Military ambitions and competition in space: the role of alliances

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Executive summary

China wants to overtake Russia as a space power by 2035 and become at least a co-equal with the United States by 2045. For its part, Russia is determined to maintain its standing as a space power. Both are testing the boundaries of the existing order in space through various actions, including weapons testing, and both are keen to demonstrate that they now have the capabilities to attack adversary space assets. Partly in response to this, in 2020 the US declared its intention to radically reshape the operating environment of space to better meet its interests, while its allies and partners have announced new space ambitions as well. India and Japan are setting new strategic goals for space policy in response to China's threatening behaviour. France is positioning itself to climb higher up the ladder of military space power, while the United Kingdom and Germany have set new aspirations for economic gain and further influence on the diplomatic aspects of space. In this environment, military alliances have become more prominent in shaping space policy.

The US has stepped up its engagement with other governments, either through existing alliances or new partnerships, to secure its interests. China and Russia, which have few allies of relevance, except perhaps each other, are concentrating on constraining the effectiveness of the United States' alliances. The three space powers harbour renewed fears of technological surprise by their rivals, and this makes sharing research on space warfare among allies more important than ever. For example, testing of the most visible space weapons, direct-ascent anti-satellite (ASAT) missiles, is escalating – and this is now only one of more than 20 forms of attack on space assets being tested or already in place. But there remain questions about how to achieve scale and military effect using all these methods for wartime operations, including kinetic ASAT weapons: would China or Russia be able to launch successful attacks against the entire military satellite fleet of the US (all 173 units) in the opening stages of a war? Assuming they could not, what proportion of the fleet would have to be disabled for the attack to have a positive military or strategic effect for the attacker?

The US and its allies (within NATO and Japan, and potential partners like India) have publicly articulated a set of coordinated or at least corresponding views on governance of space for international-security purposes. They have not articulated coordinated views on military strategic aspects of space policy, especially on issues like deterrence or country-specific military planning issues for potential adversaries such as Russia or China.

The military contribution that allies can make to space security and shared strategic interests in space can be best understood by reference to the main military missions taking place there, the most important of which is intelligence collection. This is closely linked to other information-support capabilities in space, such as the global positioning system (GPS), which also provides accurate timekeeping essential for much military targeting. The US and its allies have worked closely together on space-based intelligence and information support for decades, and are now devising new ways to strengthen one particular element – space domain awareness (SDA). This would allow better monitoring for civilian purposes (such as space traffic regulation), but also extend alliance preparedness. Early warning of potential nuclear-missile strikes will remain a very high priority for space operations within an alliance framework, including through key ground stations in several allied countries. Better SDA will also help counter growing anxiety about the vulnerability of satellites to the many and varied forms of attack.

In this frame, states give high importance to defence of the 'ground segment' of space operations. For example, key governments (the US, Russia, China, the UK and France) now see cyber attacks, especially on the ground segment, as a major threat to space capabilities. In addition, many states already have diverse capabilities to degrade adversaries' space assets by kinetic attacks on the ground segment. The larger the alliance that a space power can muster to support, defend or amplify the ground segment of its space operations, the less likely its adversaries will be to imagine that they can neutralise its space assets in a war.

In military uses of space, none of the three great space powers has capabilities that match its ambitions because of the weaknesses in space protection. There are two sets of dilemmas which result from this. Firstly, attacks on space assets that play a role in early warning of nuclear attack or in the command and control of nuclear-war fighting would trigger major policy dilemmas around deterrence and pre-emptive nuclear attack. Secondly, because of an inadequate range of space-defence systems, states may resort to active defence or directly offensive measures to disable adversary assets.

Our estimate is that the sense of competition and even hostility seen between the great powers will intensify, with the consequence of driving up budgets for military space activities. China will continue to gain capabilities and continue closing the gap between it and the US in military space power. The prospects for direct combat encounters in space remain very low outside of war between the great powers. That said, harassment operations – already a minor feature of space operations – will likely increase in frequency, although neither China nor Russia will want to see any incidents they provoke in space to lead to a confrontation. Widespread attacks by one nuclear-weapons state on the space-based intelligence, surveillance and reconnaissance (ISR) capabilities of another, or the related ground segment, would immediately raise the prospect of major war, possibly involving nuclear weapons.

It will take several decades before space alliances result in joint combat forces operating in space alongside each other, as we expect in traditional combined combat formations during wartime. For the space aspirants, outside of direct military contributions in intelligence, there are probably three modest military benefits in alliances with any great space power: possible redundancy if some space assets are disabled; alliance pooling of the science and technology of space; and privileged access to space-derived information or analysis of it. Other strategic benefits include privileged participation in commercial and governmental space activities of other partners and diplomatic collaboration to curb threatening behaviours of adversaries. The US works hard to reap these benefits for itself, even if they are relatively less important to it, given its huge capabilities.

Taken collectively, traditional US allies (Australia, Japan and those in NATO) spend almost double what China does in space, and even more compared with Russia. But this balance of effort does not assuage security concerns about the ambitions and space actions of these two countries. Most states recognise the pressing need to avoid irresponsible and dangerous actions, especially the testing of anti-satellite weapons that result in thousands of pieces of debris capable of fatally damaging satellites or spacecraft. Russia and China are diplomatically isolated at present in their stand against a range of initiatives on cooperative security in space, as demonstrated by the overwhelming consensus displayed in the meeting of the United Nations General Assembly First Committee on Disarmament and International Security in November 2021, led by the UK and supported by like-minded countries.

There is considerable room for inter-alliance debate about how, in the circumstances outlined above, states should reasonably advocate for reductions of tensions in space, in the expectation that important gains can be made in more cooperative and less confrontational behaviours than those that we are now seeing. This debate will be lively, and perhaps combative at times, but will not easily derail the overall trend toward consolidation of the collective power of the many and varied US-led space alliances.

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Introduction

In October 2021, reports of China's test of a space glide vehicle with the capacity to release a hypersonic missile provoked talk of a new 'sputnik moment' in international security, a concern that was aggravated by Russia's test of an anti-satellite weapon in November 2021. The events gave a new sense of urgency to efforts, already underway, within NATO and other more ad hoc coalitions to build stronger alliance relations to secure shared interests in space. The backdrop to these events included the headline-grabbing operations earlier in 2021 of new commercial ventures, including for space travel. On several levels, states have become more invested in the need to regulate these events, a sentiment that worked itself into ground-breaking levels of support in the United Nations in 2021 for UK-led efforts to advance debate on several new approaches to global governance of space. This occurred against the objections of Russia, China and six other authoritarian states which favoured their own long-standing proposals about placement of weapons in outer space and confidence-building measures.[1]

This paper analyses the likely impact on alliances, partnerships or other national-security coalitions of the emerging trends in space ambitions and capabilities of major state actors. We consider the following questions: how is the balance of power in space perceived, and how does that shape alliance behaviours, or attitudes to alliances? What are allies and partners looking for from each other in their cooperative action on space issues? What are the prospects that these expectations will be fulfilled? The time frame covered by the paper's projections looks mainly to the next ten years. We note, however, that some of the great powers and more modest space powers alike are looking to establish conditions of power or law that might endure for decades, looking as far as the end of the century.

The paper reviews the ambitions and operational capabilities of the leading space powers, each considered in turn below, to provide the essential background to address these questions. We look first at China and Russia, then the US. This discussion helps us to better understand claims to space dominance or space superiority.

After looking at the three great space powers, we turn to the next tier of space powers to see how their policies may shape consideration of space alliances and strategic competition in space. These include France, Germany, India, Japan and the UK. All are treaty allies of the US, except for India, which has been shifting toward much closer security relations with the US and its allies, notably through the Quad, for several years. We then analyse the implications of our review of ambitions and space operations of the countries mentioned for several existing, emerging and potential alliances, including NATO, the Quad, and Russia–China, respectively.

Military space missions and assets

Long-standing military uses of space include intelligence, surveillance and reconnaissance (ISR); positioning, navigation and timing (PNT); early warning of nuclear missile attack; environmental monitoring; and communications for command and control. Outer space is the main operating medium for essential aspects of military cyberspace operations, too. Cyber capabilities are already being used by state and non-state actors to target both civilian and military satellites and space ground facilities.[2] At the same time, a very large share of US military cyber operations are either transmitted through space, often using internet protocol, or depend on computer-processed intelligence collected through space-based assets. This has been summarised neatly as follows: 'space is now militarised and weaponised through cyber means'.[3] Thus, for international-security purposes, we need to understand space policies and capabilities in terms of not only space-based assets but the ground components supporting them, as well as the data and communications links between them. There are four vectors of interest to consider: space to space, space to ground, ground to space and ground to ground.[4]

Military activities and capabilities are intended to serve a variety of possible strategic purposes, including deterrence of potential adversaries, supporting a stable balance of power and war fighting. Military space assets can support all these missions, but do not do so independently of other elements of national power – political, economic or military. This paper focuses on the military ambitions, operations and capabilities of the three great space powers and the way in which they shape alliance behaviours in specific cases. We analyse these operations and capabilities very broadly against the missions set out in Box 1.

The last of these capabilities – space protection – is not developed for all states involved and is the least well studied. These circumstances are a major driver of current security concerns, with China's president highlighting space protection as an important new priority in China's security policies in 2021. The weaknesses of space defence push states toward offensive operations as the only reliable way of protecting their assets. Yet there are more than 20 types of defensive measures that can be implemented to protect against attack methods that are currently available.[5] Direct-ascent anti-satellite (DA-ASAT) weapons, once considered the main form, are now just one of a suite of threats.

To position this analysis, it is useful to note the level of military assets currently operating in space. Table 1 shows the IISS assessment of the current numbers of military assets in space by type.

