

eSpace EPFL Space Center Activities 2021

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EXECUTIVE SUMMARY

2021 was another year for the record books, when the world saw the first all civilian crews flying on SpaceX and Blue Origin Rockets. For eSpace, this year was also marked by a record number of events organised, an increase in the number of students participating in the EPFL Minor in Space Technologies, and the successes of the EPFL Rocket Team in the European Rocketry Competition (Euroc) and the Xplore Team in the European Rover Challenge (ERC). 2021 was also the year when eSpace was selected to be the host and operator of the Space Sustainability Rating (SSR) and when Switzerland officially joined the Square Kilometre Array Observatory (SKAO) led by the LASTRO laboratory. eSpace was also able to be physically present in Dubai for the Dubai Expo 2021 and the International Astronautical Congress (IAC).

The missions of eSpace are:

- To inspire, educate, and boost the next generation of top talents in space science and engineering;
- To promote and support space research in laboratories, developing synergies through innovative and visionary projects.

Based on eSpace's missions, the activities of the center are focused around three main areas: **education, research, and communication and outreach.**

The report presents the main activities performed in 2021 by eSpace and the associated goals for 2022. The goal of this report is to present to the community the activities eSpace has performed to fulfil its missions and objectives. First, we will introduce the objectives set for 2021, followed by a report detailing the activities the center conducted to meet these objectives during 2021 within the areas of research and

education. Then, we will present the overall center management. Finally, the report concludes with a brief look forward at 2022.

Education

The main activities performed were the establishment of two new classes for the EPFL Minor in Space Technologies, the streamlining of the MAKE project supervision, and the supervision of different student projects. eSpace organised a series of monthly seminars at which EPFL professors and scientists, as well as external experts, were invited to present their work and their vision on a wide range of topics. These seminars also provide educational content to students. In addition, 13 student projects were supervised by eSpace staff in 2021.

For 2022, the goals for the Minor in Space Technologies are:

- to ensure the **high quality of the education** provided and facilitate the incorporation of a younger generation of educators;
- to continue to **secure financing** to serve students, provided via MAKE projects supervision, engineers to supervise projects, external teachers, and potential scholarships;
- to prepare the **future of new space education programs** with the possibility of having a master's degree in Space Technologies and continuing education for professionals, while developing new synergies with ETH Zürich;
- to ensure the **availability of engineers** for the supervision of the MAKE projects;
- to ensure the **educational value** of the MAKE projects and provide quality education for the students; and
- to provide **support for the students' transition** to industry.

Research

The research and innovation activities of the eSpace were focused around four main axes: the Research Initiative on Sustainable Space Logistics, the Space Sustainability Rating, the Lunar Initiative, and providing a series of services for the EPFL Space Profs.

The **Research Initiative on Sustainable Space Logistics (RISSL)** achieved a major milestone in 2021. The first phase ended with a successful report to the Swiss Space Office. eSpace and its partners managed to provide tangible research outcomes, to engage the Sustainable Space Logistics community, and to begin working towards the next steps of the initiative. eSpace also performed a first assessment of these two years.

eSpace also produced several publications which present the outcome of the research performed within eSpace at the macro, meso, and micro scale. The main projects conducted at eSpace focused on the ESA strategic planning system 2.0, NewSpace innovation, the development of a space logistics modelisation tool, system studies on space mission design and architecture, and on technology development in relation with the labs (capture system and relative navigation for ClearSpace, on-ground and in-space space debris tracking). In order to perform these activities, eSpace was able to secure funding from external entities such as ESA, Innosuisse, and Bridge.

Fourteen students from different backgrounds have supported or conducted research for the Initiative on Sustainable Space Logistics during the past three years. The initiative attracted a lot of students and researchers, which was highlighted by the success of the first Sustainable Space Logistics Symposium that was held virtually in February 2021. More than 350 attendees participated in the symposium with around 30+ speakers and panellists from the space and sustainability community.

In early 2021, eSpace was selected to be the host and operator of the **Space Sustainability Rating (SSR)**. The SSR is a tool to assess and recognise missions that are designed to be compatible with sustainable and responsible operations that reduce the potential harm to the orbital environment and the impact on other operators. Over the past two years, an international and transdisciplinary consortium consisting of the World Economic Forum (WEF), Space Enabled Research Group at Massachusetts Institute of Technology (MIT) Media

Lab, ESA, University of Texas at Austin, and BryceTech have been working on the design and development of the SSR. Formulated as a composite indicator, the SSR consists of six modules highlighting key related decisions faced by space operators in all phases of the mission. In 2021, eSpace performed the hand-over of the project with the consortium.

The beta testing phase took place in early 2022. The goal of the beta testing was to gather feedback from potential users on the rating and the process associated. A platform is currently under development in order to automate the rating. eSpace has been working in order to get funding for 2022 and also to set up a structure that will allow the SSR to be financially independent. Finally, the SSR team has been extending their network in order to raise awareness and push new research projects around space sustainability.

At the end of 2020, eSpace set out to create a **Lunar Initiative** aimed at bridging a set of identified major technological and scientific gaps within the global exploration and infrastructure development roadmap for the Moon. The initial idea behind this initiative was to leverage EPFL's technical expertise, through its many labs, units, and motivated students, to play a part in making the current lunar plans a reality, while positioning eSpace as an enabler and facilitator of major Swiss lunar research and technology development efforts. The activities envisioned within the framework of this initiative could be classified into one of the following six pillars as defined in the Lunar Research & Technology Development Initiative Strategy 2021 report (available upon request): (i) Science, (ii) Technology & infrastructure, (iii) Logistics, (iv) Sustainability, (v) Policies and standardisation, and (vi) Funding opportunities. The main project, undertaken with the Moon Village Association, was to fly EPFL's own scientific instrument to the surface of the Moon. In addition, proposals were submitted with the ISAE Supaero SAC Lab on "Moonrise: Human-robot cooperation for prospecting in unstructured environments", and eSpace led a project proposal as an answer to an ESA Invitation to Tender titled "EL3 polar explorer radio antenna payload pre-phase A study". In response to a new ESA Invitation to Tender ESA AO/1-10865 "Robust and (semi) autonomous platform for increased distances (RAPID)", eSpace partnered with the Belgian company Space Application Services. These different proposals should set up the technological knowledge and create visibility to place EPFL and eSpace as a credible actor when it comes to the Moon technologies.

During 2021, eSpace's support to EPFL's Space Professors group was carried out through three major activities:

- Management of projects and system engineering support, including for students
- Information on space activities to the space community
- Finding new opportunities

Other activities have also been performed, such as providing input on space activities to the EPFL management and the ETH domain and compiling a list of the space labs within EPFL. This year, eSpace continued its effort in managing projects and providing system engineering support, in particular through the management of two Innosuisse projects with ClearSpace and also the negotiation and kick-off of the ADRIOS contract with ClearSpace. Information was disseminated to the Space Profs community in particular to inform them about the European Funding available in the Green Deal Call and the Horizon Europe opportunities.

eSpace operations

While 2020 was a challenging year in terms of staff due to the departure of key personnel, 2021 gave eSpace the possibility to reinforce the team with a few competences such as a new communication manager, two guest researchers and also one new additional research engineer.

Regarding communication and outreach, two major events were organised, virtually in Tokyo (EPFL Virtual Space Tour) and in-person at Expo 2020 Dubai (Switzerland, a space nation exhibition). eSpace developed and began to implement its communication strategy, with a significant boost in social media activity and audience (total increase of more than 50% followers over the several media channels). In addition, eSpace continued to organise the Seminar Series for the EPFL student and researcher community with guests from academia and industry. During these ten seminars, the audience went from 10 to 50 participants online. After being selected to operate the Space Sustainability Rating in June 2021, an effort has been made to develop the associated communication strategy and plan.

Finally, an assessment of the activities in 2021 was performed. Most of the objectives have been fully met or surpassed. The main challenges were securing sufficient funding to serve both the student and researcher community, and achieving visibility for most of eSpace's

activities. Therefore, it will be key in 2022 to consolidate the initiatives started in 2021 in order to secure them in the mid-term.

Despite some challenges, 2021 was again a very successful year, with eSpace fulfilling its missions of education and research.

Acronyms

AQUA	Advanced Quantum Architecture Laboratory (EPFL)
BioRob	Biorobotics Laboratory (EPFL)
CNES	Centre national d'études spatiales (French Space Agency)
CVLab	Computer Vision Laboratory (EPFL)
DLR	Deutsch Zentrum für Luft und Raumfahrt (German Aerospace Center)
ECEO	Environmental Computational Science and Earth Observation Laboratory (EPFL)
ENAC	School of Architecture, Civil and Environmental Engineering (EPFL)
ESA	European Space Agency
ESL	Embedded Systems Laboratory (EPFL)
ERC	European Rover Competition
EuRoC	European Rocketry Competition
IAC	International Astronautical Congress
IRGC	International Risk Governance Center (EPFL)
KPI	Key performance indicator
LASTRO	Laboratory of Astrophysics (EPFL)
LSMS	Computational Solid Mechanics Laboratory (EPFL)
MOOC	Massive open online course
RRL	Reconfigurable Robotics Lab (EPFL)
SKAO	Square Kilometre Array Observatory
SW	Software
SSL	Sustainable space logistics
SSR	Space sustainability rating
SSO	Swiss Space Office
TCAT	Technology combination analysis tool

References

- [RD1] LEX 1.1.1 du 01.03.2004 (au 11 avril 2019), EPFL Strategic Plan 2021–2024, version 1.9
- [RD2] Research Initiative on Sustainable Space Logistics (RISLL), progress report, March 2020
- [RD3] Research Initiative on Sustainable Space Logistics, presentation, November 2020
- [RD4] EPFL RISLL – Final report, issue 1 review 2, November 2021

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1.

OBJECTIVES

eSpace's objectives in 2021 were based on the achievements and challenges identified in the 2020 Activity Report. These objectives were agreed on with the Associate Vice President for Centers and Platforms, as well as within the eSpace team.

Education

EPFL Minor in Space Technologies

- Increase participation by 10%
- Assess the curriculum

EPFL interdisciplinary projects (MAKE fund)

- Renewal of all projects in the MAKE fund
- Top 5 performance of all projects participating in competitions
- Sponsorship meeting the needs of the projects

Research

Research initiative for sustainable space logistics

- Renewal of funding
- 2 journal papers
- 3 technology transfer activities (2 ongoing with ClearSpace)
- Successful SSL symposium (variety of participation, papers)

Space related research and space application within EPFL labs

- Push two new research topics within EPFL, "Remote sensing and big data", and "Intelligent system with space applications (Smart telescope for SSA, Lunar rover)"

Communication and outreach

- Interviews in the media (radio, newspaper)
 - Participation at EUCASS Conference, IAC
 - Participation in the House of Switzerland during the Tokyo Olympics and the Dubai Expo 2020
 - Host one event (SSL digital symposium)
-

01

This report will present activities performed in order to meet these objectives.

2.

EDUCATION

The Minor in Space Technologies is attached to the School of Engineering (STI) Section of Electronics (SEL). eSpace manages the Minor in Space Technologies, supervises student interdisciplinary projects (in collaboration with the MAKE team), and supervises semester and master student projects. In 2021–2022, 95 students enrolled in the Minor in Space Technologies, which represents an increase of 40% from the previous academic year.

The main activities performed were the establishment of two new classes for the Minor in Space Technologies, the streamlining of the MAKE project supervision and also supervision of different student projects. eSpace also organised a series of monthly seminars to which EPFL professors and scientists, as well as external experts, are invited to present their work and vision on a wide range of topics. These seminars also provide content to the students.

2.1 Evolution of the Minor in Space Technologies

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In 2020, a survey was performed to assess students' satisfaction regarding the minor. One of the main requests coming out of this survey was the creation of new technical classes. To accommodate this suggestion, eSpace has worked to set up two new classes: Space Propulsion and New Space Economy.

The class Space Propulsion (ENG-510, 3 ECTS) will be taught by Markus Jäger, system engineer in propulsion at ArianeGroup. Markus Jäger has more than 20 years of experience in liquid propulsion and electrical propulsion. He is also

the committee chair of the IAF Space Transportation Committee. The main objective of the course is to provide an overview of space propulsion systems. The course will also describe the basic design principles of propulsion systems. By the end of the course, students will be able to:

- Analyse propulsion system requirements
- Plan a project in phases
- Coordinate tasks between different engineering disciplines
- Translate system requirements into subsystem requirements
- Justify propulsion system selection.

As part of a digital education program and to use the skills of EPFL students to create new jobs rather than look for existing jobs, eSpace has partnered with Space4Impact and E2MC Ventures to provide the New Space Economy online course. The New Space Economy course will eventually be a hybrid class taught on the EPFL campus as well. It is based on a massive open online course (MOOC) with 30+ Swiss space experts that was recorded during the summer of 2021. The goal of the course is to teach students about the application of space technologies and their potential uses in business. During the course, the students will also work on a business idea and receive feedback from experts. The goal of this course is to motivate and inspire students to start their own companies. The course may also become accessible to corporations in the canton who want to integrate innovative solutions and existing start-ups who want to scale up in Switzerland. The class is expected to be taught in Autumn 2022 and will be available to students in the Minor in Space Technologies and also in EPFL's Management, Technology and Entrepreneurship master and minor.

