LESSONS LEARNT FROM THE FIRST 18 MONTHS OF ESA'S NEW SPACE DEBRIS MITIGATION POLICY

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ABSTRACT

As part of ESA *Zero Debris* approach, in 2023, ESA updated two fundamental documents that regulate how all the Agency's space missions are designed, built, operated and disposed: ESA's Space Debris Mitigation Policy and Space Debris Mitigation Requirements. The more stringent technical requirements, combined with the policy's scope and its immediate applicability to any mission have requested some practical implementation measures that will be discussed in the paper, together with the identified critical points, especially in view of the planned update of ESA's Space Debris Mitigation Requirements by 2030 to fully align with the goal of ESA's Zero Debris Approach.

Keywords: space debris mitigation; policy; requirements; zero debris.

1. INTRODUCTION

In response to the significant change in the use of space and the increasing concern related to the space debris issues and space sustainability topics at large, ESA has decided to introduce the so-called *Zero Debris* approach. The goal is to significantly limit the production of debris in Earth and Lunar orbits by 2030 for all future missions, programmes and activities. As part of said initiative, in 2023, ESA updated two fundamental documents that regulate how all the Agency's space missions are designed, built, operated and disposed: ESA's Space Debris Mitigation Policy [1] and Space Debris Mitigation Requirements [2]. This process took place through two working groups where more than 50 experts from all-over ESA were involved, with dedicated workshops organised in parallel with industry stakeholders to gather their feedback.

The new ESA Space Debris Mitigation Requirements (ESSB-ST-U-007) [2] are built upon an existing European framework, which has been in effect since 2008 with the first ESA Space Debris Mitigation Policy and Requirements, enforced in 2014 by applying the ECSS-U-AS-10C standard [3], adoption notice of ISO 24113 [4], and eventually evolved through a series of additional requirements that cover several aspects of a mission. These aspects include more stringent conditions for orbital clearance, the adoption of design-for-removal features for missions with high-risk scenarios of space debris generation, the formalisation of best practices for collision avoidance and space traffic coordination, the extension of the applicability of the requirements to missions beyond the protected regions (including lunar missions), and, finally, the request for assessment of the impact of space missions on astronomy.

The more stringent technical requirements, combined with the policy's scope and its immediate applicability to any mission have requested some practical implementation measures, ranging from the definition of a phased approach in the application of the requirements, the organisation of extensive training sessions, the preparation of example cases that could be used as references for other missions, together with the update of ESA's Space Debris Mitigation Compliance Verification Guidelines (ESSB-HB-U-002) [5]. This paper provides an overview of the first 18 months of application of the policy, considering not only the level of compliance, but also the identified critical points, together with the lessons learned during this transition period, especially in view of the planned update of ESA's Space Debris Mitigation Requirements by 2030 to fully align with the goal of ESA's Zero Debris Approach.

2. ESA'S SPACE DEBRIS MITIGATION POLICY

ESA's new Space Debris Mitigation Policy [1] was published in November 2023, introducing some noticeable changes with respect to the previous policy document applicable [6] to ESA missions. Besides the application of the new ESA Space Debris Mitigation Requirements [2], those changes include

- the expansion of the scope to any ESA contribution to space systems,
- the immediate applicability to any mission regardless of their phase,
- the introduction of a Space Debris Mitigation Board.

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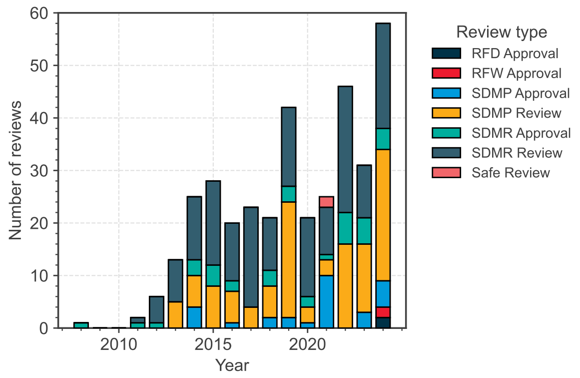

Figure 1. Number of reviews by type over time. RfD: Request for Deviation, RfW: Request for Waiver, SDMP: Space Debris Mitigation Plan, SDMR: Space Debris Mitigation Plan.

