PERSPECTIVES FOR AERONAUTICAL RESEARCH IN EUROPE

PARE

CHAPTER 10

Attracting Young Talents to Aeronautics

Final Report

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769220. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Chapter 10 – Attracting Young Talent to Aeronautics

The career inclinations of young people begin with a range of factors that influence their choices (10.0) and can form gradually more consciously from childhood and primary school (section 10.1), through teenage and secondary school (section 10.2) to adulthood and university (section 10.3), with the influence of educators and the natural family. The choice of employment depends on the image and reputation of the employer (section 10.4) and its ability to provide good living and working conditions (section 10.5) and to foster the commitment and fidelity of the workforce (section 10.6) as a second family.

10.0 Academic and Career Choices

Academic and career choices, as the factors that influence them, can be explained by the Social Cognitive Career Theory (SCCT). According to the Social Cognitive Career Theory, the career and/or academic choices of young people are influenced by personal, cognitive and contextual factors and form gradually more consciously from childhood and primary school, through teenage and secondary school to adulthood and university, as proposed by the Life Span, Life Span Theory. Therefore, to attract young talent to the aerospace sector, we may start at an early life stage and always keep in mind the fours factors from SCCT that help identify and understand the reasons why students pursue a university course: prior experience, social support, self-efficacy, and outcome expectation.

Social Cognitive Career Theory (SCCT) is a recent career theory that intends to unify common elements from previous career theorists, such as Super, Holland, Krumboltz, and Lofquist and Dawis, in order to create one framework to understand the (1) development of vocational interests, (2) making (and remaking) occupational choices, and (3) achievement of varying levels of career success and stability (Lent, Brown, & Hackett, 1994).

According to SCCT (Lent, Brown, & Hackett, 1994), three social cognitive variables play a significant role in vocational development: self-efficacy, outcome expectations, and goals (Lent, Brown, & Hackett, 1994; Lent, Brown, & Hackett, 2000a; Lent, Brown, & Hackett, 2000b). SCCT has guided some of the inquiry on the pursuit (or avoidance) of science, technology, engineering, and mathematics (STEM) activities and academic majors. Findings indicate that individual SCCT variables, for instance, self-efficacy, are good predictors of STEM interests, goals, persistence, and performance (Betz & Hackett, 1983; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lapan, Boggs & Morrill, 1989; Lent, Brown, & Larkin, 1984).

SCCT proposes that a wide range of individual and environmental factors contributes to a person's learning experiences that serve as a basis for developing self-efficacy and outcome expectations. According to Soldner, Rowan-Kenyon, Inkelas, Garvey, & Robbins (2012, p. 314) self-efficacy are beliefs about one's capabilities, which are hypothesized to affect academic and vocational decision-making by attenuating the judgments a student makes about his or her likelihood of surmounting obstacles that may lie in the path leading to attaining the desired career. Outcome expectations, or a person's anticipated results of performing one or more certain behaviours, shape vocational development differently (Soldner, Rowan-Kenyon, Inkelas, Garvey & Robbins, 2012, p. 314). Positive future expectancies are hypothesized to motivate individuals to look past proximate situations, particularly challenging ones so that they can maintain focus on the attainment of long-term desires (Soldner, Rowan-Kenyon, Inkelas, Garvey & Robbins, 2012, p. 314). These self-efficacy and outcome expectations, individually or in concert, lead to the generation of interests and goals. Goals are the intentions to engage in a given activity. Then, according to Rogers and Creed (2010, p. 163) "in turn, these social cognitive variables stimulate career choice actions (...) such as career planning and career exploration, which are necessary for the young person to make progress towards identified career goals". Moreover, immediate environmental influences, such as social support and career barriers, can also affect self-efficacy's influence on an individual's interests, goals, and performance.

Self-efficacy has been identified as a major influence on student performance and persistence (e.g., Schunk & Pajares, 2005). Among students in STEM programs self-efficacy beliefs have been found to influence academic performance (e.g., mathematics) and key indicators of academic motivation, including choice of activities and goals, persistence (e.g., graduation rates), and positive emotions (Lent, Lopez & Bieschke, 1991; Lent, Lopez, Sheu, & Lopez, 2011). Self-efficacious students participate more readily, work harder, persist longer, and have fewer adverse reactions when encountering difficulty than students who doubt their capabilities (Zimmerman, 2000). Hackett and Betz (1981) further proposed that self-efficacy has additional positive effects on educational and career decision-making, an assertion supported by research by findings from Multon, Brown, and Lent (1991) showing self-efficacy to predict both college-major choices and academic performance.

Consequently, in order to attract young talent to the aerospace sector we may ground in Lent, Brown, and Hackett's (1994, 2000a, 2000b) SCCT to examine how young people develop and elaborate on career and academic interests, select and pursue choices based on interests, and perform and persist in their occupational and educational pursuits on the aerospace sector.

Some changes can begin in the curriculum and pedagogies, to increase students' opportunities to learn and practice STEM topics necessary to perform tasks successfully and ensure student's mastery experience, one source of self-efficacy on STEM. In general, STEM education should be project-based and integrate technology on the education program, in such a way that students can learn how to solve real-world technology and engineering problems using knowledge of science and mathematics (Sanders, 2009).

10.1 Childhood and Primary School

Aerospace can easily enter the imagination of children, as shown by the story of the "Petit Prince" created by the aviator François Saint-Exupéry in the setting of the Moon. The stories about flying creatures and the visible objects in the universe can take an enormous diversity and lead to a variety of tales, including mythological episodes. The latter raises the question of how far to take these stories, for example, Icarus. It is imaginative to build wings of wax to fly higher and higher; and tragic if the heat of the sun melts them and causes a fall. On one hand, it warns of the risks of flying, on the other hand, it is a story with a tragic end. Without venturing into controversial realisms there is in phantasy world plenty of room for flying machines and travels to space objects. Also, demonstrations like balloons and origami paper gliders are quite entertaining for children.

A key aspect (Key Topic T10.1) is catching and retaining the attention of children and also specific programme developed for children (Key Topic T10.2).

KEY TOPIC T10.1 – CATCHING AND RETAINING THE ATTENTION OF CHILDREN

Although flying objects and creatures are usually entertaining for both children and adults, the attention paid to an aviation story or tale is deeply affected by different factors, among which age is included.

Focusing on children, attention span depends on age and other aspects such as the interest shown in the activity. Generally, attention is a process by which people can address their mental resources to some aspects, the most relevant ones, or also to the execution of determined actions that are considered the most adequate within possible ones. In other words, it is a process that allows people to focus on some stimulus and not on others, and to control and guide their activity to a determined goal.

Attention has multiple variations but the most interesting one is the voluntary attention in which people decide to pay attention whilst in the involuntary attention or passive attention the stimulus attracts people.

In this context, children's attention span evolves and get improved along with growth, thus at the beginning of childhood, a child's attention span is focused on interesting objects nearby that they can manipulate. In this manner, interest is essential to make the child pay attention to a specific object and no to another one, in such a way that if a new more interesting object shows up, children stop focusing on the first object and start to focus on the new one. In other words, children easily move on from one action to another frequently.

As children grow, attention span increases and becomes more stable as well, so they usually can remain longer periods doing an activity. Typically, attention span can even triplicate within 2 or 3 years, from 30 minutes when children are 3 or 4 years old to 1 hour and a half when children are 5 or 6 years old.

At this stage of growth, the main change in children's attention span is the capacity to focus consciously and voluntarily thus attention can be focused on determining objects and activities. Besides, parents and teachers hold a key role in children development, including their attention span development as they can stimulate kids to focus on the activities that they want to.

Summarizing, children's attention span depends on their growth and on the interest that objects and tasks awaken in them in such a way that it is difficult for kids to focus on a monotonous and less attractive activity.

Fortunately, flying-related stories are usually entertaining for children. In this manner, they usually enjoy doing activities such as playing with kites, listening to tales that take place in space or watching flying-related cartoon as well as make paper gliders.

Regarding aviation-related cartoon, Super Wings (Figure 10.1) is an animated television series in which a group of different planes travel the world delivering packages to children and solving problems thereby they are called the Super Wings. Being broadcasted since 2015, it has become popular in many countries as their stories are fun for kids.

Figure 10.1 – Super Wings Poster

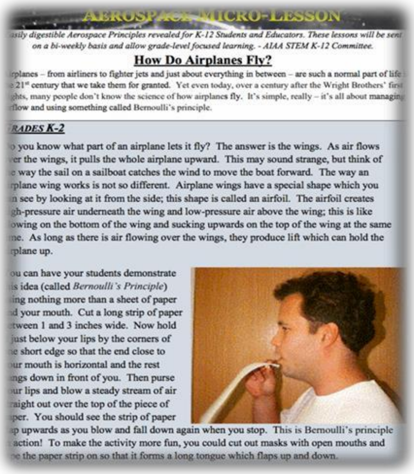
Additionally, to television series, movies in which aircraft are main characters are also usually entertaining for kids. For example, Planes (Figure 10.2) is an animated movie produced by Disney and released in 2013 in which a crop-dusting plane with a fear of heights lives his dream of competing in a famous around-the-world aerial race. This movie was successful as it grossed $239.3 million worldwide on a $50 million budget and, due to this, a sequel was also released afterwards.

Figure 10.2 - Planes Poster

These kinds of funny activities related to aviation can act as an incentive to awaken in kids the feel of loving this thrilling sector and, in this way, they could grow up willing to work in a job related to aviation.

KEY TOPIC T10.2 – SPECIFIC PROGRAMMES FOR CHILDREN

Besides children stories including flying and space objects, related illustrations, and origami paper gliders there are many other activities to make STEM funny for young children and, specifically, aerospace. The American Institute of Aeronautics and Astronautics (AIAA) has developed STEM programs which aims to inspire, influence, and mould the next generation of aerospace scientists and engineers by providing a series of resources and programming to teachers, students, parents, and aerospace professionals. These programs focus on STEM (science, technology, engineering, and mathematics) subjects, as these will give pupils the tools to advance aerospace. AIAA supplies teachers with all the tools they will need to stir the curiosity of their students, and those tools are fun, engaging, and, mostly, “hands-on,” to ensure the students thrive in their learning environment. From classroom grants to standards-based projects, to its signature program “Generation STEM: Discovering Aerospace Through Experience,” AIAA is committed to providing students with exceptional learning experiences, and teachers with the tools and resources to create those moments. Also, AIAA has available "Aerospace Micro- Lessons” (Figure 10.3) that are specially prepared for K-12 students and focused on aerospace principles. Each lesson is broken down into grade levels and is meant to


AEROSPACE MICRO-LESSON

asily digestible Aerospace Principles revealed for K-12 Students and Educators. These lessons will be sent on a bi-weekly basis and allow grade-level focused learning. - AIAA STEM K-12 Committee.

How Do Airplanes Fly?

rplanes – from airliners to fighter jets and just about everything in between – are such a normal part of life 21st century that we take them for granted. Yet even today, over a century after the Wright Brothers' first ghts, many people don't know the science of how airplanes fly. It's simple, really – it's all about managing flow and using something called Bernoulli's principle.

RADES K-2

o you know what part of an airplane lets it fly? The answer is the wings. As air flows er the wings, it pulls the whole airplane upward. This may sound strange, but think of e way the sail on a sailboat catches the wind to move the boat forward. The way an rplane wing works is not so different. Airplane wings have a special shape which you n see by looking at it from the side; this shape is called an airfoil. The airfoil creates gh-pressure air underneath the wing and low-pressure air above the wing; this is like owing on the bottom of the wing and sucking upwards on the top of the wing at the same ne. As long as there is air flowing over the wings, they produce lift which can hold the rplane up.

ou can have your students demonstrate is idea (called *Bernoulli's Principle*) ing nothing more than a sheet of paper d your mouth. Cut a long strip of paper tween 1 and 3 inches wide. Now hold just below your lips by the corners of e short edge so that the end close to ur mouth is horizontal and the rest ngs down in front of you. Then purse ur lips and blow a steady stream of air aight out over the top of the piece of per. You should see the strip of paper p upwards as you blow and fall down again when you stop. This is Bernoulli's principle action! To make the activity more fun, you could cut out masks with open mouths and e the paper strip on so that it forms a long tongue which flaps up and down.

Figure 10.3 - Micro-Lesson example for K-2

conversation and interest in aerospace. Lessons will range from engineering to mathematics, to physics, to highlighting aerospace anniversaries -- all of which will be presented in a way that easily relates to your students.

A variety of educational resources is also available in NASA'S website, it includes several entertaining materials such as: explanatory videos with attractive illustrations; interactive online games and "hands-on" experiences and activities that children can explore as they learn about science, technology, engineering, and mathematics. On one hand, when youngsters get the opportunity to watch and manipulate science, they get inquisitive and involved with it. Some simple experiments that promote this scope are described by Lauren Elrik (2015) from Rasmussen College. On the other hand, engineering skills can be both fun and rewarding, because building can happen with blocks or even household items like straws and marshmallows. Building can also happen on the computer using games and programs. For instance, one activity is to test the strength of paper (Figure 10.4), folded in differently shaped columns, by piling books on top. This is very similar to how columns are used to support buildings and other structures, being a funny and clear way to enhance kids' interest in STEM fields, more specifically on engineer. Other activity can be a competition that aims to build the paper aeroplane that takes the longest time to fall on the floor, which is a funny way leads to a discussion about some fly principles.

Figure 10.4 - How strong is a piece of paper?

As mentioned before, online games can be an effective way to trigger kids' interest, so in NASA'S website children can find a Kid's Club section (Figure 10.5) with games related to the aerospace.

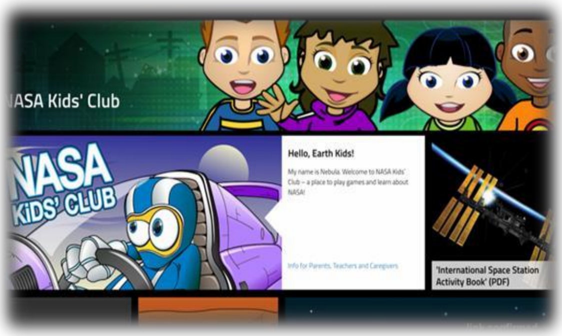


Figure 10.5. NASA Kid's Club section

Sports have a major role in most children's life, they play because it is fun and brings enjoyment. As the science of aerodynamics has also applications in sports, sports can be a pleasant way to learn about the "aviation world". From ball games like baseball, football and tennis to athletics, skiing, swimming and many other sports, the proper application of some basic principles of aerodynamic can make a difference between winners and losers. Throwing a ball along a curved trajectory or reducing the drag for a runner, all can be explained and improved through the science of flight. Teachers and parents may give some brief explanations of these basic aerodynamic principles or even make some funny experiments, so children can experience the "secrets" of the flight in sports and get some tips they might use if they practice the sport.

Also, cartoons may be good channels to boost a kid's curiosity about aerospace. For instance, "Super Wings" is a TV show with Friendly aeroplanes that travel the world and teach kids multiculturalism. UP! is a Disney movie in which one of the main characters unveils hundreds of helium balloons to fly his house to Paradise Falls. Also, Leap! is about two kids, Felicie and Victor, who make their escape from the orphanage using a pair of aerodynamic wings that Victor invented.

Contests and events can also be organized. For instance, in the United States, there is a Science and Engineering Festival with events that aim to show where "STEM Can Take You" and with a program named "The Nifty Fifty" which is a group of noted science and engineering professionals who fan out across the country to speak about their work and careers at various middle and high schools[1]. In Switzerland, Fédération Aéronautique Internationale (FAI) sponsors the Young Artists Contest which encourages young people to demonstrate the importance of aviation through their art, and to motivate them to become more familiar with and participate in aeronautics, engineering, and science[2]. Also, in London, the Royal Aeronautic Society organizes events that "aim to introduce young people to the wonderful world of aerospace and aviation, with a through-life approach to the industry which aims to inspire young people about past and future aerospace achievement". For primary education specifically, there are 2 programs: Cool Aeronautics (outreach programme) and Amy's Aviation (two children's animated series called 'Amy's Aviation' that charts the adventures of Amy as she discovers the wonderful world of aerospace and aviation)[3]. In Portugal, the Aeronautical Promotion Centre along with Nortávia organizes visits for the children to have their first contact with the aeronautical environment, in which they can have direct contact with the aircraft and their pilots and mechanics in a playful and relaxed way, thus arousing enthusiasm for the aeronautical culture. Similarly, but in a larger scale, in France, Tarmaq project aims to bring culture and share aeronautical know-how to all: families, children, curious and professionals. In an area of 35,000 m2, Tarmaq, "will make it possible to experience the aircraft in all its forms". The theme park will include a leisure area, with airliner simulators, driving leisure drones, arcade games, a mini- airport for 7-17-year-old to discover the trades of a hub. In sum, the career inclinations of young people can form gradually more consciously from childhood and primary school, it is all about making STEM fields funny and enjoyable for kids.

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[1] https://usasciencefestival.org/
[2] https://www.fai.org/fai-young-artists-contest
[3] https://www.aerosociety.com/careers-education/schools-outreach/primary-education/
[4] https://air-chapter.squarespace.com/blog/2018/1/11/visita-escola-de-aviao-nortvia

10.2 Teenage and Secondary School

The basic teaching of physics, natural science, and mathematics, even at the secondary school level, can lead to some understanding of flying in the atmosphere and travelling in space. It is possible to explain why balloons fly up in air; to build and throw some paper planes. To explain how the earth moves around the sun and the seasons; the motion of the moon around the earth and the moon cycle; the rotation of the earth and the daily cycle. About the sun, other planets, the comets, and stars. About helicopters and drones. The drones are now so common and cheap that they can be readily used to train piloting skills. Some of these activities can occur in leisure times at school or outside school with the families.

In fact, before choosing what studies to pursue in university, young people need prior experiences in the subject, meaning that we should promote the exposure to aerospace matters before university. As years pass by, the basic teaching of STEM, even at the secondary school level, can lead to some understanding of flying in the atmosphere and travelling in space and students' interest to pursue careers in the aerospace sector.

In order to specifically promote aerospace engineering, the ALLIES partnership has focused upon the design and development of wind tunnels that are donated to secondary schools. The wind tunnels have proven to spark interest in aerospace-related phenomena among the secondary students. The most recent ALLIES effort focuses upon the design of a wind tunnel that can be fabricated using materials, parts, and components available in most regions of the world, such that disadvantaged schools can easily replicate a wind tunnel (Carmen, Groenewald, Setshedi, & Abrahams, 2016).

Also, Learn&Fly project, currently in progress, has a double complementary objective: on the one hand it aims at addressing underachievement in the basic skills of maths, science and literacy through more effective, innovative teaching methods using the world of aeronautics as inspirational theme; on the other hand it aims at supporting schools (especially teachers) to tackle early school leaving (ESL) and disadvantage, by providing information and materials about career opportunities in the aeronautics field and different education/training paths available to embrace them. Learn&Fly is being implemented in Spanish, Portuguese and Poland Schools, and will make the pupils' interest rise towards STEM-related subjects, including those leading to a career in the aerospace sector, and will follow up by supporting their career decisions, in a context where teachers, parents and professionals work together to ensure a positive environment for a proper human, social and professional development of the younger generations.

More, the path of students from secondary to higher education can be illustrated considering two universities in distinct European countries (Key Topic T10.3).

KEY TOPIC T10.3 – STUDENT PATH FROM SECONDARY TO HIGHER EDUCATION

Introduction

The fast development of the aeronautical industry over the last few decades has led to the creation of many jobs for both engineers and technicians. In the last 10 years, the air transportation industry has employed over 350000 people (figure 10.6). On the other hand, that from the perspective of future employment, the scenario has a European context. This is due to the fact that the corporations employing these numbers may be the same in different countries, either because they are cross border transnational companies (like EADS and Airbus), or they are joint ventures (like Thales Alenia Space and Alcatel, Agusta and Westland, KLM and Air France, etc.) or, finally, they are co-operations on specific projects (e.g. Clean- Sky).

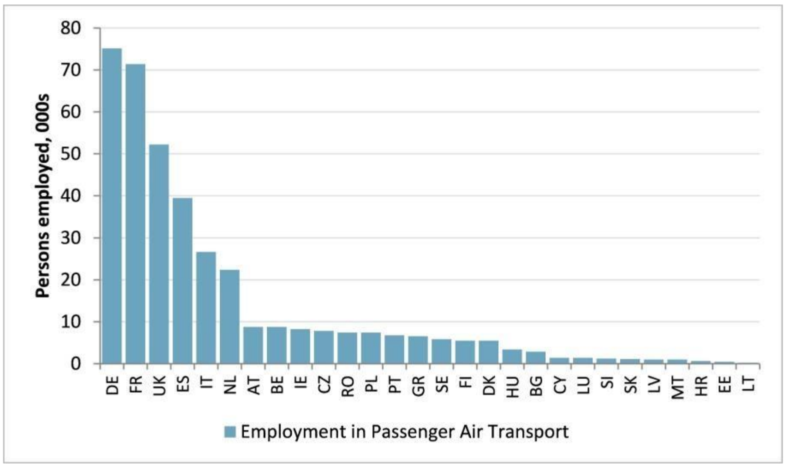


Figure 10.6 - Employment in Passenger Air Transport (http://eur-lex.europa.eu/legal-content/es/TXT/?uri=CELEX:52015SC0261)

The student finishing secondary school has a wide and sometimes bewildering choice of university degrees to apply for. Even restricting to Science, Technology, Engineering and Mathematics (STEM) the options can be numerous and confusing. The aerospace engineering domain can be attractive from different points of view: technical knowledge acquired, and an interesting job in research, manufacturing, or exploitation, with very good retribution. The fascinating promise of aerospace engineering must be delivered in a high-quality university course that gives the necessary knowledge, skills, and ability to reason and work in all these disciplines and their combination. Because universities have an admission exam (with a typical procedure), high school graduates need to have a strong motivation, and to know very well mathematics and physics, to pass steeps of the admission process.

In the aerospace industry, the fluctuations of aerospace engineering employments depend from the strategies of the main players in Europe: EADS, ESA, Alenia, etc. In present (and the trends is maintained) the "big" members of aerospace industry have a certain specialization in manufacturing of parts and components (table 10.1), and graduates of aerospace faculties may choose first to work in aerospace capabilities present in their country, although there is considerable mobility on the aerospace sector.

	France	United Kingdom	Germany	Italy	Spain
Major competences	Cockpit technologies and manufacture, engine manufacturing, broadest range, e.g. final assembly of wide-body aircraft, helicopter, aircraft funding	Manufacturing of wings, strong in related composite applications, engine manufacturing, military products, MRO	Avionics, fuselages, complex cabin equipment, high-lift systems, vertical tails, manufacture of and technologies for engines, final assembly of large civil aircraft, helicopter	Electronics, Military aircraft, helicopter manufacturing, strong integrated in non-EU value chains	Tail, fin and pitch elevator, growing strength in composites, assemblage of military transport aircraft and helicopters

Table 10.1 - Specialization of bigger member states in the aerospace industry in Europe (Source: Competitiveness of the EU Aerospace Industry with focus on: Aeronautics Industry, 2009).
(https://www.albertacanada.com/EU_AerospaceIndustry.pdf)

In the next section we will present the educational offers of three European universities in aerospace domain. They belong to the larger group Pegasus of Aerospace Engineering universities, about which more information is provided in pages 37 to 45.

Politecnico di Torino (Italy)

The Politecnico di Torino is considered one of the best Italian universities for engineering studies. The admission test to the Polito is selective because the students who try to enter are many and coming from all over Italy, and from many European countries. The test to be admitted to the Politecnico di Torino at the three-year degree will not be held on a single date, but in different periods. Many students sign up for the test. Precisely the dates of the test are March 15, April 20, May 19, April 20-21, August 31, September 1-2, and September 14. The test consists of answering 42 questions in an hour and a half. The questions are divided into 4 sections related to 4 different disciplinary areas: mathematics, verbal understanding, logical and physical themes.

The students can obtain the Aerospace Engineering, Laurea (1st degree and Bachelor-level of the Bologna process) in the Department of Mechanical and Aerospace Engineering ("Collegio di Ingegneria Meccanica, Aerospaziale, dell'Autoveicolo e della Produzione, Classe: ingegneria industriale (L-9), Corso: ingegneria aerospaziale (L-9)"). The program has a duration of 3 years and it held in Italian language, but the first year is common to other graduate programs and is also offered in English language.

An average number of 200 students graduates the program; an average number of 150 graduates do not work at the time of graduation (2015-2017 period).