2.2 Supervision of MAKE projects

In 2021, eSpace provided direct support to five EPFL associations: EPFL Rocket Team, EPFL Spacecraft Team, Xplore, GrowBotHub, and the Space Situational Awareness Team, along with partial support to Asclepios and the emerging RadioWaves Team. Together, these teams include over 350 students developing innovative technologies and learning hands-on skills complementing and going beyond EPFL's curriculum. eSpace also supervised nine credited semester projects and one master's thesis in the context of the work being done within MAKE-funded associations.

In 2021, eSpace consolidated its internal structure of main and backup coordinators for each supported association, as well as the approach to track their progress and preserve know-how. At present, eSpace's organisational structure is as follows.

General coordinator/external point-of-contact:
David Rodríguez

Administrative coordinator: Candice Norhadian

Main coordinators (MCs). MCs are the main point-of-contact for the teams:

- EPFL Rocket Team: Michaël Juillard with Nicola Cardines taking over in Dec. 2021
- EPFL Spacecraft Team: Simon Hamel with the assistance of Denis Galagan
- GrowBotHub: David Rodríguez
- Space Situational Awareness: David Rodríguez
- Xplore: David Rodríguez

Back-up coordinators (BCs). In the absence of MCs, BCs assume responsibility:

- EPFL Rocket Team: David Rodríguez
- EPFL Spacecraft Team: David Rodríguez
- GrowBotHub: Simon Hamel
- Space Situational Awareness: Simon Hamel
- Xplore: Simon Hamel

Recently, eSpace also kicked off a series of quarterly inter-team brainstorming sessions, in which members of every team eSpace support are invited to participate alongside coordinators and other eSpace staff members. These are great opportunities for students from different associations to get to know each other, share new ideas and learn from one another. The first of these sessions took place in October around the topic of fundraising, and was extremely

well received by the students. Upcoming brainstorming sessions will focus on the following topics:

- **1Q2022** - Team management, dynamics, communication and conflict resolution
- **2Q2022** - Systems Engineering
- **3Q2022** - Preserving know-how, how to manage team turnover and new year transitions.

The following summarises major achievements accomplished by the different teams throughout the year.

EPFL Rocket Team



The EPFL Rocket team came out as the overall winner of the 2021 European Rocketry Challenge (EuRoC) held in Ponte de Sor, Portugal. In 2022, the team is focusing its efforts on the development of the supersonic Wildhorn rocket while keeping their eyes set on reaching space by 2027.

EPFL Spacecraft Team



The EPFL Spacecraft Team continues to work hard towards making its CHES mission a reality. With the goal of launching in Q4 2023, the team is now developing its own in-house OBC and UHF ground station and recently partnered with the emergent team RadioWaves for the development of EPFL's own X-band ground station. Additionally, the CHES team presented its work at the 12th European CubeSat Symposium held in Paris.

Xplore



Xplore came in 3rd place at their first participation in the European Rover Challenge (ERC) and won two additional awards for best geological representation of the Mars yard at the competition and best scientific probing on-site. The team is currently developing a completely new rover to participate in the 2022 edition of the ERC.

GrowBotHub



The team successfully tested and remotely operated their automated harvesting aeroponic system while located at the top of Mt. Pilatus during the last IGLUNA campaign. Due to the cancellation of the 2022 edition of IGLUNA, the association was forced to dissolve and all work has stopped for the time being.

Space Situational Awareness



The Space Situational Awareness team managed to secure funding from MAKE to pursue the development of its AI-powered debris-tracking optical telescope. With significant improvements expected in 2022, their new system aims to help manage the rising concern of and prevent further issues with unknown orbital debris.

Asclepios



The Asclepios I analog mission finally took place in the Bernese Alps at the Grimsel Test Site in July. The team passed the preliminary design review for their upcoming mission, Asclepios II, which is currently in process and is taking place in the summer of 2022.

2.3 Supervision of semester / master projects

Student projects are performed under eSpace staff supervision requiring around one hour per week per student. Master's students are provided with office space and materials when required. Some students come from external universities and perform the projects through an exchange program. Students do not receive any funding for these projects. They get ECTS credits to validate a course or a master's thesis program. For exchange students, the supervision is often performed in collaboration with a professor from their home university.

Alexandre Merkli, EPFL

Assessment of the compliance of large constellation operators with space debris mitigation guidelines

In this work, Merkli assessed the compliance of large constellation operators with the space debris mitigation guidelines published by IADC, COPUOS and ISO. The constellations considered are SpaceX's Starlink, OneWeb, Iridium Block 1 and NEXT, Planet Labs' Flock and Spire Global's LEMUR. The analysis shows that the plans proposed by SpaceX and OneWeb are entirely compliant with the existing guidelines and are even more ambitious. On the other hand, Iridium Block 1 constellation is not compliant with several spacecraft stranded in orbit with remaining lifetime far exceeding 100 years, whereas the plan for Iridium NEXT is designed only for minimum compliance with the existing guidelines. Planet Labs and Spire Global both operate a fleet of CubeSats without propulsion systems that are naturally compliant with the

25-years disposal rule by using low injection altitudes. However, this type of spacecraft causes several issues regarding collision avoidance capability, even if alternative manoeuvring solutions, such as differential drag, are currently being developed. Finally, since space debris mitigation guidelines were developed before the appearance of these constellations of thousands of satellites, some improvements are proposed regarding the specific case of large constellations.

John Matthew Lane, Politecnico di Milano
Rapid spacecraft sizing & logistics tool:
Extension to LEO low-thrust

This thesis continues the work on the space logistics optimisation tool (TCAT), with a focus on improving the optimization algorithms, and extending it to the difficult problem of unscheduled low-thrust LEO servicing missions.

Matthias Wüst, EPFL
System dynamics modelling – Extension of the cis-Lunar model

This project focused on extending the scope of the existing System Dynamics model to better modelling of R&D, exploration, and industry in particular. Several other avenues were tested, and both qualitative and semi-quantitative modelling done, based on expert input and literature review. The outcome is several promising model fragments and directions – e.g. R&D and satellite industry dynamics.

David Keller, EPFL
System-level Safety for ClearSpace-1

This semester project follows up on the deployment of the “system-level” safety approach STAMP (systems-theoretic accident model and processes). It analyses the ClearSpace-1 mission in detail, derives design constraints and requirements, and compares STAMP to existing ClearSpace-1 requirements, including several discussions to merge the two sets. The outcomes are new and better validated safety constraints, requirements, and an overall safety model for ClearSpace-1.

Alex Widderski, Interactive media designer trainee, EPFL
Lunar Simulator web design

In this internship, Widderski worked on the Lunar resource’s online simulator, redesigning it to make it user-friendly, professional looking, and accessible to a wide audience, helping both space science and tech outreach, and tech planning.

Mathieu Udriot, EPFL
Space Sustainability Rating

The student was responsible for developing the Space Sustainability Rating platform, performing trade-offs, collecting requirements,

proposing a platform architecture (mandatory), interacting with LASTRO for database management, and helping with coordination mechanisms to maintain and update the SSR technical definition. Udriot also performed ratings for satellite operators that applied for it, in particular computing the mission’s parameters and providing technical analysis on the results (in support to the technical officer). He also helped tune the rating by performing sensitivity analysis and he applied the SSR to launcher systems (propose solutions, define new criteria and models).

Abraham Bahari, IML executive master student, EPFL

Assessment of business model for a 4/5PL space logistics service provider, collaboration with DHL

The goal of the project is to assess the lead logistics provider’s business model in space logistics and satellite operations and to develop an innovative LLP business model in space logistics. For that objective, the student is performing a market study, literature review and data collection through interviews and focus groups.

Dimitri Hollosi, EPFL
System engineering of a small radio telescope

This semester project presented a general overview of the systems engineering work conducted for RadioWave association’s first radio telescope project during the Spring 2021 semester. Key steps and procedures are identified with the aim of better anticipating future radio telescope projects at EPFL.

Hadrien Sprumont, EPFL
Polar Rover Mission, a preliminary concept study

The objective of this semester project was to serve as a preliminary concept study to ease the future development of a rover and its deployment in a polar environment for scientifically oriented missions. This project was conducted in the context of the EPFL Xplore Team’s effort toward the eventual deployment of an autonomous rover for terrestrial and lunar science-driven tasks. The project covered mission design, general environmental, and the high-level technical requirements that the rover must fulfil, as well as some logistical steps that need to be taken into account for the deployment and operation of the rover.

Aurélien Balice-Debbas, EPFL
GrowBotHub organisation & systems engineering

This semester project analysed part of the systems engineering pipeline of GrowBotHub, looking at which elements were successful and what were the errors and limitations encountered.

tered. The project described GrowBotHub's systems engineering approach and looked for solutions in the published literature aimed at integrating agile methods that respect the constraints of EPFL projects. Based on this, the project presented a set of guidelines to improve GrowBotHub's systems engineering approach.

Thomas Manteaux, EPFL

Critical analysis of the systems engineering approach for a short-term space project

This semester project performed a critical analysis of the approach at the systems engineering level for the development of a rover, within the framework of the EPFL Xplore association. The project reviewed and analysed what Xplore had done until the phase C of the Argos rover project life-cycle, highlighting major drawbacks and limitations based on the short-term nature of the project. The project then proceeded to suggest a set of improvements on the basis of Agile Systems Engineering methodologies.

Erik Uythoven & Thomas Pfeiffer, EPFL

Conceptual design of a lunar reconnaissance drone

Upcoming exploration missions to the lunar surface demand robotic assets with the capability to explore longer distances (> 100 km) under highly constrained time windows (e.g., focused missions to the polar regions, < 8 days of surface operations). Effective, faster, and resilient surface mobility requires the use of high-resolution mapping and imagery. This project explored the design of small-scale, lightweight "airborne" robotic systems for the Moon via the use of long-distance, self-propelled drones based on a set of mission profiles (nominal, PSRs, lunar pits).

Vincent Claude Michel Dor, EPFL

Preliminary design of a low radio frequency antenna payload for a mission the far side of the Moon

This semester project defined a preliminary design of a radio antenna payload and its concept of operations based on the requirements and current design constraints of the ESA's European Large Logistic Lander (EL3) set of mission concepts, the objective of which is to enable sustainable human exploration activities on the Moon. This payload will demonstrate the suitability of the surface on the lunar far side as a platform for low radio frequency astronomy and will attempt to provide the very first measurement of the long wavelength radio emission (2 to 60 MHz) from the heavily red shifted ($z=80$) Hydrogen I emission from the cosmic dark ages.

Clément Vincent, EPFL

Definition of a lunar camera payload architecture

As part of an upcoming mission to the lunar surface alongside the Moon Village Association (MVA), EPFL has been offered the opportunity to develop a camera payload that will be used to re-enact the famous "overview effect." This semester project defined the preliminary system architecture and concept design of the camera, broke down known information into high-level requirements, and performed a functional analysis of the payload while identifying major systems, subsystems, and components required.

2.4 Education goals for 2022

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The upcoming goals for the Minor in Space Technologies are:

- To ensure that high quality of the education is provided and to facilitate the incorporation of a younger generation of educators.
- To continue to secure financing to serve the students via MAKE projects supervision, engineers to supervise projects, external teachers, and potential scholarships.
- To prepare the future of new space education programs with the possibility to have a master's degree in Space Technologies and continuing education for professionals, while developing new synergies with ETH Zürich.
- To ensure the availability of engineers for the supervision of the MAKE projects.
- To ensure the educational value of the MAKE projects and provide quality education for the students.
- To provide support for the students' transition to industry.





3.

RESEARCH

The activities of eSpace carry out the mission of the Vice Presidency for Research, which is: *“Supporting research activities – Supporting and promoting the valorisation of research results, notably through the transfer of knowledge and technologies, as well as through collaborations with the industrial, economic and public sector.”* [RD1]

The main research activities performed in 2021 were part of the Sustainable Space Logistics Initiative. Detailed reporting can be found under the following references [RD2&3].

eSpace has also supported several interdisciplinary Innosuisse projects with several EPFL labs, in collaboration with the start-up ClearSpace.

At the end of 2020, EPFL also launched a new initiative to foster and support lunar research and technology development efforts within EPFL, with new activities and opportunities taking place in 2021.

3.1 Research Initiative on Sustainable Space Logistics (RISSL)

In recent years, the space industry has undergone profound changes. To stay on the path of innovation, the next logical step for eSpace is to re-shape itself and adapt to new trends. In the current context of space developments being driven by low-cost launches, which are opening the doors for large space infrastructures and new services in and from space, it is natural to rethink and align eSpace's strategy along with these new perspectives.

RISSL work can be defined by four overlapping parts, with several projects continuing beyond:

1. **Internal eSpace work:** comprising mostly academic research (five main projects), applied R&D (four projects, for ESA and ClearSpace), and one implementation project.
2. **External work:** mostly tech development in four EPFL labs as well as in HEIG-VD, a research project in an EPFL center, and support for ClearSpace.
3. **Outreach,** with 675+ participants at a symposium and other events, articles, networking etc.
4. **Education,** largely via student supervision, overlapping with (1) and to a lesser extent (2).

