Britain and the Geopolitics of Space Technology

Policy Exchange

Safeguarding long-term UK space interests in an era of great power competition

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Foreword by Rt Hon Chris Skidmore MP

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About the Author

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About the Space Policy Unit

Launched in April 2019 by the then US Secretary of the Air Force, Hon Heather Wilson, and then UK Science Minister Rt Hon Chris Skidmore MP, Policy Exchange's Space Policy Unit – founded and led by Gabriel Elefteriu FRAeS – is the first of its kind at any UK think tank. The Unit's mission is to champion a comprehensive development of UK "space power" as a critical component of the UK national interest in the 21st century. Our goal is to help lift Britain's space ambitions to the next level, and help build a strong, exciting vision for UK in space that can be taken up by Government and Parliament in the years ahead.

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Foreword

By Rt Hon Chris Skidmore MP

The United Kingdom is fortunate to possess world-class space scientists and engineers, and a formidable space industrial base that has consistently won business abroad without any government assistance or favouritism.

The Prime Minister is committed to helping the UK space sector achieve better and greater things, as set out in the recently released *National Space Strategy* – the first high-level commitment to UK space in decades. The *National Space Strategy* takes us in the right direction, but as Dr. John Sheldon notes in this timely Policy Exchange report, British policy makers need to do more to ensure that UK space industry has a fighting chance in increasingly challenging foreign markets. China's aggressive commercial and economic tactics involve the Chinese government subsidising Chinese space and satellite companies, and increasingly adopt what can only be described as economic warfare, in markets where British companies should have a fair chance. Government should not pick national champions, but it should ensure that British space companies can compete – through international alliances if necessary – against economic rivals that use unfair influence and underhand tactics. Global Britain presents many opportunities for UK businesses, and our space sector is especially suited to help extend British influence, values, and opportunity at a literal global scale. In many instances UK space companies are more than equipped to go out and win business by themselves in many markets abroad. Increasingly, however, many markets that UK space companies should be able to access are becoming harder to access due to the mercantilist practices of strategic and economic rivals. Whenever possible, UK governments should not pick commercial winners or losers, but government should help create the conditions for fair competition where needed.

Moreover, successive British governments have failed to harness the capabilities, creativity, and diplomatic potential of UK space technologies and services. By many metrics the UK is a considerable global space power but often does not use these resources as a strategic tool for global influence as both our friends and rivals do. This Policy Exchange report correctly argues that more can be done to increase the importance and relevance of UK space across a range of economic, diplomatic, and other interests abroad to our greater strategic and economic advantage.

It is my hope that politicians, executives, and others interested in the success of UK space read this report and carefully consider its findings and recommendations. Britain is a space power, and we must do more to better use and promote this dimension of our national interest.

Executive Summary

- **Spacepower has become critical in shaping 21st century geopolitics and geoeconomics.** Space is a strategic sector of national security interest and importance that provides critically needed technologies and services to the government and military. Government should view the space sector not just in hard geopolitical terms, but also from a wider geoeconomic perspective as well.
- **The global space race is sharpening and competing effectively requires industrial scale.** Western space sector services and supply chains, alongside broader technology sectors, are undergoing a great decoupling from Chinese commercial partners. This will likely drive global supply chain realignments, market volatility and industry consolidation, as governments attempt to maintain strategic interests in space and companies seek to retain competitive advantage.
- **Safeguarding space-industrial competitiveness via an internationalist policy is essential.** The UK should also consider how, in an industry where consolidation is both inevitable and needed, it can continue to participate in an emergent space ecosystem with fewer large-scale players in ways that continue to serve its economic and geopolitical interests.
- **AUKUS offers an ideal framework for space cooperation.** The recently established AUKUS agreement, while initially focused on nuclear propulsion, artificial intelligence, and quantum technologies, should also be expanded to include strategic space technology cooperation in everything from next-generation reconnaissance and communication technology through to space exploration.
- **Allies should prevent the repeat of a Huawei-type situation in space technology.** The response to China's aggressive build-up in global tech markets (including key space sectors) must ensure viable Western alternatives to Beijing-backed players. Beyond securing vital security imperatives, protectionist tendencies should be balanced against the higher imperative of collective allied strategic competitiveness. Additionally, the UK and its allies should be more proactive in ensuring a level playing field for their respective space sector's access to key markets abroad.

- **Meeting the ambitions of Global Britain requires spacepower which is founded on a strong, competitive domestic industry.** The Government should use its national procurement programmes to encourage inward investment that grows the space sector. This would be improving the sector's resilience through competition and industrial presence which in turn enables complementary international partnerships to be developed in space with allies in the US, Indo-Pacific and other regions beyond Europe.

Introduction

The space domain has strategic utility and meaning, and constantly intersects with terrestrial geopolitics and geoeconomics. Space may be a vast, physical vacuum but it is not a political vacuum where scientists carry out occasional experiments and nation-states do one-off spectacular missions such as putting humans on the moon and then safely returning them to Earth.

In the early 21st Century space is as important to geopolitics and geoeconomics as the world's oceans or the complex transportation routes that criss-cross continents. A variety of satellites in Earth-orbit, such as communications, Earth observation, and positioning, navigation, and timing (PNT) systems, are not only valued at an estimated $400 billion in 2020, but enable global economic activity valued at trillions of dollars. Moreover, these same satellites not only generate and enable significant economic activity in and of themselves, they also enable the economic activity and wellbeing of everything from ocean-going trade, air travel, rail and auto routes, and every other kind of critical infrastructure that all societies and economies depend upon. These satellites are also vital to national security and our preferred way of warfare is conducted upon the foundation of spacepower.

Spacepower is the ability of a state in peace, crisis, and war to exert influence in, from, and through space using military, civil, and commercial space systems to achieve geopolitical, geoeconomic, and other strategic objectives around the world, and in the coming decades, possibly the inner solar system. Policymakers in most G20 countries are becoming increasingly aware of the geopolitical and geoeconomic salience of space for their national power and influence. Until recently, however, there has been a tangible reticence among UK policymakers, as well as among influential opinion formers in national politics and the media, to take space as a geopolitical and geoeconomic multiplier for Britain as seriously as in other countries. The recently released UK National Space Strategy is a sign of political progress where government at the highest level demonstrates a growing understanding of space as a geopolitical and economic multiplier, not just another tech sector.

Since the early 1970s the attitude of most British policymakers and media opinion toward national space matters could be summed up as a bizarre mash-up of Monty Python's mirthless Colonel, brilliantly played by Graham Chapman, and the core sentiment of the 1973 comedy film *No Sex Please, We're British*. In other words, space was broadly regarded as politically 'silly' and something of which British politicians wanted little,

if any, part in. At best space was a matter best left to the Americans, at worst something to be avoided altogether.

The 2021 *National Space Strategy*[1] released by the government, along with the Integrated Review[2], represent a refreshing approach to space issues at the political and strategic levels compared to previous governments. The strategy illustrates a growing awareness among policy and decision makers that space is not merely a lucrative industrial sector and militarily important but is also an increasingly useful instrument of statecraft and geoeconomic influence on the world stage, analogous in many ways to sea power.

1. Department for Business, Energy & Industrial Strategy and Ministry of Defence, "National Space Strategy", September 27, 2021, URL:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1020617/national-space-strategy.pdf
2. Cabinet Office, "Global Britain in a Competitive Age: the Integrated Review of Security, Defence, Development and Foreign Policy", March 16, 2021, URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/975077/Global_Britain_in_a_Competitive_Age-_the_Integrated_Review_of_Security__Defence__Development_and_Foreign_Policy.pdf

21st Century Spacepower Seeks Its Mackinder and Spykman

Global geopolitics today centres on the continuing rise of China and how this impacts the economic and military balance of power on the Eurasian supercontinent and the enduring relationship between continental landpowers and maritime sea powers. Spacepower is a relatively recent newcomer to this geopolitical dynamic but plays an important role in great power balancing, securing alliances and coalitions, and in keeping geographical chokepoints open, and is of equal utility to all sides in great power competition. It is of vital importance, therefore, that spacepower is not only secured in terms of assured access and balanced capabilities but is also wielded in concert with other instruments of national power in order to achieve maximum geopolitical influence in great power competition. Until very recently, it is fair to characterise British use of spacepower in this regard as under-utilised.

