Abstract

Organized by KU Leuven and Ghent University, two leading Belgian universities, the Master of Space Studies is an interdisciplinary post-master program that aims to equip students with the skills they need to initiate a career in the space sector. Beyond the deepening of their initial expertise, the program exposes the participating students to a broad range of topics, from human science (space law and policy, international organizations, project management, ...), to technical science (space missions, spacecraft and payload engineering, satellite telecommunications, ...), and exact sciences (Earth and Space observations, medical sciences, human explorations, ...) with the aim to provide the students with a broad overview of the interdisciplinary expertise required by many space projects. Initiated in the late 2000s, the program has served as a gateway into the space sector for over 100 students since its creation.

After a brief introduction to the program, we present a programmatic analysis, based on quantitative and qualitative surveys of students and alumni. We present the demographic, career tracks and current professional situations of students in the last 10 years, allowing us to identify trends that affects tertiary education to space sector. We conclude by briefly highlighting other ongoing space education activities, from the Belgian antenna of ESERO to the involvement of students in CubeSpec, a 6U CubeSat platform selected as ESA in-flight demonstrator to enable low-cost versatile spectroscopy of astronomical targets.

Keywords
Tertiary interdisciplinary post-master education

---

1 Corresponding author: Institute of Astronomy, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium. Email: hugues.sana@kuleuven.be
2 Institute of Astronomy, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
Acronyms/Abbreviations

MSS  Master of Space Studies
STE(AMS)  Science, Technology, (Arts) and Mathematics

1. Introduction

Together with the depths of our oceans and the mystery of our brain, space symbolizes the next frontier of knowledge and human exploration. Space is a place of wonder and of discovery. Because of this, space has been and remains today one of the most inspiring topics to promote the fields of Science, Technology and Mathematics (STEM) among the next generations of girls and boys and to attract them to much needed STEM careers in our technology-driven society.

The inspiration potential of space reaches out beyond STEM and is nowadays regularly associated with Arts in STE(AMS) events that touch an even wider and more diverse public. The recently organized Big Bang festival ("KNAL" in Dutch [1]) in Leuven, Belgium, is a concrete example of such a STE(AMS) endeavor. Organized around the theme of the Big Bang to celebrate the contribution of the Belgian physicist Georges Lemaitre, the KNAL festival was a city-wide festival organized over a three-month period in the fall and winter of 2021 and has guided almost 100 000 visitors through exhibits, concerts, conferences and public events that mixed arts, science and technology.

Aside from providing a gathering theme able to touch a very large public, space is of course a crucial sector for our modern societies. Its importance has been growing in the last 50 years and now occupies a central place that directly or indirectly impacts an estimated 60% of our modern economic activities [2]. From a scientific point of view, space provides us with unmatched laboratory conditions and a unique perch to observe the universe. Downwards observations from space allow us to collect crucial information for understanding our planet, forecasting our weather, monitoring human activities, hence providing key support to our modern economies. Spaceborne facilities are indeed important assets with undeniably large geo-strategic and geo-political impact.

From this brief sketch of the landscape, it is obvious that operating in space is a globalized and complex activity that lays at the crossroad of science, technology, management, economics, law and politics, to mention but a handful.

In this paper, we first introduce the KU Leuven and Ghent University Master of Space Studies (MSS), an interdisciplinary post-master tertiary education program organized in Flanders, Belgium. In a second part of this paper, we look back to the statistics of the program, tracing our alumni through social media and assessing their professional occupation to identify trends and themes relevant for the space education sector. Finally, we present other high-profile educational activities at KU Leuven.

2. The Master of Space Studies (MSS)

Space activities occur in a broad interdisciplinary landscape. This means that the space sector needs skilled experts that can operate in an interdisciplinary environment. Unfortunately, there are usually two main roadblocks. On the one hand, there are very few initial training programs that directly prepare the students to enter the space sector. On the other hand, most new graduates have typically specialized in only one of the fields related to space and lack a much-needed interdisciplinary perspective.

In this context, the KU Leuven and Ghent University set up, in 2009, an advanced master program to help prepare new generations of students to start successful careers in the space sector as well as to provide industries, regional, (inter-) national and (inter-) governmental agencies and organizations with new talents that have a broad view of the space sector. To reach these objectives, the program acts at two levels: a broadening of the skills of the student by exposing them to a diversity of fields related to space and a deepening of the background specialization of the students, applied to the space sector.

The resulting Master of Space Studies (MSS, [3,4]) is a post-master English-taught interdisciplinary program of purely academic nature. It is organized jointly by KU Leuven and Ghent University, two leading Belgian universities, and involves lectures organized by the faculties of Sciences, Engineering, Laws and Economics. The program is unique in Belgium, and beyond, by its breadth and nature. The MSS is internationally oriented, interdisciplinary, interfaculty, and interuniversity.

As an advanced post-master program, applicants must have successfully completed an initial master’s program in either the
humanities and social sciences, exact sciences and technology, or biomedical sciences. The initial trainings of the influx students are very diverse but share a common thread: that the students demonstrate a strong interest in the space sector and that they are able to project their future self in a topic relevant to space.