2.1. Policy scope

Figure 1 shows the number of reviews of space debris mitigation documentation performed over time by the Independent Safety Office. It can be observed how a significant increase in the number of reviews was registered in 2024. This is directly linked to the entry into force of ESA's new Space Debris Mitigation Policy [1], which includes in its scope any co-developed and co-funded missions next to spacecraft that will be registered as ESA assets (already fully covered by [6]). The publication of the policy contributed to create more awareness on ESA's internal processes related to Space Debris Mitigation and ensure a more systematic involvement of the Independent Safety Office in the relevant reviews promoting the development of a corporate (harmonised) approach to the assessments, with the possibility of triggering dedicated support from specialised experts across ESA when required.

This also meant reaching for the first time ESA projects (and related industry) that never went through an independent assessment of their mitigation approach, showing the impact of the expanded policy. On the other hand, during the actual implementation of the policy, some clarifications were required in terms of the applicability to some projects (e.g. R&D developments) and considerations on the implementation to projects with a strong industry-led component.

An interesting example is represented by operations, which is one of the cases explicitly mentioned in the scope of applicability of ESA's Space Debris Mitigation Policy [1], with the ESA's Space Debris Mitigation Requirements [2] introducing a significant number of clauses directly related solely to operations, around 20% of the engineering requirements (Figure 2).

Figure 3 shows the distribution of the reviews in 2024 based on the type of system according to the definitions in [2]. In addition to the classification based on the system type, Figure 3 also shows whether for the reviewed missions the operations are planned to be under ESA's responsibility. Figure 3 shows how the large share of the reviews, as expected, is related to *Single spacecrafts* and how operations are under ESA's responsibility in 48% of the cases. In the other cases, ESA's role is expected to end with the support to the mission development. This means that ESA cannot play a direct role in monitoring the implementation of operational requirements and those are intended as constraints for the space/ground segment development (i.e. the space segment shall have all the features/capabilities required to implement the operational requirements) and guidelines/recommendations for the operators on how to conduct operations in line with ESA's space debris mitigation principles, with contributions from ESA in terms of knowledge sharing. This is in line with the broader goal of the Zero Debris approach to lead by example and to foster a community that contributes to a sustainable future (e.g. with the Zero Debris Charter [7]). A classification of the category of the requirements is available at [8].

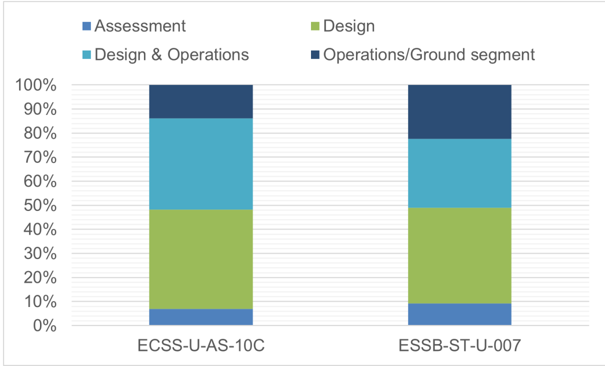

Figure 2. Number of requirement by category for ECSS-U-AS-10C Rev.1 [3] and ESSB-ST-U-007 [2].

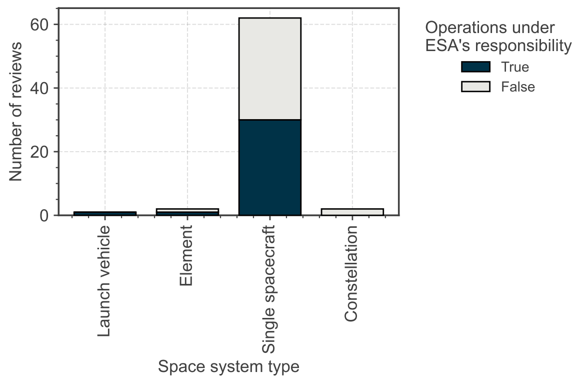

Figure 3. Number of reviews by system type and operations responsibility in 2024.