The educational programme is divided in the following sections:

- Scientific and methodological foundations: mathematics and basic sciences (physics and chemistry) for engineering. These courses are held in the first three semesters, although the third-year programme also provides optional courses in mathematics and statistics for students wishing to strengthen their background.

- General engineering: timetabled in the second year, this provides the base common to all industrial engineers and it focuses on industrial technical design, materials science and technology, machinery mechanics, electrical engineering, electronics, applied thermodynamics, heat transfer and structural mechanics (the last three subjects are treated with greater attention to the connection with subsequent courses in aeronautic construction and aerodynamics).

- Aerospace engineering: the third year covers the core of knowledge in aerospace engineering, including flight mechanics, aerospace construction and structures, aerospace equipment and systems, fluid dynamics and aerodynamics, and aerospace propulsion. These form the basis for the main technical competences of graduates, and for the integration in the aerospace industry or to continue further studies.

- Aeronautic maintenance: in the third year, students have more practical options, necessary for forming a professional skill, focused on aircraft maintenance. These training activities are supervised by the Italian Civil Aviation Authority (ENAC), a member of the European Aviation Safety Agency (EASA), which guarantees full recognition for the purposes of awarding graduates Aircraft Maintenance Licence Class C, in accordance with EASA Part-66 international norms.

The aerospace engineering programme concludes with a final exam based on an assignment carried out independently by the student, who will present his or her dissertation before a reviewing commission. For students who choose the EASA Part66 a part of the dissertation is associated to an internship in an industry or company.

Before graduating, students must also attain English language certification at the level of the Cambridge Preliminary English Test, "Pass with Merit".

Employment opportunities for which graduates in Aerospace Engineering are specifically trained lie mainly in the aerospace field:

- Major European aerospace industries.
- Small and medium-sized industries which supply the former.
- Agencies and contractors responsible for aircraft maintenance.
- Airline companies.
- Air traffic management authorities.
- The air force and other military aviation sectors.
- Public and private bodies for testing in the aerospace field.

The multidisciplinary knowledge of the aerospace engineer and some of its specific competencies (fluid dynamics and aerodynamics, light structures, computer-aided design, advanced materials and technologies, integration of various mechanical systems, sensitivity to safety issues) can readily be applied in a range of jobs outside the aerospace sector (e.g. civil construction, automotive domain, etc.). European-level data show that about 50% of aerospace engineers are employed in other industrial sectors, even in regions where aerospace activities are most strongly established and offer the greatest employment opportunities (France, Germany, UK, Italy, Spain).

The qualification for further studies (Higher Education inside MSc programmes, especially in aerospace engineering), the graduates must to have solid theoretical knowledge, oriented to the engineering practice, of mathematics, physics, aerodynamics, mechanics, etc., excellent language skills and ability to formulate problems in mathematical terms, and also a capacity for analysis and synthesis.

TU DELFT (Netherlands)

Due to increasing number of students in the last years, the TU Delft bachelor programme Aerospace Engineering has determined a fixed capacity, a *numerus clausus*, of 440 new students that can be admitted into the bachelor's degree programme for the academic year 2018-2019 (the deadline for application is annually before January 15, and the result is published at April 15). The selection procedure aims at a good match between the student and educational programme and focusses on the Motivation and Academic Performance of an applicant. Every applicant will receive a rank number. Higher final selection scores result in better rank numbers that offer the possibility to be placed in the top 440 applicants. The Academic Test (available from March 1 to March 25) is used to determine the score on the criterion Academic Performance. The Academic Test has three sections: Mathematics, Physics, and First Year Material.

The programme structure (36 months) is based on: 28% aerospace design, 28% aerospace engineering sciences and technology, 27% basic engineering sciences, and 17% minor. The average studying week has 42 hours (16 hours -lectures, 8 hours - projects and laboratory courses, and 18 hours self-study/tutorials), being 100% English-language BSc (&MSc) programme.

In the first year, students learn the basic engineering sciences, such as mechanics and calculus, and the main focus is to apply these disciplines in the aerospace design projects. The second-year is dedicated to designing systems and processing measurement data. With intensive mathematics courses, the topics briefly discussed in the first year are exploited in-depth, providing with a solid theoretical background in aerodynamics and orbital mechanics. The aerodynamic courses are accompanied by practical applications using two aerodynamic tunnels. The first semester of the third year allows extended the student education by means of minor programmes. Students can choose to do this at other Tu Delft faculties, at other universities in the Netherlands or at one of the partner universities. The last semester consists of the final BSc courses and offers a practical flight with a Cessna Citation aircraft to carry out measurements in flight. Everyone finishes the third year with the Design Synthesis Exercise (working with a team of students on an original and relevant design assignment, in many cases the design project being proposed by aerospace companies or research organization.

The necessary profile of an aerospace engineering student must be included the capacity to acquire new maths and physics skills at a rapid pace, ability to solve multidisciplinary design in a team, and capacity to study in an international-oriented environment.

A study regarding career for graduates (year 2017) concludes that:

- 88% of MSc graduates find a job within 6 months after graduating
- 40% become employed in the Aerospace sector
- 60% find a job within another engineering (wind energy, automotive) sectors, consultancy or management.

MSc programmes have the following directions: Space Flight, Flight Performance & Propulsion, Aerodynamics & Wind Energy, Control & Operations, and Aerospace Structures & Materials.

In addition, a variety of informal and complementary learning activities could be promoted among students and STEM educators, in a way to connect them with the STEM community and workforce, such as:

- Teach youth at science summer camps or after-school programs.
- Getting students to join STEM-related clubs, namely Space and Aeronautics Clubs.
- Promote and support students' participation in science fairs and competitions.
- Create job shadow opportunities.
- Promote visits to Aerospace Companies.
- Give them books and magazines on STEM topics.

IST – Lisbon (Portugal)

Admission to universities in Portugal is by a national exam and each course has a "numerus clausus" – the maximum number of students that can be admitted. Students make a list of preferred courses/universities and are admitted based on their marks. This country wide-open competition has the secondary effect of ranking the courses: which do not fill the "numerus clausus" (bad)? Of those which fill the "numerus clausus" what is the minimum entry mark? How many more candidates (first choices or total) than places? Each university/course can put minimum entry requirements based on the national examination. For Aerospace Engineering at Instituto Superior Técnico (IST) of Lisbon University the minimum is 12 out of 20 in Mathematics and Physics in the national exam. The real minimum is much higher.

When Aerospace Engineering was created in 1991, the "numerus clausus" was 35, the minimum entry mark 16.4 out of 20, the highest of all engineering degrees in Portugal. In 2020, the "numerus clausus" was 92, the minimum entry mark 18.95 out of 20, the highest of all university degrees in Portugal. Over 30 years, the "numerus clausus" increased from 35 to 92, the minimum entry mark from 16.4 to 18.95, the number of first choices from 1.1. to 3 times the "numerus clausus, and the number of candidates from 3 to 6 times the number of available places.

Aerospace Engineering at IST-Lisbon has the best university students in the country, 90% employment within 1 month of graduation and 100% within 3 months. Demand has always exceeded supply, employers want more and make recruitment seminars. The university strongly advises students not to accept job offers before graduation, because it could affect their academic performance, and they will not be short of job offers when they graduate. Employers include the aeronautical and other technology sectors in Portugal and Europe, and international consulting firms.

The course (as can be seen in the following diagram) has a 3-year B.Sc. common core with a strong background on Mathematics (6 subjects), Physics (2 subjects) and Computation (2 subjects), followed by a spinal cord of vehicle performance, stability, control and testing (6 subjects), plus Fundamentals of Mechanics, Fluids, Thermodynamics, Structures, Materials, Control, Electronics, Telecommunications, Informatics and Systems, Soft Skills and Humanities. The broad-base 3-year common-core B.Sc. is followed by a 2-year M.Sc. with a wide choice: 3 branches, 6 minors and 20 specializations. The "Aircraft Branch" has minors "Aerodynamics and Propulsion" and "Structures and Materials"; the "Avionics Branch" has minors "Control and Computing" and "Electronics and Telecommunications"; the "Space Branch" has minors "Vehicles and Missions" and "Multidisciplinary Modelling". The 20 specializations include: Multidisciplinary design optimization, Aircraft, Helicopter, Drones, Launchers, Satellites, Aerodynamics, Propulsion, Structures, Materials, Production, Control, Electronics, Computing, Telecommunications, Air traffic management, additional Mathematics and/or Physics.

The high standard of the course is testified by: (i) The highest minimum entry mark on all university degrees; (ii) Students having equal or higher marks in other universities in numerous exchange programs (about 35% of the students go abroad and a similar number comes from other countries); (iii) Full employment within 3 months; (iv) Former employers trying to retain their graduates and recruit more.

With seminars, technical stays, joint master thesis, prizes for best students, most students finish the degree in the minimum time of 5 years, except for the M.Sc. thesis occupying the last semester, that may take longer; Many M.Sc. theses have original work and lead to papers in refereed journals and communications to symposia. There is a Ph.D. program that covers all 20 specializations and is very open to new subjects that can meet the highest quality standards.

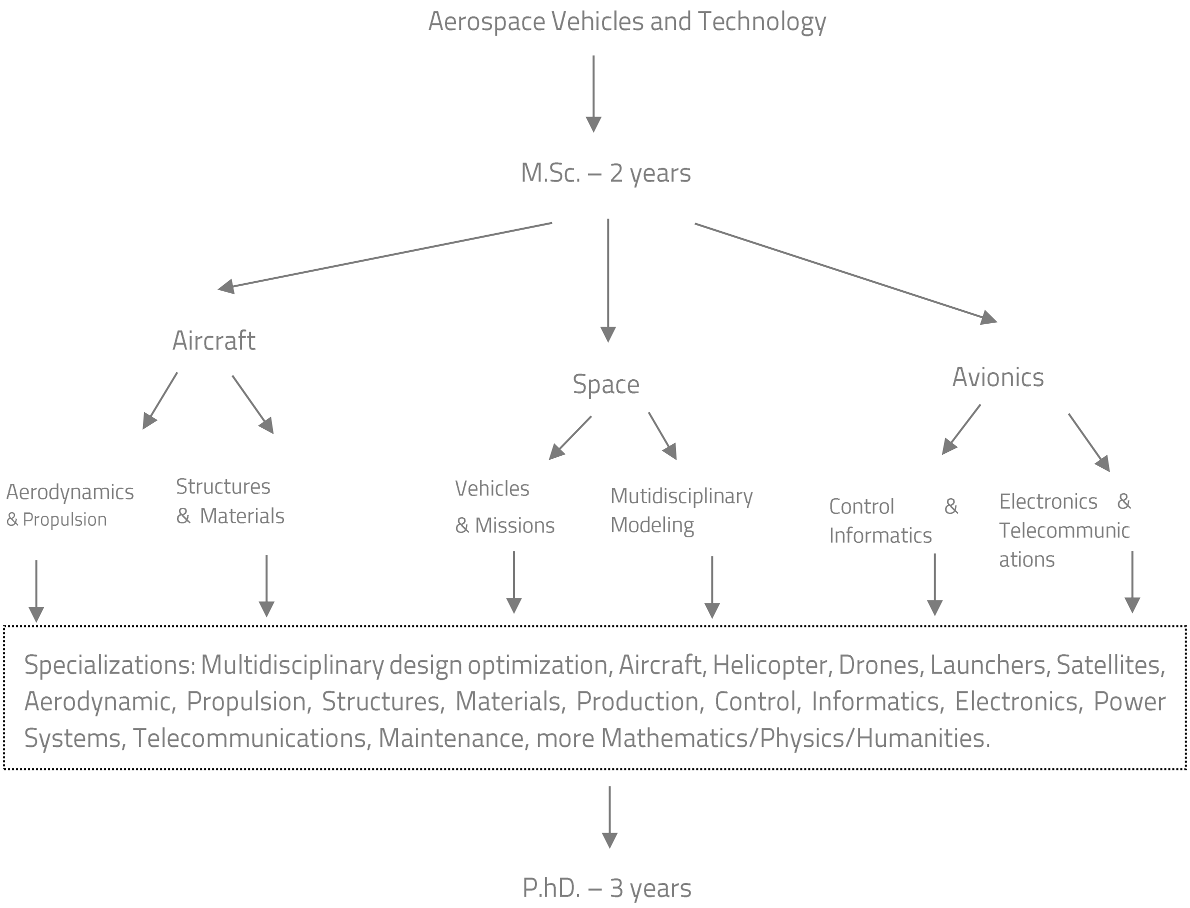
Aerospace engineering at IST at all levels, B.Sc., M.Sc., and Ph.D. gives equal emphasis to mechanical and electrical disciplines and is a joint degree between the departments of Mechanical and Electrical Engineering.

Aerospace Engineering at IST-Lisbon

B.Sc. – 3 years

ELECTROMECHANICS

Mathematics, Physics, Computing



10.3 Adulthood andUniversity

The student finishing secondary school has a wide and sometimes bewildering choice of university degrees to apply for. Even restricting to Science, Technology, Engineering and Mathematics (STEM) the options can be numerous and confusing. Aeronautics and aerospace should be presented as:

- An advanced technology that takes most benefit of mathematics and physics and is thus an ideal combination of all three rather than a narrowing down of focus into one of them.
- One of the most interdisciplinary branches of engineering since a flying machine involves most technologies: mechanics of flight, aerodynamics, propulsion, structures, materials, production, control, avionics, computing, telecommunications, man-machine interface.
- An enabler of a variety of vehicles, including airliners, high-performance aircraft, light private aircraft, helicopters, convertibles, drones, space launchers, satellites, space stations and interplanetary explorers.
- The ability to integrate all these technologies in a vehicle that is safe, efficient, and environmentally friendly while allowing fast travel to a wide range of destinations, some previously inaccessible.

The fascinating promise of aerospace engineering must be delivered in a high-quality university course that gives the necessary knowledge, skills, and ability to reason and work in all these disciplines and their combination.

European universities offer a wide choice of high-quality aerospace education, with comprehensive curricula (Key Topic T10.4) and strong collaboration (Key Topic T10.5) but it's important to understand how to enrich academic persistence in these areas (Key Topic T10.6).

KEY TOPIC T10.4 – ANALYSIS OF A COMPREHENSIVE AEROSPACE CURRICULUM

The aerospace is one of the main technological sectors of the European Union and a strategic sector to guarantee the future of European integration, its independence, prosperity, and its competitiveness in the global economy. In short, it is a catalyst for growth and qualified employment.

The European aerospace industry has evolved over the past 40 years through a general and collective effort of public and private institutions, large companies, small and medium-sized enterprises (SMEs), academia and research, etc., to become an industry leader in the world. Today, aeronautics and air transport are among the main drivers of European cohesion and competitiveness, representing 220 billion euros and providing 4.5 million jobs in Europe, a figure that is expected to double in 2050. These data reveal that aeronautics plays a key role in facilitating European economic growth and social inclusion, providing income to regions that are otherwise isolated and helping people to broaden their horizons.

Two fundamental aspects must be taken into account and that affect directly to the implementation of university aerospace studies: the availability of qualified professionals and the breadth of the environment in which the aerospace sector develops and for which professionals must be trained.

Attracting talented younger generations is one of the big challenges that face the aerospace industry nowadays. In order to maintain European leadership and competitiveness in the aerospace sector, it is essential to attract young talent with high-quality university courses that provide the necessary knowledge, skills and abilities that allow them to work in an efficient way within the aerospace field.

In the following sections, it is given an overview of the main courses related to aerospace studies that are available in Europe, with special attention for the Spanish case.

Once students finish secondary school, it is possible to choose a great variety of aerospace degrees across Europe. In Europe, aerospace education is usually structured in a three-year bachelor's degree in aerospace engineering, with exceptions such as the Spanish case, which offers a four-year degree. Once students have finished these studies, they can choose a later specialisation with a two-year Master in various disciplines within the aerospace sector.

In Europe, many universities offer studies in aerospace engineering, with bachelor, masters, and doctoral programs. France, United Kingdom, Spain, or Germany are the countries with more programs available.

The duration of the degree programs of the universities considered in the previous image is indicated in the figure 10.7.

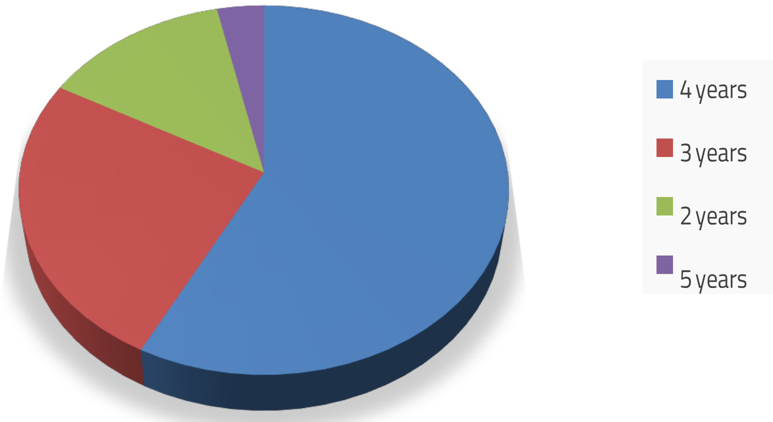


Figure 10.7 - Duration of the European Degrees in Aerospace Engineering

The previous graphic shows that most degree programs have a duration of four or three years, however, other countries such as Germany or Greece are the exception, with studies programs with a duration of two or five years, respectively.

Later, these studies can be extended with a two-year master's in aerospace engineering, which is also offered by the universities. Within this master, it is possible to choose several specialisations such as airports, propulsion systems or aerospace structures. In addition, other types of masters offered provide the opportunity of enlarging knowledge in other disciplines related to the aerospace sector such as, for example, space flight or energetics. The trend in recent years is studying a Degree in Aerospace Engineering, in which students acquire knowledge about the basic principles of aerospace technology and engineering sciences and, then, students continue their training with a master, which provides them the opportunity to specialize in a specific area of the aerospace filed.

On the other hand, aviation is an extensive sector, and, for that reason, it is difficult to cover all the areas related to the aerospace industry in the study programs offered by the universities. Therefore, depending on the university, the degrees in aerospace engineering cover different disciplines within the aviation sector, such as airports, management, or air navigation.

After analysing the degrees offered by the different universities, the areas that have been considered are the following ones:

- Aircraft: this area is related to the basic operation principles of an aircraft
- Airport: this area refers to the airport processes and its operation mode
- Propulsion: it refers to the basic principles of the aircraft engines system
- Science/materials: this area is focused in the mathematics principles of the aircraft performance as well as the study of aerospace structures and materials
- Management: it refers to all the business management within the aviation sector
- Navigation: this area is focused in the air traffic management
- Systems: this area is related to the aircraft systems such as avionics and electronic systems.

The following table 10.2 shows the areas mentioned above, and which of them are covered by the degrees of the different European universities that have been considered for the analysis.

University	Aircraft	Airport	Propulsion	Science/ materials	Management	Navigation	Systems
Polytechnic University of Catalunya	x		x	x			
University of Sevilla	x	x				x	
Polytechnic University of Valencia	x	x	x	x			
University of Leon	x	x		x			
University of Cadiz	x		x	x		x	
Polytechnic University of Madrid	x	x	x	x		x	x
European University of Madrid	x			x			
Carlos III University of Madrid	x		x				
University of Rey Juan Carlos	x	x	x			x	
University of Alfonso X el Sabio	x	x	x			x	
Polytechnic University of Milan	x		x	x	x		x
Polytechnic University of Turin	x		x	x	x		

Sapienza University of Rome	x		x	x			x
University of Luigi Vanvitelli	x		x	x		x	
University of Bologna	x					x	x
University of Padova	x			x	x	x	
University of Pisa	x		x				
University of Napoli	x		x				x
Zurich University of Applied Sciences	x	x	x		x		
Delft University of Technology	x		x	x			
Amsterdam University of Applied Sciences	x	x			x		
RWTH Aachen	x	x					
TU Berlin			x	x			
TU Braunschweig	x			x			x
Universitat Stuttgart	x		x			x	x
TU Dresden	x		x				x
Instituto Superior Técnico (IST)	x		x	x	x	x	x
Inholland University of Applied Sciences	x			x			
Institute of Technology Carlow	x			x			x
University of Limerick	x			x	x		x
FH JOANNEUM Graz	x		x		x		
University of Patras	x		x	x	x		
University of Zilina	x	x			x		
Kaunas University of Technology	x			x			x
Vilnius Gediminas Technical University	x		x	x			x
Polytechnic University of Bucharest	x	x	x	x	x		
Transilvania University of Braşov	x			x	x		
Technical University of Košice	x		x		x	x	
BRNO University of Technology	x			x			
Czech Technical University in Prague	x			x		x	

Riga Technical University	x		x	x			
Newport University Centre for Educational Development	x		x	x	x		
University of Belgrade	x	x	x			x	
National Technical University of Ukraine	x			x		x	
Ecole-air de Salon de Provence (military school)	x			x		x	
ENAC Toulouse	x	x				x	x
ENSMA Poitiers	x	x	x	x			
ISAE-SUPAERO Toulouse	x	x		x			
ESTACA (France)	x	x				x	
University of Bristol	x			x		x	x
Queen Marry University of London	x			x			
Loughborough University				x	x		
University of Glasgow	x			x		x	x
Warsaw University of Technology	x			x		x	

Table 10.2 - Areas covered by the European degrees within the aerospace sector

In the following points, it is included a brief description of the main universities that offer aerospace engineering studies, with the Spanish case analysed in detail (10.3.11 - Spain).

France

In France, several institutions offer courses in aerospace engineering:

- In the first place, ISAE-SUPAERO Institut Supérieur de l'Aéronautique et de l'Espace, a world leader in higher education for aerospace engineering, which was officially created in October 2007 from the merging of two institutions: ENSICA and SUPAERO. It is located in Toulouse and it offers a degree program, the ingénieur ISAE-SUPAERO Degree, a program which is based on a multidisciplinary core curriculum comprised of courses in three main areas: science, humanities, engineering and businesses. It also offers a Master of Science in Aerospace Engineering, 15 Advanced Masters and 6 Doctoral programs.
- ENAC Ecole nationale de l'aviation civile, which is also based in Toulouse and belongs to the Ministry in charge of Civil Aviation. It trains pilots, air traffic controllers and engineers for future work in aerospace companies and in the public sector of civil aviation. It offers several degree programs including ENAC engineer, two masters and eight advanced master's courses.
- ENSMA Ecole nationale supérieure de mécanique et d'aérotechnique, which is based in Poitiers. It offers a degree in Aeronautics, Transport, Mechanics and Energy with a possibility of choosing the following specialisations in the third year: aerodynamics, energetics, heat transfer, structures, advanced materials and computer science and avionics. It also offers several masters in turbulence, aeronautical mechanics and energetics, air and ground transportation, etc.
- The Ecole-air Salon de Provence is a military school and it is located at Salon-de-Provence Air Base in Salon-de-Provence. Since 2008, The École de l'Air also proposes two mastères spécialisés courses in

aviation safety aircraft airworthiness and aerospace project management in partnership with the École nationale de l'aviation civile and the Institut Supérieur de l'Aéronautique et de l'Espace.

- The ESTACA was founded in 1925 and is a member of ISAE Group, 1st world cluster in aerospace training and research. ESTACA's graduates undertake the design, development and production of transport systems and components. The school's expertise is well recognized by the industry, which has ranked it among the best engineering schools for the quality of its graduates.

Portugal

In Portugal, the main university that offers an aerospace program is IST (Instituto Superior Técnico), which is in Lisbon. It was founded as an autonomous school in 1911 and integrated into the Universidade Técnica de Lisboa in 1930. IST is the largest school of engineering in Portugal by number of enrolled students, faculty size, scientific production, and patents.

More details about IST can be found in the section (10.3, PAGE 18) of this paper.

The aeronautical engineering degree of the Portuguese Air Force Academy is closely aligned with the 5-year Aerospace Engineering M.Sc. at IST, adding a further year of military subjects.

A separate M.Sc. of Aeronautical Engineering exists at *Universidade da Beira Interior*, in Covilhã.