The following section will focus on the achievements from 2021. More details are available in the RISSL final report [RD4]. A literature list of scientific publications is also provided. References are available upon request if the reader wants to see the detailed outcome.

3.1.1 Objectives and scope

- Create and support research initiatives to drive innovation and contribute to Swiss know-how in space logistics.
- Build communities around selected research subjects coupled with specific projects, by federating and coordinating research across Switzerland, while including industry players and space agencies as key partners.
- Develop talents and inspire new vocations, with attractive projects for researchers and students.

Main achievements

(for the whole initiative 2019–2021)

- Submitted more than 22 proposals from 20 kCHF to 1.7 MCHF (14 accepted, 8 rejected)
- Connected to more than 25 universities and partners (15 universities, 10 organisations)
- SSL session accepted at EUCASS
- SSL Special Session accepted at IAC 2020 (cancelled due to Covid)
- 1 magazine cover, editorial and article: "Sustainable logistics in Space", *Commodities Magazine (AGEFI)*, Special Edition April 2020
- 1 keynote graduation ceremony delivered at the Institute for Management of Logistics & Supply Chain (IML)
- 2 conference sessions chaired, and on the organising committee: Swiss Systems Engineering Day
- 1 Short radio interview: 'Va-t-on privatiser les ressources lunaires?' in the show La Matinale, RTS radio, July 13 2020.
- Organisation of the Sustainable Space Logistics symposium for February 2021 (more details in the next section)
- Contribution to the IRGC Workshop in May 2021 involving an interdisciplinary and multi-stakeholder group of experts to consider the "risk governance challenges posed by space debris"
- 1 eSpace PhD student was appointed lead of the Space Safety and Sustainability working group of the Space Generation Advisory Council.

The list of proposals and research outcomes is available in the Annex.



3.1.2 Research council meetings

In May 2021, the research council gathered again after a long break.

- Feedback was provided on current projects.
- SSR was deemed interesting and to have a large potential in visibility, but also political complexities. The SSR has the potential to create research collaborations, for example between UT Texas and LASTRO.
- It was recommended to focus on creating standards useful for space logistics

Finally, in September 2021, a lessons learned exercise was performed.

3.1.3 Lessons learned

Two lessons learned sessions were conducted, one internal and one with the research council. It was agreed that the basic idea of the RISSL is correct and the actual deployment of large constellations (during the timeframe of this initiative) confirmed this trend. Having Sustainable Space Logistics at the heart of the future of space transportation is positive; this long-term view is complementary to the industry perspective, and there are various interesting research streams ongoing. Yet it has been difficult for the group to foster a community that includes industry interests as well. Difficulties due to Covid and a lack of physical discussion hindered the effort by limiting networking and socialising opportunities. The research council

would have expected a stronger contribution from the Swiss community. Regarding industry, the research council advised organising presentations with companies to get an overview of current technology development to identify common interests.

The main difficulty the team faced was the recruiting and retention of postdoctoral researchers. This may be due to the novelty of the thematic and limited expertise. Two of the postdocs found other opportunities after 1 year and 4.5 months, limiting the research outcomes and creation of new research streams. The team structure should be rethought to avoid this type of issue. Secondly, new professors have become involved in the initiative, especially during the second year; the creation of new research collaborations is a lengthy process. It took a long time to start the effort.

For the next step, it is recommended to focus on the large constellation trend that was seen during the last two years, and to further bring the science community together in order to stay cutting edge. In addition, it was recommended to bring more end users and the satellite industry on board.

Finally, the research council acknowledges the effort and is looking forward to working further with the team.

3.1.4 New projects in 2021

NESTS (New European Space Transportation Solutions) ESA project

NESTS is a 4-month ESA FLPP study with the goal of investigating defined preliminary elements for future space transportation solutions to be used in 2030–2050. In this project, eSpace's goal is to contribute value to the NESTS project and ESA's efforts to plan future European space transportation; to strengthen collaboration with ArianeGroup; to gain capability in practical future planning criteria and trade-offs. From eSpace, this project was led by David Rodríguez and Flavio Brancato in March–April 2021, with Emmanuelle David supervising.

eSpace's role in this fast-paced project was (a) to establish the method and criteria that will be used to assess the different space transportation services and system concepts, including criteria and weighting factors; (b) to contribute to the elaboration of high-level specifications related to on-orbit servicing, constellation deployment, and Moon missions; and (c) to manage the trade-offs to be performed on space transportation services, including through online workshops.



The work was successfully completed, with the ArianeGroup very pleased with the results. eSpace's work contributed to European technology planning and service selection, and trained two engineers in related methods.

PhD project: Connecting space logistics and architecture

This PhD project by Anne-Marlène Rüede is hosted by eSpace and co-supervised by eSpace and Prof. Jeffrey Huang of the Media and Design Laboratory, EPFL Architecture and Computer Sciences. The 4-year project, Connecting Space Logistics & Architecture: A Pattern Language for Robust Mission Design, formally began 1 May 2020. It aims to improve decision-making methods for early-phase system architecture design in long-term space missions with repeated material flow. In 2021, a successful proof-of-concept study was performed, demonstrating that using a pattern language could potentially significantly improve space mission design. Based on this, Rüede has passed the doctoral candidacy exam and ESA has accepted to co-fund the project (€90,000) and support its development with eSpace's industrial partner ArianeGroup. An 8-month research visit during which the pattern language and program will be developed is currently taking place at MIT's Engineering Systems Laboratory. Another 6-month visit at ESA during which cases studies around the lunar exploration will be developed and tested is planned.

Optimal control approach for dedicated on-board computer in active debris removal mission

This PhD project by Michaël Juillard began in March 2018 and was completed in April 2022. The goal is to assess the feasibility of a payload computer for an active debris removal mission. The project has been split into two tracks. The first one is to study the "Flexible Leo Platform" designed by Airbus D&S Friedrichshafen to accommodate the need of the ADR mission ClearSpace-1. The work primarily consists of analysing the Hardware-in-the-loop testbench located at eSpace to accommodate various configurations of payload computers and characterise them. This topic included collaboration with ClearSpace as well as Airbus engineers and the development of various communication protocols. The second track focuses on the simulation and optimization of the avionic architecture for a payload computer with the creation of a tool. The task included the mathematical definition of the architecture as well as the typical constraints applied to such computers. During the development, emphasis was placed on parametric analyses of various parameters and the first step toward the validation of the tool.

3.1.5 Applied research within EPFL labs

ClearSpace-1 Service

The ClearSpace-1 Service will constitute an unprecedented environmental recovery action of an ESA space object currently in orbit since 2013. The objective of the ADRIOS (Active Debris Removal In-Orbit Servicing) – ClearSpace-1 – service is not only to remove an ESA-owned object (a VESPA Upper Part COSPAR-ID 2013-021D) from orbit, but also to develop and demonstrate the complete value chain necessary for sustainable and commercial Active Debris Removal (ADR) service, and to set a precedent in the space industry. This initiative aims at fostering capacities for the future commercial market of in-orbit services for institutional and private sector needs. In 2021, eSpace coordinated the start of the activities to be performed by EPFL within the frame of the ADRIOS mission.

ClearSpace-1 Service's main goal is the capture and removal of a payload adapter, the VESPA, an ESA-owned object, by the end of 2025 at the latest. It also aims to demonstrate the basic technical building blocks of the complete assisted removal value chain (technologies and operations): uncooperative rendezvous, capture (including stack stabilisation), stacked de-orbiting, and target release, enabling a versatile and safe commercial assisted disposal. Finally, this in-orbit demonstration shall enable an economically viable commercial service.

The capture and removal operation can be divided into several phases, which are:

- Launch into orbit at 500 km altitude
- Perform LEOP (launch and early orbit phase), commissioning and phasing to the target
- Rendezvous with target
- Capture and stack the target
- De-orbit the target.

ClearSpace is the prime contractor of the ClearSpace-1 Service and therefore has the responsibility of systems engineering, flight and ground software development, management of ground and mission control infrastructure, and mission operations.

As part of the mission and system developments, EPFL is responsible for capture system and relative navigation developments as well as system engineering support, developments that are key for a successful debris removal mission. eSpace is responsible for managing the aforementioned activities project within EPFL.

FlatSat Test Bench

In the frame of ClearSpace-1, the FlatSat Test Bench plays a central role, especially for system-level validation in the assembly, integration, verification & test (AIV&T) phase of the project. In 2021, the test bench, which is located at eSpace, was made remotely available via secure shell (SSH) connection to the different development and testing teams working from anywhere. Moreover, a configuration management strategy was established to keep track of FSW binary releases and to make them readily available to users through the flight software (FSW) repository.

A thorough review of the FSW v1.0 Data Pack issued by the ClearSpace subcontractors was made. In particular, requirements flow down from Software System Specification Interface Requirement Document (SSS/IRD) to the Interface Control Document (SRS/ICD) level and test case coverage analysis was performed.

The User Manual v1.0 of the FlatSat Test Bench was released, which will be part of the data pack delivered by ClearSpace to ESA for the Key Performance Gate (KPG-1) milestone.

Throughout 2021, eSpace supported system development and testing activities of ClearSpace and its partners through weekly co-engineering sessions, system tests and hardware/software (HW/SW) troubleshooting work.

MBSE

Activity is ongoing for ClearSpace to support the MBSE (Model-Based System Engineering) activities. Main achievements in 2021 were the change in the MBSE strategy and tools. The strategy was switched from “traditional” MBSE, as a service supporting the System Engineering work, to MBSE as an enabler of a “concurrent engineering” way of working. The tool now used is Valispace, which is also used by MAKE associations EPFL Spacecraft Team and Xplore, enabling more efficient support for these teams in the future.

Side activities in support of the system engineering at ClearSpace were also performed in a timely manner. These were assistance in safety-related analysis, mission timeline definition, CAD design and in-mission orbit simulations.

- Capture system (follow-up from Innosuisse) performed by the EPFL Computational Solid Mechanics Laboratory (LSMS) and the REHAssist research group. The goal of this work package was to characterise contact laws on the capture system and to perform high level control simulations.

- Relative navigation (follow-up from Innosuisse, more information [here](#)) performed by ESL and CVLab. The goal of this work package was to perform six degrees of freedom target post estimation activities and to implement vision algorithms on Field-Programmable Gate Array (FPGA).

In addition to some specific system engineering tasks, eSpace staff provided support to the labs in setting up new projects, performing project management and also administrative tasks with the funding provider and/or internal EPFL contacts.

3.1.6 Conclusion of the RISSL initiative

At the end of this pilot phase in 2021, eSpace achieved the following three goals:

1. Created and supported research initiatives to drive innovation and contribute to Swiss know-how in Space Logistics;
2. Built communities around selected research subjects coupled with specific projects, by federating and coordinating research across Switzerland, while including industry players and space agencies as key partners;
3. Developed talents and inspired new vocations, with attractive projects for researchers and students.

Create and support research initiatives

Research outcomes within eSpace are grouped at three scales:

- At the **macro** scale – sector and industry-level – the three main outcomes were the Sustainable Futures project, design and deployment of ESA's *Strategic Tech Planning System 2.0*, and the collaboration with Prof. Dominique Foray for the *NewSpace Innovatisation* project. Secondly, a system dynamics model of the Lunar ecosystem was improved and an online interface created, resulting in finishing a paper for *Acta Astronautica*.
- At the **meso** scale – large-scale or interacting systems planning – the principal outcomes are a significantly extended space logistics/spacecraft sizing tool (TCAT), and PhD research developing a new pattern language for mission design. In addition, the NESTS project worked on real-world criteria for road-mapping, within a European consortium for ESA.
- At the **micro** scale – design of systems and subsystems – the main outcome was the concept development, approval and funding of the CD²F as a novel research platform

(Design Observatory for a CDF). Other projects include deploying STAMP/STPA, a new system safety modelling technique to help ClearSpace, and a pilot project on workplace safety for private astronauts. Finally, there was the improvement of the modelling of a lifecycle metric for modularity (resulting in journal revisions, a large proposal, constellation case study IDed).

Furthermore, many new developments are in progress, such as a collaboration with IRGC, and the BRIDGE funding between CVLAB and LASTRO for RISSL.

Build communities around selected research subjects

Through the different events organised by eSpace in collaboration with EPFL, IRGC, Skoltech, the Swiss embassy in Tokyo and Swissnex for Dubai, different target groups have been reached from researchers, policymakers, industry, students, and a general audience both in Dubai and Japan. There could have been a better focus on including industry players.

Develop talents and inspire new vocations

The initiative received great interest from the students and researchers. More than 14 student projects from different backgrounds were conducted over three years. New collaborations with researchers within EPFL were started, bringing in “non-space” actors such as IRGC, Prof. Foray, and others. Efforts have been made to reach out to ETHZ, UZH and HES-SO, but in practice, the only effective technical work conducted was with HEIG-VD. Outside of EPFL, the group was able to connect with universities such as MIT, the University of Texas, the University of Tokyo, Imperial College London and Supaero in Toulouse.

As of October 2021, the investment multiplier from the total project is at 4.5. The multiplier is calculated based on the funding that was acquired during the two years on the funding provided by SSO.

