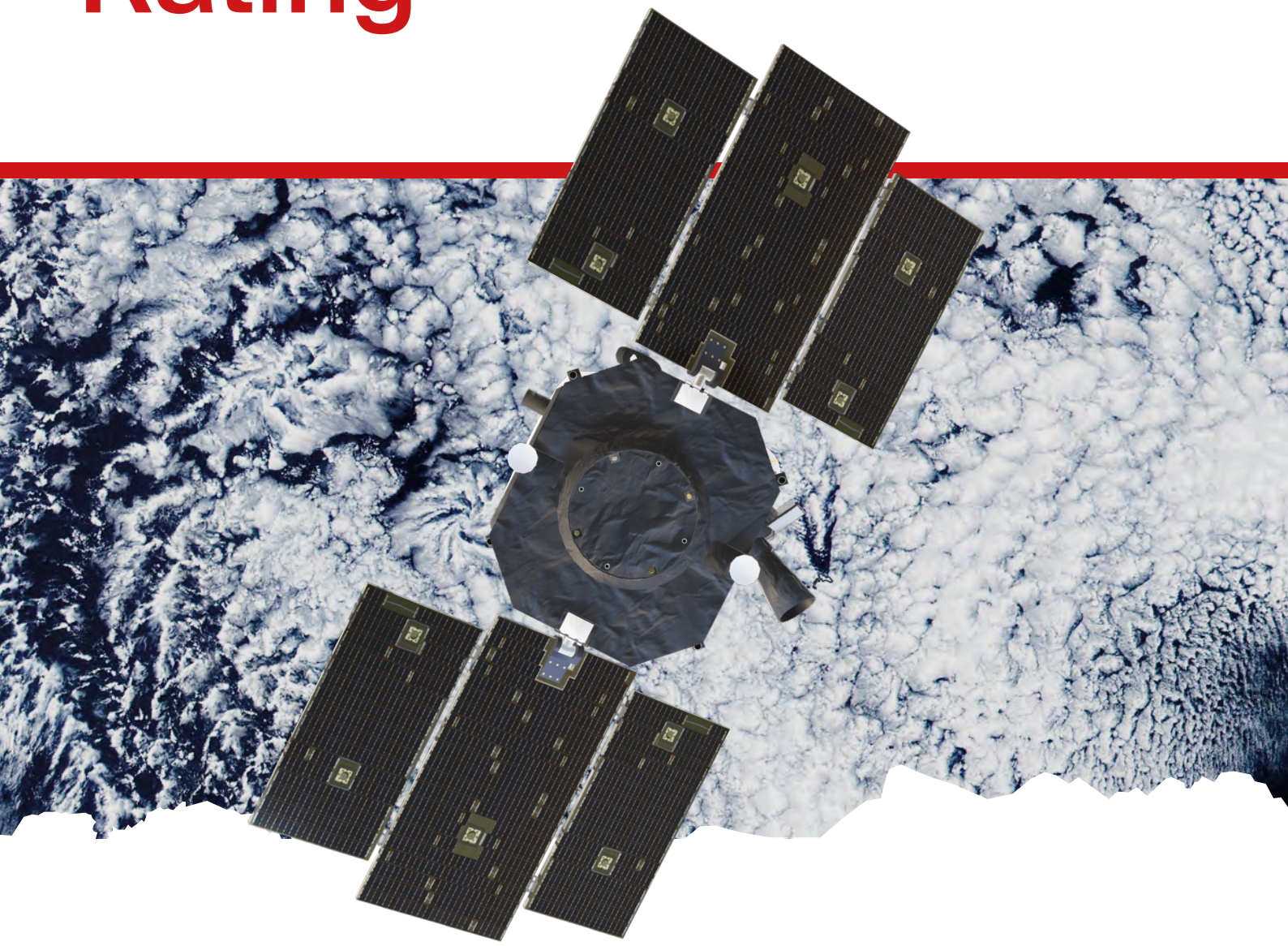
Space Sustainability Rating



Progress Report 2022

Space Sustainability Rating Association
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Switzerland
SPACE SUSTAINABILITY RATING
Progress Report

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I. 2022 in review: key milestones achieved

1. Beta-testing & rating system calibration
During the first half of 2022, four beta-tests were performed on a variety of missions from operators such as OneWeb, Astrocast, Axelspace, as well as with the EPFL Spacecraft Team. While the rating process is complex and requires adjustment from rating to rating, the SSR team worked iteratively on improving this process, allowing it to be more precise and efficient, but also resilient to diverse mission architectures, such as constellations. The 2022 beta-testing phase built on the learnings acquired in 2021 to test and calibrate the SSR before public registration and engage with operators and manufacturers (including Airbus, Astroscale, Lockheed Martin, Planet and SpaceX) to help improve aspects of the SSR.

3. Official launch of the SSR at the 4th Summit for Space Sustainability
In June 2022, the SSR entered a new phase of its mission by officially going live. The official launch of the SSR took place at the 4th Summit for Space Sustainability in London organised by the Secure World Foundation, a member and active supporter of the initiative. The SSR team would like to thank again Krystal Azelton, Ian Christensen, Brian Weeden and the SWF team for the opportunity to present the rating to a public of internationally renowned experts and industry leaders.

2. Launch of the SSR website
A central component of the rating system's visibility and outreach, the SSR website consolidates all the information on the rating system in one place. In parallel, SSR's presence on social media (LinkedIn and Twitter) began and has built a relatively strong community.

SSR launch and official issuance of the first rating to Stellar at the 4th Summit for Space Sustainability on 23 June 2022 in London, UK (left to right: Florian Micco, Prof. Moriba Jah, Prof. Danielle Wood, Damien Garot, Adrien Saada, Simon Potter and Dr. Minoo Rathnasabapathy).

4. Performance & issuance of official ratings
The SSR celebrated its launch in front of a public of experts from the space sector and issued the first official rating to Stellar, a founding member and longstanding supporter of the SSR.

SSR certificate template

The SSR team also worked with EnduroSat, an early supporter, rating user and SSR association member, to rate one of their missions.

5. SSR awarded Euroconsult's Sustainable Development & Business Award
In recognition of the SSR's role in incentivising sustainable behaviour in space and creating value for the space industry, it was awarded Euroconsult's Sustainable Development & Business Award at the World Space Business Week (WSBW) in September 2022. This milestone showcases future positive economic prospects for the SSR, with a potential important uptake from space industry leaders.

The SSR team was honoured to receive Euroconsult's Sustainable Development & Business Award in Paris on 16 September 2022 .

6. SSR at the 71st International Astronautical Congress (IAC)
In September 2022, the SSR was well-represented at the IAC in Paris, with several papers being presented by the team and experts involved in the development of the rating system. One paper by lead author Adrien Saada focused on documenting the rating process; another by Dr. Minoo Rathnasabapathy put the SSR into a global policy perspective. The team also participated in several panels, including with the support of the Swiss delegation to the IAC. In addition, the IAC provided a unique opportunity for SSR representatives to liaise and exchange in more detail with a wide range of stakeholders and industry leaders.

The SSR and EPFL Space Center team at the IAC in Paris on 19 September 2022 (Emmanuelle David, Mathieu Udriot, Florian Micco, Adrien Saada).

7. Establishment of the SSR Association
From the outset, it was decided by the SSR Consortium that once the rating system was fully operational, an independent non-profit association would be created to operate the SSR, which would allow the establishment of a neutral platform through which all tactors interested in space sustainability could exchange. In January 2023, this milestone has been accomplished successfully.

II. Foreword

2022 has been a landmark year for the Space Sustainability Rating (SSR), as it has officially begun its operations. This launch is an important milestone of an ambitious and collaborative effort that started seven years ago within the Global Council on Space of the World Economic Forum. Nevertheless, we see this not as a final step of an ambitious effort, but as the pursuit of a longer journey towards a more sustainable and safer space environment. With eSpace – EPFL Space Center, we are honoured to have been selected in 2021 to lead theimplementation of a rating system unique in its kind. As the global discussion for space sustainability is gaining momentum, the SSR is well-positioned by providing a tangible indicator to help guiding space actors' actions to minimize their negative impact. Yet, being a trailblazer requires patience: we have to accept that much work remains ahead of us to finetune the rating system, and maximize its potential for the space ecosystem.

Another priority is to create new partnerships and deepen our relationships with our important stakeholders. In 2022, we put in place a partnership with Japan, formalized with the founding membership of the Nihon University, with the support of Japan's Ministry of Economy, Trade and Industry. In 2023, we will continue to seek the global expansion of the SSR network in key regions, with a focus on China and emerging space nations. With the SSR now fully operational and its value to space actors recognized, we are entering a new phase of its mission. A wider adoption of the SSR among the space industry and broader ecosystem remains our most ambitious goal, and our association will strive to advance its work programme to achieve this vision.

