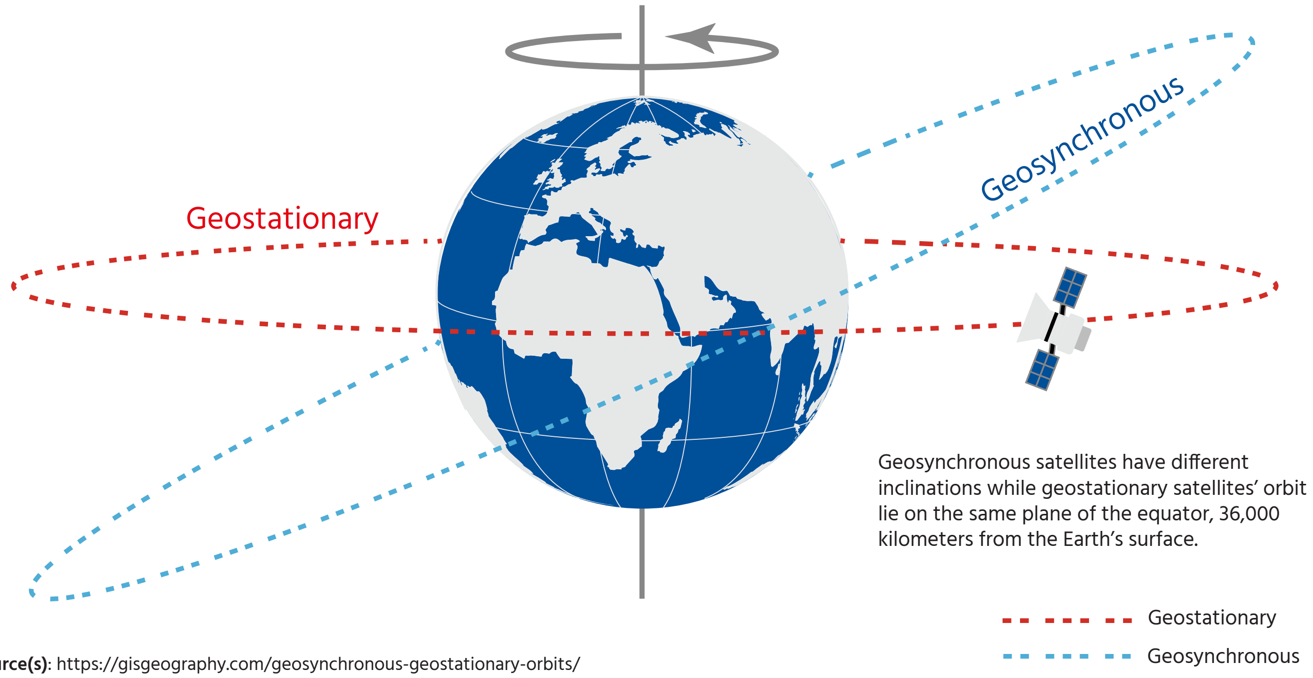
Geosynchronous and geostationary satellites

Historically, orbital space networks have relied upon "exquisite" satellites, which are large, powerful, and highly expensive. These are primarily geosynchronous (GSO), meaning they have an orbital period that matches earth's rotational period; thus, they remain in the same spot in space in relation to a specific spot on the ground.

Certain geosynchronous satellites remain stationary along the earth's equator at a set distance of 36,000 kilometers above the planet. These types of satellites are referred to as geostationary (GEO).[2] By hovering over the equator at great distance, the signal from GEO satellites covers wide areas of the earth's surface.

Most GEO satellites are for telecommunications and television broadcasting. Launching a large GEO satellite into geostationary orbit costs between $100 million and $400 million. A sophisticated GEO weather satellite can, for example, cost around $300 million. A GSO reconnaissance spy satellite put into high orbit could run around $100 million.[3]

Figure 1 – Geosynchronous satellites vs. geostationary satellites



Source(s): https://gisgeography.com/geosynchronous-geostationary-orbits/

First-mover advantages in LEO technology and rocket science and high barriers to entry in the LEO sector have benefited companies like Elon Musk's Starlink.

