INTERNATIONAL SPACE UNIVERSITY

REPORT ON THE ACADEMIC YEAR

2018-2019

International Space University

The International Space University, founded in 1987 in Massachusetts, US and now headquartered in Strasbourg, France, is the world's premier international space education institution. It is supported by major space agencies and aerospace organizations from around the world.

The graduate level programs offered by ISU are dedicated to promoting international, interdisciplinary and intercultural cooperation in space activities.

ISU offers the Master of Science in Space Studies program at its Central Campus in Strasbourg.

Since the summer of 1988, ISU conducts the highly acclaimed two-month Space Studies Program at different host institutions in locations spanning the globe and more recently the Southern Hemisphere Space Studies Program.

ISU programs are delivered by over 100 ISU faculty members in concert with invited industry and agency experts from institutions around the world. Since its founding, 30 years ago, more than 4800 students from over 109 countries graduated from ISU.

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Introduction

Dear reader,

This report covers the **International Space University's (ISU)** academic year 2018-2019, including the educational programs, statistics on our students, participants and alumni as well as our publications, research and library services.

Our growing community now includes 4800 alumni from 109 countries, most of them working in the space field, as well as more than one hundred faculty members from academia, government and industry who regularly contribute to the teaching effort and to whom are very thankful as they often volunteer time and money to share their knowledge.

Special efforts are being made to increase the diversity and inclusiveness of our students, faculty and staff, and we are particularly proud that the class of the Masters of Space Studies 2020 is composed, for the first time, of more women than men.

The members of our community are the best spokespersons of the ISU vision for interdisciplinary space education for peaceful international cooperation, and we thank them for their ambassadorship and generous contributions.

Our thanks also go to our partners and sponsors, who are making our presence possible at the Strasbourg Central Campus and wherever our programs take place: Adelaide, Canberra, Florida, Luxembourg, Seattle… and more locations to come in 2020.

We hope that you will find this report both interesting and relevant.

The ISU faculty and staff

1. Summary and Key Figures

1.1 Participants in the ISU Programs

Program	Location	#Participants
Master of Space Studies Year A (MSS-A)	**Strasbourg Central Campus**	**40**
Master of Space Studies Year B (MSS-B)	**Strasbourg Central Campus**	**2**
Space Studies Program (SSP)	**Strasbourg Central Campus**	**127**
Southern Hemisphere Space Studies Program (SH-SSP)	**Adelaide, Australia**	**46**
Commercial Space Program (CSP)	**Florida Institute of Technology**	**10**
Executive Space Course 1 (ESC 1)	**Strasbourg Central Campus**	**18**
Executive Space Course 2 (ESC 2)	**Seattle, USA**	**17**

1.2 Employment statistics

Nine months after completing the program:

81 % of the MSS18 alumni reported having a job or continuing studies (mainly PhD). About 50% of students in full-time employment report working in large companies and 50% in start-up companies.

For the SSP, employment figures must take into account that many participants returned to their previous jobs after the program so this statistic is less representative.

1.3 Faculty

During the academic year 2018-2019, ISU counted:

- **71 Full Faculty** (see list in annex 1)
- **63 Adjunct Faculty** (see list in annex 1)
- **14 Associate Faculty** (see list in annex 1).

1.4 Alumni

After SSP19 and MSS19 graduation, ISU now counts more than 4800 alumni from more than 109 countries worldwide.

2. Master of Space Studies - MSS19

2.1 Overview

The Master of Space Studies program 2019 (MSS19) counted 40 students from 18 countries in the first year (MSS-A) and 2 students were registered for the second year (MSS-B). An overview is given in Fig. 1.

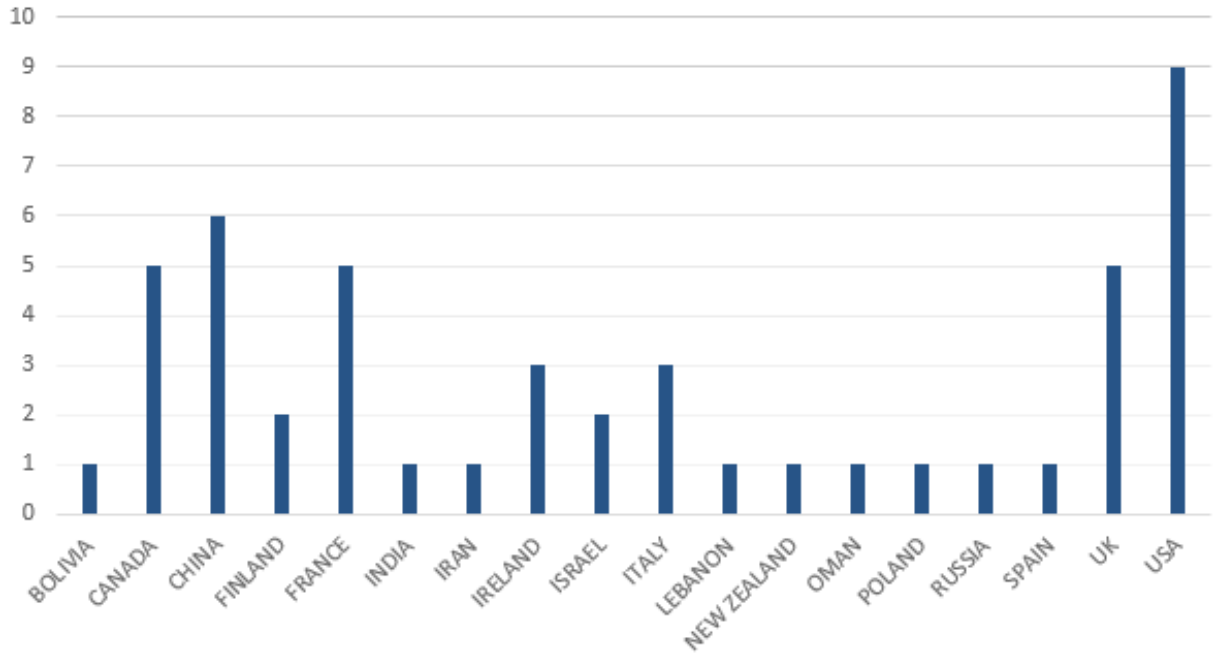


Fig. 1: Distribution of MSS19 participants per country including dual citizenships (*)

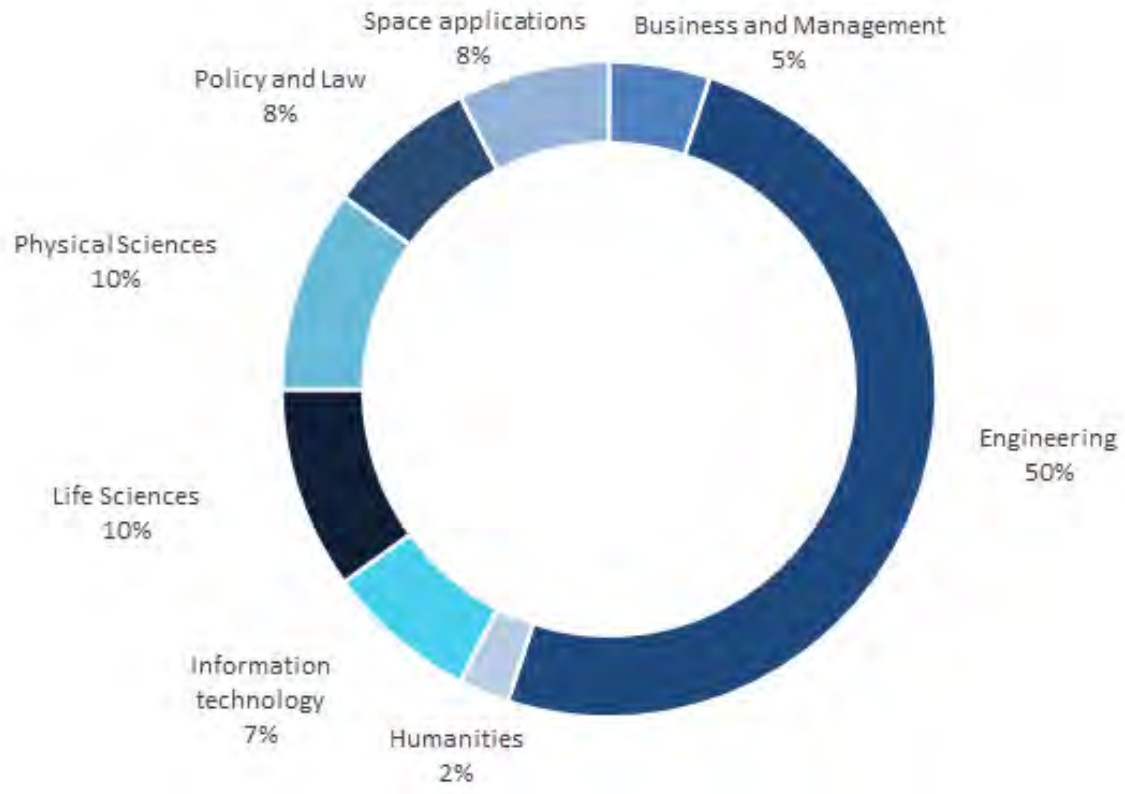


Fig. 2: Educational background of MSS19 participants

(*) The European Space Agency provided partial scholarships allowing a total of 19 participants from 7 of its Members States plus Canada to attend the MSS19 program.

The mean age of the MSS19 participants was 29 years, in line with previous years, with a distribution that can be noted from Fig. 3. This average age is partially explained by the presence of experienced Chinese participants.

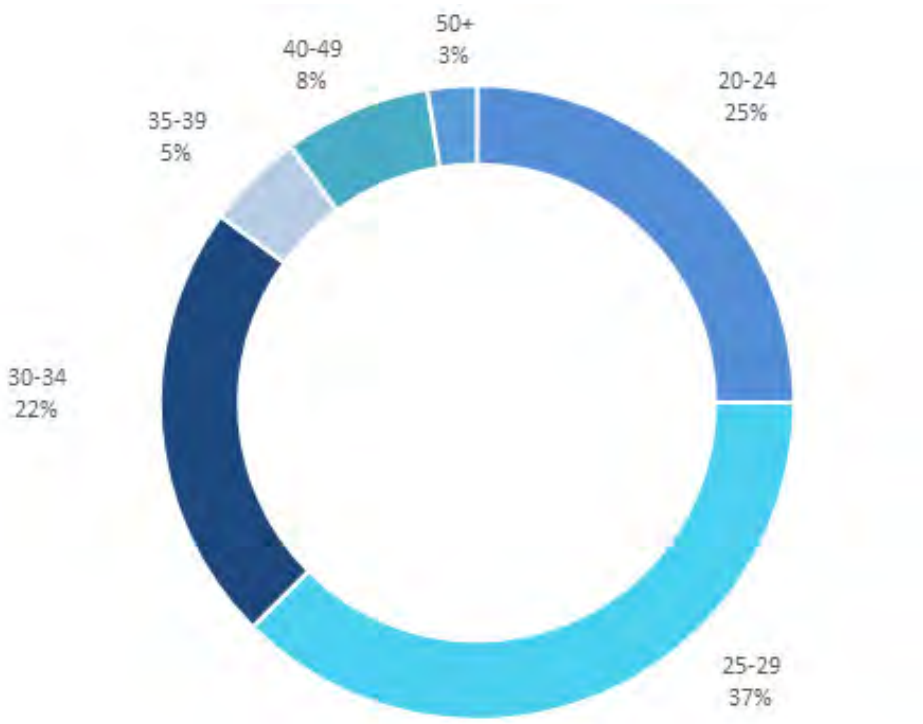


Fig. 3: Age Distribution of MSS19 participants

The age distribution is also linked to the fact that several students have previous professional experience, as we can note from Fig. 4. This figure is increasing yearly and also contributes to the enrichment of the group dynamics, thanks to exchanges of experience.

