INTERNATIONAL® SPACE UNIVERSITY

ANNUAL REPORT

Academic Year 2020-2021

International Space University

Back in 1987, three visionary university students had the inspiration for “an institution dedicated to international affiliations, collaboration, and open, scholarly pursuits related to outer space exploration and development. ISU is a place where students and faculty from all backgrounds are welcomed; where diversity of culture, philosophy, lifestyle, training and opinion are honored and nurtured.” Today, ISU is a success story with 5200 alumni shaping the international space ecosystem in 110 countries. Within two years of graduation, over 80% of these alumni have found employment in academia, space agencies or industry.

Recent developments in the global space economy, unprecedented entrepreneurial leadership, private investment, and innovative technologies provide ample opportunities for exciting endeavors and interesting jobs for ISU graduates. ISU educates international postgraduate students and professionals to provide a trained workforce for the space sector to support the global space economy, space applications and infrastructure, bold space exploration ventures, and mitigate global challenges.

At its Central Campus in Strasbourg, France, and in partnership with other universities, ISU offers five programs based on the international, intercultural and interdisciplinary (3Is) learning. At ISU, students, faculty, and visiting lecturers from around the world share their experience in all space-related fields including: space applications, space engineering, space humanities, human performance in space, space business and management, space policy, economics and law; and space sciences. ISU empowers students and professionals to contribute to the dynamically expanding industrial and public space sector through engagement with 150 global faculty members and thousands of alumni from around the world. Joining ISU means living and working in a unique international and intercultural environment and working towards a collective goal – an intense and unforgettable experience.

Since early 2020, ISU has innovated in online education with highly interactive and live-in programs such as the Interactive Space Program (ISP) and online mentorship. Virtually all ISU programs can be delivered online in synchronous mode and still provide participants with the interactivity, professional networking and bonding for which the university is known.

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1. Introduction

The 34th year in the history of the International Space University has been rich in experience, learning and recognition on many fronts, both for the university as an institution and for the members of our growing community.

We had to endure hard losses, as two dear colleagues left us while being active members of the team. Our thoughts are still with the families and friends of Laurence Heiser and Oscar Rosas.

September 2020 saw the start of the Master of Space Studies (MSS) program in hybrid format (in person and remote) and the progressive arrival of students as they were cleared from pandemic and visa related hurdles. Faculty and staff in all programs have continued to innovate in interactive distance teaching and adapting to the ever-changing environment dictated by pandemic.

October saw the visit to our Central Campus by Ms. C. Zorn, the newly elected Vice-President of Strasbourg Eurometropolis, who could see first-hand the impressive facility built for ISU by the local administrations twenty years ago, and the growth of the ISU space start-up incubator.

A sixth start-up joined the incubator, and the first MSS internship arrangements were discussed with several companies, paving the way for effective internships and subsequent employment observed in the following months.

November saw the first edition of an online Executive Space Course (ESC), offered in the Americas time zone to give continuity to the series of ESCs hosted in Seattle, Washington State, USA. Other online ESCs followed in December (for Eumetsat employees), April (European time zone) and May (Asia-Pacific time zone).

December saw the promotion of two Central Campus Faculty to Full Professors, Virginia Wotring and Hugh Hill, in recognition of their performance in teaching and research.

The last lecture of the calendar year was delivered remotely by MSS alumna and NASA astronaut Jessica Meir, concluding with an inspiring note what had been a challenging year due to the pandemic.

January 2021 saw the start of the 10th edition of our five-week Southern Hemisphere Space Studies Program, a long-standing partnership with the University of South Australia. For the first time, the SHSSP was held fully online, and in two time zones: a challenging yet unforgettable experience for the 33 participants from 11 countries and for staff and faculty alike. The Mentorship component of the program was built on the experience of the ISP20 program and was highly appreciated by the participants.

An online “Discover ISU” series of interactive presentations in three time zones allowed numerous prospective students to learn about ISU’s offerings in the absence of in-person opportunities.

February saw the second ISU Adelaide Conference gathering 230 attendants from 21 countries, mostly in the Asia-Pacific region. This professional conference was offered in hybrid format and was fully organized by ISU alumni.

Two senior ISU alumni presented recent achievements of the ambitious and successful Chinese space program during a televised celebration of the Chinese New Year. With more than 500 ISU alumni working in the Chinese space sector, China is one of the top three countries in number of ISU alumni, along with Canada and the USA.

At its February meeting, the ISU Board of Trustees selected the proposal from the Portuguese Space Agency as the winning one to host the SSP22 program. The local hosts include the University of Lisbon’s Instituto Superior Técnico and the municipality of Oeiras near Lisbon.

The Board acknowledged that ISU alumni are founders or co-founders of over 100 start-ups in 27 countries, and decided to establish *ISU Ventures*, a private organization to provide alumni-founded start-ups with financial incentives. The Board endorsed the initiative of an ISU Endowment Fund for long-term financial security.

March saw two dozen new faculty appointments and promotions, bringing the ISU Global Faculty to over 160 professionals, all with demonstrated experience in the ISU “3Is” learning philosophy and ready to contribute with their expertise to the ISU academic, research and professional development programs.

April announced the appointment of our Chancellor, Prof. Pascale Ehrenfreund, as the next ISU President. ISU is privileged to have attracted such a respected world expert to lead the university in the next years, starting in September 2021.

The second edition of the Space Resources Professional Course was conducted online, in collaboration with the Luxembourg Space Agency and the Colorado School of Mines.

May saw the arrival in Strasbourg of NASA's new seconded staff member, Mr. Kenol Jules, who follows on the lineage of managers seconded as director of the Space Studies Program (SSP) since the year 2000. Our students benefit immensely from having almost daily access to full-time staff supported or seconded by NASA, ESA, CNES and CASC.

Also in May, we said goodbye to the MSS21 students who concluded their classes and departed to their in-person or virtual internships in companies, universities or space agencies in Belgium, France, Japan, Germany, Iceland, Italy, Luxembourg, Switzerland, UK, and USA.

More recently, ESA appointed one of its senior staff , Mr. Nicolas Peter, to join the Central Campus Faculty, following the lineage of five other ESA staff seconded to ISU in previous years. Our sincere thanks go to ESA and all its Member States for their endorsement of the ISU education, which includes a multi-year package of scholarships.

June saw a key milestone in the process towards the accreditation of the MSS program, with the virtual visit by the auditors from our accreditation agency who met with over 50 members of the program's stakeholders: faculty, students, program management, staff, alumni, external partners and employers.

The end of June saw the start of a most ambitious and complex Space Studies Program organized for a class of 110 participants representing 35 nationalities and distributed in equal numbers in three cohorts: Online, at the University of Granada in Spain ant at ISU's Central Campus in Strasbourg. The curriculum included daily seminars, fundamental and elective workshops, mentorship sessions, departmental activities, professional visits and intense team project work.

July saw the conclusion of the third edition of ISU's Commercial Space Program (CSP) graduate certificate, hosted by the Florida Institute of Technology in collaboration with the Aldrin Institute.

During the last weekend in July, over 600 alumni and other space professionals including heads of space agencies and astronauts, engaged in the online ISU Alumni Conference. The 48 hours of non-stop panels, presentations and networking sessions covered many of today's important topics related to space, future workforce, sustainable development and applications, security, new technologies, science, and exploration.

August saw the conclusion of SSP21 with impressive presentations of five Team Project reports.

At the end of the month and as we are writing these lines, we begin to see the arrival of the new class of MSS22 representing 21 nationalities from four continents and a variety of backgrounds, making up for a promising class of over 40 students.

Join us in wishing to ISU a successful and safe 2021-2022 academic year for its 35th anniversary!

2. Summary and Key Figures

2.1 Participants in the ISU Programs

Program	Location	#Participants
Master of Space Studies Year A (MSS21-A)	**Central Campus**	**35**
Master of Space Studies Year B (MSS21-B)	**Central Campus**	**2**
Space Studies Program (SSP21)	**Strasbourg/Granada/Online**	**110**
Southern Hemisphere Space Studies Program (SHSSP21)	**Online**	**33**
Commercial Space Program (CSP21)	**Florida Institute of Technology**	**12**
Space Resources Professional Course (SRPC)	**Online**	**82**
Executive Space Course 1 (ESC 1) The Americas	**Online**	**16**
Executive Space Course 2 (ESC 2) Strasbourg	**Online**	**19**
Executive Space Course 3 (ESC 3) Asia Pacific	**Online**	**12**
Executive Space Course 3 (ESC 4) Eumetsat	**Online**	**21**

2.2 Employment statistics

Nine months after completing the program:

86 % of the MSS20 alumni reported having a job, and 14% of the MSS20 alumni reported continuing studies. The SSP being a professional development program, the employment rate is significantly higher, but it cannot be attributed solely to the SSP learning because many participants return to their previous jobs.

2.3 Faculty

During the academic year 2020-2021, ISU counted:

- **75 Full Faculty** (see list in annex 1)
- **46 Adjunct Faculty** (see list in annex 1)
- **15 Associate Faculty** (see list in annex 1).

2.4 Alumni

After SSP21 and MSS21 graduation, ISU now counts **more than 5200 alumni** from 110 countries. See chapter 10 Alumni Affairs for more details.

3. Master of Space Studies - MSS21

3.1 Introduction

As noted in last year's report, due to the coronavirus pandemic, at the end of the previous academic year only around 30% of the MSS20A cohort had been able to complete their mandatory internships and so be in a position to graduate. The vast majority of the remaining 70% of the MSS20A cohort undertook their internships and graduated during the 2021 academic year, though a small number with very late internships joined with the MSS21A cohort as described below.

The academic year started in 'hybrid mode' with those students able to travel to Strasbourg arriving for in-person classes, albeit under strict sanitary conditions, while others attended classes remotely until such a time that they were able to travel to Strasbourg. All of the cohort had arrived in Strasbourg by mid-October. Unfortunately, at the same time and despite the strict sanitary conditions imposed by/at ISU, a significant proportion of the students contracted coronavirus and onsite student attendance was suspended by ISU. Towards the end of October national restrictions on universities in France came into effect and, as with MSS20A the previous academic year, MSS21A moved into fully remote mode with all students, staff and faculty working offsite. The program continued in this mode for most of the academic year. Some students remained in Strasbourg while others elected to return to their homes or other locations.

Unsurprisingly, internships remain heavily affected with only a few MSS21A students being able to complete them in time for a normal graduation, while the remainder will be carrying out their internships and graduating during the coming academic year (MSS22). The additional workload on the MSS team to both deliver the program and manage multiple student cohorts simultaneously over the last two academic year years has been very significant and has required considerable sacrifice. Despite this, the team has responded in a highly committed and professional manner.

3.2 MSS21 Cohort and Actvities

Fig. 1: MSS21A Space Coin (photo credit: C. Welch)

Focusing now on the specifics of the Master of Space Studies (MSS) program 2021 (MSS21), Year A (MSS21A) counted 35 students from 16 countries in Year A.

38% of this cohort identified as female. Year B (MSS21B) featured one thesis student who combined this with a role as a Teaching Associate.

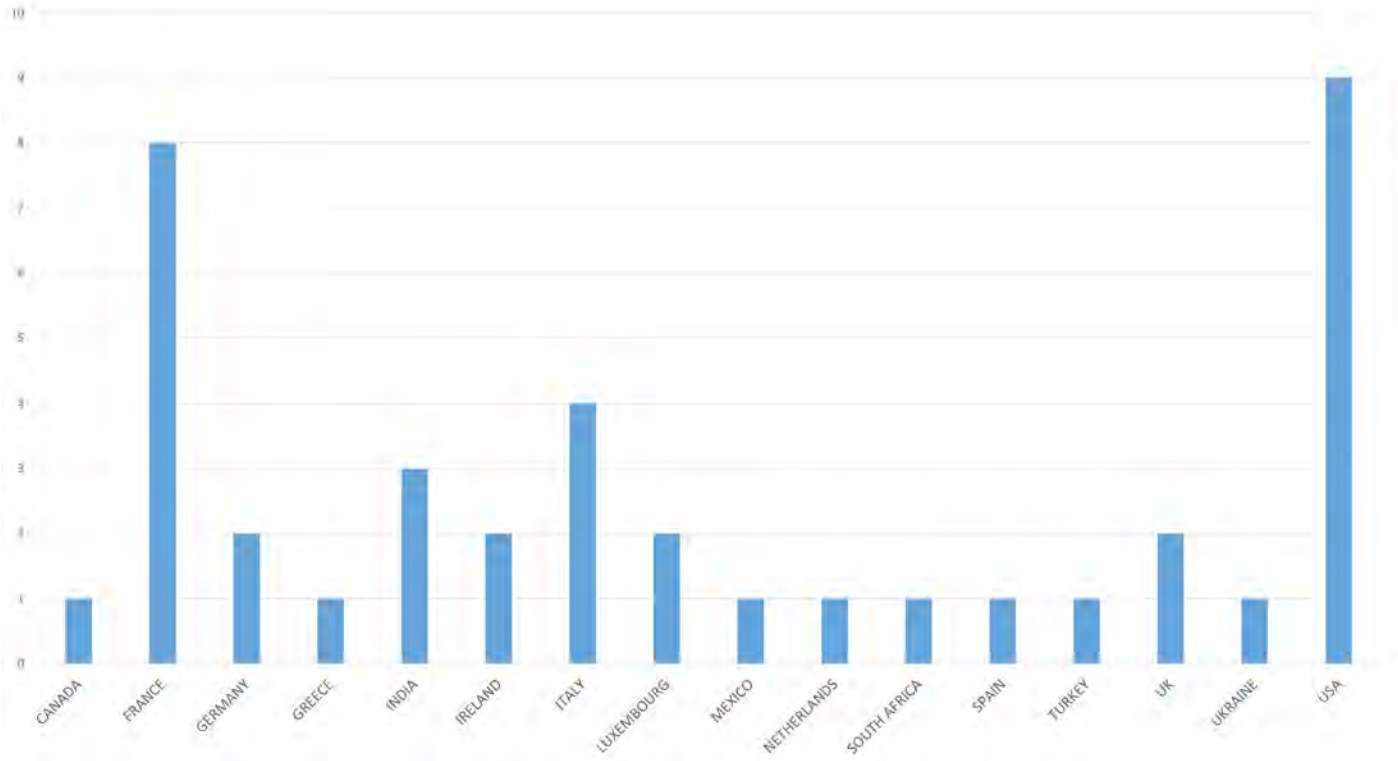


Fig. 2: Distribution of MSS21 participants per country including dual citizenships