The geopolitical thinking of Sir Halford Mackinder[3] and the Dutch-American scholar Nicholas Spykman,[4] while originally formulated in the first half of the twentieth century, is still relevant today in spite of a concerted effort among faddish academics in the UK and the United States to mischaracterise them.[5] Geopolitical thinkers such as Saul Bernard Cohen, C. Dale Walton, Geoffrey Sloan, and the late Colin S. Gray provide a useful contemporary lens through which to understand the continuing relevance of Mackinder and Spykman in the broad conduct and character of geopolitics.[6]

At issue is not just the spectacular economic and political rise of China over the past few decades, but how that country has shifted the heartland of Eurasian power eastward and in the process has recast relations and power dynamics – to include the wider technological order - among all other powers on the supercontinent and beyond.[7] Mackinder was the first to understand that any power in Eurasia able to accrue sufficient human and natural resources could undermine the ability of maritime powers to maintain trade and order across the so-called rimland powers – those countries on the Eurasian littoral where continental-maritime great power balancing takes place.[8] Mackinder, and his near-contemporary Spykman, argued that a Eurasian heartland power could harness the massive resources at their disposal and by building large rail networks, wider industrialisation, and military expansion could 'break out' of their continental confinement and use their industrial might to dominate the Eurasian littoral and directly contest more liberal-minded maritime powers.

3. See Halford Mackinder, "The Geographical Pivot of History," *The Geographical Journal*, Vol. 23, January-June 1904, pp. 421-437; *Democratic Ideals and Reality: A Study in the Politics of Reconstruction* (London: Constable & Company Ltd., 1919); and "The round world and the winning of the peace," *Foreign Affairs*, Vol. 21, No. 4, July 1943, pp. 595-605.
4. See Nicholas J. Spykman, *America's Strategy in World Politics: The United States and the Balance of Power* (New York, NY: Harcourt, Brace and Company, 1942); and *The Geography of the Peace* (New York, NY: Harcourt, Brace and Company, 1944).
5. See, for example, Gearóid Ó Tuathail and Simon Dalby (eds.), *Rethinking Geopolitics* (Abingdon, Oxon.: Routledge, 1998); Gearóid Ó Tuathail, Simon Dalby, and Paul Routledge (eds.), *The Geopolitics Reader*, Second Edition (Abingdon, Oxon.: Routledge, 2006); and Klaus Dodds, *Geopolitics: A Very Short Introduction* (Oxford: Oxford University Press, 2019).
6. See, respectively, Saul Bernard Cohen, *Geopolitics: The Geography of International Relations*, 3rd Edition (Lanham, MD: Rowman & Littlefield, 2015); C. Dale Walton, *Geopolitics and the Great Powers in the 21st Century: Multipolarity and the Revolution in Strategic Perspective* (Abingdon, Oxon.: Routledge, 2007); Geoffrey Sloan, *Geopolitics, Geography, and Strategic History* (Abingdon, Oxon.: Routledge, 2018); Colin S. Gray and Geoffrey Sloan (eds.), *Geopolitics, Geography and Strategy* (London: Frank Cass, 1999); and Colin S. Gray, *Geopolitics of the Nuclear Era: Heartland, Rimlands, and the Technological Revolution* (New York, NY: Crane, Russak & Co., 1977), and *The Geopolitics of Superpower* (Lexington, KY: University Press of Kentucky, 1989).
7. See Walton, *ibid.*
8. See Mackinder, "The Geographical Pivot of History," and *Democratic Ideals and Reality*, op.cit..

When Mackinder was initially writing about geopolitics the heartland power was Imperial, and then Nazi, Germany, and the preeminent maritime power was the British Empire. For Spykman, writing in the 1930s and 1940s prior to his untimely death, the Eurasian heartland power was shifting from Germany to the Soviet Union with its rapid industrialisation, military expansion, and vast geographical scope, and the preeminent maritime power that contested the Soviets in the Eurasian rimlands of Western Europe, Middle East, and Southeast Asia was the United States. Today the Eurasian heartland has shifted further eastward to China thanks to its meteoric economic and military rise. This rise to power has been accompanied by the locus of global economic activity also shifting eastward from North America and Western Europe to Southeast and Northeast Asia, regions in China's immediate orbit. The United States remains the preeminent maritime power but the rise of China has diminished the influence of America in relative terms and this, in turn, is recasting relations between the United States and its allies.

While grand continental-maritime geopolitics remains an enduring – if, for some, inconvenient – feature of international politics, there have been significant changes since the times of Mackinder and Spykman – not least the emergence of space and cyberspace as key domains of technological, economic, and national power– but the underlying geopolitical framework first posited by these thinkers still endures to this day.[9]

Most prominent space countries understand, albeit imperfectly, the geopolitics of space from a national security perspective, but this strategic rationale for spacepower rarely extends to the commercial, diplomatic, and economic spheres. The UK and its space allies are adept at using military space capabilities to not only enable the effective use of force around the world, but to also forge and strengthen alliances and partnerships, enhance defence diplomacy, and expand cooperation in everything from intelligence sharing through to technology transfers. The UK has benefitted from this thanks in large part to its exceptionally close relationship to the United States and the access to advanced satellite technology this has allowed. That relationship can be extended on all fronts, including in the commercial sphere. In a world where Western commercial interests are fragmented whereas countries like China can pursue a focused strategy, Western-aligned allies are better working together on all fronts in the public and private spheres.

As the UK starts to expand the number and types of sovereign space capabilities in the years ahead the Ministry of Defence, along with the Foreign, Commonwealth and Development Office, should use its own military space capabilities and relationships to wider geopolitical effect as a means of strengthening defence and intelligence relationships with countries of strategic and diplomatic significance around the world. This might involve using military satellites to facilitate coalition operations, bolstering partner capacity, sharing intelligence, or even sharing capabilities to further wider national interests. This also raises the issue of how UK commercial space companies can play a role in these areas, and

9. For example, see the compelling arguments made by Colin S. Gray, "Nicholas John Spykman, the Balance of Power, and International Order," *Journal of Strategic Studies*, Vol. 38, Issue 6, 2015, pp. 873-897; Colin S. Gray, "In Defence of the Heartland: Sir Halford Mackinder and His Critics a Hundred Years On," *Comparative Strategy*, Vol. 23, Issue 1, 2004, pp. 9-25; Geoffrey Sloan, "Sir Halford J. Mackinder: The Heartland theory then and now," *Journal of Strategic Studies*, Vol. 22, Issues 2-3, 1999, pp. 15-38; and R. Gerald Hughes and Jesse Heley, "Between Man and Nature: The Enduring Wisdom of Sir Halford J. Mackinder," *Journal of Strategic Studies*, Vol. 38, Issue 6, 2015, pp. 898-935.

how this role and the imperative of a competitive UK space marketplace is understood: UK commercial space is not just another commercial market that should be left to the vagaries of a global market, but is a *strategic sector* of national security interest and importance that provides critically needed technologies and services – such as enabling Critical National Infrastructure – to the government and military. This, in turn, strengthens the need for the government to view the space sector not just in hard geopolitical terms, but also from a wider geoeconomic perspective as well.

The geopolitics of national security space offers the potential for the UK and its global friends and allies to have secure and redundant real-time global communications as well as ubiquitous Earth observation of the Eurasian landmass and the land- and sea-based chokepoints that allow both transit across it as well as access to and from its littoral. This, in turn, allows for strategic early warning of events as well as the efficient allocation of terrestrial military and naval resources to defend and advance national and coalition interests.

Beyond national security, spacepower influences contemporary geopolitics on two significant levels. The first is as a super-enabler of critical infrastructure to include transportation links such as transcontinental railroads and global shipping routes. Communications coupled with positioning, navigation, and timing (PNT) satellites provide critical, long-distance connectivity that makes terrestrial operations more efficient, responsive, and effective.

The second level of analysis is spacepower as a high-technology sector not just in the UK, but also globally. The technologies and subsystems used to build satellites and the companies that use them to provide both lucrative and essential services to governments and the wider economy are strategic technologies and carry out functions worthy of the highest policy attention.

Much like with 5G networks and the controversial role of Chinese telecommunications company Huawei, policymakers should beware of ending up creating a critical technological dependency that cannot be managed as well as help ensure through sensible policies and regulation that its global supply chains are secure. But this is not enough: alternative industrial solutions and providers must be available – created, if necessary – at a sufficient scale as to reduce the vulnerability, i.e. the risk of becoming subordinate to a hostile power in critical technological fields.

In this sense, UK policy and decision makers should understand that British commercial space providers of satellite communications and Earth observation are often competing against Chinese companies that receive state subsidies and often unfair advantages in markets that would otherwise be competitive. The commercial satellite communications industry, for example, is expecting an imminent round of consolidation. This can be a problem if it results in undermining critical UK capabilities; or an opportunity if it involves companies from allied nations that align with UK strategic objectives. The UK government needs to think strategically about how the trend towards consolidation can be harnessed in its interests

– to ensure Britain is able to share in the economic and strategic value of emerging scale players in a world where sub-scale national champions are unlikely to remain competitive.