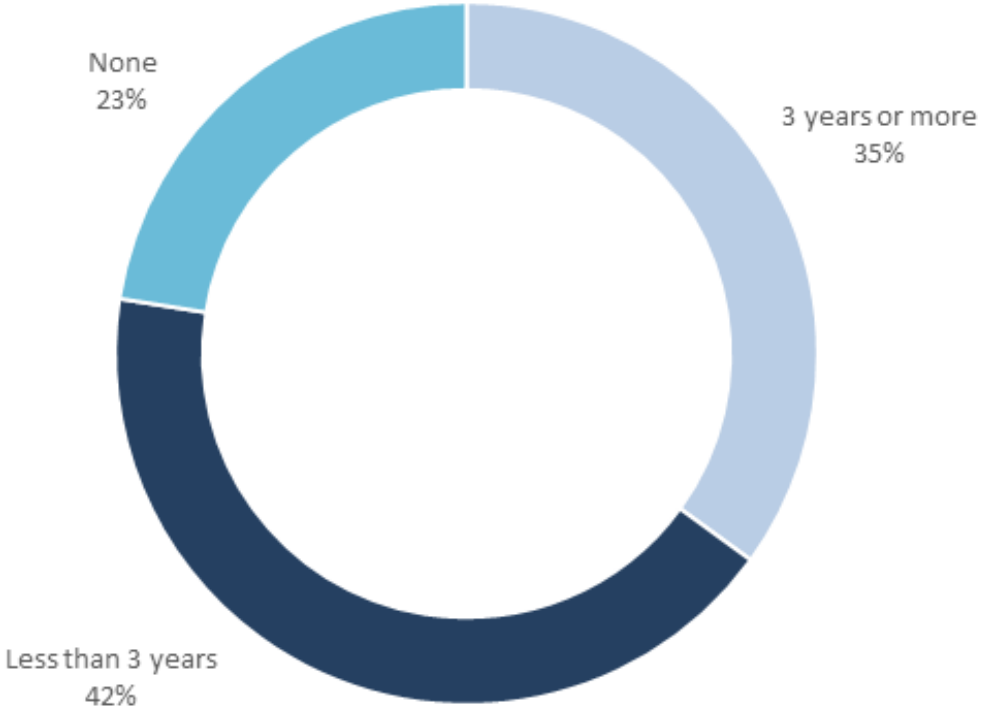


Fig. 4: Distribution of previous experience in MSS19

Several students did not graduate in September 2019, as there is a strong trend of extended internships (e.g. 6 months). Therefore, a second graduation took place in December 2019.

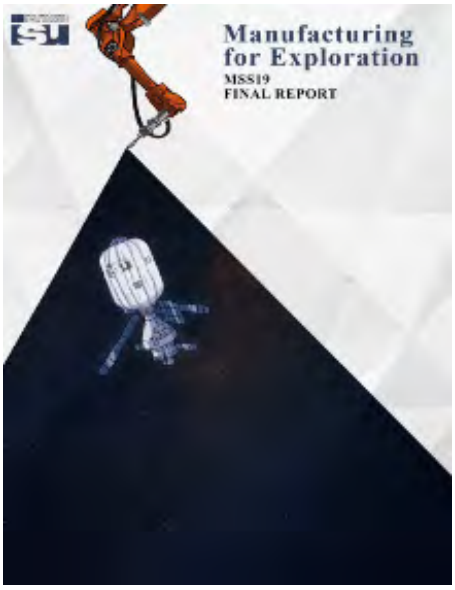
2.2 MSS Team Projects

The MSS19A class carried out two Team Projects:

Sustainable Moon

Space Agencies and private players are currently proposing interesting options for lunar exploration, ranging from building space telescopes and solar power plants to habitats and human settlements. The Sustainable Moon project focused on the evolution of a sustainable and eco-friendly human lunar settlement. Guided by the UN Sustainable Development Goals the team developed a report consisting of three main sections: rationale for a return to the Moon, a roadmap that details the development and operations of a new human settlement, and sustainable goals for the establishment of the settlement.

This project received a prize from the Moon Village Association for its work.



Manufacturing for exploration

This report discussed the potential of In-Space Manufacturing (ISM) as a solution to enable a self-sustaining space habitat without re-supply requirements. The first part of the report uses the International Space Station (ISS) as an analog, identifying areas where ISM can be and is being leveraged during expeditions. The second part examines a human deep space mission and identifiers current or developing ISM technologies. For each of these technologies, the report provides an analysis and mapping of requirements, technology readiness levels (TRL), challenges and risks.

2.3 Structure of the MSS Program

No significant changes have been made to the structure of the MSS, the first (teaching) year of which is shown below in Fig 5. For MSS19, the electives which ran were:

- M7-LSS Life Support Systems for Future Human Space Voyages
- M8-CMD ChipSat Spacecraft and Mission Design
- M10-ABL Astrobiology
- M13-NSE New Space and Entrepreneurship

M8-CMD was a brand new elective for MSS19.

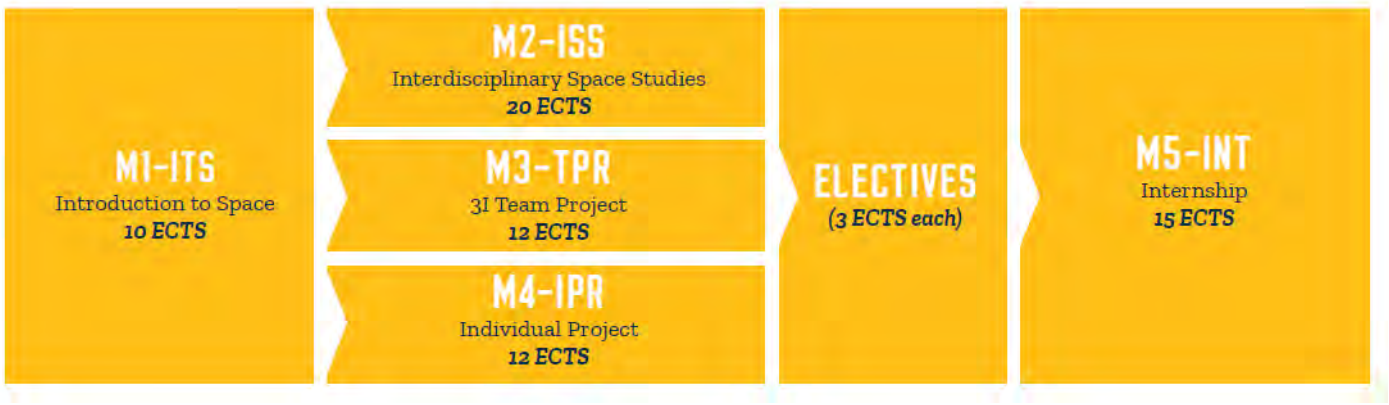


Fig. 5: structure of MSS19A

As each year, the MSS19A taught program was enhanced by a number of offsite activities, as follows:

- Remote Sensing Field Trip to Mont St Odile, France
- Professional visit to Airbus Defence and Space, Friedrichshafen, Germany
- Professional visit to the Observatory of Strasbourg
- Professional visit to SES, Luxembourg
- Professional visit to DLR (Lampoldshausen) and IRS Stuttgart, Germany
- Professional visit to Eurospace and ESA HQ in Paris
- Professional visit to ESA-ESOC and Telespazio Vega in Darmstadt, Germany
- Field Trip to Ries Crater in Nordlingen, Germany

Fig. 6: MSS19 hands-on activities included micro-rocket design and launch, a Poster presentation, and Robotics)

Fig. 7: Visit to SES in Luxembourg

Fig. 8: Visit to ESA Headquarters in Paris

2.4 Internships linked to the MSS19 program

As observed last year, geopolitics continues to influence the situation with some students being barred from some internships on nationality/visa grounds. Also, the trend towards 6- month internships (as opposed to 3-months one) continued.

As positive points, KARI accepted a second intern this year (their first being last year), while JAXA accepted two interns. In addition, SAS in Brussels accepted a Chinese MSS19A student as an intern.

A few pictures of internships are shown below:

Fig. 9: MSS19A interns at ESA EAC

Fig. 10: MSS19A interns at NASA

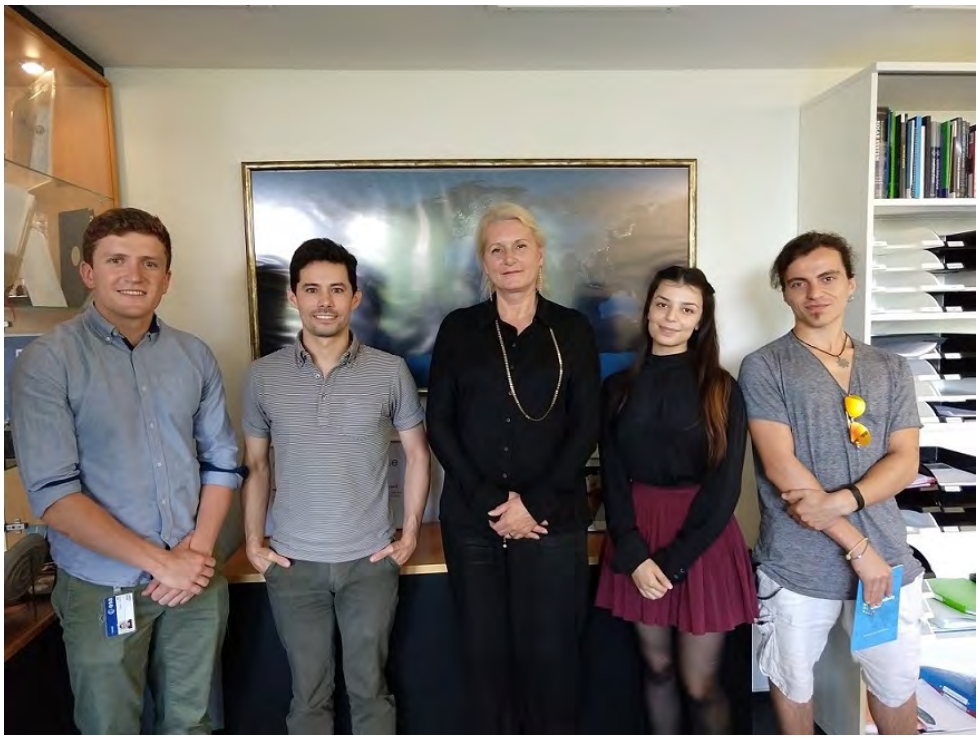


Fig. 11: MSS19A interns at DLR with Prof. Dr. Pascale Ehrenfreund

Fig. 12: MSS19A intern and her colleagues at SES

Fig. 13: MSS19A intern at KARI

Fig. 14: MSS19 class picture

3. Research and support to Space Start-Ups

3.1 Active Research Projects

Three ISS payloads have flown to ESA's Columbus module of the ISS through the new SAS ICE-Cubes Service.

a. Hydra 1 - ISS Plant Growth Experiment Payload

- Launch: 5 December 2018 (CRS16); Return: 15 January 2019 (CRS16)
- Partners: Stanford University/Utah University, University of Strasbourg (NASA Ames)
- Main objective: Observation of transgenic seed chemically- inducible protein expression in a microgravity environment.
- Current status: Post-flight science underway. First publication drafted.

b. Hydra 2 - ISS Methanogenesis Experiment Payload

- Launch: 29 June (CRS15); Return: 15 January 2019 (CRS16)
- Partners: University of Strasbourg, University of New South Wales, DLR
- Main objective: Effect of space environment on methanogen growth.
- Secondary objectives: Measurement of radiation environment + effect of radiation on E coli DNA
- Current status: Main objective was not achieved. DOSIS hardware returned to DLR. Post-flight science underway

c. Hydra 3 - ISS Interactive Artistic Payload

- Launch: 29 June (CRS15); Return: Early 2021
- Partners: Studio Nahum, McQuarie University
- Main objective: Interactive space art payload.
- Secondary objectives: Tech demonstration of radiation tolerant FPGA electronics
- Current status: Main payload has been operated as part of terrestrial performances. RUSH FPGA board operating well and generating data.

Fig. 15: The three ISU Hydra Payloads on-board the ISS (ESA Photos)

One additional payload is currently under active development:

d. Hydra 4 – Lunar Technology Test Demonstration Payload

- Launch: Q2 2021
- Partners: MacQuairie University, Spire Global, ESA (NASA Ames)
- Main objective: Tech demo of liquid dispersal in lunar gravity for future plant growth experiments.
- Secondary objectives: Evaluation of COTS electronics in cis-lunar and lunar surface environments, tech demonstration of radiation tolerant electronics, use of AI algorithms for EDL feature recognition.
- Current status: Under development. PDR completed May 2019 but status of launch providers (PTScientists) unclear, since company went bankrupt in summer of 2019 and was purchased by private owners.

Three H2020 proposals were submitted:

a. ALIFE – Advance Lunar Take-Off For Europe

- Funding Scheme: H2020-FetOpen-01-2018-2020
- Partners: University of Stuttgart, FH Aachen University of Applied Sciences, Ingenaria Sistemi Impianti Servizi R&D Sri, Industrial Research Institute for Automation and Measurements (PIAP), Concepts Evolutions UG, TU Bergakedie Freiberg.
- Main objective: Development of feasibility requirements for a small-sized autonomous lunar additive manufacturing plant.

b. CBPOINT – Capacity Building Platform On INTegrated applications

- Funding Scheme: H2020-SPACE-EGNSS-4-2019
- Partners: Blue Dot Solutions,Fondazione LINKS – Leading Innovation and Knowledge for Society, SIVECO Romania, United Nations Office for Outer Space Affairs
- Main objective: Construction of interactive and participatory platform designed to connect experts with users, facilitate market uptake and build capacity on integrated applications combining Earth observation and EGNSS, specifically Copernicus and Galileo

c. ELISE – Educating Lunar In-situ resource utilisation Scientists for Europe

- Funding Scheme: H2020-MSCA-ITN-2019
- Partners: The Open University, Centrum Badań Kosmicznych, Cranfield University, Imperial College London, Politecnico di Milano, Technische Universität Braunschweig, Technical University Munich, UPC Barcelona Tech, Abengoa Innovacion, Airbus Defence and Space, European Astronaut Centre, iSpace Europe S.A., Metalysis Ltd., PIAP Space, STFC RAL Space, Teledyne-e2V Ltd., Minerva Health and Care Communications UK Ltd
- Main objective: European training network dedicated to equip Early Stage Researchers with the relevant skills and networks for a successful career in lunar ISRU.

