UNIVERSITÄT OSNABRÜCK

Geostrategy and Geopolitics
Department 1
49069 Osnabrueck
apl. Prof. Dr. Dr. Klaus Saalbach

The Control of the Lunar South Pole

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Summary

After the Apollo missions to the moon in 1969 and the 1970ies, the space research shifted to other goals. But since the 1990ies, the lunar research was restarted and intensified. Initially, the focus was on the development of science and technology for future moon missions. In addition to space agencies, commercial providers became increasingly active and were e.g., motivated by the Google Lunar X-Prize competition, which originally intended to award projects for a moon landing until 2018 the latest.

But with the release of the US Commercial Space Launch Competitiveness Act in 2015, the focus began to shift from scientific to economic aspects, i.e., the potential exploitation of lunar resources. However, for a long-term presence, a habitable moon base would be needed with water, enough sunlight, and a stable landing place.

The best combination of these factors is present on certain places of the Lunar South Pole which is now the key area of space geopolitics. Lunar settlements without access to lunar water are not possible and who controls the lunar water, has factual control over future lunar long-term activities. Indications for the existence of lunar water ice were found in the late 1990ies. Further research identified six craters on the Lunar South Pole as likely targets for water ice deposits and direct evidence for water ice resulted from lunar impactor studies.

The United States with the Artemis program and China with the Chang'e program make steady progress to permanent moon bases (Artemis Base Camp vs. International Lunar Research Station ILRS) in overlapping lunar South Pole areas. Other competitors like Russia, India, Israel, and Japan were affected by landing accidents.

Meanwhile, both East (China/Russia) and the West suspect each other that the true objective of their lunar research is the control of the Lunar South Pole and its water ice which would constitute a factual control over moon settlements and consequently of the lunar resources.

There are growing tensions between United States and China in space policy. With respect to the moon, both sides have formed growing multi-national space alliances, the US Artemis Accord with over 20 countries including India and the Chinese International Lunar Research Station Cooperation Organization ILRSCO with 5 initial member states countries including Russia.

Satellite hacking and laser weapons made substantial progress. Consequently, high altitude espionage balloons were re-activated as safer alternatives as they are low-cost, unmanned, can carry payloads for electronic warfare, surveillance, jamming and observation, are difficult to detect, and can be easily replaced.

From a strategic perspective, the United States were leading for decades, but as there were substantial delays in the implementation of the Artemis program already, it is meanwhile possible that China's moon base will come first. For this reason, every effort must be made by the United States to meet the future Artemis timelines, if they want to keep the leadership.

Content

1. Introduction

After the successful crewed *Apollo* missions to the moon in 1969 and the 1970ies, the space research shifted to other goals. But since the 1990ies, the lunar research was restarted and intensified. Initially, the focus was on the development of science and technology for future moon missions. In addition to space agencies, commercial providers became increasingly active and were e.g., motivated by the *Google Lunar X-Prize* competition, which originally intended to award projects for a moon landing until 2018 the latest, including the Japansese *Hakuto-1* mission which took place in March 2023[1].

But with the release of the *US Commercial Space Launch Competitiveness Act* in 2015, the focus began to shift from scientific to economic aspects, i.e., the potential exploitation of lunar resources. However, for a long-term presence, a habitable moon base would be needed with water, enough sunlight, and a stable landing place. A polar location would be able to provide nearly continuous solar power and would avoid phases of extreme heat and cold[2].

The best combination of these factors is present on certain places of the Lunar South Pole which is now the key area of space geopolitics. Lunar settlements without access to lunar water are not possible and who controls the lunar water, has factual control over future lunar long-term activities.

Indications for the existence of lunar water ice were found in the late 1990ies both on the lunar North and South Pole. Further research identifed six craters on the Lunar South Pole as likely targets for water ice deposits[3]. Direct evidence for water ice resulted in particular from impactor studies, such as *Chandrayaan-1* from India in 2008 to 2009 and *LCROSS (Centaur)* from United States in 2009. The majority of surface water ice at the lunar south pole is located in large, old (>2.8 billion years) cold-trapping craters[4].

While the United States with the *Artemis* program and China with the *Chang'e* program make steady progress to permanent moon bases (*Artemis Base Camp* vs. *International Lunar Research Station ILRS*) in overlapping lunar South Pole areas[5], other competitors like Russia, India, Israel and Japan were affected by landing accidents.

Meanwhile, both East (China/Russia) and West suspect each other that the true objective of their lunar research is the control of the lunar South Pole and its water and its water ice which would constitute a factual control over moon settlements and consequently of the lunar resources. This conflict is embedded in growing tensions in space policy which are analyzed in this paper.