Low earth orbit (LEO) satellites

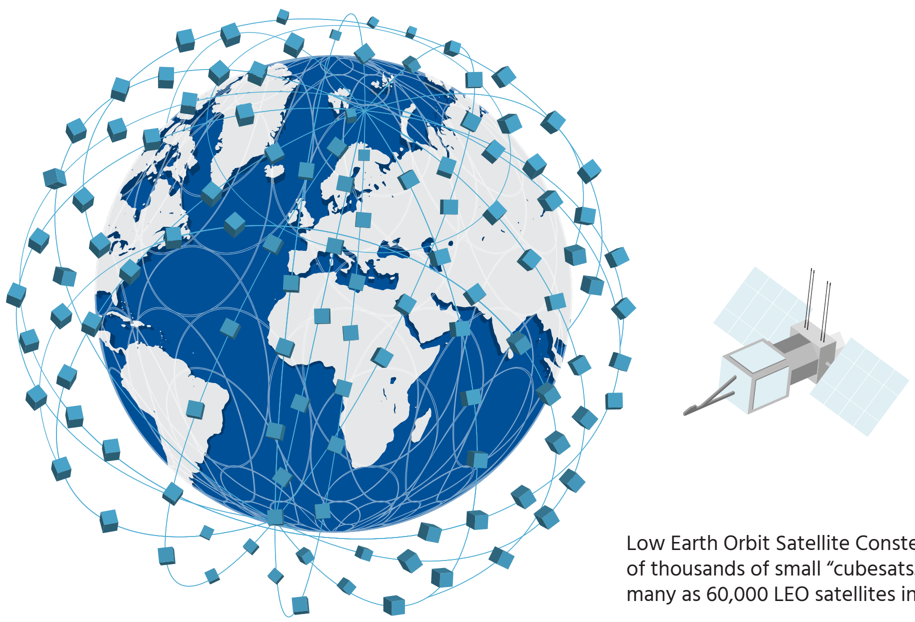
Revolutionary advances in technology have led to the creation of a "mesh" or "constellation" of hundreds or even thousands of LEO satellites. LEOs orbit 2,000 kilometers at the high end, and 160 kilometers at the low end, above the planet's surface. The majority of LEOs orbit between 500 to 1,000 kilometers above the planet.

Because they are relatively close to earth's surface, LEOs cover a much smaller area, hence, many more are needed to extend coverage over vast swaths of geography, especially in less developed regions or over the world's oceans. But LEOs offer faster communications (lower latency) than their higher-altitude cousins.

As of May 2023, Starlink had deployed just under 4,000 LEO satellites and its high-speed internet is accessed by one million paying subscribers worldwide.[4] The company has applied for licenses to put as many as 40,000 small satellites into low earth orbit.[5] Starlink is operated by SpaceX, the pioneering company founded by Musk that builds, launches, and is a contract operator of reusable rockets and other spacecraft.

The average cost of an LEO satellite is around $14 million.[6] This is far less than a GSO or GEO exquisite satellite, but a proliferated LEO constellation that contains hundreds or even thousands of "smallsats" is expensive. A McKinsey report, published in 2020, estimated that, at a minimum, a functional LEO constellation would cost around $5 billion.[7]

Figure 2 – Low earth orbit (LEO) satellites



Low Earth Orbit Satellite Constellation consisting of thousands of small "cubesats." There may be as many as 60,000 LEO satellites in orbit by 2030.

Source(s): https://satellitemarkets.com/news-analysis/next-wave-low-earth-orbit-constellations

A revolution in technology and manufacturing

Rapid advances in semiconductor technology and AI, along with supercomputing, have led to a revolution in onboard processors and optical laser crosslinks, which allow the secure transfer of data and other high-speed communications to occur between different “layers” within a satellite constellation.

Along with technology advances, production costs for LEO satellites have come down significantly. Now, standardization and commoditization of satellite parts and components allow manufacturers to resort to modularization. This, in turn, has resulted in the building of large assembly lines that can produce hundreds of satellites per month.[8]

Mass-produced LEO satellites will bring high-speed internet to virtually anyone, anywhere, from adventurous yachtsmen plying the most remote stretches of open ocean, to scientists traversing the last swaths of the world’s unexplored jungles. Space-based internet will bridge the digital divide between rich and poor, like never before, as it brings e-commerce and digital trade to every town and village.