Unfortunately, none of the proposals was successful.

3.2 Incubator and Booster function in ISU

A number of different steps were taken by the Executive, in close cooperation with the local partners and the SEMIA local incubator in Strasbourg.

- A study was performed with recent ISU alumni on the interest for an incubator. The results of the study are represented in Fig. 16.

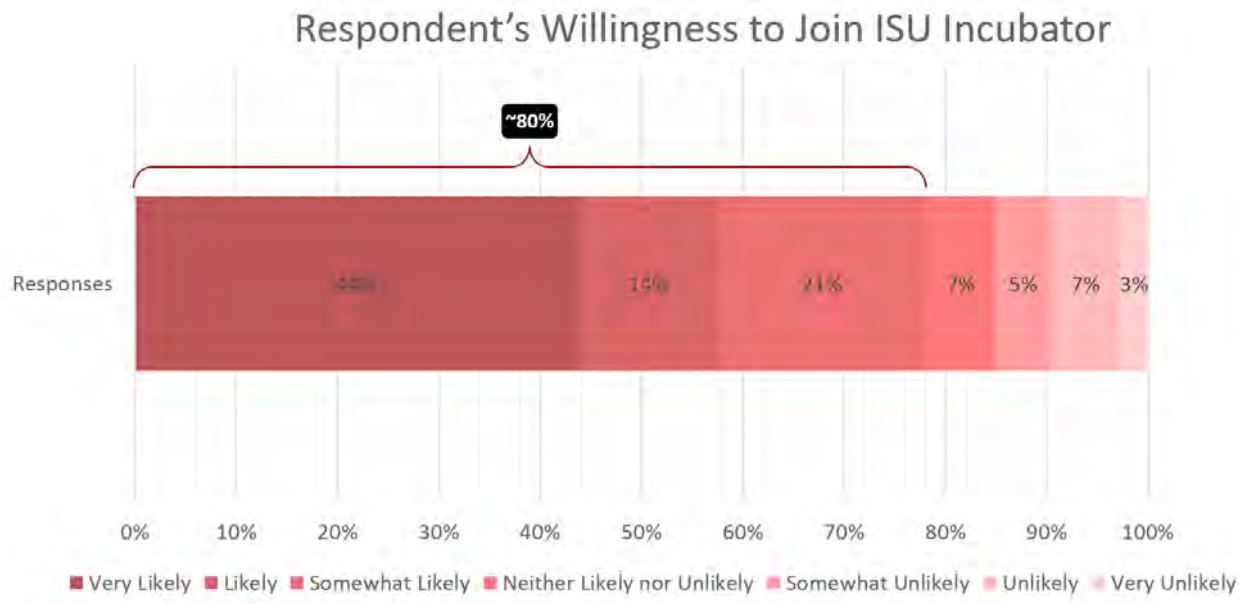


Fig. 16: Survey respondents' willingness to join the ISU Incubator

Based on the survey analysis, more than 60% of respondents had a startup idea while at ISU or currently have a space startup idea.

More than 78% of ISU alumni responded that they would have been at least somewhat likely to join the ISU incubator at the time of their ISU program, as can be noted from the graphical representation of the results.

If an ISU incubator was currently available, 67% of respondents would be at least somewhat likely to join the ISU Incubator.

- In parallel a number of incubator types were examined, in relation with the services expected from the alumni. As far as incubator types are concerned, they can be summarized as per Fig. 17 below.

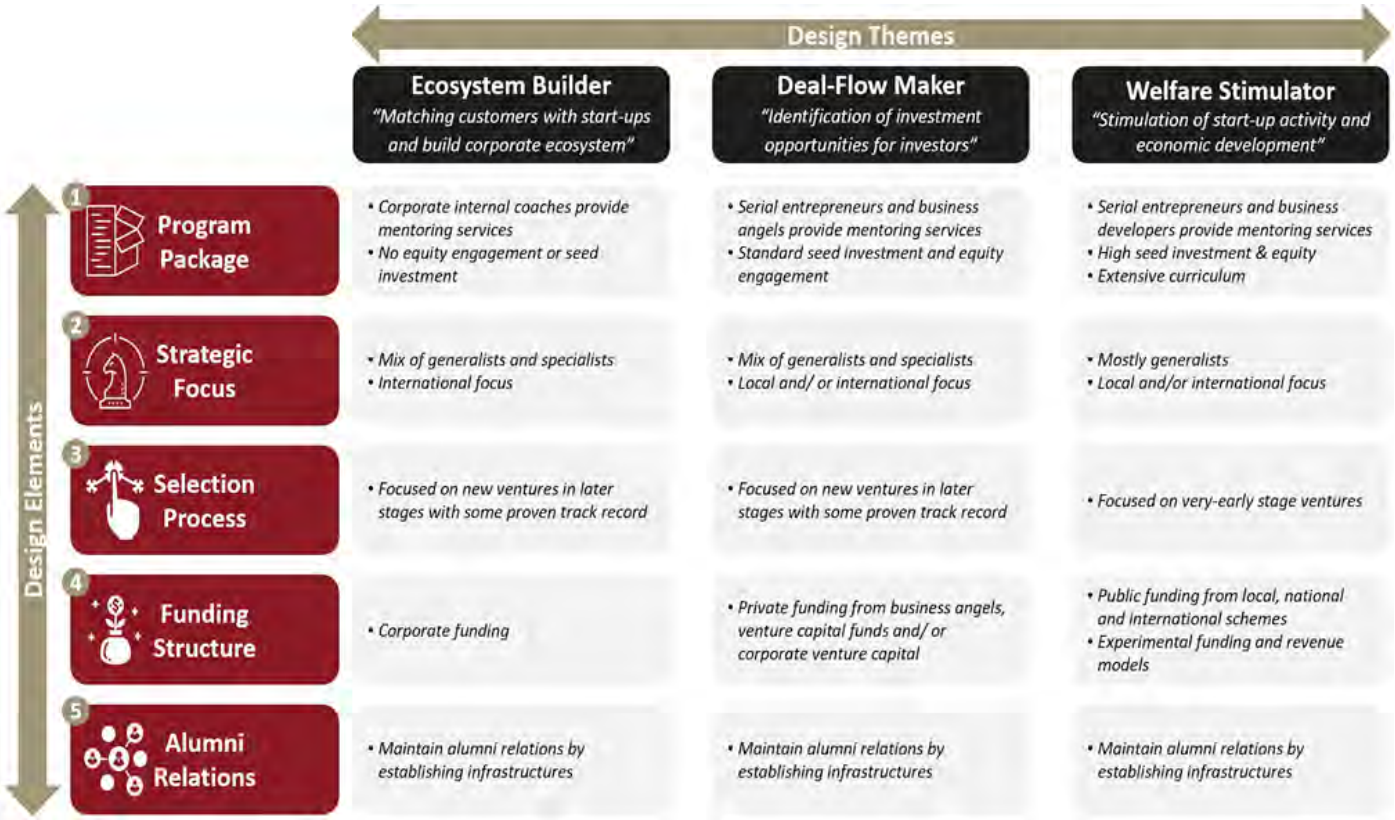


Fig. 17: Incubator Design Themes (credit: Marc Abi Fadel, ISU MSS19)

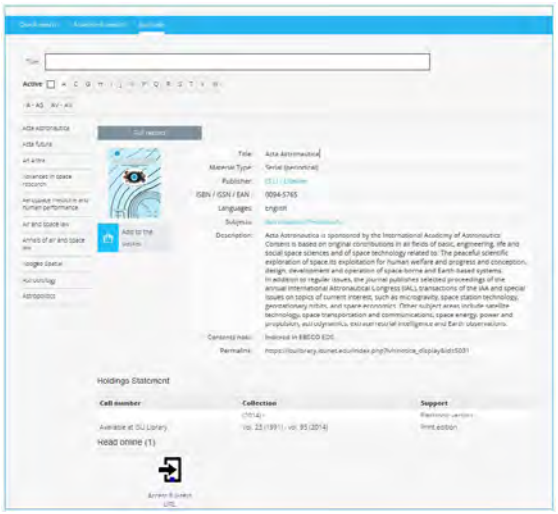
- Following advice from the Board of Trustees, steps were taken to find the right legal format to run a Deal-Flow Maker incubator in ISU. Although some forms of nonprofit organizations looked promising, participation in equity in start-up companies (as a source of future income) as well as fiscal risks were considered too high. A new approach is therefore to look into a relevant for-profit legal structure.
- Irrespective of this, a number of steps have been pursued:

1. Contacts were made and seed money is secured for start-ups with local investment funds
2. Also the possibility to work via the ESA-BIC system is now secured
3. For existing start-ups, the COSPACE label has been obtained for the RHINESPACE Booster.

- As far as resources are concerned:

1. An incubator/booster coordinator has been hired with funding from the local authorities for 3 years (@ 105,000€ per year with expenses) to organize events and attract companies
2. An area in the Eurometropole part of the ISU building is being equipped with furniture and communication equipment to support up to 10 startups, via a grant from the local authorities.

4. Library



The Library has launched a new AtoZ Journal browser on the Library website. Users can search for a specific title, see the current holdings and collection status – whether in print or in electronic- and access the full-text article when available.

Instead of providing immediate access to a large variety of journals, the Library subscribes to key space-related journals and provides fast and free document supply service to Library users who need to access full-text journal articles.

In 2019, the Library has taken new subscriptions to:

- Acta Astronautica
- Astropolitics
- Journal of Spacecraft and Rockets
- Proceedings of IISL (International Institute of Space Law)
- Space Policy

SSP19 took place in our central campus! Our team of three librarians was ready to welcome 120+ participants over the summer. We created several paper and online guides to our collection and services, provided embeded Team Project literature research support, developped new online videos tutorials and provided extended opening hours.

5. Space Studies Program - SSP19

5.1 Overview and structure of the program

The Space Studies 2019 program (SSP19) took place in Strasbourg, France from 24 June to 23 August.

For a Strasbourg-based program, the number of 127 participants representing 37 nationalities and with 37% women was a record. As many as 51 participants represented ESA Member or Cooperating States (see Figure 20.)

As is customary for Strasbourg-based SSPs, the support of Strasbourg Eurometropolis and of Region Grand Est was significant, as well as the recurrent support from ESA and CNES.