Box 1: **Operational capabilities to match space ambitions**

- Intelligence: space-based assets, such as intelligence-collection satellites or meteorological satellites, supporting national-security policy or military operations, including ballistic missile launches and early warning of adversary missiles
- Command: space-based assets, such as communications satellites, which are integral to national-security operations (especially cyber operations) in space or terrestrial settings
- Counter-space: kinetic and non-kinetic military capabilities, regardless of basing (space or terrestrial) that can disable or destroy assets in outer space
- Space protection: physical defence of space-based assets and the terrestrial operations and assets supporting them

Table 1: **Military satellites by type and country**[6]							
Country	**Early warning**	**Space surveillance satellite**[7]	**ELINT & SIGINT**[8]	**ISR satellite**	**PNT**[9]	**Communications satellite**	**Total**
US	9	6	27	18	31	46	137
China	-	-	41	29	45	9	124
Russia	4	-	5	11	28	58	106
India	-	-	1	11	7	2	21
Japan	-	-	-	9	-	2	11
Israel	-	-	-	7	-	3	10
France	-	-	-	6	-	3	9
Italy	-	-	-	5	-	4	9
UK	-	-	-	-	-	8	8
Germany	-	-	-	5	-	2	7
UAE	-	-	-	1	-	3	4
Spain	-	-	-	1	-	2	3
Mexico	-	-	-	-	-	2	2
Morocco	-	-	-	2	-	-	2
Turkey	-	-	-	2	-	-	2
Australia	-	-	-	-	-	1	1
Brazil	-	-	-	-	-	1	1
Canada	-	1	-	-	-	-	1
Chile	-	-	-	1	-	-	1
Egypt	-	-	-	1	-	-	1
Peru	-	-	-	1	-	-	1
Qatar	-	-	-	-	-	1	1
South Africa	-	-	-	1	-	-	1
Sudan	-	-	-	1	-	-	1
Vietnam	-	-	-	1	-	-	1
Venezuela	-	-	-	-	-	1	1
Total							466

China: maximising ambition and deterrence

In 2015, China's leaders articulated a new vision of the strategic significance of space in order to reorient their military space programme, declaring that 'outer space and cyberspace are the new commanding heights of international security competition'.[10] A 2016 white paper on space activities highlights the current leadership's resolve to 'build China into a space power in all respects'.[11] And in 2017, the five-yearly Congress of the Chinese Communist Party (CCP) endorsed the goal of surpassing Russia as a space power by 2030 and becoming a world-leading space power by 2045.[12] The time frame was new, but the ambition was not, as China has clearly been pursuing it for two to three decades.[13]

The country's national-security priorities in space have not been articulated as consistently as those of the US, but they have firmed up in the past decade. (It should be noted that official sources underplay or ignore military aspects of the country's space programme and do not paint China as engaging in a strategic competition in space.)[14] The stated goals include the need to achieve space superiority in wartime.[15] However, two unannounced goals are to restrain the continuing accumulation of US and allied space power and to disrupt the diplomatic efforts of the US and its allies to consolidate and expand collaborative actions related to space.

China has defined space superiority as 'ensuring one's ability to fully use space while at the same time limiting, weakening, and destroying an adversary's space forces'.[16] For now, it is pursuing three broad capabilities of relevance to this paper: 'operationally responsive space launch capabilities, space-based C4ISR, and counterspace capabilities'.[17]

For the People's Liberation Army (PLA), the new importance of space operations mandates 'stronger flexibility and adaptability' in military strategy.[18] Outer space is one the three major security domains, along with nuclear and cyberspace.[19] Building capability for space activities is essential to the overall mission of 'building informationised [cyber-enabled] armed forces, for winning informationised wars, and for propelling the PLA's strategic transformation'.[20] China sees that the 'military intelligence information of global space powers mainly comes from space systems' and that the 'space activity of nations around the world, as well as their spacecraft operating in orbit, is mostly used for military goals'.[21]

The PLA's authoritative doctrinal statement from 2013 identified the following objectives (in the order listed below) for military space policy:

- space-derived intelligence and information
- space deterrence
- space attack and defence operations
- the struggle against weaponisation of space[22]

Military space operations

China's space forces are organised by the Space Systems Department (SSD), which is a part of the PLA's Strategic Support Force (SSF). The SSF came into being as part of a 2015 reorganisation, directed by President Xi Jinping, to align China's military prowess and modernisation with its regional and international interests.[23] The SSD is responsible for most of the PLA's space operations, including launching and operating space-based assets. The establishment of the SSD underscores China's designation of space as a 'critical domain in international strategic competition' in its 2015 defence white paper.[24] China anticipates that space will play an important role in future conflicts, and its efforts to improve its offensive and defensive capabilities reflect this.[25]

Intelligence

China operates a large fleet of satellites dedicated to intelligence collection, second in size only to the United States' inventory, and which delivers global coverage for China. Of China's roughly 120 satellites (civilian and military) that contribute to intelligence, the PLA operate around half (electro-optical and synthetic aperture radar [SAR] imagery and electronic and signals intelligence [ELINT and SIGINT respectively]). This includes remote-sensing systems such as the *Yaogan* series, of which China currently operates 45 across all variants.[26] The SSD's ability to maintain space domain awareness (SDA) provides important support to the PLA Rocket Forces (PLARF), which has several hundred nuclear warheads mounted on inter-continental nuclear missiles.[27]

Details are lacking on Chinese early-warning capabilities, although Beijing expressed a desire to develop 'its capabilities for strategic early warning, air strike, air and missile defence' as part of its 2015 defence white paper.[28] China is thought to operate a nascent space-based early-warning capability and is further developing this through a mixture of indigenous and foreign-assisted efforts.[29] Three Chinese geostationary satellites of the *Tongxin Jishu Shiyan* series that are ostensibly designed for high-speed and multi-frequency wide-band data-transfer communications may actually have early-warning roles.[30] Published imagery of these satellites appears inconsistent with the design of conventional communication satellites.[31] The system is possibly equipped with infrared sensors to detect missile launches.[32] Russia is assisting China with developing early-warning systems, although whether this incorporates ground- or space-based assets is unknown.[33]

Command

China operates fewer communications satellites compared with Russia and the US, although Beijing is seeking to 'accelerate the construction of military-civil and dual-use global mobile communications satellite systems'.[34] Given its ambition to 'advance military-civil fusion in the space domain',[35] it is possible that some of China's civil and commercial satellites have dual capabilities and may be used by the PLA in certain circumstances. According to the US intelligence community, the PLA will continue to integrate a variety of 'space services' (such as satellite reconnaissance and position, navigation and timing [PNT]) as well as satellite communications into its command-and-control systems.[36]

Counter-space

China reportedly operates a direct-ascent anti-satellite (DA-ASAT), the SC-19, which is believed to be capable of targeting satellites in low-earth orbit (LEO).[37] China confirmed it conducted a DA-ASAT test in 2007, in which a *FengYun* 1 weather satellite was intercepted by a ground-launched SC-19.[38] Although details on the SC-19's capabilities are scarce, it may incorporate some elements from China's DF-21C medium-range ballistic missile. China is alleged to have also conducted non-destructive tests of DA-ASATs in 2013 and 2014, although some of the parameters and characteristics of the systems tested do not match those estimated of the SC-19, suggesting China has other DA-ASAT programmes underway.[39] An official Chinese source has confirmed two DA-ASAT tests in May 2013 and July 2017, respectively, involving the second-generation DN-2 and the third-generation DN-3.[40] The source claimed that these could now cover the low, medium and high orbits and that China's capability in this area is now world class. According to the United States' Office of the Director of National Intelligence (ODNI), counter-space operations will become integral to military planning and operations, including both new destructive and non-destructive ground- and space-based ASAT weapons. In its 2021 Annual Threat Assessment, ODNI notes that China has already fielded 'ground-based ASAT lasers probably intended to blind or damage sensitive space-based optical sensors on LEO satellites'.[41] China has also developed a satellite with a robotic arm that could be used for grappling other satellites in geosynchronous earth orbits (GEO) (the *Shijian* 7). A senior official has expressed an interest in developing micro-satellites for future ASAT operations, as well as reversible electronic or non-kinetic options to disable satellites for a specified period of time.[42] China demonstrated capabilities to use electronic jammers, laser and cyber attacks against satellites as long as 15 years ago.[43] It may see its counter-space EW capabilities as contributing to deterrence rather than being able to disable large numbers of US satellites.[44] One Chinese view has it that the main purpose of counter-space operations (and space protection) is to maximise the role of space information warfare.[45]

Space protection

Public PLA sources discuss space protection only in very broad terms. They include both the ground and space segments, as well as passive and active defence measures. They understand space protection in a systemic way – a balance between keeping their assets and information systems working, while degrading those of the adversary. In September 2021, in what may be the first time the term 'space protection' has ever been uttered in public by a leader of China, President Xi urged the PLA SSF to improve by building a comprehensive protection capability.[46] China's space assets are even more vulnerable than those of the US, especially to cyber attack, given China's weak cyber-security capabilities.[47]

Russia: undaunted aspirations

Russia has lost the position in space power that the Soviet Union possessed when it was considered a near equal of the United States, and it has been forced to modify its ambitions accordingly. This sudden transformation is captured in the fact that Russia still relies heavily on the former Soviet launch facilities at Baikonur in Kazakhstan for its space operations. Nevertheless, in 2020 Russia spent around US$4 billion on civil and military uses of space, which represents more than 0.21% of its GDP, a share of GDP only surpassed by the US.[48] Its military space budget has been estimated at around US$1bn per year,[49] but this is only a fraction of what the US spends – in the vicinity of tens of billions per year (on space intelligence and on the US Space Force, the latter having bid for US$17.5bn in FY22).

The military uses of space remain among Russia's highest priorities, more from the fear of increasing US power than from confidence that it can turn space into a war-fighting domain it can dominate. The main military goal of space operations for Moscow in a war with the US would be to neutralise the latter's assets. The Russian National Security Strategy of 2015 mentions outer space only once, in connection with possible future placement of weapons in space by the US.[50] The 2021 National Security Strategy warns that 'space and information spaces are being actively developed as new spheres of military operations', once again the sole mention of the military dimension of space.[51] The 2014 military doctrine identifies the need to overcome threats to its space monitoring systems, and sees simultaneous multi-domain operations (in the 'global information space, airspace and outer space, on land and sea') as a particular concern.[52] It considers the promotion of a treaty on Prevention of Placement of Weapons in Outer Space and of the Threat of Use of Force Against Outer Space (PPWT) as one of a long list of policy objectives for military security. Similarly, it calls for actions to adopt regulatory provisions in the UN framework to 'govern the secure conduct of outer space activities, including safety of outer space operations'. It also advocates for an improvement in Russian space monitoring of near-earth orbit, including collective space situational awareness.