Space-based Super-Enablers for Critical Infrastructure

Space-based assets are recognised in the UK as critical national infrastructure, enabling many key services.[10] Communication satellites provide a global communications network whilst complementing terrestrial communication networks. Data communications and internet connectivity, DTH broadcasting, mobile services, and secure government communications are just a few examples of satellite communication services. For the military, satellite communications enable enhanced command and control.

Earth observation satellites[11] allow us to monitor the Earth in many ways, with satellites being equipped with a number of sensor types for varying applications. Remote sensing data is used to create maps, to monitor different environmental metrics of the atmosphere, land, sea and oceans, and for tracking objects and physical phenomena. Other areas of application include agriculture, forest and city management, locating minerals for extraction, and disaster management. A U.S. Geological Survey study found that Landsat imagery provided around $3.45 billion in economic benefits worldwide in 2017.[12] Regarding military applications, remote sensing allows for significantly improved intelligence, surveillance and reconnaissance.

PNT satellite signals[13], like GPS, readily provide data to enable precise positioning and navigation, with applications across many domains across land, sea and air transportation. Amongst other benefits, this allows trades routes to become more efficient whilst reducing congestion. The precise timing component of PNT signals underpins the financial sector, providing the crucial timestamps for transactions. GPS has generated $1.4 trillion in economic benefits for the private sector.[14] Within the military, PNT services enable precision weapons, as well as geographical guidance for personnel.

10. See Parliamentary Office for Science and Technology, "Defence of space-based assets", September 2021, URL: https://researchbriefings.files.parliament.uk/documents/POST-PN-0654/POST-PN-0654.pdf
11. See Parliamentary Office for Science and Technology, "Environmental Earth Observation", November 2017, URL: https://researchbriefings.files.parliament.uk/documents/POST-PN-0566/POST-PN-0566.pdf
12. See U.S. Geological Survey & U.S. Department of the Interior, "Economic Valuation of Landsat Imagery", 2019, URL: https://pubs.usgs.gov/of/2019/1112/ofr20191112.pdf
13. See Government Office for Science "Satellite-derived time and position: Blackett review", January 30, 2018, URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/676675/satellite-derived-time-and-position-blackett-review.pdf
14. See RTI International, "Economic Benefits of the Global Positioning System (GPS)", *Sponsored by the National Institute of Standards and Technology*, June 2019, URL: https://www.nist.gov/system/files/documents/2020/02/06/gps_finalreport618.pdf

The Rise of China, Decoupling, and Spacepower

The most potent competitor – and potential spoiler - for UK and Western satellite manufacturers and service providers is undoubtedly China, and along with other global technology sectors the space sector supply chain and services market is in the midst of a great decoupling from Chinese commercial partners, interests, and Beijing's traditional markets.[15] This decoupling will likely spur global space sector supply chain realignments, market share volatility, and – as mentioned above - a round of industry consolidation as companies seek to remain competitive and governments attempt to maintain their geoeconomic interests in space. This can be managed in a way that gives the UK strategic leverage, if the West ends up with companies with the necessary scale to innovate and compete over the long-run.

China has long considered its space sector as a useful diplomatic and geoeconomic tool, and Beijing's signature Belt and Road Initiative (BRI) has a substantial space element. The network of railways, roads, ports, and shipping routes China is building out for both its continental belt across Eurasia, Africa, and more recently, Latin America, and its maritime 'Silk Road' throughout the Indian and Pacific Oceans (with the melting Arctic Ocean also a BRI objective), and even the Mediterranean Sea, are all enabled by a growing number of Chinese communications, PNT, and Earth observation satellites. Two subsidiary projects of the BRI, the Digital Silk Road and the Space Information Corridor (also known as the Space Silk Road), use and promote Chinese space and satellites technologies and services across a range of areas. For example, through its Digital Silk Road China promotes media cooperation and capacity building with large national broadcasters and news providers across Eurasia and Africa. In return, these national media organisations are encouraged to lease Chinese communication and broadcast satellites at heavily subsidised rates, squeezing Western providers out of key global markets.

15. Perhaps the most prominent proponent of the argument that a technological and economic decoupling from China is underway is Nigel Inkster, see his *The Great Decoupling: China, America and the Struggle for Technological Supremacy* (London: Hurst & Company, 2021). See also, among others, Gordon C. Chang, *The Great U.S.-China Tech War* (New York, NY: Encounter Books, 2020); and Pak-Nung Wong, *Techno-Geopolitics: U.S.-China Tech War and the Practice of Digital Statecraft* (Abingdon, Oxon.: Routledge, 2022).

Space Information Corridor (Space Silk Road)

In September 2013, the newly appointed President of the People's Republic of China, Xi Jingping, announced the "One-Belt One-Road" project (the Belt and Road Initiative (BRI)), with a basis in the ancient Silk Road routes connecting China with regions stretching across to Europe and Africa. Similarly, the BRI aims at extending China's land and sea trading routes, bolstering itself as a trading superpower and expanding its global influence whilst reinforcing national security. As the space component linked to China's terrestrial digital connectivity ambitions, the Space Silk Road (or Belt and Road Spatial Information Corridor (SIC)) was unveiled to complement the initiative by offering space-based services to participating member states. The Chinese State Administration for Science, Technology and Industry for National Defense (SASTIND) and the National Development and Reform Commission outlined their plan to utilise China's navigation, communication and remote sensing satellites to complete construction of the SIC by the late 2020's.[16] Many components are already in operation, including the BeiDou navigation system, estimated to generate a services market worth $156 billion by 2025.[17] The space-based services offered by China help in deepening user state's reliance and economic dependence on China, with particular effect on developing countries. As of 2018, a USCC report noted that China claims it has signed 121 space cooperation agreements with 37 countries.[18] Such partnerships grant China the additional ability to market other services including satellite manufacturing and launch.

Similarly, China is actively promoting its Beidou PNT system that has over 30 satellites in medium-Earth and geostationary orbits and provides global coverage, but is aimed primarily at BRI member states in Eurasia, Africa, and Latin America. Beidou is one of a growing number of global PNT constellations in operation along with the Global Positioning System (GPS) operated by the United States, GLONASS operated by Russia, and Galileo operated by the European Union. At issue is not necessarily that China has decided to invest in its own global PNT system, but that it is spending both money and diplomatic capital on actively promoting Beidou's use in everything from agriculture and transportation through to mapping and even military operations.[19] To this end, for example, China funds a Beidou Navigation Satellite Centre in Tunisia that trains Arab governments and industry associations in how to use Beidou.[20] This initiative, of course, promotes the use of Chinese-made PNT receivers and other user hardware, benefiting China's satellite navigation industry at the expense of its Western counterparts. Moreover, the Beidou training initiative provides the basis for promoting Chinese PNT standards in key international forums that would further diminish Western economic and geopolitical influence in the long-term.[21]

19. See Liangping Gao and Ryan Woo, "China's Beidou navigation system to serve $156 bln home market by 2025," *Reuters*, May 26, 2021, URL: https://www.reuters.com/world/china/chinas-beidou-navigation-system-serve-156-bln-home-market-by-2025-2021-05-26/
20. See "BeiDou Navigation Satellite System Centre opens in Tunisia," *Space in Africa*, April 16, 2018, URL: https://africanews.space/beidou-navigation-satellite-system-centre-opens-in-tunisia/
21. On this, and the rapid adoption of Beidou around the world, see Toru Tsunashima, "In 165 Countries, China's Beidou Eclipses American GPS," *Nikkei Asia*, November 25, 2020, URL: https://asia.nikkei.com/Spotlight/Century-of-Data/In-165-countries-China-s-Beidou-eclipses-American-GPS
16. See U.S. China Economic and Security Review Commission, "2019 Report to Congress", Section 3, Page 370, November 2019, URL: https://www.uscc.gov/sites/default/files/2019-11/2019 Annual Report to Congress.pdf
17. See Liangping Gao and Ryan Woo, "China's Beidou navigation system to serve $156 bln home market by 2025," *Reuters*, May 26, 2021, URL: https://www.reuters.com/world/china/chinas-beidou-navigation-system-serve-156-bln-home-market-by-2025-2021-05-26/
18. See U.S. China Economic and Security Review Commission, "2019 Report to Congress", Section 3, Page 368, November 2019, URL: https://www.uscc.gov/sites/default/files/2019-11/2019 Annual Report to Congress.pdf

BeiDou Satellite Navigation Constellation

The BeiDou Satellite Navigation System is China's PNT equivalent to the United States' GPS or EU's Galileo. Construction of the first generation of BeiDou-1 (BDS-1) satellites, 4 in total, began in the early 1990's, becoming operational in 2000, and decommissioned in 2012. BDS-2 satellites started to become operational in 2012, and BDS-3 from 2015. In total, there are currently around 40 BDS-2 and BDS-3 satellites in orbit, with BDS-3 comprising the majority. Whilst all BDS generations are interoperable, BDS-3 presents significant improvements upon the previous two. The BDS constellation currently provides PNT services; global short message communication; international search and rescue services for global users; as well as the satellite-based augmentation, ground augmentation, precise point positioning and regional short message communication services for users in China and the surrounding region.[22]