2. Political and legal framework

2.1 Space Policy

Space policy is about the plans and activities of political actors in Outer Space, their motives, and strategies. Political actors are nation states, but also international organizations like the *United Nations (UN)* and the *European Space Agency (ESA)*. In addition, there are commercial actors such as *Blue Origin* and *SpaceX* with rockets, and *RocketLab* with a private orbital launch site[6]. In addition, several national and international scientific organizations are involved in research. Thus, actors can have political, economic, and scientific motives (or a motive mix) to act in Outer Space. The Outer Space can be differentiated by usage in different zones:

[1] iSpace 2023a
[2] Jones 2019
[3] Schaler/Purucker 2006
[4] Deutsch et al., 2018
[5] Space News 2022
[6] Pekkanen 2019, p.93

Table 1: Outer Space Sectors

Sector	Details	Primary Usage
Orbital Space	Low Earth orbit (LEO): below 2,000 km Medium Earth orbit (MEO): between 2,000 and 35,786 km Geosynchronous orbit (GEO): Geocentric circular orbit of 35,786 km High Earth orbit (HEO): higher than 35,786 km	Satellites, International Space Station (ISS) Environmental issue: space debris
Cislunar Space	The space up to the Moon	The region of Outer Space that could be physically controlled by human mankind now (currently the factual limit of military strategies)
Moon and Mars	Neighbored celestial bodies	Unmanned robotic research missions ('Mars Rover'), targets for future settlements Environmental issue: Lunar and Martian water
Solar system	Comprising eight planets and hundreds of larger planetoids, also periodically returning comets and asteroids	Can be reached with research satellites, but travel not yet possible. Near-Earth asteroids are a major security issue.
Far Outer Space	Everything outside the solar system	Observation by astronomy/telescopes

From this table, 'active' space policy is only reaching up to the Moon now and soon to the Mars while anything else is still out of reach from a practical and political perspective.

This is also the key aspect of Outer Space strategies: the primary aim is to settle on Moon and Mars and if technically possible, to exploit resources, from there and other celestial bodies. This may allow territorial expansion, advantage in military conflicts and the mitigation of resource shortage on earth, e.g., for platinum, titanium, scandium, and yttrium[7]. Also new lunar energy sources such as Thorium[8] and Helium-3 are under discussion.

2.2 The United Nations Space Law

Space Law can be described as the body of law applicable to and governing space-related activities[9]. The *United Nations Office for Outer Space Affairs (UNOOSA)* is the *United Nations* office responsible for promoting international cooperation in the peaceful uses of outer space. UNOOSA serves as the secretariat for the *United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)*.

Agreements with relevance for the moon are[10] The *Outer Space Treaty (Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies)*, entered into force 1967 and the *Moon Agreement (Agreement Governing the Activities of States on the Moon and Other Celestial Bodies)*, which entered into force 1984, but was ratified by only 18 countries so far.[11]

The *Outer Space Treaty* prohibits states from placing in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, installing such weapons on celestial bodies, or stationing such weapons in outer space in any other manner. The Moon and other celestial bodies shall be used exclusively for peaceful purposes and prohibits the establishment of military bases, installations and fortifications, the testing of any

[7] Goswami 2021, McLeod/Krekeler 2017
[8] Cannara 2011
[9] UNOOSA Website 2023
[10] UNOOSA Website 2023, United Nations 2017
[11] GPO 2020

types of weapons and the conduct of military maneuvers on such celestial bodies. Outer space, including the Moon and other celestial bodies (asteroids) is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. The Treaty establishes the exploration and use of outer space as the "province of all mankind".[12]

The *Moon Agreement* expanded these provisions by stating that neither the surface nor the subsurface of the Moon (or other celestial bodies in the solar system), nor any part thereof or natural resources in place, shall become property of any state, international intergovernmental or non-governmental organization, national organizations, or non- governmental entity or of any natural person.

From that perspective, discussions about the control of the Lunar South Pole seem to legally irrelevant, but in political practice, lunar settlements without access to lunar water are not possible and who controls the lunar water by physical presence, has the factual control of lunar long-term activities.

An important legal step to commercial use of lunar resources was the *U.S. Commercial Space Launch Competitiveness Act (CSLCA)* from 2015[13].

Section 402 states that "*The bill directs the President, acting through appropriate federal agencies, to facilitate the commercial exploration for and the commercial recovery of space resources for U.S. citizens […], which shall be entitled to own, possess, transport, use and sell it according to applicable law*." But Section 403 also states that U.S. "*does not assert sovereignty or sovereign or exclusive rights or jurisdiction or ownership of any celestial body*" [14]. In other words, U.S. citizens can exploit space resources, but this does not exclude other states or organizations from doing the same.

Referring to this law, the *Presidential Executive Order 13914 of April 6, 2020* clarified that United States have not ratified the *Moon Agreement* as this is not considered to be an effective or necessary instrument and that *"Americans should have the right to engage in commercial exploration, recovery, and use of resources in outer space"*[15].

