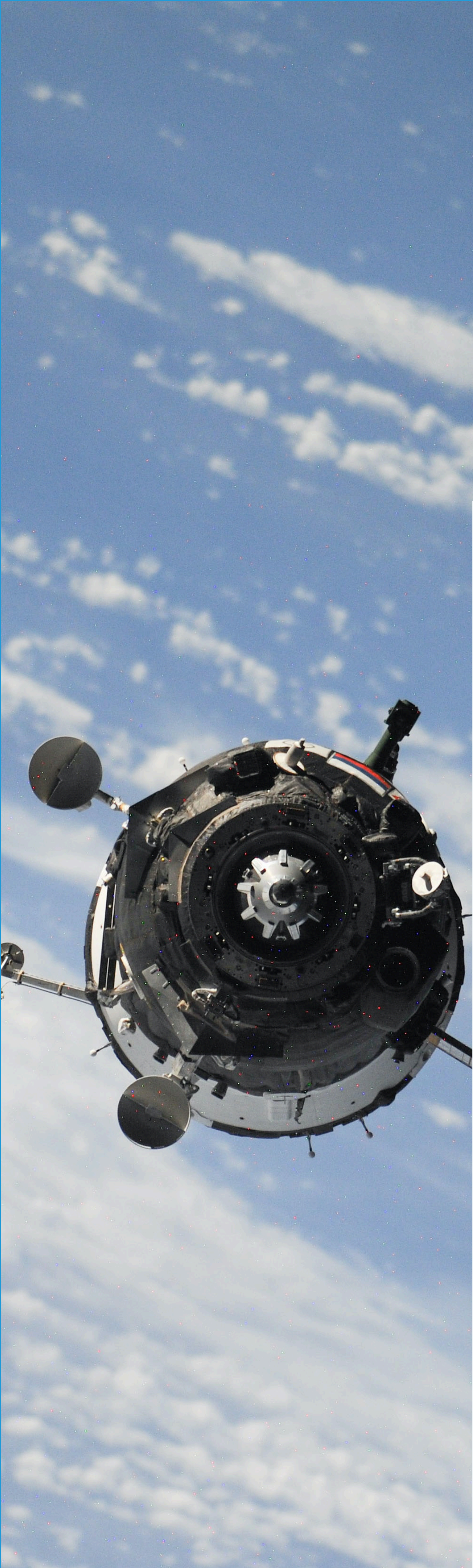
The Hague Centre for Strategic Studies



MARCH 2021

Towards a Space Security Strategy

Action Points for Safeguarding Dutch Security and Prosperity in the Space Age

Key Takeaways

Issue brief

- The world is entering a new – and highly consequential – phase of the Space Age.
- Launch costs have reduced significantly and the number of actors launching satellites into orbit will continue to increase.
- Major powers have set up space forces and are militarizing and weaponizing space in support of terrestrial warfighting capabilities. At the same time, lower costs of space travel are opening the door to the establishment of extraterrestrial footholds.
- Experts have identified 17,000 asteroids which can be exploited for resources' extraction, with one estimate putting the size of the space industry at $2.7tn per year by 2050.
- The prospect of enormous economic gains associated with the exploitation of celestial bodies for raw materials, the development and sale of technologies for space industry, and the (inter)national security relevance of space-based infrastructure are fueling interstate competition.
- Widespread access to space brings with it risks of congestion, collisions, and of the formation of debris fields capable of destroying or disabling satellites, both in- and advertently.
- The Netherlands (NLD) is critically dependent on satellites for positioning, navigation, and timing. It derives significant economic and military value from their communication and remote sensing functionalities.
- The democratization of space access poses a growing risk to the NLD's dependence on space-based infrastructure.
- The NLD boasts a productive and innovative space industry which can contribute to the development of technologies and services for the Space Age.

Recommendations

- Formulate a space security strategy: identify objectives, set priorities, and designate ways and means.
- Act to mitigate the impact of space disruption:
  - Improve NLD and European situational awareness of space.
  - Harden current and future NLD and European space infrastructure against jamming, cyberattacks, and space weather.
  - Formulate contingency plans for mitigating the terrestrial impact of space-based disruptions and support and promote the European Commission's inclusion of the space domain in its 2020 proposed revision of the EU's 2008 Directive on Critical Infrastructure Protection.
- Develop policies and capabilities through multilateral cooperation:
  - Ensure that space is included in the EU's "Strategic Compass" initiative and co-develop space capabilities through EU-level initiatives.
  - Strengthen NLD and European space industry. Options range from expanding the EU's small and medium enterprise strategy, reducing critical dependencies in key space technologies and supporting competitively priced, EU-developed launch vehicles.
  - Consider the establishment of a European Space Security Center – with the NLD as host country – to boost space situational awareness (SSA).
  - Leverage NATO's capability planning process by pushing for the introduction of state-level capability goals which contribute to satellite hardening and to infrastructure for operational support.
- Expand and revise existing (inter)national space regulation:
  - Update international legislation to clear up ambiguities concerning private ownership, allow for the removal of and reduce the risks posed by space debris, and address disarmament & arms control in space.
  - Engage with the UK's 2020 UNGA resolution to agree on responsible behavior in space.

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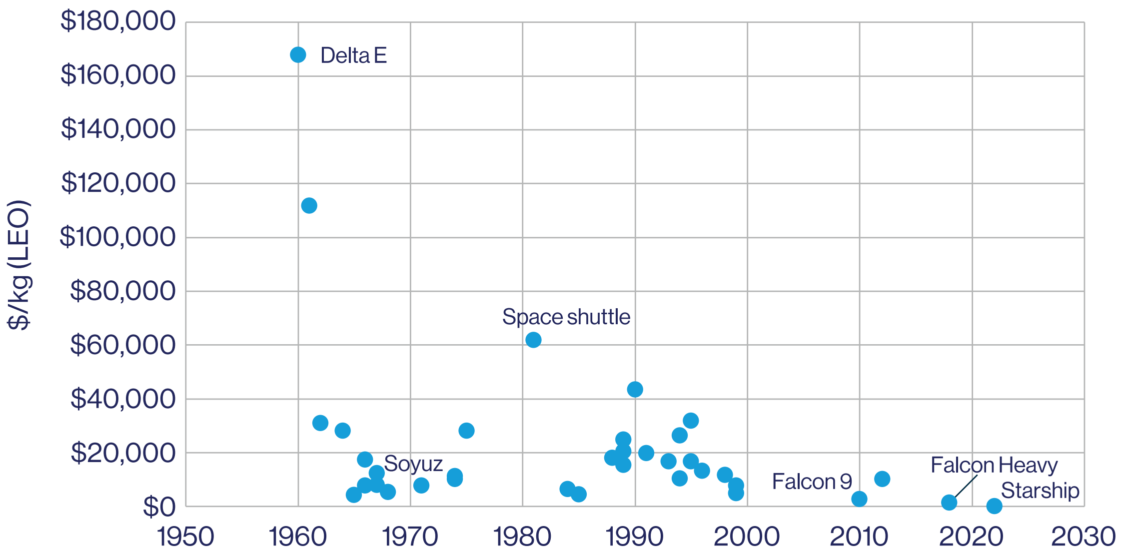
Strategic Alert | Space

Introduction

The Space Age has taken off and is now entering a new – highly consequential – phase. Spurred on by innovations pioneered by private entities such as Elon Musk's SpaceX, Jeff Bezos' Blue Origin, and the United Launch Alliance (ULA), the per-kilo cost of launching objects into Low-Earth Orbit (LEO) has decreased over 700-fold from close to $1,000,000 in the mid-late 1950s to $1,400 today.[i] Costs are set to further decline in the coming years. The development of platforms such as Starship, a reusable SpaceX-developed launch vehicle with an ascent payload capacity of more than 100 tons, is expected to further reduce the per-kilo cost of launching objects into LEO to around $10 sometime within the next decade (Figure 1).

Figure 1 - Per kilo cost of launching objects into LEO over time[ii]

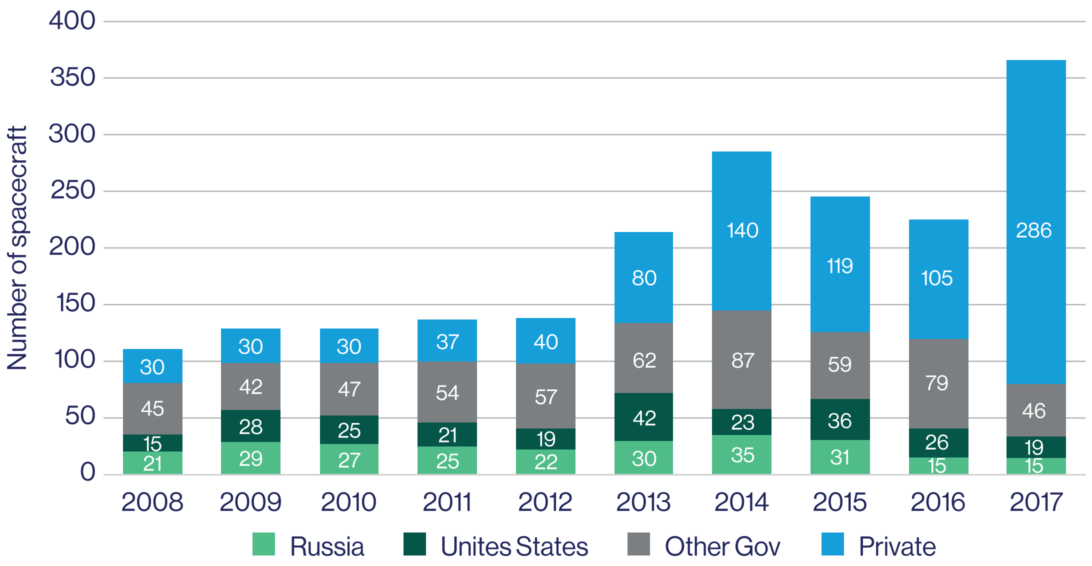


The democratization of space has created huge opportunities for state and corporate actors. The number of spacecraft launched more than tripled since 2008, with private-sector actors accounting for the bulk of this growth (Figure 2).[iii] Bryce – a US-based research firm – placed the size of the global space economy at $366bn in 2020, a $6bn

The exploitation of space-based resources is expected to add trillions to the global economy. Some estimate that the space domain will generate $2.7tn per year by 2050.

increase over 2018.[iv] SpaceX's StarLink initiative – now no longer merely a proof of concept – has unveiled plans to launch a staggering 42,000 satellites into LEO in a bid to disrupt the telecommunications industry and to blanket the globe in reliable, high speed internet.[v] Joining major powers such as the United States, Russia, and China, several middle and small powers – most notably, Turkey, the UAE, Iran, India, Luxembourg, and the Netherlands – are investing or plan on investing in the exploration of space and the development of space assets for national security purposes. The exploitation of space-based resources, including water and rare earth elements (REEs), is expected to add trillions to the global economy. Experts have identified 17,000 asteroids which are likely to become accessible for mining in the near future[vi] – something which, by one estimate, will allow activities in the space domain to generate $2.7tn per year by 2050.[vii]

Figure 2 - Number of spacecraft launched, 2008-2017



The existing body of rules and regulations is growing long in the tooth. The United States took steps to do-away with the notion that space ought to be regarded as a global commons as early as 2017.