China is also building its Gaofen high-resolution Earth observation satellite constellation,[23] and again through subsidies and the insistence (although not always successful) that BRI client governments squeeze out rivals through discriminatory legislation and data regulation.[24] These Earth observation satellites provide imagery for China and BRI member states for a range of applications from resource, land, and urban management through to disaster response and national security.[25]

Gaofen Earth Observation Satellite Constellation

Gaofen (GF) is a series of Chinese civilian remote sensing satellites for the state-sponsored China High-definition Earth Observation System (CHEOS) program, feeding into the Earth observation component of the Space Silk Road and BRI.[26] The Gaofen project was established in 2010, launching the first satellite, Gaofen-1, in 2013.[27] The project is in many ways similar to the EU Copernicus programme, with each satellite in the series being equipped with varying sensors designed to monitor different aspects of the Earth's environment (air, land, sea and atmosphere). Between 2013-2020, China launched over 20 satellites in the series from Gaofen-1-14, completing the final link in the constellation programme in December 2020. Little information is available regarding the newer Gaofen satellites which may have very high-resolution optical imagers.[28]

China is also increasingly adept at using satellite diplomacy with countries it deems important for market access as well as for Chinese food and energy security needs. In several African and in states, such as Ethiopia, Nigeria, Pakistan, Laos, and Cambodia, the Chinese have offered cheap loans and development funds to build and launch communication and Earth observation satellites for these countries. In other countries, such as in Egypt, China offers satellite manufacturing technology transfers and technical capacity building in return for favourable trade concessions and

22. China Satellite Navigation Office, "BeiDou Navigation Satellite System Open Service Performance Standard (Version 3.0)", May 2021, URL: http://m.beidou.gov.cn/xt/gfxz/202105/P020210526216231136238.pdf
23. See "China's Gaofen-7 satellite put into service," *XinhuaNet*, August 20, 2020, URL:http://www.xinhuanet.com/english/2020-08/20/c_139305526.htm
24. One notorious example is that of Indian satellite manufacturers being squeezed out of markets in Bangladesh and Sri Lanka in 2013 by what was, in effect, Chinese economic warfare. See Joji Thomas Philip and K.K. Sruthijith, "China's satellite deals with neighbours jolt Indian security agencies into action," *The Economic Times*, March 19, 2013, URL:https://economictimes.indiatimes.com/news/politics-and-nation/chinas-satellite-deals-with-neighbours-jolt-indian-security-agencies-into-action/articleshow/19051078.cms
25. See, for example, Malcolm Davis, "The coming of China's Space Silk Road," *The Strategist*, August 11, 2017, URL: https://www.aspistrategist.org.au/coming-chinas-space-silk-road/
26. See Gunter's Space Page, "Gaofen 1 (GF 1)", accessed October 2021, URL: https://space.skyrocket.de/doc_sdat/gf-12.htm
27. See Deren Li et al., "China's high-resolution optical remote sensing satellites and their mapping application", *Geo-Spatial Information Science*, 24:1, 85-94, November 04, 2020, URL: https://www.tandfonline.com/doi/pdf/10.1080/10095020.2020.1838957
28. See Andrew Jones, "*China launches hyperspectral Earth observation satellite*", *Space.com*, September 10, 2021, URL: https://www.space.com/china-long-march-4c-launches-gaofen-5-02

market access in other, more lucrative sectors.[29]

Lastly, China is also promoting its Space Silk Road through robotic space exploration and future human spaceflight missions. Here Chinese space activities appear to be more in line with other national space programmes where payload capacity on spacecraft going to the Moon and Mars are offered to international partners in the spirit of scientific cooperation and goodwill. For example, Saudi Arabia has contributed a camera to China's Chang'e-4 lunar lander mission.[30] China is also likely to offer places for foreign astronauts on board its Tiangong space station,[31] and is also expected, with Russia as a partner, to unveil a rival international initiative to the American Artemis Accords regarding future human and commercial missions to, and exploitation of, the Moon.[32]

All of China's Digital and Space Silk Road initiatives, of course, translate directly and indirectly into tighter economic integration with BRI member states where Chinese companies and state corporations can dominate market share not just in space and satellite sectors, but in other lucrative economic sectors too. For example, China's proactive promotion of Beidou PNT satellites in developing world agricultural sectors encourages precision agricultural methods by farmers that, in turn, promotes more mainstream Chinese agricultural products and hardware such as tractors, ploughs, seeds, and so forth.[33] China's space and satellite initiatives also help it grow diplomatic support for its geopolitical and geoeconomic agenda bilaterally and in multilateral institutions, and builds up international support for the promotion and adoption of Chinese technical standards in key technologies such as 5G and 6G networks, biological sciences, artificial intelligence, and space.[34] This cumulative strategy has only recently come to the attention of UK and Western policy makers in light of the Huawei case and requires a coordinated and substantive response.

29. For example, see, "Egypt receives $72 million grant from China for EgyptSat-2 project," *SpaceWatch.Global*, January 21, 2019, URL: https://spacewatch.global/2019/01/egypt-receives-72-million-grant-from-china-for-egyptsat-2-project/
30. See Andrew Jones, "Saudi Arabia to contribute optical camera to China's Chang'e-4 lunar far side mission," *SpaceWatch.Global*, February 9, 2018, URL: https://spacewatch.global/2018/02/saudi-arabia-contribute-optical-camera-chinas-change-4-lunar-far-side-mission/
31. See Stephen Clark, "China repeats call for international astronauts to join space station crews," *Spaceflight Now*, October 15, 2021, URL: https://spaceflightnow.com/2021/10/15/china-repeats-call-for-international-astronauts-to-join-future-space-station-crews/
32. For example, see Andrew E. Kramer and Steven Lee Myers, "Russia, Once a Space Superpower, Turns to China for Space Missions," *The New York Times*, June 15, 2021, URL: https://www.nytimes.com/2021/06/15/world/asia/china-russia-space.html
33. See Liangping Gao and Ryan Woo, "China's Beidou navigation system to serve $156 bln home market by 2025," *Reuters*, May 26, 2021, URL: https://www.reuters.com/world/china/chinas-beidou-navigation-system-serve-156-bln-home-market-by-2025-2021-05-26/
34. For a summary of China's ambition to re-write international technology standards by 2035, see Alexander Chipman Koty, "What is the China Standards 2035 Plan and How Will it Impact Emerging Industries?" China Briefing, July 2, 2020, URL: https://www.china-briefing.com/news/what-is-china-standards-2035-plan-how-will-it-impact-emerging-technologies-what-is-link-made-in-china-2025-goals/

Commercial Space and Western Geoeconomics

The Western response to China's BRI has been slow and long in coming, but is beginning to coalesce around several infrastructure initiatives where government and commercial space systems will play a central role. The United States, Japan,[35] European Union,[36] the so-called Quad (consisting of Australia, India, Japan, and the U.S.),[37] as well as the Group of Seven (G-7)[38] are all rolling out infrastructure initiatives.[39] These initiatives are not only designed to rival China's BRI and its aggressive economic influence, but are also much needed in order to plug the large and very real global infrastructure gaps that currently exist.

Sitting alongside these initiatives, the recent AUKUS announcement is a further example of the intensification of novel international arrangements, which look to generate scale and benefits from technology transfer across multiple countries. It is noteworthy that the countries involved in these programmes have exposure to space, and host companies of different sizes, many of which are sub-scale as global competitors – so there is an opportunity for deepening international commercial cooperation in space aligned with geopolitical objectives.