Military space operations

Intelligence

Russia possesses 24 intelligence, surveillance and reconnaissance (ISR) satellites, of which the Russian military operate around half.[53] Russia's ISR capabilities have deteriorated partly due to funding constraints and the impact of US and Western sanctions which have restricted Russian access to essential imports of electronic components for satellite production, especially microchips.[54] Russia only possesses two *Persona* satellites that may be used for optical reconnaissance.[55] It is therefore seeking to recapitalise its high-resolution optical reconnaissance capabilities by developing stopgap and eventual replacement satellite designs.[56] To this end, the small optical-reconnaissance satellite design, *Razbeg*, has been suggested as a bridge design until the larger and more sophisticated *Razdan* series will provide Russia with improved optical capabilities.[57] However, given delays in the launch dates for the first two *Razdan* satellites, Russia will likely have to rely on its ageing *Persona* models for the time being.

Like other Russian space-based assets, the development of replacements to Soviet-designed signals intelligence (SIGINT) systems has also suffered from delays due to financial constraints and technical setbacks, thwarting plans for new projects. Beginning in 1993, Russia began work on replacing its *Tselina* series of SIGINT satellites and its *Ledenda* ocean-reconnaissance satellite system with a new system named *Liana*.[58] As with their Soviet predecessors, Russia opted to develop two separate systems within the *Liana* programme to satisfy the separate but partially overlapping requirements of its primary users. The *Lotos* design is to collect SIGINT and has been operational since 2014, with four launches recorded up to 2021.[59] It is likely that *Lotos* may also have an auxiliary role to provide SIGINT for the Russian Navy since its *Pion* design has been delayed due to possible issues with the payload, resulting in only a single satellite being launched.[60]

Investments in redeveloping Russia's space-based early-warning capabilities for detecting ballistic missile launches have been modest when compared with that of its ground-based radar systems, which have been extensively improved with the development and deployment of the *Voronezh*-type radar.[61] Between 2014 and 2020, Russia lacked a space-based early-warning capability following the failure of its two *Oko* satellites.[62] Despite Russia's greater focus on upgrading ground-based early-warning systems, Moscow has recapitalised its space-based early-warning assets to provide additional coverage, beginning with the launch of the first of ten planned *Tundra* satellites in 2015.[63] The *Tundra* system reached initial operating capability in 2020, following the successful launch of a fourth satellite in May 2020.[64]

Command

Russia operates multiple types of communications satellites to provide command and control of its military forces.[65] Operations outside of Russia's immediate periphery have likely emphasised the importance of updating and expanding the coverage of Russia's command and control infrastructure. These systems are stationed in a variety of different orbits depending on their role. For instance, as geosynchronous earth orbits (GEO) and low-earth orbit (LEO) satellites provide limited coverage of polar regions, Russia has placed many of its newer communications satellites, such as the *Meridian* and improved *Meridiam-M* systems, into highly elliptical orbits (HEO). These have apogees over the Russian landmass, thereby providing reliable communications for its armed forces.

Counter-space

Russian military doctrine and military theory emphasises the importance of space as a war-fighting domain. Russia inherited the Soviet Union's interest in developing anti-satellite (ASAT) technology and has restarted several Soviet-era programmes to develop the Aerospace Forces' (VKS) ground- and space-based ASAT capabilities. Factors driving the development of offensive kinetic systems include a recognition in Russian military doctrine that space-based assets will play a decisive role in military operations. Russian military thinkers have also advocated for the development of offensive space capabilities, as future conflicts with peer-competitors will likely feature the extensive use of stand-off munitions, which are partly reliant on space-based assets.[66]

Russia appears to have three publicly known counter-space programmes with kinetic functions underway. This includes a ground-based missile system named *Nudol*, which appears to have been under development since 2009. The system may share some design details with an earlier-developed Soviet exo-atmospheric interceptor, the 51T6 (RS-SH-11 *Gorgon*), although how much technological overlap *Nudol* shares with this system is uncertain.[67] Whether *Nudol* is a dedicated direct-ascent anti-satellite (DA-ASAT) weapon is also unclear. Russian sources have noted that it will have the ability to target LEO satellites and intercept ballistic missiles.[68] It is possible that *Nudol* will have some crossover capability, given that it will allegedly be equipped with conventional or nuclear warheads, the latter having been used by Russia for ballistic-missile defence.[69] *Nudol* may be a mobile system, according to imagery released by its developer, Almaz-Antey.[70] Russia has tested *Nudol* at least ten times since recordings began in 2014.[71] At the time of publication, the most recent confirmed *Nudol* test took place in December 2020.[72]

Russia also appears to be developing an air-launched ASAT capability known as *Burevestnik* (not to be confused with Russia's nuclear-powered and nuclear-armed cruise missile under development, the RS-SSC-X-09 *Skyfall*, which shares the same name).[73] The system may be a derivative of a Soviet-era ASAT named *Kontakt*. Both *Kontakt* and *Burevestnik* share a launch platform in modified variants of the MiG-31 (the MiG-31D and MiG-31BM *Foxhound* respectively).[74] However, the Soviet-era system differs from the more recent Russian programme, as the former was an air-launched missile with the capability to kinetically intercept satellites in LEO, while *Burevestnik* is thought to act as a launch vehicle for smaller interceptor satellites that will act as co-orbital ASATs.[75]

Russia's S-500 system, still under development, has also been categorised as having a potential ASAT capability.

There have been no known examples of Russia's S-500 ballistic-missile defence system demonstrating the capability of targeting systems beyond the earth's atmosphere.[76] Given the S-500's intended ability to intercept incoming ballistic missiles exo-atmospherically at altitudes of up to 200 kilometres, according to Russian media, there have been suggestions of the system being utilised in an ASAT role in the future.[77] Sergei Surovikin, commander-in-chief of the Military Space Forces (VKS), said that the S-500 will be the 'first generation of counter-space defence systems, since in the future it will be able to destroy low-orbit satellites and space weapons'.[78]

Like China, Russia has tested co-orbital options for satellite disablement, including directed energy, cyber weapons, laser and microwave beams.[79] It has an experimental airborne laser capability and a ground facility. In 2019, it unveiled its *Peresvet* mobile laser system, for temporarily dazzling low-flying photo-reconnaissance satellites.

Space protection

Russia has had a strategy and plans for space protection since 1960, though it was more focused on active defence (satellite destruction and missile destruction) than passive.[80] It gave high priority to early warning of aerospace attack and boosting the country's space-protection capability. These goals remain unchanged. To meet these aims, the armed forces are giving special attention to electronic warfare, increasing the survivability of space communication systems and developing offensive capabilities against adversaries' ground segment as a form of space protection.[81]

The approach has in some respects been indistinguishable from its missile defence and ASAT development. The Russian Space Force has as its primary mission anti-ballistic-missile defence and it is often hard to distinguish whether experimental techniques developed for anti-ballistic-missiles can be used in certain ways for ASAT operations. Moreover, some techniques considered by Russian academics for ASAT purposes can be used for defence of space assets, and these include chemical sprays, aerosol obscurants and nanoparticles in orbit to interfere with satellite data transfers.[82] GPS spoofing is also a technique available to Russia (as it is to China and the US) to disrupt adversary counter-space operations.

US: 'digital dominance'

The US government, its senior military officers and its security elites see US power in space as part of the country's ambition to remain the leading power in global security. Though there have been moments of doubt about its relative power in space, the US has been at the cutting edge of space science, space activities and space innovation for national security since at least the early 1960s. Nevertheless, between 1999 and 2006, a strong sentiment began to emerge in the US Congress that China posed a strategic challenge in space.[83] By 2012, as China stepped up its competition with the US in space, some Americans became seized with a fear that their country would be deposed by China from its leading position, despite the continuing superiority of the US at the time in most aspects of space research, technology and operations.[84] The fear of being eclipsed has not dissipated and has been exacerbated as China has stepped up the pace, despite regular official US statements that it has clear edge over China. Spurred by China's ambition, the US announced in 2020 a plan to transform its space power[85] through the most substantial reorganisation of related capabilities for 60 years, including the creation of a revamped Space Command, a new Space Force and a number of other organisational changes in the Department of Defense (DoD) and the US Air Force (USAF) for policy, intelligence, procurement and administration. The US is not preparing for a war conducted exclusively in space, but for 'an extension of traditional armed conflict into the space domain'.[86]

The 2020 strategy document lays out a radical policy comprised of four legs, of which one is alliances and partnerships. The US intention has been expressed in terms of ensuring a 'secure, stable, and accessible space domain, whose use by the United States and our allies and partners is underpinned by comprehensive, sustained military strength'.[87] The explicit mention of allies was carried through to a further statement of the execution process for defensive missions, but one which implied there was no automatic and wide-ranging commitment by the US to protection of allied space assets or interests. The DoD would only do that on an 'as-directed' basis. At the same time, for combined operations in space, as with allies in any domain, the DoD would 'deliver advanced space capabilities and effects' to enable them.[88]

The strategy identifies China and Russia as major drivers of the change in its approach since they have 'weaponized space as a way to deter and counter a possible U.S. intervention during a regional military conflict'.[89] The US sees itself as poorly placed to respond for several reasons: 'limited operational experience with conflict beginning in or extending into space'; inadequate international agreement on 'what constitutes unsafe, irresponsible, or threatening behavior in space'; new limitations on US freedom of manoeuvre caused by 'advances in potential adversary, restof-world, and commercial space-based capabilities'; decreasing costs for potential adversaries to expand their space technologies and capabilities; and poor 'public understanding of their reliance on space systems, the changing character of the space domain, and the significantly growing counterspace threats to the United States and its allies and partners'.[90]

The Space Strategy makes a point of noting the advantages that a highly engaged set of allies and partners would bring to the execution of US policy and operations, whom the US sees as 'increasingly interested in collaborating in the development of space capabilities, sharing space-related information and intelligence, and partnering in space operations to secure access to, and ensure freedom of action in, space'.[91] This goal is identified as one of four lines of effort for future activity, alongside three more nationally oriented defence-related activities, which the paper notes also depend on 'allies, partners and industry'. Saying that the space capabilities of these actors is already 'integral … to collective security', the strategy calls for the following actions to lay the foundations for the long term:

