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Star Wars and Space Clubs

By Tom Goulding

In 1999, Thomas Bell, writing for the US Center for Strategy and Technology suggested that it was "inevitable that mankind will weaponize space and equally likely that this will take place in the next thirty years". Space is increasingly openly considered as a military domain alongside land, sea, air, and cyber, where national security and civilian livelihoods are to be defended. General Mark Milley, Chairman of the USA Joint Chiefs of Staff believes "the first shots of a future war between great powers is likely to be in space and cyber", and militaries around the world echo his sentiment. In this edition of Space in Focus, Tom Goulding investigates what space warfare is, why it matters, and what can be done about it.

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A very short introduction to space warfare

The history of the weaponization of space follows hot on the heels of exploration. The earliest documented tests of American anti-satellite weapons took place within two years of the nation's first satellite launch, and since the Cold War space has been a key area to demonstrate technical and scientific achievements. In turn, attempts mitigate the threat of military proliferation in space began early with the 1967 Outer Space Treaty[1] and the 1979 Moon Agreement[2]. Governments wanted assurance against both threats to space assets (such as communications satellites) and the use of space to deliver weapons to targets on Earth. Nevertheless, as the use and value of space assets for both military and civil applications have grown, militaries have taken note of the vulnerabilities that this introduces. In the words of the Chief of Space Operations in the USA's Space Force, "[Space] underpins our national security, it underpins our intelligence efforts, it underpins our treaty verification, it underpins our economy, it underpins every instrument of national power." The Americans are not alone in realising the fundamental importance of space: at the turn of the millennium Chinese strategic communications noted that "for countries that can never win a war with the United States by using the method of tanks and planes, attacking US space systems may be an irresistible and most tempting choice."[3] Funding was poured into militarising space in direct response to such risks, with American, Chinese, and Russian tests taking place throughout the 21st century. As India joined the ranks of anti-satellite weapon testers in 2019, Todd Harrison of the

[1] United Nations Office for Outer Space Affairs (1967). *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.*

[2] United Nations Office for Outer Space Affairs (1979). *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*.

[3] Wang Hucheng, The U.S. Military's "Soft Ribs" and Strategic Weaknesses (Liaowang, vol. 27, reprinted in Xinhua Hong Kong Service, 5 July 2000, in FBIS-CHI-2000-0705, 25 July 2000)

Center for Strategic and International Studies commented that they had made their belief in space weapons as "a legitimate means of self-defense by deterrence."[4]

Recent developments that have attracted widespread attention[5] focus on launches of space objects with unclear purposes. 'Counterspace' is an umbrella term for any technology that could be used to deceive, disrupt, or destroy space systems, and the line between satellites that are designed for this and those that are for purely scientific purposes is becoming blurred. This is exemplified by the development of Russian satellites that release other, smaller projectiles that they claim are merely other satellites, Chinese satellites with robotic arms that can grab other satellites as well as collect samples, and increasing watchfulness around 'space stalkers', ostensibly peaceful satellites positioned near other satellites during peacetime, potentially to be used during a crisis.

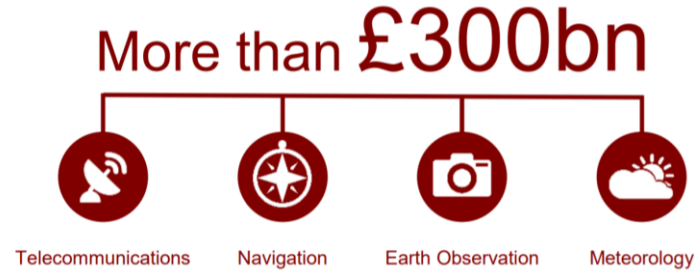
What you can't see can hurt you

Despite our satellites being out of sight, the protection of space should absolutely be kept in mind.

Economic value

The economic value generated and enabled by space is staggering. Succinctly summarised by Neil deGrasse Tyson, a famous science communicator, "The value of our space assets is not just the cost of the design and launch of that one satellite, it is the commerce it enables, which is rising through trillions of dollars of our commerce and our economic stability."[6] London Economics have repeatedly found support for this claim in the United Kingdom and European Union in our *Size and Health of the UK Space Industry* and *GSA GNSS Market* reports.

Figure 1 Wider UK GDP supported by satellite services



Note: UK non-financial business economy only.

Source: London Economics (2018). Size and Health of the UK Space Industry 2018.

