

# Space Academy of Île-de-France: Evolution of taught courses and educational practices in the space domain facing new emerging professions

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## Abstract

In the context of strong evolutions of the business, eight Higher Education French institutions have initiated an ambitious program called “Space Academy” that aims at transforming the training of new space professionals in the   le de France region (Paris), either through the creation of new University curricula or the development of innovative teaching methods. The objective of the program includes the mapping of training programs available in France to guide students considering their educational background in a context where multi-disciplinarity and flexibility are essential skills for actors involved in making the space domain a competitive sector. Such a sector needs to take into account environmental challenges, the large variety of increasing applications, digital developments, miniaturization, as well as geopolitical, legal, commercial, security, and military issues. The project goal is to develop dedicated and shared technical platforms so as to provide industrial-grade practical and hands-on courses to the largest possible number of students in these high-level facilities as well as to promote research and internationalization of student’s education. Financial support is dedicated to student mobility grants, PhD scholarships, apprenticeship contracts in academic laboratories, short educational stays and visits of specific sites.

## Keywords

Space, Education, Profession,   le-de-France

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## Acronyms/Abbreviations

AI	<i>Artificial Intelligence</i>
CNES	<i>Centre National d'Etudes Spatiales</i>
CS	<i>CentraleSupélec</i>
DLR	<i>Deutsches Zentrum für Luft- und Raumfahrt</i>
Eumetsat	<i>European Organisation for the Exploitation of Meteorological Satellites</i>
ESA	<i>European Space Agency</i>
HAPS	<i>High Altitude Platform Station</i>
MBDA	<i>Matra BAE Dybamic Alenia</i>
MOOC	<i>Massive Open Online Courses</i>
NASA	<i>National Aeronautics and Space Administration</i>
OHP	<i>Observatory of Haute-Provence</i>
PSU	<i>Paris-Saclay University</i>
SU	<i>Sorbonne University</i>
UPC	<i>Université Paris Centre</i>
UPEC	<i>Université Paris-Est-Créteil-Val-de-Marne</i>
CPUT	<i>Cape Peninsula University of Technology (South Africa)</i>
UVSQ	<i>Université de Versailles Saint-Quentin en Yvelines</i>

## 1. Introduction

The space domain is undergoing a historic transformation: some forecasts estimate that 70,000 satellites will be placed in Earth orbit in the coming years, compared to the 11000 already launched in 64 years since the beginning of the space age [1]. The most significant development in this sector concerns the involvement and investment of the private companies in a field originally managed by public organizations such as national or international space agencies. The market is expected to reach 40 billion \$ per year by 2040 [2], while the cost of launching equipment into orbit has already been reduced tenfold in the last 20 years. This increased competition is leading to the emergence of numerous new players, with many startups offering more miniaturized, standardized, mass-produced, higher-performing, and more economical technological solutions, as highlighted in the 2018 French parliamentary inquiry [3]. To address these challenges, the French government has launched "Skills and Future

Professions". The current study, named "Space Academy of Île-de-France" has been successful to the "France2030" dedicated call [4].

## 2. Analysis of emerging professions

The evolution of the space domain is characterized by significant service fragmentation. Our analysis shows that it will primarily concern systems engineers and logistics programming engineers in general. These engineers will be able to optimize manufacturing processes and therefore costs while ensuring the optimal performance. A broad vision, strong adaptability, and multidisciplinary expertise will be essential.

As systems become increasingly complex and require more and more in-flight services, maintenance and upgrades, space device designers, who rely on combined expertise in mechatronics, remote sensing, and digital technologies, addressing standardization challenges, will be also required.

Finally, numerous professions covering operational and production aspects are also in high demand. These are production specialists, responsible for large-scale integration, testing, control, and maintenance; trajectory calculations and flight control operations; and the ever-increasing challenges of data reception related to autonomous systems, constellations, suborbital flights, HAPS and end-of-life management.

This sector of activity requires not only engineers but also many technicians.

All of these challenges need to be addressed in light of manufacturing standards, environmental considerations, legal constraints, logistics related to purchasing, utilities and energy, frequency band availability, and geopolitical issues.

The industry and scientific research fields also require ever-increasing amounts of data from space, whether for giant telescopes outside the atmosphere, solar system exploration and the search for extraterrestrial life, the protection of systems in space and space weather, or for addressing Earth climate, environmental, risk prevention, and security challenges.

Generally speaking, customer support will meet the fastest-growing needs, driven by digitalization, finance, maintenance requirements, training on these developments and the development of interfaces, and commercial considerations.