- expand information-sharing relationships with capable allies and partners

- align with them on space policy
- join with them to promote favourable standards and norms of behaviour in space
- expand cooperative research, development and acquisition (RD&A) with them[92]

Military space operations

The US Space Force (USSF), formally established as a separate uniformed branch of the US military in 2020, is tasked with organising, training and equipping US military personnel to conduct global space operations, including maintaining space superiority, providing space domain awareness (SDA), offensive and defensive space control, command and control of space forces and satellite operations, and missile defence and early-warning operations.[93] As the USSF commander, Chief of Space Operations General John W. Raymond, observed, in 2021 the USSF is the only US single service created in the 'digital environment'; it was 'born digital' and takes 'digital dominance' as its main operating principle.[94] As an illustration of this, the term 'cyber ASAT' now figures in professional engineering literature.[95]

Intelligence

The US possesses the world's largest and most capable intelligence, surveillance and reconnaissance (ISR) and remote-sensing satellite fleet. Its satellites are capable of gathering electronic intelligence and signal intelligence data, obtaining optical or radar images of the surface of the earth and providing early-warning capabilities to detect missile launches. The strategic significance of US space-based intelligence collection is enormous: global in scope; consuming the largest single slice of the intelligence community's budget; shaping almost all aspects of US national-security planning; and directly supporting the conduct of all military combat operations. These capabilities shape how potential adversaries of the US must plan their combat operations and therefore their own national-security posture. Space-based capabilities also influence approaches to cooperative security, conflict resolution and in some cases conflict prevention. The US sees its space-based intelligence capability as part of its winning edge ('information superiority') over potential adversaries, and wants to preserve its space superiority to protect that information advantage.

The US intelligence community has now declared outer space itself as a high-priority intelligence target, along with the ground segment that supports it.[96] This brings with it the recognition that the intelligence community and the DoD's space-related entities are now co-equals in space policy.[97] The FY22 budget request includes funding of US$20 million for a dedicated National Space Intelligence Center (NSIC), which reports through the space force commander to the director of national intelligence.[98] The request for the USSF was US$17.5bn,[99] but the NSIC is funded from the separate Military Intelligence Program (MIP) request of US$23.3bn.[100] For FY22, the National Intelligence Program budget request, separate from the MIP, was US$62.3bn, a large slice of which goes to military space-intelligence activity.

The US operates a mixture of legacy and replacement space-based early-warning systems to detect adversary missile launches and is making qualitative and quantitative efforts to improve the efficiency, flexibility and sensitivity of its current inventory. The USSF operates four Defense Support Program (DSP) early-warning satellites that are stationed in geosynchronous earth orbits (GEO), the oldest of which was launched in 1997.[101] DSP satellites are equipped with infrared sensors to detect heat from missile and booster plumes against the Earth's background. Although this technology was initially more suited to detecting the launch of larger missiles, such as intercontinental ballistic missiles, improvement projects, such as advancements in ground processing systems and increasing on-board signal-processing to improve clutter rejection, have enhanced the capability of DSP to detect less visible heat signatures, thereby providing better detection of shorter-range missiles.[102]

As part of the United States' efforts to provide a follow-on capacity and improve the utility and flexibility of its missile early-warning system, DSP is being replaced by the successor Space Based Infrared Surveillance (SBIRS) missile-warning satellite.[103] The US currently operates five SBIRS in GEO, with a sixth system expected to be launched in the first half of 2022.[104] SBIRS-GEO has two sensors, a scanner and a step-starer. The scanner allows the satellite to scan the earth continuously, while the step-staring sensor provides the USSF with the capability for closer coverage of theatre areas.[105] In addition to these five satellites, two smaller scanning sensors are placed in highly elliptical orbits and are able to see close to the ground.[106] Considering that SBIRS-GEO has an expected service life of 12 years, the USSF has already planned for its replacement, the Next Generation Overhead Persistent Infrared (Next-Gen OPIR) missile warning satellite, the first of which is scheduled to be launched in 2025.[107]

In 2020, the main photo-reconnaissance organisation, the National Geospatial-Intelligence Agency (NGA) announced a moonshot initiative to 'maintain and expand [its] GEOINT advantage, in all realms – including space'.[108] NGA is a critical component of all combat missions of the US armed forces, by providing 'assured positioning, navigation, timing and targeting' data.[109] NGA comprises 15,000 personnel.[110]

Command

The United States operates the largest inventory of civil and military communications satellites of any country, with an estimated 50 satellites dedicated to military use.[111] (Russia has 58 dedicated military communications satellites, while China has nine.)[112] The US fleet provides connectivity to US personnel operating worldwide; stores and relays data and enables the DoD to exercise command and control of US tactical and strategic forces. The mainstay of the United States' military communications system is fulfilled by four Wideband Global SATCOM (WGS) Satellites, deployed in GEO, which provide global high-data-rate and long-haul communications for the various branches of the US armed forces, and facilitate command and control.[113] Additional command and control capabilities are provided by the Defense Satellite Communications System-3 (DSCS-3), a high-priority communications satellite operating in GEO that allows for secure and uninterrupted voice and high-data-rate communications between fixed and mobile DoD users to battlefield commanders, as well as NATO allies. Although six DSCS-3 systems remain in service, they are augmented by a constellation of the WGS series, which are set to eventually succeed the DSCS-3 once the systems are retired. The WGS has ten times as much bandwidth as the DSCS-3 and operates at an ultra-high frequency. Newer iterations of the WGS series feature a radio-frequency bypass capability that can support platforms that require ultra-high bandwidth, such as airborne intelligence, surveillance and reconnaissance equipment, as well as the data rates demanded by uninhabited aerial vehicles (UAVs).[114]

For strategic military communications, the US deploys the Advanced Extreme High Frequency (AEHF) satellite. The AEHF operates in GEO and provides survivable, protected communications capabilities that are jam-resistant to adversaries. These defences provide guards against full-spectrum cyber and electronic threats; for instance, by defeating jammers using wide bandwidths and pinpointing and eliminating jammer noise. Strategic missions of the system include communications with the air and sea leg of the United States' nuclear triad, emergency-action message dissemination, missile defence and warning and near-real-time targeting. Compared with the Military Strategic & Tactical Relay, an earlier communications satellite that the AEHF is replacing, a single AEHF satellite is able to provide a greater total capacity than the entire five-satellite Milstar constellation.[115] Along with providing communications for US forces, the AEHF also serves international partners including Canada, the Netherlands and the UK. The AEHF is slated to be replaced by the Evolved Strategic Satellite (ESS) from 2032, which will feature further enhanced resilience and cyber security capabilities. The ESS will also replace the AEHF's mid-latitude system capability, thereby extending its survivable communications capability to the Arctic region.[116]

Counter-space

The US has several options for counter-space capabilities: kinetic (through classic ASAT attack), cyber attack, other electronic warfare means, or directed-energy weapons. The US capability for all of these forms of counter-space operations remains either largely experimental or largely unrevealed, since there are no publicly known examples of such actions against the space assets of foreign states.

In 2008, the US successfully intercepted one of its own weather satellites, demonstrating a possible latent capacity for conducting kinetic operations in space, despite not acknowledging it had an official direct-ascent anti-satellite (DA-ASAT) programme.[117] Similarly, US testing of underlying co-orbital ASAT technologies also points to a dormant capacity and indicates the possibility that the US could quickly acquire dedicated technologies if it chose to. The US established several programmes during the Cold War to develop a DA-ASAT capability and conducted several successful actual and simulated intercepts during the course of these various programmes.[118] We assess that the US does not possess an operational and readily available DA-ASAT capability.

Space protection

The US has several assets and strategies for protecting its space operations, though is more confident in protecting the ground segment than the orbital segment. Since it does not currently possess the ability to prevent many forms of attack on its assets in space, it relies on a policy of 'mission assurance', adequate redundancy to suggest to a would-be attacker that there would be no profit, and only loss and risk, in such an attack.[119]

Since the US sees cyberspace as one of the more important vectors of threat to space assets, it has been undertaking relevant measures. In 2021, Space Command held discussions with Cyber Command to expand the cyber-defence effort in space. It is noteworthy that the time horizon was a long one, with a senior officer saying that she expected that it would be three to five years for specialist cyber-protection teams trained for the space environments (ground and orbital) to be in operation.[120] The officer confirmed that when Space Command was set up, it took personnel from the USAF unit, Delta 6, to stand up five active-duty squadrons, with missions including space safety analysis for the command and operating communications systems for the USSF. She also confirmed the involvement of cyber specialists at the acquisition stage of space vehicles and related equipment. The Air Force Research Lab has a Space Vehicles Directorate, which in November 2021 committed to doubling its investment in cyber-related technologies, both to counter threats and exploit opportunities.[121] In August 2021, the Space Force rebadged a pre-existing command, the Space and Missile Command, as the Space Systems Command (SSC), which will be the focus of planning and execution of defensive and offensive cyber missions in space. To that end, in November 2021, SSC was planning its second 'hack a satellite' competition, aimed at attracting global non-uniformed cyber talent.[122]

Ambitious allies: autonomy and security

There are several states operating at lower levels of intensity in military uses of space: India, Japan, France, the UK and Germany. Their military satellite fleets comprise 21, 11, 9, 8 and 7 satellites respectively. None of these states has the ambition or pretension to space dominance or space superiority in the same way as the US, Russia or China, but all value the benefits that alliance with the US can bring to their space programmes, especially the scientific and economic aspects, and their national security more broadly defined. They all believe they add value to US interests and those of the alliances or partnerships in which they operate alongside the US. India is not a treaty ally of the US, and may never be one, but since at least 2011 has been moving quite deliberately, on and off, toward much closer security relations with the US.

India

India's space programme has evolved away from economic-development priorities to a much keener interest in military space operations, especially after the first successful Chinese anti-satellite (ASAT) test in January 2007 and the rapid expansion of China's military space programme. Though India does not yet have a declared space policy, its approach can be gleaned from official statements as well as India's positions in various multilateral forums, such as the Conference on Disarmament in Geneva.