In matters of human conflict, however, Starlink and similar networks empower both the proverbial “freedom fighter” and “terrorist” alike.

Within the modularized supply chain, commercial operators such as Telesat, Blue Canyon Technologies, and Airbus specialize in making satellite “buses”—the body and structural component that holds the satellite payload and provides the thermal environment, radiation shielding, telemetry, optical sensors, altitude, power, and other controls of the satellite.[9]

Other companies such as SA Photonics, Mynaric, and Raytheon specialize in “payloads”—the scientific and technical equipment onboard a satellite, which might include, for example, antennae, transponders, and cameras. These payloads enable telecommunications, navigation, surveillance, imaging, high-speed internet, and more.[10]

The growth of prolific LEO constellations, together with the rise of private, specialized manufacturers, will drive the value of just the payload market from around $5 billion in 2022 to around $30 billion in 2030, according to Business Market Insights.[11] Meanwhile, the value of the market for data services, provided by growing numbers of LEOs, will reach $45 billion by 2030.[12]

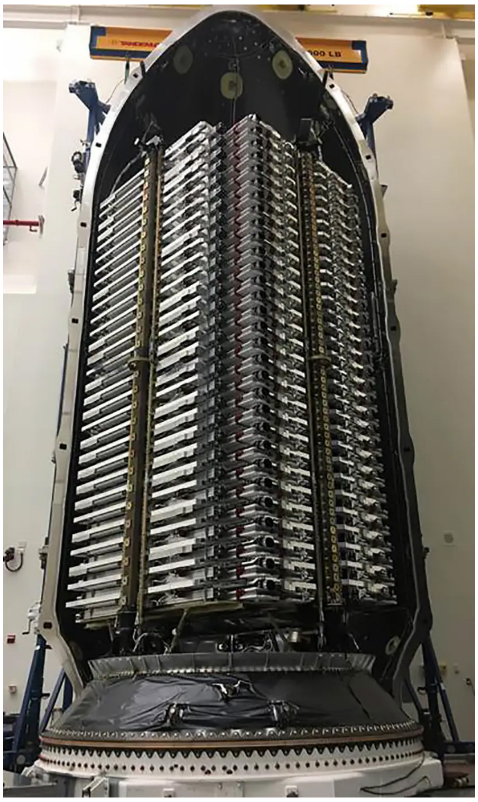
SpaceX and the rocket revolution

No space-based internet satellite constellation would be possible without the means to launch payloads into space at affordable cost and with great frequency. Here, SpaceX's breakthrough involving reusable launch vehicles changed the economics of the space race.

SpaceX's rocket scientists made it possible to reuse the first stage of its Falcon 9 and Falcon Heavy launch vehicles, which cut the cost of a typical National Aeronautics and Space Administration (NASA) space launch dramatically. Launching a Falcon Heavy rocket is 10 times cheaper than NASA's retired space shuttle.[13]