The democratization of space has also highlighted and exacerbated the potential impact of several threats and vulnerabilities. As the number of satellites in orbit around the Earth increases, so does the risk of a collision that would disrupt critical infrastructure on Earth or that would cause communications or intelligence problems for militaries. An increasing number of states – including the United States,[viii] Russia,[ix] China,[x] India,[xi] and Israel[xii] – have successfully deployed both kinetic and non-kinetic anti-satellite (ASAT) weapons. The integrity of international regulation of the space domain has been furthered by the adoption of a new set of guidelines by the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS – 2020) and by the University of Adelaide's Woomera Manual (2018).[xiii] Yet the existing body of rules and regulations is growing long in the tooth and is in need of a refresh. It hampers dispute resolution and incentivizes state and nonstate actors to engage in races to the bottom. The United States took steps to do-away with the notion that space ought to be regarded as a global commons as early as 2017,[xiv] something which clashes with the provisions included in the Outer Space Treaty (OST) and the Moon Treaty. The US Space Force has also made a case for being exempt from the Posse Comitatus Act, something which would allow it to be employed as an instrument for enforcing US space law in orbit.[xv]

These developments generate both threats and opportunities for the security and prosperity of the Netherlands. Due to its highly connected nature, Dutch dependence on foreign-operated satellite constellations is comparatively high. Positioning, navigation, and timing (PNT) and communications are both examples of function areas in which the Netherlands maintains a high degree of dependence on the US, through the Global Positioning System (GPS) and Milstar constellations respectively. Military operations also increasingly depend on space-based assets. The Netherlands' industrial base is well-positioned and organized under SpaceNed to reap the financial benefits of the coming space boom, with small satellite (smallsat) manufacturers such as ISISPACE being the most likely to secure sizable market shares in the short term. The country has a sophisticated space industry which includes commercial (e.g., Airbus Defense and Space) and public-

Dutch dependence on foreign-operated constellations - GPS and Milstar included - remains comparatively high.

sector (e.g., the Faculty of Aerospace Engineering at the Delft University of Technology) innovators alike.

The space domain is thus relevant to the Netherlands' commercial interests, its economic, territorial, and physical security, and to the integrity of the international rule of law. Yet the significance of space continues to be underappreciated in political and popular debates. In order to convey the relevance of space in a tangible way, this Strategic Alert employs a narrative scenario-based approach to identifying threats and opportunities.[xvi] The three scenarios outlined in the following pages – which are arranged in descending order of likelihood – spell these out in concrete terms (Table 1). Each scenario is followed by an analysis of the concrete implications for the Netherlands. On that basis, conclusions and recommendations for the development of space policies are offered in the final section.

Table 1 - Scenario overview

Scenario	Information	
Voyage of IRAS	Feasibility, timeframe	Highly feasible, short term (2-5 years)
	Description	A collision between two satellites disrupts the Dutch MoD's Earth observation operations.
Luna	Feasibility, timeframe	Medium feasibility, medium-long term (10-20 years)
	Description	The US GPS constellation is disrupted by a Chinese cyberattack after a dispute over mining rights on the Moon escalates.
Europa	Feasibility, timeframe	Medium feasibility, long term (15-30 years)
	Description	An EU legislative initiative kickstarts a revitalization of the European space sector, reducing the bloc's dependence on US infrastructure.

> **The space domain is relevant to the Netherlands' commercial interests, as well as to its economic, territorial, and physical security. The significance of the domain has continued to be underappreciated.**

The tone of these scenarios differs somewhat:

- *Voyage of IRAS* details the implications of a collision between two satellites, highlighting the dangers posed by space debris and orbital congestion, as well as the (military) relevance of military Earth observation.
- *Luna* imagines a more distant future in which a dispute over mining rights on the Moon results in a temporary disruption of the US' GPS constellation. It touches on the commercial benefits of space exploration, ambiguities and lacunae in existing space law, the relevance of PNT, the dangers posed by ASAT weapons, and – perhaps most importantly – the strategic implications of opting into continued dependence on US (or 3rd party)-operated space infrastructure.
- *Europa,* by contrast, offers a more positive outlook. It sketches a future in which EU integration and long-term strategic foresight have kickstarted an EU-level initiative to legislate the trading bloc's relationship with the space domain. This legislative process cascades, ultimately culminating in a meaningful reduction in European dependence on US space infrastructure, bringing with it significant opportunities for Dutch industry and for EU strategic autonomy in the process.

Scenario 1

Voyage of IRAS (13777)

Voyage of IRAS (13777)

The Netherlands launched its first military satellite, the BRIK-II, into LEO in 2021.[xvii] In the years since, it has launched several more. Equipped with a series of Earth observation sensors, they are being employed to support possible upcoming military missions in Libya. They pass over the Netherlands periodically, bursting information regarding troop movements and activities, use of the electromagnetic spectrum, armament type, and the location of Command and Control facilities. This information is crucial. It is used to inform the decision making of both military planners and of Dutch lawmakers, which are mulling the Netherlands' participation in the EU Tunisia-Libya (TULI) mission.

The Netherlands' space situational awareness is managed by the Air Operations Control Station in Nieuw-Milligen. Equipped with a SMART-L ER radar, the installation contributes to the integrity of the Netherlands' airspace and to space situational awareness by tracking objects in space. In its space modus, the SMART-L ER radar can track all objects present above a wide arc surrounding the territory of the Netherlands, provided they are located in orbits *below* the 2,000-kilometer mark. The images it captures are shared with the EU's Air and Space Defense Centre at Vigna di Valle, some 25 kilometers north of Rome. They are also shared with NATO's Air and Space Command Centre in Ramstein, Germany, as well as with the Netherlands Defense Space Security Centre.

The station has been monitoring the voyage of *IRAS (13777)* – a joint Dutch, UK and US space telescope satellite formerly operated by NASA – for weeks. Defunct since its decommissioning in 1983, *IRAS (13777)* has been orbiting aimlessly for 42 years. Traveling at a speed of approximately 7.5 km/s, it is projected to pass within 600 meters of GGSE-4 – another defunct satellite – in the near future. Though the chances of a collision are low, they nonetheless warrant close attention. A collision would result in the formation of a debris field, something which would pose a credible threat to the satellites that the Netherlands employs to conduct reconnaissance over Libya.

At 08:21 of January 29, 2025, the improbable happens: *IRAS (13777)* and *GGSE-4* collide. The impact obliterates both satellites, sending approximately 1,000 pieces of debris – a relatively small amount – careening through space. Operators at the Air Operations Control Station receive a notification from the automated collision detection and prevention system that Dutch observation satellites *Kuipers* and *Ockels* – in parallel orbit with one-another – are threatened by the resulting debris field. *Kuipers* and *Ockels* – both of which are equipped with their own proximity sensors – register the debris field and fire their steering rockets to evade. It is too late. An object, about 5 centimeters in diameter, tears through *Kuipers'* hull, destroying it instantly and causing it to go dark.

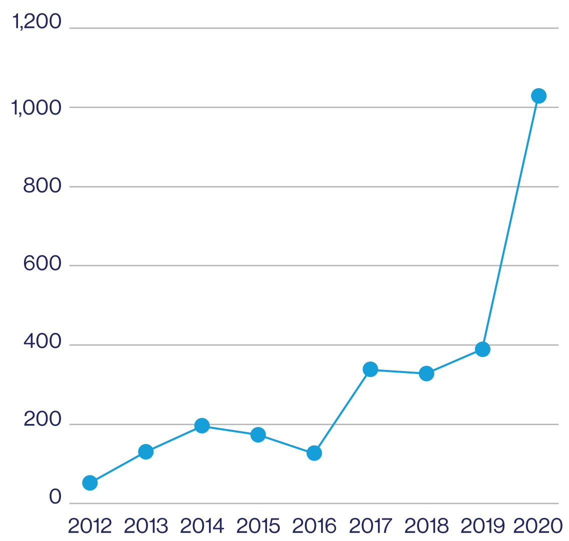
For the Dutch Ministry of Defense, the effects of *Kuipers*' destruction are evident immediately. In addition, it poses an immediate danger to *Ockels*, which must maneuver to avoid a collision and – by extension – a complete loss of the constellation. It also disrupts intra-satellite comms between the two satellites, reducing the accuracy of *Ockels*' intelligence gathering efforts, and resulting in the delayed transmission of largely irrelevant images to headquarters.[xviii] This degradation in intelligence quality significantly reduces the Ministry's situational awareness, prompting a majority in the Dutch parliament to motion the government not to participate in the EU TULI mission following an Article 100 Letter, damaging the Netherlands' credibility as a reliable partner in the short term.

