

Promoting Space Sustainability

Skyrora Limited**1 July 2021**

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

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

Registered in Scotland, Skyrora Limited is a private company vying to offer space transportation services to the global small satellite market. The organisation adopts a central focus on sustainability and successfully pivots this commitment to differentiate itself from the wider market.

Skyrora's commitment to the safe and sustainable use of space is evidenced by its active debris removal (ADR) solution, capabilities for on-orbit servicing (OOS), choice of propellant and the development and use of a proprietary eco-aviation fuel. Furthermore, Skyrora demonstrates continued industry leadership through its collaboration with UK Space Agency and UK government to create and encourage engagement of new principles or codes, aligning with the Guidelines for the Long-term Sustainability of Outer Space Activities.

The Earth's orbital space environment constitutes a finite resource that is being used by an increasing number of states, international intergovernmental organizations and private companies. The proliferation of space debris, the increasing complexity of space operations, the emergence of large constellations and the increased risks of collision and interference with the operation of space objects may affect the long-term sustainability of space activities. Active debris removal (de-orbiting objects in space) is necessary to stabilise the growth of space debris.

Subsequently, on-orbit servicing extends the lifespan of satellites, avoiding the need for excessive launching of new satellites therefore reducing the environmental footprint left by the space industry. Furthermore, with a minimised number of satellites being launched, the risk of space debris is significantly reduced.

Solutions for active debris removal and on-orbit servicing centre around the Space Tug (pictured below), a proprietary orbit manoeuvring vehicle (OMV). The spacecraft measures 1.9m in diameter and 3.1m in length. It is capable of providing 3.5kN of thrust in a vacuum and houses versatile capabilities in rendezvous and proximity operations through robotics. Critically, the Space Tug is reignitable, meaning it can address increasingly complex missions and lessen mission footprint by improving efficiency.



Skyrora Space Tug - Source: Skyrora Limited

A successful full mission duration (450s) static fire test was completed in Q4 2020 and the spacecraft now stands commercially ready. This demonstration signified to the market that UK-based capabilities for active debris removal and on-orbit servicing now exist. Active debris removal is necessary to stabilise the growth of space debris and ensure the continued use of space.

Skyrora intends to undertake a full feasibility study to assess the practicality of retrieving the Prospero satellite and Booster Stage of R3 Black Arrow from their respective geocentric orbits. As part of the study, Skyrora will explore different means by which the satellite and rocket stage could be returned to Earth using Skyrora technology. Furthermore, it is the aim that both removal targets will be preserved in transportation.

The 1960s Black Arrow programme represents the UK's only successful launch of a sovereign satellite into space. The Prospero satellite, which remains in orbit today, stands not only as a reminder of that momentous achievement but also the longevity of satellites which remain in orbit longer than their functionality serves.

Skyrora is investigating possibilities to introduce and encourage engagement with a code of ethics dubbed the Prospero Principles. Working in collaboration with space situational awareness organisations, top legal thinkers in the UK and UK government, Skyrora is investigating a multitude of best-practise behaviours, including a "one up, one down" approach to satellite launch.

Skyrora's propellant combination of HTP and Jet-A1 equivalent result in a 45% reduction in overall CO² emission when compared to the industry standard LOX/RP-1 combination. This also eliminates the need for cryogenic resources, further reducing environmental footprint. This tangible commitment to ecological launch has translated to meaningful praise from real clients within the market.

Skyrora have developed an eco-aviation fuel named Ecosene to minimise the environmental impact of rocket launches. Ecosene is the solution to a greener and more socially responsible energy source as it utilises waste plastics to manufacture high grade fuel which can be used to launch Skyrora's rockets.

Ecosene was test fired in the LEO rocket engine with great success in early 2020 where it was described as the "solution to a greener and more socially responsible energy source". Qualifying as flight-ready, the fuel was subsequently used in the static test fire, the first test of this magnitude in the UK since the Black Arrow programme 50 years ago.

Ecosene does not concern Earth's precious fossil fuels and non-renewables as the manufacturing process reuses waste plastics which would have otherwise been disposed of in landfill or in the oceans. Ecosene prevents the use of a limited natural resource and offers an alternative, greener use for waste plastic.