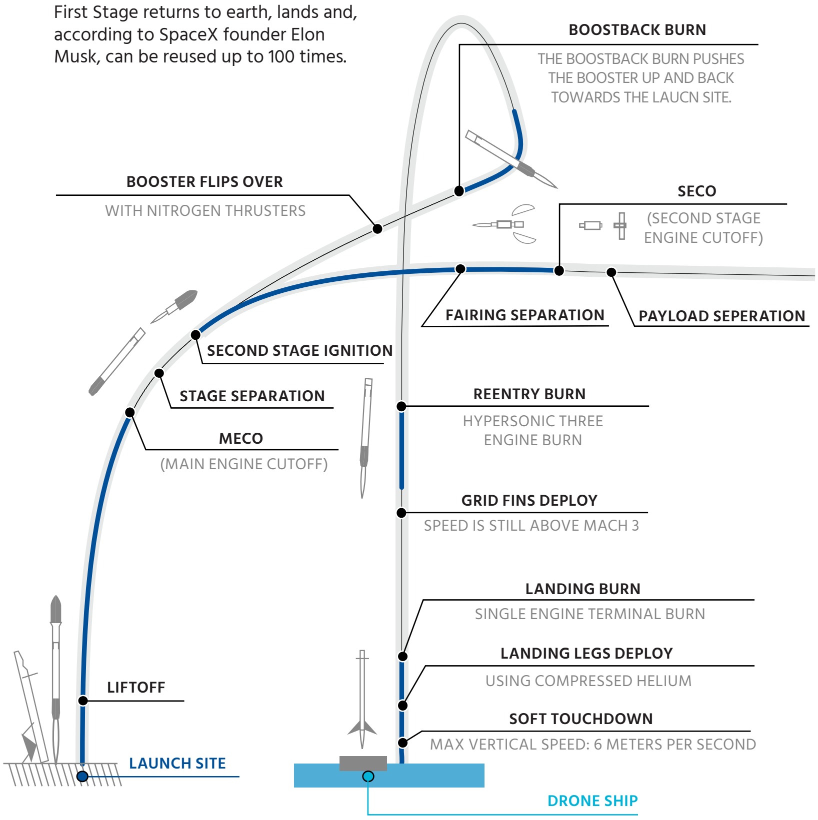
Relying upon leading-edge AI and algorithms, once a SpaceX rocket carries its payload up into space, it flips around and is guided back to earth—rather than falling back to earth and becoming yet another useless piece of space debris on the ocean floor—where it decelerates and lands upright with pinpoint accuracy. A SpaceX rocket can land on a designated landing spot on solid ground or on a floating landing pad at sea.

Figure 3 – SpaceX and the rocket revolution



A SpaceX rocket payload can release more than 50 Starlink LEO satellites in one launch. After entering orbit, each satellite migrate to its proper place in the constellation.

SpaceX Rockets are reusable. After liftoff and deployment of payload, the First Stage returns to earth, lands and, according to SpaceX founder Elon Musk, can be reused up to 100 times.



Source(s): Elon Musk's Twitter (image) ; http://justatinker.com/Future/ via NBC News (graphic)

According to Musk, the company aims to reuse a launch vehicle up to 100 times. By March 2022, SpaceX had launched 148 rockets, recovered 110 first stages, and reused 87 of them.[14]

SpaceX's ability to shorten the timespan between launches, primarily because of its reuse of first stage launch vehicles, allowed the company to capture more than 20% of the global commercial space launch market by 2020.

When it comes to Starlink, however, having a vertically integrated model that combines LEO satellite construction with SpaceX's unique launch capabilities has made the company a dominant player in the sector. In addition to high-speed internet, Starlink aims to eventually provide universal space-based mobile phone service.

Another major technological achievement, also pioneered by SpaceX, is the launching of numerous satellites, all in one single mission. In early February 2023, SpaceX successfully completed its 200th launch of a Falcon 9 rocket, which dispatched a cluster of 53 Starlink satellites into low earth orbit.[15]

The compact size of today's LEO smallsats relies on the exponential increases in micro processing power. Here, again, modularization has brought down costs significantly.

The militarization of space

National security imperatives are accelerating the development of LEO constellations. In 2019, for example, the US established the Space Development Agency (SDA) with the mandate of building more resilient space architecture. That same year, Space Force[16], a new branch of the armed forces (often ridiculed in mainstream cultural circles) was created to address very real existential issues.

US-China geopolitical rivalry and the war in Ukraine pushed the SDA to put in place a set of demands for the next generation of satellite constellations. These new networks must have layer upon layer of sensors that not only enable seamless and secure data communications but can closely track hypersonic missiles (which travel at five times the speed of sound) and cruise missiles. Other functions of the constellation are to provide navigational services and general surveillance capabilities.[17]

Historically, the infrastructure behind satellite communications networks involved small constellations with a few large "exquisite" satellites. Such a configuration, however, can be disabled by destroying a single large satellite within the system. This security dilemma became very real in 2007, when China used a missile to destroy one of its own satellites, in an event that sparked an international outcry,[18] due to uncertainty over whether China intended to convey a geopolitical signal by doing so, and the space debris the shootdown left behind.