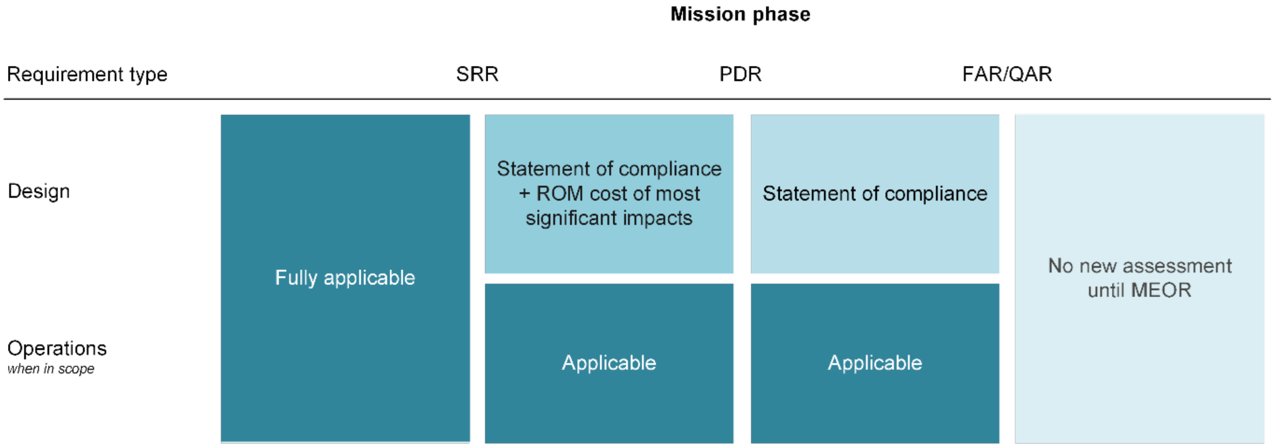

Figure 4. Proposed phased approach for the implementation of ESA's Space Debris Mitigation Policy. Acronyms are defined in the text.

2.2. Phased implementation

ESA's new Space Debris Mitigation Policy [1] became immediately applicable to all ESA projects, regardless of their development phase, and it is formally applicable to all flying ESA missions. Clearly, it is not expected that missions that are already flying can be retroactively adapted to the new requirements. Therefore, a practical implementation of the Policy to the missions depending on their phases needed to be defined in order to avoid processing a large number of waivers, with limited additional value.

The proposed approach is illustrated in Figure 4 and summarised here:

- for missions before their System Requirements Review (SRR), the new requirements in [2] are fully applicable;
- for missions between SRR and the Preliminary Design Review (PDR), the new requirements in [2] are fully applicable; as it is expected that design changes after SRR may have significant cost impact, a Rough Order of Magnitude (ROM) cost of the most significant impacts is requested to industry, so that this information can support the evaluation of any deviation;
- for missions between PDR and F/QAR (Flight/Qualification Acceptance Review), the operational requirements from the new ESA Space Debris Mitigation Requirements [2] are applicable, if the operations are under ESA's responsibility; for the design requirements, the requirements agreed in the Space Debris Mitigation Plan (SDMP) are maintained and a status of compliance with respect to the new ESA Space Debris Mitigation Requirements [2] is required;
- for missions past F/QAR, no new assessment is requested until MEOR (Mission Extension Operations Review), but regularly updates on the expected status of compliance to the space debris mitigation approach agreed in the Space Debris Mitigation Report (SDMR) are recommended.

The advantages of this approach is that, while removing the need for re-design (and related costs) for missions past PDR, it still offers the opportunity to evaluate the current status, build a complete picture of the space debris risk associated to ESA projects, and identify margins for improved compliance. In addition, the proposed phased implementation is meant to facilitate a stepped approach towards ESA Zero Debris goals, and build awareness within ESA but also outside, with industry and operators.

2.3. Space Debris Mitigation Assessment Board

ESA's new Space Debris Mitigation Policy [1] introduces a Space Debris Mitigation Assessment Board, which is activated in case of

- requests for deviation or waiver to the requirements,
- anomalies affecting the execution of the planned space debris mitigation measures,
- mission extension requests.

The purpose of the Board in these three cases is respectively to

- support to the projects in the identification of margins to improve compliance and limit deviations, especially in this initial transition phase;
- collect lessons learnt on operational consideration, disposal implementation and long-term implications (e.g. in the case of re-entries occurring in several decades),

- harmonise the risk approach and the requested assessments in case of mission extensions.

In addition, the Board can be activated in case of changes to the planned space debris mitigation approach or to report about relevant mitigation activities (e.g. as in the recent cases of the disposal of the Cluster II Salsa satellite [9] and of Gaia [10]).

