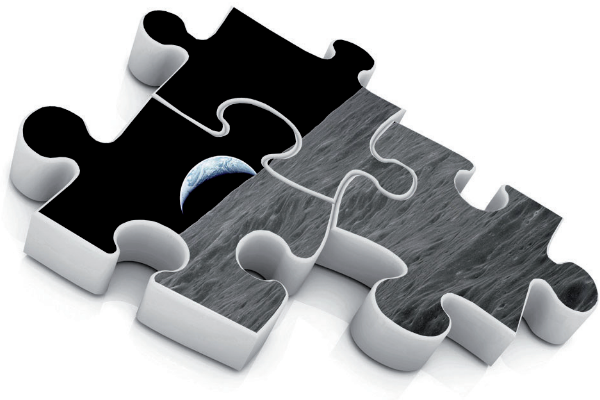

Coordination Failure:

Risks of US-China competition in space

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LSE IDEAS

STRATEGIC UPDATE

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Special thanks to Antonino Salmeri,
Doctoral Researcher at the University of Luxembourg,
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Introduction

> Geopolitical competition and technological progress in space are closely intertwined and feed into each other

On March 18th, 2021, NASA's Space Launch System (SLS) core stage fired its four RS-25 engines for more than eight minutes, burning through enough Hydrolox to create its own rain clouds, and marking a key milestone on the way to bringing American astronauts back to the moon. Just months before, China's Chang'e 5 (嫦娥五号) probe bounced across Earth's atmosphere at 11km/s, safely returning 1.7kg of lunar regolith back to Earth after a mere 22 days.

These are the dramatic scenes of the world's two superpowers pushing scientific and technological boundaries in an endeavour to explore and develop beyond the Kármán line, the 100km atmospheric boundary that delineates the edge of space. Whilst these efforts are largely in the pursuit of scientific knowledge and—in the case of each country's commercial space industry—profit, geopolitics has always been a factor, and is increasingly holding sway. This has prompted popular commentary to brand the increasingly competitive dynamics between the US and China in this sphere as a "new space race".

Geopolitical competition and technological progress in space are closely intertwined and feed into each other. In some cases, competition drives technological change and programme decision making, most obviously in military space applications, but also in the execution of "national pride" projects often associated with crewed spaceflight. In others, technological developments impact the intensity of terrestrial competition and inter-state tensions.

US-China competition as it relates to space, as in other areas, may take two forms. In a mode of healthy competition, the two countries' race to expand humanity's celestial boundaries will drive technological and scientific innovation, with clear derivable benefits on Earth. Should such competition turn ugly, however, it may hinder scientific and technological progress in space, with detrimental consequences not just for the US and China, but for all actors with an interest in outer space, that is, almost everyone else.

This Strategic Update seeks to outline and call attention to two high-risk flash points arising from the development of the US and China's national space programmes and industries. These are the roll-out of broadband mega-constellations and increasing activities in extra-terrestrial geographically concentrated sites of interest. These risks are highlighted primarily for the consideration of third parties to great power competition, be they nations with strong interests in space, or organisations active in, or reliant on, the industry. This serves the purpose of risk mitigation and highlighting the need for international coordination.

This piece endeavours to be observational and speculative, not judgemental. It is, on the whole, a good thing that the world's two great superpowers are seeking to push humanity's boundaries in space. This, however, comes with inevitable geopolitical risks, two of which this piece seeks to identify and discuss.

The Current State of the USA's and China's Space Programmes

The United States is, and has been for the last 50 odd years, the world's largest space power. Its national programmes are overseen and executed by NASA, which wields an annual budget of north or south of $23 billion.[1] The US has recently formed the US Space Command and Space Force, which act as the country's space combatant command and service branch respectively. NASA and the US military have traditionally relied on a broad network of contractors, with companies such as Boeing, Lockheed Martin and Northrop Grumman being household names.