The militarization of space has become inevitable. China, Russia, India, and the US have developed anti-satellite missiles as well as electronic jammers and lasers that could disable another country's satellites.[19]

By putting in place hundreds of LEO satellites, the SDA aims to achieve "resilience by numbers," on the assumption that it's too difficult and too costly for an adversary to destroy a swarm of so many smallsats.[20] Other nations assume the same.

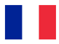
LEO satellite technologies add to a growing list of strategic industries affected by techno-nationalism. To compete with the likes of Starlink, China is building its own LEO constellation, GuoWang.

The rise of dual-use and techno-nationalism

In 2018, the Defense Advanced Research Projects Agency (DARPA) launched Project Blackjack, which drew heavily on partnerships with commercial companies. Among other things, Blackjack developed interoperability standards and architecture that would allow seamless communications between commercial satellite operators and the US military. Lasers are one technology often in the spotlight. So-called "optical cross-link" laser communications have emerged as a key part of the solution.

It's fitting that in 1966, it was DARPA (then known as ARPA) that produced the predecessor of the modern internet, known as ARPANET. It took decades for standard coding protocols to emerge, however. When it comes to the expansion of LEO constellations, today, DARPA and the US defense establishment have sought to both influence and preempt the creation of standards that drive the commercial satellite internet sector.

Table 1 – Partial listing of existing and future LEO satellite operators, constellations, and frequency bands, as of 2023

Constellations	LEO satellites (Launched)	LEO satellites (Planned)*	Frequency band	Country
Orbcomm	50	52	VHF	
GlobalStar	25	41	S and C	
Iridium	75	75	L and Ka	
OneWeb	582	648	Ku and Ka	
Boeing	0	132	V and Ka	
Starlink (SpaceX)	3,580	40,000	Ku, Ka and V	
Kuiper (Amazon)	0	3,236	Ku and Ka	
Telesat Lightspeed	2	198	Ku and Ka	
ViaSat	0	20	Ka	
Spacelink	0	4	V	
GuoWang	0	12,992	Ku and Ka	
Eutelsat	1	Unknown	Ku and C	
Geely	9	Unknown	Unknown	
Galaxy Space	7	1,000	Q and V	

Note: In 2023, Starlink applied for permission to triple its planned LEO satellite mesh, bringing its target constellation size to around 40,000.
* "Planned" means the number of satellites "permissions" applied for by respective companies.

Source(s): https://www.newspace.im/Telecoms.com ;
https://telecoms.com/513965/china-enters-the-leo-space-race/ ;
https://economictimes.indiatimes.com/news/science/oneweb-launches-another-40-leo-satellites-from-musks-spacex-centre-in-us/articleshow/98534568.cms?from=mdr ;
https://spacenews.com/telesat-still-bullish-on-lightspeed-despite-funding-uncertainty/

There are clear geopolitical motives behind DARPA and the SDA's mandate to work with the likes of Starlink to spread internet coverage to every square inch of the planet's surface. One goal is to expand the reach of Western soft power by providing ubiquitous internet access.

It is likely that US intelligence and defense-related agencies would also enjoy significant advantages in signals intelligence with the expansion of LEO constellations built by American companies.

In the same vein, space-based internet empowers people engaged in wars and other struggles under extreme conditions, such as the Ukraine war. By providing access to open-sourced platforms and online resources and the unrestrained flow of data and information, space-based internet service has upended modern warfare. This applies to friend and foe alike, whether they are seen as "freedom fighters" or "terrorists."

Musk's Starlink is the most prominent name in space-based internet coverage, but other emerging players include Amazon's Project Kuiper, Telesat's Lightspeed, Viasat, and Spacelink. These companies compete and innovate under the oversight of DARPA and the defense establishments of their own respective countries.

All commercial entities must adapt to the realities of geopolitics and collaborate on matters of interoperability and national security. For this, there are both the incentives of generous public research and development (R&D) funding and lucrative public sector contracts as well as the threat of being left out of key partnerships, or more starkly, the threat of punitive measures such as sanctions and penalties.

Within the GEO-to-LEO ecosystem are a host of key companies producing parts and components such as York Space Systems, Lockheed Martin, L3Harris, and SpaceX. Blue Canyon Technologies and Airbus, for example, make satellite buses, while the likes of SA Photonics, Mynaric, and Raytheon produce a wide range of payloads.