The *United Nations* noted already in 2019 an increasing erosion of the agreements of space law,[16] as some states try to promote their national vision and norms as international standards which undermines the strict compliance with the prohibition of national appropriation of outer space. A particular problem is the planned exploitation of the natural resources of celestial bodies (Moon, Mars, asteroids). This is in line with a general global trend of treaty decline and exit[17].

3. Current Lunar Space Activities

Any launch of a space object without humans is an unmanned mission, such as exploration and communication satellites. *Space Robotics* is not precisely defined. In daily routine, any unmanned space probe can be called a robotic probe, but in research, this typically means remotely controlled devices used for complex operations in space, e.g., *lunar landers* for identification of lunar water such as *Chandrayaan-1*.

[12] UNOOSA Website 2023, United Nations 2017
[13] Congress 2015
[14] Congress 2015
[15] GPO 2020
[16] United Nations 2019, notes 30 ff.
[17] Pekkanen 2019, p.95

After the successful crewed *Apollo* missions in 1969 and the 1970ies, the space research shifted to other goals. But since the 1990ies, the lunar research was restarted and intensified. Initially, the focus was on the development of science and technology for future moon missions[18].

The United States with the *Artemis program* and China with the *Chang'e* program make steady progress to permanent moon bases (*Artemis Base Camp* vs. *International Lunar Research Station ILRS*) in overlapping lunar South Pole areas.

A habitable moon base requires water, a sufficient amount of sunlight and a stable landing place[19]. A polar location would be able to provide nearly continuous solar power and would avoid phases of extreme heat and cold[20]. A systematic analysis of the resource need for a moon base showed that a crew member requires approximately 12 kilogram input per day and produces a similar amount of waste per day. The input includes water for food preparation, drinking, washing/shower, urine and oxgen, while the waste includes water from respiration and perspiration condensate, used washing/shower water and urine flush water as well as carbon dioxide which can be removed by lithium hydroxide filters. A lot experience comes from the *International Space Station (ISS)*, but the distance and transportation costs are higher. The reasonable launch cost for a Moon base would already be about 10,000 $/kg. For a cost-effective management, the best results are achieved for larger crews and long-term missions, as this would allow the use of recycling systems[21].

The *Artemis program* is a lunar program by the United States' *National Aeronautics and Space Administration (NASA)* and a cooperation with the *European Space Agency (ESA)*, the *Japan Aerospace Exploration Agency (JAXA)*, the *Canadian Space Agency (CSA)*, the *Israel Space Agency (ISA)* and the *Australian Space Agency (ASA)*. The *Artemis Accords* on 15 May 2020 is a series of bilateral agreements between the governments of participating nations in the *Artemis* program, meanwhile signed by more than 20 states, including France and India. Due to security concerns, all researchers from the NASA are prohibited from working with Chinese citizens affiliated with a Chinese state enterprise or entity since 2011 (China exclusion policy).

The goal of this program is to land "the first woman and the next man" on the lunar South pole region by 2024. The *Lunar Gateway* is a planned new space station in orbit about the Moon for temporary human habitation. The *Gateway* is like the *Artemis Base Camp* intended to maintain US global space leadership as a sustained presence in the region between the Moon and Earth[22].

Artemis 1 was the successful uncrewed test of the *Space Launch System (SLS)*, a powerful heavy-lift rocket with high transportation capacity to the lunar environment and placed the spacecraft Orion into a lunar orbit and then returned to Earth, but with several years behind plan in 2022. *Artemis 2* in late 2024 is planned to be the first crewed test flight of SLS and the *Orion* spacecraft[23].

Artemis 3 will be the most critical step in late 2025. In a first mission, a *Starship Human Landing System (HLS)* will be placed in an orbit around the moon. In a second mission, the *SLS/Orion* will be launched and four crew members will rendezvous and dock with HLS. Two astronauts will land with the HLS to the moon for about 6.5 days, then return with the HLS to *Orion* and with *Orion* back to Earth.

Artemis 4 planned for 2028 consists again of two parts. The first mission will launch the *Lunar Gateway* station and bring it into lunar orbit. *Artemis 4* will deliver the *International Habitation*

[18] Wikipedia "List of missions to the Moon", last access on 22 Aug 2023
[19] Jones 2019, NASA 2021
[20] Jones 2019, NASA 2021
[21] Jones 2019
[22] NASA 2020a
[23] NASA 2020b

(I-Hab) module to the Gateway, then two astronauts will be transported with *Orion* and an upgraded *Starship HLS*. With the HLS, they land on the lunar surface for a week

Artemis 5 is planned for 2029 to bring four astronauts to the Gateway Space Station. The mission will deliver the *European Space Agency's ESPRIT refueling and communications module* and the *Lunar Terrain Vehicle LTV*[24].