Italy

The main universities that offer aerospace programs are the following ones:

- The Polytechnic of Milano, a scientific-technological university that trains engineers, architects, and industrial designers. It offers a three-year bachelor's degree in aerospace engineering, a training program focused on the acquisition of a solid background in methodological aspects and basic subjects, such as the study of flight mechanics, aerospace technologies, aerospace propulsion systems and on-board systems. Graduates in Aerospace Engineering may continue their studies with a Master of Science in Aeronautical or Space Engineering.
- The Polytechnic of Turin, which offers a three-year bachelor's degree in aerospace engineering, within the department of mechanical and aerospace engineering. After the degree, students can continue their studies with a two-year master's in aerospace engineering, with the following specialisations: aerospace structures, propulsion systems, aeromechanics, aero-gas dynamics, and space. It also offers a master's in aerospace engineering.
- The University of Rome "La Sapienza". It offers a three-year bachelor's degree in aerospace engineering and two Master of Science Degrees (Aeronautical Engineering and Space and Astronautical Engineering). After the Master of Science Degree, the training in Aerospace can be continued at Sapienza by joining one of three one-year Professional Master Courses in Civil Aviation, in Satellites and Orbiting Platforms, or in Space Transportation Systems. Finally, the educational offer is completed with a three-year Ph.D. Course in Aeronautical and Space Engineering.
- The University of Napoli, which Department of Aerospace Engineering has a long tradition dating its roots back in 1926. The Department of Aerospace Engineering plays an important role in the European Scientific Community through a continuous contribution to the most important European funded research projects; furthermore, stable collaborations with the most important European and US Universities are the witness of an established tradition of education of aerospace sciences. Main research activities in the Space field deal with Microgravity, Aerothermodynamics, Space Systems and Remote Sensing.
- The University of Bologna was founded in 1088 by an organised guild of students and it is the oldest university in the world. The university has as research fields: Aerospace Structures, Aerospace Systems, Design and Methods in Industrial Engineering, Flight Mechanics, and Fluid dynamics. In Forli, besides aeronautical activities, the University is also focusing on two aspects: on the one hand, it is working on how

to adapt classrooms using new technological infrastructure; on the other, it is implementing the transformations necessary to assist teachers in the process of constantly improving teaching methods.

- The University of Pisa was founded in 1343 and is ranked within the top 10 nationally and the top 400 in the world. As research fields, University of Pisa count with Advanced chemical propulsion, Aerodynamics of road vehicles, Development of fly-by-wire control systems, Fatigue & damage tolerance of aerospace structures, Flow stability & control, Low thrust space propulsion, and Space mission analysis & space vehicle design.

United Kingdom

The universities that offer Degrees in Aerospace Engineering include:

- Cranfield University, which offers the widest range of disciplines and is well equipped with research and simulation resources (>200 graduates per year). This university is highly specialised in one-year masters and does not offer any bachelor's training. It attracts many foreign students (>50%).
- The University of Bristol, offering degree courses and research in aeronautics and space.

The aerospace engineering department has close links with major industrial companies, including Leonardo Helicopters, Airbus and Rolls-Royce.

- University of Glasgow, with a wide offer in aerospace training, including several degrees

and masters.

- Queen Marry University of London, where it is possible to complete the Aerospace Engineering degree in three, four or five years and to apply for Aerospace Engineering BEng or MEng with a Year Abroad.
- Loughborough University, which is on the top 10 in the UK Aeronautical and Manufacturing Engineering.
- Queen's University Belfast was founded in 1845 and is ranked in the top 180 universities in the world (QS World Rankings 2019).
- The University of Cambridge has a Department of Engineering that is the largest department at the University of Cambridge and one of the leading centres of engineering in the world. In the Engineering Tripos, students can specialise in Aerospace and aerothermal engineering.
- The University of Oxford has an important Department of Engineering Science, which exists since 1908.

Germany

Germany is a hub of state-of-the-art developments in the field of Aerospace and Avionics. That is why they have a large number of universities that offer studies in the sector. Below are the three examples of universities as well as the degrees, master, and university degrees they offer:

- Bremen University of Applied Sciences. This is the public university of the applied sciences, which is situated at Bremen in Germany. This institute has various courses with bachelor's degree programs offered, while twenty-six master's degree courses are offered. In the field of aeronautics, it has a first program: Master's degree in Aeronautical Management and a second program: Master's degree in aerospace technologies.

- Technical University of Applied Sciences Wildau. The Technical University of Applied Sciences Wildau has twenty-degree programmes in direct study programmes, and 2 in distance learning programmes. Relative to aeronautics, they offer an Aviation Management master's degree and an Aeronautical Engineering/Aeronautical Logistics master's degree.

- The Technical University of Munich. This is a research university with campuses in Arcisstrasse, Garching and Freising-Weihnstephan. It is a member of TU9, and until now, it is the only state university dedicated to technology. They offer a program orientated in Earth Oriented Space Science and Technology and an Aerospace Engineering master's degree.

- Hamburg University of Technology (TUHH). Founded in 1978. Engineering is the main focus of TUHH. The central focus of the Aircraft Systems Engineering program is on acquiring the skill to think in systems engineering terms, to take an overall view, and to solve aeronautical engineering problems. The program is rounded off by a project report, seminars, laboratories, and the master's thesis.

- RWTH Aachen. It is the largest technical university in Germany and in 2007 was chosen by the DFG as one of nine German Universities of Excellence for its future concept RWTH 2020: Meeting Global Challenges and additionally won funding for one graduate school and three clusters of excellence.

- The Technical University of Berlin or TU Berlin. TU Berlin is a member of TU9, an incorporated society of the largest and most notable German institutes of technology and of the Top Industrial Managers for Europe network, which allows for student exchanges between leading engineering schools. As research fields has Flight mechanics and aeroelasticity, Propulsion technology and engine acoustics, Combustion dynamics and kinetics, Aerodynamics, Air traffic, Aerospace structures and materials, and Space.

- TU Braunschweig. It was founded in 1745 and is also a member of TU9, being commonly ranked among the top universities for engineering in Germany. Main research fields: Jet propulsion and turbine machinery, Flight guidance, flight control and air traffic management, Aircraft and lightweight design, Space systems, Fluid mechanics, aerodynamics and aeroacoustics, Aerospace materials, and Adaptronics and function integration.

- TU Dresden. It is one of the 10 largest universities in Germany (32,389 students in 2018). The university is a member of TU9. As research fields has Aircraft engineering, Space systems, Experimental aerodynamics, Fluid mechanics, Air Traffic Logistics, and Propulsion.

- Universität Stuttgart. It was founded in 1829 and is organized into 10 faculties. It is one of the oldest technical universities in Germany with highly ranked programs in civil, mechanical, industrial, and electrical engineering and it is also a member of TU9. As research fields has Aerodynamics and Gasdynamics, Aerospace Thermodynamics, Flight Mechanics and Control, Aircraft Design, Propulsion Systems, Aircraft Systems, Navigation, Space Systems, Statics and Dynamics of Aerospace Structures, and Combustion Technology.

Netherlands

In the Netherlands, the most important university is the TU Delft, which is a reference in aerospace with more than 100 graduates per year. It offers a Degree in Aerospace Engineering and, during the first two years, students can acquire knowledge in aerospace design projects, aerospace technology and basic engineering sciences. In the third year, students can choose a minor program between the followings:

- Simulation, verification, and validation
- Production of aerospace materials
- Systems engineering and aerospace design
- Aerospace flight dynamics

The university also offers a two-year master's in aerospace engineering, with the possibility of choosing between six specialisations:

- Aerodynamics and wind energy

- Aerospace structures and materials
- Rotor design
- Flight performance and propulsion
- Space flight

Switzerland

- The ZHAW Zurich University of Applied Sciences is one of the universities of applied sciences in Switzerland, which provides aerospace training. It offers a three-year bachelor's degree in aviation, with the possibility of choosing one specialisation from the fourth semester. The specialisations available are the following ones:

- Technics and Engineering, which is focused on aircraft systems and mechanics, as well as in maintenance and certification.
- Operational engineering, which is focused on security management and airports processes.
- Finally, the aviation degree program can be combined with obtaining a commercial pilot license, which makes possible to shorten the training period since the academic basis for the licensing theory is already provided in the Aviation degree program.

- The École Polytechnique Fédérale de Lausanne (EPFL) is a research institute and university in Lausanne, Switzerland, that specializes in natural sciences and engineering. The QS World University Rankings ranks EPFL 14th in the world across all fields in their 2020/2021 ranking, whilst Times Higher Education World University Rankings ranks EPFL as the world's 19th best school for Engineering and Technology.

Poland

In Poland, an important university is Warsaw University of Technology. The origins of Warsaw University of Technology date back to 1826 and nowadays is one of the leading institutes of technology in Poland and one of the largest in Central Europe. The Warsaw University of Technology has about 5,000 graduates per year. The main research fields of Warsaw University of Technology are: Computational fluid dynamics, Aerodynamics, Automation and aeronautical systems, Mechanics, Fundamentals of machine design, Aeroplanes and helicopters, Theory of machines and robots, Strength of materials and structures and Heat engineering. Graduates of the Aerospace Engineering are provided with a knowledge allowing for scientific research and design, optimisation, modernisation as well as maintenance of the flying vehicles.

Also, Wrocław University of Science and Technology rates high in the annual rankings of Polish universities. The Polish Wrocław University of Technology was founded 24 August 1945. The university ranked 1st in the modern technologies group (disciplines: computer science, electronics, materials science) of the *Where to study?* ranking. It ranked 2nd among the best technical universities in Information Technology and 1st in the Most Innovative Universities by 2012 Computerworld Magazine USA.

Slovakia

The University of Žilina was established in 1953 as the College of Railways in Prague. In 1959 the institution changed its name to the University of Transport and moved to Žilina.

The University of Žilina provides education at all three levels of higher education both in full-time and part-time forms (Bachelor's degree, Engineer/Master's degree, and Doctoral degree). All the University's faculties provide a supplementary course of pedagogical studies for students and graduates. Over the last 57 years, more than 52,000 students have graduated from the university.

In aerospace, research fields are Airports, Unmanned aerial vehicles and systems, Air transport economy and policy, Airlines' management, Aircraft maintenance, and Safety and security in aviation.

Czech Republic

Czech Technical University in Prague was established as the Institute of Engineering Education in 1707 and is now one of the largest universities in the Czech Republic and is one of the oldest institutes of technology in Central Europe. In 2018 Czech Technical University was ranked as 220th in Engineering and Technology in the QS World University Rankings. In aerospace, the main research fields are: Navigation, Flight dynamics & control, Air Traffic Modelling, Radio systems, Space science, Aeroelasticity, Aerodynamics, Structures & design, Propulsion, Air Traffic Management systems, and Aviation Safety and Security.

Brno University of Technology is located in Brno, Czech Republic and was founded in 1899. Now it is a major technical Czech university with over 24,000 students enrolled at 8 faculties, namely Faculty of Civil Engineering, Faculty of Mechanical Engineering, Faculty of Chemistry, Faculty of Architecture, Faculty of Business and Management, Faculty of Electrical Engineering and Communication, Faculty of Fine Arts and Faculty of Information Technology.

Spain

The professional environment in which the aerospace sector develops is very broad. Any study on the aerospace sector cannot lose sight of the broad framework in which this sector is framed, which is none other than the vast and complex aerospace system. In this area, aircraft, satellites, and missiles move, which demand the performance of a series of essential agents for their development: manufacturers, airlines, airports, ATM's, R & D Centres, etc.

The relevant components of the Aerospace education include the airports and Air Traffic Management System or ATM.

In the field of airports, Spain is proud to host the first airport operator in the world and the fourth provider of air navigation services in Europe, Aena. The Aena Group is a group of companies dedicated to airport management and the provision of air navigation services. Through Aena Aeropuertos S.A. (of which Aena owns 100% of the capital) manages 47 airports and 2 heliports in Spain and participates directly and indirectly in the management of another 26 airports around the world. It is the first airport operator in the world by number of passengers, with more than 200 million. Through the public body, Aena provides air navigation services. Aena is the fourth provider of air navigation services in Europe and participates prominently and actively in all projects of the European Union related to the implementation of the Single Sky. The professionals who manage this network of airports and air navigation have been formed mostly in the aeronautical schools of the UPM.

The purpose of the bachelor's Degrees is to obtain a general education in one or several disciplines by the student, aimed at preparing for the exercise of professional activities. The overcoming of these teachings gives right to the obtaining of the corresponding title of Graduated.

The official university degree programs are specified in the curricula that are prepared by the universities, subject to the rules and conditions that apply to them in each case. These curricula must be verified by the Council of Universities and their implementation must be authorized by the corresponding Autonomous Community. Additionally, official university degrees are subject to an evaluation procedure every 6 years, starting from the date of their registration in the RUCT, in order to maintain their accreditation. The Agencia

Nacional de Evaluación de la Calidad y Acreditación (ANECA) is responsible for establishing the necessary verification and accreditation protocols. After the authorization of the Autonomous Community and the verification of the curriculum, the Ministry of Education and Science will submit to the Government the proposal for the establishment of the official title and its registration in the RUCT, whose approval by agreement of the Council of Ministers will be published in the Boletín Oficial del Estado (BOE).

Each study plan of a degree title contains 240 credits, which include all the theoretical and practical training that the student must acquire:

- Basic aspects of the branch of knowledge
- Compulsory or optional subjects
- Seminars
- External practices
- Targeted work
- Final Degree Project
- Other training activities

Each degree concludes with the elaboration and public defence of a Final Degree Project. Each one of the degrees is assigned, at the proposal of the University where it is taught, in one of the following branches of knowledge:

- Arts and Humanities.
- Sciences.
- Health Sciences.
- Social and Legal Sciences.
- Engineering and Architecture.

The curriculum of a degree must contain a minimum of 60 credits of basic training, of which at least 36 must be linked to some of the subjects listed in annex II of Royal Decree 1393/2007 for the branch of corresponding knowledge. These subjects must be specified in subjects with a minimum of six credits each and must be offered in the first half of the study plan.

The remaining credits up to 60, if applicable, must be configured by basic subjects of the same or other branches of knowledge, or by other subjects as long as their basic character is justified for the initial training of the student or its transversal nature. If the degree includes external internships, these must have a maximum length of 60 credits and should preferably be offered in the second half of the study plan. The end of the degree project can have between 6 and 30 credits, be oriented to the evaluation of competences associated with the degree and therefore must be done in the final phase of the study plan.

Additionally, students can obtain academic recognition in credits for participation in cultural, sports, student representation, solidarity, and cooperation activities up to a maximum of six credits of the total curriculum studied.

In the case of qualifications that qualify for the exercise of regulated professional activities in Spain, as is the case at hand, the curriculum must guarantee and must be designed in such a way as to obtain the necessary competences to obtain that profession and must if there is an adaptation to European regulations.

Access to official bachelor’s degrees requires holding the bachelor's degree or equivalent and passing the exam. The fulfilment of these conditions gives access to obtaining a place in the public system of university education. The global calculation of the offer of university places is higher than the demand. However, the greater demand to study in certain universities and especially, to take certain qualifications produces local imbalances between supply and demand. For this reason, and to objectify the access mechanisms to the University, the University Council approves annually, at the proposal of the respective Universities, access limits for all or some of the studies that make up its academic offer.

In Spain, several universities offer degree courses in the area of aeronautics, being the Polytechnic University of Madrid the one that provides the greatest number of graduates.

One of the most important characteristics of the UPM University is that the program in aerospace engineering contemplates several disciplines in the student training. That is, as the aerospace industry is a very wide sector, there are many areas that are necessary to consider. At European level, it only exists a title denominated Aeronautic Engineer, but it does not include all the competencies or skills that are required in the aerospace industry. Most European universities offer three-year degrees, which provide general knowledge about the sector, without including important specialisations such as air navigation or airports and focusing most of them in the vehicle.

However, the Aerospace Engineering Degree of the UPM University contemplates almost all the professional areas of the complex and wide aerospace system, including aircraft, propulsion, air navigation, airports, and aerospace technologies.

In addition to the UPM University, there are other national centres that offer studies in aerospace engineering. Nowadays, the Degree in Aerospace Engineering is taught in eleven schools (in brackets, it is indicated the university and the year in which the degree in aerospace became available):

- Superior Technical School of Aeronautical Engineering and Space (UPM / 2010-11)
- Superior School of Engineers of Seville (US / 2010-11).
- E.T.S.I. Industrial and Aeronautics of Terrassa (UPC / 2010-11).
- Superior Technical School of Design Engineering (UPV / 2010-11).
- School of Industrial Engineering and Information Technology of Leon (ULE / 2010-11).
- Superior Polytechnic School of Castelldefels (UPC / 2010-11).
- Superior Polytechnic School (Carlos III University of Madrid / 2010-11).
- Superior Polytechnic School (Alfonso X el Sabio University of Madrid / 2010-11).
- Polytechnic School (European University of Madrid / 2010-11).
- Superior Engineering School (University of Cadiz / 2011-12).
- E.T.S. of Telecommunications Engineers (Rey Juan Carlos University of Madrid/ 2011-12)

The following table 10.3 offers a comparative analysis of the degrees offered by these centres, which includes:

- Denomination of the degree title offered.
- University/centre where it is taught.
- Previous experience of the centre in aeronautical degrees.
- Year in which the Degree in Aerospace Engineering is offered for the first time.
- Language.
- Number of places available and access notes.
- Specialisations.
- Duration.
- Number of credits of the title.

Title	University/ Centre where it is taught	Previous experience of the centre in aeronautical degrees	Year in which the Degree in Aerospace Engineering is offeredfor thefirsttime	Language	Places available. Accessnote	Specializations	Duration	Number of credits
Degree in Aerospace Engineering	Polytechnic University of Madrid Superior Technical School of Aeronautical Engineering and Space	Degrees to be extinguished: Technical Aeronautical Engineer (in Airports, Aircraft, Air Navigation, Aerospace Equipment and Materials, Aeroengines) Aeronautical Engineer	2010/2011	Spanish	630 11,386	Five specialisations: -Aerospace Vehicles, -Aerospace Propulsion -Science and Technologies -Airports and Air Transport -Navigation and Aerospace systems	4 years	Total: 240 ECTS Basic training: 60 Compulsory common credits: 60 Compulsory specialisation credits: 82,5 compulsory UPM-EIAE credits: 13,5 Optional credits and/or internships: 9-12 Final Degree Project: 12
Degree in Aerospace Engineering	University of Seville Superior Technical School of Engineering	Degrees to be extinguished: Aeronautical Engineer	2010-2011	Spanish/ English	125 12.34	Three specialisations: -Aerospace Vehicles. -Air Navigation -Airports and air Transport	4 years	Total: 240 ECTS Basic training: 64.5 Compulsory 76.5 Optional: 87 Optional internships: 9 Final Degree Project: 12
Degree in Aerospace Vehicles Engineering	Polytechnic University of Catalunya Superior Technical School of Industrial and Aeronautical Engineering of Terrassa (ETSEIAT)	Degrees to be extinguished: Aeronautical Engineer	2010/2011	Spanish/ Catalan	60 11.590	Aerospace Vehicles	4 years	Total: 240 ECTS Compulsory: 210 Internships: 0 Final Degree Project: 24
Degree in Aerospace Technologies Engineering	Polytechnic University of Catalunya Superior Technical School of Industrial and Aeronautical Engineering of Terrassa (ETSEIAT)	Degrees to be extinguished: Aeronautical Engineer	2010/2011	Spanish/ Catalan	60 12.286	Aerospace Technologies	4 years	Total: 240 ECTS Compulsory: 210 Optional: 18 Internships: 0 Final Degree Project: 24

Title	University/ Centre where it is taught	Previous experience of the centre in aeronautical degrees	Year in which the Degree in Aerospace Engineering is offeredfor thefirsttime	Language	Places available. Accessnote	Specializations	Duration	Number of credits
Degree in Air Navigation Engineering	Polytechnic University of Catalunya School of Telecommunications and Aerospace Engineering of Castelldefels (EETAC)	Degrees to be extinguished: Aeronautical Technical Engineer in Air Navigation	2010-2011	Spanish: 25% Catalan: 60% English: 15%	80 10.166	Air Navigation	4 years	Total: 240 ECTS Basic: 60 Compulsory: 120 Optional: 36 Final Degree Project: 24 Optional internships: 12
Degree in Airports Engineering	Polytechnic University of Catalunya School of Telecommunications and Aerospace Engineering of Castelldefels (EETAC)		2010-2011	Spanish/ Catlan	40 9.072	Airports		Total: 240 ECTS Compulsory: 216 Final Degree Project: 24
Degree in Aerospace Engineering	Polytechnic University of Valencia Superior Technical School ofDesign Engineering	Degrees to be extinguished: Aeronautical Engineer	2010/2011	Spanish and Valencian	120 12,29	Five specialisations: -Aircrafts -Aeroengines -Airports -Aerospace equipmentand materials -Air Navigation	4 years	Total: 240 ECTS Basic training: 60 Compulsory: 88.5 Optional: 79.5 Final Degree Project: 12
Degree in Aerospace Engineering	University of Leon School of Industrial Engineering and InformationTechnology	Degrees to be extinguished: Aeronautical Technical Engineer in Aero engines	2010/2011	Spanish/ English	60 11,478	Aircrafts	4 years	Total: 240 ECTS Basic training: 60 Compulsory: 132 Optional: 36 Final Degree Project: 12
Degree in Aerospace Engineering	Carlos III University Superior Polytechnic School	NO	2010/2011	English	70 11,269	Two specialisations: -Aerospace Vehicles -Aerospace Propulsion	4 years	Total: 240 ECTS Basic training: 78 Compulsory: 129 Optional: 12

Title	University/ Centre where it is taught	Previous experience of the centre in aeronautical degrees	Year in which the Degree in Aerospace Engineering is offeredfor thefirsttime	Language	Places available. Accessnote	Specializations	Duration	Number of credits
								Internships: 12 Final Degree Project: 12
Degree in Aerospace Engineering	AlfonsoXelSabio University Superior Polytechnic School	NO	2010-2011	Spanish	80	Four specialisations: -Aircrafts -Aeroengines -Airports -Air navigation	4 years	Total: 240 ECTS Basic Training: 60 Compulsory: 159 Optional: 9 Internships: 0 Final Degree Project: 12
Degree in Aerospace Engineering in Aircrafts	EuropeanUniversityof Madrid SuperiorPolytechnic School	NO	2010/2011	English	40	Aircrafts	4 years	Total: 240 ECTS Basic training: 60 Compulsory: 138 Optional: 12 Internships: 12 Final Degree Project: 18
Degree in Aerospace Engineering	University of Cadiz Superior Engineering School of Cadiz.	NO	2011/2012	Spanish	70 11,55	Two specialisations: -Aircrafts -Aerospace equipment and materials	4 years	Total: 240 ECTS Basic training: 60 Compulsory: 145.5 Optional: 16.5 Internships: 0 Final Degree Project: 18
Degree in Aerospace Engineering in Air Navigation	Rey Juan Carlos University	NO	2011-2012	Spanish	55 9.416	Air Navigation	4 years	Total: 240 ECTS Basic training: 78 Compulsory: 114

Table 10.3 - Degrees in Aerospace Engineering offered in Spain

In this section, it is analysed in detail the Degree in Aerospace Engineering of the Polytechnic University of Madrid, which is taught by the Superior Technical School of Aeronautical Engineering and Space (ETSIAE).

First, this degree became available in the 2010-2011 academic course, when the Aeronautic Engineer and Aeronautic Technical Engineer Degrees extinguished.

The Degree in Aerospace Engineering of the UPM University is structured in a common basic training and the following specialisations:

- Aerospace Vehicles
- Aerospace Propulsion
- Navigation and aerospace systems
- Airports and air transport
- Science and aerospace technologies

After a common basic training, the first two courses, students choose a specialisation for the last two courses, where they acquire the competences and skills of those specialisations.

The study plan complies with the provisions of the Resolution of January 15, 2009, of the Secretary of State for Universities (BOE, January 29, 2009) and by Ministerial Order CIN / 308/2009, of February 9 (BOE, February 18, 2009).

The Degree in Aerospace Engineering of the UPM University is composed of 240 credits. They are distributed as it is indicated in the following table 10.4.

Credits distribution		Number of credits
Basic credits		60 ECTS.
Compulsory common credits		60 ECTS.
Compulsory specialisation credits	Aerospace Vehicles	82,5 ECTS.
	Aerospace Propulsion	82,5 ECTS.
	Science and Aerospace Technologies	82,5 ECTS.
	Airports and Air Transport	82,5 ECTS.
	Navigation and Aerospace Systems	82,5 ECTS
Compulsory credits of UPM-ETSIAE		13,5 ECTS
Optional credits and/or internships	Specialisation of Science and Aerospace Technologies	9 ECTS
	Rest of specialisations.	12 ECTS
Credits of Final Degree Project		12 ECTS.