In early April 2023, DARPA and SDA were rewarded with the successful launch of "Tranche 0," when a SpaceX rocket dispatched 10 separate LEO satellites into orbit. The launch featured two satellites built by SpaceX that were designed to track ballistic and hypersonic missiles. The other eight satellites, built by York Space Systems, featured laser optics designed to transfer data from space-based sensors to the ground.[21]

Decoupling, ring-fencing, and friend-shoring will shape the growth of space-based internet ecosystems.

Export controls and sanctions bifurcate global value chains

The national security implications of LEO constellations have profound effects on trade and global supply chains. As is the case with other ecosystems involving "dual use" technology such as telecommunications equipment, semiconductors, AI, and quantum science, LEOs are subject to export controls and other restrictions on trade and technology transfer.

The result will further bifurcate global value chains. Should any existing linkages with Chinese or Russian or other blacklisted enterprises (or third parties with linkages to them) exist, they will come under increased scrutiny and, ultimately, pressure to decouple. As is the case with semiconductors, techno-nationalist pressures will subject supply chains to re-shoring and ring-fencing.

SPOTLIGHT

The Huawei effect

In 2021, Beijing released its 14th Five-Year Plan, which called for the building of its own LEO constellation. China's answer to America's Starlink is GuoWang LEO. Beijing aims to place approximately 13,000 smallsats into space, with worldwide coverage.[22] Such an undertaking would be carried out by state-owned China Aerospace Science and Industry Corporation (CASIC)[23] and other Chinese entities, which will be heavily subsidized.

Head-to-head competition between China's GuoWang LEO and Starlink, as well as other Western space-internet service providers, among them, Telesat, OneWeb, and Eutelsat, begs the question whether this new area of communications infrastructure will result in a "Huawei 2.0" situation.

Recall that, beginning in 2019, Washington mounted a global assault on Chinese telecommunications equipment giant, Huawei, to block its installation of 5G wireless networks in other countries. Washington cited national security concerns regarding Beijing's ability to install spyware throughout Huawei's 5G infrastructure.

Australia, Canada, the United Kingdom, New Zealand, France, Sweden, Japan, and Taiwan joined the US in banning Huawei from their networks, while a host of others such as Germany and India imposed stringent security requirements or limitations on dealings with Huawei. Other countries that didn't ban Huawei outright, like Denmark, began to float the idea that future 5G or 6G supply chains should be ring-fenced inside the geographic boundaries of trusted allies.[24]

Meanwhile, middle powers as well as developing countries in Southeast Asia, Central Asia, Africa, and South America (and Mexico, the US' neighbor and major trading partner) remained open to Huawei.

The world will likely similarly bifurcate around space-based internet service providers, and eventually, space-based mobile phone service, just as it did around Huawei and 5G networks. The interaction of American and foreign companies with the Chinese LEO sector will be heavily impacted by US international traffic in arms regulations (ITAR) and sanctions, fortified by subsidies and other economic enticements as well as diplomatic pressure and security-related frameworks.

Starlink and the Ukraine war

The use of commercial products provided by Starlink and China's DJI (the world's leading maker of consumer drones) for lethal purposes has prompted calls for new rules to govern the increasing convergence of commercial and military assets.

The Ukraine war ushered in a new era of warfare, where everyday technologies redefined military strategy and leveled the playing field between large and small powers.

The weaponization of inexpensive commercial drones blurred the line between simple day-to-day commercial utility and deadly warfare.

Whereas previous military conflicts stressed the primacy of large, expensive weapons systems, the Ukraine war demonstrates the advantages of decentralized, independently operated devices and weapons systems connected to cloud-based platforms and networks.

Space-based broadband enabled unmanned arial vehicles (UAVs), commonly referred to as drones, provided valuable intelligence and reconnaissance for Ukrainian troops, allowing them to locate, target, and destroy Russian military assets.

It's estimated that within a year after Russia's invasion of Ukraine, by February 2023, there were about 150,000 active users of Starlink inside the country.[25]

Even as Russian bombs and missiles were pounding the cities of Kharkiv and Bakhmut to rubble, Ukrainian citizen-soldiers were buying new Starlink dishes and receivers on eBay and Amazon and having them delivered to their bunkers via local last-mile logistics providers, sometimes within plain sight of the battlefront.