A strategic presence is planned at the lunar South Pole near to the *Shackleton Crater*, the *Artemis Base Camp* for one to two-month stays for long-term economic and scientific activity, and as an important step to a crewed Mars mission in the 2030s[25]. It will consist of the *Foundation Habitat* for four astronauts on the lunar surface as the center of the *Artemis Base Camp*, the *Lunar Terrain Vehicle* and a *habitable mobility platform* for long-duration trips and should ensure the US presence at the South Pole[26]. A further lunar landing is planned for 2030 as *Artemis 6* and further missions until *Artemis 13* are already in the planning stage.

The scientific areas will include studies of planetary processes, the universe and geospace, the *in-situ resource utilization*, the impact history of the Earth-Moon system, analysis of ancient sun activity and experimental science in the lunar environment[27].

In 2021, China and Russia announced the plan for an *International Lunar Research Station (ILRS)* near the lunar South Pole and China starts the *International Lunar Research Station Cooperation Organization (ILRSCO)* headquartered in *Hefei Deep Space Science City* in 2023, currently with China, Russia, Pakistan, Venezuela, and United Arab Emirates as initial member states; the formal signature of Agreements will follow in October 2023[28].

In 2007, the lunar program *Chang'e* program started with an evaluation of the lunar soil for Helium-3[29] and ended with an impactor mission in 2009, followed by *Chang'e-2* in 2010 with a mapping of the lunar surface; both missions were primarily orbiting missions, while the next ones were landing operations[30]. In 2013, China landed the spacecraft *Chang'e-3* with the *Yutu rover* on the Moon in *Mare Imbrium*[31]. In 2018, the *Queqiao* satellite was released in advance to enable signal transmission from the far side of the moon, followed by the *Chang'e-4 Moon Rover* landing on the far side of the moon in 2019 with water expeditions and some planetary science experiments[32]. The project included a growth experiment on the moon with a small lunar biosphere in a box (air, water, and soil): a cotton plant managed to grow under these conditions while certain other plants failed to grow[33]. *Chang'e-5* in 2020 collected and returned 1.7 kg lunar samples to Earth.

Chang'e 6 will investigate the South Pole-*Aitken basin* in 2025 and return samples to Earth[34]. *Chang'e 7* will explore the South Pole for resources in 2026 and a second *Queqiao-2* relay satellite will be released. *Chang'e 8* will test the use of lunar resources (in situ resource utilization) with a 3-D printer to test-build structures and a small sealed ecosystem experiment.

China plans to reduce resource problems by a scalable and maintained nuclear-powered facility that operates autonomously on the lunar surface and lunar orbit for a long time, only with *short-*

[24] NASA 2020b
[25] NASA 2020a
[26] NASA 2020b
[27] NASA 2020b
[28] CLEP 2023
[29] Mann 2019
[30] CLEP 2023, Mann 2019
[31] Pekkanen 2019, p.94
[32] Mann 2019
[33] Devlin 2019
[34] Mann 2019

term manned participation[35]. The 5 research areas will be the origin and evolution of the moon, insights into eolution of the universe, analyze Earth-like living environments, lunar experiments for plant growth and resource development and utilization for energy, materials, construction[36].

The plan is to expand the *International Lunar Research Station (ILRS)* stepwise in 5 versions from ILRS-1 to ILRS-5. ILRS-5 will have *in-situ* observation facilities. After 2040, the plan is to focus on ways from Moon to Mars[37]. A launch from moon to Mars is estimated to be 22 times more effective than from Earth[38].

Other competitors like Russia, India, Israel, and Japan were affected by landing accidents.

Beresheet (Genesis), was a lunar lander funded and built by the non-profit organization *SpaceIL* and *Israel Aerospace Industries*, with technical support from the *Israel Space Agency*[39]. The mission launched on 22 February 2019 on a *SpaceX Falcon 9* from *Cape Canaveral* and attempted to land on the Moon on 11 April 2019, but a main engine failure resulted in a crash on the lunar surface in *Mare Serenitatis*[40]. The plan was to test a soft-landing procedure and the probe carried literature and further things which would then have been archived on the moon[41].

The *Indian Space Research Organization (ISRO)* is the space agency of India. *Chandrayaan-1* was a robotic lunar exploration mission with a lunar orbiter and an impactor called the *Moon Impact Probe* and proved the existence of lunar water as ice in the polar regions from 2008 to 2009[42].

The second lunar mission *Chandrayaan-2* to study the lunar geology and the distribution of lunar water in 2019 could successfully separate the lander from orbiter, but a software problem led to a crash on 06 September 2019 during a landing attempt and the lander and rover were destroyed[43].

Like *Chandrayaan-2*, the third lunar mission *Chandrayaan-3* consists of the lander *Vikram* and the rover *Pragyan* was launched on 14 July 2023 with the aim to demonstrate a soft-landing in the Lunar South Pole region, to test the moon rover and to investigate presence of water ice in the lunar soil and the thin lunar atmosphere (exosphere). The lander was successfully separated on 17 August 2023 and landed as planned on 23 August 2023.