Scenario Description: Voyage of IRAS (13777)

The *Voyage of IRAS (13777)* scenario touches on several threats, opportunities, and dynamics which are directly relevant to the Netherlands.

The first of these has to do with the (military) relevance of remote sensing. As a result of significant progress in the miniaturization of electromagnetic and photoelectric sensors, and the relative affordability of developing and launching smallsats into orbit (Figure 3),[xix] state and nonstate actors have increased their investments into Earth observation and remote sensing. The satellites described in the *Voyage of IRAS (13777)* scenario are also equipped with communications technologies, a feature which they share with the soon-to-be-launched BRIK-II nanosat.[xx] Earth observation, remote sensing, and communications are of critical relevance to military operators. In *Voyage of IRAS (13777)*, *Kuipers*' destruction results in the loss of data. As a result, Dutch military operators are forced to make decisions pertaining to unit movement and deployments based on spotty intelligence, something which increases risk to troops. Though not featured or described in the *Voyage of IRAS (13777)* scenario, it is important to note that satellites such as *Kuipers* and *Ockels* may – by 2025 – well be involved in tactical missions and in beyond-line-of-sight BLOS) targeting. This would make them even more integral to the fighting capacity of modern Dutch-operated platforms such as the F-35.[xxi]

Figure 3 - Number of smallsats launched over time



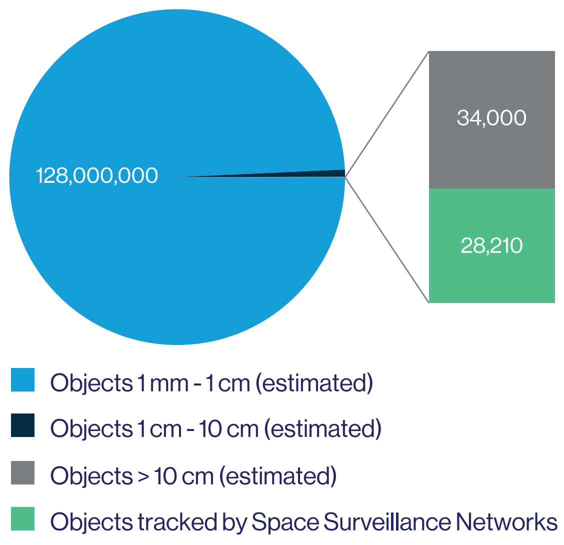
Earth observation and remote sensing have a wide range of applications. In addition to being of critical relevance to intelligence gathering, they are also relevant to ballistic missile defense,[xxii] agriculture & forestry, environmental and coastal monitoring, disaster response planning, law enforcement, city & urban planning, and archaeology, among others.[xxiii] The potential applications of an always-on, ever watchful eye in the sky – especially one which can measure fluctuations in temperature, gas composition, and ground density – are manifold.[xxiv]

> **Earth observation and remote sensing have a wide range of applications. Satellites such as *Kuipers* and *Ockels* may - by 2025 - well be involved in BLOS targeting.**

Of equal relevance is the problem of space debris. In *Voyage of IRAS (13777)*, *Kuipers*' destruction is caused by space debris generated by the collision of two defunct satellites – *IRAS (13777)* and *GGSE-4* – in LEO. Defunct satellites' presence in LEO is a growing concern.[xxv] Though these satellites will eventually disintegrate in Earth's atmosphere, it can in some cases be tens of years before they no longer pose a threat to other satellites. These objects will become increasingly problematic as the number of satellites being launched into space increases.

The destruction of defunct satellites poses significant potential risks to their operational counterparts.[xxvi] Satellite collisions are rare, but they are far from hypothetical. A commercially operated *Iridium 33* satellite famously collided with a deactivated military satellite (*Kosmos-2251*) in 2009, creating approximately 1,000 pieces of space debris in the process.[xxvii] ESA put the number of *trackable* debris objects in orbit around Earth at 28,210 as of January 8, 2021 (Figure 4).[xxviii] Because these objects travel at speeds of up to 27,000 km/h, even an object with a radius of three millimeters – which cannot be tracked with current technology – can penetrate and destroy a satellite.[xxix]

Figure 4 - Space debris infographic



Even an object with a radius of three milimeters can penetrate and destroy a satellite. ESA was currently tracking 28,210 objects in orbit around Earth as of January 8, 2021.

Space debris is slowly but certainly starting to be recognized as a pressing issue by policymakers and by industry. ESA signed an €86 million contract with Swiss startup ClearSpace to remove a Vespa payload adapter from its gradual disposal orbit in 2020.[xxx] Elon Musk's SpaceX has committed to equipping its StarLink satellites with boosters capable of de-orbiting them within months of decommissioning.[xxxi] While encouraging, these initiatives are a far cry from the structural changes that are needed. Space situational awareness systems such as the SMART-L ER radar described in *Voyage of IRAS (13777)* allow satellite operators to maneuver to avoid debris, but a far better – and also more commercially lucrative – arrangement would be one in which international regulation mandates satellite operators to de-orbit, or pay for the de-orbiting of, hardware they launch into space.[xxxii]

Such an arrangement is currently blocked by the Outer Space Treaty's (OST's) Liability Convention, which precludes any actors *other* than the launching party from de-orbiting or interfering with defunct hardware.[xxxiii] This is not entirely without reason. Many of the vehicles that could feasibly be used to de-orbit or repair defunct satellites are dual use in nature, meaning that they could just as easily be employed to de-orbit or damage functional satellites as they could be to conduct repairs or to clean up space debris.[xxiv]

Scenario 2

Luna

Luna

It is the year 2030. Tensions between US-based Moon Express and China's Origin Space, both of which have mapped out areas suitable for resource extraction, have been rising for months over the companies' competing claims to – and intentions to commence resource extraction from – the *Mare Tranquillitatis*, an area ten times richer in titanium than the surface of Earth.

Having both recognized the strategic importance of controlling this resource, Washington and Beijing have taken an active role in the dispute, with both having provided technical and financial support to their respective proxies. In a bid to kickstart resource extraction in earnest, the US government invokes the US Space Resource Exploration and Utilization (SREU) Act of 2015, a move that – under US law – grants Moon Express permission to begin mining operations. In February of 2030, Moon Express plants a US flag on the contested area, citing SREU. The move draws immediate condemnation. Flying from their bases in the Spratly Islands, Chinese J-50s are deployed to begin buzzing US Navy ships in the South China Sea. Chinese state-run media begins airing footage of ASAT weapons, lamenting Moon Express' actions in the *Mare Tranquillitatis* as a provocation.

The weeks following Moon Express' planting of the US flag are characterized by further escalation. The US and China both resort to threatening military retaliations. Diplomats are expelled from both countries. Recognizing the danger of further escalation, UN COPUOS intervenes. Referencing the OST and the 2020 guidelines, the body issues an explicit request to the US and Chinese governments to exert pressure on Moon Express and Origin Space to put their lunar mining intentions on hold.

Washington ignores UN COPUOS' request. In May of 2030, Moon Express formally initiates mining operations in the *Mare Tranquillitatis*.

Beijing responds by ordering a cyberattack against the US' GPS constellation. Hackers affiliated with China's specialized military network warfare forces immediately target Schriever Air Force Base. Operated by the 2nd Space Operations Squadron, the base is charged with (among other things) ensuring the reliability of PNT by synchronizing GPS satellites' onboard atomic clocks through regular navigational updates. Not wishing to fully escalate the situation, Beijing instructs its specialized military network warfare forces to what it considers tread lightly: rather than authorizing navigational updates designed to modify the satellites' orbits, it orders its hackers to change their onboard date-time values.xxxv Slow to register the attack, the USSF – headquarter in Arlington, VA – restores each satellite's correct daytime value and liaises with White House, which demands an apology and reparations from Beijing. When these are refused, high-ranking USSF officers in the Pentagon – in consultation with the Secretary of Defense and the President – decide to act. The *USA 312 Keppler* is authorized to execute a combined laser/directed energy against China's Beidou 3GEO3 navigation satellite, which is disabled immediately.

On the other side of the Atlantic, the Netherlands is immediately impacted.[xxxvi] As satellite operators based at Schriever Air Force Base are scrambling to revert datetime changes, Hans Janssen, a middle-aged man living in The Hague, loses his television signal. He initially does not think much of it, resolves to call a mechanic in the morning and goes to bed. Waking up the next day – long after the disruption has been resolved – he is irritated still to find that his car is unable to ascertain its location and (by extension) to navigate him to the nearest supermarket.[xxxvii] At a nearby shopping center, shoppers grapple with an outage affecting the financial sector, making electronic card payments impossible. Unable to make payments, many resort to ATMs, which are also out of order.

Luna

As server managers at the major Dutch banks such as Rabobank, ING, and ABN-AMRO scramble to identify the source of the outage, it becomes clear that the stock exchange is in turmoil. Some exchange dealers are in panic. They try to secure their funds but find themselves incapable of trading stocks. International trade in goods and services grinds to a halt as money transfers slow down and, in some cases, cease altogether. Millions of individuals across the Netherlands are experiencing difficulties accessing mobile networks. Weather apps are no longer providing information about the expected weather conditions for the day. News apps are showing hours-old items and fail to update, leaving people unaware of the reason for the digital standstill.

The internet and financial sector are not alone in experiencing disruptions. Energy providers are unable to exchange demand and supply data with energy producers or to match output to consumer needs, resulting in power outages being reported in Groningen and across the Randstad. The Dutch Ministry of Defense, for its part, has lost SatCom contact with its troops deployed in Lithuania as part of NATO's Enhanced Forward Presence initiative. The initiative includes four multinational battlegroups consisting of armored infantry battalions with organic air defense, artillery, special forces and logistics, a squadron of attack and transport helicopters, two dozen F-35s, and the continuous presence of anti-submarine warfare frigates and mine countermeasures vessels.