For decades prior to China's ASAT test, India was vehemently critical of US and Soviet Cold War military space programmes, including their ASAT tests, but the Chinese test was a rude wake-up call that altered India's space-security threat perception. The test triggered a new debate in the country, both within the official security establishment as well as the broader strategic community, about India's space policy. The dominant view was that India needed to take proactive steps to develop its own ASAT technology for deterrence against China. Consequently, an ASAT capability was sanctioned by the government, leading to a test in 2019. Outlining the deterrent logic for India's ASAT test, Dr Satheesh Reddy, head of India's Defence Research and Development Organisation (DRDO), stated that 'the best way to ensure security is to have deterrence', adding that the DRDO was 'working on a number of technologies like DEWs, lasers, electromagnetic pulse (EMP) and co-orbital weapons'.[123] Another reason India tested was to avoid repeating the mistakes it made in the nuclear arena, when it was left out of the non-proliferation regime because it did not conduct a nuclear test in time. If a new space-security regime is established, India wants to be a member rather than an outcast.

Along with these changes, India has been undertaking institutional reforms driven largely by space-security concerns, though some of the internal debates about that predate China's ASAT test. Moreover, India has been debating the establishment of an aerospace command for more than a decade, though one is yet to be established.[124] In September 2018, India established a Defence Space Agency (DSA), which was meant as an interim institutional arrangement under the leadership of the Indian Air Force prior to the establishment of a full-fledged aerospace command. India has also instituted another organisation, the Defence Space Research Organisation, for research and development of space-security capabilities to implement strategies framed by the DSA.[125] The DSA is reported to house around 200 personnel from the current Defence Imagery Processing and Analysis Centre, New Delhi, and the Defence Satellite Control Centre, Bhopal.[126] Prior to this, in June 2012 the Indian Navy had established a new office called the Assistant Chief of Naval Staff (Communications, Space and Network-Centric Operations), responsible for overseeing and managing space-based military assets and capabilities. In June 2019, for the first time, India also conducted a space-security war gaming exercise, IndSpaceEx, which included the military and scientific establishments as well as members of civil society.[127]

Overall, these efforts are a response to space-security challenges emerging in India's own backyard, as well as to secure itself as an important voice in framing global regulations. India should be expected to continue developing and utilising space assets for a number of defence-oriented functions, as well as pursuing the safety and security of its space assets, while also enhancing its civilian space sector.

Japan

Much like India, Japan's space programme and its ambitions were initially oriented toward the peaceful uses of space. In Japan's case, the non-military orientation of its space programme was conditioned by Article 9 of the Japanese Constitution that prohibited the country from acquiring military capability of any kind, a prohibition that was incrementally weakened by decades of subsequent practice. These reinterpretations of the constitutional intent still shaped the space programme to limit it to the use of space assets only in a non-military and non-aggressive manner. In 1969, Japan's parliament passed a resolution titled 'Space Development for Exclusively Peaceful Purposes' to restrict the country's use of space to peaceful purposes alone.[128]

Nevertheless, technological advancements over the past few decades and the changing regional and international security conditions have compelled Japan to re-examine its approach to space, with an emphasis on developing a 'full-spectrum national space policy that includes military usage'.[129] Japan's Basic Space Law that entered into effect in August 2008 enabled a transformation in the country's approach toward space.[130] It invigorated space activities, as well as questioning the normative assumption of the 'exclusively peaceful purpose' clause of the 1969 parliamentary resolution.[131] In June 2020, the Basic Plan on Space Policy was updated by Japan's National Space Policy Secretariat. It highlights the growing significance of outer space for national security and characterises 'superiority in outer space' as critical for Japan's national security.[132]

More critically, with the changing space-security environment, especially the emergence of a potent Chinese space power in its backyard, Japan has felt the need to develop appropriate countermeasures, including institutional innovation and capability development to maximise its freedom of manoeuvre, while minimising vulnerabilities and gaps. Accordingly, in May 2020, Japan established a new defence space unit. The Space Operations Squadron was set up as part of the Air Self-Defense Force. The new unit is expected be fully operational in 2023 and will be responsible for tracking space debris, as well as for protecting Japan's space assets from other potential threats. The new unit will also cater to the Self-Defense Force's (SDF) satellite-based navigation and communication requirements. According to then-defence minister Kono Taro, the squadron will work with the United States, especially the US Space Command.[133] Even though the new unit is planned as a small one, its establishment is clearly more than symbolic. It is in line with Japan's goals 'to ensure superiority in use of space at all stages from peacetime to armed contingencies', as stated in the December 2018 National Defense Program Guidelines.[134] This guidelines document further calls on Japan's SDF to develop appropriate 'capabilities including mission assurance capability and capability to disrupt [an] opponent's command, control, communications and information' due to the increasing development, testing and deployment as well as use of counterspace capabilities by a number of countries, including China and Russia. In November 2021, the government announced its decision to establish a second space operations unit to track counter-space threats via electromagnetic waves.[135] Defense Minister Nobuo Kishi said that the new base will form part of Japan's efforts to build its own countermeasures against a growing number of threats in space, pointing out that for Japan, the security and stability of outer space is critical.

In a related development, in 2019 news broke that Japan was considering plans to develop a satellite interceptor in order to be able to defend against a number of counter-space threats that could potentially target Japanese space assets.[136] The interceptor is to be built by the mid-2020s. Japan also has plans to launch a space surveillance satellite by 2026.[137] Driven by developments like the People's Liberation Army's (PLA) establishment of the Strategic Support Force that combines space, cyberspace and the electromagnetic domains, Japan's National Defense Program

Guidelines sought to develop a 'truly effective defence capability, "Multi-Domain Defense Force", which organically fuses capabilities in all domains including space, cyberspace and [the] electromagnetic spectrum', and 'can execute cross-domain operations'.[138]

Since the 2008 Basic Space Law, Japan has also undertaken structural changes that would streamline its space activities. For instance, recognising the requirement for a government oversight body for space activities, Japan has set up a Strategic Headquarters for National Space Policy within the Japanese Cabinet, under the leadership of the prime minister but with the participation of all cabinet ministers. This body is considered 'the highest decision-making body for national space policy'.[139] In addition, in 2012 the government established the National Space Policy Secretariat within the Cabinet Office, which acts essentially as the back office of the headquarters, while also coordinating space policies and space-related activities pursued by different ministries.

Despite maintaining a peaceful space programme for several decades, Japan faces compelling security drivers pushing it to adopt an ambitious space-security agenda that encompasses policy, institutions and capabilities. Since the Basic Space Law came into force, commercial and security concerns have become the two pillars of Japan's space approach. This approach is unlikely to change in the short to medium term, given the worsening regional and international security conditions and the expansion of great-power politics and conflict into outer space.

France

In a 2019 Defence Space Strategy, the minister of the Armed Forces, Florence Parly, called for a new urgency in development of military space capabilities, as the sudden emergence of 'New Space' begins to alter 'existing balances', and 'faster-moving innovation cycles are rapidly changing the criteria on which space power is based'.[140] Space protection, she said, based on much-improved space domain awareness (SDA), had to be a new, high-priority mission.[141] Cyber threats were identified as the main source of threat to space assets, even though such an attack would require 'precise knowledge' of the target's technical parameters.[142] The response had to be pan-European, centred 'mainly around a Franco-German core' which would build off 'complementary SSA [Space Situational Awareness] resources'.[143] The vision also included working with other partners, most importantly the US.

The document warned that France reserved the right to take countermeasures against wrongful acts against it in space, to retaliate against hostile acts and to exercise self-defence in the event of an armed attack in space'.[144] The underlying policy objectives for military development are identified, in a rather predictable way, as:

- strengthen space doctrine to establish concepts of military space operations,
- rejuvenate military space governance, and
- deliver adequate capabilities and human resources.[145]

More bluntly, the document says that the three main objectives are 'autonomous assessment and decision-taking'; seeing France as a 'driver of the space sector in Europe'; and acquiring the 'means to defend our capabilities and ensure compliance with international law, including self-defence'.[146] France has set itself four missions (doctrinal objectives): space service support, space situational awareness, operations support and active space defence.[147] The document called for complete capability by 2030, including in critical areas like the space contribution to ballistic-missile defence.[148]

In 2019, as foreshadowed in the Defence Space Strategy, France created its Space Command out of a pre-existing Joint Aerospace Force, which is set to grow from an initial 220 to 500 personnel by 2025.[149] In 2021, the Space Command participated in 'AsterX 2021', the first space-defence exercise in Europe, involving Germany, Italy and the US.[150] The aim was to expose Space Command personnel to various contingencies likely to arise in a conflict that extended into space.

A unique feature of the Defence Space Strategy was its detailed exposition on alliances and collaboration as a necessary precondition for the achievement of strategic autonomy.[151] The policy focuses first on Europe, with highest priority going to its partner Germany, and second-place mention for Italy. The UK was treated with a rather simple formula: 'possibilities for cooperation on space operation'.[152] While the EU possesses considerable civilian space power, it has no advanced military capacities, but, the paper says, it should. It called for a 'Space Europe' as part of the concept of

'Defence Europe', with the Franco-German axis at the centre, working especially on SDA. This has been made more urgent, the paper implies, by the fact that while NATO had agreed in 2018 on new security concerns about outer space, there is no plan for it to develop space capabilities, relying instead on their provision by individual member states if needed.

The policy downplays the US role, placing it among other French partners outside Europe, even though it is the most important ally in the area of SDA and military space operations.[153] Canada and Australia are treated together as offering space-industry development opportunities while being on the front lines of the Indo-Pacific.[154] India and Japan are singled out for expanding current value offerings, citing 'long-standing cooperation in the civilian space sphere' with India, especially on launchers, and a more recent set of joint initiatives with Japan, including a dialogue on space surveillance under the aegis of the General Secretariat for Defence and National Security.