While for these last cases the Space Debris Mitigation Assessment Board is contacted directly by the project team, for the three cases mentioned above (and defined directly in the Policy document [1]), the activation of the Board is requested by the affected Director. The Board, after the interaction with the Project team and with the support of independent experts, will formulate some recommendations addressed to the concerned Director, to the Head of ESA's Quality Department, to ESA's Inspector General, and to ESA's Director General, who is the only authority that can approve or reject deviations and waivers. The inclusion of all these actors is done also to ensure that programmatic considerations can be taken into considerations, next to the technical assessment provided by the Board, which, for example, in case of requests for deviation or waiver, evaluates whether the maximum results in terms of the efficacy of the mitigation measures is achieved given the mission's existing constraints (e.g. budget, launch date).

Over these 18 months, the Space Debris Mitigation Assessment Board has convened five times, demonstrating to be an effective mechanism to ensure knowledge transfer across different projects and contribute to the definition of an ESA-wide approach to space debris mitigation.

3. ESA'S SPACE DEBRIS MITIGATION REQUIREMENTS

The new ESA Space Debris Mitigation Requirements (ESSB-ST-U-007)[2] build upon an existing European framework that has been in effect since 2014 [3] and introduce a series of additional requirements that cover several aspects of a mission. An overview of the principles, rationale, and technical content of the requirements can be found in [11, 12].

In line with the findings on recently developed space debris mitigation instruments analysed in [13], ESA Space Debris Mitigation Requirements [2] present several identified traits, such as

- coverage of collision avoidance operations,
- evolution of numerical values (i.e. decay duration reduction),
- tailoring of the requirements based on the risk of contributing to the space debris issues,
- inclusion of provisions beyond the protected regions,

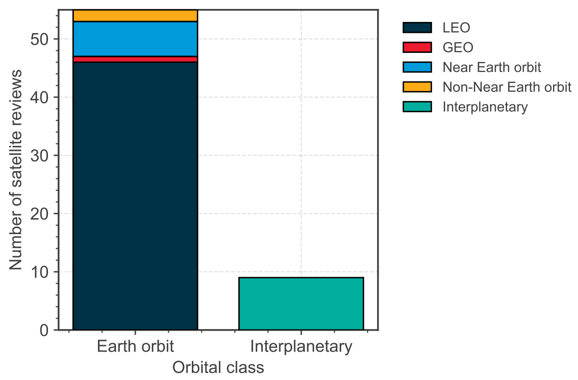

Figure 5. Number of satellite reviews by orbital class in 2024.

- endorsement of the foundations for active debris removal/servicing missions,
- extensions to other topics (e.g. Dark&Quiet skies).

In the current paper, two specific aspects related to the inclusion of the provisions beyond the protected regions and the one of the tailoring based on risk will be briefly discussed.

3.1. Provision beyond the protected regions

Space debris mitigation measures are generally applied to the so-called *protected regions*, defined as the Low Earth Orbit (LEO) Region (up to 2000 km of altitude), and the Geosynchronous (GEO) Region one (a segment of the spherical shell around the geostationary altitude, considering 200 km in altitude and 15° in latitude) [14]. However, historically, ESA has been active in applying space debris mitigation measures for missions outside the protected regions, such as the Galileo constellation in Medium Earth Orbit (MEO), missions in High Elliptical Orbits (HEO) [9, 15], and missions at the Libration Point Orbits (LPO) [16, 17, 18, 19]. Such practices are now formalised in the ESA Space Debris Mitigation Requirements (ESSB-ST-U-007) [2], and extended with a specific section dedicated to missions in lunar orbits.

Figure 5 shows the distribution of satellite reviews across the different orbital regions. As a reminder, in [2], near-Earth orbits are defined as orbits with perigee below 100000 km, whereas non-near Earth orbits include Lagrange point orbits that have the Earth as one of the two main bodies. As expected, missions in LEO represent the vast majority of the cases (72%) and 9 interplanetary missions, for which it is checked that no long-term interference with the LEO and GEO protected region exists, together with no risk for re-entry safety.

In addition, the new requirements [2] aim at improving the coordination with Space Surveillance segments, for example in the cases of Earth's fly-bys by interplanetary missions. The objective here is again to promote the adoption of the approaches already applied in the case of the Solar Orbiter [20] and JUICE [21] flybys.