The Netherlands Air Force, currently engaged in a high intensity operation supporting ground troops in build-up areas in the Libyan heartland, is also experiencing setbacks (see Scenario 1). Navigation systems are behaving erratically, leaving them to rely more heavily on chart and time dead-reckoning techniques. More troublingly, the high precision small diameter bombs that they are obliged to use under their Rules of Engagement – which are fitted with GPS guidance sets – become unusable. Pilots are limited to making shows of force by flying low overhead, but are unable to push back the opposing forces that are putting pressure on the Netherlands and coalition ground troops.

The logistic and transportation units from the 100th Supply and Transport Battalion, on their way from the Sea Point of Embarkation for the Libyan operation to the main camp in the heartland of Libya, are also experiencing navigation troubles. They have to backtrack regularly, prolonging their journey by two days and leaving the encampment without food, water, fuel and ammunition.

Scenario Description: Luna

Luna envisions a future in which a territorial dispute between two privately held organizations escalates into a diplomatic row between the US and China, ultimately prompting a cyberattack against the US' GPS constellation. This cascades into a disruption of Dutch critical infrastructure. As such, *Luna* draws attention to several threats, opportunities, and dynamics which are directly relevant to the Netherlands.

The first of these centers around the fact that the functioning of the Netherlands' critical infrastructure remains, by and large, dependent on satellites operated by the US. Dutch dependence on US satellites manifests most clearly in the GPS constellation (outlined in *Luna*) on the one hand, and in military communications constellations such as Milstar and the Advanced Extremely High Frequency System (AEHF) on the other.[xxxvii] The GPS constellation provides PNT, a functionality which allows for inter-device synchronization and geolocation. The Netherlands has increasingly reduced the risk of a scenario such as *Luna* occurring by relying more heavily on the EU-operated Galileo constellation, but it nonetheless remains vulnerable to a PNT disruption. A 2011 study found that PNT functionality– which functions by measuring the time it takes for a radio-signal emitted by an Earth-based device to be received by one or more satellites in the GPS constellation – forms the backbone of more than 6-7% of Western countries' GDP, a value which amounts to more than €800 billion in the EU alone.[xxxix]

It is also relevant to the functioning of much of the Netherlands' critical infrastructure. The Dutch power grid, increasingly dependent as it is likely to be on renewable energy, would be unable to transfer energy between areas without PNT.[xl] It would likely suffer serious outages as a result. [xli] Deprived of PNT, the country's telecom sector would be unable to access the public switch telephone network or to synchronize cell sites, with the result being widespread outages in individuals' ability to contact one-another by phone and via internet.[xlii] Unable to verify the timestamps on transactions, the country's financial sector would grind to a halt.[xliii]

Dependence on US satellites could, in the event of a conflict between ASAT-equipped nations, equally result in the disruption of the Netherlands' military communications. The functionalities unlocked by the launching of BRIK-II notwithstanding, a significant share of the Dutch military's communications are handled by the US' Milstar and AEHF constellations. These constellations shield military communications from interception by frequency hopping within a spread spectrum. This is achieved by equipping each satellite within the constellation with transmission security (TRANSEC) keys. TRANSEC keys ensure that each satellite within the constellation "knows" what frequency to transmit and/or receive at any given time.[xliv]

The widespread development and deployment of ASAT weapons is a trend which speaks to states' increasing recognition of space's strategic and economic relevance. It is also one which increases, from the Netherlands' perspective, the risk associated with being dependent on US-operated infrastructure. In *Luna*, Beijing leverages a cyberattack to disrupt the US' GPS constellation. ASAT weapons can take the form of – as is described in *Luna* – non-kinetic capacities, but they can also take the form of direct-ascent or of co-orbital weapons. The US, Russia, China, Israel, and India have all demonstrated their capability to down satellites in LEO using ground,[xlv] sea, or air-based launch platforms. In recent years there has been a trend towards the launch of satellites capable of close proximity maneuvers. These satellites are equipped with hardware – be it an arm, a particle beam, or something else – which allows them to tamper with, disable, or destroy adversaries' satellites.[xlvi] The difficulty of distinguishing between space debris and co-orbital ASAT capabilities is one of several factors driving an increase in demand for space situational awareness capabilities such as the SMART-L ER radar described in *Voyage of IRAS (13777).*

The use of ASAT weapons also poses a potential threat to strategic stability. A besieged state may well interpret an attack on its military satellites as a precursor to a first strike directed at destroying its nuclear deterrent, something which may well trigger it to take preemptive action. This is because an ASAT attack would hamstring early warning systems, thus undermining the besieged state's ability to detect incoming missiles.[xlvii] The potential for

> **The Netherlands has reduced the risk of a *Luna* scenario by increasing its use of the EU's Galileo constellation. PNT forms the backbone of more than 6-7% of Western countries' GDP.**

Russia, China, Israel, and India have all demonstrated their capability to down satellites in LEO using ground, sea, or air-based launch platforms. Recent years have also seen a trend towards the launch of satellites capable of close proximity maneuvers.

inadvertent nuclear escalation is therefore considerable – ASAT weapons' impact on strategic stability should not be ignored.

Luna also touches on the threats and opportunities associated with space exploration. Made possible by advances in technology and the reduction in the per-kilo costs of launching objects into space, extracting resources from celestial bodies such as the Moon, Eros, Ceres, or any of the other 17,000 near-earth objects which are likely to become accessible in the near future, promises to add trillions to the global economy.[xlviii] It is also of significant non-monetary relevance. An abundance of REEs will contribute to the realization of an energy transition on Earth,[xlix] whilst water is a resource which is likely to play a role in facilitating deep-space travel.[l]

Human exploration of space also has significant security implications in the traditional sense. The Soviets pondered the logistics of placing nuclear weapons on the Moon as early as 1962. China's Chang'e 4 moon lander (2019) mission has raised alarms not only due to the mission's potential utility as an ASAT weapon, but also because it may allow Beijing to conduct strategically important research away from prying eyes.[li]

The events described in *Luna* can also be placed against the background of ambiguities and lacunae in international space law. The OST, a document which was originally drawn up in 1967, is ill-equipped to mediate the types of disputes which are likely to materialize in the space domain. Because state and non-state activity in the space domain has been historically limited, few precedents have emerged to clarify its contours.[lii] But it is also due to the fact that the language of OST is sometimes obscure. As an example, while the OST explicitly allows for the extraction of resources in space and disallows *national* appropriation, it makes no mention of private-sector actors and incorporates no meaningful enforcement mechanism.[liii] This problem is further exacerbated by the fact that few states have ratified what arguably amounts to the OST's most relevant provisions. The Moon Treaty – a piece of 1979 legislation which stipulates that all non-Earth resources are the common heritage of all mankind – was signed by only four countries.[liv]

International space law contains many lacunae and ambiguities. The Moon Treaty - a piece of legislation which stipulates that non-Earth resources are the common heritage of all mankind - was signed by only four countries.

One of the possible side-effects of this ambiguity is touched upon in *Luna*. Relatively unbound by international law and in need of introducing a legislative framework which a) allows it to mediate disputes between corporate actors, and b) secures its interests in the space domain, the US gives Moon Express the green light to start mining by citing the SREU – a domestic law. This form of norm setting – which is accomplished through the establishment of *faits accomplis* rather than through multilateral dialogue – creates a detrimental incentive structure in which state and nonstate actors alike contribute to norm setting by taking actions and passing laws which encode *their* best interests rather than those of the international community at large.

This dynamic has already started to manifest. As early as 2018, US Air Force Majors Dustin L. Grant and Matthew J. Neil argued in a white paper that the USSF should be organized as an independent force as opposed to a force organized under the Air Force because such an arrangement would allow it to be exempt from the Posse Comitatus Act.[lv] Passed in 1878, the Posse Comitatus Act is a law that restricts the use of Federal troops to enforce US law, meaning that such an arrangement sets the stage for the USSF being employed as an instrument for enforcing US space law in orbit.[lvi] Another example is the US House of Representatives' 2017 American Space Commerce Free Enterprise Act, which redrafted the rules and regulations surrounding space's designation as a global commons.[lvii]

UN COPUOS published twenty-one guidelines for the long-term sustainability of outer space activities in 2019. These include everything from recommendations for revising regulatory frameworks for outer space activities at the national level to best practices for ensuring the safety of space operations.[lviii] While these efforts are likely to partially mitigate the impact of the previously outlined trends, the fact remains that acting on them is entirely voluntary. This means that meaningful cooperation on the issues addressed by the UN COPUOS – which range from sustainable space utilization supporting sustainable development on earth to space debris, space weather, and regulatory

> **Ambiguities in space law invite competition. UN COPUOS published twenty-one guidelines for the long-term sustainability of outer space activities in 2019, but early signs point towards state willingness to pursue *faits accomplis*-based approaches to norm setting.**

regimes and guidance for new actors in the space arena – is likely to remain limited.

Europa

In response to (among others) a marked erosion in EU innovators' ability to compete with Chinese and American mega-corporations and concerns over European Member States' increased technological dependence on the US and China, the European Commission unveiled and launched the European Recovery Initiative (ERI) in 2025. Funding for research and innovation – distributed through research programs such as Horizon 2030 (the successor to the aborted Horizon Europe) – was significantly increased, with acquisition processing being designed to prioritize funding for dual-use technologies such as artificial intelligence (AI), quantum computing, the application of biotechnologies such as CRISPR, additive manufacturing, and aerospace research. In a bid to significantly expand EU prosecutor's ability to punish and prevent unwanted technology transfers and to reduce foreign service providers' leverage over EU companies, the Commission also introduced a handful of far-reaching amendments to the EU's antitrust law.

Though the impacts of the ERI were widespread, they were particularly pronounced within the space domain. Lawsuits introduced against internet providers such as SpaceX and Amazon (which operate the StarLink and Kuiper constellations respectively) between 2025 and 2030 decried their collection of user browsing data and drew attention to EU businesses' dependence on these corporations' hardware. The EU's standard-setting body – CEN-CENELAC – introduced a set of EU-mandated technical and behavioral standards geared towards regulating satellite operators' handling of EU user data and introducing minimum requirements pertaining to the reliability and speed of their services in 2027. The Commission followed-up on this initiative by introducing legislation which placed more rigorous behavioral and technical requirements on satellite operators providing services to entities affiliated with the (now expanded) European Programme for Critical Infrastructure Protection.

