UNITED NATIONS
Office for Outer Space Affairs

Promoting Space Sustainability

[Title of activity]

German Space Agency at DLR

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Implementation of the Guidelines for the Long-term Sustainability (LTS) of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space

Operational Case Studies

[Operational case studies are drafted by the submitting entity in their own words using the following template. Please avoid using national jargon and spell out acronyms to assist readers from other jurisdictions. All case studies will be made publicly available to facilitate peer-to-peer exchange, share experiences and raise awareness.]

I. Short description of the outer space activity [*1000-word max.*]

Space activities by the German Space Agency at DLR are consistently aligned with the idea of sustainability. In 2009 DLR established the space debris mitigation (SDM) requirements for space projects as part of the product assurance and safety requirements. These SDM requirements are applicable for all space mission projects within DLR national program for space and innovation. They are derived from or refer to internationally recognized standards and guidelines, such as:

- UN Space Debris Mitigation Guidelines
- IADC Space Debris Mitigation Guidelines
- ISO Standards, mainly ISO 24113

In the frame of the adoption process the standards and guidelines are tailored to the specific needs of projects of the DLR national program. DLR monitors the implementation and verification of the requirements and decides on possible waivers.

In the last years, the number of space objects especially in Low Earth Orbit (LEO) is growing almost exponentially, caused predominantly by the materialization of large satellite constellations, today each spanning hundreds or even thousands of satellites. But also, collisions with and break-up events by abandoned satellites and rocket bodies contribute to the steep increase of objects in LEO. As a consequence, international guidelines and standards addressing space debris mitigation and long-term sustainability of outer space activities are updated to incorporate the current situation in space. Because the DLR SDM requirements are derived from these guidelines and standards, they are also updated regularly. The last update was performed in 2018.

Space projects are very complex projects, combining cutting-edge technology in a harmful, non-forgiving environment like space. Typical space projects span many years, challenging projects may span well over a decade. At DLR, SDM requirements are implemented already in very early phases of a space project. Therefore, a situation can easily arise where the initially implemented SDM requirements undergo a major update to reflect the latest threat by the space debris environment as well as internationally agreed countermeasures. As SDM requirements influence the design of a space project, the adaptation of updated SDM requirements in later phases can have substantial effects.

DLR’s mission EnMAP (Environmental Mapping and Analysis Project) is an Earth observation mission to be launched in 2022. The 1000 kg satellite will be placed in a sun-synchronous orbit with an altitude slightly above 600 km. EnMAP is foreseen to operate for at least 5 years and to provide hyperspectral images of the Earth’s surface in the spectral range of 420 – 2450 nm with a spectral resolution below or equal to 10 nm. With the data from EnMAP, accurate, quantitative measurements of the state and evolution of ecosystems is possible.

Early in the preliminary design phase (phase B) of the EnMAP project, the DLR SDM requirements were not established yet. For EnMAP, the SDM requirements based on the European Code of Conduct (CoC), Issue 1 (2004) were implemented instead. However, after the Critical Design Review of the EnMAP project it was decided by DLR to formally implement the DLR SDM requirements which were established after the start of the EnMAP project and to replace the CoC as the applicable SDM requirements document for this project. This decision followed a trade off between the additional effort to implement the new SDM requirements late in the project as well as ensuring mission success and ensuring a sustainable use of space.

The implementation of the DLR SDM requirements had some major impacts on the EnMAP mission design and operations. The collision risk analyses were updated using the currently available data for the space environment. As a consequence, active collision avoidance, which had previously not been foreseen, was implemented with a consecutive update of the mission budgets, most notably to account for the additional fuel necessary to accomplish the collision avoidance manoeuvres. In addition, the deorbit manoeuvre as part of the disposal phase after mission completion was updated to lower the perigee of EnMAP below 500 km to ensure a re-entry of the spacecraft well within 25 years. The last manoeuvre alone consumes around 1/3 of the total propellant aboard the spacecraft.

Also, the casualty risk due to fragments of the spacecraft surviving the atmospheric re-entry was redone using state-of-the art modelling tools to properly reflect the complex composition of the EnMAP satellite and the unavoidable usage of heat-resistant materials. The analysis showed that the EnMAP design is compliant with the requirements. A controlled re-entry, however, was beyond the capabilities of the selected satellite platform, but in the end not necessary to comply with the safety requirements.

II. Connection with the LTS Guidelines [*500-word max.*]

The measures introduced in the EnMAP mission are aimed at increasing the safety of the mission, both in space and on the ground, thereby contributing to the overall objective of Chapter B of the LTS guidelines.

In particular, the measures support Guideline B.8, which recommends that States "design [space] objects to implement applicable international and national space debris mitigation standards and/or guidelines in order to limit the long-term presence of space objects in protected regions of outer space after the end of their mission." By ensuring an atmospheric re-entry of the spacecraft within 25 years, the mission will adhere to the timeframe recommended in international space debris mitigation guidelines, most importantly those of the Inter-Agency Space Debris Coordination Committee (IADC).

In addition, the measures also contribute to Guideline B.9, which states that States "should consider applying design techniques to minimize the risk associated with fragments of space objects surviving uncontrolled re-entry." By re-assessing the casualty risk from spacecraft fragments using modern modelling tools, it could be confirmed that the satellite design has taken into account these risks and minimized them to such a degree that it is in line with applicable international standards and guidelines.

Finally, adding an active collision avoidance capability to the spacecraft is indirectly supporting Guideline B.4, which recommends to perform conjunction assessments during all phases of controlled flight. The mission will now be able to act upon such conjunction assessments and perform an avoidance manoeuvre if a potential collision with another spacecraft is detected.

III. Lessons learned [*500-word max.*]

The current rising activity in space dramatically changes the space environment, especially in LEO. International guidelines and standards are updated or newly created to address this issue. Space projects can span long times until they are finally launched to space. The need to update the project requirements even in later project phases can arise to properly reflect the current state of the space environment as well as the state-of-art of countermeasures. The decision to update the requirements is not necessarily only a question of response for a sustainable use of space. An adequate SDM concept also ensures mission success by adjusting the risks associated with SDM.

The DLR EnMAP example described in this case study shows that the implementation of updated SDM requirements is feasible even in late project phases. The decision should be based on a trade balancing the risk for mission success by implementing outdated, insufficient SDM measures as well as the accompanying risk for the space environment on the one hand and the additional effort due the implementation of new requirements on the other hands. This additional effort is not limited to repeating and adapting analyses, the new and potentially more challenging requirements can call changes in the design and operations of the spacecraft.