In some more detail, the MSS is a 60 ECTS program, taken up as a 1-year full-time or a 2-year part-time program (Figure 1). The mandatory common core of 29 ECTS acquaint the students with the different aspects that together form the foundation of space-related activities. Mandatory courses cover law & policy, space missions and satellite technology, sciences aspects and earth observations.

Depending on their background and interests, the students then deepen their existing knowledge through more domain-specific optional courses, for a total of 16 ECTS. These courses cover the domains of (i) Space Law, Policy, Business and Management, (ii) Space Sciences – which is very broad and covers topics ranging from space weather to radiation physics, to life science – (iii) Space Technology and Applications. Students can furthermore choose courses from other master programs at KU Leuven and Ghent University, as long as they are appropriate for their master thesis or their future professional project.

The master thesis is the final part of the interdisciplinary program, in which the acquired knowledge and interdisciplinary skills are applied to a complex and concrete project. The master thesis is a four months project mostly performed in the second semester during which the student is embedded in a research team at KU Leuven or Ghent University, or at an external institute, organisation or private partner, under the supervision of an academic promotor.

Thanks to the interuniversity effort of the program, students get embedded in the academic research expertise of two internationally-ranked Belgian universities. Furthermore, the program benefits from high-profile lecturers, including Frank De Winne, one of two Belgian astronauts, or Prof. Sarah Baatout, head of the Radiobiology Unit of the Belgian Nuclear Research Centre; as well as several international experts speaking in the yearly lecture series of the KU Leuven Centre for Global Governance Studies.

Finally, extracurricular initiatives are taken to bring the students in contact with actors in the different fields of space studies. Each year student excursions are organised, including visits to the European Astronaut Center in Cologne, Germany and the European Space Research and Research and Technology Centre (ESTEC) of ESA in Noordwijk (NL) and the Belgian Nuclear Research Center (SCK-Cen). Whenever relevant, students are given the opportunity to take part in a variety of national and international events. Recent

![Figure 1. MSS program structure. (*) Students can also include courses from other master programs at KU Leuven or Ghent University. (**) Depending of the profile of the student: students with an initial master in Science or Technology have to follow (a) while students with a Humanities background will follow (b).](image-url)
examples encompass the ESA Young Laywers’ Symposium, the Luxembourg NewSpace Europe Conference or the Belgian Switch to Space event, allowing students to expand the local expertise, interact with industry leaders, policymakers and research experts, grow their network and explore new career opportunities.

3. Programmatic analysis

The MSS program is nearing the end of its 13\textsuperscript{th} academic year and has graduated over 100 students since it was first offered in 2009-2010. This provides us an interesting sample of alumni specifically trained to enter the space sector. In this section, we investigate the demographics of the program, including attendance, gender balance and the distribution of students among the main study profiles. In a second step, we use social media and personal contacts to trace the current professional occupations of the program’s alumni to identify the sector (space- vs. non-space-related) and subsectors (academia, (inter)governmental agencies, industry) in which they are working. Finally, we use the results of interviews from alumni to shed some additional perspectives offered by young professional on the space education.

3.1. MSS demographics

Students’ influx: Figure 2 displays the number of students that have entered the program for each academic year. With an influx rate of less than 10 students per year in the first few years, the influx rate has more than doubled in the last couple of years with currently no less than 29 students registered for the academic year 2021-2022 (22 new students and 7 students spreading the 60-ECTS program over two years). As the reader will notice, Poisson error bars that are appropriate for counting statistics have been overlaid in Figure 2. Of course, one exactly knows the number of registered students each year, so one may wonder “Why error bars?”. As data scientists would explain, considering the number \(N_i\) of registered students each year \(i\) as the realization of a random variable \(X_i\) allows us to investigate whether the observed year-to-year variations can be explained by statistical fluctuations due to random sampling of a constant parent population or whether significant time-depending trends can be identified.

For example, the 2012 and 2018 peaks in Figure 2 are by no mean significant, nor is the 2010 valley. Yet, the increase observed of the last couple of years cannot be explained by statistical fluctuations around a constant average (null hypothesis rejected at 99.9%-confidence). This suggests that an external factor came into played to modify the landscape in which students choose their orientation. While the number of students in tertiary education in Belgium grows over the years, this cannot be invoked to explain a short-term increase by a factor of more than 2.5. As an alternative explanation, one may note that the increase coincides with the first academic year after the start of the COVID crisis. One may therefore wonder whether (some) graduating students felt that the job-market would be difficult and have therefore chosen to pursue a complementary (post-master) education to increase their attractivity on the markets while weathering the crisis. Interactions with the students revealed however a different message in which they put forward their long-lasting interest for space, the perceived attractivity of the sector and the larger media attention to space-related news. Time will certainly help to differentiate between the latter two hypothesis.
Gender balance: A similar analysis can be done with respect to the gender of the students’ population. From 2009 to 2017, the fraction of female students was on average of 14% while, since 2018, its average now reaches 32%. The post-2017 fraction of female students cannot be explained by statistical fluctuation around the pre-2017 rate and should therefore be considered as significant (null hypothesis rejected at the 95%-confidence). The beginning of the trend precedes the start of the COVID crisis, and we might hope that this will be a long-lasting trend to improve the influx of women in a sector that has long standing gender imbalance (as other STEM-related sectors do).