Space systems allow people and governments around the globe to see with clarity thanks to Earth Observation, communicate with certainty thanks to Satellite Communications, and navigate with accuracy thanks to GNSS. As the space economy continues to grow and underpin more value, the security of space operations is essential to secure the benefits from further services, exploration, and potentially even the Martian colonisation aspirations of the likes of Elon Musk's SpaceX. Taking the UK as an example, as a broadly typical developed and globalised economy we find that over 15% of GDP[7] is currently enabled or supported by satellite services space, with a space-sector income growth rate of 3.3% per annum between 2014/15 and 2016/17, outpacing growth in the general UK

[4] Center for Strategic & International Studies (2021). *Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons.*
[5] ibid.
[6] United States Space Force (2021). *CSO Raymond and astrophysicist Neil deGrasse Tyson discuss future of the Space Force.*
[7] London Economics (2018). *Size & Health of the UK Space Industry 2018*

economy by 1.3%[8]. **Humanity's economic dependence on space now and in the future is a foregone conclusion.**

Space systems are also critical to our ability to respond to natural and man-made disasters and monitor long-term environmental trends. They underpin the international Cospas-Sarsat programme that detects and locates emergency beacons for search-and-rescue authorities and play increasingly vital roles in on-the-ground disaster recovery work.[9] London Economics have previously[10] outlined how the automated, repeatable, consistent, objective, and wide-area coverage of space-based Earth Observation techniques mean that 35 out of 45 essential climate variables are already monitored from space[11], with programmes such as the UK Space Agency's International Partnership Programme[12] pioneering the use of space-based data collection in an increasing number of domains.

Humanity's future

The second reason to care about space is that **space weapons can permanently hamper humanity's long-term capabilities**. The fear among many commentators is that the use of space weaponry will create debris. Debris in space is extremely dangerous due to the large relative speed between objects. If weapons are used against satellites, the destroyed satellites effectively become uncontrollable weapons themselves and, as such, they indiscriminately impact all other satellites around them, regardless of country of origin or intended use of those satellites. Follow-on cascading impacts from such debris clouds can cause collateral damage that render entire swathes orbit uninhabitable by satellites. Loss of these orbits can and will result in reduced functionality from space-based assets, and in the extreme 'Kessler effect'[13] case could leave humanity trapped within Earth's atmosphere as launches become impossible. Space warfare has all the markers of heading towards a Tragedy of the Commons[14] situation, whereby prioritisation of personal goals override the long term interests of all.

Geopolitical escalation

A third reason to be seriously concerned about the weaponization of space is the threat it poses to political stability back on Earth. Military strategists have long used 'wargaming' – playing out real military scenarios – to test out strategies and prepare themselves for the real conflict. In most modern war games, commanders have repeatedly resorted to pre-emptively destroying or denying opposing space assets. This often, inevitably, leads to rapid escalation into a full-scale war and even triggers nuclear responses. One such commander commented 'If I don't know what's going on because I have lost my eyes and ears in space, I have no choice but to hit everything, with everything I have'[15]. Space warfare, then, is simultaneously an extremely attractive option for a high-impact pre-emptive strike and an almost sure-fire way to rapidly escalate conflicts.

[8] London Economics (2018). *Size & Health of the UK Space Industry 2018.*
[9] European GNSS Agency (2019). *GSA GNSS Market Report – Issue 6.*
[10] London Economics (2020). *Space in Focus – Earth Observation: a tool for a more resilient and sustainable world?*
[11] UK Space (2019). *Stratospheric green growth.*
[12] London Economics (2019). *Economic evaluation of the International Partnership Programme (IPP): Cost Effectiveness Analysis.*
[13] European Space Agency (2020). *The current state of space debris.*
[14] London Economics (2020). *Space in Focus – Gold from Trash.*
[15] DeBlois, M., et al. (2004). *Space Weapons.*

So, what can we do?

There are generally three categories of solutions discussed. In the order that they will be evaluated, these are:

- Technological dominance, which aims to make space warfare unlikely to be successful for opponents;
- Treaties, which aim to make space warfare impossible by making it illegal; and
- Trusting in national self-interest, which aims to set up institutions that ensure space warfare is sufficiently harmful to deter all would-be involved parties.

Technological Dominance

Big-stick diplomacy relies on the threat of military strength in international diplomacy. To maintain an effective threat in the space domain, technological dominance is essential, and so military innovation and investment in space continues.

A pre-condition for technological dominance in space is likely to involve placing more assets in space. However, satellites move along easily observable and predictable paths, so increasing military dependence on them reduces resilience and makes them more attractive targets. The impact of lost space assets is greatest for more developed nations. In short:

- The more dominant a nation is in space, the greater the incentives are for others to attack their space assets as they stand to lose less from retaliation or collateral damage.
- The smaller the gap in technology between nations in space, the greater the incentives are to invest in more destructive technology to gain the upper hand, with only the constant mutual threat of colossal damage keeping any country from going on the offensive.

