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# Financial Incentives for Debris Removal Services

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## Abstract

Our use of space is already unsustainable. One of the biggest global challenges facing the space sector is orbital congestion and space debris. This paper assesses financial incentives for satellite operators to adopt debris removal services as well as the value of debris remediation to ensure future space sustainability. There are already more than 36,500 debris objects larger than 10cm in space and debris-generating events continue to occur. As more satellites are launched each year, the risk within crowded orbital regions will only grow. Space debris not only poses a threat to individual space assets but also to the long-term sustainability of the entire orbital environment. To tackle the growing problem of space debris and develop commercially viable debris removal services, a confluence of mature technological solutions, a favorable regulatory environment, and cost-effective solutions that customers are willing to pay for is required. Governments and space agencies have an important role to play in space debris mitigation and remediation in incentivizing the adoption of debris removal and reducing the risk in orbit to ensure space sustainability. As in other sectors, once satellites reach their end-of-life, they no longer provide revenue to the operator, which means funds are not necessarily available for decommissioning at the required time. This presents a challenge for the financing of decommissioning services if funds are not accounted for during the operational and revenue generating phase of an asset's life. In this paper, we will assess different financial incentives in the context of debris removal services. First, we highlight the value of debris removal to government and space agencies and the role they must play to ensure space sustainability. Secondly, we focus on external sinking or accrual funds, decommissioning guarantees, and subsidies that bring the most value to incentivize debris removal. Then, we analyze the benefits and drawbacks of each as well as their application to the satellite industry and the debris removal market. Finally, we conclude with the value of financial incentives to support the adoption of debris removal services and considerably reduce the risk in orbit to ensure long-term space sustainability.

**Keywords:** Debris removal services, orbital congestion, space debris, financial incentives, performance bond.

**Acronyms/Abbreviations**

ADR: Active Debris Removal
AMC: Advance Market Commitment
APAC: Asia-Pacific
ASAT: Anti-Satellite Weapons
EOL: End-of-Life
EPFL : Ecole Polytechnique Federale de Lausanne
ESA: European Space Agency
FCC: Federal Communications Commission
JAXA: Japanese Aerospace Exploration Agency
LEO: Low Earth Orbit
NASA: National Aeronautics and Space Administration
OECD: Organisation for Economic Cooperation and Development
OIG: Office of the Inspector General (NASA)
R&D: Research and Development
UK: United Kingdom
UKSA: United Kingdom Space Agency
US: United States
VAT: Value Added Tax

## 1. Introduction

Our use of space is already unsustainable. As of January 2022, there are 4852 active satellites in orbit and around 3500 inactive objects in space [1]. The last 20 years has seen increasing deployments of CubeSats and constellations, as well as debris generating events such as the Fengyun-1C Anti Satellite Weapons (ASAT) test (2007), Iridium Cosmos Collision (2009), and more recently the Russian ASAT test destroying Cosmo 1408 (2021) which created 1500 pieces of debris larger than 10cm and thousands of smaller ones [2].These events and trends have led to an increase in the number of objects throughout Low Earth Orbit (LEO) region (see Fig.1). One of the biggest global challenges facing the space sector is orbital congestion and an increasingly hazardous level of space debris. The deployment of an unprecedented number of satellites in the next 5-10 years will contribute to more crowded and dangerous orbits.

As such, there is a need for satellite operators to protect, manage, and optimize operational service in an increasingly congested environment. Space debris poses a persistent threat to governments, industry space assets, and their downstream applications, as well as a growing risk to the sustainability of the entire orbital environment.

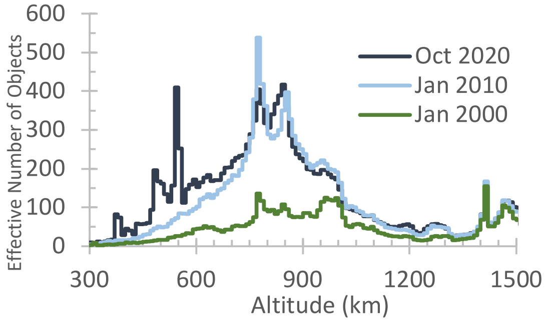


Fig. 1. Evolution of objects in LEO. (NASA Orbital Debris Program Office).