Starlink broadband provided the eyes and ears of Ukrainian forces and enabled the deadly use of drones, including the American "kamikaze" Switchblade drones.

Eyes, ears, and the drone revolution

Starlink broadband provided the eyes and ears of Ukrainian forces and enabled the deadly use of the Turkish made TB2 drone, among others—including lethal American "kamikaze" Switchblade drones and the Phoenix Ghost Drone which are, essentially, munitions with wings.[26]

Ukraine's hyper-connected war influenced other countries in the region facing possible aggression from Moscow to adjust their military philosophy. After less than a year of highly scrutinized battlefield intelligence, for example, Lithuania purchased 600 kamikaze drones from the US, with a combined value of almost US$50 million.[27]

Farther afield, Taiwan's government observed the outsized effect that Starlink has had on the war and has tasked its space agency, Taiwan Space Agency (TASA), with creating a new satellite division and building a national LEO constellation. Motivated by fears of what many consider an imminent invasion by China, TASA is looking to emulate Starlink's LEO constellation as quickly as possible.[28]

This has changed the calculus in Beijing, as well, as the People's Liberation Army (PLA) has become increasingly preoccupied with Starlink and other LEO constellations. Indeed, Chinese defense-related research has focused on possible ways to disable or destroy Starlink and other similar satellite constellations—currently a near impossible task.[29]

In Ukraine, other portable weapons such as the US Stinger missile, designed to shoot down low-flying aircraft up to 4,500 meters in the sky, were made available to Ukrainian fighting forces, as were much more advanced expensive systems such as high-mobility artillery rocket systems.

The Ukraine war drew regular citizens who had previously led lives as gamers, engineers, information technology workers, or just regular "internet geeks," to become part of an open-source war machine.

Starlink has been an unexpected ingredient in the comprehensive US military aid package to Ukraine. Within the first year of the war, Washington had provided around $3 billion and commitments for another $27 billion.[30] Consider that the success or failure of this massive expenditure could come down to whether Ukrainian forces can continue to effectively use Starlink which, ironically, runs on just $500 worth of purchased hardware per subscription.

Space-based internet connectivity has produced a large asymmetric power multiplier. The International Institute for Strategic Studies (IISS) estimated that by February 2023, one year into its invasion, Russia had lost about 2,000 tanks, more than 50% of its fleet deployed in Ukraine.[31]

Open-sourced and crowd-sourced war in the digital commons

Starlink enabled connectivity between troops in the field and their weapons systems, and, more broadly, it allowed for the mass-mobilization of crowd-sourced intelligence, which has sustained Ukraine's war effort.

A vast reservoir of expertise resides in the global commons, and internet access via Starlink allowed Ukrainian actors to benefit from open-sourced ideas and analysis provided by people all over the world, in think tanks, academia, and non-governmental organizations (NGOs) or from uniquely qualified armchair observers and hobbyists.

The Ukrainian military received free geospatial surveillance analysis, for example, from volunteer experts who pored over free satellite imagery from the European DigitalGlobe open data program[32] or from others who used Google Maps to obtain real-time road movements of the Russian military. Still others analyzed front-line intelligence uploaded via YouTube and provided valuable insights to Ukrainian intelligence and military planners.

The Ukraine war drew regular citizens who had previously led lives as online gamers, engineers, information technology workers, or just regular "internet geeks," to become part of an open-source war machine.

Others such as the secretive "hacktivist" group known as Anonymous took matters into their own hands and declared cyber war on Russia. Anonymous is an amorphous collective, consisting of computer programmers, coders, and cybersecurity experts.

Anonymous hacked into the databases of, among others, the Russian central bank, the Russian space agency, Russia's state space company, and Russian oil and gas companies such as Gazprom, and deleted or scrambled their data.[33] Anonymous hacktivists also broke into the networks of Western companies who continued to conduct business in Russia, such as Nestle, and stole usernames, passwords, and emails, and dumped them onto the internet. They also blocked and shut down access to websites in Russia and Belarus, hijacked Russian media platforms and news outlets, and posted censored data and imagery.[34]

Geopolitics and the future of space-based internet

Constellations comprising close to 60,000 LEO satellites will envelope the earth by 2030. Geopolitics, not inclusive economic development, will drive this historic transfiguration.