A final concern is that defence justifies offence: the militarisation of space in the name of defensive technological superiority can itself be used to justify retaliatory or pre-emptive offensive action.

Treaties

Treaties are the primary source of international law, creating grounds for actions of sovereign states to be punished as illegal. Despite a historical focus, several issues hinder the success of treaties.

The number of parties who must agree is growing constantly: in 1959, when the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was formed, there were 24 members. As of 2019 there are 95[16]. Once agreement has been achieved the rapid rate of innovation means that treaties require updating to be fit for purpose. A final complication comes from the self-interest of heavily space-involved countries, whose involvement is essential for treaties to have a meaningful impact. At present, the US on one side and China and Russia take turns vetoing each other's proposed treaties, which are wielded as attempts to asymmetrically hamper the other side, such as by banning technology they are known to have under development or in orbit. Multiple draft treaties failed in the United Nations in 2008 and 2014, and the international community seems to have moved on since then to alternate, less strict options. These softer options are the focus of the last option we consider.

[16] United Nations Office for Outer Space Affairs (2021). *Committee on the Peaceful Uses of Outer Space: Membership Evolution.*

Trust in national self-interest

By some metrics, weaponization of space has already happened, rendering many conversations of regulating this moot and leading to US Space Force commanders focusing instead "on norms of behaviour"[17]. The United Kingdom has also made a recent proposal — "Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviours"[18] — looking at problems in space through a 'soft law' approach. Such an approach involves agreeing to rules or guidelines that have legal significance but are not binding. In the context of space, this could create something similar to the 1972 Convention on International Regulations for Preventing Collisions at Sea, which govern the "rules of the road" for ships. Importantly, these bodies of soft law only require the definition of behaviours that all agree are best practice, such as agreed-upon safe distances between satellites.

Crucial to understanding the shift in attention by nations to soft law and 'norm and behaviour' based solutions is that they only work when it is in the interest of all parties to abide by the rules. These soft laws harness the self-interest of nations to get them to agree to 'rules of the road' that ensure they can pursue their interests in space without fear of accidentally triggering economic or geopolitical harm. Where pursuit of technological dominance exacerbates the risks of space warfare and treaties continue to go unsigned, relying on the self-interest of nations to develop positive rules, norms, and behaviours seems to be the most promising solution available.

An economic approach to space warfare

Game Theory and rational choice

Game Theory is a branch of economics that came to prominence in the early days of the Cold War as a means to mathematically describe the interdependencies between the USA and the Soviet Union that govern decisions on whether or not to engage in nuclear attacks. The theory is built on the idea of 'rational choice', which states that rational individuals (or, in this case, nation states) will always act in their own self-interest and, in fact, will seek to maximize their own welfare. Welfare is generally defined along the lines of maximising the 'payoff' of an action, where the payoff is the gain from carrying out the action minus the cost of any reaction to it. For example, the payoff from stealing an apple takes into account both the gain from having the fruit, the gain of not of having to pay for it, and the cost of an increased chance of being caught and punished.

Rational choice theory has found applications in explaining a variety of phenomena, from contract negotiations[19] to the development of nation states[20]. In both examples, self-interested agents developed institutions, rules, and norms that create positive returns for society. With the right starting conditions, effective solutions to space warfare could also come about in a similar fashion.

Club model economics

The power to define norms rests with the ability to enforce them, and so achieving the right starting conditions requires some clever policy. Club economics provide a starting point. Clubs, in the economic sense, are defined as voluntary groups whose members derive mutual benefits by sharing some resources or the cost of producing something, where members can be excluded from the

[17] Space News (2021). *U.S. to support international effort to set rules of behaviour in space.*
[18] UN General Assembly (2020). *Seventy-fifth session, First Committee, Agenda item 101 (a).*
[19] See 'The Theory of Incentives: The Principal-Agent Model' by Laffont and Martimort
[20] See 'Why Nations Fail' by Acemoglu and Robinson

group and its benefits at will[21]. There has been analysis of 'climate clubs' among nations, where introducing small trade penalties on non-members can generate "large stable coalition[s] with high levels of [commitment]"[22] to economically-restrictive climate-improving measures. Countries can be depended upon to act in their own interest, and so clubs of this sort are deliberately set up such that it is in each country's interest to act according to the rules of the club. This is particularly important when dealing with international agreements – as no one country has the power to enforce rules, they must be self-reinforcing.

Within space, useful services such as space debris monitoring systems or Space Traffic Management infrastructure can be denied to non-members of a similar style of club. This is the equivalent of a small trade penalty and could be leveraged to ensure members of a space club adhere to some mutually beneficial soft law rules. With the introduction of such a penalty, club model economics suggests that positive rules, norms, and behaviours around space warfare can be achieved.