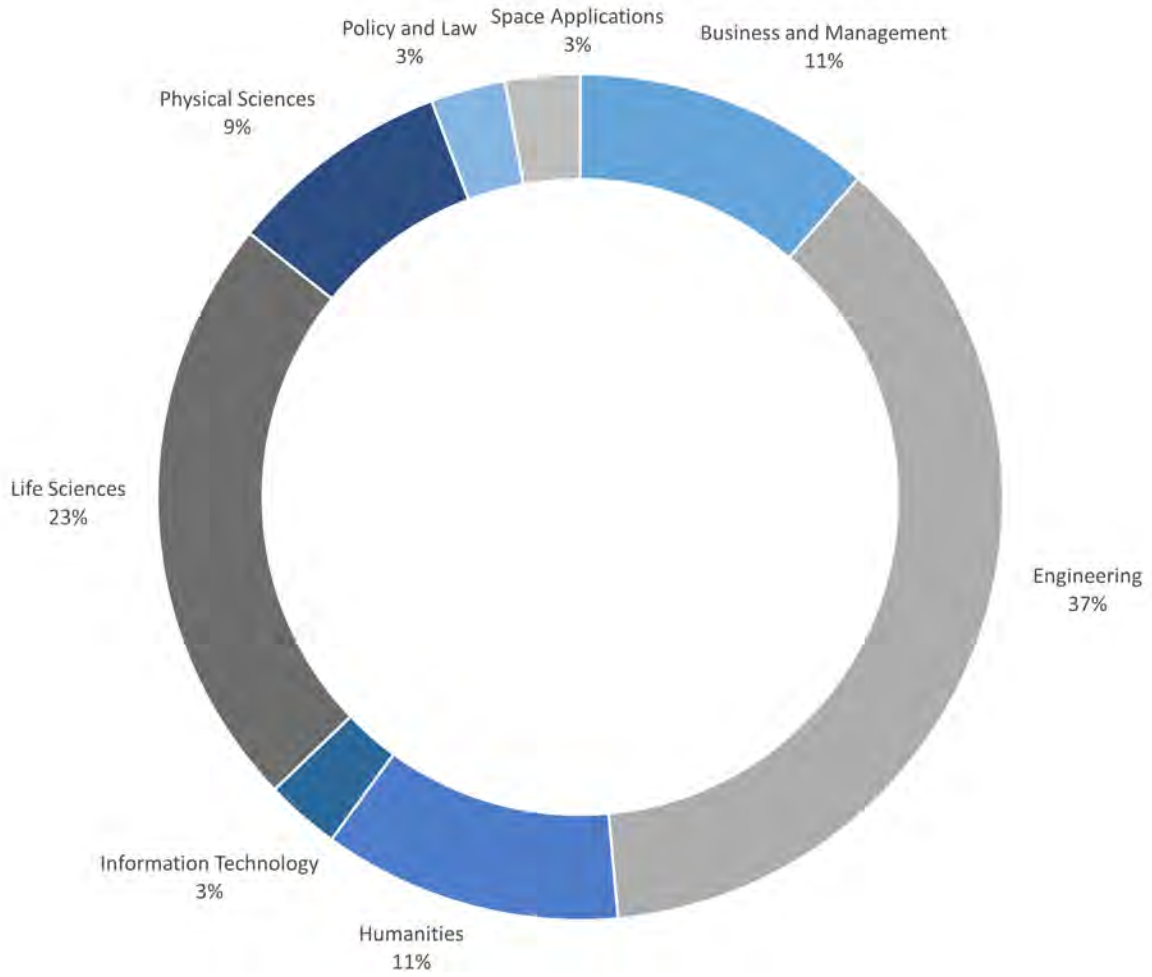


Fig. 3: Educational background of MSS21 participants

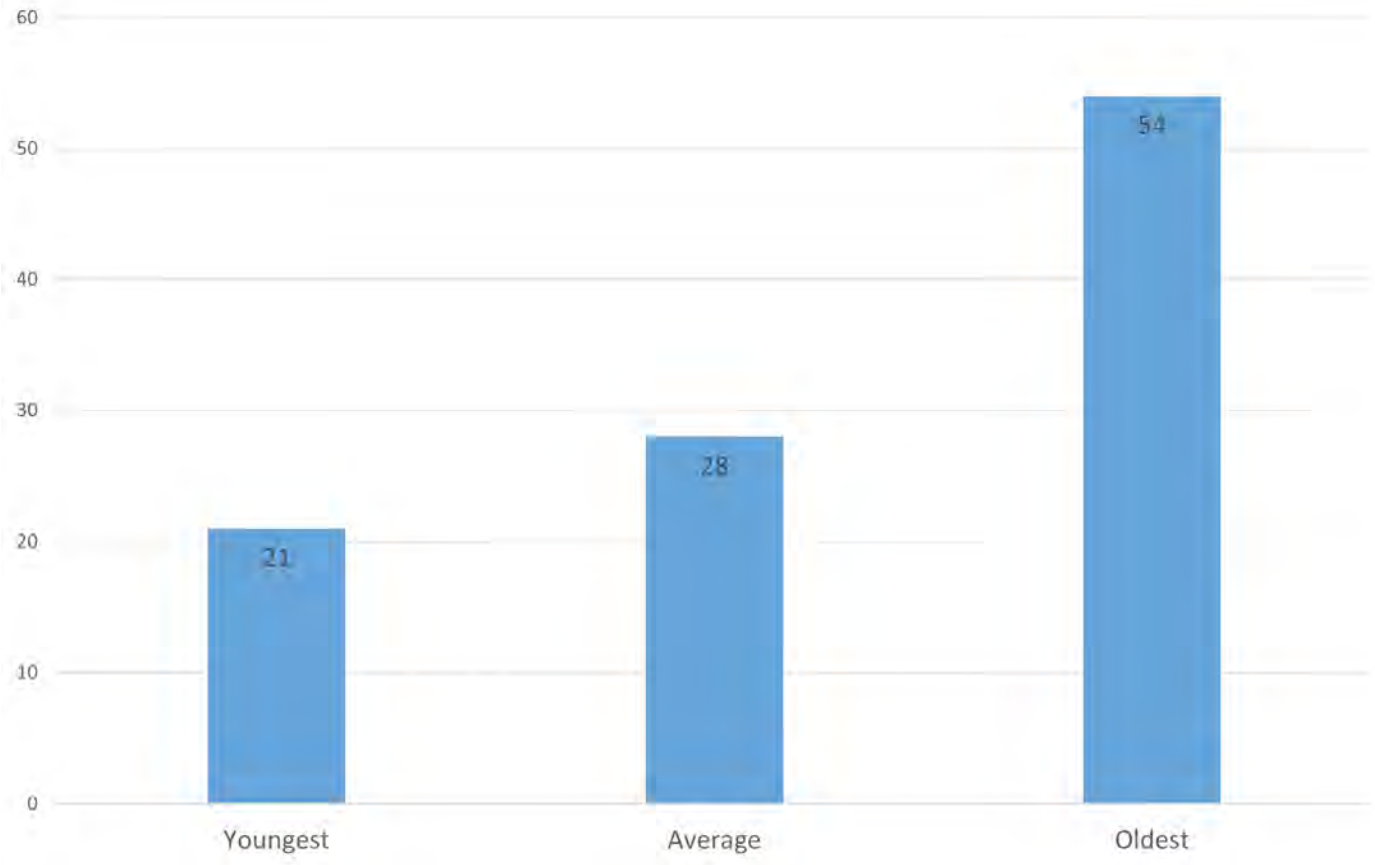


Fig. 4: Age Distribution of MSS21 participants

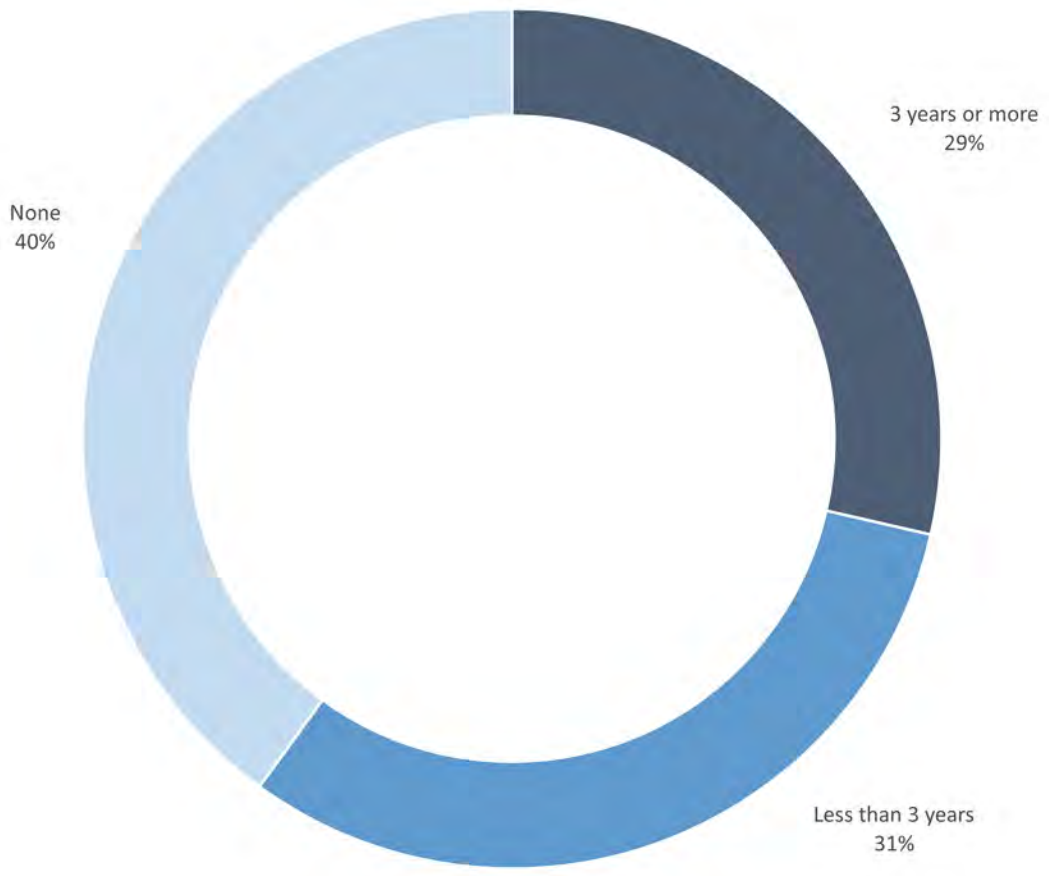


Fig. 5: Distribution of previous experience in MSS21

3.3 Structure of the MSS Program

No significant changes were made to the structure of the MSS, although adaptations for remote teaching and assessment of student were implemented. For MSS21A, the electives which ran were:

- M7-OMX Space Omics
- M8-ISR Interstellar Studies
- M10-ABL Astrobiology
- M13-NSE New Space and Entrepreneurship

M7-OMX Space Omics was a brand new elective for MSS21A. This addressed how spaceflight affects humans and the molecular and biochemical level and how this translates into physiological adaption to space. As far, as is known, this is the first time this topic has been taught in any masters program.

Fig. 6: structure of MSS21A

Normally, the MSS21A program would have been enhanced by a number of offsite activities. Because of the coronavirus pandemic, none of these were able to take place in person, though some remote visits were able to be arranged.

One particularly positive visit that of the MSS21 cohort to the cyber version of the International Astronautical Congress (IAC2020) in October. At this, amongst all the many offerings, MSS21A were able to see individual project and team project presentations by the MSS20A class (see Fig. 7).

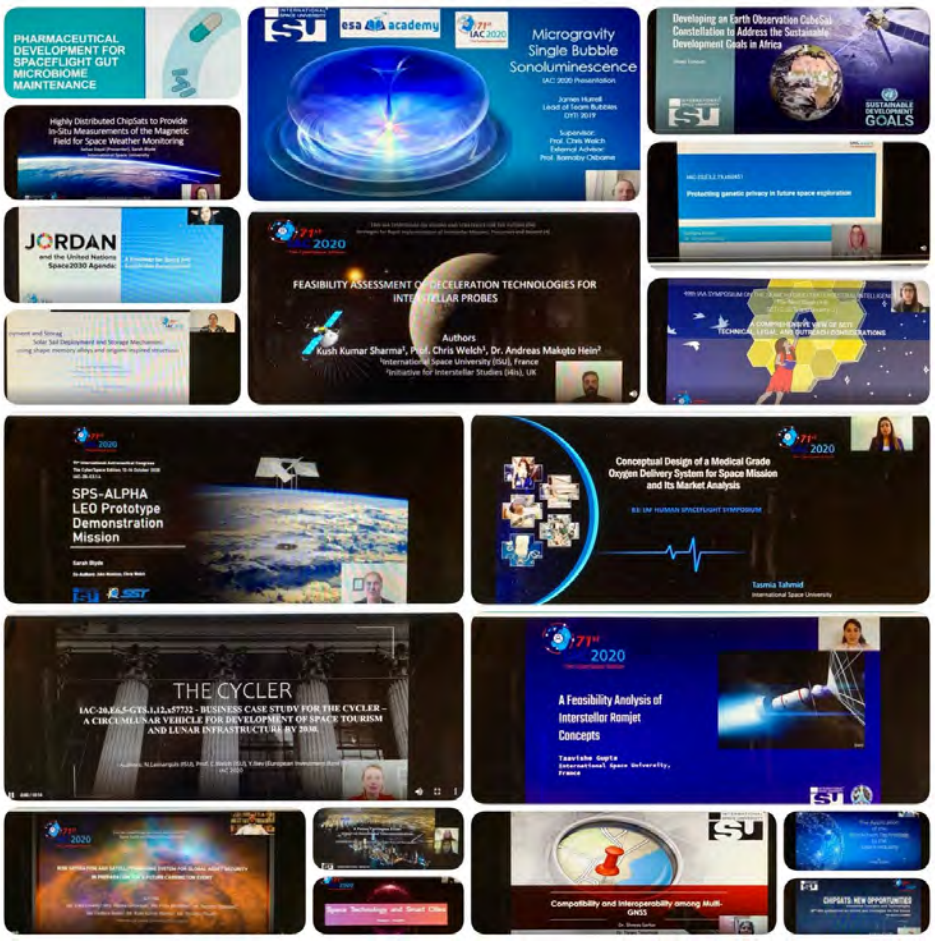


Fig. 7: MSS20A Individual and Team Project presentations at IAC2020 (photo credit: C. Welch)

Another important highlight, which was particularly valuable for student morale during lockdown was a call in December with MSS alumna and NASA astronaut Dr Jessica Meir who spoke to the cohort about her mission to the ISS and life in extreme situations.

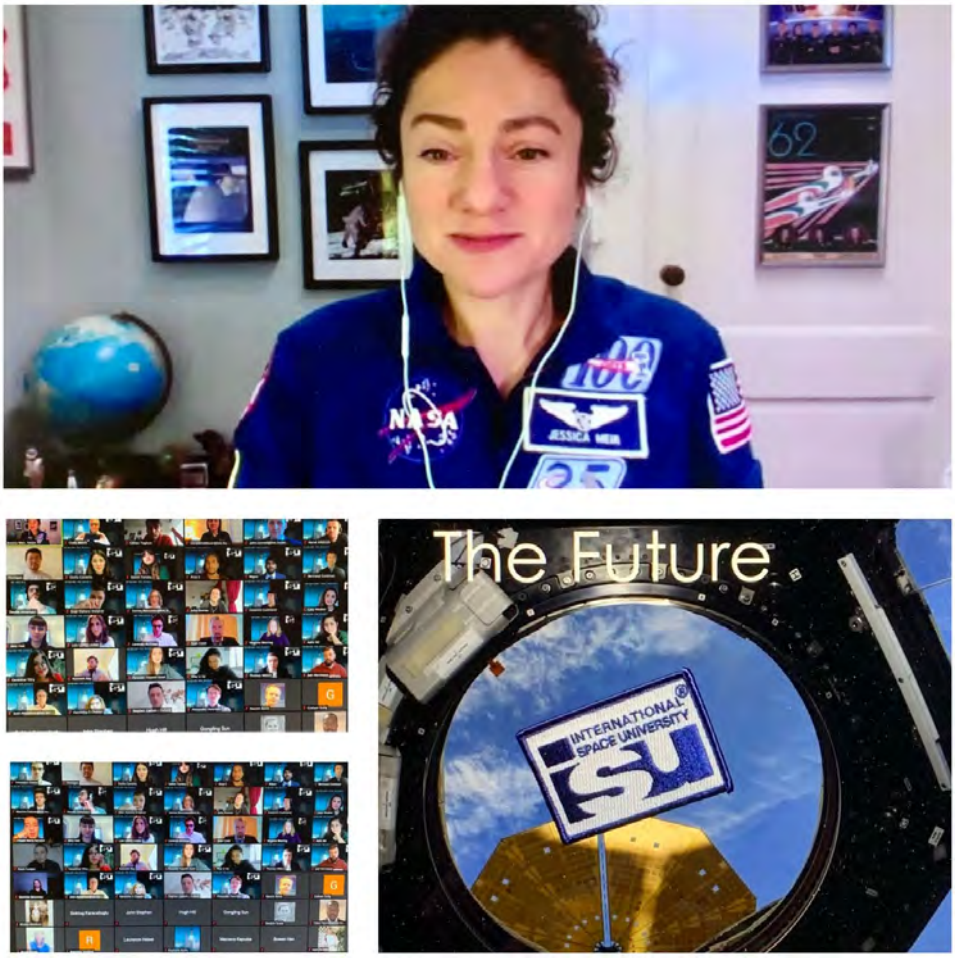


Fig. 8: MSS21A call with MSS alumna and NASA astronaut Jessica Meir (photo credit: C. Welch)

3.4 MSS21A Individual Projects

MSS21A carried out individual projects supervised by central campus faculty, some with the involvement of external advisors. The following individual project prizes were awarded:

- **Association of Space Explorers Europe Prize** - awarded to the student for the best Individual Project related to Human Space Flight: *Amy Holt - Development of a sustainable off-world habitat utilizing a bio-architectural approach*
- **Hypatia Prize** - awarded to the student with the best Individual Project bridging Conceptual Research with Technology Design and Implementation in Space: *Finnegan Kallmyer - Prospective markets for terrestrial use of space mining and resource utilization*
- I**nitiative for Interstellar Studies Alpha Centauri Prize** - awarded to the student for the best Interstellar-related Individual Project: *Laia Llobet - Space missions to interstellar objects: Build-and-wait missions*
- **Icarus Prize** - awarded to the student with the best Individual Project related to commercial space activities including business, financial or investment strategy: *Maxime Falduto - Trade-off between rideshare launch and individual micro-launcher*
- **Manx Precision Optics Prize** - awarded to the student with the highest grade in their Individual Project: *Amy Holt - Development of a sustainable off-world habitat utilizing a bioarchitectural approach*

3.5 MSS21A Team Projects

The MSS21A cohort carried out two team projects:

Space Medical Center

"As mission duration and human presence in space increases, so too will the risk of injury, and likelihood of illness. To ensure long-term settlement of space in-situ medical care will become more essential. This report outlines three different scenarios. Scenario 1 consists of a near-term, space station module and associated configuration to provide optimal medical services to the increasing number of mission crews and space tourists transiting through Low-Earth Orbit in the coming decades. Scenario 2 consists of an idealized modular ground station facility on the lunar surface developed with the aim of providing sustainable and autonomous medical care for future lunar settlements and human deep space exploration. Scenario 3 consists of a concept for an artificial gravity station that will act as a dedicated space facility in Low-Earth Orbit.