United Kingdom

Under Prime Minister Boris Johnson and his agenda of making Britain 'great', space has been at the heart of his vision to establish the country as a great science power,[155] despite the fact that the UK spends less on space than either France or Germany. The government has also evoked new threats in space as a driver of policy. For example, in late 2020, the government called out Russia's aggression in space and escalating threats to space stability from kinetic ASAT weapons, ground-based lasers and attacks on highly vulnerable ground stations.[156]

In the UK's 2021 Space Strategy, national security was one of five key goals, expressed in terms of strengthened security and enhanced resilience, featuring both 'increased autonomy and more diverse collaboration' in order to 'respond to threats and deter hostile behaviour'.[157] The military and security significance of the strategy was underlined by the fact that the defence secretary was the first of two secretaries of state signing the public document, along with the prime minister. Space, the strategy says, has a role to play in multi-domain operations, and in critical infrastructure protection. One diplomatic objective would be to prevent the transfer of sensitive UK technologies for use in hostile space programmes. The strategy's departure points are like those of its allies, well captured in the observation of 'growing investment by other states in capabilities that threaten the use of space by the UK and its allies'.

When the Space Strategy was announced, the government also released a two-page document on the themes of a forthcoming Defence Space Strategy with the following three objectives:

- Enhance military space resilience and operational effectiveness for space protection, recognising that international cooperation will play a central role, obliging the UK to 'maximise the benefits of any space activities we conduct to our allies and partners'.
- Optimise space support to the front line, by integrating space policy and operations 'into a much wider range of activity than before, including operational planning, doctrine, capability development and training'.
- Support non-defence activities of the government, mainly through the UK Space Agency in its 'plans for small satellite launch and industrial growth at home', and through 'international collaboration on civil space programmes'. The latter will involve the provision of capabilities, infrastructure and personnel to partners at home and abroad. A major goal will be support to non-military critical national infrastructure in space to enhance their resilience, including through co-ordinated contingency and response plans. This would include development of options for a joint military/civilian National Space Operations Capability.[158]

In April 2021, the UK established its Space Command, billing it as a 'step in the development of a strategy to operate in space and protect UK interests'.[159]

Germany

The drivers of German space policy are similar to those of other leading economic powers and have not changed much since 2010: increasing great-power competition, the high dependence on space assets for everyday life, the potential of space assets to contribute to solutions for emerging global challenges, and US interests in working with its allies to shore up allied strategic positions in space.[160] There is the additional requirement to carve out a national space identity and sovereign capability as the European Space Agency (ESA) – which is not an EU agency – and the EU become more active. In 2021, the German Space Industry Association (BDLI) gave a simplified three-point summation of the policy goals: 'Space technology is indispensable in everyday life' and 'ensures state sovereignty', while 'spaceflight provides key strategic technologies of central importance for the economy'.[161] These priorities reveal a shift toward more explicit interest in space flight and national security compared with a decade earlier.[162] Internationalisation and partnership are key themes of German space strategy, in spite of an interest in carving out a clear national identity in space technology and space security.

In 2021, Germany announced the creation of a Space Command in its armed forces. Its main role will be earth observation and monitoring of space traffic, especially space junk. At the time, its military satellite capability comprised six units. The defence minister, Annegret Kramp-Karrenbauer, said the command was needed because of the 'increasing significance of space for our state's ability to function'.[163] The move followed similar steps by Australia, China, France, Russia, the UK and the US. Germany has no independent sovereign capabilities for space launch or weaponised space vehicles.[164]

The German air base in Ramstein is host to the NATO Space Centre, set up only in 2020. Key priorities will be coordinating the allies' activities in space, sharing information and supporting deployments using space-based capabilities provided by NATO countries. The government anticipates that issues related to space will play a prominent role in both the new fundamental security policy document of the EU – the Strategic Compass – and future NATO strategies. In the coming years, Germany will extend its own capabilities in areas such as space surveillance and contribute its own insights and capacities to NATO and the EU. Of some note, Germany has shown itself willing to operate outside NATO and EU frameworks by agreeing with Australia on a Declaration of Intent for a Military Space Partnership.[165]

BDLI has become an ardent advocate of an expansion of Germany's influence in European space policy in order to ensure 'independent access to space and sovereignty [for Europe and Germany] in satellites and launch vehicles, especially in a time of political upheaval'.[166] But in the very same breath, BDLI observed that 'no other branch of industry stands for peaceful international cooperation comparable to spaceflight'. This apparent contradiction in German policy seems somewhat unresolved, but the organisation clearly favours an expansion of the domestic national space sector, arguing that the country needs to remain 'successful in all segments of the space value chain – from small- and medium-sized enterprises (SMEs) to subsystem and system integrators'.[167] It called for the government to secure and expand 'Germany's leading role in the ESA … for the long term'.

One of the main vehicles for this influence has been direct subvention to the ESA budget. In 2021, Germany contributed 21.3% (€968.6m) of the annual activities budget, just behind France at 23.4% (€1065.8m).[168] In 2010, the government spent €1.2bn on space, the bulk of which was a subvention to the ESA (€637m), with only €240m going to the National Space Programme.[169] In 2018, the balance of the expenditure on these two items remained much the same (€852m and €285m respectively) though slightly more proportionately went to the ESA.[170] Significantly, the EU central budget supplied a bigger share of ESA contributions in 2021 (some 26%) than either Germany or France. The closest EU member was Italy, with 13%, and the non-EU member paying the greatest share was the UK, with 9.2%. Thus, while Germany is a leading funder of ESA, it faces competition for influence from other top funders.

The focus of Germany's national space efforts has been directed at the following priorities: strategic space skills, space science, new markets, whole-of-government security, exploration and technological independence.[171] This independence, however, is understood more in terms of unfettered access to state-of-the-art technology than having a fully self-sufficient space industry.

Implications for international security

There is a remarkably strong international consensus, reflected in the UN Committee on Disarmament in November 2021, that outer space is, for better or worse, a potential war-fighting domain among the great powers, as well as the site of information collection that is highly critical to daily social and economic life of all states. Space is seen by most states as a focal point both of great-power political competition and emerging commercial activity, each of which needs to be regulated in some way. This is the setting in which the three great space powers (the US, Russia and China) currently position their security interests, their competition and their ambitions.

The strategic significance of space operations depends primarily on the military uses (capabilities delivered) to which countries can put their space assets in a timely fashion. These uses align with the main capabilities categories analysed above: intelligence, command, counter-space and space protection. Through these aspects of space operations, states individually or in partnership can potentially contribute to all aspects of their own defence policies: intelligence assessment of the intent and capabilities of potential adversaries; one's own force generation and development (raise, train and sustain); deterrence of potential adversaries; early warning of changes in adversary war readiness; war fighting; and military operations other than war. Space is now a national-security issue for all states.

China, Russia and the US can achieve far more in space denial than in space dominance (freedom of manoeuvre). Ground-launched cyber attack or kinetic attack on ground stations may be the most practical decisive elements to achieve space denial.

To a lesser extent, the strategic significance of space operations will also be determined by political perceptions of the power that these capabilities represent. This might be understood as the diplomatic context, but as important as that is, it will not be the dominant consideration either for the three great space powers or their current and potential allies. The diplomatic context and perceptions of the balance of space power will shape the motivations of states to align with one power or another, but will not shape the character of the alignment as much as the military capability uses discussed in this paper.

Prompt global strike

The strategic significance of outer space is global, at a time when military capabilities supported by space assets or operating in space can deliver effects in any region of the world. This is well captured in the United States' concept of 'prompt global strike', which is helping to drive US interest in hypersonic weapons, as well as other technologies.[172] This concept, which first emerged in the US in 2003, is that the US should be able to 'strike targets anywhere on earth with conventional weapons in as little as an hour, without relying on forward-based forces'. Effective and sustained use of such a capability in wartime, in conformity with international law, is not possible without space-based systems. For Russia and China, this is one of their greatest concerns, short of nuclear war with the US.[173] On the other hand, notwithstanding the perceptions in Moscow and Beijing of clear US superiority in such capabilities, the US – looking to the longer term – has a similar concern about those two countries. The US Congress is now pressing the Department of Defense to quicken the pace of developments in this area, driven in part by news in October 2021 that China had successfully tested a hypersonic missile just two months previously.[174] Along with prompt global strike, the more enduring concerns about how to avoid placement of weapons of mass destruction in space and missile proliferation remain a high priority, while more novel concerns have arisen, such as directed-energy weapons and cyber threats to space systems (including ground support).

Strategic stability

Our estimate is that the sense of competition and even hostility that we see among the great powers will intensify, driving up budgets for military space activities. China will continue to gain capabilities and continue closing the gap between it and the US in military space power. The prospects for direct combat encounters in space remain very low outside of near or imminent war between the great powers. That said, harassment operations – already a feature of space operations – will likely increase in frequency, although neither China nor Russia will want to see any incidents they provoke in space have an escalatory effect.

Regardless of these judgements, the next decade will see increasing diplomatic disputes around space policy, especially traffic control and space domain awareness. Some breakthrough on traffic management is possible, as is wider information sharing and transparency on civil uses of space. On the other hand, testing and development of space-related weaponry and intelligence, surveillance and reconnaissance capabilities will continue to heighten anxieties and insecurities. Advocates of cooperative security and responsible state behaviour in space will continue to push for new norms or regimes, possibly even confidence-building measures. These may have a positive effect and help dampen tensions. But as long as the main driver of these tensions in space – the state of geopolitical competition – continues on its current trend of escalation, then the prospects for new agreements in the spirit of cooperative or mutual security are unlikely to make much progress.