Space strategy for the self-interested

We now turn to considering the payoffs from instigating or participating in space warfare, or actions that could lead to such conflict, and how these might support specific policies. Fundamentally, the payoff decreases as the likely cost of involvement increases or as the benefit of involvement decreases.

Club models are a demonstrated way of increasing the costs of space warfare and associated actions. By introducing benefits for club members such as access rights to useful space infrastructure, services, and preferential trade agreements, members have a self-interested reason to first join the club and then continue to follow its rules. By linking benefits to rules, clubs create credible threats of additional economic and technological costs for those engaging in space warfare or escalation. Notably, those who have little to gain from such a club are precisely those who have the most to gain from pre-emptive strikes: countries at a significant technological advantage in space and who thus have less to lose from retaliation or collateral damage in space. It is therefore of further importance to encourage broad take-up of space-based solutions to ensure that as many nations as possible have a stake in space and something to gain from such a space club. This can be achieved through public sector initiatives that utilise space-based solutions, such as the UK Space Agency's International Partnership Programme[23], or through private companies such as SpaceX that spread space-based solutions to frontier locations around the globe.

One effective way to reduce the benefit of involvement is to make the advantage gained by attacking a space system smaller. This tactic includes building redundancy and resilience. Using a diverse range of orbits and varied space system designs can make space systems far more difficult to attack. Lowering launch costs through technical innovation can make replacing infrastructure easier and cheaper – in the USA, government commentators have already argued that the Pentagon must 'reduce its dependence on large, billion-dollar satellites in geosynchronous orbits that are vulnerable to anti-satellite weapons'[24]. Interestingly, discussions with Japan are underway to share space infrastructure, creating another candidate for a club model benefit.

Existing support for the incentives-based approach outlined here does exist. While advocates may not use the language of self-interested actors and club models, there were calls back in 2004 for the

[21] Buchanan (1965). *An Economic Theory of Clubs.*
[22] Nordhaus, (2015). *Climate Clubs.*
[23] London Economics (2019). *Economic evaluation of the International Partnership Programme (IPP): Cost Effectiveness Analysis.*
[24] Space News (2020). *On National Security: The promise and perils of LEO constellations.*

US President to "drop the rhetoric about banning space weapons"[25] in favour of pursuing some basic 'rules of the road', engaging nations in discussions aimed at preventing an arms race, and investing in resilience. On the academic side, game-theoretic analysis[26] indicates that investment in resiliency and redundancy for space assets consistently provide better deterrence than investments in space weapons.

Conclusion

There's an unimaginable amount at stake, today and in the future. Neil deGrasse Tyson, asked how to communicate how critical space is to everyday life despite the benefits often not being tangible or easy to notice, commented that if you were to "systematically remove all the things from a person… that were enabled, empowered, or conceived by us having access to space. By the end, they're left in a cave."[27]

Given our dependence on space assets, it is extremely concerning that the international community has yet to make meaningful progress towards reducing the risk posed by space warfare. As militaries around the world continue to fund the weaponization of space, the Chief of Space Operations for the United States Space Force, General John W. Raymond can seemingly only look on and comment that "space is the Wild, Wild West. There really [are] no rules."[28] Attempts to construct such rules have repeatedly failed.

Economic theory tells us that self-interested individuals, and countries, can, under the right circumstances, be relied on to generate positive solutions. This is particularly important as for rules to work while no single country has the power to enforce them, they must be self-reinforcing. Clubs, such as those modelled for climate policy, are a leading contender for a way for rules to be self-reinforcing.

Space clubs could, in theory, blunt efforts to seize the moral high ground with disingenuous calls for bans on space weapons, better protect space assets, and make space operations safer and more predictable for all concerned. Despite Thomas Bell's prediction of the inevitability of the weaponization of space, mankind by no means must accept this fate. Apollo 11, the first spaceflight to land humans on the Moon, had a plaque that read "We came in peace for all mankind."[29] With a little thinking and careful policy, this proclamation that predates Thomas Bell's by 30 years may yet prove to be the truer of the two.

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[25] Space News (2004). *Banning Space weapons – and Reality.*
[26] Triezenberg (2017). *Deterring space war – an explanatory analysis incorporating prospect theory into a game theoretic model of space warfare.*
[27] United States Space Force (2021). *CSO Raymond and astrophysicist Neil deGrasse Tyson discuss future of the Space Force.*
[28] C-Span (2021). *Space Force Chief John Raymond at National Press Club*. Available at: https://www.c-span.org/video/?509471-1/space-force-chief-john-raymond-national-press-club [Accessed March 2021].
[29] NASA (2017). *Apollo 11 Plaque.*