As interplanetary missions are clearly not the first to come in mind when discussing space debris mitigation practices, a dedicated annex was added to ESA Space Debris Mitigation Compliance Verification Guidelines [5] to clearly explain what are the expected activities for this type of missions and for missions outside the protected regions more in general.

3.2. Tailoring based on risk profile

Several elements contribute to quantify the potential of a mission to contribute to the space debris issue, but a main driver is the *fragmentation risk*, intended as the possibility for a spacecraft to add a significant number of fragments to the environment in case of breakup, i.e. explosion or collision [22]. Elements such as the spacecraft mass, the density of debris along its operational and disposal orbits, and its permanence in orbit drive the fragmentation risk, and they are, therefore, natural parameters to use to identify different risk categories. In addition to the on-orbit component of the debris risk, it is also important to recall the aspect of casualty risk on ground due to spacecraft re-entries, which is receiving an increasing scrutiny in the last years [23].

Both these elements are considered in the risk categorisation applied in [2] and used to tailor the applicability of some requirements and the value of some threhsolds. Focussing on the satellites in LEO, Figure 6 presents a visualisation of this risk categorisation for a satellite in LEO and the corresponding tailoring of the applicable mitigation measures. In line with such classification, the following risk categories are defined:

Very high Always if operating in GEO; in LEO, if the natural orbital decay from the operational orbit either takes longer than 25 years, and it is associated to a cumulative collision probability with objects larger than 1 cm above 10^{-3}. This risk class is also selected for missions in LEO for which the casualty risk on ground in case of uncontrolled re-entry is larger than 10^{-4},

High For missions operating in LEO, if the natural orbital decay from the operational orbit either takes between 5 and 25 years or it is associated to a cumulative collision probability with objects larger than 1 cm above 10^{-3}.

Medium For missions operating in LEO with a natural orbital decay from the operational orbit shorter than 5 years and associated to a cumulative collision probability with objects larger than 1 cm below 10^{-3}.

Low For missions not operating in the protected regions.

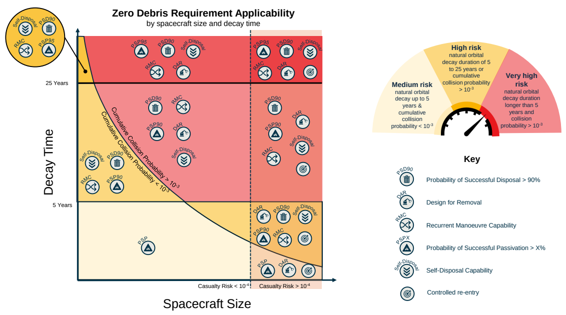

Figure 6. Visualisation of the risk categorisation for single spacecraft in LEO in ESSB-ST-U-007 [2].

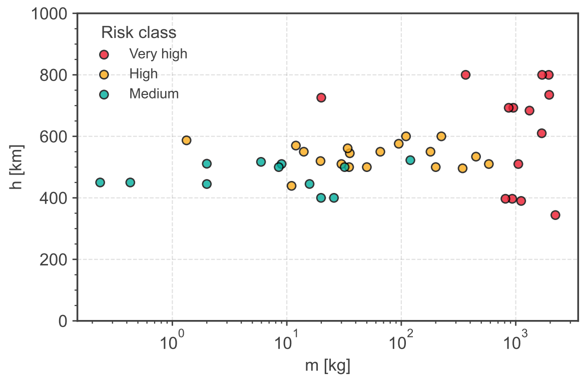

Figure 7. Distribution of the satellites reviewed in 2024 planned to be operated in LEO as a function of mass (m) and mean altitude (h). The colour indicates the risk level according to the classification in Figure 6.

Figure 7 shows the distribution according to their risk level, mass, and mean altitude. One can observe how the distribution in terms of risk level is quite balanced with, respectively, 26% classified as *Medium* risk, 41% as *High* risk, and 33% as *Very high* risk. This clearly represents the variety of projects in which ESA is involved, as visible also from the wide range of the satellite masses, from around 0.2 up to more than 2000 kg, and the importance of having developed a requirement document [2] with such a prominent tailoring of mitigation measures depending on the risk profile.