In October 2021, eSpace issued a call for ideas among EPFL labs and a proposal was submitted to the Swiss Space Office. In order to strengthen the sustainable space activities, eSpace proposed supporting research within EPFL Laboratories for three projects by providing partial funding (100 kCHF /projects for one year). This requires that the EPFL laboratories contribute to the awarded project with their own funding (in-kind, experimental facilities, etc.) with a minimum of 50 kCHF matching funds. The EPFL lab can also connect with another Swiss laboratory or industry to make the proposal stronger, yet non-EPFL labs cannot receive any funding.

The short-term (1–3 years) desired outcome of these proposals is a stronger collaboration between EPFL and Swiss labs and also maturation of technologies for future MARVIS (Swiss Space Office – SERI Fundings NCCR type financing), SNF/Bridge/Innosuisse and ESA proposals. eSpace will support the further financing research effort. For the long-term, this initiative will contribute to developing a sustainable space ecosystem.

3.2 Space Sustainability Rating



The increasing number of large satellite constellation projects will inevitably lead to an increasing amount of space debris. To confront this pressing issue, the World Economic Forum's Global Future Council on Space Technologies created the Space Sustainability Rating (SSR), which eSpace has been chosen to lead along with an international, transdisciplinary consortium that includes BryceTech, the European Space Agency (ESA), the Space Enabled Research Group at the Massachusetts Institute of Technology (MIT) Media Lab, the University of Texas at Austin, and the World Economic Forum (WEF).

The SSR is a voluntary ratings system that provides space operators with a sustainability assessment of their proposed missions. This will encourage mission designs that are compatible with sustainable and responsible operations, as well as on-orbit operations that reduce potential damage to the orbital environment and impact on other operators. Beta testing began in early 2022 and the SSR officially launched in June 2022.

3.2.1 Objectives and scope

Prior to eSpace being selected to host the project, the rating system had been developed and seven modules were identified, mostly related to space debris mitigation actions and assessment of the impact of a mission on the space environment. Beta-testing of the rating system had already started, involving major actors of the space industry. The goal of this beta testing was to identify problems, receive feedback from satellite operators and fine tune the rating system. The period from May 2021 (selection of eSpace to be the host of the SSR) to December 2021 completed the handover of the project from the consortium to eSpace,

both on the technical and operational aspects. To accomplish this, the following tasks were undertaken:

- Planning, budgeting, preliminary architecture and development of an online rating platform
- Planning of the beta testing at eSpace
- Business plan development
- Defining an operational strategy
- Stakeholder management takeover and market facing
- Defining and carrying out a communication strategy.

3.2.2 SSR 2021 achievements

SSR project handover

The SSR handover phase successfully took place with the SSR Consortium, ensuring a smooth transition of the project to eSpace. Bi-weekly meetings were attended by representatives of the consortium and members of eSpace, during which participants received a summary of the activities and answers to questions. Additional meetings were scheduled when needed to tackle specific issues. For instance, at the end of 2021, a bi-weekly meeting was set up with the engineering student at MIT to find solutions concerning the Detectability, Identification, and Trackability (DIT) module.

Beta testing

After the beta tests performed by the consortium, it was decided that another round would be conducted under the lead of eSpace. The idea was to get hands-on experience issuing the rating, identifying bottlenecks in the rating process, and increasing the geographical and mission diversity of the rated operators to make sure the system will be globally recognized and applicable to the complete mission spectrum, from cubesats to constellations and large science or telecom satellites.

When rating a mission, the contractual phase was identified as the one requiring the most operational time. It would take weeks or even months for companies to review the SSR agreements and contracts. Discussions about data protection and data transfer were also found to be an important parameter for some operators. Some of them required a non-disclosure agreement (which is not necessary for eSpace), and some specifically asked that their data not be sent or stored anywhere other than on EPFL servers.

The only beta test that could be conducted by eSpace in 2021 was for the EPFL Spacecraft Team's CHESS mission. Their close proximity and the fact they are students made the signature and data collection processes much easier.

Many interesting points for improvement of the rating process, platform, and system were highlighted during this beta test. For instance, the way to compute the bonus score was not well defined and suggestions were made to have a sensible method of counting bonus points. Also, many input data required in the excel sheet used until now by the consortium are in fact not used in the computation of the score (mostly for the DIT and mission index modules), so removing them reduces the amount of work required of the operator and makes the input form clearer. For the first time, a recommendation report was issued at the same time as the certification score, underscoring areas where the operator can improve the sustainability of its mission with quick gains, cost-effective and useful actions to increase space safety depending on the project phase.

Platform development

In order to streamline the rating process, facilitate the exchange of data with operators in a secure way, and improve the overall user experience of the future customers, eSpace developed a web-based platform to issue the certifications. Starting mid-September, a student working on his master's thesis prepared the systems engineering work for the platform development, with another student actually programming it. The technical team was reinforced by an engineer intern and a web designer.

An agile method was implemented with weekly meetings, and sprints of short deadlines with short-term objectives of around three weeks. The objectives of the sprint were defined during a sprint planning, several reviews with internal and external stakeholders were held throughout the semester and the process was improved thanks to sprint retrospective meetings. After four sprints, the web platform is almost at its minimum viable product (MVP). This stage will be reached in June for the official launch of the SSR with the basic functionalities including: a user frontend for data collection, a processing unit for score computation, a monitor frontend for input verification by eSpace issuers, and a link to the backend servers to provide storing space and login credentials. A first iteration of a graphical user interface will also be integrated. It will therefore be usable for June 2022, at which time it must be ready for normal operations, rating about ten missions in the second half of the year.

Business model and value proposition consolidation

Several aspects of the business model were addressed during 2021, a first social business model canva was developed with the goal to identify and classify the different stakeholders to approach or inform, to identify the resources,

define a value proposition, and draft a revenue model.

Advisory group meeting

In December 2021 the first advisory group meeting of the SSR was held. This was the occasion for the consortium to officially hand over the SSR to eSpace, and for members to meet (online) and discuss the progress made. The meeting was split into two parts. The first one was a presentation about what had been achieved so far. In the second phase, breakout rooms allowed small groups to discuss three prepared topics: the status and governance of the entity issuing the SSR, the pricing strategy, and the technical and operational implementation of the rating.

This meeting was a success with the attendance of most of the registered members (23/28, or 82%). The presence of major space actors confirmed the interest of companies, academics, and decision makers in the SSR project. Small polls organised during the session confirmed that eSpace is on the right track when it comes to the values important to the advisors: sustainability, neutrality, independence, credibility and responsibility were the most cited strengths of SSR. A summary of the talking points is available upon request.

A post-event form asking for feedback from the attendees was shared after the event and showed a positive response, despite a relatively low response rate (28%). The organisations that answered all said they are willing to continue being informed and involved in the future activities of the project. Most (77.8%) considered that the information provided and the presentation were useful and comprehensive.

3.2.3 Communication around SSR

Communication strategy

Last December, a communication strategy was finalised and presented to the SSR advisory board. Communication objectives are divided into three categories:

1. Image and reputation

- Raise awareness of SSR
- Create a positive image of SSR

2. Purpose and operations

- Highlight SSR's purpose and benefits
- Make it easy to understand how SSR works

3. Customers, partnerships, and support

- Support in getting new applicants
- Take care of partnerships
- Encourage support

This leads to the 2022 communication plan that will support the official launch of the SSR. The plan is divided in three phases:

- Preparation (January–March)
- Teasing (March–June)
- Launch and continuation (starting in June)

Note that the exact timeframe will depend on the readiness of SSR. eSpace is currently working on the corporate ID and various actions/assets (website, newsletter, etc.)

IAC

SSR was showcased for two days at the IAC (International Astronautical Conference) in October at the booth coordinated by the Swiss Space Office (SERI). A short presentation was shown on the main screen, while flyers for visitors were handed out. The conference was an opportunity to meet various stakeholders. The rating was well-received and satellite operators stated their willingness to be rated and communicate about the SSR to others.

SpaceTech

SSR also had the opportunity to be introduced during the pre-event of the SpaceTech Europe Hackathon through an “expert pitch” alongside other experts from leading organisations such as ESA.

3.2.4 Summary of 2021 achievements

Type of activities	Implementation level and actions
Management	
SSR project handover from the consortium	Fully implemented.
2022 operational strategy and schedule	On track.
Stakeholder management: eSpace was effectively introduced through meeting, mail exchanges, and the advisory board meeting	Effectively implemented, follow up meetings and outreach still needed.
SSR association governance draft	Articles of the association are validated by the EPFL legal office, and membership form in the process of being validated by the EPFL legal office. Creation of the association will have to be accepted by the EPFL VPA and with the target of having the association ready for the official launch of the SSR in June.
Technical implementation	
Further technical understanding of the rating system and first implementation of a rating procedure through beta testing	On track, a few adjustments needed.
Rating process definition through beta testing	On track, a few adjustments needed.
Rating platform MVP in progress and expected for Q1 2022	The development is still ongoing, the frontend data collection part has been finished in Q1 2022. However, the deployment of the platform has been delayed to June.
Modules hand-over (mission index and detectability, identification, and trackability)	Work to be done, but workload and actions have been defined in order to have necessary resources for 2022.
Business implementation	
Market facing and interest of space actors confirmed through multiple pitch, meetings and the advisory group meeting	Achieved, maintain efforts for 2022.
Value proposition defined	On track, a few more ideas to test (SSR as an expertise for space actors to be sustainable for instance).
Stakeholders identified and categorised	Implemented, continue to update.
2022 budget	Implemented, continue to update.
Legal entity definition for SSR in progress	Work to be done, push in Q1 2022.
Communication	
2022 communication strategy defined	Implemented, need to coordinate with operational timeline to have the definitive 2022 planning.
SSR represented at SpaceTech Europe pre-event	Achieved.
Presence at the IAC Dubai	Handed out flyers and met with participants of the conference.

3.2.5 Planning for 2022

Main tasks and processes were defined for 2022. A brief summary is detailed here:

- Consolidate business model and pricing strategy
- Seven founding members to be secured
- Create the SSR Association
- Acquire members in the SSR association (around 30 targeted for 2022)
- Perform around 12 ratings
- Finish the MVP of the rating platform and continue to improve it
- Design the logo, labels, and corporate identity of the SSR association
- Officially launch the Space Sustainability Rating project
- Reach fundraisers to secure funds for first year
- Continue to be on the main space events (IAC, Eucass 3AF)

More details and the process derived from these objectives available upon request.

3.3 Lunar Initiative

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At the end of 2020, eSpace set out to create a new initiative aimed at bridging a set of identified major technological and scientific gaps within the global exploration and infrastructure development roadmap for the Moon. The initial idea behind this initiative was to leverage EPFL's technical expertise, through its many labs, units, and motivated students, in an attempt to play a part in making the current lunar plans a reality, while positioning eSpace as an enabler and facilitator of major Swiss lunar research and technology development efforts. The activities envisioned within the framework of this initiative could be classified into one of the following six pillars as defined in the Lunar Research & Technology Development Initiative Strategy 2021 report (available upon request): i) Science, ii) Technology & Infrastructure, iii) Logistics, iv) Sustainability, v) Policies and Standardisation, and vi) Funding opportunities.



3.3.1 Objectives & achievements

With the goal of developing and flying EPFL's first scientific instrument to the Moon, throughout 2021 we have considerably increased the number of lunar-themed projects in eSpace's portfolio. Four project proposals, ranging from €25k to €715k, were submitted this year, three of which were unfortunately rejected, while the last one is still being evaluated. The most relevant ongoing projects and project proposals submitted this year are briefly described in the next section.

The reason for the number of rejections experienced this year has been attributed to the ambitious nature of the projects with overly broad scopes, missing heritage technology and know-how to be leveraged (within EPFL as a whole and within eSpace in particular), and the lack of awareness selecting the most appropriate funding sources for the projects pursued. In the second half of 2021, eSpace started to build its technological and knowledge foundation via a number of preliminary concept design studies. These activities are planned to continue during the upcoming year. The scope of research and technology development project proposals will be narrowed, and more targeted funding opportunities will be pursued.

In 2021, we also had the goal of increasing visibility around the ideas and projects planned within the framework of this initiative and expanding the network of research institutions and private companies supporting lunar activities.

In line with the latter, a new section on the website was created as an up-to-date source of information on eSpace's lunar activities and a point of contact for interested partners, colleagues, and the general public.

As part of the goals envisioned within pillar V, Policies and Standardization, eSpace has joined as an observer to the Moon Village Association (MVA) Global Expert Group on Sustainable Lunar Activities (GEGSLA), whose main goal is to provide the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) with a set of documents containing principles and key elements for the design, development and implementation of lunar activities.

eSpace has also been a regular participant at the Lunar Surface Innovation Consortium (LSIC) recurrent meetings, particularly within the Extreme Access and Extreme Environments focus areas. LSIC fosters communication and collaborations among academia, industry, and government with the purpose of providing the NASA Space Technology Mission Directorate

with the latest information on pressing needs for technology developments and increased research to advance the exploration of and infrastructure development for the Moon.