Organizations across the space enterprise, from governments and regional space agencies to international organizations, commercial satellite operators, academia, and civil society all play influential roles to advance more sustainable operations and the effective tracking, mitigation, and remediation of orbital debris.

This paper first highlights the value to space actors of remediating the existing large orbital debris object population and describes the role of those actors in shaping the future space environment. We then introduce and assess different financial incentive mechanisms that could be applied for debris removal and end-of-life disposal of functional space assets, including external sinking funds, advanced market commitments (AMCs), subsidies, and performance bonds. We examine the variations in political acceptance of these incentive mechanisms among a range of stakeholders across two of Astroscale's regional locations (U.S. and Japan/Asia-Pacific (APAC). Based on our analysis, we propose that both AMCs and performance bonds, when properly designed and implemented, have the potential to become an effective mechanism for the space industry in incentivising debris removal if tailored and accounting for industry goals.

## 2. Value of Debris Removal and Role of Governments, Space Agencies & Policy Makers

Just as there are monetary expenditures associated with a debris-filled, collision risk-laden space operations environment, there also exists a monetary value associated with a lower-risk, more stable space operations environment that could be gained through the implementation of a wider range of enforcement and incentive mechanisms, tools, and approaches. In 2019, the Organisation for Economic Cooperation and

Development (OECD) Space Forum surveyed a group of twenty commercial satellite operators active in satellite communications and Earth Observation about debris protection, mitigation practices, and possible policy responses for in-orbit activities [3]. Respondents welcomed renewed government action in space debris mitigation, but when presented with options for new regulatory tools, preferred the implementation of incentives for sustainable operations over the imposition of fines for pollutive practices.

Though there has been a notable influx of private investment in space companies and technologies, particularly in the past decade [4], the priorities of major spacefaring national governments and regional space agencies still hold an outsized role in shaping the future space environment. With supervisory control over the regulatory and financial conditions for non-government operators of space systems, governments are the principal actors through which unsustainable commercial operator behaviors can be course-corrected, and the competitive market for cost-effective third-party debris removal services technologies can continue to develop. Governments have a range of tools and approaches at their disposal, including the following:

- **Invest in Research and Development (R&D) to mature debris removal technology:** The recent G7 statement advocates for research and development of debris removal services. The United Kingdom (UK), Japan, the European Space Agency (ESA), and others have provided funding for debris removal technology development. In the United States (US), the Office of the Inspector General (OIG) report [5] on the National Aeronautics and Space Administration (NASA)'s efforts to mitigate the risks posed by orbital debris specifically recommended that NASA's Administrator invest in methods and technologies for removing defunct spacecraft. The UK Space Agency (UKSA) is funding feasibility studies for a UK debris removal mission with an explicit requirement to consider commercial viability to support the development of a realistic and sustainable market [6].
- **Advocate and prioritize space debris solutions on the public and political agenda:** In June 2021, the G7 committed to the safe and sustainable use of space [7] stating that they "welcome all efforts, public and commercial, in debris removal and on-orbit servicing activities and undertake to encourage further institutional or industrial research and development of these services". The former UK Minister of Science, George Freeman, announced a new Plan for Space Sustainability at the 2022 Summit for Space Sustainability in London and was quoted saying, "A 'Wild West' space race without effective regulation risks a growing crisis of debris in space" [8]. Elected officials from 15 different countries have publicly endorsed [9] the Paris Peace Forum [10] "Net Zero Space" coalition to develop concrete actions aimed at making the Earth's orbital environment safer and encouraging the sustainable use of space by 2030.
- **Become a customer and early adopter of debris removal services:** By procuring debris removal services, governments and space agencies create a demand signal to investors and operators. Astroscale's selection as the commercial partner for Phase I and for the Front-Loading Technology Study in Phase II of the Japan Aerospace Exploration Agency (JAXA) debris removal project was a step by Japan to commercialize space debris removal. The ESA Clearspace-1 mission is being procured as a service contract [11] "to help establish a new market for in-orbit servicing, as well as debris removal". Paying for such a service contract represents a new way for ESA to do business – intended as the first step in establishing a new commercial sector in space.
- **Support industry in overcoming barriers for debris removal service adoption:** Astroscale has identified a series of barriers that satellite operators face in adopting debris removal. Governments and space agencies can help overcome these barriers, including funding Research and Development (R&D) to reduce End-of-Life (EOL) mission risk, mature EOL technologies, and increasing regulatory action (see Fig.2).