Meanwhile, President Joe Biden's Build Back Better infrastructure initiative, initially intended for the United States, now has an international remit.[40] Similarly, the EU has recently approved its own infrastructure initiative in its near-abroad,[41] and Japan has for several years run its Partnership for Quality Infrastructure initiative to great acclaim in Southeast Asia.[42][43] These initiatives, so far at least, have not explicitly promoted space and satellite systems as critical enablers of infrastructure operations, trade and transport, and as tools in alliance and coalition building. Perhaps a notable exception to this occurred in September 2021 when the heads of state of the Quad partnership announced several infrastructure programmes, to include one that promotes norms of safe behaviour in space and the exchange of Earth observation imagery to collaboratively tackle climate change and more effective disaster response in the Indo-Pacific region.[44]

The nexus of the intensifying international competition between China and the West is in infrastructure building and trade - in essence geoeconomics - and the use of commercial as well as national space and satellite capabilities are an intrinsic part of this contest. As part of its Belt

35. Ministry of Foreign Affairs of Japan, *Announcement of "Partnership for Quality Infrastructure : Investment for Asia's Future"*, 21 May 2015, link
36. See Ursula von der Leyen, "2021 State of the Union Address by President von der Leyen", *European Comission*, September 15, 2021, URL: https://ec.europa.eu/commission/presscorner/detail/ov/SPEECH_21_4701
37. See White House Briefing Room, "Fact Sheet: Quad Leaders' Summit", 24 September, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/24/fact-sheet-quad-leaders-summit/
38. See U.S. International Development Finance Corporation, "DFC Announces Support for New Build Back Better World Initiative, Bolstering Global Infrastructure Investments", June 12, 2021, URL: https://www.dfc.gov/media/press-releases/dfc-announces-support-new-build-back-better-world-initiative-bolstering-global
39. On this, see "FACT SHEET: President Biden and G7 Leaders Launch Build Back Better World (B3W) Partnership," *The White House*, June 12, 2021, URL: https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/12/fact-sheet-president-biden-and-g7-leaders-launch-build-back-better-world-b3w-partnership/; "Announcement of "Partnership for Quality Infrastructure : Investment for Asia's Future"," *Ministry of Foreign Affairs of Japan*, May 21, 2015, URL: https://www.mofa.go.jp/policy/oda/page18_000076.html; David Sacks, "Europe's Global Gateway Plans To Counter China, But Questions Remain," *Council on Foreign Relations*, September 21, 2021, URL: https://www.cfr.org/blog/europes-global-gateway-plans-counter-china-questions-remain; Jonathan Hillman, "The Quad's Strategic Infrastructure Play," *Center for Strategic and International Studies*, September 27, 2021, URL: https://www.csis.org/analysis/quads-strategic-infrastructure-play; and on Australia's role in these and other infrastructure initiatives, see "Enhancing Australia's role in Pacific infrastructure projects," *Export Finance Australia*, April 2019, URL: https://www.exportfinance.gov.au/resources-news/news-events/government-news/2019/april/enhancing-australia-s-role-in-pacific-infrastructure-projects/
40. See the "Carbis Bay G7 Summit Communiqué: Our Shared Agenda for Global Action to Build Back Better," *G7 Cornwall UK 2021*, June 12, 2021, URL: https://www.g7uk.org/wp-content/uploads/2021/06/Carbis-Bay-G7-Summit-Communique-PDF-430KB-25-pages-1-2.pdf.
41. See "2021 State of the Union Address by President von der Leyen," *European Commission*, September 15, 2021, URL: https://ec.europa.eu/commission/presscorner/detail/en/speech_21_4701.
42. See Tobias Harris, "'Quality Infrastructure': Japan's Robust Challenge to China's Belt and Road," *War on the Rocks*, April 9, 2019, URL: https://warontherocks.com/2019/04/quality-infrastructure-japans-robust-challenge-to-chinas-belt-and-road/
43. See Ministry of Foreign Affairs of Japan, "Partnership for Quality Infrastructure", accessed October 2021, URL: https://www.mofa.go.jp/files/000117998.pdf

and Road Initiative China has harnessed its civil, commercial – and even national security – spacepower to help achieve its geoeconomics goals throughout Eurasia, Africa, and increasingly, in Latin America.[45] Japan uses its geoeconomic heft to not only sell communications and Earth observation satellites in the Middle East and in Southeast Asia,[46] but also builds relationships with developing countries through its space development programmes where Japanese universities with satellite engineering departments host teams of young engineers from countries such as Kenya, Bhutan, and Vietnam to build small satellites in Japan through its KiboCUBE programme in cooperation with the United Nations Office for Outer Space Affairs (UNOOSA).[47] These teams of newly minted satellite engineers then return to their home countries with the skillsets and knowledge needed to start their own space programmes. The satellites built by these small teams are then launched to the International Space Station and are placed into orbit from Japan's Kibo module.[48] Japan is also providing Vietnam with two synthetic aperture radar (SAR) Earth observation satellites through Japan's overseas aid development programme.[49]

India seems intent to follow the Japanese model of bringing small teams of engineers from developing countries to Indian space and satellite research institutes where they will build their own satellites along with experienced Indian satellite engineers through its UNispace Nanosatellite Assembly & Training by ISRO (UNNATI) programme.[50] To date, however, there seems to have been little activity on this front beyond a couple of diplomatic agreements between India and countries such as Oman. In terms of space capability that could be harnessed for Indian geoeconomic aims the country has a lot to offer in satellite communications, Earth observation, and its regional PNT system known as NAVIC, but in terms of promoting the use of these systems to advance Indian interests and build partnerships with key countries it seems that more could be done. This is a wasted opportunity since India not only has significant space capability but also considerable experience in using these capabilities for public health programmes in rural areas,[51] remote education tools,[52] and other poverty reduction and development initiatives throughout India, but curiously not to the rest of the world. It should be hoped that India's participation in Quad infrastructure and development initiatives will spur Delhi to take its considerable spacepower experience abroad.

Australia is a recent newcomer to spacepower, and at present has little civil and commercial space and satellite capability to use in pursuing its geoeconomic interests. Over the past decade, however, the Australian federal government as well as state governments, have undertaken the policy changes required to develop substantial satellite capabilities and significant investments in places like Adelaide to stimulate the growth of New Space industrial hubs and this has so far met with some success as a cluster of promising companies have experienced notable growth recently.[53] It should be expected that in time Australia will become a regional space power able to utilise both commercial, and eventually, civil

44. See Ken Moriyasu, "Quad expands cooperation to space at first in-person summit," *Nikkei Asia*, September 25, 2021, URL: https://asia.nikkei.com/Politics/International-relations/Indo-Pacific/Quad-expands-cooperation-to-space-at-first-in-person-summit; and Rajeswari Pillai Rajagopalan, "The Quad Commits to Regulating Space," *The Diplomat*, October 1, 2021, URL: https://thediplomat.com/2021/10/the-quad-commits-to-regulating-space/. Also see Ministry of Foreign Affairs of Japan, "Fact Sheet: Quad Leaders' Summit", September 24, 2021, URL: https://www.mofa.go.jp/files/100238181.pdf

45. See Rob Miltersen, *Chinese Aerospace Along the Belt and Road* (Maxwell AFB, AL: China Aerospace Studies Institute, June 2020), URL: https://www.airuniversity.af.edu/Portals/10/CASI/documents/Chinese_Aerospace_Along_BR.pdf?ver=2020-06-26-085618-537.

46. Japanese satellite manufacturer Mitsubishi Electric has, in the recent past, sold communications satellites to Qatar and to Turkey. See, for example, Peter B. de Selding, "Es'hailSat Taps Mitsubishi for 1st Fully Owned Satellite," *Space News*, September 12, 2014, URL: https://spacenews.com/41850eshailsat-taps-mitsubishi-for-1st-fully-owned-satellite/; and "Japanese company delivers new satellite to Turkey," *Hurriyet Daily News*, January 8, 2014, URL: https://www.hurriyetdailynews.com/japanese-company-delivers-new-satellite-to-turkey-60755.

47. See Science, Technology and Innovation Governance (STIG), "Evaluating Japanese university-led space technology development and utilisation capacity building programmes in emerging countries", *University of Tokyo*, March 2021, URL: https://stig.pp.u-tokyo.ac.jp/stig/wp-content/uploads/2021/03/SciREX_space_capacity_building_report_Verspieren-et-al.pdf

48. United Nations Office for Outer Space Affairs, "UNOOSA and Jaxa deploy first KiboCUBE satellite as part of capacity-building initiative", UN-SPIDER Knowledge Portal, 18 May 2018, URL https://un-spider.org/news-and-events/news/unoosa-and-jaxa-deploy-first-kibocube-satellite-part-capacity-building

49. See NEC Corporation, "NEC to provide Vietnam with "LOTUSat-1" Earth observation satellite system", April 23, 2020, URL: https://www.nec.com/en/press/202004/global_20200423_02.html. LOTUSAT-1 is expected to be launched in 2023, and LOTUSAT-2 in the mid- to late-2020s.