3.3.2 Ongoing projects & proposals

Moon Village Association (MVA) payload project

In 2019 the MVA founded a new program aimed at fostering the development and launch of payloads to the lunar surface and its vicinity. With this program, the Payload Project, the MVA envisions creating a framework that enables a series of missions to the Moon as a way to foster global cooperation and to continue inspiring the general public.

eSpace, together with Prof. Edoardo Charbon and doctoral student Minglo Wu from the EPFL Advanced Quantum Architecture (AQUA) Laboratory, will fulfil a key role as payload developer in MVA's maiden mission to the Moon.

The project, currently under discussion between the MVA and EPFL teams, could result in EPFL's flagship endeavour to fly its very own scientific instrument all the way to the surface of the Moon.

This payload consists of an optical camera incorporating the latest SPAD sensor technology developed by Prof. Charbon and his team. Once on the surface of the Moon, this camera will be used to record images and potentially livestream video of our home planet from above with the goal to allow people from anywhere on Earth to experience what is known as the overview effect. The images and other scientific data obtained during the mission will later be used for specific scientific and outreach campaigns yet to be fully defined alongside the MVA mission team. A breadboard of the camera has already been produced and partially tested. Manufacturing and assembling of a first engineering model, and potentially the final flight model of the camera, are currently expected for 2022. An NDA was signed early this year, with an MoU currently being drafted, between the Moon Village Association and EPFL.

To raise awareness about this project within EPFL, a call for expression of interest was released followed by an information session to which all EPFL professors and scientists were invited. The session was recorded and uploaded to the eSpace [YouTube channel](#).

eSpace was also invited to speak at the 5th Global Moon Village Workshop & Symposium, organised by the MVA in cooperation with Cyprus Space Exploration Organisation (CSEO) on 6–8 December. This 3-day event was attended by people from all over the world and

featured multiple sessions with the participation of all the major stakeholders currently aiming for the Moon (NASA, ESA, CNSA, JAXA, ISRO, LSA, EgSA, AEM), as well as representatives from industry and academia.

Moonrise: Human-robot cooperation for prospecting in unstructured environments

Together with Associate Prof. Stéphanie Lizy-Destrez from the Space Advanced Concepts Lab at ISAE-SUPAERO in Toulouse we submitted a research proposal on the topic of human-robot partnership and lunar telerobotics to the French National Research Agency (ANR) 2021 Generic Call in the frame of bilateral agreements with the Swiss National Science Foundation (SNF). Prof. Lizy-Destrez's lab has been part of a great number of exciting and varied projects within the space field and her research team has experience studying and analysing the human condition. The main goal of the research project was to understand what affects human operators and what level of performance and functionality is required from robotic assets to fulfil the objectives envisioned for the Moon over the next decade. The project would have culminated in a 10-day field campaign, in which a prospecting rover developed at EPFL would operate in Switzerland while being commanded from Toulouse, simulating the conditions of a polar prospecting mission remotely operated from the Lunar Gateway. The proposal was unfortunately rejected, but work is still ongoing to improve the content and redefine the scope to attempt to secure funding for the project during the upcoming year.

ESA Terrae Novae benefits and socio-economic impact

Led by Leoni Corporate Advisors (LCA), this project proposal was developed in the frame of the proposal Request for Quotation ESA/ RFQ/1-10808 "Terrae Novae Benefits and Socio-Economic Impact." The overall objective of the activity was to provide a socio-economic evidence base to support the prioritisation and planning of future Terrae Novae activities in general (formerly known as ESA's European Exploration Envelope Programme (E3P)), and the programme proposal for the ESA Council at Ministerial level in 2022 for the third period (2023–2025) of the Terrae Novae programme in particular. As part of this proposal, eSpace would have analysed a series of relevant case studies previously identified in order to extract key technologies and potential technological spillovers while defining their characteristics in accordance with ESA's portfolio of exploration technologies. In the end, the consortium led by LCA was not selected to conduct this study.

ERE: Extreme Redshift Explorer

eSpace led a project proposal in response to an ESA Invitation to Tender titled "EL3 Polar Explorer Radio Antenna Payload Pre-Phase A Study." The objective of this activity was to conduct a preliminary design of a radio antenna for ESA's European Large Logistics Lander (EL3) mission, planned to take place in 2028. The primary objective of this radio antenna would be to demonstrate the suitability of the lunar surface, particularly those regions within the "radio quiet zone" on the far side of the Moon, as a platform for low-frequency radio observations. The Agency's Directorate of Human and Robotic Exploration (D-HRE) is studying the European Large Logistic Lander (EL3) mission as part of its preparations for future exploration of the lunar surface. For this proposal, we partnered with the Institute of Information and Communication Technologies (IICT) of the School of Business and Engineering Vaud (HEIG-VD). The proposal was unfortunately rejected.

RAPID: Robust and (semi) autonomous platform for increased distances

In response to a new ESA Invitation to Tender ESA AO/1-10865 "Robust and (semi)autonomous platform for increased distances (RAPID)" eSpace partnered with the Belgian company Space Application Services. The objective of this proposal is to design, prototype, and test a rover capable of traversing the typical surface of the Moon and Mars (regolith clad with scattered boulders and occasional outcrops), with a speed exceeding 1m/s. The project proposal was unfortunately rejected.

3.4 Support to the Space Profs

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During 2021, the support to the EPFL Space Profs was focused around three major activities:

- Management of projects and system engineering support, including for students;
- Information on space activities to the space community;
- Finding new opportunities.

Other activities included providing input on space activities to the EPFL management and the ETH domain and doing a mapping of the space labs within EPFL.

3.4.1 Management of projects and system engineering support

Starting in mid-2021, eSpace began negotiating the ClearSpace contract, which was finally agreed on and signed in early 2022. This entailed discussions with ClearSpace system engineers, defining the work packages, creating budgets, and coordinating with the legal office and the labs. The project with ClearSpace will involve four EPFL laboratories: ESL, CVLaB, Biorob, and LSMS.

eSpace also provided support to the Advanced Quantum Architecture (AQUA) laboratory on the Lunar Initiative, specifically in collaboration with the Moon Village Association.

Finally, eSpace is devoting extensive work to coordinating interdisciplinary projects within the framework of the MAKE program.

3.4.2 Communicating with the EPFL space community about space activities – Focus on Horizon Europe

eSpace sent emails to the Space Profs with information regarding funding opportunities (in particular ESA calls and upcoming European Commission Horizon Europe program funding) and relevant conferences.

eSpace scouted potential opportunities for EPFL laboratories and external partners to participate in the Horizon Europe Cluster 4: Digital, Industry and Space program calls

The actions taken involved screening the different calls for proposals, preparing a template

email to contact potential partners, and having one-on-one calls with these partners.

In particular, eSpace identified the following call “Future space ecosystems: on-orbit operations, new system concepts”, in which EPFL could participate in the following areas:

- In-space logistic scenario simulation (constellation deployment, debris removal, cislunar economy)
- Space debris removal (image processing and capture system)
- Ground-based and in-orbit tracking
- In-situ resource utilisation
- Design for demise (materials)

One event on funding requests took place online on Horizon Europe funding for R&I related to environmental and Earth observation. This 1-hour info session co-organised by Euresearch, eSpace and ENAC presented opportunities with a deadline mid-February or later. For projects with a mid-February deadline, the focus will be on how Swiss participants can integrate consortia with their own (Swiss) funding.

Unfortunately, the effort was not successful due to the uncertainty around Switzerland's participation in the Horizon Europe program. In addition, it is very challenging on the space calls to understand in which topics Switzerland can or cannot engage.

3.4.3 Provide new opportunities

In 2020, eSpace participated in the initiation of the EPFL Earth Observation Working Group which continued in 2021. A webpage was created that gathers the information about earth observation at EPFL with a focus on the research labs, which courses are available and the resources available such as software. More information is available on epfl.ch/research/domains/eo/research/

eSpace also coordinated the effort to update the Space Innovation members list brochure. The new labs featured are AQUA Lab, Biorob, CVLab, ECEO, ESL and RRL.

Overall, the set of services provided by eSpace to the Space Profs increased in 2021 with a focus around finalising ClearSpace contract, sharing information around Horizon Europe funding, and providing new opportunities to the Space Profs through internal working groups and also external communication (featuring the labs in the brochure, presenting them at conferences). Overall the services provided have been rated as “excellent” and “very good” by the Space Profs. They feel that we add

value in supporting student collaboration on interdisciplinary projects, supporting the writing of proposals, providing information on sources of funding, and finding and facilitating contacts from academic partnerships.

3.5

Goals for 2022 for research and innovation



SSL

- To renew the funding for the 2022–2023 period.
- To have a broader visibility at the national level and in particular among industry.

SSR

- To generate income with the launch of the SSR and provide the rating service.
- To create the legal structure that will perform the operations.
- To extend the SSR community to emerging space-faring nations.
- To perform outreach around in-space sustainability (for the public and the students).
- To initiate research projects around in-space sustainability.

Lunar Initiative

- Better define the goals, milestones, and strategy of the initiative.
- Consolidation of initiative's three foundational projects including funding for at least one of the consolidated project ideas (MVA project, Lunar Drone Project, Moonrise).
- Increase visibility and awareness around the activities of and opportunities offered by the initiative both in and outside of EPFL at two levels:
 - technical level through peer-reviewed journal papers and key annual/biannual conferences
 - outreach level via social media presence and the website of the initiative.
- Connect to the SSL and other initiatives.

Space-related research outreach to EPFL labs

- To provide information about funding opportunities to the Space Profs.
- To provide relevant content on space research to the Space Profs.
- To initiate new research projects, with industry in particular.
- To make EPFL space-related research more visible.

4.

eSpace OPERATIONS

4.1 Staff

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During 2021, we had the following personnel changes within the eSpace team:

- **Sung Wook Paek**, postdoc researcher, stay ended in April 2021.
- **Alexandre Lucas**, communication manager, contract ended in June 2021.
- **Nicola Cardines**, research engineer, started in July 2021.
- **Horiyuki Koizumi**, guest researcher, associate professor, arrived in July 2021 for a 1-year stay.
- **Denis Galagan**, guest researcher, engineer, arrived in September 2021 for a 1-year stay.
- **Adrien Saada**, intern, started in September 2021.
- **Tinh Roulet**, mediamatecien apprentice, started in September 2021.
- **Marc-André Chavy-Macdonald**, postdoc researcher, contract ended in November 2021.
- **Muriel Richard**, senior scientist, contract ended in December 2021.

4.2 Outreach and communication

Despite the pandemic, two major events were organised virtually (SSL Symposium, webinar series), in Tokyo (EPFL Virtual Space Tour), and in-person at the Expo 2020 Dubai with the exhibition “Switzerland, a space nation exhibition”.

4.2.1 Communication strategy

In early 2021, eSpace started to implement its communication strategy 2021–2023, based on its actual strategic plan for the same period, leading to a significant boost in social media activity and audience.

After being selected to operate the Space Sustainability Rating in June 2021, an effort has been made to develop the associated communication strategy and plan. The main objectives are divided in five strategic areas.

Image and reputation

- To increase eSpace's reputation and awareness of eSpace activities among stakeholders

Activities promotion

- Promote the Minor in Space Technologies
- Promote the SSL initiative

Community management

- Set up an EPFL and public community management
- Gathering a community around SSL
- Double the current audience of social media channels
- Develop media relations

Channels and content

- Define an editorial line for the production of English and French content
- Identify the most efficient cost/contact/follow-up channels given eSpace resources and audience habits
- Create “evergreen” content that is easier to plan than news
- Organise/participate in regular Swiss and international events

Synergy and collaboration

- Strengthen the relationship with Mediacom
- Coordinate communication with EPFL space actors (Space Innovation, ClearSpace, labs, student associations)

This strategy has resulted in a 2021 communication plan and most of the goals above were reached or started this year.

4.2.2 Events

Despite the pandemic that forced most of the events to be postponed or to happen virtually, eSpace was involved in several in 2021.

Sustainable Space Logistics Symposium

16–18 Feb. | virtual | >1,000 people reached

The SSL Symposium was eSpace's first event that had to move to virtual because of the sanitary restrictions in February. It was conducted by Emmanuelle David from EPFL studios in Lausanne, in collaboration with the EPFL Audiovisual Service (SAVE) unit.



For this first digital symposium, eSpace organised a 3-day journey featuring space and sustainability experts, as well as observers from outside the space area:

- **Day 1** was about the vision of SSL and exploring the current relationship between space activities and sustainability.
- **Day 2** was a look at the ongoing revolution gripping the new space industry. It also featured the experience of non-space industry actor DHL that has faced similar transformation.
- **Day 3** concluded by highlighting Swiss success stories such as ClearSpace, looking at the legal and policy framework and giving voice to the younger generation.

The speakers gathered a qualitative panel of space experts and leaders, including an astronaut, logistics specialists, science communicators, an architect, young professionals and students. The list of speakers is available in the annex.

The event was a success, thanks to the quality and diversity of the speakers. Thanks to this program and communication effort, mainly on social media, the event had 787 registrations, of which 371 attended, and reached 447 total views on eSpace's YouTube channel. The survey conducted after the event shows a high level of satisfaction from the audience.