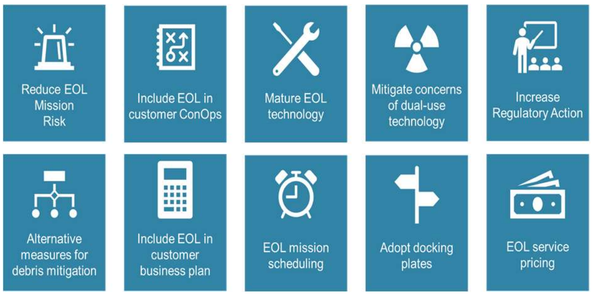


Fig. 2. Tools to overcome barriers for debris removal adoption.

- **Incentivize the commercial debris removal market**: As in other industries with common pool resource challenges, there is a role for government to provide financial incentives to establish and commercialize the market for debris removal services. A recent Ecole Polytechnique Federale de Lausane (EPFL) report on Policy Options to Address Collision Risk from Space [12] noted that "*the development and deployment of technology to manage the risk and the implementation of best practices should be encouraged and rewarded, including through economic incentives*."

## 3. Financial Incentives Assessment & Application to the Satellite Industry

As in many other sectors, once satellites reach their end-of-life, the revenue they provide is diminished which means funds are not necessarily available for decommissioning at the time it is required. This presents a challenge for the financing of decommissioning services if funds are not preserved during the operational and revenue-generating phase of an asset's life. In other sectors, innovative solutions have been identified --for example, the application of decommissioning bonds and insurance requirements -- to ensure that funds are available at the end of the life cycle of a complex or otherwise risk-intensive asset to return its operating environment to its natural state. In this section, we will assess financial incentives from other industries and analyse how they can be applied to the space industry.

### *3.1 Financial Incentives Assessment*

We have reviewed a number of financial incentives used in other industries to provide funds for decommissioning high-value assets (see Appendix A). However, in this section, we focus on assessing four that bring the most value to incentivizing debris removal: external sinking or accrual funds, subsidies, advance market commitments (AMCs), and performance bonds.

#### *3.1.1 External Sinking Funds*

External sinking funds consists of funds set aside during the operational lifetime of an asset to cover future decommissioning costs. Such external sinking funds are used in the nuclear [13] and offshore windfarm [14] industries, whereby funds are aside, in a segregated trust fund outside the operator's control, through an additional levy fee that is passed onto consumers. Sufficient funds must be accrued ahead of the end of the useful operational lifetime of the installation or asset.

| Advantages | Disadvantages |
|---|---|
| • Operator pays during operational lifetime whilst assets are revenue generating.<br>• Ensures funding for EOL is reliably acquired, depending on definition of decommissioning / thresholds set for space debris mitigation. | • Sufficient funds must be accrued ahead of the end of life of the installation or asset.<br>• Uncertainty around fund size and timescale of satellite operators |

#### *3.1.2 Subsidies*

Subsidies can take many forms [3] and include payments from governments to producers, grants, subsidized loans, loan guarantees, Value Added Tax (VAT) exemptions on specific technologies (e.g., electric cars), feed-in tariffs, or tax credits for environmentally relevant investments. Subsidies provide support for positive externalities and contribute to delivering more social benefits than would otherwise be the case.

| Advantages | Disadvantages |
|---|---|
| Provides immediate benefit for the debris removal market, depending on how the subsidy is structured, reducing barriers for | • Risk of technology lock-in, rebound effects, windfall gains and freeriding. |

| | |
|---|---|
| satellite operator to adopt EOL services | • Unlikely to work as a market-based solutions. |

*3.1.3 AMC*

Advance Market Commitments (AMCs) are financial mechanisms through which binding contracts are secured in advance to purchase a set quantity of useful, but currently unavailable products, thereby establishing a guaranteed viable initial market for the products at an attractive starting price once it has been successfully developed by the private sector. In exchange, private sector developers agree to offer a minimum quantity of the product or service at a lower subsidized rate for a set period. AMCs offset the private sector's hesitance to invest in cost-intensive technologies that could meet a critical need but are considered high-risk in the absence of reliable or easily predicted indicators of future demand or returns. In other words, AMCs are intended to incentivize rapid private sector development of 'chicken and egg' technologies and products that, once introduced, could be harnessed to resolve significant problems or meet under-served needs, but for which their perceived utility or future beneficial role in shaping a market is diffused among many players, or challenging to accurately characterize under the status quo. Advanced Market Commitments can be structured for both early-stage products (e.g., those requiring significant scientific progress and extensive testing of candidate methods or technological approaches) or for late-stage products (e.g., in final or near-final stages of regulatory approval and technological development).