The market dynamics created by these regulations, particularly in combination with the revitalization of the EU's aerospace industry, created sizable opportunities for EU industry. An increase in EU consumers' awareness of the privacy implications of relying on internet providers such as SpaceX's StarLink and Amazon's Kuiper resulted in a boom in demand for alternative services. EU critical infrastructure operators – now, due to changes to the European Programme for Critical Infrastructure Protection, no longer able to rely solely on the US' GPS constellation for PNT – lobbied national governments for an expansion and modernization of the Galileo and Copernicus constellations, prompting a new round of funding for those programs and ultimately resulting in an expansion of both constellations by 2033.

These market dynamics also resulted in robust innovation. Between 2027 and 2033, ERI, the formulation of space-specific regulations and increases in consumer demand significantly augmented the technological sophistication of – and reduced the operating costs of – the EU space industry. Now having access to improved funding and an ever-growing list of industry partners, ESA's Themis rocket – the EU's first to feature a reusable first stage – completed development ahead of schedule, going on to launch its first payload into LEO by 2029. Demand-driven investments in R&D resulted in EU industry becoming a world leader in sensory and materials technologies, allowing for the construction of highly sophisticated manufacturing facilities and, by extension, the at-scale production of satellite components.

Leveraging the EU's industrial powerhouse, the European Defense Agency (EDA) secured funding to develop and launch – in cooperation with NATO – an alternative to the US' AEHF by 2035.

Scenario Description: Europa

> **The Netherlands' industry is well-positioned to benefit from an EU-level push into the space domain. The European Space Research and Technology Centre and the space business innovation center are based in Noordwijk.**

Europa envisions a future in which the EU invests in the development of a space program which is capable of providing its Member States with robust – and competitive – PNT and Earth observation capabilities. The Galileo and Copernicus constellations, which respectively provide PNT and Earth observation capabilities, replace (in the case of PNT) the GPS constellation as a service provider and, in the case of Earth observation, individual states' and/or organizations' custom solutions. What sets the events of *Europa* apart from the present, is that – in addition to providing a service which has true functional parity with constellations such as the GPS – EU-level integration has progressed to a point at which EU-operated hardware forms the backbone of EU Member States' critical infrastructures, military operations, and economies.

A scenario such as the one described in *Europa* benefits the Netherlands in several ways. This is, first and foremost, because it contributes to the EU's strategic autonomy.[lix] In *Europa*, the autonomy brought on by the EU's space program manifests in the presence of an EU-operated constellation that handles military communications and encryption, meaning that EU militaries looking to reduce their dependence no longer need to procure individual solutions. Systems interoperability between EU military operators is also improved, and an integrated approach to Earth observation and mission & operations planning means that EU Member States have access to far more robust information.

European businesses similarly enjoy greater autonomy. Access to and the widespread adoption of the EU's PNT solution allows for greater interoperability within the European single market. EU legislation, combined with a certification scheme and enforced through robust fees and/or market access, regulates the behavior of foreign entities seeking to serve EU businesses and consumers, protecting them from coercive behaviors and reducing antitrust concerns.

Another reason that the Netherlands stands to gain from a scenario such as the one described in *Europa* is because its industry is well-positioned to benefit from the opportunities that would likely accompany it. The European Space Research and Technology Centre and the space business innovation center are based in Noordwijk, and Dutch companies are well-established as suppliers of space-related technologies at the European level.

Airbus Defence and Space has developed solar panels for (among others) ESA's Sentinel 1 and Sentinel 2 programs.[lx] Aerospace Propulsion Products is involved in the development of new applications within ESA's Future Launchers Programme.[lxi] Smallsat developers such as ISISPACE are well positioned to serve the growing nano/smallsat market (Figure 3). All of this speaks to the Netherlands' ability to leverage its existing industry and know-how to secure a meaningful share of an economic domain that has previously been projected to generate $2.7tn per year by 2050.[lxii]

Conclusion

The Space Age has taken off and is now entering a new phase. The cost of launching objects into orbit is continuing to decline, the number of satellites in operation is set to increase exponentially, and a future in which humans are able to extract resources from celestial bodies is likely to manifest within the next few decades.

Addressing key challenges of increasing orbital congestion, the prevalence of space debris, and the militarization of interstate competition – and realizing the opportunities associated with doing so – is imperative to protect Dutch national security and promote Dutch national prosperity in the coming Space Age. Many of these challenges already pose a threat to the Netherlands' military warfighting capacity and economic prosperity in the here-and-now. Dutch policymakers' efforts to mitigate them should begin in earnest now, too. A well-considered and well-executed initiative to address the Netherlands' vulnerabilities within the space domain has the long-term potential of generating billions for the Dutch economy, aiding Dutch efforts at energy transition, strengthening Dutch warfighting abilities, and contributing to the realization of European strategic autonomy in this sphere.

The Netherlands is therefore recommended to, first and foremost, formulate a space security strategy which acknowledges space's relevance to Dutch national security and which unifies, clarifies, and streamlines government agencies' responsibilities as they relate to the domain. Building on the Ministry of Foreign Affairs' recently published letter to parliament and on the Ministry of Economic Affairs' 2019 "*Nota Ruimtevaartbeleid*,[lxiii] the space security strategy should clearly identify overall objectives, outline priorities, and sketch and allocate funds to a path geared towards achieving them. Though it is beyond this publication's scope to address each of these elements in detail, such a strategy is recommended to at least address how to (1) prepare and cope with space-based disruptions, (2) develop space policies and capabilities while pursuing deep multilateral cooperation, and (3) revise and expand on (inter)national space regulations.

> **The Netherlands' dependence on space-based assets warrants the formulation of contingency plans and the implementation of protective measures in the short term.**

Prepare for and Mitigate the Impact of Space-Based Disruptions

The Netherlands' dependence on space-based assets warrants the formulation of contingency plans and the implementation of protective measures in the short term. These range from improving situational awareness of space as a relevant security domain within relevant Dutch ministries, to taking preventive measures – including the hardening of Dutch space infrastructure – going forward. It also includes the formulation and implementation of contingency plans designed to mitigate the impact of space-based disruptions. In concrete terms, the following efforts are envisaged:

- **Improve situational awareness**. The first step towards minimizing the fallout of a space-based disruption of critical infrastructure takes the form of improving situational awareness. The Dutch government, either through the Ministry of Infrastructure and the Environment or through the National Security Strategy Process, is recommended to expand on its 2016 efforts to assess the country's vulnerabilities as they relate to PNT by assessing the likely impact that a disruption of its access to space-based infrastructure is likely to have on its food stocks, its critical infrastructure, and its social stability.[lxiv] It is recommended to identify those space-based services which are of critical relevance and create an overview of the entities which operate the constellations that support them. This overview should be disseminated within its Ministries, ensuring that knowledge of the potential military and economic implications of a disruption becomes commonplace. In line with this, and in line with the fifth objective outlined in the Dutch Defense Vision 2035 (to attain a 'Commanding Information Position'),[lxv] the Dutch

The Ministry of Foreign Affairs can (and should) take steps towards contributing to the EU's "Strategic Compass" initiative.

Ministry of Defense should assess its reliance on 3rd party-operated infrastructure and begin to map out how and to what degree it can develop and field – in cooperation with EU and NATO partners – redundant and/or supporting infrastructure. At the EU level, the Ministry of Foreign Affairs can (and should) look to – and take steps towards contributing to – the bloc's "Strategic Compass" initiative as a starting point.[lxvi]

- **Harden European and Dutch space infrastructure.** It is too late and, in many cases, not economically feasible to harden any European and Dutch infrastructure currently in orbit. The Netherlands' government is therefore recommended to factor satellite hardening into its decision-making process surrounding the use of satellites which provide services critical to national security going forward.[lxvii] Part of this hardening process hinges on the further improvement of European and Dutch space situational awareness. This will contribute to the ability to put contingency plans in place in the event of a collision in orbit or the use of an ASAT weapon. Another improvement hinges on fitting satellites with technologies that increase their resistance to Earth-based jamming devices, to cyberattacks, or to their sensors being disabled by satellite-mounted lasers. Working to harden European and Dutch critical infrastructure against jamming and cyberattacks – both relatively cheap, easy-to-deploy offensive measures – should be a priority. Similar types of hardening also mitigate the threat posed by space weather which – though not explicitly touched on within this publication – can also disrupt satellite functions.[lxviii] These efforts align closely with the priorities outlined in NATO's space strategy, which stresses the importance of ensuring the alliance's satellites are hardened against hacking, jamming, or weaponization.[lxix] The Dutch government is recommended to design future acquisition processes accordingly and be willing to raise the issue of hardening in any and all future joint ventures in which a national security angle is present.
- **Improve physical and operational resilience.** Dovetailing on the previously outlined increased space situational awareness and hardening initiatives, the Dutch government is recommended to formulate contingency plans detailing the procedural "what ifs" surrounding a disruption of space-based infrastructure for the Netherlands. These should be drawn up for civil and military sectors alike, with all relevant agencies and actors being provided with materials outlining among others communication strategies, operating procedures, and worst-case scenarios. The Netherlands is recommended to supplement its efforts at putting the aforementioned procedures in place with EU-level diplomacy. The 2008 EU Directive on Critical Infrastructure Protection – which is currently under revision – does not cover space, something which is particularly concerning given Galileo's dependence on ground segments located in several different EU Member States.[lxx] The Commission has rectified this shortcoming in its 2020 proposal to update the Directive,[lxxi] something which the Netherlands should support and promote. This would likely contribute to the identification of useful procedural best practices in the short term, and to EU-level initiatives to develop a connectivity constellation or to regulate and support satellite hardening in the medium-long term. This means it constitutes a first step towards realizing the future described in Europa.