In December 2022, launched from the United States on a *SpaceX Falcon 9* rocket, the private company *iSpace* brought a lunar lander into the orbit on 21 March 2023 as part of the *Hakuto-R Mission 1*[44]. *iSpace* is awarded a NASA *Commercial Lunar Payload Services (CLPS) Program* contract to land on the far side of the moon by 2025 and was selected by the *European Space Agency ESA* to be part of the Science Team for *Prospect*, a program which seeks to extract water on the moon[45] and is partner of the European *Ariane Group*[46]. The contact was lost during final stage of landing due to a sensor software issue (which also destroyed the *Rashid* lunar rover of the United Arab Emirates)[47].

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[35] CLEP 2023
[36] CLEP 2023
[37] CLLEP 2023
[38] Goswami 2021
[39] Wattles 2023
[40] NASA 2019
[41] Arch Mission Foundation 2019
[42] NASA 2023
[43] Wattles 2023
[44] iSpace 2023a
[45] iSpace 2023a
[46] iSpace/Ariane 2021
[47] iSpace 2023b

Russia launched its *Luna-25* spacecraft on 10 August 2023 with a *Soyuz-2.1b/Fregat* system for a soft-landing at the Lunar South Pole and a search mission for lunar ice water. After a successful orbital positioning on 16 August 2023, an engine maneuver problem resulted in a crash on the moon surface on 19 August 2023.[48]

A *Falcon 9* booster from the *SpaceX* company had an expected crash on the moon near the *Hertzsprung crater* on 04 March 2022, but as little attention was paid to this event; media reported later about a 'mystery rocket' on the moon[49].

4. Growing Tensions in Space Policy

The conflicts around the Lunar South Pole are embedded in growing tensions in space policy, in particular for satellites. Satellite hacking and laser weapons made substantial progress. Consequently, high altitude espionage balloons were re-activated as safer alternatives to espionage satellites.

4.1 The Lunar South Pole as Strategic Key Area

There are growing tensions between United States and China in space policy. With respect to the moon, both sides have formed growing multi-national space alliances, the *US Artemis Accord* with over 20 countries including India and the *Chinese International Lunar Research Station Cooperation Organization ILRSCO* with 5 initial member states countries including Russia.

The NASA administrator Bill Nelson said that "*it is a fact: we are in a space race*" and that if China gets a place on the moon, they may claim this as their own territory like the Spratly Islands in the South Chinese Sea[50]. He further said that he "*does not want China to go the lunar South Pole first"*[51]. The concern of the United States is that who gets back to the moon first will control the moon, or more specifically: who controls the South Pole, controls the best landing place and the lunar water and by this the moon as a whole[52].

The spokesman of the Chinese embassy in US, Liu Pengyu, responded promptly and rejected this statement as "*irresponsible*" and said that "*outer space is not a wrestling ground*"[53].

However, the head of the Chinese lunar exploration program, Ye Peijian, stated that: *"…the moon is the Diaoyu islands…If others go there, then they will take over, and you won't be able to go even if you want to."*[54] The *Diaoyu* islands are also known as *Senkaku* islands which are currently controlled by Japan, but China makes territorial claims.

On the other hand, United States emphasize that their *Artemis* program has also a strategic dimension, as the *Artemis Base Camp* intended to maintain U.S. global space leadership and to ensure physical presence[55]. From the Chinese perspective, the *US Commercial Space Launch Competitiveness Act* from 2015, the *Presidential Order* from 2020 and the *Artemis Accord* are no extensions of the United Nation's *Outer Space Treaty*, but the factual start of space colonization[56].

From a strategic perspective, the United States were leading for decades, but as there were substantial delays in the implementation of the *Artemis* program already, it is meanwhile

[48] NZZ 2023
[49] E.g., ABC news online 01 July 2022, USA today 30 Jun 2022.
[50] Pao 2023
[51] Whittington 2023
[52] Whittington 2023
[53] Pao 2023
[54] Davis 2018
[55] NASA 2020a
[56] Goswami 2021

possible that China's moon base will come first. For this reason, every effort must be made by the United States to meet the future *Artemis* timelines, if they want to keep the leadership.

4.2 Threats to Satellites

The arms race in space is already going on. The *US Congressional Research Service* noted that "*China, Russia, and other nations are pursuing capabilities to target U.S. space systems using jammers, lasers, kinetic-kill, and now cyberattack capabilities*" [57].

The threats to satellites can be categorized into:

- Space weather
- Anti-satellite missiles[58]
- Co-orbital systems[59]
- Space debris
- Cyber-attacks (Satellite hacking)
- Electronic warfare: jamming, laser beams for sensor dazzling or destruction.

Space weather caused by solar variability is a potential threat to space systems, human space flight and ground- and space-based infrastructures upon which societies increasingly depend. Solar winds have a similar effect like an electromagnetic pulse and can damage sensitive electronic elements.