For all three scenarios, medical care, countermeasures, and technologies were analyzed and selected for use in a Space Medical Center (SMC) based upon their capability to provide effective care and preventative measures in confined microgravity or reduced gravity environments.
Appropriate present and future medical care for space crews and tourists include primary, acute, critical, pharmaceutical, surgical, and psychological care alongside suitable countermeasures and emergency services.

The scope of this report considers real-life scenarios and current trends in space medical practices. This is in an effort to develop comprehensive in-situ medical care in each proposed environment while complementing current efforts in a synergistic way. The modular approach to constructing a medical center considers scenarios pertaining to the growth of space economies for in-orbit missions, lunar exploration, and space tourism."

Space and Oceans - Tracking Plastic Pollution in the Arctic Ocean from Space

"There is a growing concern over the ubiquitous distribution of plastic pollution that is evolving in the Beaufort Gyre in the Arctic Ocean, prompting international collaboration and new environmental measures. Despite an exponential increase in the amount of data on plastic in the five ocean gyres using space technologies (i.e. satellites) and applications, trends in the Arctic Ocean remain scarce, requiring innovative solutions to monitor the growing situation. The geophysical characteristics and presence of sea ice make it difficult for current technologies, specifically Earth observation, to detect and track microplastic. Marine pollution is recognized as an immediate threat to both land and marine ecosystems. Satellites have proven useful in identifying ocean plastic patches and current movements in other oceans but little research has been applied to the Arctic, a region that impacts eight countries making up the Arctic Circle.

This is in part because plastics are less observed compared to melting ice caps. Nonetheless, as noted by environmentalists and academics, waiting until an ecological problem becomes a disaster only exacerbates the situation. Moreover, as sea ice melts, new economic opportunities for marine activities including new trade routes (i.e. Transpolar Sea Route), fishing locations, and resource exploitation will lead to increased pollution. Due to the expanse of the Arctic Ocean, its frozen characteristics, and developing plastic problem, adapting current space technologies and applications to monitor and track plastics on the surface, in the ice, and below the surface could be a solution for tackling the problem before it meets the level of the existing five Gyres.

This interdisciplinary team project paper investigates the use of Sentinel-2, Sentinel-6, Fourier-Transform Spectroscopy, stratospheric balloons, and autonomous underwater vehicles to provide an integrated strategy, including communication and outreach, to tackling marine plastic pollution while recognizing that it is necessary to also prevent plastics from entering the ocean in the first place.

The general cost of the operations was considered in tandem with an overview of the financial loss and societal burden of ocean plastic. Included in the paper is a proposal for the enhancement of the Arctic Council

3.6 MSS Accreditation

Following the decision by the ISU Board of Trustees to embark on a process of accreditation of the Master of Space Studies program, the ISU resident faculty and staff prepared a Self-Assessment Report on the MSS2021, consulted with the ISU Academic Council and submitted the Report to the Accreditation Agency for Study Programmes in Engineering, Informatics, Natural Sciences and Mathematics ASIIN in April 2021.

A virtual visit followed in June 2021, and allowed ISU to present additional information regarding the different modules, such as the electives and individual project, and describe the campus facilities.

In order for ISU's Master of Space Studies program to satisfy all the requirements set by the European qualification framework against which ASIIN performs its evaluation, the program has to be redesigned to comply with European Standards and Guidelines.

In particular, more specialized courses as well as an introductory module addressing specific needs of incoming students based on their field of expertise will be included in the redesigned Master program.

In addition, it must be ensured that the study program encompasses a final thesis or final project based upon scientific research and methodology. The additional teaching material and extended research project require a longer program of 18-months.

At the same time the entire MSS program (Courses, Projects, Experiments, Thesis) will be modernized reflecting the dynamic, public and commercial space sector.

4. Space Studies Program (SSP21)

This year's Space Studies Program of the International Space University (SSP21) brought together 110 participants representing 35 nationalities and bringing a variety of backgrounds in science, engineering, humanities and social sciences.

For the 9-week residential SSP21, participants and lecturers were geographically distributed between the University of Granada, Spain, and the ISU Central Campus in Strasbourg, France.

The content was delivered by around 150 experts from the ISU Global Faculty under the academic leadership of a team of 34 Faculty Chairs.

Fig. 9: SSP21 participants

Fig. 10: Mission patch designed by SSP21 participants

4.1 SSP21 Participants

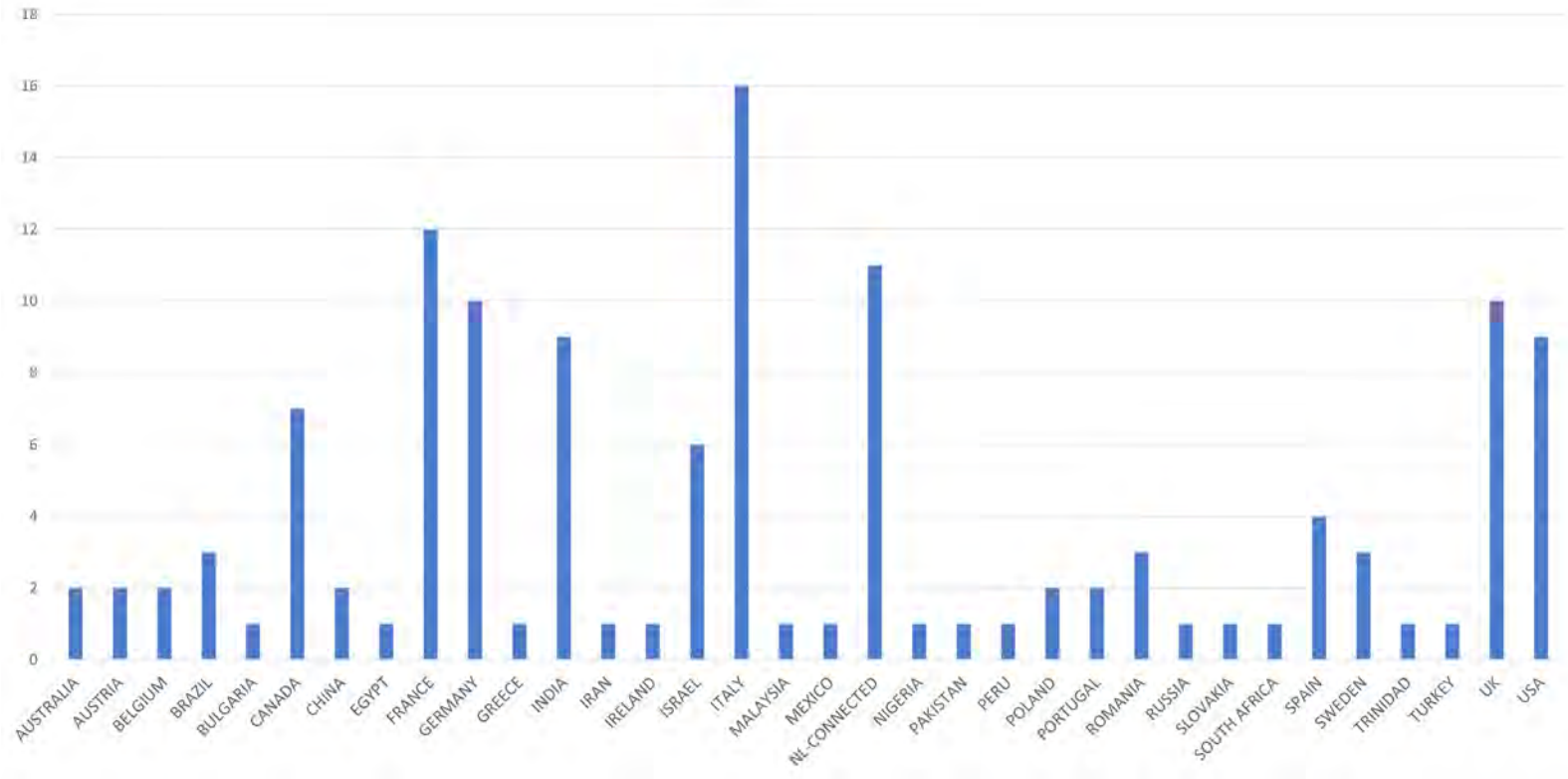


Fig. 11: number of SSP21 participants by nationality (*)

(*) Stichting Space Professionals Foundation (SSPF) contributed to the selection and partial funding of 11 participants from The Netherlands or based in the Netherlands.

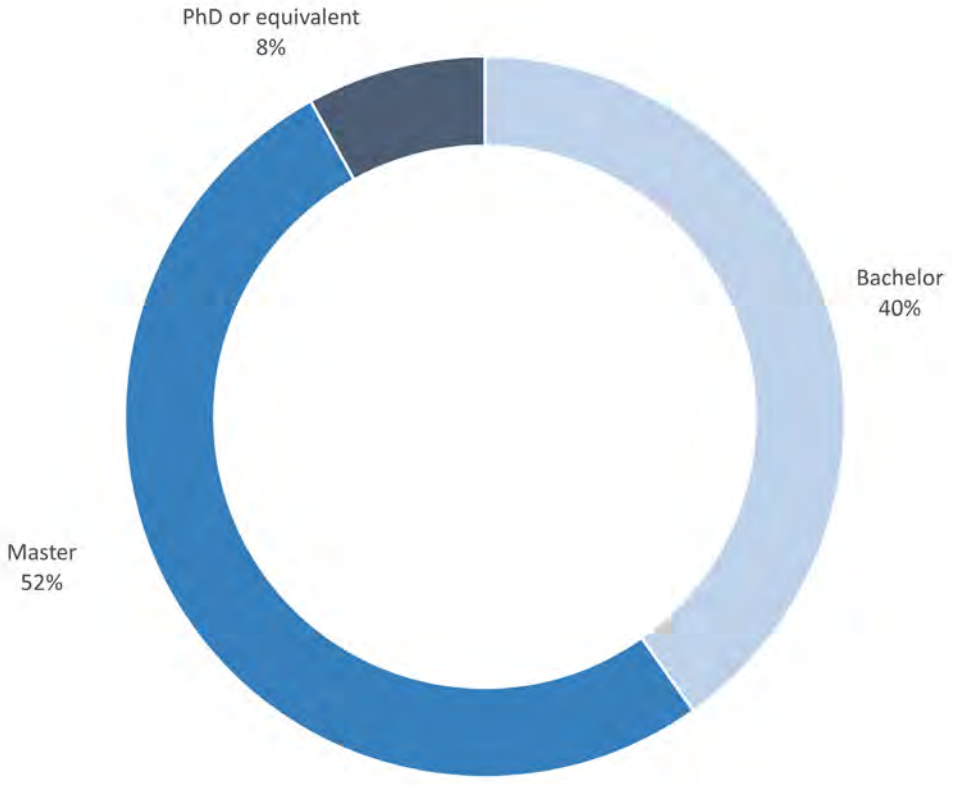


Fig. 12: Educational background of SSP21 participants

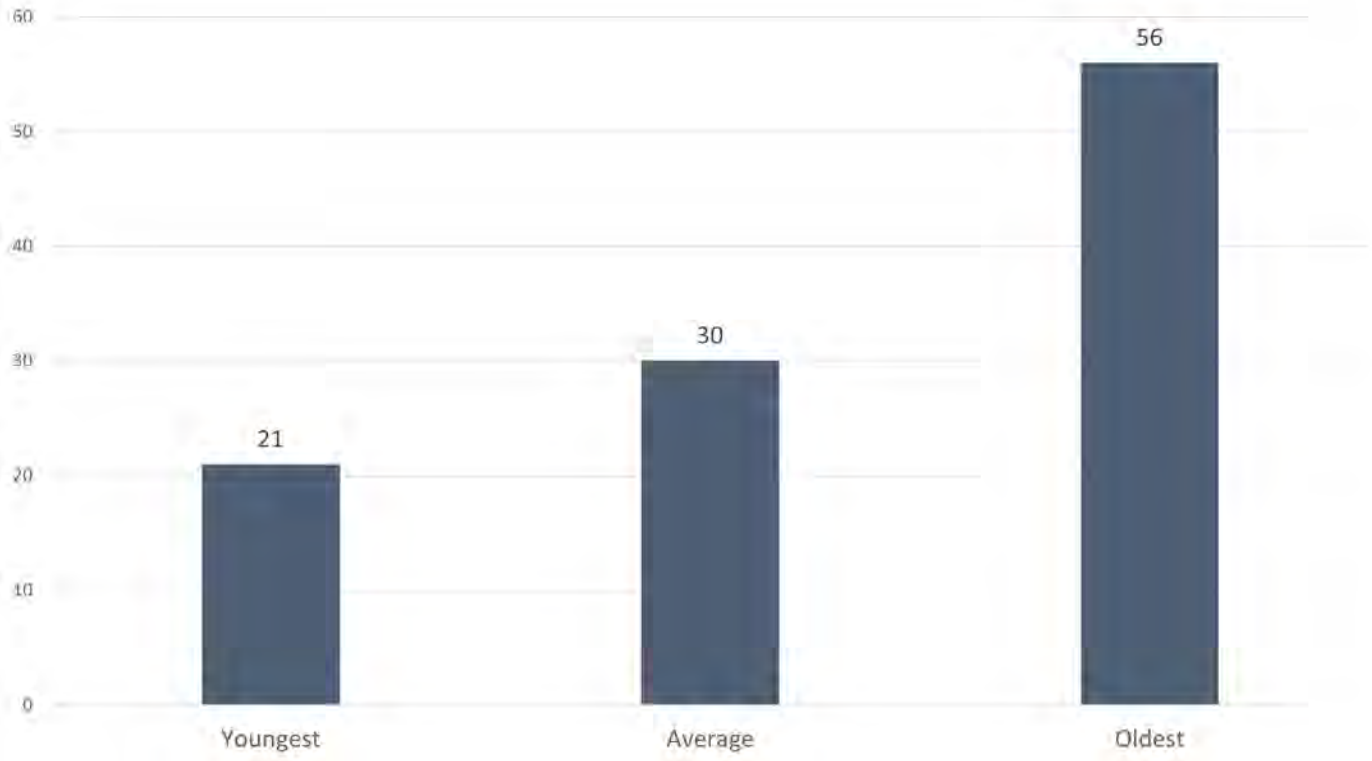


Fig. 13: Age Distribution of SSP21 participants

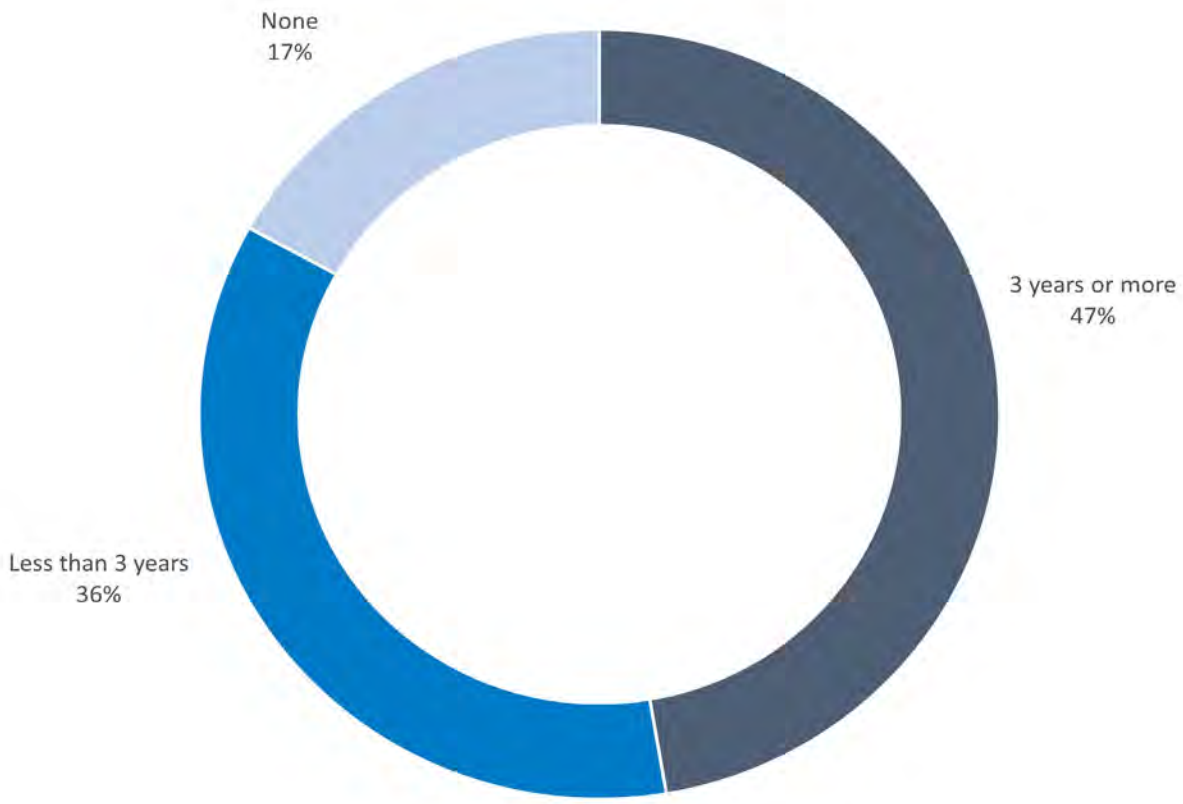


Fig. 14: SSP21 participants professional experience

4.2 SSP21 Program content

The SSP21 curriculum offered the following components:

- Over 40 Core Lectures on all Space-related disciplines
- Over 50 hands-on workshops
- 12 half-day sessions offered by each of the 7 Departments: Sciences; Engineering; Human Performance in Space; Humanities; Management and Business; Policy, Economics and Law; and Satellite Applications
- 5 Team Projects presented in more detail in the next section
- Professional visits to Space-related Research facilities and companies in France, Germany, Luxembourg and Spain
- More than 10 distinguished lectures and fireside chats with prominent speakers from Academia, Government and Industry
- A 48 hours non stop onlime Alumni Conference with over 600 registered participants.