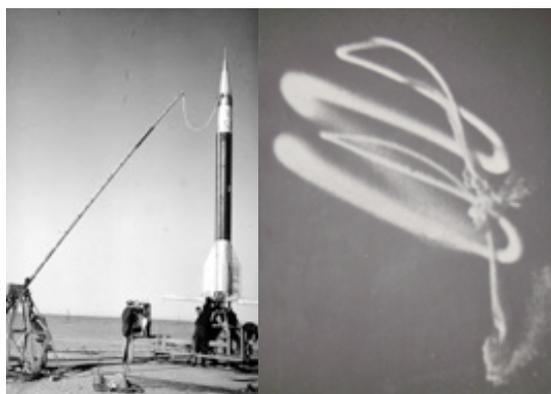
Given the importance of this evolution and these new needs, our economy has become highly vulnerable to potential failures in the space sector. This observation naturally leads to a surge in issues related to sovereignty, legal

matters, international diplomacy, military affairs, data protection, cybersecurity, debris management, consulting, and the associated commercial and financial processes. These major trends are reflected in the themes and methods developed by doctoral students co-funded by the Space Academy's call for proposals [4].

In summary, the two key qualities/expertise to develop in most of these new professions are agility and interdisciplinarity.

### 3. Organization of education and research in France

France has a strong heritage in space exploration. Indeed, as early as 1958, Jacques Blamont initiated the French space research field by experimenting with rockets to probe the upper atmosphere (Figure 1) and balloons of all kinds. This led to the emergence of the French space agency, so-called CNES, in 1961, followed by significant investment in launch vehicles within the framework of ESA, culminating in the Ariane series and contributions to nuclear deterrence. Faced with these challenges, major industrial groups emerged.



**Figure 1. Experimentation of sodium injection from French Véronique rockets in 1958 in the Sahara at Hammaguir to investigate wind and turbulence of the upper atmosphere (© CNRS).**

Thanks to CNES, France invests heavily in space research across all fields, from deep astronomy to climate studies at increasingly fine scales. New devices such as CubeSats have also been developed by universities (Figure 2) within the framework of the international INSPIRE program [5]. Small satellites have also responded to scientific issues [6] and contribute to miniaturized some sensors. Numerous innovative developments are taking place in the numerous startups that have emerged.

The space sector is more than just a niche; it drives the development of all technological fields. The spin-offs from space-specific

developments find applications in a wide range of areas, extending beyond technology to include, for example, healthcare, particularly physiotherapists who often encounter issues of muscle degeneration. We have raised awareness among these physiotherapists about the experiences of astronauts through ESA physicians. While there is a significant lack of public awareness regarding the challenges and opportunities of the space sector, the French government has launched the current space academy project [4], bringing together eight academic institutes (Universities, governmental research organization) in the Île-de-France region (Paris, France) to combine their expertise and efforts to address these challenges.



**Figure 2. Installation of the 6U UVSQSat-NG cubesat developed with internship students from the University of Paris-Saclay, here before entering the cubesat into the vacuum chamber for thermal cycling tests at PIT/UVSQ (© M. Meftah).**

### 4. Educational tools

While it is clear that greater interdisciplinarity and flexibility are needed, a more nuanced analysis is required to integrate this evolution with the existing education system. The competency wheel approach (Figure 3) ensures the best possible alignment between the needs expressed by the socio-economic sector, training institutions, and the national structure. However, we believe it is important to make training highly practical. This is achieved through the recruitment of numerous work-study students in our "space" laboratories, allowing them to explore various professions within flexible, and small-scale structures. For students in initial training programs, we focus on additional modules that develop interdisciplinarity and flexibility.

### 5. Identification of missing training courses

One of the challenges facing the evolving space sector is the need for increasingly diverse

expertise. Therefore, our initial initiatives focused on improving information through the development of a portal (which will become an observatory of space-related professions and training programs) to explain new opportunities in the sector to students and present the most suitable training programs. This goal of such an approach is to involve industry professionals as much as possible in order to produce video clips showcasing their new roles; a medium often better suited to younger audiences.