EPFL Virtual Space Tour Tokyo

11 Aug. – 30 Sept. | hybrid | >10,000 people

In order to increase the visibility of Swiss space-related scientific and technological activities, and also to create new bottom-up platforms for international collaborations, eSpace led a consortium to contribute to the "Tokyo 2020 – House of Switzerland" project, that was to take place in Tokyo during the 2020 Tokyo Olympic Games (rescheduled to 2021), supported by a Leading House Asia ETH funding.

Due to the sanitary situation in Tokyo, the House of Switzerland was cancelled. However, eSpace and the Embassy of Switzerland in Japan's Science and Technology Office Tokyo (STO) continued their efforts to organise an EPFL presence in the Japanese capital.

The EPFL Virtual Space Tour Tokyo was created to showcase two science communication projects:

1. Tranquillity Base, a virtual escape game produced by EPFL student association Space@yourService.
2. VIRUP, the virtual map of the universe made by the EPFL Laboratory of Astrophysics (LASTRO), consisting of three events:
 - **11 August – 30 September:** a VIRUP movie was screened at the Synra Dome of the Science Museum and there was a 2-day beta testing of Tranquillity Base.
 - **15–16 September:** the official launch of Tranquillity Base behind closed doors at the Swiss embassy for VIPs, sponsors and alumni, with conferences on Observational Big Data and on our Milky Way.
 - **17–18 September:** the first official public showcase of Tranquillity Base and the latest prototype of VIRUP using VR headset.

On 17 and 18 September, presentations were held on Tranquillity Base, the SpaceBok project from ETH and MORI robogami from EPFL Reconfigurable Robotic Lab, as well as two conferences bringing together Swiss and Japanese experts, professors and students on "The Space Debris Problem: Monitoring and solving it" and "Careers in space".

The full programme is available in the annex.



These events were a great opportunity to showcase Switzerland's projects in the space field. The virtual experiences were appreciated and seen as impressive by the public, local partners, and the Swiss embassy.

This was particularly the case with VIRUP, as the Science Museum of Tokyo deputy offered a 1-month extension in the Synra Dome. Tranquillity Base escape game was very fun to play and easy to distribute, as it is a free app. The fact that it integrates real science projects, both from EPFL and ETH Zürich, was another big asset, leading to many discussions about science.

Another benefit was the great collaboration with Japanese partners. Although plans had to change due to the cancellation of the House of Switzerland, there has always been a strong willingness to achieve the project in Tokyo, both from STO and eSpace. Both entities enjoyed working together and look forward to setting up another collaboration very soon. There was also very positive feedback from the speakers, who were keen to participate in the online conferences.

There were several communications materials produced for these events, such as roll-ups presenting the virtual experiences, the actual scientific projects and the partners involved. Conferences were held in English and included live Japanese translation for the public events on 17 and 18 September. The events were also strongly supported by social media communication from EPFL, Swissnex and partners.

The events that took place in the Science Museum, at the Swiss Embassy and at Base Q, plus the online conferences, allowed eSpace to reach more than 10,000 people:

- Twitter 4,599
- LinkedIn 3,945
- Youtube 437
- On site guests 80
- Live demos 1,400

Expo 2020 Dubai

17–30 Oct. | in person | >100,000 people

eSpace was invited by Swissnex, the Swiss global network for education, research and innovation, to host an exhibition at the Swiss Pavilion during the Space Week at Expo 2020 Dubai. The event was postponed to 2021, but it finally took place as an in-person event.

eSpace communicated the following messages to the public:

- The first was to highlight the fact that Switzerland is a space nation, with more than a half century of space activities from the first scientific experiment on the Moon during the Apollo 11 mission. Being one of the founding members of ESA, Switzerland provides high added-value technologies that can be found in most of the European missions and beyond, such as NASA's Perseverance Mars mission.
- eSpace also wanted to profile EPFL as a space hub of excellence. EPFL had its first collaboration with ESA in 1986 and created its own Space Center in 2004, which evolved into eSpace and the Space Innovation



Unit. eSpace educates motivated students through a Minor in Space Technologies and is conducting several research projects, some of them leading to spin-offs such as ClearSpace SA, Astrocast and Swissto12.

- Finally, eSpace aimed to raise awareness on space sustainability, including the topic of space debris. In addition to a keynote and a panel discussion, this was comprehensively summarised in a short video using VIRUP – the virtual map of the Universe from the Laboratory of Astrophysics (LASTRO).

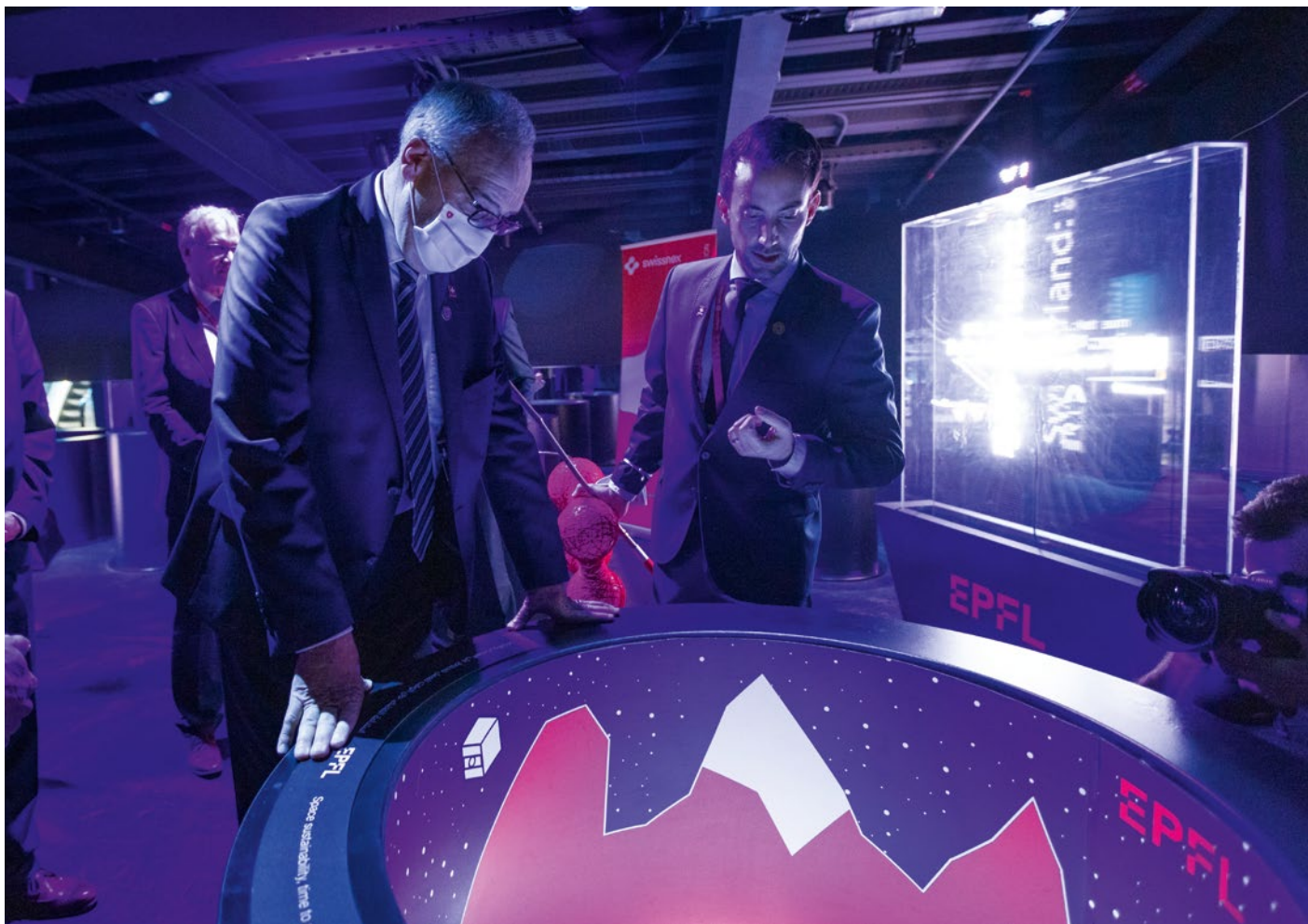
Homemade virtual technology tools, such as the Tranquility Base escape game developed by EPFL student association Space@yourService and the virtual reality headset, which let visitors travel through VIRUP, were very popular.

Finally, Expo 2020 Dubai also brought in-person meeting opportunities. Several of the conferences, workshops and visits eSpace organised or took part in gathered experts from all over the world, including Swiss astronaut Prof. Claude Nicollier and local students.

Expo 2020 Dubai was one of the biggest public events in 2021, so eSpace was able to reach a very large audience:

- **100k** visitors in two weeks, including Swiss President Guy Parmelin during the Expo 2020 Dubai Swiss National Day on 29 Sept.
- **160** Tranquility Base Escape Game players
- **40** VIRUP VR experiences
- **250** eSpace conferences attendees (on site + online)
- **10** media interviews
- **9,433** impressions / **486** engagements on Twitter and LinkedIn

Finally, eSpace wants to highlight the great partnership with EPFL Middle East, EPFL Mediacom, EPFL Audiovisual Service (SAVE), student association – EPFL Rocket Team, EPFL Spacecraft Team, Space@Your Service, EPFL X-plore –, EPFL Laboratory of Astrophysics, ETH Zürich Robotic Systems Lab, Presence Switzerland, and Swissnex in making this event successful.



4.2.3 eSpace webinars and other events

In 2021, eSpace organised 10 webinars that gathered 20–50 people each.

This year's program included a series from Prof. Hiroyuki Koizumi, who is currently conducting research at eSpace about Space Propulsion Systems (series continues in early 2022).

The 2021 line-up included:

- 18 January – **Space safety is foundation for reliable Space traffic management**, by Darren McKnight
- 8 March – **Astrophysical dust measurements in our cosmic backyard**, by Veerle Sterken
- 10 May – **Evolution of crew safety criteria for future Space transportation systems**, by Aline Decadi
- 31 May – **Single band nano-satellite remote sensing: BGUSAT's challenges and opportunities**, by Shimrit Maman
- 28 June – **An Introduction to the Biotechnology Space Support Center (BIOTESC) and the Cimon Project**, by Gwendolyne Pascua
- 27 September – **Can an airship explore Mars?** by Roméo Tonasso, Alice Barther, and Laurene Delsupexhe
- 8 November – **Destinus SA**, by Mikhail Koko-rich, CEO
- 2 December – **Space propulsion systems part.1**, by Prof. Hiroyuki Koizumi
- 13 December – **Space sustainability: From space environment management to life cycle assessment of space systems**, by Prof. Massimiliano Vasile
- 16 December – **Space propulsion systems part.2**, by Prof. Hiroyuki Koizumi

Most of them are also available on eSpace's YouTube channel, others are available upon request.

eSpace also participated in the following events:

- 4 March – **On-orbit servicing, Debris & Proximity operations Workshop**, co-organised by eSpace and Skoltech
- 4–5 May – **Space debris risk management workshop**, collaboration with IRGC
- 16–19 June – **Vivatech Paris**, Swisstech booth
- 1 October – **#wetegether Conference 2021**
- 25 October – **International Astronautical Congress 2022**
- 24 November – **Spacequest ventures online event – Switzerland: A keystone actor in sustainable space**
- 14 December – **Horizon Europe funding for R&I related to environmental and Earth observation**

In total, eSpace organised and was featured in almost 20 events which represents a huge growth compared to 2020.

4.2.4 Media relations

eSpace and space-related labs and student associations had more presence in various media, such as newspapers (*PME Magazine*, *Heidi News*, *24 heures*, *Le Temps*), TV and radio (RTS), specialised websites (Space Watch Global, Space.com) and the EPFL website and EPFL magazine *Dimensions*.

In June, eSpace announced in a press release with the World Economic Forum, ESA, and MIT that eSpace has been selected to operate the Space Sustainability Rating (SSR), bringing international media attention.

In October, the presence at Expo 2020 Dubai brought some media interviews with eSpace's Academic Director Jean-Paul Kneib, Prof. Claude Nicollier, and ClearSpace CEO Luc Piguet.

Some other events, such as the Asclepios Mission by Space@Your Service and the victory of the EPFL Rocket Team in Portugal, also brought EPFL's space activities positive attention in the media.

4.2.5 Social media

As part of the communication strategy, eSpace wanted to increase its activity and followers on social media.

Social media platforms are a key channel in eSpace's communication mix, especially for the promotion of larger events (SSL Symposium, EPFL Virtual Space Tour Tokyo, Expo 2020 Dubai) and for sharing webinars on YouTube.

Indeed, a considerable increase can be observed on YouTube, while LinkedIn and Twitter each doubled the number of followers.

	January 2021	December 2021	Difference
FB	995	1184	+ 19.0%
Twitter	190	394	+ 107.4%
Instagram	855	1125	+ 31.6%
LinkedIn	564	1292	+ 129.1%
YouTube	10	106	+ 960.0%
Total	2614	4101	+ 56.9%

4.2.6 eSpace and EPFL in the media

Annex 5 presents the press review performed by eSpace to track the presence of EPFL and eSpace in the media on space related articles.