Prof. Jean-Paul Kneib
President
SSR Association

To that end, the SSR aims at achieving more than ten ratings in 2023 and will convert as many companies as possible to official rating users. Collaboration and partnerships will play a central role in this endeavour. Everyone is welcome to engage with the SSR and to this end the team is entirely committed to cultivating impactful and mutually benefitting collaboration. On behalf of the SSR Association, I would especially like to thank our three Founding Members, Ansys, Nihon University and Stellar, for their generous and crucial support, as well as our Association members, ALTER TECHNOLOGY, EnduroSat, Neuraspace, Privateer, the Secure World Foundation and Slingshot Aerospace. As we look back to the progress realized in 2022, I would like to take this opportunity to call on you, space experts and enthusiasts, to join the SSR and engage with us to make sustainability in space a reality.

III. About the Space Sustainability Rating

The Space Sustainability Rating (SSR) provides a new and innovative way of addressing the orbital challenge by encouraging responsible behaviour in space through increasing the transparency of organizations' debris mitigation efforts. It is an initiative seeking to foster voluntary actions by satellite operators to reduce the risks related to space debris and on-orbit collisions by incentivizing operators:

•To design missions compatible with sustainable and responsible operations; and

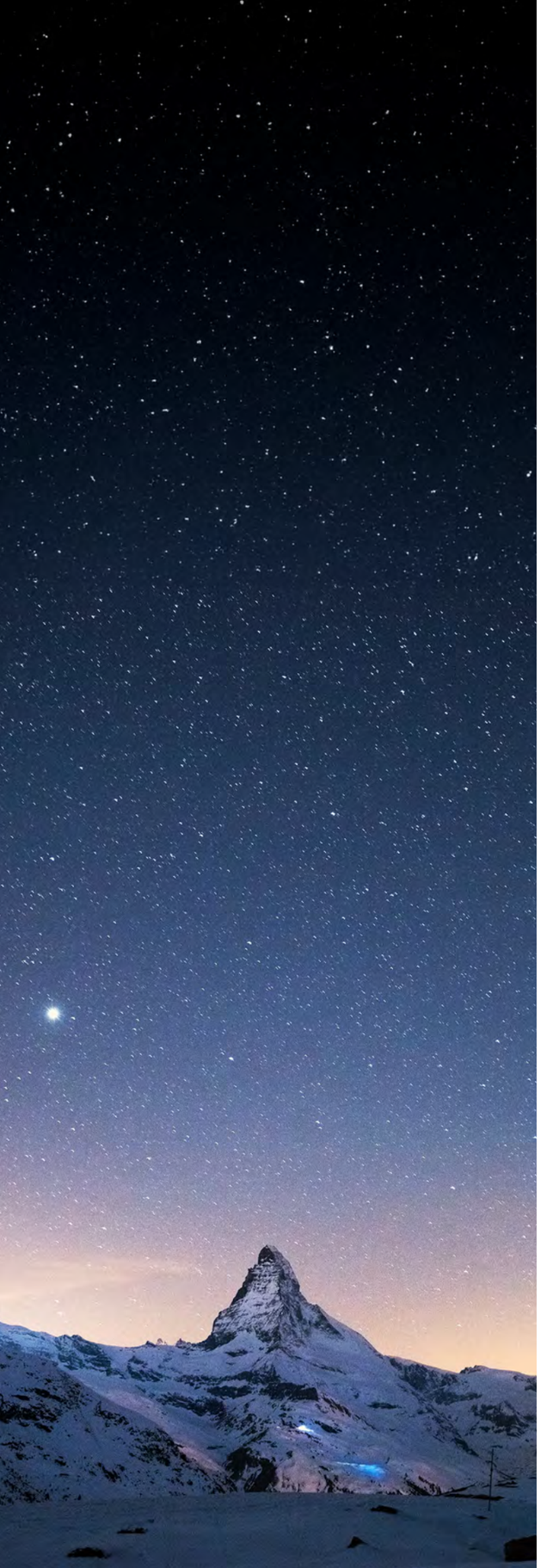
•To operate missions considering not only mission objectives & service quality, but also the potential harm to the orbital environment and on other operators.

The SSR is a rating system based on a set of criteria that cover a range of areas, including a mission's collision risk footprint, collision avoidance and post mission disposal strategies, data sharing, compliance to existing standards, detectability and trackability, and readiness for on-orbit servicing and removal.

Our rating system supports space actors, such as governments, space agencies, and commercial companies, in understanding the impact of their activities on the space environment, and identifying opportunities to minimize those impacts.

Inspired by the successful use of sustainability ratings in other industries, the SSR was developed in 2016 under the leadership of World Economic Forum's Global Council on Space and is operated by an eponymous non-profit organisation, hosted at eSpace – EPFL Space Center. The SSR also involves the Massachusetts Institute of Technology (MIT), the European Space Agency (ESA), BryceTech and the University of Texas at Austin (UT Austin) to compose a consortium.
In May 2021, eSpace was selected to lead the operational development and implementation of the SSR, with the mandate to implement and operate the rating system. In 2023, the SSR transitioned to an independent association.

EPFL , picture by Thomas Delacrétaz , Unsplash



IV. About this report

This activity report provides an overview of the progress achieved by the SSR in 2022, including details on the key milestones reached as well as the strategic questions that the rating system has been striving to address and that will shape its work programme for the biennium 2023-2024.

This is the first report that the SSR has released. We are proud to share the progress of the SSR and excited to continue delivering on the work programme. Officially an association since 2023, the SSR will continue to advance its philosophy based on four pillars: inclusivity, collaboration, data-based assessments and recognition.

The first sections cover general management items, with a focus on financing, business model and offering of the SSR. Offered as a paid service, ratings constitute the main source of revenue for the SSR, in addition to the membership fees to the newly formed SSR association. This follows the approach of certification schemes and rating systems in other industries.

In 2022, the Swiss Confederation provided financial support for the implementation of the SSR, which has been instrumental to the progress achieved. In addition, rating and membership fees have enabled a positive financial forecast for 2023 – yet additional sources of funding will be crucial to cover operational, research and development and the overall growth of the rating.

The report also addresses the activities led with partners to establish regional hubs of the SSR, and support research around the rating system and space debris. Communication successes and priorities are also detailed in the following sections. Technical developments of the rating system, of which there were many in 2022, are further explained in the final section.

Mont Cervin, picture by Joshua Earle , Unsplash

V. General management and strategy

a. Financing the SSR

As stated in the SSR Association articles (art. 11), the SSR will fund its operations with financial resources such as:

- Private or public subsidies or grants;
- Membership fees
- Revenues from its activities
- Revenue generated by the Association's assets
- Donations by third parties
- Legacies
- Sponsoring
- Partnerships
- Other means of financing authorised by the law,

including but not limited to consulting mandates performed by the employees of the association secretariat.

All the resources of the SSR should, have been and will be used exclusively for its not-for-profit purposes.

Satelite, picture by Nasa , Unsplash

Securing the support of public institutions

As the SSR is still in calibration mode, the business model approach is designed to be flexible and allow for adjustments. Still, support for public actors is crucial to put the rating system into orbit. In that regard, the financial support of the Swiss Space Office (SSO) of Switzerland's State Secretariat for Education, Research, and Innovation has been instrumental for the growth of the SSR.

For 2022, the SSO contributed CHF 278,000 via eSpace – EPFL Space Center. The funding is valid from June 2022 to June 2023, and enabled the hiring of a staff of two FTEs (one project manager and one operations officer), and to cover essential expenses (including three business trips essential for the SSR representation).

For 2023, the SSR team is seeking to secure additional public funding for the biennium 2023-2024, with a focus on adding valuable additional features to the rating system web-based platform and support an effective management of operations. Additionally public support will allow the rating to be further automatised, allowing increased enhancement of the rating's business case.

To direct financial management, the SSR is also exploring how it can collaborate with national and regional space agencies, with a focus on supporting a wider adoption of the rating system. As such, the team has been continuously assessing what such a collaboration would entail with these essential partners. Promotion of the SSR as an informal standard for space actors and enhancing financial incentives for potential users are central objectives. The main sources of expenses in 2022, and forecasted for 2023, are related to the development and the operation of the rating in terms of:

- **Development and management of the rating system and technicalities.**
  - It includes two (2) full time equivalents (FTEs) and social charges based on the Swiss legal system
  - Travel cost to meet and present the SSR.