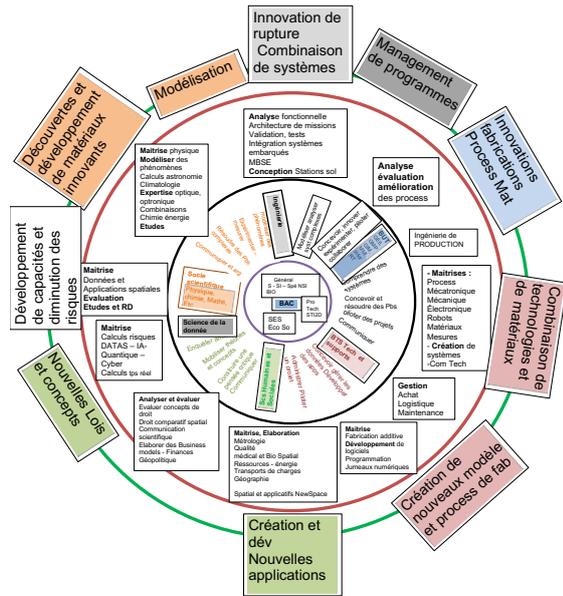


Figure 3. Skills wheel adapted to space-related professions (© M-A. Zakin)

In parallel, the first new training programs concerns first-year university students to raise awareness of generalist programs and opportunities in this sector (such as remote sensing at SU), to train specialized technicians in electronics (SU) or mechatronics (UVSQ), or space systems engineering and their applications within an international joint Master's program (UPEC/CPUT). An international Master of Science in Space Business program has also been established (CS) to address the lack of business training related to this sector in France. For short courses, students are involved in practical projects, based on satellite data distributed by NASA or ESA, or via nanosatellite, rover, or balloon projects (Figure 4).

In parallel, numerous short courses lasting a few days or in the form of MOOCs [7] have been established to provide supplementary training for students in single-discipline programs, doctoral candidates, and potentially continuing education. These courses cover AI (UPC), remote sensing (SU), nanosatellites (UVSQ), and analog astronauts (UVSQ/AGH) and will

develop in the future into sustainable lifelong learning programs.



Figure 4. Examples of new training activities: from left to right, the balloon challenge open mainly to students during the second or third year of the technical courses at the university, the summer school is intended to discover space training in Île-de-France for those searching for master's specialization, and the school is focused on AI applications with space for master and PhD students.

### 6. New agile training methods

Agility is related to flexibility in new methods of project management, used especially in what we call the *Newspace* sector that is characterized by the division of tasks into short phases of work frequently reassess depending of the project evolution. Regarding the development of this skill, we have integrated as much as possible into initial trainings the possibility of participating in Hackathons (DefinSpace, ActinSpace, Stars-Up, MBDA) which forces students to mobilize their expertise in a very short time (24 hours) and in difficult conditions of tiredness and stress.



Figure 5. Students, coming from several training programs in the Île-de-France region, working together for 24 hours as part of the DefinSpace Hackathon on a challenge proposed by the new French Space Command (© P. Keckhut).

They also have the opportunity to participate to specific Serious Games (Hussar Academy, CLIMACT, CONCEPTO) typically organized within scenario during a full week with students with different educational backgrounds that push students to work collectively. It results of student becoming aware of and confident in their own expertise (Figure 5). Also some specific modules have been introduced to

increase multi-disciplinary approaches like in bootcamps and summer schools (Figure 4).

## 7. Pedagogic platform sharing

The space sector requires specific platforms for integrating and testing equipment, as well as digital tools for visualizing observations or undertaking 3D or multi-screen design for concurrent engineering.



**Figure 6. Master's students working in the shared space platforms: (left) in the cleanroom and (right) with the vacuum tank during thermal cycling (© M. Meftah).**

Given the cost of this equipment and their primary importance for providing practical training and helping students to understand specificities of this sector, they are being developed collaboratively in the Île-de-France region. There, the density of the public transport network allows a large number of students to benefit from multiple experimental platforms and avoids the unnecessary duplication of such expensive equipment (Figure 6).

## 8. Needs for European academic research and industry

Since the employment pool in the space sector is mostly at the international level, especially the European level, we have therefore prioritized student mobility. This translates into individual travel but also visits (Figure 7) to space-related observatories (OHP), international organizations (ESA, DLR, Council of Europe) or companies (Eumetsat, ISPACE).



**Figure 7. Visit to the German space agency DLR by Master's students from several universities in the Île-de-France region.**

The international mobility is also promoted through internship grants from France to any country in the world and through a funding of academic stays for one semester or a one-year period within one of the master program of the

Space Academy with the objective of attracting the best international students to provide them with a high-level education background in the space domain.