The Netherlands should promote and support the European Commission's inclusion of the space domain in its 2020 proposed revision of the 2008 Directive on Critical Infrastructure Protection.

Develop Space Policies and Capabilities, Pursue Deep Multilateral Cooperation

Efforts to reduce infrastructure's susceptibility to space-based disruption and to develop international space regulation should be pursued within the context of multilateral cooperative initiatives. Through its EU and NATO's memberships, the Netherlands can play a role in and benefit from a wide range of initiatives which can positively impact its national security. These include, but are not limited to, the EU External Action Service's "Strategic Compass," the EU Framework for Space Surveillance and Tracking Support (EUSST) and

The EU should create market opportunities for the bloc's space industry by improving access to funding through instruments such as its SME strategy and by prioritizing sustainability within its future procurement processes.

coordinated military R&D efforts such as the EU's Permanent Structured Cooperation (PESCO) and European Defense Industrial Development (EDIDP) initiatives. This will not only increase the country's ability to mitigate the risks that space competition poses to infrastructure. It is also likely to be instrumental to the realization of several key opportunities, the manifestation of the space domain's economic potential for Dutch industry and the furthering of EU strategic autonomy in the field of security and defense included. Establishing the EU as a major space player – and streamlining EU Member States' views regarding the space domain – will also strengthen its ability to contribute to a revision of international legislation in the process.

Within this context, the Dutch government is recommended to prioritize the following initiatives:

- **Take steps to boost space industry**. Boosting the Dutch and European space industry constitutes something of a prerequisite as far as fully realizing the space domain's economic and strategic autonomy-related opportunities is concerned. EU Member States – and the businesses operating within them – will need access not only to competitively priced, EU-developed launch vehicles, but also to European spaceports and to functionally competitive technologies (life support systems, solar panels, composite materials, etc.) to reduce their dependence on the US, China, and Russia in the future. While much of the expertise necessary to realize the items on this bucket list exist within EU Member States' borders, several factors – most notably the fragmentation and subsequent duplication of efforts and a lack of consistent demand – arguably stand in the way of the industry's ability to produce "national champions" such as the US' SpaceX. Several steps can be taken at the EU level to address this. First and foremost, the EU should create market opportunities and demand for the bloc's space industry. One way of doing this is by further improving access to funding for European space small and medium enterprises (SMEs) through instruments such as the EU's SME strategy or through Horizon Europe.[lxxii] The EU should take steps to increase funding for launch systems, life support systems, solar panels, and composite materials specifically. It should also take steps to improve the sustainability of its investments by putting procedures in place which ensure that a market case exists for the outputs of all funded research and by increasing the length of funding periods. Another way is to introduce standards of regulations governing the behavior of satellite operators which provide services to EU Member States' critical infrastructure, for example by supporting the Commission's December 2020 legislative proposal to revise the EU's 2008 Directive on Critical Infrastructure Protection. Because the Netherlands' space sector is already organized under SpaceNed (with inclusion of knowledge institutions as TNO and NLR), it is well positioned to benefit from EU-level initiatives. One specific field where the Netherlands' space industry can excel is in laser communications between space and air-based assets and surface-based infrastructure.[lxxiii]

The Netherlands should seize on the momentum created by NATO's identification of space as a "fifth domain" to promote its inclusion within the framework of the alliance's Defense Planning Process.

- **Leverage NATO's Defense Planning Process**. In recognition of the space domain's increasing relevance to military operators, NATO announced its intention to open a space center of excellence (CoE) in Toulouse.[lxxiv] The Netherlands should seize on the momentum created by this initiative, and by NATO's identification of space as the Alliance's "fifth domain,"[lxxv] to promote space's inclusion within the framework of NATO's Defense Planning Process. One potential capability area to prioritize within its Minimum Capability Requirements and (by extension) within individual states' capability goals is the hardening of space-based assets against attacks mounted from Earth-based jamming devices, cyberattacks, satellite-mounted lasers, or against the radiation caused by space weather. Another is the continued development and deployment of military space infrastructure, particularly infrastructure that offers operational support. Modern weapons platforms are connected to more sensors and require faster data flows than those that preceded them, resulting in many military satellites being in need of increases in their voice communications and data transfer capacities. Future military operations will be dependent on satellite-based signals intelligence (SIGINT) which requires the development of tactical satellite launch capabilities and investments into nanosats, cluster launches, and even mini-launchers. The reams of data produced by military earth observation satellites in the near future will require improvements in most

> **PESCO, EDIDP, and PADR are all examples of initiatives which EU-level initiatives which provide the Netherlands with opportunities to co-develop key military technologies.**

European militaries' information processing infrastructure (algorithms, computing capacity).[lxxvi] Leveraging NATO's Defense Planning Process for these capabilities – almost all of which are dual use – will also contribute to reducing fragmentation and the creation of markets of scale. A first small step towards furthering this recommendation centers around the allocation of personnel to NATO's space CoE in Toulouse.

- **Leverage EU-level opportunities to co-develop key military capabilities**. PESCO, EDIDP, and EDA's Preparatory Action on Defence Research (PADR) – all of which include space-related technologies – are good examples of EU-level initiatives which, in addition to being geared towards combating redundancies in Member States' procurement spending, provide the Netherlands with opportunities to co-develop key military capabilities. The Netherlands is recommended to look into the benefits of the development of low-TRL technologies such as those outlined in the previous recommendation – satellite hardening, infrastructure that offers operational support, nanosats, cluster launches, and mini-launchers – through these instruments. It is also recommended to look at EU-level initiatives to improve SSA. The Netherlands' operational independence hinges on its ability to keep track of – and take steps to avoid – objects within the space domain. The Kingdom's domestic capacity to do so is currently limited, with the range of systems such as the SMART-L ER being constricted to an arc surrounding the country's borders. Projects such as the EU's EUSST – which the Netherlands has not yet contributed to – or EDA's ongoing Space Security Awareness project offer clear examples of SSA initiatives which warrant expansion. The Netherlands can contribute to the EUSST or to the Space Security Awareness project by leveraging its existing (SMART-L ER radar-based) capabilities. These systems' data feeds can (and should) be integrated with the data feeds generated by projects such as EUSST, something which – though likely costly – would open the door to true EU-level SSA. This would lay the foundation for the establishment of a European Space Security Center in the Netherlands. The country is uniquely qualified for this task: it already hosts the European Space Agency and the International Court of Justice. It would also position the Kingdom to participate in future space-related discussions from a position of legitimacy and influence.

> **Projects such as the EUSST or EDA's Space Security Awareness Project offer opportunities. The Netherlands can contribute by leveraging its existing SMART-L ER capabilities to make the case for the establishment of a European Space Security Centre within own borders.**

Revise and Expand on (Inter)national Space Regulation

International space law needs to be updated. In some cases widespread international support for existing regulatory frameworks is lacking – see for instance the low ratification rate of the Moon Treaty). In other cases, rules and regulations are either insufficiently comprehensive or insufficiently specific – something which incentivizes a faits accomplis-based approach to rule setting within the space domain. This foments, rather than constrains, negative forms of interstate competition. It also does not offer solutions or dispute mechanisms as far as addressing the issues of space debris and space exploitation are concerned. The de-orbiting of defunct satellites is not required under international treaties, and commercial actors are precluded from offering services to de-orbit them if their owners do or cannot. Despite the fact that several major powers have engaged in the weaponization of space, no real discussion has taken place at the international level to discuss arms control.[lxxvii]

Given these shortcomings, the government is recommended to support efforts to revise and expand inter(national) space regulation by placing emphasis on the following themes:

- **Establish and ratify rules pertaining to resource exploitation and ownership in space**. The Moon Agreement stipulates that all resources in space are "the common heritage of mankind". It has been ratified by only seven countries; the Netherlands included. The treaty is ambiguously phrased and offers little to no guidance to private sector actors. Given the potential economic value of space-based resource extraction,

Austria, Belgium, France, and Romania have all either ratified or acceded to the Moon Treaty. They may constitute useful EU-level partners to work towards a rework of existing space law with.

this invites negative forms of competition. The Dutch government is recommended to work with international partners and formulate policies followed by legislation on the exploitation and ownership of space-based resources, which is very likely to become a reality in the coming decade. Such policies should clearly stipulate the position of the Netherlands and its partners on commercial sector actors' ability to claim ownership of (swathes of) celestial bodies such as the Moon. They should also clarify how the country intends to regulate instances of (inter)national disagreements over ownership. It is recommended that the Netherlands promote the introduction of EU-level legislation covering resource exploitation and ownership. Austria, Belgium, France, and Romania have all either ratified or acceded to the Moon Treaty, implying that these countries may constitute useful partners at the European level. Leiden University has a highly esteemed space law faculty, meaning that – given strong government support – it could take a leading role here.

- **Address the debris problem**. The Dutch armed forces depend on satellite infrastructure for information, navigation, communication, targeting, and logistics. A major disruption would leave them "deaf, blind, and mute".[lxxix] Of equal relevance is the country's economic reliance on PNT signals to coordinate and maintain everything from its power grid to its telecom networks and financial systems. Taken together, these variables mean that space debris poses a serious risk to Dutch national security. Because any uptick in the amount of space debris in orbit around Earth is likely to derive primarily from collisions with defunct satellites, the Netherlands should push for international legislation which mandates satellite operators to de-orbit their hardware in a timely fashion. Such legislation should ideally modify the OST's Liability Convention to allow for the commercial removal of space debris. Japan and the UK, both countries which have previously shown interest in tackling the space debris problem, may constitute useful partners.
- **Pursue disarmament and arms control**. Though the militarization of space may be an all but foregone conclusion, it is worrying to note that space has been relatively absent in disarmament and arms control debates.lxxviii This warrants rectification. The use of ASAT weapons directly affects the functioning of societies. It also poses a real risk to nuclear stability, especially if nuclear powers perceive an ASAT attack as a precursor to a nuclear strike. In addition to inflicting significant suffering on the parties it targets, the use of military force against satellites also promises to generate vast quantities of space debris. Though many disarmament and arms control initiatives have come to face increasing resistance, the Netherlands is not powerless to act. Norm setting initiatives, especially at the EU level, may contribute to galvanizing an international discussion around the weaponization of space's implications for (strategic) stability and for the development of norms of behavior to address these implications. The UK's 2020 resolution to agree on responsible behavior in space, which invites countries to draft documents outlining their views, offers an opportunity to do so.[lxxx] The Netherlands should push for meaningful disarmament and arms control initiatives in its contributions. It should also present a framework for regulating dual use space vehicles' use, with an eye towards allowing for their deployment within the context of space debris removal.