Table 10.4 - Credits distribution of the UPM Degree in Aerospace Engineering

As it can be seen in the previous table, students' study 133,5 common credits for all the specialisations and 82,5 credits of compulsory subjects for the specialisations of Aerospace Vehicles, Aerospace Propulsion, Navigation and Aerospace systems and Airports and Air Transport. In the case of Science and Aerospace Technologies specialisation, they are 85,5 credits.

In addition to the previous credits, the optional credits and the credits are belonging to the Final Degree Project.

The following table 10.5 shows the list of subjects, which are part of the study plan of the Degree in Aerospace Engineering offered by the UPM.

Subjects	Subjects	ECTS	Specialisations
	Mathematics I	9	All
	Mathematics II	9	All

Subjects	Subjects	ECTS	Specialisations
Mathematics	Mathematical methods	6	All
	Numerical calculation	3	Science and Aerospace Technologies
	Mathematics extension	6	Science and Aerospace Technologies
	Statistics	6	All
Economy and Business Management	Business Economics	6	All
	Business and Project Management	4,5	All
Aerospace production	Aerospace Manufacturing	3	All
	Aerospace Production Systems	3	Aerospace Vehicles, Aerospace Propulsion
physics	Physics I	6	All
	Physics II	6	All
	Meteorology	3	Airports and Air Transport, Navigation and Aerospace systems
Design engineering	Graphic expression	6	All
	Graphic design	3	Aerospace Vehicles, Aerospace Propulsion, Science and Aerospace Technologies
	Mechanical design	4,5	Aerospace Vehicles, Aerospace Propulsion
Science and technology of materials	Chemistry	6	All
	Material science	6	All
	Construction materials	3	Airports and Air Transport
	Structural Materials for Propulsive Systems	3	Aerospace Propulsion
	Composite materials	3	Aerospace Vehicles, Science and Aerospace Technologies
	Aerospace alloys	3	Aerospace Vehicles, Aerospace Propulsion, Science and Aerospace Technologies
	Alloys	3	Science and Aerospace Technologies
Aerospace Technology complements	Specialisation Orientation Conferences	1,5	All
	Aerospace Technology	6	All
	Computing	6	All
	Computational Fluid Dynamics	3	Science and Aerospace Technologies
	Finite element method	3	Science and Aerospace Technologies
	MEF and CFD	4.5	Aerospace Vehicles, Aerospace Propulsion
Electrical and Electronic Engineering	Electronics and Automation	6	All
	Electric engineering	6	All
	Electrical installations	4,5	Airports and Air Transport, Navigation and Aerospace systems
Mechanics and thermofluidic dynamics	Classical Mechanics	6	All
	Thermodynamics	6	All
	Fluid mechanics	6	All
	Analytical Mechanics	3	Science and Aerospace Technologies
	Orbital Mechanics	3	Science and Aerospace Technologies
	Applied thermodynamics	3.75	Aerospace Propulsion
	Heat and Mass Transportation	3.75	Aerospace Propulsion

Subjects	Subjects	ECTS	Specialisations
	Fluid mechanics II	6	Aerospace Vehicles, Aerospace Propulsion, Science and Aerospace Technologies
Aerodynamics, Aeroelasticity and Flight Mechanics	Aerodynamics and Flight Mechanics	6	Airports and Air Transport, Navigation and Aerospace systems
	Aerodynamics	6	Science and Aerospace Technologies
	Aerodynamics, Aeroelasticity and Flight Mechanics	9	Aerospace Propulsion
	Aerodynamics and Aeroelasticity	9	Aerospace Vehicles
	Flight Mechanics	6	Aerospace Vehicles, Science and Aerospace Technologies
	Aeroelasticity	3	Science and Aerospace Technologies
Air Transport Engineering	Air Transport	3	All
	Air Transport Engineering	6	Airports and Air Transport, Navigation and Aerospace systems
Air Traffic Management Engineering	Air Traffic Management	6	Navigation and Aerospace systems
	AirTrafficControlandManagement	3	Airports and Air Transport
	Positioning, Guidance and Control	4,5	Navigation and Aerospace systems
Resistance of Materials, Elasticity and Structures	Resistance of materials and Elasticity	7,5	All
	Solid mechanics	3	Aerospace Vehicles, Aerospace Propulsion, Science and Aerospace Technologies
	Structures	6	Science and Aerospace Technologies
	Structures	3	Airports and Air Transport
	Steel structures	4,5	Airports and Air Transport
	Concrete structures	4,5	Airports and Air Transport
	Aeronautical Structures	4,5	Aerospace Vehicles, Aerospace Propulsion
	Vibrations	3	Aerospace Vehicles, Aerospace Propulsion, Science and Aerospace Technologies
Airport Engineering	Aerodromes	6	Airports and Air Transport
	Construction	6	Airports and Air Transport
	Buildings and Facilities, Urbanization and Access	6	Airports and Air Transport
	Geotechnics	3	Airports and Air Transport
	Geodesy and Topography	4,5	Airports and Air Transport
	Airports	6	Navigation and Aerospace systems
	Airports facilities	4,5	Airports and Air Transport
	Operation Engineering and Airport Management	3	Navigation and Aerospace systems
Navigation and Aerospace Systems Engineering	Introduction to Air Navigation	3	Airports and Air Transport, Navigation and Aerospace systems
	Communications and Networks	4,5	Navigation and Aerospace systems
	Geodesy and Cartography	4,5	Navigation and Aerospace systems
	Communications and Surveillance Systems	4,5	Navigation and Aerospace systems
	Automatic Control Systems	3	Navigation and Aerospace systems
	Air Navigation Systems	4,5	Navigation and Aerospace systems
	Radio Frequency Systems	4,5	Navigation and Aerospace systems

Subjects	Subjects	ECTS	Specialisations
	Digital Treatment of Information	4,5	Navigation and Aerospace systems
	Avionics	4,5	Navigation and Aerospace systems
	Aerospace Systems Engineering	3	Navigation and Aerospace systems
Aerospace propulsion	Air reactors	6	Aerospace Propulsion, Science and Aerospace Technologies
	Alternative Aeronautical Engines	4.5	Aerospace Propulsion
	Air reactors	4	Aerospace Vehicles
	Alternative Aeronautical Engines	2	Aerospace Vehicles
	Rocket engines	3	Aerospace Vehicles
	Aircrafts Propulsion	3	Airports and Air Transport, Navigation and Aerospace systems
	Alternative Aeronautical Engines	3	Science and Aerospace Technologies
	Engine Systems	4	Aerospace Propulsion
	Fuels and lubricants	2	Aerospace Propulsion
	Rocket engines	4.5	Aerospace Propulsion, Science and Aerospace Technologies
Aerospace vehicles	Control and Optimization	6	Science and Aerospace Technologies
	Aerospace vehicles	6	Science and Aerospace Technologies
	Space vehicles	3	Aerospace Vehicles
	Fixed Wing Aircrafts	6	Aerospace Vehicles
	Rotary Wing aircrafts	3	Aerospace Vehicles
	Missiles	3	Aerospace Vehicles
Sustainability and Sustainability	Legislation and Management	3	Airports and Air Transport
	Operation and maintenance	6	Airports and Air Transport
	Maintenance and Certification of Engines	7.5	Aerospace Propulsion
	Maintenance and Certification of Aerospace Vehicles	6	Aerospace Vehicles
	Final Degree Project	12	All
	Professional and Academic English	6	All
	Internships or optional	6	Science and Aerospace Technologies
	Internships or optional	12	Aerospace Vehicles, Aerospace Propulsion, Airports and Air Transport, Navigation and Aerospace systems

Table 10.5 - List of subjects of the Degree in Aerospace Engineering study plan by the UPM

KEY TOPIC T10.5 – COLLABORATION AMONG EUROPEAN UNIVERSITIES WITH AEROSPACE ENGINEERING DEGREES

Universities of almost all countries offer Programs in Aeronautic/Aerospace Engineering and therefore it would be almost impossible to give a precise idea of the different organization adopted in such diversified academic systems. Moreover, beyond the structure of engineering programmes, the programme contents themselves may vary considerably from one institution to another.

On this topic, as well in many others concerning specific scientific/professional/cultural contexts, different non-profit Associations/Networks/Partnerships have been created by Academic/Governmental Institution to share common backgrounds and visions of the general characteristics required to the University Degree Programs in each specific field.

Therefore, a criterion to select possible examples concerning the organization of typical University Degrees in Aeronautic/Aerospace Engineering could be that of focusing on those ones participating to specific networks existing in this field, such as PEGASUS and EASN.

In particular, the Partnership of a European Group of Aeronautics and Space Universities - PEGASUS represent one of such networks.

PEGASUS (www.pegasus-europe.org) has been formed from an initiative taken by the four main French Grandes Ecoles involved in aerospace to attract the best students and also to offer highly relevant educational and research programmes.

PEGASUS partners are public and/or non-profit institutions of higher education in aeronautical/aerospace engineering located in the EU.

- 20 Founding Members in 1998.
- Presently 25-member Institutions.
- European countries represented.

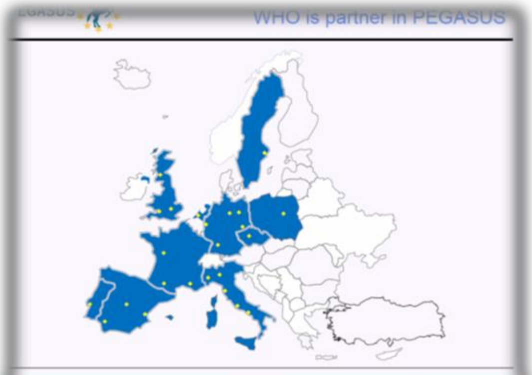
Co-ordinated change and innovation are required to achieve objectives to be defined through close links and interaction with our aerospace Industry and relevant Government agencies. PEGASUS is open to all EU institutions providing a sufficiently qualified education in aerospace engineering. These programmes must include:

- Degree-awarding programmes.
- Continuing Education.
- Research.
- Intercontinental Affairs.

The participating Institutions (as of 2014) to the PEGASUS Partnership are depicted in Figure. Partners of the

Pegasus Network are categorised as:

- Full Partners, who fulfil the conditions stipulated by the internal procedural regulations.
- Probationary Partners, who joined the Pegasus Network according to the Internal Procedural Regulations and have not yet been upgraded to the Full Partner status.
- Associate Partners, namely institutions not fulfilling all admission requirements but in possession of a high reputation.



Country	Institution	Country	Institution
Italy	Politecnico di Milano Politecnico di Torino Università degli Studi di Napoli Università degli Studi di Pisa Università degli Studi di Roma	Germany	RWTH Aachen TU Berlin TU Braunschweig Universität Stuttgart TU Dresden
France	Ecole-air de Salon de Provence ENAC Toulouse ENSMA Poitiers ISAE Toulouse	United Kingdom	Cranfield University University of Bristol University of Glasgow
Netherlands	TU Delft	Sweden	KTH Stockholm
Spain	UPM/ETSIA Madrid US/ESI Sevilla UPV/ETSID Valencia	Czech Republic	CVUT Prague
Portugal	IST Lisboa	Poland	Politechnika Warszawska

Figure 10.8 - Academic Institutions (as of 2014) members of the PEGASUS Partnership. Source: https://www.pegasus-europe.org/userfiles/Pegasus_presentation.pdf

The PEGASUS associated partners are shown in Figure below.

PEGASUS Associate Partners

Country	Institution	Country	Institution
Russia	Kazan State Technical University Ufa State Aviation Technical University Moscow Aviation Institute	Ukraine	Kharkiv Aviation Institute

Figure 10.9 - Associated Partners of the PEGASUS Partnership.
Source: https://www.pegasus-europe.org/userfiles/Pegasus_presentation.pdf

All partners have agreed on a specific curriculum description format, PEGASUS Course Catalogue in 2009 enabling an immediate understanding of the level of education provided by the partners. The PEGASUS members agree that a new European system for QA in Aerospace Engineering Education should be applied for on a voluntary basis and if possible, should not duplicate existing accreditation systems. The new system should focus on the qualifications and skills of the graduates right after graduation. PEGASUS, through PEGASUS-Industry Alliance, has established an entity for developing a quality/excellence label, named PERSEUS which is awarded at Master Level (level 5 of Bologna process) based on peer reviews and site visits.

According to the PEGASUS Course Catalogue (https://www.pegasus-europe.org/userfiles/Pegasus_Brochure_issue3.pdf), the commonalities of the programmes in Aeronautic/Aerospace Engineering have been classified into the following categories:

FS: FUNDAMENTAL SCIENCES

They are the background scientific knowledge required to understand and utilise the techniques and methods used in aerospace engineering. FS include courses such as mathematics, physics, chemistry, computer science basics, etc.

ES: ENGINEERING SCIENCES

They are sciences applied to general engineering purposes, such as mechanics, fluid mechanics, gas dynamics, electronics, telecoms, software engineering, simulation tools and techniques, etc.

AE: AEROSPACE ENGINEERING SCIENCES

Among engineering sciences, those having a strong orientation towards aerospace have been identified separately. They include aerodynamics, propulsion techniques, aeronautical structures & materials, aircraft design, flight dynamics, air traffic control, aircraft operations, aviation safety, avionics, space engineering, among others.

GC: GENERAL COURSES

Today, engineers can no longer limit themselves to purely technological projects, and they are in need of knowledge and skills in various "soft" sciences domains. These general courses include a large variety of topics (often proposed as optional courses) such as economics, finance, management, project management, history of aviation & industry, foreign languages, etc.

IT/FYP: INDUSTRIAL TRAINING / FINAL YEAR PROJECT

Most PEGASUS engineering programmes include also one or several periods of practical training, in laboratories or industrial structures. These may take place during the training program (industrial training/internship) and/or right at the end of it (Final Year Project). In this case, the practical training period is rather long (generally 4 to 6 months) and represents an opportunity to apply to real industrial problems the skills acquired during the period of courses.

In some countries with a strong centralised administration of education (France, Italy) little dispersion in their programmes' profiles can be found. However, their programmes are also quite similarly balanced as those of Spain, Portugal and Sweden. For instance, in all those countries, the proportion of basic science and technology (the sum of the first two categories: FS and ES) is roughly the same, 40% to 50% of the overall curriculum (although the respective weights of FS and ES may vary more importantly according to some national inclinations towards more or less theoretical studies). Conversely, in countries with a long tradition of decentralised education (Germany, UK), the dispersion between categories is greater from one university to another.

Nevertheless, some German universities (Stuttgart, Munich, Dresden and Aachen) show a similar proportion of basic science and technology (50%) as French, Italian, Spanish and Swedish institutions.

A summary of the different percent composition (in terms of ECTS) of the Degree Programs in Aeronautic/Aerospace engineering in the PEGASUS Universities is shown in Figure 10.10.

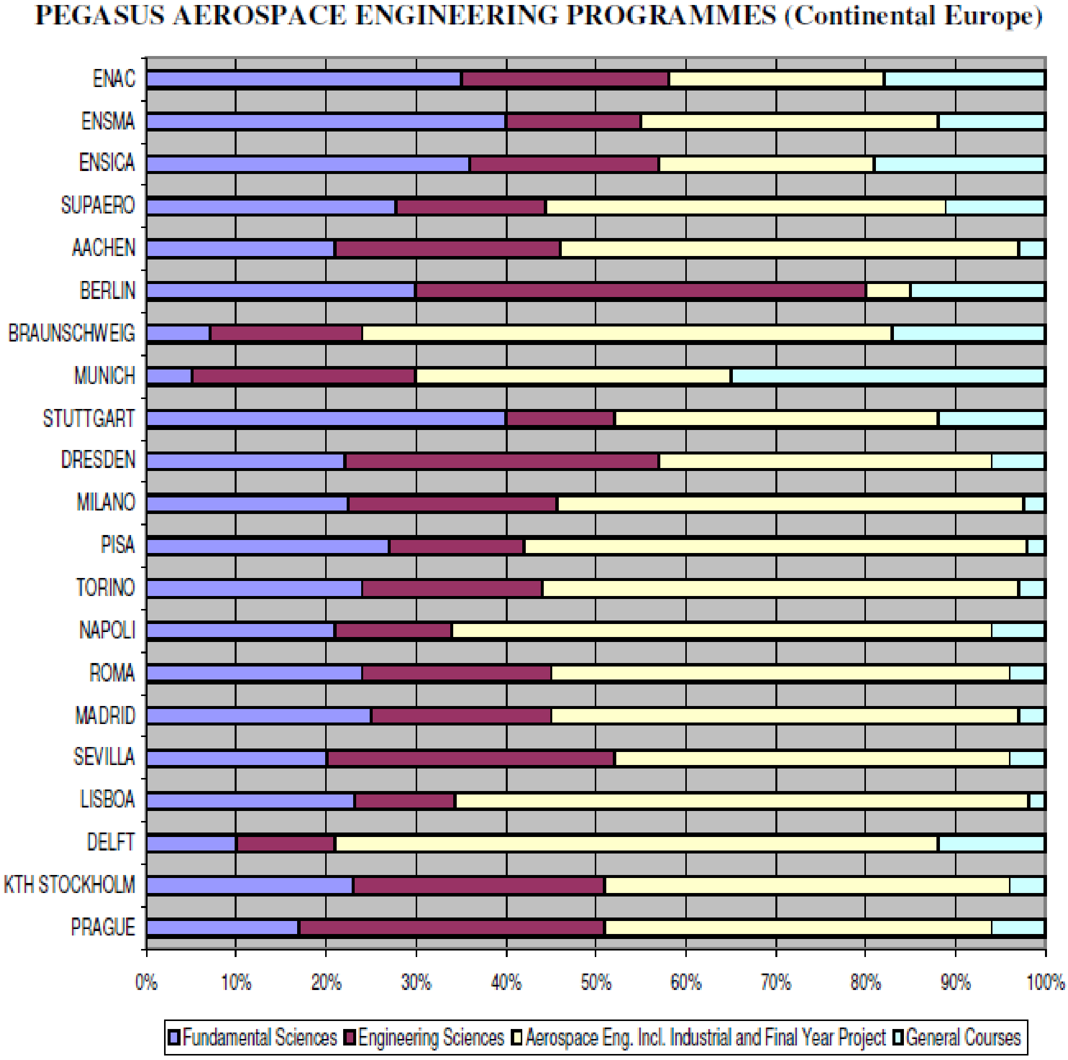


Figure 10.10 - Percent composition (in terms of ECTS) of the Degree Programs in Aeronautic/Aerospace Engineering in the PEGASUS Universities.
(Source: https://www.pegasus-europe.org/userfiles/Pegasus_Brochure_issue3.pdf)

PEGASUS member institutions are characterized by diverse aerospace engineering specialities which are reflected through a variety of courses or programmes, some of which are mandatory for all students while others are optional (electives). Some topics are widely taught across the PEGASUS engineering programmes, such as aerodynamics, aeronautical structures & materials, aircraft design, propulsion & combustion. Others are more concentrated in some member institutions, which put on emphasis on certain specialities like aircraft operations, air traffic control, space engineering & technology, etc. However, it is also possible to list "strong" areas for each institution.

FRANCE

- ENAC (Toulouse) Aircraft operations, aviation safety, airline/airport operations & management, air traffic management; Aircraft navigation, avionics, communications; Aircraft Design, Subsystems and Integration; Performance, Stability and Control.

- ENSICA (Toulouse) Aircraft design, subsystems & integration; Aircraft navigation, avionics, communications; Structures, materials; Aerodynamics, gas dynamics; Space engineering & technology.
- ENSMA (Poitiers) Aerodynamics, gas dynamics, heat transfer; Structures, materials; Propulsion, combustion.
- SUPAERO (Toulouse) Aerodynamics, gas dynamics; Propulsion, combustion; Aircraft, navigation, avionics, communications; Space engineering & technology; Structures, materials.

GERMANY

- RWTH AACHEN Aerodynamics, gas dynamics; Structures, materials; Propulsion, combustion; Aircraft design, subsystems & integration; Production and maintenance.
- TU BERLIN Aerodynamics, gas dynamics; Propulsion, combustion; Aircraft operations, aviation safety, airline/airport operations & management, air traffic management
- TU BRAUNSCHWEIG Aircraft operations, aviation safety, airline/airport operations & management, air traffic management; Aircraft navigation, avionics, communications; Structures, materials.
- TU MUNICH Aerodynamics, gas dynamics; Space engineering & technology; Propulsion, combustion; Structures, materials; Aircraft navigation, avionics, communications.
- UNIV. STUTTGART Propulsion, combustion; Aircraft design, subsystems & integration; Structures, materials; Aerodynamics, gas dynamics.
- TU DRESDEN Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Space Engineering & Technology; Aircraft Navigation, avionics & Communications.

ITALY

- POLITECNICO DI MILANO Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Space engineering & technology; Rotary Wing Systems and Non-conventional Aircraft.
- UNIV. DI PISA Structures, materials; Aerodynamics, gas dynamics; Performance, stability & control, flight dynamics; Space engineering & technology.
- POLITECNICO DI TORINO Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Aircraft design, subsystems & integration; Performance, stability & control, flight dynamics; Space engineering & technology.
- UNIV. DI NAPOLI Structures, materials; Aerodynamics, gas dynamics; Aircraft navigation, Avionics, Communications; Performance, Stability and Control; Aircraft design, Subsystems and Integration.
- UNIV. DI ROMA Space Engineering &Technology; Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Performance, Stability and Control, Flight Dynamics.

THE NETHERLANDS

- TU DELFT Aerodynamics, gas dynamics; Space engineering & technology; Aerodynamics, gas dynamics; Aircraft design, subsystems & integration.

PORTUGAL

- IST LISBOA Aircraft navigation, Avionics, Communications; Performance, Stability and Control, Flight Dynamics; Aerodynamics, gas dynamics; Aerodynamics, gas dynamics; Propulsion, combustion.

SPAIN

- ETSIA MADRID Propulsion, combustion; Aircraft operations, aviation safety, airline/airport operations & management, air traffic management; Aircraft navigation, avionics, communications; Structures, materials; Aerodynamics, gas dynamics.

- UT SEVILLA Structures, Materials, Aircraft Operations, Aviation Safety, Airlines / Airports Operations and Management, Air Traffic Management, Production & Maintenance, Aerodynamics, Gas Dynamics, Heat Transfer, Aircraft Navigation, Avionics, Communications

SWEDEN

- KTH STOCKHOLM Structures, materials; Aerodynamics, gas dynamics; Performance, stability, and control; Aircraft design, subsystems & integration; Propulsion, combustion.

UNITED KINGDOM

- UNIVERSITY OF BRISTOL Structures, materials; Aerodynamics, gas dynamics; Aircraft design, subsystems & integration; Performance, stability & control.

- CRANFIELD UNIVERSITY Aircraft operations, aviation safety, airlines/airports operations & management, air traffic management; Aerodynamics, gas dynamics; Structures, materials; Aircraft design, subsystems & integration.

- UNIVERSITY OF GLASGOW Structures, materials; Aircraft design, subsystems & integration; Performance, stability & control; Aircraft operations, aviation safety, airlines/airports operations & management, air traffic management; Aerodynamics, gas dynamics.

CZECH REPUBLIC

- CVUT PRAGUE Aircraft Navigation, Avionics, Communications, Aircraft Operations, Aviation Safety, Airlines / Airports Operations and Management, Air Traffic Management, Aerodynamics, Gas Dynamics, Heat

Transfer, Aircraft Design, Subsystems and Integration, Performance, Stability and Control, Flight Dynamics.

ITALY

The Italian University System is organized, after the Bologna process on three-degree levels as shown in Figure 10.11.