Companies that have attempted to manufacture an eco-fuel in the past have found it difficult to extract the excess paraffin waxes created in the manufacturing process. Skyrora have developed a solution incorporating low-temperature catalytic pyrolysis to extract the paraffin wax.

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

The LTS Guidelines offer policy-makers a voluntary framework which ensures the long-term sustainability of outer space activities. As a private launch provider, Skyrora is not directly addressed by these guidelines.

Despite this, Skyrora's vision is deeply integrated with the aims of the LTS Guidelines and holds them centrepiece throughout its technical development, strategic decision-making, industry leadership and campaigning.

Skyrora identified connections with the following LTS Guidelines.

A.2. Skyrora partners with Situational Awareness organisations and the UK Government to allow for consultation of significant sources in developing frameworks for best practise behaviours in space use. A titular homage to the first UK satellite launched from a UK rocket, the Prospero Principles offer a code for which space users can ensure sustainable practise, including a "one up, one down" approach to satellite launch.

A.4. Skyrora's launch vehicles do not use overly obtrusive bandwidth or frequency spectrum.

B.4. Skyrora have the capability to perform collision analysis before orbital insertion of client payloads.

B.8. The Skyrora Space Tug complies with applicable international space debris mitigation standards.

C.1. Skyrora demonstrate industry leadership in support of the long-term sustainability of outer space activities and demonstrate this through multiple intergovernmental relationships. Such collaboration has allowed Skyrora to develop frameworks demonstrating best practise behaviours in space use, such as the Prospero Principles.

C.2. Skyrora's innovative alternative to kerosene, Ecosene, is a high grade fuel manufactured using waste plastics which would otherwise have ended up in local landfill or our oceans, making for sustainable launching of satellites with very little environmental footprint. The company intends to open this product up to the wider space and aviation market to encourage sustainable vehicle launch across the industry.

C.4. Skyrora extend interest and understanding of space activities to industry members and the wider public through its multiple events. For example, Skyrora's recent 'Finding Prospero' event was streamed online to inform industry and the public of plans to safely retrieve the Prospero satellite using sustainable space technology. The event successfully married captured public interest and current industry sentiment, featuring key people in industry and public figures such as ESA astronaut Tim Peake.

D.1. Skyrora announced the Finding Prospero challenge in July 2021. As described in the BBC, Skyrora challenged the UK space community “to find a way to retrieve the Prospero satellite” in what would be a “statement of Britain's commitment to the sustainable use of space”. This action stands to encourage research into sustainability space activities and raise awareness.

D.2. Alongside the development of Skyrora’s space tug technology for active debris removal, the company is continuously contributing to the consideration of space debris management. Through work with the UK Government and top legal minds in the UK, the development of the Prospero Principles proposes space companies take measures such as the “one up, one down” approach to launch to manage space debris across a longer term.

III. Lessons learned [500-word max.]

Skyrora’s experience in delivering complex programmes means it has developed good practise in looking inwards, reviewing and learning from its successes and failures. Through this review, Skyrora has identified and listed below a set of lessons learned.

Skyrora has recognised the importance of open resource and data sharing. In collaboration with Skyrora’s clients, orbital data will be shared with major space situational awareness service operators such as ESA and the United States Space Force's 18th Space Control Squadron.

To improve efficiency of the space supply chain it’s critical that launchers are clear and concise on requirements.

Media coverage of growing threat posed by congested space debris in orbit has grown significantly over the past five years. This has successfully raised awareness but also created hysteria, impeding action rather than stimulating it.

Skyrora has learned that the approach to the growing threat posed by congested space debris in orbit centres around space situational awareness, allowing us first to measure the magnitude of the risk and then deploy collision preventative measures.

At present, an unexploited wealth of knowledge and skills in space situational awareness exists in the UK. Greatly improved state-backed investment in UK civil space situational awareness systems would allow the UK to effectively develop and deploy sovereign capabilities in this area.

Securing the continued safe use of space requires international cooperation from states and international intergovernmental organizations. Skyrora has learned that the global private space industry actively desires engagement with their governments and international intergovernmental organizations to create a measured regulatory framework.

Private space companies (such as Skyrora) encourage regulators to undertake meaningful interaction with industry and thorough assessment of the true risk. Measured action from the regulator to ensure sustainable use of space will be embraced by the private sector, allowing their activities to continue safely whilst protecting the dependency on space from wider society.