Fig. 18: ISU SSP19 poster designed by the Eurometropolis of Strasbourg

Fig. 19: ISU SSP19 patch -
Design activity led by Hugo Simoes

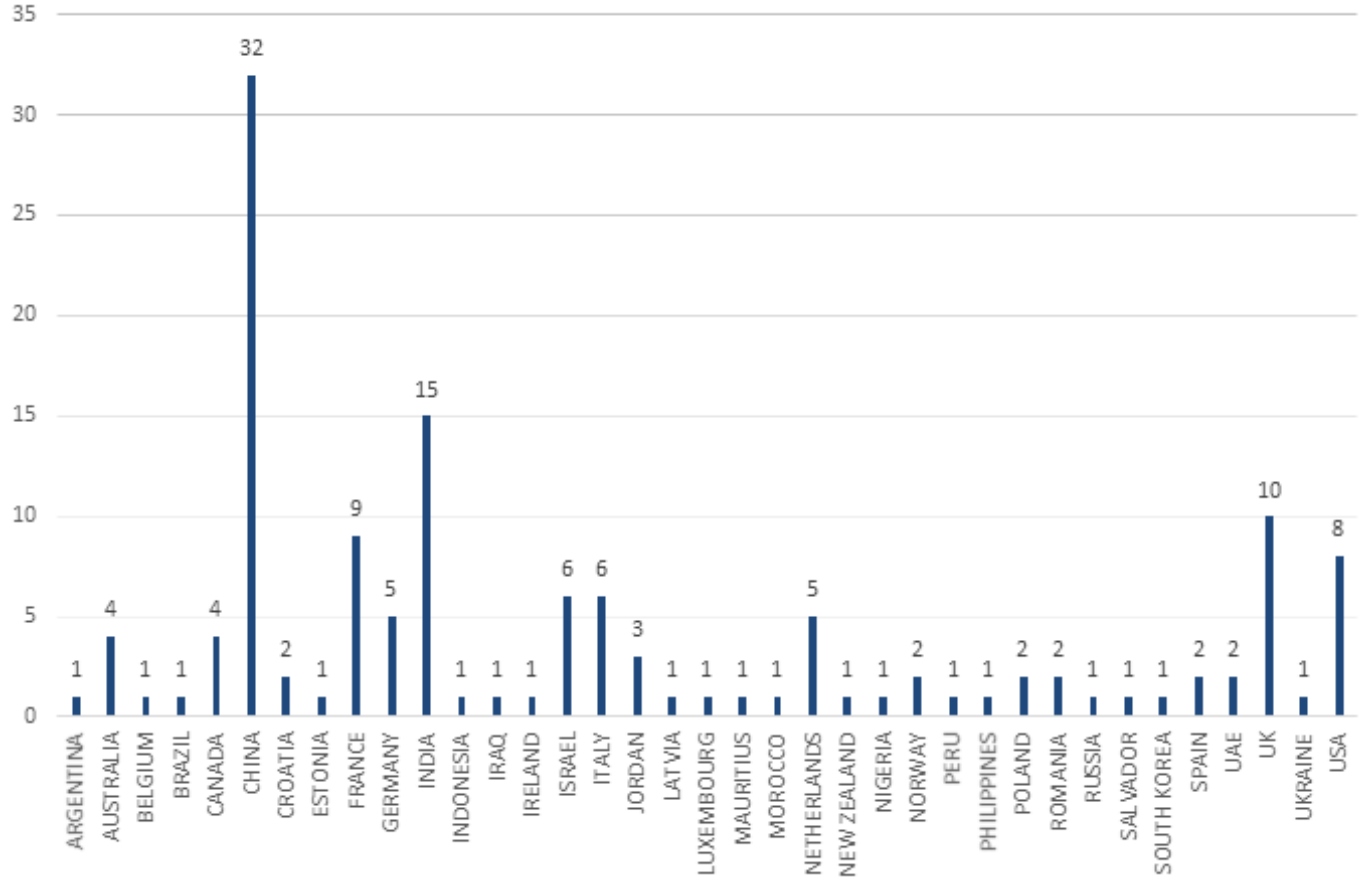


Fig. 20: Distribution of SSP19 participants per country (*) (**)

Some nationalities were represented in this class thanks to recent efforts to attract candidates and obtain scholarships from under-represented regions.

These include Croatia, Estonia, Jordan, Mauritius, Morocco, Nigeria, Peru, Philippines, Russia, Ukraine and the UAE. It was also the first time participation of a new country: El Salvador.

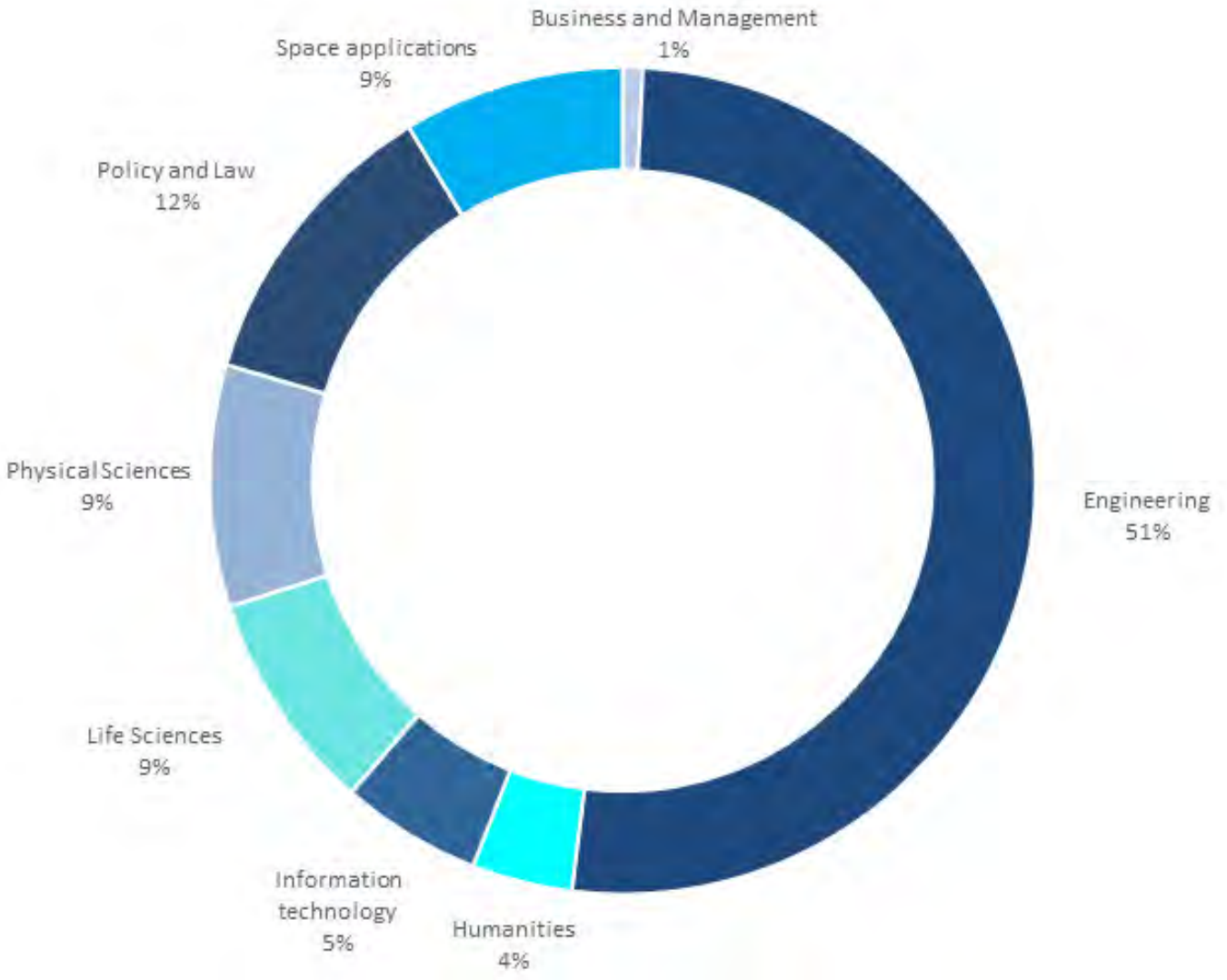
Note that several participants have double nationalities, which explains the differences in the number of nationalities in the graphs and the real number of participants, also for the other programs.

(*) The European Space Agency provided partial scholarships allowing a total of 35 participants from 14 of its Members States plus Canada and Estonia to attend the SSP19 program.
(**) Stichting Space Professionals Foundation (SSPF) contributed to the selection and partial funding of 11 participants from The Netherlands, including 6 nationals from other countries who study or work in The Netherlands.

Fig. 21: Picture of SSP19 class taken at the European Parliament of Strasbourg

The next diagrams provide an overview of the educational background and the entry academic level of the SSP19 participants. In line with previous years, compared to the MSS program a considerably higher number of participants were holder of higher degrees, including a rather large number of PhD's.

Consequently, the average age of the participants is higher than in MSS, namely 32 years for SSP19. Also the fact that 65% of the participants have more than 3 years' experience explains this age difference.



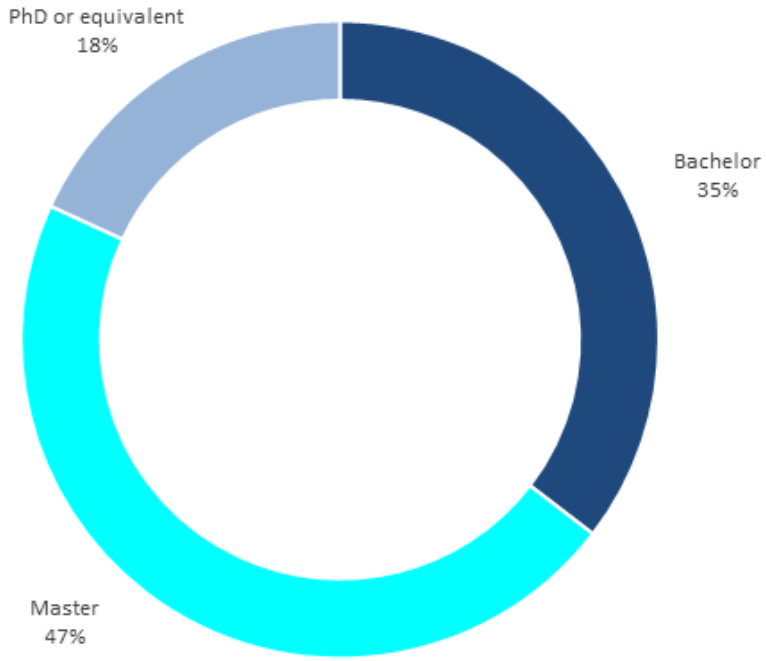


Fig. 22: Distribution of educational background and degree levels at SSP19

It is also worth mentioning that the continuous efforts to attract female students is now showing positive results. The target of more than 37% female students is now reached in virtually all ISU programs (for MSS19 a female participation of 40% is even reached).

This figure is, however, in global terms misleading as the gender distribution of groups of participants of certain countries is only in the order of 10-20% women, which evidently strongly influences the overall statistic.

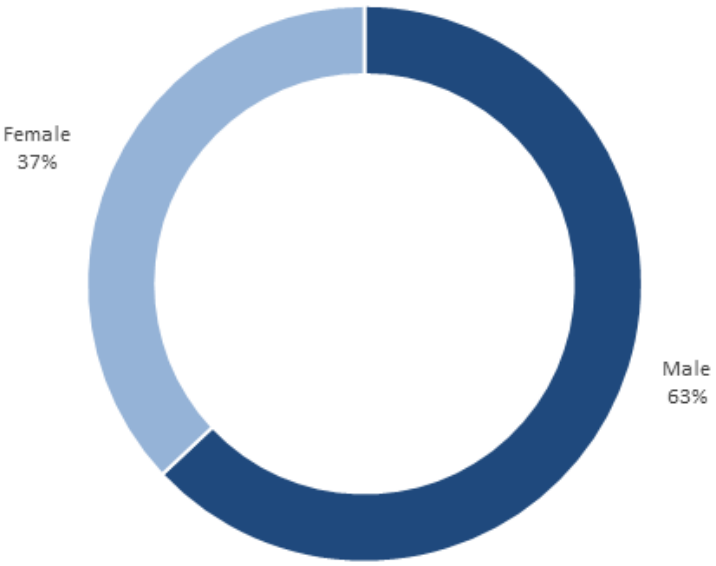


Fig. 23: Gender Distribution at SSP19

The SSP19 curriculum offered the following components:

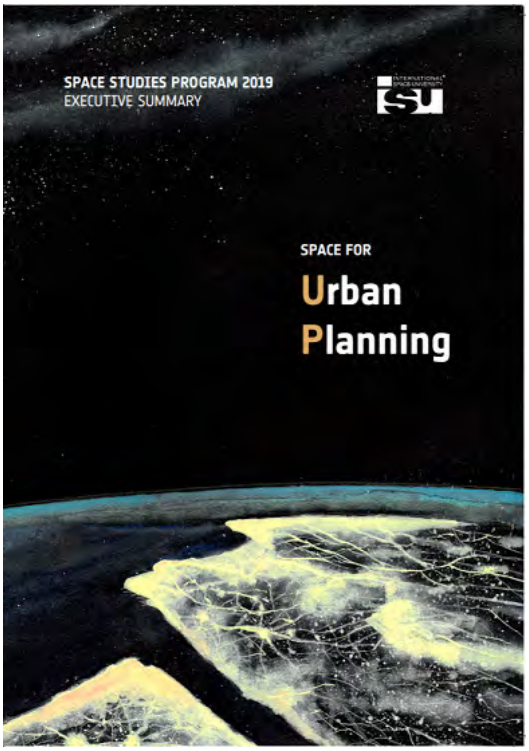
- Over 50 Core Lectures on all Space-related disciplines.
- Over 60 hands-on workshops.
- 15 half-day sessions offered by each of the 7 Departments: Sciences; Engineering; Human Performance in Space; Humanities; Management and Business; Policy, Economics and Law; and Satellite Applications.
- 4 Team Projects on “Fast Transit to Mars”, “Space for Urban Development”, “Space for Industrial Competitiveness” and “Satellite Swarms”. They are presented in more detail in the next section.
- Professional visits to Space-related Research facilities and companies in France (Semia Incubator, University of Strasbourg, Strasbourg Observatory), Germany (ESA-EAC, ESA-ESOC, Eumetsat, OHB System AG), Luxembourg (SES, ispace) and Switzerland (CERN).
- 10 distinguished lectures with prominent speakers from Academia, Government and Industry from all continents.
- An Alumni Conference and a TEDxISU event.