Balance of space power

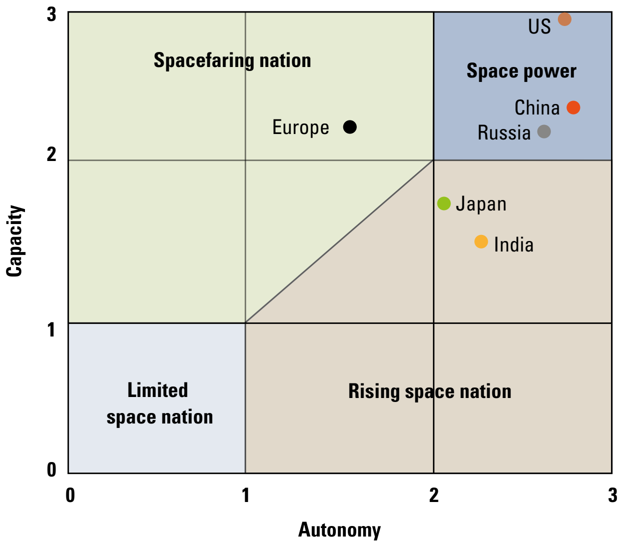
In terms of broadly defined space power, China will easily overtake Russia by 2035 and by so doing it will become one of the two world-leading space powers, a good decade ahead of its official, if somewhat formulaic, target date of 2045. In terms of military space power, China will increasingly be able to disrupt the United States' and allied space operations, either through attacks in space or on space-related ground infrastructure. But by most measures, China has a long way to go to match the strategic power of the US in space, if we understand it to be based on formal collective-security arrangements among allies or through emerging relationships, especially with India.

An authoritative study published in 2020 estimated that the US 'remains the leading space power and will retain that position for decades'.[175] A similar conclusion was reached in a 2021 report about the ground segment of China's space programme.[176]

A different view of relative space power, one that pays more attention to comprehensive space power, would see China as much closer to the US. This is the approach taken by several researchers at the European Space Policy Institute (ESPI), who devised the broad assessment represented graphically in Figure 1, which also puts Russia much closer to the US. The assessment measured four broad categories of space power: hard capacity, soft capacity, technical autonomy and political autonomy.

One value in this model of analysis of space power, in contrast to a view of states that can launch and operate satellites (a space-faring state), is that we see only three poles of space power around which states can gravitate for strategic and military power – the US, China or Russia. The European Union is not a military space power and its leading military space actors (Germany, France and Italy) do not by themselves or collectively represent a significant pole of strategic space power. Another virtue of ESPI's analytical approach is that it helps us appreciate, in this complex multi-element evaluation, that India and Japan are (merely) rising or aspiring space states that might not yet qualify for the appellation of 'space power'.

Figure 1: **Space power matrix**



Source: Marco Aliberti, Matteo Cappella and Tomas Hrozensky, *Measuring Space Power: A Theoretical and Empirical Investigation on Europe* (Cham: Springer, 2019), p. 54. Reproduced by permission.

Implications for allies and partners

The most significant national-security alliances in the world all involve the United States: the Five Eyes agreement and underpinning bilateral relationships (such as UK/US and Australia/US), NATO, several bilateral or trilateral US treaties or commitments (with Israel, Japan, South Korea and Taiwan), and the coalition (emerging alliance) of the Quad (the US/Japan/India/Australia). Of these, only the Quad and the US/Taiwan relationship are not governed by formal treaties. In comparison, Russia has military alliance relations of a sort with several countries (such as Belarus and some other members of the Commonwealth of Independent States), and China has a formal security treaty with North Korea, in place for six decades and renewed in 2021. Except for the Russia–Kazakhstan agreement on use of the latter's launch facility at Baikonur, extended in 2021 to run until 2050, and a space-tracking facility in Belarus, issues of military space operations do not intrude into these relationships.[177] India and Russia enjoy cooperative relations in national security, including some level of commonality in diplomatic positions on outer space, but not in space operations for national security. Looking ahead, the emerging closeness of military and security relations between Russia and China remain a focus of interest in this paper for non-US alliances or coalitions.

Deterrence is a foundation

US allies addressed in this report base their national-security policies for space on a broad concept of strategic stability, but one which is defined in practice largely in terms of UN negotiations on governance. We rarely see language from them that matches our analysis above on strategic stability in space or the ambitions of the three great space powers. Ultimately, strategic stability is probably more about questions of hard military deterrence in an environment of escalating military tensions than some European countries would like it to be. There are differing views on whether deterrence can only be country specific or whether it can be domain specific as well. For example, the US wants to deter China from attacking Taiwan but it also wants single-domain deterrence, such as deterring Chinese cyber attacks every day of the year. In space policy, should the US and its allies strive for a specific 'balance of power' in space capabilities and intent that might be seen to deter aggression in space, or can it only reasonably expect to deter China based on the sum of its military capabilities and those of its allies in all domains? Whatever the theoretical answer to this may be, it is a question for which there is almost no reflection in the space polices of certain European allies of the US. That said, there seems to be an implicit consensus around the belief that the allied contribution to space situational awareness and cyber defence of the ground segment are important elements of collective deterrence in space.

Ground segment is key

No US ally has operational space forces that could undertake integrated kinetic combat operations in space with it. This is unlikely to change for the next decade. This isn't the case for allied kinetic or cyber operations against space ground-support facilities of an adversary or for allied cyber operations against targets in space (including the data being transmitted between space and earth). Most US allies would have the capabilities to mount kinetic attacks on an adversary's ground segment. There is room to believe that some US allies, such as the UK and France, already have the capability for cyber strike to degrade an adversary's ground segment and could already be working in close cooperation with the US on its use.

Underpinning its global network of military and civil-sector space partners, the US Defense Department has signed around 120 agreements with some 35 countries for the Provision of Space Situational Awareness Services and Information, the most recent being with Ukraine in September 2021, although it is not a NATO member. The Space Force has personnel deployed in a number of non-treaty allied countries, such as Saudi Arabia, where their mission is related to electronic warfare principally involving Iran.[178] There are Space Force units or personnel operating on the territory of treaty allies, such as Japan, Greenland (Denmark) and Diego Garcia (UK).

Intelligence as the main vector of new allied effort

The single most important military consequence of space alliances, long standing or more ad hoc, is in the field of intelligence collection and analysis. Good intelligence helps keep the peace and, if war breaks out, can enable a military victory. Even now, intelligence assets, and related information capabilities such as GPS, remain the most important military capabilities based in space. States are paying much more attention to a particular part of this intelligence effort – space domain awareness (SDA). This is the ability to stay informed of normal satellite operations in peacetime, both civil and military, and for early warning of potential military strikes on space or ground assets. Sitting between these two important interests is the ability to monitor weapons testing in and from space. The most powerful driver of the heightened interest in SDA is growing anxiety about states' ability to defend their satellites from the many and varied forms of attack, a mission called 'space protection'.

Outside of direct military contributions, there are probably three further military virtues in space alliances with any great space power: possible modest redundancy if some assets go down, alliance pooling of the science and technology of space, and privileged access to space-derived information or analysis of it. Other strategic benefits include: diplomatic collaboration on irresponsible behaviours and privileged participation in commercial and governmental space activities of allies.

Combined Space Operations initiative

In spite of reservations about expansion of the Five Eyes, there has been a de facto move to do so in space policy, with France and Germany being invited to the Combined Space Operations (CSpO) initiative. This was set up in 2014 by four of the Five Eyes countries, eventually expanding to include New Zealand in 2015, then Germany in 2019 and France in 2020. Senior military officers of the seven countries met in 2019 to discuss the expansion, including a focus on 'operational concepts, personnel needs and infrastructure requirements for multinational command and control of space forces in and through the Combined Space Operations Center and the other national Space Operations Centers'.[179] One of the motivations of growing the initiative was to optimise resources for enhanced mission assurance and resilience.[180]

One indicator of the full potential of the CSpO will be the extent to which the US is prepared to share sensitive space-related technologies, including IT-based analytical tools. In 2021, the UK was the first country to join a US-led initiative called Operation Olympic Defender (OOD), which is tasked with developing a 'coalition of allied spacefaring nations to work together to deter hostile acts in space, strengthen deterrence against hostile actors and reduce the spread of debris orbiting Earth'.[181] OOD was set up in 2013 but provision for allied participation was only made in 2018, in part due to reluctance in the US to share its last remaining 'crown jewels'.[182] Australia and Canada have since joined OOD, but it is unclear which other allies will do the same.[183] In August 2021, as part of the implementation of OOD, the UK became the only country to gain access to the Americans' Standardised Astrodynamics Algorithm Library, a 'collection of algorithms and information about orbital physics that helps the Space Force determine the trajectory of objects in space'.[184]

This element suggests three emerging characteristics of military space alliances: the most important arrangements will be those with a tiny core of countries with very high levels of mutual trust; the ground segment will be the main focus; and there will be a military cyber aspect that will be indistinguishable from the space element.

NATO

NATO agreed its first space policy in 2019. In 2021, NATO members agreed that attacks to, from or within space could lead to the invocation of Article 5, with a decision to be taken 'on a case by case basis'.[185] However, the US is a strong advocate of NATO doing more in space and has high expectations of it: 'NATO's Space strategy and doctrine should be poised to counter, respond to, and deter the full range of competition and military conflict, including hybrid threats and military activities that fall short of war', according to the head of US Space Command.[186]

In 2021, the alliance announced it was developing a Strategic Space Situational Awareness System (3SAS) at NATO headquarters at a cost of €6.7m, to be funded by Luxembourg, a notable stakeholder in civil-sector space operations.[187] NATO space activities also include operational planning, capability development, industrial innovation and integration of space scenarios in training and exercises. NATO has committed over €1bn to buy satellite communications services for the period of 2020–34, its largest such investment. NATO has included space in its seven priorities for R&D in emerging and disruptive technologies.

NATO activities will be limited by the German position, which is that while NATO missions and operations will 'receive support from space services such as reconnaissance, navigation and communications', its role in space will be one of coordination and it 'will not have its own capabilities in space or deploy weapons systems there; nor 'carry out any operations in space'.[188] Yet the German position, shared by many NATO countries, will not overly constrain the alliance's contribution in military space operations since it will be working mainly in the ground segment, where it brings important assets to bear.

Non-NATO European institutions, especially the European Space Agency (ESA) and the EU, are important influences or at least 'book-ends' on NATO positions and capabilities. ESA, exclusively a civilian operation, and including non-EU members like the UK, is one of the most powerful actors in space. While funded by its members and through the EU budget, it spends more than any single European country except for France and sits in third place after the US and China.[189] Its work contributes to SDA and therefore to the national-security intelligence of all its member states. In geopolitical terms, the ESA appears close to the status of a neutral state, but at least acts as a counterweight to the symbolic and nationalistic over-claiming and ambitions of countries like the US and China. It also serves as a unifying force in civilian space operations and policy for Europe in circumstances where NATO and the EU do not. There is some prospect for a coherent EU policy as it works toward a space strategy for security and defence. But ESA and the EU, like NATO itself, have little prospect as organisational hubs for national-security policies of European states in space, if only because of the emerging tilt toward Russia of some of its members.