3.3. Alignment level

In this section, the level of adherence to ESA's Space Debris Mitigation requirements [2] is evaluated. As ESA's Space Debris Mitigation Policy [1] became applicable to any mission regardless of its development phase, the same approach is adopted here. This means that for all missions the level of alignment with ESA's Space Debris Mitigation requirements is considered, also in the cases where such requirements were not formally applied in the review.

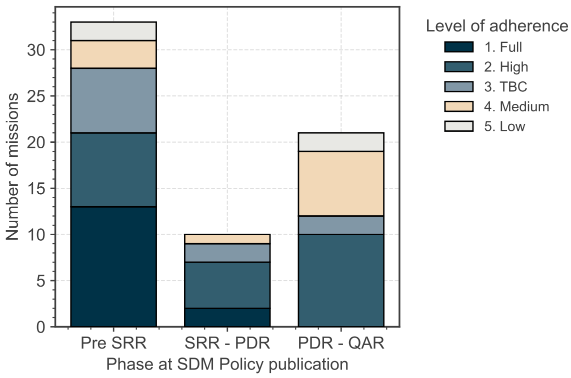

Figure 8. Level of adherence to ESA's Zero Debris principles as a function of the project phase at the publication of updated ESA's Space Debris Mitigation Policy for the spacecraft reviewed in 2024.

The determination of the level of adherence is based on the following definitions

Full ESA's Space Debris Mitigation Requirements [2] are applicable, and the mission is compliant or plans to be compliant with a high level of credibility

High ESA's Space Debris Mitigation Requirements [2] are not applicable, but the main principles of the new requirements (e.g. approach to clearance in LEO) are respected

TBC ESA's Space Debris Mitigation Requirements [2] may or may not be applicable, the mission plans to be compliant with the main principles of the new requirements, but the maturity of the mitigation plan needs consolidation

Medium The mission is compliant with the previous requirements in ECSS-U-AS-10C [3], but not with the main principles in ESA's Space Debris Mitigation Requirements [2]

Low The mission is not compliant with ESA's Space Debris Mitigation Requirements [2] nor with the previous requirements in ECSS-U-AS-10C.

It needs to be noted that the assessment is linked to the specific reviews performed in 2024, and that the classification for a certain mission can therefore change in the future. This is particularly relevant as for some critical areas in some projects, there is currently a significant effort ongoing to improve compliance, so that better level of adherence may be reach at the next reviews.

Following the phased approach described in Section 2.2, the level of adherence is first checked with respect to the project phase at the publication of updated ESA's Space Debris Mitigation Policy [1]. As expected, for missions past PDR, there is a portion of projects in the *Medium* adherence category as the new requirements were published too late with respect to the project development. A few instances are also present where a no compliance to ECSS requirements [3] is registered, and in particularly the deviation is related to the requirement on the casualty risk on ground. Similarly, the entries classified as *Low* in the early-phase missions (pre SRR) are cases where the compliance with requirement on the casualty risk on ground could not be fully demonstrated. On the positive side, half of the missions past PDR already show a *high* level of adherence with ESA's Space Debris Mitigation Requirements [2], in part because some of these missions are flying in orbital regions where the requirements were not significantly changed and in part because some critical elements of Zero Debris approach (e.g. the reduction of the time for orbital clearance in LEO, the adoption of design-for-removal features) were anticipated in the large institutional projects (e.g. by adopting a controlled re-entry as disposal strategy, by incorporating an ESA-developed standard interface for capture).

For small missions, a wide range in the level of preparedness exists, with some missions already pro-actively selecting a disposal orbit compliant with the 5-year rule before the publication of the requirements (also in view of the changes to the FCC regulations in the United States [24]), and other projects less familiar with the change in the requirements and with the policy applicability. An important open point for this class of missions, which usually employs rideshare launches, remains the availability of launch opportunities into naturally compliant orbits. More generally, for small missions, especially the ones operating at higher altitude, the request for the demonstration of high level of confidence in the disposal implementation (i.e. passivation and disposal, but also reliability of the solar panel deployment mechanisms) is perceived as particularly challenging by the projects. The update of ESA Space Debris Mitigation Compliance Verification Guidelines (ESSB-HB-U-002) [5] tackles this point by describing several options to compute the probability of successful disposal. Nevertheless, further specifying a general methodology for the assessment (also considering available information sources), promoting data collection on COTS components, and sharing information on observed anomalies in missions supported by ESA or under ESA's responsibility can promote the definition of a harmonised process and of a shared vision on what's currently (and in the short-term future) achievable with small missions.