4.2.7 Coming in 2022

The Space Sustainability Rating (SSR) is the main project for 2022. The communication strategy and plan were prepared at the end of last year and have now entered the preparation phase, including the corporate identity, the website, and several other actions/assets.

eSpace is (co)organising or taking part in additional events, such as:

January

- LRA Conference- speaker
- ISU alumni conference- speaker

February

- UNCOPUOS @Vienna- speaker

March

- Space Week with SATW- co-organisers

May

- LEO Kinetic Space Safety Workshop @EPFL- co-organiser
- CNES modelling and remediation workshop- speaker

June

- Secure World Foundation 4th Summit for Space Sustainability: Launching the SSR
- EUCASS @Lille- co-chairing symposium on sustainable space: Logistics and Space Debris

September

- IAC @Paris- speaker

In addition, eSpace will continue to organise the webinar series to provide relevant content to the EPFL space community and students. In addition, this year, EPFL researchers will also be invited in order to give more visibility to EPFL space related research.

4.3 eSpace 2021 assessment

4.3.1 Objectives assessment

Project	Objective	Status	Rationale
Management			
EPFL Minor in Space Technologies	Increase participation 10%	Exceeded	Participation increased 40%. Two new classes were added in the study plan.
EPFL inter-disciplinary projects (MAKE fund)	All projects renewed in the MAKE fund. Groups participating in competitions are in the top 5. Sponsorship meets needs of the groups.	Partially met	One project did not get renewed. EPFL Rocket Team number 1 at Euroc competition and Xplore number 3 at the ERC competition. All teams have enough sponsorship.
Research			
Research Initiative for Sustainable Space Logistics	Renewal of the funding 2 journal papers 3 technology transfers (2 on-going with ClearSpace) Successful SSL symposium (variety of participation, paper)	Partially met (pending one answer)	Waiting for answer 2 journal papers 2 Innosuisse closed and one contract with Clearspace started. SSL Symposium successful with 650+ people signed up and 300+ connections.
Space related research or space application within EPFL labs	Two new research topics pushed within EPFL. Remote sensing and Big Data. Intelligent system with Space applications (smart telescope for SSA, Lunar rover).	Fully met	Working group EPFL on-going and webpage created. Bridge project started + new MAKE team on SSA.
Communication and outreach			
eSpace communications	Interviews in the media (radio, newspaper). Participation at EUCASS Conference, IAC. Participation at the House of Switzerland at Tokyo Olympics and at Dubai Expo 2021. eSpace host one event (SSL Digital Symposium)	Exceeded	More than 40 articles listed in the press review and increase of 56% of followers in total on social media. EUCASS cancelled, successful participation to IAC with a delegation of six EPFL members (including two students). SSL Digital Symposium successful.

4.3.2 Summary of 2022 goals

The goals that eSpace has set for 2022 are listed in the following table. This summary will then allow us to define the 2022 objectives.

Project	Goals
Education	
General	Continue to secure financing to serve students (MAKE supervision, engineers to supervise projects, external teachers, scholarships for students).
EPFL Minor in Space Technologies	Ensure the high quality of the teaching . Provide students the support for transition from studies to industry.
EPFL interdisciplinary projects (MAKE fund)	Ensure the availability of engineers for the supervision of the MAKE projects. Ensure the educational value of the MAKE projects and provide quality education for students.
Research	
Research Initiative for Sustainable Space Logistics	To renew the funding for the 2022–2023 period. To have a broadier visibility at the national level and in particular within the industries.
Space Sustainability Rating	To generate income with the launch of the SSR and provide rating service. To create the legal structure that will perform the operations. To extend the SSR community to emerging space nations. To perform outreach around in-space sustainability (for the public and the student). To initiate research projects around in-space sustainability.
Lunar Initiative	To improve the definition of the goals, milestones, and strategy of the initiative. To consolidate three foundational projects of the initiative including funding for at least one of the consolidated project ideas (MVA project, Lunar Drone Project, Moonrise). To increase visibility and awareness around the activities of and opportunities offered by the initiative both in and outside of EPFL at two main levels: <ul style="list-style-type: none">• Technical level through peer-reviewed journal papers & key annual/bi-annual conferences• Outreach level via social media presence and the website of the initiative. To connect to the SSL and other initiatives.
Space related research or space application within EPFL labs	To provide information about funding opportunities to the Space Profs. To provide relevant content on space research to the Space Profs. To initiate new research projects and in particular with industries To make EPFL space-related research more visible.
Espace operations	
Communication and outreach	To serve eSpace projects in term of communication and support the visibility. To provide content to the Space Profs through presence on social media, organisation of seminars and with a newsletter. To support and encourage EPFL researchers and students to attend space related events.

5.

CONCLUSION

This report has presented the main activities of eSpace in 2021. The main objectives were defined around three key areas: **education**, **research**, and **communication & outreach**.

In **education**, eSpace continued to provide the best support possible to the students. Two new classes were added to the Minor in Space Technologies curriculum. eSpace also supervised more than 15 students performing semester projects and master's theses. Finally, the supervision of MAKE projects turned into successful results for the space associations at EPFL. eSpace is very proud of the success of the EPFL Rocket Team and the Xplore team as well as the hard work and objectives met by the other teams (SSA, GrowBotHub, EPFL Spacecraft Team). eSpace also provided support to the student association Space@Your Service, which managed their first student analog astronaut mission.

In **research**, eSpace's activities were focused in two areas: an internal research initiative and

support to the Space Profs. In the first, the Sustainable Space Logistics Initiative completed its first phase and its performance over the first two years was assessed. Multiple research projects began during this period within eSpace and within EPFL Labs. To be highlighted are the projects around space logistics modelisation and technology developments such as relative navigation towards uncooperative targets in orbit, capture system for orbital debris, and in-orbit debris tracking. In addition, the reputation of EPFL in the space domain has increased and was showcased when eSpace was selected as the host and operator of the Space Sustainability Rating. Finally, two new initiatives were launched on the subjects of lunar research and technology, and earth observation.

Finally, in **communication & outreach**, the preparatory work performed in 2020 paid off with the successful organisation of and participation in three main events: The Sustainable Space Logistics Symposium, The EPFL virtual Space tour in Tokyo and Expo Dubai 2020. The



presence of eSpace and EPFL in the media also grew with the number of followers increasing by 50% on the various social media platforms. Media review shows more than 41 articles citing eSpace, EPFL Students, and EPFL labs.

eSpace looks forward to providing the best services to its students, Space Profs, and the space community in 2022. While funding and visibility are the main challenges across the different missions of the center, eSpace is confident that 2022 will be another successful year!

Thank you to all our supporters starting from the eSpace team, all of EPFL's support staff, the motivated students, the dedicated researchers, our followers, our audience at eSpace Seminars and all our partners that trusted us to develop new projects!

Annexes

- A1 List of proposals and research outcomes SSL
- A2 List of speakers at the Sustainable Space Logistics symposium
- A3 Tokyo full program
- A4 Expo 2020 conference full program
- A5 List of articles featuring eSpace

A1 List of proposals and research outcomes SSL

The RISSL research team has written and supported the following proposals and letter of intent.

Accepted proposals

- EPFL – House of Switzerland – Japan project (50 kCHF), started November 2020.
- Bridge – Space situational awareness (1.4 MCHF awarded), started September 2021.
- Extension at Innosuisse for the Relative Navigation Project due to Covid until December 2020.
- Research Preparation Grant submission – Swiss-Russian leading house, with Skoltech, started December 2020 (20 kCHF).
- DAWN – Development of Space Logistics generic Process (ESA FLPP), started November 2020 (130 kCHF).
- MdP ISRU – (Completing the OSIP and securing three years of research) – research project, started October 2020 (250 kCHF).
- ESA Concurrent Engineering Challenge – support and materials to set up a Concurrent Engineering facility, for students to participate in a week-long workshop (non-research proposal, though synergistically used for research. Delayed due to Covid).
- ClearSpace ADRIOS missions – contract negotiation, started December 2020 (up to 1,300 kCHF).
- ESA strategy proposal for technology road mapping workshop (3-month pilot, 1-year follow-on) – Sustainable Futures for Space Logistics (87 kCHF).
- ESA OSIP – PhD Anne-Marlene Rüede, Space architecture & logistics – confirmed industry partner, accepted first round- (97 kCHF).
- ESA Sustainable Futures for Space Logistics GSTP de-risk – “Strategic Tech Planning System 2.0” (80 k€, follow-on linked proposal likely 1–2 M€ (not yet submitted)).
- EPFL Equipment Grant – A new platform for innovation: The Concurrent Design & Data Facility (CD²F) (50 kCHF).
- Space Sustainability Rating of the World Economic Forum.
- NEST – New European Space Transportation Solutions (30 k€) with Arianegroup.

Rejected proposals

- Bridge Proof of Concept – Concurrent Design & Data Facility (CD²F)
- SNF Spark – Concurrent Design & Data Facility (CD²F)
- Developing a new platform for innovation: The Concurrent Design & Data Facility – Hasler Stiftung
- Research seed fund – Collaboration EPFL Ukraine KPI university
- Space Use case for CIS grant (application from 3D smart camera)
- SNF Ambizione – Marc-Andre Chavy-Macdonald – “Measuring Design: Lifecycle value metrics for sustainable spacecraft”
- Holcim Stiftung – Marc-Andre Chavy-Macdonald – “Enabling and Measuring Aerospace Design with the Concurrent Design & Data Facility” (CD²F)
- SNF-ANR – with Supaero SACLAB – Teleoperation Robotics

Research outcomes

Published

- Chavy-Macdonald, M.-A., Oizumi, K., Kneib, J.-P., & Aoyama, K. (2021). The cis-lunar ecosystem – A systems model and scenarios of the resource industry and its impact. *Acta Astronautica*, 188, 545–558.
- Juillard, M., & Kneib, J.-P. (Eds.). (2021). Simulation Tool: Resources Management in High Performance Avionic for ADR Missions. *2021 IEEE Aerospace Conference (Aeroconf 2021)*.
- Juillard, M., & Kneib, J.-P. (2021, August 10). Optimal Control Approach for Dedicated On-Board Computer in Active Debris Removal Mission. *35th Proceedings of the AIAA/USU Conference on Small Satellites*.

Accepted

- Juillard, M., & Kneib, J.-P. (2022). Validation of Optimal Control Design Tool for Dedicated Avionic in Active Debris Removal Mission. *2022 IEEE Aerospace Conference*.

In progress

- Juillard, M., & Kneib, J.-P. Onboard Computer and Dedicated Payload Interaction: Study case for Active Debris Removal Missions. *Acta Astronautica*

Journal paper submitted (major revisions)

- Chavy-Macdonald, M.-A. Towards Real Options Criteria for Modular Changeability. *Journal of Engineering Design*.

Conference presentations

- IAC 2020: “What is New Space” – an Innovation Studies perspective, Marc-André Chavy-Macdonald.
- SECESA 2020 (ESA Concurrent Engineering for space applications): “Concurrent Design & Data Facility (CD²F): conceptualizing a next-generation CDF”, Marc-André Chavy-Macdonald.
- SWISSED20 (Swiss Systems Engineering Day): “A systems view of Systems Engineering – the field in its intellectual context”, Marc-André Chavy-Macdonald.
- SmallSat Conference: *Dedicated On-Board Computer for Active Debris Removal Mission*, Michaël Juillard.
- *Repetitive-Use Rocket-Crane / Rover System (R3S) for Planetary Surface Missions*, Anne-Marlene Rüede with Yu Ito from Yamato Holdings Co. and Claudio Leonardi from EPFL TRANSP-OR (AIAA SciTech).
- *Asteroid Mining: Multiple Spacecraft Logistics for Mars Supply*, with Shamil Biktimirov & Anton Ivanov from the Skoltech Space Center (GLEC Conference).
- SWISSED21: “A new platform for innovating system design: The Concurrent Design & Data Facility (CD²F)”, Marc-André Chavy-Macdonald.
- SWISSED21: “An Overview of Systems Architecting Approaches”, Anne-Marlene Rüede.
- Aeroconf: “Resources Management in High Performance Avionic for ADR Missions”, Michaël Juillard.
- IAC 2021: “Space debris risk governance: Proceedings from a workshop held at EPFL in 2021”, Emmanuelle David, Romain Buchs, Jean-Paul Kneib, Marie-Valentine Florin.

- “Governing collision risk from space debris in low earth orbit”, Romain Buchs, Marie-Valentine Florin, Emmanuelle David, Jean-Paul Kneib.
- Five eSpace talks, an interactive workshop, chair at EPFL-Skoltech On-orbit Servicing, *Debris & Proximity Operations Workshop* (March 4th 2021).
- 2021 IEEE Aerospace Conference: “Simulation Tool: Resources Management in High Performance Avionic for ADR Missions”, Michaël Juillard, Jean-Paul Kneib.
- SmallSat Conference: “Optimal Control Approach for Dedicated On-Board Computer in Active Debris Removal Mission”, Michaël Juillard, Jean-Paul Kneib.