- **Explore the development and launch of an independent certification system stemming from the rating system**
  - This important development for the SSR should take place in partnership with a recognized expert in the field, including through in-kind contribution.

- **Further development of the online platform Rate Space (Reporting and Assessment Tool** for the Evaluation of Sustainable sPace ACtivitiEs):
  - Mission index module automated computation
  - Detectability, Identification, and Trackability automated computation
  - Increase data analysis capabilities
  - Enhanced user experience
  - Start the development of an automated-dynamic score reassessment based on publicly available data (API calls)

- **Research:**
  - Consultants and experts for the development of new modules (e.g., impact on astronomy, Life-Cycle-Assessment)
  - Exploring the development of a rating system for launch vehicles (LVSR)

- **Communications, advocacy and outreach efforts**

- **Resources needed to develop and manage the activities of the SSR Association. This may include:**
  - The contracting of a trustee to help manage the accounts
  - Banking fees
  - Legal advice to draft and sign contracts with companies Insurance
  - IT costs (Website, domain, cloud infrastructure), which in 2022 were covered by
  - Space as the SSR sat within the Center.

Stars in the sky, picture by Nick Owuor , Unsplash

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b. Developing the SSR offering & branding

The SSR is designed to provide an incentive for space actors (including spacecraft operators, launch service providers and satellite manufacturers as targeted customers for the rating system) to design and implement sustainable missions.

Carrots & sticks: reinforcing the incentive for space actors to engage with the rating system

In 2022, the SSR has benefited from intense and valuable discussions with various forums for space. This has generated debates on what is truly the incentive for using the SSR.

As of now, the main strengths of the incentive offered by the SSR are reputational and operational:

- Similar to Corporate Social Responsibility (CSR) demonstrated by companies in other sectors, the SSR is a platform for space actors to showcase their commitment and actions to pursuing long-term sustainability in current and future missions.

- Using the rating system can back the risk management strategy and processes of participating companies with regard to the safety of their missions, as the assessment considers key elements for collision avoidance and safety of the mission. Additional discussion is needed to better identify how the SSR can become a more compelling tool for space actors. This should involve policy dimensions (e.g., in anticipation and/or support of more stringent regulations) and finance experts (with a focus on establishing linkages with Environmental, Social and Social (ESG) indicators). In the longer term, and according to feedback received from a range of stakeholders in the space ecosystem throughout 2022, we will be seeking to reinforce the incentive aspects and overall value proposition of the SSR.

- Based on their rating, actors may one day be rewarded through financial an economic incentives that could influence how nations deliver launch/spectrum licenses, how agencies procure space missions or impact insurance premiums for satellite operators, potentially reducing costs, and leading to more positive customer and public perception, acting as a competitive advantage and offering greater prestige.

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The SSR is designed to provide an incentive for space actors (including spacecraft operators, launch service providers and satellite manufacturers as targeted customers for the rating system) to design and implement sustainable missions.

Companies will pay to have their mission evaluated and receive a score. Consequently, the ratings will be offered as a service, and the SSR Association will also provide a platform for multi-stakeholder collaboration to both articulate a joint vision and raise awareness on space sustainability and support in shaping the future evolutions of the rating and ensuing certification system.

There is a growing demand from space actors for practical solutions to better understand their impact on the orbital environment, driven by:

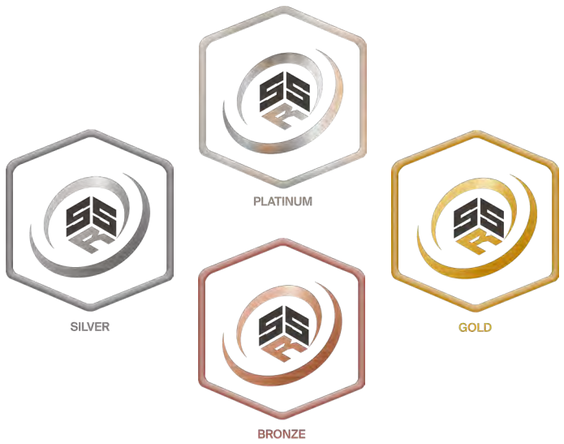
● The lack of enhanced risk-management tools available: Space actors are under growing pressure to develop strategies and address the challenges posed by space debris and the impact on the space environment. These constitute a pressing concern for the safety and ultimately, success of their operations, in the short-, medium- and long-term. The SSR, as an easy-to-use instrument to support internal risk-management approaches, offers a practical solution.

● Policy: As international guidelines provide a framework to address space safety and sustainability, there is no means available to enforce them. The need for sustainability rating systems as a tool to recognize actors for demonstrating their commitment to the long-term sustainability of the space environment and adherence to space debris mitigation practices in the space industry has been supported by the Satellite Industry Association and U.S. Federal Communications Commission.

The SSR therefore fills in a gap, with the ambition to support the industry's journey towards the ntegration of a sustainability mindset into strategy and operations. The market that the SSR is targeting is in development; hence, our objective is to foster and leverage the demand for such solutions. In that regard an important effort was made to build a business model that should be sustainable in the medium- and long-term, generating revenue to finance both operational and development costs.

Echoing the business proposal, with a comprehensive effort involving the experts of the SSR Consortium, we developed an offering aiming to allow for the involvement of satellite operators and any other stakeholder from the space industry, as well as organisations with an interest in space sustainability.The offering of the SSR aims at driving the development of a strong membership base as well as building partnerships, with a view to use the momentum around the SSR to nurture and extend its network of supporters.

After further thinking and calibration with experts and industry leaders, the SSR has centred its offering on a paying rating system and related practical guidance on how to improve sustainability performance and practices based on the results of the assessment.



The different ssr rating badges

SSR offering:

● A rating system informed by transparent, data-based assessments of the level of sustainability of space missions – without disclosing confidential mission data and proprietary information
● Practical guidance on how to improve sustainability performance & practices
● A platform for action-focused collaboration centred on the rating system to support research and leverage best practices. What is the incentive for using the SSR?

By voluntarily taking part in the rating, companies will:

● have a clear picture of their current sustainability performance;
● identify where improvements can be made;
● communicate about the sustainability level of their mission to shareholders,
investors, insurers and the wider public;
● in the long term, benchmark their sustainability scorecard with peers.

As of 2023, this is offered through a subscription with a flat fee to simplify the offering. In 2022, two companies became rating subscribers and around half a dozen have expressed their interest and engaged with the SSR. 2023 will be dedicated to translating them into full rating subscribers.

It should be noted that the SSR team is still evaluating what would constitute the most efficient and compelling offering. As such, in 2023 much more effort will be conducted to refine the SSR business plan and strategy.

Somewhere over the clouds, picture by Kendrick Fernandez , Unsplash

c. Development of the membership base & partnerships

i. New members

In its current shape, the rating system is most useful for satellite and spacecraft operators. The SSR Association enables the participation of other important stakeholders in the space ecosystem and to increase engagement around the rating, association membership with paying fees has also been further developed.

Through the SSR Association, we want to collaborate on the technical, communication and organisational levels with a wide variety of stakeholders from the private sector, international and public institutions, non-profit organisations, as well as universities and research centres. An association allows us to formalise the establishment of a neutral platform through which all these actors interested in space sustainability could exchange.

Why should you become a member of the SSR Association?
By joining our nine members, your organisation will have an opportunity to:

1. Take on a leadership role in the global discussion for space sustainability
2. Join a safe-space forum to exchange and build relationships with a multi-stakeholder group of leading organisations
3. Get involved in the discussion to continuously enhance the rating system, and support its establishment as an internationally recognized and independent certification systems
4. Have a say in the decision-making authority to bring resilience, independence and expertise to the SSR

In 2022, nine forward-thinking organisations have embarked upon the SSR adventure, including three founding members who were early supporters of the initiative:

- Ansys, which provided in-kind contribution through the provision of a license for the STK software essential to the computation of the DIT module.
- Nihon University, who will head the development of a regional-hub for the SSR in Japan and the Asia-Pacific region
- Stellar, a longstanding supporter of the SSR, who participated in the first ever rating.

ALTER TECHNOLOGY, EnduroSat, Neuraspace, Privateer, the Secure World Foundation and Slingshot Aerospace have joined the SSR, providing key expertise and a network to enhance the rating system and ensure its relevance and accuracy.

The input of space actors has helped ensure these analytic approaches can be applied to various missions. In that regard, it is of benefit to both the SSR and operators to exchange on the rating system, and collaborate to enhance the rating's methodology and process.

