

Dear reviewer,

Thank you for your detailed and demanding assessment. The comments identified some major and minor problems in the paper; therefore, the paper has been changed substantially. I hope that the new version will be satisfactory.

The principal changes are as follows: the introduction has been rewritten with research questions clearly stated, literature review has been modified to include; the literature review method, literature on sustainability assessment and definitions/ conceptualization of space sustainability have been broadened.. The theoretical part has been restructured, to include legitimacy theory and voluntary disclosure. As recommended, the proposed governance model was moved into discussion. Methodological part has been rewritten and now it is reproducible. The selection of cases has been made based on mass, i.e. share in the national launch mass, addressing the comment that satellites of different size and capability cannot be treated as equivalent. Data was drawn from UNOOSA, GCAT and UCS databases and the raw data is presented in the Supplementary materials. Inclusion criteria and each step of the procedure has been explained in the text.

Case Studies (qualitative research) has been modified. Operators were selected based on a threshold – at least 2% share in the national launch mass- this means three operators in the case of the USA and four operators in the case of China. The corpus of documents include only documents issued by the operators themselves, and each document was coded against analytical framework four domain framework and descriptive codes (codebook is available in the supplementary materials) Analysis has been rewritten with new findings stated clearly (subsections 6.1., 6.2, 6.3). Discussion was added (to include the proposed governance model) and Conclusion was modified.

The list of comments and modifications in the manuscript are listed as bellow.

Reviewer comment	Modification explanation	How/where it appears in the paper
Major aspects of evaluation of sustainability impacts and how to handle them, e.g. LCA and the PEFCR framework, the ESA framework, are missing in the review as well as incorporation of the	Thank you for this detailed comment. This is addressed as follows: - LCA, PEFCR are explained under 2.3 Assessing sustainability impacts	- 2.3. Assessing sustainability impacts (page 8-10)

analysis and its results. The purpose of the paper remains largely unclear, which is also attributed to the fact that it lacks any clear structure. For instance after a somewhat chaotic introduction, the author presents a literature review, without even explaining how it was conducted, and after that review presents the research question.	- The purpose of the paper is elaborated in the introduction with 3 research questions - Introduction has been rewritten to show more clear structure of the introduction and the whole paper - Literature review now opens with 2.1. Literature review method	- 1. Introduction (pages 1-3) 2.1. Literature review method (page 3)
The exact background and science question is unclear. Needs to be stated beyond "This study focuses on the issue of satellite ownership structures and their implications for sustainability". What is that issue? Why is it relevant? How are ownership structures putting up implications for sustainability?	Thank you for this comment, I have addressed it by rewriting the whole Introduction, and going through the literature that indicated the question of ownership but treated it as a background, not as a key variable.	Page 1. (second paragraph of the introduction) Page 2 second paragraph – identifying the gap pointing towards the question of ownership
RE-PGM is dropped on line 34. This needs to be explained. Why that? Where is this coming from? In which context is that relevant?	Thank you for this observation. Accordingly I have moved the new proposed model of governance RE-PGM in discussion.	The last part of 3.1. with RE-PGM was deleted Discussion part was added 7. Discussion; Towards a Responsibility-Embedded Polycentric Governance Model
The paper structure	Thank you for this comment,	Introduction – rewritten

needs to be revised. What I the chapter 2 doing? The Background needs to be explained, the research goal and then the method, including a well explained literature review. The research questions need to be clearly derived and integrated into the text and not mentioned in passing at the end of the literature review	after additional research. I opted to focus on more clear research questions. The Background is based on a fact that previous studies were pointing out to the question of ownership (as stated in the introduction), literature on international law, governance and sustainability assessment (presented in details in the chapter 2 – literature review) pointed out that information disclosure is important. Followed by these observation, the study stated clear research questions – in the introduction.	Research questions- clearly stated in the introduction and repeated at the end of literature review. Literature review expanded and divided in 4 parts 2. Literature review 2.1. Literature review method 2.2 Defining space sustainability 2.3. Assessing sustainability impacts 2.4. Research gap and research questions
Within the paper statements without foundation occur frequently, e.g. p 2, "The sustainability of space exploration, along with the related problems, constitutes one of the most frequently addressed research topics in the existing literature" without any explanation how that was found and how even the literature	Thank you for this observation. This sentence was modified. Following sentence briefly explains literature review method and strains of scholarship identified.	Space sustainability, thus, has attracted growing scholarly attention. Through a thematic literature review, the study identified several strands in the existing scholarship on space sustainability, including studies that present narrow (Buitrago-Leiva et al 2025) and broad definition of space sustainability (Mo et al 2024; Lawrence et al 2022; Boley and Byers 2021), as well as studies highlighting specific issues such as sustainable space technologies (Palmroth and Hukkinen 2025), and optical interference (Bassa et al 2022). There are also studies that address the issue of how to measure space sustainability. These studies