The convergence of geopolitics and techno-nationalism on space-based internet presents unique challenges to the international community.

Serious questions arise, for example, regarding whether a government should be allowed to weaponize a private company's core competencies for a war effort.

In February 2023, SpaceX took steps to limit Ukraine's use of drones to perform certain operations such as attacking targets with bombs. Initially, Starlink's executives reviewed the use of its network for defensive purposes but then, as weaponization of the network increased, both in scale and sophistication, Starlink implemented controls. As expected, this drew an outcry in Kyiv. Ukrainian forces continue to access Starlink, but the debate about what constitutes use of the network for "offensive" or "defensive" purposes remains unresolved and an ongoing source of ire for all sides.

But even beyond the military applications of Starlink, there are ethical questions on the consequences of a violent conflict live-streamed on social media platforms. Such imagery begs the question as to what rules should be enforced to block it—or prevent it from happening in the first place.

Regarding the need to avoid overreliance on a foreign entity, the UK and EU are working together on OneWeb, a competitor to Starlink (although they collaborate via US LEO defense and interoperability initiatives.) OneWeb's top investors include the UK government, the French government, and India's Bharti Enterprises.

Brussels has announced plans to spend 6 billion euros to build its own resilient LEO satellite constellation, which it hopes will provide cybersecurity and relative independence.

Brussels has announced plans to spend 6 billion euros to build its own resilient LEO satellite constellation, which it hopes will provide the bloc cybersecurity and relative independence.[35]

While Britain, the EU, the US, and others closely cooperate on LEO constellation projects, regionalization and localization of networks will continue apace.

A multilateral framework for space?

Nations have a vested interest in agreeing to mutually beneficial rules regarding the commercialization and the militarization of space.

The first issue involves the overcrowding of low-earth orbit. Nearly 60,000 LEO satellites could be in space by 2030.[36] As such, the dangers of collisions and resulting space debris could pose a hazard to global communications and trade.

Beyond the issue of space debris is the problem of light pollution. As more LEOs fill the night sky, they reflect more light and change the nightscape for astronomers and others. These issues require joint management and cooperation amongst governments and private interests.

Even accidents such as a malfunctioning of satellites or catastrophic failures of an entire network might occur, which might serve as a catalyst to look for other earth-bound options, such as expanding existing fiber-optic cable networks.

But this is unlikely. Ninety five percent of the world's internet traffic currently passes through just 200 intercontinental and regional undersea fiber-optic cables. And there are a mere 10 major chokepoints where these cables come ashore.[37] As such, the risks of geopolitically motivated sabotage, disablement, and their inability to connect far-flung geographic places, make undersea cables a secondary choice as the internet of the future.

The LEO constellation will represent the next phase of human connectivity, for both the internet and mobile phone service. Nations, corporations, and private citizens, therefore, must learn to adapt to this next phase of the space age.

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Alex Capri is a research fellow at the Hinrich Foundation and a lecturer in the Business School and Lee Kuan Yew School of Public Policy at the National University of Singapore.

He is the author of *Techno-Nationalism: How it's reshaping trade, geopolitics, and society* (Wiley), due out later this year.

From 2007-2012, Alex was the Partner and Regional Leader of KPMG's International Trade & Customs Practice in Asia Pacific, based in Hong Kong. Alex has over 20 years of experience in global value chains, business and international trade – both as an academic and a professional consultant.

He advises governments and businesses on matters involving trade and global value chains. Areas of focus include: IT solutions for traceable supply chains, sanctions, export controls, FTAs and trade optimization.

Alex has been a panelist and workshop leader for the World Economic Forum. He writes a column for Forbes Asia, Nikkei Asia and other publications and is a frequent guest on global television and radio networks.

He holds a MSc from the London School of Economics in International Political Economy and a BSc in International Relations from the University of Southern California.

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- The geopolitics of climate change and cleantech
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- Geopolitics and the race for data supremacy

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Endnotes

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