NASA is a scientific powerhouse, delivering a plethora of projects and engaging in countless cases of international cooperation. Its current flagship programme, however, is Artemis, an effort to create a sustainable crewed presence on the lunar surface and in orbit, enabling the development of a cis-lunar economy as well as future deep space missions, most prominently a crewed mission to Mars.

The US is currently aiming for a crewed lunar landing in 2024, establishing a "Lunar Gateway"—a space station in the moon's orbit—in tandem. A surface base camp is planned for the late 2020s. These timelines, especially the 2024 landing, are likely to slip. However, a crewed landing is very likely this decade.

In recent years, NASA has increased its reliance on a broader range of commercial actors to deliver its programmes. This was done in a bid to increase competition amongst contractors, as well as NASA's number of fall-back options, in order to push down costs and prevent programme disruption. This, amongst other factors, has driven the considerable growth of the commercial space industry in the US, with innovative companies such as SpaceX pushing the envelope on what will be possible in the current decade. In 2019 alone, the US saw upwards of $4.6 billion in seed and venture investment into American space companies.[2]

China's space programme development warrants considerable praise and respect. From launching its first satellite in 1970 (12 years after the US), China now regularly tops the charts for most annual orbital launches. China is one of only three countries to return a lunar sample to Earth, one of three with an operational heavy lift launch vehicle, and the first to operate a rover on the far side of the moon. This year, it will establish its own modular orbital space station. The country's national programme is overseen and executed by the China National Space Administration (CNSA), with a budget around half that of NASA's, at upwards of $10 billion.[3] China's military space activities are spearheaded by the People's Liberation Army (PLA) Strategic Support Force, a theatre command-level organisation tasked with centralising space functions, alongside cyber, electronic and psychological warfare.[4]

> "China's space programme development warrants considerable praise and respect. From launching its first satellite in 1970 (12 years after the US), China now regularly tops the charts for most annual orbital launches"

In 2017, China's State Council outlined the intention to establish a robotic lunar research station,[5] and this vision was expanded in 2021, when China and Russia announced an MOU indicating the intention to develop the International

Lunar Research Station (ILRS).[6] More details surrounding China's future plans for its space programme are likely to be revealed some time after the launch of the first module of its orbital space station in late April 2021, likely after the station goes into full service. However, the announcement of a crewed lunar landing by the early 2030s, with the intention to establish a permanent surface and orbital presence, seems very likely.

CNSA and the PLA primarily rely on the state-owned China Aerospace Science and Industry Corporation (CASIC) and the China Aerospace Science and Technology Corporation (CASC) for the technical execution of projects. While China has its own burgeoning private space industry, strongly encouraged by the CCP, purely commercial actors do not currently play a major role in the delivery of agency programmes, certainly not to the same degree as in the United States. Investment is growing quickly, however, with $314.2 million flowing into Chinese ventures during 2019, a 10% increase to the year prior, and growth rates likely to match or exceed this in future.[7]

Mega-constellations

As of April 2021, SpaceX has launched upwards of 1,300 Starlink satellites into low earth orbit (LEO). OneWeb, its closest competitor, has launched over 140. These satellite systems seek to provide global broadband satellite internet coverage, initially by bouncing data back and forth between users and "gateways"—terrestrial ground stations that act as conduits for data flows. Users will purchase a terminal—a receiver and supporting equipment—for connectivity. Later phases of these constellations seek to establish inter-satellite optical links, increasing bandwidth, and reducing latency and the need for ground infrastructure.

Little publicised in Western nations is the fact that at least one organisation based in China is also likely to be a major player in the provision of mega-constellation-enabled global broadband. CASC and CASIC are each developing their own constellations, named Hongyan (鸿雁) and Hongyun (虹云) respectively. Additionally, Galaxy Space (银河航), a private company founded in 2018 and backed enthusiastically by the CEO of Xiaomi is seeking to develop its own commercial constellation. Further, recent comments by officials, alongside representatives of CASC and CASIC indicate that Hongyun and Hongyan may be folded into a multi-phase mega-constellation named Guowang (国网), which would seemingly be operated by a newly formed SOE of the same name. ITU filings regarding this latest development indicate a possible constellation of just under 13,000 satellites.[8]