		predominantly rely on European Space Agency (ESA)'s Life Cycle Assessment and suggest measurement improvements (Maury et al 2020), provide method to measure and communicate environmental performance (European Commission 2021), highlight collection of data as major obstacle for performing LCA (Verkammen et al 2023) etc. The study also examined literature on international law that serves as a basis of space governance. These studies highlight voluntary nature of the international law and transparency problems in registration (Di Pippo 2016; Masson-Zwaan et al 2024), while some emphasize the issue of corporate accountability (Freeland and Ireland-Piper 2022; Cirkovic, Rathnasabapathy, and Wood 2021; Campodonico 2023).
The theoretical background chapter 3 comprises several elements, which are more conclusions or ideas of the author, e.g. interpretation of ADP. This is a result or a discussion, not part of the background.	Theoretical framework was changed, Interpretation of ADP along with the proposed new governance model RE-PGM was moved in the Discussion (section 7)	Theoretical framework now includes 3.1. 3.1 From International Law towards Polycentric Governance of Space as Global Commons (some sentences were modified, authors interpretation and RE-PGM were moved to Discussion) 3.2. Legitimacy and organizational disclosure (this part in newly written)

		3.3. From Ownership Structures towards Voluntary Disclosure (this part is newly written)
The method is not explained at all. The author derives numbers for satellites in an unknown way. How e.g. the countries were selected is not explained. Why e.g. ESA and ESA member states are separately used, is not explained. Why other nations are left out, is not explained. There are evaluations of the numbers, which should be in the results section. Also, the satellite numbers are not representative to make the statements about who is a "dominant" or "leading actor" (p 11). Satellites sizes differ significantly, as do mission durations. This is also why just stating launched objects is not very representative. It is a significant difference in achievement, capability and purpose if a nation launches a cube sat or a multi ton satellite.	Thank you for this comment. Methodology section is completely rewritten. - Methodology explains exactly how numbers were obtained, each step of the procedure along with the rationale is explained - Raw data is available through the supplementary files - Explanations why certain states were omitted, and why the study focuses only on the USA and China is available under page 16th (last paragraph and page 17 – table 4). ESA and ESA member states are recoded separately because this is how they are registered by UNOOSA. - UNOOSA database has been recently publicly unavailable, that fact has been stated under footnote 4 (raw data available through Supplementary files)	Pages 16 -20

	- Words dominant / leading actor were deleted through the whole paper - Satellites numbers were replaced by mass (i.e. case studies were selected according to a threshold – more than 2% share of the national launch mass)	
No systematic approach is conceivable in the paper. There is not objective, reproduceable procedure. What is presented is conjecture from the author.	Thank you for this observation, in order to make the approach systematic and reproducible – the literature review section has been expanded, literature review method explained, methodology – data was acquired through 3 databases , each step has been elaborated and raw data made available	2.1. Literature review method 4. Research Methodology and Satellite Data
Overall, this paper is not presenting any useful findings in any meaningful way. Many aspects, e.g. SDG relation to space and activities to add another SDG, are omitted. It is very evident that the author is not very familiar with space policy and governance and it is highly recommended that the author gets more familiar with the subject and how sustainability is approached in that field. It must exceed space	The author accepts that the original manuscript treated sustainability too narrow and engaged insufficiently how he field approaches assessment. The revision addressed this in following parts. The conception of sustainability has broadened. (Literature review 2.2.). The study relies on a four domain framework by Mo et al (2024) adapted to orbital context. The framework now incorporates orbital deposition, the finite character of orbitals, interference with astronomy	