Recently, the AMC mechanism has been applied to fast-track the development of COVID-19 vaccines as one pillar under the global COVAX Facility initiative [15]. By committing to purchase a large quantity of vaccines at a set price once they were developed, the COVAX AMC incentivized the development of several vaccines, and has since harnessed higher-income nations' investments and other donor funds from foundations and the private sector to make doses available at low cost to 92 low-income and lower-middle income countries [16] (defined by the World Bank as those with annual gross national incomes per capita of US $1,085 or less and between US$1,086 and US$4,4255 respectively for the current 2023 fiscal year [17]). Across a range of technological sectors and challenges, AMCs offered by governments and other financial entities have proven effective in accelerating nascent markets, especially those in which basic research has already been performed and technology milestones and challenges are well-understood [18]. AMCs are meant to "…supplement, not replace, direct R&D support," while mitigating the challenges associated with traditional procurement approaches that attempt to pick "winners and losers" at the proposal stage "under asymmetric information" [19].

| Advantages | Disadvantages |
|---|---|
| • Reduces demand uncertainty thus incentivizing market entry.<br>• Creates demand that justifies research and development (R&D) investment. | • Relies on government agreeing to pay for debris removal.<br>• Challenging to identify a single entity to manage an AMC; best applied collaboratively. |

*3.1.4 Performance bond*s

A performance bond is a surety bond issued by an insurance company or a bank to guarantee satisfactory completion of a project by a contractor. The underwriter guarantees an amount equal to the decommissioning sum in return for an arrangement fee and premium. Performance bonds are used in other industries that operate under risk-laden conditions in extreme environments, such as offshore wind, maritime, and mining industries [3]. For these industries, performance bonds applied to decommissioning operational equipment at end-of-life are often coupled with other incentives, such as subsidies, levies, and tax incentives, among others [20].

While performance bonds present many advantages including ensuring that the funding is secured in advance and a precedence with other regulators such as in the mining, Offshore Wind and Maritime industries, recurrent negative have been identified for performance bonds in Australia, Canada, and the US. Indeed, there is often a lack of enforceability by the responsible stakeholders and the fact that performance bonds cover only partially the estimated liabilities which leave the government to pay the remaining part. For instance, in Canada, a report on mining compliance and enforcement found that British Columbia struggled with compliance and enforcement by the government of financial securities and that only half of the environmental liabilities have been covered by financial securities at major mines [28].

| Advantages | Disadvantages |
|---|---|
| • Surety bonds boost liquidity and financial flexibility and allows for other investments or paying down on debt.<br>• Ensures funding for EOL in advance, depending on definition of decommissioning / thresholds set for space debris mitigation.<br>• Established precedent for bonds in the satellite industry | • Lack of enforceability and capacity of the government to enforce them<br>• Only covers partially the estimated liabilities (leaving the financial risk to government).<br>• Uncertainty around performance bond value and timescale of satellite operators that could be agreed through satellite licensing process |

*3.2 Application of incentives to the satellite industry*

In the following section we explore the possible application to the satellite industry of the financial incentives assessed: external sinking bonds, subsidies, AMCs, and performance bonds. This analysis stems from previous work on decommissioning in the space industry [20] as well as a thorough assessment of their application within other industries. Nonetheless, the authors acknowledge that there are undoubtedly a range of other approaches not assessed here, that could be harnessed to adapt financial incentive mechanisms to encourage the decommissioning of space assets.

In an external sinking fund mechanism, satellite operators would pay during operational lifetime to ensure that satellites can be decommissioned. The external fund value must be determined based on operator debris mitigation plan and expected post mission disposal plans. More understanding of expected future debris mitigation or remediation actions and costs of compliance (including third party debris removal servicing) is required.

Such an arrangement could be considered favorable compared to prepayment by operators, with the fund contributions offset with End-of-Life (EOL) service contracts and informed by operator practice (e.g., timely post- mission disposal behaviors).