The Hongyan, Hongyun and Galaxy Space constellations have all launched successful technology demonstrators, and the organisations behind them have indicated they intend to begin building out their systems in 2021. CASC's Hongyan and CASIC's Hongyun constellations were primarily envisioned to serve the PLA, rural customers within China, and overseas Chinese assets. However, announcements of the larger Guowang constellation hint at potential broader state ambitions. Furthermore, Galaxy Space's CEO, Xu Ming (徐鸣), has signalled the intention to rival the likes of OneWeb and SpaceX, alongside state players.[9]

Most of these constellations' early customers are likely to be national entities such as airlines, maritime users and militaries. However, all were established with the express aim of improving internet access to those with poor connections and connecting the "other three billion", the almost 50% of the Earth's population yet unconnected to the internet. Should one or more of these companies succeed in developing cheap user terminals, large new markets will be available to them. Initially, retail customers will be domestic—American and Chinese users seeking to get online or improve their connection. However, as these entities seek to expand their user base, they may increasingly compete over the same customers abroad.

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This process could prove fraught. Hongyun and Hongyan (and Guowang, when/if it is formed) are state-owned. Galaxy Space's satellites are being developed in collaboration with CASC and the China Electronics Technology Corporation (CETC), both of which are SOEs.[10] This fact could well raise similar concerns from the US as those over Huawei once these constellations begin to seek global customers. One could well imagine, for example, the US objecting to allies, trade partners, or both, allowing market access to Galaxy Space or other Chinese constellations, on the grounds of security concerns. Even where security concerns may be questionable in their foundation, what country uses which constellation could still be a geopolitical issue, with the US and China backing their own national players. Should Galaxy Space or others be able to provide a cheaper service through state backing, this would prove particularly contentious to the US and would likely raise all too familiar calls of unfair competition.

Should such tensions arise, they would be detrimental for several reasons. Firstly, this would likely place unpleasant pressure on countries not particularly aligned with the US or China, but nonetheless considered strategically important by both (most likely overwhelmingly in the Global South) to choose sides. This would degrade their sovereignty and potentially force them to make unpleasant trade-offs in the important endeavour to connect their citizens.

Secondly, the expansion of such constellations against the backdrop of geopolitical tensions increases risks around the generation of space debris. Should the rollout of mega-constellations become geopolitically confrontational, actors may become less likely to coordinate their respective systems, share information, and take precautionary measures to prevent satellite collisions. The possibility also exists for actors, in a race for market share, to cut corners in ensuring their satellites deorbit in a reasonable period of time or can be removed from orbit should they fail. This coordination failure and corner-cutting would be extremely dangerous. As has been pointed out by many concerned parties, increased and escalating in-space collisions risk the development of a catastrophic chain reaction of collisions, known as Kessler Syndrome. This, in the worst-case, would make LEO unusable, and would make it difficult, if not impossible, for humans to launch spacecraft beyond orbit without significant risk of damage.

All this considered, several lessons can be drawn. Nations considering allowing market access to a LEO broadband provider should recognise early on that they may well be making a geopolitical decision. On the other end of the transaction, one must consider the case of OneWeb, which saw the UK Government becoming one of its shareholders following the company's 2020 bankruptcy, quite possibly to prevent OneWeb's UK-based assets being acquired by a Chinese company.[11] The UK Government must recognise that a company in which it has a direct shareholder interest may one day be competing directly with a Chinese state-backed entity for foreign market share. Most crucially, however, all actors with an interest in space must put pressure on, and encourage, nations hosting constellation operators to coordinate to the greatest degree possible. This is particularly pertinent in the case of the US and China, where such coordination may be hindered by general geopolitical tensions, and more specific sensitivities in regard to the rollout of these systems. The need for greater coordination among mega-constellation (and smaller system) operators has already been widely noted, but the potential for geopolitics to make this more difficult warrants attention and highlights the particular need for the US and China, as major hosts of constellation operators, to be brought together.