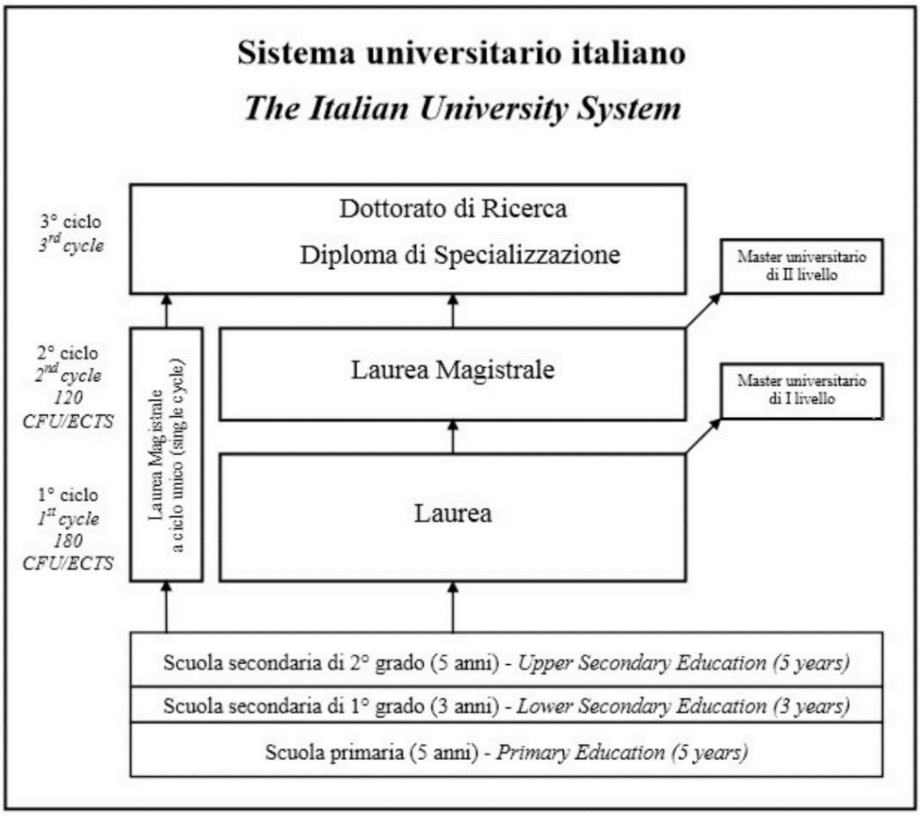


Figure 10.11 - Organization of the Italian University system.
Source: www.universitaly.it

There are several Italian Universities offering First Cycle (Bachelor), Second Cycle (Master) and Ph.D. Degrees in Aerospace/Aeronautical Engineering. However, since the Bachelor offers limited work opportunities it seems more appropriate to limit the analysis only to Master and Ph. D courses.

In Italy, there are 11 National Universities offering a Second Level (master's degree in Aerospace/Aeronautical Engineering. Detailed information on the organization and specific contents of each Degree Program can be found, as shown in Figure 10.12, on a site provided by the Italian Ministry for University and Research https://www.universitaly.it/.

University / Course	Class	Link
Università degli Studi di BOLOGNA (University page)		Website
Aerospace Engineering , FORLI' [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Politecnico di MILANO (University page)		Website
Aeronautical Engineering , MILANO [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Space Engineering , MILANO [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università degli Studi di NAPOLI "Federico II" (University page)		Website
AEROSPACE ENGINEERING , NAPOLI Interateneo [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università degli Studi della Campania "Luigi Vanvitelli" (University page)		Website
Aerospace Engineering , AVERSA [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università degli Studi di PADOVA (University page)		Website
Aerospace Engineering , PADOVA [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università degli Studi di PALERMO (University page)		Website
Università di PISA (University page)		Website
Aerospace Engineering , PISA [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università degli Studi di ROMA "La Sapienza" (University page)		Website
Aeronautical engineering , ROMA [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Space and astronautical engineering , ROMA [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università degli Studi ROMA TRE (University page)		Website
Aeronautical engineering , ROMA [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Università del SALENTO (University page)		Website
AEROSPACE ENGINEERING , BRINDISI Interateneo [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	
Politecnico di TORINO (University page)		Website
Aerospace Engineering , TORINO [scheda completa (SUA-CDS)] [scheda sintetica] [Course website]	LM-20	

Figure 10.12 - Italian Universities offering a master's degree in Aeronautic/Aerospace Engineering.

Source. https://www.universitaly.it/

The meaning of the symbols in Figure 10.12 is as follows:

Accession requirement –undergraduate degree

OfferedbyUniversityInstitution

Compulsory admission test

Admission test not required Face

to face class lessons Duration 2

Years

Programwithinternationalagreements

Courses taught in English

Full information on learning outcomes, study plan, syllabus, professors, opportunities for international mobility of students, placement opportunities, etc. can be obtained by accessing the link "SUA-CDS" or the "Course web site".

Typical catalogues of some master's degrees offered by the Italian Universities are shown in 10.15. As indicated previously, in Italy there is a strong centralised administration of education which binds the Institutions to provide a curriculum with little dispersion in their programs.

1st Year

Code	SSD	Course Title	Num Sec	Language	Course location	Type	Sem	CFU	CFU Group
081066	ING-IND/06	AERODYNAMICS			BV	M	1	10.0	10.0
096008	ING-IND/03	FLIGHT DYNAMICS			BV	M	1	10.0	10.0
083768	ING-IND/04	AEROSPACE STRUCTURES			BV	M	1	10.0	10.0
099255	ING-IND/04	AEROSPACE STRUCTURES			BV	M	1	10.0	
099245	ING-IND/04	DYNAMICS AND CONTROL OF FLEXIBLE AIRCRAFT			BV	M	2	10.0	10.0
096024	ING-IND/06	COMPRESSIBLE FLUID DYNAMICS			BV	M	2	10.0	10.0
096010	MAT/08	NUMERICAL MODELING OF DIFFERENTIAL PROBLEMS			BV	M	2	6.0	6.0
099268	ING-IND/14	MACHINE DESIGN			BV	M	2	6.0	
099256	ING-INF/04	ADVANCED AEROSPACE CONTROL			BV	M	2	6.0	
083903	ING-IND/10	HEAT TRANSFER AND THERMAL ANALYSIS			BV	M	2	6.0	
084149	ING-IND/15	COMMUNICATIONS SKILLS			BV	M	2	2.0	2.0
099257	ING-IND/03	TECHNICAL COMMUNICATION IN ENGLISH			BV	M	2	2.0	

2nd Year

Code	SSD	Course Title	Num Sec	Language	Course location	Type	Sem	CFU	CFU Group
091224	ING-IND/04	AERO-SERVO-ELASTICITY			BV	M	1	8.0	24.0
091254	ING-IND/06	INSTABILITY AND TURBULENCE			BV	M	1	8.0	
091253	ING-IND/06	EXPERIMENTAL FLUID DYNAMICS			BV	M	1	8.0	
099244	ING-IND/06	COMPUTATIONAL FLUID DYNAMICS			BV	M	1	8.0	
097502	ING-IND/14	MECHANICAL SYSTEMS RELIABILITY			BV	M	1	6.0	6.0
091222	ING-IND/35	MANAGEMENT OF AEROSPACE PROJECTS			BV	M	1	6.0	
051177	MAT/09	OPERATION RESEARCH			BV	M	1	6.0	
091335	ING-IND/06	AERODYNAMIC PROJECT			BV	M	2	6.0	12.0
051173	ING-IND/06	ROTOR AERODYNAMICS			BV	M	2	6.0	
091336	ING-IND/03	DESIGN OF WIND TURBINES			BV	M	2	6.0	
091339	--	GRADUATION THESIS AND FINAL WORK		--	--	V	1	20.0	20.0
091339	--	GRADUATION THESIS AND FINAL WORK		--	--	V	2	20.0	

Figure 10.13 - General contents of the Aeronautic Engineering master's degree (taught in English at the Polytechnic of Milan)
Source: www.polimi.it

KEY TOPIC T10.6 – CURRENT AEROSPACE ENGINEERING EDUCATION MODEL: A REVIEW FOR THE FUTURE

Europe has successfully managed, during the past decades, to ensure a world-leading position in the global civil Aeronautics and Air Transport (AAT) market. This can, in part, be attributed to the excellently trained human potential ensured through several world-class European Universities offering aeronautics education. However, due to societal, environmental and competitiveness shifts, the education of the Aerospace Engineers of the 21st Century can be a challenge for universities. In fact, the evolution of engineering practice in the aerospace business provides some clues to discerning future trends and requirements for both university and post-employment engineering education programs.

Some challenges are being critical, namely continuous demands for improved safety, reduced noise, increased fuel efficiency and environmental topics, which requires more effort from engineers to make increasingly small improvements. It is exactly the increasing importance of environmental considerations and the warning of the vulnerability of the world's fossil fuel supply that seems to be more interesting for the future of aerospace engineering[4]. Consequently, a change from project and design to other activities has characterized the working environment of aerospace engineering. These activities require a background in finance and management fields, of ethical and human issues, environmental protection, human factors, regulatory and legal subjects, which are disciplines that in the past time was considered as lying outside the domain of engineering. So, the aerospace engineering programmes did not include them or included them in a limited form.[5]

First, and more evidently, today's aerospace sector is many times larger than that of 70 years ago and therefore must employ more people. Also, a large proportion of these people has a university degree due to the complexity related to the sector. In fact, modern aerospace products are extremely complex not only in their conception but also in their interactions with the societal and economic external environments. If we look at the employment breakdown by the activity of today's employees, we find that that 60% of them are working in production and 16% in Research and Development (R&D). The remaining 24% includes a 7% of managers and a 17% performing other activities. Therefore, only 16% of the industrial aerospace employees is working in R&D, i.e. the activity in which project and design take place. Despite all this, employment in aerospace is constantly increasing[5].

In fact, as already mentioned, modern aerospace products are extremely complex in their interactions with the societal and economic external environments, so technology, processes and people form an inseparable triad in aerospace - in both industry and in academe. In this simplistic view, the most important assets of most companies and institutions in our society are their people (intellectual capital) and the cash flow that results from their activities. In this people-centric view of our industry, it may then be argued that the best technology and processes in the world are useless without the right skilled and motivated people to apply them. Maintaining and enhancing the excellence of our technical workforce must be a central focus within the technical community in aerospace[4]. With that, emerge an emphasis on a large set of abilities and skills, including team working, languages and communication, networking, use of multimedia and internet tools, adaptability and flexibility, open-mindedness to different cultures, which turned to be optional to appear in the engineering profiles as mandatory for the employers.

Actually, when contacted nowadays, companies affirm that would appreciate graduates provided with the following characteristics: 1) Technical skills (simulation and software proficiency / CAD-CAE-CAM, writing technical specifications, conducting a technical or economical study); 2) Methodological skills (analysing and solving a technical problem, managing a technical meeting, managing a technical project/program, writing a synthetic report, final project report or technical document); 3) Interpersonal skills (team working, team management, working in a multicultural environment, proficiency in English); 4) Other skills and abilities as proficiency in a (second) foreign language other than English, industrial experience (internship); ability to integrate non-technical parameters (economical, juridical, environmental) in proposed technical solutions; personal skills/behaviours (independent working, autonomy, well-being, stress management); analytical skills (time management, intercultural, open mindset, capability to work in different countries/business environment); management skills (leadership/decision making, influencing/negotiating skills). So, we can say that that the "desired attributes of an engineer" is: 1) a good understanding of engineering science

[4] McMasters, J. H. (2004). Influencing engineering education: one (aerospace) industry perspective. *International Journal of Engineering Education*, *20*(3), 353-371.

[5] Chiocchia, G., & Guglieri, G. (2017). The Education of the Aerospace Engineers of the 21 st Century: a Challenge for Universities. *Aerotecnica Missili & Spazio*, *96*(2), 96-100.

fundamentals (e.g., mathematics, physics); 2) a good understanding of design and manufacturing processes; 3) a multi-disciplinary, systems perspective; 4) a basic understanding of the context in which engineering is practiced (e.g., the environment); 5) good communication skills; 6) high ethical standards; 7) an ability to think both critically and creatively; 8) flexibility to adapt to rapid major changes; 9) curiosity and a desire to learn for life; 10) understanding of the importance of teamwork[4] .

Basing on these considerations Kamp (2016)[6] points out eight key aspects that will characterize the (not only aerospace) engineering education in 2030: 1) Rigour of engineering knowledge; 2) Critical thinking and unstructured problem solving; 3) Interdisciplinary and systems thinking; 4) Imagination, creativity, initiative; 5) Communication and collaboration; 6) Global mind-set: diversity and mobility; 7) Ambitious learning culture: student engagement and professional learning community; 8) Employability and lifelong learning. It is important to note that only the first and third of these aspects might directly affect the scientific and technical contents of the engineering curricula. Even if most aerospace programmes already provide a rigorous knowledge, in fact, these two aspects imply the necessity to enlarge it by strengthening the general engineering fundamentals, by adding elements of human, societal and economic factors and by making it more interdisciplinary. To achieve that it's critical to introduce academic changes and enhance engineering education because the students cannot acquire these skills through formal learning. Rather, it will be necessary to reconsider the whole way of teaching by putting much more emphasis on student projects, team activities, autonomous research tasks and so on[5].

For many years, undergraduate engineering education has been based on the implicit assumption that we somehow need to teach students "everything they might need to know" before they enter professional practice. However, what is really important is to demonstrate to students that engineering is practised within a much broader societal context, and instead of creating a course to meet a need, it's critical to develop in the students a fundamental understanding of the unity of the fundamental tools and concepts needed for engineering practice. It is important to emphasize "design (system) thinking", where students learn creative thinking and open-ended problem-solving, but always within the context of design's close connection with manufacturing and customer/societal needs - the "Why" and "What" of theory, and how these basics are then applied in practice. In parallel with technical skills, aerospace engineering should include other components as project management, operations and economics and design skills.

More precisely, the main curriculum in aeronautical/aerospace engineering should include a mix of fundamental sciences, general engineering sciences, specific aerospace engineering sciences and general courses. Indicatively, considering the average teaching and learning capacity, the following division among the 4 groups can be identified as a preliminary indication: 1) Fundamental Sciences (recommended minimum 15%); 2) Engineering Sciences (recommended minimum 40%), having their roots in mathematics and basic sciences but carrying knowledge further toward creative application; 3) At least 50% of the Engineering Sciences should be Aerospace Engineering Sciences (that is, minimum 20% of the overall program or 60 ECTS for a 5-year programme); 4) General Courses, which complement the technical content of the curriculum.[7] [8] So, the specific Aero-Engineering Sciences should provide the graduates with learning outcomes in the following knowledge areas: 1) A/C Design, avionics and subsystems design/integration; 2) Flight dynamics, performances, flight operations and flight testing; 3) Fluid Dynamics, Aerodynamics; 4) Structures, materials; 5) Propulsion systems design; 6) Aerospace telecoms/CNS/ATM systems engineering; 7)

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[6] A. Kamp, Engineering Education in a Rapidly Changing World, TU Delft Centre for Engineering Education, June 2016, ISBN 978-94-6186-609-7

[7] Bernelli-Zazzera, F., & Prats, M. A. M. (2017, November). The PERSEUS Project to Promote Excellence in Aerospace Education. In *2017 7th World Engineering Education Forum (WEEF)* (pp. 568-573). IEEE.

[8] Guglieri, G., Hanus, D., & Revel, P. (2017). A Proposal for Ensuring the Quality of Aerospace Engineering Higher Education in Europe. *Transportation Research Procedia*, *28*, 207-216.

Airworthiness/Aviation safety, A/C Ops & Product Life Cycle; 8) Aeronautical production and A/C maintenance; 9) Non-conventional/Rotary wing aircraft design; 10) Space technology; 11) Space applications; 12) Economic/Financial aspects of aerospace projects, Air Transport Economics; 13) Environmental aspects/Sustainable development of aerospace projects; 14) Configuration Management in Design and production; 15) Integrated and complex technical environment.

A benchmark study started by MIT [9] tried to identify which institutions worldwide are the current or the emerging leaders in engineering education. To this aim, it indicates four key features that are likely to distinguish the world's best programmes of engineering education in the coming decade: 1) the combination of digital technology and active learning to deliver a world-class, student-centred education to large cohort sizes; 2) the increase in flexibility, choice and diversification offered to students in their engineering studies; 3) curricula that bring together the themes of cross-disciplinary learning, global experience and the use of engineering to drive positive societal change; 4) ensuring that key learning experiences, such as work-based learning and user-centred design projects let students reflect, contextualize and build upon their learning across the rest of the curriculum. To achieve that it's important to change the nature of many engineering schools and universities that inhibits collaboration and cross-disciplinary learning; change faculty appointment, promotion and tenure systems that reinforce an academic culture that does not appropriately prioritise and reward teaching excellence; pursue the challenge of delivering high quality, student-centred education to large and diverse student cohorts and find the alignment between governments and universities in their priorities and vision for engineering education.

In Europe, along with the national agencies, a relevant role is played by ENAEE, the European Network for Accreditation of Engineering Education. It was established formally as a not-for-profit association under Belgian law in February 2006 as the output of a European-funded project "EUR-ACE – European Accredited Engineer". ENAEE is composed of organizations which are concerned with engineering education and/or the engineering profession. Also, in order to optimize academia in Europe, PERSEUS (Promoting Excellence & Recognition Seal of European Aerospace Universities) program was created. The PERSEUS project has laid out the basis for the establishment of one European quality assessment system for aerospace-related higher education and his main goal is the evaluation of the quality of the aerospace curricula in the European context, whereas the accreditation of the programme can be seen as an optional extension of the process, subject to further national regulations[8]. The PERSEUS project has stimulated discussions within the global EU aerospace community, having involved 15 EU Countries, 21 Universities, 4 research establishments, 25 EU companies (Large and SME), 2 accreditation agencies. The 8 visits to Universities have involved degree courses counting for approximately 6,500 students potentially involved.

In order to test the applicability of the PERSEUS across the EU, and as referred before, a study of 8 Universities that have been selected voluntarily was made in 2014-2017, trying to compose a diverse group of curricula to analyse. As a result, TU Delft University was reported as a good example. TU Delft is one of the three engineering universities in the Netherlands and the Faculty of Aerospace Engineering is one of the largest of the eight faculties at the Delft University of Technology and one of the largest faculties devoted entirely to aerospace engineering in Europe. It is the only institute carrying out research and education directly related to aerospace engineering in the Netherlands. Today the Faculty has a student body of approximately 1,300 undergraduate and 1,300 graduate students and 250 PhD students. Over 40% of the student population has a foreign nationality. For all these reasons, TU Delft was reported as a reference in the EU for aerospace and is well suited for the PERSEUS project.

[9] R. Graham, The global state-of-the-art in engineering education: Outcomes of Phase 1 bench-marking study, published by MIT, February 2017

Moreover, since in most European countries this represents a bigger sector, with huge investments at university level, TU Delft is not alone in this excellence. In fact, in Italy can be identified 13 Master's Degrees in Aeronautic or Aerospace Engineering. At Universidad Politécnica de Madrid (UPM) there are four main degrees (Degree in Aerospace Engineering (GIA); Degree in Air Transport Management and Operations (GyOTA); Master's Degree in Aeronautical Engineering (MUIA); Master's Degree in Air Transport Systems (MUSTA), which have a focus on transversal competences (e.g. graduates will have the ability to understand content in the English language, to lead multidisciplinary work teams, to work effectively both individually and as a member of a team, to manage technical and scientific documents by going to the appropriate sources, to adopt creative solutions and to Work in international contexts) and emphasis on acquiring of the ability to analyse and assess the social and environmental impact of technical solutions. Also, in University POLITEHNICA of Bucharest there is a huge focus on the environmental challenge, where it's possible to see contents related in Bachelors (e.g., the program provides courses like 'Eco-design in aeronautical engineering' and 'Packaging design' and 'Product design engineering' that provide information on improvements in design from the perspective of environmental protection), Masters (e.g. 'Airport Management', 'European and International Air Law', 'Air Transport Systems' Airline management', 'Airport Infrastructure' and 'Aeronautical Meteorology' are the master courses which addresses environmental issues in aviation from different perspectives) and PhDs (e.g. Environmental issues are covered in PhD reports such as: 'Constructive requirements and equipment for fire protection at hangars and airport terminals', 'Airport model 4.0 ', 'Computer systems applied on Airport 4.0', 'Study on methods of disposal of space waste', 'Optimization of bidirectional turbines for energy extraction of thermoacoustic engines', etc. But, thematic like aircraft composite structures technology, aircraft structures, Aerothermochemistry could bring in the background the problem of environmental protection, thus developing interdisciplinary topics).

Assuming that these cases reflect a good EU average, the general structure of the EU education in Aerospace and Air Transport sectors is solid in terms of technical and scientific content. Some efforts should be addressed in assuring that European graduates have, in addition to the technical knowledge, also those professional and interpersonal skills and competencies that up to now have been considered less important, such as foreign language proficiency, international attitude, team-working and communication skills. These qualities are now fundamental even in the most technical disciplines. According to some major EU players and stakeholders in the sector, lack of professional skills is one of the most common reasons for not recruiting the graduates.

To sum up, European universities should invest in a curricula harmonization, mainly in terms of contents. The fundamental disciplines of the aerospace curriculum are well identified and given at an advanced level in the majority of the Universities. The improvement of the curricula may rely on specialised subjects. These considerations should drive the future strategy of the universities towards stabilization of the fundamental disciplines and flexibility for specialised subjects which may also represent an open window of the university regarding the aerospace job market[7]. These adjustments can be, in part, the response to the challenges of the XXI century in the sector.

KEY TOPIC T10.7 – ACADEMIC PERSISTENCE

There is also a need to better understand the role of environmental supports and barriers relative to the choice and persistence in science and engineering majors, but specifically in aerospace disciplines.

In fact, studies show that students who matriculate in engineering are more likely to persist in engineering than students in other majors (Ohland et al., 2011) but the academic success and retention of engineering students is a central issue in engineering education.

Models of student success and persistence provide a way to examine the effects of cognitive and noncognitive factors on specific academic outcomes. Although among engineering students, cognitive indicators have been shown to be the best predictors of achievement and persistence, academic success and persistence cannot be fully explained without the consideration of noncognitive factors. Actually, about the persistence and success of the students, three categories can be identified: a) sociocultural factors, where the family support and structured social support are key contributing factors to successful students' experiences; b) academic factors, where better preparation with study skills and career development will lead to greater persistence and c) personal factors, where the perceptions of confidence and competence were key aspects of students' motivation for academic achievement (Jackson & Smith, 2003).

It's important to consider that students decide to pursue an engineering major for a variety of reasons and, as said before in this report, work characteristics and high school math and science courses have been reported to play a key role in a student's decision to pursue an engineering degree (academic factors). More, social integration and family can act as a motivating factor for some students (sociocultural factors). Also, about the personal factors, motivation is perhaps the most commonly considered student characteristic in relation to academic outcomes. Characteristics of motivated students include persistence, goal setting, and resilience. More, in this area, we should point out "self-efficacy". Studies show that higher levels of academic self-efficacy, a motivational process, were related to academic success and adjustment among first-year college students (French, Immekus & Oakes, 2003) and subjects reporting high self-efficacy for educational requirements generally achieved higher grades and persisted longer in technical/scientific majors over the following year than those with low self-efficacy. One of the major streams of research on academic and career-related self-efficacy has involved science, technology, engineering, and mathematics (STEM) fields. These studies have shown that self-efficacy regarding scientific-technical tasks, such as the perceived capability to successfully complete the academic requirements in engineering, is predictive of students' interests, academic performance, persistence and career aspirations in STEM-related fields (Lent et al., 2003). But how is the subjacent development process and how it's possible to improve self-efficacy?

According to self-efficacy theory (Bandura, 1977), self-efficacy beliefs, meaning beliefs about one's ability to successfully perform a given task or behaviour, may determine performance accomplishments and persistence in pursuing a difficult course of action. Actually, Hackett and Betz (1981) have specifically hypothesized that efficacy expectations are related to the degree of persistence and success in college major and career choices. Also, the development of self-efficacy can be explained with the already mentioned SCCT theory (Key Topic T10.0). As described previously SCCT focuses on the interplay among a variety of person, environmental, and behavioural variables that are hypothesized to influence the processes through which people (a) develop basic academic and career interests, (b) make and revise their educational and vocational plans, and (c) achieve performances of varying quality in their academic and career pursuits. According to SCCT's overlapping models of interest and choice, self-efficacy promotes favourable outcome expectations (beliefs about the consequences of given actions), and students tend to develop interests in academic subjects at which they possess strong self-efficacy and positive outcome expectations. Choice goals (i.e., intent to choose or persist at a particular course of action) are seen as resulting from self-efficacy, outcome expectations, and interests. More, goals are also assumed to be affected by the presence of contextual (e.g., social) supports and the relative absence of barriers. Specifically, about the academic adjustment of engineering majors, an integrative model was developed and postulate that having interests that are consistent with one's major (and being able to pursue these interests) is posited to predict academic major satisfaction. Such satisfaction is, in turn, assumed to nurture intentions (goals) to persist in one's major. The path from interest to persistence intentions is seen as both direct and indirect (through satisfaction). That is, students likely wish to remain in majors that allow them to perform activities they like and to experience an environment they find intellectually and interpersonally satisfying (Lent et al., 2003). In summary, self-efficacy and outcome expectations, two key building blocks of academic/career choice and development, derived from a variety of personal (e.g., affective state) and socially mediated (e.g., modelling, encouragement) experiences and, involved with other social cognitive variables, can be a predictor of students' interests, goals, persistence, and performance. (Lent et al., 2005). In particular, academic goal progress, self-efficacy, and environmental supports is individually and collectively predictive of engineering students' academic satisfaction and academic satisfaction is, indeed, strongly related to intended persistence (Lent, Singley, Sheu, Schmidt & Schmidt, 2007).