The overall structure of the program is shown in Fig. 15.

Fig. 15: SSP21 program structure

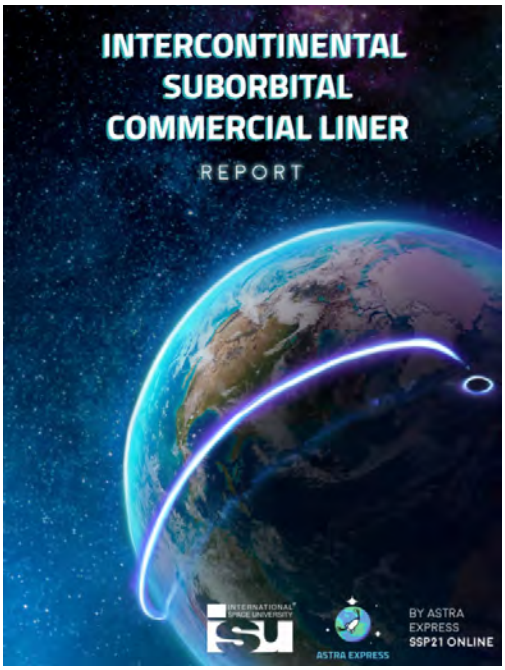
The 6-week online version of SSP21 included Phases 1 (core lecture series) and 3 (team project) of the usual SSP. In addition, this online version included its own workshops specifically designed for an online audience, which were not part of the on-site curriculum.

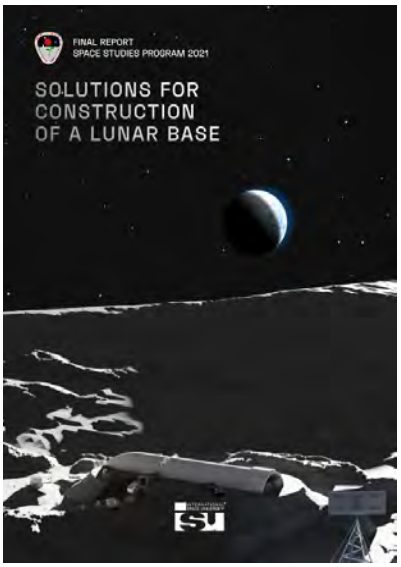
4.2 SSP21 Team Projects

The SSP21 Team Projects tackled the following topics:

Team Project Intercontinental suborbital transportation liner

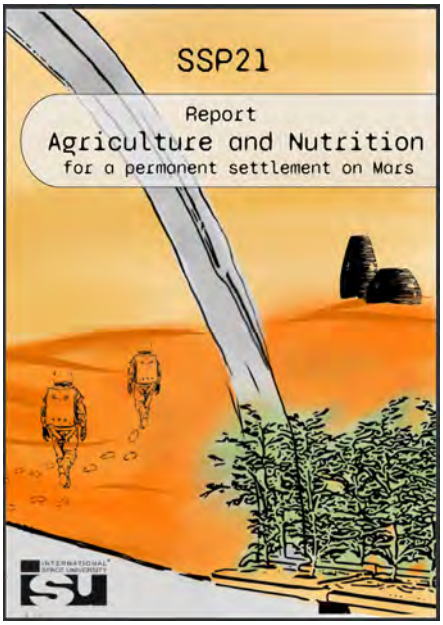
An investigation on reusable space transportation technology to build a fast and convenient intercontinental passenger/cargo service: its commercial value in the future, and its related technical, commercial and legal issues.





Team Project Mobility: cost-effective transportation between the Earth and the Moon

A solution for cost-effective and faster Earth-Moon transportation based on reusable orbital vehicles, to enable a thriving economy on and around the Moon. The study compares different propulsion technologies such as chemical, nuclear electric and laser from the performance, risks to human health, legal, business, and engineering aspects. The report describes the new opportunities for scientific advancement that could be enabled by such new transportation systems, as well as their impact on society.

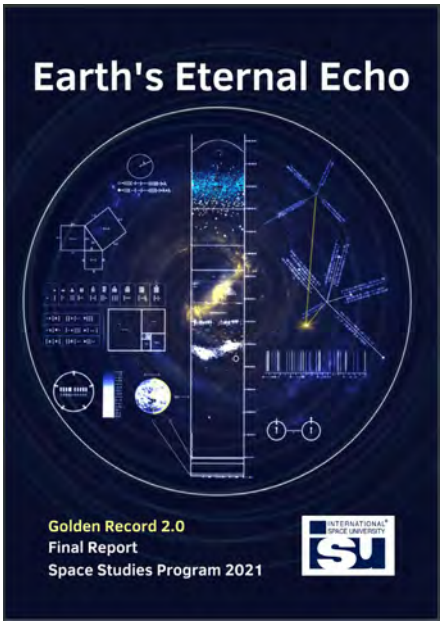


Team project Agriculture and nutrition for a long-term Mars mission, and benefits to Earth

A study of the challenges and solutions in nutrition and agriculture for a population of 100 in a water-rich equatorial region of Mars. The inhabitants will remain on Mars for long periods ad will be able to return on completion of their mission. The project assesses the inhabitants' health and well-being, as well as the scientific, technical, legal, and business aspects of an agriculture system. The report identifies how the technologies developed could be applied for the benefit of society on Earth.

Team Project Lunar: towards a permanent and sustainable lunar base

A roadmap for the construction of a sustainable, habitable, and permanent lunar base. The study addresses regulatory and policy frameworks, as well as technological and anthropological challenges. The report presents how scientific and commercial lunar activities can contribute to the common interest of humankind.



Team Project Eternal Echo: humanity's next message to the Cosmos

Following Voyager's Golden Record launched in the 1970s, our new message aims to portray our human essence as part of the universe, with the hope of connecting with other intelligence among the stars, and to allow our memory and existence to endure forever throughout the cosmos as an Eternal Echo.

5. Southern Hemisphere Space Studies Program - SHSSP21

The tenth Southern Hemisphere Space Studies Program was conducted online from 18 January to 19 February, 2021, in partnership with the University of South Australia (UniSA). The novelties this year include the fully virtual format of the program and its delivery in two time zones: Asia Pacific and Europe, with some components delivered in each time zone separately, and daily sessions that brought together the entire class, especially for the Team Project (TP) work.

The five week program was modelled on and designed to complement the Northern Hemisphere SSP each year during the Southern Hemisphere summer. It attracts a diversity of students at various levels of experience from both the Southern and Northern Hemispheres. SHSSP21 attracted 33 participants from 11 countries.

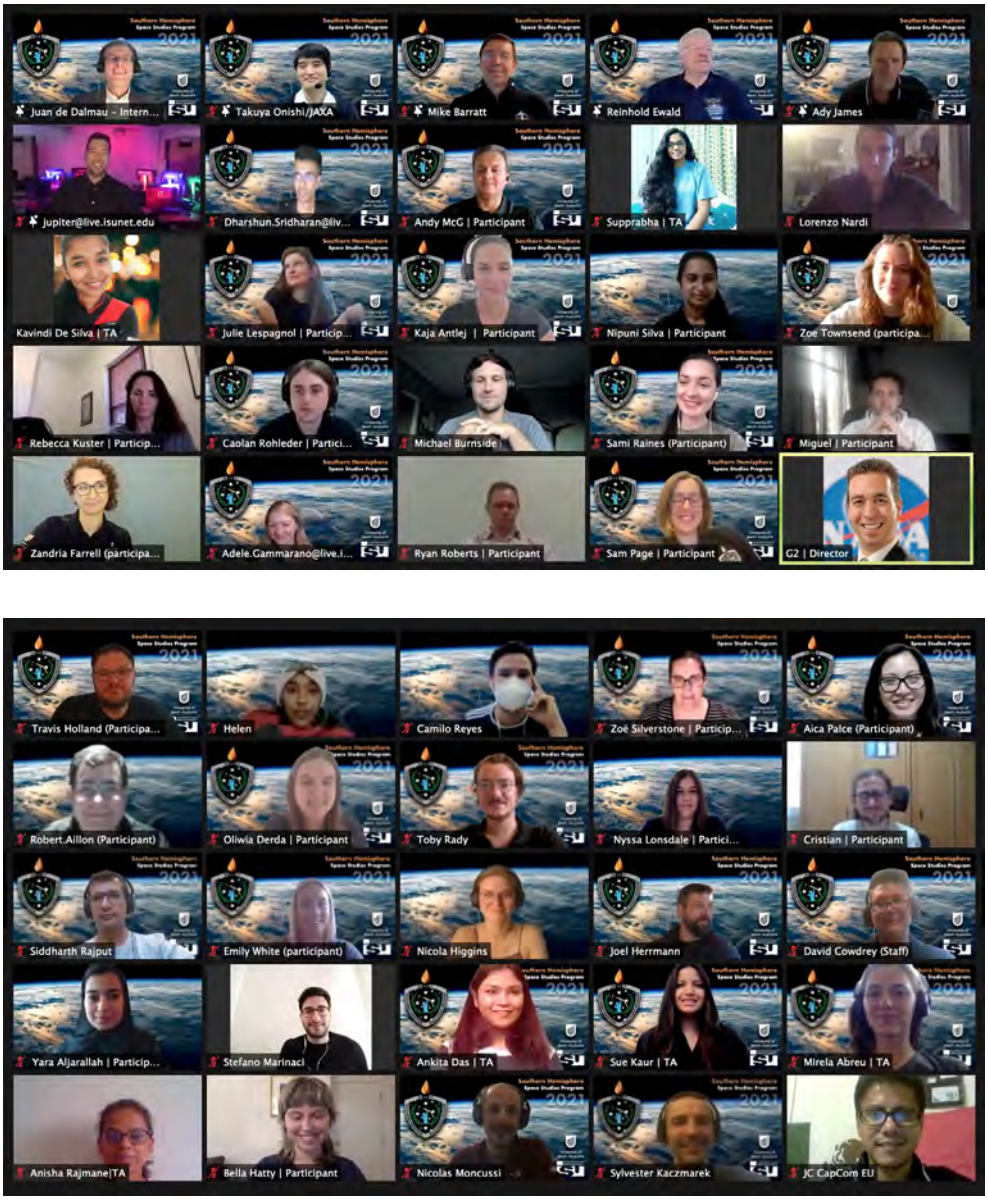


Fig. 16: SHSSP21 participants

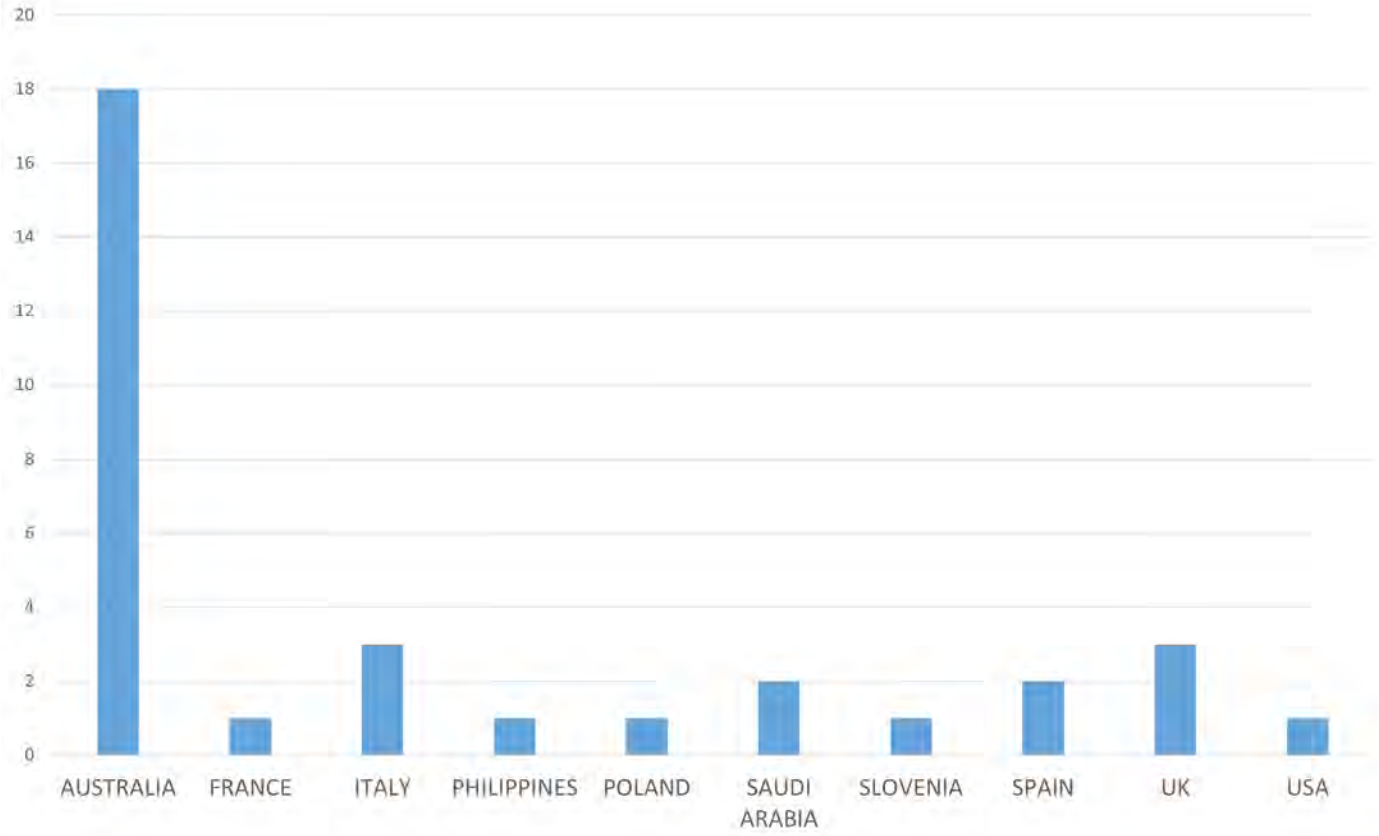


Fig. 17: Distribution of SHSSP21 participants by country

The distribution of educational backgrounds for SHSSP in 2021 continues to show a broad mix of disciplines:

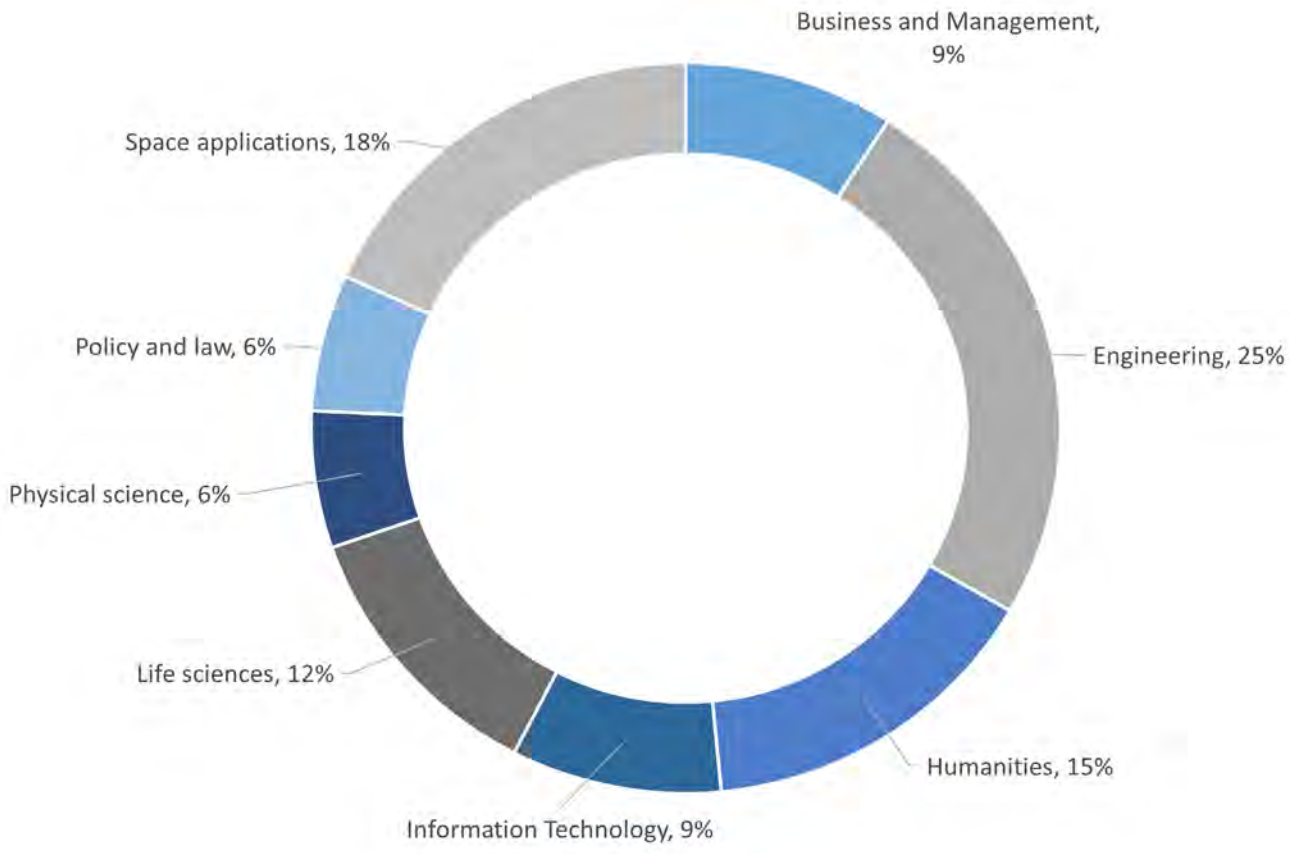


Fig. 18: Distribution of SHSSP21 participants by background

All participants received Certificates of Completion from ISU and Executive Certificates from the University of South Australia, and each year participants are eligible to receive 50 percent credit upon admission to the **UniSA Graduate Certificate in Space Studies.**

The SHSSP's core lecture series comprises one third of the program, presenting 40 lectures covering the world's space activities with a focus on space applications, services and policy. A broad understanding of the role of space, the current status of our capacity to use it and future directions, opportunities, and challenges for the space sector will be presented in a manner clearly understandable to participants from a broad range of backgrounds.