Table 1: Prominent US and Chinese LEO broadband mega-constellations

Country	Name	Key developers	Planned size	Satellites in Orbit (as of 20 April 2021)
China	Galaxy Constellation	Galaxy Space (银河航天), CASC, CETC	Phase 1: 144 Phase 2-: 1,000+	1
China	Hongyan (鸿雁)	CASC	300+	1
China	Hongyun (虹云)	CASIC	Phase 1: 150+ Phase 2: 800+	1
China	Guowang (国网)	TBD	~13,000	
USA	Starlink	SpaceX	Phase 1: 1,584 Phase 2: 12,000+	1378
UK/ USA[12]	OneWeb	OneWeb, Airbus	Phase 1: 650 Phase 2: 6,000+	146
USA	Project Kuiper	Amazon, TBD	3,000+	-
USA	Athena	Facebook, TBD	TBD	-

Geographically Concentrated Sites of Interest

Given the vast expanse of space beyond Earth orbit, it may seem odd to raise the US and China "stepping on each other's toes" as a potential concern. However, should sites of scientific, commercial and exploration interest be geographically concentrated, the risks of a national incident stemming from miscalculation or obstinacy by either the US, China, or both, are not to be dismissed. This will likely be less due to direct competition over resources or scientific data, but because of the fact that harsh space environments increase the risk of harmful interference from other parties.

At present, no comprehensive, agreed framework of norms exists to coordinate the activities of state and commercial actors beyond Earth orbit. Whilst international treaties exist that provide general provisions, most infamously the preclusion of the appropriation of celestial bodies by the Outer Space Treaty, a need exists for more detailed mechanisms of coordination of various interests seeking to expand their operations beyond the Earth's well-populated orbital spheres. The US has initiated the Artemis Accords, which have been signed by nine nations to date, and establish provisions such as the creation of safety zones to de-risk simultaneous operations. However, being bilateral and US-led, these have been met by effective silence from China (and outright condemnation by Russia). This fact elevates the risk of harmful miscalculations by respective actors. Both nations' lunar exploration programmes are exemplary of these issues and present the most urgent imminent risks.

Both Artemis Basecamp and the ILRS will be situated on the Lunar South Pole. Most likely, any crewed CNSA mission hoping to establish a sustainable presence on the moon will also situate itself at the South Pole. Reflecting this, the majority of the US and China's robotic surface missions, under the Commercial Lunar Payload Services (CLPS) and Chang'e programme respectively, are bound for the region. This trend is primarily driven by the fact that the South Pole presents an optimal environment for the establishment of semi-permanent and permanent crewed bases on the moon, and, in the longer term, for the enablement of future missions beyond the Earth-Moon system. Reasons for this include the high-duration exposure to sunlight of certain terrain within the region, alongside an apparently elevated concentration of useful and accessible resources, most immediately water.[13] A lack of coordination in such a concentrated geography could pose considerable risk, primarily because of the harsh and unforgiving environment of space.

The first factor that must be recognised is the considerable impact of take-off and landing operations on an extra-terrestrial, low-gravity environment, which all future bodies of interest are. On the moon, take-off and landing of lunar spacecraft generates both considerable emission of lunar dust, as well as shaking of the surrounding terrain. It has been speculated that such operations, or more potentially disruptive actions such as resource extraction, could even trigger lunar avalanches, for example in crater regions.[14] Such environmental effects of high-frequency utilisation of lunar geography poses a non-negligible risk of disruption to other actors' equipment in areas hosting high concentrations of multi-actor activity. Even in the initial stages of robotic exploration, dust generated could cover instruments, rendering them ineffective. Shaking of the lunar terrain could ruin measurements. In the worst case, larger scale disruptions could permanently damage the equipment of other states. All of these cases would cause considerable terrestrial inter-state tensions, leading to geopolitical consequences back home and, in the worst case, a further worsening of the prospects of coordination on the moon, initiating a vicious cycle of deteriorating conditions.