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ii. SSR Asia-Pacific Regional Hub led by Nihon University

In 2022, Nihon University officially joined the SSR as a founding member, supported by Japan's Ministry of Trade, Economy and Industry (METI) and the New Space Global Strategy Lab (NGSL). This important partnership for the SSR will lead to creation of a Regional Hub for Asia and the Pacific, in which Nihon University under the leadership of Prof. Yasuyuki Miyazaki will play a central role.

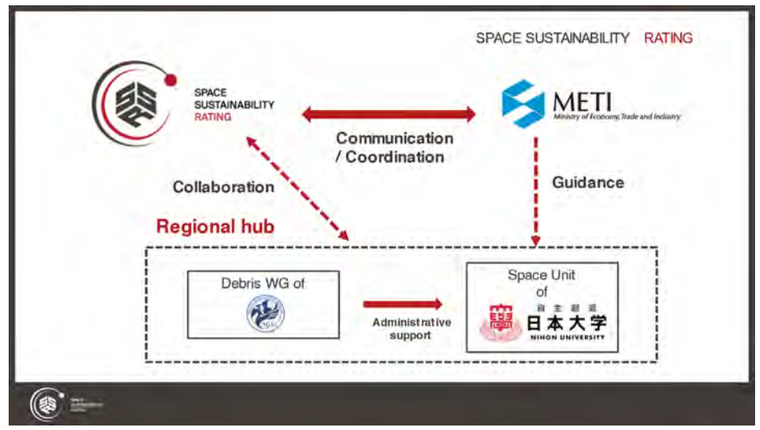
The creation of an SSR Regional Hub for Asia and the Pacific and the activities performed are aimed at:

1. Providing space actors in Japan and the Asia-Pacific region with appropriate tools, resources and guidance to perform ratings and continuously improve their sustainability performance

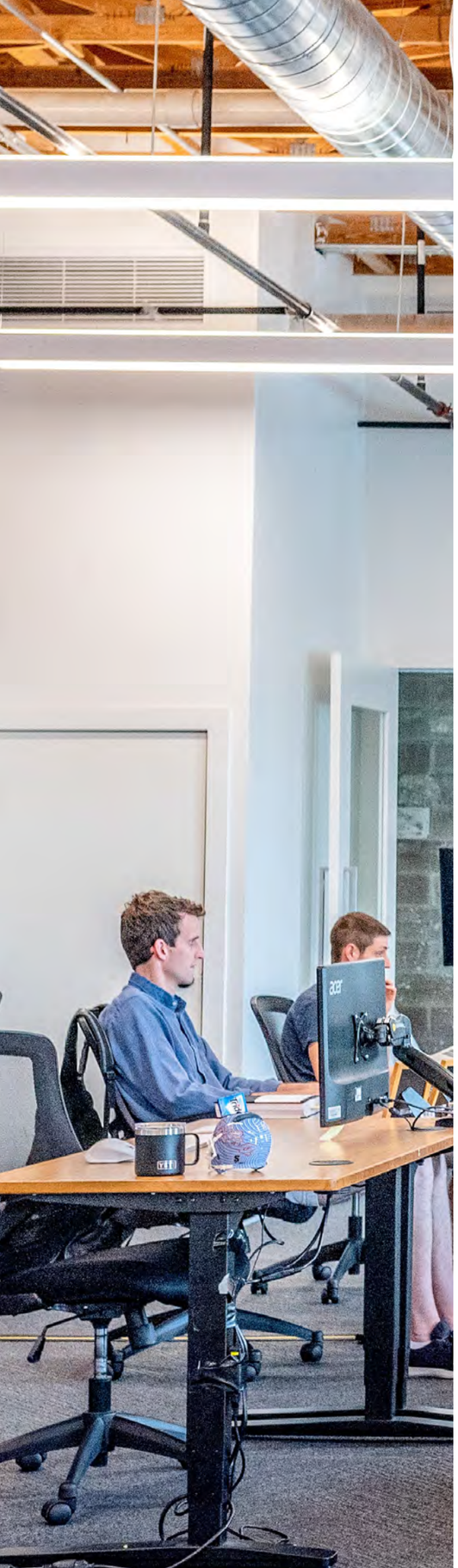
2. Providing a platform for discussion and collaboration between space actors in the SSR initiative in the Asia-Pacific region (with at first, a focus on Japan)

3. Promoting and increasing the visibility of the Space Sustainability Rating in the Asia-Pacific region.

The SSR team meeting with METI, Nihon University and Axelspace at the Swiss Pavilion at the 71st IAC in Paris, September 2022. Left to right: Adrien Saada (eSpace), Chihiro Kajihara (METI), Emmanuelle David (eSpace), Dr. Yukihito Kitazawa (Nihon University), Florian Micco (eSpace) and Yuya Nakamura (Axelspace).



SSR Asia Pacific Regional Hub proposed structure



iii. Development of an SSR certification scheme

A certification scheme, similar to that of the Forest Stewardship Council, the Concrete Sustainability Council and other certification systems, would provide another layer of credibility to the rating system, enhancing its overall value. This will consist in a stronger level of verification, involving third-parties to review the data provided by rating subscribers, and assessment results.

However, the certification scheme, as with the rating, should not serve as an assurance that getting a good rating score would absolve the participating operator of responsibility with regard to its impacts on the orbital environment. In 2022, the SSR and ALTER TECHNOLOGY have explored how could the two join forces to develop an impactful collaboration to launch a certification scheme.

The main focus is on developing and launching an SSR certification process by defining an audit methodology and testing method for later updates to the rating system, in accordance with relevant ISO standards and international guidelines. In 2023, the SSR team intends to build on the learnings from this initial phase and resume this work.

Working space,
picture by Austin Distel ,
Unsplash

V. General management and strategy

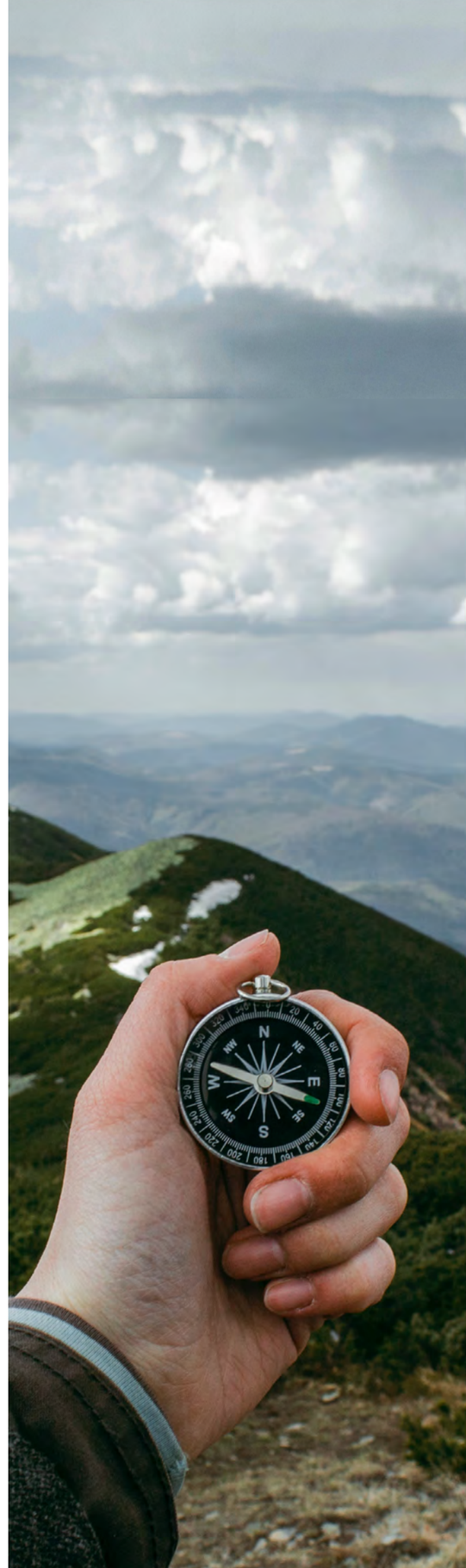
a. Cultivating the SSR narrative

The SSR is the result of a unique enterprise led by space experts, united around a joint vision for space sustainability. The SSR team has been striving in 2022 to double down efforts to implement our vision, and the narrative around the SSR aims to reflect this endeavour.

The starting point has been to emphasise the history of the rating system. In **2016**, the concept of the SSR was kickstarted by space experts and industry leaders within the Global Council on Space of the World Economic Forum. In **2019**, they appointed a consortium formed by ESA, the Space Enabled Research Group at MIT, UT Austin and BryceTech to develop the methodology of the rating system and grow the rating idea into a data-based framework.