Government subsidies could help to commercialize EOL servicing by paying for part of the cost of the production of debris removal services, by offering tax credits or reimbursements, or by paying for part of the cost a satellite operator would pay to purchase debris removal services. The Organization for Economic Cooperation and Development (OECD) [21] recommends that subsidy eligibility criteria should be based on technology-neutral performance measures and represent behavior that goes beyond “normal” practices.

In contrast to other financial incentive structures such as grants, tax credits, loans, or prize competitions, AMCs cement a clear user base for the future product, and only commit funds for purchases from developers whose products achieve the technical specifications and requirements set under the details of the commitment. In this way, AMCs create a link between the quality of the product and the future revenues that can accrue to a developer, incentivizing both timely development, and continuous innovation by developers after a product is brought to market to ensure they remain competitive for follow-on procurements (as opposed to prize competition mechanisms, which apply a ‘winner-take-all’ approach that often fails to foster competition for subsequent improvements) [21]. AMC could be used by governments to commit to purchase a number of debris removal missions in return for a lower cost of cleaning in the future.

In various sectors, the use of performance bonds, often in combination with other measures, ensure that funds are available at the end of operations to return the environment to its natural state.

In the United States, surety bonds are required ($1-5M) within 30 days of a license being granted for systems [22], although these are related to spectrum use milestones [23] rather than debris mitigation. Performance bonds can create an economic incentive for operators to comply with space debris mitigation plans after their license has been approved at the point of launch. The FCC’s Further Notice of Proposed Rulemaking for Orbital Debris Mitigation in a New Space Age [24] sought comment on a performance bond tied to successful post-mission disposal for space station licenses. In the satellite industry, performance bonds would also create an economic incentive for operator to comply with space debris mitigation plan after their license has been approved. The value of the bonds would need to be tied to the cost of completing decommissioning, and in the case where the operator cannot decommission their own assets, to a debris removal service.

**4. Challenges of political acceptance and regional differences**

In this section, we will be exploring how our financial incentives for active debris removal are perceived throughout the world focusing on specific countries: Japan and the United States, this is a non-exhaustive overview that would be complemented by investigation of incentive structures within other spacefaring nations in a further study.

*4.1 Japan*

At this point, no in-depth discussion on financial incentives at a policy-making level has been conducted in Japan. However, the sub-working group for on-orbit servicing formed by the Japanese Government's Space Debris Task Force, has discussed the economic externality of space debris issues. The study report by the Sub-Working Group on On-Orbit Servicing pointed out that *"what is needed now is to make it clear how a government vision and design in order to create an economic ecosystem where Active Debris Removal commercially viable."* Since *"any rule that enable to internalize the cost of removal of space debris requires an approach that adopts both regulation and incentives*", the report introduces some policy ideas instead of making a single policy recommendation and leaves it for future consideration that includes economic incentives.

*4.2 United States*

Overall, the response from U.S. satellite operators to the FCC's proposed performance bond rule was concern regarding the formulation and structure of performance bonds, particularly the expected financial burden it ostensibly imposed ahead of the revenue-generating phase of operations. The bond calculation proposed by the Commission considered the deployment altitude of satellites and did not acknowledge that: a) failures can occur at high operating altitudes or b) the risk that satellites pose to the wider orbital environment is not captured by altitude alone. Because of this, operators informed the FCC that, if implemented, the proposed performance bond calculation methodology could lead to unintended consequences wherein satellite operators seek to minimize the bond value, at the expense of space safety.

However, rather than categorically denying the applicability of financial incentive mechanisms such as performance bonds for the U.S. space industry, Astroscale U.S. called for the establishment of a working group and for government-commissioned studies to further assess and recalibrate the methodology proposed by the Commission, with the intention of successful application to space activities [25].

*4.3 UK and ESA*

In the UK, although there is not financial mechanism in place yet for space debris incentivization, the government took a role to demonstrate leadership in sustainable space and unveiled a Plan for Space Sustainability in June 2022. As part of this strategy, the UK is undertaking a regulatory review to incentivize sustainable practices, investment, and growth, for ADR and IOSM. The UK will revise its regulatory refine to evolve with technology progress and lead the way on operating in a sustainable environment [29]. ESA's countries such as the UK and France already introduced in-orbit third party liability insurance and France also has one of the most stringent regulations regarding legally binding debris mitigation requirement which could be coupled with financial incentives to incentivize compliance and support the market of In-Orbit Services. [31] Finally, the OECD report on economics of space debris mentioned throughout this paper has been also highlighted by the European Space Agency Space Debris office which recommended the use of financial incentives and pointed out that it was 'time to act. [30].