debris.	(Bassa et al 2022; Lawrence et al 2022). This four domain framework is used also for coding procedure (qualitative assessment of operators' public disclosure – 5. Case studies)	
Comments from PDF file		
Reviewer comment	Modification explanation	How/where it appears in the paper
Less than decade ago? Based on what source? The vast majority of satellite launches have been commercial, a decade ago, by far. Especially launch vehicles were produced by private companies, such as ULA.	This part of the introduction was modified to more specific wording and a specific source.	The number of satellites operating in orbit reached 11,539 in 2024, compared to 3,371 in 2020 (Satellite Industry Association 2025). In 2024 alone, there were 259 launches deploying 2,172 tons and 2,695 satellites into the orbit. Space economy grew by 4%, producing a revenue of \$415 billion, among which commercial satellite industry accounted for \$293 billion or 71%.
which comemrcial space exploration activities occured? On what scale, in what relation to non-commercial? Space exploration is not the same as space utilization.	This part of introduction was changed Space exploration was replaced by space utilization through the paper	In 2024 alone, there were 259 launches deploying 2,172 tons and 2,695 satellites into the orbit. Space economy grew by 4%, producing a revenue of \$415 billion, among which commercial satellite industry accounted for \$293 billion or 71%. All these developments, even though welcomed by futurists, technology enthusiasts, public and private sectors, produced also some unintended consequences. These primarily include congestion risks for the growing

		presence of mega constellations in the Low Earth Orbit (LEO), collision risks, space debris, atmospheric deposition, interference with astronomy, etc.
from where stems this direct quotation? Who says it is the Magna Carta of Space? In what context?	The wordings were modified to a more objective expression. The citation is added at the end of the sentence.	The Outer Space Treaty (OST), ratified by all major spacefaring nations in 1967, established foundations of the international space law, and it is a binding treaty that obliges states to obey key principles (freedom of use, non-appropriation, peaceful uses, benefit to mankind, and liability) and, thereby, respect obligations including space objects registration, responsibility for space activities carried by public and private entities, avoiding harmful contamination, etc. (Cirkovic, Rathnasabapathy, and Wood 2021; Di Pippo 2016).
You are jumping between topics. Climate change and governing climate protection actions are very different from space. Space is a commodity distributed based on terrestrial governance, whereas climate change actions are in-situ regulated	Thank you for this comment. The references to climate change were removed.	
At this moment this cannot be assessed. Objects launched comprise more than just satellites. Are you sure you are only referring to satellites?	Thank you for this observation, This is modified by refereeing only to data assessed.	
Why limit it to these antions?	Explanation is available under 4. Research Methodology and	In the first step – establishing population, the study

	Data(2 nd paragraph)	undertakes the following analysis of the UNOOSA database. The database was analysed from January 1, 2026 until January 31st, 2026, by downloading the data in a separate excel sheet. The search included the following inclusion criteria; launching year- from 2019 to 2025, state of registry and satellite status "in orbit" (satellites with failed launch, inactive satellites and de-orbited satellites were omitted from the search). In this stage, the study identifies states with the largest numbers of satellites according to the above mentioned inclusion criteria. (Table 4), the USA, China, Russia, and European states France, Germany, Italy, the United Kingdom (UK). As demonstrated in the Table 4, the USA and China possess the largest number of satellites in orbit; furthermore the number of launches is consistently growing year-by-year (with the exception of the year 2020 for China). Russia launched comparatively small number of satellites. European countries launched satellites individually and under the European Space Agency (ESA). Their number of launches presented both, individually and under ESA, is relatively small compared to the USA and
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		China. The UK launched comparatively large number of satellites from 2020-2023; however, later that number dropped significantly. The study also analysed launching data of other countries such as Japan and South Korea; however, their numbers are relatively small and inconsistent compared to the above-mentioned states.
What does that mean? While there are cooperations, ESA and EU are two separate entities and not related.	Mentions of EU were deleted and the paper mentioned only European states FRA, GER, ITA, UK	
Starlink is not a separate company. It is a division of SpaceX.	Thank you for this observation. This is now modified in a way that the name of company appears as SpaceX(Starlink) through the paper.	
This link is not working	Thank you for this comment. UNOOSA database has not been available for public access since July 2026. This was noted in a text and cited.	Footnote no 4. UNOOSA database displays launches of space bodies, the search does not automatically allow removing rockets and other satellite bodies, those were removed by re-examining the data according to the space object name. Furthermore, selection criteria; launching year 2019-2025 and status "in orbit," combined together, include satellites launched between 2019 and 2025 that were still in the orbit at the time of the search, January 2026. In the manuscript writing period (July – August 2026), the database

		became inaccessible due to maintenance (UNOOSA 2026b). Downloaded data is made accessible through Supplementary file no.1. Citation has been modified to record unavailability of UNOOSA database (UNOOSA 2026b).
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