Space debris: The space activities in the past 60 years have created an estimated 23,000 pieces of uncontrolled debris that can disable or destroy a satellite[60]. However, space debris can also be used to cover *virtual satellites*. Virtual satellites consist of small parts in slightly different orbits which wireless cooperate and act like a regular satellite. Virtual satellites are an attractive approach for spy satellites, but also for military *sleeper satellites*[61].

Established weapons are *anti-satellite (ASAT) missiles* which however cause a lot of space trash which brings all other space objects into danger[62]. For testing purposes, satellites in low earth orbit have been destroyed by ballistic missiles launched from earth by Russia, the United States, China, and India. The testing of anti-satellite weapons by China in 2007 and recently by India in 2019 caused additional debris to the space environment[63].

Co-orbital systems are satellites placed on similar orbits and can intercept or interfere with other satellites through close orbital rendezvous operations[64]. In 2017, the Russian *Louch-Olympus* spy satellite came very close to the French-Italian *Athena-Fidus* military satellite and has meanwhile 'visited' eight satellites[65]. In January 2020, it was reported that the Russian satellite *Cosmos 2542* came close to the US satellite *USA 245*. The orbit of *USA 245* was then changed, but *Cosmos 2542* was able to follow. Later, it released a sub-satellite, *Cosmos 2543*, to continue the observation of *USA 245*[66].

Another weapon is *satellite hacking* which can be done as direct attack on satellites or as attack on the ground station and or providers. Little is published, but one can say that direct takeover of satellites in space is cumbersome and has little effect, while hacking of space control centers

[57] CRS 2019
[58] Finkbeiner 2021
[59] Rajagopalan 2019
[60] CRS 2019
[61] Abbany 2020
[62] Finkbeiner 2021
[63] CRS 2019
[64] Rajagopalan 2019
[65] DW 2019
[66] Finkbeiner 2021

on earth has led to a substantial increase of satellite hacking activities. Satellite hacks of US satellites were already reported since a decade and China was suspected by the *US-China Economic and Security Review Commission* since a longer time already[67]. In June 2018, *Symantec* reported successful breaches of satellite and defense companies by a new espionage hacking group (*Advanced Persistent Threat APT*) called *Thrip* which has been active since 2013.

While in the past people thought that future wars on earth would be decided in space, it seems now that future wars in space may still be decided on earth: the hacking of space control centers could be used for sabotage, i.e., by sending false commands to move satellites resulting in damage, collision, or loss. This does not only affect satellites, but is also applicable for all kinds of space robotics in general.

High-energy lasers (HELs) might be used to "dazzle" (i.e., temporarily disable) or damage satellites and sensors[68]. The *US Department of Defense DoD* plans to increase power levels from currently around 150 kilowatts (kW) to around 300 kW in 2022, 500 kW in 2024, and 1 megawatt by FY2030. A megawatt laser could be able to destroy missiles and hypersonic weapons[69]. However, the US military lasers like the *Tactical high-energy laser THEL* and the *Airborne Laser ABL* still show size and weight problems, and limited range and destructive power[70].

In 2018, China presented a Laser Weapon System on a *People's Liberation Army (PLA) Navy Ship Type 055* destroyer which looks very similar to the US Navy laser weapon system on the *USS Ponce*[71]. In 2023, a new cooling system was presented to solve the overheating problem which limited operating time and performance and makes lasers to potential low-cost anti-satellite weapons and it was reported that a ground-based anti-satellite laser system was built in Xinjiang[72]. In addition, a space-based megawatt laser system was developed that can fire five nanosecond beams 100 times per second over 30 minutes[73].

Laser weapons were already used in military practice: In May 2018, the United States reported that in Djibouti, where both the United States and China are present with military bases, China has repeatedly used lasers to interfere with US aircraft landing[74]; at least three times military-grade lasers were used in the above-described incidents and two pilots suffered from minor eye injuries[75]. In the same year, it was reported that US military aircrafts were attacked more than 20 times over the East Chinese Sea, also Australia in one case. On 17 February 2020, a US *P8-A Poseidon* surveillance aircraft was hit by a laser beam from a Chinese *Luyang III* class destroyer 380 miles west of Guam[76]. In February 2023, a blinding laser attack on a Philippian Coast Gurad Ship was reported[77].

Based on the increasing threats, there is need for a concept of space resilience as the technical backbone of space defense. There is no official NATO definition, but resilience (or resiliency) is commonly understood as robustness and survivability[78]. The space defense needs to cover the space segment with spacecrafts, the ground segment with control center, ground station and

[67] Menn 2018
[68] Hoehn 2021, Sayler et al. 2021
[69] Sayler 2021
[70] Honrada 2023
[71] The Maritime Executive 2019
[72] Honrada 2023
[73] Honrada 2023
[74] Cronin/Neuhard 2020
[75] Cronin/Neuhard 2020
[76] Cronin/Neuhard 2020
[77] Honrada 2023
[78] Console 2018

remote centers as well as the IT facilities and the launch facility, and finally the user segment with customer terminals (such as satellite TVs or now the satellite-based internet system *Starlink*)[79].