Another one third of the program is allocated to hands-on workshops and the final one third is the group Team Project assignment to be completed in week 5.

The Team Project tackled by the class of SHSSP21 was "Space assets and technology for bushfire management". The final report and the executive summary are freely available in the ISU Library's website. Only an abstract is reproduced below.

With specific reference to the 2019-20 Australian fire season, the report looks at the:

a) current state of the art,

b) key challenges, and

c) how bushfires can be better predicted and mitigated in the future.

Comparing this to the future desired state, gaps were identified for each of the three domains a), b) and c) above. Several of these recommendations were derived independently by two or more of the three groups, highlighting the importance of a holistic and collaborative approach.

The report concludes with recommendations covering technology, policy and international collaboration.

6. Commercial Space Program - CSP21

For the third consecutive year, the Commercial Space Program Graduate Certificate Program was conducted in partnership with the Florida Institute of Technology. The 12 students from diverse backgrounds in science, engineering and business followed an intensive series of courses focused on commercial space with an emphasis on technical and entrepreneurial management, public-private partnership, and New Space activities.

Fig. 19: CSP21 participants

7. Short Courses

7.1 Executive Space Course (ESC) The Americas Online

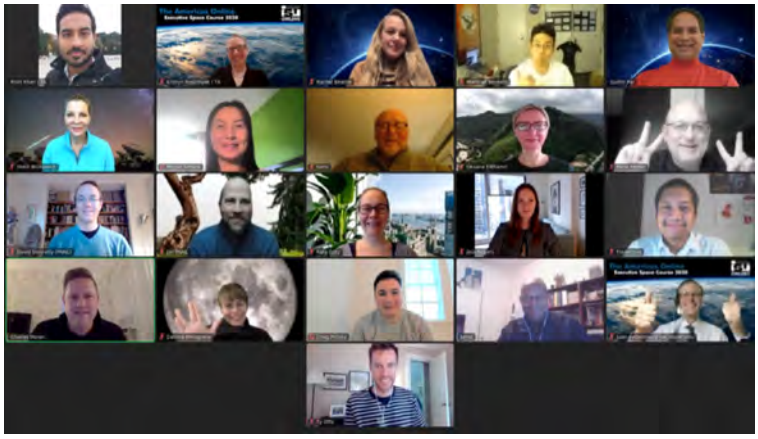


Fig. 20: ESC21The Americas participants

ESC-Seattle was held online this academic year, from 16 to 20 November 2020, in close cooperation with the hosts of the traditional in-person ESC offered each year in Seattle, USA, and with ISU partners and experts in Central and South America.

16 participants attended the course, representing companies such as the US Pacific Northwest National Laboratory (PNNL), the US Space Foundation and ManSat, with backgrounds from a wide range of disciplines such as legal, investment management, manufacturing, IT, and business operations.

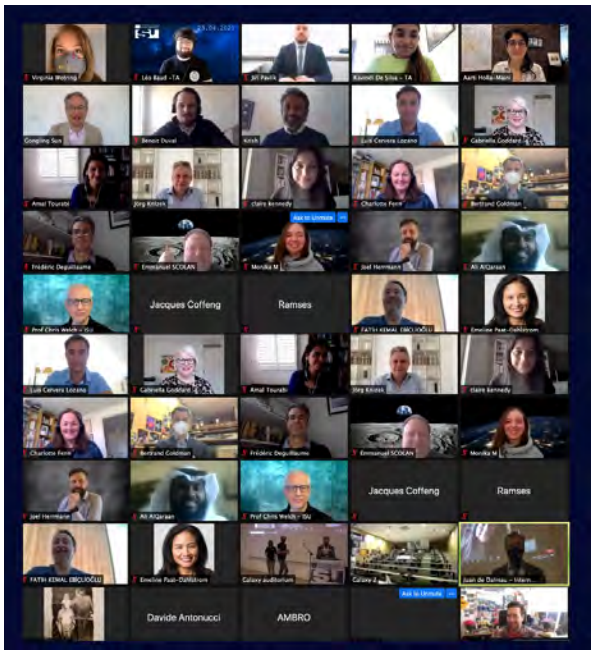
7.2 Executive Space Course (ESC) for the Asia Pacific Region Online

Fig. 21: ESC21 Asia Pacific participants

The first International Space University Executive Space Course in the Asia Pacific region was attended by 12 professionals from agencies, research institutions, and industry executives from Australia and South Africa. The program was co-developed with New Zealand based SpaceBase, co-founded by two ISU alumni, Emeline Paat-Dahlstrom and Eric Dahlstrom. The course was opened by the head of the New Zealand Space Agency, Dr. Peter Crabtree.

The five-day intensive course included sessions from seven space disciplines – from policy and law, to engineering, and satellite applications. The program was delivered by over 40 specialists from seven space agencies, academia, and industry experts from 16 countries. There were workshops from UNISEC Global as well as panel sessions on Asia-Pacific activities, entrepreneurship, and investments. Representatives from start-up companies in the region such as I-Space, Astroscale, Dawn Aerospace, and Earth2Orbit discussed the challenges and opportunities in commercial space. Investor groups Singapore Space and Technology Ltd, Moonshot, and E2MC described the growing funding opportunities in the New Space sector.

7.3 Executive Space Course (ESC) Strasbourg Online



ISU Strasbourg was held online again this academic year, from 19 to 23 April 2021.

Nineteen participants from eleven countries attended the course, representing companies such as the NOVA Systems, Airbus Defence and Space, or organizations like European Investment Bank, with backgrounds from a wide range of disciplines such as legal, investment management, marketing, IT, and business operations.

Fig. 22: ESC21 Strasbourg participants

7.4 Space Resources Course - Luxembourg Online

The first online edition of the Space Resources Professional Course (SRPC) was co-organized with the Colorado School of Mines and the Luxembourg Space Agency.

The 82 participants represented four continents and came from a diversity of backgrounds and industries.

The lectures covered resource identification, collection, extraction (a range of extraction processes to produce useable resources have been proposed, such as oxygen production from lunar regolith, extraction of lunar ice and construction of habitation by 3D printing), processing, and utilization systems under development. Also discussed were economic and technical feasibility studies; legal and policy issues, and space ex ploration architectures and commercial ventures that may be enabled in the near future by using extraterrestrial resources.

Fig. 23: Space Resources Course 2021 poster

8. Research and Publications

8.1 Library Services

The Library reopened in September 2020 with new health procedure, physical distancing, book quarantine and **'click & collect'** service. By mid-October, France imposed a second curfew and the Library returned to online services only. Despite these challenges, the Library managed to provide services as close to "normal" and to maintain services and close communication with the students.

On a weekly basis, we provided l**ists of available book titles** related to the lectures of the week and students used the electronic version or came to pick up the books at the Library. **Reference and research services** were offered at a distance by email and we continued to provide journal articles in pdf for their Team Project and Individual Project. We increased **digital access and virtual interactions**. We organized online trainings and negotiated databases trials with our suppliers.

For **SSP21** participants, we provided five online onboarding sessions to get them introduced to Library services and resources. We created five online subject guides for the Team Projects to highlight key resources, acquired relevant journal articles in pdf as an introduction to TP research. We are using the MS Teams platform to get embedded in the Team Projects groups and support them from the inside.

As part of the **building renovation**, the Library will undergo major transformation. During the work, we will have to create a small Library in another part of the building. To prepare this move, we undertook a large weeding of the collection and updated the online catalog accordingly. Removed items were mainly donated to staff and students, some were trashed and some have been sold to SSP21 participants.

To respond to the **impact of Covid-19** on ISU's financial situation, the Library unfortunately had to cancel subscriptions to journals and online databases. Nevertheless, the Library had to maintain acquisition of ebooks as most of the MSS21 program was performed remotely and the SSP21 program was off-campus for two groups of participants.
Our **content curation service** gathers scholarly journal articles, reports and information from various scholarly and peer-reviewed sources about subjects relevant to the University's curriculum, to which anyone can subscribe via RSS feeds.
Information selected by ISU librarian:
https://bit.ly/2UIYWqc

8.2 Research activities

ISU faculty and students continued to pursue their research activities during the academic year, despite the restrictions set on research travels and conferences due to the pandemic.

Two internal calls for proposals were issued to assign, through a competitive process, the resources allocated by the Board of Trustees for FY21. The goal was to develop internal and collaborative research projects and fund equipment and internships. Six proposals were submitted, to support projects in the fields of life sciences, astronomy and payload engineering.

One student, Ms. Stephanie Rocha, defended her research work conducted during her MSS thesis year. The purpose of the project was to conduct the thermal analysis of a 1-U CubeSat Lunar Plant Growth Experiment (LPX) placed on the South side of the Moon, using the case of the Arabidopsis plants to define the temperature constraints. The thermal analysis was conducted with the Systema Thermica modeling software, courtesy of Airbus Defense and Space.

Two students started a thesis year research project, one working part-time on polarimetric observations of nearby brown dwarfs; and the other on the initial chipsat design as a hosted payload to a cubesat mission.

Several external proposals to European and French funding agencies were submitted, which included provisions for PhD and postdoc fellowships, but none was yet successful. Nonetheless, the submission of those proposals allowed us to strengthen our link with potential partners.

As in the previous year, the faculty pursued research primarily in the following fields:

IISRU: the rationale of the project is the building of future lunar habitats using in-situ material in combination with on-site additive manufacturing (AM) technologies. The material considered is lunar regolith, represented by various simulants. This constitutes the core of the PhD thesis of Ms. Danijela Stupar.

The project is split into two parts: a simulation performed with COMSOL Multiphysics software; and experiments conducted at the nearby ICube laboratory of the University of Strasbourg, ECAM, the IS2M laboratories, and in collaboration with the Institute Clément Ader of the Mines Albi-Carmeaux engineering school.

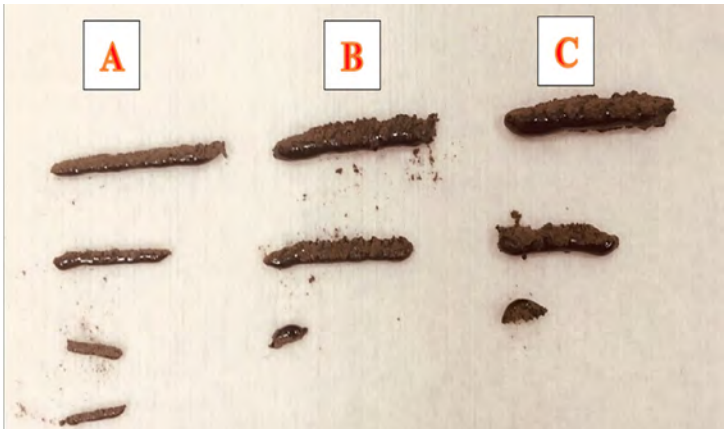


Fig. 24: Samples of 2D printed samples of regolith stimulants

Regolith looks like dust, with irregular shape of grains ranging between 40 µm to 800 µm. Its chemical composition primarily consists of silica and aluminum, but it also contains iron, titanium, calcium and magnesium. Respecting those chemical and physical characteristics, regolith simulants were created in specific laboratories. For this particular research, we selected JSC-2A, LHS and LMS as the most suitable material, as well as the most readily available. Current conclusions find that simulation and experimental results are in good agreement. So far, all experiments were done in 2D (see Fig.1). Ms. Stupar aims to start tests of 3D laser printing. This research was published in the proceedings of five conferences this year.

Space Payload Laboratory: Activities related to the Hydra ISS cubelab series continued, with the publication of one refereed paper based on the Hydra-1 payload together with six conference papers, the majority of which were outcomes of MSS student individual projects, under the supervision of Prof. Chris Welch.

The Hydra-3 ISS payload (see Fig.25) celebrated its third orbital birthday in June. Additional utilization of the Hydra-3 with MacQuarie University and the Bits-core Company has been investigated and is currently moving forward.

Support for research-related external activities has continued through membership of the UK Future AI and Robotics in Space (FAIR-SPACE) Hub, Independent Steering Committee and co-editorship of the Frontiers Online - Creative Performance in Extreme Human Environments: Astronauts and Space topic.

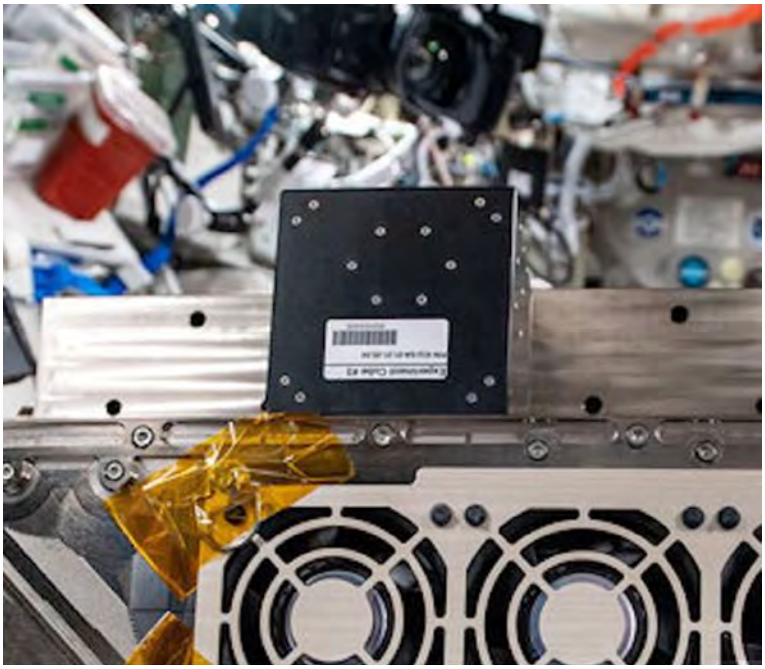


Fig. 25: Hydra-3 payload on board the ISS

Dr. Taiwo Tejumola joined the team of the Institut für Raumfahrtsysteme (IRS) at the University of Stuttgart on the Design and Development of a Plasma Instrumentation for Research and Observation in Medium Earth Orbit (ROMEO) Satellite as a mission specialist for the design and development of a low-cost plasma measurement system. The main objective of the mission is to develop a cost-efficient satellite bus that demonstrates new technologies in low (LEO) and medium Earth orbit (MEO). The plasma instrumentation will apply the principle of double Langmuir probe for the characterization of transitional orbit (LEO to MEO) of the satellite (see Fig.26).

