Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: SUSTSP / REUSYS / NEWSPA
Corresponding author: FROLOVA Angelina
e-mail of corresponding author: angelina.frolova@epfl.ch
Type: Oral
Status of corresponding author: Student
For student corresponding author: student member of one of the following:
~~3AF / AAAR / AIAE / AIDAA / CzAeS / DGLR / FTF / NVvL / PSAA / RAeS / SVFW / EUROAVIA~~

Title

Sustainability Aspects of Rapid Prototyping with Frequent In-Orbit Demonstrations of CubeSats.

Authors
Angelina FROLOVA [1], Lina Kuhlmann [2], Joaquim Silveira [3] ,Santiago Evangelista [4]*

** Corresponding author*
[1] EPFL Spacecraft Team, 1015 LAUSANNE, Switzerland, angelina.frolova@epfl.ch
[2] EPFL Spacecraft Team, 1015 LAUSANNE, Switzerland, lina.kuhlmann@epfl.ch
[3] EPFL Spacecraft Team, 1015 LAUSANNE, Switzerland, joaquim.silveira@epfl.ch
[4] EPFL Spacecraft Team, 1015 LAUSANNE, Switzerland, santiago.evangelista@epfl.ch

Abstract
The growth of the space industry is accompanied by the pressing challenge of minimizing negative externalities and maximizing benefits for humanity, in other words, finding and maintaining the sustainable development track. This research aims to carry out an up-to-date analysis of sustainability issues associated with rapid prototyping and frequent in-orbit demonstration (IOD) with CubeSats, and, building on the results of this analysis, provide an exhaustive set of guidelines for the said processes. By sustainability issues the authors mean *environmental* (material waste, particulate pollution, greenhouse gasses emissions, etc.), *economic* (cost and value analysis, economic viability, contribution to economic development) and *legal* aspects [1]. The sustainability problems concerning prototyping and flight-proving with CubeSats are legion with the existing body of research not offering clear and exhaustive solutions for fixing the entirety of them, yet, the demand for this format of a satellite is growing, which necessitates fixing the gap and explains the relevance of the research at hand.
The choice of the CubeSat format as the object of research for this paper stems from its compactness, relative cost-efficiency, simplicity and functionality. The characteristics listed above explain the format's popularity, which is expected to grow tremendously in the near future, potentially leading to the problem of drastically reduced orbit availability. As of today, the space industry is severely underregulated. Therefore, in this paper the authors take into consideration legal aspects on top of the aforementioned sustainability issues.
The subject of the research, which is the prototyping and IOD in the context of space sustainability, was chosen due to the fact that nowadays the space industry lacks clear and unambiguous criteria for the said actions concerning CubeSats. Moreover, the authors identified these particular stages, because they present vital importance and cannot be neglected. Fast prototyping allows for accelerated technological and economic growth, however it can come at a cost both literally (material expenses) and figuratively (possible impact on sustainable development). As for the IOD, it is particularly important when it comes to the development of new space technologies, as it allows for the testing of new systems in the harsh and demanding environment of space [2]. Given the increasing demand, vital importance and high risks of

IOD, the sustainability issues of this stage deserve significantly more attention from researchers and policy-makers than they currently are paid.

The authors of this article provide a comprehensive analysis of the trade-offs between the number of IODs and their associated costs, risks, benefits and externalities in the context of CubeSat missions. Based on their findings, the authors present a balanced approach to determining the appropriate number of IODs, as well as practical recommendations for the prototyping phase to ensure the sustainability and success of CubeSat operations. The overall conclusion is that it is more sustainable to perform IOD demonstrations than to neglect this phase, yet, such missions must be more thoroughly planned and more regulated. Additionally, better end of life strategies for CubeSats are required to make the industry more sustainable.

References

[1] Peter Martinez, The development and implementation of international UN guidelines for the long-term sustainability of outer space activities, Advances in Space Research, 2022, ISSN 0273-1177, https://doi.org/10.1016/j.asr.2022.06.046.

[2] About In-Orbit Demonstrations. European Space Agency. https://www.esa.int/Enabling_Support/Space_Engineering_Technology/About_In-orbit_demonstrations