A2 List of speakers at the Sustainable Space Logistics symposium

- Rüdiger Albat, Head of Ariane 5 and Future Preparation at the European Space Agency (ESA).
- Natália Archinard, holder of the space portfolio at the Federal Department of Foreign Affairs of Switzerland.
- David Barnhart, Research Professor in the Dept of Astronautical Engineering at USC.
- Emmanuelle David, Executive Manager of the EPFL Space Center (eSpace).
- Olivier De Weck, Professor of Aeronautics and Astronautics and Engineering Systems at MIT.
- Simonetta Di Pippo, Director of UN Office for Outer Space Affairs (UNOOSA).
- Klaus Dohrmann, Vice President Sector Development for DHL Customer Solutions and Innovation (CSI).
- Pascale Ehrenfreund, President of the International Astronautical Federation IAF.
- Jason Forshaw, Head of Future Business (Europe) at Astroscale.
- Jean-Paul Kneib, Head of EPFL Laboratory of Astrophysics and Director of EPFL Space Center (eSpace).
- Torsten Kriening, Publisher and CEO of SpaceWatch.Global.
- Renato Krpoun, Head of Swiss Space Office.
- Tanja Masson-Zwaan, Assistant Professor and Deputy Director of the International Institute of Air and Space Law at Leiden University.
- Markus Mooslechner, Vienna, Austria-based filmmaker, TV host and science communicator.
- Claude Nicollier, astrophysicist, former astronaut and professor at EPFL.
- Kevin Pahud, founding member of Space@yourService.
- Maxime Puteaux, principal advisor at Euroconsult.
- Muriel Richard-Noca, Chief Engineer and co-Founder of ClearSpace.
- Luca Rossettini, CEO and Founder of D-Orbit.
- Anne-Marlene Rüede, space and extreme environment architect from EPFL, PhD at eSpace.
- Jeremy Schiel, co-founder, and Chief Development Officer of Orbit Fab.
- Thomas Schildknecht, Director of the Swiss Optical Ground Station and Geodynamics Observatory Zimmerwald and the Vice-Director of the Astronomical Institute of the University of Berne (AIUB).
- Joost van Tooren, responsible for business development of new Space Logistics Services within the Future Programmes directorate at ArianeGroup.
- Brian Weeden, Director of Program Planning for Secure World Foundation.

A3 Tokyo full program

Wednesday 15 September 2021

6 pm JST (11 am CEST) – VIPs and sponsors

Introduction

- Mr Markus Reubi, Chargé d'affaires a.i, Embassy of Switzerland in Japan.
- Prof. Jean-Paul Kneib, Director eSpace and LASTRO.
- Mr Renato Krpoun, Head, Swiss Space Office.

Space outreach: introducing Tranquillity Base and VIRUP

- Mr Florian Cabot, scientific assistant, Laboratory of Astrophysics, EPFL.
- Mr Alexandre de Montleau, Space@yourService, EPFL.

Understanding our universe from observational big data

- Prof. Prof. Masahiro Takada, KAVLI IPMU, University of Tokyo.
- Prof. Jean-Paul Kneib, Director eSpace and LASTRO.

⇒ Watch the recording

Thursday 16 September 2021

7 pm JST (12 pm CEST) – Alumni

Introduction

- Mr Markus Reubi, Chargé d'affaires a.i, Embassy of Switzerland in Japan.
- Ms Emmanuelle David, Executive Manager at eSpace.

Space outreach: introducing Tranquillity Base and VIRUP

- Mr Florian Cabot, scientific assistant, Laboratory of Astrophysics, EPFL.
- Mr Alexandre de Montleau, Space@yourService, EPFL.

Our galaxy, the Milky Way, in a cosmological context

- Prof. Kentaro Nagamine, Graduate School of Science, Dept. of Earth and Space Science, Osaka University.
- Dr Yves Revaz, Senior Scientist, Laboratory of Astrophysics, EPFL.

⇒ Watch the recording

Friday 17 September 2021

6 pm JST (11 am CEST)

Tranquillity Base: The project and SpaceBok, a four-legged robot for planetary exploration

- Alexandre de Montleau (Space@yourService EPFL, Tranquillity Base Project).
- Hendrik Kolvenbach (ETH Zurich, SpaceBok project).

The space debris problem: monitoring and solving it

- Prof. Thomas Schildknecht, Head of Optical Astronomy and Space Sustainability Group, Vice Director Astronomical Institute, University of Bern.
- Prof. Sinichi Kimura, Faculty of Science and Technology, Dept. Electrical Engineering, Tokyo University of Science.
- Dr Luc Piguet, CEO ClearSpace SA
- Chris Blackerby, COO Astroscale.
- Marie-Valentine Florin, Executive director EPFL International Risk Governance Center (IRGC).

⇒ Watch the recording

Saturday 18 September 2021

3 pm JST (8 am CEST)

Careers in Space

- Prof. Jean-Paul Kneib, Director eSpace.
- Ms Chloé Carrière, Space@yourService EPFL.
- Prof. Genya Ishigami, Department of Mechanical Engineering, Faculty of Science and Technology, Keio University.
- Mr Naoyuki Oota, Dept. of Physics, Graduate School of Science Tokyo University of Science.
- Mr Taiki Kanda, Dept. of Electrical Engineering, Faculty of Engineering, Tokyo University of Science.

Tranquillity Base: the project and the modular origami robot MORI

- Alexandre de Montleau, Space@yourService, Tranquillity Base project.
- Kevin Holdcroft, EPFL Reconfigurable Robotics Lab, Mori modular origami project.

⇒ Watch the recording

A4 Expo 2020 Conference full program

Tuesday 19 October 2021

9:30 am–12:00 pm: Panel (Australian Pavilion)
in cooperation with the UAE University and Curtin University, Australia

Radio astronomy research & development.
including Prof. Jean-Paul Kneib, Director eSpace and LASTRO (EPFL)

2:45 pm: Forum (Dubai Exhibition Center)
in collaboration with Dubai Chamber of Commerce and Industry.

Space thematic business forum – Opportunities for tomorrow
Including Dr Luc Piguet, CEO & co-founder (Clearspace)

4:00 pm–6:00 pm: World Majli (Indian Pavilion)
co-hosted by Switzerland and India
Lessons from apace: Applying approaches from space to fight climate change
Including Prof. Claude Nicollier, former Swiss Astronaut and Ms Emmanuelle David, Executive Manager eSpace (EPFL)

Wednesday 20 October 2021

11:00 am–12:00 pm: Keynote (Swiss Pavilion)
Sustainable Space Logistics and Space Sustainability Rating
Prof. Jean-Paul Kneib, Director eSpace and LASTRO (EPFL) and Dr Tim Flohrer, Head Space Debris Office (ESA)

1:30 pm–3:00 pm: Guest lecture (Swiss Pavilion)
In collaboration with the Japanese Pavilion and the UAE University

Human spaceflight: Inspiring humankind
Prof. Claude Nicollier, former Swiss astronaut and Ms Naoko Yamazaki, former JAXA astronaut

Thursday 21 October 2021

10:30 am–12:30 pm: Workshop (Swiss Pavilion)
In collaboration with the UAE University
Space education: How to design an outreach program
Ms Emmanuelle David, Executive Manager eSpace (EPFL eSpace), Ms Chloé Carrière, EPFL student (Space at your Service), Dr Aquib Moin, Assistant Professor (UAE University)

4:00 pm–6:00 pm: Panel (Australian Pavilion)
in collaboration with the Australian Pavilion
Square kilometre array (SKA) science showcase
Including Prof. Jean-Paul Kneib, Director eSpace and LASTRO (EPFL)

4:30 pm – 6:00 pm: Panel (Swiss Pavilion)
Space debris: Knowledge creation & problem solving
Dr Luc Piguet, CEO and co-founder (ClearSpace), Prof. Moriba Jah, Professor and space environmentalist (University of Texas at Austin, remotely), Prof. Thomas Schildknecht, Director Swiss OGS (University of Bern, remotely)

Saturday 23 October 2021

10:00 am–13:00 pm: Sustainability @ Expo (Nexus North) *in collaboration with the UAE Space Agency and the Slovenian Pavilion.*
Protecting the great unknown
including Ms Emmanuelle David, Executive Manager eSpace (EPFL) and Dr Luc Piguet, CEO and co-founder (ClearSpace)

Sunday 24 October 2021

1:00 pm – 3:30 pm: Workshop (Zabeel House by Jumeirah), on invitation only, *in collaboration with Skoltech*
Sustainable Space Logistics: How to design and build more sustainable space missions?
Including Ms Anne-Marlene Rüede, PhD student eSpace (EPFL) and Shamil Biktimirov PhD student (Skoltech)

A5 List of media articles featuring eSpace in 2021

- 19.01 **EPFL news article** [EPFL works to address debris collision risks](#), about IRGC
- 22.01 **Sciena.ch** [«J'ai débuté grâce à un échec!»](#), about Chloé Carrière, Space@YourService
- 17.02 **Le Nouvelliste** [Des satellites valaisans bientôt dans l'espace](#), about Emmanuelle David, Spacecraft Team, CHES
- 19.03 **20 minutes** [On mange ça sur Mars?](#) about Asclepios
- 19.03 **RTS** [Pédagogie - la vie sur Mars](#), about Asclepios
- 22.03 **Le Point** [Aller sur Mars, c'est vraiment mon rêve](#), about Asclepios
- 22.03 **Urdupoint** [Swiss kids suit up for 'Mission To Mars'](#), about Claude Nicollier, Asclepios
- 09.04 **RTS radio** [Les ondes qui nous parviennent de l'espace](#), about Jean-Paul Kneib, LASTRO
- 26.04 **Femina** [Chloé Carrière \(Galactic Chloé\): la passion de l'espace](#), about Chloé Carrière
- 27.04 **RTS** [TTC: La course vers l'espace est relancée](#), about Claude Nicollier, ClearSpace-1
- 10.05 **RTS Radio** [Déchets spatiaux: la start-up ClearSpace](#), about Luc Piguet, ClearSpace-1
- 22.06 **EPFL news article** [New connector for sustainable structures on Earth and in space](#), about Romain van Wassenhove
- 08.06 **Phys.org** [New connector for sustainable structures on Earth and in space](#), about Romain van Wassenhove
- 17.06 **MIT Media Lab** [A New Chapter for Space Sustainability](#), about SSR
- 18.06 **Eurasia Review** [New Space Sustainability Rating Addresses Space Debris With Mission Certification System](#), about Jean-Paul Kneib, SSR
- 21.06 **Space Watch Global** [WEF and ESA launch new Space Sustainability Rating](#), about SSR
- 21.06 **Heidi News** [L'avenir des satellites est-il dans le bois?](#) about Alexandre Looten, LPAC, Design for demise
- 22.06 **Fintechzoom.com** [Earth's orbit is congesting, World Economic Forum has a solution](#), about SSR
- 22.06 **Pressnewsagency.org** [New spacecraft sustainability rating targets space junk](#), about SSR
- 22.06 **Space.com** [New spacecraft sustainability rating targets space junk](#), about SSR
- 29.06 **Technology.com** [A new chapter for space sustainability](#), about SSR
- 28.06 **MIT News** [A new chapter for space sustainability](#), about SSR
- 28.06 **Triple pundit** [Space Junk, the Final Frontier for Sustainability](#), about SSR
- 01.07 **24 heures / TdG** [Emploi - Les Suisses rêvent de travailler dans l'espace](#), about Volker Gass
- 08.07 **Heidi News** [Les débris spatiaux, casse-tête pour la gouvernance internationale](#), about IRGC
- 08.07 **Heidi News** [La population des astronautes va se diversifier](#), about Claude Nicollier
- 10.07 **Le Temps** [Le danger du chaos spatial](#), about IRGC

- 11.07 **Spacewatch global** [🔗](#) *#SpaceWatchGL Opinion: Addressing the limitations of our current approach to collision risk from space debris*, about IRGC
- 19.07 **msn.com** [🔗](#) *Conquête spatiale : en Suisse, des étudiants vivent en autarcie dans une base lunaire*, about Julien Corsin, Space@YourService, Asclepios
- 26.07 **RTS Radio** [🔗](#) *Chloé Carrière : « On pourrait imaginer qu'un jour tout le monde puisse aller dans l'espace »*, about Chloé Carrière, Space@YourService
- 26.07 **Canal 9** [🔗](#) *Mondbasis in den Felsen des Grimselpasses*, about Elfie Roy, Space@YourService, Asclepios
- 07.10 **Dimension-EPFL** [🔗](#) *Making space a safer place*, about IRGC
- 24.10 **24 heures** [🔗](#) *La passion des fusées fuse à l'EPFL*, about EPFL Rocket Team
- 29.10 **RTS, Le 19:30** [🔗](#) *Le président Parmelin en visite au Pavillon Suisse à l'expo 2020 Dubai*, about EPFL
- 02.11 **RTS** [🔗](#) *Des étudiants EPFL ont construit le prototype de la meilleure fusée d'Europe*, about Emmanuelle David, EPFL Rocket Team
- 04.11 **RTS Radio** [🔗](#) *Forum des idées: des étudiants constructeurs de fusées*, about EPFL Rocket Team
- 12.11 **Le Temps** [🔗](#) *L'espace, nouvelle frontière de la Paix explorée à Paris*, about ClearSpace
- 30.11 **PME Magazine** [🔗](#) *Quel avenir pour le tourisme spatial?* about Anne-Marlene Rüede, eSpace
- 15.12 **Swissinfo** [🔗](#) *Débris spatiaux: avertissement suisse au monde*, about IRGC

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