This issue will only intensify once In Situ Resource Utilisation (ISRU) begins to scale. Industry players such as ULA have pointed out that the volume of cis-lunar water is practically limitless.[15] Nevertheless, early stage ISRU missions will be expensive. State actors will seek to exploit the most economical options for water extraction. This may, at least judging from currently available evidence, lead them to the bottom of permanently shadowed regions on the lunar surface identified to have high concentrations of water, potentially in particularly accessible physical forms. We must await further data. However, should the most accessible and economical resource sinks, especially for water, also be geographically concentrated, especially within the South Pole region, similar issues as outlined above could arise.

Finally, a lack of coordination increases the risks for lunar crew members, once these arrive on the moon. The disruptions of the kind described above should be self-explanatory in their risk to humans attempting to establish a permanent presence. However, more insidious factors also abound. One of these is the lack of standardisation driven by a bifurcation into geopolitical blocs of lunar activity. As has been pointed out, widely adopted standards of lunar exploration promise considerable benefits.[16] A balkanisation of standards would do the opposite, limiting any attempt of future cooperation in exploration and scientific endeavour. In the most extreme cases, it endangers lives. Mutual aid is a core tenet of both the Outer Space Treaty and the Artemis Accords. Yet, a lack of universally accepted technological standards for lunar (and beyond) crewed operations potentially makes such action considerably more difficult. As the ISS has proven, any inter-operational system must be designed from the outset to be inter-operational. For future lunar activities, this presently seems impossible. Though currently remote, the possibility of the loss of life due to conflicting standards of crewed lunar technology is nevertheless a tragedy worth contemplating.

Again, the described issues are most likely to occur should terrestrial geopolitical tensions between the US and China preclude proactive coordination and information sharing. While the establishment of separate lunar operations can, at this point, be taken as a given, it is far from too late to establish functionally sufficient coordination mechanisms to prevent a major international incident. While US-China coordination is limited by the Wolf Amendment, it is not

> “Ideally ... the United States would proactively take the necessary bilateral steps to work with China to coordinate its respective beyond-Earth surface activities and prevent harmful interference”

Table 2: Upcoming US and China robotic missions to the lunar surface

Country	Mission	Year	Destination	Region
USA	CLPS 1	2021	Lacus Mortis	North-East
USA	CLPS 2	2021	Vallis Schroteri	North-West
USA	CLPS 3	2022	TBD	South Pole
USA	CLPS 4	2022	TBD	South Pole
USA	CLPS 5	2023	Mare Crisium	North-East
USA	CLP 6	2023	TBD	South Pole
China	Chang'e 6	2024	TBD	South Pole or Far Side
China	Chang'e 7	2023	TBD	South Pole
China	Chang'e 8	2026	TBD	South Pole

wholly precluded, as indicated by NASA's monitoring of the Chang'e 4 mission, utilising the Lunar Reconnaissance Orbiter,[17] and, more recently, an exchange of data to mitigate the risks of an orbital collision of Mars orbiters.[18] Ideally, therefore, the United States would proactively take the necessary bilateral steps to work with China to coordinate its respective beyond-Earth surface activities and prevent harmful interference.

Alongside, and regardless of, these efforts, it will be the task of members of international bodies, such as The Committee on the Peaceful Uses of Outer Space (COPUOS) to facilitate coordination activities. In the midst of such initiatives, ESA member states are primary actors eligible for leading such efforts, with ESA having engaged in collaborative activities in space with both the US and China. While diplomats active within UN COPUOS will be well aware of these issues, and their role in enabling such necessary coordination, it is incumbent upon national governments allied to the US to recognise these flashpoints and spearhead broader policy responses to proactively support coordination and the activities of their diplomats at the UN. The UK government, whose diplomats already play a major role in coordinating international space activities, must lend them its full support.