Specialization profiles: Figure 3 displays the distributions of students across the three MSS specialization profiles. Averages are 28%, 25% and 47% for the Law & Humanities, Science and Technology profiles, respectively. Our analysis reveals no statistically significant trends albeit smaller sample sizes may limit our sensitivity.

Internationalization: A last trend of interest is the larger internationalization of the program, with an influx from abroad that has doubled, from an average of 11% from 2009 to 2017 to an average of 22% in the last 5 years, despite a drop to pre-pandemic level in 2020.

3.2. Professional occupation

One of the aims of the MSS is to help preparing the students to start a career in the space sector. A possible metric of success is thus to investigate the first professional occupation of the MSS alumni immediately after graduating. Figure 4 reveals that a consistent fraction off about 70% to 75% of the MSS students find a job in the space sector after graduation, but for 2020 (possible impact of the pandemic?). The retention rate however decreases over the years and drops below 50% at the 10-year horizon. Discussion with a subset of the alumni that have left the space sector indicates that this is rather the result of new opportunities and professional developments, or personal circumstances, rather than a lack of options within the space sector itself.

Among alumni working in the space sector, one may wonder which sub-sectors they are working in. Figure 5 reveals a good mix of alumni working in academia (e.g., researchers and PhD students at universities and research centers), governmental agencies (e.g., ESA, national agencies) or the industry. While the error bars are large given the limited sample size, the clear rise of the private sector share (mostly from within Belgium) in the last four or five years seem to suggest a more dynamic Belgian job market and a growing number of private opportunities in the space sector.

3.3. Testimonials

The quality of the MSS program is regularly monitored through surveys and interviews of our alumni and of representative of the workforce. Below, we report on a small subset of quotes that illustrate the perception of students and workforce alike.

(Alumni) “When I found out this Advanced Master existed, I immediately applied. We had all sorts of subjects. Can you imagine what it must have been like for an engineer to have Space Law or Life Sciences in Space? The diversity was exactly what I loved about the Master.”

(Alumni) “Another aspect of the 1-year experience that changed my life was the networking. Because we were so few in the class, we became a tight group. Together, we
organised many trips to different kinds of events.”

(Alumni) “The diverse company visits allowed me to really get to know the industry. Thanks to this master, I found out what I wanted to do in life. I became [...]. As you can probably imagine, I would never have known this job even existed without this awesome program.”

(Workforce) “There are only limited real multidisciplinary spaces studies programs available, globally, and the quality of this program is, arguably, amongst the highest if not the highest in academic quality pur sang.”

(Workforce) “The program is really tailored to where your interests lie while at the same time giving all students the same basis to build on.”

4. Other space-education activities at KU Leuven

KU Leuven hosts ESERO Belgium [5], the Belgian antenna of the European Space Education Resources Office which we do not develop her further for the sake of place. We rather focus on a less known CubeSpec project [6-8]. CubeSpec is a KU Leuven-led in-orbit demonstration mission that have been selected by the ESA GSTP technology program with a preliminary launch date in 2023. The goal of the mission is to enable low-cost astronomical spectroscopy from a 6-unit CubeSat using an innovative optical design and pointing mechanism. While the mission aims are scientific and technological in nature, CubeSpec offers significant educational opportunities with several master thesis projects organized so far around various aspects of the mission development.

5. Conclusions

In this paper, we have reported on the advanced Master of Space Studies (MSS), an interdisciplinary post-master tertiary education program organized jointly by KU Leuven and Ghent University. The inspection of the students demographics and the professional occupation of the MSS' alumni since its creation has allowed us to identify a number of interesting trend that we summarize below:

Student demographics
- Increase in registered students in the last 2 years
- Increase in gender diversity and fraction international students since 2018

Professional markets
- About 75% of MSS alumni start a professional career in the space sector, about 2/3 of which remain in the sector 10 years after graduation
- The private sector seems to be hiring a larger fraction of our alumni in the last 4 years, correlating well with its increase role in the space sector.

These trends need to be consolidated over the next few years by further monitoring of the students’ population and their professional tracks, but also by a comparison with similar statistics from other branches of STEM education.

Appendix: Admission requirements [3,4]

As an advanced master's program, applicants are required to have successfully completed an initial master’s program before starting the MSS. The initial training can be very diverse (e.g., Law, Business, Economics, Physics, Astronomy, Management, Engineering, Design, Psychology, Biochemistry, Medicine, ...). All applicants must further present a CV and a two-page motivation letter describing the importance of the program for their professional expectations, especially in view of their previous master education. A TOEFL English proficiency test is also required.

References
[2] J. Borrell, High Representative and Vice-President, European Commission, "Opening address of the 2020 European Space Conference"