50. See "International Cooperation," *Indian Space Research Organisation (ISRO)*, URL: https://www.isro.gov.in/international-cooperation. Also see Indian Space Research Organisation (ISRO), "UNispace Nanosatellite Assembly & Training by ISRO (UNNATI)", accessed October 2021, https://www.isro.gov.in/unispace-nanosatellite-assembly-training-isro-unnati

51. See Indian Space Research Organisation (ISRO), "Tele-Medicine", accessed October 2021, URL: https://www.isro.gov.in/applications/tele-medicine

52. See Indian Space Research Organisation (ISRO, "Tele-Education", accessed October 2021, URL: https://www.isro.gov.in/applications/tele-education

53. See, for example, the work done by the South Australian Space Industry Centre (SASIC) and their space strategy for the state of South Australia, *Space Sector Strategy* (Adelaide: South Australia Space Industry Centre, November 2020), URL: https://sasic.sa.gov.au/wp-content/uploads/2020/11/SASIC_Space_Sector_Strategy.pdf.

space capabilities for geoeconomic and diplomatic purposes.[54]

As the UK looks to implement its vision of Global Britain with friends and allies it should consider space as one of several prominent avenues of partner building. The UK's burgeoning relationship with its long-standing ally Australia should be a case in point. The UK Space Agency and its counterpart the Australian Space Agency have already created a UK-Australian "Space Bridge" framework that harmonises space policies and regulatory environments to enhance national space sector collaborations and mutual investments. This is a good start and should be considered as a model for building geoeconomic space relations with other countries vital to the success of Global Britain. In the case of Australia, of course, there is also a prominent hard geopolitical space aspect to the relationship.

The recently established AUKUS agreement, while initially focused on nuclear propulsion, artificial intelligence, and quantum technologies, should also be expanded to include strategic space technology cooperation in everything from next-generation reconnaissance and communication technology through to space exploration.[55] This points to an important principle: for the UK the key focus needs to be on how it can protect its interests through commercial arrangements that transcend individual countries and build the capacity, and the capability, to deliver world beating technologies and applications at a time when they are much needed. Global Britain is best advanced through an internationalist approach that acknowledges when consolidation and technology require more than a domestically-focused policy perspective.

The European Union is also using its spacepower for geoeconomic aims, notably with its Copernicus remote sensing satellites. The Copernicus programme promotes the free use of its satellite imagery around the world to help countries and universities on dealing with issues such as climate change, environmental degradation, resource management, and infrastructure planning. This said, however, there seems to be little linkage between the relatively successful Copernicus programme and the EU's recently announced infrastructure programme[56] that will focus on the Caucasus, Middle East, and North African needs. Curiously, while the EU's Galileo PNT system is a global constellation, there is little indication that Brussels is promoting its use and adoption for economic development outside of its member states.

South Korea, while formally keeping its distance from initiatives and international partnerships that are perhaps deemed overtly opposed towards China, is also a growing space power with a geoeconomic agenda that might be brought into the fold of a growing coalition of liberal economies. South Korea has just started a well-funded push to develop a range of space capabilities to include Earth observation, satellite communications, a regional PNT augmentation system, and a sovereign space launch capability.[57] In terms of commercial players there are not many South Korean companies of global stature, but several of the countries largest corporations are looking to enter the space business. One area of the space sector, however, where South Korea is strong

54. See Australian Space Agency (ASA), "*Advancing Space Australian Civil Space Strategy 2019 – 2028*", April 2019, URL: https://publications.industry.gov.au/publications/advancing-space-australian-civil-space-strategy-2019-2028.pdf

55. On this see Malcolm Davis, "Boosting space capabilities through AUKUS," *The Strategist*, October 6, 2021, URL: https://www.aspistrategist.org.au/boosting-space-capabilities-through-aukus/; and Tory Shepherd, "Aukus pact to deepen Australia, US collaboration on space technology," *The Guardian*, October 7, 2021, URL: https://www.theguardian.com/science/2021/oct/07/aukus-pact-to-deepen-australia-us-collaboration-on-space-technology.

56. See Ursula von der Leyen, "2021 State of the Union Address by President von der Leyen", September 15, 2021, *European Commission*, URL: https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_21_4701

57. See Park Si-soo, "South Korea seeks $553 million space budget for 2022", *SpaceNews*, September 14, 2021, URL: South Korea seeks $553 million space budget for 2022

is in Earth observation thanks to the international efforts of the Satrec Initiative company. The Satrec Initiative was instrumental in building capacity and technology transfer in the United Arab Emirates, helping train Emirati engineers in how to build their own satellites.[58] As a result of this assistance from the Satrec Initiative, the UAE has successfully built and launched their DubaiSat-1 and KhalifaSat Earth observation satellites that offer one metre resolution.[59] The Satrec Initiative is also active in developing business among Central Asian states as South Korea looks to open new export markets and offer infrastructural aid throughout Eurasia. It can certainly be argued that Seoul wields what few national champions it has in the space sector to great effect for its geoeconomical aims.

The United States has by far the most capability, both in civil and commercial space, in pursuit of its geoeconomic and diplomatic interests. From Landsat remote sensing satellites[60] to the Global Positioning System PNT constellation the United States has long provided satellite functions as global public goods.[61] A US Geological Survey study found that Landsat imagery provided around $3.45 billion in economic benefits worldwide in 2017[62], whilst GPS has generated $1.4 trillion in economic benefits for the private sector.[63] These capabilities help build stronger international partnerships and, in the case of GPS, tying countries and their economies to that of the US. With regard to commercial space the United States is the indisputable global leader in everything from satellite manufacturing and commercial satellite communications and Earth observation through to launch, such as SpaceX, and space situational awareness. The United States also boasts the world's largest space startup sector in terms of finance invested as well as number of companies. What is missing, however, is the explicit coordination of these commercial capabilities for the geoeconomical aims of the United States.

The terms of international commercial and economic competition in space are changing as governments in countries like China are not only the investor and customer of choice for its own space sector but are also the primary business development entity for that sector abroad. Through direct subsidies, manipulation and even intimidation of foreign markets, as well as its use of space technologies as an economic inducement for larger infrastructure deals, China uses geoeconomic strategies by fair means or foul to secure business for its space sector.[64]

It is not argued here that the UK and other Western powers should adopt the strongarm tactics of the Chinse government on behalf of their civil and commercial space sectors. It is suggested, though, that the UK and its friends and allies should act more proactively in providing their respective space sectors support in ensuring a level playing field in key markets abroad to counter China's aggressive economic approach.

As China seeks to set up global champions in various technology sectors[65]– to include the space sector – there is a danger that the challenge posed by Huawei to UK and Western policy makers will repeat itself in the satellite and space sectors. The Chinese playbook used in the Huawei case applies to other technology sectors such as artificial intelligence, robotics,

58. See Jeong Hae-yoon, "Satrec Initiative's Double Debut", *Korea IT Times*, February 27, 2009, URL: http://www.koreaittimes.com/news/articleView.html?idxno=764

59. See Adnan Al Rais, Ali Al Suwaidi, and Hosni Ghedira, "DubaiSat-1: Mission overview, development status and future applications," *IEEE Xplore IEEE International Symposium on Geoscience and Remote Sensing (IGARSS)*, Cape Town, South Africa, July 12-17, 2009, URL: https://ieeexplore.ieee.org/document/5417697; and "Khalifa Sat: First UAE made satellite space launch," *Roya News*, October 29, 2018, URL: https://en.royanews.tv/news/15671/Khalifa-Sat--First-UAE-made-satellite-space-launch.

60. See National Aeronautics and Space Administration & U.S. Geological Survey, "*Landsat: Benefiting Society for Fifty Years*", 2018, URL: https://landsat.gsfc.nasa.gov/sites/landsat/files/2019/02/Case_Studies_Book2018_Landsat_Final_12x9web.pdf

61. On Landsat remote sensing satellites, see *Landsat: Benefiting Society for Fifty Years* (Washington, DC: National Aeronautics and Space Administration and the U.S. Geological Survey, 2018), URL: https://landsat.gsfc.nasa.gov/sites/landsat/files/2019/02/Case_Studies_Book2018_Landsat_Final_12x9web.pdf; on the Global Positioning System, see "The Global Positioning System: What Is GPS?" URL: https://www.gps.gov/systems/gps/.