4.3 High Altitude Espionage Balloons

High Altitude espionage balloons were already used in the cold war, but the research focus shifted to satellite technology. But meanwhile, the above-mentioned problems with satellite security led to a re-activation of these balloons by the *US Army* due to multiple advantages: they are low-cost, unmanned, can carry payloads for electronic warfare, surveillance, jamming and observation, are difficult to detect, and can be easily replaced. In 2021, balloons were released in Norway and the Indo-Pacific region, in 2022 the *Thunderhead balloon system* in the Philippines[80].

In the meantime, China made research for high-altitude balloons as near-space earth observation platforms on sensor systems which are resilient against the near-space environment conditions[81].

From 28 January 2023 to 04 February 2023, a Chinese high-altitude balloon flew over the Aleuts, Alaska, Canada, and the United States. An airport was closed when the balloon was observed on 02 February 2023, but it was decided to wait with shooting until the balloon drifted over the open water. Then, a F-22 fighter jet fired a single *AIM-9X Sidewinder* to take the 90-feet large balloon down into the Atlantic Ocean. Only F-15 and F-22 jets can reach the necessary altitude of 60,000 to 65,000 feet (approximately 20 kilometers)[82].

The analysis showed that China already sent at least three times intelligence balloons over the United States in the Trump era. The US Intelligence found that Chinese balloons have previously been spotted in 40 countries[83]

5. Concluding Remarks

There are growing tensions between United States and China in space policy. With respect to the moon, both sides have formed growing multi-national space alliances, the *US Artemis Accord* with over 20 countries including India and the Chinese *International Lunar Research Station Cooperation Organization ILRSCO* with 5 initial member states countries including Russia.

The paper has shown that the Lunar South Pole is the strategic key area as the best place for a permanent moon base with access to sunlight and lunar water ice and both East and West suspect each other to attempt control over the moon and its resources.

The conflicts around the Lunar South Pole are embedded in growing tensions in space policy, in particular for satellites. Satellite hacking and laser weapons made substantial progress. Consequently, high altitude espionage balloons were re-activated as safer alternatives.

From a strategic perspective, the United States were leading for decades, but as there were substantial delays in the implementation of the *Artemis* program already, it is meanwhile possible that China's moon base will come first. For this reason, every effort must be made by the United States to meet the future *Artemis* timelines, if they want to keep the leadership.

[79] Console 2018
[80] US Army 2023
[81] Wang et al. 2020
[82] Gordon et al. 2023
[83] Naegele 2023

6. Literature

Abbany, Z. (2020): Modern spy satellites in an age of space wars. Deutsche Welle online 25 Aug 2020 Article a-54691887

Arch Mission Foundation (2019): the Lunar Library. www.archmission.org

Cannara, A. (2011): Presentation Thorium-Based Molten-Salt Reactors. Sbcglobal.net

CLEP (2023): International Lunar Research Station (ILRS) China Lunar Exploration Program. Presentation at the United Nations Office for Outer Space Affairs (UNOOSA) 29 May 2023

Congress (2015): The U.S. Commercial Space Launch Competitiveness Act (CSLCA) H.R. 2262 114th Congress Final Version 25 Nov 2015 www.congress.gov

Console, A. (2018): Space Resilience – Why and How? The Importance of Space Resilience and the Current Approach. Joint Air Power Competence Centre (JAPCC) Journal Edition 27/2018, p.10-16

Cronin, P.M., Neuhard, R.D. (2020): Countering China's Laser offensive. The Diplomat 02 April 2020

CRS (2019): "Space Force" and Related DOD Proposals: Issues for Congress. Congressional Research Service CRS Paper 08 April 2019

Davis, M. (2018): Space: the next South Chinese Sea. The Maritime Executive online.

Deutsch, A.N., Head J.W., Neumann, G.A. (2018): Distribution of surface water ice on the Moon: An analysis of host crater ages provides insight into the ages and sources of ice at the lunar south pole. Nasa/Brown University Paper on Nasa.gov

Devlin, H. (2019): Battlefield Moon: how China plans to win the lunar space race. The Guardian Jan 2019

DW (2019): France details military command of space plans to protect satellites. Article a-49747318

Feldman W.C. et al. (1998): Evidence for Water Ice Near the Lunar Poles. Feldman et al., Science, 281, 1496, 1998

Finkbeiner, A. (2021): Kampf im Orbit. Spektrum der Wissenschaft 17 Mar 2021

Gordon, C., Hadley, G., Naegele T. (2023): Concerns Over China Reach New Heights Air & Space Forces Magazine (ISSN 0730-6784) March 2023 (Vol. 106, No. 3), pp.22-25