Finally, Figure 9 shows the level of adherence with ESA's Space Debris Mitigation Requirements [2] as a function of the planned launch year. For clarity, the level of alignment is shown here grouping the cases with *High* or *Full* adherence versus the remaining cases. Considering all the satellite reviews performed in 2024, regardless of the system type and mission phase, 59% of the missions to which ESA contributes have a high level of alignment with the Zero Debris principles contained in the new ESA Space Debris Mitigation requirements [2]. The value goes up to 100% for the few missions with planned launch date after 2030, showing a good trend in terms of meeting the agency goal of Zero Debris by 2030.

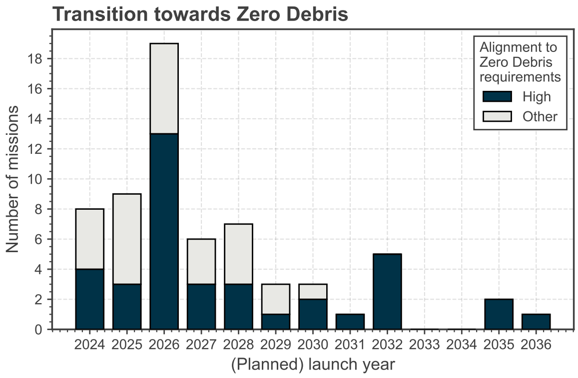

Figure 9. Level of adherence to ESA's Zero Debris principles as a function of the (planned) launch year for the spacecraft reviewed in 2024.

4. ESA'S SPACE DEBRIS MITIGATION COMPLIANCE VERIFICATION GUIDELINES

ESA's Space Debris Mitigation Policy and Requirements were prepared in 2023 in only eight months from the creation of the corresponding working group, with a very disruptive approach not only in terms of the content (as discussed in the previous sections), but also in terms of their timeline, especially when compared with the usual cycles for document approval within standardisation bodies.

After the publication of those documents, ESA's Space Debris Mitigation working group was convened again in 2024 to update also ESA's Space Debris Mitigation Compliance Verification Guidelines, a handbook that provides guidance on the interpretation of the requirements and on the related verification approaches. As shown in Figure 10, the document is currently within the ESA review phase (i.e. where anyone in ESA can provide feedback and requests for modification), with a target publication date for the second quarter of 2025.

Figure 10 clearly show the extent of preparation phase for the handbook, which can be explained by the following considerations:

- the novelty of some requirements in [2] required the documentation of new analyses approaches, and, in some cases, the development of tools to simplify the execution of such analyses by industry,
- the fast pace adopted in the preparation of the Space Debris Mitigation Policy [1] and Requirements [2] meant that a significant amount of feedback (both within the Agency and from industry) was received after the publication of the two documents and needed to be addressed in the handbook update, while ensuring consistency also with the translation of the policy document into internal processes.

In relative terms, twenty months for the preparation of such document covering almost one hundred technical requirements meant that ESA's Space Debris Mitigation working group had still to work with a fast pace. In absolute terms, however, this meant that for more than one year and half there has been a gap between the request to apply the new requirements and the availability of resources on their verification methods. For this reason, several mitigation approaches have been implemented.

Firstly, internally in ESA, the draft document of the handbook was made accessible through the whole agency (and not only to the working group), so the latest version of the document could be used by the internal projects, while also providing an open channel for general feedback.

Secondly, numerous training sessions have been organised, both internally and externally, with the largest session organised in October 2024 with more than 250 participants [25]. Even when general training material was available, there has been often the request for specific follow-up (e.g. at project level). This was interpreted as an indication that, for the near future, it may be beneficial to organise regular training sessions, with a limited audience size, to ensure that specific requests for clarification can be addressed. This training programme will start to be developed after the handbook publication, and it will be initially addressed to ESA workforce. It is also worth mentioning that in 2024 there has been also the occurrence of a training session organised by one of ESA Member States, gathering their industry representatives (both on the side of platform development and of operations), so that they could be aware of the new requirements and of the resources that ESA makes available. This proactive attitude is extremely positive and limits the risk, discussed in Section 3, that (especially) new space actors discover the requirements only at formal reviews with ESA.