62. See U.S. Geological Survey & U.S. Department of the Interior, "Economic Valuation of Landsat Imagery", 2019, URL: https://pubs.usgs.gov/of/2019/1112/ofr20191112.pdf

63. See RTI International, "Economic Benefits of the Global Positioning System (GPS)", *Sponsored by the National Institute of Standards and Technology*, June 2019, URL: https://www.nist.gov/system/files/documents/2020/02/06/gps_finalreport618.pdf

64. On this see the highly informative Nicholas Jackman, *Chinese Satellite Diplomacy: China's Strategic Weapon for Soft and Hard Power Gains* (Dayton, OH: Wright State University, 2018), URL: https://corescholar.libraries.wright.edu/cgi/viewcontent.cgi?article=3064&context=etd_all; U.S. Chamber of Commerce, Made in China 2025: "Global Ambitions Built on Local Protections", 2017, URL: https://www.uschamber.com/sites/default/files/final_made_in_china_2025_report_full.pdf; Efekan Bilgin, "Techno-nationalism: China's bid for global technological leadership", London School of Economics, September 28, 2021, URL: https://blogs.lse.ac.uk/cff/2021/09/28/techno-nationalism-chinas-bid-for-global-technological-leadership/; Laura Grunberg, "China's Tech Companies Are Going Global – and Remaking China's Image in the Process", The Diplomat, June 04, 2021, URL: https://thediplomat.com/2021/06/chinas-tech-companies-are-going-global-and-remaking-chinas-image-in-the-process/

65. See Stewart Baker, "*Six rules to guide the West's efforts to counter China's Industrial Policy*", *TheHill*, October 10, 2021, URL: https://thehill.com/opinion/international/576072-six-rules-to-guide-the-wests-efforts-to-counter-chinas-industrial. Also see Andrew Jones, "China's commercial satellite sector sees boost from 'new infrastructure' policy", *SpaceNews*, May 15 2020, URL: https://spacenews.com/chinas-commercial-satellite-sector-sees-boost-from-new-infrastructure-policy/

and biotechnologies as well as space, and policymakers in the UK and in other democracies must not only implement their own strategies for countering malign Chinese influence, but must also proactively coordinate their approach together. If the UK and its allies are to meet this challenge, the question of competing with these emerging Chinese global champions becomes strategic. The answer will likely require market-driven structural changes to the allied space-industrial landscape in key exposed sectors – allowing for bigger international players to arise that can compete effectively.

Global Britain and The Geoeconomics of Space

The Government's 2021 *Integrated Review* has provided the foundations for an ambitious global foreign policy agenda, and the more recent *National Space Strategy* adds a welcome space dimension to this agenda. Much more, however, remains to be done both in terms of establishing sustainable economic and military foundations for a Global Britain as well as utilising UK spacepower – civil, military, and commercial – in the pursuit of national interests in a more coordinated and proactive manner.

The UK is in the throes of a significant build-up of spacepower capability that is to be welcomed. This capability build-up is not only in the defence sector, but also includes the recent acquisition of a stake in OneWeb as well as continued growth in a thriving, world-class commercial space sector that now ranges from space launch and satellite manufacturing through to commercial satellite communications and Earth observation services, space situational awareness, and deep space communications.[66] Current and previous governments have made important strides in creating the right conditions and incentives for building out the UK commercial space sector, but must now take the next step in overtly championing the UK space sector's comparative advantage (as opposed to championing individual UK companies) in key markets abroad where China's influence has taken hold, particularly in Africa, Southeast Asia, and Latin America.

Referring back to the section in this report on the continued salience of classical geopolitics – and by extension, geoeconomics – several issues become apparent when thinking of what the UK government can do to help level the playing field for UK space companies and maintain influence in a fast-growing and changing global space sector.

First, the economies across the Eurasian Rimlands as well as Africa and Latin America are especially vulnerable to aggressive Chinese tactics in economic influence and commercial development. This Chinese approach threatens fair market access to UK space companies, whether they be satellite manufacturers or commercial space services providers, in these key economies. This effort should focus on lobbying governments in these countries to stand up to Chinese intimidation, and even providing political and economic support in helping them withstand Chinese pressure. In parallel, the government in partnership with UK industry as well as those in friendly governments should increase cooperation and coordination with each other in order to provide plausible economic alternatives to countries tempted to accept unsustainable Chinese infrastructure and economic development deals.

66. See for example: UK Space Agency, Department for Transport, & Civil Aviation Authority, Brochure: A guide to the UK's commercial spaceports, LaunchUK, 23 March 2021, URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/983775/4156_A5_brochure_UKSA_Spaceport_Broch_V2_TC_Folder_WEB_PDF_4156_A5_brochure_UKSA_Spaceport_Broch_TC_Web__1_.pdf; Sky News, UK space missions to launch from 2022 as rocket company Skyrora and SaxaVord Spaceport secure landmark deal, 12 October 2021, URL: https://news.sky.com/story/uk-space-missions-to-launch-from-2022-as-rocket-company-skyrora-and-saxavord-spaceport-secure-landmark-deal-12431910; Surrey Satellite Technology Ltd., Space Portfolio, accessed October 2021, URL: https://www.sstl.co.uk/space-portfolio; Spire, Unlock our data, accessed October 2021, URL: https://spire.com/our-data/; Deimos, Activities, accessed October 2021, URL: https://elecnor-deimos.com/activities/.

China-Bolivia space cooperation

Following the creation of the Bolivian Space Agency in February 2010, in the same year Bolivia signed a contract with China for the orbital delivery of a Chinse-developed Tupac Katari (TKSAT-1) COMSAT satellite. As per the contract, China would be responsible for providing Bolivia with an all-round satellite manufacture and launch package, complete with ground control stations and satellite operator training.[67] The contract itself was valued at $295 million – $250 million financed through the China Development Bank, with the remainder funded by the Bolivian Government.[68] TKSAT-1 was launched in 2013 has been used to extend television and broadband to unconnected areas in Bolivia – expected to generate upwards of $500 million through its lifetime.[69] By 2016, Bolivia owed more than $600 million to Chinese banks, comprising 9.2% of Bolivia's total foreign debt. Since then, Bolivia's debt to China has multiplied, most notably with the announcement of a credit line valued at $7 billion in 2015, extended to $10 billion in 2016.[70] In the last fifteen years, Chinese banks have become the largest lenders to Latin American and Caribbean countries, financing around $150 billion into the region.[71]

Second, the situation today does not merit the Government somehow selecting individual UK companies as 'national champions' but more can be done to promote and champion the UK space sector as a whole in foreign markets by relevant government departments. The traditional stance, outside of the defence sector at least, of government's leaving large foreign deals involving UK companies to market forces is all well and good when all economic powers abide by the same rules of the game, but when the second largest – and soon to be the largest overall – economy in the world abandons those rules in favour of mercantilist economic policies then UK policy must change accordingly.

Some effort has already been accomplished in this regard. Recent UK legislation subjecting foreign mergers and acquisitions of UK companies considered to be in strategic sectors is a start, as is the release of the first national space strategy that provides a much-needed political imprimatur on the UK space sector overall. What constitutes a strategic sector, however, is still somewhat vague when it comes to space. Some companies are obviously strategic in that they are the only UK providers of a particular space capability or service, but it is far from clear whether UK commercial launch, space situational awareness, deep space communications, and key satellite manufacturing capability are also considered strategic by the government at the present time. As the global satellite manufacturing and commercial satellite communications industry prepares for a round of significant consolidation,[72] UK policymakers should pay attention to how this imminent wave of mergers and acquisitions within the sector unfolds, and take steps to ensure that the UK as a whole maintains an element of autonomy – even sovereignty, in critical areas – across the space value chain where possible. This regard for the sovereign industrial capacity

67. See Nicholas Jackman, "Chinese Satellite Diplomacy: China's Strategic Weapon for Soft and Hard Power Gains", Wright State University, 2018, URL: https://corescholar.libraries.wright.edu/cgi/viewcontent.cgi?article=3064&context=etd_all

68. Reuters, "China lends Bolivia £25` mln to fund satellite", December 23, 2010, URL: https://www.reuters.com/article/bolivia-china-satellite-idUKN2313961920101223

69. Peter B. de Selding, "Bolivia's TKSAT-1 Expected To Generate $500 Million", *SpaceNews*, December 28, 2015, URL: https://spacenews.com/bolivias-tksat-1-expected-to-generate-500-million/

70. See Margaret Myers & Kevin Gallagher. "Chinese Finance to LAC in 2016", *The Dialogue*, URL: https://www.bu.edu/gdp-cn/files/2017/11/Chinese-Finance-to-LAC-in-2016-Web-and-email-res.pdf; *Reuters*, "Bolivia says China to lend $7 billion for energy, transport infrastructure", October 19, 2019, URL: https://www.reuters.com/article/us-bolivia-china-loans-idUSKCN0S-D2A420151019

71. See Congressional Research Service, "China's Engagement with Latin America and the Caribbean", July 1, 2021, URL: https://sgp.fas.org/crs/row/IF10982.pdf

72. See Jeff Foust, "SES CEO thinks satellite industry consolidation likely", *SpaceNews*, October 06, 2021, URL: https://spacenews.com/ses-ceo-thinks-satellite-industry-consolidation-likely/

element must not come, however, at the cost of its own underlying, long-term commercial viability. A balance must be struck. In this sense, consolidation that creates long-term scale opportunities for the UK that align with wider strategic interests merit support; but deals that could contribute to a strengthening of Chinese or hostile spacepower must be rigorously scrutinised and potentially prevented. In this context, the National Security and Investment Act 2021, which has an explicit focus on high threat jurisdictions as part of its assessment criteria, provides an important legislative tool.