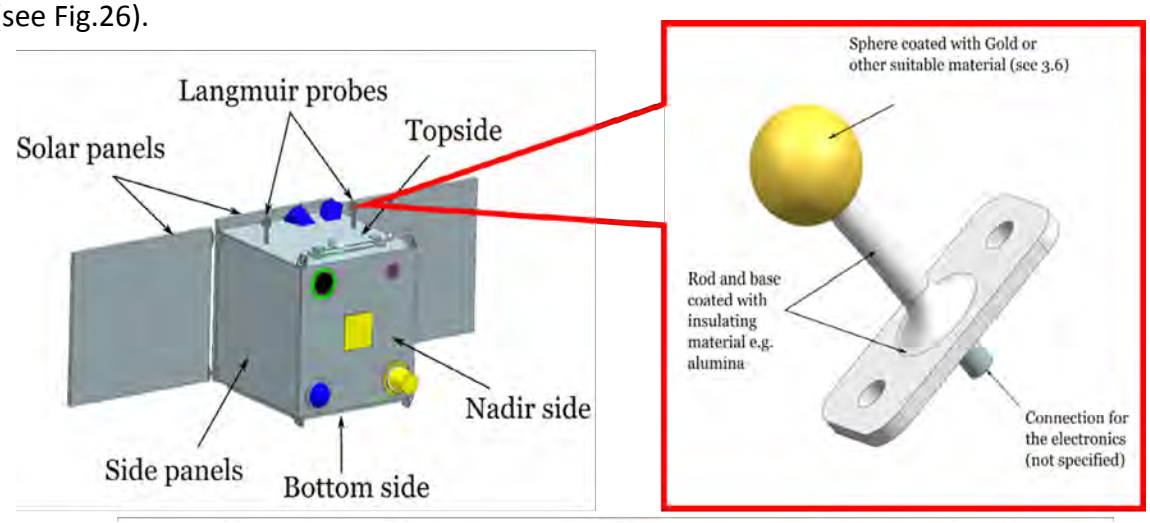


Fig. 26: Schematic view of the ROMEO satellite with the two Langmuir probes contributed by ISU

Dr. Tejumola also joined a group of development experts in Africa, South America and South-East Asia, to study the significance of cubesats for development goals. Even though it is specific to the space technology sector, space technology is essential to development practice, and studies thereof, because much of it depends on the Earth observation, navigation, communication and other functions provided by satellite infrastructure. The study is an interdisciplinary approach covering social sciences, economics, policy, and systems engineering principle to posit that bigger is not always better. In this context, cubesats represent an opportunity to rethink and redefine development, on Earth and in space.

Unfortunately, the sanitary measures limited experimental work, and the position of the Space Payloads Laboratory Mission Systems Engineer was discontinued for budgetary reasons when the position holder left ISU in January.

In **Astronomy**, five peer-reviewed publications resulted in the fields of Astrobiology – including the origin of life – and Astrochemistry, with ISU contribution led by Prof. Hugh Hill.

Novel carbon chemical cycles in the inner Solar System were investigated, as were volatile-rich asteroids in near-Sun orbits.

Astrochemistry occurring on the surfaces of astrophysical ices -- such as cometary ices – was also analyzed along with potential astrobiological implications.

All of these areas of investigation are most relevant to current and future Planetary Science missions, e.g., the Discovery program.

Regarding the origin of life, the processing of nucleobases following hypervelocity collisions was assessed with respect to potential processes leading to nucleosides, nucleotides and nucleic acids.

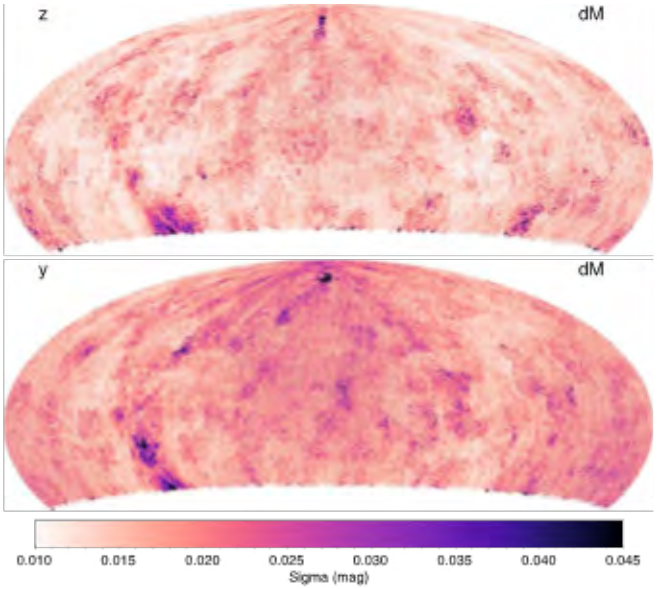


Fig. 27: Sky maps illustrating the internal repeatability of the PanSTARRS1 photometry in two filters, z and y, using the standard deviation of photometry residuals for stars in each pixel

The study suggests that our method of shock processing of nucleobases provides a pathway by which these self-assembled organized structures could have appeared on the Earth, without invoking catalytic activity or atmospheric conditions, only triggered by shock energy provided by impact events.

Three additional refereed papers originated from the contribution of Dr. Bertrand Goldman to the Panoramic Survey Telescope And Rapid Response System 1 (Pan-STARRS1) project. One is the reference paper explaining the calibration performed on the astrometry and photometry of the Pan-STARRS1 survey and was attached to the second data release of the project (see Fig. 27). It is already referred to 153 times. The other two articles used the extensive PanSTARRS1 catalogues to set constraints on the white dwarf luminosity function, and the variability properties in the optical of ICRF3 quasars.

In **Life Sciences**, Dr. Wotring began refurbishing the existing ISU laboratory facilities to support a new invertebrate animal model feasible for use in a variety of space analog environments. These small aquatic worms are capable of sensing the Earth's magnetic field and using it for navigation as well as regenerating significant amounts of their tissue after injury. New colonies of the flatworm Planaria (Girardia dorotocephala and G. tigrina, see Fig. 28) are thriving in the ISU laboratory and ready for new experiments in regeneration and wound healing in a reduced magnetic field environment. Research proposals to support repeated testing in radiation and simulated microgravity environments are underway.

Fig. 28: SPlanarians Girardia tigrina (left) G. dorotocephala (right) are now established in the ISU Life Sciences Laboratory. Planarians are widely-recognized as an excellent model for the study of wound healing and regeneration. Each animal is about 1 cm in length

During the periods of restrictions this year, Dr. Wotring pursued systematic reviews with partners in the UK regarding exercise countermeasures for astronauts (Swain et al. **https://doi.org/10.1016/j.actaastro.2021.05.005**) and with a US medical student, performing an extension of previous work on astronaut risk of venous thromboembolism, specifically examining the risk of cerebral venous sinus thrombosis, the rare blood clots associated with certain Covid vaccines. This manuscript is currently under review. She is also developing a manuscript with an MSS22 student, based on their Individual Project analyzing communication strategies in space conferences around the world.

In the field of **Management and Business**, with the change to entrepreneurial space activities, not only education but also research at ISU had to be refocused on this field. An important milestone was a survey and comparison of incubator types (Abi-Fadel & Peeters, 2019), which led to the creation of the ISU incubator. After the Southern Hemisphere SSP, ISU also got involved in research supporting start-ups of alumni, in this case in Australia (Peeters et al., 2020). Invited as experts on the topic, ISU faculty provided keynote speeches on New Space at several occasions (Peeters, 2020, 2021a) and was invited to express thoughts about the New Space Economy (Peeters, 2021b). Prof. Peeters, furthermore, helped alumni with research on space education in Africa (Peeters, 2021c) and on Cyber-attacks (Van Camp & Peeters, accepted). At present, a chapter in a book on Space and Society, dealing with the impact of NewSpace on Society, is under publication.

8.3 Research Lunches

The Research lunch series continued in its second year. The purpose of the series is to discuss the research conducted on the Central Campus; learn from our visitors and Strasbourg colleagues about their research and think about possible collaborations; educate our master's students about what work researchers do and what topics are most promising. The MSS students are invited to join as audience or speaker on a voluntary basis. The sanitary situation during the first weeks allowed some ISU and local researchers to present in person in the Pioneer Hall. We then moved to online presentations, which again allowed us to invite distant colleagues who would not have the chance to come to Strasbourg. We sought to achieve a balance between the ISU disciplines, speaker gender (44% of female speakers) and geographic distribution (although due to time zone consideration, Europe and Africa were over-represented). For instance, a speaker, Dr. Povic of the Ethiopian Space Science and Technology Institute (ESSTI) discussed both her scientific projects and her carrier and the situation of female researchers in her chosen land of Ethiopia, in a meeting co-organized with the local chapter of Women in Aerospace–Europe (WIA-Europe).

Because of the complexity connected to the sanitary conditions, dead-lines of some MSS deliverables were delayed, and we ended the season earlier to allow the students to concentrate on the elective modules and their individual reports. Still, 17 lunches were organized over the academic year, slightly less than last year's 20 lunches.

Calendar of sessions during the academic year:

- 26 April: Kenza Bousedra (Unistra/BETA): How to measure downstream space activities in the New Space era? Theoretical analysis and development of economic indicators
- 15 April: Mengu Cho (Kyutech)
- 30 March: Michele Armano (ESA): Science and technology of gravitational waves with the ESA LISA Pathfinder Mission
- 23 March: Katarzyna Malinowska (Kozminski): In-orbit servicing
- 4 March: Marie Vanstalle (Unistra/IPHC): Nuclear data for space radiation protection
- 26 January: Prof. Virginia Wotring (ISU): Dose Tracker – the story of an ISS study
- 9 February: Dr. Francis Rocard (CNES): Mars exploration
- 6 January: Ezequiel Gonzáles (ISU/ESTEC): Exoplanet atmosphere transit spectroscopy
- 18 November: Colin McInnes (Glasgow): Micro-to-macro: space technologies at extremes of length-scale
- 26 November: Gongling Sun (ISU): the Chinese Lunar Exploration Program
- 1 December: Andrew Winnard (Northumbria): Space Medicine Systematic Reviews
- 5 November: Géraldine Vitry (ISU): DNA damage, cell adaptation and oxidative stress managing in pulmonary arterial hypertension
- 7 October: Mirjana Povic (ESSTI/IAA): Astronomy for Development in Africa: Ethiopia as an example
- 30 September: Cécile Doubre (Unistra/EOST): Geodesy and Seismology from Space
- 23 September: Christophe Dabin (CNES): the CNES Scientific Ground Segment
- 16 September: Andy Williams (ESO, remotely): satellite megaconstellations and ground-based astronomy: How to regulate clashes between earth and space based activities, between science and commerce
- 9 September: Virginia Wotring (ISU, hydrid): A new virus among us–season 2

Fig. 29: Dr. Cécile Doubre as Research lunch speaker

9. Space start-up incubator

Although hindered by the Covid-19 situation and resulting restrictions, which considerably limited access to the ISU building, alumni interest continued to grow in the last reporting period.

In order to attract more companies, a leaflet has been developed and distributed at the appropriate fora.

Irrespective of this, several incubatees were further developing their activities in the ISU building, covering the following start-up activities:

- Monitoring of water quality using Earth observation data
- 3D printing of highly resistant material for the use in space projects
- Use of drones in combination with GIS
- Use of drones for detection, using a combination of geomagnetic methods and GNSS
- Lean management of space projects using cloud-based tools
- Modern space communication methodologies, in particular for virtual communications.

*Fig. 30: **ISU Incubator flyer***

In addition to this formal incubation, ISU set-up a pre-incubation program, to allow candidates to refine their business plans and improving the chances for seed funding.

Projects under this pre-incubation scheme include:

- Use of GIS to support real estate projects location and to provide information to insurance companies
- Development of a device to compensate strong odors (for use in space stations with terrestrial spinoff in e.g. chemical plants)
- Use of drones to support agricultural/vineyards planning in combination with GNSS.

A considerable number of potential incubatee-candidates are waiting for the relaxation of Covid-19 restrictions to apply.

Most of the aforementioned incubatees have benefited from local seed money; this is the case of the start-ups in ISU.

In addition, at present four start-ups (both located in the ISU incubator as well as in the local Strasbourg incubator) are benefitting from ESA-BIC support and two new ones will be proposed to be coached by ISU.

In order to support start-ups for further financing rounds and based upon the decision of the ISU BOT, a for-profit spinoff has been established, called ISU Ventures. The modus operandi of this new ISU spin-off organization is presently under discussion, with the support of ISU alumni experienced in space financing.

10. Alumni Affairs

As in previous years, employment of the previous MSS class has been used as a benchmark, as most of the participants in the professional development programs returned to their previous jobs (which would give a distorted picture).

After an average of nine months of graduation, a questionnaire is sent to the MSS alumni asking for their job situation (together with feedback on the program).

Due to the outbreak of Covid-19 in 2020, the usual dynamic of the internship has been different.

11 students graduated in September 2020, 16 graduated in December 2020, 9 graduated in May 2021 and 5 are shifted to MSS21.

The survey has been sent to the students who graduated in September and December 2020 and May 2021.

86% of the respondents reported having a job, and 14% of the MSS20 alumni reported continuing studies.

The alumni who are fully employed declared obtaining this position:

- before graduation (72%)
- within 1 to 3 months (17%)
- within 3 to 6 months (5%)
- within 6 to 10 months (6%)

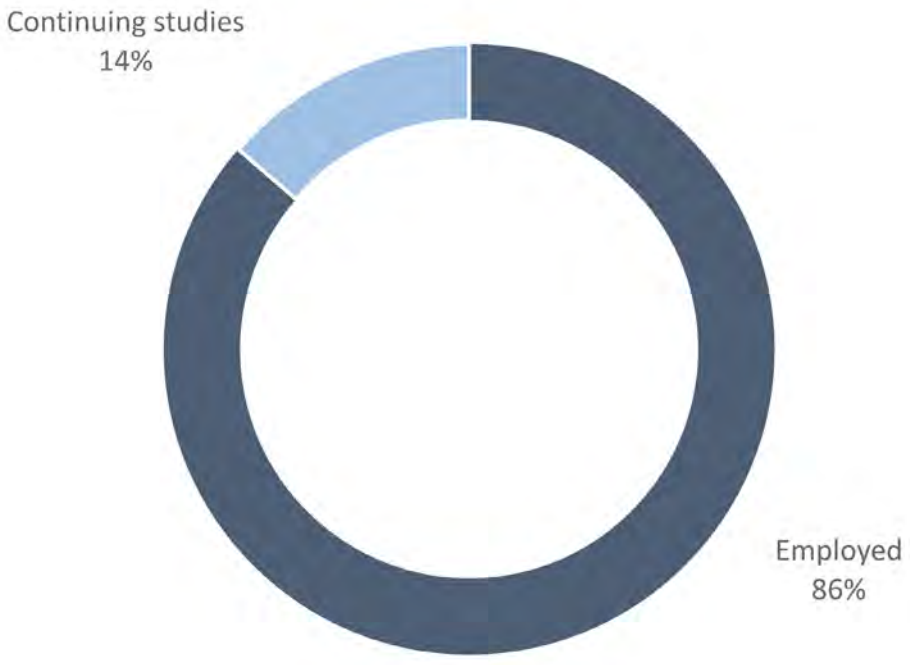


Fig. 31: Employment statistic of MSS20 alumni

This year, the Student Affairs Office organized “MSS success stories” in order to make up for the lack of networking opportunities for students due to the sanitary situation. The concept is to invite MSS alum to talk about their MSS internship, how the MSS helped them enter the job market, where they are currently working and give tips how to land a successful job or internship. Recent MSS alumni who interned at DLR, ESA, Tohoku University, as well as private companies, start-up companies and universities were invited to give such a presentation (all online).