## 9. Space awareness

### 9.1. Various audiences

For a large part of the French public, space exploration is limited to Thomas Pesquet and Elon Musk careers, which remains strongly associated with technology. As a result, the opportunities in this sector are not perceived by computer scientists, lawyers, business professionals, finance professionals, and others. The need for technicians is also not readily apparent. It is a sector that carries an image of elitism, in opposite to a sector wishing to attract more talent. To address these shortcomings, it is therefore necessary to engage with these diverse audiences, particularly at student fairs or more specific events organized in the vicinity of Paris such as Science InFuze, Déclit Collège, Astronomy Olympiad, Moon festival, or Ecospace. To facilitate access to information for younger people, we have tasked PhD and Master's students funded by the project with interacting and answering questions directly via the MyJobGlasses networking platform [8]. Students aged 15 or 16 are required to complete a company internship during their schooling. So, we organized ourselves to welcome these young students to our laboratories by groups of about twenty people. Students in initial training, enrolled in their first year of university, can benefit from an in-person or remote internship during which they are introduced to careers and training opportunities in the space sector before choosing their Master's specialization (Figure 4).

### 9.2. Inclusivity

One of the critical points for opening up this sector more broadly concerns children from disadvantaged socio-cultural backgrounds. Since recruitment in the past has been carried out primarily through private schools, recruiters need to demonstrate greater openness in their selection processes. From a training perspective, the programs offered by French universities contribute to breaking down barriers, provided that significant information and awareness campaigns are conducted. Finally, this sector, like many sectors perceived as technological, is underrepresented by girls. One of the approaches we have chosen to address such a gender imbalance consist in highlighting female models through the "Elles

font l'espace" podcasts [9], launched with the Beta Pi [10] association (Figure 8). Our proper calls for proposals did not include gender criteria, and girls received 37% of the funding. While doctoral and mobility grants show a slight gender imbalance, apprenticeship grants are predominantly awarded to men at 76%. Meaning that efforts in this direction remains to be pursued.



Figure 8. Example of one of the podcasts [9] about the journeys of women who have contributed to the vitality of the European space sector.

## 10. Conclusions and perspectives

The Space Academy of Île-de-France has a regional dimension in the Île-de-France region (Paris, France) to facilitate student travel to access educational platforms. It also has a national dimension to provide students with better information and training programs that evolve according to the sector's needs, and is coordinated with two other similar regional projects (BIOSPACE and COMETES). Furthermore, the project has an international dimension as it funds mobility incoming and outgoing grants (internships, academic stay up to one year), PhD doctoral fellowships, and work-study opportunities for international students. The target job market is clearly the sovereign European space sector, given that many players themselves have an international presence and operations that extend beyond France. While numerous collaborations already exist with each of the French Universities members of the Space Academy, a greater cooperation at the European level is searched. More information about opportunities is available online at the international page of the project web portal [4].

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## References

- [1] Report of the *McKinsey Office* : <https://www.mckinsey.com/featured-insights/week-in-charts/a-giant-leap-for-the-space-industry>
- [2] Report of the *Morgan Stanley Agency* : <https://www.morganstanley.com/Themes/global-space-economy>
- [3] Note N°19 from *OPECST*: [https://www.senat.fr/fileadmin/Fichiers/limages/opecst/quatre\\_pages/OPECST\\_2019\\_0081\\_note\\_satellites.pdf](https://www.senat.fr/fileadmin/Fichiers/limages/opecst/quatre_pages/OPECST_2019_0081_note_satellites.pdf)
- [4] *Space Académie of d'Île-de-France, Project web site* : <https://www.academiespatiale.fr>
- [5] *INSPIRE* collaboration and education on the International Satellite Program in Research and Education: <https://lasp.colorado.edu/inspire/partner>
- [6] Keckhut, P., M. Meftah et L. Croizé, *Observation de la terre et du soleil depuis l'espace : vers un changement de paradigme*, « *L'Espace Politique* »: <https://journals.openedition.org/espacepolitique/12541>
- [7] *SACE\_READY*: innovative curriculum and an e-learning platform to prepare students, researchers, and professionals for analog space missions: <http://www.spaceready.eu>
- [8] *MyJobGlasses*, 1<sup>st</sup> Europe's leading professional networking platform : [www.myjobglasses.com](http://www.myjobglasses.com)
- [9] Podcast about female figures in the space domain: <https://ellesfontlespace.castos.com>
- [10] *Beta-Pi*; association for mediation combining scientific and technical culture with popular education: <https://www.labetapi.fr>