Other key European countries are pressing ahead with flexible (non-NATO) approaches to collective security for space. They point to independent arrangements for information sharing (e.g. between France and Sweden, or France and Italy) or advanced capabilities in cyber security that are already contributing to mutual defence.

The concept of 'sovereign space capability' is often used in policy statements about new directions of space policy and often linked to other concepts of European strategic autonomy and national self reliance. There are few reliable metrics for evaluating such statements. The upper limit for sovereign space capability for the national security of all NATO members, apart from the US, would appear to be in independent command and control satellites and in analysis of space-derived intelligence.

Another key element of the new space policies of leading European members of NATO has been the drive to boost domestic space industries. This implies a degree of civil–military fusion, to use a Chinese term, that has been less well developed in the sector in Europe. In certain countries, like Germany, this policy setting is much weaker than in countries like the US and France, who have more longstanding military space programmes, with a domestic industry engaged in it for just as long. The general picture in Europe as a whole is that the absence of great demand from the armed forces (due to over-reliance on US assets) has meant that Europe's space industry has had little chance of creating economies of scale in the same way that its US counterpart has.

Quad

The Quad, which brings together the US, Japan, India and Australia, may well be the most promising new vehicle for alliance cooperation, including as it does two second-tier space powers (Japan and India) as well as the US and Australia (as a key southern-hemisphere location for ground-stations). In September 2021, at the first in-person meeting of the group's leaders, they agreed for the first time to extend their cooperation to outer space.[190] The summit led to the creation of a working group on space, though the scope of its work was to be entirely for peaceful purposes ('monitoring climate change, disaster response and preparedness, sustainable uses of oceans and marine resources'), and on responding to challenges in shared domains. More importantly, they agreed to consult on international regimes and principles for 'ensuring the sustainable use' of space.

Among the possible areas of Quad cooperation, SDA will be the most important. All four members see China as a cause of the worsening space-security environment and all share a sense that space tracking and monitoring capabilities need to be upgraded, especially for early warning. Traditionally, India has been sceptical of SDA partnerships with other countries, but has recently agreed to SDA cooperation with the US, Japan and France. The Quad countries could take the lead in forming an SDA partnership, which could be expanded to include other countries later.

Another area for Quad cooperation is in dealing with the growing intelligence, surveillance and reconnaissance (ISR) requirements over land and maritime spaces in the Indo-Pacific. Space-based ISR collaboration can be a win-win for all four partners, considering both the amount of coverage needed and the complementarities among their space agencies. They can share both ISR data analysis and cost. India has signed an agreement with the US that will ensure security of any information shared between them, while Japan and Australia have their own bilateral information agreements.

Russia and China

Over many years, Russia has demonstrated clear ambitions to court China as an ally or partner in space policy, reflected in 2021 by the statement that it wanted to strengthen ties in aerospace technologies and enlist China's support in diplomatic initiatives to prevent the weaponisation of space (meaning the continued expansion of US and allied military space potential).[191] Also in 2021, the two countries signed a Memorandum of Understanding on new joint activities, including a permanent research station, the International Lunar Research Station, that will orbit the moon and also support lunar surface research.[192] The two countries had previously signed a space cooperation agreement in 2017.[193]

Russia has also extended assistance to China for its space station. China was not part of the International Space Station because of the risk of Chinese espionage. In 2011, the US put in place legislation that has prohibited any cooperation between the US and China in the space arena, forcing China to seek Russian help. Beijing took Russian equipment to build two temporary space stations in 2011 and 2016.[194] In April 2021, China and Russia announced yet another collaboration, a robotic asteroid mission called Kamoʻoalewa, to be launched in 2024.[195]

The Russia–China partnership is a natural one: Russia has the experience, while China has the resources.[196] While their partnership could provide healthy competition to other space programmes, there is also concern that this cooperation includes counter-space capabilities that are meant to disrupt, deny and destroy other countries' assets. Furthermore, their collaboration now includes common positions on many issues of space governance. Such space cooperation could further sharpen the divide within the global community, resulting in insurmountable governance challenges.

Russia and China could form a closer relationship on military space matters, and it may be that such a relationship, if developed to its full potential, could have a more serious impact on international security than closer Russia–China naval and air operations in the Western Pacific. However, the trust levels between Russia and China do not match those that operate in the Five Eyes or in the seven countries in the CSpO, which makes meaningful long-term military cooperation in space less likely. Of some note is Russia's reaction to China's reported test of a space glide vehicle with in-flight hypersonic-missile launch capability, which was to reject the need for concern, claiming that 'China is developing its armed forces and weapons systems without going beyond the scope of any international commitments'.[197]

Conclusion

Before the collapse of the USSR, geopolitical tensions over space, its connections with nuclear-war fighting and the placement of weapons in space were vital considerations for the two superpowers. Since that time, China has become a space power with many more achievements behind it than Russia. While the likelihood of nuclear war has been substantially reduced, geopolitical tensions around space issues are taking an ominous turn. In fact, states have even higher levels of suspicion and insecurity about the military uses of space than during the Cold War, in large part because of new military-related technologies. Great-power ambitions in space have become more sharp-edged and confrontational. Russia, in spite of its weakened economy and struggling space programme, can still cause considerable physical disruption to US and allied space assets. China has become the world's largest single economy (on purchasing power parity estimates), with ambitions in the military uses of space to match. Its disruptive potential in wartime against US and allied space assets will continue to grow. At the same time, the US and its closest allies are already committed to strengthening their collective space power to constrain the effects of China's increasing potential.

On the technological front, the three great space powers, especially the US and China, see strategic competition in space as a subset of their information-technology confrontation, with the US in 2021 conspicuously framing its military strategy for space as one of 'digital dominance'. Even as new kinetic weapons for use in space are being developed, a very large share of policy attention is taken up by the need to manage cyber threats in space and exploit the same technologies for offensive purposes, in the ground segment as well as the orbital domain.

This paper framed space power in several dimensions according to the ambitions of leading countries in the field: informational and intelligence; command; counter-space; and space protection. There is a visible mismatch between the criticality of military space activity (especially informational, intelligence and command) and the ability of states to defend physical assets (space protection), especially from cyber attack. This almost inherent vulnerability of space systems is a major driver of new insecurities around space competition among the great powers. States are tying this insecurity to the need to prevent irresponsible behaviours in outer space and to avoid actions that might impede access to it. But the two problem sets – building better systems of space protection and promoting good behaviour – are quite different types of challenges.

Our forecast is that geopolitical tensions over space will increase, though the risk of war will not be particularly aggravated by current space operations and emerging capabilities. US and allied space power will contribute to deterrence of China and Russia for major war, though not for lower-level conflict. The most important single contribution that allies can make to shared strategic and military interest in space operations is in the area of intelligence analysis. This can be information about and/or analysis of the ground segment or the orbital segment. But most importantly, the intensity and scope of the exploitation of space-derived raw intelligence determines the primary military and strategic value of a space asset. At certain times in a conflict, depending on the circumstances, decisions about how to direct a particular satellite asset and the degree of protection to be given to it will be based on the value of the intelligence being collected and the potential weight given to analysis of it. Accurate positioning and timing data from space is equally essential for most modern weapons systems.

In these circumstances, the civilian sector can be more valuable for intelligence purposes than dedicated military satellites. Space-derived intelligence contributes massively to indicators and warning, current intelligence analysis (especially in review of massive volumes of photo reconnaissance materials) and longer-term analysis. These can be highly significant contributions which are often not as prominent for traditional space analysts or planners, for whom the main preoccupations are the objects in space. The importance of this aspect is demonstrated in efforts to strengthen military space cooperation in the Five Eyes intelligence partnership.

Notes

1 See UN General Assembly, 'Delegates Approve 5 Draft Resolutions, as First Committee Takes Action on Peaceful Use, Non-Weaponization of Outer Space, Chemical Weapons', GA/DIS/3676, 1 November 2021, https://www.un.org/press/en/2021/gadis3676.doc.htm. The First Committee of the UN General Assembly voted 163 to eight, with nine abstaining, to establish an open-ended working group to 'make recommendations on possible norms, rules and principles of responsible behaviours relating to threats by States to space systems'. The resolution, proposed by the UK, was co-sponsored by 30 other governments. The eight voting against the resolution included Russia, China, North Korea and Iran.

2 Rajeswari Pillai Rajagopalan, 'Electronic and Cyber Warfare in Outer Space', UNIDIR Space Dossiers 3, 2019, p. 1, https://www.unidir.org/files/publications/pdfs/electronic-and-cyber-warfare-in-outer-space-en-784.pdf. In October 2021, a senior US official articulated a long-held view in the US that cyber attacks were the most serious threat to space assets. See Don Graves, 'Remarks by U.S. Deputy Secretary of Commerce Don Graves at the Department of Homeland Security Space Cybersecurity Symposium', 13 October 2021, https://www.commerce.gov/news/speeches/2021/10/remarks-us-deputy-secretary-commerce-don-graves-department-homeland-security.

3 Clémence Poirier, 'Interdependence between Space and Cyberspace in a Context of Increasing Militarization of Outer Space–a French Perspective', in Annette Froehlich (ed.), *Outer Space and Cyber Space: Similarities, Interrelations and Legal Perspectives* (London: Springer, 2021), p. 68.

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6 IISS, Military Balance+, accessed 27 November 2021.

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14 Brendan S. Mulvaney, 'Preface', in Kevin Pollpeter et al., *China's Space Narrative: Examining the Portrayal of the US–China Space Relationship in Chinese Sources and Its Implications for the United States*, China Aerospace Studies Institute and the Center for Naval Analyses, 2020, p. 5, https://www.airuniversity.af.edu/Portals/10/CASI/Conference-2020/CASI%20Conference%20China%20Space%20Narrative.pdf?ver=FGoQ8Wm2DypB4FaZDWuNTQ%3d%3d; Pollpeter et al., *China's Space Narrative*, p. 24.

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