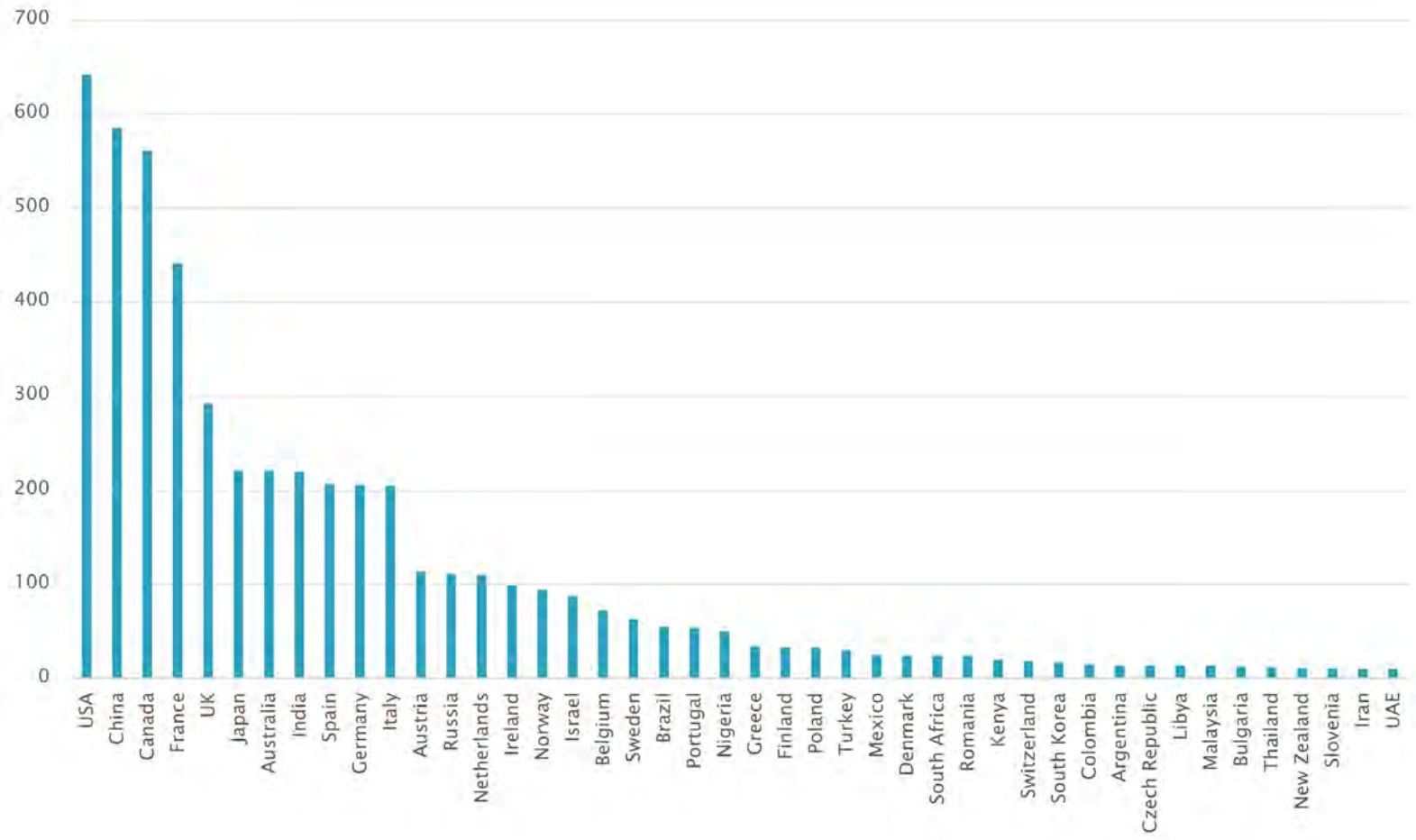


Fig. 32: Alumni distribution since start of ISU (top 40 countries only, September 2021)

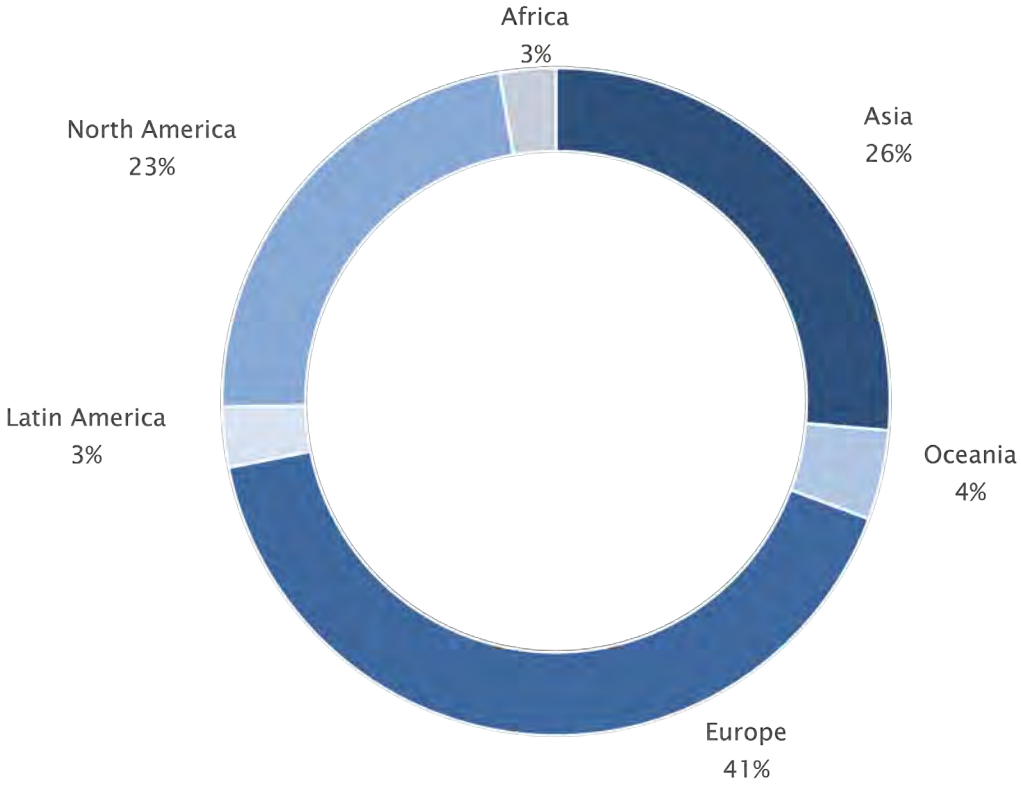


Fig. 33: Geographical distribution of ISU's 5200 alumni

10.3 Alumni Conferences

ISU Adelaide conference

More than 200 delegates from across the Asia-Pacific region attended the first hybrid (in person and online) ISU Adelaide conference.

Embodying the theme of “International Collaboration in Asia-Pacific Space Activities”, the program featured a prominent space agency panel representing Australia, New Zealand, Japan, India and the Philippines; a lively discussion on the state of the new space launch industry in the region; as well as industry experts hosting parallel tracks on space topics such as orbital debris, wildfire mitigation, and deep space missions.

Dignitaries included the head of the Australian Space Agency and ISU alumnus, Enrico Palermo who opened the conference, as well as a keynote speech delivered by the Premier of South Australia, The Hon Steven Marshall MP.

Fig. 35: ISU Adelaide Conference

While the pandemic restricted the opportunity to hold a physical event, the expansion of the conference being held online facilitated greater diversity and inclusion, attracting wider participation from 35 countries and reflecting ISU’s 3Is philosophy. Delegates from India, Philippines, Nepal, Bangladesh, the Pacific Islands, and the width of Asia-Pacific (APAC) joined, who might otherwise have not been able to attend. Connecting with each other featured prominently throughout the conference in activities such as speed networking and regional networking, allowing the participants to experience similar interactive experiences as in a traditional conference.

ISU Annual Alumni Conference

The Annual Alumni conference was held online from July 30th 15:00 UTC till August 1st 15:00 UTC. There were no less than 40 panels and more than 80 speakers and 40 moderators, with a team of more than 30 volunteers, and 640 registered participants. There were some breaks for alumni to meet and discuss.

As ISU is committed to the employability and to remain at the forefront of education for Space, a varied panel of members within industry highlighted the main needs for tomorrow. We had distinguished guests form agencies at board and chairman level from ESA, EU Satcen, EUSPA, Secure World Foundation, China (CNSA), Turkey, South Africa, Israel, Kenya, Djibouti, Egypt, Angola, Rwanda, and more. There were highlights on innovation and partnership, sustainability, climate change monitored from space, and space security.

The conference was crafted around hot topics currently of interest for the Space community with a less traditional spin and with several entrepreneurship alumni initiatives, whether on Exploration in Mars or the Moon, with Jim Green (NASA); other hot topics of this year like the JWST, as well as Analog missions or Astrobiology. In the same area, the Astronauts panel could share their career paths as well as job aspects (Soyeon Yi and Anastasia Stepanova), and also how to prepare the astronauts themselves with the latest technologies (Laura André Boyet from ESA preparing Thomas Pesquet). The conference was the chance to highlight alumni on different topics as commercialization of Space, private missions, smallsat innovations (with Joe Pelton and Jordi Puig-Suari, cubesat co-inventor), how to give affordable access to Space, or the latest advances in NewSpace in China or Japan. Finally, the latest industry trends were covered by Manny Shar, who also moderated the new Constellations panel with Jonathan Hofeller (Space X) and the Starlink VP. A panel on legal changes around constellations reminded us of the challenges still open. There were European industry presentations on the need for Space robotics to tackle some of these problems.

SSP21 participants were able to present shortly their Team Projects, to better connect with the alumni community, and there were presentations from alumni Associations. Finally, the SSP89 participants could give a warm applause to their classmate Juan De Dalmau on his retirement as ISU President, and President-elect Pascale Ehrenfreund closed the conference.

Replays can be seen at: **https://alumconf21.isunet.edu/**. The event was kindly sponsored by the Aerospace Corporation.

11. Faculty and Executive appointments

11.1 New Faculty appointments and Academic Council Elections

The professionals listed below have cumulated sufficient teaching time at ISU to join the Global Faculty, and they have accepted to contribute with their expertise to the ISU academic, research, and professional development programs.
The updated list of over 160 faculty members is accessible on the **ISU website** with links to the profile of each individual.
The procedures for faculty eligibility, appointments and currency are established in the **ISU Academic Handbook**.

- Promoted to Full Professor: Virginia Wotring and Hugh Hill
- Central Campus Faculty appointment: Mr. Nicolas Peter is seconded by ESA for a full-time assignment as Professor of the Practice on Space Policy and International Relations, starting 1st September 2021.
- Promoted Full members of the ISU Global Faculty: Farhan M. Asrar, David Bruce, Jacob Cohen, Andrea Gini, Natalia Larrea-Brito, Tanja Masson-Zwaan, Michaela Musilova, Niamh Shaw, Jan-Walter Schroeder, Remco Timmermans

- Appointed Adjunct Faculty: Philomena E. Bonis, Graziella Caprarelli, Ryan Clement, André Farand, Anderson Liew, Nahum Romero-Zamora, Alexandra Ryan, Matt Sorgenfrei, Dimitra Stefoudi, Julien Tallineau, Irina Thaler, Maurizio Nati
- Becoming Associate Faculty: Tarik Kaya

New members of the Academic Council - elected or re-elected in May 2021 for a second term:

Volker Damann, ESA (retired), Germany, elected Chair of the Academic Council as from July 2021

Maria-Antonietta Perino, Thales Alenia Space, Italy

Su-Yin Tan, University of Waterloo, Canada

For reference, the continuing Academic Council Members are:

- Carol Carnett, Legal Aid Bureau Inc., USA
- Dan Glover, Independent Consultant,USA
- Geoff Steeves, University of Victoria, Canada
- Lucy Stojak, HEC Montréal, Canada, elected Vice Chair of the Academic Council as from July 2021
- Virginia Wotring, International Space University, France
- Olga Zhdanovich, MODIS, The Netherlands

11.2 New Executive appointments

The International Space University is pleased to announce that its Board of Trustees has selected Professor Pascale Ehrenfreund as ISU's next President to take office in September, 2021 succeeding Mr. Juan de Dalmau whose term ended in August 2021.

Prof. Ehrenfreund is currently the Chancellor of ISU and the President of the International Astronautical Federation. She is also a Research Professor of Space Policy and International Affairs at George Washington University in Washington DC.

In addition to her strong academic and research background in astrophysics, biology and as Principal Investigator and Team Leader for ESA and NASA astronomy and planetary missions, Prof. Ehrenfreund brings to ISU her management experience, having served as President of the Austrian Science Fund (FWF) and as Chair of the Executive Board of the German Aerospace Center (DLR).

As President Elect until the start of the 2021-2022 academic year, Prof. Ehrenfreund maintains her role of Chancellor and continue her interactions with students, staff, faculty and alumni. She said "I am delighted to become a full member of the exceptional team that works at ISU and I look forward to building on the achievements of my predecessor Juan de Dalmau, whom I thank for his availability to brief me on all aspects of the university's management."

On the ambitions for her mandate, Prof. Ehrenfreund said "I am prepared to further develop ISU as the global leader in space education and as an engine driving the evolution of the dynamic space sector. It is an honor and privilege for me to contribute to these very important tasks as future ISU President."

12. Special events and outreach

12.1 Special events

On 1st October, ISU was honored by the in-person visit to Central Campus by Ms. Caroline Zorn, Vice-President of Strasbourg Eurometropolis for Higher Education, Innovation and Student Life.

The visit was followed by a second one, held online on 12th November, where Ms. Zorn was briefed on the ISU Incubator and talked with representatives from different start-ups hosted on Campus.

On 9th November, ISU participated remotely to the International Symposium on Peaceful Uses of Space Technology for Health, IPSPACE 2020.

ISU representatives included Faculty member and astronaut Robert Thirsk as a keynote speaker, and alumni of the ISP20 program who presented the results of their Team Project on The Role of Space during Pandemics.

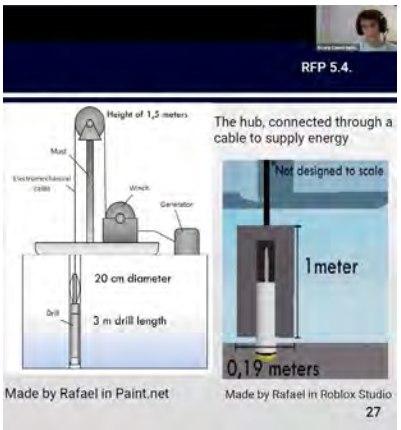
On 18th December, NASA Astronaut Jessica Meir and ISU alumna delivered the last lecture of the calendar year, setting an optimistic and festive tone for the end-of-year season. The online event was supported by the NASA Public Affairs Office, the City of Strasbourg and the US Consulate General in Strasbourg.

On 24th December, the Saudi Space Commission and ISU signed an Agreement on cooperation for space education, training and research for the benefit of Saudi students and professionals.

الهيئة السعودية للفضاء
SAUDI SPACE COMMISSION

From 3rd to 13th June, ISU contributed visible hardware and volunteer students to “Cosmos District”, an exhibition of space-related hardware and digital art in front of the Strasbourg Cathedral. The exhibition was visited by some 35.000 persons and the ISU effort was well received by local political decision makers.

ISU was the virtual host for 68 participants to the “EU Space Design Competition” EUSDC 21 for secondary school students, as part of an international initiative that takes the finalists to NASA’s Kennedy Space Center.



12.2 Outreach

ISU wants to take its full place in promoting space exploration and studies to the younger generation.
Space, thanks to its inspirational and fascinating power, has a strong impact on young and not so young people, to raise interests for the STEM (science, technology, engineering and mathematics) disciplines.

To achieve these goals, ISU benefits from a diverse staff and student body, and from its collection of space artefacts. A MSS20 student has created over the course of her Individual Project a set of educational cards that describe our collection and helps ISU staff and students become a tour guide of the building.

In September 2020, the editors of “Space Talk TNG”the ISU Alumni Magazine (the Next Generation” published the eighth issue since the start of the second series.

ISU’s Head of Admissions regularly attends space conferences and space-up gatherings, offering talks and information booths that prove to be an effective student recruitment tool, but as the pandemics further prevented us to meet and present our educational programs in the various forums of the space world community, ISU invited on 30th January and 06th February 2021 prospective students and participants to join one of three events, during which they could learn more about those programs that we will offer in 2021 and 2022. Attendees could attend a Europe-Africa event at 16:00 CET, the Americas event right afterwards at 13:00 EST, or the Asia-Pacific event on February 6 at 17:30 ACDT, right after the ISU Adelaide conference; some even attended all three!

This online open day started with the ISU Chancellor Pascale Ehrenfreund, Jean-Yves Le Gall of CNES, and high profiles alumni such as Élodie Viau of ESA or Val Munsami of SANSA speaking about how the interdisciplinary and international environment provided by ISU helps them and others succeed in today’s space world. They were joined by Jim Green of NASA and Chris Sallaberger, Chair of ISU Board of Trustees, and took questions from the audience, discussed the contribution of ISU alumni to the space economy, and how the community of ISU alumni helps bring space projects forward. The recording of that discussion can be found on the dedicated Discover ISU! web page.

In all three events, the head of admissions and program directors explained the goals and teaching methods of each program, as well as the admission process.

Alumni from around the world delivered powerful testimonials about their ISU experience, during and after the programs. Finally, breakout rooms were organized for each program and attendees could meet with alumni of those programs, as well as the director, and ask questions about the delivery, format, curriculum, general experience and career path after graduating.

13. Extra-curricular activities

Despite the attention dedicated to the pandemic and its many adverse consequences, concerns related to the degrading environmental conditions remained high on ISU's agenda. The Climate Change working group, established late 2019, resumed meeting after the 2020 summer break, inviting staff and MSS21 students to join.

The group pursued two goals:

- complete the writing of, and getting approval for the ISU sustainability policy;
- connect with similar groups and socially responsible actors in the space community to develop our activities.

The Sustainability Policy draft was completed, signed, and enacted by the President early 2021. It was announced to the ISU community on April 22, which marked Earth Day 2021. It compels the ISU community to act to reduce its negative impact on the planet, in particular its footprint of greenhouse gases; and to increase its positive societal contribution by educating and communicating on those issues, to raise awareness and capacities.