The overall structure of the program is shown in Fig. 24.

Fig. 24: Structure of the SSP19 Program

5.2 SSP19 Team Projects

One of the highlights of the SSP are the four team projects, which were presented in the presence of several



Space for Urban Planning

Cities are economic development and innovation hubs: they support and benefit from the development and application of space technologies. Datasets from Landsat and MODIS (Moderate Resolution Imaging Spectro-radiometer) programs, Sentinel constellation satellites, and globalnavigation satellite systems (GNSS), are already routinely utilized to monitor land, water, and urban infrastructure, and to complement emergency and rescue systems.

More opportunities exist to integrate space technologies into Earth-based infrastructure: passive thermal control systems, developed to regulate the temperatures of spacecraft components, have been tested on Earth to reduce building energy consumption.

When innovation in polymeric film technology and photo-voltaic cells brings down their production costs, their application as thermal insulators and power storage devices will become part of the mix of solutions to save energy and reduce the carbon footprint of cities.

The decreasing availability of resources can be addressed by imaginative solutions: for example, water scarcity can be managed by the realization of infrastructure modeled after natural water cycles, with its components consisting of natural and artificial reservoirs, monitored through ground-based and space-based sensors, controlled through intelligent systems run by programs initially developed for space.

Implementation of space solutions in urban planning depends on levels of national development: urban planners in least developed countries have different priorities than those working in the developed world.

Climate change and conflicts causing new waves of mass migration will globalize challenges, however, and urban planners all over the world will need to adapt to the resulting increased levels of socioeconomic inequalities. This report focuses on urban planning challenges depending on global scale factors, i.e. those that are more effectively incorporated into the future space agenda. The team's vision is that the urban planning process of addressing global challenges will transform cities into fundamental nodes of Earth-space integration.

Enhancing industrial space competitiveness: Global trends and local positioning

All over the world, countries and their regions are becoming increasingly interested in how to anticipate and enable their economies and societies to prepare and take advantage of the promising new opportunities in space exploration and development.

At the same time, a shift has taken place where governments were the only competent space actors, and now private actors have or are developing space competencies. As a result, nations and their regions need to have a thorough understanding of their space competencies and industrial expertise.

Governments can stimulate industries through enacting policies, and have a parallel aim to encourage space related industries from which their societies can benefit.

The Grand Est region has potential to participate and contribute to the global space economy and should take a proactive role to support and accelerate its contribution to the space industry, for the benefit of the people in this region of France.

The report presents the concept of SpacEst and develops guidelines to help Grand Est boost its regional space competitiveness. Current space industry trends worldwide were analyzed, as was the industrial competitiveness of the region, and innovative methodologies to determine policies, methods and tools were applied to come up with recommendations for Grand Est.

This innovative methodology allows an instant overview of what pillars of industrial competitiveness can be enhanced, and shows the potential for the region to enhance its competitiveness in the global space industry. For the Grand Est region, the four most promising areas identified are labor market efficiency, technological readiness, business sophistication, and innovation.

From a more detailed analysis, a set of recommended policies matching these four pillars of industrial competitiveness were made, such as adopting a long term investment strategy, utilizing satellite observation data for precise agricultural practices, water management and vineyard management.

Fast Transit to Mars

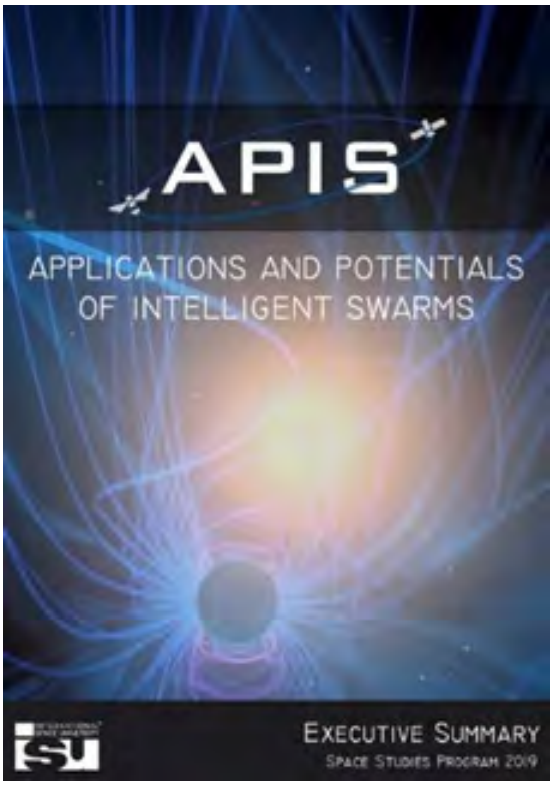
The team's goal was to determine a method for crewed fast transit using continuous acceleration to reduce the mission length from eighteen months to weeks. This would minimize exposure to radiation and the effects of low gravity on human travelers.

Reflecting ISU's spirit of interdisciplinary research, work was organized in sub-teams to handle mission feasibility and hazards, mission profile and orbits, aspects of business and law, spacecraft design, human performance in space, and humanities.

After defining the mission's top level requirements, a wide range of propulsion technologies was reviewed and compared. The most promising technologies proved to be antimatter catalyzed fusion propulsion and magnetic inertial confinement fusion. Despite the current relatively low level of technical readiness, both solutions seem to be capable reaching up to 1g acceleration.

In the second part, a mission scenario demonstrates how this technology could be applied to a fast transit to Mars, and a roadmap shows the path towards 2050.

The report also identifies new opportunities arising from this technology and discusses potential impacts of this travel on our society. The report concludes with a summary and pledge for decision makers.



Next Generation Space Systems: Swarms

Satellite swarms are developing as a high-capability and robust mission architecture. The APIS team analyzed satellite swarm technology and applications regarding science, law, and the commercial market. Based on the results, we designed a swarm mission for heliophysics research.

From nature, such as bees, we can mimic natural swarm systems. This report presents an analysis of the strengths and weaknesses of satellite swarms, as well as the opportunities and threats they face. Our analysis is the result of research and discussion from the perspectives of science, applications, engineering, human performance in space, humanities, management and business, and policy, economics, and law.

Building on our SWOT analysis, we propose a swarm-based heliophysics mission to meet the scientific requirements set out by our APIS team. The mission is designed to carry out radio tomography in Earth's magnetosphere at various scales, thereby addressing two of the four key science goals in the National Research Council's Decadal Survey.

The swarm architecture enables both large-scale and high-resolution tomographic imaging, gathering critical data that traditional constellations are not able to collect because of their inability to respond autonomously to changes in their environment.

This report presents an interdisciplinary summary of the analysis and mission concept, with particular emphasis on scientific motivation, engineering, operational design, and commercial and legal challenges.

5.3 SSP19 Public Events

- **International Astronaut Panel**

To commemorate 50 years of the Apollo 11 landing, ISU and Strasbourg were privileged to host Buzz Aldrin among the visiting astronauts.

Naturally, a highlight in the program was the astronaut panel. Two female astronauts, Nicole Stott and Soyeon Yi contributed via video recordings, and Paolo Nespoli, Jean-François Clervoy and Buzz Aldrin (previous ISU Chancellor) gave a lively presentation and discussion. The panel's moderator was ESA's flight surgeon Volker Damann, who is completing his secondment from ESA as ISU resident faculty this year.

Fig. 25: SSP19 Astronaut panel

- **Head of Agency Talk**

On 8 July 2019, the Eurometropolis of Strasbourg, represented by Mme Catherine Trautmann welcomed the European Space Agency ESA director general – Jan Woerner as part of the International Space University's ISU Space Studies Program SSP19 events series open to the general public.

Fig. 26: ESA The European Space Agency by Jan Woerner

- **As each year, also at this SSP19 a number of notable hi-level speakers provided keynote presentations, such as:**

- UAE Space Agency Director Gerneral Mohammed Al Ahbabi: UAE's Journey to Mars
- ISU Faculty John Logsdon: Once we went to the Moon
- ESA Director General Jan Wörner for the Space Agencies Panel
- Astronauts Buzz Aldrin, Jean-Francois Clervoy and Paolo Nespoli
- Joe Pelton: Saving Earth, Is Space Technology Up to the Challenge?
- Ramon Vullings: How to become an ideaDJ? Insights on Cross Industry Innovation
- John Connolly: Planning Human Missions to Mars
- Pete Worden: Starships

6. Southern Hemisphere Space Studies Program - SHSSP19

The Southern Hemisphere session continues to develop and was again offered in 2019 in Adelaide on the basis of the five-year agreement with University of South Australia (UniSA), co-signed by the Australian minister of Sciences at IAF in Adelaide.

The number of participants has reached 46 from 13 countries. As one can note from Figures 28 and 29, the program continues to attract mainly students from the southern hemisphere (also due to its timing in January/February, during the Southern Hemisphere summer) and is therefore fully complementary to the Northern Hemisphere SSP.

Fig. 27: SH-SSP19 participants

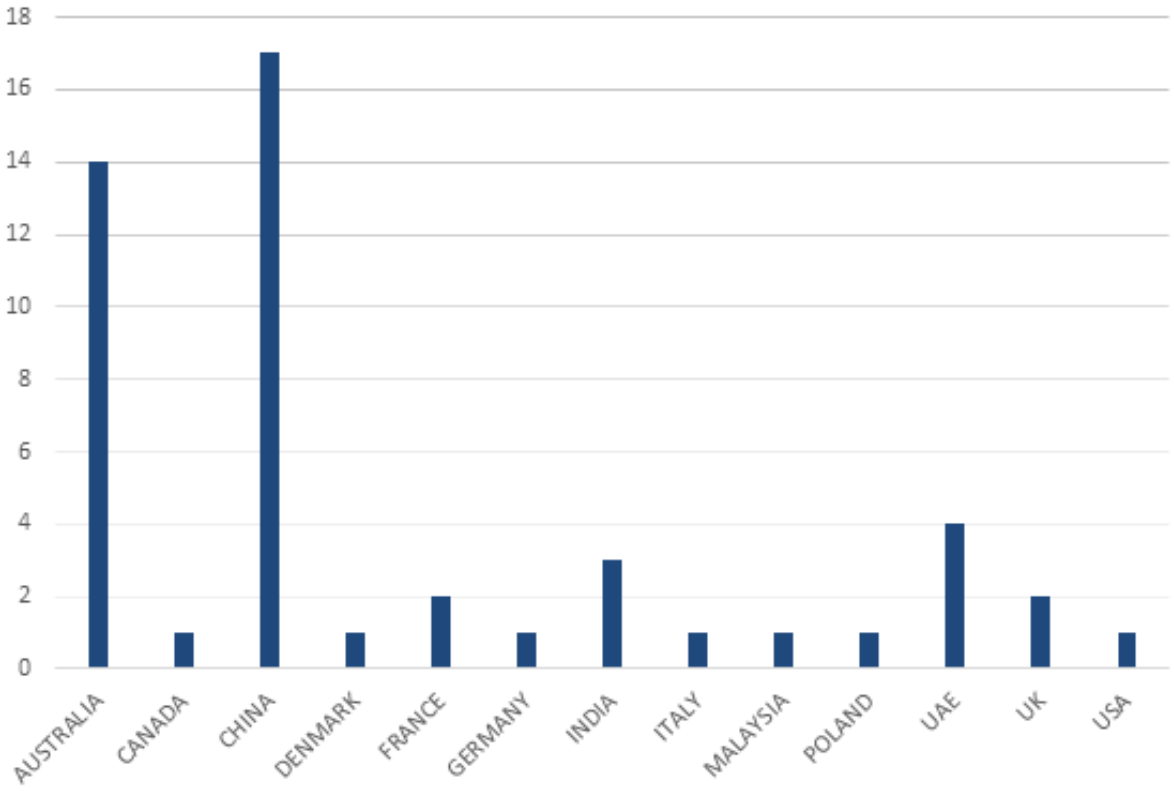


Fig. 28: Distribution of SH-SSP19 participants per country

The distribution of educational backgrounds for SH-SSP continues to show a well-balanced mix of disciplines:

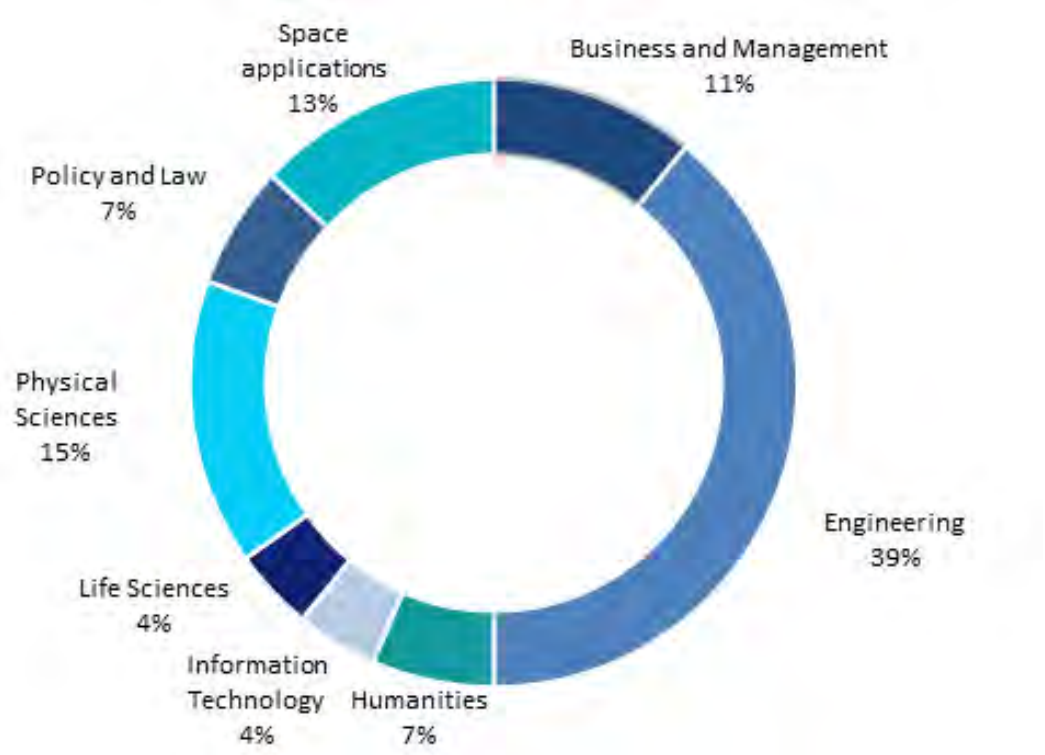


Fig. 29: Distribution of SH-SSP19 participants per background

All participants received certificates of completion from ISU and executive certificates from the University of South Australia, and several continued studies towards an advanced degree at UniSA.