Since **2021**, the next phase of the SSR journey has been to leverage this framework to build a product that is useful and valuable to the space community. The question of the SSR narrative is closely linked to its overall strategic positioning, with a view to anchor its status as an innovative solution to the complex and intricate challenges related to the proliferation of space debris.

The concept of carbon footprint is recognized as a critical environmental sustainability indicator to quantify the environmental performance of products, companies or countries. Framing the SSR as a “space footprint” for the space industry has constituted the backbone of the story-telling of the rating system.



Compass,
picture by Anastasia Petrova ,
Unsplash

Why a rating system for space activities?

We are used to considering space as an infinite resource. We could not be more wrong. Decades of space exploration have led to tremendous technological progress, bringing crucial services,such as weather forecasting, climate monitoring, global positioning and communications, contributing to economic and social development globally. However, therising number of satellites launched to already crowded orbits has amplified concerns about preserving the long-term sustainability and safety of the space environment.

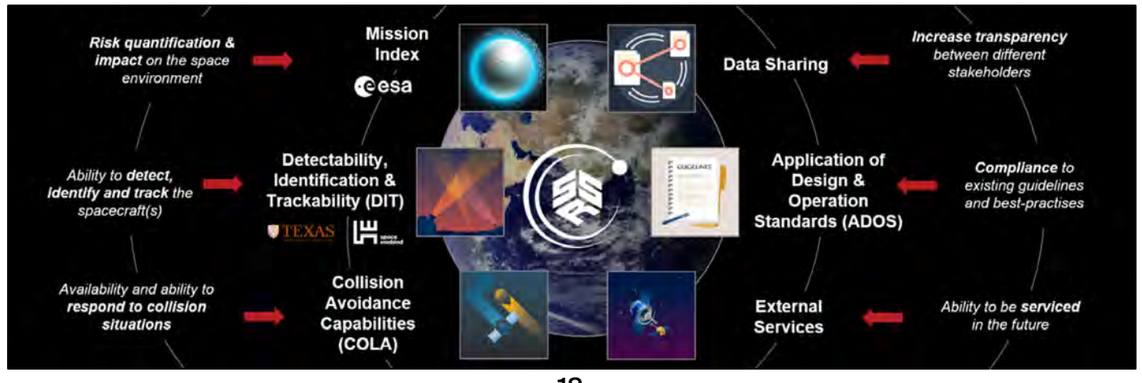
Space traffic has increased exponentially in the last ten years, driven by a fast-changing space sector with a declining cost to entry, and an increasing number of space actors. Predictions of a gradual and uncontrolled increase in numbers of space debris and objects in space under a 'business-as-usual' scenario are often in contrast to slower, incremental changes to sustainability regulations and guidelines, leading to amplified concerns about the preservation and long-term use of the space environment.

As the challenge of orbital debris or "space junk" is set to grow, it is crucial to address the challenges related to old debris management, ensure the safety of the current working satellites, and innovate for the production and monitoring of future satellites.

The SSR provides a new, innovative way of addressing the orbital challenge by encouraging responsible behaviour in space through increasing the transparency of organizations' debris mitigation efforts. It is an initiative seeking to foster voluntary action by satellite operators to reduce the risks related with space debris and on-orbit collisions, by incentivizing operators:

- To design missions compatible with sustainable and responsible operations
- To operate missions considering not only mission objectives & service quality, but also the potential harm to the orbital environment and on other operators Its methodology encompasses six modules: Mission Index (or space traffic footprint);

Detectability, Identification & Tracking; Collision Avoidance Capabilities; Data-sharing; Standards & Regulations; and External Services. An overarching data verification module finally ensures the robustness of the information provided to the SSR issuer.



b. Promoting the SSR among the global space ecosystem

In **2022**, we witnessed space sustainability increasingly gaining ground globally. This has provided an excellent opportunity for the SSR to feature discussions and benefit from a strong interest from key stakeholders of the global space ecosystem – thanks to the steady support of the Consortium, partners and growing network. As the first half of **2022** was dedicated to the beta-testing phase of the rating system, the SSR-going live in June provided a chance to focus on promotion for the remainder of the year. Promoting the SSR has been centred on four pillars:

1. Building relationships with key players from the space industry and ecosystem

2. Attending and participating to key space conferences

3. Developing compelling communication materials

4. Increasing our online presence.

Creation of a visual identity: SSR logos and rating badges have been designed to give the SSR a unique identity. The logos are inspired by the design of CubeSats and an orbiting shape. The SSR team thanks Alex Widerski for his support.

SPACE SUSTAINABILITY RATING

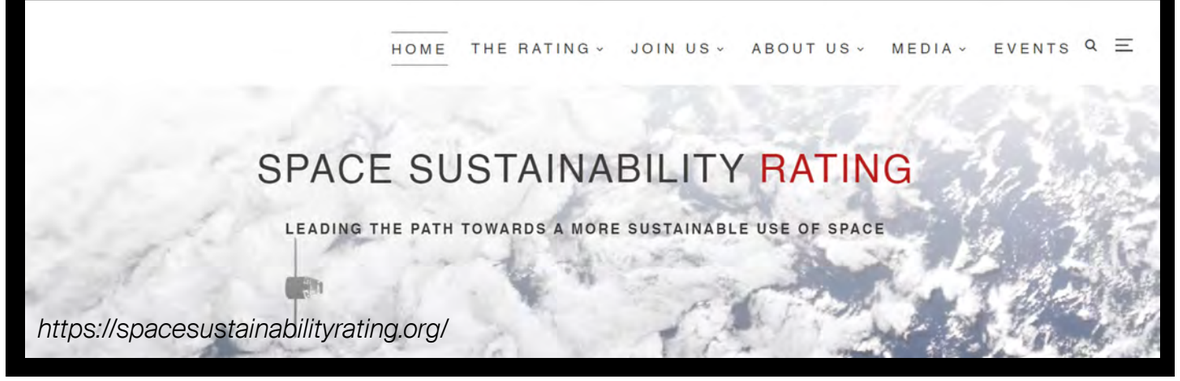
SPACE SUSTAINABILITY RATING

SSR's logo

The SSR website

Prepared for the launch of the rating on 23 June 2022, the SSR website consttutes the main arm of the SSR outreach strategy. As much information as possible is shared, specifically on technical aspects of the rating, to ensure the SSR transparency. The SSR team specially thanks Ms. Candice Norhadian for her help and guidance in setting up the website.

Visit SSR's website



Adrien Saada presenting his paper The Space Sustainability Rating: An operational process incentivizing operators to implement sustainable design and operation practices detailing the SSR process at the 20th IAA symposium on Space Debris during the International Astronautical Congress.

On stage at the Space Law Congress. Madrid , summer 2022.

Oct. 10 2022

- *Presentation at the session "Utilizing the ultimate frontier responsibly" during the UNOOSA World Space Week Webinar series.*

Nov. 02 2022

- *Participation to the "Roundtable 1: Policy coherence for tackling space debris" at the IASC 2022 Commons in Space Virtual Conference.*

Nov. 22 2022

- *Presentation at the Session 2: International Laws and Policies in Space Exploration and Innovation at the UN/China 2nd Global Partnership Workshop on Space Exploration & Innovation .*

Nov. 30 2022

- *At the Space Sustainability for the Next Decade (and beyond) session at the GNOSIS Annual Conference 2022.*

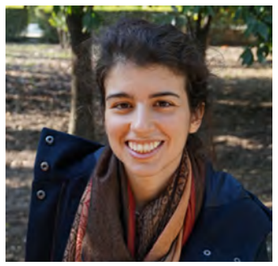
SPACE SUSTAINABILITY RATING

The SSR Ambassadors

The SSR has benefitted from the expertise and network of the five organizations that make up the Consortium since it was selected by the World Economic Forum to lead the development of the rating system methodology in 2019.

Simon Potter
BryceTech

Stijn Lemmens
European Space Agency



Dr. Francesca Letizia
European Space Agency

Dr. Minoo Rathnasabapathy
Massachusetts Institute of Technology (MIT) & World Economic Forum

Prof. Danielle Wood
Massachusetts Institute of Technology (MIT)

Prof. Moriba Jah
University of Texas at Austin (UT Austin)

Nikolai Khlystov
World Economic Forum

Conference room, picture by Benjamin Child , Unsplash

In 2022, the SSR management transitioned to an independent non-profit association – a major milestone in a journey that started six years ago.

a. Why an association to manage and operate the SSR?

The SSR approach, shared with the consortium since the outset, is to ensure inclusivity and transparency. This has naturally influenced the decision to adopt the organisational structure of a non-profit, aligned with this philosophy. This would support the achievement of the ambitions and objectives sitting at the heart of the SSR.