Third, all UK government departments utilise space capabilities to some extent or another, but there appears to be a lack of understanding and experience in using UK spacepower for advancing and defending our interests abroad. Friendly countries such as the United States, particularly in its international defence relationships, Japan, and France, for example, all overtly use space capabilities (to include commercial capabilities) as part of their diplomatic, geoeconomic, and defence diplomacy agendas. In many cases, especially with the United States and France, space capabilities are used to strengthen and deepen defence diplomacy relationships through sharing satellite capacity as well as sharing satellite data. The United States is very good at providing free access to critically important capabilities like its Global Positioning System, Landsat remote sensing capabilities, as well as the use of cooperative science and technology initiatives through its world famous space agency, the National Aeronautics and Space Administration (NASA).

Japan's strength is in systematically using its powerful research and development capacities, mostly through its universities, to build up the space capacity of countries throughout Eurasia and Africa as part of its wider overseas development strategy as well as its geoeconomic strategy of acquiring access to new markets and acting as a commercial counterweight to China.

The UK space sector – both civil and commercial – has similar strengths to Japan but lacks coordinated and strategic guidance from policymakers. In the recent past the UK has made good use of satellite data and applications in its provision of overseas development aid, such as in new, more productive agricultural techniques, environmental monitoring, ecological conservation, and public health. Unfortunately, however, this innovative use of space technologies for international aid is all too often unfairly criticised in some elements of the British news media – exemplifying what the some have described as a propensity for "lame takes"[73] of space issues in British journalism.

Additionally, UK satellite manufacturers have, on their own initiative, helped numerous developing countries develop satellite technologies. Moving forward, a more coordinated UK government effort should be made to help these and other UK space companies gain a foothold in key foreign markets. One suggestion would be for the UK Space Agency to start a space capacity building initiative in cooperation with the Foreign, Commonwealth, and Development Office. Such an initiative would focus

73. Jonathan Amos (@BBCAmos) on Twitter, September 28, 2021, 15:16 hrs., URL: https://twitter.com/BBCAmos/status/1442810517790277638?t=fvZNhxgD7CtyvxzjmpCKzA&s=19.

on countries in Eurasia, Africa, and Latin America viewed as particularly vulnerable to Chinese pressure and, through UK companies, help them develop and use high-quality space technologies. In turn, such an initiative will help orient such countries towards other, more broad UK economic and trade links, not just in the space sector.

While China's geopolitical and geoeconomic space ambitions pose the biggest challenge to the health and viability of the UK's space sector, another emerging threat is that of the so-called space billionaires building satellite communication megaconstellations and cornering the Western space launch market. The endeavours of Elon Musk and others are, of course, understandably exciting and even inspiring. When viewed through the prism of long-term national interest, however, there is a danger that these foreign private space capabilities create undue dependencies in satellite communications and space launch. These dependencies would be one bankruptcy, personal whim, or even rage-Tweet away from being denied to UK private and government users. Whether it's aggressive Chinese economic practices or billionaire reliability, UK policy makers should carefully consider how important assured access to space is for British national interests and how a UK space sector can be sensibly nurtured in order to maintain a strong position in the game.

In cooperation with other liberal democracies, the UK government should also create and lead an international coalition that helps ensure that international supply chains used by the space sector are secured from Chinese goods, components, and other interests. Such an initiative would follow along the same lines being pursued in the Western telecommunications industry, but applied more overtly to satellite manufacturing supply chains, as well as to commercial satellite communications and Earth observation. Additionally, a comprehensive and long-term strategy, in cooperation with like-minded states, needs to be developed to counter China's strategic ambition to dominate technological standards across a range of technologies, to include space. These technological standards, long-dominated by Western countries, "determine how technologies work with each other, enabling their interoperability around the world, meaning they can function irrespective of where they are being used."[74] It is in setting technological standards that the proverbial 'rubber hits the road' and will require UK policy makers to evaluate policies that strengthen and promote competitive markets for the UK space sector, provide investments for next-generation technological research and development, and closer cooperation on these issues with friends and allies.[75]

UK policy makers should also resist the easy headlines of the tabloid press when it comes to British space policy. There are obviously some space technologies that the government should seriously consider securing as sovereign capabilities as in crisis and war not having reliable commercial and allied access could have catastrophic strategic consequences. Then there are the misleading calls for autarkic British spacepower,[76] where there must be a sovereign solution to every space and satellite technology and cooperation is regarded, explicitly and implicitly, as a sign of

74. Yu Jie and Joyce Hakmeh, "The UK's Huawei Decision: Why the West is Losing the Tech Race," *Chatham House*, July 17, 2020, URL: https://www.chathamhouse.org/2020/07/uks-huawei-decision-why-west-losing-tech-race.

75. See *ibid.*

76. For example, Sebastian Kettley, "UK Remainer Science Minister plots 'mission' to revive EU relations with 'strong' ties," *Express*, September 28, 2021/ . URL: https://www.express.co.uk/news/science/1497336/uk-science-minister-george-freeman-europe-brexit-britain-national-space-strategy.

weakness. Policy makers of every political stripe long involved in space policy implicitly understand that to be a contemporary spacepower is to be internationalist in policy outlook and spirit. British commercial space companies look abroad, to include continental Europe, to sell their products and services. Even UK sovereign space capabilities will require a network of ground stations and other facilities abroad in order to ensure their seamless functioning. Additionally, given the long development lead times and satellite operational lifetimes of up to 20 years in some cases, policy makers should do all they can to insulate UK space policy, capabilities, and interests from tabloid chest thumping and impulses.

Lastly, the UK government should not shy away from using UK commercial space services overtly in its international dealings. Such use might include paying for UK space services in a particular country hard hit by natural disaster or some other national emergency, or providing the services as part of an overseas development aid package to close the digital divide in poor, rural areas – the excellent work of this type done under the International Partnership Programme[77] should be expanded. Not only does this provide much needed space technologies to where and when they are needed the most, but it also helps promote the UK space sector as a whole, as well as extend and strengthen British influence on the global stage.

International Partnership Programme

The International Partnership Programme (IPP) is a five year, >£150 million international development initiative run by the UK Space Agency.[78] The IPP uses UK space capabilities to deliver satellite and data services to developing countries for measurable and sustainable economic, societal, and environmental benefits. As a five-year programme, since its launch in 2016 the IPP has provided grants for 43 projects in 47 countries across Africa, Latin America, and Asia Pacific to tackle a range of global development challenges ranging from climate and disaster resilience to financial services and food security.[79] Whilst managed by the UK Space Agency, funding is channelled from the Department for Business, Energy and Industrial Strategy's (BEIS) Global Challenges Research Fund (GCRF) – a £1.5 billion Official Development Assistance (ODA) fund to support research and innovation on global issues for developing nations.[80]

In 2021, broader cuts to overseas aid saw many IPP projects have their funding support cancelled, with no new collaborations receiving financial packages in 2021/2022.[81]

77. The International Partnership Programme (IPP) is the UK Space Agency's award-winning space for sustainable development initiative. See URL: https://www.gov.uk/government/collections/international-partnership-programme
78. See UK Space Agency, "International Partnership Programme: Project overview", June 15, 2021, URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/838118/IPP_Brochure_April_2019__finaL.pdf
79. See UK Space Agency, "International Partnership Programme", last updated April 7, 2021, URL: https://www.gov.uk/government/collections/international-partnership-programme
80. Ibid.
81. See Jonathan Amos, "Space projects scrubbed in UK overseas aid cut", *BBC News*, March 17, 2021, URL: https://www.bbc.co.uk/news/science-environment-56431346

Conclusions: Incorporating Spacepower into UK Grand Strategy

The UK's political and media elites have, since the early 1970s until very recently at least, had a curious relationship with, and attitude towards, space issues. Among G7 countries the UK has stood alone, for example, in not possessing a national high-resolution Earth observation satellite capability. Britain is also in a minority of Organisation for Economic Cooperation and Development (OECD)in not explicitly integrating all of its space capabilities into wider economic and foreign policy goals. The 2021 *National Space Strategy* is a step in the right direction in this regard, but it is just a start. UK policymakers and opinion formers have for too long held space policy issues either in contempt or as something generally best left to the Americans.

The stakes are high. China's geoeconomic strategy, and to a lesser extent the ambitions of the space billionaires, could ultimately squeeze out the UK space sector from global markets unless policy makers take action to ensure Britain can compete on a level playing field. Importantly, the UK must safeguard its interests in space through deepening international collaborations and fostering its comparative advantage through enacting a wide-reaching and ambitious innovation drive. Failure to act and view the UK space sector as a strategic tool rather than just a technological or scientific category could result in the UK becoming dependent on the space capabilities of others, leaving it powerless in one of the most important strategic domains of the 21st Century.

Change has to happen or it will happen to us, and thankfully as space becomes more affordable to access and of growing importance to British economic, diplomatic, and national security interests, there is a focused incentive for policymakers to get to grips with how UK spacepower can be wielded, much like how we wield British seapower.

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