Holders of the Executive Certificate receive 50 percent credit upon admission to the **UniSA Graduate Certificate in Space Studies.**

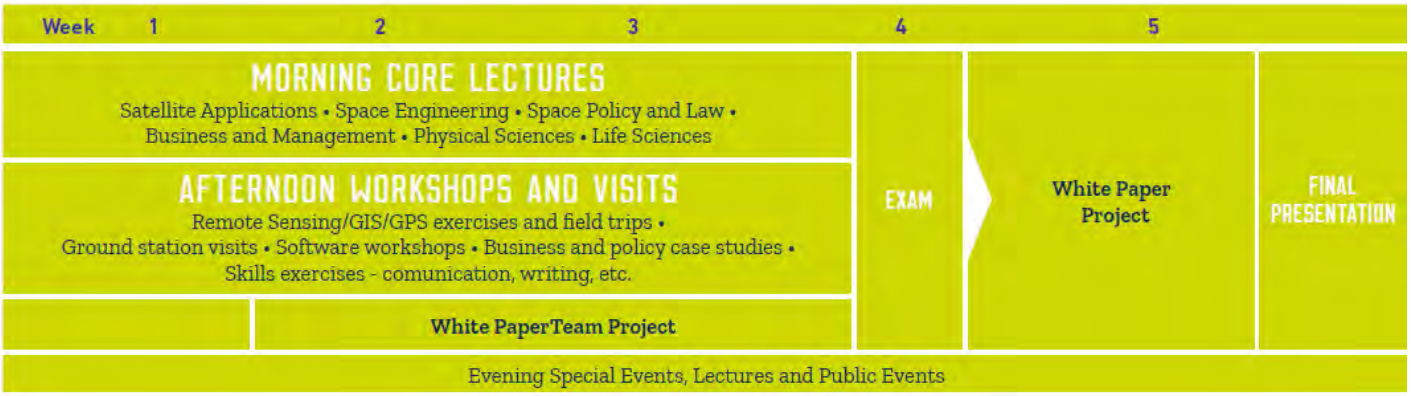


Fig. 30: Structure of the SH-SSP program

6.1 SH-SSP Team Projects

Due to the higher number of participants than in previous years, it has been decided to have two team projects: one proposed by ISU and one by the Australian partners.
The two projects performed during SH-SSP19 are shown below:

Without space : in a world without space, what will happen?

In the modern world it is easy to forget how humans rely on having unrestricted access to space. Since the iconic 'beep... beep... beep' began cascading down to Earth from Sputnik 1, space has been both a play-ground and a tool for the citizens of Planet Earth. So, what would happen if everything in space—suddenly, and without warning—disappeared?

This report envisions a time without space capabilities; an exploration of possible commercial, economic, ethical, legal, political, societal, and technological consequences of an outage of satellites and other space assets. The information provided in this report will demonstrate our global reliance on space assets and their importance to everyday life, framed to be easily understood by a reader without space expertise.

The case studies are presented with purposeful ambiguity to the cause of the outages, encouraging con-sideration of the theorized effects.

Space 2030 : space for the future, space for all

To strengthen the contributions of space activities and tools in addressing global development challenges, building stronger partnerships, and bridging the space divide between developed and developing nations, the UN are developing a "Space2030" Agenda (UN, 2018b, pp.6–7). The agenda- setting process takes place at a time of rapid change in the space sector, with an increasing number of private actors entering the scene and major technological advances.

Space2030 presents a unique opportunity to insert ideas into the discussion about the next ten years of space collaboration and, in particular, about how to advance the Sustainable Development Goals through the use of space science and technology. This report focuses in particular on the perspectives of the Economic South and their priorities for a vision for the next decade. It also provides practical examples which highlight how space technology and applications create environmental, economic, and social benefits for all and help to attain the goals of the international development agendas.

7. Commercial Space Program - CSP19

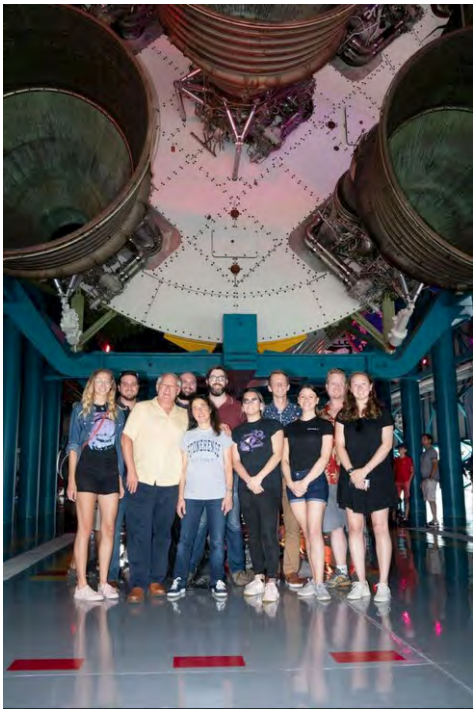


Fig. 31: CSP19 participants

The Commercial Space Program (CSP), in partnership with Florida Institute of Technology, is a six-week long accredited graduate program that comprises four courses, each worth three semester hours of credit.

The Global Commercial Space Programs, Space Technology and Systems, and Global Space Policy and Law courses each run for two consecutive weeks during the program. The fourth course, Technological Entrepreneurship, runs for the full six weeks.

Each course involves 45 student contact hours plus work outside the classroom making for an intense space entrepreneurship learning experience. The program is accredited by the Southern Association of Colleges and Schools (SACS). Ten members of the first cohort of CSP successfully completed the course.

A number of ISU alumni and faculty members supported the course. Included in the various course lecturer line-ups were Andy Aldrin, Chris Welch, Angie Bukley, Alain Berinstain, Ryan Kobrick, Grant Anderson, Ondrej Doule, Sonny Mitchell, Joe Pellegrino, Peter Eckart, Ken Davidian, and Henry Hertzfeld.

8. Short Courses

8.1 Executive Space Course (ESC) at Central Campus in Strasbourg

In 2019 we counted 18 participants, coming among others from organizations from space agencies, government offices, corporate and finance organizations in France, Isle of Man, Japan, The Netherlands, United Arab Emirates and the European Space Agency.

Fig. 32: ESC19 participants

8.2 Executive Space Course (ESC) in Seattle

A second short course, targeting more the US space public, was organized for a third time in Seattle in October 2018, with 17 participants.

Participants came not only from the New Space environment but also from the peripheral space environment, such as financial analysts or belonging to the investor community. This provided for an interesting mix with participants from the traditional space sector such as NASA.

Fig. 34: ESC18 Seattle participants

9. Our Alumni

As per 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 therefore give a distorted picture).

After an average of 9 months of graduation a questionnaire is sent to the alumni asking for a.o. their job situation (together with feedback on the program).

As far as all alumni are concerned, the result show:

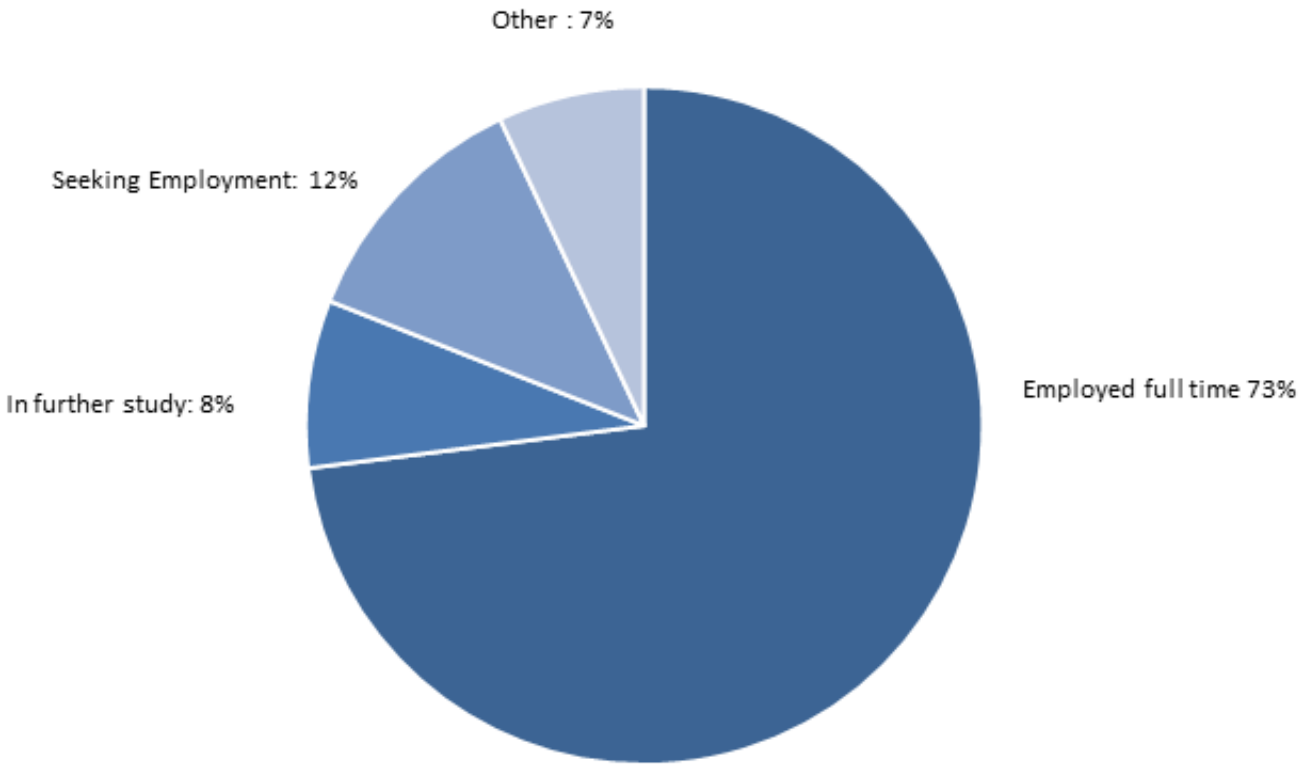


Fig. 36: Employment statistic of MSS18 alumni

The alumni who are fully employed declared obtaining this position:

- before graduation (50%)
- within 1 to 3 months (20%)
- within 3 to 6 months (20%)
- within 6 to 10 months (10%)

About 50% of students in full-time employment report working in large companies and 50% in start-up companies.

Figure 37 provides the latest statistic of the main alumni countries.

The chart demonstrates an ongoing trend with an increasing number of Chinese alumni, but also the progress of UK, France Germany and several other European countries. The increase in alumni from the Netherlands illustrates the positive effect of a previous SSP in a specific country, i.e. in The Netherlands in 2018, where a dedicated foundation, SSPF, has been set up to provide scholarships for space-related studies abroad.

Also the correlation between available scholarships and alumni is evident. In Europe we can for example notice the steady growth of French alumni, also thanks to CNES and local scholarships from Strasbourg Eurometropolis and Region Grand Est. A similar effect can be noted in the UK and, recently, in Italy thanks to the ASI scholarship support.