• The association structure enables collaboration on technical, communication and organisational levels with a variety of stakeholders from the private sector, international and public institutions, non-profit organisations, as well as universities and research centres. It provides a neutral platform through which all these actors interested in space sustainability could exchange.

• The SSR being the first rating of its kind will need to constantly adapt to the market and evolving technology, therefore the proximity to a university is essential to conduct research. In that regard, a non-profit association also allows for maintaining the strong relationship between the EPFL Space Center for the future of the rating system, while ensuring it objectivity.

• Another motive for establishing the association is to facilitate fundraising efforts to support the rating system and its growth, opening new funding opportunities.

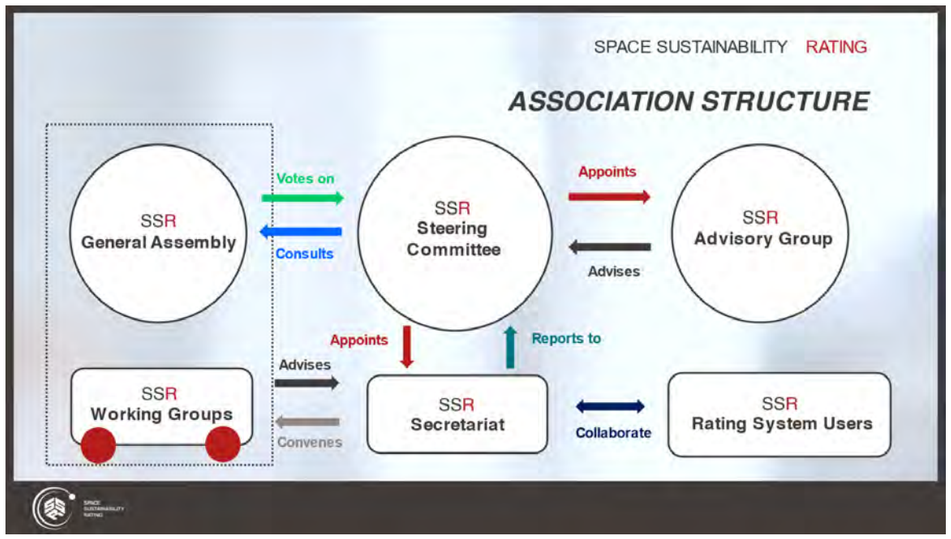
• Finally, the central pillar of the SSR project is formed by the implementation of the rating system, of which the Association will become the sole owner in the long term. This requires that the SSR project be perceived as credible, transparent, fair and impartial by all space actors. A non-profit organisation structure would make it possible to achieve this objective.

b. Assosiation bodies

The SSR Association is a non-profit organisation whose main objectives are to manage, strengthen and promote the rating system among space actors (commercial, institutional and civil) and the general public, and to contribute to the global discussion and research on the sustainability and safety of the space environment, and related challenges.

The functioning of the SSR Association is defined broadly by the articles of the Association. A set of policies and management guidelines will further define procedures for the management of the association. eSpace – EPFL Space Center will serve as one of the founders of the Association.

As such, three main bodies constitute the backbone of the association:



i. The Steering Committee

The Steering Committee serves as the executive body of the SSR Association. It is designed to continue the work led by the Consortium, and implement its vision. The initial Steering Committee members are appointed by the founders of the Association for a three-year period. The Consortium, formed by the five organisations steering the development of the SSR, continues to participate in the association through the Steering Committee, the executive body of the Association.

For the period 2023-2026, it is composed of:

- Prof. Jean-Paul Kneib, President
- Emmanuelle David, Vice-President and treasurer
- Stijn Lemmens, member
- Dr. Francesca Letizia, member
- Simon Potter, member
- Dr. Minoo Rathnasabapathy, member
- Dr. Danielle Wood, member

ii. The Advisory Group

In parallel, the Advisory Group, made up of internationally renowned experts and organisations, serves as the advisory body of the association.

Its main responsibility is to provide expertise and recommendations to the Steering Committee, but it formally holds no formal decision-making powers in the association. Its members can also be members of the General Assembly of the Association.

In particular and without limitations, the tasks of the Advisory Group are to:

- Provide support and expertise to the Steering Committee on any matters deemed as relevant to the Association;
- Propose amendments to the rating system to the Steering Committee;
- Provide recommendations to the Steering Committee on the Association strategy and management of operations, and on any matters deemed as relevant to the Association;
- Serve as an advocate of the Association, including for space sustainability and safety;
- Assist in the identification and recruitment of new members of the Association and organisations interested in completing ratings.

The initial Advisory Group members are appointed by the founders of the Association (which have been involved in the SSR for a long period of time and have provided extensive support for its development), and are appointed for two-year terms.

In 2023, the Advisory Group is composed of:

- Airbus Defence and Space, represented by Daniela Genta
- ALTER TECHNOLOGY Group, represented by Rafael Rodríguez Muñoz and Eladio Montoya Redondo
- The Aerospace Corporation, represented by Dr. Josef Koller
- Australian Space Agency, represented by Aude Vignelles
- AXA XL, represented by Chris Kunstadter
- Clearspace, represented by Dr. Tim Maclay and Romain Buchs
- COMSPOC, represented by Daniel Oltrogge
- Debris-X, represented by Prof. Yan Jun
- EnduroSat, represented by Dr. Anja Nakarada Pecujlic
- European Southern Observatory, represented by Dr. Andy Williams
- GSOA – Global Satellite Operator's Association
- Helvetia Insurance, represented by Jan Schmidt
- Lockheed Martin, represented by Jennifer War-ren
- Japan's Ministry of Economy, Trade and Indus-try, represented by Takashi Takeda
- Luxembourg Space Agency, represented by Dr. Muriel Hooghe
- Middlebury College, represented by Prof. Akhil Rao
- Nihon University, represented by Prof. Miyazaki Yasuyuki
- Secure World Foundation, represented by Ian Christensen
- Stellar, represented by Damien Garot
- University of Colorado, Boulder, represented by Dr. Zach Donohew
- Universiteit Leiden, represented by Dr. Tanja Mas-son-Zwaan
- Voyager Space, represented by Eric Stallmer
- World Economic Forum, represented by Nikolai Khlystov (Chair)

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iii. General Assembly

The General Assembly is the main authority of the Association, as defined by the articles. It is composed of all its members, and will meet annually.

iv. The Working Groups

As part of the association setup, two Working Groups have been scoped and presented to the members of the association with the objective of channelling engagement around the rating system in December 2022. One Working Group will address technical matters, and the other will cover policy considerations – two key dimensions of the SSR.

v. The Secretariat

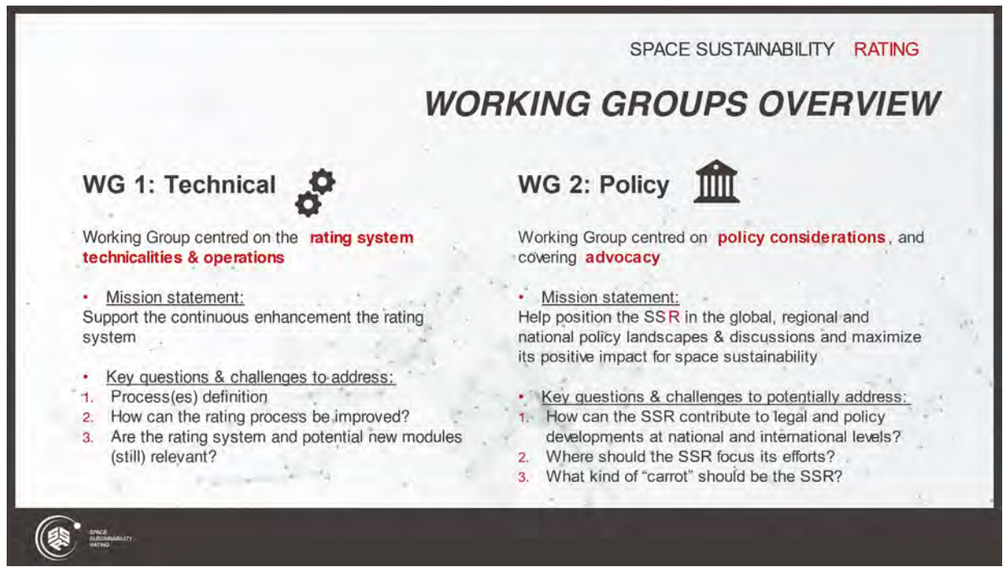
In **2022, the SSR team was composed of two FTEs, affiliated to eSpace – EPFL Space Center:**

- Florian Micco, Project Manager
- Adrien Saada, Operations Officer

The two SSR team FTEs had EPFL contracts, fixed-term, valid until June 2023. When the association is operational, the two FTEs will be employed directly by the association.