A third mitigation strategy that was adopted is the development of tools to clarify the process of the analyses and support the verification process by industry. Among these tools sits the already mentioned compliance matrix template [8], which includes an apportionment of the requirements between space and ground segment to guide the verification activities for requirements with shared responsibility between the spacecraft developer and the operator. Even more interesting is the preparation of supporting scripts available at [26], aimed at automating some of the new analyses through the ESA DRAMA tool, while its interfaces and workflows are fully aligned to the new requirements. This approach has been very beneficial in lowering the barriers to the adoption of the new requirements, specifically for some of the novel ones (e.g. the computation of the cumulative collision probability), where a perceived complexity was used as justification for delaying the corresponding analyses. Providing some example scripts not only offers a low effort option for the computation of the assessments, but also facilitate the familiarisation of a larger number of users with the new metrics introduced in [2], instead of having each company to re-implement multiple versions of

Figure 10. Timeline of the preparation of the Space Debris Mitigation Policy, Requirements, and Verification Guidelines.

the same computational approach. Interestingly, for the topic of Dark&Quiet Skies, a similar trend is observed: over these first months of the policy applicability, no assessment of the brightness has been provided so far, with the motivation that nor methodology nor tools were made available by ESA, even if analytical approaches are already present in literature [27]. This is a clear reminder that novel requirements can be introduced and pushed for implementation only when supported by the entity in charge of the requirements invests in the demonstration of their verification methodology (as done, for example, with the DRAMA updates [28]) and, more in general, in their feasibility. For this last point, one of the features of the *Zero Debris* approach is exactly to present the change of the policy and the requirements as one of the pieces together with the investment in related research and development activities, and the support to the creation of a community around the topic of space debris mitigation and space sustainability more in general.

Finally, a last mitigation strategy that was defined was the preparation of sample space debris mitigation documents, which could be used as a reference to explain the level of detail expected in the different analyses, especially in considerations of the different development phases. A first example document was prepared to cover the case of a cubesat mission with no propulsion capabilities [29], which was considered a high priority case in view of the new verification methodology for the orbital lifetime assessment [12] and in view of the fact that new space actors may start from this category of mission. The document was made available internally in ESA, and its wider publication is currently under evaluation. In the meantime, several requests have been received to extend this exercise to cover a larger variety of missions, including constellations, cases with controlled re-entry, and missions outside the LEO region.

5. CONCLUSIONS

In 2023, ESA updated two fundamental documents that define its approach to space debris mitigation. The first document is ESA Space Debris Mitigation Policy[1], whose last version contains some impactful elements such as the enlarged scope of applicability (to include any ESA contributed project and not only ESA missions) and its immediate applicability. These two aspects have been particularly effective in triggering awareness within ESA about space debris mitigation and related internal processes. This also meant that a non-negligible amount of effort has been spent after the publication of the Policy to define practical implementation approaches. In addition, the formulation of the Policy has also stimulated the development of a harmonised approach through the Agency for the assessment and quantification of ESA's risk profile in terms of space debris mitigation.

The second document that was updated was ESA Space Debris Mitigation Requirements (ESSB-ST-U-007) [2], which relies heavily on a tailoring approach based on the risk profile, evaluated by looking at the space system type, its operational orbit, and its interaction with the debris environment, measured in terms of the orbital lifetime and cumulative collision probability with space debris objects larger than 1 cm. This approach appears particularly valuable for ESA given the diversity in the supported projects. When looking at the actual level of adoption of the requirements, it is observed that, overall, 59% of the missions to which ESA contributes (and reviewed in 2024) have a high level of alignment with the Zero Debris principles. This includes missions at any level of their development, and this could be achieved thanks to a pro-active approach registered both in large and small missions.

After the publication of the two documents, the year 2024 was dedicated to the update of ESA's Space Debris Mitigation Compliance Verification Guidelines (ESSB-HB-U-002) [5], which is planned to be published in Q2 2025, after a period of internal ESA review, and around 20 months after the publication of ESA Space Debris Mitigation Requirements (ESSB-ST-U-007) [2]. This gap needed to be managed to enable ESA Projects and Industry to start getting familiar with the new requirements. This was done through a variety of approaches, which included early sharing of the draft document, training sessions, development of dedicated tools, and preparation of sample documents covering the analyses requested by the new requirements. This is line with ESA's historical approach of making several resources available to support space debris mitigation efforts and lower the barrier in the adoption of effective space debris mitigation strategies.

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