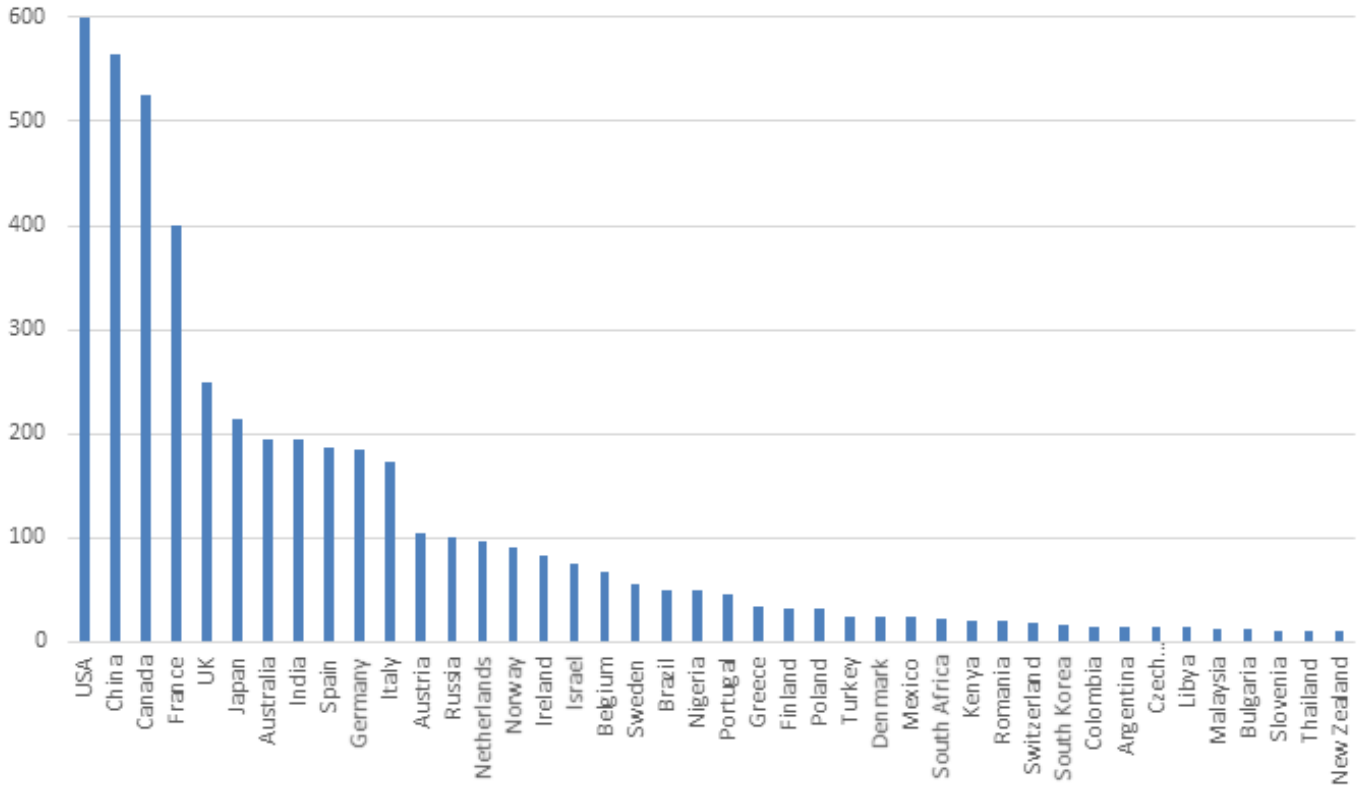


Fig. 37: Alumni distribution since start of ISU (top 40 countries only, September 2019*)*

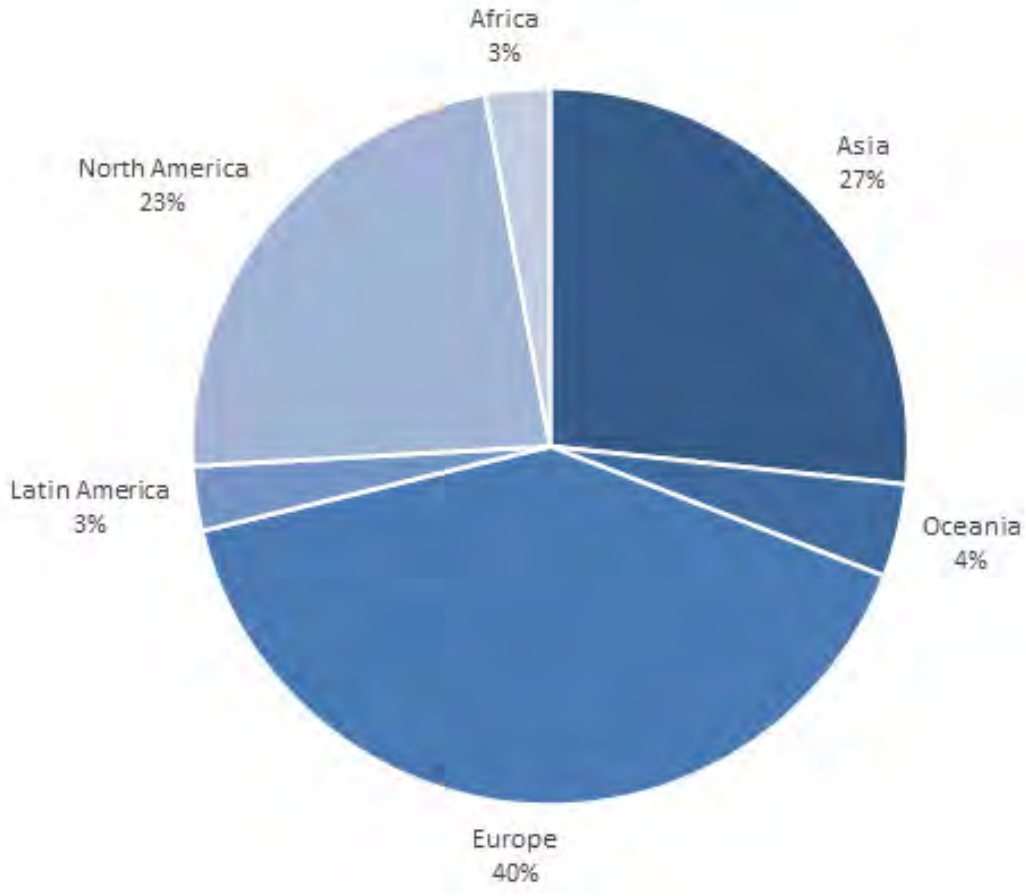


Fig. 38: Geographical distribution of ISU's 4800 alumni

A distribution of alumni in the different space sectors is provided in fig. 39.

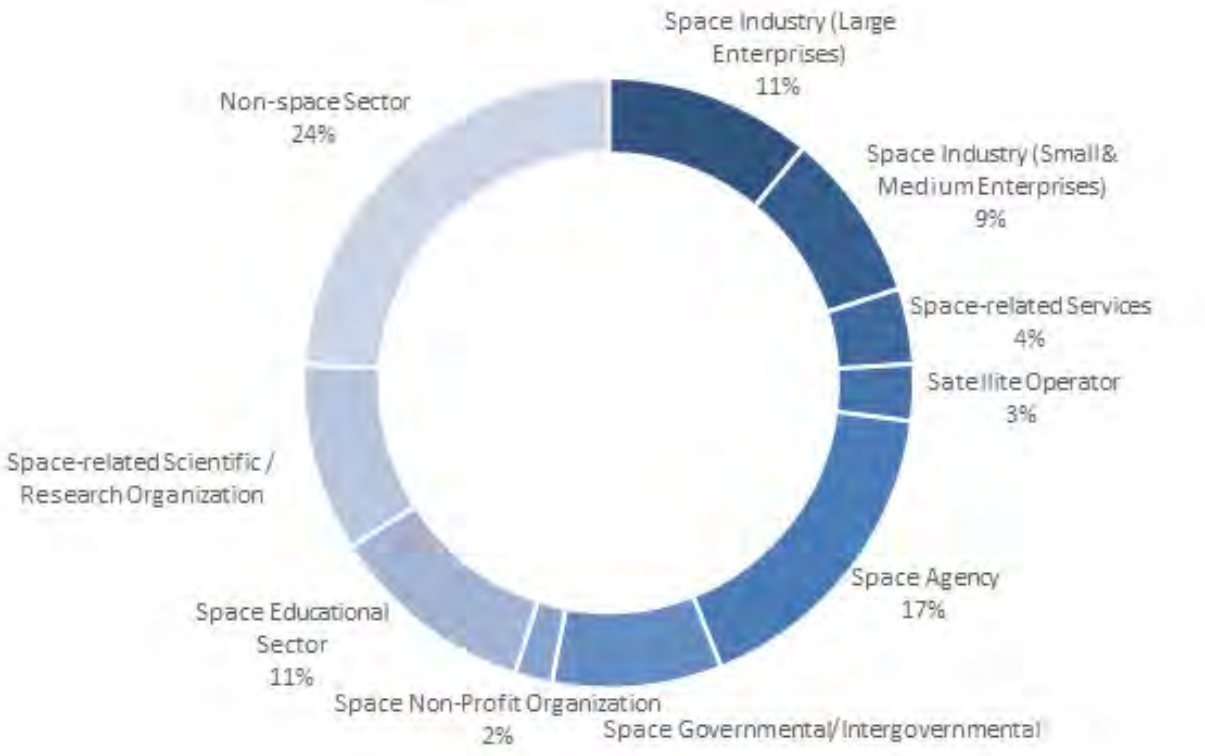


Fig. 39: Distribution of ISU alumni per sector

Contact with alumni are intensified with the distribution of the Space Talk quarterly magazine that is produced by alumni. The use of social media to stay in contact with the alumni community has been intensified.

Attendance to the Alumni Conference in July 2019 has reached the record of over 200 alumni. We can note that there are more alumni present every year – 135 in SSP17, 160 in SSP18 and 200 in SSP19.

10. Special events

10.1 Agreements

Cooperation agreements, either as generic MoUs or for specific projects, have been signed during the academic year with the following organizations:

- European Commission – DG GROW
- Moon Village Association
- Valispace
- University of Luxembourg
- Sacred Heart University Luxembourg
- Luxembourg Space Agency
- Colorado School of Mines
- China Launch and Tracking General (CLTC)
- Strasbourg Eurometropolis for SSP19 support
- Region Grand Est (France) for SSP19 support
- OHB for SSP19 support
- NASA for MSS Year B support

10.2 UNISEC-Global Meeting

ISU hosted the 6th UNISEC-Global Meeting and a short course of HEPTA-Sat hands-on training at its Central Campus from 19 – 23 November 2018.

UNISEC-Global is an international non-profit, non-governmental organization consisting in local chapters across the world. It facilitates and promotes practical space development projects in academic institutions. UNISEC-Global's vision is: "By the end of 2030, let's create a world where university students can participate in practical space projects in all countries."

The collaboration between ISU and UNISEC-Global was initiated by Rei Kawashima, Secretary General of UNISEC-Global. Rei graduated from the Space Studies Program (SSP) in 1994 and ISU's Master of Space Studies (MSS) in 1996 – the first ever ISU master class.

All MSS students took part in the conference with many volunteering to take responsibility for organizational roles.

Fig. 40: UNISEC Global Meeting at ISU

10.3 ISU and STEM activities in Strasbourg

- **School Visits**

Over the course of the year, ISU hosted visits by schools which are good for demystifying ISU Staff and alumni in collaboration with the Heinlein Prize Trust organized several visits allowing local children and high school students to discover the International Space University, Space and give them real hands on experience.

Fig. 41: Third grade pupils discovering some space hardware and equipment

- **Evening with Bob Thirsk**

ISU brings astronaut activities to the people of Strasbourg! In the context of the now traditional astronaut panel for the International Space University ISU Master of Space Studies MSS class, the opportunity was taken to organize a public event in cooperation of the Eurometropolis of Strasbourg on 18 December 2018 in the early evening.

Fig. 42: Former Canadian Space Agency Astronaut Dr. "Bob" Thirsk

- **Space Up**

In February 2019 ISU hosted its third Space Up ISU gathering more than 70 people from Europe and beyond, with as decorum ESA's street art exhibition "Graffiti without Gravity".

Fig. 43: SpaceUp ISU including the exhibition "Graffiti without Gravity"

- **TEDxISU**

Like TED, ISU is committed to open ideas focusing on international, intercultural, and interdisciplinary thought from the world. TEDx brings the spirit of TED' s mission of ideas worth spreading to local communities around the globe. TEDx events are organized by curious individuals who seek to discover ideas and spark conversations in their own community. The theme for TEDxISU, which took place for the first time at the ISU's central campus was "Exploration".