In 2023, through eSpace (EPFL), the SSR also benefits from the support of:

- Prof Jean-Paul Kneib, Academic director and President of the Association
- Emmanuelle David, Executive Director and Vice-President of the Association
- Candice Norhadian, Administrative Assistant
- Stephanie Parker, Communications Manager



VIII. Operations & technical advances

a. Why an association to manage and operate the SSR?

During the first half of 2022, the SSR team performed four beta-tests on a variety of missions led by satellite operators including OneWeb, Astrocast, Axelspace, and with the EPFL Spacecraft team (CHESS mission). These beta-tests enable the final finetuning and calibration of the rating system before the Consortium and the SSR team decided to officially launch. This phase built on the learnings and adjustments implemented in the previous beta-test phase in 2021 with participating companies including Airbus, Planet and SpaceX.

b. Web-based rating platform

One of the key objectives of the SSR is to establish in the near future an automated online reporting and rating platform. This product would streamline and quicken the calculation process of the rating, which would then facilitate the computation of ratings.

In 2022, a major milestone has been reached in this endeavour with the development of a valuable platform named RATE-SPACE (Reporting and Assessment Tool for the Evaluation of Sustainable sPace ACtivitiEs). This provides a steady basis for an online platform that will allow the SSR applicants to input their information and retrieve the SSR scores. The development of this platform will allow a more professional process, as well as increase the automation level of the operation, allowing to rate more missions and have a greater impact. This platform is operating and will be tested in operating conditions in the beginning of 2023, but still needs further development in order to automatize the entire rating process.

c. Fine-tuning the SSR process

The complexity of the rating system requires evaluation, decision-making, testing and adjusting the process from rating to rating. This exercise has enabled us to ensure that the rating system is relevant to and relatively easy to use for participating organizations.

Consequently, the SSR team worked iteratively on improving the process by making it more precise, efficient, but also resilient to diverse mission architectures, including constellations.

d. Research & development

The SSR is dynamic by nature and aims at being as comprehensive as possible when assessing sustainability and responsible behaviour in space. The six modules composing the rating system have been selected after an intense reflection as part of the scope definition led by the experts of the then Consortium – using a series of recognized metrics globally and aligned with the vision of space sustainability as defined by landmark documents and renowned experts and committees. Nevertheless, this exercise has also pointed out to areas worth exploring when addressing sustainability, where a lack of consensus and research have been led to develop such modules at the time.
In that regard, the SSR team has identified three potential new developments (two modules and one product extension to launch vehicles) which provide much added-value to the initiative, described in this section.

Satelite above earth, picture by Nasa, Unsplash

2022 Progress on the Rating Process:

As the team performed ratings, several questions were addressed regarding the process, documentation, as well as on the technical methodology itself.

As the rating process needs to be clear and well-understood by rated entities, the team has focused its effort from the beta-testing feedback to assemble all the necessary documentation to perform a rating in a single rating data-pack. This data-pack provides the SSR applicants a better understanding of the rating process, references, but most importantly of the technical methodology through:

- Module handbooks;
- Tutorial documents explaining how to compute critical input values (such as the so-called "mitigated collision risk", input to the mission index allowing to quantify the efficiency of a given collision avoidance strategy based on the accepted risk).
- Additional tools allowing to approximate certain rating values based on simplified assumptions. These tools are especially useful for missions in pre-design, in order to be able to play with mission parameters and preview an approximated score for certain modules.

2022 allowed the team to efficiently test the rating on a large variety of missions, enabling us to significantly enhance the model's accuracy for peculiar mission cases such as constellations, and for challenging concept of operations, including orbit raising, parking orbits at intermediate altitudes, and low-thrust propulsion. This rating computation capability increase are also driving new developments, as the aforementioned mission aspects are not yet implemented in the RATE SPACE web-based interface.

Finally, as the hand-over from the SSR consortium to the EPFL Space Center was performed, the ownership of the computation method of the Detectability, Identification, and Trackability (DIT) module was performed between the Space Enabled Research Group at MIT and the SSR team. This transfer allows a faster computation timeline, as well as more score analysis capabilities. The SSR wishes to express gratitude to the team at MIT, and especially Scott Dorrington, who allowed the SSR team to be trained to compute DIT scores.

i. New modules development

1. Dark and Quiet skies

While the number of both active satellites and space debris is set to grow in the coming years, there is growing concern among the astronomy community regarding the impact of such a densely populated sky on observations.

In that context, the development of a Dark and Quiet Skies module was considered in a view to continuously enhance the rating system, with the support of the IAU CPS Policy Hub. This module aims at proposing a quantification methodology to assess the impact of satellites on astronomical observations, both for optical and radio telescopes.

In 2022, the following three projects were carried out by:

- Ambre Ghisalberti, Dark and Quiet Skies for the SSR: Through her summer internship, Ambre conducted a preliminary literature review and module preliminary definition, with a larger focus on the optical astronomy part.
- Emma l'Emira Chehab, Dark Skies for the SSR, semester project: Emma's project solely focused on optical astronomy. Emma conducted detailed module definition and initiation of the quantification model usage from the SSR Detectability methodology.
- Koki Kimura, Quiet Skies for the SSR, semester project: Koki's work focused solely on radio astronomy. Koki conducted high-level module definition and qualitative questionnaire definition.

The Dark and Quiet Skies (DQS) module will be split into two sub components, addressing the impacts on both optical and radio astronomy. As other SSR modules, the Dark and Quiet Skies module will (i) assess the impact of a given mission that can be composed of one or several spacecrafts, and (ii) account for efforts from operators to mitigate their impact through design or operation of their satellites.
The Dark Skies (optical) component is derived from the detectability framework of the SSR, and aims at quantifying the apparent and effective magnitudes of spacecraft composing a mission. The impact of a mission in terms of data loss for a given set of telescopes is set to be quantified. Whereas the aggregated impact of a mission shall be included, the goal of the SSR is also to incentivize every mission to implement best-practices. In that regard, a rating methodology to rate missions at spacecraft and mission (fleet) level will be proposed.

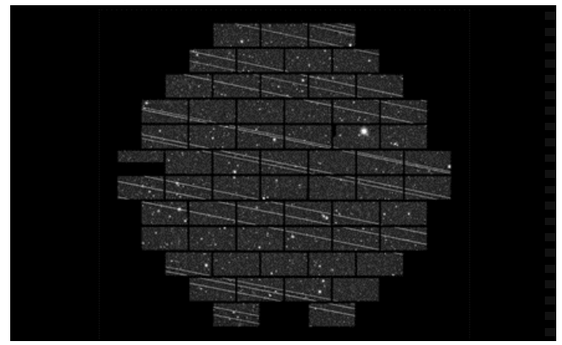


Figure: wide-field image (2.2 degrees across) from the Dark Energy Camera on the Víctor M. Blanco 4-m telescope at the Cerro Tololo InterAmerican Observatory, taken on 18 November 2019.

Several Starlink satellites crossed the field of view. Image credit: CTIO/NOIRLab/NSF/AURA/ DECam DELVE Survey

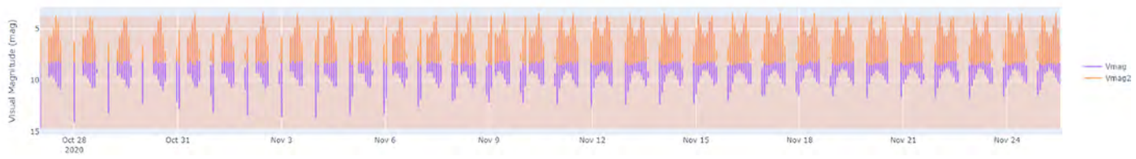


Figure: Preliminary outputs from the SSR detectability code to estimate visual magnitude of a satellite as seen from a defined ground station. Credits: Scott Dorrington

1. Life Cycle Assessment

The SSR formula is currently focused on the impacts on the space environment, in particular looking at space debris risks, end-of-life management from orbit, and debris mitigations. Yet with a continuously growing number of satellites launched in orbit, it becomes increasingly important to assess their impacts on the Earth's environment too and in a standardised manner.

While interest in Life-Cycle Assessment (LCA) for space missions has gained in strength in the past few years, particularly in Europe, no consensus has yet been reached on a single-score LCA system.

eSpace has started a feasibility study for a single-score LCA module which could be integrated within the Space Sustainability Rating, to further broaden its scope. The focus of the study lies in the identification of the initial inputs and the methodology to assess them, as well as a normalisation method to reach a single score.