**5. Recommendations**

Following the assessment of financial incentives and the analysis of how they can be applied in the space industry, an initial recommendation is that performance bond could present an effective financial incentive provided industry criticisms are addressed. Additionally, AMCs also have a high potential to incentivize debris removal for government projects. Overall, both performance bonds and AMCs present valid solutions that have been implemented in other industries, with sufficient mechanisms in place for the governments and regulators to implement them and adapt them to the satellite industry.

While other incentives are effective for IOS providers such as subsidies, performance bonds have the advantage of boosting liquidity and financial flexibility, allowing for other investments, or paying down on debt [3]. One of the core advantages of the bond is that the decommissioning will be paid off in the event of operator default. In addition, funding is secured in advance and depends upon thresholds and definitions of debris mitigation and decommissioning of space assets. Moreover, there is precedent of performance bonds being employed in other industries (such as oil spills, land rehabilitation, or mining. For example, Peabody issued bonds with Australian insurers to rehabilitate mining sites) [26]. These parallels in other industries indicate greater maturity in the development and acceptance of performance bonds relative to other mechanisms. Even though performance or surety bonds have many advantages, they have faced criticism, particularly following a proposed rule by the FCC (see *section 4.2*) and in others sectors recurrent problems have been highlighted such lack of enforceability and partial recovering of the estimated environmental liability [28].

Both the value and timescale of the bond need additional definition as for the application of the bonds in practice. Nonetheless, regulators have the oversight and compliance responsibility to make sure operators comply with space debris mitigation requirements from launch to de-orbit whether it is through decommissioning space assets with onboard propulsion or other mechanisms (in which case the performance bond is returned to the operator) or alternatively paying for an ADR service provided by a third party IOS service provider (using the funds reserved in the performance bond) to ensure their space objects are safely deorbited at end of the their mission in a timely manner.

To incentivise comprehensive debris removal, another mechanism could be used as presented in this paper: AMCs. Indeed, by providing a binding commitment to purchase, governments reduce uncertainty and create a clear demand signal for the industry and the IOS market as a whole. AMCs are more effective when governments are the customer for debris removal services. While AMCs boost the market if government agrees to purchase a number of removal missions, it may not fully incentivise market entry if pricing is near marginal cost. This mechanism, while providing direct payment to debris removal companies, in conjunction with performance bonds, strongly incentivizes debris removal for both institutional and commercial operators and mature the market.

Given the unprecedented numbers of space objects being launched in orbits and the increasing hazards of collisions between space objects and/or space debris, adopting the right financial incentives for industry is urgent. Policy makers should engage collaboratively with industry, scope potential options, then implement financial incentives such as performance bonds and AMCs reviewed in this paper.

**6. Conclusion**

There is an urgent need to mitigate the rising risk of on-orbit collisions. Governments, policy makers, and space agencies have a critical role to play in space debris mitigation and remediation. Financial incentives are needed to provide effective mechanisms that have been implemented and proven to work in other industries, ensuring fund are allocated to reducing the risk in orbit and preserving space sustainability.

Governments and policy makers can act by supporting R&D to mature technology, and prioritising space debris on the public agenda contributes to advance the debris removal market. While subsidies and external sinking funds both provide benefit for the market and ensure funds are available during the operational lifetime of a satellite, carefully considered performance bonds and AMCs show promise and could be translated to the satellite industry to establish and commercialize a market for active debris removal.

For effective regulatory formulation and implementation, these two financial incentives would need to be tailored for the satellite industry. Both bonds and AMCs ensure that funds are allocated to decommissioning thus reducing the uncertainty on market demand and allowing for investment in debris removal services. Finally, financial incentives could be directly implemented in the satellite mission license process as an effective enforcement measure. This would be beneficial in establishing a mechanism for the government to successfully enforce financial securities, ensuring space actors return the space environment to its natural state. Overall, enabling a nascent market such as debris removal requires a combination of technological solutions that customers are willing to pay for, bound by a comprehensive regulatory environment. Financial incentives can provide a push in that direction to ensure our orbital use is sustainable and accessible now and for future generations.