The Netherlands should push for international legislation which mandated satellite operators to de-orbit their hardware in a timely fashion.

The implementation of these recommendations requires an expeditious approach. The space domain is of significant relevance to Dutch prosperity and security. The Kingdom should chart a course accordingly. It should improve situational awareness within its ministries, put a plan in place for hardening its (future) space infrastructure, and work on improving its physical resilience by (among others) putting contingency plans in place and supporting and promoting the European Commission's inclusion of the space domain in its proposed revision of the 2008 Directive on Critical Infrastructure Protection. It should also take steps to contribute to the EU's "Strategic Compass" initiative. This initiative should be supplemented by increased attention for space-related technologies within civilian and military procurement processes. The Netherlands should also push forward and introduce multilateral initiatives to clarify and reinforce international space law.

These steps lay the foundations for the strengthening of the bloc's (and, by extension, the Netherlands') space industry and for the realization of both actors' operational

> **Despite the fact that several major powers have engaged in the weaponization of space, no real discussion has taken place at the international level to discuss arms control.**

independence. They contribute to the prevention and mitigation of events such as those outlined in *Voyage of IRAS (13777)* and *Luna*. They improve the chances of realizing a future such as the one described in *Europa*.

Endnotes

i Harry W Jones, "The Recent Large Reduction in Space Launch Cost," 2018, 10.

ii Jones.

iii Claude Lafleur, "The Spacecrafts Encyclopedia - A Comprehensive Census of All the Spacecraft Ever Launched," 2017, http://claudelafleur.qc.ca/Spacecrafts-index.html.

iv "Bryce - Reports," accessed March 8, 2021, https://brycetech.com/reports.

v Loren Grush, "With Latest Starlink Launch, SpaceX Touts 100 Mbps Download Speeds and 'Space Lasers,'" The Verge, September 3, 2020, https://www.theverge.com/2020/9/3/21419841/spacex-starlink-internet-satellite-constellation-download-speeds-space-lasers.

vi Amanda James Hughes, "Mining Asteroids Could Unlock Untold Wealth – Here's How to Get Started," Phys.org, 2018, https://phys.org/news/2018-05-asteroids-untold-wealth.html.

vii "VIDEO | ULA's Vision for 1,000 People Living and Working in Cislunar Space in 30 Years," SpaceNews, April 20, 2016, https://spacenews.com/video-ulas-vision-for-1000-people-living-and-working-in-cislunar-space-in-30-years/.

viii The US Navy successfully destroyed a nonfunctional National Reconnaissance Office satellite using a single modified tactical Standard Missile-3 launched from an AEGIS-class cruiser in 2008. See Jim Wolf, "U.S. Shot Raises Tensions and Worries over Satellites," Reuters, 2008, https://www.reuters.com/article/us-satellite-intercept-vulnerability-idUSN2144210520080222.

ix Russia carried out the first successful flight test of its anti-satellite missile, the Nudol, in 2015. See Bill Gertz, "Russia Flight Tests Anti-Satellite Missile - Washington Free Beacon," The Washington Free Beacon, 2015, https://freebeacon.com/national-security/russia-conducts-successful-flight-test-of-anti-satellite-missile/.

x China carried out a test of its SC-19 ASAT missile in 2007, during which the missile successfully intercepted and destroyed the FY-IC polar orbit satellite. See Brendan Nicholson, "World Fury at Satellite Destruction," The Age, 2007, https://www.theage.com.au/national/world-fury-at-satellite-destruction-20070120-ge416d.html.

xi The Indian Ballistic Missile Defense Programme tested its Prithvi Defense Vehicle Mark-II in 2019, successfully destroying a Defense Research and Development Organization Microsat-r satellite. See Marco Langbroek, "Why India's ASAT Test Was Reckless," The Diplomat, 2019, https://thediplomat.com/2019/05/why-indias-asat-test-was-reckless/.

xii Israel hasn't truly demonstrated is ASAT capability. However, it has the Arrow 3 or Hetz 3 anti-ballistic missile in service that provides exo-atmospheric interception of ballistic missiles. The Israeli Space Agency reported in 2009 that its Arrow-3 interceptor missile would be adapted to also fulfill an ASAT role. See Barbara Opall-Rome, "Israeli Experts: Arrow-3 Could Be Adapted for Anti-Satellite Role," SpaceNews, 2009, https://spacenews.com/israeli-experts-arrow-3-could-be-adapted-anti-satellite role/.

xiii "The Woomera Manual on the International Law of Military Space Operations" (The University of Adelaide, 2018), https://law.adelaide.edu.au/woomera/system/files/docs/Woomera%20Manual.pdf.

xiv See the 2017 American Space Commerce Free Enterprise Act (2017).Victor L. Shammas and Tomas B. Holen, "One Giant Leap for Capitalistkind: Private Enterprise in Outer Space," Palgrave Communications 5, no. 1 (December 2019): 10, https://doi.org/10.1057/s41599-019-0218-9.

xv Kelsey D. Atherton, "Governance Abhors A Vacuum," Wars of Future Past, 2021, https://athertonkd.substack.com/p/governanceabhorsavaccum.

xvi These approaches are commonly applied. "Signpost"-based scenario analyses employ a "preferrable future" model to sketch out a path between the present and a positive future. See Florence Gaub, "What If...? 14 Futures for 2024," Chaillot Paper (European Union Institute for Security Studies, 2020). Another type of scenario formulation entails the identification of worst-case scenarios and sketching out how current-day trends and events might proliferate and worsen. For an example, see "Future(s) of Multidomain Battle," 2018.

xvii Bruno Van Wayenburg, "Nederland krijgt eerste militaire satelliet," NRC, 2021, https://www.nrc.nl/nieuws/2021/02/02/nederland-krijgt-eerste-militaire-satelliet-a4030168.

xviii Satellites such as "Kuipers" and "Ockels" might – by 2025 – be equipped with sensors which allow them provide tactical imagery and to facilitate beyond light of sight (BLOS) targeting. The US Space Force is already exploring this functionality in its "Guardian" satellites. See Nathan Strout, "The Space Force Considers a New Mission: Tactical Satellite Imagery," C4ISRNET, February 3, 2021, https://www.c4isrnet.com/battlefield-tech/space/2021/02/03/the-space-force-is-considering-adopting-a-tactical-geoint-mission/.

xix Erik Kulu, "CubeSat Tables," Nanosats Database, accessed March 8, 2021, https://www.nanosats.eu/tables.html.

xx Van Wayenburg, "Nederland krijgt eerste militaire satelliet."

xxi Strout, "The Space Force Considers a New Mission."

xxii NATO, "Ballistic Missile Defence," NATO, 2019, http://www.nato.int/cps/en/natohq/topics_49635.htm.

xxiii George-Alexandru Ilie and Gabriel Vasile, Spaceborne SAR Tomography: Application in Urban Environment, 2011, https://doi.org/10.13140/RG.2.2.22514.71365.

xxiv "Newcomers Earth Observation Guide," ESA Spce Solutions, 2020, https://business.esa.int/newcomers-earth-observation-guide.

xxv Dan Falk, "2 Large Pieces of Space Junk Nearly Collided in 'high Risk' Situation," National Geographic, October 15, 2020, https://www.nationalgeographic.com/science/article/two-large-pieces-of-space-junk-have-a-high-risk-of-colliding.

xxvi Jeff Foust, "Decommissioned NOAA Weather Satellite Breaks Up," SpaceNews, March 20, 2021, https://spacenews.com/decommissioned-noaa-weather-satellite-breaks-up/.

xxvii Ram Jakhu, "Iridium-Cosmos Collision and Its Implications for Space Operations," January 1, 2010, https://doi.org/10.1007/978-3-7091-0318-0_10.

xxviii "Space Debris by the Numbers," The European Space Agency, 2021, https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers.

xxix Linda Dawson, War in Space (2019)

xxx "ESA Purchases World-First Debris Removal Mission from Start-Up," The European Space Agency, 2020, https://www.esa.int/Safety_Security/ESA_purchases_world-first_debris_removal_mission_from_start-up.

xxxi "Starlink," Starlink, 2021, https://www.starlink.com.

xxxii "Solving the Space Junk Problem: Internationally Agreed upon Fees to Put Satellites in Orbit Could Boost Value of the Space Industry," ScienceDaily, May 2020, https://www.sciencedaily.com/releases/2020/05/200526091401.htm.

xxxiii Joel A Dennerley, "State Liability for Space Object Collisions: The Proper Interpretation of 'Fault' for the Purposes of International Space Law," European Journal of International Law 29, no. 1 (May 8, 2018): 281–301, https://doi.org/10.1093/ejil/chy003.

xxxiv Paul Rincon, "Russia Tests 'Satellite Catcher,'" BBC News, November 20, 2014, sec. Science & Environment, https://www.bbc.com/news/science-environment-30097643.

xxxv The use of cyberattacks to disrupt PNT services constitutes a highly feasible scenario. A 2019 study lamented NATO's space-based strategic assets' vulnerability to cyberattacks, placing a particular emphasis on the risk of a "spoofing" attack in which hackers disrupt ground-based sensors' ability to receive satellite signals. See Beyza Unal, "Cybersecurity of NATO's Space-Based Strategic Assets," Chatham House – International Affairs Think Tank, July 1, 2019, https://www.chathamhouse.org/2019/07/cybersecurity-natos-space-based-strategic-assets. Other studies have envisioned scenarios in which hackers attack satellites directly, thus disrupting their ability to transmit signals. See Malcolm Davis, "The Cyber Threat to Satellites," The Strategist, September 9, 2019, https://www.aspistrategist.org.au/the-cyber-threat-to-satellites/.