Goswami, N. (2021): The Strategic Implications of the China-Russia Lunar Base Cooperation Agreement. The Diplomat 19 March 2021

Goswata, N. (2019): China's future space ambitions: What's ahead? The Diplomat 04 Nov 2019

GPO (2020): Executive Order 13914 of April 6, 2020 Encouraging International Support for the Recovery and Use of Space Resources Federal Register Vol. 85, No. 70 Friday, April 10, 2020

Hoehn, J. (2021): Defense Primer: Directed-Energy Weapons. Updated September 29, 2021. Congressional Research Service CRS, Document IF 11882

Honrada, G. (2023): China claims laser weapon gain on US space dominance. Asia Times 14 August 2023

iSpace (2023a): HAKUTO-R Mission 1 Lunar Lander Successfully Enters Lunar Orbit Press Release March 21, 2023

iSpace (2023b): ispace Announces Results of the "HAKUTO-R" Mission 1 Lunar Landing Press Release May 26, 2023

iSpace/Ariane (2021): ispace Europe and Ariane Group and European Space Agency assess Commercial Partnership for Lunar Transportation Services. December 2021

Jones, H.W. (2019): Moon Base Life Support Design Depends on Launch Cost, Crew Size, and Mission Duration. 49th International Conference on Environmental Systems ICES-2019-17. 7-11 July 2019, Boston, Massachusetts NASA Ames Research Center, Moffett Field, CA, 94035-0001

Mann, A. (2019): China's Chang'e Program: Missions to the Moon. Ww.space.com Article 41300

McLeod, C.L., Krekeler M.P.S. (2017): Sources of Extraterrestrial Rare Earth Elements: To the Moon and Beyond. Resources 2017, 6, 40; doi:10.3390/resources6030040

Menn, J. (2018): China-based campaign breached satellite, defense companies: Symantec. Reuters online 19 June 2018

Naegele, T. (2023): Myth busting. Editorial. Air & Space Forces Magazine (ISSN 0730-6784) March 2023 (Vol. 106, No. 3)

NASA (2019): Beresheet. Nasa Space Science Coordinated Archive. NSSDCA/COSPAR ID: 2019-009B https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2019-009B

NASA (2020a): NASA's Plan for Sustained Lunar Exploration and Development. Nasa Document NSPC Report 4220 final.

NASA (2020b): Artemis Plan -NASA's Lunar Exploration Program Overview September 2020

NASA (2021): NASA's Artemis Base Camp on the Moon will need Water, Light, Elevation. Nasa.gov 27 January 2021

NASA (2023): Fast facts: Chandrayaan-1. www.solarsystem.nasa.gov Last access on 23 Aug 2023

NZZ (2023): Russische Mondmission scheitert. Neue Zürcher Zeitung 21. August 2023, p.1

Pao, J. (2023): What do the moon and South Chinese Sea have in common? Asia Times 08 Feb 2023

Pekkanen, S.M. (2019): Introduction to the Symposium on the New Space Race. Governing the New Space Race. Ajil Unbound. doi:10.1017/aju.2019.16

Rajagopalan, R.P. (2015): Japan's Shift in Space Policy Reflects New Asian Realities. 23 Feb 2015

Sayler, K.M. (2019): Defense Primer: Emerging Technologies. Updated December 19, 2019. Congressional Research Service CRS, Document IF 11105

Sayler K.M. et al. (2021): Department of Defense Directed Energy Weapons: Background and Issues for Congress. Version 2Updated September 28, 2021, R46925

Schaler, E.W., Purucker, M.E. (2006): Lunar South Pole Hydrogen & Water Ice Deposits: Constraints from Lunar Prospector magnetic field observations. Draft paper Geophysical Research Letters August 25, 2006, 2:32pm

Space News (2022): NASA and China are eyeing the same landing sites near the lunar south pole. SpaceNews.com 31 Aug 2022

United Nations (2017): International Space Law: United Nations Instruments. New York, 2017. UN Office for Outer Space Affairs

United Nations (2019): Report of the Committee on the Peaceful Uses of Outer Space. Sixty-second session (12–21 June 2019), General Assembly Official Records Seventy-fourth Session Supplement No. 20, 75 pages

UNOOSA website (2023): United Nations Office for Outer Space Affairs (UNOOSA)

US Army (2023): High Altitude Ballons. US Army Yearbook 2023, p.26. Key Publishing.

Wang, Z. et al. (2020): High-Altitude Balloon-Based Sensor System Design and Implementation. Sensors 2020, 20, 2080; doi:10.3390/s20072080

Wattles, J. (2023): Lunar spacecraft likely fell 3 miles before crashing into the moon in historic landing attempt. CNN 26 May 2023

Whittington, M.R. (2023): How NASA's Artemis program could help to defeat China. The Hill on Msn.com August 2023