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**Appendix A (Policy Approaches and Financial Incentives)**

**Collision risk from space debris – Current status, challenges and response strategies (EPFL)**
- Advance market commitments
- Marketable permits
- Regulatory fees
- Insurance
- Bounty schemes

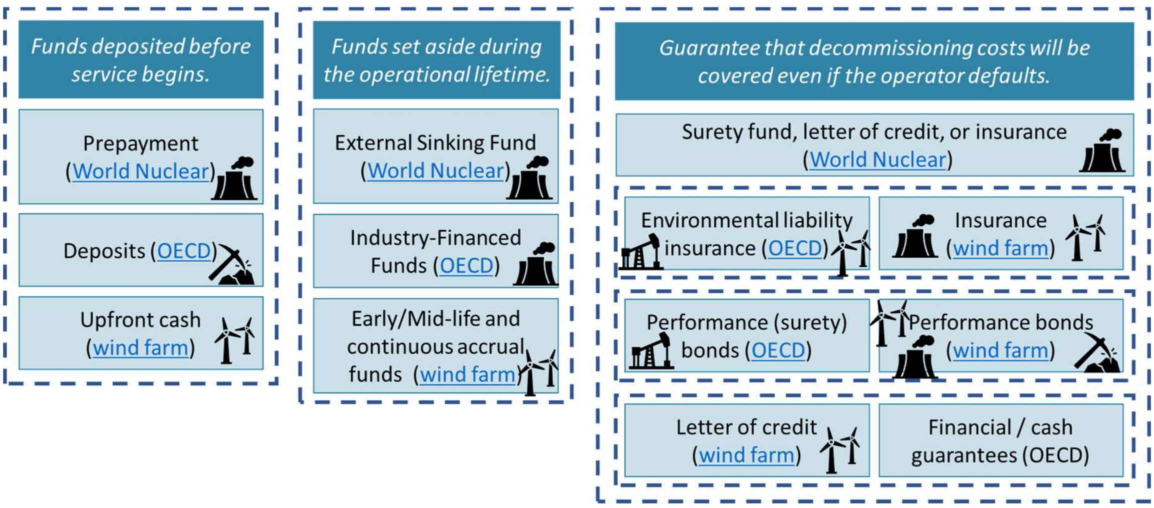
**Policy Options to Address Collision Risk from Space (EPFL)**
*Policies used to foster innovation in environmental technologies.*
Technology-push policies:
- Government sponsored R&D
- Tax credits for companies to invest in R&D
- Enhancing the capacity for knowledge exchange
- Support for education and training
- Funding demonstration projects

Demand-pull policies:
- Intellectual property protection
- Tax credits and rebates for consumers of new technologies
- Government procurement
- Technology mandates
- Regulatory standards
- Taxes on competing technologies

**The Economics of Space Debris (OECD)**
- Environmentally related taxes
- Fees and charges
- Tradable permits
- Deposit-refund systems
- Subsidies
- Insurance
- Financial security instruments:
  - Environmental liability insurance
  - Performance (surety) bonds
  - Financial/cash guarantees
  - Deposits
  - Industry-financed funds

**Incentivizing Deorbit (Aerospace Corporation)**
- Direct government management
- Mandatory satellite collision avoidance insurance
- Industry consortium (CONFERS, Space Safety Coalition, Space Data Association)
- Sustainability rating, certifications, and awards
- Deorbit year trading scheme

**Offshore Wind Decommissioning (BEIS)**
- Upfront cash
- Letter of credits
- Performance bonds
- Early/mid-life and continuous accrual funds
- Insurance



**Appendix B (Relevant Astroscale Policy Engagements)**

- Astroscale U.S. Inc. comment into IB Docket 18-313 Further Notice of Proposed Rulemaking for Orbital Debris Mitigation in a New Space Age (October 2020)
- Astroscale U.S. Inc. comment to the White House's Office of Science and Technology Policy to provide input on their Orbital Debris Research and Development Plan [27] (submitted January 2022)
- Astroscale U.K. comment (and contribution to UK Space comment) into UK Government call for evidence seeking views on orbital liability limits and alternatives to traditional third-party liability insurance (submitted 7th January 2022).
- Astroscale contribution to ESOA input into the European Commission – Space Traffic Management project: ESOA Space Sustainability Report

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