xxxvi The authors acknowledge that the risk of a scenario such as this one developing is reduced significantly by the Netherlands' increasing use of the EU-operated Galileo constellation. This notwithstanding, the GPS example is maintained as a vehicle for showcasing not only a PNT outing's likely impact on the Netherlands, but also the Netherlands' reliance on foreign operated space infrastructure – something which continues to exist within the commercial and military sectors.

xxxvii The effects of a PNT disruption would likely persist well past the disruption itself. When EvilCorp – a Russian cybercrime group – denied Garmin access to PNT signals in 2020, the company experienced disruptions for weeks. The company's internal systems experienced syncing issues and delays as a result of the outage, and were unable to resolve them as soon as services were restored. This effect would likely be far more pronounced when applied to the societal level, as is envisioned in Luna. See"The Cyber-Attack on Garmin: Exposing GPS Vulnerabilities," Mission Secure, 2020, https://www.missionsecure.com/blog/the-cyber-attack-on-garmin-exposing-gps-vulnerabilities.

xxxviii "Advanced Extremely High Frequency System (AEHF)," Space Operations Command (SPOC), 2020, http://www.spoc.spaceforce.mil/About-Us/Fact-Sheets/Display/Article/2381348/advanced-extremely-high-frequency-system-aehf.

xxxix Royal Academy of Engineering (Great Britain), Global Navigation Space Systems: Reliance and Vulnerabilities. (London: Royal Academy of Engineering, 2011).

xl Vox Creative, "The Power of PNT: Protecting Our Sophisticated Positioning, Navigation, and Timing Technology," The Verge, November 21, 2019, https://www.theverge.com/ad/20976108/pnt-positioning-navigation-timing-technology-gps-satellites.

xli Alison Silverstein, "Electric Power Systems and GPS," 2016, 17.

xlii Chris Farrow, "Introduction to Timing and Synchronisation," accessed March 8, 2021, https://www.chronos.co.uk/files/pdfs/wps/chronos_intro_timing_and_synchronisation.pdf.

xliii "Financial Services Sector Use of Positioning, Navigation and Timing (PNT) Services," 2015, https://rntfnd.org/wp-content/uploads/Financial-Sector-V1.pdf.

xliv Dan Goure, "The Military Has An Intra-Service Communications Problem. SOCOM Might Have The Answer.," Text, The National Interest (The Center for the National Interest, March 21, 2020), https://nationalinterest.org/blog/buzz/military-has-intra-service-communications-problem-socom-might-have-answer-135467.

xlv See endnotes viii to xii.

xlvi "Challenges to Security in Space" (Washington, D.C.: Defense Intelligence Agency, 2019), https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.

xlvii See Forrest E. Morgan, "Deterrence and First-Strike Stability in Space: A Preliminary Assessment," April 2, 2010, https://www.rand.org/pubs/monographs/MG916.html. See also Kurt Gottfried and Richard Ned Lebow, "Anti-Satellite Weapons: Weighing the Risks," Daedalus 114, no. 2 (1985): 147–70.

xlviii Hughes, "Mining Asteroids Could Unlock Untold Wealth – Here's How to Get Started."

xlix Matthew Bohlsen, "The Cobalt Market Prepares for Another Ride," InvestorIntel, August 13, 2019, https://investorintel.com/sectors/technology-metals/technology-metals-intel/cobalts-time-to-shine-will-come-again/.

l Loren Grush, "Why Mining the Water on the Moon Could Open up Space Exploration," The Verge, August 23, 2018, https://www.theverge.com/2018/8/23/17769034/nasa-moon-lunar-water-ice-mining-propellant-depots.

li Tyler Rogoway, "China's Lunar Satellites Could Stab U.S. Early Warning Satellites In The Back," The Drive, 2018, https://www.thedrive.com/the-war-zone/24287/chinas-lunar-satellites-could-stab-u-s-early-warning-satellites-in-the-back.

lii When the US-operated Iridium 33 and Russian-operated Kosmos-2251 satellites collided in 2009, neither party filed a complaint. See "Space Law Is Inadequate for the Boom in Human Activity There," The Economist, 2019, https://www.economist.com/international/2019/07/18/space-law-is-inadequate-for-the-boom-in-human-activity-there.

liii Garrison Breckenridge, "The Entrepreneur's Guide to Space Law," Medium, July 5, 2018, https://medium.com/humanizing-the-singularity/the-entrepreneurs-guide-to-space-law-3e6b5b31da9f.

liv Breckenridge.

lv Dustin L Grant, "The Case for Space: A Legislative Framework for an Independent United States Space Force," 2020, 22.

lvi Atherton, "Governance Abhors A Vacuum."

lvii The American Space Commerce Free Enterprise Act clashes with the Moon Treaty, which stipulates that all non-Earth resources are the "common heritage of mankind." See Breckenridge, "The Entrepreneur's Guide to Space Law."

lviii UN COPUOS has formulated a relatively comprehensive set of voluntary guidelines. For a full overview, see "Report of the Committee on the Peaceful Uses of Outer Space" (United Nations, 2019), 50–75, https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf.

lix For an in-depth analysis of how the space domain might contribute to the European Union's strategic autonomy, see Daniel Fiott, "The European Space Sector as an Enabler of EU Strategic Autonomy" (European Parliament, 2020).

lx "Solar Arrays," Airbus Defence & Space Dutch Technology (blog), accessed March 8, 2021, https://www.airbusdefenceandspacenetherlands.nl/activities/solar-arrays/.

lxi "APP - Aerospace Propulsion Products," APP Ariane Group, accessed March 8, 2021, https://app.ariane.group/en/.

lxii "VIDEO | ULA's Vision for 1,000 People Living and Working in Cislunar Space in 30 Years."

lxiii See Stef Blok, "Betreft Introductie ruimteveiligheidsbeleid," 2021. See also "Nota Ruimtevaardbeleid 2019" (Ministerie van Economische Zaken, 2019), https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/beleidsnota-s/2019/06/19/bijlage-1-nota-ruimtevaartbeleid-2019/bijlage-1-nota-ruimtevaartbeleid-2019.pdf.

lxiv "Synthese Rapport: Inventarisatie Kwetsbaarheid Uitval Satellietnavigatie" (Ministerie van Infrastructuur en Milieu, 2016).

lxv "Defence Vision 2035 - Fighting for a Safer Future" (Ministry of Defence, 2020).

lxvi "Towards a Strategic Compass," Text, EEAS - European External Action Service - European Commission, 2021, https://eeas.europa.eu/headquarters/headquarters-homepage/89047/towards-strategic-compass_en.

lxvii Kris Osborn, "Air Force 'Hardens' Satellites to Prepare for Space War (Think Russia or China)," Text, The National Interest (The Center for the National Interest, March 22, 2018), https://nationalinterest.org/blog/the-buzz/air-force-hardens-satellites-prepare-space-war-think-russia-25027.

lxviii Paul Cannon, Extreme Space Weather: Impacts on Engineered Systems and Infrastructure. (Royal Academy of Engineering, 2013).

lxix "NATO's Approach to Space," NATO (blog), 2020, http://www.nato.int/cps/en/natohq/topics_175419.htm.

lxx "Council Directive 2008/114/EC" (The Council of the European Union, 2008), https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:345:0075:0082:EN:PDF.

lxxi See "Proposal for a Directive of the European Parliament and of the Council on the Resilience of Critical Entities," Pub. L. No. COM(2020) 829 final (2020), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:829:FIN. See also "Communication from the Commission on the EU Security Union Strategy," Pub. L. No. COM(2020 605 final (2020), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0605.

lxxii "SME Strategy," Text, Internal Market, Industry, Entrepreneurship and SMEs - European Commission, September 7, 2020, https://ec.europa.eu/growth/smes/sme-strategy_en.

lxxiii See "Hyperion's laser communication terminal to fly into space in 2022," Hyperion Technologies B.V., January 5, 2021, https://hyperiontechnologies.nl/hyperions-laser-communication-terminal-to-fly-into-space-in-2022/. See also "ESA Awards Contract for IOD of Laser Communication Terminal," TNO, 2021, /en/about-tno/news/2021/1/esa-contract-iod-laser-communication-terminal/.

lxxiv Ministère de l'Europe et des Affaires étrangères, "Defence – Establishment of the NATO Space Centre of Excellence in Toulouse – Communiqué Issued by the Ministry for the Armed Forces," France Diplomacy - Ministry for Europe and Foreign Affairs, 2021, https://www.diplomatie.gouv.fr/en/french-foreign-policy/security-disarmament-and-non-proliferation/news/article/defence-establishment-of-the-nato-space-centre-of-excellence-in-toulouse.

lxxv "NATO Space Centre," SHAPE | NATO Space Centre, accessed March 8, 2021, https://shape.nato.int/about/aco-capabilities2/nato-space-centre.aspx.

lxxvi "Space Defence Strategy," Space Working Group (The French Ministry for the Armed Forces, 2019).

lxxvii John Lauder, Frank G. Klotz, and William Courtney, "How to Avoid a Space Arms Race," RAND, October 26, 2020, https://www.rand.org/blog/2020/10/how-to-avoid-a-space-arms-race.html.

lxxviii Tim Sweijs and Frans Osinga, "Maintaining NATO's Technological Edge," Whitehall Papers 95, no. 1 (January 2, 2019): 109, https://doi.org/10.1080/02681307.2019.1731216.

lxxix Lauder, Klotz, and Courtney, "How to Avoid a Space Arms Race."

lxxx "UK Push for Landmark UN Resolution to Agree Responsible Behaviour in Space," GOV.UK, 2020, https://www.gov.uk/government/news/uk-push-for-landmark-un-resolution-to-agree-responsible-behaviour-in-space.

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