Beyond the moon, the issue of geographically concentrated sites of interest is only likely to prevail. While space is boundless, areas of economical or scientific value are nonetheless often concentrated. Some preliminary analysis, for example, places the number of economically viable near-Earth asteroids at around only ten,[19] due to the fact that metallic, accessible, and economically viable near-Earth asteroids are comparatively rare in number. Given the considerable geographic challenges associated with on-asteroid operations, the need for multi-actor coordination will only become more pressing, especially if terrestrial US-China competition intensifies.

Failures to Coordinate

The risks outlined above are non-exhaustive, and do not touch upon the military dimension of space which carries equal if not greater weight. However, they demonstrate clearly the fact that US-China coordination in space will become ever more pressing as the exploration and commercialisation of space advances. Such risks will only manifest themselves if the US and China are unable to coordinate their activities sufficiently and allow geopolitical tensions to obstruct this crucial work.

> “if the detriments of geopolitics can be bypassed, we may yet witness a new golden age of space exploration”

Looking forwards, all third-party actors in space should closely monitor terrestrial US-China relations and map these to their own activities relating to space (be this in the realm of space exploration or applications), taking mitigating measures as necessary should tensions spill over beyond Earth. In tandem, states with notable diplomatic influence should increase further efforts to enable frictionless coordination and information sharing between the two great powers. Crucially, should formal coordination mechanisms in orbit, on the moon, or beyond be in sight, imperfect coordination should be prioritised if institutional gridlock driven by the pursuit of national interest is the alternative.

For the UK, this poses a non-negligible opportunity to increase its international standing, particularly given the fact that it is close to becoming a space-launch capable power, and that it is already a major economic and diplomatic actor in space. In this context, expanded international cooperation and efforts in agenda-setting, supported, for example, by further increasing ESA contributions, would be a beneficial addition to the continued development of national capability.

In the realm of space, it is often scientific endeavour that suffers in the absence of concrete rules, as has been demonstrated by the already evident impacts of satellite mega-constellations on terrestrial astronomical observations. Beyond Earth's orbit, it will be no different. One can imagine, for example, the detrimental effects to scientific data gathering that could arise from an uncoordinated and fractious flurry of lunar activity. Severe disruption to humanity's scientific endeavours in space would be a generational tragedy and is to be avoided at all costs. Conversely, if the detriments of geopolitics can be bypassed, we may yet witness a new golden age of space exploration. ■

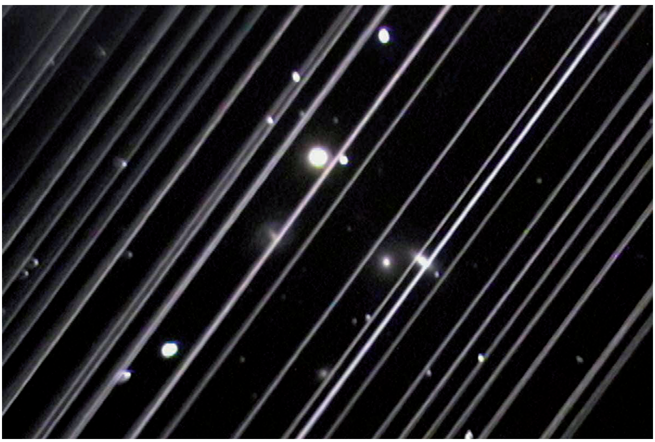

Figure 1: Exposure trails left by SpaceX's Starlink—Scientific progress is the first to suffer from a lack of agreed international norms in space *(Image credit: Lowell Observatory/Victoria Girgis)*

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Coordination Failure:
Risks of US-China competition in space

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The 2020s will see a flurry of space activity, with both national and commercial programs picking up pace. Both the United States and China hold strong ambitions in telecommunications, lunar exploration, and beyond. However, currently fraught relations between the superpowers are unlikely to improve and may yet deteriorate further. On the one hand, competition between both countries may drive space activities and foster technological innovation. On the other, as both superpowers expand their activities in space, geopolitical tensions may increase the risk of harmful dynamics that could endanger the sustainable rollout of future programs. In this Strategic Update, Gidon Gautel seeks to outline and call attention to two high-risk flash points arising from the development of the US and China's national space programmes and industries.

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