Figure: Eco-design infographic, Credit: ESA

The end goal is to develop an LCA module that can help SSR applicants assess the environmental impacts of their missions, and incentivise them to implement eco-designed elements to tackle the identified environmental hotspots

ii. Launch Vehicle Sustainability Rating

The largest contributors to debris risks on orbit are mission-related objects and rocket bodies generated by launch vehicles. *(ESA Space Debris Office, 2022)*. Passivating and deorbiting upper stages are thus critical to safeguard valuable orbits, even more since some end up crossing crowded low Earth and geostationary orbits, threatening many operating satellites.
A new formulation focusing on the sustainability of launch vehicles is being developed, building on the approach and methodology of the SSR. A paper presenting the first iteration of this new rating methodology was written and presented at the 71st International Astronautical Congress in Paris last September. *(Udriot et. al., 2022, Development of a launch vehicle sustainability rating).*

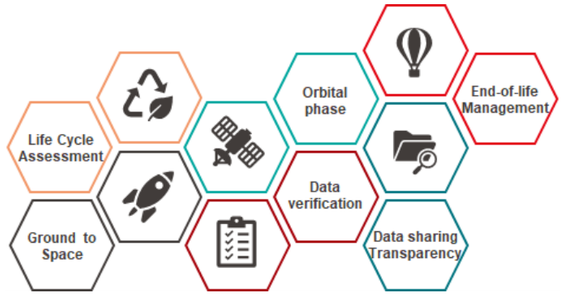


Figure: LVSR modules as identified in 2022, further developments incoming

The end of the 2022 year allowed the team of the EPFL Space Center to prepare for the LVSR beta-testing phase, which is set to start in 2023, and a student project will improve and refine the definition of the LVSR during the semester.

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2. Next steps

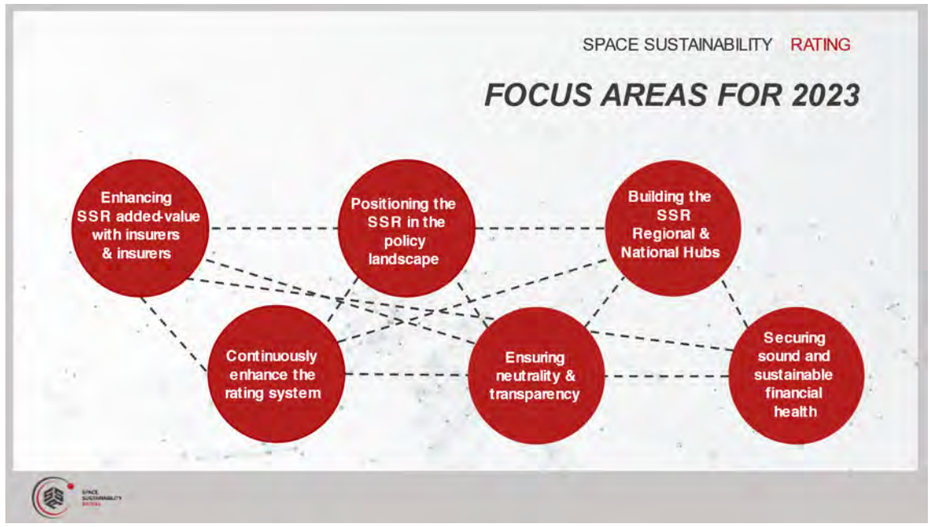
2022 was a landmark year for the SSR, marked by the closing of its testing phase and its official launch. 2023 be an equally pivotal year for the rating, with the goal of growing the community of users within the space industry, advancing development of additional modules and extensions, and steadily anchoring it in the global space sustainability landscape as a leading certification scheme.

The main priority for the SSR is to reach a sound and sustainable financial situation to continue operations and pursue development of additional features. In that regard, the business case of performing a rating will be re-assessed, with the goal of reaching financial stability with a mixed strategy between rating incomes and public fundings. The association is willing to perform 10 ratings in 2023. With the setup of the SSR Association to host the rating system, and its registration to the relevant commercial authorities in Switzerland, the business strategy of the SSR will continue its implementation, convert the growing interest in the SSR into tangible results.

The opening of a bank account to create, supervise and manage the financial resources stemming from the ratings completed and membership fees will gradually support the sound and sustainable management of the SSR.

The signature of a collaboration agreement between the newly created association and EPFL defining the scope of the support provided by EPFL will also enable to ensure a smooth transition for the SSR and pursue research thanks to the resources of the EPFL Space Center.

In parallel, the SSR team is striving to continue its research and development effort, with a focus on additional modules listed previously (i.e., Dark & Quiet Skies, Life Cycle Assessment) and the rating for launch vehicles (LVSR). These modules, as well as the LVSR, are not essential to the operationality of the SSR today, but they will provide, once developed and tested, much added-value to the rating system in areas where no similar modules have been created. To that end, four students have joined the SSR through eSpace to resume and conduct research as part of special semester projects and theses in February 2023. Later in 2023, a number of organisations will support a testing phase of the modules and LVSR. Their work will consolidate the foundations for potential integration in 2024.



IX. Acknowledgments & Contact

Many people have contributed to the SSR through diverse ways in 2022. These individuals have generously given their time and contributed their professional perspectives. We have listed the main contributors on these pages. Many stakeholders have also given valuable advice and comments at workshops, dialogues and other forums. To all contributors, we express our sincere thanks.

• Asociación Española de Derecho Aeronáutico y Espacial (AEDEA): Victor Barrio

• European Southern Observatory (ESO): Dr. Andrew Williams and Dr. Olivier Hainaut

• The IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS)

• LeoLabs: Darren McKnight

• OECD: Claire Jolly and Marit Undseth

• Secure World Foundation: Krystal Azelton, Ian Christensen and Brian Weeden

• Square Kilometre Array Observatory (SKAO): Federico di Vruno

● EPFL Space Center:
o Prof. Jean-Paul Kneib, Academic Director
o Emmanuelle David, Executive Director
o Florian Micco, SSR Project Manager
o Adrien Saada, SSR Operations Officer

The team thanks its colleagues from the EPFL Space Center for their excellent, generous and kind support, especially: Mathieu Udriot, Candice Norhadian, Stephanie Parker, Thomas Delacretaz, John Maxwell, and Alex Widerski.

The team also would like to thank EPFL students Ahmed Zouaoui and Badr Larhdir for their contribution to the rating platform.

• SSR Consortium:
o BryceTech: Simon Potter
o ESA: Dr. Francesca Letizia, Stijn Lem mens, Denis Weber
o Space Enabled Research Group at MIT: Prof. Danielle Wood, Dr. Minoo Rathna sabapathy, Dr. Scott Dorrington,
o UT Austin: Prof. Moriba Jah
o World Economic Forum: Nikolai Khlystov

Please get in touch with the team through contact@spacesustainabilityrating.org.

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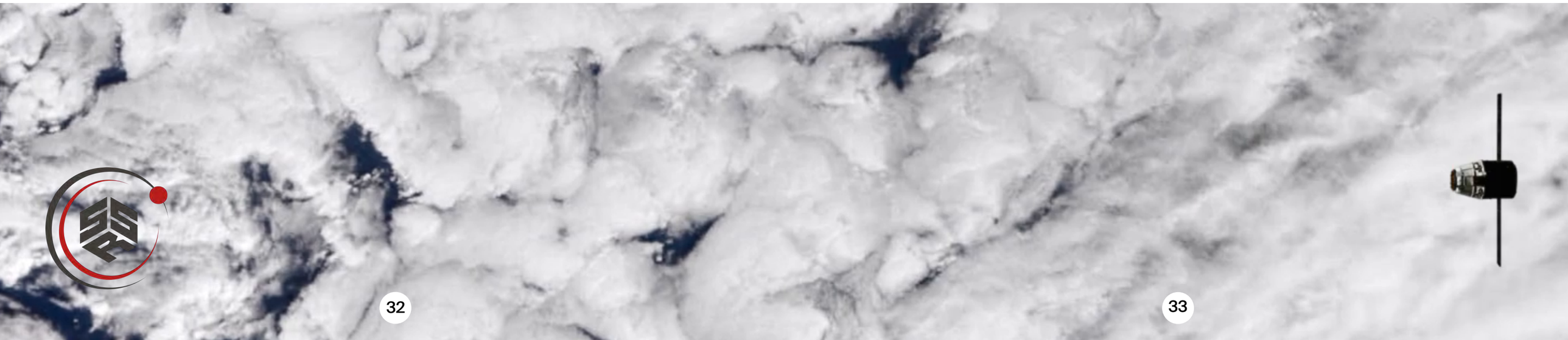

XI. Table Of Illustrations