Specifically, the policy identifies six areas of action, namely: green buildings, clean energy, sustainable transportation, zero waste, sustainable procurement, teaching and learning for sustainability.

While the pandemic and remote activities during most of MSS21 have hampered actions over the academic year, we are actively preparing MSS23 with several hours of teaching dedicated or related to those problems, naturally across all ISU's disciplines. Indeed, the problems created by the impact of human activities touch on a broad range of disciplines and must be addressed in an interdisciplinary way, as ISU excels to prepare its students to do. In addition to the lectures in Module 2, a dedicated elective will be proposed, stressing the benefits of space in handling the crisis, as well as evaluating the greenhouse gas footprint of the space industry and studying the solutions to reduce it.

We have established contacts with groups in academia and agencies in charge of social and economic responsibility, and in particular we held discussions with our ESA colleagues from the Clean Space initiative.

The Sustainability Committee, set up by the policy to report ISU's progress to the ISU Academic Council and Board of Trustees, has been established and is composed of staff and alumni, and will soon welcome a member of the MSS22 cohort. The Committee will start its regular activities after the 2021 summer break.

14. Conclusions

We hope you found this report useful and perhaps it has triggered some thoughts on how you could be (more) engaged with the International Space University in the future through participation in our education and research programs, or through contributions to their content, mentorship, or sponsorship.

We wish you a safe and enriching academic year 2021-2022 and we remain at your disposal to discuss any space-related topic.

The ISU staff and faculty

ANNEX 1: Faculty

ANNEX 1.1 ISU Faculty

Philippe Achilleas, IDEST, Université Paris Sud & ISU, France
Farhan Asrar, University of Toronto, Canada
Steve Brody, Independant Aerospace Professional, USA
David Bruce, University of South Autralia/Flinders University, Autralia
Angie Bukley, The Aerospace Corporation, USA
Carol Carnett, Legal Aid Bureau Inc., USA
Ed Chester, Goonhilly Earth Station, UK
Jacob Cohen, NASA Ames Research Center, USA
Patrick Cohendet, Université de Strasbourg/HEC Montreal, Canada
John Connolly, NASA Johnson Space Center, USA
Bill Cowley, Institute for Telecommunications Research, Australia
Eric Dahlstrom, International Space Consultants, USA
Juan de Dalmau, International Space University, France
Volker Damann, International Space University, Germany
Michael Davis, International Space Univeristy, Australia
Emmanouil Detsis, European Science Foundation – ESF, France
Kerrie Dougherty, Australian Space Agency, Australia
George Dyke, Symbios Communications, Australia
Reinhold Ewald, University of Stuttgart, Germany
Stefano Fiorilli, European Space Agency – ESA, Spain
Daniel Garcia Yarnoz, Spain
Andrea Gini, D-Orbit, The Netherlands
Daniel Glover, NASA Glenn Research Center (retired), USA
Bertrand Goldman, International Space University, France
James Green, NASA Headquarters, USA
Gerhard Haerendel, Max-Planck-Institut für extraterrestrische Physik (retired), Germany
Omar Hatamleh, NASA, USA
Hugh Hill, International Space University, France
Jeffrey Hoffman, Massachusets Institute of Technology, USA
Marcello Ingrassia, Italy
Dennis Irwin, Ohio University (retired), USA
Adil Rahim Jafry, Chandah Space Technologies, USA
Ady James, University of South Australia, Australia
Christopher Johnson, Secure World Foundation, USA
Joan Johnson-Freese, Naval War College, USA
Otto Koudelka, Technical University Graz, Austria
Ofer Lapid, Israel
Natalia Larrea Brito, Euroconsult, Canada
Rene Laufer, Baylor University, USA
Tanja Masson-Zwaan, International Institute of Air and Space Law at Leiden University, The Netherlands
Ruth McAvinia, ATG Europe, The Netherlands
Christopher McKay, NASA Ames Research Center, USA
Bernd Madauss, Project Management Team Madauss, Germany
Gary Martin, International Space University, USA
Michaela Musilova, International Moonbase Alliance (IMA), Hawaï, USA
Joshua V. Nelson, USA
Barnaby Osborne, European Space Agency, UK

Norah Patten, Irish Centre for Composites Research, Ireland
Walter Peeters, International Space University, France
Joseph Pellegrino, One Web, USA
Maria Antonietta Perino, Thales Alenia Space, Italy
Christian Sallaberger, Canadensys Aerospace, Canada
Niamh Shaw, Dream Big Space Communications, France/Ireland
Noel Siemon, Australia
Michael Simpson, International Space University (retired), USA
Robert Shishko, NASA Jet Propulsion Laboratory, USA
François Spiero, CNES, France
Geoffrey Steeves, University of Victoria, Canada
Lucy Stojak, HEC Montreal, Canada
Chris Stott, ManSat LLC, Isle of Man
Danijela Stupar, International Space University, France
Gongling Sun, International Space University, France
Su-Yin Tan, University of Waterloo, Canada
Taiwo Tejumola, International Space University, France
Remco Timmermans, Spaceside, UK
Diego Urbina, Space Applications Services, Belgium
Alain Wagner, Airbus Defence and Space, France
Jan-Walter Schroeder, Sensovo, Germany
Chris Welch, International Space University, France
Ray Williamson, Secure World Foundation (retired), USA
Pete S Worden, Breakthrough Foundation, USA
Virginia Wotring, International Space University, France
Soyeon Yi, Korean Astronaut, Republic of Korea
Kazuya Yoshida, Tohoku University, Japan
Vasilis Zervos, International Space University, France
Olga Zhdanovich, MODIS, Netherlands

ANNEX 1.2 ISU Adjunct Faculty

Andrew Aldrin, Florida Institute of Technology, USA
Heather Allaway, Texas A&M University, USA
Audrey Allison, The Boeing Company, USA
Julio Aprea, European Space Agency – ESA, France
Jacques Arnould, CNES – Headquarters, France
Merryl Azriel, Salient CRGT Inc. , USA
Jaime Babb, Canada
Melissa Battler, Mission Control Space Services, Canada
Nelly Ben Hayoun, Nelly Ben Hayoun Studio Ltd, UK
Philomena Bonis, Silverheights Public School Waterloo Region District School Board, Canada
David Bruce, University of South Australia (UniSA), Australia
Graziella Caprarelli, Hypatia Scientifica Pty Ltd, Australia
Francis Chizea, National Space Research and Development Agency (NASRDA), Nigeria
Eric Choi, AeroScribe Consulting, Canada
Ryan Clement, University of Winnipeg, Canada
Philippe Clerc, CNES, France
Ana Diaz, Texas A&M University, USA
Kim Ellis, International Earth & Space Technology Pty Ltd, Australia
Stuart Eves, SJE Space Ltd, UK
Andre Farand, Institut du droit de l'espace et des télécommunications – IDEST, France
Barbara Imhoff, LIQUIFER Systems Group, Austria
Tricia L. Larose, Norwegian University of Science and Technology, Norway

Kris Lehnhardt, Baylor College of Medicine and NASA, USA
Anderson Liew, HSBC, UK
Zhuoyan Lu, China
Peter Martinez, Secure World Foundation, USA
Ioannis Michaloudis, Institute of Nanoscience and Nanomaterials, Greece
Maurizio Nati, ESA (retired), The Netherlands
Paolo Nespoli, European Space Agency – ESA (retired), Italy
Cory Newman, CAE, Canada
Andrée-Anne Parent, University of Quebec in Rimouski, Canada
Robert Parkinson, The British Interplanetary Society, UK
Ewan Reid, Mission Control Space Services Inc., Canada
Daniel Rockberger, NSLComm, Israel
Nahum Romero Zamora, KOSMICA, Germany
Claude Rousseau, Northern Sky Research, France
Alex Ryan, ISU, Australia
Kai-Uwe Schrogl, International Institute of Space Law – IISL, France
Matt Sorgenfrei, Cruise, USA
Dimitra Stefoudi, International Institute of Air and Space Law, The Netherlands
Julien Tallineau, Veoware Space, Belgium
Erin Telley (Tranfield), Instituto Gulbenkian de Ciência, Portugal
Irina Thaler, Racah Institute of Physics, Hebrew University of Jerusalem, Israel
Madhu Thangavelu, University of Southern California, USA
Robert Thirsk, Canadian Space Agency – CSA (retired), Canada

ANNEX 1.3 ISU Associate Faculty

Sheila Bailey, NASA Glenn Research Center, USA
Phillipe Berthe, European Space Agency – ESA, The Netherlands
Isabelle Bouvet, Airbus, France Milan Cermack, Switzerland
Hansjörg Dittus, German Aerospace Center (DLR), Germany Stacey Falzarano (Solomone), Chandah Space Technologies, USA
Arthur Guest, TreoScope Technologies, USA
Ozgur Gurtuna, Turquoise Technology Solutions Inc., Canada
Douglas Hamilton, KRUG Life Sciences, USA
Tarik Kaya, Carleton University, Canada
Wiley Larson, Stevens Institute of Technology, USA
William Marshall, Cosmogia Inc., USA
David Miller, University of Oklahoma, USA
Todd Mosher, Amazon, USA
Annelie Schoenmaker, W.L. GORE & associates, Spain
Isabelle Scholl, Intitute for Astronomy – University of Hawaii, USA
Alexandra Seneta, Department of Industry & Science, Australian Government, Australia

ANNEX 2: Research publications by ISU Central Campus Faculty and students

Peer-Reviewed Publications

Abi-Fadel, M. and Peeters, W.: The Role of Incubators in the European New Space Economy, New Space Vol 7(4) (2019), pp. 201-207. DOI: 10.1089/space.2019.0035

Berghea, C. T.; Makarov, V. V.; Quigley, K. ; **Goldman, B**.: Optical Variability of ICRF3 Quasars in the Pan-STARRS 3Pi Survey with Functional Principal Component Analysis, The Astronomical Journal, Volume 162, Issue 1, id.21, 9 pp.: 10.3847/1538-3881/abfc51

Kitto, R.; Dhillon, Y.; Bevington, J.; …, **Welch, C.**; et al.: Synthetic biological circuit is functional in spaceflight, Life Sciences in Space Research, Volume 28, February 2021, pp57-65. DOI: 10.1016/j.lssr.2020.09.002

Magnier, E.. A.; Schlafly, E. F; Finkbeiner, D. P.; Tonry, J. L.; **Goldman, B**.; et al.: Pan-STARRS Photometric and Astrometric Calibration, The Astrophysical Journal Supplement Series, Volume 251, Issue 1, id.6, 32 pp., 10.3847/1538-4365/abb82a

Nuth, J.A.; Abreu, N.; Fergusson, F.T.; …, **Hill, H.G.M**.; et al. Volatile-rich Asteroids in the Inner Solar System. Published in the A'Hearn Symposium Special Edition of the American Astronomical Society (AAS) Planetary Science Journal (PSJ), 1, 82, doi.org/10.3847/PSJ/abc26a

Nuth, J.A.; Ferguson, F.T.; **Hill, H.G.M**.; and Johnson, N.M. Did a Complex Carbon Cycle Operate in the Inner Solar System? Life, 10, 206 (doi:10.3390/life10090206). Part of the Special Issue "Chemical Evolution of Organic Molecules in Solar System Small Bodies." DOI: 10.3390/life10090206

Peeters, W.; Damp, L. and Williams, P.: Launching Smallsats. The Example of Southern launch, New Space Vol. 8(4) (2020), pp. 201-212: DOI: 10.1089/space.2020.0034

Peeters, W.: The Role of Space Education in Africa, New Space, Vol. 9(1) (2021c), pp. 27-32. DOI: 10.1089/space.2020.0056

Shivakarthik, E.; Meka, J.K.; Surendra, H.V.S.; …, **Hill, H.G.M**.; et al. Sticking of dust and micrometeorite particles on to ices at high impact velocities - Implications for astrochemical ice enrichment. Planetary and Space Science, Volume 190, DOI: 10.1016/j.pss.2020.104972

Singh, S.V.; Vishakantaiah, J.; Meka, J.K.; …, **Hill, H.G.M**.; et al.: Shock Processing of Amino Acids Leading to Complex Structures—Implications to the Origin of Life. Molecules 2020, 25(23), 5634. This article belongs to the Special Issue, "From Molecules to Origin of Life: The Astrobiology Network". DOI: 10.3390/molecules25235634

Surendra, V.S.; Jayaram, V.; Muruganantham, M.; …, **Hill, H.G.M**.; et al.: Complex structures synthesized in shock processing of nucleobases – implications to the origins of life. International Journal of Astrobiology. DOI: 10.1017/S1473550421000136

Jain, V.; Ploutz-Snyder, R.; Young, M.; and **Wotring V.**: Potential Venous Thromboembolism Risk in Female Astronauts. Aerospace Medicine and Human Performance. 2020 May; 91(5). DOI: 10.3357/AMHP.5458.2020.

Van Camp, C. and **Peeters W.**: A world without satellites as a result of a global cyber-attack, Space Policy Journal (accepted for publication)

Wotring, V. and Smith, L.: Dose Tracker Application for Collecting Medication Use Data from International Space Station Crewmembers, Aerospace Medicine and Human Performance, Volume 91, Number 1, January 2020, pp. 41-45(5). DOI: 10.3357/AMHP.5392.2020

Reviews

Swain, P.; Laws, J.M.; De Martino, E.; **Wotring V.**, Caplan N, Winnard A.: Effectiveness of exercise countermeasures for the prevention of musculoskeletal deconditioning in simulated hypogravity: A systematic review, Acta Astronautica, Volume 185, 2021, Pages 236-243. DOI: 10.1016/j.actaastro.2021.05.005.

Laws, J.M.; Caplan, N.; Bruce, C.; …, **Wotring V.**, Winnard A. Systematic review of the technical and physiological constraints of the Orion Multi-Purpose Crew Vehicle that affect the capability of astronauts to exercise effectively during spaceflight. Acta Astronautica. 2020 March; 170:665. DOI: 10.1016/j.actaastro.2020.02.038

Conference Proceedings

Blyde, S.; Mankins, J.; and **Welch, C.**: Demonstrating space solar power in orbit: SPS-ALPHA LEO prototype demonstration mission design, IAC-20,C3,1,4,x58411, 71st International Astronautical Congress, 12-14 October 2020, Online

Gupta, T.; **Welch, C.**; and Hein, A.: A Feasibility Analysis of Interstellar Ramjet Concepts, IAC-20,D4,4,11,x58592, 71st International Astronautical Congress, 12-14 October 2020, Online

Ignjatović Stupar, D.; Chabrol, G.R.; Faron, S.; et al.: Experimental and Theoretical Optimisation of a Lunar Soil Simulant Laser Sintering Process, in: PLI Conf. 2021, Strasbourg, France, 2021a

Ignjatović Stupar, D.; Chabrol, G.R.; Faron, S.; et al.: Finite Element Modelling of Laser Sintering Process for Various Lunar Soil Simulants, in: E-MRS 2021 Spring Meet. Conf., Strasbourg, France, 2021b

Kawashima, R.; Steyn, W.; Nakasuka, S.; …, **Welch, C.**; et al.: A Micro/Nano Satellite Mission Idea Contest for Deep Space Science and Exploration, IAC-20,A3,5,10,x59532, 71st International Astronautical Congress, 12-14 October 2020, Online

Lemarquis, N.; Iliev, Y.; and **Welch, C**.: Business case study for the Cycler – a circumlunar vehicle for development of Space Tourism and Lunar Infrastructure by 2030, IAC-20,E6,5-GTS.1,11,x57732, 71st International Astronautical Congress, 12-14 October 2020, Online

Peeters, W.: Overview of the New Space Economy, Keynote Speech, S2S Conference (Belgium, 13.10.2020)

Peeters, W.: Can Newspace Deliver its Promises? Keynote Speech, STDI (Malaysia), 12.4.2021a.

Peeters, W.: Is Newspace really so new? ROOM, Summer 2021b (28), pp. 72-75.

Sharma, K.; **Welch, C.**; and Hein, A.: Feasibility assessment of deceleration technologies for interstellar probes, IAC-20,D4,4,6,x61030, 71st International Astronautical Congress, 12-14 October 2020, Online

Shreya, S., and **Tejumola, T.R.**: Compatibility and Operability Among Milti-GNSS Systems, IAC-20,B2, 6,13x56294, 71st International Astronautical Congress, 12-14 October 2020, Online

Tahmid, R.; and **Welch, C.**: Conceptual design of a medical grade oxygen delivery system for space mission and its market analysis, IAC-20,B3,7,7,x58767, 71st International Astronautical Congress, 12-14 October 2020, Online

Tanouti, I., and **Tejumola, T.R.**: Developing an Earth Observation CubeSat Constellation to Address the Sustainable Development Goals for Africa, IAC-20, B4,1,4,x59338, 71st International Astronautical Congress, 12-14 October 2020, Online

ANNEX 3: Useful Links

ISU Website

ISU Library

Student Projects

Job Center

Photo Gallery

ISU Twitter account

ISU Facebook page

ISU LinkedIn page

ISU Youtube channel