However, the famous "pipeline" problem in STEM fields, that is, the need to attract more students and workers to, and to retain them (especially women and minorities) can be related with self-efficacy expectations. In fact, self-efficacy expectations were related to both ranges of occupations considered and expressed vocational interests in male and female college students, so such expectations may affect the type and number of perceived career options. Women report greater self-efficacy than men for traditionally female fields and lower self-efficacy than men for traditionally male occupations, who may result in women limiting their range of career choices, thus failing to realize their full career capabilities (Betz and Hackett, 1981). This has a special impact for aeronautics, where one of the reasons for the problems in attracting and training professionals is the gender bias and the fact that there is only a small number of minorities in the industry. Since that gender stereotypes were a factor in career choice, many young women were discouraged from pursuing aeronautics careers (Pendergrass, 1983).

In conclusion, what can be done to ensure the persistence of students in aeronautics?

First, it's important to retain the factors that are linked to persistence, either directly (e.g., persistence goals, satisfaction), indirectly (e.g., social support), or both (e.g., self-efficacy) and design interventions focused on social cognitive factors (e.g., access to social support, information about intrinsic occupational rewards, and demographically similar models), that may help to expand the gender and racial/ethnic diversity of the STEM pipeline (Lent et al., 2016).

In sum, two factors external to the school contribute to higher success in aeronautics courses: 1) Students who are made aware of aviation as a career earlier are more likely to succeed in their training and 2) Students who had either friends or family in aviation who could explain what a career in aviation consisted of were more likely to succeed.

Actually, one of the reasons for choosing a career in aeronautics might be a prior interest in the field and in some cases, a student could have a family member, or a friend, who was in the aviation industry. Friends and family who have had experiences in the industry are more likely to help the students make informed decisions. Besides the importance of external communities (families, mentors, etc.) in student retention, some interventions can be developed. The earlier students make decisions to pursue careers in aviation, the better the chance that they will be prepared for college when the time comes and have accurate career awareness and guidance. For encouraging young people some career training programs can show how mathematics and sciences are applied in aviation training and practice and stimulate informed career choices through some activities (e.g., free flights and aviation activities for students). Also, many secondary school teachers and counsellors may not prepared to help their students make informed decisions about the different careers in aeronautics, so it's important to work with them so can be better prepared to advise students about careers such as aviation. In order to reach students as soon as possible and ensure the future persistence the companies can make partnership with schools and participate in workshops to make educators more aware of the types of careers that exist in aeronautics and promote aviation careers to young people. Later, in the university, to facilitate the development of academic integration, persistence can be developed through the development of formalized mentoring programs and initiatives to involve students in research or activities (Foltz, Gannon, & Kirschmann, 2014).

10.4 Careers in Aeronautics and Space

The kind of multidisciplinary competence in advanced technologies necessary in the aerospace sector is also sought in other sectors, such as:

- the automobile, railway and other transport and non-transport industries looking for better aerodynamics, lighter strong structures, more efficient engines, advanced control, safe traffic management.
- the consulting companies needing managers of technological projects, that require scientific skills out of reach of economists or legal people and find that the latter aspects can be assimilated to a sufficient extent by engineers.

Although an aerospace engineer would have as first-choice aeronautics or space, it may happen that some consultant companies are quicker to offer professionally enticing and well- paid job opportunities, often advertising before the university degree is complete. The aeronautical industry can have the lead if it invites promising students to stay during their university course, thereby establishing early links that ensure their choice before other attractions arise.

The unrelenting technological progress changes the shape of the aerospace industries (Key Topic 10.7) and the careers it offers (Key Topic T10.8).

KEY TOPIC T10.7 – EVOLUTION OF THE AEROSPACE INDUSTRY

The aerospace industry is currently experiencing profound changes. With emerging countries such as China, India, Brazil, and Russia entering into the market, global competition is steadily on the increase. Whilst long-term growth predictions are generally positive, continued success can only be achieved by those who excel at developing and implementing innovative product and service concepts, particularly with regard to environmental and ecologically sustainable issues. In order to serve the global market and sell technologically highly specialised products, cooperation between companies, as well as entire regions, is essential. The strategic response to the rapidly changing world has been the bundling of resources and competencies by clustering.

Within this context, EACP (European Aerospace Cluster Partnership) was established (figure 10.14) in 2009. This initiative provides a permanent platform for mutual exchange, policy learning, and cooperation to achieve high-level performance among European aerospace clusters. It focuses on the exchange of experiences concerning both cluster policy and the implementation of effective solutions needed to address various challenges faced by the partners. In order to be admitted to the network, a member must represent all segments of the regional aerospace sector, including industry, R&D and administrative bodies.

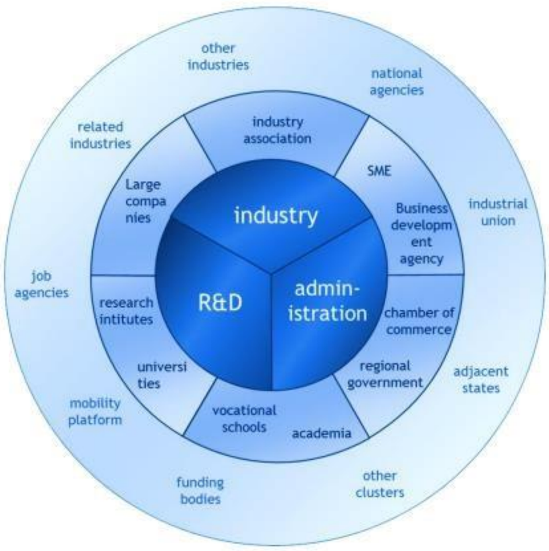

Figure 10.14 - Stakeholders represented within EACP (Source: EACP web page)

After 5 years of existence, EACP currently constitutes a network of 42 aerospace clusters (figure 10.15) from 17 European countries, thus largely covering the entire aerospace value chain in Europe.

Figure 10.15 - EACP Cluster map (Source: EACP web page)

Since its inception, EACP has been based on a set of core values (figure 10.16) which shape the culture and define the character of its transnational approach. As the most active aerospace collaboration platform, EACP provides a permanent framework for information exchange and policy study as well as opportunities for mutual transnational cooperation between its members and all market actors. With a focus on European clusters, EACP shapes the future trajectories for international cluster relations, whilst acknowledging the regional needs, challenges, and characteristics of the aerospace sector. This relies on the core values of trust, engagement, dependability, and joint added value generation, rendering EACP a network based on plurality and mutual commitment. In a global context, EACP strives to position Europe as the leading centre for innovation and competitiveness in the aerospace realm, thus addressing the contemporary challenges of an increasingly globalised world. Taken together, EACP represents a set of cooperative values and close interaction, both of which stand in line with its vision to strengthen the whole through the diversity of the many.

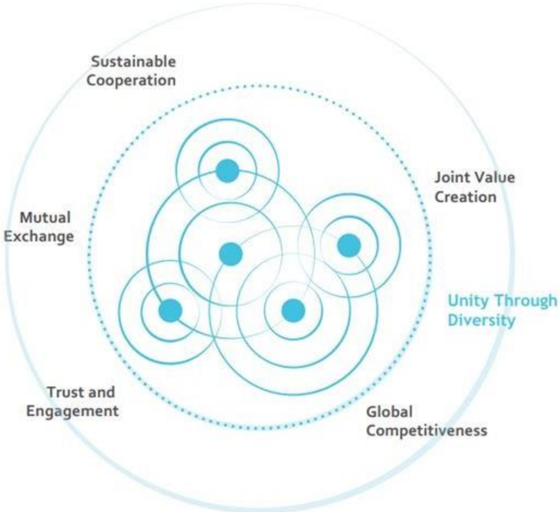

Figure 10.16 - EACP values (Source: EACP web page)

The main objective of the EACP initiative resides in improving the global competitiveness in Europe through intense inter-cluster collaboration. This goal is pursued (figure 10.17) within three major fields of action:

- Knowledge exchange
- Push innovation
- Strengthen EU position

All EACP activities follow these guidelines to improve competitiveness in a European context.

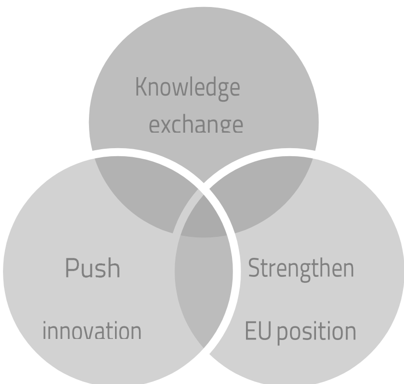

Figure 10.17 - EACP fields of action

- Knowledge exchange: to enable inter-cluster knowledge exchange, presentations and discussions on best practice are conducted at regular EACP meetings. Participation in the European Strategic Cluster Partnership (ESCP) allows for the exchange of experience and knowledge regarding economic, political and social developments that affect aerospace and other industry sectors. Thus, the regional clusters are not only prepared for possible future developments but also work to further cluster excellence.
- Push innovation: the second main objective is pursued by developing skills and qualification among the existing and future aerospace workforce. Examples include the establishment of other EU-projects which specifically target technological innovation, such as the CARE and BeAware or CANNAPE. These and other projects are supplemented by EACP match-making events, as part of which EACP unites actors from industry and R&D to develop new ideas needed to improve technology, products and processes.
- Strengthen EU position: the third main objective constitutes a number of activities related to the continued internationalisation of the member clusters, their regions, and resident companies. A crucial factor in this regard is the development of a competitive aerospace supply chain in the EU. Specific problems faced by suppliers are to be monitored and integrated into the EU technology roadmap. In order to improve the EU's global competitiveness in the aerospace sector, a strategic assessment of future technological fields as well as collaborations with strategic actors are planned. In this manner, EACP also supports the efforts of other institutions such as ASD, ACARE, CleanSky, EASN, SESAR and EEN.

KEY TOPIC T10.8 – CAREERS IN THE AEROSPACE SECTOR

About the Sector

The global Aerospace and Defence industry will strengthen in 2018 as revenues are forecasted (figure 10.18) to increase by 4.1 percent, doubling last year's 2.1 percent growth. The recovery of global gross domestic product (GDP), stable commodity prices, and heightened passenger travel demand are likely to ramp up growth in the commercial aircraft sector in 2018.

The sector can be divided into two major areas:

- aeronautics industry and
- air transport.

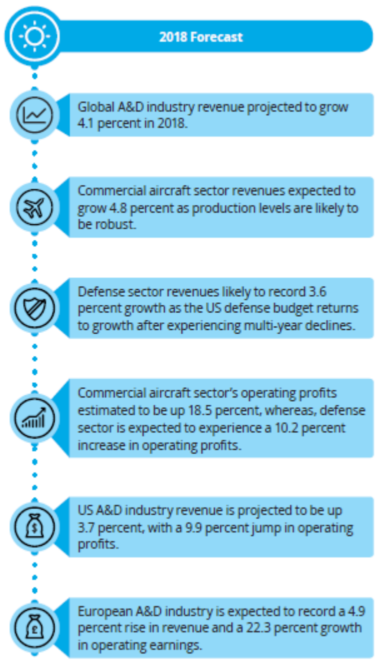

Figure 10.18 - 2018 Forecast for the Aerospace Industry Source: Deloitte 2018 Global Aerospace and Defense Industry Outlook

AERONAUTICS INDUSTRY

According to the European Commission, Aeronautics is one of the EU's key high-tech sectors on the global market:

- the EU is a world leader in the production of civil aircraft, including helicopters, aircraft engines, parts, and components
- the EU has a trade surplus for aerospace products, which are exported all over the world.

The European aeronautics industry develops and manufactures civil and military aircraft, helicopters, drones, aero-engines and other systems and equipment. The industry work involves designing components and systems and generating CAD models and drawings; work such as fluids analysis or thermal analysis; manufacturing the technology; developing and testing it; and supporting the products in service.

Big manufacturing companies include Airbus, BE, Leonardo Embraer and Bombardier, who design, manufacture, and build aircraft, and Rolls-Royce, Safran, General Electric and Pratt and Whitney, who design, manufacture and build engines. Liebherr, Cobham and GKN are other big names. There is a large network of smaller suppliers who support the big companies.

Productivity is considerable and despite high employment costs, the sector is quite profitable. A sizeable share of value-added is spent on research and development (R&D), which is reflected in an increasing number of patent applications. (European Commission).

AIR TRANSPORT

According to Aviation Benefits Beyond Borders, Air transport (figure 10.19) supports 11.9 million jobs and $860 billion in GDP in Europe. The air transport industry in Europe directly generated an estimated 2.5 million jobs in 2014.

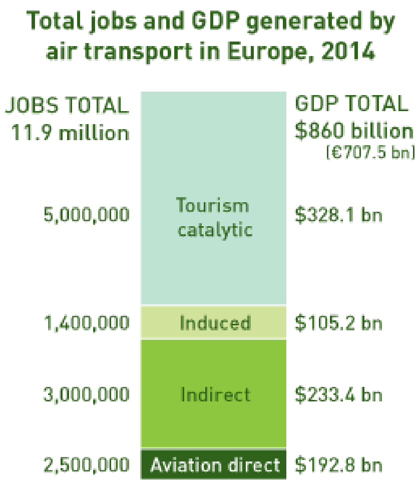

Figure 10.19 – Air Transport in Europe

The total impact – including those from the operations of the air transport sector itself, the impact of the air transport sector's procurement of inputs of goods and services from its supply chain, and the impact of employees of the air transport sector and its supply chain spending their wages – mean the air transport sector supported 6.9 million jobs and contributed $531.9 billion to GDP in Europe. (Aviation Benefits Beyond Borders, 2014).

Moreover, substantial benefits derive to regional economies via the catalytic impacts of tourist spending, much of which is generated by tourists travelling by air. In 2014, the spending of tourists arriving at their destination by air is estimated to have added 5 million to employment and $328.1 billion in GDP. (Aviation Benefits Beyond Borders, 2014).

At the same time, according to most recent statistics from the latest edition and Eurostat data, the EU air transport cluster and airport-related activities direct contribution to the EU's GDP in €110bn while the overall total impact, including the indirect effects, is as much as €30.

Human Dimension of the sector

Employment in Aerospace and Defence industry has been increasing and, in 2015, reached its maximum by employing 847.700 people (Figure 10.20). Employment in the aerospace sector is particularly significant in Europe (Figure 10.21), mainly in the United Kingdom, France, Germany, Italy, Spain, Poland, and Sweden.

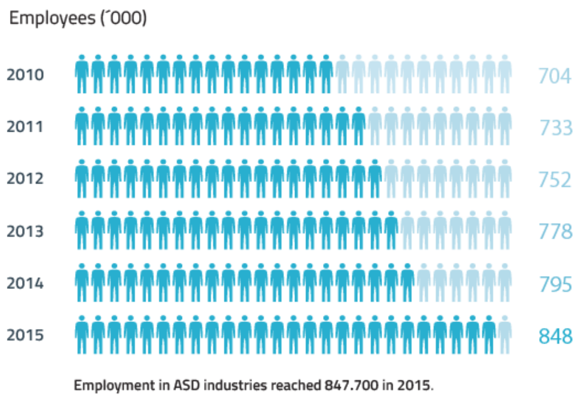

Figure10.20-AerospaceandDefenseIndustryEmploymentbetween2010-2015
Source:AerospaceandDefenseIndustriesAssociationofEurope

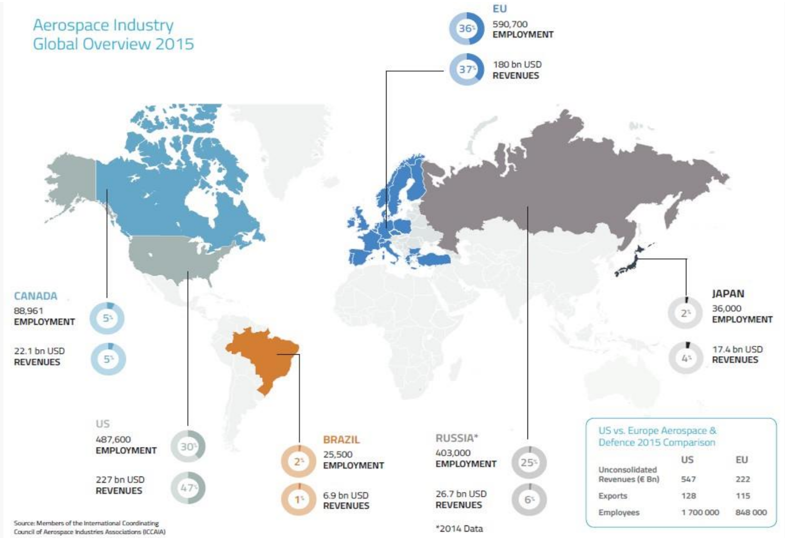

Figure 10.21 - Aerospace Industry Overview

AERONAUTICS INDUSTRY

According to the Aerospace and Defence Industries Association of Europe (ASD), 65% of employment in the Aerospace and Defence sector accounts to aeronautics related careers (figure 10.22):

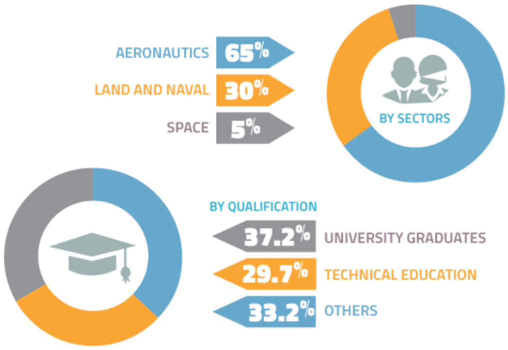

Figure 10.22 - Aerospace and Defense 2015 Employment Breakdown Source: Aerospace and Defense Industries Association of Europe

AIR TRANSPORT

According to Aviation Benefits Beyond Borders, the air transport industry in Europe directly generated (Figure 10.23) an estimated 2.5 million jobs in 2014. 533,000 of those people (21% of the total) were in jobs for airlines or handling agents (for example, flight crew, check-in staff, maintenance crew, reservations, and head office staff). Another 174,000 people (7% of the total) worked for airport operators (for example, in airport management, maintenance, security, and operations). 1.4 million jobs (57%) were on-site in airports, at retail outlets, restaurants, hotels, etc. A further 311,000 people (12%) were employed in the manufacture of civil aircraft (including systems, components, airframes, and engines). Air navigation service providers employed an additional 84,000 people (3%).

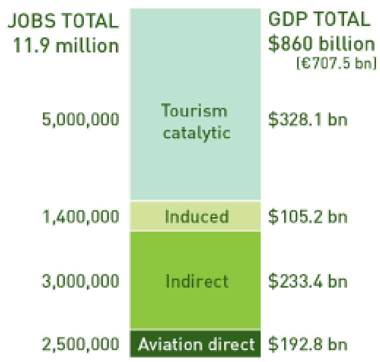

Figure 10.23 - Total jobs and GDP generated by air transport in Europe, 2014

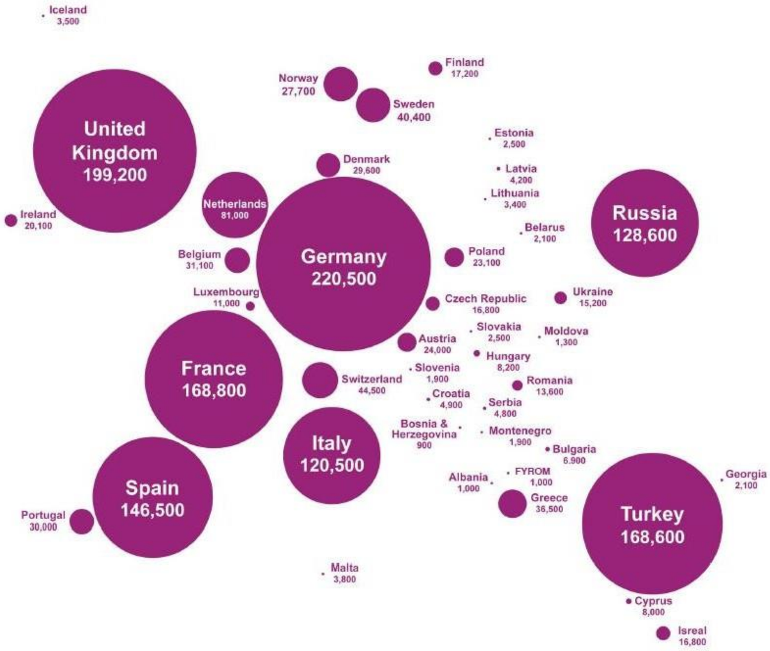

Figure 10.24 - Map of the Direct Employment at Airports in Europe, 2013 Source: Economic Impact of European Airports, InterVISTAS

European airports (figure 10.24) are a source of a wide variety of job categories, with different positions spread on-site and off-site across the airports (Figure 10.25).

Figure 10.25 - Direct Job by Employment Type Source:EconomicImpactofEuropeanAirports,InterVISTAS

The direct employment generated by airports is affected by the size of the airport and the mix of traffic handled. Direct employment data was gathered from 125 airports representing 71% of European passenger traffic. For those airports where no employment information could be obtained an econometric model was developed to infer their direct employment. The analysis was conducted of the airports from which data was collected to analyse the relationship between direct employment and characteristics of the airport. The results are summarised in Figure 10.26:

Airport Size / Traffic Type	Comment
Less than 1 million traffic units	Each increase of 1000 traffic units increases employment by 1.2 Jobs
1 million - 10 million traffic units	Each increase of 1000 traffic units increases employment by 0.95 Jobs
Over 10 million traffic units	Each increase of 1000 traffic units increases employment by 0.85 Jobs
Connecting passengers	Connecting passengers generate 3% less direct jobs than origin/destination passengers
LCC passengers	LCC passengers generate 20% less direct jobs than non-LCC passengers

Figure 10.26 - Factors Determining Airport Direct Employment (Source: Economic Impact of European Airports, InterVISTAS)

The latest edition of the Eurostat data reported that the EU air transport cluster and airport-related activities directly employ around 1.9 million people and directly or indirectly support 4.7 million jobs. According to the European Commission, since the completion of the aviation internal market, direct employment in aviation has remained stable while the aviation market was booming. While over the period 2000-2013 passenger traffic in the EU has grown at a compound average rate of +3.0% p.a., i.e. totalling +47% over that period, employment in the air transport cluster saw a net reduction of -7.0% over the same 13-year period. These developments took place in a context of rapidly increasing productivity and more widespread recourse to outsourcing.

In the European report (2015) "Study on employment and working conditions in air transport and airports" is indicated a percentage of 60% men and 40% women in air transport.

Careers in aeronautics and air transport

This sector can be divided into two major areas:

- Aeronautic Industry - includes prime contractors and system designers (aircraft manufacturers, missile and satellite manufacturers, designers of on-board electronic systems and others), engine manufacturers (propulsion system designers) and equipment manufacturers (pneumatic, electric, electronic, mechanical). It is based on trades classified into 3 categories:

    1. engineers (system engineer, mechanical design engineer and others),
    2. senior technicians (logistic technician, method preparer and others) and
    3. operators (boilermaker, fitter-fitter, and others).

- Air transport - includes the transportation of people, goods and mail on regular lines and non-scheduled activities (charter, taxi, plane rental with pilot, flight training and others). It relies on aeronautical maintenance activities and airport assistance activities (rack and field operations, shipboard trades, civil aviation professions).

Needs and tendencies

AIR TRANSPORT (MAINTENANCE TECHNICIANS, PILOTS, AND CABIN CREW)

The commercial passenger aircraft fleet is growing, and Airbus forecast suggested it will continue to grow in terms of the numbers of aircraft over 100 seats in the coming years. In fact, the GMF suggests the fleet will more than double from today's level of around 19,000 aircraft to 40,000 in 20 years' time (Figure 10.27). (Airbus Global Market Forecast 2017-2036, 2017).