Fig. 43: TEDxISU speaker Bethany Downer, a recent MSS alumna

11. Conclusions

Thank you for having read so far.

We hope that you have found this report useful and relevant, and we look forward to interacting with you during the academic year 2019-2020 in any of the many capacities that space enthusiasts do work with ISU: as a student, member of the staff, faculty, expert lecturer, mentor, member of our boards, alumni, partner or sponsor.

The ISU founders had the vision of "…an institution which recognizes the importance of interdisciplinary studies for the successful exploration and development of space. To this end, ISU will be augmented by an expanding base of campus facilities, networks and affiliations both on and off the Earth."

Today, 4800 space enthusiasts have completed our courses and are benefiting from the powerful ISU network with its unparalleled links with space professionals in academia, government and industry. ISU alumni from all continents have started new space companies, conducted space experiments, joined space agencies or become employees of space industry giants.

Experiments developed by ISU students and faculty are flying on board the International Space Station, and new ISU initiatives in space entrepreneurship are opening their doors in Australia, Europe and the USA.

We welcome your feedback and suggestions via info@isunet.edu

Your ISU Faculty and Staff

ANNEX 1: Faculty

ANNEX 1.1 ISU Faculty

Philippe Achilleas, IDEST, Université Paris Sud & ISU, France
Alberto Behar (+), NASA Jet Propulsion Laboratory, USA
Phillipe Berthe, ESA-ESTEC, The Netherlands
Steve Brody, International Space University, USA
Angie Bukley, The Aerospace Corporation, USA
Carol Carnett, Legal Aid Bureau Inc., USA
Milan Cermack, Applied Space Technologies Network Ltd., Switzerland
Ed Chester, Catena Space Ltd. / Systemlevel Ltd., UK
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, ISU, France
Volker Damann, International Space University, France
Michael Davis, Adelta Legal, Australia
Kerrie Dougherty, Powerhouse Museum, Australia
George Dyke, Symbios Communications, Australia
Reinhold Ewald, ESA-EAC, Germany
Stacey Falzarano, USA
Stefano Fiorilli, ESA-ESTEC, The Netherlands
Daniel Garcia Yarnoz, Spain
Daniel Glover, NASA Goddard Space Flight Ceter (retired), USA
James Green, NASA Headquarters, USA
Arthur Guest, TreoScope Technologies, USA
Ozgur Gurtuna, Turquoise Technology Solutions Inc., Canada
Douglas Hamilton, KRUG Life Sciences, USA
Omar Hatamleh, NASA, USA
Hugh Hill, International Space University, France
Jeffrey Hoffmann, Massachusets Institute of Technology, USA
Dennis Irwin, Ohio University, USA
Adil Rahim Jafry, Chandah Space Technologies, USA
Rüdiger Jehn, ESA-ESOC, Germany
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Bernd Madauss, Project Management Team MADAUSS, Germany
Scott Madry, Informatics International Inc./University of North Carolina, USA
Gary Martin, NASA Ames Research Center, USA
Chiaki Mukaï, JAXA, Japan
Joshua V. Nelson, USA

Barnaby Osborne, Australia
Norah Patten, Irish Centre for Composites Research, Ireland
Walter Peeters, International Space University, France
Joseph Pellegrino, ATK Spacecraft Systems, USA
Maria Antonietta Perino, Thales Alenia Space, Italy
Christian Sallaberger, Canadensys Aerospace, Canada
Annelie Schoenmaker, Zero2Infinity, Spain
Alexandra Seneta, Department of Industry & Science, Australian Government, Australia
Michael Simpson, Secure World Foundation, USA
Noel Siemon, Australia
Vern Singhroy, Canadian Center for Remote Sensing, Canada
Geoffrey Steeves, University of Victoria, Canada
Lucy Stojak, HEC Montreal, Canada
Chris Stott, ManSat LLC, Isle of Man
Danijela Stupar, International Space University, France
Su-Yin Tan, University of Waterloo, Canada
Alain Wagner, Airbus Defence and Space, France
Chris Welch, International Space University, France
Ray Williamson, Secure World Foundation, USA
Pete S Worden, Breakthrough Foundation, USA
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Kazuya Yoshida, Tohoku University, Japan
Vasilis Zervos, International Space University, France
Olga Zhdanovich, MODIS, Netherlands

ANNEX 1.2 ISU Adjunct Faculty

Andrew Aldrin, United Launch Alliance, USA
Heather Allaway, Texas A&M University, USA
Audrey Allison, The Boeing Company, USA
Julio Aprea, ESA, France
Jacques Arnould, CNES - Headquarters, France
Farhan Asrar, McMaster University and University of Toronto, Canada
Merryl Azriel, INNOVIM, USA
Jaime Babb, Canada
Werner Balogh, United Nations Office at Vienna, Austria
Melissa Battler, Mission Control Space Services, Canada
Nelly Ben Hayoun, Nelly Ben Hayoun Studio Ltd, UK
Jon Bergstrom (+), Bergstrom Learning Center, USA
David Bruce, University of South Australia (UniSA)
Francis Chizea, NASRDA, Nigeria
Eric Choi, AeroScribe Consulting, Canada
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Stuart Eves, SJE Space Ltd
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Marco Ferrazzani, ESA, France

Tracy Roy Gill, NASA Kennedy Space Center, USA
Lesley Grady, Australia
Marlene Grenon, San Francisco VA Medical Center, USA
Georg Herdrich, University of Stuttgart, Germany
Felipe Hernandez, QUEARTEQUIRA – Felipe A. Hernandez Associated Architects, Chile
Henry Hertzfeld, George Washington University, USA
Barbara Imhoff, LIQUIFER Systems Group, Austria
Marcello Ingrassia, Italy
Bhupendra Jasani, King's College London, UK
Christopher Johnson, Secure World Foundation, USA
Matt Killick, Avcorp industries Inc. Canada
Ofer Lapid, Israel
Tricia L. Larose, Norwegian University of Science and Technology, Norway
Kris Lehnhardt, GW Medical Faculty Associates, USA
Zhuoyan Lu, China
Peter Martinez, University of Cape Town, South Africa
Tanja Masson-Zwaan, International Institute of Air and Space Law at Leiden University, The Netherlands.
Wallace John McDonald, University of Alberta, Canada
Ioannis Michaloudis, Institute of Nanoscience and Nanomaterials, Greece
Paolo Nespoli, ESA, Italy
Andrée-Anne Parent, University of Quebec in Rimouski, Canada
Robert Parkinson, Astrium Ltd. (retired), UK
Daniel Rockberger, NSLComm, Israel
Nahum Romer Zamora, KOSMICA Institute - Nahum Studio, Germany
Claude Rousseau, Northern Sky Research, France
Rogan Shimmin, NASA Ames Research Center, USA
Kai-Uwe Schrogl, ESA HQ, France
Wolfgang Seboldt, DLR (ret.), Germany
Robert Shishko, NASA Jet Propulsion Laboratory, USA
Klaus Slenzka, OHB-System GmbH, Germany
François Spiero, CNES, France
Madhu Thangavelu, University of Southern California, USA
Remco Timmermans, Open Cosmos Ltd, UK
Robert Thirsk, Canadian Space Agency (ret.), Canada
Erin Tranfield, EMBL, Germany
Diego Urbina, Space Applications Services, Belgium

ANNEX 1.3 ISU Associate Facult

Oleg Atkov, Joint Stock Company Russian Railways, Russia
Sheila Bailey, NASA Glenn Research Center, USA
Isabelle Bouvet, EADS, France
Hansjörg Dittus, DLR, Germany
Yoshinori Fujimori, JAXA, Japan
Gerhard Haerendel, Max-Plank-Institut für Extraterrestrische Physik, Germany
Vladimir Lytkin, Kaluga State University, Russia
William Marshall, Cosmogia Inc., USA
David Miller, University of Oklahoma, USA
Yoshiki Morino, Waseda University, Japan
Todd Mosher, Sierra Nevada Corp, USA
Didier Schmitt, ESA-ESTEC, The Netherlands
Isabelle Scholl, Intitute for Astronomy - University of Hawaii, USA
Paul Henry Tuinder, European Commission, Belgium

ANNEX 2: Central Campus Faculty Publications

Dr. Bertrand Goldman

- Lam, M.C.;…; Goldman, B.; et al.: The white dwarf luminosity functions from the Pan-STARRS 1 3π Steradian Survey, 2019, MNRAS 482, 715
- Röser, S.; Schilbach. E.; Goldman, B.: Hyades tidal tails revealed by Gaia DR2, 2019, Astronomy & Astrophysics 621, 2
- Smart., R.L.;…; Goldman, B.; et al.: Parallaxes of Southern Extremely Cool objects III: 118 L and T dwarfs, 2018, MNRAS 481, 354
- Goldman, B.; Röser, S.; Schilbach, E.; et al.: A Large Moving Group within the Lower Centaurus Crux Association, 2018 Astrophysical Journal 868, 32
- Malhan, K.;…; Goldman, B.; et al.: STREAMFINDER II: A possible fanning structure parallel to the GD-1 stream in Pan-STARRS1, 2018, ApJ 478, 3862
- Tang, S.-Y.;…; Goldman, B.: Characterization of Stellar and Substellar Members in the Coma Berenices Star Cluster, 2018, Astrophysical Journal 862, 106
- Röser, S.; Schilbach. E.; Goldman, B.: et al.: A new compact young moving group around V1062 Scorpii, 2018, Astronomy & Astrophysics 614, 81

Prof. Hugh Hill

- Gale, J., Wandel, A. & Hill. H. (2019). A midsummer-night's dream (nightmare?): Do rapid advances in Computation and AI portend an imminent Singularity, the end of Humanity and a paradigm change in SETI? Abstract for European Astrobiology Network Association (EANA) 19th Astrobiology Conference, Orleans.
- Gale, J., Wandel, A. & Hill. H. Will recent advances in AI result in a paradigm shift in Astrobiology and SETI? International Journal of Astrobiology (Cambridge University Press). Accepted for publication, August 2019.

Ms. Danijela Ignjatovic Stupar

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- Chen X, Ignjatović Stupar D. High-Accuracy Determination of the Upper Atmosphere Temperatures of the Sun, International Astronautical Congress, October 1-5, Bremen, Germany, 2018.
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Prof. Walter Peeters

- Peeters, W. Towards a definition of New Space? The entrepreneurial perspective. New Space Vol 6(3) (2018), pp. 187-190.
- Yuan Y. and Peeters, W., Rapid Growth of the Chinese commercial space sector, Astropolitics, Vol 17(3)

Dr. Tejumola Taiwo Raphael

- Taiwo Raphael Tejumola, Guillermo Wenceslao Zarate Segura, Sangkyun Kim, Arifur Khan, Mengu Cho "Validation of Double Langmuir Probe in-Orbit Performance onboard a Nano-Satellite" Acta-Astronautica Vol. 144 (2018) 388-396 doi: 10.1016/j.actaastro.2018.01.016
- Taiwo Raphael Tejumola, Chris Welch, Ibukun Adebolu, George Maeda, Mengu Cho "The Role of CubeSat Program in Workforce Development for Developing Countries" 70th International Astronautical Congress (IAC), Washington DC, USA, October 2019. (Conference paper and presentation).

Prof. Chris Welch

- D Couthino and C Welch, Interface Standardization for the Moon Village, IAC-18,D3,1,4,x47716, 69th International Astronautical Congress, 1-5 October 2018, Bremen, Germany
- Z Burkhardt, N Perakis and C Welch, Project Glowworm: Testing Laser Sail Propulsion in LEO,
- IAC-18,D4,4,6,x47477, 69th International Astronautical Congress, 1-5 October 2018, Bremen, Germany
- W Hu, E Ancona and C Welch, A minimal chipsat interstellar mission: technology and mission architecture,
- IAC-18,B4,8,16,x46958, 69th International Astronautical Congress, 1-5 October 2018, Bremen, Germany
- S Huang, C Welch and Y Iliev, The Technical and Commercial Increment of the Fusion of Big Data Analysis, Artificial Intelligence and Earth Observation,IAC-18,B5,3,8,x46903, 69th International Astronautical Congress, 1-5 October 2018, Bremen, Germany

Dr. Virginia Wotring

- Jain V, Ploutz-Snyder R, Young M and Wotring VE. Evaluating Potential Venous Thromboembolism Risk Factors in Female Astronauts: a retrospective cohort study. (in review).
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- Blue RS, Bayuse T, Daniels V, Wotring VE, Suresh R, Mulcahy R and Antonsen E. Supplying a Pharmacy for NASA Exploration Spaceflight: Challenges and Current Understanding", npj Microgravity 2019;5:14.
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ANNEX 2: Useful Links

ISU Website

ISU Library

Student Projects

Job Center

Alumni Directory

Photo Gallery

ISU Twitter account

ISU Facebook page

ISU LinkedIn page

ISU Youtube channel