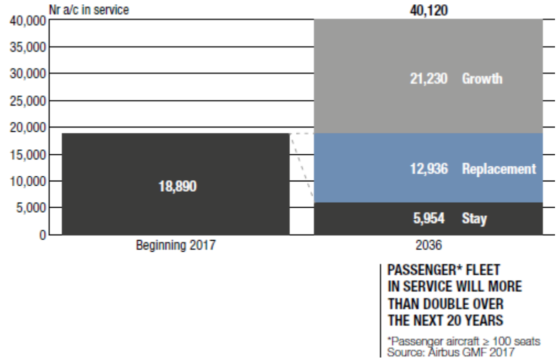

Figure 10.27 – Passenger fleet in service will more than double over the next 20 years

Based on the expected increase of passenger fleet in service for the next 20 years, the 2017 Airbus Global Market Forecast Report underlines future needs for:

1. Maintenance, Repair and Overhaul market (MRO);
2. New pilots and
3. Technicians.

Firstly, this fleet growth will also drive the size of the MRO business, which Airbus also expects to double, US$60 billion to more than US$120 billion a year by 2036, or a cumulative US$1.85 trillion over the same period. Unsurprisingly, as the fleet grows in Asia-Pacific so too will its share of the overall MRO business with 36% of the value or more than US$660 billion over the next 20 years (Figures 10.28, 10.29 and 10.30). As represented on Figure 6, MRO demand will more than double over the next 20 years.

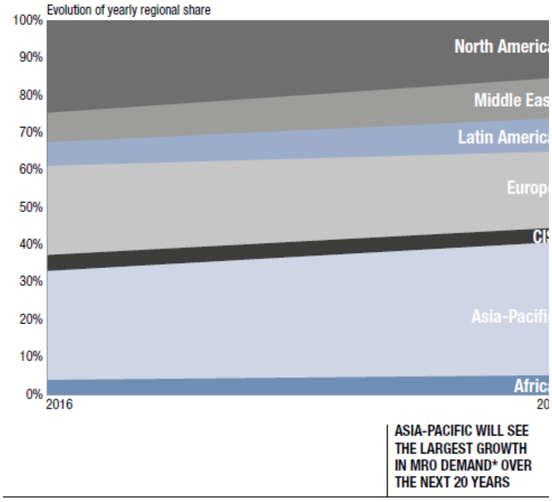

Figure 10.28 – Evolution of yearly regional share

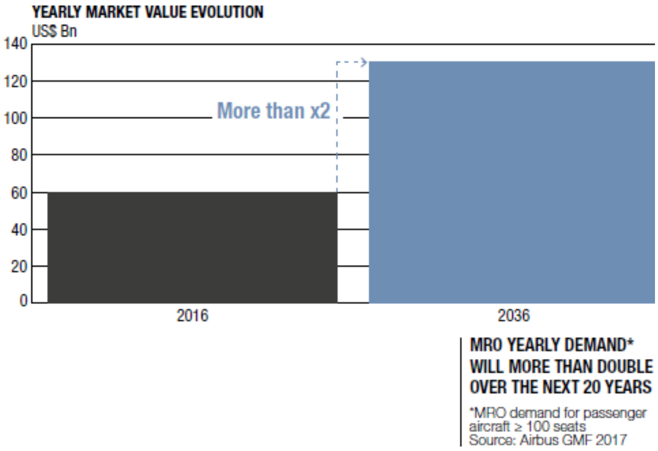

Figure 10.29 – Yearly market value evolution

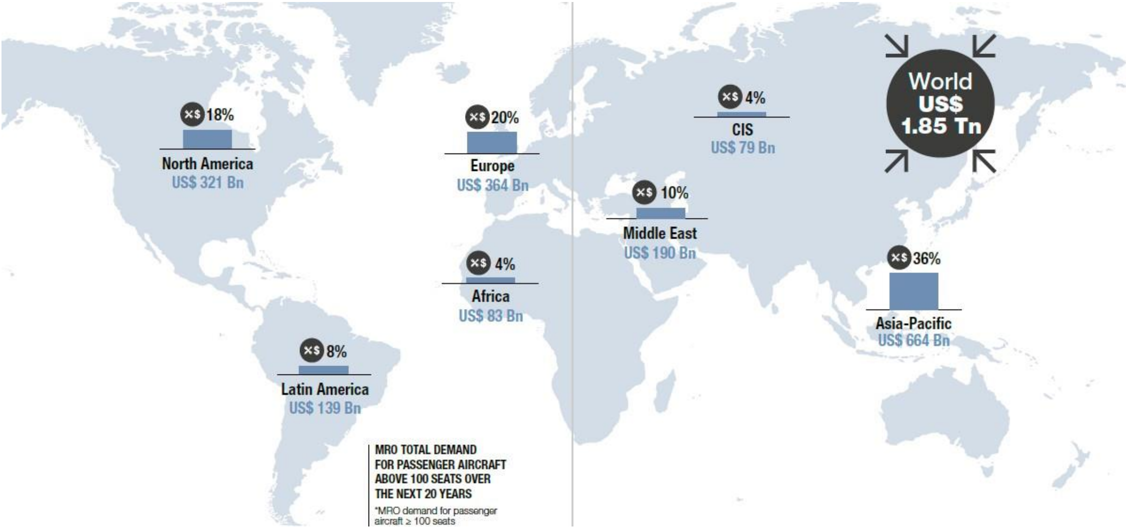

Figure 10.30 – MRO total demand for passenger aircraft above 100 seats over the next 20 years

As the world fleet grows so too does the need for more pilots and technicians to meet the needs of airlines and passengers. Airbus forecast (figure 10.31) that over the next 20 years more than a million such professionals will be needed to be trained to the highest levels.

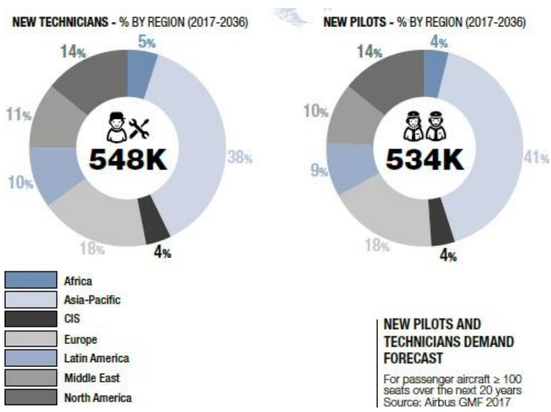

Figure 10.31 – Need for technicians and pilots

According to Boeing, the airline industry will require 637,000 new pilots, 648,000 new mechanics and 839,000 cabin crew members during the period. The Boeing forecast shows the most pronounced demand for pilots, technicians, and flight attendants in the Asia-Pacific region, which, according to Boeing, stands soon to surpass North America as the world's biggest commercial aviation market. Specifically, Asia-Pacific will need 253,000 new pilots over the forecast period, as well as 256,000 mechanics and 308,000 cabin crew. While North America promises to command the second-highest demand for pilots and mechanics, at 117,000 and 118,000, respectively, Europe will need more cabin crew, at 173,000, than will North America (154,000).

However, the Aviation Technician Education Council (ATEC) Pipeline report shows that new entrants make up 2% of the aviation maintenance technicians' population annually, while 30% of the workforce is at or near retirement age, which reinforces the need to attract women and students to the sector.

AEROSPACE ENGINEERS

Aerospace engineers will be other promising career (table 10.6), not only because of the estimated global demand for new passenger airplanes, but also because of the rapid advances in aerospace technology. Research and development projects, such as those related to improving the safety, efficiency, and environmental soundness of aircraft, will help sustain demand for workers in this occupation. Aerospace engineers in all areas will continue to be needed as design and production focus on aircraft that are less noisy and more fuel-efficient. In addition, as international governments refocus their space exploration efforts, new companies are emerging to provide access to space beyond the access afforded by standard governmental space agencies. The growing use of unmanned aerial vehicles will create more opportunities for aerospace engineers as authorities find domestic uses for them, such as finding missing persons lost in large tracts of forest or measuring snowpack and other water resources. Commercial interests will also find increasing uses for these unmanned vehicles, and workers in this occupation will find employment in designing and perfecting these vehicles for specified uses. Employment opportunities should be favourable for those trained in software, such as C++, or with education and experience in stress and structural engineering. Finally, the ageing of workers in this occupation should help to create openings in it over the next decade. (Occupational Outlook Handbook, 2017).

Occupational Title	Employment, 2016	Projected Employment, 2026	Change, 2016-26	
			Per cent	Numeric
Aerospaceengineers	69,600	73,800	6	4,200

Table10.6-EmploymentprojectionsdataforAerospaceEngineers,2016-26Source:BureauofLabour Statistics, U.S. Department of Labour.

In the United Kingdom (Table 10.7) two-thirds of aerospace engineering graduates are in employment six months after graduation. A fifth of those in employment (Table 10.8) are working as mechanical engineers, and a further fifth are working either as design and development engineers or other engineering professionals (Association of Graduate Careers Advisory Services, 2017).

Destination	Percentage
Employed	66.5
Further study	17.2
Working and studying	3.2
Unemployed	8.3
Other	4.7

Table 10.7 - Graduate destinations for aerospace engineering

Type of work	Percentage
Engineering and building	43.2
Technicians and other professionals	11.1
Retail, catering and bar work	8.8
Business, HR and financial	6.8
Other	30.0

Table 10.8 - Types of work entered in the UK

Internships are often the best way to get your foot in the door. Applying for a graduate programme or a direct entry position are other good ways. Most companies offer lots of training and professional development opportunities, including the opportunity to move into different roles.

According to Carrie Lambert, back in 2016, when was capability manager in engine noise at Rolls-Royce, the aerospace industry seeks graduates from the following disciplines: aerospace/aeronautical, chemical, control, electrical, electronics, environmental, instruments, manufacturing, materials, mathematics, mechanical, physics, power systems, software. Also, areas receiving a lot of attention include unmanned aerial vehicles, supersonic aircraft, distributed propulsion, electric aircraft, and higher bypass ratio engine products such as geared fans and open rotor technology. However, along with a solid technical background, good communication skills are absolutely critical. Engineers in this sector need to think and reason logically and use a combination of forensic and creative thinking to solve problems. There is always a lot to do so the ability to plan, prioritise and judge the level of detail and time to spend on a task is important.

OTHER CAREERS

Also, digital transformation is a reality for the A&D industry, so, besides a strong vision from the top management, attracting and retaining talents like data scientists and software experts will be key.

10.5 Motivating and Rewarding the Workforce

The best motivation and reward for the workforce is the openness to new ideas and giving opportunity for sensible innovation that also benefits the company's interests. This is more easily achieved in a small spin-off in a more dynamical atmosphere with less constraints. In many cases, a spin-off cannot do more than a specific work, or the initial stages of a larger task and the greater resources of a larger organization are needed to progress further. The commitment of larger resources requires a clear assessment of potential benefit. When that benefit materializes it should reach all levels of the workforce that contributed to it. Some companies:

- Share a part of the profits with the employees.
- Give employees the opportunity to buy a limited number of shares at favourable prices with the condition that they cannot be sold for a number of years.

Measures like these motivate employees to work harder for the aims of the company they share, knowing that the success due in part to their efforts will be recognized. These objectives relate to the principles of Strategic Human Resource Management (Key Topic T10.9) and their application in the Aerospace Sector (Key Topic T10.10).

KEY TOPIC T10.9 – PRINCIPLES OF STRATEGIC HUMAN RESOURCE MANAGEMENT

According to HIPAIR Erasmus+ project high-performance working practices (HPWP) must be recognized as important elements of business strategy development, in which the human resources play the key role. HPWPs include, for example, recruitment and integration, employee involvement, internal communication, training and reward and commitment. Strategic human resource management theory asserts that these practices increase employees' knowledge, skills, and abilities (KSAs), empower employees to leverage their KSAs for the organizational benefit, and increase their motivation to do so (Becker & Huselid, 1998; Delery & Shaw, 2001). The result is greater job satisfaction, lower employee turnover, higher productivity, and better decision making, all of which help improve organizational performance (Becker, Huselid, Pickus, & Spratt, 1997). Therefore, this approach helps to accept and involve the HR function as a strategic factor in the formulation and implementation of the company's strategies, since human resource management capabilities are important not only for attracting and selecting but also retaining, motivating and developing the workforce in an organization. Some practices that were identified in HIPAIR Project and may be effective on the motivating workforce are:

1. **REWARD & COMMITMENT** - practices focused on facilitating a greater sense of belonging to the specific organisation. Financial and non-financial incentives establish a sense of stakeholding within the company, having long term positive impact on employees.

- Compensation plans (production, administrative, administrative, etc.)
- Flexible working conditions
- Rooms for nursing mothers
- Retention policy

2. **EMPLOYEES INVOLVEMENT** - practices that are focused on the increase of the involvement and commitment of the employees inside the company. They can help in the evaluation and improvement of workers performance as well as the achievement of excellence in specific areas.

- Functional flexibility program
- Suggestions Programs
- Organisational Climate and Satisfaction Surveys
- Employee Engagement Survey
- Individual Development Plans
- Employee Action Plans
- Performance appraisal
- Annual objectives for each employee, individual and/or global
- KPI for teams
- Excellence achievement programme.

3. **TRAINING** - Practices aiming at improvement and development of the skills and competences of the company employees, needed for the specific company goals.

- Mentoring, Coaching, Tutoring
- Talent identification and development plan
- Talent development program to women-leadership in the aeronautics industry
- Specific training plans based on competencies/skills matrix to answer to identified gaps and to support life-long learning processes

Also, because environmental conditions play a role on individual's motivation to perform their work task, employers should guarantee work/task enrichment through more autonomy and discretion in one's job, feedback on performance, opportunity to use multiple skills (i.e., skill variety), identification of the contribution of one's job to the overall work context (i.e., task identity), and knowledge of the significant contribution of one's job to others' lives (i.e., task significance) (Aycan, 2004). This reflects Hackman and Oldham process motivation theory.

Besides the above mentioned, some people's motivation is based on fairness with which they are treated and compare this treatment with the one that is received by others whom they consider relevant for this comparison. Consequently, organizational justice is a key element to enhance worker's motivation. (Adams Equity Theory, 1963) There are ways in which to restore equity such as changing inputs (e.g., working less), changing the comparison group, changing the outcomes (e.g., asking for a salary increase), and leaving the organization. Reward allocation based on an equity principle is not endorsed in all cultural contexts.

As reported by Gibson et al. (2000), process motivation theories have important impact on managers who are involved in the motivational process as per their job nature. However, it is crucial to notice that there are individual differences concerning to the importance given to different properties or results and that these differences are related to other aspects of the organization. The relationship between the individual and the organization is interactive, of mutual influence in the establishment of a psychological contract - individual motivations and organizational conditions interact in complex ways.

KEY TOPIC T10.10 – HUMAN RESOURCE MANAGEMENT IN THE AEROSPACE SECTOR

Over the years, Human Resources Management (HRM) faced the requirement to adapt to new markets reality, work forms and workers' needs. Nowadays, it is necessary even a faster adaptation due to the constant market's demand change, technological developments, globalisation, and strong competition.

Traditional and rigid forms of work organisation have proved that they are not efficient for motivating the workforce, which is a very important resource to achieve more efficiency and benefits, as employees work harder for the aims of the company they share.

Therefore, the new challenge to be achieved will be to improve and adapt new HRM paradigms, by developing new methods to reward employees, in order to increase productivity and competitiveness in global markets.

In relation to the aviation sector, HRM becomes a key issue to assure its competitive position since it is considered as one of the most innovative industries worldwide. Therefore, to maintain the favourable position of the European aerospace industry, companies should pay special attention to HRM matters.

According to the HiPAir project, a strategic partnership co-funded by the ERASMUS+ programme of the European Commission, one of the new forms of work organisation, which have been developed, is the concept of High-Performance Work Practices (HPWP). Though many of the practices referred as high performance are commonly used by most organisations to motivate workers, such as financial incentives, flexible job descriptions and continuous skills development programs, the concept of HPWP is fairly unknown. HPWP can be defined as modern management practices design to stimulate the employees and the organisation performance.

According to literature worldwide, there is a relation between the systematic and integrated implementation of HPWP and performance indicators, such as productivity and profitability. This link may exist due to the effect of HPWP in employee attitudinal and behavioural variables such as job satisfaction, organisational commitment, employee empowerment, etc. Therefore, HPWP could develop better work conditions, affecting employee perceptions towards his employer, increasing satisfaction levels and the will to do more and better in the workplace.

At European level, no company openly uses integrated sets of HPWP, nevertheless, it is possible to identify some isolated practices considered High Performance, such as leadership abilities' development program, job rotation, retain talent programs, etc.

The following table 10.9 shows examples of High-Performance practices which are used in companies at European level:

Recruitment and integration	Interviews, theoretical tests Welcome Induction programs Internship programmes Search talented people in collaboration universities and other training institutions Preparation of job descriptions and selection procedures
Employees involvement	Functionalflexibilityprogram(mobilityinterandintra-department); Suggestions programs; Organisational climate and satisfaction Surveys; Employee engagement survey; Individual development plans; Employee action plans; Performance appraisal; Annualobjectivesforeachemployee,individualand/orglobal; KPI for teams; Continuous improvement system Excellence achievement programme
Internal Communication	Communicationpackagesforemployees; Intranet; Webinars; Communication meetings (involving all the workers, who may present their opinions and suggestions to improve company's procedures)
Training (learning and education)	Scholastic program; Post-graduate studies; Language courses; Trainingtechnicalandnon-technical(internalandexternalcourses); Mentoring, coaching, tutoring; Talent identification and development plan Talent development program to women-leadership in aeronautics industry; Specifictrainingplansbasedoncompetences/skillsmatrixinordertoanswertoidentified gaps and to support life-long learning processes.
Reward and commitment	Compensations plans (production, administrative, management, etc.); Flexible working conditions; Rooms for nursing mothers; Retention policy; Standardized job roles; Compensation, bonuses related with objectives achievement; Salary increment related with objective review.

Table 10.9 High-Performance practices used in European companies (Source: Hip Air, High-performance work practices in the aviation sector report).

In the following sections, it is included, as examples, companies that use High-Performance practices.

FerroNATS

FerroNATS (Table 10.10) provides the aerodrome control service that manages the operations of aircraft and vehicles within its area of responsibility, both on land and in the air.

Size	+ 130
Products	Air Traffic control services
Location	Spain
Established	2011
Ownership	Ferrovial Services and NATS

Table10.10FerroNATScharacteristics(Source:HipAir,High-performanceworkingpracticesbest cases)

The professional development of the employees in this company has a strategic value, that why this is one of the company's cornerstones. To achieve this objective, since its beginnings in 2011, FerroNATS has been putting in place High-Performance Practices. These are some examples of human resources programmes aimed at its employees:

CAREER PATH

The company informs its employees about the opportunities for career progression and growth and encourages its employees to achieve new professional goals.

Through its internal selection policy, FerroNATS encourages its employees to take part in all the company's selection processes, thereby fostering the professional growth of the team.

INDIVIDUAL DEVELOPMENT PROGRAMMES

FerroNATS has been running Individual Development Programs since 2014. These programmes involve the direct participation of the Human Resources Department, the Operations and Training Department, and the Tower Managers of each unit.

FerroNATS Secondment Programs 2016 saw the start of the FerroNATS Secondment Program whereby control tower and central office staff are seconded for one to six months to the offices of Ferrovial Services or NATS where they join one of the teams there.

The purpose of this programme is to promote the professional development of employees, enabling them to acquire new knowledge and skills, to create a teamwork culture among FerroNATS and its shareholders, to encourage knowledge exchange, to improve professional practices, and to foster networking.

At FerroNATS there is a professional development path (Figure 10.32) which enables its employees to know where they are and to focus their development on an area of interest within the company. This path is defined below:

The benefits of this kind of programs are reciprocal and they have repercussions for both the employee and the company:

- Increase of the employees' motivation
- Increase of the employees' commitment
- Improvements in the working environment among employees
- Decrease in the staff's rotation
- Greater professionalization of the employees in their workstations

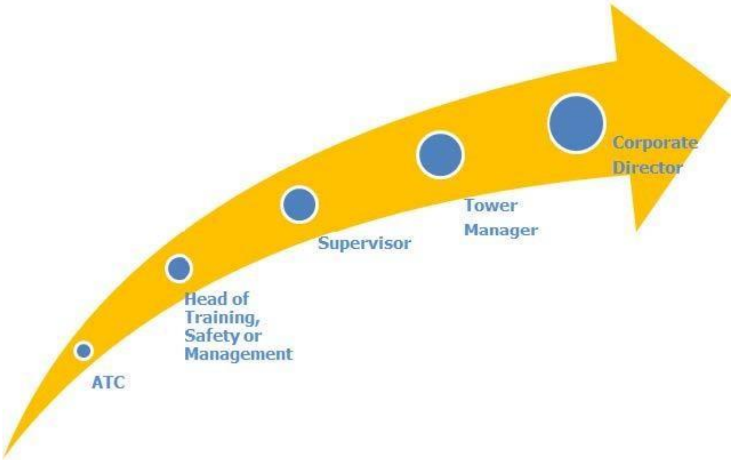

Figure 10.32 Areas of interest in FerroNATS

(Source: Hip Air, High-performance working practices best cases)

Fokker Elmo Turkey

The company develops and manufactures high technology products for the aerospace sector and has been operating in Turkey. Fokker Elmo (table 10.11) is accepted as an expert in electrics in planes and plane motors internationally.

Size	302 employees
Products	Electrical Wiring Interconnection Systems
Location	Izmir, Turkey
Established	2007
Ownership	GKN Group

Table 10.11 Fokker Elmo Turkey characteristics

(Source: Hip Air, High-performance working practices best cases)

Golden Idea System is one of the initiatives that aim to continuously improve all functions and involve all employees. The purpose of the system is to humanize the workplace, eliminate overly hard work and teach people how to perform experiments on their work using the scientific method and how to learn to spot and eliminate waste in business processes.

There are some of the benefits of Golden Idea System:

- Less waste: inventory is used more efficiently as are employee skills
- People are more satisfied: they have a direct impact on the way things are done

- Improved commitment: team members have more of a stake in their job and are more inclined to commit to doing a good job
- Improved competitiveness: increases in efficiency tend to contribute to higher quality products
- Improved customer satisfaction: coming from higher quality products with fewer faults
- Improved problem solving: looking at processes from a solutions perspective allows employees to solve problems continuously
- Improved teams: working together to solve problems helps build and strengthen existing teams

Groundforce

This is (Table 10.12) an aircraft ground service company.

Size	2335 employees
Products	Auxiliary activities to Air Transport (ground handling activities)
Location	Lisbon, also operates in Oporto, Funchal and Porto Santo Airports.
Established	2003
Ownership	Private/Public/mixed owned

Table 10.12 Groundforce characteristics
(Source: Hip Air, High-performance working practices best cases)

Given the fact that Groundforce is a labour-intensive aviation company, that works on shifts, responding to the different flows of the operation (by season, by the operational peak, by day of the week, per day) and the inevitable irregularities resulting from an operation that is intended to be just in time, employees are mainly hired for operational areas located on passenger, ramp, baggage terminal and cargo areas according to the specific job description with inherent soft skills.

Prior to their admission, there is a training paid package for each job function with eliminatory stages (according to IATA and ANAC procedures) that also includes on the job training, with a binding opinion of a tutor (senior employee on airside operation). This training package allows the company to ensure compliance with industry regulations and carrying out the first screening of operational talent in the organization. Soft skills are provided by external consultants that respond to strategic training aspects (leadership, communication, assertiveness, coaching, mentoring, etc.).

Another general training in Security, Airside Safety, Dangerous Goods Regulation, Human Factors and OSH (occupational safety and health) at work is given by internal trainers with that specified qualification.

Thanks to the training received, employees have a better perception of the company, its directions, workflows, processes, procedures and are more satisfied with working conditions. Safety is the main focus and employees feel it top-down and everybody assesses the other ones in the same way. Employees also feel that technology has come to stay, revolutionizing forms and methods of work, internal communication, and the relationship with different stakeholders.

Global Training & Aviation (GTA)

They are experts in the operation of full flight simulators. GTA (Table 10.13) invest in high quality training equipment and instructors to provide the most reliable and professional training.

Size	+150 employees
Products	Aviation Training Solutions
Location	Spain & Indonesia.
Established	2002

Table 10.13 Global Training & Aviation characteristics (Source:HipAir,High-performanceworkingpracticesbestcases)

One of the pillars of Global Training Aviation is the communication between its employees. There exists an information network which connects all employees and generates a very effective communication and it also contributes to making the employee feel involved in circumstances which are not necessary of his main accountability. GTA is based (figure 10.33) on the maximum employees' involvement making them, part of the whole company's functions and tasks. This is applied to all company's positions, so we can find that the Executive Director is developing basic and technical tasks of a project.

Global Training Aviation offers more effective training through reinforcing the emotional and personal element of teaching. At the same time, GTA stands up for technological excellence which is reflected in its business:

- All the instructors are staff inactive in airlines and they share and transmit their passion for what they are explaining.
- The company always uses E-learnings and CBTs with the support of an instructor. Custom tracking is performed during the student's evolution to detect and anticipate to possible learning issues.
- Along the training process, each instructor receives a personal report of the student from the previous instructor. This lets the instructor know which the student's strengths and weakness are.
- The training schedule is adapted to the multi-culturalism of GTA's students, building a "tailor-made" training process.

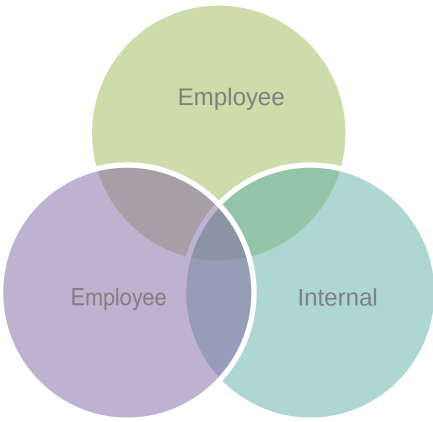

Figure 10.33 Factors on which GTA is based (Source: Hip Air, High-performance working practices best cases)

FTB Lisi Aerospace

The company (Table 10.14) presents the following characteristics:

Size	555 employees
Products	Fasteners for aeroplanes
Location	Izmir, Turkey
Established	Year 2001
Ownership	Lisi- Fastener Technology

Table 10.14 FTB Lisi Aerospace characteristics
(Source: Hip Air, High-performance working practices best cases)

FTB is executing "Lisi Excellence Achievement Program (LEAP Project) "since March 2013, which aims to involve employees to every application/ step at all levels in the company. The five LEAP principles (figure 10.34) are the following ones:

- Eliminating waste, rework and other recurrent situations at all levels by getting to the origin cause
- Having progress-oriented attitudes at work
- Viewing matters under a different light: The 3 reals: observing facts in the floor with the process workers
- Putting in place work standards produced by the process workers, and checking and improving these standards
- As a matter of routine, think: HSE, quality and then production.

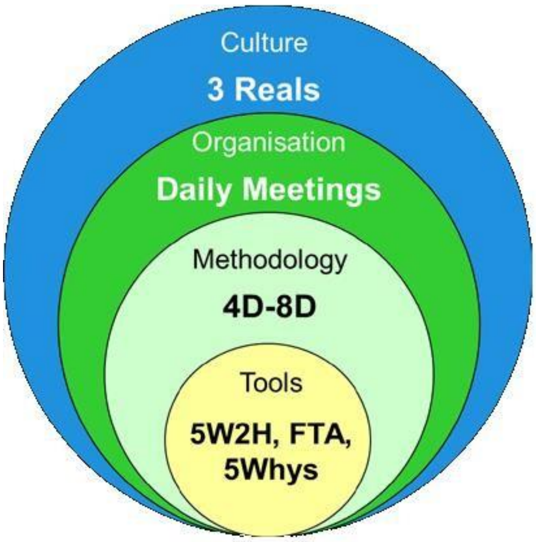

Figure 10.34 LEAP Project principles
(Source: Hip Air, High-performance working practices best cases)

MTU Aero Engines Polska

The company (Table 10.15) presents the following characteristics:

Size	580 employees

Products	Aviation business
Location	Rzeszow/ Jasionka, Poland
Established	2008
Ownership	MTU Aero Engines

Table 10.15 MTU Aero Engines characteristics
(Source: Hip Air, High-performance working practices best cases)

MTU Aero Engines Polska is an active member of Aviation Valley in Podkarpackie region. During the first years, within the company, there were different standards of attitude, work, and values, since most employees came from other companies. The company noticed that company culture influences everyday business and decided to carry out Company Culture Surveys, which showed them the directions to be followed.

As a result, the company decided to focus on values such as healthy lifestyle and teamwork and proposed several activities to create team spirit and engagement, improve health, practice hobbies and business together. In addition, the company created a virtual special agent named "Health", which promotes healthy activities at work.

Pratt & Whitney Rzeszów S.A.

The company presents the following characteristics in table 10.16:

Size	3500 employees
Products	Aircraft engine manufacturers
Location	Rzeszow, Poland
Established	1937
Ownership	United Technologies Company (UTC)

Table 10.16 Pratt and Whitney Rzeszów S.A characteristics (Source:HipAir,High-performanceworkingpracticesbestcases)

Pratt&Whitney Rzeszów is an important element of the chain of world aerospace component suppliers and aircraft engine manufacturers. One of the initiatives of carried out by the company is Techno Tour, which aims to change the culture of the firm and stimulate the activity of the employees, strengthening their sense of belonging to the company. The program will acquaint the employees with the key specialties, technology, and strategic areas of the organisation.

Southwest Airlines

The company presents the following characteristics in table 10.17:

Size	46000 employees
Products	Airline industry
Location	Dallas, USA
Established	31 years ago

Ownership	Southwest Airlines Company Institutional

Table 10.17 The Southwest Airlines characteristics (Source:HipAir,High-performanceworkingpracticesbestcases)

Southwest Airlines has focused on relationships to improve the quality and efficiency of its performance. The organisation works hard at enhancing team-building skills by giving employees training for relational competence. In terms of hiring, the company prefer new people who can integrate smoothly with other members on a team. With this strategy, every employee share company goals regardless of the functional area in which they work. In this way, it allows them to respond in a coordinated way whenever new challenges arise, or new information becomes available. It also provides a context by which decisions can be made and information shared.

KEY TOPIC T10.11 – THE EMPLOYER BRANDING STRATEGY AS A WAY TO ATTRACT WORKFORCE TO AERONAUTICS

The so-called war for talent, the intensified competition to attract the best employees to companies, arose motivated by the growing global competition and the mobilization of individuals for international markets, the rapid technological and demographic changes, as well as the clarification that human capital it is a source of value for organizations (Michaels, Handfield-Jones & Axelrod, 2001). In this way, attracting and retaining talent has become one of the prominent challenges for the management of human resources, verifying that talent management, i.e., the systematic attraction, identification, development and retention of individuals with high potential, who are particular value for the organization (Tansley et al., 2006), should focus on developing strategies to ensure that the talent pipeline remains adequate to the business challenges (Wilden , Gudergan & Lings, 2007).

A strategy that could prove to be an effective weapon in this war for talent involves employer branding, the efforts made to communicate to current and potential employees that the organization is a desirable and distinctive workplace (Lloyd, 2002), integrating a long-term strategy that even allows managing the knowledge and perceptions of stakeholders (Sullivan, 2004). In fact, characteristics such as culture, values, recruitment, remuneration, training and leadership have a strong impact on the employer brand that the organization builds (Chhabra & Mishra, 2008), with positive repercussions in terms of attracting and retaining employees, attract talents, and also with regard to reducing recruitment costs, optimizing results (Wilska, 2014) and increasing employee satisfaction and commitment (Robertson & Khatibi, 2013), influencing individuals' perception of quality employment and the associated risk of being an integral part of the organization (Wilden, Gudergan & Lings, 2007).

In this sense, the human resources of organizations must invest in a set of practices underlying a successful employer branding, namely defining the organization's profile, creating and maintaining a unique organizational culture, promoting a supportive culture, ensuring effective leadership (Wilska, 2014), identifying talent needs, ensuring an efficient communication plan (Shah, 2011), promoting work-family balance, as well as training and integrating new employees (Lazorko & Zajac, 2014), while also investing , in communicating with the outside through social media and holding open days in the organization. Nevertheless, it is crucial that there is consistency between these practices, not only to reflect the authenticity of the conceived image, but also so that there is coherence between internal and external employer branding, as positive experiences in employees enhance the effectiveness of external employer branding as a source of positive promotion of the organization's values and culture (Shah, 2011).

In short, currently, one of the biggest challenges is related to the attraction and retention of talent, which translates into costs for organizations that invest in the recruitment, training and development of employees who, therefore, tend to demonstrate high levels turnover. Thus, investing in employer branding may, in fact, constitute an effective solution, seeking, however, to adapt this strategy to socio-economic conditions (Alnıaçık, Alnıaçık, Erat & Akçin, 2014), since these generate different needs and, as such, distinct components of attractiveness for current and potential employees.

This is particularly relevant in aeronautics, due to the challenge of attracting young people and should be the main strategy of all HR departments all over the world. In fact, a good example of employer branding in Aeronautics is the case of TAP Portugal. In 2016, 2017 and 2018, TAP received an honour for their Employer Branding, which gives awards for the most desirable companies to work for using a countrywide survey and reinforces the award-winning management model at TAP[10]. For that, TAP legitimizes the need for alignment between both personal and organizational context, seeking a balance between the professional success of its employees and, simultaneously, competitiveness and sustainability. In this way, based on a participatory management model and personal recognition, sustainable development is enhanced through a better performance and contribution of the Company's Employees to competitiveness and to the best results. Human Resources practices are clearly aligned with the Company's strategy, thus contributing to the achievement of the Company's global objectives, in a logic of enhancing the credibility of the TAP as a brand. In this sense, considering the importance of a specialized and competent human capital, TAP guides its Human Resources strategy in terms of greater appreciation, motivation, and recognition of its Employees. The Employer Branding area is also responsible for ensuring aspects of health and well-being, promoting the balance between the personal and professional lives of TAP workers. Specific examples of practices to the employees are the special conditions in scope of health, nutrition, physical exercise, training and development and others as social benefits (e.g. tickets for entertainment appointments as theatre, music concerts).

KEY TOPIC T10.12 – ORGANIZATIONAL CULTURE

The study of culture has the particularity that there are numerous underlying meanings, the result of different approaches and theoretical perspectives related to the concept (Chambel & Curral, 2008). Although several definitions can be identified, in a more general way culture can be conceived as a set of values and practices defined and developed by the organization, on the basis of which a system of beliefs, norms and expectations that shape thought is socially built and the behaviour of individuals (Cunha, Rego, Cunha, & Cabral-Cardoso, 2007, p. 633).

Its conceptualization acquired consistency with the Schein model, which allowed a better understanding of the depth levels of the culture (Camara et al., 2013). According to Schein (1996), culture can be defined as the set of shared implicit assumptions that a group has and that determines the way it perceives, thinks and acts in relation to its various environments. Thus, this involves a learning process that has been carried out over time, as the group has been solving its problems of external adaptation and internal integration and, therefore, is being transmitted to new members as the correct way to perceive, think and feel about these problems (Schein, 1990).

[10] https://www.tapairportugal.com/en/media/press-releases/Press-Release-676

According to Schein (1990), culture manifests itself at three distinct levels: observable artefacts, values and basic assumptions. At a more superficial level are Artefacts, which convey what can be seen and felt when an individual enters an organization, such as the physical environment, clothing, language and other manifestations of permanent dominance, such as records and annual reports. At an intermediate level, Values stand out, which reflect the organization's norms, ideologies, and philosophies and, therefore, define the desired objectives and behaviours. Finally, there are the Basic Assumptions, which constitute the core of the organizational culture and define the organizational context, insofar as they allow employees to understand how to direct their attention and the actions they must exhibit in different situations (Chambel & Curral, 2008). Thus, by constituting the interpretative framework of the company's reality, they allow employees to model their behaviour (Camara et al., 2013).

Organizational culture acts as a form of attracting and motivating the workforce and is especially important in Aeronautics. In fact, organizational culture can influence not only the workforce but also the clients – when you have a strong organizational cultural you can increase both employee satisfaction, customer satisfaction and your profitability.

A specific example of organizational culture in aviation is the concept of Safety Culture, which is crucial in airlines. Actually, the organisation's Safety Culture is made up of a collection of individual cultures and other subcultures within the environmental constraints and promotions of the organisation. (Hudson, 2001). Is, in fact, commonly viewed as an enduring characteristic of an organization that is reflected in its consistent way of dealing with critical safety issues (Zhang et al., 2002). According with INEEL (2001), the 8 core components of a total Safety Culture are:

- Management commitment to Safety: Management involvement in safety is reflected by managers' presence and contribution to safety seminars and training, and also their active oversight of safety-critical operations.

- Job satisfaction: Safety is expected to affect people's attitudes, and subsequently organizational outcomes. The extent to which employees felt management was committed to workers' welfare and helped employees feel safe was predictive of employees' reported satisfaction with safety in the workplace. However, with low satisfaction, airline employees might report experiencing tension.

- Training, equipment, Physical environment: Some of the important human resource predictors affecting safety climate are preparation and planning, training, reporting system and rewards. In fact, Preparation and planning is required for safe flight operations and it has been estimated that over 100 hours of preparation are spent on each hour of flight (Sternstein & Gold, 1991).

- Organisational commitment: The extent to which upper-level management identifies safety as a core value or guiding principles of the organization.

- Worker Involvement: Motivation is presented as an intermediary process variable that mediates the effects of predictors on individual (first-level) outcomes. The extent to which the stated goals are aligned with actual goals an organization is trying to reach will act as a motivator for employees to achieve the goals and will define the level of involvement of the worker, which is proportionally related to the safety culture (bigger involvement, bigger concern to contribute to Satefy Culture of the organization).

- Co-worker support: In fact, peer cohesion, and support for safety are important variables that might affect safety climate in the aviation industry.

- Performance management and Personal accountability: Performance management such take in account work schedules, work hours, shift patterns, and fatigue. Personal characteristics, such as safety consciousness, are associated with taking safety precautions, and low levels of safety consciousness can lead to adverse outcomes, such as accidents.

In what concerns to the predictors of safety culture, we can list: Induvial predictors (characteristics of people who are employed in an organization and the characteristics of the jobs in which they work); Group predictors (leadership and psychosocial stressors) and organizational predictors (organization's structure and resulting organizational politics).

This Safety Culture has a strong impact on important outcomes, such as: 1) cognitive outcomes: exposure to informal or formal safety training and experience of incidents or accidents influences an individual's appraisal of potentially threatening situations. Prevention of accidents can be accomplished by making sure that aviation workers comprehend the gravity of risk and have the competencies for managing risks, as precursors to risk reduction. One way to ensure competencies is through reinforcement of one's knowledge of regulations and ensuring that off-the-job training is transferred on-the-job; 2) Organizational outcomes: attrition, accident and incident rates, the reputation of safety, and employee well-being and health. The main emphasis of the aviation industry is accident prevention and a "no accident" record (Glazer, Laurel & Narasimhan, 2005).

Additionally, organizational culture has a solid influence on a firm's innovativeness, a crucial factor in every aeronautics organization (Duygulu & Özeren, 2009). In today's contemporary business world, firms are under the great pressure of highly competitive and global markets. For aeronautics companies, it is highly critical to become innovative and differentiate themselves to act as a key piece on this complex and competitive environment. By creating and sustaining an organizational culture that nurtures creative efforts and facilitates the diffusion of learning, leaders can significantly boost organizational creativity (Jung et al., 2004). Also, organizations can develop and maintain a system that values and rewards creative performance through compensation. When exists a way to reward intrinsically and extrinsically the efforts to make creative work, organizations can take an advantage of the motivation of employees to be creative and learn new skills.

To sum up, safety and innovativeness are in the list of the greatest demands placed on aeronautics. It is not enough to have locked cockpits or to have checklists to ensure all safety procedures are followed. Maintaining a good organizational culture is one strategy for thwarting injuries and to allow companies to evolve in these competitive times and markets. So, the identification of key variables related to safety culture innovativeness and the process to construct a good and solid organizational culture should be a top priority to aeronautics companies in order to improve their results and sustainability.

10.6 Retaining the Fidelity of Employees

The traditional model of the society of lifetime work in a company still exists in countries like Japan but is presented by some as a 'lack of mobility', so that the US is a good and Europe is a bad example. In fact, the mobility of employment has more to do with cultural traditions than with company efficiency: are Japanese companies with stable employment less efficient than American companies with volatile employment? The trade surplus of Japan versus the United States tends to suggest the reverse. The fact that Japanese run factories in the US are often more efficient than American run companies also suggests that worker-management relations at an informal level are a contributor to productivity. Worker mobility is essential to allow the more capable to find jobs where their skills are put to better use for the benefit of society, but there is nothing wrong with a company gaining the fidelity of its employees by giving them good working conditions, competitive wages, stable job prospects and also the prospect of eventual retirement without major concerns. Cooperation with worker unions, if possible, is preferable to confrontation.

Retired workers can also continue to be of benefit to their former employers, by their testimonials of job satisfaction that may help recruit others with comparable competence and allegiance. An interesting example is the Museum of Safran at Villaroche that is run by former employees. Besides having a good collection of company products past and present, it also serves as a meeting place just outside restricted premises. As former employees, the 'keepers' of the museum have first-hand knowledge about some the exhibits that were part of their work. They edit documentation about the most famous company products and sell some nice models at reasonable prices. Everyone benefits: the company with a well-run museum, the former employers with a part-time work of their choice and the visitors with knowledge and crafts of their hosts.

The satisfaction employees (Key Topic T10.11) is closely related to the stability of the workforce (Key Topic T10.12).

KEY TOPIC T10.13 – SATISFACTION OF EMPLOYEES

Employees satisfaction is a measure of how happy workers are with their job and working environment and can be seen as an emotional state that results from the evaluation of one's job or experience.

In the journey of the consolidation of a company, employees and collaborators have a key role cooperating for the same goal. In a job environment, it is usual that some employees are dissatisfied with their work due to the fact that their conditions in the company are not optimal, so they end up leaving the company which causes a constant rotation in the organizations. Clearly, this is a negative point for the company due to it generates distrust and instability besides it increases the costs in the search and recruiting of new personnel. Thus, keeping employees is an essential requirement in order to make the company successful.

Related to that, sometimes the wages do not match the working hours or the quantity or, even worse, the quality of the job done by the employees. The fact that an employee feels that he is not valued by the company is completely subjective in such a way that many times increasing wages is not the solution to make the employee happy at work but also the company should provide the employee with the right environment in which he feels comfortable. However, it is also important that the company pays fair and competitive wages according to the job itself and according to the rest of the market.

Additionally, in a market where people work about 8 hours a day, it is difficult to find the right moment to solve personal issues thereby employees' value positively having flexibility at work. If a company provide the employees with an environment where schedule changes and other facilities are possible, employees will be willing to stay working for the firm as they feel comprehension and empathy from the company.

Another important factor is that employees feel that their bosses appreciate their work in the company. In this manner, the experience and commitment of the employees along the years should be valued by the company thus it strengthens employees' loyalty.

In fact, and in accordance with the previous information, having good relationships with the colleagues, high salary, good working conditions, training and education opportunities, career developments or any other benefits may be related with the increasing of employee satisfaction.

In order to enrich the levels of employee satisfaction, some changes can be made (Sageer, Rafat & Agarwal, 2012):

- Organizational Development, in order to implement effective change in an organizational.

- Policies of Compensation and Benefit, because it is important that employees are satisfied with the salary package and a feel of satisfaction is achieved by attaining fair rewards.

- Promotion and Career Development.

- Job Satisfaction, and the importance of the nature of the work itself, often called "intrinsic job characteristics" (job challenge, autonomy, variety) that should be as interesting and challenging as possible (Saari & judge, 2004);

- Job Security, that consists in the assurance or confidence that the employee will keep their current job.

- Working Environment and Condition: it's essential to have good conditions, as feeling safe and comfortable, have good tools and equipment, have good working methods, etc.

- A good relationship with Supervisor.

- Work Group, i.e., people like to interact with others and the existence of group in organizations it is an important factor.

- Leadership Styles, where it is preferable to choose a democratic style of leadership in order to have a friendship, respect and warmth relationship.

But why should organizations make all this investment? Along the time, various studies have been showing that employee satisfaction is positively correlated with motivation, job involvement, organizational citizenship behaviour, organizational commitment, life satisfaction, mental health, and job performance, and negatively related to absenteeism, turnover, and perceived stress. Also, with these changes, the employee will care about the quality of their work and is more productive, contributing more and better for the organization.

Definitely, some actions that a company can carry out to improve workers experience develop, foster and reward the training of employees, the public and private recognition, facilitate schedule flexibility, give opportunities for professional improvement, provide laptop and/or mobile phone for work, value the opinions expressed by the employees, create a good work environment for workers, promote business trips and so on. In conclusion, are this kind of practices, with focus on employee and their well-being, that assure the satisfaction, happiness, and loyalty. Since dissatisfied employees are more likely to quit their jobs (Saari & judge, 2004), that is exactly the way we can retain workers and guarantee the stability of the workforce.

KEY TOPIC T10.14 – STABILITY OF THE WORKFORCE

Employee fidelity can be defined as employees who are devoted to the success of their organization and believe that being an employee of this organization is in their best interest. Not only do they plan to remain with the organization, but they do not actively seek alternative employment opportunities[11].

What is identified in the US as a "mobility problem" is a combination of the behavioural loyalty (the perception of the shortage in the labour market) and the Peter Principle (promotion of a person until it reaches its level if incompetence)[12] . A favouriting factor in this approach in the US is the huge size of the workforce in Aerospace: over 700 000 people employed, compared with about 400 000 in Europe and nearly the same figure in China[13]. The average productivity (sales per employee) in Japan Aerospace industry is higher (12%) than its US counterpart.[14.]

Workforce issues in aerospace are near the top of the list of challenges facing the industry. A significant number of workers in aerospace are eligible for retirement or approaching retirement eligibility in the next five years. Unfortunately, the uncertainty of workforce retirement makes it difficult to plan for the future. Regardless of these issues, companies must ensure they maintain current expertise while forecasting future hiring needs, such as what skill sets will be needed and when to hire for them.[15]

In the fight for talent, aerospace companies face industry-specific challenges. To recruit and retain talent, especially people with the STEM (Scientific, Technical, Engineering, Maths) skills that are so highly prized in many different industries (with critical skills for today and emerging skill requirements for the future). It is currently considered of great importance how best to ensure the transfer of talent from older to younger employees, an issue that is becoming more acute as the older employees retire. They have a relatively high proportion of older workers (approximately 60% of aerospace employees are over age 45 vs. 44% in the overall US workforce. Conversely, approximately 42% of aerospace employees is under age 44 vs. 56% in the overall workforce).[16]

This lopsided demographic mix, coupled with high attrition rates and increased labour mobility, poses serious risks to the industry. Companies can mitigate the risks with employee retention and succession planning. But as retirement rates creep up, it is increasingly important to approach the issue of succession in a systematic way that includes leaders and management as well as critical technical employees.

The loyalty of the workforce in an aerospace organization is a very important ingredient in the quality of the output. The first determinant is pay. The average hourly wages in the aerospace industry, at $45 (compared with $30 in the automotive industry and $28 in manufacturing overall), is surpassed only by the $46 in coal and petroleum. However, such a very meagre gain in pay in the extractive industries is not attractive when the working conditions are considered. The working conditions are the second determinant. And an "esprit de corps" (a feeling of pride and mutual loyalty) is probably the third. This happy combination makes

[11] Susan DeFranzo: "Tips to Improve Employee Loyalty" in https://www.snapsurveys.com/blog

[12] Nik Penhale Smith: "The employee mobility problem" in https://www.effectory.com/knowledge/blog

[13] Deloitte Touche Tohmatsu Limited ,http://reports.weforum.org/manufacturing-growth/aerospace-industry-infographics/

[14] https://www.wolframalpha.com/

[15] Jim Adams: "Will the A&D workforce be prepared for the future?" in http://usblogs.pwc.com/industrialinsights/

[16] Ibidem

employment in aerospace desirable and competitive within the labour market. What would further enhance the fidelity of the employees? Perceived high job security (reduced risk of being made redundant), a good and reliable pension system, an effective health insurance scheme and an optional extension of the retirement age could only increase the attractivity and the excitement of the employment in aerospace and retain talent, especially people with the STEM skills.

In conclusion, retaining the workforce should be a top priority for the aeronautics because the intention of the workforce to leave the organization and the withdrawal itself can have a domino effect on other human resource concerns as the quality of the service, productivity and the organizational success in general.[17]

[17] (Baloch, 2009).